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A COMPUTERIZED MODEL FOR SIMULATING THE BRAKING AND STEERING DYNAMICS OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES COMBINATIONS

USER'S MANUAL - PHASE 4

Charles C. MacAdam
Paul S. Fancher
Garrick T. Hu
Thomas D. Gillespie

MVMA Project 1197

Highway Safety Research Institute
The University of Michigan
Ann Arbor, Michigan 48109

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16. Abstract

This report contains the information needed to use a detailed, computerized model (called "PHASE 4") for simulating the braking, directional, and/or braking performance of heavy trucks and combination vehicles. After concise discussions concerning (1) the history of the development of PHASE 4 and (2) the uses, operation, and validity of the computerized model, comprehensive descriptions of the required input data and the program output are provided to allow a user to submit a run and interpret the output obtained.

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The computer simulation program described in this manual is derived from computerized models of trucks and tractor-trailers developed since 1971 at the Highway Safety Research Institute of The University of Michigan. These models were developed in the Motor Truck Braking and Handling Research Program sponsored by the Motor Vehicle Manufacturers Association (MVMA). The opportunity to consolidate several programs into a single program capable of representing vehicles from trucks to triples combinations was provided by the Federal Highway Administration (FHWA) under the project "Simulation of Effects of Increased Truck Size and Weight."

Development of the computer program described here was supported by the MVMA and this program is an extended version of the computer code delivered to the FHWA.

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1.0 INTRODUCTION AND GENERAL INFORMATION

1.1 Introduction

The title of this report, "A Computerized Model for Simulating the Braking and Steering Dynamics of Trucks, Tractor-Semitrailers, Doubles, and Triples Combinations," pertains to a simulation program (called "PHASE 4")* developed in 1980 by the Highway Safety Research Institute (HSRI) of The University of Michigan under the sponsorship of the Motor Vehicle Manufacturers Association (MVMA). The HSRI/MVMA goal in developing this program has been to consolidate all existing modifications to the so-called "Phase II" program [2]**, originally developed in 1973, into a single program. This document contains instructions for using the PHASE 4 computerized model, that is, this user's manual provides the specific information needed for submitting a run and interpreting the output obtained.

Since 1971, HSRI has been conducting research under the sponsorship of MVMA with the ultimate goal of developing optimum means for predicting and evaluating the longitudinal and directional response of trucks and tractor-semitrailer vehicles. The specific objectives of this continuing program have been to: (1) understand the physics of truck braking and handling, (2) develop computer-based methods for simulating truck braking and handling, (3) minimize the effort and cost to use the computerized methods, (4) extend the range of application of the simulation models, and (5) provide a common basis for communication between industry and government with regard to heavy vehicle dynamics. The major outputs from this program have been (a) computer-based models for predicting braking and directional response [1 through 5], (b) test techniques and equipment for measuring parameters describing heavy commercial vehicles [6 through 18], and (c) studies of simulation and test results to illustrate the utility of a methodology (consisting of parameter measurement, simulation, and full-scale testing) for developing a detailed understanding of the

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*This simulation program is called PHASE 4 since there are Phase 1, 2, and 3 models [1,2,3].

**References are listed in Section 6.0 of this Manual.

directional response characteristics and braking performance of commercial vehicles [19 through 24].

In recent years, many improvements, modifications, and revisions have been made to the directional response programs first described in 1973 [2]. These changes in the programs have been developed for a variety of purposes and under several different sponsors. Hence, these changes have been implemented in several different versions of the program rather than in one version.

During the past year, HSRI has produced a single, updated directional response simulation. The coding format for this simulation is based on a revised computer code, called "T3DRS:V1," delivered to FHWA in 1979 [36]. The T3DRS:V1 simulation was chosen as a starting point for this year's work because it had the following features: (1) an improved set of documentation describing the input parameters, (2) a new method for implementing longitudinal and lateral tire force data, (3) a driver representation for path-following maneuvers, (4) the ability for representing doubles and triples combinations, and (5) a new capability for incorporating roadway geometrics into the vehicle dynamics model.

The principal differences between the T3DRS:V1 and the PHASE 4 computerized models are the addition of the following features in the PHASE 4 model:

1) The capability for improved representation of suspension spring force/deflection characteristics

2) A brake torque and temperature model

3) A representation of brake torque-pressure hysteresis phenomena

4) Load leveling action in tandem suspensions

5) A simplified semi-empirical tire model

6) A brake proportioning program

7) Steering system compliance

8) Tractor frame compliance in torsion

These features, with the exception of the tractor frame compliance in torsion and the load-leveling action of tandem suspensions, are optional in the sense that the user may choose to omit them if the nature of a particular research investigation does not warrant their use. Nevertheless, each of these items has been found to be of significance in specific cases. Under MVMA support, HSRI has spent considerable effort in developing equipment for measuring component characteristics to obtain as complete and accurate an understanding as possible of the mechanical properties represented in this computerized model [6-18]. In particular, research studies devoted to measuring and characterizing tires, brakes, suspensions, and steering systems have motivated the development of the optional computerized models of component performance contained in PHASE 4. These optional features extend the range of application of the computerized model into advanced studies of yaw divergence [31,38], in-stop brake fade [21], antilock braking [22], directional response during braking [37], the influence of roll compliance properties on directional response [38], and the influences of brake proportioning alternatives.

The remainder of this document provides information on using PHASE 4. The format of this report closely parallels that employed in the User's Manual for T3DRS:V1 [35], thereby utilizing the revised and improved documentation developed for T3DRS:V1. In fact, the documentation presented here is practically identical to that used previously except where the additional features are discussed. With the addition of directions for using the new features, a complete and self-contained manual for using PHASE 4 has been assembled herein.

1.2 Engineering Units and Computer Requirements

1.2.1 Engineering Units. Throughout the PHASE 4 program, the English system of units is used. With the exceptions listed below, all input data are given in units of pounds, inches, degrees, and seconds. Masses and weights are in units of pounds, with a gravitaional constant of 386 in/sec/sec assumed. The units for input data parameters are defined in the input data echo.

Exceptions:

1) Input for the initial velocity is given in units of ft/sec.

2) Input describing trajectory points for the path-follower steering mode are defined in terms of feet lateral versus feet longitudinal.

3) Longitudinal and lateral road slope is defined in percent grade (Rise/Run).

4) Certain tandem-axle parameters are described in units of percent.

Output data units are defined on the printed output pages. In general, the same units are used throughout, although the vehicle position, velocity, and acceleration variables use the length dimensional unit of "ft."

1.2.2 Computer Requirements. The PHASE 4 program is written for use on any large-scale computer system, and requires only one input and one output device. The source code is in level-G Fortran IV language, with 800,000 bytes of memory required for loading. Support software must include the IBM Scientific Subroutine Package (HPCG, SMPY, LOC, GMPRD, GMADD, and MINV).

Copies of the program are available to the public by contacting the Physical Factors Division, Highway Safety Research Institute, The University of Michigan, Huron Parkway and Baxter Road, Ann Arbor, Michigan 48109; (313) 764-2168.

2.0 APPLICATION

2.1 Description of the Program

The PHASE 4 program is a time-domain mathematical simulation of a truck/tractor, a semitrailer, and up to two full trailers. The vehicles are represented by differential equations derived from Newtonian mechanics that are solved for successive time increments by digital integration.

The program is written in a generalized fashion to allow simulation of a large number of vehicle configurations. The first vehicle is the power unit and may be a truck or tractor, both of which may carry payload. As a single unit with no payload, it is equivalent to an empty truck or bobtail tractor. With payload, it is a truck, which, with a semitrailer as well, simulates a car hauler, dromedary tractor, etc. The second unit is always a semitrailer (i.e., current models do not include a truck with full trailer). The third and fourth units are full trailers consisting of semitrailers on either a fixed or converter dolly. Separate payload may be specified for each trailer.

The truck/tractor unit is distinguished by the fact that it can have only a single front axle with single tires, and can be arbitrarily steered. All other axles on the vehicle combination can be represented as single or tandem axles with single or dual wheel sets.

The mathematical model (see Appendix E) incorporates up to 71 degrees of freedom. The number of degrees of freedom are dependent on the vehicle configuration and derive from the following:

- Six degrees of freedom (three translational and three rotational) for the truck/tractor sprung mass
- Three degrees of freedom for the semitrailer (the three other degrees of freedom of the semitrailer are effectively eliminated by dynamic constraints at the hitch)
- Five degrees of freedom for each of the two full trailers allowed.

-Two degrees of freedom (vertical and roll) for each of the 13 axles allowed

-A wheel rotational degree of freedom for each of the 26 wheels allowed

The motion of each of the sprung masses is determined from the summation of forces and moments upon it arising from the tires (acting through the unsprung mass of the axle and suspension), gravity, and the hitch point constraints. Small angle assumptions are made in the implementation of the mathematical equations so that the simulation can be validly applied only up to a maneuver limit at which wheel lift-off occurs.

2.2 Uses of the Program

Since PHASE 4 includes the basic features of T3DRS:V1, it can be used to simulate the following vehicle configurations:

Straight truck, empty and loaded

Bobtail tractor

Tractor-semitrailer (3 to 5 axles), empty and loaded

Tractor-semitrailer-full trailer (5 to 9 axles), empty and loaded

Tractor-semitrailer-full trailer-full trailer (7 to 13 axles), empty and loaded

For simulation of braking performance, the program incorporates state-of-the-art representation of truck air brake systems, antilock wheel control systems, and tire-road friction models. Typical examples of braking studies for which it can be or has been used are:

1) Stopping distance performance

2) Effects of brake timing

3) Dynamic behavior in braking

4) Comparisons of antilock wheel control logic

5) Influence of tire-road friction coupling

6) Split friction surfaces

7) Brake proportioning

8) Tandem-axle effects on braking limits

For simulation of cornering performance behavior, the program incorporates state-of-the-art representations of truck tire lateral force characteristics (with roll-off effects during combined braking), and vehicle suspension properties of significance to cornering behavior. Typical examples of studies involving cornering are as follows:

1) Understeer/oversteer properties of commercial vehicles

2) Determining cornering limits

3) Assessing tandem-axle effects on cornering

4) Jackknife prediction

5) Effects of suspension properties on cornering and cornering limits

6) Accident simulation

In addition to the above, the program can be operated open-loop (defined steer angle inputs) or closed-loop (defined path input), and on roads of specified grade or cross-slope.

The PHASE 4 program is uniquely applicable in directional response studies in which the influence of the following items are to be considered in detail:

1) Spring force/deflection characteristics (hysteresis and free-play)

2) Brake "fade" -- brake temperature

3) Brake hysteresis

4) Load-leveler action in tandem suspensions

5) Brake proportioning algorithms

6) Steering system compliance (inputs at the steering wheel)

7) Frame torsional stiffness

2.3 Operation

Operation of the PHASE 4 program is accomplished by submission of the necessary job control instructions followed by a list of input parameters. The specific job control instructions required are dependent on the user's computer system and whether batch or remote job entry is being used. However, the input parameter list is common to all and is described in Section 3.0 of this Manual.

The program commences by reading the input list containing parametric data describing the vehicle configuration, initial conditions, steering and braking inputs, the output desired, and the road conditions. As input data is read, the data is normally "echoed" as the first pages of output. At the completion of the input read process, the program calculates necessary properties of the total vehicle combination and prints a page of output containing a summary of those vehicle properties. The program then "runs," solving the differential equations of motion for the vehicle until the vehicle reaches a full stop, a default stop (such as rollover), or until the designated maximum simulation time is reached. At various points during the run, simulation output is printed, which (at the option of the user) may include time-based values for the vehicle motion variables, tire forces at each axle, braking conditions on each axle, tire cornering conditions, and the suspension motions and forces.

2.4 Validity

The validity of PHASE 4, like any computer program, is dependent on the accuracy and execution of program statements, the capabilities of the simulation models, and the quality of the vehicle and maneuver descriptions defined by the input data.

Every effort, of course, is made to ensure that the program statements are correct and result in solution of the problem to a reasonable level of precision. The time steps have been selected so that round-off and truncation errors do not substantially influence the precision of the calculated results. Nevertheless, if programming errors are discovered, the user should contact the Physical Factors Division, Highway Safety Research Institute, The University of Michigan, Ann Arbor, Michigan.

The modeling used in the simulation is effectively state-of-the-art, reflecting the most practical approaches to mathematical representation of commercial vehicles for braking and handling studies. Over the years, modeling has grown more in sophistication than in detail. For example, early models for truck brake systems extending to mechanical details within the individual brakes have proven no more capable of predicting braking performance than the "black box" representation as a pressure-input, torque-output device. Hence, the latter approach was used in T3DRS:V1, with a substantial saving in the complexity associated with understanding and using the simulation. With nearly every component model used in the simulation, there are instances where more modeling details would be appropriate for the study at hand; yet, provision for every instance would result in a simulation for which the input data requirements would be untenable. To some extent, this dilemma is alleviated in PHASE 4 by including optional features as means to describe component characteristics in more detail when desired.

Finally, the ultimate determinant of validity is the user-supplied input data and the interpretation applied to the results. Properly used, the program is capable of validly predicting most aspects of braking performance and directional response in maneuvers up to the limits of wheel lift-off. In the special case where a direct comparison between a vehicle and simulation (i.e., validation) is intended, an iterative process is often involved as the first comparisons of simulation and test reveal unexpected differences, which, when examined, are traced to inaccuracies or errors in the experimental measurements or program input. Fortunately, the usefulness of these simulation programs are not dependent on every user going through the same process. In most applications, the user can assume, for example, a given tire characteristic and investigate vehicle performance with that tire, knowing that it is typical, but yet, not precisely equivalent to any specific tire on hand. Much of the utility of computer simulation programs derives not from absolute prediction of a certain vehicle/test maneuver situation (as required for validation), but as a tool for studying generalized performance and sensitivity of performance to the vehicle parameters.

In this general sense, the PHASE 4 program can be expected to yield valid measures of the braking and handling performance comparison when specific vehicle parameters are changed. The PHASE 4 program has been tested against other simulations, including its predecessors, which in turn have proven capable of reasonably duplicating actual vehicle performance. The user is referred to the following references for examples of the use and validation of those programs:

	References
Straight Truck Braking	1, 2, 25, 21, 28, 19, 36, 22, 20
Straight Truck Cornering and Braking	2, 29, 36
Straight Truck Cornering	23, 36
Tractor-Trailer Braking	1, 2, 36
Tractor-Trailer Cornering and Braking	2, 29, 36
Tractor-Trailer Cornering	26, 36
Tractor-Trailer-Full Trailer Cornering	27, 36

2.5 Modeling Differences Between the T3DRS:V1 and PHASE 4 Simulation Programs

Aside from the additional model options which are available in PHASE 4, the two principal differences between T3DRS:V1 and PHASE 4 lie in the manner in which (a) the tractor fifth wheel is modeled in roll and (b) the inclusion of load-leveling action for tandem suspensions in PHASE 4. In the V1 model, the fifth wheel compliance represented a torsional coupling between the tractor and trailer sprung masses. No torsional frame compliance in the tractor was included. In the PHASE 4 model, the fifth wheel is a rigid connection in roll (for small articulation angles) between the trailer sprung mass and the top of the tractor rear suspension. The torsional frame compliance included in the tractor links the tractor sprung mass to the fifth wheel connection. This feature has been added to PHASE 4 to more accurately represent the observed roll response with tractor-trailer vehicles, although its effect on handling response is not always significant.

The load-leveling action which takes place in tandem suspensions during braking and handling is more accurately represented in the PHASE 4 version. The dynamic load equalization is now calculated continuously during simulation to achieve a more accurate value for the instantaneous suspension forces. Both four-spring and walking-beam type tandem suspensions are available in the PHASE 4 model.

3.0 PROGRAM INPUT

3.1 General

Program operation is effectively accomplished by input of a parametric data list, along with the necessary job control instructions. This section provides a detailed description of the input data required. Appendix C provides a ready reference list of input parameters. Sample input lists covering the various options are provided in the text and in Appendices A and B.

Depending on the vehicle configuration, the input data list will contain the following elements:

- Title Line (up to 80 characters)
- Simulation Operation Parameters
- Truck/Tractor Parameters
- Truck/Tractor Front Suspension and Axle
- Truck/Tractor Front Tires and Wheels
- Truck/Tractor Rear Suspension and Axle
- Truck/Tractor Rear Tires and Wheels
- Truck/Tractor Front and Rear Brake Parameters (Optional - used only when braking is called)
- First Trailer Parameters (Optional)
- First Trailer Rear Suspension and Axles (Optional)
- First Trailer Rear Tires and Wheels (Optional)
- First Trailer Rear Brake Parameters (Optional)
- Second Trailer Parameters (Optional)
- Second Trailer Dolly, Suspension and Axles (Optional)
- Second Trailer Dolly Tires and Wheels (Optional)
- Second Trailer Rear Suspension and Axles (Optional)

-Second Trailer Rear Tires and Wheels (Optional)

-Second Trailer Front and Rear Brake Parameters (Optional)

-Third Trailer Parameters (Optional)

(Same as Second Trailer)

The input data is identified only by its position in the input list and hence must be ordered exactly to match the vehicles and options used in the simulation. Errors in the input list will result either in a read fault (with possible system interrupt and abort of the program), or in simulation of the wrong conditions. Every effort has been made to define the input sequence and its alteration with various options in this section. Example input lists are shown throughout the Manual for reference by the user in compiling an input data list.

3.1.1 Tandem-Axle Option. To suit the simulation to the great variety of commercial vehicles, either single or tandem axles may be specified for any suspension in the total vehicle configuration, except on the front (steering) axle of the truck/tractor. Details on use of the tandem suspension are provided in Section 3.3.4.

3.1.2 Table Lookup Option. It is often desirable to include nonlinear characteristics of vehicle components (particularly for tires, springs, and brakes) in the model simulated. For such parameters a table lookup option can be used, allowing the parameter to be described by a multiple point approximation over the range of interest rather than assigning to it a single valued linear characteristic. The program thence interprets the dependent variable's value when needed using linear interpolation methods. In the event the program exceeds the range of the table, the dependent variable is limited to the last entry in the table.

The table lookup option may be used with the following input parameters:

-Suspension spring rate
-Tire cornering stiffness
-Tire longitudinal stiffness
-Brake torque

The table lookup option is called by entry of a negative whole number value for the parameter. The negative sign identifies it as a table lookup and the numerical value identifies that table and distinguishes it from other tables in the input list. The table is then entered in the input list immediately following the calling point. For the two-dimensional tables (spring rates and brakes), the first line entry in the table is an integer value equal to the number of data sets to follow, each being a separate line entry of independent versus dependent variable values. Tire parameter tables are more complicated and are explained in Section 3.3.3.

The same table can be used at subsequent points in the input list by entry of the negative whole number identifying that table. The table values should not be re-entered at these subsequent calling points.

More detailed instruction for entering lookup tables are provided in Sections 3.3.2, 3.3.3 and 3.3.6.

3.1.3 Side-to-Side Option. In most simulation studies, a vehicle has symmetric properties left and right. Nevertheless, it is occasionally of interest to investigate the influence of side-to-side differences in springs, tires, brakes, etc. While vehicle mass properties are modeled as symmetric about the vehicle centerline, most components that are paired, one to each side of the vehicle, may be assigned different parametric values. Different values side-to-side may be assigned for the following parameters:

-Steer angle inputs

-Suspension spring rate
    viscous damping
    coulomb friction

-Tire cornering stiffness
    longitudinal stiffness
    camber stiffness
    aligning moment
    spring rate
    loaded radius
    polar moment of inertia

-Brake time lag
rise time
torque
antilock systems

In normal input of those parameters, one entry causes the program to assign that value to both sides of the vehicle. The side-to-side option is exercised by making a double entry on the line, in which case the first value is assigned to the left side of the vehicle and the second to the right. A zero value cannot be assigned to the right-hand side with a nonzero left-hand side value due to the way this option operates, but zero values can be effectively obtained by entry of very small nonzero values. The side-to-side option can also be combined with the table lookup option. By entry of two negative values, tables are assigned to both the left and right sides. The tables for the left and right sides are entered in sequence immediately after the calling line. More detailed instruction for side-to-side entry options are provided in Sections 3.2, 3.3.2, 3.3.3, and 3.3.6.

3.1.4 Compatibility of T3DRS:V1 and PHASE 4 Data Sets. Data sets for the T3DRS:V1 program are compatible with the PHASE 4 program with the exception of five parameters:

1) The FIFTH WHEEL STIFFNESS parameter in the V1 data set is replaced by TRACTOR FRAME STIFFNESS in PHASE 4 (Section 3.3.1).

2) Addition of the TRACTOR FRAME TORSIONAL AXIS HEIGHT parameter immediately following the FRAME STIFFNESS parameter (Section 3.3.1).

3) Addition of the STEERING GEAR RATIO parameter immediately following the UNSPRUNG WEIGHT parameter for the tractor front suspension (Section 3.3.2).

4) Addition of the KHST parameter (global brake hysteresis key) following the BRAKE TORQUE coefficient for the truck/tractor front suspension (Section 3.3.6).

5) Addition of the KPROP parameter (global brake proportioning key) following the KHST parameter (Section 3.3.6).

3.2 Simulation Operation Parameters

The first line entry in the input list is always a user-supplied title line consisting of up to 80 alphanumeric characters. Thereafter, the Simulation Operation Parameters are entered and subsequently echoed as the first page of output, as shown in Figure 1.

The first line of the Simulation Operation Parameters is VEHICLE CONFIGURATION defined by the number of trailers, entered in I2 format, which indicates to the program the extent of input to be expected. Zero trailers indicates a single unit straight truck, which is also equivalent to a bobtail tractor. An "01" entry indicates a tractor-semitrailer. An "02" entry indicates a tractor-semitrailer-full trailer (doubles) configuration. An "03" indicates tractor-semitrailer-full trailer-full trailer (triples) configuration, the maximum number of vehicles allowed.

The second line is INITIAL VELOCITY in units of ft/sec (F15.3 format). At the initiation of the simulation run, all vehicles are in a straight-line configuration, moving forward at the indicated velocity.

The next entries define the steering input to the simulation. Either front-axle steering inputs (open-loop) or a path-follower (closed-loop) mode are selected by the respective entry of a positive or negative integer value for STEER TABLE (NUMBER OF LINES (I3 format)). This choice in combination with the optional specification of a steering system model in the truck/tractor front suspension and axle parameters (Section 3.3.2) results in four possible steering modes. In the absence of a steering system model, the steer angle specified in the table or by the path-follower model are applied directly to the front wheels. With a steering system, the steering inputs are applied at the steering wheel. Thus, depending on the choice, the following is obtained:

1) Steer table without steering system - The steering angles defined as a function of time in the table are applied directly to the front wheels. Different left and right steer angles can be specified.

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HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.      INPUT PAGE NO.  1
                              TRACTOR-TRAILER EXAMPLE RUN - 1 DEGREE STEER

  SIMULATION OPERATION PARAMETERS:
  --------------------------------

     VEHICLE CONFIGURATION (NUMBER OF TRAILERS - ENTER 0 FOR A STRAIGHT TRUCK)                              1
     INITIAL VELOCITY (FT/SEC)                                                                          66.00
     STEER TABLE (NUMBER OF LINES):  POSITIVE -STEER ANGLE TABLE, NEGATIVE - PATH FOLLOWER TABLE            3
          TABLE ENTRIES:                                   TIME (SEC)  LEFT WHEEL (DEG)  RIGHT WHEEL (DEG)
                                                           ----------  ----------------  -----------------
                                                              0.0           0.0              0.0
                                                              0.10          1.00             1.00
                                                             10.00          1.00             1.00

     TREADLE PRESSURE TABLE (NUMBER OF LINES)                                                               1
          TABLE ENTRIES:                                               TIME (SEC)   PRESSURE (PSI)
                                                                       ----------   --------------
                                                                          0.0           0.0

     MAXIMUM SIMULATION TIME (SEC)                                                                       0.40
     TIME INCREMENT OF OUTPUT (SEC)                                                                      0.10

     ROAD KEY =  0 : FLAT ROAD.

     OUTPUT PAGE OPTION KEYS:  0 DELETES PAGES
     -----------------------------------------
          SPRUNG MASS    SPRUNG MASS    SPRUNG MASS    TIRE FORCES   BRAKE SUMMARY   LATERAL    UNSPRUNG MASS    TEMP
          POSITION       VELOCITY       ACCELERATION      PAGES          PAGES        PAGES         PAGES        PAGES
              1              1               1              1              1            1             1            1
```

Figure 1. Example of simulation operation parameters.

2) Steer table with steering system - The steer angle specified in the table is applied to the steering wheel. The steer angle divided by the steering ratio determines an attempted steer angle (the same for both front wheels), although the forces on the wheels acting against the stiffness properties of the steering system will cause each wheel to deviate slightly from the attempted steer angle. These deviations play an important role in the directional response behavior of a vehicle.

3) Path-follower table without steering system - The path-follower model generates steering inputs to cause the vehicle to follow a desired path. The steer angles are applied equally to both front wheels.

4) Path-follower with steering system - The steering inputs calculated by the path-follower are scaled up by the steering ratio and are applied at the steering wheel. The steering angles obtained at the left and right road wheels, however, may deviate slightly from the attempted angle due to the steering system model.

The numerical value of the entry for STEER TABLE (NUMBER OF LINES) specifies the number of lines in the subsequent table. A "000" entry indicates that no steering is involved in the maneuver, hence, no table entries are made and the vehicle performs as if the steering wheel were held fixed in the straight-ahead position. No steering action is applied to the front wheels except as may result from front suspension roll steer, or in the case where a steering system has been defined, steer action may be obtained as a result of forces applied to the front wheels. When a nonzero number of lines is given, a table of the prescribed length must follow according to the following instruction.

Steer Table (positive numerical entry) - Each line is a set of time (sec) versus left-wheel steer angle (deg) and right-wheel steer (deg) in 3F10.3 format as shown in Figure 1. If both wheels are to be steered identically, only the time and left-wheel angles are required; the absence of the right-wheel steer angle entry causes it to be assigned the same value as left-wheel steer angle. Up to 25 lines of table are allowed. Steer angles are obtained from the table at each time increment by linear interpolation. The table should always start off with an entry for zero time to assure definition of steer angles throughout the simulation run and be listed in ascending order with time. If simulation time exceeds the last time entry in the table, the last steer angle values are retained.

If the STEERING GEAR RATIO parameter, entered later (see section 3.3.2) is a positive value, the above steer table is interpreted as a steering wheel angle table instead of a front-wheel angle table. In this case, each line of the table is a set of time (sec) versus steering-wheel angle (deg) values in 2F10.3 format.

Path-Follower Table (negative numerical entry) - Each line is a pair of X (inertial forward) and Y (inertial lateral) path coordinates (in units of ft, 2F10.2 format) defining the desired path to be followed by the vehicle during closed-loop operation as shown in Figure 2. Linear interpolation is used by the program to determine path coordinates between entered points.

Following the last line of the closed-loop path-follower table, two additional parameters are entered which permit the program user to exert influence over the manner in which the closed-loop driver model functions. The first of these parameters, DRIVER TRANSPORT LAG (F10.4 format) generates a transport time lag (sec) within the controller to provide a simple means for representing human operator lag characteristics when desired. Values for this parameter should range between 0.0 and 0.5 (sec). Values larger than about 0.5 sec will generally produce an unrealistic and potentially unstable vehicle/driver system, and are hence not allowed. A zero entry inactivates the transport lag feature.

The remaining closed-loop parameter, END OF PREVIEW INTERVAL (F10.4 format), indicates the distance ahead in time (sec) that the driver model looks during closed-loop steering operation. Hence, a value of 1.0 sec for this parameter would cause the driver model to look ahead over a 1-sec interval, or an equivalent maximum distance of 88 ft at a forward speed of 60 mph. Larger values for this parameter

```
HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.        INPUT PAGE NO.  1
                         TRACTOR-SEMITRAILER -- CLOSED-LOOP CIRCULAR RUN.

  SIMULATION OPERATION PARAMETERS:
  --------------------------------

     VEHICLE CONFIGURATION (NUMBER OF TRAILERS - ENTER 0 FOR A STRAIGHT TRUCK)                               1
     INITIAL VELOCITY (FT/SEC)                                                                           66.00
     STEER TABLE (NUMBER OF LINES):  POSITIVE -STEER ANGLE TABLE, NEGATIVE - PATH FOLLOWER TABLE           -14

          CLOSED-LOOP PATH FOLLOWING MODE

          X-Y PATH COORDINATES :

                                                                         X          Y

                                                                      (FEET)     (FEET)
                                                                        0.0        0.0
                                                                      100.00     -10.10
                                                                      200.00     -41.70
                                                                      300.00    -100.00
                                                                      350.00    -143.00
                                                                      375.00    -169.00
                                                                      400.00    -200.00
                                                                      425.00    -237.00
                                                                      450.00    -282.00
                                                                      460.00    -304.00
                                                                      480.00    -360.00
                                                                      490.00    -400.00
                                                                      500.00    -500.00
                                                                      505.00    -900.00

          DRIVER TRANSPORT LAG (SEC) :            0.0
          END OF PREVIEW INTERVAL (SEC) :         2.00

     TREADLE PRESSURE TABLE (NUMBER OF LINES)                                                               3
        TABLE ENTRIES:                                              TIME (SEC)    PRESSURE (PSI)
                                                                    ----------    --------------
                                                                       0.0             0.0
                                                                       0.10            0.0
                                                                      10.00            0.0

     MAXIMUM SIMULATION TIME (SEC)                                                                       4.00
     TIME INCREMENT OF OUTPUT (SEC)                                                                      0.10

     ROAD KEY =  0 : FLAT ROAD.

     OUTPUT PAGE OPTION KEYS:  0 DELETES PAGES
     ---------------------------------------
        SPRUNG MASS    SPRUNG MASS    SPRUNG MASS    TIRE FORCES    BRAKE SUMMARY    LATERAL    UNSPRUNG MASS    TEMP
        POSITION       VELOCITY       ACCELERATION      PAGES           PAGES         PAGES         PAGES        PAGES
            1              1               1              1               1             1             1            1
```

Figure 2. Example of simulation operation parameters with path-follower option.

will produce a less responsive, more heavily damped system behavior during closed-loop operation. Likewise, smaller values will provide more responsive system behavior exhibiting less damping. Recommended values for this parameter are 1.0 to 3.0 sec. A more detailed description of the operation of the path-follower model is provided in Appendix G of this Manual.

Treadle Pressure Table - The next entry following the last steer table parameter is the integer (I2 format) for the TREADLE PRESSURE TABLE (NUMBER OF LINES) which is to follow. The treadle pressure is the line pressure demanded by the driver during braking and controlled by the driver-actuated pedal valve. Each line of the treadle pressure table is entered as a pair of time (sec) versus pressure (psi) numbers (2F10.2 format). The complete table defines the desired treadle pressure time history used by the program during a braking maneuver and may be varied with time to simulate the pressure depletion caused by antilock cycling, or to simulate fade in the brakes due to heating effects. The table should begin at zero time and be listed in ascending order with time. Intermediate points in the treadle pressure table are obtained by linear interpolation. The numberof lines in the table must equal the integer number of lines indicated and may not exceed 10. If the treadle pressure table is given zero lines, the program will not execute any braking, and brake parameters (Section 3.3.6) are deleted from the input data list. On the other hand, entry of a table with one or more lines (even if all are zero pressure values) keys the program to look for entry of brake data.

Immediately following are two lines of program instruction. The first is MAXIMUM SIMULATION TIME (sec, F15.3 format) which defines the time duration of the maneuver to be simulated. The program will run for this simulated time period unless the vehicle reaches a stop within the period or a fault (such as vehicle rollover) occurs. To ensure printout of the last time increment desired, it is helpful to specify the MAXIMUM SIMULATION TIME as 0.001 seconds longer than the desired time. Typical simulation times are 4-8 sec. The second line is TIME INCREMENT OF OUTPUT (sec, F15.3 format) which selects the intervals of simulation time at which the instantaneous values of output parameters are printed. Since the normal integration interval is 0.0025 sec, the time increment should be a multiple of this value. Section 4.4 gives some hints on selection of this input parameter.

ROAD KEY - A key for defining one of three road options is the next entry. ROAD KEY is an integer entry and provides the following three road options:

	> 0	:	Planar road with a fixed down-slope and cross-slope
ROAD KEY	= 0	:	Flat horizontal road
	< 0	:	User-defined road surface programmed in SUBROUTINE ROAD

ROAD KEY should be entered in I2 format when the flat road or user-defined road surface options are selected.

When the planar road option (IROAD > 0) is selected, two additional numbers need to be entered on the same line as the ROAD KEY (I2, 2F10.2 format). These two additional entries represent the <u>percentage</u> of down-slope (forward) and cross-slope (lateral, positive slopes down to the right) of the road plane at time zero and fixed with respect to the inertial coordinate system. The planar road option is not currently available for down-slopes when simulating vehicle configurations requiring two or more trailers. (Truck and tractor-semitrailer configurations only.) The initial conditions of the truck or tractor-trailer sprung and unsprung masses in pitch and roll are selected by the program under this option as equal to the specified down-slope and cross-slope of the road. A small initial transient will occur at the beginning of the simulation run using this option, since the lateral and fore/aft suspension forces are not initially in equilibrium.

Selection of the third road option, User-Defined Road (IROAD < 0) allows the program user to define an arbitrary road surface (e.g., road roughness, parabolic bowl, cone, etc.) by providing a SUBROUTINE ROAD containing code which defines road elevation as a function of X-Y inertial coordinates. Appendix H discusses this option in greater detail and provides an example user-written subroutine and required format.

OUTPUT PAGE OPTION KEYS - The last line entered for simulation operation parameters requires eight integer keys (8I1 format) that specify which output pages will be printed during program execution. Entry of 1 for any key will cause that page to be printed; entry of 0 will cause its deletion during output printing. The eight output page types corresponding in order from left to right in the 8I1 field are:

Truck, Tractor, Trailer Sprung Mass Position
Truck, Tractor, Trailer Sprung Mass Velocity
Truck, Tractor, Trailer Sprung Mass Acceleration
Longitudinal, Lateral, and Vertical Tire Forces
Brake Summary
Lateral Tire Forces and Moments
Unsprung Mass Summary
Brake Model Temperatures

3.3 Truck/Tractor Description

The first vehicle is the truck or tractor that is modeled as the sprung mass associated with the cab, chassis, body, payload, etc., supported by suspension systems linking it to the unsprung masses of the axles, supported on the ground, in turn, by the tire/wheel assemblies. Reference [2], Section 2, provides a comprehensive discussion of the type of mathematical formulation used in the simulation model. Parametric data are needed to describe each of the vehicle components. Figure 3 shows the first portion of that input corresponding to input page 2 "echoed" by the program.

3.3.1 Truck/Tractor Parameters. The basic properties of the truck or tractor are described by its sprung mass parameters included in the first group of entries shown in Figure 3. The sprung mass is modeled as a rigid body shown in Figure 4. The characteristic length

```
HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.        INPUT PAGE NO.  2
                                    TRACTOR-TRAILER EXAMPLE RUN - 1 DEGREE STEER

TRACTOR PARAMETERS
------------------
     WHEELBASE - DISTANCE FROM FRONT AXLE TO CENTER  OF REAR SUSPENSION (IN)                          150.00
     BASE VEHICLE CURB WEIGHT ON FRONT SUSPENSION (LB)                                               9437.00
     BASE VEHICLE CURB WEIGHT ON REAR SUSPENSION (LB)                                                7953.00
     SPRUNG MASS CG HEIGHT (IN. ABOVE GROUND)                                                          40.13
     SPRUNG MASS ROLL MOMENT OF INERTIA (IN-LB-SEC**2)                                              36757.00
     SPRUNG MASS PITCH MOMENT OF INERTIA (IN-LB-SEC**2)                                            105493.00
     SPRUNG MASS YAW MOMENT OF INERTIA (IN-LB-SEC**2)                                              241479.00
     PAYLOAD WEIGHT (LB)                                                                                 0.0
          *** ZERO ENTRY INDICATES NO PAYLOAD ***
          *** FIVE PAYLOAD DESCRIPTION PARAMETERS ARE NOT ENTERED ***
     FIFTH WHEEL LOCATION (IN. AHEAD OF REAR SUSP. CENTER)                                               0.0
     FIFTH WHEEL HEIGHT ABOVE GROUND (IN)                                                               47.50
     TRACTOR FRAME STIFFNESS (IN-LB/DEG)                                                            250000.00
     TRACTOR FRAME TORSIONAL AXIS HEIGHT ABOVE GROUND (IN)                                              36.00

TRACTOR FRONT SUSPENSION AND AXLE PARAMETERS                                       LEFT SIDE           RIGHT SIDE
--------------------------------------------                                       ---------           ----------
     SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)                                       1380.00              1380.00
     SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)                                  0.0                  0.0
     COULOMB FRICTION (LB/SIDE/AXLE)                                                 300.00               300.00
                                                                                   ------------------------------------
     AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)                                               5307.00
     ROLL CENTER HEIGHT (IN. ABOVE GROUND)                                                      20.00
     ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)                                               0.17
     AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)                                                9900.00
     LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)                                           36.00
     TRACK WIDTH (IN)                                                                           79.50
     UNSPRUNG WEIGHT (LB)                                                                     1450.00
     STEERING GEAR RATIO (DEG STEERING WHEEL/DEG ROAD WHEEL)                                     0.0
      *** NEGATIVE OR ZERO ENTRY INDICATES NO STEERING SYSTEM ***
      *** STEERING SYSTEM PARAMETERS NOT TO BE ENTERED ***

TRACTOR FRONT TIRES AND WHEELS                                                     LEFT SIDE           RIGHT SIDE
------------------------------                                                     ---------           ----------
     CORNERING STIFFNESS  (LB/DEG/TIRE)                                              722.50               722.50
     LONGITUDINAL STIFFNESS  (LB/SLIP/TIRE)                                        28000.00             28000.00
     CAMBER STIFFNESS (LB/DEG/TIRE)                                                    0.0                  0.0
     ALIGNING MOMENT  (IN-LB/DEG/TIRE)                                                 0.0                  0.0
     TIRE SPRING RATE (LB/IN/TIRE)                                                  5700.00              5700.00
     TIRE LOADED RADIUS (IN)                                                          20.30                20.30
     POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)                                    245.00               245.00
```

Figure 3. Example of first page of truck/tractor parameters.

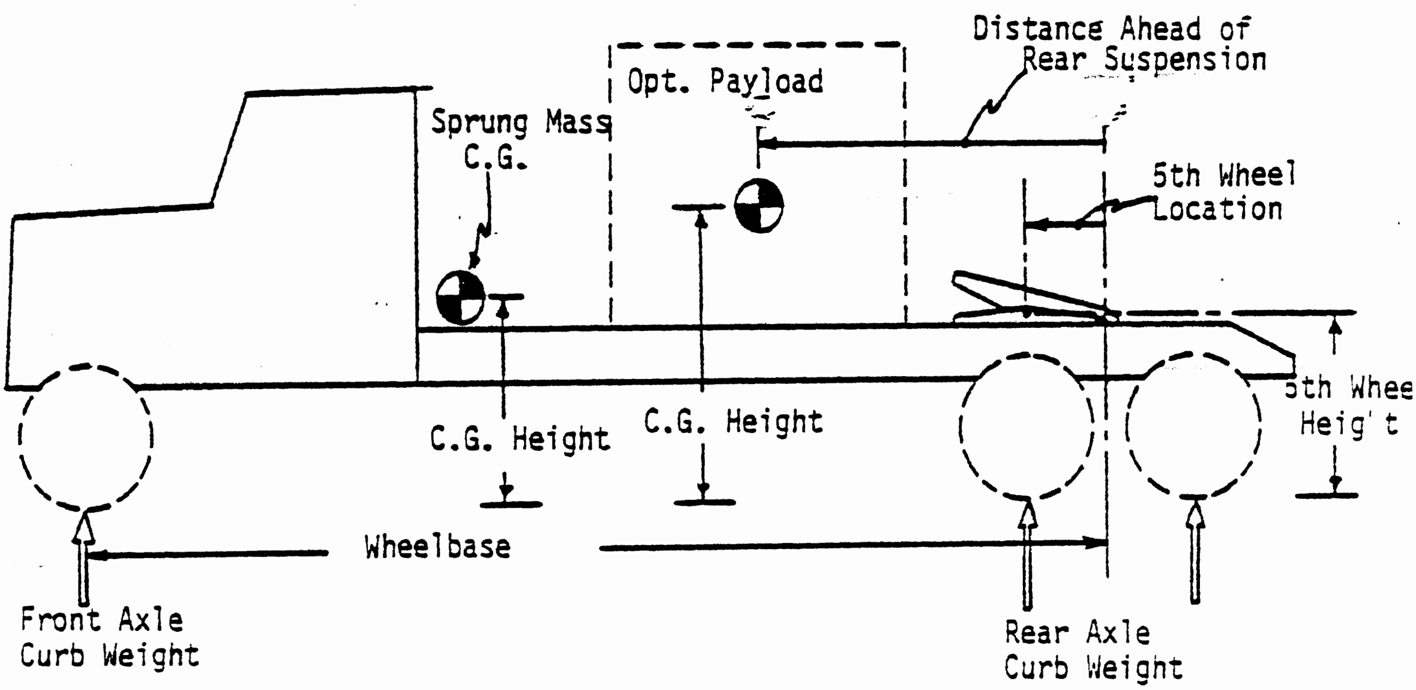


Figure 4. Modeling elements of the truck/tractor sprung mass.

of the vehicle is its WHEELBASE, defined as the longitudinal distance in inches (F15.3 format) between the geometric center of the front and rear suspensions. For two-axle vehicles, this is the same as the distance between the front and rear axle centerlines, but for three-axle vehicles it is the distance between the front axle and the geometric center of the rear axles.

The rigid-body sprung mass is represented by mass properties concentrated at its center of gravity (c.g.) at the lateral center of the vehicle. Its mass and fore/aft location are determined by the BASE VEHICLE CURB WEIGHT values in pounds for the FRONT and REAR AXLES (the next two line entries, F15.3 format). This approach is used because the curb weight data is more readily available to users than the properties of sprung mass weight and fore/aft position. Internally, the program determines these parameters by calculations that subtract out the unsprung weight of the axles entered later in the input. The base vehicle curb weight is defined as the weight <u>without</u> payload <u>or</u> a trailer. The rear suspension curb weight with tandem axles is the total ground load for both axles.

The vertical location of the c.g. is defined by the next entry, SPRUNG MASS CG HEIGHT, which is measured in inches above the ground (F15.3 format). As specified, this is the c.g. of only the sprung mass in the base vehicle configuration corresponding to the curb weight values given above. The height should be given with the vehicle in its fully deflected position as results from loading by a payload or trailer. The sprung mass c.g. height is not readily available to most program users; however, in the absence of such data reasonable estimates can be made. For heavy vehicle cab-chassis configurations, the sprung mass c.g. is usually close to the top of the frame rails (typically 38-40 inches above the ground). Such an estimate is reasonable for a tractor or for a truck with a low, light platform bed. However, if the truck includes a substantial body, the c.g. must be measured or estimated from the combined properties of the cab-chassis and vocational body.

The rotational inertia properties of the sprung mass are given by the next three entries for SPRUNG MASS ROLL MOMENT OF INERTIA, PITCH MOMENT OF INERTIA, and YAW MOMENT OF INERTIA. The inertias are given in units of in-lb-sec^2 in F15.3 format. It is normally recommended that these parameters are measured for a vehicle to be simulated, though methods for estimating them have been developed [30]. Appendix F provides a short method for estimating these properties.

As a convenience in using the program to investigate performance of heavy vehicles with variations in payload, the payload parameters are entered separately. The first parameter is PAYLOAD WEIGHT, in lbs (F15.3 format). Thereafter, it is necessary to describe its location by DISTANCE AHEAD OF REAR SUSPENSION CENTER (in., F15.3 format) and CG HEIGHT (inches above the ground in its loaded position, F15.3 format). The payload is always assumed to be located laterally in the center of the vehicle. Likewise, ROLL, PITCH, and YAW MOMENTS OF INERTIA are required, in units of in-lb-sec^2 (F15.3 format). If the simulated vehicle is to have no payload, the payload weight is entered as zero, and no entry is required for the subsequent payload parameters. Payload can be specified for both trucks and tractors. If payload is not to be varied, the payload may be lumped in with the vehicle sprung mass properties by entering loaded vehicle axle weights for the BASE VEHICLE CURB WEIGHTS. In that case, the c.g. height and sprung mass moments of inertia must be for the same combination of masses.

Finally, the connection point for a fifth wheel is also located on the sprung mass. If a tractor is being simulated (as indicated by one or more trailers in the VEHICLE CONFIGURATION input), fifth wheel parameters are included at this point in the input list. (The entries are deleted if no trailers are entered.) Four parameters are required: FIFTH WHEEL LOCATION (inches ahead of the rear suspension), HEIGHT ABOVE GROUND (in.), TRACTOR FRAME STIFFNESS (in-lb/deg, in the roll direction), and TRACTOR FRAME TORSIONAL AXIS HEIGHT above ground (in.). Further details on the tractor frame compliance model are found in Appendix I.4. All four entries are F15.3 format. The fifth wheel location is arbitrary, typically from 0 to 12 in., and determines the distribution of trailer load on the tractor axles. The height above the ground is the height to the pitch plane hinge point on the fifth wheel for the fully loaded tractor (typically 45 in.). The tractor frame stiffness parameter is included to allow representation of typical tractor frame compliances. Reasonable levels of tractor frame stiffness can be approximated with values for this parameter ranging from 20,000 to 200,000 in-lb/deg. Values of frame torsional axis height should be near the value used for the sprung mass height above ground.

The user should be aware that the fifth wheel coupling (as well as pintle hitch couplings, described later) are all represented by spring connections. Thus represented, the equations of motion for different vehicles are coupled by force inputs rather than displacement constraints and may be solved separately and more economically. All fifth wheel spring rates are selected within the program for optimum operation of the simulation. The resulting rates are high enough to appear effectively rigid.

3.3.2 Truck/Tractor Front Suspension and Axle Parameters. The PHASE 4 program models the I-beam type front axle commonly used on medium and heavy trucks. The suspension serves as a compliant link between the sprung and unsprung masses, and is characterized by the forces and moments it produces. All suspensions are modeled in the generalized fashion shown in Figure 5. The parameter entries for the truck or tractor front suspension are shown in Figure 3. The primary compliance of the suspension is in the vertical direction and is defined by SUSPENSION SPRING RATE in lb/in per side of the vehicle. Since these are paired components on an axle, the side-to-side option is available. The rates for the left and right springs are entered on one line in 2F10.2 format. If left and right are the same, only the first (left) entry needs to be made, and the zero or blank read for the right side causes it to be assigned the same value as for the left.

Two options exist for representing nonlinear springs: (1) the simple Spring Table used in T3DRS:V1 and (2) a new Spring Envelope Table. Nonlinear spring tables are selected by entering a negative spring rate. The type of nonlinear spring table option is determined by the numerical value of the negative spring rate. Spring rates

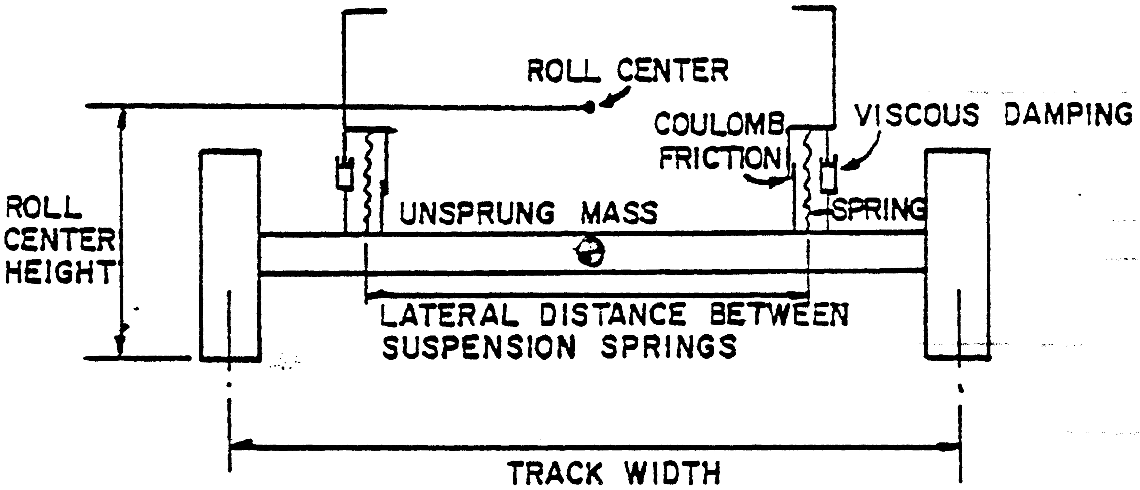


Figure 5. Model of suspension systems.

ranging from -1. to -99. will key the Spring Table option; spring rates ranging from -100. to -199. key the Spring Envelope Table. The input requirements for each of these options are described below.

Spring Table:

1) Enter a negative whole number for spring rate (the negative sign keys the program for a table lookup, and the numerical value identifies the table; -99. < value < -1.).

2) A single (left spring) entry results in use of the table for both left and right springs.

3) Entry of a separate negative number for each spring keys the program to look for two tables.

4) Enter the left spring table immediately in the form as follows:

   Line #1 - Number of lines to follow, maximum of 10 (I2 format)

   Line #2 - Spring force (lb) vs. deflection (in) (2F10.2 format)

   ⋮

   Line #n - Spring force (lb) vs. deflection (in) (2F10.2 format)

5) If a separate right spring table was called for, it is entered next in the same format.

The tables are entered in the positive sense; i.e., positive deflection (spring compression) corresponding to positive force (load) on the axle. The reference point for deflection is arbitrary, since the program simply identifies the initial deflection from the static load, and calculates changes thereafter. It should be noted that even with side-to-side differences in spring characteristics, the program always assumes equal loads on both sides of the axle, adjusting the initial (or static) spring deflection for the fully loaded vehicle to achieve this condition. When using the lookup table, the range of the table should always exceed the expected range of operation of the spring. Typically, it should extend from zero load to the maximum dynamic load expected. Excursions beyond the range of the table causes it to limit at the last load condition in the table in the direction of the excursion. If tension loads are expected due to the maneuver, the spring force characteristics should be defined in the tension (negative force) range.

Spring Envelope Table:

To enter spring data for the Spring Envelope Table option, two envelope tables and two parameters need to be entered for each spring (see Appendix I.3 for further explanation of these parameters).

1) Enter a negative whole number for spring rate; -199 < value < -100.

2) As above, a single (left spring) entry results in use of the table for both left and right springs.

3) Enter the number of lines in the spring compression envelope table, maximum of 10. (I2 format)

4) Enter the spring force (lb) versus deflection (in) compression envelope table, (2F10.2 format).

.
.
.
.

n lines

5) Enter the Deflection Constant (in) for compression (F10.2 format).

6) Enter the number of lines in the spring extension envelope table, maximum of 10. (I2 format)

7) Enter the spring force (lb) versus deflection (in) extension envelope table, (2F10.2 format).

.
.
.
.

n lines

8) Enter the Deflection Constant (in) for extension (F10.2 format).

9) If a separate right-side spring table is called for, it is entered next, repeating steps (3)-(8).

The damping characteristics within the suspension are characterized by viscous damping and coulomb friction. SUSPENSION VISCOUS DAMPING is entered in units of lb-sec/in for each side of the suspension (2F10.2 format). The side-to-side option is available. Viscous damping effectively represents the shock absorber damping in the vertical direction, and is applied to motions in both directions. If the shock absorbers to be simulated are at an angle to the vertical, their damping coefficient should be multiplied by the square of the cosine of the angle between the shock absorber centerline and the vertical. Typical front-axle shock absorber damping coefficients should be in the range of 10-20 lb-sec/in.

For heavy vehicles the more common, and sometimes only, damping is coulomb friction derived from interleaf friction of the leaf spring suspensions [18]. Note that if the Spring Envelope Table option is selected, the suspension coulomb friction is implicitly represented within that model. Hence the COULOMB FRICTION parameter discussed here would add to that amount of coulomb friction already represented by the Spring Envelope Table data. Unless additional coulomb friction is desired, the COULOMB FRICTION parameter should be entered as 0.0 in this case. The COULOMB FRICTION parameter is primarily used with the linear spring or the simple spring table. COULOMB FRICTION is entered in units of lb/side (2F10.2 format) with the side-to-side option available. The coulomb friction is defined here as one-half the width of the hysteresis loop of the spring force-deflection curve as illustrated in Figure 6. When possible, the coulomb friction magnitude should be selected at the static load condition. In the absence of specific data, the coulomb friction can be estimated at 10% of the static load value. The coulomb friction is neglected during the initial static spring deflection calculations. During the dynamic calculations thereafter, the coulomb friction force is added to or subtracted from the calculated spring force, depending on the direction of relative motion. Sources of spring data compatible with the Spring Envelope Table option are available in References [18,39].

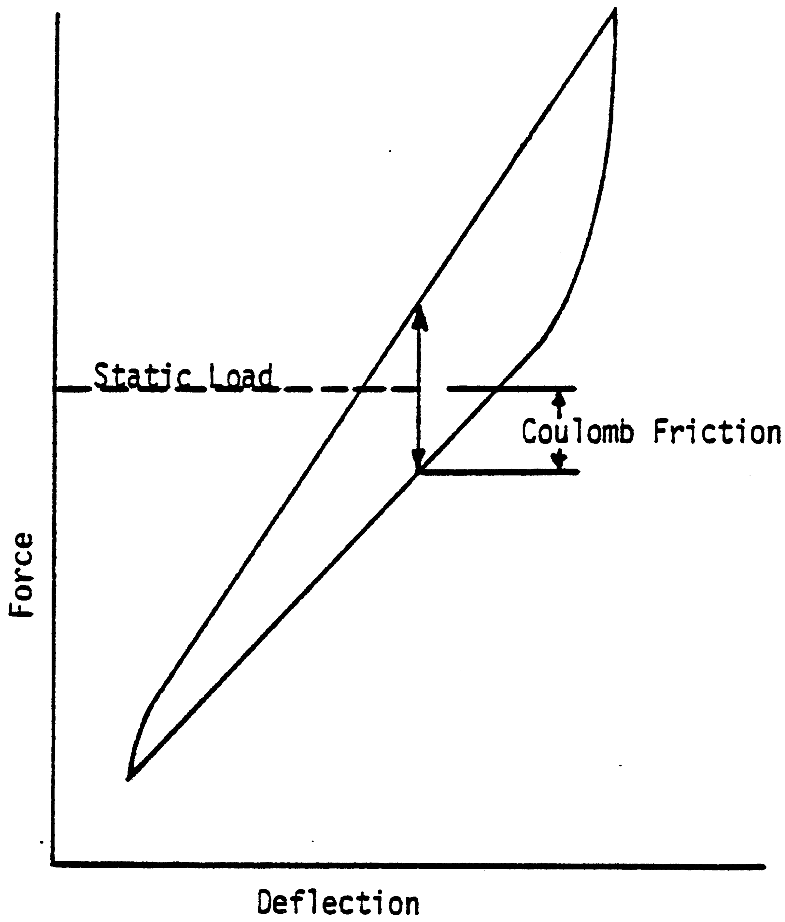


Figure 6. Coulomb friction in a suspension leaf spring assembly.

The front axle components of the vehicle, including the axle, springs, spindles, hubs, brakes, and wheels, are lumped into one unsprung mass, as shown in Figure 5. The mass has a center of gravity located on the axis of the wheels at the lateral center of the axle. The mass is characterized by a ROLL MOMENT OF INERTIA (units of in-lb-sec^2, F15.3 format), and its UNSPRUNG WEIGHT (entered later in this group). The yaw moment of inertia is assumed equal to the roll moment of inertia, and since the axles are constrained to yaw with the sprung mass, the yaw moments of inertia of this and all other axles are added to that of the sprung mass by the program. The pitch moment of inertia for axles is negligible in effect and is not included in the modeling.

While the suspension is primarily a vertical compliance, it also serves to transmit horizontal forces to the sprung mass. The mechanism for transmission of lateral forces through the suspension is important and significant to the overall directional response of the vehicle. When a vehicle is caused to roll on its suspension, it tends to roll about a point designated as the roll enter, as shown in Figure 5. Conceptually, the roll center is the point at which lateral forces are transmitted between the sprung and unsprung masses. This parameter is significant to vehicle response because lateral forces present at the roll center cause lateral load transfer on the axle (and hence, tires) and thereby influence the lateral forces developed by the tires. This effect is significant in transient maneuvers due to load transfer effects before the sprung mass has time to roll, and in steady-state maneuvers due to the distribution of roll moment between front and rear suspension roll centers. The effects of roll center height are included in the modeling and a ROLL CENTER HEIGHT parameter (in. above the ground, F15.3 format) is included in the input list. The suspension and axle system is considered constrained with the sprung mass in the pitch degree of freedom so a similar concept in the pitch plane is not needed to characterize transmission of longitudinal forces and pitch moments.

For various reasons, a suspension system may not always maintain the wheels in alignment with the longitudinal axis of the vehicle throughout all suspension motions. Most suspensions are subject to a small amount of steer effect when the vehicle rolls. Such factors can play an important role in vehicle directional response and overall stability. The input list includes a ROLL STEER COEFFICIENT (in units of degrees steer per degree roll, F15.3 format) to simulate this effect. A positive entry implies an incremental steer to the right when the sprung mass rolls to the right. Hence, a positive front axle roll steer coefficient has an understeer influence.

The vertical force developed within the suspension is the sum of spring deflection, coulomb friction, and viscous damping forces. Roll of the axle relative to the sprung mass produces a roll moment within the suspension due to the lateral spacing between the springs and shock absorbers. The LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (in., F15.3 format) is included as an input parameter, as a basis for calculating the roll moment effect. At times, the suspension may exhibit a roll stiffness in excess of that accountable by the springs and their separation because of the additional effects of linkages, spring twist, antisway bars, etc. An AUXILIARY ROLL STIFFNESS input parameter (in-lb per deg., F15.3 format) is provided to allow modeling these effects.

The next parameter to be specified for the suspension-axle system is the TRACK WIDTH (in., F15.3 format), defined as the distance between the wheel planes (center of the wheels) of the right and left tires. Following this the UNSPRUNG WEIGHT is entered (lb, F15.3 format). For the truck/tractor steering axle at least one more parameter, STEERING GEAR RATIO (degrees steering wheel/degree road wheel), needs to be entered (F10.2 format) immediately following the UNSPRUNG WEIGHT parameter. If the STEERING GEAR RATIO is entered as 0.0, the steering system model is not activated and no additional parameters are required in this group. In the absence of a steering system model, steering inputs from a steer table or the path-follower model are applied directly to the front wheels.

A positive entry for STEERING GEAR RATIO activates the steering system model during the simulation and steer inputs (from a steer table or path follower) are applied at the steering wheel. In this case, five additional steering system parameters need to be entered immediately following the STEERING GEAR RATIO, each in F10.2 format. The first of these parameters is STEERING STIFFNESS (IN-LB/DEG). The STEERING STIFFNESS is the stiffness of the steering components between the steering wheel and the left front road wheel, as measured at the road wheel. Following this, separate line entries are made for the TIE ROD STIFFNESS (IN-LB/DEG), MECHANICAL TRAIL (IN), TORSIONAL WRAP-UP STIFFNESS (IN-LB/IN), and LATERAL OFFSET OF STEERING AXIS (IN). Each of these steering system parameters are described in Appendix I.5 and Reference [37]. Use of the steering system model (STEERING GEAR RATIO > 0) implies entry of steering-wheel angle data in the STEER Table, Section 3.2.

3.3.3 Truck/Tractor Front Tires and Wheels. Tire forces within the PHASE 4 program are calculated from models that, in effect, determine the forces from the operating conditions. For example, tire vertical load is a result of its instantaneous vertical height (rolling radius) above the road. The cornering and longitudinal force behavior can be represented one of three ways:

1) A linear model of cornering and longitudinal stiffness characteristics

2) A nonlinear table lookup model for cornering and longitudinal characteristics with variations due to load and speed conditions

3) A semi-empirical tire model based on a theoretical representation of the tire traction field.

The first line entry for front tires and wheels, as shown in Figure 3, is the left and right CORNERING STIFFNESS (lbs/deg/tire, 2F15.3 format). If the right-side value is left blank or entered as zero, it is assumed equal to the left-side value. The cornering stiffness is the slope of the lateral force versus slip angle behavior of the tire in the vicinity of zero slip angle, as illustrated in Figure 7. It is entered as a positive number and is typically numerically equivalent to approximately 10 percent of the static load (i.e., a tire at

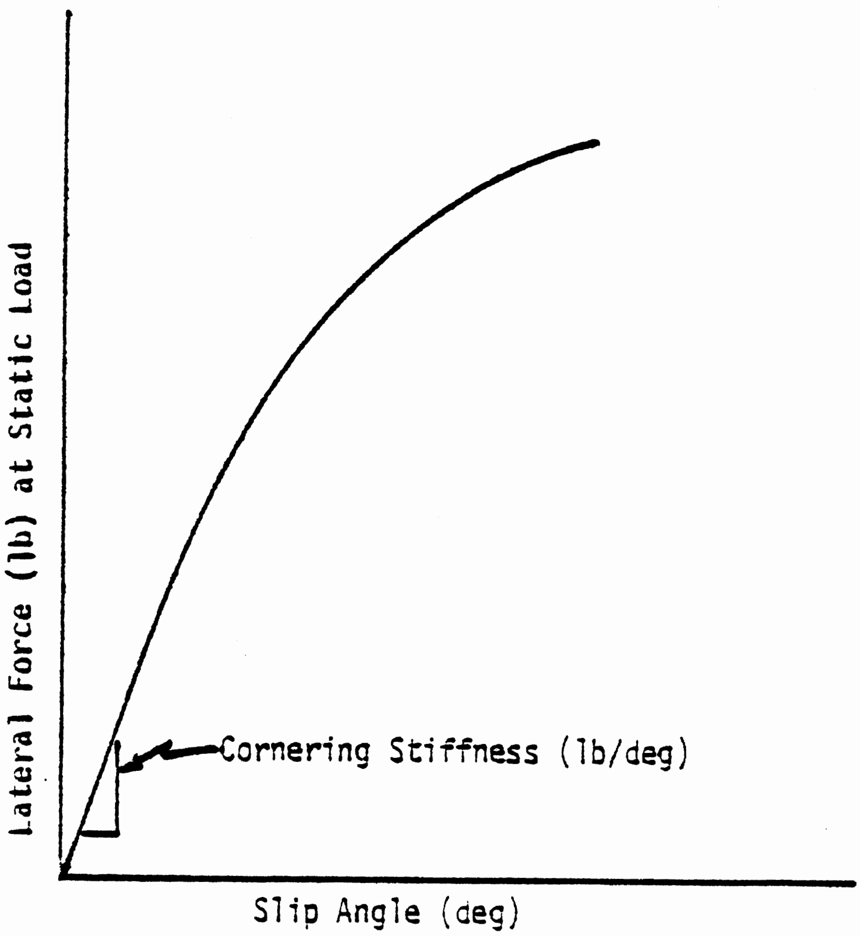


Figure 7. Definition of cornering stiffness parameter.

5000 lbs load has a cornering stiffness of approximately 500 lb/deg). Since the stiffness is dependent on the tire load, it should be entered for the condition equivalent to the full static load on that tire in the simulation. Internally, the program continuously adjusts the cornering stiffness in proportion to the changing dynamic load conditions. The linear cornering stiffness model should only be used with moderate cornering maneuvers, where the tire cornering forces generated are less than 50 percent of the vertical load. Beyond this point, the cornering force becomes nonlinear and saturates (no saturation or limit on lateral traction occurs with the linear model). In such cases, either the nonlinear table lookup model or the semi-empirical tire model can be used. The entry of a negative whole number between -1. and -99. will key the table lookup model. The entry of a negative whole number between -201. and -299. will key the semi-empirical tire model. The numerical value of the entry either identifies the table number for the tabular tire force data, or the set of parameters used to describe a specific tire model associated with the number. (The format for the tabular tire data is discussed in Section 3.3.3.1, the format for the semi-empirical tire model is discussed in Section 3.3.3.2.)

The next line entered for front tires and wheels is the left- and right-tire LONGITUDINAL STIFFNESS in lbs/slip (2F15.3 format). The LONGITUDINAL STIFFNESS is equivalent to the initial slope of the brake force versus longitudinal slip curve for a tire, as illustrated in Figure 8, and typically has a numerical value equivalent to about four times the tire static load. The longitudinal stiffness is proportioned inside the program to change with the tire dynamic load. Like the cornering stiffness entry, positive values specify the linear tire model for longitudinal tire force calculations with zero right-side entries, causing the program to assume a right-side value equal to the left. Since it is a linear model, it should only be used with braking maneuvers for which the friction level on each tire is well below the peak (the braking is well below the wheel lockup condition). For high level braking or when antilock braking is used, the tire longitudinal force characteristics are best represented by a table lookup.

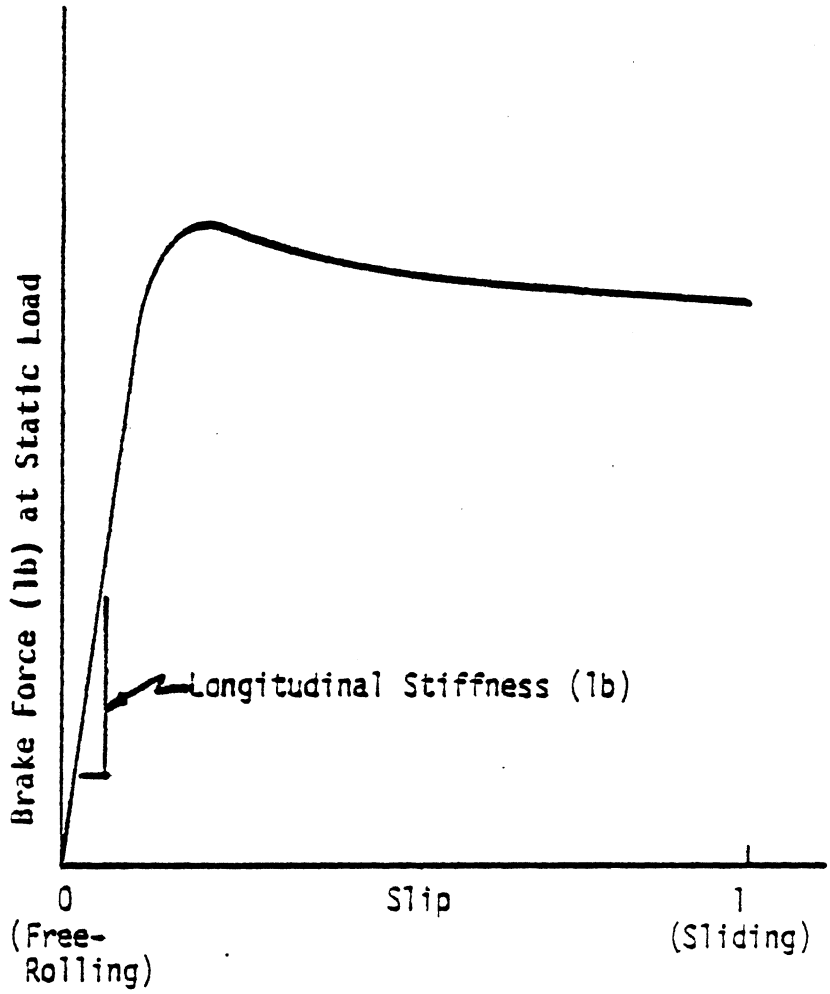


Figure 8. Definition of longitudinal stiffness parameter.

A negative entry with values between -1 and -99 for longitudinal stiffness keys the nonlinear tire force table lookup option. As above, the numerical value of this entry identifies the longitudinal tire force table of data which needs to follow. (Section 3.3.3.1.) If the semi-empirical tire model is used, the entered values for longitudinal stiffness is ignored, as a calculated value based on the tire model parameters is used (Section 3.3.3.2).

Mixtures of linear and nonlinear tire options for longitudinal and lateral tire force representations are permitted for the same tire. Linear and nonlinear mixtures side-to-side are also allowed.

The remaining parameters (except for aligning moment) to be entered for front tires and wheels should be positive or zero. Negative table entry options are not allowed. Two values per line are entered representing left- and right-side values (2F15.3 format). Zero right-side values will equate right with left. The first of these, CAMBER STIFFNESS, defines the lateral force per degree of camber at static load conditions and is entered in lbs/deg. ALIGNING MOMENT at the static load condition is entered next in units of in-lb/deg. TIRE SPRING RATE (lb/in), TIRE LOADED RADIUS (in), and POLAR MOMENT OF INERTIA (in-lb-sec^2) then follow as the last three lines of the tire/wheel parameters. The polar moment of inertia for all rotating wheel components is defined about the spin axis of the wheel. This parameter can be of importance in antilock braking maneuvers.

3.3.3.1 Nonlinear lateral and longitudinal tire table formats. Negative values (in the range of -1 to -99) for CORNERING STIFFNESS or LONGITUDINAL STIFFNESS parameters trigger the nonlinear tire model table lookup option. Tire data conforming to a specific format needs to be entered immediately following each of these negative entries.

Cornering Stiffness (MU-Y) Tables:

Tabular cornering (lateral) force tire data called by a negative CORNERING STIFFNESS value is entered in terms of a normalized lateral traction coefficient, MU-Y, as a function of tire sideslip angle, ALPHA, for at least one, and as many as three, different vertical tire loads and velocities. MU-Y is defined as the nondimensional ratio of tire lateral force to the prevailing vertical load at zero longitudinal slip (free rolling). Two-way linear interpolation is used by the program between entered table points. The format required for entering MU-Y tabular data is as follows (see Appendix B for examples):

(Define number of loads and velocities)	
Number of vertical loads, NL (3 max.)	(I2 format)
Vertical load values	(3F10.2 format)
Number of velocities, NV (3 max.)	(I2 format)
Velocity values	(3F10.2 format)
(First load/first velocity table)	
Number of tire sideslip angles, N11, in first ALPHA versus MU-Y table (max. of 10)	(I2 format)
N11 lines of ALPHA (deg), MU-Y pairs comprising the first table	(2F10.2 format, each line)
(First load/second velocity table)	
Number of tire sideslip angles, N12, in second ALPHA versus MU-Y table (max. of 10)	(I2 format)
N12 lines of ALPHA (deg), MU-Y pairs comprising the second table	(2F10.2 format, each line)
(First load/third velocity table)	
Number of tire sideslip angles, N13, in third ALPHA versus MU-Y table (max. of 10)	(I2 format)
N13 lines of ALPHA (deg), MU-Y pairs comprising the third table	(2F10.2 format)
(Repeat for second load condition)	
(Repeat for third load condition)	

Note: The total number of ALPHA versus MU-Y tables is equal to the product of NV × NL. Hence, a maximum of nine (9) such tables are permitted (NV = NL = 3) and a minimum of one (1) table (NV = NL = 1) is required.

Immediately following the ALPHA versus MU-Y tables, a "roll-off" tabular function which allows for reduction of the free-rolling tire lateral forces under longitudinal (braking) slip conditions is required. In the event no braking occurs, a simple one-point table may be used. The "roll-off" table is a two-way table of the parameter, ROLLY, as a function of longitudinal slip (SLIP) and sideslip (ALPHA) of the tire. ROLLY is simply a multiplication factor for MU-Y defined at the selected SLIP and ALPHA values in the table and interpolated elsewhere. ROLLY values of 1.0 simply return the free-rolling MU-Y value. Likewise, a ROLLY value of 0.75 would diminish the value of MU-Y by 25 percent at the specified longitudinal/sideslip point in the "roll-off" table.

The following format is used for entering lateral "roll-off" function tabular data:

(Define arguments of the table)

Number of longitudinal slip (SLIP) points, NS, in the "roll-off" table (10 max.)	(I2 format)
NS lines of longitudinal slip (SLIP) values	(F10.2 format, each line)
Number of sideslip (ALPHA) points, NSS, in the "roll-off" table (10 max.)	(I2 format)
NSS lines of sideslip (ALPHA) values	(F10.2 format, each line)
NSS × NS matrix of ROLLY values defining the "roll-off" tabular function. NSS lines containing NS ROLLY values/line as shown below.	(10F8.2 format)

	$Slip_1$	$Slip_2$	etc.
$Alpha_1$	$ROLLY_{11}$	$ROLLY_{12}$	.....
$Alpha_2$	$ROLLY_{21}$	$ROLLY_{22}$	.....
etc.	⋮	⋮	

ROLLY TABLE

Note: The maximum size of the ROLLY table is 10 × 10 (NSS = NS = 10). Minimum size is 1 × 1 (NSS = NS = 1).

Aligning Moment Parameters:

In the case where nonlinear CORNERING STIFFNESS is used, an optional aligning torque model may be used by entry of a negative value of ALIGNING MOMENT. The option allows a more accurate representation of aligning moment characteristics (see Appendix I.8). In this case, an additional line of eight (four left side, four right side) aligning moment curve fit parameters (8F10.2 format) are inserted after the ALIGNING MOMENT entry. If the four right-side parameters are not entered, they are equated internally to those values entered for the left side.

Longitudinal Stiffness (MU-X) Tables:

Tabular braking (longitudinal) force tire data is entered in exactly the same format as used for cornering data. This data must follow immediately after the negative LONGITUDINAL STIFFNESS entry. MU-X, a normalized longitudinal traction coefficient, now replaces MU-Y as the dependent table variable and longitudinal slip, SLIP, replaces ALPHA as the independent table variable. MU-X is defined as the non-dimensional ratio of longitudinal tire force to the prevailing vertical load at a zero tire sideslip angle. Like the lateral force table data, up to three vertical loads and speeds may be specified.

A longitudinal "roll-off" function is likewise required in the case of MU-X tabular data. ROLLX, a multiplicative factor analogous to ROLLY for cornering data, is specified in a two-way table of longitudinal slip (SLIP) versus sideslip (ALPHA) identical to that format used for the lateral "roll-off" table.

Sources of lateral and longitudinal tire force data for heavy trucks, that are largely compatible with the PHASE 4 program, are contained in References [2,8,10,31,32,33,39].

3.3.3.2 Semi-empirical tire model. Entry of negative values between -201. and -299. for the CORNERING STIFFNESS parameter keys the semi-empirical tire model option. Parameters describing the tire to be modeled need to be entered immediately following the negative value, just as with the nonlinear tire table lookup option.

The tire model uses a limited number of readily obtained (or estimated) parameters to compute the shear forces and aligning moments produced during braking and/or steering maneuvers. The user is referred to Appendix I.1 for a more detailed description of the model and its required parameters. The user also has the option of entering sensitivities of the parameters with respect to load and/or velocity. If these sensitivities are not entered, the program assigns the value of 0. to them. These sensitivities allow the user to fit particular load and velocity dependent trends observed in test data. The format for entering the tire model data is as follows.

(Parameters and Load/Velocity Sensitivities)

- NOMINAL CORNERING STIFFNESS - C_α (lb/deg), $\partial C_\alpha/\partial F_z$ (1/deg), $\partial C_\alpha/\partial V$ (lb-sec/deg/ft), (3F10.4 format)

- PEAK FRICTION VALUE - μ_p, $\partial \mu_p/\partial F_z$ (1/lb), $\partial \mu_p/\partial V$ (sec/ft), (3F10.4 format)

- LOCKED WHEEL FRICTION VALUE - μ_s, $\partial \mu_s/\partial F_z$ (1/lb), $\partial \mu_s/\partial V$ (sec/ft), (3F10.4 format)

- LONGITUDINAL SLIP VALUE AT PEAK FRICTION - S_p, $\partial S_p/\partial F_z$ (1/lb), $\partial S_p/\partial V$ (sec/ft), (3F10.4 format)

- NOMINAL PNEUMATIC TRAIL - X_p (in), $\partial X_p/\partial F_z$ (in/lb), $\partial X_p/\partial V$ (in-sec/ft), (3F10.4 format)

- LATERAL STIFFNESS - C_y (lb/in), $\partial C_y/\partial F_z$ (1/in), $\partial C_y/\partial V$ (lb-sec/in/ft) (3F10.4 format)

- NOMINAL VERTICAL LOAD (lb) - F_{z_o} (F10.4 format)

- NOMINAL VELOCITY (ft/sec) - V_o (F10.4 format)

If the same tire model is to be represented at other locations on the vehicle, entry of the same negative value for CORNERING STIFFNESS will cause the program to internally duplicate the previously entered data for that tire. Note that all conventions used for lookup tables apply to the tire model.

3.3.4 Truck/Tractor Rear Suspension and Axle Parameters. Medium and heavy trucks all use one or more solid rear axles. Since a large percentage of such vehicles use two (tandem) rear axles, an optional tandem axle is provided in the program models. The rear suspension and axle parameters are the next group of input parameters, as shown in Figure 9. The first parameter is a SUSPENSION KEY (I2 format) for which "00" indicates a single axle is to be used, and "01" indicates a tandem axle set.

3.3.4.1 Single axles. When a single axle has been specified, its characteristics are described by the same set of parameters used to describe the front suspension and axle (see Section 3.3.2 for detailed discussion). Hence, following a "00" suspension key, the following parameters are entered:

- SUSPENSION SPRING RATE (lbs/in/side/axle); 2F10.2 format; table lookup and side-to-side options allowed

- SUSPENSION VISCOUS DAMPING (lbs-sec/in/side); 2F10.2 format; side-to-side option allowed

- COULOMB FRICTION (lbs); 2F10.2 format; side-to-side option allowed

- AXLE ROLL MOMENT OF INERTIA (in-lb-sec^2); F15.3 format

- ROLL ENTER HEIGHT (in. above ground); F15.3 format

- ROLL STEER COEFFICIENT (deg steer/deg roll); F15.3 format

- AUXILIARY ROLL STIFFNESS (in-lb/deg); F15.3 format

```
HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.        INPUT PAGE NO.  3
                        TRACTOR-TRAILER EXAMPLE RUN - 1 DEGREE STEER

  TRACTOR REAR SUSPENSION  AND AXLE PARAMETERS                        LEADING TANDEM AXLE            TRAILING TANDEM AXLE
  -------------------------------------------                       -----------------------        -----------------------
                                                                   LEFT SIDE   RIGHT SIDE         LEFT SIDE   RIGHT SIDE
                                                                   ---------   ----------         ---------   ----------
     SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM         1
          TANDEM AXLE SEPARATION (IN BETWEEN LEADING AND TRAILING AXLES)                   50.00
          STATIC LOAD TRANSFER (PERCENT LOAD ON LEAD AXLE)                                 50.00
          DYNAMIC LOAD TRANSFER (% BRAKE TORQUE REACTED AS TANDEM AXLE LOAD TRANSFER)       0.0
     SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)                      5000.00     5000.00            5000.00     5000.00
     SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)                 0.0         0.0                0.0         0.0
     COULOMB FRICTION (LB/SIDE/AXLE)                                500.00      500.00             500.00      500.00
                                                                   --------------------------------------------------
     AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)                        3058.00                          3058.00
     ROLL CENTER HEIGHT (IN. ABOVE GROUND)                               29.62                            29.62
     ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)                        0.00                             0.00
     AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)                        15000.00                         15000.00
     LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)                    40.75                            40.75
     TRACK WIDTH (IN)                                                    72.00                            72.00
     UNSPRUNG WEIGHT (LB)                                              2462.50                          2462.50

  TRACTOR REAR TIRES  AND WHEELS                                    LEADING TANDEM AXLE            TRAILING TANDEM AXLE
  ------------------------------                                   --------------------           --------------------
                                                                   LEFT SIDE   RIGHT SIDE         LEFT SIDE   RIGHT SIDE
                                                                   ---------   ----------         ---------   ----------
     DUAL TIRE SEPARATION (IN)                                        12.80       12.80              12.80       12.80
     CORNERING STIFFNESS  (LB/DEG/TIRE)                              690.00      690.00             690.00      690.00
     LONGITUDINAL STIFFNESS  (LB/SLIP/TIRE)                        28000.00    28000.00           28000.00    28000.00
     CAMBER STIFFNESS (LB/DEG/TIRE)                                    0.0         0.0                0.0         0.0
     ALIGNING MOMENT  (IN-LB/DEG/TIRE)                                 0.0         0.0                0.0         0.0
     TIRE SPRING RATE (LB/IN/TIRE)                                  5700.00     5700.00            5700.00     5700.00
     TIRE LOADED RADIUS (IN)                                          20.30       20.30              20.30       20.30
     POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)                    229.00      229.00             229.00      229.00

  TRACTOR FRONT BRAKES                                                         LEFT SIDE          RIGHT SIDE
  --------------------                                                         ---------          ----------
     TIME LAG (SEC)                                                              0.0200              0.0200
     RISE TIME (SEC)                                                             0.1700              0.1700
     BRAKE TORQUE (IN-LB/PSI/BRAKE)                                            710.0000            710.0000
     BRAKE HYSTERESIS KEY: 0 ENTRY INDICATES BRAKE HYSTERESIS OPTION NOT IN USE ON VEHICLE TRAIN           0
     BRAKE PROPORTIONING KEY: 0 ENTRY INDICATES BRAKE PROPORTIONING OPTION NOT IN USE ON VEHICLE TRAIN     0

  TRACTOR REAR BRAKES                                               LEADING TANDEM AXLE            TRAILING TANDEM AXLE
  -------------------                                              --------------------           --------------------
                                                                   LEFT SIDE   RIGHT SIDE         LEFT SIDE   RIGHT SIDE
                                                                   ---------   ----------         ---------   ----------
     TIME LAG (SEC)                                                  0.0500      0.0500             0.0500      0.0500
     RISE TIME (SEC)                                                 0.4000      0.4000             0.4000      0.4000
     BRAKE TORQUE (IN-LB/PSI/BRAKE)                               1390.0000   1390.0000          1390.0000   1390.0000
```

Figure 9. Example of second page of truck/tractor parameters.

•LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (in); F15.3 format

•TRACK WIDTH (in); F15.3 format

•UNSPRUNG WEIGHT (lbs); F15.3 format

Because of the dual tires commonly used on rear axles, the TRACK WIDTH must be carefully defined. As used here, track width is the lateral distance between the centers of the dual tires, as shown in Figure 10. The dual tire separation parameter is included in the Tires and Wheels data and defines the wheel locations relative to the track width.

3.3.4.2 Tandem axles option. The tandem axle model has been reformulated for the PHASE 4 program. Previously, seven different tandem options have been variously available among the predecessor programs. These included:

1) Walking-beam suspension
2) Basic four-spring suspension
3) Four-spring with spring-type torque rods
4) Four-spring with long load leveler
5) Multiple torque rod four-spring
6) Multiple torque rod four-spring with spring-type lower torque rod
7) Air suspension

Reference [3] provides a detailed discussion of these seven types of tandem suspensions. Each axle/suspension system was defined by a detailed list of geometric parameters that served to establish three basic characteristics:

1) The tandem axle separation
2) The static load distribution among the axles
3) The dynamic load transfer between axles during braking.

That approach to modeling was taken under the philosophy that tandem axle geometric characteristics were more readily available to users than such parameters as dynamic load transfer characteristics. However,

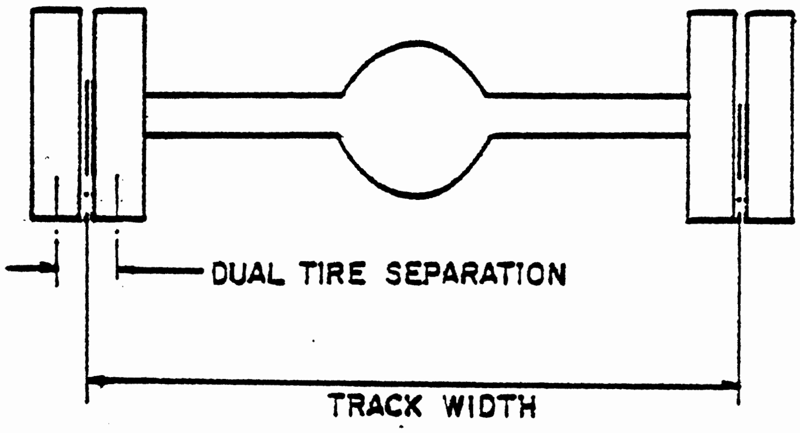


Figure 10. Definition of track width and dual tire separation.

the limitations of each geometric formulation has resulted in a proliferation of models, each required to handle particular details associated with the many varieties of tandem systems in use.

In PHASE 4, tandem-axle systems are modeled as two single axles with load-leveling action to approximate either (a) four-spring suspensions or (b) walking-beam suspensions. Specification of the three parameters listed above and the type of suspension (four-spring or walking-beam) define the tandem suspension characteristics. Hence, the entry of a tandem-axle system is accomplished by entry of a data list as described below.

The tandem-axle option is indicated by entry of either a "01" (four-spring option) or a "02" (walking-beam option) value (I2 format) as the first parameter, SUSPENSION KEY. Note that if the walking-beam option is selected (one suspension spring for tandem axles), the PHASE 4 program interprets the suspension spring rate/friction parameters (or tabular data) entered for the leading axle, as the walking-beam spring. Data entered as spring rate/friction parameters for the trailing axle are ignored under the walking-beam option, but must still be entered. The next entry is TANDEM AXLE SEPARATION (in. between the centers of the leading and trailing axles, in F15.3 format). Tandem-axle separation is typically 48-52 in. for closely spaced tandem sets. Next is the STATIC LOAD TRANSFER (F15.3 format) which is the percent of the total tandem load carried on the lead axle under static conditions. On the most common tandem suspensions, this is intended to be 50 percent (50.0 entry), although minor variations may occur due to inaccuracies in the equalizing system or due to differences in the unsprung weights of the axles. The value entered here establishes the final static distribution of the loaded vehicle used in the simulation. Internally, the program works back from the load distribution specified, compensates for the unsprung weights of the axles, and selects the necessary static spring deflection on each axle to achieve this static load distribution. If different side-to-side spring characteristics are also specified, the static deflections of the springs on the right and left are selected to achieve equal load on both sides of the axle under static conditions.

Next, the DYNAMIC LOAD TRANSFER parameter is entered (F15.3 format). This parameter, in units of percent, describes the fraction of the total brake torque (generated on the rear axles) applied to transferring load from the trailing to the leading axle of the tandem set. That is, the brake torque generated by the rear axles results in a pitch plane moment on the vehicle that must be counteracted by a moment generated either by a dynamic load transfer to the front axle of the vehicle, or by dynamic load transfers to the leading tandem axle. For example, if the total brake torque on a tandem axle set with a 50-in. TANDEM AXLE SEPARATION is 100,000 in-lb, a DYNAMIC LOAD TRANSFER value of +10.0 (percent) would result in an increase/decrease of 200 lbs of vertical load on the leading/trailing axles. The load transfer characteristics are determined by the inherent geometry of the suspension and torque rod systems. With ideal torque rod designs, all brake torque reaction transfers to the vehicle frame, resulting in load transfer to the front axle. In practice, less than that ideal is achieved. Walking-beam and air suspensions are reasonably effective and a zero entry may be appropriate to those cases. However, some four-spring suspensions by the nature of their load equalization systems may transfer load from the leading to the trailing axle, in which case a negative value for the parameter is required.

After entry of these three special tandem parameters, the remainder of the rear suspension and axle parameters are entered as two serial sets of single axles. That is, a single axle data set of 10 parameters, from SUSPENSION SPRING RATE through UNSPRUNG WEIGHT, is entered to describe the leading axle; followed by a similar data set to describe the trailing axle. Different parametric values, along with the table look-up and side-to-side options, can be used as desired with each axle. More detailed discussion of the 10 parameters is contained in Sections 3.3.2 and 3.3.4.1. These data are echoed, as shown in Figure 9, in a side-by-side format rather than the serial format actually used in the input list.

3.3.5 Truck/Tractor Rear Tires and Wheels. The rear tires and wheels (see Fig. 9) are generally described by the same parametric information needed for the front wheels, that is described in detail in Section 3.3.3. The primary difference arises from the fact that rear axles commonly employ a dual tire arrangement. Hence, the first parameter to be entered is DUAL TIRE SEPARATION (F15.3 format) which is the distance in inches between the center-plane of the two tires in a dual wheel set (see Fig. 10). Thence the parametric data on a per tire basis is entered. If the dual tire separation is input as zero, a single wheel is assumed at that position defined by the track width entered previously. Different values can be assigned for tires on the left and right side of the axle by side-to-side entry format, but both tires in the dual set are assigned the same parameter values. The last entry, the POLAR MOMENT OF INERTIA, is likewise entered on a per tire basis, and hence, with dual wheels should be entered as half the value for the dual wheel set. If tandem axles have been specified, two complete sets of tire data from DUAL TIRE SEPARATION to POLAR MOMENT OF INERTIA should be entered in series, the first set for the leading axle and the second set for the trailing axle.

3.3.6 Truck/Tractor Front and Rear Brakes. The brake systems on the axles of the simulated vehicles are represented by the timing characteristics of the pneumatic system and the pressure torque characteristics of the brakes. Brake system data are entered as the last category of information about each vehicle and are entered only if a Treadle Pressure Table was entered in the Simulation Operation Parameters. Zero lines in that table signals the program to skip over brake data read instructions. One or more lines in the Treadle Pressure Table, even if all values are zero, is considered a table entry.

Brake data are entered for each axle of the vehicle in sequence from front to rear, the number of brake data sets being equal to the number of axles on the vehicle (see Fig. 9). The brake data sets consist of at least five entries for the first axle on the vehicle, and at least three entries for each remaining axle.

The first entry is the TIME LAG in seconds for the left and right brake (2F10.4 format). This parameter describes the time for a pressure signal to proceed from the treadle valve to the brake chamber and is equivalent to the time from the first motion of the treadle valve to the beginning of the pressure rise at the brake chamber. Typical values are in the range of 0.02 to 0.10 sec for truck/tractor air brake systems.

The second entry is brake RISE TIME in seconds for the left and right brakes (2F10.4 format). The rise time is the effective time constant when the chamber pressure rise is characterized by a first-order lag (i.e., time required to reach 63 percent of the steady-state step response). Typical values are in the range of 0.2 to 0.5 sec.

The third entry in the brake set is the left and right BRAKE TORQUE coefficient in units of in-lb of brake torque/psi (2F10.4 format). The brake torque coefficient characterizes the brake in a linear fashion and, as with the first two entries, can be given a side-to-side difference. (One entry with any of the above parameters, as with any side-to-side parameter, causes the right side to be given the same value as the left side.) In the event it is desired to model the brake with nonlinear characteristics, as, for example, having a nonzero pushout pressure before the brake is actuated, a brake lookup table can be called by entry of a negative whole number (in the range of -1 to -299) for the BRAKE TORQUE coefficient. Immediately thereafter, a brake table should be entered in the following format:

Line #1	Number of Lines, n (max. of 10)	(I2 format)
Line #2, etc.	'n' lines of the table of pressure (psi) versus torque (in-lb)	(2F10.2 format)

If left and right brakes are given separate tables, the left brake table is entered first, followed immediately by the right brake table. The side-to-side lookup table options may be mixed as desired on each axle or on different axles.

If even greater detail is desired in representing brake torque, the Brake Model option may be used. The principal inputs of this option are (1) parameters describing the actuation mechanism (brake power), (2) brake fade coefficients that can be chosen to match the in-stop fade measured in tests using inertia dynamometers, and (3) parameters needed for describing the thermal condition of the drum and the lining (see Appendix I.2 for further details). The brake factor coefficients represent (a) the basic gain of the brake and (b) the instantaneous influences of actuation effort (pressure), sliding velocity, and internal temperatures on brake gain. Provision for including the influences of initial brake temperature are also contained in this semi-empirical model. The brake model provides the capability for detailed studies of the influences of changes in brake power and lining properties plus predictions of brake temperature and fade.

The Brake Model option is activated by entering a negative BRAKE TORQUE coefficient with a value in the range from -300 to -399. The first Brake Model data line read following the BRAKE TORQUE coefficient contains eight parameters (8F10.2 format): (1) Chamber Area (in^2), (2) Drum Diameter (in), (3) Wedge Angle (deg) for a wedge brake, or Slack Adjuster Length (in) in the case of a cam brake, (4) - (7) four brake factor coefficients 1→4 defined in Appendix I.2, and (8) Pushout Pressure. The next line contains the number of lines to follow in the Initial Brake Temperature Table (I2 format). The Initial Brake Temperature Table is then entered in (2F10.2 format) per line. The last two lines entered under this option are geometric and thermal properties of the drum and lining needed for temperature calculations in the Brake Model. The first line contains five parameters (5F10.2 format): Drum Rubbing Area (ft^2), Drum Thickness (ft), Drum Convection Coefficient (BTU/sec/in^2/°F), Initial Drum Temperature (°F), and Ambient Temperature (°F). The next line contains four parameters (4F10.2 format): Lining Area (ft^2), Lining Thickness (ft), Lining Convection Coefficient (BTU/sec/in^2/°F), and Initial Lining Temperature (°F).

The Brake Model data entered under this option needs to be entered only once. If the same brake model characteristics are needed for a different wheel location on the vehicle train, entry of the same

BRAKE TORQUE coefficient (-300. to -399.) will cause the program to internally duplicate the previously entered data for that wheel. Note that this is the same convention used for the lookup table options.

The fourth or next required entry for the first axle is the global brake hysteresis key, KHYST, in I1 format (see Fig. 9). If this key is entered as 0, the brake hysteresis calculation option is bypassed for all brakes on the vehicle train and no hysteresis data needs to be entered for any brake. If KHYST > 0, at least one brake on the vehicle train is assumed to contain hysteresis and hysteresis parameters must then be entered for each brake on the vehicle train.

For KHYST > 0, data for the brake hysteresis calculation (see Appendix I.6) is entered on the next line after KHYST (if first axle on vehicle); and for all remaining axles, on the line following either: (a) BRAKE TORQUE (if > 0) or (b) nonlinear brake torque tables/Brake Model data (if BRAKE TORQUE < 0). Each brake hysteresis data line contains five left side and five right side parameters (10F8.2 format): HY, HY2 (IN-LB/PSI), RESBRK (PSI), RESID (IN-LB), and HYL. (Repeated for right side.) Each of these brake hysteresis parameters are explained in Appendix I.6. Entry of 0.0 for the HY parameter on a particular brake will cause the hysteresis calculation to be bypassed for that brake. Zero or nonentry of right side hysteresis parameters will cause the program to internally equate the right side values to those entered for the left side.

The fifth or next required entry for the first axle is the global brake proportioning key, KPROP, in I1 format (see Fig. 9). Like KHYST, if KPROP is entered as 0, the brake proportioning option is bypassed for all brakes on the vehicle train and no brake proportioning data should be entered for any brake. If KPROP > 0, at least some brake proportioning is assumed on the vehicle train and brake proportioning data must then be entered for each brake on the vehicle.

If KPROP > 0, the following brake proportioning data (see Appendix I.7 for further details) must be entered for each brake immediately after the last hysteresis input line (or, KPROP in the case of the first axle):

Format

IPRO	0 => No proportioning, this brake 1 => Vertical load proportioning 2 => Suspension deflection proportioning 3 => Longitudinal deceleration proportioning	I1

- -

** The following data is entered only if IPRO > 0 **

- -

NT1	# of pairs in Treadle Table	I2
x_1, y_1 . . . x_{NT1}, y_{NT2}	Treadle Table	2F10.2 each line
NT2	# of pairs in Valve Table	I2
x_1, y_1 . . . x_{NT2}, y_{NT2}	Valve Table	2F10.2 each line
(SpringØ only if IPRO = 2)		**F10.2**

- -

Then,

Repeat for right side, same axle,

beginning with,

IPRO

.
.
.
.

The performance of hydraulic brake systems can be represented as well by the brake models. In that case, the BRAKE LAG and RISE TIME parameters are negligible and may be entered as zero. Table 1 summarizes the brake data input requirements.

3.4 First Trailer Description

The first trailer is always a semitrailer which is modeled as a rigid body sprung mass supported at the front by the tractor fifth wheel coupling and at the rear by its own suspension and axles. Parametric data for the trailer is shown in Figures 11 and 12.

3.4.1 Trailer Parameters. The basic properties of the trailer are described by sprung mass parameters that constitute the first group of entries. The sprung mass is modeled as a rigid body, shown in Figure 13. The first entry is WHEELBASE, the characteristic length of the trailer defined as the longitudinal distance in inches (F15.3 format) from the kingpin to the center of the rear suspension. For a single-axle trailer, this is the same as the distance to the rear axle centerline, but for a tandem-axle trailer it is the distance to the geometric center of the rear axles.

The rigid body sprung mass is represented by mass properties concentrated at its center of gravity (c.g.). Its mass and fore/aft location are established by input of the BASE VEHICLE KINGPIN STATIC LOAD (lbs., F15.3 format) and CURB WEIGHT ON REAR AXLES (lbs., F15.3 format). The base vehicle weight data defines the mass of the semi-trailer only and should exclude loads imposed from other trailers. Rear axle curb weight with tandem axles is the total for both axles.

Thereafter, the sprung mass and payload properties consisting of the following entries are made:

- SPRUNG MASS C.G. HEIGHT
- SPRUNG MASS ROLL MOMENT OF INERTIA
- SPRUNG MASS PITCH MOMENT OF INERTIA

Table 1. Brake Parameter Input Summary.

Brake Parameters	Units	Format
1) TIME LAG	(SEC)	(2F10.4)
2) RISE TIME	(SEC)	(2F10.4)
3) BRAKE TORQUE		(2F10.4)
a) if > 0		
=> Linear Brake	(IN-LB/PSI)	
b) if > -300 and < 0		
=> Lookup Table		
Enter Brake Table for first occurrence		
c) if > -399 and < -300		
=> Brake Model option		
Enter Brake Model data for first occurrence		
4) KHYST only for first axle on vehicle		(I1)
a) if = 0		
=> No brake hysteresis data entered for entire vehicle		
b) if > 0		
=> Brake hysteresis option		
Enter brake hysteresis parameters for each brake		(10F8.2)
5) KPROP only for first axle on vehicle		(I1)
a) if = 0		
=> No brake proportioning data entered for entire vehicle		
b) if > 0		
=> Brake proportioning option		
Enter brake proportioning data for each brake		

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. INPUT PAGE NO. 4
SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 PARAMETERS

WHEELBASE - DISTANCE FROM KINGPIN TO CENTER OF REAR SUSPENSION (IN)	383.00
BASE VEHICLE KINGPIN STATIC LOAD (LB)	2815.00
BASE VEHICLE CURB WEIGHT ON REAR SUSPENSION (LB)	8650.00
SPRUNG MASS CG HEIGHT (IN. ABOVE GROUND)	74.80
SPRUNG MASS ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	66224.00
SPRUNG MASS PITCH MOMENT OF INERTIA (IN-LB-SEC**2)	542486.00
SPRUNG MASS YAW MOMENT OF INERTIA (IN-LB-SEC**2)	644483.00
PAYLOAD WEIGHT (LB)	46800.00
PAYLOAD DISTANCE AHEAD OF REAR SUSPENSION CENTER(IN)	183.00
PAYLOAD CG HEIGHT (IN. ABOVE GROUND)	60.00
PAYLOAD ROLL MOMENT OF INERTIA(IN-LB-SEC**2)	13000.00
PAYLOAD PITCH MOMENT OF INERTIA(IN-LB-SEC**2)	240000.00
PAYLOAD YAW MOMENT OF INERTIA(IN-LB-SEC**2)	240000.00
LOCATION OF PINTLE HOOK (IN BEHIND REAR SUSP. CENTER)	48.00
HEIGHT OF PINTLE HOOK (IN ABOVE GROUND)	40.00

TRAILER NO. 1 REAR SUSPENSION AND AXLE PARAMETERS	LEADING TANDEM AXLE			TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE		LEFT SIDE	RIGHT SIDE
SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM			1		
TANDEM AXLE SEPARATION (IN BETWEEN LEADING AND TRAILING AXLES)			48.00		
STATIC LOAD TRANSFER (PERCENT LOAD ON LEAD AXLE)			40.00		
DYNAMIC LOAD TRANSFER (% BRAKE TORQUE REACTED AS TANDEM AXLE LOAD TRANSFER)			10.00		
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	7818.00	7818.00		7818.00	7818.00
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	5.00	5.00		5.00	5.00
COULOMB FRICTION (LB/SIDE/AXLE)	800.00	800.00		800.00	800.00
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	4746.00			4746.00	
ROLL CENTER HEIGHT (IN. ABOVE GROUND)	29.60			29.60	
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	-0.00			-0.00	
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	35490.00			35490.00	
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	38.00			38.00	
TRACK WIDTH (IN)	71.25			71.25	
UNSPRUNG WEIGHT (LB)	1530.00			1530.00	

TRAILER NO. 1 REAR TIRES AND WHEELS	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
DUAL TIRE SEPARATION (IN)	12.40	12.40	12.40	12.40
CORNERING STIFFNESS (LB/DEG/TIRE)	600.00	600.00	600.00	600.00
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	21000.00	21000.00	21000.00	21000.00
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	0.0	0.0	0.0	0.0
TIRE SPRING RATE (LB/IN/TIRE)	4500.00	4500.00	4500.00	4500.00
TIRE LOADED RADIUS (IN)	20.20	20.20	20.20	20.20
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	212.00	212.00	212.00	212.00

Figure 11. Example of first page of semitrailer parameters.

```
HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.        INPUT PAGE NO.  5
                         SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

  TRAILER NO. 1 REAR BRAKES                                  LEADING TANDEM AXLE            TRAILING TANDEM AXLE
  --------------------------                                 --------------------           --------------------
                                                          LEFT SIDE    RIGHT SIDE        LEFT SIDE    RIGHT SIDE
                                                          ---------    ----------        ---------    ----------

      TIME LAG (SEC)                                         0.1400        0.1400           0.1400        0.1400
      RISE TIME (SEC)                                        0.1700        0.1700           0.1700        0.1700
      BRAKE TORQUE (IN-LB/PSI/BRAKE)                      1000.0000     1000.0000        -310.0000     -310.0000
           ***  NEGATIVE ENTRY INDICATES TABLE ENTERED ***
           ***  ECHO WILL APPEAR ON TABLE INDEX PAGE ***
```

Figure 12. Example of second page of semitrailer parameters.

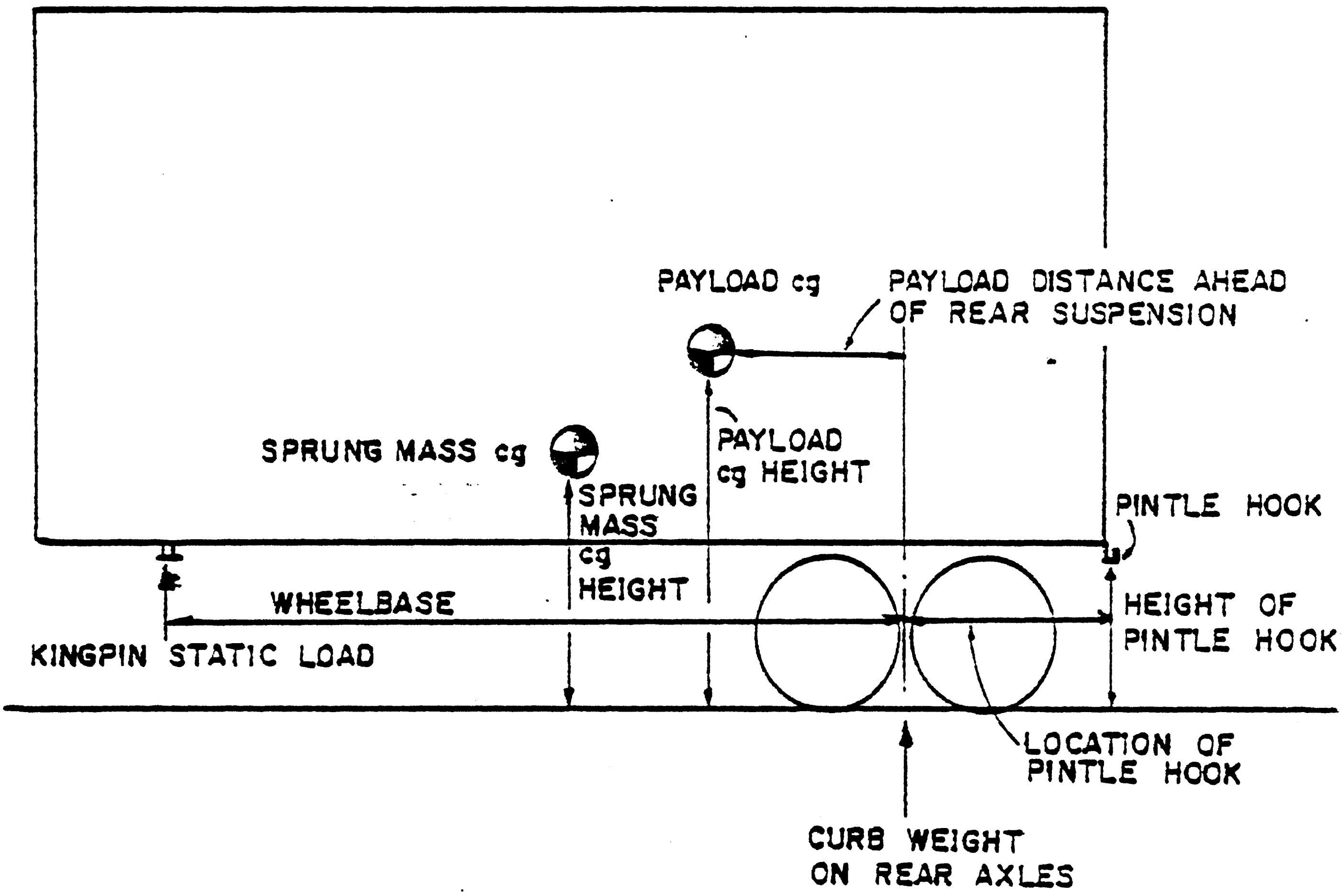


Figure 13. Modeling elements of a semitrailer.

- SPRUNG MASS YAW MOMENT OF INERTIA
- PAYLOAD WEIGHT
  - PAYLOAD DISTANCE AHEAD OF REAR SUSPENSICN - Optional
  - PAYLOAD C.G. HEIGHT - Optional
  - PAYLOAD ROLL MOMENT OF INERTIA - Optional
  - PAYLOAD PITCH MOMENT OF INERTIA - Optional
  - PAYLOAD YAW MOMENT OF INERTIA - Optional

Section 3.3.1 gives a detailed description of these parameters for the truck/tractor that is equally applicable here.

If only a tractor-trailer is being simulated, this completes the parameter entries describing the trailer sprung mass. However, if a doubles or triples are to be simulated (i.e., another trailer follows), two more parameters must be entered at this point to locate the pintle hook. The entries required are LOCATION OF PINTLE HOOK (distance in inches behind the rear suspension, F15.3 format), and HEIGHT OF PINTLE HOOK (inches above ground, F15.3 format). The height is taken to be the value when the semitrailer is in its fully loaded static position.

3.4.2 Trailer Suspension, Axle, Tires, Wheels, and Brakes. The parameters to describe these components of the semitrailer follow as shown in Figures 11 and 12. These component entries are identical in format and function to the Truck/Tractor Rear Suspension and Axle Parameters (Section 3.3.4), Truck/Tractor Rear Tires and Wheels (Section 3.3.5), and Truck/Tractor Rear Brakes (Section 3.3.6). The user should refer to these sections to answer questions relating to definitions or format.

3.5 Second and Third (Full) Trailer Descriptions

The second and third trailers are always full trailers consisting of a rigid-body sprung mass supported at the front on either a fixed or converter dolly, and at the rear by its own suspension and axles. Parametric data for the second trailer is shown in Figures 14 and 15 and is the same for the third trailer. When a third trailer (triples)

```
HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.        INPUT PAGE NO.  6
                  SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 2 PARAMETERS
------------------------
     DOLLY KEY: 1 = CONVERTER DOLLY, 2 = FIXED DOLLY                                                   1
     DISTANCE FROM DOLLY SUSPENSION TO PINTLE HOOK (IN)                                            60.00
     TURNTABLE LOCATION (IN AHEAD OF SUSP. CENTER)                                                  0.0
     TURNTABLE HEIGHT ABOVE GROUND (IN)                                                            52.00
     WHEELBASE - DISTANCE FROM CENTER OF FRONT SUSP. TO CENTER OF REAR SUSP. (IN)                 300.00
     BASE VEHICLE CURB WEIGHT ON FRONT SUSPENSION (LB)                                           8650.00
     BASE VEHICLE CURB WEIGHT ON REAR SUSPENSION (LB)                                            8650.00
     SPRUNG MASS CG HEIGHT (IN. ABOVE GROUND)                                                      74.80
     SPRUNG MASS ROLL MOMENT OF INERTIA (IN-LB-SEC**2)                                           66224.00
     SPRUNG MASS PITCH MOMENT OF INERTIA (IN-LB-SEC**2)                                         542486.00
     SPRUNG MASS YAW MOMENT OF INERTIA (IN-LB-SEC**2)                                           644483.00
     PAYLOAD WEIGHT (LB)                                                                             0.0
          *** ZERO ENTRY INDICATES NO PAYLOAD ***
          *** FIVE PAYLOAD DESCRIPTION PARAMETERS ARE NOT ENTERED ***
     LOCATION OF PINTLE HOOK (IN BEHIND REAR SUSP. CENTER)                                         48.00
     HEIGHT OF PINTLE HOOK (IN ABOVE GROUND)                                                       40.00

TRAILER NO. 2 FRONT SUSPENSION AND AXLE PARAMETERS                                    LEFT SIDE            RIGHT SIDE
--------------------------------------------------                                    ---------            ----------
     SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM           0
     SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)                                         7818.00              7818.00
     SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)                                    5.00                 5.00
     COULOMB FRICTION (LB/SIDE/AXLE)                                                   800.00               800.00
                                                                                      -----------------------------------
     AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)                                                  4746.00
     ROLL CENTER HEIGHT (IN. ABOVE GROUND)                                                         29.60
     ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)                                                 -0.00
     AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)                                                  35490.00
     LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)                                              38.00
     TRACK WIDTH (IN)                                                                              71.25
     UNSPRUNG WEIGHT (LB)                                                                        1530.00

TRAILER NO. 2 FRONT TIRES AND WHEELS                                                  LEFT SIDE            RIGHT SIDE
------------------------------------                                                  ---------            ----------

     DUAL TIRE SEPARATION (IN)                                                           12.40                12.40
     CORNERING STIFFNESS   (LB/DEG/TIRE)                                                600.00               600.00
     LONGITUDINAL STIFFNESS   (LB/SLIP/TIRE)                                          21000.00             21000.00
     CAMBER STIFFNESS (LB/DEG/TIRE)                                                       0.0                  0.0
     ALIGNING MOMENT   (IN-LB/DEG/TIRE)                                                   0.0                  0.0
     TIRE SPRING RATE (LB/IN/TIRE)                                                     4500.00              4500.00
     TIRE LOADED RADIUS (IN)                                                             20.20                20.20
     POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)                                       212.00               212.00
```

Figure 14. Example of first page of full trailer parameters.

TRAILER NO. 2 REAR SUSPENSION AND AXLE PARAMETERS

	LEADING TANDEM AXLE LEFT SIDE	LEADING TANDEM AXLE RIGHT SIDE		TRAILING TANDEM AXLE LEFT SIDE	TRAILING TANDEM AXLE RIGHT SIDE
SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM			1		
TANDEM AXLE SEPARATION (IN BETWEEN LEADING AND TRAILING AXLES)			48.00		
STATIC LOAD TRANSFER (PERCENT LOAD ON LEAD AXLE)			50.00		
DYNAMIC LOAD TRANSFER (% BRAKE TORQUE REACTED AS TANDEM AXLE LOAD TRANSFER)			10.00		
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	-3.00	-3.00		-3.00	-3.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***					
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***					
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	5.00	5.00		5.00	5.00
COULOMB FRICTION (LB/SIDE/AXLE)	800.00	800.00		800.00	800.00
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	4746.00				4746.00
ROLL CENTER HEIGHT (IN. ABOVE GROUND)	29.60				29.60
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	-0.00				-0.00
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	35490.00				35490.00
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	38.00				38.00
TRACK WIDTH (IN)	71.25				71.25
UNSPRUNG WEIGHT (LB)	1530.00				1530.00

TRAILER NO. 2 REAR TIRES AND WHEELS

	LEADING TANDEM AXLE LEFT SIDE	LEADING TANDEM AXLE RIGHT SIDE	TRAILING TANDEM AXLE LEFT SIDE	TRAILING TANDEM AXLE RIGHT SIDE
DUAL TIRE SEPARATION (IN)	12.40	12.40	12.40	12.40
CORNERING STIFFNESS (LB/DEG/TIRE)	600.00	600.00	600.00	600.00
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	21000.00	21000.00	21000.00	21000.00
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	0.0	0.0	0.0	0.0
TIRE SPRING RATE (LB/IN/TIRE)	4500.00	4500.00	4500.00	4500.00
TIRE LOADED RADIUS (IN)	20.20	20.20	20.20	20.20
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	212.00	212.00	212.00	212.00

TRAILER NO. 2 FRONT BRAKES

	LEFT SIDE	RIGHT SIDE
TIME LAG (SEC)	0.1400	0.1400
RISE TIME (SEC)	0.1700	0.1700
BRAKE TORQUE (IN-LB/PSI/BRAKE)	-5.0000	-5.0000
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***		
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***		

TRAILER NO. 2 REAR BRAKES

	LEADING TANDEM AXLE LEFT SIDE	LEADING TANDEM AXLE RIGHT SIDE	TRAILING TANDEM AXLE LEFT SIDE	TRAILING TANDEM AXLE RIGHT SIDE
TIME LAG (SEC)	0.1400	0.1400	0.1400	0.1400
RISE TIME (SEC)	0.1700	0.1700	0.1700	0.1700
BRAKE TORQUE (IN-LB/PSI/BRAKE)	1000.0000	1000.0000	1000.0000	1000.0000

Figure 15. Example of second page of full trailer parameters.

is simulated, the complete data set as shown in Figures 14 and 15 (with the exception of the two pintle hook parameters) is entered for the third trailer immediately following the second trailer.

3.5.1 Full Trailer Parameters. A full trailer is modeled by a semitrailer setting on a fixed or converter dolly. The two types of dollies are functionally different, as illustrated in Figure 16. The fixed dolly is attached directly to the trailer and is constrained to move with the trailer in all but the yaw direction. Hence, a pitch direction hinge in the dolly tongue is used to decouple pitch motions from the towing vehicle. The converter dolly incorporates a conventional fifth wheel as a coupling to the trailer. This type of dolly has a rigid tongue and is decoupled from the trailer in yaw and pitch.

Kinematically, the dollies are modeled as shown. The assumptions in the models are as follows:

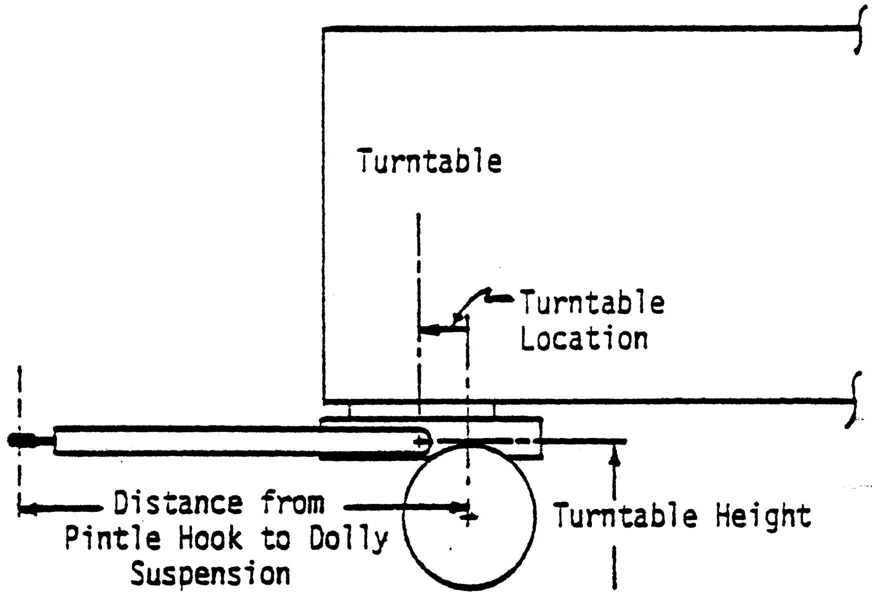
1) The yaw inertia of the dolly is assumed negligible.

2) The effective sprung mass properties of the dolly are lumped in with that of the trailer.

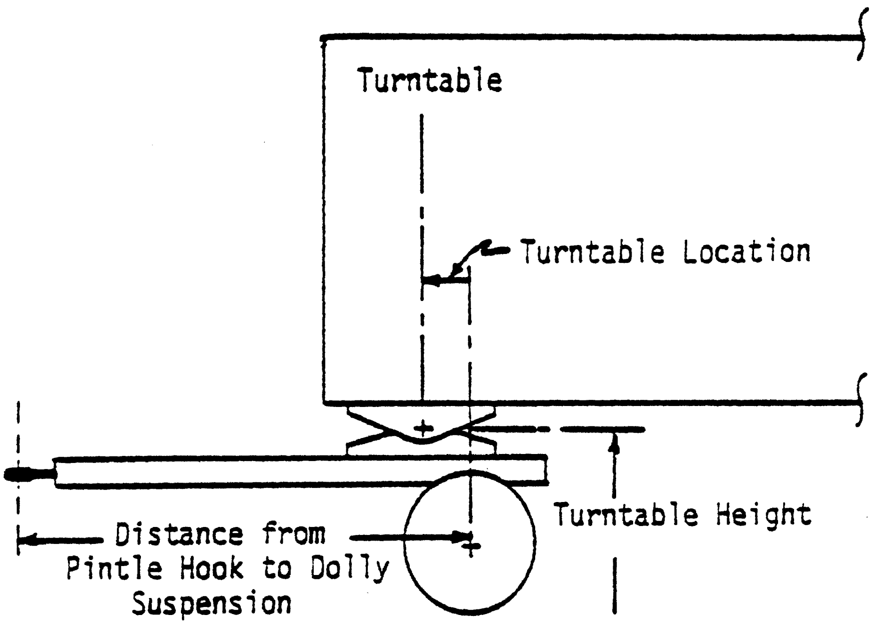
3) Tire longitudinal velocity due to dolly yaw is neglected.

The primary functional difference between the two types of dollies in the simulation is that the converter dolly can exert static load on the rear of the towing trailer, whereas the fixed dolly does not. Like the tractor fifth wheel, the pintle connection is modeled by springs of suitably high stiffness such that they are realistic, yet allow the equations to be coupled by forces rather than displacements. The pintle hitch transmits only longitudinal, lateral and vertical forces, but no moments.

The first parameter entry with a full trailer is the DOLLY KEY (I2 format) for which "01" indicates a converter dolly and "02" a fixed dolly. The next three entries define the geometry for both types of dollies as shown in Figure 16. The first is DISTANCE FROM PINTLE HOOK TO DOLLY SUSPENSION (in., F15.3 format), which defines the effective tongue length of the dolly. For the single-axle dolly this is the



Fixed Dolly



Converter Dolly

Figure 16. Modeling elements of the fixed and converter dollies.

distance to the center of the axle, whereas for the tandem axles it is to the midpoint between the two axles. Second is TURNTABLE LOCATION (inches ahead of the suspension center, F15.3 format), which defines the offset between the kingpin or turntable center and suspension system. Last is TURNTABLE HEIGHT (inches above the ground, F15.3 format). By this simplified representation, it is implicitly assumed that the longitudinal tongue forces are applied to the full trailer at the longitudinal location of the kingpin and at the vertical location defined by the turntable height. Hence, the height should be taken as that of the pitch pivot on the fifth wheel of a converter dolly, and as that of the pitch direction hinge on the tongue of a fixed dolly.

The WHEELBASE (in., F15.3 format) for the full trailer is defined as the distance between the centers of the dolly and the trailer rear suspension systems. The base vehicle sprung mass and longitudinal center of gravity location is then defined by entry of BASE VEHICLE CURB WEIGHT ON FRONT AXLES (lbs, F15.3 format) and BASE VEHICLE CURB WEIGHT ON REAR AXLES (lbs, F15.3 format). In the case of a converter dolly, some weight may be carried on the tongue due to kingpin offset. The front axle curb weight for the converter dolly should include the weight carried on the tongue (i.e., vertical load on the pintle hook). From these static loads, less the unsprung weights that are entered later, sprung mass properties of the trailer are calculated, which include sprung mass contributions from the dolly.

Thereafter, SPRUNG MASS CG HEIGHT, MOMENTS OF INERTIA, and PAYLOAD data, shown in Figure 14, are entered as for a truck/tractor, described in Section 3.3.1.

If the trailer is the second of a three-trailer (triples) combination, pintle hook location data, as follows, appears next.

- LOCATION OF PINTLE HOOK (distance in inches behind the rear suspension, F15.3 format)
- HEIGHT OF PINTLE HOOK (inches above the ground, F15.3 format)

This concludes the trailer parameters.

3.5.2 Full Trailer Suspension, Axles, Tires, Wheels, and Brakes. Input data for these parameters are shown in Figures 14 and 15. The component entries for both the dolly and trailer rear suspensions and axles are identical in format and function to the Truck/Tractor Rear Suspension and Axle Parameters (Section 3.3.4). The tires, wheels, and brake component entries are identical to Truck/Tractor Rear Tires and Wheels (Section 3.3.5) and Truck/Tractor Rear Brakes (Section 3.3.6). The user should refer to these sections for definitions and format.

3.6 Antilock Brake Description

After the last entries of parametric data (normally the brake data) for the last vehicle in the combination, the user has the option to enter antilock brake control system data for any wheel on the vehicle train. If no antilock data is to be entered for the vehicle, a "00" entry (I2 format) should be entered for the VEHICLE ANTILOCK KEY at this point in the input stream. If antilock data is to be entered, the VEHICLE ANTILOCK KEY entry should be "01" (I2 format). The "01" entry will activate the antilock subprogram to read and echo antilock data according to the format documented in Appendix D, Antilock Simulation. All antilock data must be entered following the "01" entry for the VEHICLE ANTILOCK KEY.

The antilock simulation is a general-purpose program which requires the user to specify operating characteristics of each antilock system simulated. Because of the program's built-in flexibility, permitting simulation of a wide variety of antilock system characteristics, entry and selection of numerical values defining the desired features may be challenging tasks for some first-time users. Examples appearing in Appendix D should prove helpful in understanding the basic program usage.

3.7 End of Input

The last line entered in the input stream is the RERUN parameter (I2 format). Note that this parameter is never echoed as an element of the input data list. A "00" entry for RERUN will terminate the program following the simulation run by a CALL EXIT system return. A "01" entry for RERUN is used to perform multiple runs. In this case, a second data set beginning with a Title Line should follow immediately in the same input stream. The "01" RERUN parameter will cause the program to read the second data set and execute the simulation. Following execution for the second data set, its RERUN parameter will be read and the program terminated (RERUN = 00) or a third data set read (RERUN = 01). In the event a data set is not entered following an "01" RERUN entry, a system I/O interrupt will occur and the program generally terminated by the specific system executive.

Job Control Language cards, when required at a specific computer installation to terminate/unload the program, should follow the RERUN parameter.

4.0 PROGRAM OUTPUT

4.1 General

Operation of the PHASE 4 program generates output in a format compatible with line printer systems with 132 or more characters per line. The output falls in three categories--echo of input data, a Summary Page describing the load conditions of the simulation vehicle(s), and time-based listing of simulation output variables.

Fixed and separate page numbering systems are used with the input echo and simulation output pages. The numbering systems are described in Sections 4.2 and 4.4 where those outputs are discussed. All pages have a two-line heading with the title of the PHASE 4 program and the one-line title supplied by the user.

4.1.1 Output Options. Only the simulation output pages can be optionally selected by the user. The Input Echo pages and simulation vehicle Summary Page are always printed if the input data is successfully read. The output page options are specified by an eight-digit key read in the Simulation Operation Parameter input group (see Section 3.2). If a simulation input is submitted with zero SIMULATION TIME and no output options, only the Input Echo pages and simulation vehicle Summary Page are obtained. This technique can be used to check an input list prior to making a simulation run.

4.1.2 Coordinate Systems. In order to interpret the vehicle motion parameters given in the simulation output, it is necessary to define the coordinate systems used. Two coordinate systems are necessary to describe the simulated motion of each vehicle; an inertial coordinate system and a body fixed coordinate system, as shown in Figure 17.

The inertial coordinate system is a right-hand orthogonal system fixed in space that serves as the reference point from which vehicle motions and attitudes are defined. The origin is placed at the truck/tractor sprung mass center of gravity at the beginning of the simulation (time=0). The inertial coordinate system is aligned with the gravity vector and the

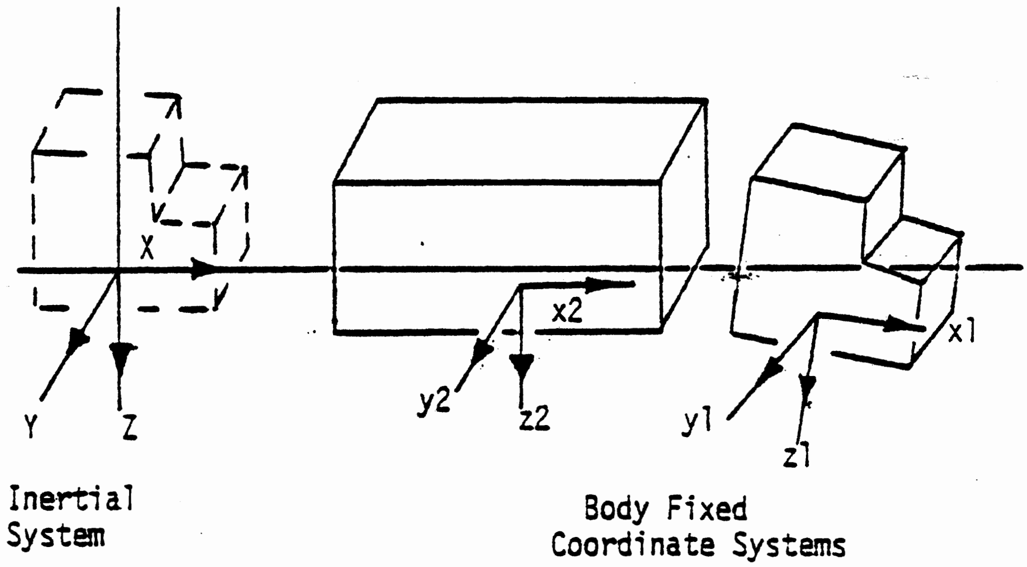


Figure 17. Illustration of coordinate systems.

horizontal projection of the truck/tractor longitudinal axis. The axes are defined according to SAE convention as follows:

X - horizontal out the front of the vehicle

Y - horizontal out the right side of the vehicle

Z - vertically downward in the direction of gravity

The body fixed coordinate system is located and fixed in the vehicle and defines the vehicle location and attitude. Its origin is at the sprung mass center of gravity and is oriented as follows:

x - longitudinally out the front of the vehicle

y - laterally out the right side of the vehicle

z - vertically in the plane of the vehicle sprung mass

Each vehicle in the simulated combination has a separate body fixed coordinate system.

At the beginning of a simulation run, the origin of the truck/tractor body fixed coordinate system is at the origin of the inertial coordinate system. Furthermore, if the vehicle is on a level surface, the axes of the body fixed system are coincident with those of the inertial system.

Since all vehicles in a combination are aligned on the inertial X axis at the beginning of a simulation, all trailers start off with a negative X coordinate and a zero Y coordinate. Since all vehicles may have a different sprung mass center of gravity height as well as different elevations due to road grade, the height of each vehicle in the inertial system is referenced from its initial height (i.e., the Z coordinate for each vehicle is defined by the change from its initial elevation.)

During a simulation, the position and attitude of each vehicle is defined by the position and attitude of its body fixed coordinate system in the inertial coordinate system. The vehicle position is given by the X, Y, and Z coordinates locating the origin of the body fixed system. The attitude is defined by Euler angles which orient the body fixed coordinate system with respect to the inertial coordinate system. That is, at any instant of time, the vehicle attitude is defined by the following three rotations going from the orientation of a translated inertial coordinate system to the orientation of the body fixed system.

1) Heading angle - rotation in the X-Y inertial plane about the Z axis; positive clockwise when veiwed from above.

2) Pitch angle - rotation about the y body axis, out of the X-Y inertial plane; positive clockwise looking from left to right on the vehicle.

3) Roll angle - rotation about the x body axis; positive clockwise looking forward on the vehicle.

4.2 Input Echo

The first series of pages in the program output is an echo of the input data used to define the vehicles and simulation to be made. The echo pages are labeled as "Input Page No.___" and are numbered sequentially as follows:

Input Page No.	Content
1	Simulation Operation Parameters
2-3	Truck/Tractor Parameters
4-5	First (Semi-) Trailer Parameters
6-7	Second (Full-) Trailer Parameters
8-9	Third (Full-) Trailer Parameters

As a minimum, pages 1-3 are always printed, while pages 4-9 appear only if a tractor-trailer, doubles, or triples are being simulated.

The input echo is designed to match line for line as much as possible with the input data list so that a copy of the echo can be used as a model for assembling a new input data list. Every line showing a numerical value corresponds to an input line. Blank lines on the echo pages are there only for ease of reading and should not be included in a input list, lest they be read as zero entries. Where multiple numbers are entered on one input line (see discussions in Section 3.0 for format,) they appear on one line of echo. Where the side-to-side option is available (see Section 3.1.3) left- and right-side values are shown on a line. Three exceptions to the above rules must be observed:

1) When a table lookup option is used, the tabular data entered beginning on the next line in the input is printed on the Table Pages of the output (see example in Appendix B.)

2) When the tandem-axle option is used, data in each group (suspensions and axles; tires and wheels; brakes) which were entered first for the leading axle then for the trailing axle are printed side by side in the echo for ease of reading.

3) When either the analytical Brake Model or semi-empirical Tire Model options are used, the corresponding input data is printed with the table pages of the output.

The input echo is produced during the input data reading process, printing after every few lines of read. An error in the input list will at times halt the reading process and prevent the program from running. In those cases, output of the echo up to the point of the reading fault will be produced, serving as an aid in diagnosing the input error.

The various lookup tables that have been entered are printed in an unnumbered series of pages as required at the end of the entire input echo. The tables are printed by categories as follows, in the order in which they were entered:

1) Suspension Spring Rate
2) Tire Data
3) Brake Torque

The tables are identified by the number assigned in the call statement.

If antilock brake control systems were used at any wheel in the vehicle configuration, a series of output pages follows at this point to describe the antilock system(s) used. The format and meaning of the antilock echo pages are given in Appendix D.

4.3 Summary Page

At the completion of a successful input data read, the program calculates the necessary composite characteristics of the vehicle combination. These data are printed on the Summary Page, as shown in Figure 18, just prior to the printout of any lookup tables.

The program first calculates the composite center of gravity location and moments of inertia for the vehicle sprung mass with payload, the resultant data being listed on the Summary Page by vehicle for the empty and loaded condition. To minimize the program memory requirements, these data are printed in the order by which they are calculated, which is from the last to the first vehicle.

Second, the static loads on each of the axles of the assembled vehicle combination is printed, front to rear, along with the total (gross combination) weight. The axles are identified by the number NS(i,j,k) where i is the number of the vehicle (numbered consecutively front to rear,) j indicates front (1) or rear (2) suspension, and k indicates the axle number on that suspension. These data serve as a good check to ensure that the desired vehicle has been produced by the input data list.

Last, the longitudinal center of gravity location and yaw moment of inertia for the total mass of each vehicle is printed. The longitudinal c.g. location determines the overall axle loads resulting from the vehicle with payload. The total vehicle yaw moment of inertia is the overall resultant from contributions of the sprung mass, payload and axles.

4.4 Simulation Output

The simulation output pages are the product of the simulation run, providing a description of what happens to the vehicle combination in the course of the simulated maneuver. The output pages present lists of the selected vehicle motion variables and operating conditions at specified intervals of time throughout the maneuver. The variables and conditions are presented in columns with each line representing a point in time, measured in seconds, from the beginning of the simulation.

The output is identified by the "Output Page Number" appearing in the upper right-hand corner of each page. The numbering code is as follows:

```
HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.        SUMMARY PAGE
                                   SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3            PAYLOAD =        0.0    LBS.                                EMPTY          LOADED
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO REAR SUSPENSION (IN)                    150.000         150.000
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO GROUND (IN)                              74.800          74.800
ROLL MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)                      66223.938       66223.938
PITCH MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)                    542485.938      542485.938
YAW MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)                      644482.938      644482.938

TRAILER NO. 2            PAYLOAD =        0.0    LBS.                                EMPTY          LOADED
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO REAR SUSPENSION (IN)                    168.057         168.057
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO GROUND (IN)                              74.800          74.800
ROLL MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)                      66223.938       66223.938
PITCH MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)                    542485.938      542485.938
YAW MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)                      644482.938      644482.938

TRAILER NO. 1            PAYLOAD =  46800.000 LBS.                                   EMPTY          LOADED
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO REAR SUSPENSION (IN)                    125.082         174.182
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO GROUND (IN)                              74.800          62.253
ROLL MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)                      66223.938       83267.250
PITCH MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)                    542485.938      848450.250
YAW MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)                      644482.938      946404.000

 TRACTOR            PAYLOAD =       0.0    LBS                                       EMPTY          LOADED
DISTANCE FROM TRACTOR SPRUNG MASS CENTER TO REAR SUSPENSION (IN)                    108.519         108.519
DISTANCE FROM TRACTOR SPRUNG MASS CENTER TO GROUND (IN)                              40.130          40.130
ROLL MOMENT OF INERTIA OF TRACTOR SPRUNG MASS (IN-LB-SEC**2)                      36756.996       36756.996
PITCH MOMENT OF INERTIA OF TRACTOR SPRUNG MASS (IN-LB-SEC**2)                    105492.938      105492.938
YAW MOMENT OF INERTIA OF TRACTOR SPRUNG MASS (IN-LB-SEC**2)                      241479.000      241479.000

THE STATIC LOADS ON THE AXLES ARE:
AXLE NUMBER          LOAD
NS(1,1,1)          9604.379
NS(1,2,1)         16445.969
NS(1,2,2)         16445.969
NS(2,2,1)         13263.469
NS(2,2,2)         19895.293
NS(3,1,1)          8650.000
NS(3,2,1)          4325.000
NS(3,2,2)          4325.000
NS(4,1,1)          4325.000
NS(4,1,2)          4325.000
NS(4,2,1)          4325.000
NS(4,2,2)          4325.000
               ---------------
 TOTAL        110254.938

THE TRACTOR TOTAL MASS CENTER IS        68.600 INCHES BEHIND THE FRONT AXLE
THE TOTAL YAW MOMENT OF INERTIA IS    401301.875 IN-LB-SEC**2

THE FIRST TRAILER TOTAL MASS CENTER IS       217.966 INCHES BEHIND THE KINGPIN
THE TOTAL YAW MOMENT OF INERTIA IS   1188344.000 IN-LB-SEC**2

THE SECOND TRAILER TOTAL MASS CENTER IS       150.000 INCHES BEHIND THE TURNTABLE CENTER
THE TOTAL YAW MOMENT OF INERTIA IS    941574.000 IN-LB-SEC**2

THE THIRD TRAILER TOTAL MASS CENTER IS       150.000 INCHES BEHIND THE TURNTABLE CENTER
THE TOTAL YAW MOMENT OF INERTIA IS   1046017.500 IN-LB-SEC**2
```

Figure 18. Example of summary page output.

x.yy.z

where

x = time block

yy = variable page number

z = vehicle number (1 - truck or tractor, 2 - semitrailer, 3 - first full trailer, 4 - second full trailer)

The time block code arises from the need to minimize computer memory requirements. Each page of output contains up to 41 time increments of output. If the duration of the maneuver and selected time interval for printing results in more than 41 lines of output, to minimize the number of output devices, output for the first 41 time increments (time block 1,) is printed; then it continues with the second block of 41 (time block 2,) etc. In order to minimize the number of time blocks and hence the bulk of the output pages, the user may want to choose carefully the TIME INCREMENT OF OUTPUT specified in the Simulation Operation Parameters (Section 3.2,) using the following information for guidance:

Maneuver Duration	Time Increment of Output	No. of Time Blocks
2 sec.	.05 sec.	1
4	.10	1
4	.05	2
6	.15	1
6	.10	2
6	.05	3
8	.20	1
8	.15	2
8	.10	2
8	.05	4

Up to twenty-three output variable pages can be requested for each vehicle. The page numbering system and contents of each page are shown in Table 2. All pages are printed for each vehicle, with the vehicles taken in Sequence. Variable pages are printed in ascending order by page number, but are not necessarily consecutive since output printing can be suppressed by choice of the OUTPUT PAGE OPTION KEYS. In addition, the numbering system allows for four pages in the last five groups since one page is required per axle and some vehicles can have up to four axles. If

Table 2. Simulation Output Page Contents.

Page No.	Title	Variables
01	Sprung Mass Position (Inertial Coordinate System)	Forward, Lateral and Vertical Translation Roll, Pitch and Heading Angles Turn Radius Body Sideslip Angle Articulation Angle
02	Sprung Mass Velocity (Body-Fixed Coordinate System)	Forward, Lateral and Vertical Roll, Pitch, Heading and Articulation Rate
03	Sprung Mass Accelerations (Inertial & Body Fixed Coordinate Systems)	Forward, Lateral and Vertical Roll, Pitch and Heading Vehicle Longitudinal and Lateral
04-07	Tire Forces* (Tire Axis System)	Vertical, Longitudinal and Lateral Longitudinal and Lateral Coefficient of Friction Steer Angle (First Vehicle Front Axle Only)
08-11	Brake Data Summary* (Tire Axis System)	Treadle Pressure, Brake Pressure and Brake Torque Wheel Slip and Brake Force Wheel Angular Velocity and Acceleration
12-15	Lateral Tire Forces and Moment Summary* (Tire Axis System)	Tire Sideslip Angle Lateral Force and Coefficient of Friction Aligning Torque
16-19	Unsprung Mass Summary* (Inertial Coordinate System)	Axle Position and Velocity (Vertical and Roll) Auxiliary Roll Torque Spring Deflection, Velocity and Force
20-23	Brake Model Temperatures	Interface, Drum, and Lining Temperatures Brake Torque

*One page per axle, up to four axles per vehicle.

the vehicle has less than four axles, certain output page numbers will not appear.

4.4.1 Sprung Mass Position Page. Variable page 01, Sprung Mass Position, shown in Figure 19, describes the simulated vehicle motion by its position and rotational attitude in the inertial coordinate system. The inertial coordinate system is located at the truck/tractor sprung mass center of gravity at time zero in the simulation (see Section 4.1.2.) The vehicle position is defined by X (forward), Y (lateral), and Z (vertical) inertial coordinates of the vehicle sprung mass center of gravity during the simulation. For the truck/tractor, the initial coordinates are always zero. Trailers are always aligned behind the tractor so that they start from a negative forward position and zero lateral. Positive lateral is to the right of the vehicle. To avoid confusion from the differing sprung mass heights and road slopes, the vertical position always begins at zero and indicates relative change in elevation. Note that, by SAE convention, positive values of vertical position are downward, in the direction of gravity.

The attitude of the vehicle is given in the next three columns as defined by the Euler angle rotations (roll, pitch and heading) of the body fixed coordinate system (see Section 4.1.2) in the inertial coordinate system.

In addition, the position page contains lists of the instantaneous radius of turn (positive is right turn); the body sideslip angle (arc-tangent of the lateral over forward velocity at the center of gravity); and with articulated combinations, the articulation angle which is the difference between the heading angles of the leading and trailing vehicles (leading minus trailing).

4.4.2 Sprung Mass Velocity Page. Variable page 02, Sprung Mass Velocity, shown in Figure 20, describes the velocity of the sprung mass in the body fixed coordinate system. Forward velocity is along the longitudinal axis of the vehicle (x), Lateral velocity is positive to the right along the y-axis, and Vertical velocity is positive through the bottom of the vehicle. The velocity components given are the time rate of change of the vehicle

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. CUTPUT PAGE NO. 1.00.2
SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 1 SPRUNG MASS POSITION

TIME (SEC)	FORWARD (FT)	LATERAL (FT)	VERTICAL (FT)	ROLL (DEG)	PITCH (DEG)	HEADING (DEG)	TURN RADIUS (FT)	SIDE SLIP (DEG)	ARTICULATION ANGLE (DEG)
0.0	-26.3614	0.0	0.0	0.0	0.0	0.0	************	0.0	0.0
0.05	-24.0514	0.0000	-0.0000	0.0000	0.0000	0.0000	275992.8750	0.0002	0.0015
0.10	-21.8520	0.0000	-0.0000	-0.0013	0.0004	0.0003	416555.1875	0.0004	0.0108
0.15	-19.6555	0.0000	-0.0002	-0.0096	0.0031	0.0011	-427493.8750	-0.0005	0.0334
0.20	-17.4657	0.0001	-0.0009	-0.0284	0.0090	0.0031	111325.8125	-0.0023	0.0732
0.25	-15.2846	0.0001	-0.0024	-0.0567	0.0128	0.0072	22209.0742	-0.0031	0.1336
0.30	-13.1113	0.0004	-0.0047	-0.0903	0.0057	0.0146	9584.4727	-0.0010	0.2175
0.35	-10.9460	0.0012	-0.0073	-0.1273	0.0017	0.0263	5645.2852	0.0052	0.3276
0.40	-8.7919	0.0029	-0.0100	-0.1702	0.0139	0.0437	3775.0171	0.0156	0.4656
0.45	-6.6546	0.0057	-0.0128	-0.2220	0.0276	0.0683	2675.1523	0.0306	0.6320
0.50	-4.5403	0.0102	-0.0155	-0.2825	0.0238	0.1020	1971.8765	0.0510	0.8261
0.55	-2.4539	0.0170	-0.0170	-0.3473	0.0117	0.1463	1486.2251	0.0783	1.0454
0.60	-0.3981	0.0265	-0.0166	-0.4132	0.0121	0.2028	1143.2817	0.1145	1.2857
0.65	1.6266	0.0397	-0.0147	-0.4809	0.0227	0.2727	916.1719	0.1607	1.5436
0.70	3.6206	0.0570	-0.0125	-0.5505	0.0235	0.3563	761.6282	0.2165	1.8174
0.75	5.5843	0.0793	-0.0111	-0.6212	0.0107	0.4548	645.8633	0.2824	2.1022
0.80	7.5177	0.1071	-0.0104	-0.6912	0.0030	0.5693	567.2251	0.3545	2.3986
0.85	9.4217	0.1411	-0.0104	-0.7558	0.0121	0.6989	500.6599	0.4334	2.7091
0.90	11.2964	0.1817	-0.0116	-0.8157	0.0244	0.8425	450.7876	0.5203	3.0383
0.95	13.1420	0.2294	-0.0138	-0.8699	0.0239	0.9993	412.2910	0.6131	3.3900
1.00	14.9580	0.2845	-0.0165	-0.9157	0.0173	1.1698	378.1414	0.7106	3.7657
1.05	16.7436	0.3473	-0.0182	-0.9543	0.0208	1.3544	345.5369	0.8137	4.1640
1.10	18.4988	0.4182	-0.0187	-0.9874	0.0325	1.5523	315.2178	0.9254	4.5781
1.15	20.2220	0.4974	-0.0183	-1.0125	0.0352	1.7625	290.9236	1.0467	5.0024
1.20	21.9133	0.5853	-0.0173	-1.0246	0.0249	1.9845	271.5610	1.1753	5.4319
1.25	23.5715	0.6819	-0.0157	-1.0278	0.0164	2.2183	255.2108	1.3085	5.8604
1.30	25.1967	0.7874	-0.0138	-1.0349	0.0199	2.4642	241.0734	1.4445	6.2832
1.35	26.7897	0.9015	-0.0125	-1.0516	0.0257	2.7215	229.1027	1.5821	6.6982
1.40	28.3509	1.0244	-0.0124	-1.0719	0.0222	2.9896	218.0656	1.7213	7.1041
1.45	29.8807	1.1558	-0.0133	-1.0874	0.0154	3.2682	207.0162	1.8627	7.4989
1.50	31.3793	1.2958	-0.0148	-1.0983	0.0181	3.5570	195.9681	2.0079	7.8810
1.55	32.8484	1.4442	-0.0160	-1.1118	0.0264	3.8560	182.5410	2.1615	8.2492
1.60	34.2915	1.6012	-0.0166	-1.1344	0.0229	4.1672	171.7455	2.3248	8.6054
1.65	35.7056	1.7670	-0.0160	-1.1529	0.0129	4.4911	160.4937	2.4955	8.9467
1.70	37.0827	1.9416	-0.0144	-1.1532	0.0164	4.8253	149.2876	2.6827	9.2605
1.75	38.4212	2.1250	-0.0128	-1.1399	0.0272	5.1663	143.9207	2.8807	9.5462
1.80	39.7241	2.3163	-0.0124	-1.1158	0.0255	5.5106	143.8707	3.0717	9.8117
1.85	40.9946	2.5147	-0.0133	-1.0778	0.0141	5.8558	144.3370	3.2466	10.0636
1.90	42.2351	2.7193	-0.0147	-1.0287	0.0134	6.2020	142.0525	3.4099	10.3044
1.95	43.4490	2.9295	-0.0157	-0.9823	0.0227	6.5505	136.9190	3.5725	10.5368
2.00	44.6374	3.1452	-0.0158	-0.9504	0.0239	6.9046	130.7935	3.7368	10.7587

Figure 19. Example of sprung mass position page.

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.   OUTPUT PAGE NO. 1.01.2
SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 1 SPRUNG MASS VELOCITY (BODY AXES)

TIME (SEC)	FORWARD (FT/SEC)	LATERAL (FT/SEC)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	PITCH (DEG/SEC)	HEADING (DEG/SEC)	ARTICULATION RATE (DEG/SEC)
0.0	44.00	0.0	0.0	0.0	0.0	0.0	0.0
0.05	44.00	0.00	-0.00	-0.00	0.00	0.00	0.09
0.10	44.00	0.00	-0.00	-0.08	0.01	0.01	0.30
0.15	43.99	-0.00	-0.01	-0.27	0.08	0.03	0.61
0.20	43.95	-0.00	-0.01	-0.48	0.14	0.06	0.99
0.25	43.84	-0.00	-0.03	-0.63	0.01	0.11	1.43
0.30	43.63	-0.00	-0.04	-0.70	-0.15	0.19	1.93
0.35	43.32	0.00	-0.05	-0.79	0.12	0.29	2.48
0.40	42.92	0.01	-0.04	-0.94	0.39	0.42	3.04
0.45	42.47	0.02	-0.03	-1.13	0.16	0.58	3.61
0.50	41.97	0.04	-0.02	-1.27	-0.20	0.77	4.15
0.55	41.44	0.06	-0.00	-1.31	-0.13	1.00	4.61
0.60	40.88	0.08	0.04	-1.33	0.20	1.26	4.99
0.65	40.28	0.11	0.07	-1.38	0.20	1.54	5.32
0.70	39.67	0.15	0.06	-1.40	-0.14	1.81	5.60
0.75	39.07	0.19	0.03	-1.43	-0.26	2.13	5.80
0.80	38.47	0.24	0.02	-1.35	0.03	2.45	6.06
0.85	37.88	0.29	0.00	-1.24	0.29	2.74	6.38
0.90	37.29	0.34	-0.01	-1.16	0.14	3.01	6.80
0.95	36.69	0.39	-0.03	-1.00	-0.14	3.27	7.27
1.00	36.08	0.45	-0.03	-0.84	-0.09	3.55	7.76
1.05	35.46	0.50	0.00	-0.72	0.18	3.83	8.15
1.10	34.83	0.56	0.03	-0.60	0.17	4.09	8.40
1.15	34.20	0.62	0.05	-0.38	-0.14	4.32	8.56
1.20	33.56	0.69	0.06	-0.12	-0.29	4.55	8.60
1.25	32.93	0.75	0.06	-0.06	-0.10	4.80	8.53
1.30	32.30	0.81	0.06	-0.24	0.10	5.04	8.39
1.35	31.67	0.87	0.05	-0.41	-0.02	5.26	8.22
1.40	31.04	0.93	0.02	-0.38	-0.22	5.46	8.02
1.45	30.42	0.99	0.00	-0.25	-0.14	5.67	7.78
1.50	29.80	1.04	0.00	-0.21	0.10	5.88	7.51
1.55	29.19	1.10	0.02	-0.37	0.00	6.10	7.24
1.60	28.60	1.16	0.04	-0.49	-0.29	6.35	7.01
1.65	28.02	1.22	0.06	-0.20	-0.20	6.59	6.58
1.70	27.44	1.28	0.07	0.15	0.12	6.77	5.98
1.75	26.82	1.35	0.07	0.36	0.04	6.86	5.49
1.80	26.17	1.40	0.04	0.61	-0.29	6.89	5.16
1.85	25.51	1.45	0.01	0.89	-0.27	6.91	4.92
1.90	24.86	1.48	0.01	1.02	0.07	6.94	4.72
1.95	24.25	1.51	0.03	0.78	0.06	7.02	4.59
2.00	23.67	1.54	0.04	0.51	-0.15	7.15	4.18

Figure 20. Example of sprung mass velocity page.

position vector resolved into components along the body axis system. The forward velocity is the component along the vehicle longitudinal axis which may be interpreted as vehicle speed.

The Roll, Pitch, and Heading rates are obtained by resolving the vehicle rotation vector into components in the body fixed axis system. The user may note that the frequently used term "yaw rate" is the same as heading rate.

With articulated vehicles, the rate of change of the articulation angle is also shown. If the simulation is operated with a steering system, the calculated steering-wheel angle will appear on this page for the truck/tractor unit.

4.4.3 Sprung Mass Acceleration Page. Variable page 03, Sprung Mass acceleration, shown in Figure 21, describes the acceleration of the sprung mass in the body fixed coordinate system. The accelerations in a moving, rotating coordinate system referenced to an inertial system are given by the expressions

$$u = \Sigma F_x/M + r \cdot v - q \cdot w$$
$$v = \Sigma F_y/M + p \cdot w - r \cdot u$$
$$w = \Sigma F_z/M - q \cdot u + p \cdot v$$

where

F_x, F_y, F_z = forces in the longitudinal, lateral, and vertical directions

M = vehicle mass

u = velocity along the x (forward) axis

v = velocity along the y (lateral) axis

w = velocity along the z (vertical) axis

p, q, r = rotation rates about the x, y, z axes

The dot denotes differentiation with respect to time.

The forward, Lateral and Vertical accelerations on the left side of the page are the time derivatives of the velocities shown on the preceding page, and hence represent the velocity derivatives ($\dot{u}$, $\dot{v}$, $\dot{w}$) defined by the above equations. Most users, however, are interested in the total or inertial acceleration of the simulated vehicle (i.e., the first term on the right-hand side in the above equations). Therefore, a set of Longitudinal and Lateral inertial accelerations resolved into the body axis coordinate

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SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TIME (SEC)	TRAILER NO. 1 SPRUNG MASS ACCELERATION (BODY AXES) FORWARD (FT/SEC**2)	LATERAL (FT/SEC**2)	VERTICAL (FT/SEC**2)	ROLL (DEG/SEC**2)	PITCH (DEG/SEC**2)	HEADING (DEG/SEC**2)	INERTIAL ACCEL. ALONG BODY AXES LONGITUDINAL (FT/SEC**2)	LATERAL (FT/SEC**2)
0.0	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
0.05	-0.0026	0.0057	-0.0028	-0.2868	0.0633	0.0841	-0.0026	0.0071
0.10	-0.0683	-0.0026	-0.0565	-3.0828	0.3308	0.2218	-0.0683	0.0042
0.15	-0.4089	-0.0243	-0.2320	-4.3181	-0.8651	0.4663	-0.4089	-0.0048
0.20	-1.2612	-0.0249	-1.5977	-3.8151	-28.6117	0.8415	-1.2612	0.0195
0.25	-3.0930	0.0073	-2.0134	-1.9950	-41.5299	1.2494	-3.0930	0.0926
0.30	-5.3224	0.0657	-2.0442	-1.1468	-34.3410	1.6779	-5.3222	0.2073
0.35	-7.0843	0.1273	-1.6722	-2.3175	-28.0840	2.2149	-7.0844	0.3428
0.40	-8.4978	0.1895	-1.4939	-3.6463	-34.9556	2.8348	-8.4982	0.5002
0.45	-9.4844	0.2602	-1.5830	-3.6200	-43.9355	3.4736	-9.4847	0.6879
0.50	-10.1950	0.3421	-1.4514	-1.5745	-39.4600	4.1107	-10.1954	0.9081
0.55	-10.9009	0.4460	-1.0195	-0.1052	-29.7382	4.7794	-10.9019	1.1708
0.60	-11.6640	0.5721	-0.9432	-0.6401	-30.8372	5.2493	-11.6657	1.4739
0.65	-12.1443	0.6954	-1.5161	-0.7035	-40.3027	5.2855	-12.1471	1.7772
0.70	-12.1071	0.8084	-2.1387	-0.1389	-42.2109	5.5793	-12.1120	2.0643
0.75	-11.8683	0.9011	-2.2144	0.2873	-33.3463	6.3047	-11.8756	2.3523
0.80	-11.7732	0.9460	-1.9710	2.8388	-28.0143	5.8597	-11.7834	2.5894
0.85	-11.8208	1.0234	-1.9552	2.0058	-34.4536	5.2539	-11.8345	2.8341
0.90	-11.8639	1.0808	-2.1091	2.6155	-41.8470	4.8919	-11.8817	3.0367
0.95	-11.9674	1.1070	-1.9320	3.9668	-38.6507	5.0756	-11.9897	3.1999
1.00	-12.1910	1.1235	-1.3862	3.3540	-30.9250	5.3891	-12.2187	3.3586
1.05	-12.4832	1.1610	-1.0368	2.4805	-31.8864	5.0518	-12.5169	3.5326
1.10	-12.6615	1.2321	-1.2096	3.5518	-39.8890	4.4590	-12.7015	3.7175
1.15	-12.6192	1.2838	-1.5401	6.0879	-41.8195	4.1706	-12.6665	3.8629
1.20	-12.6233	1.2965	-1.6235	4.4272	-34.7563	4.3705	-12.6783	3.9629
1.25	-12.6183	1.2768	-1.6046	-1.2166	-30.1068	4.5533	-12.6814	4.0331
1.30	-12.6147	1.2432	-1.8382	-3.8841	-34.7863	4.2390	-12.6862	4.0826
1.35	-12.5242	1.2012	-2.2015	-0.9663	-40.2527	3.7915	-12.6045	4.1066
1.40	-12.4242	1.1631	-2.2478	2.7441	-37.4629	3.7244	-12.5132	4.1227
1.45	-12.3387	1.1367	-1.9093	2.5707	-31.2771	3.8008	-12.4366	4.1481
1.50	-12.3168	1.1245	-1.5817	-0.1910	-32.5153	3.5515	-12.4239	4.1818
1.55	-12.0932	1.1895	-1.3729	-4.1009	-41.4542	4.4673	-12.2104	4.2949
1.60	-11.5709	1.2064	-1.2945	2.0924	-39.3774	4.6363	-11.6997	4.3768
1.65	-11.3942	1.2635	-1.3451	8.8404	-28.8867	3.8315	-11.5347	4.4852
1.70	-11.9754	1.3291	-1.6024	5.7339	-32.2321	2.3991	-12.1270	4.5698
1.75	-12.7432	1.2277	-2.1523	4.5536	-41.7679	0.6916	-12.9047	4.4406
1.80	-13.1461	0.9873	-2.3857	6.3563	-40.1913	-0.1735	-13.3151	4.1356
1.85	-13.0789	0.7719	-2.0241	5.2036	-30.5974	-0.0072	-13.2533	3.8476
1.90	-12.6929	0.6657	-1.5200	-0.6183	-30.8743	0.5377	-12.8721	3.6762
1.95	-11.8501	0.6612	-1.3243	-6.4046	-39.8004	1.8811	-12.0354	3.6318
2.00	-11.1561	0.6813	-1.5082	-3.0740	-37.4026	2.5348	-11.3489	3.6352

Figure 21. Example of sprung mass acceleration page.

system are given on the right side of the page. In effect, these are equivalent to those accelerations felt while in the vehicle. The Longitudinal and Forward accelerations are effectively equivalent because of the small velocities and rotation rates normally involved in the longitudinal equation. (The same would be true for vertical acceleration if it were shown.) The lateral accelerations will differ in turning maneuvers, however, because of the "r · u" term, which is the centripetal acceleration.

The Roll, Pitch and Heading accelerations are the resolution of the total rotational acceleration vector into the body fixed coordinate system. (The time derivatives of the rotational velocities appearing on the preceding page.)

4.4.4 Tire Forces Page. Variable pages 04-07, Tire Forces, shown in Figure 22, provide a summary of the vertical, longitudinal and lateral forces exerted on the tires at the tire/road interface. The forces are presented for tires on both the left and right sides of the axle, with each axle on a separate page. The forces are defined in the axis system of the wheel according to SAE convention (see Figure 23). All forces and moments acting on the tire are measured relative to the center of the tire/road contact patch which may be defined as the point of intersection of the road plane, wheel plane and a perpendicular plane through the wheel spin axis.

The Vertical force is the instantaneous force in the center of tire/road contact patch normal to the road. Vertical force on the tire in the upward direction is defined by SAE convention as positive. The Longitudinal force is the force in the road plane in the direction of the wheel heading. Negative values correspond to a braking force. Lateral force is the force in the road plane perpendicular to the wheel heading with positive values corresponding to a force on the tire to the right, when looking in the direction of wheel heading. A positive Lateral force results when the tire is steered to the right.

Two variables, "MU-X" and "MU-Y" are also printed. These variables are the respective ratios of the longitudinal and lateral forces to the vertical force, and represent the normalized friction levels being utilized in each direction.

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SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 1 REAR SUSPENSION TIRE FORCES
LEADING TANDEM AXLE

TIME	LEFT SIDE					RIGHT SIDE				
	VERTICAL	LONG.	LATERAL	MU-X	MU-Y	VERTICAL	LONG.	LATERAL	MU-X	MU-Y
(SEC)	(LB)	(LB)	(LB)			(LB)	(LB)	(LB)		
0.0	6631.73	-0.0	0.0	0.0	0.0	6631.73	-0.0	0.0	0.0	0.0
0.05	6631.99	-0.02	0.31	-0.0000	0.0000	6631.51	0.05	0.31	0.0000	0.0000
0.10	6634.20	0.37	-3.18	0.0001	-0.0005	6633.91	0.59	-3.18	0.0001	-0.0005
0.15	6658.61	0.55	-10.59	0.0001	-0.0016	6647.41	1.05	-10.57	0.0002	-0.0016
0.20	6674.07	-100.56	-12.98	-0.0151	-0.0019	6618.86	-99.24	-12.88	-0.0150	-0.0019
0.25	6689.52	-346.48	-4.97	-0.0518	-0.0007	6563.12	-342.98	-4.88	-0.0523	-0.0007
0.30	6622.68	-593.29	12.94	-0.0896	0.0020	6389.23	-587.15	12.49	-0.0919	0.0020
0.35	6573.84	-782.44	33.82	-0.1190	0.0051	6226.28	-773.75	32.06	-0.1243	0.0051
0.40	6708.55	-927.22	56.45	-0.1382	0.0084	6235.35	-917.13	52.52	-0.1471	0.0084
0.45	6847.46	-1029.54	83.90	-0.1504	0.0123	6217.32	-1016.84	76.28	-0.1636	0.0123
0.50	6788.47	-1101.09	120.21	-0.1622	0.0177	5973.54	-1083.72	105.98	-0.1814	0.0177
0.55	6708.34	-1159.80	169.00	-0.1729	0.0252	5685.66	-1139.19	143.59	-0.2004	0.0253
0.60	6874.01	-1209.75	229.38	-0.1760	0.0334	5629.20	-1191.00	188.44	-0.2116	0.0335
0.65	7207.23	-1241.82	292.60	-0.1723	0.0406	5735.91	-1225.78	233.78	-0.2137	0.0408
0.70	7404.91	-1260.77	348.73	-0.1703	0.0471	5713.66	-1242.05	270.35	-0.2174	0.0473
0.75	7412.00	-1279.46	403.46	-0.1726	0.0544	5503.25	-1255.03	301.25	-0.2281	0.0547
0.80	7471.00	-1299.89	468.58	-0.1740	0.0627	5336.52	-1276.83	336.91	-0.2393	0.0631
0.85	7689.24	-1314.03	532.60	-0.1709	0.0693	5342.05	-1297.64	372.79	-0.2429	0.0698
0.90	7860.83	-1317.49	575.76	-0.1676	0.0732	5337.60	-1301.25	394.21	-0.2438	0.0739
0.95	7812.71	-1316.62	605.38	-0.1685	0.0775	5143.34	-1294.27	402.22	-0.2516	0.0782
1.00	7689.51	-1319.25	637.13	-0.1716	0.0829	4892.29	-1295.06	409.49	-0.2647	0.0837
1.05	7734.70	-1324.58	676.35	-0.1713	0.0874	4815.60	-1308.26	425.80	-0.2717	0.0884
1.10	7911.45	-1325.75	709.94	-0.1676	0.0897	4887.09	-1315.91	443.88	-0.2693	0.0900
1.15	7987.22	-1323.47	728.02	-0.1657	0.0911	4894.79	-1311.09	452.00	-0.2679	0.0923
1.20	7915.36	-1322.58	732.91	-0.1671	0.0926	4799.50	-1307.72	450.65	-0.2725	0.0939
1.25	7889.17	-1326.50	725.21	-0.1681	0.0919	4781.57	-1316.54	446.19	-0.2753	0.0933
1.30	8013.00	-1330.17	704.38	-0.1660	0.0879	4915.53	-1325.97	439.09	-0.2698	0.0893
1.35	8129.65	-1329.53	675.79	-0.1635	0.0831	5028.89	-1322.74	425.24	-0.2630	0.0846
1.40	8085.00	-1327.55	654.33	-0.1642	0.0809	4967.07	-1314.08	409.34	-0.2646	0.0824
1.45	7968.38	-1328.98	644.56	-0.1668	0.0809	4831.07	-1314.04	398.60	-0.2720	0.0825
1.50	7953.33	-1332.17	632.72	-0.1675	0.0796	4809.39	-1322.92	390.44	-0.2751	0.0812
1.55	8002.41	-1334.54	603.27	-0.1668	0.0754	4864.91	-1325.45	374.70	-0.2725	0.0770
1.60	7943.76	-1338.79	586.13	-0.1685	0.0730	4782.59	-1321.99	361.04	-0.2764	0.0755
1.65	7883.72	-1343.35	606.87	-0.1704	0.0770	4661.67	-1328.15	367.63	-0.2849	0.0789
1.70	8007.10	-1340.36	604.67	-0.1674	0.0755	4791.25	-1340.25	371.10	-0.2797	0.0775
1.75	8134.01	-1327.95	527.37	-0.1633	0.0648	5043.13	-1332.81	335.67	-0.2643	0.0666
1.80	8017.19	-1316.68	418.81	-0.1642	0.0522	5107.66	-1316.06	274.12	-0.2577	0.0537
1.85	7748.63	-1315.71	334.21	-0.1698	0.0431	5018.54	-1312.36	222.53	-0.2615	0.0443
1.90	7602.99	-1323.44	267.25	-0.1741	0.0352	5058.39	-1324.80	182.94	-0.2619	0.0362
1.95	7583.35	-1334.70	192.35	-0.1760	0.0254	5237.75	-1335.42	136.81	-0.2550	0.0261
2.00	7512.79	-1343.43	141.10	-0.1788	0.0188	5306.50	-1338.89	102.74	-0.2523	0.0194

Figure 22. Example of tire forces page.

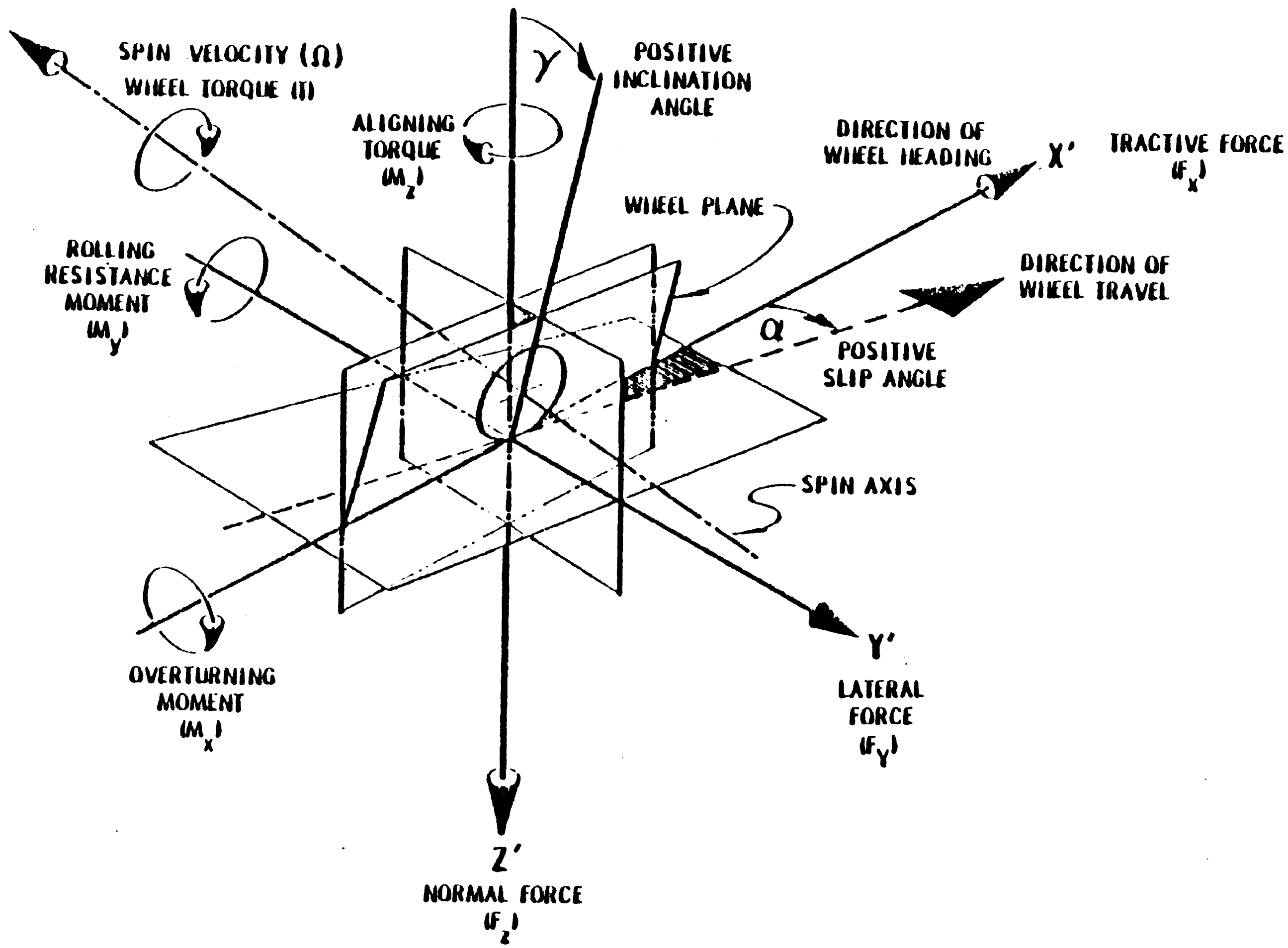

Figure 29. SAE Tire Axis System

4.4.5 Brake Data Summary Page. Variable pages 08-11, Brake Summary, provide detailed information on the brake function on the left and right wheels of each axle. The page, shown in Figure 24, lists the treadle pressure being applied by interpolation of the Treadle Pressure Table input for the simulation, and the brake pressure in the chamber that results from action of the time lags and rise times for each brake. Next is listed the actual brake torque produced at the wheel. If the wheel is moving, the torque corresponds to that of the brake torque coefficient or table value input at the applied pressure. However, if the wheel reaches lock-up, the actual torque is limited by the tire friction and may be less than the attempted value. In addition to brake torque, the tire brake force is listed which, in effect, is an indication of the portion of the brake torque applied to decelerating the vehicle. In the simulation, the torque is actually applied to the wheel causing it to decelerate, with the tire brake force resulting from longitudinal slip in the tire model. Hence, at any instant of time a portion of the brake torque may be devoted to decelerating the wheel rather than to developing actual braking force. The wheel slip, angular wheel velocity and angular wheel acceleration are also listed for their utility in investigating antilock braking system performance.

4.4.6 Lateral Pages. Variable pages 12-15, Lateral Tire Force and Moment Summary, shown in Figure 25, provide detailed information on the cornering performance of each tire on the vehicle combination. Each page lists the left and right side cornering parameters for an axle on the vehicle. The first parameter is tire sideslip angle, which by SAE convention is positive when the tire is sideslipping to the right of its heading direction (see Fig. 23). Next is listed the tire lateral force, which is the force on the tire in the road plane perpendicular to the wheel heading, positive force being to the right. The parameter "MU-Y" is the lateral force value normalized by the instantaneous vertical load. Finally, the aligning torque developed on the tire is listed. The aligning torque is perpendicular to the road plane and is positive clockwise looking down on the tire.

On axles with dual wheel assemblies, the values listed on this page are the total for the two tires.

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SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 1 REAR SUSPENSION - BRAKE SUMMARY
LEADING TANDEM AXLE

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	-0.02	0.0000	26.14	0.00	0.0	0.0	0.05	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.37	-.0000	26.14	-0.02	0.0	0.0	0.59	-.0000	26.14	-0.03
0.15	30.00	0.16	161.07	0.55	-.0000	26.13	-0.41	0.16	161.07	1.05	-.0000	26.13	-0.43
0.20	30.00	3.18	3175.51	-100.56	0.0024	26.05	-2.70	3.18	3175.51	-99.24	0.0024	26.05	-2.76
0.25	30.00	9.08	9083.05	-346.48	0.0082	25.84	-4.92	9.08	9083.05	-342.98	0.0083	25.83	-5.08
0.30	30.00	14.41	14413.03	-593.29	0.0141	25.55	-5.73	14.41	14413.03	-587.15	0.0145	25.53	-6.02
0.35	30.00	18.38	18384.68	-782.44	0.0188	25.26	-6.08	18.38	18384.68	-773.75	0.0196	25.22	-6.50
0.40	30.00	21.34	21344.23	-927.22	0.0218	24.97	-6.17	21.34	21344.23	-917.13	0.0232	24.91	-6.65
0.45	30.00	23.55	23549.72	-1029.54	0.0237	24.65	-6.49	23.55	23549.72	-1016.84	0.0258	24.57	-7.10
0.50	30.00	25.19	25193.21	-1101.09	0.0256	24.31	-6.96	25.19	25193.21	-1083.72	0.0286	24.19	-7.79
0.55	30.00	26.42	26417.89	-1159.80	0.0273	23.97	-7.05	26.42	26417.89	-1139.19	0.0316	23.81	-8.03
0.60	30.00	27.33	27330.53	-1209.75	0.0278	23.65	-6.82	27.33	27330.53	-1191.00	0.0334	23.44	-7.72
0.65	30.00	28.01	28010.60	-1241.82	0.0272	23.33	-6.90	28.01	28010.60	-1225.78	0.0337	23.08	-7.66
0.70	30.00	28.52	28517.44	-1260.77	0.0269	22.98	-7.19	28.52	28517.44	-1242.05	0.0343	22.70	-8.09
0.75	30.00	28.90	28895.07	-1279.46	0.0273	22.63	-7.19	28.90	28895.07	-1255.03	0.0360	22.30	-8.36
0.80	30.00	29.18	29176.49	-1299.89	0.0275	22.30	-6.88	29.18	29176.49	-1276.83	0.0378	21.92	-7.58
0.85	30.00	29.39	29386.20	-1314.03	0.0270	21.99	-6.70	29.39	29386.20	-1297.64	0.0384	21.57	-7.49
0.90	30.00	29.54	29542.49	-1317.49	0.0265	21.66	-6.91	29.54	29542.49	-1301.25	0.0385	21.21	-7.68
0.95	30.00	29.66	29658.98	-1316.62	0.0266	21.31	-7.22	29.66	29658.98	-1294.27	0.0397	20.83	-8.29
1.00	30.00	29.75	29745.74	-1319.25	0.0271	20.96	-7.30	29.75	29745.74	-1295.06	0.0418	20.43	-8.46
1.05	30.00	29.81	29810.44	-1324.58	0.0270	20.62	-7.20	29.81	29810.44	-1308.26	0.0429	20.06	-7.98
1.10	30.00	29.86	29858.63	-1325.75	0.0265	20.27	-7.26	29.86	29858.63	-1315.91	0.0425	19.70	-7.73
1.15	30.00	29.89	29894.53	-1323.47	0.0262	19.91	-7.45	29.89	29894.53	-1311.09	0.0423	19.32	-8.04
1.20	30.00	29.92	29921.27	-1322.58	0.0264	19.54	-7.56	29.92	29921.27	-1307.72	0.0430	18.94	-8.27
1.25	30.00	29.94	29941.28	-1326.50	0.0265	19.18	-7.42	29.94	29941.28	-1316.54	0.0435	18.57	-7.89
1.30	30.00	29.96	29956.13	-1330.17	0.0262	18.84	-7.28	29.96	29956.13	-1325.97	0.0426	18.22	-7.48
1.35	30.00	29.97	29967.18	-1329.53	0.0258	18.48	-7.34	29.97	29967.18	-1322.74	0.0415	17.87	-7.66
1.40	30.00	29.98	29975.43	-1327.55	0.0259	18.12	-7.45	29.98	29975.43	-1314.08	0.0418	17.50	-8.09
1.45	30.00	29.98	29981.56	-1328.98	0.0263	17.76	-7.40	29.98	29981.56	-1314.04	0.0429	17.12	-8.11
1.50	30.00	29.99	29986.14	-1332.17	0.0264	17.42	-7.26	29.99	29986.14	-1322.92	0.0434	16.77	-7.70
1.55	30.00	29.99	29989.56	-1334.54	0.0263	17.07	-7.15	29.99	29989.56	-1325.45	0.0430	16.41	-7.58
1.60	30.00	29.99	29992.09	-1338.79	0.0266	16.72	-6.95	29.99	29992.09	-1321.99	0.0436	16.05	-7.75
1.65	30.00	29.99	29994.00	-1343.35	0.0269	16.39	-6.74	29.99	29994.00	-1328.15	0.0450	15.70	-7.47
1.70	30.00	30.00	29995.39	-1340.36	0.0264	16.08	-6.89	30.00	29995.39	-1340.25	0.0442	15.39	-6.89
1.75	30.00	30.00	29996.44	-1327.95	0.0258	15.73	-7.48	30.00	29996.44	-1332.81	0.0417	15.07	-7.25
1.80	30.00	30.00	29997.22	-1316.68	0.0259	15.34	-8.02	30.00	29997.22	-1316.06	0.0407	14.70	-8.05
1.85	30.00	30.00	29997.83	-1315.71	0.0268	14.95	-8.07	30.00	29997.83	-1312.36	0.0413	14.32	-8.23
1.90	30.00	30.00	29998.21	-1323.44	0.0275	14.57	-7.70	30.00	29998.21	-1324.80	0.0414	13.96	-7.63
1.95	30.00	30.00	29998.52	-1334.70	0.0278	14.22	-7.16	30.00	29998.52	-1335.42	0.0403	13.62	-7.13
2.00	30.00	30.00	29998.82	-1343.43	0.0282	13.87	-6.75	30.00	29998.82	-1338.89	0.0398	13.29	-6.97

Figure 24. Example output of brake summary page.

UMTRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.13.2
SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 1 REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY
LEADING TANDEM AXLE

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	-0.0003	0.3084	0.0000	0.0	-0.0003	0.3084	0.0000	0.0
0.10	0.0026	-3.1785	-0.0005	0.0	0.0026	-3.1785	-0.0005	0.0
0.15	0.0088	-10.5868	-0.0016	0.0	0.0088	-10.5696	-0.0016	0.0
0.20	0.0107	-12.9823	-0.0019	0.0	0.0108	-12.8767	-0.0019	0.0
0.25	0.0041	-4.9689	-0.0007	0.0	0.0041	-4.8763	-0.0007	0.0
0.30	-0.0108	12.9372	0.0020	0.0	-0.0108	12.4866	0.0020	0.0
0.35	-0.0284	33.8232	0.0051	0.0	-0.0285	32.0566	0.0051	0.0
0.40	-0.0465	56.4507	0.0084	0.0	-0.0465	52.5209	0.0084	0.0
0.45	-0.0677	83.8965	0.0123	0.0	-0.0678	76.2824	0.0123	0.0
0.50	-0.0979	120.2147	0.0177	0.0	-0.0981	105.9837	0.0177	0.0
0.55	-0.1392	168.9959	0.0252	0.0	-0.1396	143.5894	0.0253	0.0
0.60	-0.1844	229.3791	0.0334	0.0	-0.1850	188.4391	0.0335	0.0
0.65	-0.2244	292.5996	0.0406	0.0	-0.2252	233.7829	0.0408	0.0
0.70	-0.2603	348.7300	0.0471	0.0	-0.2615	270.3503	0.0473	0.0
0.75	-0.3008	403.4631	0.0544	0.0	-0.3025	301.2483	0.0547	0.0
0.80	-0.3466	468.5833	0.0627	0.0	-0.3489	336.9087	0.0631	0.0
0.85	-0.3828	532.6018	0.0693	0.0	-0.3857	372.7869	0.0698	0.0
0.90	-0.4048	575.7576	0.0732	0.0	-0.4082	394.2056	0.0739	0.0
0.95	-0.4282	605.3816	0.0775	0.0	-0.4322	402.2170	0.0782	0.0
1.00	-0.4579	637.1326	0.0829	0.0	-0.4626	409.4915	0.0837	0.0
1.05	-0.4833	676.3469	0.0874	0.0	-0.4887	425.8035	0.0884	0.0
1.10	-0.4959	709.9392	0.0897	0.0	-0.5020	443.8787	0.0908	0.0
1.15	-0.5037	728.0190	0.0911	0.0	-0.5103	451.9971	0.0923	0.0
1.20	-0.5117	732.9055	0.0926	0.0	-0.5189	450.6538	0.0939	0.0
1.25	-0.5080	725.2090	0.0919	0.0	-0.5157	446.1892	0.0933	0.0
1.30	-0.4858	704.3784	0.0879	0.0	-0.4937	439.0913	0.0893	0.0
1.35	-0.4594	675.7886	0.0831	0.0	-0.4673	425.2373	0.0846	0.0
1.40	-0.4473	654.3335	0.0809	0.0	-0.4554	409.3418	0.0824	0.0
1.45	-0.4473	644.9644	0.0809	0.0	-0.4560	398.6040	0.0825	0.0
1.50	-0.4396	632.7168	0.0796	0.0	-0.4487	390.4443	0.0812	0.0
1.55	-0.4166	603.2661	0.0754	0.0	-0.4257	374.7031	0.0770	0.0
1.60	-0.4078	586.1335	0.0738	0.0	-0.4172	361.0388	0.0755	0.0
1.65	-0.4254	606.8735	0.0770	0.0	-0.4358	367.6260	0.0789	0.0
1.70	-0.4173	604.6660	0.0755	0.0	-0.4280	371.1038	0.0775	0.0
1.75	-0.3583	527.3655	0.0648	0.0	-0.3678	335.6733	0.0666	0.0
1.80	-0.2887	418.8057	0.0522	0.0	-0.2966	274.1189	0.0537	0.0
1.85	-0.2384	334.2051	0.0431	0.0	-0.2451	222.5332	0.0443	0.0
1.90	-0.1943	267.2537	0.0352	0.0	-0.1999	182.9387	0.0362	0.0
1.95	-0.1402	192.3530	0.0254	0.0	-0.1444	136.8138	0.0261	0.0
2.00	-0.1038	141.1049	0.0188	0.0	-0.1070	102.7450	0.0194	0.0

Figure 25. Example of tire lateral force and moment summary page.

4.4.7 <u>Unsprung Mass Summary Page</u>. Variable pages 16-19, Unsprung Mass Summary, provide detailed information as to what is happening to each of the axles and suspensions on the simulated vehicle. On the left side of the page, shown in Figure 26, are given axle motion parameters; specifically, the position and velocity for the axle's two degrees of freedom (vertical and roll.) The axle vertical and roll positions are measured relative to the inertial coordinate system. Positive vertical is down and is the elevation relative to its starting position. Roll is positive in the clockwise direction facing forward on the vehicle. Roll angle is always measured relative to the horizontal X-Y plane in the inertial coordinate system.

Suspension motions and forces are given on a side-to-side basis (at the suspension spring locations.) The auxiliary roll torque arising from the auxiliary roll stiffness is listed first since it is associated with both sides of the suspension. A positive torque corresponds to a positive roll moment exerted <u>on</u> the vehicle sprung mass.

Thence the relative suspension deflection, velocity and force is listed for each side of the suspension. The deflection is indicated in terms of its change from the static loaded deflection, with positive values equivalent to extension of the suspension. The suspension force is actually the change in force from its static value. Positive force is a downward force on the sprung mass. The suspension force is the total of contributions from the springs, coulomb and viscous friction and braking load transfer effects.

4.4.8 <u>Brake Model Temperature Page</u>. Variable pages 20-23 contain brake temperature calculations performed when using the Brake Model option (see Figure 27.) Only those temperature pages (axles) for which the Brake Model option has been requested will be printed. The interface temperature appearing in Column 2 is the calculated temperature at the drum-lining interface. The drum temperature, Column 3, is for the midway thickness point in the drum, and the lining temperature, Column 4, corresponds to the 1/3 lining thickness point inward from the interface. The brake torque is simply repeated here for convenience from the Brake Summary page.

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.17.2

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 REAR SUSPENSION - UNSPRUNG MASS SUMMARY

LEADING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0	0.00	0.0000	0.0	0.00
0.05	0.0000	-0.0000	0.0000	-0.0017	-1.9	0.0000	-0.0011	0.03	-0.0000	-0.0012	-0.25
0.10	0.0000	-0.0000	0.0011	0.0023	43.3	-0.0005	-0.0391	-14.76	-0.0000	0.0132	-7.31
0.15	0.0002	-0.0009	0.0032	-0.0463	308.9	-0.0047	-0.1914	-94.12	-0.0008	-0.0445	-53.45
0.20	0.0002	-0.0046	-0.0314	-0.1059	839.6	-0.0170	-0.6991	-780.09	-0.0060	-0.4514	-677.86
0.25	0.0001	-0.0108	-0.0541	-0.1811	1621.3	-0.0188	-0.4269	-909.75	0.0033	-0.1264	-735.24
0.30	-0.0009	-0.0203	-0.0863	-0.1762	2471.2	-0.0045	-0.2035	-848.28	0.0291	0.1471	-584.34
0.35	-0.0020	-0.0304	-0.0587	-0.2212	3422.2	0.0059	-0.6571	-806.49	0.0522	-0.2830	-442.87
0.40	-0.0014	-0.0415	-0.0303	-0.2471	4541.3	-0.0050	-1.1598	-920.68	0.0562	-0.7005	-439.52
0.45	-0.0007	-0.0554	-0.0578	-0.2968	5880.6	-0.0167	-0.8349	-1027.68	0.0623	-0.2805	-406.81
0.50	-0.0020	-0.0718	-0.0940	-0.3581	7441.0	-0.0086	-0.3315	-974.19	0.0913	0.2741	-190.84
0.55	-0.0038	-0.0902	-0.0726	-0.3828	9076.7	0.0018	-0.6909	-903.78	0.1233	-0.0765	49.15
0.60	-0.0035	-0.1100	-0.0212	-0.4033	10703.5	-0.0139	-1.5540	-1037.10	0.1290	-0.9391	82.86
0.65	-0.0014	-0.1303	-0.0150	-0.4055	12380.2	-0.0485	-1.7444	-1312.32	0.1163	-1.0983	-21.52
0.70	-0.0005	-0.1500	-0.0564	-0.3843	14141.8	-0.0702	-1.1399	-1480.88	0.1174	-0.4675	-11.45
0.75	-0.0014	-0.1694	-0.0764	-0.3972	15951.2	-0.0720	-0.8001	-1494.77	0.1390	-0.1181	157.66
0.80	-0.0020	-0.1895	-0.0480	-0.4077	17711.8	-0.0780	-1.1819	-1543.95	0.1558	-0.5550	285.98
0.85	-0.0010	-0.2087	-0.0260	-0.3507	19315.5	-0.0999	-1.5034	-1717.43	0.1544	-0.9137	272.75
0.90	-0.0001	-0.2246	-0.0530	-0.2918	20871.8	-0.1182	-1.0653	-1857.88	0.1559	-0.4929	286.51
0.95	-0.0012	-0.2378	-0.0892	-0.2434	22319.5	-0.1139	-0.4260	-1820.79	0.1786	0.0774	466.75
1.00	-0.0029	-0.2493	-0.0784	-0.2242	23530.3	-0.1008	-0.5091	-1718.54	0.2070	-0.1044	688.28
1.05	-0.0032	-0.2602	-0.0388	-0.2127	24506.6	-0.1043	-1.1065	-1748.20	0.2156	-0.7722	752.24
1.10	-0.0021	-0.2697	-0.0306	-0.1656	25339.1	-0.1220	-1.2589	-1887.15	0.2076	-0.9707	688.73
1.15	-0.0016	-0.2760	-0.0588	-0.0894	26000.4	-0.1305	-0.8021	-1950.33	0.2062	-0.6093	680.89
1.20	-0.0023	-0.2784	-0.0701	-0.0101	26345.3	-0.1239	-0.5635	-1897.33	0.2159	-0.4918	757.16
1.25	-0.0026	-0.2777	-0.0434	0.0213	26484.2	-0.1225	-0.9710	-1887.58	0.2177	-0.9154	769.55
1.30	-0.0015	-0.2768	-0.0231	0.0071	26765.5	-0.1378	-1.3590	-2008.45	0.2044	-1.1942	664.23
1.35	-0.0004	-0.2770	-0.0440	-0.0201	27349.4	-0.1534	-1.0803	-2128.91	0.1944	-0.8256	588.73
1.40	-0.0008	-0.2785	-0.0751	-0.0396	28012.3	-0.1516	-0.5432	-2111.71	0.2033	-0.3205	661.02
1.45	-0.0019	-0.2802	-0.0713	-0.0305	28499.1	-0.1406	-0.5184	-2024.86	0.2196	-0.3735	788.23
1.50	-0.0022	-0.2809	-0.0450	-0.0008	28860.1	-0.1396	-0.9077	-2019.28	0.2240	-0.7689	820.92
1.55	-0.0017	-0.2803	-0.0510	0.0041	29355.2	-0.1456	-0.8499	-2065.25	0.2228	-0.6057	812.46
1.60	-0.0023	-0.2822	-0.0743	-0.0937	30087.8	-0.1421	-0.5080	-2035.40	0.2341	-0.2476	902.86
1.65	-0.0032	-0.2876	-0.0565	-0.0896	30549.0	-0.1363	-0.7926	-1991.23	0.2444	-0.7212	981.50
1.70	-0.0021	-0.2876	-0.0148	0.1057	30558.2	-0.1489	-1.3665	-2092.75	0.2298	-1.4001	864.11
1.75	-0.0003	-0.2770	-0.0297	0.2860	30464.0	-0.1675	-1.1312	-2236.84	0.2069	-1.1838	686.54
1.80	-0.0004	-0.2610	-0.0782	0.3333	30180.1	-0.1622	-0.3056	-2190.82	0.2060	-0.4917	682.47
1.85	-0.0021	-0.2449	-0.0834	0.3122	29406.9	-0.1373	-0.0731	-1995.04	0.2194	-0.4598	787.68
1.90	-0.0027	-0.2284	-0.0449	0.3462	28256.1	-0.1226	-0.5835	-1882.76	0.2176	-1.0297	771.10
1.95	-0.0019	-0.2106	-0.0424	0.3329	27246.2	-0.1214	-0.7704	-1874.33	0.2029	-1.0717	655.67
2.00	-0.0019	-0.1976	-0.0609	0.1721	26577.4	-0.1161	-0.5821	-1832.25	0.1964	-0.8108	606.27

Figure 26. Example of unsprung mass summary page.

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

BRAKE MODEL TEMPERATURES --- AXLE 2

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	INTERFACE TEMP (DEG-F)	DRUM TEMP (DEG-F)	LINING TEMP (DEG-F)	BRAKE TORQUE (IN-LB)	INTERFACE TEMP (DEG-F)	DRUM TEMP (DEG-F)	LINING TEMP (DEG-F)	BRAKE TORQUE (IN-LB)
0.0	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.05	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.10	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.15	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.20	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.25	74.26	70.00	70.00	15282.68	74.81	70.00	70.00	15267.26
0.30	84.91	70.00	70.01	34545.36	85.47	70.00	70.01	34509.41
0.35	96.42	70.00	70.01	48065.84	96.84	70.01	70.02	48027.03
0.40	107.55	70.05	70.03	57446.95	107.78	70.06	70.03	57421.52
0.45	122.74	70.34	70.06	63269.95	122.60	70.35	70.06	63288.19
0.50	131.70	70.74	70.08	67638.31	131.27	70.76	70.08	67697.63
0.55	139.73	71.34	70.10	70564.13	138.97	71.37	70.10	70675.69
0.60	146.96	72.15	70.13	72468.38	145.82	72.18	70.13	72642.75
0.65	156.58	73.70	70.18	73165.06	154.84	73.73	70.18	73439.44
0.70	162.24	74.95	70.22	73869.94	160.10	74.96	70.21	74214.19
0.75	167.32	76.33	70.25	74228.38	164.77	76.33	70.25	74646.75
0.80	171.93	77.83	70.29	74345.69	168.91	77.80	70.29	74845.81
0.85	176.15	79.43	70.33	74291.75	172.64	79.36	70.33	74877.00
0.90	181.83	81.96	70.39	73821.00	177.64	81.83	70.39	74525.13
0.95	185.20	83.72	70.44	73609.69	180.56	83.53	70.43	74392.44
1.00	188.24	85.51	70.48	73359.69	183.12	85.26	70.47	74226.94
1.05	191.03	87.33	70.53	73085.19	185.39	87.00	70.52	74041.69
1.10	194.83	90.07	70.60	72591.19	188.49	89.63	70.58	73669.25
1.15	197.10	91.91	70.65	72316.38	190.35	91.38	70.63	73465.50
1.20	199.16	93.74	70.70	72050.25	192.01	93.11	70.67	73268.25
1.25	201.04	95.56	70.75	71794.88	193.49	94.82	70.72	73081.75
1.30	202.78	97.36	70.80	71547.94	194.87	96.51	70.77	72898.44
1.35	205.16	100.02	70.87	71186.81	196.77	98.99	70.84	72616.69
1.40	206.56	101.76	70.92	70978.94	197.88	100.61	70.89	72458.63
1.45	207.82	103.47	70.98	70788.75	198.83	102.20	70.94	72323.25
1.50	208.98	105.15	71.03	70613.00	199.64	103.75	70.99	72205.50
1.55	210.54	107.62	71.11	70368.94	200.74	106.02	71.06	72040.06
1.60	211.45	109.23	71.16	70228.88	201.34	107.49	71.11	71952.06
1.65	212.28	110.80	71.22	70100.88	201.83	108.92	71.16	71882.50
1.70	213.06	112.33	71.27	69980.44	202.27	110.32	71.21	71819.56
1.75	213.77	113.83	71.33	69870.75	202.73	111.68	71.26	71752.56
1.80	214.60	116.02	71.41	69744.19	203.31	113.66	71.34	71668.13
1.85	215.00	117.44	71.46	69688.06	203.54	114.93	71.39	71630.56
1.90	215.30	118.82	71.52	69646.38	203.69	116.17	71.44	71623.94
1.95	215.55	120.17	71.57	69614.06	203.81	117.38	71.49	71612.56
2.00	215.83	122.14	71.65	69580.38	203.95	119.12	71.56	71602.88

Figure 27. Example of brake model temperature page.

5.0 PROGRAM DIAGNOSTICS

Errors in operation of PHASE 4 occur basically in two categories--Input Errors and Simulation Run Errors. Only a few error messages are contained within the program so that the user needs to be aware of some of the pitfalls that may be experienced in order to identify the proper corrective action. In the normal batch running mode, the user will find the error only by the fact that the program fails to run properly and a correction and resubmission is required.

5.1 Input Errors

The most critical operation and most likely source of errors in using the program occurs in the process of reading input data describing the vehicle and maneuver desired. Since the data type is only identified by its location in a sequence of input lines, one data line missing, out of place, or with incorrect format can confound the entire data reading process. For this reason, the users should consult Section 3 of this Manual and the numerous examples of input provided when preparing an input list. The severity of any error depends on its meaning to the program when read, and the type of computer system on which the simulation is operating. The most common error is a simple format error. Systems that allow a free read format can significantly reduce this type of problem.

Three error messages are incorporated in the input subroutine of the program. Tables in the table lookup option are identified by the whole number value following the negative sign keying the table lookup. Unique numbers must be used for each table, unless the table is to be used at multiple points on the vehicle. If the number identifying a table for one type of parameter (e.g., suspension spring rate) is inadvertently assigned for a second type of parameter (e. g., brake torque,) an error message to this effect is printed and execution terminates.

The second error message relates to the value for the DRIVER TRANSPORT LAG parameter, included in the path-follower model. If the value assigned is greated than one second, the simulated vehicle is certain to be unstable and unable to run. Hence, an error message is printed indicating that the value is too large and program execution is terminated.

The third error message is printed when using the spring envelope option and an insufficient range of spring data is provided in the table. An error message is printed and execution terminated.

Recognizing that errors will occur, several scenarios of possible consequences are given below.

1) Non-Fatal Errors - In simple cases where a parametric value is misread (due to a forgivable format error) or values are interchanged (due to lines being out of order), the program may not recognize that an error has occurred. In that case, the program may successfully complete the read process and execute the simulation even though with an erroneous vehicle description. To discover such errors, the user should continually review the input echo pages and vehicle summary page to ensure that the proper vehicle conditions have been obtained.

2) Fatal Errors - The more common case is an error that is incompatible with the input reading process resulting in a system interrupt and termination of the program execution. Since the input echo is printed after every few lines of reading, the major portion of the input successfully read is reflected in the output obtained. For diagnosis of the problem, the user should review the echoed portion of the input, then the lines immediately following the termination point as the likely locations of the error.

5.2 Simulation Run Errors

Once the calculation process constituting the vehicle simulation has begun, only two types of errors will occur that will halt the execution. Normal job termination occurs by either the vehicle reaching a full stop, or simulation to the MAXIMUM SIMULATION TIME limit specified in the input. The first run error message occurs if longitudinal slip exceeds 20 percent or tire sideslip angles exceed 11.5 degrees (0.2 radians) when using the respective longitudinal or lateral linear tire model options. In either case, a message is printed and program execution terminated.

Otherwise, the simulation may terminate with the message "IHLF=11." The message derives from the inability of the integration process (the IBM Scientific Subroutine Package HPCG) to converge on a solution at a particular point in time. Integration is normally carried out at 0.0025-second time steps with the option of halving the time step when necessary to meet an error criteria. The integration algorithm is allowed to halve the time step eleven times in an effort to achieve a satisfactory integration, and if unsuccessful, the execution is terminated with the above error message. As a general rule to prevent this error, the user should ensure that all dynamic systems being simulated have a natural frequencey of less than 20 H_Z. In particular, this error most commonly occurs when inertia values are inordinately low or stiffness values (especially spring and tire rates) are too high. In general, a simple check for this is to ensure that the smallest mass connected to any spring has a mass (in pounds) to spring rate (pounds/inch) ratio greater than 0.025 inches.

Finally, the simulation is only expected to be valid in maneuvers up to the severity point where a wheel lifts off the ground. The above error will often occur after a prolonged period of wheel lift-off or when the vehicle has reached a divergent rollover condition. The accuracy of the calculations up to this point is limited by the small angle assumptions used in the programming. However, it should be found that the wheel lift-off condition occurs at body roll angles of 8-10 degrees with most heavy vehicles simulated, whereas the small angle assumptions should not create significant error until angles approach 20 degrees.

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APPENDIX A

SAMPLE RUN OF A TRUCK

The following pages are copies of the complete computer output package obtained from a four-second simulation of a straight truck in a step-steer maneuver. The first four pages are an echo of the input with a summary of composite vehicle characteristics. These pages are normally reviewed to ensure that the desired vehicle and maneuver is being simulated. The remaining 12 pages are all the output pages (excluding the Brake Data Summary Page, since no braking is applied) indicating the vehicle's response in the maneuver.

The maneuver is a right-hand step-steer of 8 degrees at the front wheels, applied at 0.1 seconds into the run. The vehicle responds by turning to the right with some initial transients that effectively settle out after a few seconds into the run. The vehicle is stable and assumes a steady-state turn at about 0.25 g's (8 ft/sec^2) lateral acceleration.

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

SIMULATION OPERATION PARAMETERS:

```
VEHICLE CONFIGURATION (NUMBER OF TRAILERS - ENTER 0 FOR A STRAIGHT TRUCK)        0
INITIAL VELOCITY (FT/SEC)                                                     30.00
STEER TABLE (NUMBER OF LINES):  POSITIVE -STEER ANGLE TABLE, NEGATIVE - PATH FOLLOWER TABLE   3
     TABLE ENTRIES:
                     TIME (SEC)   LEFT WHEEL (DEG)   RIGHT WHEEL (DEG)
                     ----------   ----------------   -----------------
                        0.0            0.0                0.0
                        0.10           8.00               8.00
                        5.00           8.00               8.00

TREADLE PRESSURE TABLE (NUMBER OF LINES)                                          0
     * ZERO ENTRY INDICATES NO FURTHER TABLE DATA IS NECESSARY - THE FOLLOWING TABLE IS ASSIGNED INTERNALLY *
     TABLE ENTRIES:
                     TIME (SEC)   PRESSURE (PSI)
                     ----------   --------------
                        0.0            0.0

MAXIMUM SIMULATION TIME (SEC)                                                  4.00
TIME INCREMENT OF OUTPUT (SEC)                                                 0.10

ROAD KEY =  0 : FLAT ROAD.

OUTPUT PAGE OPTION KEYS:  0 DELETES PAGES
-----------------------------------------
```

SPRUNG MASS POSITION	SPRUNG MASS VELOCITY	SPRUNG MASS ACCELERATION	TIRE FORCES PAGES	BRAKE SUMMARY PAGES	LATERAL PAGES	UNSPRUNG MASS PAGES	TEMP PAGES
1	1	1	1	0	1	1	0

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

```
TRUCK   PARAMETERS
------------------
     WHEELBASE - DISTANCE FROM FRONT AXLE TO CENTER  OF REAR SUSPENSION (IN)                     142.00
     BASE VEHICLE CURB WEIGHT ON FRONT SUSPENSION (LB)                                           9073.80
     BASE VEHICLE CURB WEIGHT ON REAR SUSPENSION (LB)                                           10519.20
     SPRUNG MASS CG HEIGHT (IN. ABOVE GROUND)                                                      47.90
     SPRUNG MASS ROLL MOMENT OF INERTIA (IN-LB-SEC**2)                                          33852.00
     SPRUNG MASS PITCH MOMENT OF INERTIA (IN-LB-SEC**2)                                        120000.00
     SPRUNG MASS YAW MOMENT OF INERTIA (IN-LB-SEC**2)                                          120000.00
     PAYLOAD WEIGHT (LB)                                                                        24907.00
          PAYLOAD DISTANCE AHEAD OF REAR SUSPENSION CENTER(IN)                                      6.00
          PAYLOAD CG HEIGHT (IN. ABOVE GROUND)                                                     70.25
          PAYLOAD ROLL MOMENT OF INERTIA(IN-LB-SEC**2)                                           7485.00
          PAYLOAD PITCH MOMENT OF INERTIA(IN-LB-SEC**2)                                         50896.00
          PAYLOAD YAW MOMENT OF INERTIA(IN-LB-SEC**2)                                           54422.00

TRUCK   FRONT SUSPENSION AND AXLE PARAMETERS                                  LEFT SIDE            RIGHT SIDE
---------------------------------------------                                 ---------            ----------
     SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)                                  1012.50              1012.50
     SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)                            15.00                15.00
     COULOMB FRICTION (LB/SIDE/AXLE)                                            200.00               200.00
                                                                              -----------------------------------
     AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)                                           5307.00
     ROLL CENTER HEIGHT (IN. ABOVE GROUND)                                                  24.55
     ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)                                           0.0
     AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)                                            4000.00
     LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)                                       32.00
     TRACK WIDTH (IN)                                                                       80.50
     UNSPRUNG WEIGHT (LB)                                                                 1190.00
     STEERING GEAR RATIO (DEG STEERING WHEEL/DEG ROAD WHEEL)                                 0.0
      *** NEGATIVE OR ZERO ENTRY INDICATES NO STEERING SYSTEM ***
      *** STEERING SYSTEM PARAMETERS NOT TO BE ENTERED ***

TRUCK   FRONT TIRES AND WHEELS                                                LEFT SIDE            RIGHT SIDE
------------------------------                                                ---------            ----------
     CORNERING STIFFNESS  (LB/DEG/TIRE)                                          600.00               600.00
     LONGITUDINAL STIFFNESS  (LB/SLIP/TIRE)                                    20000.00             20000.00
     CAMBER STIFFNESS (LB/DEG/TIRE)                                                0.0                  0.0
     ALIGNING MOMENT  (IN-LB/DEG/TIRE)                                          1080.00              1080.00
     TIRE SPRING RATE (LB/IN/TIRE)                                              5700.00              5700.00
     TIRE LOADED RADIUS (IN)                                                      20.30                20.30
     POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)                                244.60               244.60
```

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TRUCK REAR SUSPENSION AND AXLE PARAMETERS

	LEADING TANDEM AXLE LEFT SIDE	LEADING TANDEM AXLE RIGHT SIDE		TRAILING TANDEM AXLE LEFT SIDE	TRAILING TANDEM AXLE RIGHT SIDE
SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM			1		
TANDEM AXLE SEPARATION (IN BETWEEN LEADING AND TRAILING AXLES)			48.00		
STATIC LOAD TRANSFER (PERCENT LOAD ON LEAD AXLE)			50.00		
DYNAMIC LOAD TRANSFER (% BRAKE TORQUE REACTED AS TANDEM AXLE LOAD TRANSFER)			0.0		
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	4000.00	4000.00		4000.00	4000.00
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	15.00	15.00		15.00	15.00
COULOMB FRICTION (LB/SIDE/AXLE)	400.00	400.00		400.00	400.00

	LEADING TANDEM AXLE	TRAILING TANDEM AXLE
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	11088.00	11088.00
ROLL CENTER HEIGHT (IN. ABOVE GROUND)	22.00	22.00
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	0.10	0.10
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	0.0	78000.00
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	35.00	35.00
TRACK WIDTH (IN)	72.00	72.00
UNSPRUNG WEIGHT (LB)	2340.00	2170.00

TRUCK REAR TIRES AND WHEELS

	LEADING TANDEM AXLE LEFT SIDE	LEADING TANDEM AXLE RIGHT SIDE	TRAILING TANDEM AXLE LEFT SIDE	TRAILING TANDEM AXLE RIGHT SIDE
DUAL TIRE SEPARATION (IN)	13.00	13.00	13.00	13.00
CORNERING STIFFNESS (LB/DEG/TIRE)	500.00	500.00	500.00	500.00
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	20000.00	20000.00	20000.00	20000.00
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	1080.00	1080.00	1080.00	1080.00
TIRE SPRING RATE (LB/IN/TIRE)	5700.00	5700.00	5700.00	5700.00
TIRE LOADED RADIUS (IN)	20.30	20.30	20.30	20.30
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	196.60	196.60	196.60	196.60

*** ZERO LINES IN TREADLE PRESSURE TABLE INDICATES NO BRAKING ***
*** THREE BRAKE PARAMETERS PER AXLE ARE DELETED AT THIS POINT ***

ANTILOCK KEY: 1 INDICATES ANTILOCK WILL BE USED -1

```
HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.      SUMMARY PAGE
                          STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

 TRUCK            PAYLOAD =  24907.000 LBS
DISTANCE FROM TRUCK   SPRUNG MASS CENTER TO REAR SUSPENSION (IN)              EMPTY        LOADED
DISTANCE FROM TRUCK   SPRUNG MASS CENTER TO GROUND (IN)                        80.580        32.705
ROLL MOMENT OF INERTIA OF TRUCK   SPRUNG MASS (IN-LB-SEC**2)                   47.900        62.247
PITCH MOMENT OF INERTIA OF TRUCK   SPRUNG MASS (IN-LB-SEC**2)               33852.000     52878.234
YAW MOMENT OF INERTIA OF TRUCK   SPRUNG MASS (IN-LB-SEC**2)                120000.000    310949.438
                                                                           120000.000    302934.375

THE STATIC LOADS ON THE AXLES ARE:
AXLE NUMBER      LOAD
NS(1,1,1)     10126.215
NS(1,2,1)     17186.891
NS(1,2,2)     17186.891
              ---------------
 TOTAL        44499.996

THE TRUCK   TOTAL MASS CENTER IS       109.687 INCHES BEHIND THE FRONT AXLE
THE TOTAL YAW MOMENT OF INERTIA IS   385770.188 IN-LB-SEC**2
```

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TRUCK SPRUNG MASS POSITION

TIME (SEC)	FORWARD (FT)	LATERAL (FT)	VERTICAL (FT)	ROLL (DEG)	PITCH (DEG)	HEADING (DEG)	TURN RADIUS (FT)	SIDE SLIP (DEG)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	************	0.0
0.10	3.0742	0.0072	0.0000	-0.3374	-0.0045	0.2387	282.7366	0.1317
0.20	6.0690	0.0389	0.0001	-1.3392	-0.0317	1.2874	255.3099	-0.3671
0.30	9.0589	0.1063	0.0009	-2.4044	-0.0515	2.8038	157.7401	-0.9884
0.40	12.0424	0.2308	0.0019	-3.3619	-0.0453	4.5173	116.7563	-1.3945
0.50	15.0161	0.4321	0.0020	-4.0785	-0.0257	6.3130	97.0609	-1.5352
0.60	17.9756	0.7251	0.0007	-4.4742	-0.0191	8.1384	87.9780	-1.4641
0.70	20.9166	1.1187	-0.0004	-4.5688	-0.0332	9.9737	84.8268	-1.2781
0.80	23.8354	1.6157	-0.0003	-4.4626	-0.0389	11.8171	85.2854	-1.0794
0.90	26.7291	2.2144	0.0008	-4.2659	-0.0287	13.6591	87.5879	-0.9208
1.00	29.5947	2.9108	0.0015	-4.0660	-0.0207	15.4905	90.7303	-0.8190
1.10	32.4300	3.7004	0.0009	-3.9063	-0.0243	17.3121	93.7701	-0.7770
1.20	35.2331	4.5789	-0.0003	-3.8010	-0.0317	19.1287	95.8619	-0.7846
1.30	38.0025	5.5431	-0.0003	-3.7538	-0.0322	20.9429	96.6074	-0.8200
1.40	40.7363	6.5908	0.0008	-3.7595	-0.0263	22.7540	96.2743	-0.8586
1.50	43.4316	7.7210	0.0016	-3.7972	-0.0236	24.5603	95.4658	-0.8834
1.60	46.0858	8.9325	0.0011	-3.8366	-0.0290	26.3628	94.6760	-0.8914
1.70	48.6959	10.2246	0.0001	-3.8562	-0.0361	28.1638	94.0475	-0.8873
1.80	51.2595	11.5961	-0.0000	-3.8554	-0.0360	29.9641	93.5630	-0.8755
1.90	53.7739	13.0457	0.0009	-3.8455	-0.0295	31.7616	93.2829	-0.8570
2.00	56.2367	14.5716	0.0015	-3.8325	-0.0255	33.5537	93.3110	-0.8339
2.10	58.6459	16.1719	0.0010	-3.8129	-0.0290	35.3410	93.6019	-0.8119
2.20	60.9995	17.8443	0.0001	-3.7848	-0.0344	37.1257	93.9384	-0.7968
2.30	63.2955	19.5867	-0.0000	-3.7556	-0.0340	38.9086	94.1195	-0.7887
2.40	65.5322	21.3969	0.0008	-3.7359	-0.0283	40.6883	94.1443	-0.7825
2.50	67.7079	23.2727	0.0014	-3.7270	-0.0251	42.4630	94.1562	-0.7745
2.60	69.8207	25.2119	0.0010	-3.7200	-0.0284	44.2334	94.2233	-0.7655
2.70	71.8688	27.2124	0.0002	-3.7076	-0.0335	46.0014	94.2678	-0.7583
2.80	73.8506	29.2717	0.0001	-3.6920	-0.0334	47.7677	94.2024	-0.7526
2.90	75.7643	31.3873	0.0008	-3.6803	-0.0285	49.5311	94.0741	-0.7454
3.00	77.6087	33.5569	0.0013	-3.6734	-0.0256	51.2900	94.0223	-0.7346
3.10	79.3824	35.7785	0.0009	-3.6648	-0.0284	53.0448	94.0926	-0.7226
3.20	81.0839	38.0499	0.0002	-3.6499	-0.0327	54.7971	94.1913	-0.7127
3.30	82.7122	40.3688	0.0001	-3.6318	-0.0326	56.5477	94.2049	-0.7054
3.40	84.2660	42.7328	0.0007	-3.6177	-0.0283	58.2948	94.1537	-0.6978
3.50	85.7445	45.1395	0.0012	-3.6090	-0.0257	60.0373	94.1481	-0.6881
3.60	87.1463	47.5863	0.0009	-3.6001	-0.0281	61.7759	94.2246	-0.6778
3.70	88.4707	50.0707	0.0003	-3.5866	-0.0320	63.5121	94.3036	-0.6694
3.80	89.7170	52.5904	0.0002	-3.5708	-0.0319	65.2466	94.2985	-0.6630
3.90	90.8841	55.1429	0.0007	-3.5585	-0.0281	66.9783	94.2322	-0.6561
4.00	91.9716	57.7254	0.0011	-3.5505	-0.0258	68.7061	94.2107	-0.6470

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TRUCK SPRUNG MASS VELOCITY (BODY AXES)

TIME (SEC)	FORWARD (FT/SEC)	LATERAL (FT/SEC)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	PITCH (DEG/SEC)	HEADING (DEG/SEC)
0.0	30.00	0.0	0.0	0.0	0.0	0.0
0.10	29.98	0.07	0.00	-8.02	-0.19	6.48
0.20	29.93	-0.19	-0.01	-10.76	-0.59	13.47
0.30	29.88	-0.52	-0.03	-10.34	-0.74	16.39
0.40	29.83	-0.73	-0.06	-8.56	-0.85	17.62
0.50	29.77	-0.80	-0.08	-5.61	-1.09	18.09
0.60	29.70	-0.76	-0.08	-2.31	-1.47	18.20
0.70	29.64	-0.66	-0.07	0.26	-1.59	18.28
0.80	29.58	-0.56	-0.05	1.71	-1.36	18.35
0.90	29.52	-0.47	-0.04	2.10	-1.22	18.29
1.00	29.47	-0.42	-0.04	1.84	-1.25	18.17
1.10	29.42	-0.40	-0.05	1.34	-1.29	18.10
1.20	29.37	-0.40	-0.05	0.77	-1.23	18.08
1.30	29.32	-0.42	-0.03	0.20	-1.13	18.06
1.40	29.27	-0.44	-0.03	-0.26	-1.10	18.02
1.50	29.22	-0.45	-0.04	-0.43	-1.19	17.97
1.60	29.17	-0.45	-0.05	-0.31	-1.26	17.93
1.70	29.12	-0.45	-0.05	-0.07	-1.23	17.93
1.80	29.06	-0.44	-0.04	0.08	-1.14	17.92
1.90	29.01	-0.43	-0.03	0.12	-1.11	17.88
2.00	28.96	-0.42	-0.04	0.16	-1.17	17.82
2.10	28.91	-0.41	-0.05	0.25	-1.22	17.78
2.20	28.86	-0.40	-0.05	0.32	-1.19	17.76
2.30	28.82	-0.40	-0.04	0.27	-1.10	17.75
2.40	28.77	-0.39	-0.03	0.14	-1.08	17.71
2.50	28.72	-0.39	-0.03	0.07	-1.13	17.65
2.60	28.67	-0.38	-0.04	0.10	-1.18	17.62
2.70	28.62	-0.38	-0.04	0.16	-1.15	17.60
2.80	28.57	-0.38	-0.03	0.16	-1.08	17.59
2.90	28.53	-0.37	-0.03	0.09	-1.06	17.55
3.00	28.48	-0.37	-0.03	0.07	-1.10	17.50
3.10	28.43	-0.36	-0.04	0.12	-1.15	17.46
3.20	28.38	-0.35	-0.04	0.19	-1.12	17.45
3.30	28.34	-0.35	-0.03	0.18	-1.06	17.43
3.40	28.29	-0.34	-0.03	0.12	-1.03	17.40
3.50	28.25	-0.34	-0.03	0.08	-1.07	17.35
3.60	28.20	-0.33	-0.04	0.12	-1.11	17.32
3.70	28.16	-0.33	-0.04	0.16	-1.09	17.30
3.80	28.11	-0.33	-0.03	0.16	-1.03	17.28
3.90	28.07	-0.32	-0.03	0.11	-1.01	17.25
4.00	28.03	-0.32	-0.03	0.08	-1.05	17.21

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TIME	TRUCK SPRUNG MASS ACCELERATION (BODY AXES)						INERTIAL ACCEL. ALONG BODY AXES	
(SEC)	FORWARD (FT/SEC**2)	LATERAL (FT/SEC**2)	VERTICAL (FT/SEC**2)	ROLL (DEG/SEC**2)	PITCH (DEG/SEC**2)	HEADING (DEG/SEC**2)	LONGITUDINAL (FT/SEC**2)	LATERAL (FT/SEC**2)
0.0	0.0000	0.0000	0.0	-0.0000	-0.0000	-0.0000	0.0000	0.0000
0.10	-0.5887	-0.3366	-1.6305	-91.4049	-17.1485	104.8232	-0.5965	3.0562
0.20	-0.4179	-3.4516	-1.7648	-2.3332	-14.0795	43.5518	-0.3727	3.5840
0.30	-0.4896	-2.7289	-1.7794	10.8835	-12.3322	18.1002	-0.3417	5.8150
0.40	-0.5791	-1.3285	-1.7835	25.0950	-13.1725	7.0856	-0.3550	7.8354
0.50	-0.6283	-0.0042	-1.7082	33.6698	-14.9739	1.9293	-0.3751	9.3854
0.60	-0.6329	0.8718	-1.5503	32.1798	-14.7667	-0.1557	-0.3898	10.3042
0.70	-0.6131	1.1760	-1.4383	21.6115	-10.2916	0.4696	-0.4001	10.6312
0.80	-0.5712	1.0487	-1.3452	10.4413	-9.1257	-0.5310	-0.3915	10.5215
0.90	-0.5305	0.7747	-1.4786	1.4385	-11.0772	-1.6206	-0.3783	10.1986
1.00	-0.5043	0.4578	-1.6755	-2.7761	-12.1442	-1.5525	-0.3698	9.8064
1.10	-0.4912	0.1606	-1.6528	-4.0198	-11.4386	-0.9438	-0.3641	9.4548
1.20	-0.4874	-0.0481	-1.4781	-4.4623	-10.4308	-0.5880	-0.3595	9.2178
1.30	-0.4895	-0.1253	-1.4298	-4.0716	-10.6628	-0.7290	-0.3565	9.1166
1.40	-0.4943	-0.0863	-1.5875	-1.9617	-11.8923	-1.0060	-0.3558	9.1189
1.50	-0.4994	0.0043	-1.7357	1.2834	-12.5144	-0.9645	-0.3573	9.1657
1.60	-0.5028	0.0820	-1.6740	3.5607	-11.7553	-0.6388	-0.3596	9.2110
1.70	-0.5029	0.1288	-1.4891	3.5549	-10.6858	-0.4824	-0.3607	9.2401
1.80	-0.4997	0.1637	-1.4269	2.2298	-10.7167	-0.7271	-0.3599	9.2548
1.90	-0.4947	0.1953	-1.5567	1.5680	-11.7054	-1.0548	-0.3587	9.2494
2.00	-0.4898	0.2057	-1.6890	2.0433	-12.2385	-1.0422	-0.3580	9.2142
2.10	-0.4857	0.1816	-1.6434	2.3431	-11.6041	-0.7442	-0.3575	9.1538
2.20	-0.4817	0.1400	-1.4906	1.5096	-10.7122	-0.5740	-0.3562	9.0896
2.30	-0.4778	0.1148	-1.4434	0.2981	-10.7815	-0.7464	-0.3543	9.0412
2.40	-0.4746	0.1174	-1.5622	0.1439	-11.6821	-0.9954	-0.3526	9.0080
2.50	-0.4723	0.1280	-1.6808	1.1525	-12.1739	-0.9691	-0.3521	8.9765
2.60	-0.4707	0.1250	-1.6410	1.9919	-11.6262	-0.7095	-0.3520	8.9399
2.70	-0.4688	0.1125	-1.5051	1.7038	-10.8336	-0.5660	-0.3515	8.9054
2.80	-0.4661	0.1111	-1.4607	0.8687	-10.8748	-0.7192	-0.3502	8.8816
2.90	-0.4632	0.1267	-1.5624	0.7409	-11.6509	-0.9432	-0.3490	8.8639
3.00	-0.4607	0.1413	-1.6657	1.4891	-12.0793	-0.9290	-0.3485	8.8393
3.10	-0.4585	0.1376	-1.6311	2.0523	-11.5996	-0.7064	-0.3484	8.8036
3.20	-0.4560	0.1217	-1.5121	1.6558	-10.9015	-0.5806	-0.3477	8.7657
3.30	-0.4531	0.1141	-1.4730	0.8349	-10.9337	-0.7100	-0.3464	8.7359
3.40	-0.4502	0.1220	-1.5624	0.6741	-11.6165	-0.9004	-0.3451	8.7123
3.50	-0.4479	0.1311	-1.6539	1.3121	-12.0006	-0.8862	-0.3446	8.6851
3.60	-0.4459	0.1268	-1.6245	1.8275	-11.5866	-0.6942	-0.3444	8.6504
3.70	-0.4438	0.1137	-1.5202	1.5396	-10.9733	-0.5847	-0.3437	8.6156
3.80	-0.4412	0.1088	-1.4851	0.8813	-10.9958	-0.6960	-0.3425	8.5886
3.90	-0.4386	0.1174	-1.5630	0.7664	-11.5926	-0.8611	-0.3414	8.5673
4.00	-0.4365	0.1267	-1.6435	1.3208	-11.9330	-0.8504	-0.3409	8.5425

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.03.1

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TRUCK FRONT AXLE TIRE FORCES

	LEFT SIDE					RIGHT SIDE					STEER ANGLE	
TIME (SEC)	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	LEFT (DEG)	RIGHT (DEG)
0.0	5063.11	-0.0	0.0	0.0	0.0	5063.11	-0.0	0.0	0.0	0.0	0.0	0.0
0.10	7066.88	-39.30	4267.57	-0.0056	0.6039	3095.77	41.62	1842.19	0.0134	0.5951	8.00	8.00
0.20	6544.70	-17.46	2534.18	-0.0027	0.3872	3701.83	23.27	1321.41	0.0063	0.3570	8.00	8.00
0.30	6636.11	-6.01	2412.82	-0.0009	0.3636	3679.81	11.06	1195.77	0.0030	0.3250	8.00	8.00
0.40	6846.07	-0.97	2660.52	-0.0001	0.3886	3458.61	6.11	1205.93	0.0018	0.3487	8.00	8.00
0.50	7016.80	1.44	2964.44	0.0002	0.4225	3213.00	3.93	1233.11	0.0012	0.3838	8.00	8.00
0.60	7075.54	2.52	3173.27	0.0004	0.4485	3047.26	3.00	1253.46	0.0010	0.4113	8.00	8.00
0.70	7145.93	2.36	3245.94	0.0003	0.4542	3124.48	3.29	1303.74	0.0011	0.4173	8.00	8.00
0.80	7084.05	2.66	3157.30	0.0004	0.4457	3209.18	2.95	1308.95	0.0009	0.4079	8.00	8.00
0.90	6975.80	3.07	3023.70	0.0004	0.4335	3270.49	2.33	1291.17	0.0007	0.3948	8.00	8.00
1.00	6908.93	3.04	2911.99	0.0004	0.4215	3330.43	2.21	1272.58	0.0007	0.3821	8.00	8.00
1.10	6869.71	2.76	2830.81	0.0004	0.4121	3374.79	2.39	1255.74	0.0007	0.3721	8.00	8.00
1.20	6843.00	2.57	2777.11	0.0004	0.4058	3394.78	2.52	1240.40	0.0007	0.3654	8.00	8.00
1.30	6833.44	2.59	2749.92	0.0004	0.4024	3396.27	2.46	1228.40	0.0007	0.3617	8.00	8.00
1.40	6844.48	2.71	2748.92	0.0004	0.4016	3388.37	2.34	1222.74	0.0007	0.3609	8.00	8.00
1.50	6865.61	2.71	2767.20	0.0004	0.4031	3377.74	2.34	1224.23	0.0007	0.3624	8.00	8.00
1.60	6879.55	2.59	2788.94	0.0004	0.4054	3368.65	2.48	1229.40	0.0007	0.3650	8.00	8.00
1.70	6878.37	2.52	2798.85	0.0004	0.4069	3364.07	2.58	1232.97	0.0008	0.3665	8.00	8.00
1.80	6869.42	2.60	2794.11	0.0004	0.4067	3365.43	2.50	1232.74	0.0007	0.3663	8.00	8.00
1.90	6863.51	2.74	2783.25	0.0004	0.4055	3372.05	2.35	1230.79	0.0007	0.3650	8.00	8.00
2.00	6861.21	2.75	2773.76	0.0004	0.4043	3381.38	2.32	1229.87	0.0007	0.3637	8.00	8.00
2.10	6854.52	2.62	2763.73	0.0004	0.4032	3390.65	2.43	1229.43	0.0007	0.3626	8.00	8.00
2.20	6840.52	2.53	2748.52	0.0004	0.4018	3398.54	2.51	1227.07	0.0007	0.3611	8.00	8.00
2.30	6826.70	2.58	2729.73	0.0004	0.3999	3405.42	2.44	1222.37	0.0007	0.3589	8.00	8.00
2.40	6821.40	2.68	2715.01	0.0004	0.3980	3411.74	2.32	1217.96	0.0007	0.3570	8.00	8.00
2.50	6822.77	2.68	2708.33	0.0004	0.3970	3417.13	2.30	1216.19	0.0007	0.3559	8.00	8.00
2.60	6821.57	2.57	2704.93	0.0004	0.3965	3421.16	2.40	1216.09	0.0007	0.3555	8.00	8.00
2.70	6813.48	2.50	2697.85	0.0004	0.3960	3424.33	2.47	1215.01	0.0007	0.3548	8.00	8.00
2.80	6804.05	2.55	2686.49	0.0004	0.3948	3427.94	2.42	1212.07	0.0007	0.3536	8.00	8.00
2.90	6800.21	2.64	2676.27	0.0004	0.3936	3432.68	2.31	1209.10	0.0007	0.3522	8.00	8.00
3.00	6800.73	2.64	2670.65	0.0004	0.3927	3437.95	2.29	1207.95	0.0007	0.3514	8.00	8.00
3.10	6798.20	2.55	2666.21	0.0004	0.3922	3442.80	2.38	1207.83	0.0007	0.3508	8.00	8.00
3.20	6789.39	2.49	2657.72	0.0004	0.3915	3447.12	2.44	1206.50	0.0007	0.3500	8.00	8.00
3.30	6779.58	2.52	2645.37	0.0004	0.3902	3451.70	2.39	1203.38	0.0007	0.3486	8.00	8.00
3.40	6775.06	2.60	2634.45	0.0004	0.3888	3456.92	2.29	1200.25	0.0007	0.3472	8.00	8.00
3.50	6774.84	2.60	2628.11	0.0004	0.3879	3462.20	2.28	1198.80	0.0007	0.3463	8.00	8.00
3.60	6772.30	2.52	2623.33	0.0004	0.3874	3466.76	2.35	1198.33	0.0007	0.3457	8.00	8.00
3.70	6764.55	2.46	2615.51	0.0004	0.3866	3470.62	2.40	1196.92	0.0007	0.3449	8.00	8.00
3.80	6755.95	2.50	2604.61	0.0004	0.3855	3474.63	2.36	1194.05	0.0007	0.3436	8.00	8.00
3.90	6751.90	2.56	2594.96	0.0004	0.3843	3479.31	2.28	1191.25	0.0007	0.3424	8.00	8.00
4.00	6751.45	2.56	2589.11	0.0004	0.3835	3484.19	2.27	1189.90	0.0007	0.3415	8.00	8.00

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.
TRUCK REAR SUSPENSION TIRE FORCES
LEADING TANDEM AXLE

	LEFT SIDE					RIGHT SIDE				
TIME (SEC)	VERTICAL (LB)	ICNG. (LB)	LATERAL (LB)	MU-X	MU-Y	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y
0.0	8593.45	-0.0	0.0	0.0	0.0	8593.45	-0.0	0.0	0.0	0.0
0.10	8057.64	-54.44	-846.46	-0.0068	-0.1051	9049.82	68.02	-971.51	0.0075	-0.1074
0.20	8840.14	-24.43	-648.26	-0.0028	-0.0733	8174.09	32.84	-622.44	0.0040	-0.0761
0.30	9741.49	-8.14	-4.20	-0.0008	-0.0004	7257.20	15.88	7.87	0.0022	0.0011
0.40	10559.94	-0.92	648.65	-0.0001	0.0614	6535.36	8.99	442.10	0.0014	0.0676
0.50	11177.72	2.54	1213.31	0.0002	0.1085	5986.25	6.00	709.64	0.0010	0.1185
0.60	11489.82	4.08	1596.80	0.0004	0.1390	5606.70	4.74	848.61	0.0008	0.1514
0.70	11523.48	3.85	1730.16	0.0003	0.1501	5449.49	5.19	890.54	0.0010	0.1634
0.80	11450.03	4.30	1689.30	0.0004	0.1475	5514.90	4.67	885.88	0.0008	0.1606
0.90	11355.93	4.86	1552.23	0.0004	0.1367	5726.04	3.79	852.60	0.0007	0.1489
1.00	11228.63	4.80	1389.92	0.0004	0.1238	5930.45	3.62	800.25	0.0006	0.1349
1.10	11064.96	4.39	1263.39	0.0004	0.1142	6030.22	3.88	751.12	0.0006	0.1246
1.20	10927.51	4.11	1188.93	0.0004	0.1088	6058.34	4.06	719.44	0.0007	0.1188
1.30	10888.43	4.15	1152.73	0.0004	0.1059	6094.23	3.96	704.47	0.0007	0.1156
1.40	10938.90	4.31	1140.42	0.0004	0.1043	6147.02	3.78	699.99	0.0006	0.1139
1.50	10994.64	4.32	1147.90	0.0004	0.1044	6157.44	3.79	702.27	0.0006	0.1141
1.60	10994.98	4.15	1170.91	0.0004	0.1065	6099.14	4.00	709.39	0.0007	0.1163
1.70	10965.37	4.05	1194.93	0.0004	0.1090	6030.59	4.14	717.53	0.0007	0.1190
1.80	10965.59	4.17	1202.66	0.0004	0.1097	6025.58	4.02	721.51	0.0007	0.1197
1.90	11000.36	4.36	1189.92	0.0004	0.1082	6080.79	3.80	718.28	0.0006	0.1181
2.00	11014.48	4.37	1168.87	0.0004	0.1061	6125.52	3.77	710.02	0.0006	0.1159
2.10	10972.67	4.19	1152.37	0.0004	0.1050	6117.54	3.92	701.81	0.0006	0.1147
2.20	10910.34	4.06	1140.17	0.0004	0.1045	6094.11	4.03	695.69	0.0007	0.1142
2.30	10886.83	4.13	1124.16	0.0004	0.1033	6113.27	3.93	689.67	0.0006	0.1128
2.40	10907.64	4.27	1102.58	0.0004	0.1011	6171.56	3.75	681.80	0.0006	0.1105
2.50	10921.62	4.27	1083.93	0.0004	0.0992	6209.88	3.74	673.76	0.0006	0.1085
2.60	10892.88	4.11	1075.34	0.0004	0.0987	6195.41	3.88	668.66	0.0006	0.1079
2.70	10847.58	4.01	1072.61	0.0004	0.0989	6165.11	3.97	666.44	0.0006	0.1081
2.80	10834.52	4.08	1065.63	0.0004	0.0984	6173.61	3.89	663.87	0.0006	0.1075
2.90	10857.18	4.20	1051.15	0.0004	0.0968	6220.09	3.74	658.58	0.0006	0.1059
3.00	10870.55	4.20	1036.10	0.0004	0.0953	6253.02	3.72	651.95	0.0006	0.1043
3.10	10843.76	4.07	1027.32	0.0004	0.0947	6242.34	3.84	646.96	0.0006	0.1036
3.20	10800.71	3.98	1022.23	0.0004	0.0946	6218.89	3.92	643.88	0.0006	0.1035
3.30	10785.43	4.04	1013.03	0.0004	0.0939	6229.65	3.84	640.17	0.0006	0.1028
3.40	10802.15	4.14	997.64	0.0004	0.0924	6273.49	3.71	634.08	0.0006	0.1011
3.50	10811.91	4.14	982.49	0.0004	0.0909	6304.86	3.69	627.18	0.0006	0.0995
3.60	10787.38	4.03	973.59	0.0004	0.0903	6296.95	3.80	622.19	0.0006	0.0988
3.70	10749.09	3.94	968.56	0.0004	0.0901	6276.72	3.86	619.18	0.0006	0.0986
3.80	10735.43	3.99	960.35	0.0004	0.0895	6285.92	3.80	615.69	0.0006	0.0979
3.90	10749.96	4.08	946.82	0.0004	0.0881	6324.39	3.69	610.07	0.0006	0.0965
4.00	10758.40	4.08	933.32	0.0004	0.0868	6352.44	3.67	603.73	0.0006	0.0950

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TRUCK REAR SUSPENSION TIRE FORCES

TRAILING TANDEM AXLE

	LEFT SIDE					RIGHT SIDE				
TIME (SEC)	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y
0.0	8593.45	-0.0	0.0	0.0	0.0	8593.45	-0.0	0.0	0.0	0.0
0.10	8875.61	-55.49	-37.36	-0.0063	-0.0042	8223.51	66.68	-34.75	0.0081	-0.0042
0.20	10962.05	-24.13	1480.04	-0.0022	0.1350	6046.38	32.73	859.22	0.0054	0.1421
0.30	12974.46	-7.95	3285.54	-0.0006	0.2532	4018.96	15.72	1082.89	0.0039	0.2694
0.40	14716.07	-0.84	4929.15	-0.0001	0.3350	2373.72	8.47	850.23	0.0036	0.3582
0.50	15975.64	2.57	6238.49	0.0002	0.3905	1182.37	4.88	494.80	0.0041	0.4185
0.60	16604.25	4.07	7036.44	0.0002	0.4238	486.18	2.79	220.94	0.0057	0.4544
0.70	16694.97	3.82	7291.53	0.0002	0.4367	272.11	2.43	127.49	0.0089	0.4685
0.80	16527.97	4.29	7197.22	0.0003	0.4355	430.98	4.60	201.39	0.0107	0.4673
0.90	16275.50	4.85	6900.21	0.0003	0.4240	800.07	6.25	363.91	0.0078	0.4548
1.00	15986.10	4.77	6549.18	0.0003	0.4097	1166.34	5.11	512.44	0.0044	0.4394
1.10	15685.03	4.36	6262.66	0.0003	0.3993	1403.76	4.23	600.95	0.0030	0.4281
1.20	15452.88	4.09	6085.96	0.0003	0.3938	1526.97	4.09	644.77	0.0027	0.4223
1.30	15375.81	4.13	6012.39	0.0003	0.3910	1600.93	3.99	671.18	0.0025	0.4192
1.40	15440.09	4.30	6010.59	0.0003	0.3893	1639.63	3.78	684.34	0.0023	0.4174
1.50	15532.98	4.30	6045.48	0.0003	0.3892	1612.70	3.66	672.94	0.0023	0.4173
1.60	15562.16	4.12	6090.46	0.0003	0.3914	1525.72	3.76	640.20	0.0025	0.4196
1.70	15541.98	4.03	6127.38	0.0003	0.3942	1448.03	3.92	612.13	0.0027	0.4227
1.80	15541.55	4.15	6142.61	0.0003	0.3952	1443.69	3.96	611.87	0.0027	0.4238
1.90	15574.75	4.34	6129.72	0.0003	0.3936	1500.19	3.83	633.11	0.0026	0.4220
2.00	15581.98	4.34	6094.43	0.0003	0.3911	1551.59	3.73	650.67	0.0024	0.4194
2.10	15519.80	4.16	6050.63	0.0003	0.3899	1564.13	3.80	653.80	0.0024	0.4180
2.20	15427.71	4.04	6009.29	0.0003	0.3895	1570.71	3.92	655.97	0.0025	0.4176
2.30	15379.96	4.12	5973.59	0.0003	0.3884	1614.15	3.92	672.20	0.0024	0.4164
2.40	15390.55	4.25	5941.36	0.0003	0.3860	1682.45	3.77	696.35	0.0022	0.4139
2.50	15400.96	4.24	5912.02	0.0003	0.3839	1724.17	3.68	709.57	0.0021	0.4115
2.60	15363.15	4.09	5888.00	0.0003	0.3833	1718.89	3.75	706.24	0.0022	0.4109
2.70	15302.13	3.99	5870.03	0.0003	0.3836	1704.54	3.86	701.02	0.0023	0.4113
2.80	15276.16	4.06	5854.41	0.0003	0.3832	1725.97	3.86	709.16	0.0022	0.4109
2.90	15294.45	4.19	5835.76	0.0003	0.3816	1776.62	3.73	726.76	0.0021	0.4091
3.00	15305.44	4.18	5812.63	0.0003	0.3798	1811.79	3.66	737.63	0.0020	0.4071
3.10	15268.64	4.05	5788.42	0.0003	0.3791	1811.22	3.73	736.08	0.0021	0.4064
3.20	15208.29	3.96	5766.38	0.0003	0.3792	1805.27	3.82	733.79	0.0021	0.4065
3.30	15177.97	4.02	5745.75	0.0003	0.3786	1831.09	3.81	743.12	0.0021	0.4058
3.40	15187.69	4.13	5723.52	0.0003	0.3769	1881.75	3.70	760.21	0.0020	0.4040
3.50	15193.18	4.12	5699.14	0.0003	0.3751	1917.26	3.64	770.94	0.0019	0.4021
3.60	15158.74	4.01	5675.54	0.0003	0.3744	1919.35	3.70	770.32	0.0019	0.4013
3.70	15104.96	3.93	5655.14	0.0003	0.3744	1914.79	3.78	768.47	0.0020	0.4013
3.80	15078.20	3.97	5636.90	0.0003	0.3738	1937.11	3.76	776.30	0.0019	0.4008
3.90	15086.63	4.07	5617.50	0.0003	0.3723	1981.54	3.66	790.91	0.0018	0.3991
4.00	15091.07	4.06	5595.80	0.0003	0.3708	2013.46	3.61	800.28	0.0018	0.3975

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4.   OUTPUT PAGE NO.   1.11.1

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TRUCK   FRONT SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY

TIME (SEC)	LEFT SIDE TIRE SIDESLIP ANGLE (DEG)	LEFT SIDE TIRE LATERAL FORCE (LB)	LEFT SIDE MU-Y	LEFT SIDE ALIGNING TORQUE (IN-LB)	RIGHT SIDE TIRE SIDESLIP ANGLE (DEG)	RIGHT SIDE TIRE LATERAL FORCE (LB)	RIGHT SIDE MU-Y	RIGHT SIDE ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10	-5.0959	4267.5703	0.6039	-7681.6172	-5.0215	1842.1902	0.5951	-3315.9404
0.20	-3.2675	2534.1765	0.3872	-4561.5117	-3.0122	1321.4055	0.3570	-2378.5283
0.30	-3.0682	2412.8232	0.3636	-4343.0742	-2.7421	1195.7717	0.3250	-2152.3879
0.40	-3.2794	2660.5225	0.3886	-4788.9375	-2.9423	1205.9319	0.3487	-2170.6760
0.50	-3.5651	2964.4402	0.4225	-5335.9883	-3.2386	1233.1116	0.3838	-2219.5994
0.60	-3.7845	3173.2686	0.4485	-5711.8789	-3.4711	1253.4604	0.4113	-2256.2273
0.70	-3.8331	3245.9370	0.4542	-5842.6797	-3.5211	1303.7351	0.4173	-2346.7214
0.80	-3.7610	3157.2957	0.4457	-5683.1250	-3.4419	1308.9485	0.4079	-2356.1060
0.90	-3.6577	3023.6970	0.4335	-5442.6484	-3.3315	1291.1719	0.3948	-2324.1079
1.00	-3.5567	2911.9917	0.4215	-5241.5781	-3.2244	1272.5845	0.3821	-2290.6504
1.10	-3.4773	2830.8083	0.4121	-5095.4492	-3.1399	1255.7427	0.3721	-2260.3354
1.20	-3.4246	2777.1118	0.4058	-4998.7969	-3.0833	1240.3967	0.3654	-2232.7126
1.30	-3.3958	2749.9158	0.4024	-4949.8438	-3.0521	1228.4048	0.3617	-2211.1274
1.40	-3.3891	2748.9236	0.4016	-4948.0547	-3.0452	1222.7397	0.3609	-2200.9299
1.50	-3.4012	2767.2002	0.4031	-4980.9531	-3.0585	1224.2312	0.3624	-2203.6147
1.60	-3.4209	2788.9402	0.4054	-5020.0859	-3.0797	1229.3979	0.3650	-2212.9148
1.70	-3.4337	2798.8455	0.4069	-5037.9141	-3.0928	1232.9705	0.3665	-2219.3452
1.80	-3.4323	2794.1069	0.4067	-5029.3867	-3.0910	1232.7368	0.3663	-2218.9248
1.90	-3.4219	2783.2520	0.4055	-5009.8477	-3.0800	1230.7937	0.3650	-2215.4270
2.00	-3.4114	2773.7573	0.4043	-4992.7578	-3.0693	1229.8730	0.3637	-2213.7700
2.10	-3.4024	2763.7288	0.4032	-4974.7070	-3.0597	1229.4258	0.3626	-2212.9651
2.20	-3.3906	2748.5159	0.4018	-4947.3242	-3.0468	1227.0681	0.3611	-2208.7212
2.30	-3.3742	2729.7275	0.3999	-4913.5039	-3.0290	1222.3730	0.3589	-2200.2700
2.40	-3.3566	2715.0076	0.3980	-4887.0078	-3.0125	1217.9648	0.3570	-2192.3352
2.50	-3.3497	2708.3303	0.3970	-4874.9883	-3.0033	1216.1853	0.3559	-2189.1323
2.60	-3.3461	2704.9316	0.3965	-4868.8711	-2.9996	1216.0891	0.3555	-2188.9592
2.70	-3.3413	2697.8530	0.3960	-4856.1328	-2.9941	1215.0098	0.3548	-2187.0161
2.80	-3.3318	2686.4861	0.3948	-4835.6719	-2.9837	1212.0659	0.3536	-2181.7170
2.90	-3.3210	2676.2678	0.3936	-4817.2773	-2.9723	1209.0994	0.3522	-2176.3774
3.00	-3.3138	2670.6523	0.3927	-4807.1680	-2.9649	1207.9534	0.3514	-2174.3147
3.10	-3.3095	2666.2107	0.3922	-4799.1719	-2.9605	1207.8298	0.3508	-2174.0925
3.20	-3.3033	2657.7163	0.3915	-4783.8867	-2.9535	1206.4998	0.3500	-2171.6982
3.30	-3.2927	2645.3745	0.3902	-4761.6680	-2.9419	1203.3770	0.3486	-2166.0771
3.40	-3.2813	2634.4453	0.3888	-4741.9961	-2.9299	1200.2478	0.3472	-2160.4446
3.50	-3.2735	2628.1123	0.3879	-4730.5977	-2.9219	1198.7983	0.3463	-2157.8357
3.60	-3.2688	2623.3279	0.3874	-4721.9844	-2.9169	1198.3276	0.3457	-2156.9883
3.70	-3.2627	2615.5051	0.3866	-4707.9023	-2.9102	1196.9194	0.3449	-2154.4536
3.80	-3.2533	2604.6138	0.3855	-4688.2969	-2.8999	1194.0537	0.3436	-2149.2952
3.90	-3.2432	2594.9565	0.3843	-4670.9180	-2.8892	1191.2490	0.3424	-2144.2471
4.00	-3.2361	2589.1104	0.3835	-4660.3945	-2.8819	1189.8982	0.3415	-2141.8154

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.13.1

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TRUCK REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY

LEADING TANDEM AXLE

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10	0.9028	-846.4636	-0.1051	1828.3601	0.9225	-971.5063	-0.1074	2098.4524
0.20	0.6302	-648.2615	-0.0733	1400.2437	0.6544	-622.4402	-0.0761	1344.4697
0.30	0.0037	-4.2018	-0.0004	9.0759	-0.0093	7.8654	0.0011	-16.9892
0.40	-0.5279	648.6504	0.0614	-1401.0837	-0.5813	442.1038	0.0676	-954.9429
0.50	-0.9328	1213.3059	0.1085	-2620.7390	-1.0187	709.6392	0.1185	-1532.8193
0.60	-1.1943	1596.8003	0.1390	-3449.0859	-1.3007	848.6125	0.1514	-1833.0022
0.70	-1.2902	1730.1567	0.1501	-3737.1357	-1.4043	890.5371	0.1634	-1923.5588
0.80	-1.2678	1689.2966	0.1475	-3648.8789	-1.3804	885.8804	0.1606	-1913.5000
0.90	-1.1746	1552.2305	0.1367	-3352.8135	-1.2796	852.6018	0.1489	-1841.6187
1.00	-1.0637	1389.9233	0.1238	-3002.2324	-1.1596	800.2524	0.1349	-1728.5442
1.10	-0.9812	1263.3870	0.1142	-2728.9138	-1.0704	751.1157	0.1246	-1622.4089
1.20	-0.9350	1188.9321	0.1088	-2568.0916	-1.0205	719.4448	0.1188	-1553.9995
1.30	-0.9098	1152.7268	0.1059	-2489.8882	-0.9934	704.4729	0.1156	-1521.6606
1.40	-0.8959	1140.4170	0.1043	-2463.2988	-0.9786	699.9854	0.1139	-1511.9673
1.50	-0.8972	1147.8962	0.1044	-2479.4541	-0.9801	702.2676	0.1141	-1516.8970
1.60	-0.9152	1170.9138	0.1065	-2529.1724	-0.9995	709.3904	0.1163	-1532.2822
1.70	-0.9365	1194.9329	0.1090	-2581.0535	-1.0225	717.5283	0.1190	-1549.8599
1.80	-0.9425	1202.6570	0.1097	-2597.7373	-1.0290	721.5100	0.1197	-1558.4604
1.90	-0.9296	1189.9189	0.1082	-2570.2231	-1.0151	718.2798	0.1181	-1551.4829
2.00	-0.9119	1168.8657	0.1061	-2524.7485	-0.9961	710.0229	0.1159	-1533.6484
2.10	-0.9025	1152.3657	0.1050	-2489.1082	-0.9859	701.8140	0.1147	-1515.9170
2.20	-0.8980	1140.1721	0.1045	-2462.7703	-0.9810	695.6885	0.1142	-1502.6860
2.30	-0.8874	1124.1646	0.1033	-2428.1938	-0.9695	689.6724	0.1128	-1489.6912
2.40	-0.8687	1102.5845	0.1011	-2381.5811	-0.9494	681.8049	0.1105	-1472.6978
2.50	-0.8529	1083.9292	0.0992	-2341.2854	-0.9324	673.7588	0.1085	-1455.3179
2.60	-0.8483	1075.3423	0.0987	-2322.7378	-0.9275	668.6631	0.1079	-1444.3110
2.70	-0.8497	1072.6072	0.0989	-2316.8298	-0.9289	666.4397	0.1081	-1439.5085
2.80	-0.8452	1065.6270	0.0984	-2301.7529	-0.9241	663.8716	0.1075	-1433.9614
2.90	-0.8320	1051.1453	0.0968	-2270.4722	-0.9099	658.5798	0.1059	-1422.5313
3.00	-0.8191	1036.0984	0.0953	-2237.9709	-0.8960	651.9512	0.1043	-1408.2131
3.10	-0.8141	1027.3186	0.0947	-2219.0063	-0.8906	646.9626	0.1036	-1397.4382
3.20	-0.8133	1022.2312	0.0946	-2208.0178	-0.8897	643.8835	0.1035	-1390.7871
3.30	-0.8071	1013.0315	0.0939	-2188.1465	-0.8831	640.1707	0.1028	-1382.7673
3.40	-0.7937	997.6355	0.0924	-2154.8914	-0.8686	634.0796	0.1011	-1369.6108
3.50	-0.7809	982.4854	0.0909	-2122.1667	-0.8548	627.1787	0.0995	-1354.7051
3.60	-0.7756	973.5950	0.0903	-2102.9636	-0.8491	622.1902	0.0988	-1343.9297
3.70	-0.7743	968.5603	0.0901	-2092.0886	-0.8477	619.1807	0.0986	-1337.4290
3.80	-0.7687	960.3523	0.0895	-2074.3596	-0.8417	615.6875	0.0979	-1329.8840
3.90	-0.7569	946.8223	0.0881	-2045.1345	-0.8290	610.0742	0.0965	-1317.7595
4.00	-0.7455	933.3237	0.0868	-2015.9780	-0.8167	603.7344	0.0950	-1304.0654

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.14.1

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.
TRUCK REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY
TRAILING TANDEM AXLE

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10	0.0362	-37.3564	-0.0042	80.6898	0.0363	-34.7520	-0.0042	75.0643
0.20	-1.1602	1480.0386	0.1350	-3196.8809	-1.2212	859.2161	0.1421	-1855.9053
0.30	-2.1761	3285.5439	0.2532	-7096.7695	-2.3155	1082.8894	0.2694	-2339.0398
0.40	-2.8784	4929.1523	0.3350	-10646.9570	-3.0780	850.2283	0.3582	-1836.4917
0.50	-3.3557	6238.4883	0.3905	-13475.1211	-3.5962	494.7971	0.4185	-1068.7610
0.60	-3.6417	7036.4375	0.4238	-15198.6914	-3.9052	220.9411	0.4544	-477.2322
0.70	-3.7532	7291.5273	0.4367	-15749.6836	-4.0264	127.4947	0.4685	-275.3884
0.80	-3.7421	7197.2227	0.4355	-15545.9883	-4.0155	201.3881	0.4673	-434.9978
0.90	-3.6433	6900.2070	0.4240	-14904.4336	-3.9087	363.9070	0.4548	-786.0383
1.00	-3.5206	6549.1758	0.4097	-14146.2070	-3.7756	512.4390	0.4394	-1106.8669
1.10	-3.4312	6262.6602	0.3993	-13527.3320	-3.6789	600.9492	0.4281	-1298.0493
1.20	-3.3844	6085.9609	0.3938	-13145.6602	-3.6286	644.7664	0.4223	-1392.6943
1.30	-3.3603	6012.3867	0.3910	-12986.7422	-3.6028	671.1807	0.4192	-1449.7488
1.40	-3.3453	6010.5859	0.3893	-12982.8555	-3.5867	684.3372	0.4174	-1478.1672
1.50	-3.3446	6045.4805	0.3892	-13058.2266	-3.5858	672.9387	0.4173	-1453.5464
1.60	-3.3632	6090.4570	0.3914	-13155.3750	-3.6059	640.2024	0.4196	-1382.8359
1.70	-3.3879	6127.3750	0.3942	-13235.1133	-3.6328	612.1338	0.4227	-1322.2078
1.80	-3.3965	6142.6133	0.3952	-13268.0313	-3.6421	611.8726	0.4238	-1321.6436
1.90	-3.3821	6129.7227	0.3936	-13240.1875	-3.6266	633.1104	0.4220	-1367.5173
2.00	-3.3611	6094.4336	0.3911	-13163.9648	-3.6037	650.6729	0.4194	-1405.4519
2.10	-3.3503	6050.6250	0.3899	-13069.3398	-3.5920	653.7993	0.4180	-1412.2053
2.20	-3.3473	6009.2891	0.3895	-12980.0547	-3.5888	655.9707	0.4176	-1416.8953
2.30	-3.3377	5973.5938	0.3884	-12902.9531	-3.5787	672.1973	0.4164	-1451.9446
2.40	-3.3174	5941.3594	0.3860	-12833.3242	-3.5568	696.3518	0.4139	-1504.1187
2.50	-3.2988	5912.0234	0.3839	-12769.9570	-3.5366	709.5676	0.4115	-1532.6648
2.60	-3.2935	5888.0000	0.3833	-12718.0703	-3.5308	706.2388	0.4109	-1525.4744
2.70	-3.2965	5870.0273	0.3836	-12679.2461	-3.5342	701.0171	0.4113	-1514.1958
2.80	-3.2933	5854.4102	0.3832	-12645.5156	-3.5309	709.1619	0.4109	-1531.7886
2.90	-3.2789	5835.7578	0.3816	-12605.2266	-3.5153	726.7583	0.4091	-1569.7969
3.00	-3.2636	5812.6289	0.3798	-12555.2617	-3.4987	737.6343	0.4071	-1593.2888
3.10	-3.2578	5788.4180	0.3791	-12502.9688	-3.4924	736.0825	0.4064	-1589.9370
3.20	-3.2583	5766.3750	0.3792	-12455.3555	-3.4930	733.7886	0.4065	-1584.9822
3.30	-3.2531	5745.7461	0.3786	-12410.8008	-3.4875	743.1155	0.4058	-1605.1284
3.40	-3.2385	5723.5195	0.3769	-12362.7891	-3.4717	760.2144	0.4040	-1642.0620
3.50	-3.2235	5699.1406	0.3751	-12310.1289	-3.4555	770.9404	0.4021	-1665.2300
3.60	-3.2175	5675.5430	0.3744	-12259.1602	-3.4489	770.3157	0.4013	-1663.8809
3.70	-3.2173	5655.1406	0.3744	-12215.0898	-3.4488	768.4651	0.4013	-1659.8835
3.80	-3.2126	5636.8984	0.3738	-12175.6875	-3.4438	776.3040	0.4008	-1676.8154
3.90	-3.1998	5617.5000	0.3723	-12133.7930	-3.4300	790.9104	0.3991	-1708.3652
4.00	-3.1865	5595.8047	0.3708	-12086.9219	-3.4156	800.2766	0.3975	-1728.5964

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TRUCK FRONT SUSPENSION - UNSPRUNG MASS SUMMARY

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10	0.0003	-0.4885	0.0008	-2.2267	-601.5	0.0424	-1.8933	-185.49	-0.0531	1.3408	166.38
0.20	0.0009	-0.3458	0.0055	-2.8070	3953.2	-0.3208	-2.6129	-564.01	0.2190	1.8297	449.19
0.30	0.0014	-0.3626	0.0017	-1.9875	8125.1	-0.6557	-2.3024	-898.45	0.4702	2.3659	711.53
0.40	0.0013	-0.4189	-0.0039	-1.2541	11711.3	-0.9110	-1.5305	-1145.39	0.7206	2.5478	967.85
0.50	0.0008	-0.4728	-0.0106	-0.6617	14348.2	-1.0675	-0.8159	-1268.27	0.9383	1.9467	1179.28
0.60	-0.0000	-0.5022	-0.0010	-0.2305	15805.9	-1.1530	-0.4196	-1263.74	1.0621	0.7417	1245.76
0.70	0.0010	-0.5024	0.0090	0.0830	16181.7	-1.1821	-0.0588	-1210.37	1.0893	-0.1503	1068.39
0.80	0.0012	-0.4846	-0.0038	0.2202	15830.1	-1.1686	0.2914	-1116.29	1.0555	-0.5280	947.39
0.90	0.0009	-0.4633	-0.0028	0.1899	15132.0	-1.1180	0.4981	-1017.55	1.0087	-0.5614	892.34
1.00	0.0008	-0.4473	-0.0001	0.1304	14400.2	-1.0602	0.4335	-973.87	0.9634	-0.5168	856.75
1.10	0.0009	-0.4367	-0.0006	0.0817	13807.0	-1.0163	0.2896	-962.53	0.9233	-0.4087	840.99
1.20	0.0008	-0.4307	-0.0013	0.0369	13411.6	-0.9893	0.1614	-964.59	0.8941	-0.2431	849.42
1.30	0.0008	-0.4292	-0.0008	-0.0064	13229.9	-0.9776	0.0358	-981.59	0.8795	-0.0713	874.10
1.40	0.0008	-0.4314	0.0000	-0.0362	13243.5	-0.9802	-0.0796	-1010.74	0.8781	0.0484	900.23
1.50	0.0009	-0.4354	0.0001	-0.0390	13377.8	-0.9928	-0.1335	-1035.91	0.8841	0.0877	915.30
1.60	0.0009	-0.4383	-0.0006	-0.0183	13522.7	-1.0068	-0.0993	-1042.21	0.8906	0.0659	916.91
1.70	0.0009	-0.4388	-0.0012	0.0057	13598.9	-1.0143	-0.0202	-1031.59	0.8942	0.0278	911.79
1.80	0.0008	-0.4376	-0.0009	0.0155	13600.9	-1.0139	0.0327	-1019.07	0.8951	0.0013	906.55
1.90	0.0008	-0.4360	-0.0002	0.0140	13567.6	-1.0100	0.0364	-1014.30	0.8943	-0.0192	901.11
2.00	0.0009	-0.4346	-0.0001	0.0153	13521.6	-1.0062	0.0295	-1011.99	0.8918	-0.0470	892.11
2.10	0.0009	-0.4326	-0.0007	0.0235	13451.6	-1.0017	0.0482	-1003.10	0.8866	-0.0735	880.79
2.20	0.0008	-0.4299	-0.0012	0.0282	13350.3	-0.9945	0.0768	-989.25	0.8797	-0.0777	872.81
2.30	0.0008	-0.4273	-0.0009	0.0209	13244.6	-0.9858	0.0743	-981.04	0.8734	-0.0570	871.27
2.40	0.0008	-0.4258	-0.0002	0.0081	13172.1	-0.9794	0.0360	-983.36	0.8695	-0.0337	872.63
2.50	0.0008	-0.4253	-0.0001	0.0032	13138.7	-0.9771	0.0034	-988.51	0.8670	-0.0284	871.32
2.60	0.0009	-0.4246	-0.0007	0.0094	13113.5	-0.9764	0.0091	-986.52	0.8642	-0.0364	866.63
2.70	0.0008	-0.4232	-0.0011	0.0160	13069.6	-0.9739	0.0365	-977.69	0.8606	-0.0386	862.51
2.80	0.0008	-0.4216	-0.0008	0.0140	13014.0	-0.9693	0.0448	-971.16	0.8574	-0.0284	861.57
2.90	0.0008	-0.4205	-0.0003	0.0069	12971.6	-0.9654	0.0242	-971.90	0.8553	-0.0197	861.45
3.00	0.0008	-0.4199	-0.0002	0.0055	12946.6	-0.9636	0.0061	-974.24	0.8535	-0.0259	858.25
3.10	0.0008	-0.4190	-0.0007	0.0122	12916.3	-0.9622	0.0173	-970.30	0.8507	-0.0401	852.12
3.20	0.0008	-0.4174	-0.0010	0.0180	12863.1	-0.9588	0.0433	-960.87	0.8467	-0.0450	846.98
3.30	0.0008	-0.4156	-0.0008	0.0155	12798.4	-0.9535	0.0496	-954.06	0.8429	-0.0360	845.21
3.40	0.0008	-0.4144	-0.0003	0.0082	12747.3	-0.9490	0.0291	-954.17	0.8402	-0.0265	844.66
3.50	0.0008	-0.4137	-0.0002	0.0060	12715.4	-0.9467	0.0100	-956.21	0.8380	-0.0289	841.87
3.60	0.0008	-0.4128	-0.0006	0.0110	12683.4	-0.9451	0.0166	-953.09	0.8352	-0.0382	836.83
3.70	0.0008	-0.4114	-0.0010	0.0157	12635.2	-0.9420	0.0374	-945.20	0.8315	-0.0403	832.68
3.80	0.0008	-0.4098	-0.0008	0.0136	12579.0	-0.9375	0.0427	-939.37	0.8282	-0.0318	831.24
3.90	0.0008	-0.4087	-0.0003	0.0075	12534.4	-0.9335	0.0256	-939.31	0.8258	-0.0240	830.60
4.00	0.0008	-0.4080	-0.0003	0.0060	12505.2	-0.9314	0.0099	-940.79	0.8238	-0.0271	827.86

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.

TRUCK REAR SUSPENSION - UNSPRUNG MASS SUMMARY

LEADING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0	0.00	0.0000	0.0	0.00
0.10	-0.0002	0.0670	-0.0228	0.6898	0.0	-0.1037	-2.8308	-915.95	0.1032	2.4882	-7.95
0.20	-0.0006	-0.0438	-0.0239	-0.8271	0.0	-0.3351	-2.9364	-1843.07	0.3536	3.1322	1002.91
0.30	-0.0006	-0.1695	-0.0192	-1.2070	0.0	-0.5969	-2.5639	-2884.59	0.6175	3.0189	2056.97
0.40	-0.0003	-0.2772	-0.0169	-1.1426	0.0	-0.8499	-1.9116	-3886.91	0.8464	2.6172	2966.44
0.50	-0.0000	-0.3599	-0.0206	-0.7690	0.0	-1.0406	-0.9590	-4635.30	1.0195	1.9971	3649.67
0.60	-0.0002	-0.4096	-0.0254	-0.3279	0.0	-1.1337	-0.0233	-4993.55	1.1285	1.1874	4073.40
0.70	-0.0007	-0.4240	-0.0243	0.0110	0.0	-1.1431	0.4843	-5023.57	1.1687	0.3403	4221.63
0.80	-0.0008	-0.4149	-0.0184	0.1721	0.0	-1.1143	0.5889	-4906.63	1.1439	-0.3367	4112.20
0.90	-0.0003	-0.3937	-0.0162	0.2301	0.0	-1.0778	0.5760	-4760.82	1.0802	-0.5582	3854.30
1.00	-0.0000	-0.3705	-0.0205	0.2109	0.0	-1.0368	0.6326	-4596.04	1.0198	-0.3576	3615.61
1.10	-0.0003	-0.3519	-0.0251	0.1530	0.0	-0.9892	0.6516	-4405.63	0.9864	-0.0685	3486.33
1.20	-0.0007	-0.3402	-0.0238	0.0881	0.0	-0.9492	0.4671	-4248.07	0.9727	0.0560	3433.44
1.30	-0.0007	-0.3348	-0.0186	0.0295	0.0	-0.9360	0.1619	-4199.87	0.9614	0.0667	3388.26
1.40	-0.0003	-0.3344	-0.0168	-0.0162	0.0	-0.9495	0.0004	-4256.29	0.9504	0.1526	3345.72
1.50	-0.0001	-0.3375	-0.0206	-0.0405	0.0	-0.9676	0.0927	-4327.32	0.9517	0.3336	3353.36
1.60	-0.0003	-0.3416	-0.0247	-0.0382	0.0	-0.9713	0.2597	-4339.85	0.9683	0.4282	3421.42
1.70	-0.0006	-0.3444	-0.0235	-0.0167	0.0	-0.9645	0.2776	-4312.23	0.9854	0.3165	3487.87
1.80	-0.0007	-0.3449	-0.0190	0.0065	0.0	-0.9631	0.1609	-4308.36	0.9863	0.1211	3488.60
1.90	-0.0003	-0.3435	-0.0173	0.0193	0.0	-0.9711	0.1119	-4341.15	0.9732	0.0543	3435.19
2.00	-0.0001	-0.3413	-0.0206	0.0226	0.0	-0.9754	0.2258	-4356.50	0.9626	0.1466	3394.16
2.10	-0.0003	-0.3390	-0.0242	0.0250	0.0	-0.9650	0.3605	-4313.12	0.9633	0.2283	3398.46
2.20	-0.0006	-0.3363	-0.0232	0.0291	0.0	-0.9475	0.3389	-4243.39	0.9667	0.1704	3410.89
2.30	-0.0006	-0.3333	-0.0192	0.0295	0.0	-0.9390	0.1919	-4211.53	0.9602	0.0535	3383.18
2.40	-0.0003	-0.3307	-0.0177	0.0224	0.0	-0.9432	0.1110	-4229.72	0.9458	0.0435	3325.57
2.50	-0.0001	-0.3289	-0.0206	0.0128	0.0	-0.9477	0.1872	-4246.36	0.9370	0.1583	3292.09
2.60	-0.0003	-0.3279	-0.0238	0.0091	0.0	-0.9413	0.2970	-4219.03	0.9402	0.2470	3306.16
2.70	-0.0006	-0.3269	-0.0229	0.0127	0.0	-0.9290	0.2817	-4170.15	0.9463	0.1975	3329.71
2.80	-0.0006	-0.3254	-0.0194	0.0168	0.0	-0.9240	0.1624	-4151.92	0.9432	0.0842	3315.85
2.90	-0.0003	-0.3237	-0.0181	0.0159	0.0	-0.9291	0.1021	-4173.25	0.9321	0.0596	3270.93
3.00	-0.0002	-0.3224	-0.0206	0.0121	0.0	-0.9333	0.1777	-4188.89	0.9246	0.1467	3242.19
3.10	-0.0003	-0.3212	-0.0234	0.0117	0.0	-0.9271	0.2799	-4162.60	0.9267	0.2168	3251.80
3.20	-0.0005	-0.3199	-0.0227	0.0160	0.0	-0.9153	0.2686	-4115.47	0.9310	0.1708	3268.38
3.30	-0.0006	-0.3181	-0.0196	0.0196	0.0	-0.9097	0.1627	-4094.82	0.9273	0.0715	3252.05
3.40	-0.0003	-0.3162	-0.0185	0.0178	0.0	-0.9132	0.1064	-4109.71	0.9166	0.0514	3208.91
3.50	-0.0002	-0.3147	-0.0207	0.0130	0.0	-0.9163	0.1691	-4120.98	0.9093	0.1309	3180.77
3.60	-0.0003	-0.3135	-0.0231	0.0114	0.0	-0.9105	0.2563	-4096.71	0.9107	0.1966	3187.58
3.70	-0.0005	-0.3122	-0.0225	0.0143	0.0	-0.9000	0.2452	-4054.92	0.9144	0.1594	3201.84
3.80	-0.0005	-0.3107	-0.0198	0.0171	0.0	-0.8951	0.1520	-4036.71	0.9113	0.0727	3187.90
3.90	-0.0004	-0.3090	-0.0188	0.0158	0.0	-0.8982	0.1025	-4049.75	0.9019	0.0533	3150.15
4.00	-0.0002	-0.3076	-0.0207	0.0121	0.0	-0.9008	0.1580	-4059.48	0.8953	0.1213	3124.92

STRAIGHT TRUCK EXAMPLE RUN: 30 FT/SEC, 8.0 DEGREE STEP-STEER.
TRUCK REAR SUSPENSION - UNSPRUNG MASS SUMMARY
TRAILING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	-0.0000	0.0	-0.00	-0.0000	0.0	-0.00
0.10	-0.0002	-0.0396	-0.0248	-1.8794	23106.4	-0.0995	-2.1004	-893.07	0.0983	1.6492	-45.51
0.20	-0.0006	-0.3354	-0.0261	-2.4584	77890.1	-0.3318	-2.7225	-1831.51	0.3511	2.3496	976.04
0.30	-0.0006	-0.6181	-0.0214	-2.2468	138616.4	-0.5933	-2.8420	-2879.16	0.6171	2.1055	2036.17
0.40	-0.0003	-0.8555	-0.0190	-1.9412	194492.1	-0.8455	-2.5536	-3883.46	0.8473	1.4873	2947.75
0.50	-0.0000	-1.0283	-0.0227	-1.3733	236682.8	-1.0357	-1.8746	-4633.98	1.0216	0.7123	3633.40
0.60	-0.0003	-1.1231	-0.0275	-0.6482	260040.7	-1.1289	-1.1397	-4995.92	1.1317	-0.1248	4061.12
0.70	-0.0007	-1.1462	-0.0264	-0.0479	265584.3	-1.1388	-0.7438	-5029.41	1.1727	-0.9239	4213.05
0.80	-0.0008	-1.1246	-0.0205	0.3106	259021.5	-1.1104	-0.6769	-4915.00	1.1482	-1.5179	4106.28
0.90	-0.0003	-1.0817	-0.0183	0.4530	247088.4	-1.0743	-0.6594	-4770.23	1.0845	-1.6575	3849.47
1.00	-0.0001	-1.0358	-0.0226	0.4319	235131.1	-1.0336	-0.5418	-4605.40	1.0239	-1.3970	3610.73
1.10	-0.0003	-0.9979	-0.0272	0.3277	225684.6	-0.9861	-0.4613	-4414.42	0.9902	-1.0748	3480.85
1.20	-0.0007	-0.9727	-0.0258	0.1882	219469.6	-0.9460	-0.5935	-4255.98	0.9762	-0.9435	3427.03
1.30	-0.0007	-0.9617	-0.0207	0.0453	216661.2	-0.9327	-0.8594	-4206.78	0.9647	-0.9449	3380.79
1.40	-0.0003	-0.9632	-0.0189	-0.0586	216988.4	-0.9461	-1.0023	-4262.49	0.9536	-0.8760	3337.50
1.50	-0.0001	-0.9714	-0.0227	-0.0924	219274.5	-0.9641	-0.9139	-4333.38	0.9548	-0.7046	3344.99
1.60	-0.0003	-0.9796	-0.0267	-0.0657	221692.2	-0.9679	-0.7627	-4346.18	0.9716	-0.6110	3413.34
1.70	-0.0006	-0.9838	-0.0256	-0.0212	222894.6	-0.9611	-0.7569	-4318.84	0.9887	-0.7207	3480.09
1.80	-0.0007	-0.9841	-0.0211	0.0073	222807.4	-0.9597	-0.8747	-4315.05	0.9896	-0.9141	3480.89
1.90	-0.0003	-0.9825	-0.0194	0.0213	222160.4	-0.9677	-0.9194	-4347.86	0.9765	-0.9757	3427.49
2.00	-0.0001	-0.9795	-0.0227	0.0390	221385.9	-0.9721	-0.8031	-4363.37	0.9659	-0.8723	3386.64
2.10	-0.0003	-0.9744	-0.0262	0.0618	220266.1	-0.9618	-0.6671	-4320.23	0.9666	-0.7769	3391.20
2.20	-0.0006	-0.9675	-0.0253	0.0701	218613.9	-0.9443	-0.6819	-4250.56	0.9700	-0.8253	3403.70
2.30	-0.0006	-0.9611	-0.0213	0.0534	216846.6	-0.9358	-0.8153	-4218.50	0.9634	-0.9390	3375.78
2.40	-0.0004	-0.9570	-0.0198	0.0282	215637.1	-0.9400	-0.8834	-4236.47	0.9490	-0.9473	3317.94
2.50	-0.0002	-0.9548	-0.0227	0.0185	215116.9	-0.9445	-0.8018	-4253.11	0.9401	-0.8272	3284.46
2.60	-0.0003	-0.9525	-0.0258	0.0269	214750.7	-0.9381	-0.6917	-4225.92	0.9433	-0.7308	3298.66
2.70	-0.0006	-0.9493	-0.0250	0.0348	214037.6	-0.9259	-0.7044	-4177.10	0.9494	-0.7750	3322.27
2.80	-0.0006	-0.9460	-0.0215	0.0284	213085.5	-0.9209	-0.8157	-4158.75	0.9463	-0.8868	3308.29
2.90	-0.0004	-0.9437	-0.0202	0.0171	212352.8	-0.9260	-0.8679	-4179.95	0.9352	-0.9096	3263.25
3.00	-0.0002	-0.9420	-0.0227	0.0181	211947.9	-0.9302	-0.7892	-4195.63	0.9276	-0.8166	3234.54
3.10	-0.0003	-0.9395	-0.0255	0.0315	211480.0	-0.9240	-0.6871	-4169.51	0.9298	-0.7381	3244.33
3.20	-0.0006	-0.9357	-0.0248	0.0405	210609.4	-0.9122	-0.6952	-4122.44	0.9341	-0.7780	3260.98
3.30	-0.0006	-0.9318	-0.0217	0.0345	209513.6	-0.9067	-0.7927	-4101.68	0.9303	-0.8747	3244.53
3.40	-0.0004	-0.9289	-0.0206	0.0228	208647.0	-0.9102	-0.8406	-4116.45	0.9196	-0.8925	3201.26
3.50	-0.0002	-0.9268	-0.0227	0.0206	208132.8	-0.9133	-0.7739	-4127.75	0.9123	-0.8075	3173.15
3.60	-0.0003	-0.9243	-0.0252	0.0296	207637.3	-0.9076	-0.6859	-4103.61	0.9137	-0.7345	3180.09
3.70	-0.0005	-0.9209	-0.0246	0.0358	206851.4	-0.8971	-0.6936	-4061.86	0.9174	-0.7663	3194.41
3.80	-0.0006	-0.9174	-0.0219	0.0299	205899.2	-0.8922	-0.7794	-4043.55	0.9142	-0.8509	3180.36
3.90	-0.0004	-0.9149	-0.0209	0.0200	205141.1	-0.8953	-0.8214	-4056.49	0.9048	-0.8681	3142.49
4.00	-0.0002	-0.9129	-0.0228	0.0191	204669.2	-0.8979	-0.7625	-4066.25	0.8982	-0.7950	3117.29

APPENDIX B

SAMPLE RUN OF A TRIPLES COMBINATION

The following pages are copies of the complete computer output package obtained from a two-second simulation of a triples combination in a braking-in-a-turn maneuver. The example illustrates use of optional spring tables, tire tables and brake torque tables. Antilock brake control systems are used on the tractor tandem rear axles, and cycling of the trailing axle can be observed on output page numbers 1.06.1, 1.10.1, and 1.14.1.

The first 20 pages are echo of the input data illustrating parameters for a triples combination; tables for suspensions, tires and brakes; an antilock system; and the vehicle summary page. These pages are normally reviewed to ensure that the desired vehicle and maneuver is being simulated.

The 60 remaining pages are the output indicating the response of each vehicle in the maneuver. In the process of exercising all options, however, the vehicle obtained is not representative and the performance indicated here should not be viewed as typical.

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

SIMULATION OPERATION PARAMETERS:

VEHICLE CONFIGURATION (NUMBER OF TRAILERS - ENTER 0 FOR A STRAIGHT TRUCK) 3
INITIAL VELOCITY (FT/SEC) 44.00
STEER TABLE (NUMBER OF LINES): POSITIVE -STEER ANGLE TABLE, NEGATIVE - PATH FOLLOWER TABLE 2
TABLE ENTRIES:

TIME (SEC)	LEFT WHEEL (DEG)	RIGHT WHEEL (DEG)
0.0	0.0	0.0
1.00	5.00	5.00

TREADLE PRESSURE TABLE (NUMBER OF LINES) 2
TABLE ENTRIES:

TIME (SEC)	PRESSURE (PSI)
0.0	0.0
0.10	30.00

MAXIMUM SIMULATION TIME (SEC) 2.00
TIME INCREMENT OF OUTPUT (SEC) 0.05

ROAD KEY = 0 : FLAT ROAD.

OUTPUT PAGE OPTION KEYS: 0 DELETES PAGES

SPRUNG MASS POSITION	SPRUNG MASS VELOCITY	SPRUNG MASS ACCELERATION	TIRE FORCES PAGES	BRAKE SUMMARY PAGES	LATERAL PAGES	UNSPRUNG MASS PAGES	TEMP PAGES
1	1	1	1	1	1	1	1

TRACTOR PARAMETERS

WHEELBASE - DISTANCE FROM FRONT AXLE TO CENTER OF REAR SUSPENSION (IN)	150.00
BASE VEHICLE CURB WEIGHT ON FRONT SUSPENSION (LB)	9437.00
BASE VEHICLE CURB WEIGHT ON REAR SUSPENSION (LB)	7953.00
SPRUNG MASS CG HEIGHT (IN. ABOVE GROUND)	40.13
SPRUNG MASS ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	36757.00
SPRUNG MASS PITCH MOMENT OF INERTIA (IN-LB-SEC**2)	105493.00
SPRUNG MASS YAW MOMENT OF INERTIA (IN-LB-SEC**2)	241479.00
PAYLOAD WEIGHT (LB)	0.0
*** ZERO ENTRY INDICATES NO PAYLOAD ***	
*** FIVE PAYLOAD DESCRIPTION PARAMETERS ARE NOT ENTERED ***	
FIFTH WHEEL LOCATION (IN. AHEAD OF REAR SUSP. CENTER)	1.00
FIFTH WHEEL HEIGHT ABOVE GROUND (IN)	47.50
TRACTOR FRAME STIFFNESS (IN-LB/DEG)	250000.00
TRACTOR FRAME TORSIONAL AXIS HEIGHT ABOVE GROUND (IN)	36.00

TRACTOR FRONT SUSPENSION AND AXLE PARAMETERS

	LEFT SIDE	RIGHT SIDE
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	1380.00	1500.00
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	5.00	5.00
COULOMB FRICTION (LB/SIDE/AXLE)	200.00	200.00

AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	5307.00
ROLL CENTER HEIGHT (IN. ABOVE GROUND)	20.00
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	0.17
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	9900.00
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	36.00
TRACK WIDTH (IN)	79.50
UNSPRUNG WEIGHT (LB)	1450.00
STEERING GEAR RATIO (DEG STEERING WHEEL/DEG ROAD WHEEL)	0.0
*** NEGATIVE OR ZERO ENTRY INDICATES NO STEERING SYSTEM ***	
*** STEERING SYSTEM PARAMETERS NOT TO BE ENTERED ***	

TRACTOR FRONT TIRES AND WHEELS

	LEFT SIDE	RIGHT SIDE
CORNERING STIFFNESS (LB/DEG/TIRE)	600.00	600.00
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	21000.00	21000.00
CAMBER STIFFNESS (LB/DEG/TIRE)	100.00	100.00
ALIGNING MOMENT (IN-LB/DEG/TIRE)	500.00	500.00
TIRE SPRING RATE (LB/IN/TIRE)	4700.00	4700.00
TIRE LOADED RADIUS (IN)	20.00	20.00
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	245.00	245.00

TRACTOR REAR SUSPENSION AND AXLE PARAMETERS

	LEADING TANDEM AXLE			TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE		LEFT SIDE	RIGHT SIDE
SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM			1		
TANDEM AXLE SEPARATION (IN BETWEEN LEADING AND TRAILING AXLES)			48.00		
STATIC LOAD TRANSFER (PERCENT LOAD ON LEAD AXLE)			50.00		
DYNAMIC LOAD TRANSFER (% BRAKE TORQUE REACTED AS TANDEM AXLE LOAD TRANSFER)			10.00		
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	3880.00	3880.00		3880.00	3880.00
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	5.00	5.00		5.00	5.00
COULOMB FRICTION (LB/SIDE/AXLE)	300.00	300.00		300.00	300.00

	LEADING TANDEM AXLE	TRAILING TANDEM AXLE
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	12230.00	12230.00
ROLL CENTER HEIGHT (IN. ABOVE GROUND)	29.60	29.60
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	0.01	0.01
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	30000.00	30000.00
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	40.75	40.75
TRACK WIDTH (IN)	72.00	72.00
UNSPRUNG WEIGHT (LB)	2450.00	2450.00

TRACTOR REAR TIRES AND WHEELS

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
DUAL TIRE SEPARATION (IN)	12.80	12.80	12.80	12.80
CORNERING STIFFNESS (LB/DEG/TIRE)	-1.00	-1.00	-201.00	-201.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***				
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***				
*** CALF LESS THAN -200. INDICATES TIRE MODEL IS BEING USED ***				
*** MODEL PARAMETERS WILL BE ECHOED FOLLOWING THE TABLE ECHOES ***				
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	-2.00	-2.00	-2.00	-2.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***				
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***				
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	0.0	0.0	0.0	0.0
TIRE SPRING RATE (LB/IN/TIRE)	4500.00	4500.00	4500.00	4500.00
TIRE LOADED RADIUS (IN)	20.00	20.00	20.00	20.00
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	229.00	229.00	229.00	190.00

TRACTOR FRONT BRAKES

	LEFT SIDE	RIGHT SIDE
TIME LAG (SEC)	0.0200	0.0200
RISE TIME (SEC)	0.1700	0.1700
BRAKE TORQUE (IN-LB/PSI/BRAKE)	1000.0000	1200.0000
BRAKE HYSTERESIS KEY: 0 ENTRY INDICATES BRAKE HYSTERESIS OPTION NOT IN USE ON VEHICLE TRAIN		0
BRAKE PROPORTIONING KEY: 0 ENTRY INDICATES BRAKE PROPORTIONING OPTION NOT IN USE ON VEHICLE TRAIN		0

TRACTOR REAR BRAKES

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
TIME LAG (SEC)	0.0500	0.0500	0.0500	0.0500
RISE TIME (SEC)	0.4000	0.4000	0.4000	0.4000
BRAKE TORQUE (IN-LB/PSI/BRAKE)	2000.0000	2000.0000	2500.0000	2500.0000

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 PARAMETERS

WHEELBASE - DISTANCE FROM KINGPIN TO CENTER OF REAR SUSPENSION (IN)	383.00
BASE VEHICLE KINGPIN STATIC LOAD (LB)	2815.00
BASE VEHICLE CURB WEIGHT ON REAR SUSPENSION (LB)	8650.00
SPRUNG MASS CG HEIGHT (IN. ABOVE GROUND)	74.80
SPRUNG MASS ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	66224.00
SPRUNG MASS PITCH MOMENT OF INERTIA (IN-LB-SEC**2)	542486.00
SPRUNG MASS YAW MOMENT OF INERTIA (IN-LB-SEC**2)	644483.00
PAYLOAD WEIGHT (LB)	46800.00
PAYLOAD DISTANCE AHEAD OF REAR SUSPENSION CENTER(IN)	183.00
PAYLOAD CG HEIGHT (IN. ABOVE GROUND)	60.00
PAYLOAD ROLL MOMENT OF INERTIA(IN-LB-SEC**2)	13000.00
PAYLOAD PITCH MOMENT OF INERTIA(IN-LB-SEC**2)	240000.00
PAYLOAD YAW MOMENT OF INERTIA(IN-LB-SEC**2)	240000.00
LOCATION OF PINTLE HOOK (IN BEHIND REAR SUSP. CENTER)	48.00
HEIGHT OF PINTLE HOOK (IN ABOVE GROUND)	40.00

TRAILER NO. 1 REAR SUSPENSION AND AXLE PARAMETERS

	LEADING TANDEM AXLE			TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE		LEFT SIDE	RIGHT SIDE
SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM			1		
TANDEM AXLE SEPARATION (IN BETWEEN LEADING AND TRAILING AXLES)			48.00		
STATIC LOAD TRANSFER (PERCENT LOAD ON LEAD AXLE)			40.00		
DYNAMIC LOAD TRANSFER (% BRAKE TORQUE REACTED AS TANDEM AXLE LOAD TRANSFER)			10.00		
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	7818.00	7818.00		7818.00	7818.00
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	5.00	5.00		5.00	5.00
COULOMB FRICTION (LB/SIDE/AXLE)	800.00	800.00		800.00	800.00
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	4746.00			4746.00	
ROLL CENTER HEIGHT (IN. ABOVE GROUND)	29.60			29.60	
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	-0.00			-0.00	
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	35490.00			35490.00	
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	38.00			38.00	
TRACK WIDTH (IN)	71.25			71.25	
UNSPRUNG WEIGHT (LB)	1530.00			1530.00	

TRAILER NO. 1 REAR TIRES AND WHEELS

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
DUAL TIRE SEPARATION (IN)	12.40	12.40	12.40	12.40
CORNERING STIFFNESS (LB/DEG/TIRE)	600.00	600.00	600.00	600.00
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	21000.00	21000.00	21000.00	21000.00
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	0.0	0.0	0.0	0.0
TIRE SPRING RATE (LB/IN/TIRE)	4500.00	4500.00	4500.00	4500.00
TIRE LOADED RADIUS (IN)	20.20	20.20	20.20	20.20
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	212.00	212.00	212.00	212.00

TRAILER NO. 1 REAR BRAKES

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
TIME LAG (SEC)	0.1400	0.1400	0.1400	0.1400
RISE TIME (SEC)	0.1700	0.1700	0.1700	0.1700
BRAKE TORQUE (IN-LB/PSI/BRAKE)	1000.0000	1000.0000	-310.0000	-310.0000

*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***

```
TRAILER NO. 2 PARAMETERS
------------------------
     DOLLY KEY: 1 = CONVERTER DOLLY, 2 = FIXED DOLLY                                   1
     DISTANCE FROM DOLLY SUSPENSION TO PINTLE HOOK (IN)                            60.00
     TURNTABLE LOCATION (IN AHEAD OF SUSP. CENTER)                                   0.0
     TURNTABLE HEIGHT ABOVE GROUND (IN)                                            52.00
     WHEELBASE - DISTANCE FROM CENTER OF FRONT SUSP. TO CENTER OF REAR SUSP. (IN) 300.00
     BASE VEHICLE CURB WEIGHT ON FRONT SUSPENSION (LB)                           8650.00
     BASE VEHICLE CURB WEIGHT ON REAR SUSPENSION (LB)                            8650.00
     SPRUNG MASS CG HEIGHT (IN. ABOVE GROUND)                                      74.80
     SPRUNG MASS ROLL MOMENT OF INERTIA (IN-LB-SEC**2)                          66224.00
     SPRUNG MASS PITCH MOMENT OF INERTIA (IN-LB-SEC**2)                        542486.00
     SPRUNG MASS YAW MOMENT OF INERTIA (IN-LB-SEC**2)                          644483.00
     PAYLOAD WEIGHT (LB)                                                             0.0
         *** ZERO ENTRY INDICATES NO PAYLOAD ***
         *** FIVE PAYLOAD DESCRIPTION PARAMETERS ARE NOT ENTERED ***
     LOCATION OF PINTLE HOOK (IN BEHIND REAR SUSP. CENTER)                         48.00
     HEIGHT OF PINTLE HOOK (IN ABOVE GROUND)                                       40.00

TRAILER NO. 2 FRONT SUSPENSION AND AXLE PARAMETERS                   LEFT SIDE            RIGHT SIDE
--------------------------------------------------                   ---------            ----------
     SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM     0
     SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)                          7818.00              7818.00
     SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)                     5.00                 5.00
     COULOMB FRICTION (LB/SIDE/AXLE)                                    800.00               800.00
                                                                     ------------------------------------
     AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)                                 4746.00
     ROLL CENTER HEIGHT (IN. ABOVE GROUND)                                        29.60
     ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)                                -0.00
     AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)                                 35490.00
     LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)                             38.00
     TRACK WIDTH (IN)                                                             71.25
     UNSPRUNG WEIGHT (LB)                                                       1530.00

TRAILER NO. 2 FRONT TIRES AND WHEELS                                 LEFT SIDE            RIGHT SIDE
------------------------------------                                 ---------            ----------

     DUAL TIRE SEPARATION (IN)                                           12.40                12.40
     CORNERING STIFFNESS  (LB/DEG/TIRE)                                 600.00               600.00
     LONGITUDINAL STIFFNESS  (LB/SLIP/TIRE)                           21000.00             21000.00
     CAMBER STIFFNESS (LB/DEG/TIRE)                                        0.0                  0.0
     ALIGNING MOMENT  (IN-LB/DEG/TIRE)                                     0.0                  0.0
     TIRE SPRING RATE (LB/IN/TIRE)                                     4500.00              4500.00
     TIRE LOADED RADIUS (IN)                                             20.20                20.20
     POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)                       212.00               212.00
```

TRAILER NO. 2 REAR SUSPENSION AND AXLE PARAMETERS

SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM	1
TANDEM AXLE SEPARATION (IN BETWEEN LEADING AND TRAILING AXLES)	48.00
STATIC LOAD TRANSFER (PERCENT LOAD ON LEAD AXLE)	50.00
DYNAMIC LOAD TRANSFER (% BRAKE TORQUE REACTED AS TANDEM AXLE LOAD TRANSFER)	10.00

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	-3.00	-3.00	-3.00	-3.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***				
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***				
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	5.00	5.00	5.00	5.00
COULOMB FRICTION (LB/SIDE/AXLE)	800.00	800.00	800.00	800.00

	LEADING TANDEM AXLE	TRAILING TANDEM AXLE
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	4746.00	4746.00
ROLL CENTER HEIGHT (IN. ABOVE GROUND)	29.60	29.60
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	-0.00	-0.00
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	35490.00	35490.00
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	38.00	38.00
TRACK WIDTH (IN)	71.25	71.25
UNSPRUNG WEIGHT (LB)	1530.00	1530.00

TRAILER NO. 2 REAR TIRES AND WHEELS

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
DUAL TIRE SEPARATION (IN)	12.40	12.40	12.40	12.40
CORNERING STIFFNESS (LB/DEG/TIRE)	600.00	600.00	600.00	600.00
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	21000.00	21000.00	21000.00	21000.00
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	0.0	0.0	0.0	0.0
TIRE SPRING RATE (LB/IN/TIRE)	4500.00	4500.00	4500.00	4500.00
TIRE LOADED RADIUS (IN)	20.20	20.20	20.20	20.20
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	212.00	212.00	212.00	212.00

TRAILER NO. 2 FRONT BRAKES

	LEFT SIDE	RIGHT SIDE
TIME LAG (SEC)	0.1400	0.1400
RISE TIME (SEC)	0.1700	0.1700
BRAKE TORQUE (IN-LB/PSI/BRAKE)	-5.0000	-5.0000
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***		
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***		

TRAILER NO. 2 REAR BRAKES

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
TIME LAG (SEC)	0.1400	0.1400	0.1400	0.1400
RISE TIME (SEC)	0.1700	0.1700	0.1700	0.1700
BRAKE TORQUE (IN-LB/PSI/BRAKE)	1000.0000	1000.0000	1000.0000	1000.0000

TRAILER NO. 3 PARAMETERS

DOLLY KEY: 1 = CONVERTER DOLLY, 2 = FIXED DOLLY	2
DISTANCE FROM DOLLY SUSPENSION TO PINTLE HOOK (IN)	60.00
TURNTABLE LOCATION (IN AHEAD OF SUSP. CENTER)	0.0
TURNTABLE HEIGHT ABOVE GROUND (IN)	52.00
WHEELBASE - DISTANCE FROM CENTER OF FRONT SUSP. TO CENTER OF REAR SUSP. (IN)	300.00
BASE VEHICLE CURB WEIGHT ON FRONT SUSPENSION (LB)	8650.00
BASE VEHICLE CURB WEIGHT ON REAR SUSPENSION (LB)	8650.00
SPRUNG MASS CG HEIGHT (IN. ABOVE GROUND)	74.80
SPRUNG MASS ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	66224.00
SPRUNG MASS PITCH MOMENT OF INERTIA (IN-LB-SEC**2)	542486.00
SPRUNG MASS YAW MOMENT OF INERTIA (IN-LB-SEC**2)	644483.00
PAYLOAD WEIGHT (LB)	0.0

*** ZERO ENTRY INDICATES NO PAYLOAD ***
*** FIVE PAYLOAD DESCRIPTION PARAMETERS ARE NOT ENTERED ***

TRAILER NO. 3 FRONT SUSPENSION AND AXLE PARAMETERS

	LEADING TANDEM AXLE LEFT SIDE	LEADING TANDEM AXLE RIGHT SIDE		TRAILING TANDEM AXLE LEFT SIDE	TRAILING TANDEM AXLE RIGHT SIDE
SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM			1		
TANDEM AXLE SEPARATION (IN BETWEEN LEADING AND TRAILING AXLES)			48.00		
STATIC LOAD TRANSFER (PERCENT LOAD ON LEAD AXLE)			50.00		
DYNAMIC LOAD TRANSFER (% BRAKE TORQUE REACTED AS TANDEM AXLE LOAD TRANSFER)			10.00		
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	7818.00	7818.00		7818.00	7818.00
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	5.00	5.00		5.00	5.00
COULOMB FRICTION (LB/SIDE/AXLE)	800.00	800.00		800.00	800.00

	LEADING TANDEM AXLE	TRAILING TANDEM AXLE
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	4746.00	4746.00
ROLL CENTER HEIGHT (IN. ABOVE GROUND)	29.60	29.60
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	-0.00	-0.00
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	35490.00	35490.00
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	38.00	38.00
TRACK WIDTH (IN)	71.25	71.25
UNSPRUNG WEIGHT (LB)	1530.00	1530.00

TRAILER NO. 3 FRONT TIRES AND WHEELS

	LEADING TANDEM AXLE LEFT SIDE	LEADING TANDEM AXLE RIGHT SIDE	TRAILING TANDEM AXLE LEFT SIDE	TRAILING TANDEM AXLE RIGHT SIDE
DUAL TIRE SEPARATION (IN)	12.40	12.40	12.40	12.40
CORNERING STIFFNESS (LB/DEG/TIRE)	600.00	600.00	600.00	600.00
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	21000.00	21000.00	21000.00	21000.00
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	0.0	0.0	0.0	0.0
TIRE SPRING RATE (LB/IN/TIRE)	4500.00	4500.00	4500.00	4500.00
TIRE LOADED RADIUS (IN)	20.20	20.20	20.20	20.20
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	212.00	212.00	212.00	212.00

TRAILER NO. 3 REAR SUSPENSION AND AXLE PARAMETERS

	LEADING TANDEM AXLE			TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE		LEFT SIDE	RIGHT SIDE
SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM			1		
TANDEM AXLE SEPARATION (IN BETWEEN LEADING AND TRAILING AXLES)			48.00		
STATIC LOAD TRANSFER (PERCENT LOAD ON LEAD AXLE)			50.00		
DYNAMIC LOAD TRANSFER (% BRAKE TORQUE REACTED AS TANDEM AXLE LOAD TRANSFER)			10.00		
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	7818.00	7818.00		7818.00	7818.00
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	5.00	5.00		5.00	5.00
COULOMB FRICTION (LB/SIDE/AXLE)	800.00	800.00		800.00	800.00

	LEADING TANDEM AXLE	TRAILING TANDEM AXLE
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	4746.00	4746.00
ROLL CENTER HEIGHT (IN. ABOVE GROUND)	29.60	29.60
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	-0.00	-0.00
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	35490.00	35490.00
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	38.00	38.00
TRACK WIDTH (IN)	71.25	71.25
UNSPRUNG WEIGHT (LB)	1530.00	1530.00

TRAILER NO. 3 REAR TIRES AND WHEELS

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
DUAL TIRE SEPARATION (IN)	12.40	12.40	12.40	12.40
CORNERING STIFFNESS (LB/DEG/TIRE)	600.00	600.00	600.00	600.00
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	21000.00	21000.00	21000.00	21000.00
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	0.0	0.0	0.0	0.0
TIRE SPRING RATE (LB/IN/TIRE)	4500.00	4500.00	4500.00	4500.00
TIRE LOADED RADIUS (IN)	20.20	20.20	20.20	20.20
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	212.00	212.00	212.00	212.00

TRAILER NO. 3 FRONT BRAKES

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
TIME LAG (SEC)	0.1400	0.1400	0.1400	0.1400
RISE TIME (SEC)	0.1700	0.1700	0.1700	0.1700
BRAKE TORQUE (IN-LB/PSI/BRAKE)	1000.0000	1000.0000	1000.0000	1000.0000

TRAILER NO. 3 REAR BRAKES

	LEADING TANDEM AXLE		TRAILING TANDEM AXLE	
	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
TIME LAG (SEC)	0.1400	0.1400	0.1400	0.1400
RISE TIME (SEC)	0.1700	0.1700	0.1700	0.1700
BRAKE TORQUE (IN-LB/PSI/BRAKE)	1000.0000	1000.0000	1000.0000	1000.0000

ANTILOCK KEY: 1 INDICATES ANTILOCK WILL BE USED 1

DICTIONARY OF ANTI-LOCK VARIABLES/PARAMETERS AVAILABLE TO USER.

VARIABLE I.D.	DESCRIPTION	VARIABLE I.D.	DESCRIPTION
1	1.0	45	WMAX1
2	TIME	46	WMAX2
3	OMEGA	47	TWMAX1
4	OMEGADOT	48	TWMAX2
5	XDOT	49	WMIN
6	XDDOT	50	TWMIN
7	POFF1	51	TPMAX2
8	POFF2	52	TPMIN2
9	PON1	53	GPV1
10	PON2	54	GPV2
11	TOFF1	55	GPV3
12	TON1	56	GPV4
13	XDOFF	57	GPV5
14	XDON	58	FOS4
15	WOFF	59	FOS5
16	WON	60	OMEGDIF
17	WDOFF		
18	WDON		
19	WDMAX		
20	WDMIN		
21	TPMAX1		
22	TPMIN1		
23	WLOCK		
24	TLOCK		
25	SLON		
26	SLOFF		
27	PMAX1		
28	PMAX2		
29	PMIN1		
30	PMIN2		
31	PD		
32	ON		
33	TMOD		
34	SLIP		
35	P		
36	CYCNT		
37	SQUARE		
38	SQUARN		
39	TOFF2		
40	TON2		
41	FOS1		
42	FOS2		
43	FOS3		
44	GPCNT		

*** UNIT 1 SUSPENSION 1 AXLE 1 LEFT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 1 SUSPENSION 1 AXLE 1 RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** ANTI-LOCK SUBROUTINE INPUT PARAMETER TABLE 6 --- UNIT 1 SUSPENSION 2 AXLE 1 LEFT SIDE ***

SYMBOL	DESCRIPTION	INITIAL VALUE	FIRST ADAPTIVE VALUE	SECOND ADAPTIVE VALUE	INITIAL VALUE VARIABLE	FIRST ADAPTIVE VARIABLE	SECOND ADAPTIVE VARIABLE	FIRST BREAK-PT	SECOND BREAK-PT
INEQUALITY EXPRESSION: 1									
C(1)	COEFFICIENT(1)	-1.0000			4				
C(2)	COEFFICIENT(2)	-30.0000			1				
INEQUALITY EXPRESSION: 2									
C(1)	COEFFICIENT(1)	0.9000			45				
C(2)	COEFFICIENT(2)	-1.0000			3				
C(3)	COEFFICIENT(3)	-20.0000			2				
C(4)	COEFFICIENT(4)	20.0000			47, 1				
INEQUALITY EXPRESSION: 3									
C(1)	COEFFICIENT(1)	1.0000			23				
C(2)	COEFFICIENT(2)	-0.1000			1				
INEQUALITY EXPRESSION: 5									
C(1)	COEFFICIENT(1)	1.0000			3				
C(2)	COEFFICIENT(2)	-1.0000			15				
C(3)	COEFFICIENT(3)	12.0000			2				
C(4)	COEFFICIENT(4)	-12.0000			11, 1				
C(5)	COEFFICIENT(5)	0.1000			1, 1				
INEQUALITY EXPRESSION: 6									
C(1)	COEFFICIENT(1)	1.0000			4				
C(2)	COEFFICIENT(2)	-1.0000			1				
EPSILION 1:									
H(1)	COEFFICIENT(1)	1.0000			35				
H(2)	COEFFICIENT(2)	-1.0000			55				
H(3)	COEFFICIENT(3)	0.0	-1000.0000		1	36		1.500	
EPSILION 2:									
G(1)	COEFFICIENT(1)	0.0	1.0000		35	41		0.500	
G(2)	COEFFICIENT(2)	-1.0000			27				

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   G(3)          COEFFICIENT(3)      1.0000                   2
   G(4)          COEFFICIENT(4)     -1.0000                  21,   1

 EPSILION 3:

   R(1)          COEFFICIENT(1)      5.0000                   1

 EPSILION 4:

   S(1)          COEFFICIENT(1)      0.0        1.0000       35        41          0.500
   S(2)          COEFFICIENT(2)     -1.0000                  27
   S(3)          COEFFICIENT(3)      1.0000                   2
   S(4)          COEFFICIENT(4)     -1.0000                  21,   1

 ONE-SHOT 1:

 OS1(1)          COEFFICIENT(1)      1.0000                  12
 OS1(2)          COEFFICIENT(2)     -1.0000                  11
 OS1(3)          COEFFICIENT(3)     -0.1000                   1

 OS1(1)          COEFFICIENT(1)      0.5000                   1
 OS1(2)          COEFFICIENT(2)     -1.0000                  32

 GEN. PURP. VARID. 3:

 GPV(1)          COEFFICIENT(1)      0.6200                  27

 ** NON-ADAPTIVE ANTI-LOCK PARAMETERS. **

  TAU1           LOGIC TIME DELAY     0.0
  TAU2                  "             0.0
  TAU3                  "             0.0
  TAU4                  "             0.0
  X1             EPSILON 1 BREAK-PT   0.0
  X2                    "             0.1000
  X3             EPSILON 2 BREAK-PT  -5.0000
  X4                    "             2.0000
  PFE1      EXP. PRESSURE FALL RATE  18.0000
  PFE2                  "             6.5000
  PFE3                  "             6.5000
  PRE1      EXP. PRESSURE RISE RATE  11.5000
  PRE2                  "            11.5000
  PRE3                  "             0.0
  X5             EPSILON 3 BREAK-PT   0.0
  X6                    "            50.0000
  X7             EPSILON 4 BREAK-PT  -5.0000
  X8                    "             2.5000
  PFL1      LIN. PRESSURE FALL RATE   0.0
  PFL2                  "             0.0
  PFL3                  "             0.0
  PRL1      LIN. PRESSURE RISE RATE   0.0
  PRL2                  "             0.0
  PRL3                  "            45.0000
  TAUON     PRESSURE-ON TIME DELAY    0.0200
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TAUOFF      PRESSURE-OFF TIME DELAY          0.0200
TAUW        TIME CONSTANT-WHEEL RATE         0.0100
TAUWD       TIME CONSTANT-WHEEL ACCEL.       0.0100
OP12        LOGICAL OPERATOR SWITCH               1
OP23                   "                          0
OP34                   "                          0
OP56        LOGICAL OPERATOR SWITCH               1
OP67                   "                          0
OP78                   "                          0
TOS1        ONE-SHOT TIME DURATION           2.0000
TSAMPLE     ANTI-LOCK SAMPLING RATE          0.0200
OPTION      SIDE-TO-SIDE                          1
OMEGDIF     SIDE-TO-SIDE TOLERANCE         100.0000

*** UNIT 1  SUSPENSION 2  AXLE 1  RIGHT SIDE WILL HAVE THE SAME ANTI-LOCK SYSTEM AS
    UNIT 1  SUSPENSION 2  AXLE 1  LEFT  SIDE

*** UNIT 1  SUSPENSION 2  AXLE 2  LEFT  SIDE WILL HAVE THE SAME ANTI-LOCK SYSTEM AS
    UNIT 1  SUSPENSION 2  AXLE 1  LEFT  SIDE

*** UNIT 1  SUSPENSION 2  AXLE 2  RIGHT SIDE WILL HAVE THE SAME ANTI-LOCK SYSTEM AS
    UNIT 1  SUSPENSION 2  AXLE 1  LEFT  SIDE

*** UNIT 2  SUSPENSION 2  AXLE 1  LEFT  SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 2  SUSPENSION 2  AXLE 1  RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 2  SUSPENSION 2  AXLE 2  LEFT  SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 2  SUSPENSION 2  AXLE 2  RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 3  SUSPENSION 1  AXLE 1  LEFT  SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 3  SUSPENSION 1  AXLE 1  RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 3  SUSPENSION 2  AXLE 1  LEFT  SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 3  SUSPENSION 2  AXLE 1  RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 3  SUSPENSION 2  AXLE 2  LEFT  SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 3  SUSPENSION 2  AXLE 2  RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 4  SUSPENSION 1  AXLE 1  LEFT  SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 4  SUSPENSION 1  AXLE 1  RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 4  SUSPENSION 1  AXLE 2  LEFT  SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 4  SUSPENSION 1  AXLE 2  RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 4  SUSPENSION 2  AXLE 1  LEFT  SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 4  SUSPENSION 2  AXLE 1  RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 4  SUSPENSION 2  AXLE 2  LEFT  SIDE WILL HAVE NO ANTIL-LOCK SYSTEM

*** UNIT 4  SUSPENSION 2  AXLE 2  RIGHT SIDE WILL HAVE NO ANTIL-LOCK SYSTEM
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SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 PAYLOAD = 0.0 LBS.	EMPTY	LOADED
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO REAR SUSPENSION (IN)	150.000	150.000
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO GROUND (IN)	74.800	74.800
ROLL MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)	66223.938	66223.938
PITCH MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)	542485.938	542485.938
YAW MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)	644482.938	644482.938

TRAILER NO. 2 PAYLOAD = 0.0 LBS.	EMPTY	LOADED
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO REAR SUSPENSION (IN)	168.057	168.057
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO GROUND (IN)	74.800	74.800
ROLL MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)	66223.938	66223.938
PITCH MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)	542485.938	542485.938
YAW MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)	644482.938	644482.938

TRAILER NO. 1 PAYLOAD = 46800.000 LBS.	EMPTY	LOADED
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO REAR SUSPENSION (IN)	125.082	174.182
DISTANCE FROM TRAILER SPRUNG MASS CENTER TO GROUND (IN)	74.800	62.253
ROLL MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)	66223.938	83267.250
PITCH MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)	542485.938	848450.250
YAW MOMENT OF INERTIA OF TRAILER SPRUNG MASS (IN-LB-SEC**2)	644482.938	946404.000

TRACTOR PAYLOAD = 0.0 LBS	EMPTY	LOADED
DISTANCE FROM TRACTOR SPRUNG MASS CENTER TO REAR SUSPENSION (IN)	108.519	108.519
DISTANCE FROM TRACTOR SPRUNG MASS CENTER TO GROUND (IN)	40.130	40.130
ROLL MOMENT OF INERTIA OF TRACTOR SPRUNG MASS (IN-LB-SEC**2)	36756.996	36756.996
PITCH MOMENT OF INERTIA OF TRACTOR SPRUNG MASS (IN-LB-SEC**2)	105492.938	105492.938
YAW MOMENT OF INERTIA OF TRACTOR SPRUNG MASS (IN-LB-SEC**2)	241479.000	241479.000

THE STATIC LOADS ON THE AXLES ARE:

AXLE NUMBER	LOAD
NS(1,1,1)	9604.379
NS(1,2,1)	16445.969
NS(1,2,2)	16445.969
NS(2,2,1)	13263.469
NS(2,2,2)	19895.203
NS(3,1,1)	8650.000
NS(3,2,1)	4325.000
NS(3,2,2)	4325.000
NS(4,1,1)	4325.000
NS(4,1,2)	4325.000
NS(4,2,1)	4325.000
NS(4,2,2)	4325.000
TOTAL	110254.938

THE TRACTOR TOTAL MASS CENTER IS 68.600 INCHES BEHIND THE FRONT AXLE
THE TOTAL YAW MOMENT OF INERTIA IS 401381.875 IN-LB-SEC**2

THE FIRST TRAILER TOTAL MASS CENTER IS 217.966 INCHES BEHIND THE KINGPIN
THE TOTAL YAW MOMENT OF INERTIA IS 1188344.000 IN-LB-SEC**2

THE SECOND TRAILER TOTAL MASS CENTER IS 150.000 INCHES BEHIND THE TURNTABLE CENTER
THE TOTAL YAW MOMENT OF INERTIA IS 941574.000 IN-LB-SEC**2

THE THIRD TRAILER TOTAL MASS CENTER IS 150.000 INCHES BEHIND THE TURNTABLE CENTER
THE TOTAL YAW MOMENT OF INERTIA IS 1046017.500 IN-LB-SEC**2

SPRING TABLES

NO. OF LINES	FORCE (LB)	DEFLECTION (IN)	TABLE NO.
5			-3
	-4000.00	-5.00	
	0.0	0.0	
	3000.00	0.50	
	9000.00	1.00	
	32000.00	4.00	

SPRING STATIC EQUILIBRIUM CONDITION: 1397.50 LB, 0.23 INCHES. UNIT 3 SUSP 2 AXLE 1

SPRING STATIC EQUILIBRIUM CONDITION: 1397.50 LB, 0.23 INCHES. UNIT 3 SUSP 2 AXLE 2

MU-Y VS ALPHA TABLES

NO. OF LOADS	NO. OF VELOCITIES	TABLE NO.
3	3	-2

VELOCITY = 25.00 FT/SEC LOAD = 3000.00 LB

ALPHA (DEG)	MU - Y
0.0	0.0
5.00	0.50
10.00	0.80

VELOCITY = 25.00 FT/SEC LOAD = 5000.00 LB

ALPHA (DEG)	MU - Y
0.0	0.0
5.00	0.40
10.00	0.70

VELOCITY = 25.00 FT/SEC LOAD = 7000.00 LB

ALPHA (DEG)	MU - Y
0.0	0.0
5.00	0.30
10.00	0.60

VELOCITY = 50.00 FT/SEC LOAD = 3000.00 LB

ALPHA (DEG)	MU - Y
0.0	0.0
5.00	0.50
10.00	0.80

VELOCITY = 50.00 FT/SEC LOAD = 5000.00 LB

ALPHA (DEG)	MU - Y
0.0	0.0
5.00	0.40
10.00	0.70

VELOCITY = 50.00 FT/SEC LOAD = 7000.00 LB

ALPHA (DEG)	MU - Y
0.0	0.0
5.00	0.30
10.00	0.60

VELOCITY = 75.00 FT/SEC LOAD = 3000.00 LB

ALPHA (DEG)	MU - Y
0.0	0.0
5.00	0.50
10.00	0.80

VELOCITY = 75.00 FT/SEC LOAD = 5000.00 LB

ALPHA (DEG)	MU - Y
0.0	0.0
5.00	0.40
10.00	0.70

VELOCITY = 75.00 FT/SEC LOAD = 7000.00 LB

ALPHA (DEG)	MU - Y
0.0	0.0
5.00	0.30
10.00	0.60

ROLL-OFF TABLE

	SLIP	
ALPHA	0.0	1.00
0.0	1.00	0.35
20.00	1.00	0.35

MU-X VS. SLIP TABLES

TABLE NO. -2

NO. OF LOADS	NO. OF VELOCITIES
3	3

VELOCITY = 30.00 FT/SEC LOAD = 2000.00 LB

SLIP	MU - X
0.0	0.0
0.20	1.00
1.00	0.60

VELOCITY = 30.00 FT/SEC LOAD = 5000.00 LB

SLIP	MU - X
0.0	0.0
0.20	0.80
1.00	0.40

VELOCITY = 30.00 FT/SEC LOAD = 8000.00 LB

SLIP	MU - X
0.0	0.0
0.20	0.60
1.00	0.20

VELOCITY = 45.00 FT/SEC LOAD = 2000.00 LB

SLIP	MU - X
0.0	0.0
0.20	0.90
1.00	0.50

VELOCITY = 45.00 FT/SEC LOAD = 5000.00 LB

SLIP	MU - X
0.0	0.0
0.20	0.70
1.00	0.30

VELOCITY = 45.00 FT/SEC LOAD = 8000.00 LB

SLIP	MU - X
0.0	0.0
0.20	0.50
1.00	0.10

```
VELOCITY =  60.00 FT/SEC LOAD =    2000.00 LB
     SLIP                  MU - X
     ----                  ------
            0.0             0.0
            0.20            0.80
            1.00            0.40

VELOCITY =  60.00 FT/SEC LOAD =    5000.00 LB
     SLIP                  MU - X
     ----                  ------
            0.0             0.0
            0.20            0.60
            1.00            0.20

VELOCITY =  60.00 FT/SEC LOAD =    8000.00 LB
     SLIP                  MU - X
     ----                  ------
            0.0             0.0
            0.20            0.40
            1.00            0.05
```

ROLL-OFF TABLE

ALPHA	SLIP 0.0	SLIP 1.00
0.0	1.00	1.00
20.00	0.50	1.00

TABLE NO.: -310.00

BRAKE TYPE KEY: 0 INDICATES WEDGE BRAKE; 1 CAM BRAKE. 0

BRAKE MODEL PARAMETERS:

CHAMBER AREA (IN**2)	16.00
DRUM DIAMETER (IN)	15.00
WEDGE ANGLE (DEG) / SLACK ADJ. LENGTH (IN)	10.00
BRAKE FACTOR COEFF. 1	5.50
BRAKE FACTOR COEFF. 2	0.0
BRAKE FACTOR COEFF. 3	-0.01
BRAKE FACTOR COEFF. 4	0.0
PUSHOUT PRESSURE (PSI)	5.00

INITIAL BRAKE TEMPERATURE TABLE:

TEMP (DEG-F)	GAIN
0.0	1.00
150.00	1.00
200.00	1.06
250.00	1.09
300.00	1.17
350.00	1.21
600.00	1.21
720.00	0.0
800.00	0.0

THERMAL PROPERTIES:

DRUM RUBBING AREA (FT**2)	1.96
DRUM THICKNESS (FT)	0.0417
DRUM CONVECTION COEFFICIENT (BTU/SEC/IN**2/DEG-F)	0.0
INITIAL DRUM TEMP (DEG-F)	70.00
AMBIENT TEMP (DEG-F)	70.00
LINING RUBBING AREA (FT**2)	1.31
LINING THICKNESS (FT)	0.0417
LINING CONVECTION COEFFICIENT (BTU/SEC/IN**2/DEG-F)	0.0
INITIAL LINING TEMP (DEG-F)	70.00

PRESSURE VS TORQUE TABLES

NO. OF LINES	PRESSURE (PSI)	TORQUE (IN-LB)	TABLE NO
5			-5
	0.0	0.0	
	10.00	0.0	
	20.00	20000.00	
	30.00	25000.00	
	100.00	150000.00	

SEMI-EMPERICAL TIRE MODEL PARAMETERS

TIRE MODEL NO. -201.00

VARIABLE DESCRIPTION	INITIAL VALUE	D(VAR)/DLOAD	D(VAR)/DVELOCITY
NOMINAL CORNERING STIFFNESS (LB/DEG/TIRE	500.00	0.0	0.0
PEAK FRICTION VALUE (PER TIRE)	0.60	0.0	0.0
LOCKED WHEEL FRICTION VALUE (PER TIRE)	0.40	0.0	0.0
SLIP VALUE AT PEAK FRICTION (PER TIRE)	0.20	0.0	0.0
NOMINAL PNEUMATIC TRAIL (IN/TIRE)	2.00	0.0	0.0
LATERAL STIFFNESS (LB/IN/TIRE)	1000000.00	0.0	0.0
NOMINAL VERTICAL LOAD (LB/TIRE)	5000.00	N/A	N/A
NOMINAL VELOCITY (FT/SEC/TIRE)	50.00	N/A	N/A

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR SPRUNG MASS POSITION

TIME (SEC)	FORWARD (FT)	LATERAL (FT)	VERTICAL (FT)	ROLL (DEG)	PITCH (DEG)	HEADING (DEG)	TURN RADIUS (FT)	SIDE SLIP (DEG)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	************	0.0
0.05	2.3100	0.0003	0.0000	-0.0037	-0.0001	0.0015	3434.6738	0.0192
0.10	4.5094	0.0020	0.0002	-0.0223	-0.0030	0.0110	1901.5537	0.0618
0.15	6.7059	0.0062	0.0014	-0.0527	-0.0236	0.0344	1306.5378	0.1200
0.20	8.8957	0.0140	0.0056	-0.0854	-0.0742	0.0763	992.2312	0.1897
0.25	11.0768	0.0267	0.0147	-0.1184	-0.1554	0.1408	798.0481	0.2669
0.30	13.2501	0.0451	0.0290	-0.1585	-0.2561	0.2321	665.2861	0.3475
0.35	15.4152	0.0706	0.0465	-0.2114	-0.3768	0.3540	560.0181	0.4296
0.40	17.5691	0.1042	0.0634	-0.2742	-0.5137	0.5093	469.8289	0.5164
0.45	19.7061	0.1472	0.0769	-0.3403	-0.6268	0.7004	403.2927	0.6085
0.50	21.8199	0.2008	0.0852	-0.4057	-0.6784	0.9281	357.3643	0.7017
0.55	23.9055	0.2658	0.0870	-0.4715	-0.6774	1.1917	324.2126	0.7904
0.60	25.9601	0.3428	0.0831	-0.5398	-0.6548	1.4885	300.3394	0.8718
0.65	27.9834	0.4323	0.0766	-0.6103	-0.6244	1.8163	279.6824	0.9443
0.70	29.9752	0.5348	0.0712	-0.6819	-0.5864	2.1738	249.7223	1.0155
0.75	31.9362	0.6510	0.0692	-0.7560	-0.5548	2.5570	236.8976	1.0921
0.80	33.8663	0.7814	0.0705	-0.8325	-0.5567	2.9679	215.8598	1.1729
0.85	35.7659	0.9267	0.0744	-0.9097	-0.5997	3.4080	199.0483	1.2616
0.90	37.6354	1.0877	0.0805	-0.9822	-0.6600	3.8807	182.4574	1.3549
0.95	39.4745	1.2649	0.0878	-1.0459	-0.7113	4.3893	166.7319	1.4562
1.00	41.2826	1.4592	0.0942	-1.0992	-0.7504	4.9355	154.1320	1.5633
1.05	43.0586	1.6707	0.0979	-1.1368	-0.7841	5.5183	156.2698	1.6398
1.10	44.8022	1.8983	0.0987	-1.1470	-0.8043	6.1304	156.2193	1.6732
1.15	46.5128	2.1411	0.0975	-1.1418	-0.7955	6.7650	154.0296	1.6768
1.20	48.1893	2.3980	0.0953	-1.1409	-0.7619	7.4164	150.3525	1.6642
1.25	49.8310	2.6685	0.0924	-1.1487	-0.7284	8.0787	146.2389	1.6455
1.30	51.4379	2.9518	0.0894	-1.1554	-0.7117	8.7474	142.2749	1.6263
1.35	53.0107	3.2478	0.0878	-1.1575	-0.7066	9.4198	138.4256	1.6089
1.40	54.5499	3.5558	0.0882	-1.1645	-0.7047	10.0937	134.6778	1.5956
1.45	56.0560	3.8754	0.0901	-1.1835	-0.7114	10.7671	131.2444	1.5881
1.50	57.5292	4.2060	0.0921	-1.2065	-0.7341	11.4380	125.7937	1.5877
1.55	58.9712	4.5479	0.0931	-1.2196	-0.7413	12.1052	113.7892	1.6423
1.60	60.3852	4.9025	0.0899	-1.2171	-0.7016	12.7726	108.2998	1.7297
1.65	61.7683	5.2688	0.0816	-1.2072	-0.6339	13.4379	111.4251	1.8170
1.70	63.1131	5.6432	0.0721	-1.1996	-0.5850	14.0858	120.8770	1.8584
1.75	64.4182	6.0229	0.0664	-1.1919	-0.5672	14.7125	126.0487	1.8602
1.80	65.6866	6.4070	0.0676	-1.1767	-0.5768	15.3223	123.2215	1.8587
1.85	66.9216	6.7955	0.0752	-1.1489	-0.6179	15.9195	116.7011	1.8832
1.90	68.1254	7.1890	0.0861	-1.1052	-0.6913	16.5064	103.4266	1.9492
1.95	69.3013	7.5891	0.0950	-1.0464	-0.7462	17.0873	95.3043	2.0942
2.00	70.4502	7.9966	0.0969	-0.9797	-0.7515	17.6633	95.4813	2.2615

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR SPRUNG MASS VELOCITY (BODY AXES)

TIME (SEC)	FORWARD (FT/SEC)	LATERAL (FT/SEC)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	PITCH (DEG/SEC)	HEADING (DEG/SEC)
0.0	44.00	0.0	0.0	0.0	0.0	0.0
0.05	44.00	0.01	0.00	-0.20	-0.01	0.09
0.10	43.97	0.05	0.01	-0.52	-0.13	0.31
0.15	43.88	0.09	0.03	-0.65	-0.61	0.64
0.20	43.71	0.14	0.08	-0.65	-1.28	1.05
0.25	43.54	0.20	0.12	-0.70	-1.83	1.54
0.30	43.39	0.26	0.14	-0.92	-2.14	2.11
0.35	43.21	0.32	0.08	-1.16	-2.61	2.75
0.40	42.94	0.39	-0.06	-1.28	-2.65	3.45
0.45	42.54	0.45	-0.23	-1.28	-1.67	4.18
0.50	42.02	0.51	-0.39	-1.24	-0.40	4.92
0.55	41.43	0.57	-0.51	-1.27	0.33	5.62
0.60	40.81	0.62	-0.58	-1.32	0.52	6.26
0.65	40.19	0.66	-0.56	-1.35	0.67	6.86
0.70	39.59	0.70	-0.47	-1.38	0.74	7.42
0.75	38.99	0.74	-0.37	-1.43	0.32	7.94
0.80	38.40	0.79	-0.30	-1.47	-0.56	8.50
0.85	37.82	0.83	-0.28	-1.42	-1.24	9.10
0.90	37.25	0.88	-0.27	-1.26	-1.29	9.78
0.95	36.67	0.93	-0.29	-1.04	-1.02	10.53
1.00	36.08	0.98	-0.34	-0.81	-0.89	11.29
1.05	35.48	1.02	-0.42	-0.32	-0.79	11.96
1.10	34.87	1.02	-0.47	0.20	-0.35	12.48
1.15	34.24	1.00	-0.49	0.29	0.28	12.89
1.20	33.60	0.98	-0.48	0.09	0.55	13.17
1.25	32.96	0.95	-0.46	-0.01	0.30	13.33
1.30	32.32	0.92	-0.43	0.09	-0.05	13.42
1.35	31.71	0.89	-0.38	0.12	-0.16	13.47
1.40	31.10	0.87	-0.34	-0.10	-0.24	13.48
1.45	30.50	0.85	-0.32	-0.30	-0.52	13.44
1.50	29.91	0.83	-0.32	-0.23	-0.75	13.37
1.55	29.40	0.84	-0.38	0.07	0.05	13.33
1.60	28.91	0.87	-0.45	0.33	1.03	13.39
1.65	28.29	0.90	-0.49	0.33	1.00	13.20
1.70	27.55	0.89	-0.43	0.26	0.45	12.75
1.75	26.84	0.87	-0.30	0.33	-0.13	12.35
1.80	26.20	0.85	-0.15	0.54	-0.68	12.05
1.85	25.61	0.84	-0.06	0.83	-1.37	11.81
1.90	25.07	0.85	-0.06	1.17	-1.66	11.62
1.95	24.63	0.90	-0.18	1.45	-0.79	11.59
2.00	24.10	0.95	-0.33	1.43	0.11	11.34

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.02.1

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TIME	TRACTOR SPRUNG MASS ACCELERATION (BODY AXES)						INERTIAL ACCEL. ALONG BODY AXES	
(SEC)	FORWARD (FT/SEC**2)	LATERAL (FT/SEC**2)	VERTICAL (FT/SEC**2)	ROLL (DEG/SEC**2)	PITCH (DEG/SEC**2)	HEADING (DEG/SEC**2)	LONGITUDINAL (FT/SEC**2)	LATERAL (FT/SEC**2)
0.0	0.0000	0.0000	0.0	-0.0000	-0.0000	-0.0000	0.0000	0.0000
0.05	-0.0854	0.5052	0.0156	-6.7560	-1.0247	3.2372	-0.0854	0.5722
0.10	-1.0895	0.7844	-3.5197	-4.8639	-83.2715	5.6036	-1.0898	1.0239
0.15	-2.8038	0.9884	-3.0892	-0.6425	-90.3057	7.3561	-2.8052	1.4777
0.20	-3.5145	1.1251	-2.8048	0.2290	-90.1478	8.9578	-3.5189	1.9256
0.25	-3.0944	1.2020	-3.0597	-2.6451	-84.9013	10.6193	-3.1038	2.3741
0.30	-3.1098	1.2236	-4.0983	-5.4305	-86.2228	12.1188	-3.1249	2.8273
0.35	-4.3837	1.2447	-6.0591	-3.8000	-85.7616	13.2195	-4.4029	3.3231
0.40	-6.7010	1.3068	-7.1694	-0.9869	-68.5827	14.1626	-6.7213	3.8882
0.45	-9.3379	1.3168	-7.1437	1.0878	-51.1232	14.6451	-9.3640	4.4131
0.50	-11.3664	1.2269	-6.6434	-0.0384	-56.0671	14.3909	-11.4079	4.8254
0.55	-12.3559	1.1044	-5.8452	-1.0201	-70.1471	12.9617	-12.4148	5.1534
0.60	-12.4509	0.9412	-4.3961	-0.8158	-75.3835	12.0284	-12.5240	5.3838
0.65	-12.1929	0.8053	-2.6542	-0.3406	-74.3316	11.5819	-12.2788	5.6070
0.70	-12.0008	0.9749	-1.7034	-1.3050	-79.9428	8.4426	-12.0978	6.0924
0.75	-11.8818	0.8510	-2.0638	-0.9709	-92.1969	10.5629	-11.9869	6.2439
0.80	-11.7170	0.9648	-2.9729	-0.3322	-95.8947	10.8018	-11.8306	6.6513
0.85	-11.5137	0.9975	-3.5514	2.2653	-85.1497	12.3294	-11.6399	6.9949
0.90	-11.5433	1.0473	-3.9107	3.9793	-73.5181	13.8900	-11.6876	7.4014
0.95	-11.7369	1.1079	-4.5568	4.4467	-72.9503	14.5645	-11.9029	7.8394
1.00	-11.9793	1.0585	-5.2605	5.3714	-76.7157	14.5745	-12.1680	8.1637
1.05	-12.1149	0.3722	-5.2865	12.4053	-72.9937	11.0322	-12.3211	7.7742
1.10	-12.2903	-0.0966	-4.5361	6.5477	-65.4132	8.6435	-12.5091	7.4995
1.15	-12.7230	-0.3830	-3.7983	-2.4610	-67.0002	6.3109	-12.9508	7.3217
1.20	-12.9422	-0.5110	-3.5393	-4.1209	-78.2176	3.7245	-13.1711	7.2133
1.25	-12.8627	-0.5255	-3.4206	0.5201	-85.4359	1.6672	-13.0853	7.1426
1.30	-12.5000	-0.5007	-3.0537	2.4221	-82.5009	0.7380	-12.7146	7.0708
1.35	-12.1901	-0.4527	-2.7854	-2.1278	-78.3794	0.0204	-12.3984	7.0026
1.40	-12.0352	-0.3863	-3.1043	-5.4540	-81.2260	-0.9305	-12.2376	6.9301
1.45	-11.9719	-0.3144	-3.7978	-1.7919	-85.0785	-1.8106	-12.1673	6.8389
1.50	-11.4308	-0.0686	-4.2495	4.3034	-68.9027	-2.3847	-11.6199	6.9086
1.55	-9.4628	0.5794	-5.3401	6.7838	-57.9697	0.0704	-9.6592	7.4216
1.60	-10.4644	0.7394	-5.3059	2.7173	-61.5199	0.0028	-10.6766	7.5003
1.65	-14.3073	0.2904	-3.5522	-1.8864	-85.6830	-8.5190	-14.5225	6.8083
1.70	-14.8114	-0.2565	-1.8175	-0.3836	-91.3703	-9.7200	-15.0136	5.8764
1.75	-13.5824	-0.4317	-0.7737	3.0381	-87.7704	-7.5625	-13.7694	5.3533
1.80	-12.1463	-0.2508	-1.2811	5.1026	-90.2233	-5.8569	-12.3232	5.2597
1.85	-11.3454	0.0498	-2.9515	6.6437	-92.8546	-4.9660	-11.5176	5.3299
1.90	-9.5000	0.7660	-5.1097	6.3188	-65.8680	-3.1057	-9.6712	5.8532
1.95	-9.0203	1.1315	-7.0263	3.9411	-54.4957	-0.7847	-9.1999	6.1186
2.00	-12.5492	0.8739	-6.1304	-5.9534	-66.7989	-12.0790	-12.7381	5.6516

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR FRONT AXLE TIRE FORCES

TIME (SEC)	LEFT SIDE VERTICAL (LB)	LEFT SIDE LONG. (LB)	LEFT SIDE LATERAL (LB)	LEFT SIDE MU-X	LEFT SIDE MU-Y	RIGHT SIDE VERTICAL (LB)	RIGHT SIDE LONG. (LB)	RIGHT SIDE LATERAL (LB)	RIGHT SIDE MU-X	RIGHT SIDE MU-Y	STEER ANGLE LEFT (DEG)	STEER ANGLE RIGHT (DEG)
0.0	4802.19	-0.0	0.0	0.0	0.0	4802.19	-0.0	0.0	0.0	0.0	0.0	0.0
0.05	4861.35	-24.69	138.58	-0.0051	0.0285	4743.45	-27.09	135.18	-0.0057	0.0285	0.26	0.26
0.10	4934.58	-193.44	248.30	-0.0392	0.0503	4685.64	-224.42	235.54	-0.0479	0.0503	0.52	0.52
0.15	5028.05	-480.08	351.11	-0.0955	0.0698	4697.23	-564.25	327.49	-0.1201	0.0697	0.76	0.76
0.20	5232.82	-736.08	458.88	-0.1407	0.0877	4785.11	-870.16	418.55	-0.1818	0.0875	1.01	1.01
0.25	5530.34	-937.42	572.70	-0.1695	0.1036	4990.92	-1112.21	514.98	-0.2228	0.1032	1.26	1.26
0.30	5887.36	-1085.34	690.15	-0.1844	0.1172	5243.15	-1289.77	611.52	-0.2460	0.1166	1.50	1.50
0.35	6252.98	-1187.45	810.78	-0.1899	0.1297	5502.79	-1414.29	708.61	-0.2570	0.1288	1.75	1.75
0.40	6676.96	-1251.41	943.75	-0.1874	0.1413	5792.71	-1494.07	811.30	-0.2579	0.1401	1.99	1.99
0.45	6992.91	-1285.94	1065.46	-0.1839	0.1524	5985.61	-1539.44	901.29	-0.2572	0.1506	2.23	2.23
0.50	7130.63	-1305.96	1162.83	-0.1831	0.1631	6000.95	-1565.25	964.15	-0.2608	0.1607	2.47	2.47
0.55	7088.29	-1324.45	1233.61	-0.1869	0.1740	5891.82	-1590.29	1007.20	-0.2699	0.1709	2.71	2.71
0.60	7001.72	-1344.93	1302.76	-0.1921	0.1861	5715.41	-1613.67	1041.41	-0.2823	0.1822	2.95	2.95
0.65	6909.02	-1364.07	1377.70	-0.1974	0.1994	5535.64	-1637.07	1077.98	-0.2957	0.1947	3.19	3.19
0.70	6869.64	-1390.15	1464.66	-0.2009	0.2132	5397.70	-1658.05	1120.90	-0.3072	0.2077	3.43	3.43
0.75	6912.62	-1394.19	1565.39	-0.2017	0.2265	5331.20	-1675.88	1172.68	-0.3144	0.2200	3.67	3.67
0.80	7042.73	-1405.24	1679.90	-0.1995	0.2385	5342.10	-1690.60	1233.82	-0.3165	0.2310	3.92	3.92
0.85	7237.79	-1413.81	1805.93	-0.1953	0.2495	5411.18	-1701.43	1302.58	-0.3144	0.2407	4.16	4.16
0.90	7454.46	-1418.36	1935.86	-0.1903	0.2597	5504.24	-1706.47	1373.16	-0.3100	0.2495	4.40	4.40
0.95	7647.32	-1418.88	2053.69	-0.1855	0.2685	5589.71	-1707.27	1434.73	-0.3054	0.2567	4.64	4.64
1.00	7787.82	-1417.62	2140.67	-0.1820	0.2749	5645.25	-1705.79	1474.27	-0.3022	0.2612	4.87	4.87
1.05	7790.20	-1412.42	2007.14	-0.1813	0.2576	5731.59	-1711.11	1389.68	-0.2985	0.2425	4.86	4.86
1.10	7732.53	-1411.86	1917.35	-0.1826	0.2480	5766.53	-1706.00	1335.83	-0.2958	0.2317	4.86	4.86
1.15	7659.46	-1407.56	1845.03	-0.1838	0.2409	5727.34	-1704.22	1280.08	-0.2976	0.2235	4.86	4.86
1.20	7543.02	-1405.13	1772.12	-0.1863	0.2349	5687.32	-1703.09	1232.37	-0.2995	0.2167	4.85	4.85
1.25	7465.33	-1405.93	1726.47	-0.1883	0.2313	5624.92	-1704.61	1194.09	-0.3030	0.2123	4.85	4.85
1.30	7413.60	-1408.90	1702.81	-0.1900	0.2297	5594.89	-1709.60	1175.87	-0.3056	0.2102	4.85	4.85
1.35	7404.89	-1412.32	1688.41	-0.1907	0.2280	5592.89	-1713.98	1163.22	-0.3065	0.2080	4.85	4.85
1.40	7425.59	-1414.07	1668.29	-0.1904	0.2247	5624.18	-1717.50	1147.93	-0.3054	0.2041	4.85	4.85
1.45	7472.16	-1414.88	1649.82	-0.1894	0.2208	5673.37	-1718.93	1133.19	-0.3030	0.1997	4.85	4.85
1.50	7530.79	-1416.41	1643.62	-0.1881	0.2183	5723.92	-1720.51	1126.44	-0.3006	0.1968	4.84	4.84
1.55	7513.66	-1429.41	1585.66	-0.1902	0.2110	5734.22	-1731.55	1083.50	-0.3020	0.1890	4.84	4.84
1.60	7306.28	-1421.80	1451.52	-0.1946	0.1987	5644.07	-1723.24	990.98	-0.3053	0.1756	4.84	4.84
1.65	7014.16	-1392.44	1310.05	-0.1985	0.1868	5475.00	-1699.54	892.17	-0.3104	0.1630	4.84	4.84
1.70	6834.98	-1387.88	1247.30	-0.2031	0.1825	5342.27	-1695.87	847.39	-0.3174	0.1586	4.84	4.84
1.75	6812.21	-1399.63	1252.52	-0.2055	0.1839	5313.56	-1707.72	851.09	-0.3214	0.1602	4.84	4.84
1.80	6929.78	-1413.77	1288.40	-0.2040	0.1859	5414.25	-1722.66	878.87	-0.3182	0.1623	4.84	4.84
1.85	7147.25	-1421.73	1324.60	-0.1989	0.1853	5622.93	-1731.71	908.89	-0.3080	0.1616	4.84	4.84
1.90	7383.99	-1431.52	1329.74	-0.1939	0.1801	5882.32	-1740.10	917.66	-0.2958	0.1560	4.85	4.85
1.95	7445.62	-1435.69	1219.27	-0.1928	0.1638	6067.34	-1742.08	840.40	-0.2871	0.1385	4.86	4.86
2.00	7267.27	-1406.46	1054.97	-0.1935	0.1452	6085.66	-1718.99	724.34	-0.2825	0.1190	4.86	4.86

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.05.1

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR REAR SUSPENSION TIRE FORCES

LEADING TANDEM AXLE

TIME (SEC)	LEFT SIDE VERTICAL (LB)	LEFT SIDE LONG. (LB)	LEFT SIDE LATERAL (LB)	LEFT SIDE MU-X	LEFT SIDE MU-Y	RIGHT SIDE VERTICAL (LB)	RIGHT SIDE LONG. (LB)	RIGHT SIDE LATERAL (LB)	RIGHT SIDE MU-X	RIGHT SIDE MU-Y
0.0	8222.98	-0.0	0.0	0.0	0.0	8222.98	-0.0	0.0	0.0	0.0
0.05	8220.05	-1.19	-6.81	-0.0001	-0.0008	8225.04	1.82	-6.81	0.0002	-0.0008
0.10	8189.73	-52.85	-16.34	-0.0065	-0.0020	8212.18	-46.19	-16.38	-0.0056	-0.0020
0.15	8136.43	-243.71	-22.37	-0.0300	-0.0027	8181.65	-234.63	-22.48	-0.0287	-0.0027
0.20	8072.80	-531.41	-24.63	-0.0658	-0.0031	8072.12	-519.56	-24.70	-0.0644	-0.0031
0.25	7998.45	-817.08	-23.02	-0.1022	-0.0029	7955.10	-802.62	-23.04	-0.1009	-0.0029
0.30	8006.97	-1075.86	-16.83	-0.1344	-0.0021	7900.82	-1057.92	-16.79	-0.1339	-0.0021
0.35	8053.32	-1290.19	-4.01	-0.1602	-0.0005	7861.02	-1269.43	-3.98	-0.1615	-0.0005
0.40	7935.76	-1456.56	14.54	-0.1835	0.0018	7658.69	-1433.19	14.37	-0.1871	0.0019
0.45	7842.99	-1599.54	37.40	-0.2039	0.0048	7444.30	-1572.61	36.65	-0.2112	0.0049
0.50	7931.43	-1731.97	64.59	-0.2184	0.0081	7390.37	-1704.06	62.71	-0.2306	0.0085
0.55	8093.14	-1851.70	93.01	-0.2288	0.0115	7402.06	-1824.69	89.49	-0.2465	0.0121
0.60	8158.88	-1961.07	122.21	-0.2404	0.0150	7318.36	-1934.14	116.41	-0.2643	0.0159
0.65	8169.65	-2066.96	155.80	-0.2530	0.0191	7171.10	-2038.78	146.60	-0.2843	0.0204
0.70	8289.74	-2168.15	187.93	-0.2615	0.0227	7111.60	-2142.64	174.68	-0.3013	0.0246
0.75	8483.76	-2254.55	214.18	-0.2657	0.0252	7176.93	-2233.93	198.02	-0.3113	0.0276
0.80	8627.47	-2325.53	245.36	-0.2695	0.0284	7146.75	-2298.94	224.60	-0.3217	0.0314
0.85	8622.05	-2385.25	278.09	-0.2766	0.0323	6958.06	-2354.47	250.64	-0.3384	0.0360
0.90	8565.77	-2442.62	322.76	-0.2852	0.0377	6773.66	-2410.69	287.25	-0.3559	0.0424
0.95	8647.07	-2496.99	376.56	-0.2888	0.0435	6659.79	-2462.86	330.33	-0.3698	0.0496
1.00	8749.61	-2536.52	435.11	-0.2899	0.0497	6607.02	-2507.25	378.14	-0.3795	0.0572
1.05	8760.15	-2566.98	508.55	-0.2930	0.0581	6484.73	-2536.43	436.94	-0.3911	0.0674
1.10	8768.73	-2597.44	596.97	-0.2962	0.0681	6281.37	-2564.98	501.99	-0.4083	0.0799
1.15	8847.59	-2624.91	689.58	-0.2967	0.0779	6210.16	-2606.32	573.16	-0.4197	0.0923
1.20	9030.75	-2649.41	779.67	-0.2934	0.0863	6262.03	-2639.87	646.06	-0.4216	0.1032
1.25	9176.31	-2667.87	860.65	-0.2907	0.0938	6291.67	-2661.37	710.82	-0.4230	0.1130
1.30	9197.48	-2687.49	931.12	-0.2922	0.1012	6238.05	-2678.63	764.18	-0.4294	0.1225
1.35	9224.71	-2710.97	993.95	-0.2939	0.1077	6142.32	-2700.16	806.04	-0.4396	0.1312
1.40	9313.30	-2730.83	1046.74	-0.2932	0.1124	6123.13	-2727.70	843.51	-0.4455	0.1378
1.45	9390.34	-2744.18	1088.60	-0.2922	0.1159	6128.44	-2740.61	874.95	-0.4472	0.1428
1.50	9371.46	-2755.07	1121.67	-0.2940	0.1197	6042.87	-2745.83	893.34	-0.4544	0.1478
1.55	9233.88	-2791.53	1111.86	-0.3023	0.1204	5916.83	-2784.07	874.13	-0.4705	0.1477
1.60	9294.97	-2802.68	1105.48	-0.3015	0.1189	6008.78	-2808.00	880.69	-0.4673	0.1466
1.65	9472.32	-2763.42	1069.73	-0.2917	0.1129	6118.58	-2781.61	856.58	-0.4546	0.1400
1.70	9394.18	-2742.86	1016.74	-0.2920	0.1082	6132.93	-2760.74	818.57	-0.4501	0.1335
1.75	9281.34	-2765.11	997.99	-0.2979	0.1075	6086.88	-2773.85	803.39	-0.4557	0.1320
1.80	9318.88	-2794.33	1005.84	-0.2999	0.1079	6074.04	-2802.44	806.73	-0.4614	0.1328
1.85	9342.57	-2811.05	1003.21	-0.3009	0.1074	6196.11	-2827.70	815.54	-0.4564	0.1316
1.90	9234.11	-2829.25	971.84	-0.3064	0.1052	6213.32	-2834.20	796.45	-0.4561	0.1282
1.95	9014.46	-2852.63	899.14	-0.3165	0.0997	6190.58	-2862.81	743.99	-0.4624	0.1202
2.00	8958.28	-2819.40	777.55	-0.3147	0.0868	6395.85	-2849.72	660.90	-0.4456	0.1033

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.06.1
SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRACTOR REAR SUSPENSION TIRE FORCES
TRAILING TANDEM AXLE

TIME	LEFT SIDE					RIGHT SIDE				
(SEC)	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y
0.0	8222.98	0.0	0.0	0.0	0.0	8222.98	0.0	0.0	0.0	0.0
0.05	8223.20	-1.52	-1.38	-0.0002	-0.0002	8221.89	2.10	-1.38	0.0003	-0.0002
0.10	8199.13	-100.71	5.97	-0.0123	0.0007	8184.40	-99.47	5.97	-0.0122	0.0007
0.15	8119.51	-394.75	27.41	-0.0486	0.0034	8081.66	-399.32	27.45	-0.0494	0.0034
0.20	8019.26	-774.75	62.02	-0.0966	0.0077	7880.64	-779.99	62.18	-0.0990	0.0079
0.25	7932.96	-1127.34	110.26	-0.1421	0.0139	7676.71	-1129.46	110.67	-0.1471	0.0144
0.30	7939.32	-1435.02	173.47	-0.1807	0.0218	7531.21	-1434.85	174.36	-0.1905	0.0232
0.35	7997.23	-1691.57	253.34	-0.2115	0.0317	7399.22	-1692.38	255.04	-0.2287	0.0345
0.40	7904.08	-1902.35	348.13	-0.2407	0.0440	7101.48	-1907.41	351.10	-0.2686	0.0494
0.45	7845.41	-2075.98	455.42	-0.2646	0.0580	6789.61	-2087.29	460.20	-0.3074	0.0678
0.50	7976.85	-2229.67	572.13	-0.2795	0.0717	6637.45	-2245.27	582.60	-0.3383	0.0878
0.55	8201.65	-2376.46	688.58	-0.2898	0.0840	6536.80	-2384.12	769.83	-0.3647	0.1178
0.60	8350.85	-2519.10	803.92	-0.3017	0.0963	6326.48	-2512.96	945.41	-0.3972	0.1494
0.65	8412.43	-2649.60	925.12	-0.3150	0.1100	6090.19	-2626.52	1082.18	-0.4313	0.1777
0.70	8588.35	-2755.16	1222.54	-0.3208	0.1423	5941.16	-2732.66	1221.67	-0.4600	0.2056
0.75	8936.98	-2856.54	1357.97	-0.3196	0.1519	5822.15	-2824.07	1246.29	-0.4851	0.2141
0.80	9044.21	-2945.27	1535.12	-0.3257	0.1697	5802.20	-2906.97	1283.34	-0.5010	0.2212
0.85	9087.39	-3022.61	1726.49	-0.3326	0.1900	5541.76	-2927.26	1234.48	-0.5282	0.2228
0.90	9059.46	-3086.96	1949.34	-0.3407	0.2152	5308.54	-2956.71	1139.39	-0.5570	0.2146
0.95	9111.07	-3143.20	2176.77	-0.3450	0.2389	5206.35	-2996.75	1066.64	-0.5756	0.2049
1.00	9258.06	-3190.79	2407.19	-0.3446	0.2600	5093.20	-3003.67	982.52	-0.5897	0.1929
1.05	9253.65	-3226.47	2629.89	-0.3487	0.2842	4971.82	-2984.66	883.99	-0.6003	0.1778
1.10	9207.86	-3261.31	2827.22	-0.3542	0.3070	4810.41	-2921.12	759.99	-0.6072	0.1580
1.15	9252.42	-3294.36	3007.58	-0.3561	0.3251	4762.55	-2895.26	649.93	-0.6079	0.1365
1.20	9398.41	-3326.25	3179.76	-0.3539	0.3383	4841.94	-2920.28	574.07	-0.6031	0.1186
1.25	9516.69	-3352.77	3321.64	-0.3523	0.3490	4890.35	-2910.19	506.40	-0.5951	0.1036
1.30	9495.27	-3377.32	3406.21	-0.3557	0.3589	4871.79	-2842.55	435.54	-0.5835	0.0894
1.35	9462.88	-3406.66	3469.84	-0.3600	0.3667	4829.05	-2737.83	364.32	-0.5669	0.0754
1.40	9519.87	-3434.49	3540.67	-0.3608	0.3719	4835.59	-2634.85	301.03	-0.5449	0.0623
1.45	9574.15	-3452.25	3600.89	-0.3606	0.3761	4858.50	-2512.88	245.37	-0.5172	0.0505
1.50	9520.48	-3199.47	3725.54	-0.3361	0.3913	4807.95	-2331.09	195.83	-0.4848	0.0407
1.55	9772.59	-1433.25	4179.03	-0.1467	0.4276	4647.00	-2283.75	199.66	-0.4914	0.0430
1.60	10086.54	-482.87	4296.41	-0.0479	0.4260	4646.61	-2494.47	287.14	-0.5368	0.0618
1.65	10075.99	-1612.91	4194.95	-0.1601	0.4163	4758.41	-2743.83	444.56	-0.5766	0.0934
1.70	9959.54	-2439.63	3991.09	-0.2450	0.4007	4600.32	-2707.03	501.93	-0.5884	0.1091
1.75	9754.46	-2925.84	3809.44	-0.2999	0.3905	4618.96	-2703.52	471.50	-0.5853	0.1021
1.80	9615.31	-3219.74	3683.45	-0.3349	0.3831	4705.50	-2693.79	401.10	-0.5725	0.0852
1.85	9633.28	-3391.34	3626.24	-0.3520	0.3764	4824.00	-2657.60	324.37	-0.5509	0.0672
1.90	9529.76	-2377.75	3871.13	-0.2495	0.4062	4887.73	-2616.68	282.44	-0.5354	0.0578
1.95	9827.55	-857.25	4017.59	-0.0872	0.4088	4797.21	-2757.27	409.84	-0.5748	0.0854
2.00	9859.13	-1552.73	3814.28	-0.1575	0.3869	4779.36	-2857.70	898.43	-0.5979	0.1880

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRACTOR FRONT SUSPENSION - BRAKE SUMMARY

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.40	-0.0	0.0	0.0	-0.0	0.0	26.40	-0.0
0.05	15.75	0.94	940.42	-24.69	0.0012	26.37	-1.82	0.94	1128.51	-27.09	0.0013	26.36	-2.39
0.10	30.00	5.29	5285.21	-193.44	0.0090	26.16	-5.78	5.29	6342.26	-224.42	0.0110	26.08	-7.57
0.15	30.00	11.40	11404.69	-480.08	0.0218	25.76	-7.36	11.40	13685.63	-564.25	0.0275	25.57	-9.80
0.20	30.00	16.14	16143.03	-736.08	0.0322	25.39	-5.80	16.14	19371.64	-870.16	0.0416	25.08	-8.03
0.25	30.00	19.67	19673.81	-937.42	0.0388	25.13	-3.78	19.67	23608.57	-1112.21	0.0510	24.71	-5.57
0.30	30.00	22.30	22304.91	-1085.34	0.0422	24.97	-2.44	22.30	26765.89	-1289.77	0.0563	24.46	-3.96
0.35	30.00	24.27	24265.59	-1187.45	0.0434	24.85	-2.11	24.27	29118.71	-1414.29	0.0588	24.27	-3.40
0.40	30.00	25.73	25726.66	-1251.41	0.0429	24.73	-2.85	25.73	30872.00	-1494.07	0.0590	24.09	-4.04
0.45	30.00	26.82	26815.43	-1285.94	0.0421	24.56	-4.48	26.82	32178.52	-1539.44	0.0588	23.86	-5.67
0.50	30.00	27.63	27626.75	-1305.96	0.0419	24.31	-6.15	27.63	33152.10	-1565.25	0.0596	23.54	-7.54
0.55	30.00	28.23	28231.36	-1324.45	0.0427	23.99	-7.11	28.23	33877.64	-1590.29	0.0617	23.14	-8.46
0.60	30.00	28.68	28681.93	-1344.93	0.0439	23.62	-7.28	28.68	34418.31	-1613.67	0.0646	22.71	-8.75
0.65	30.00	29.02	29017.65	-1364.07	0.0451	23.26	-7.09	29.02	34821.18	-1637.07	0.0676	22.27	-8.49
0.70	30.00	29.27	29267.83	-1380.15	0.0459	22.92	-6.80	29.27	35121.40	-1658.05	0.0702	21.86	-8.00
0.75	30.00	29.45	29454.25	-1394.19	0.0461	22.59	-6.41	29.45	35345.10	-1675.88	0.0719	21.47	-7.46
0.80	30.00	29.59	29593.21	-1405.24	0.0456	22.26	-6.08	29.59	35511.86	-1690.60	0.0724	21.09	-6.94
0.85	30.00	29.70	29696.77	-1413.81	0.0447	21.96	-5.80	29.70	35636.13	-1701.43	0.0719	20.75	-6.56
0.90	30.00	29.77	29773.91	-1418.36	0.0435	21.68	-5.74	29.77	35728.69	-1706.47	0.0709	20.43	-6.53
0.95	30.00	29.83	29831.45	-1418.88	0.0424	21.40	-5.93	29.83	35797.74	-1707.27	0.0698	20.11	-6.74
1.00	30.00	29.87	29874.28	-1417.62	0.0416	21.11	-6.21	29.87	35849.14	-1705.79	0.0691	19.78	-7.07
1.05	30.00	29.91	29906.20	-1412.42	0.0415	20.80	-6.77	29.91	35887.44	-1711.11	0.0683	19.45	-6.80
1.10	30.00	29.93	29930.00	-1411.86	0.0418	20.47	-6.91	29.93	35916.01	-1706.00	0.0677	19.11	-7.33
1.15	30.00	29.95	29947.75	-1407.56	0.0420	20.13	-7.33	29.95	35937.30	-1704.22	0.0680	18.75	-7.56
1.20	30.00	29.96	29960.95	-1405.13	0.0426	19.76	-7.58	29.96	35953.14	-1703.09	0.0685	18.38	-7.72
1.25	30.00	29.97	29970.77	-1405.93	0.0431	19.39	-7.56	29.97	35964.93	-1704.61	0.0693	18.00	-7.64
1.30	30.00	29.98	29978.10	-1408.90	0.0435	19.01	-7.35	29.98	35973.72	-1709.60	0.0699	17.62	-7.27
1.35	30.00	29.98	29983.56	-1412.32	0.0436	18.65	-7.09	29.98	35980.28	-1713.98	0.0701	17.27	-6.94
1.40	30.00	29.99	29987.64	-1414.07	0.0435	18.31	-6.96	29.99	35985.16	-1717.50	0.0698	16.94	-6.67
1.45	30.00	29.99	29990.67	-1414.88	0.0433	17.96	-6.91	29.99	35988.81	-1718.93	0.0693	16.61	-6.57
1.50	30.00	29.99	29992.93	-1416.41	0.0430	17.62	-6.79	29.99	35991.52	-1720.51	0.0687	16.29	-6.45
1.55	30.00	29.99	29994.61	-1429.41	0.0435	17.33	-5.74	29.99	35993.53	-1731.55	0.0691	16.01	-5.56
1.60	30.00	30.00	29995.88	-1421.80	0.0445	17.06	-6.37	30.00	35995.05	-1723.24	0.0698	15.74	-6.25
1.65	30.00	30.00	29996.80	-1392.44	0.0454	16.68	-8.77	30.00	35996.17	-1699.54	0.0710	15.38	-8.19
1.70	30.00	30.00	29997.46	-1387.88	0.0464	16.21	-9.14	30.00	35996.96	-1695.87	0.0726	14.95	-8.49
1.75	30.00	30.00	29998.03	-1399.63	0.0470	15.77	-8.19	30.00	35997.63	-1707.72	0.0735	14.54	-7.52
1.80	30.00	30.00	29998.33	-1413.77	0.0467	15.39	-7.03	30.00	35998.00	-1722.66	0.0728	14.20	-6.31
1.85	30.00	30.00	29998.64	-1421.73	0.0455	15.06	-6.38	30.00	35998.37	-1731.71	0.0704	13.90	-5.57
1.90	30.00	30.00	29998.95	-1431.52	0.0443	14.75	-5.59	30.00	35998.73	-1740.10	0.0676	13.65	-4.88
1.95	30.00	30.00	29999.02	-1435.69	0.0441	14.52	-5.25	30.00	35998.83	-1742.08	0.0657	13.44	-4.72
2.00	30.00	30.00	29999.02	-1406.46	0.0443	14.22	-7.63	30.00	35998.83	-1718.99	0.0646	13.19	-6.61

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR REAR SUSPENSION - BRAKE SUMMARY

LEADING TANDEM AXLE

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.40	-0.0	0.0	0.0	-0.0	0.0	26.40	-0.0
0.05	15.75	0.00	9.35	-1.19	0.0000	26.40	0.03	0.00	9.35	1.82	-.0001	26.40	-0.10
0.10	30.00	1.04	2071.80	-52.85	0.0017	26.35	-2.22	1.04	2071.80	-46.19	0.0015	26.33	-2.51
0.15	30.00	3.70	7407.89	-243.71	0.0078	26.13	-5.53	3.70	7407.89	-234.63	0.0075	26.10	-5.93
0.20	30.00	6.79	13587.86	-531.41	0.0171	25.79	-6.46	6.79	13587.86	-519.56	0.0167	25.73	-6.98
0.25	30.00	9.52	19041.65	-817.08	0.0263	25.45	-5.90	9.52	19041.65	-802.62	0.0259	25.37	-6.53
0.30	30.00	11.93	23854.67	-1075.86	0.0346	25.16	-5.10	11.93	23854.67	-1057.92	0.0343	25.04	-5.89
0.35	30.00	14.05	28102.17	-1290.19	0.0413	24.90	-5.02	14.05	28102.17	-1269.43	0.0412	24.73	-5.93
0.40	30.00	15.93	31850.26	-1456.56	0.0470	24.61	-5.94	15.93	31850.26	-1433.19	0.0472	24.40	-6.96
0.45	30.00	17.58	35157.62	-1599.54	0.0519	24.30	-6.91	17.58	35157.62	-1572.61	0.0527	24.03	-8.09
0.50	30.00	19.04	38076.41	-1731.97	0.0556	23.95	-7.50	19.04	38076.41	-1704.06	0.0572	23.62	-8.72
0.55	30.00	20.33	40652.21	-1851.70	0.0584	23.58	-7.90	20.33	40652.21	-1824.69	0.0609	23.18	-9.08
0.60	30.00	21.46	42925.35	-1961.07	0.0613	23.18	-8.09	21.46	42925.35	-1934.14	0.0648	22.72	-9.26
0.65	30.00	22.47	44931.45	-2066.96	0.0643	22.78	-7.84	22.47	44931.45	-2038.78	0.0690	22.26	-9.07
0.70	30.00	23.35	46701.87	-2168.15	0.0666	22.40	-7.29	23.35	46701.87	-2142.64	0.0726	21.82	-8.40
0.75	30.00	24.13	48264.21	-2254.55	0.0679	22.04	-6.93	24.13	48264.21	-2233.93	0.0749	21.42	-7.83
0.80	30.00	24.82	49642.97	-2325.53	0.0691	21.69	-6.84	24.82	49642.97	-2298.94	0.0770	21.01	-8.00
0.85	30.00	25.43	50859.70	-2385.25	0.0706	21.34	-6.89	25.43	50859.70	-2354.47	0.0801	20.59	-8.23
0.90	30.00	25.97	51933.52	-2442.62	0.0724	21.00	-6.73	25.97	51933.52	-2410.69	0.0834	20.18	-8.12
0.95	30.00	26.44	52881.05	-2496.99	0.0733	20.68	-6.42	26.44	52881.05	-2462.86	0.0860	19.79	-7.91
1.00	30.00	26.86	53717.25	-2536.52	0.0737	20.36	-6.52	26.86	53717.25	-2507.25	0.0878	19.41	-7.80
1.05	30.00	27.23	54455.16	-2566.98	0.0744	20.04	-6.80	27.23	54455.16	-2536.43	0.0899	19.02	-8.14
1.10	30.00	27.55	55106.30	-2597.44	0.0751	19.71	-6.89	27.55	55106.30	-2564.98	0.0930	18.61	-8.31
1.15	30.00	27.84	55680.98	-2624.91	0.0753	19.38	-6.95	27.84	55680.98	-2606.32	0.0951	18.23	-7.76
1.20	30.00	28.09	56188.08	-2649.41	0.0749	19.04	-6.99	28.09	56188.08	-2639.87	0.0956	17.87	-7.40
1.25	30.00	28.32	56635.69	-2667.87	0.0744	18.69	-7.16	28.32	56635.69	-2661.37	0.0958	17.51	-7.44
1.30	30.00	28.52	57030.70	-2687.49	0.0746	18.34	-7.16	28.52	57030.70	-2678.63	0.0968	17.13	-7.55
1.35	30.00	28.69	57379.27	-2710.97	0.0749	17.99	-6.90	28.69	57379.27	-2700.16	0.0985	16.77	-7.37
1.40	30.00	28.84	57687.00	-2730.83	0.0748	17.65	-6.70	28.84	57687.00	-2727.70	0.0995	16.42	-6.84
1.45	30.00	28.98	57958.50	-2744.18	0.0745	17.32	-6.71	28.98	57958.50	-2740.61	0.0997	16.09	-6.87
1.50	30.00	29.10	58198.08	-2755.07	0.0746	16.98	-6.76	29.10	58198.08	-2745.83	0.1011	15.74	-7.17
1.55	30.00	29.20	58409.53	-2791.53	0.0760	16.69	-5.63	29.20	58409.53	-2784.07	0.1042	15.43	-5.96
1.60	30.00	29.30	58596.09	-2802.68	0.0759	16.44	-5.55	29.30	58596.09	-2808.00	0.1038	15.19	-5.32
1.65	30.00	29.38	58760.77	-2763.42	0.0738	16.12	-7.63	29.38	58760.77	-2781.61	0.1013	14.90	-6.83
1.70	30.00	29.45	58906.08	-2742.86	0.0735	15.69	-8.84	29.45	58906.08	-2760.74	0.1002	14.52	-8.06
1.75	30.00	29.52	59034.33	-2765.11	0.0746	15.26	-8.15	29.52	59034.33	-2773.85	0.1012	14.12	-7.77
1.80	30.00	29.57	59147.53	-2794.33	0.0753	14.87	-7.12	29.57	59147.53	-2802.44	0.1024	13.76	-6.77
1.85	30.00	29.62	59247.33	-2811.05	0.0756	14.53	-6.61	29.62	59247.33	-2827.70	0.1017	13.45	-5.88
1.90	30.00	29.67	59335.50	-2829.25	0.0766	14.20	-6.01	29.67	59335.50	-2834.20	0.1017	13.16	-5.79
1.95	30.00	29.71	59413.31	-2852.83	0.0782	13.94	-5.15	29.71	59413.31	-2862.81	0.1028	12.92	-4.71
2.00	30.00	29.74	59481.98	-2819.40	0.0773	13.67	-6.76	29.74	59481.98	-2849.72	0.0994	12.70	-5.43

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRACTOR REAR SUSPENSION - BRAKE SUMMARY
TRAILING TANDEM AXLE

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	0.0	0.0	26.40	-0.0	0.0	0.0	0.0	0.0	26.40	-0.0
0.05	15.75	0.00	11.68	-1.52	0.0000	26.40	0.04	0.00	11.68	2.10	-.0000	26.40	-0.14
0.10	30.00	1.04	2589.75	-100.71	0.0010	26.36	-1.26	1.04	2589.75	-99.47	0.0010	26.35	-1.58
0.15	30.00	3.70	9259.87	-394.75	0.0040	26.23	-2.98	3.70	9259.87	-399.32	0.0041	26.19	-3.35
0.20	30.00	6.79	16984.82	-774.75	0.0078	26.03	-3.25	6.79	16984.82	-779.99	0.0079	25.96	-3.64
0.25	30.00	9.52	23802.07	-1127.34	0.0114	25.85	-2.74	9.52	23802.07	-1129.46	0.0114	25.75	-3.19
0.30	30.00	11.93	29818.34	-1435.02	0.0144	25.69	-2.44	11.93	29818.34	-1434.85	0.0144	25.56	-2.95
0.35	30.00	14.05	35127.71	-1691.57	0.0170	25.53	-2.83	14.05	35127.71	-1692.38	0.0170	25.36	-3.37
0.40	30.00	15.93	39812.83	-1902.35	0.0190	25.33	-3.86	15.93	39812.83	-1907.41	0.0191	25.12	-4.38
0.45	30.00	17.58	43947.02	-2075.98	0.0207	25.09	-5.30	17.58	43947.02	-2087.29	0.0209	24.84	-5.79
0.50	30.00	19.04	47595.52	-2229.67	0.0222	24.80	-6.55	19.04	47595.52	-2245.27	0.0224	24.49	-7.08
0.55	30.00	20.33	50815.27	-2376.46	0.0237	24.45	-7.17	20.33	50815.27	-2384.12	0.0243	24.09	-8.24
0.60	30.00	21.46	53656.69	-2519.10	0.0251	24.07	-7.15	21.46	53656.69	-2512.96	0.0270	23.64	-8.94
0.65	30.00	22.47	56164.31	-2649.60	0.0263	23.70	-6.93	22.47	56164.31	-2626.52	0.0308	23.18	-9.56
0.70	30.00	23.35	58377.33	-2755.16	0.0274	23.34	-7.15	23.35	58377.33	-2732.66	0.0354	22.70	-9.80
0.75	30.00	24.13	60330.23	-2856.54	0.0284	22.98	-6.99	24.13	60330.23	-2824.07	0.0404	22.22	-10.13
0.80	30.00	24.82	62053.69	-2945.27	0.0296	22.61	-6.87	24.82	62053.69	-2906.97	0.0453	21.73	-10.30
0.85	30.00	25.43	63574.59	-3022.61	0.0308	22.25	-6.82	25.43	63574.59	-2927.26	0.0535	21.19	-13.24
0.90	30.00	25.97	64916.91	-3086.96	0.0323	21.90	-6.94	25.97	64916.91	-2956.71	0.0665	20.56	-15.22
0.95	30.00	26.44	66101.25	-3143.20	0.0338	21.56	-7.07	26.44	66101.25	-2996.75	0.0812	19.89	-16.23
1.00	30.00	26.86	67146.56	-3190.79	0.0352	21.21	-7.27	26.86	67146.56	-3003.67	0.0991	19.17	-18.61
1.05	30.00	27.23	68068.88	-3226.47	0.0370	20.85	-7.73	27.23	68068.88	-2984.66	0.1221	18.34	-22.04
1.10	30.00	27.55	68882.81	-3261.31	0.0392	20.47	-7.98	27.55	68882.81	-2921.12	0.1540	17.36	-27.53
1.15	30.00	27.84	69601.19	-3294.36	0.0412	20.09	-8.11	27.84	69601.19	-2895.26	0.1952	16.21	-30.78
1.20	30.00	28.09	70235.06	-3326.25	0.0426	19.71	-8.10	28.09	70235.06	-2920.28	0.2397	15.02	-31.13
1.25	30.00	28.32	70794.56	-3352.77	0.0439	19.31	-8.16	28.32	70794.56	-2910.19	0.2873	13.80	-33.13
1.30	30.00	28.52	71288.38	-3377.32	0.0456	18.91	-8.17	28.52	71288.38	-2842.55	0.3432	12.46	-37.99
1.35	30.00	28.69	71724.06	-3406.66	0.0475	18.52	-7.84	28.69	71724.06	-2737.83	0.4125	10.93	-44.65
1.40	30.00	28.84	72108.75	-3434.49	0.0487	18.15	-7.47	28.84	72108.75	-2634.85	0.4969	9.17	-51.08
1.45	30.00	28.98	72448.13	-3452.25	0.0495	17.79	-7.43	28.98	72448.13	-2512.88	0.5970	7.20	-58.40
1.50	30.00	24.29	60718.13	-3199.47	0.0452	17.52	7.14	24.29	60718.13	-2331.09	0.7100	5.08	-37.10
1.55	30.00	11.40	28505.95	-1433.25	0.0173	17.75	0.35	11.40	28505.95	-2283.75	0.6872	5.39	45.18
1.60	30.00	4.64	11591.38	-482.87	0.0056	17.69	-4.22	4.64	11591.38	-2494.47	0.5257	8.04	100.78
1.65	30.00	15.19	37980.51	-1612.91	0.0191	17.07	-12.49	15.19	37980.51	-2743.83	0.3675	10.49	44.46
1.70	30.00	21.67	54166.69	-2439.63	0.0302	16.43	-11.73	21.67	54166.69	-2707.03	0.3129	11.09	-0.07
1.75	30.00	25.31	63275.63	-2925.84	0.0383	15.86	-10.39	25.31	63275.63	-2703.52	0.3299	10.53	-24.22
1.80	30.00	27.36	68401.69	-3219.74	0.0443	15.37	-8.75	27.36	68401.69	-2693.79	0.3878	9.38	-38.23
1.85	30.00	28.51	71286.38	-3391.34	0.0476	14.97	-7.55	28.51	71286.38	-2657.60	0.4737	7.88	-47.72
1.90	30.00	18.10	45255.93	-2377.75	0.0301	14.92	5.02	18.10	45255.93	-2616.68	0.5318	6.86	18.63
1.95	30.00	7.36	18402.42	-857.25	0.0097	14.98	-2.75	7.36	18402.42	-2757.27	0.3788	8.94	96.69
2.00	30.00	14.33	35817.56	-1552.73	0.0174	14.56	-10.40	14.33	35817.56	-2857.70	0.1683	11.73	56.15

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.11.1

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR FRONT SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	-0.2307	138.5838	0.0285	-115.4865	-0.2307	135.1800	0.0285	-112.6499
0.10	-0.4088	248.3036	0.0503	-206.9196	-0.4087	235.5380	0.0503	-196.2816
0.15	-0.5667	351.1079	0.0698	-292.5896	-0.5664	327.4897	0.0697	-272.9080
0.20	-0.7122	458.8838	0.0877	-382.4028	-0.7114	418.5513	0.0875	-348.7925
0.25	-0.8406	572.7014	0.1036	-477.2507	-0.8389	514.9824	0.1032	-429.1516
0.30	-0.9515	690.1465	0.1172	-575.1218	-0.9484	611.5203	0.1166	-509.5996
0.35	-1.0523	810.7788	0.1297	-675.6487	-1.0472	708.6121	0.1288	-590.5098
0.40	-1.1473	943.7473	0.1413	-786.4556	-1.1395	811.3027	0.1401	-676.0854
0.45	-1.2370	1065.4600	0.1524	-887.8828	-1.2256	901.2881	0.1506	-751.0730
0.50	-1.3245	1162.8252	0.1631	-969.0205	-1.3089	964.1465	0.1607	-803.4548
0.55	-1.4135	1233.6130	0.1740	-1028.0105	-1.3930	1007.1970	0.1709	-839.3306
0.60	-1.5116	1302.7590	0.1861	-1085.6321	-1.4858	1041.4143	0.1822	-867.8450
0.65	-1.6202	1377.6985	0.1994	-1148.0815	-1.5889	1077.9836	0.1947	-898.3191
0.70	-1.7326	1464.6614	0.2132	-1220.5505	-1.6953	1120.8958	0.2077	-934.0796
0.75	-1.8404	1565.3914	0.2265	-1304.4922	-1.7967	1172.6777	0.2200	-977.2310
0.80	-1.9386	1679.9006	0.2385	-1399.9167	-1.8874	1233.8228	0.2310	-1028.1853
0.85	-2.0278	1805.9326	0.2495	-1504.9431	-1.9678	1302.5850	0.2407	-1085.4868
0.90	-2.1104	1935.8606	0.2597	-1613.2166	-2.0400	1373.1553	0.2495	-1144.2957
0.95	-2.1822	2053.6021	0.2685	-1711.3345	-2.0993	1434.7300	0.2567	-1195.6077
1.00	-2.2337	2140.6711	0.2749	-1783.8923	-2.1366	1474.2673	0.2612	-1228.5557
1.05	-2.0948	2007.1384	0.2576	-1672.6150	-1.9850	1389.6794	0.2425	-1158.0657
1.10	-2.0158	1917.3489	0.2480	-1597.7903	-1.8959	1335.8308	0.2317	-1113.1919
1.15	-1.9590	1845.0337	0.2409	-1537.5276	-1.8304	1280.0796	0.2235	-1066.7327
1.20	-1.9106	1772.1226	0.2349	-1476.7683	-1.7744	1232.3689	0.2167	-1026.9736
1.25	-1.8812	1726.4749	0.2313	-1438.7285	-1.7392	1194.0881	0.2123	-995.0728
1.30	-1.8685	1702.8149	0.2297	-1419.0120	-1.7220	1175.8689	0.2102	-979.8904
1.35	-1.8550	1688.4106	0.2280	-1407.0083	-1.7044	1163.2161	0.2080	-969.3464
1.40	-1.8279	1668.2861	0.2247	-1390.2380	-1.6729	1147.9316	0.2041	-956.6094
1.45	-1.7967	1649.8184	0.2208	-1374.8481	-1.6375	1133.1895	0.1997	-944.3242
1.50	-1.7763	1643.6233	0.2183	-1369.6853	-1.6130	1126.4424	0.1968	-938.7014
1.55	-1.7182	1585.6553	0.2110	-1321.3789	-1.5505	1083.4985	0.1890	-902.9150
1.60	-1.6182	1451.5249	0.1987	-1209.6035	-1.4416	990.9807	0.1756	-825.8167
1.65	-1.5219	1310.0505	0.1868	-1091.7083	-1.3389	892.1741	0.1630	-743.4780
1.70	-1.4874	1247.2981	0.1825	-1039.4148	-1.3039	847.3882	0.1586	-706.1563
1.75	-1.4986	1252.5168	0.1839	-1043.7637	-1.3166	851.0884	0.1602	-709.2400
1.80	-1.5149	1288.3977	0.1859	-1073.6643	-1.3335	878.8696	0.1623	-732.3911
1.85	-1.5095	1324.6030	0.1853	-1103.8354	-1.3270	908.8867	0.1616	-757.4050
1.90	-1.4663	1329.7371	0.1801	-1108.1135	-1.2800	917.6636	0.1560	-764.7195
1.95	-1.3336	1219.2668	0.1638	-1016.0552	-1.1368	840.3955	0.1385	-700.3293
2.00	-1.1821	1054.9707	0.1452	-879.1418	-0.9767	724.3428	0.1190	-603.6184

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY

LEADING TANDEM AXLE

TIME (SEC)	LEFT SIDE: TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	RIGHT SIDE: TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	0.0093	-6.8095	-0.0008	0.0	0.0093	-6.8131	-0.0008	0.0
0.10	0.0224	-16.3382	-0.0020	0.0	0.0224	-16.3767	-0.0020	0.0
0.15	0.0309	-22.3698	-0.0027	0.0	0.0310	-22.4757	-0.0027	0.0
0.20	0.0344	-24.6302	-0.0031	0.0	0.0345	-24.6964	-0.0031	0.0
0.25	0.0325	-23.0180	-0.0029	0.0	0.0326	-23.0378	-0.0029	0.0
0.30	0.0239	-16.8329	-0.0021	0.0	0.0240	-16.7934	-0.0021	0.0
0.35	0.0057	-4.0095	-0.0005	0.0	0.0057	-3.9762	-0.0005	0.0
0.40	-0.0209	14.5355	0.0018	0.0	-0.0211	14.3716	0.0019	0.0
0.45	-0.0544	37.4019	0.0048	0.0	-0.0549	36.6512	0.0049	0.0
0.50	-0.0935	64.5940	0.0081	0.0	-0.0947	62.7093	0.0085	0.0
0.55	-0.1334	93.0081	0.0115	0.0	-0.1354	89.4914	0.0121	0.0
0.60	-0.1749	122.2123	0.0150	0.0	-0.1778	116.4063	0.0159	0.0
0.65	-0.2232	155.8003	0.0191	0.0	-0.2273	146.6002	0.0204	0.0
0.70	-0.2676	187.9293	0.0227	0.0	-0.2730	174.6847	0.0246	0.0
0.75	-0.3016	214.1816	0.0252	0.0	-0.3082	198.0199	0.0276	0.0
0.80	-0.3428	245.3628	0.0284	0.0	-0.3510	224.5988	0.0314	0.0
0.85	-0.3891	278.0942	0.0323	0.0	-0.3991	250.6427	0.0360	0.0
0.90	-0.4536	322.7554	0.0377	0.0	-0.4664	287.2498	0.0424	0.0
0.95	-0.5270	376.5554	0.0435	0.0	-0.5433	330.3342	0.0496	0.0
1.00	-0.6056	435.1069	0.0497	0.0	-0.6260	378.1438	0.0572	0.0
1.05	-0.7077	508.5527	0.0581	0.0	-0.7334	436.9363	0.0674	0.0
1.10	-0.8307	596.9668	0.0681	0.0	-0.8627	501.9917	0.0799	0.0
1.15	-0.9556	689.5769	0.0779	0.0	-0.9942	573.1580	0.0923	0.0
1.20	-1.0696	779.6677	0.0863	0.0	-1.1146	646.0598	0.1032	0.0
1.25	-1.1717	860.6458	0.0938	0.0	-1.2226	710.8198	0.1130	0.0
1.30	-1.2665	931.1248	0.1012	0.0	-1.3230	764.1760	0.1225	0.0
1.35	-1.3504	993.9475	0.1077	0.0	-1.4121	806.0400	0.1312	0.0
1.40	-1.4159	1046.7405	0.1124	0.0	-1.4819	843.5103	0.1378	0.0
1.45	-1.4669	1088.5969	0.1159	0.0	-1.5365	874.9456	0.1428	0.0
1.50	-1.5129	1121.6680	0.1197	0.0	-1.5857	893.3430	0.1478	0.0
1.55	-1.5110	1111.8574	0.1204	0.0	-1.5847	874.1313	0.1477	0.0
1.60	-1.4978	1105.4829	0.1189	0.0	-1.5724	880.6880	0.1466	0.0
1.65	-1.4355	1069.7314	0.1129	0.0	-1.5075	856.5828	0.1400	0.0
1.70	-1.3690	1016.7410	0.1082	0.0	-1.4372	818.5696	0.1335	0.0
1.75	-1.3519	997.9924	0.1075	0.0	-1.4189	803.3855	0.1320	0.0
1.80	-1.3607	1005.8364	0.1079	0.0	-1.4282	806.7268	0.1328	0.0
1.85	-1.3559	1003.2075	0.1074	0.0	-1.4234	815.5366	0.1316	0.0
1.90	-1.3212	971.8354	0.1052	0.0	-1.3873	796.4492	0.1282	0.0
1.95	-1.2374	899.1411	0.0997	0.0	-1.3002	743.9893	0.1202	0.0
2.00	-1.0726	777.5544	0.0868	0.0	-1.1270	660.8982	0.1033	0.0

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRACTOR REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY
TRAILING TANDEM AXLE

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	0.0014	-1.3835	-0.0002	2.7668	0.0014	-1.3837	-0.0002	2.7674
0.10	-0.0060	5.9678	0.0007	-11.8923	-0.0060	5.9722	0.0007	-11.9442
0.15	-0.0273	27.4105	0.0034	-54.0418	-0.0273	27.4541	0.0034	-54.9026
0.20	-0.0615	62.0210	0.0077	-120.5822	-0.0617	62.1816	0.0079	-124.3390
0.25	-0.1090	110.2555	0.0139	-211.5615	-0.1094	110.6700	0.0144	-221.2773
0.30	-0.1710	173.4720	0.0218	-329.0203	-0.1718	174.3648	0.0232	-348.6042
0.35	-0.2490	253.3361	0.0317	-475.8171	-0.2507	255.0448	0.0345	-509.8733
0.40	-0.3415	348.1279	0.0440	-648.5728	-0.3444	351.1016	0.0494	-701.8679
0.45	-0.4460	455.4170	0.0580	-842.7620	-0.4506	460.1997	0.0678	-919.9187
0.50	-0.5594	572.1328	0.0717	-1052.4170	-0.5663	582.5981	0.0878	-1159.1309
0.55	-0.6722	688.5781	0.0840	-1259.3364	-0.6819	769.8271	0.1178	-1376.7600
0.60	-0.7837	803.9150	0.0963	-1462.0188	-0.7964	945.4141	0.1494	-1460.2354
0.65	-0.9007	925.1157	0.1100	-1673.7454	-0.9170	1082.1772	0.1777	-1402.4641
0.70	-1.0106	1222.5371	0.1423	-2174.9900	-1.0307	1221.6704	0.2056	-1318.9077
0.75	-1.1080	1357.9702	0.1519	-2381.1257	-1.1319	1246.2866	0.2141	-1148.0015
0.80	-1.2188	1535.1157	0.1697	-2559.7183	-1.2474	1283.3438	0.2212	-1044.2522
0.85	-1.3407	1726.4883	0.1900	-2706.6121	-1.3751	1234.4751	0.2228	-807.6460
0.90	-1.4917	1949.3423	0.2152	-2816.4961	-1.5335	1139.3887	0.2146	-567.0801
0.95	-1.6599	2176.7715	0.2389	-2921.6990	-1.7107	1066.6445	0.2049	-418.5571
1.00	-1.8389	2407.1860	0.2600	-3050.3123	-1.9003	982.5151	0.1929	-302.0879
1.05	-2.0339	2629.8901	0.2842	-3044.7749	-2.1072	883.9946	0.1778	-208.1869
1.10	-2.2366	2827.2217	0.3070	-2949.7039	-2.3221	759.9854	0.1580	-130.7570
1.15	-2.4313	3007.9849	0.3251	-2891.8589	-2.5291	649.9292	0.1365	-81.6782
1.20	-2.6045	3179.7588	0.3383	-2907.9976	-2.7137	574.0693	0.1186	-55.2142
1.25	-2.7549	3321.6445	0.3490	-2906.0369	-2.8741	506.4023	0.1036	-37.5213
1.30	-2.8908	3408.2061	0.3589	-2783.6028	-3.0193	435.5376	0.0894	-24.0209
1.35	-3.0115	3469.8374	0.3667	-2647.2717	-3.1486	364.3203	0.0754	-14.1955
1.40	-3.1096	3540.6714	0.3719	-2601.3496	-3.2540	301.0278	0.0623	-7.8745
1.45	-3.1885	3600.8911	0.3761	-2577.5852	-3.3391	245.3691	0.0505	-3.9652
1.50	-3.2590	3725.5381	0.3913	-2869.4001	-3.4153	195.8285	0.0407	-1.6811
1.55	-3.2807	4179.0273	0.4276	-5441.7617	-3.4401	199.6577	0.0430	-1.8981
1.60	-3.3028	4296.4102	0.4260	-6525.6211	-3.4667	287.1418	0.0618	-6.2916
1.65	-3.2531	4194.9453	0.4163	-5543.6992	-3.4157	444.5640	0.0934	-21.1838
1.70	-3.1739	3991.0869	0.4007	-4435.7188	-3.3314	501.9336	0.1091	-30.4330
1.75	-3.1475	3809.4443	0.3905	-3558.6738	-3.3028	471.5044	0.1021	-26.3141
1.80	-3.1567	3683.4468	0.3831	-2984.9404	-3.3126	401.1042	0.0852	-17.1284
1.85	-3.1576	3626.2412	0.3764	-2739.0659	-3.3140	324.3718	0.0672	-9.4454
1.90	-3.1331	3871.1323	0.4062	-4162.0742	-3.2892	282.4387	0.0578	-6.3246
1.95	-3.0750	4017.5889	0.4088	-6218.7656	-3.2304	409.8352	0.0854	-18.6498
2.00	-2.9083	3814.2808	0.3869	-5684.1367	-3.0552	898.4316	0.1880	-135.6982

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR FRONT SUSPENSION - UNSPRUNG MASS SUMMARY

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	0.0000	-0.0157	0.0003	-0.5914	-118.3	0.0039	0.1148	12.95	-0.0040	-0.1296	-14.52
0.10	0.0001	-0.0373	0.0057	-0.2163	-147.7	0.0011	-0.2717	-16.46	-0.0091	-0.0780	-18.87
0.15	0.0010	-0.0493	0.0296	-0.3485	32.8	-0.0228	-0.8084	-84.94	-0.0218	-0.6165	-73.39
0.20	0.0034	-0.0674	0.0675	-0.3077	176.9	-0.0845	-1.8320	-237.76	-0.0743	-1.6184	-218.38
0.25	0.0077	-0.0815	0.1024	-0.3071	363.9	-0.2056	-3.0901	-488.04	-0.1835	-2.8434	-463.22
0.30	0.0131	-0.0976	0.1029	-0.3076	600.0	-0.3925	-4.5122	-764.21	-0.3557	-4.1234	-754.11
0.35	0.0186	-0.1136	0.1244	-0.3602	963.6	-0.6350	-4.9596	-1101.12	-0.5754	-4.4458	-1085.31
0.40	0.0249	-0.1339	0.1153	-0.4215	1381.4	-0.8736	-4.5718	-1428.47	-0.7876	-4.0147	-1401.41
0.45	0.0296	-0.1529	0.0706	-0.3797	1845.5	-1.0777	-3.3533	-1704.05	-0.9621	-2.7617	-1625.71
0.50	0.0313	-0.1721	-0.0048	-0.2930	2300.7	-1.2110	-1.9193	-1798.14	-1.0663	-1.2851	-1684.43
0.55	0.0301	-0.1826	-0.0386	-0.2111	2845.0	-1.2659	-0.2716	-1764.86	-1.0865	0.4375	-1600.79
0.60	0.0278	-0.1961	-0.0513	-0.2934	3385.7	-1.2477	0.8299	-1666.95	-1.0339	1.5215	-1450.24
0.65	0.0254	-0.2095	-0.0444	-0.2631	3946.9	-1.1942	1.1654	-1571.01	-0.9447	1.8933	-1291.85
0.70	0.0237	-0.2244	-0.0217	-0.3300	4506.2	-1.1401	0.8600	-1516.50	-0.8549	1.5669	-1178.79
0.75	0.0234	-0.2411	0.0078	-0.3428	5070.5	-1.1145	0.0406	-1535.30	-0.7934	0.7719	-1139.02
0.80	0.0245	-0.2592	0.0353	-0.3820	5645.5	-1.1349	-0.9514	-1629.04	-0.7772	-0.2166	-1180.05
0.85	0.0268	-0.2785	0.0520	-0.3879	6216.0	-1.2027	-1.7758	-1777.19	-0.8086	-1.0659	-1283.32
0.90	0.0295	-0.2976	0.0538	-0.3681	6742.7	-1.3031	-2.1770	-1942.27	-0.8751	-1.5478	-1415.04
0.95	0.0320	-0.3143	0.0436	-0.2998	7205.0	-1.4128	-2.1282	-2090.32	-0.9550	-1.5786	-1536.82
1.00	0.0338	-0.3276	0.0265	-0.2338	7599.6	-1.5099	-1.7061	-2196.39	-1.0265	-1.2518	-1622.57
1.05	0.0347	-0.3179	0.0066	0.5533	8065.3	-1.5841	-1.1962	-2265.11	-1.0703	-0.5432	-1641.40
1.10	0.0346	-0.3016	-0.0123	0.0349	8326.2	-1.6187	-0.1691	-2245.02	-1.0875	-0.1628	-1642.04
1.15	0.0336	-0.2972	-0.0255	0.2423	8317.7	-1.6106	0.4152	-2195.11	-1.0797	0.5010	-1586.49
1.20	0.0323	-0.2851	-0.0289	0.1342	8429.2	-1.5800	0.7506	-2130.79	-1.0424	0.8913	-1504.65
1.25	0.0310	-0.2824	-0.0219	0.0425	8531.9	-1.5385	0.7798	-2071.63	-0.9945	0.9216	-1430.86
1.30	0.0302	-0.2791	-0.0099	0.0534	8630.8	-1.5029	0.5629	-2036.84	-0.9524	0.6438	-1386.10
1.35	0.0301	-0.2779	0.0025	0.0123	8662.9	-1.4821	0.1960	-2032.27	-0.9295	0.2354	-1378.63
1.40	0.0305	-0.2764	0.0125	0.0348	8747.2	-1.4831	-0.2840	-2065.41	-0.9254	-0.0974	-1394.58
1.45	0.0313	-0.2758	0.0183	-0.0162	8940.5	-1.5060	-0.6582	-2121.81	-0.9364	-0.3725	-1429.19
1.50	0.0323	-0.2770	0.0176	-0.0255	9155.0	-1.5421	-0.7386	-2176.93	-0.9587	-0.5044	-1471.37
1.55	0.0324	-0.2737	-0.0228	0.2134	9316.2	-1.5638	-0.0026	-2158.21	-0.9696	0.1975	-1441.39
1.60	0.0300	-0.2565	-0.0728	0.4114	9460.9	-1.5326	1.3579	-2025.28	-0.9288	1.5115	-1293.30
1.65	0.0259	-0.2372	-0.0787	0.3022	9553.2	-1.4365	2.2639	-1832.63	-0.8267	2.3371	-1085.53
1.70	0.0230	-0.2290	-0.0373	0.0389	9558.9	-1.3210	2.0556	-1687.14	-0.7110	2.0011	-934.24
1.75	0.0223	-0.2296	0.0106	-0.0420	9477.4	-1.2438	0.8506	-1660.20	-0.6389	0.6952	-912.32
1.80	0.0241	-0.2322	0.0565	-0.0571	9302.6	-1.2376	-0.6757	-1752.50	-0.6434	-0.9731	-1029.49
1.85	0.0277	-0.2338	0.0849	0.0039	9012.8	-1.3045	-2.0037	-1932.74	-0.7285	-2.4451	-1254.34
1.90	0.0321	-0.2308	0.0814	0.1319	8612.4	-1.4219	-2.4668	-2125.30	-0.8708	-3.0326	-1506.76
1.95	0.0346	-0.2136	0.0097	0.5593	8202.1	-1.5276	-1.5135	-2208.11	-1.0023	-1.9811	-1634.37
2.00	0.0334	-0.1833	-0.0479	0.5281	7843.2	-1.5592	0.2482	-2135.34	-1.0569	-0.2242	-1600.10

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR REAR SUSPENSION - UNSPRUNG MASS SUMMARY

LEADING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	-0.0000	0.0	-0.00	0.0000	0.0	0.00
0.05	-0.0000	0.0004	-0.0004	0.0168	10.8	0.0003	-0.0653	-6.68	-0.0001	0.0906	8.96
0.10	-0.0002	0.0017	-0.0140	0.0626	89.8	0.0045	-0.2927	-311.47	0.0047	0.1249	-308.73
0.15	-0.0005	0.0041	-0.0259	-0.0149	407.9	0.0179	-0.0059	-283.37	0.0242	0.4485	-258.40
0.20	-0.0013	0.0003	-0.0321	-0.0980	856.7	0.0425	0.2224	-216.37	0.0579	0.6134	-157.92
0.25	-0.0022	-0.0036	-0.0281	-0.0698	1585.0	0.0632	0.0168	-163.43	0.0936	0.4648	-47.31
0.30	-0.0025	-0.0088	-0.0091	-0.1450	2432.0	0.0661	-0.3641	-176.50	0.1137	0.1917	5.94
0.35	-0.0024	-0.0165	-0.0250	-0.1447	3308.7	0.0724	-0.0589	-170.32	0.1373	0.6760	79.65
0.40	-0.0038	-0.0239	-0.0501	-0.1704	4366.6	0.0992	0.2212	-82.10	0.1854	1.0304	249.90
0.45	-0.0052	-0.0343	-0.0307	-0.2414	5599.6	0.1238	-0.3415	-4.34	0.2353	0.4265	424.27
0.50	-0.0052	-0.0469	0.0018	-0.2567	7031.5	0.1124	-0.9312	-64.70	0.2537	-0.1876	478.43
0.55	-0.0044	-0.0601	-0.0025	-0.2691	8570.6	0.0845	-0.8231	-184.41	0.2574	-0.0618	480.88
0.60	-0.0044	-0.0733	-0.0241	-0.2620	10139.7	0.0729	-0.3995	-238.15	0.2764	0.4058	546.21
0.65	-0.0050	-0.0872	-0.0224	-0.3009	11746.2	0.0695	-0.5132	-261.09	0.3063	0.2839	651.87
0.70	-0.0048	-0.1031	0.0033	-0.2980	13346.3	0.0466	-1.0302	-360.96	0.3176	-0.2073	685.00
0.75	-0.0037	-0.1147	0.0103	-0.2186	15101.9	0.0065	-1.0892	-524.10	0.3088	-0.1732	643.34
0.80	-0.0030	-0.1295	-0.0160	-0.3676	16743.4	-0.0222	-0.4275	-639.14	0.3180	0.4145	676.00
0.85	-0.0039	-0.1462	-0.0391	-0.2557	18168.0	-0.0175	-0.0354	-625.08	0.3551	0.8621	816.60
0.90	-0.0050	-0.1575	-0.0290	-0.2615	19611.8	-0.0059	-0.2465	-586.57	0.3973	0.5416	974.00
0.95	-0.0052	-0.1743	-0.0091	-0.3670	20715.1	-0.0119	-0.5244	-616.23	0.4194	0.0499	1053.31
1.00	-0.0050	-0.1887	-0.0131	-0.2016	21639.3	-0.0219	-0.3709	-658.94	0.4293	0.1663	1088.79
1.05	-0.0054	-0.2000	-0.0311	-0.3128	22436.4	-0.0176	0.1525	-643.27	0.4526	0.2756	1176.63
1.10	-0.0064	-0.2186	-0.0273	-0.3612	22852.3	-0.0044	0.1596	-595.62	0.4795	-0.1151	1276.55
1.15	-0.0064	-0.2324	-0.0012	-0.2153	23166.1	-0.0100	-0.4306	-623.89	0.4836	-0.6589	1287.49
1.20	-0.0054	-0.2439	0.0106	-0.2503	23162.4	-0.0343	-0.6533	-722.51	0.4609	-0.7675	1197.30
1.25	-0.0045	-0.2545	-0.0057	-0.1519	22920.6	-0.0512	-0.3297	-789.01	0.4396	-0.3075	1115.07
1.30	-0.0046	-0.2611	-0.0221	-0.1574	22908.2	-0.0512	0.0177	-788.43	0.4415	-0.0408	1121.43
1.35	-0.0049	-0.2716	-0.0151	-0.2381	23064.0	-0.0495	-0.1042	-783.58	0.4505	-0.2376	1152.96
1.40	-0.0047	-0.2815	-0.0030	-0.1480	23342.5	-0.0598	-0.4014	-826.62	0.4487	-0.3202	1144.43
1.45	-0.0042	-0.2879	-0.0115	-0.1260	23582.7	-0.0693	-0.2353	-864.33	0.4458	0.0100	1133.76
1.50	-0.0047	-0.2939	-0.0326	-0.0994	23697.2	-0.0599	0.0212	-808.78	0.4601	0.2337	1208.55
1.55	-0.0059	-0.2937	-0.0234	0.1143	24071.8	-0.0622	-0.7343	-751.36	0.4594	-0.5781	1271.13
1.60	-0.0053	-0.2903	0.0090	-0.0630	24809.0	-0.0814	-0.8322	-789.49	0.4428	-0.9957	1240.50
1.65	-0.0040	-0.2964	0.0099	-0.0484	25144.2	-0.1039	0.2171	-924.58	0.4329	0.0506	1156.37
1.70	-0.0041	-0.2893	-0.0346	0.2597	25332.4	-0.0950	0.2492	-925.84	0.4442	0.3446	1167.65
1.75	-0.0049	-0.2823	-0.0214	-0.0405	25122.8	-0.0716	0.2582	-855.84	0.4640	0.0833	1224.34
1.80	-0.0049	-0.2868	-0.0028	-0.0160	24251.7	-0.0666	-0.1402	-850.51	0.4583	-0.4477	1188.82
1.85	-0.0042	-0.2792	-0.0043	0.2629	23338.2	-0.0663	-0.0607	-856.19	0.4390	-0.3761	1108.81
1.90	-0.0045	-0.2678	-0.0411	0.1994	22212.4	-0.0499	-0.0679	-743.62	0.4306	-0.6603	1124.62
1.95	-0.0057	-0.2514	-0.0162	0.4661	21317.4	-0.0353	-0.1658	-628.39	0.4110	-0.7613	1105.96
2.00	-0.0051	-0.2282	0.0063	0.4294	21056.1	-0.0257	0.2614	-620.47	0.4003	-0.3435	1033.17

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.18.1

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRACTOR REAR SUSPENSION - UNSPRUNG MASS SUMMARY

TRAILING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	-0.0000	0.0	-0.00	0.0000	0.0	0.00
0.05	-0.0000	-0.0001	-0.0004	-0.0097	-2.8	0.0002	-0.0559	-6.09	0.0000	0.0812	8.38
0.10	-0.0002	-0.0013	-0.0187	-0.0111	-0.0	0.0043	-0.3224	-294.53	0.0043	0.0429	-293.19
0.15	-0.0010	-0.0030	-0.0375	-0.0989	198.1	0.0170	-0.1147	-220.90	0.0229	0.2799	-198.22
0.20	-0.0024	-0.0115	-0.0429	-0.2094	505.2	0.0416	0.1309	-95.53	0.0563	0.4427	-40.00
0.25	-0.0037	-0.0218	-0.0367	-0.2154	1039.5	0.0627	-0.0378	10.57	0.0923	0.3067	122.79
0.30	-0.0045	-0.0349	-0.0175	-0.3117	1653.8	0.0657	-0.4101	43.29	0.1123	0.0272	221.23
0.35	-0.0047	-0.0516	-0.0319	-0.3414	2260.2	0.0723	-0.0801	90.62	0.1359	0.5149	335.28
0.40	-0.0065	-0.0695	-0.0565	-0.3920	3004.6	0.0992	0.2101	214.85	0.1841	0.8617	540.83
0.45	-0.0082	-0.0915	-0.0362	-0.4822	3892.5	0.1240	-0.3423	324.45	0.2340	0.2544	746.51
0.50	-0.0085	-0.1165	-0.0031	-0.5124	4953.4	0.1127	-0.9279	292.14	0.2524	-0.3661	828.30
0.55	-0.0079	-0.1448	-0.0068	-0.6368	6042.1	0.0852	-0.7825	198.28	0.2559	-0.2827	854.03
0.60	-0.0081	-0.1768	-0.0279	-0.5940	7052.9	0.0737	-0.3760	166.27	0.2749	0.1931	941.01
0.65	-0.0089	-0.2034	-0.0258	-0.5027	8275.7	0.0699	-0.5426	160.60	0.3053	0.1109	1067.67
0.70	-0.0089	-0.2311	0.0004	-0.7989	9525.8	0.0474	-0.9612	79.21	0.3163	-0.4946	1116.09
0.75	-0.0078	-0.2734	0.0077	-0.5290	10365.6	0.0078	-1.0975	-67.40	0.3071	-0.4022	1087.72
0.80	-0.0073	-0.2857	-0.0183	-0.2532	12082.7	-0.0228	-0.5988	-177.42	0.3184	0.3246	1141.65
0.85	-0.0083	-0.3112	-0.0412	-0.6200	13243.4	-0.0165	-0.0508	-145.16	0.3540	0.5877	1287.26
0.90	-0.0095	-0.3310	-0.0308	-0.1824	14433.8	-0.0059	-0.4362	-101.14	0.3973	0.4082	1459.63
0.95	-0.0098	-0.3437	-0.0107	-0.4238	15661.6	-0.0119	-0.6838	-121.63	0.4195	-0.1499	1547.84
1.00	-0.0096	-0.3669	-0.0145	-0.3722	16321.9	-0.0212	-0.5081	-153.71	0.4287	-0.0923	1588.65
1.05	-0.0102	-0.3780	-0.0324	-0.1544	17123.9	-0.0178	-0.1173	-135.29	0.4530	0.1186	1687.82
1.10	-0.0111	-0.3880	-0.0284	-0.2272	17796.7	-0.0047	-0.1105	-81.82	0.4801	-0.2898	1794.36
1.15	-0.0112	-0.3966	-0.0022	-0.1119	18266.1	-0.0101	-0.6941	-103.92	0.4840	-0.8489	1810.10
1.20	-0.0102	-0.4023	0.0097	-0.1438	18432.8	-0.0344	-0.9210	-197.86	0.4614	-0.9595	1724.91
1.25	-0.0094	-0.4088	-0.0065	-0.0728	18315.6	-0.0512	-0.5907	-259.61	0.4400	-0.5122	1646.47
1.30	-0.0095	-0.4089	-0.0228	0.0306	18495.9	-0.0515	-0.2838	-256.55	0.4422	-0.2086	1657.90
1.35	-0.0099	-0.4095	-0.0157	-0.0651	18950.5	-0.0498	-0.4007	-248.60	0.4513	-0.4111	1692.97
1.40	-0.0097	-0.4139	-0.0035	-0.0874	19392.9	-0.0598	-0.6585	-287.13	0.4492	-0.5342	1685.80
1.45	-0.0093	-0.4168	-0.0119	-0.0288	19735.5	-0.0693	-0.5077	-322.46	0.4463	-0.1933	1677.91
1.50	-0.0097	-0.4166	-0.0294	-0.0127	20035.5	-0.0599	-0.2069	-302.92	0.4609	0.0673	1717.65
1.55	-0.0094	-0.4490	0.0150	-1.1187	19437.4	-0.0544	-0.0720	-349.98	0.4604	-0.7928	1641.48
1.60	-0.0080	-0.4812	0.0089	0.0413	19113.9	-0.0801	-1.1084	-490.93	0.4430	-1.1977	1534.93
1.65	-0.0074	-0.4704	-0.0215	0.0675	19948.9	-0.1072	-0.4346	-542.02	0.4312	-0.5186	1545.26
1.70	-0.0086	-0.4740	-0.0400	0.0296	19821.8	-0.0949	0.0430	-458.11	0.4424	-0.0253	1627.65
1.75	-0.0095	-0.4562	-0.0278	0.5610	19933.2	-0.0733	-0.2469	-356.79	0.4654	0.0061	1737.33
1.80	-0.0098	-0.4350	-0.0070	0.2247	19831.0	-0.0680	-0.4837	-327.09	0.4590	-0.6199	1721.49
1.85	-0.0092	-0.4262	-0.0050	0.2470	18952.0	-0.0660	-0.2620	-312.48	0.4391	-0.5887	1651.52
1.90	-0.0093	-0.4104	-0.0164	-0.0043	17956.9	-0.0483	0.1127	-291.99	0.4322	-0.6245	1575.47
1.95	-0.0085	-0.4420	0.0117	-0.7344	15629.4	-0.0274	0.4182	-267.05	0.4113	-1.0312	1433.52
2.00	-0.0082	-0.4501	-0.0325	0.2548	14432.7	-0.0278	-0.3056	-238.94	0.3965	-1.0346	1407.18

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 SPRUNG MASS POSITION

TIME (SEC)	FORWARD (FT)	LATERAL (FT)	VERTICAL (FT)	ROLL (DEG)	PITCH (DEG)	HEADING (DEG)	TURN RADIUS (FT)	SIDE SLIP (DEG)	ARTICULATION ANGLE (DEG)
0.0	-26.3614	0.0	0.0	0.0	0.0	0.0	************	0.0	0.0
0.05	-24.0514	0.0000	-0.0000	0.0000	0.0000	0.0000	275992.8750	0.0002	0.0015
0.10	-21.8520	0.0000	-0.0000	-0.0013	0.0004	0.0003	416555.1875	0.0004	0.0108
0.15	-19.6555	0.0000	-0.0002	-0.0096	0.0031	0.0011	-427493.8750	-0.0005	0.0334
0.20	-17.4657	0.0001	-0.0009	-0.0284	0.0090	0.0031	111325.8125	-0.0023	0.0732
0.25	-15.2846	0.0001	-0.0024	-0.0567	0.0128	0.0072	22209.0742	-0.0031	0.1336
0.30	-13.1113	0.0004	-0.0047	-0.0903	0.0057	0.0146	9584.4727	-0.0010	0.2175
0.35	-10.9460	0.0012	-0.0073	-0.1273	0.0017	0.0263	5645.2852	0.0052	0.3276
0.40	-8.7919	0.0029	-0.0100	-0.1702	0.0139	0.0437	3775.0171	0.0156	0.4656
0.45	-6.6546	0.0057	-0.0128	-0.2220	0.0276	0.0683	2675.1523	0.0306	0.6320
0.50	-4.5403	0.0102	-0.0155	-0.2825	0.0238	0.1020	1971.8765	0.0510	0.8261
0.55	-2.4539	0.0170	-0.0170	-0.3473	0.0117	0.1463	1486.2251	0.0783	1.0454
0.60	-0.3981	0.0265	-0.0166	-0.4132	0.0121	0.2028	1143.2817	0.1145	1.2857
0.65	1.6266	0.0397	-0.0147	-0.4809	0.0227	0.2727	916.1719	0.1607	1.5436
0.70	3.6206	0.0570	-0.0125	-0.5505	0.0235	0.3563	761.6282	0.2165	1.8174
0.75	5.5843	0.0793	-0.0111	-0.6212	0.0107	0.4548	645.8633	0.2824	2.1022
0.80	7.5177	0.1071	-0.0104	-0.6912	0.0030	0.5693	567.2251	0.3545	2.3986
0.85	9.4217	0.1411	-0.0104	-0.7558	0.0121	0.6989	500.6599	0.4334	2.7091
0.90	11.2964	0.1817	-0.0116	-0.8157	0.0244	0.8425	450.7876	0.5203	3.0383
0.95	13.1420	0.2294	-0.0138	-0.8699	0.0239	0.9993	412.2910	0.6131	3.3900
1.00	14.9580	0.2845	-0.0165	-0.9157	0.0173	1.1698	378.1414	0.7106	3.7657
1.05	16.7436	0.3473	-0.0182	-0.9543	0.0208	1.3544	345.5369	0.8137	4.1640
1.10	18.4984	0.4182	-0.0187	-0.9874	0.0325	1.5523	315.2178	0.9254	4.5781
1.15	20.2220	0.4974	-0.0183	-1.0125	0.0352	1.7625	290.9236	1.0467	5.0024
1.20	21.9133	0.5853	-0.0173	-1.0246	0.0249	1.9845	271.5610	1.1753	5.4319
1.25	23.5715	0.6819	-0.0157	-1.0278	0.0164	2.2183	255.2108	1.3085	5.8604
1.30	25.1967	0.7874	-0.0138	-1.0349	0.0199	2.4642	241.0734	1.4445	6.2832
1.35	26.7897	0.9015	-0.0125	-1.0516	0.0257	2.7215	229.1027	1.5821	6.6982
1.40	28.3509	1.0244	-0.0124	-1.0719	0.0222	2.9896	218.0656	1.7213	7.1041
1.45	29.8807	1.1558	-0.0133	-1.0874	0.0154	3.2682	207.0162	1.8627	7.4989
1.50	31.3793	1.2958	-0.0148	-1.0983	0.0181	3.5570	195.9681	2.0079	7.8810
1.55	32.8484	1.4442	-0.0160	-1.1118	0.0264	3.8560	182.5410	2.1615	8.2492
1.60	34.2915	1.6012	-0.0166	-1.1344	0.0229	4.1672	171.7455	2.3248	8.6054
1.65	35.7056	1.7670	-0.0160	-1.1529	0.0129	4.4911	160.4937	2.4955	8.9467
1.70	37.0827	1.9416	-0.0144	-1.1532	0.0164	4.8253	149.2876	2.6827	9.2605
1.75	38.4212	2.1250	-0.0128	-1.1399	0.0272	5.1663	143.9207	2.8807	9.5462
1.80	39.7241	2.3163	-0.0124	-1.1158	0.0255	5.5106	143.8707	3.0717	9.8117
1.85	40.9946	2.5147	-0.0133	-1.0778	0.0141	5.8558	144.3370	3.2466	10.0636
1.90	42.2351	2.7193	-0.0147	-1.0287	0.0134	6.2020	142.0525	3.4099	10.3044
1.95	43.4490	2.9295	-0.0157	-0.9823	0.0227	6.5505	136.9190	3.5725	10.5368
2.00	44.6374	3.1452	-0.0158	-0.9504	0.0239	6.9046	130.7935	3.7368	10.7587

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.01.2

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 SPRUNG MASS VELOCITY (BODY AXES)

TIME (SEC)	FORWARD (FT/SEC)	LATERAL (FT/SEC)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	PITCH (DEG/SEC)	HEADING (DEG/SEC)	ARTICULATION RATE (DEG/SEC)
0.0	44.00	0.0	0.0	0.0	0.0	0.0	0.0
0.05	44.00	0.00	-0.00	-0.00	0.00	0.00	0.09
0.10	44.00	0.00	-0.00	-0.08	0.01	0.01	0.30
0.15	43.99	-0.00	-0.01	-0.27	0.08	0.03	0.61
0.20	43.95	-0.00	-0.01	-0.48	0.14	0.06	0.99
0.25	43.84	-0.00	-0.03	-0.63	0.01	0.11	1.43
0.30	43.63	-0.00	-0.04	-0.70	-0.15	0.19	1.93
0.35	43.32	0.00	-0.05	-0.79	0.12	0.29	2.48
0.40	42.92	0.01	-0.04	-0.94	0.39	0.42	3.04
0.45	42.47	0.02	-0.03	-1.13	0.16	0.58	3.61
0.50	41.97	0.04	-0.02	-1.27	-0.20	0.77	4.15
0.55	41.44	0.06	-0.00	-1.31	-0.13	1.00	4.61
0.60	40.88	0.08	0.04	-1.33	0.20	1.26	4.99
0.65	40.28	0.11	0.07	-1.38	0.20	1.54	5.32
0.70	39.67	0.15	0.06	-1.40	-0.14	1.81	5.60
0.75	39.07	0.19	0.03	-1.43	-0.26	2.13	5.80
0.80	38.47	0.24	0.02	-1.35	0.03	2.45	6.06
0.85	37.88	0.29	0.00	-1.24	0.29	2.74	6.38
0.90	37.29	0.34	-0.01	-1.16	0.14	3.01	6.80
0.95	36.69	0.39	-0.03	-1.00	-0.14	3.27	7.27
1.00	36.08	0.45	-0.03	-0.84	-0.09	3.55	7.76
1.05	35.46	0.50	0.00	-0.72	0.18	3.83	8.15
1.10	34.83	0.56	0.03	-0.60	0.17	4.09	8.40
1.15	34.20	0.62	0.05	-0.38	-0.14	4.32	8.56
1.20	33.56	0.69	0.06	-0.12	-0.29	4.55	8.60
1.25	32.93	0.75	0.06	-0.06	-0.10	4.80	8.53
1.30	32.30	0.81	0.06	-0.24	0.10	5.04	8.39
1.35	31.67	0.87	0.05	-0.41	-0.02	5.26	8.22
1.40	31.04	0.93	0.02	-0.38	-0.22	5.46	8.02
1.45	30.42	0.99	0.00	-0.25	-0.14	5.67	7.78
1.50	29.80	1.04	0.00	-0.21	0.10	5.88	7.51
1.55	29.19	1.10	0.02	-0.37	0.00	6.10	7.24
1.60	28.60	1.16	0.04	-0.49	-0.29	6.35	7.01
1.65	28.02	1.22	0.06	-0.20	-0.20	6.59	6.58
1.70	27.44	1.28	0.07	0.15	0.12	6.77	5.98
1.75	26.82	1.35	0.07	0.36	0.04	6.86	5.49
1.80	26.17	1.40	0.04	0.61	-0.29	6.89	5.16
1.85	25.51	1.45	0.01	0.89	-0.27	6.91	4.92
1.90	24.86	1.48	0.01	1.02	0.07	6.94	4.72
1.95	24.25	1.51	0.03	0.78	0.06	7.02	4.59
2.00	23.67	1.54	0.04	0.51	-0.15	7.15	4.18

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.02.2
SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TIME (SEC)	TRAILER NO. 1 SPRUNG MASS ACCELERATION (BODY AXES) FORWARD (FT/SEC**2)	LATERAL (FT/SEC**2)	VERTICAL (FT/SEC**2)	ROLL (DEG/SEC**2)	PITCH (DEG/SEC**2)	HEADING (DEG/SEC**2)	INERTIAL ACCEL. ALONG BODY AXES LONGITUDINAL (FT/SEC**2)	LATERAL (FT/SEC**2)
0.0	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
0.05	-0.0026	0.0057	-0.0028	-0.2868	0.0633	0.0841	-0.0026	0.0071
0.10	-0.0683	-0.0026	-0.0565	-3.0828	0.3308	0.2218	-0.0683	0.0042
0.15	-0.4089	-0.0243	-0.2320	-4.3181	-0.8651	0.4663	-0.4089	-0.0048
0.20	-1.2612	-0.0249	-1.5977	-3.8151	-28.6117	0.8415	-1.2612	0.0195
0.25	-3.0930	0.0073	-2.0134	-1.9950	-41.5299	1.2494	-3.0930	0.0926
0.30	-5.3224	0.0657	-2.0442	-1.1468	-34.3410	1.6779	-5.3222	0.2073
0.35	-7.0843	0.1273	-1.6722	-2.3175	-28.0840	2.2149	-7.0844	0.3428
0.40	-8.4978	0.1895	-1.4939	-3.6463	-34.9556	2.8348	-8.4982	0.5002
0.45	-9.4844	0.2602	-1.5830	-3.6200	-43.9355	3.4736	-9.4847	0.6879
0.50	-10.1950	0.3421	-1.4514	-1.5745	-39.4600	4.1107	-10.1954	0.9081
0.55	-10.9009	0.4460	-1.0195	-0.1052	-29.7382	4.7794	-10.9019	1.1708
0.60	-11.6640	0.5721	-0.9432	-0.6401	-30.8372	5.2493	-11.6657	1.4739
0.65	-12.1443	0.6954	-1.5161	-0.7035	-40.3027	5.2855	-12.1471	1.7772
0.70	-12.1071	0.8084	-2.1387	-0.1389	-42.2109	5.5793	-12.1120	2.0643
0.75	-11.8683	0.9011	-2.2144	0.2873	-33.3463	6.3047	-11.8756	2.3523
0.80	-11.7732	0.9460	-1.9710	2.8388	-28.0143	5.8597	-11.7834	2.5894
0.85	-11.8208	1.0234	-1.9552	2.0058	-34.4536	5.2539	-11.8345	2.8341
0.90	-11.8639	1.0808	-2.1091	2.6155	-41.8470	4.8919	-11.8817	3.0367
0.95	-11.9674	1.1070	-1.9320	3.9668	-38.6507	5.0756	-11.9897	3.1999
1.00	-12.1910	1.1235	-1.3862	3.3540	-30.9250	5.3891	-12.2187	3.3586
1.05	-12.4832	1.1610	-1.0368	2.4805	-31.8864	5.0518	-12.5169	3.5326
1.10	-12.6615	1.2321	-1.2096	3.5518	-39.8890	4.4590	-12.7015	3.7175
1.15	-12.6192	1.2838	-1.5401	6.0879	-41.8195	4.1706	-12.6665	3.8629
1.20	-12.6233	1.2965	-1.6235	4.4272	-34.7563	4.3705	-12.6783	3.9629
1.25	-12.6183	1.2768	-1.6046	-1.2166	-30.1068	4.5533	-12.6814	4.0331
1.30	-12.6147	1.2432	-1.8382	-3.8841	-34.7863	4.2390	-12.6862	4.0826
1.35	-12.5242	1.2012	-2.2015	-0.9663	-40.2527	3.7915	-12.6045	4.1066
1.40	-12.4242	1.1631	-2.2478	2.7441	-37.4629	3.7244	-12.5132	4.1227
1.45	-12.3387	1.1367	-1.9093	2.5787	-31.2771	3.8008	-12.4366	4.1481
1.50	-12.3168	1.1245	-1.5817	-0.1910	-32.5153	3.5515	-12.4239	4.1818
1.55	-12.0932	1.1895	-1.3729	-4.1009	-41.4542	4.4673	-12.2104	4.2949
1.60	-11.5709	1.2064	-1.2945	2.0924	-39.3774	4.6363	-11.6997	4.3768
1.65	-11.3942	1.2635	-1.3451	8.8404	-28.8867	3.8315	-11.5347	4.4852
1.70	-11.9754	1.3291	-1.6024	5.7339	-32.2321	2.3991	-12.1270	4.5698
1.75	-12.7432	1.2277	-2.1523	4.5536	-41.7679	0.6916	-12.9047	4.4406
1.80	-13.1461	0.9873	-2.3857	6.3563	-40.1913	-0.1735	-13.3151	4.1356
1.85	-13.0789	0.7719	-2.0241	5.2036	-30.5974	-0.0072	-13.2533	3.8476
1.90	-12.6929	0.6657	-1.5200	-0.6183	-30.8743	0.5377	-12.8721	3.6762
1.95	-11.8501	0.6612	-1.3243	-6.4046	-39.8004	1.8811	-12.0354	3.6318
2.00	-11.1561	0.6813	-1.5082	-3.0740	-37.4026	2.5348	-11.3489	3.6352

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 REAR SUSPENSION TIRE FORCES

LEADING TANDEM AXLE

TIME (SEC)	LEFT SIDE VERTICAL (LB)	LEFT SIDE LONG. (LB)	LEFT SIDE LATERAL (LB)	LEFT SIDE MU-X	LEFT SIDE MU-Y	RIGHT SIDE VERTICAL (LB)	RIGHT SIDE LONG. (LB)	RIGHT SIDE LATERAL (LB)	RIGHT SIDE MU-X	RIGHT SIDE MU-Y
0.0	6631.73	-0.0	0.0	0.0	0.0	6631.73	-0.0	0.0	0.0	0.0
0.05	6631.99	-0.02	0.31	-0.0000	0.0000	6631.51	0.05	0.31	0.0000	0.0000
0.10	6634.20	0.37	-3.18	0.0001	-0.0005	6633.91	0.59	-3.18	0.0001	-0.0005
0.15	6658.61	0.55	-10.59	0.0001	-0.0016	6647.41	1.05	-10.57	0.0002	-0.0016
0.20	6674.07	-100.56	-12.98	-0.0151	-0.0019	6618.86	-99.24	-12.88	-0.0150	-0.0019
0.25	6689.52	-346.48	-4.97	-0.0518	-0.0007	6563.12	-342.98	-4.88	-0.0523	-0.0007
0.30	6622.68	-593.29	12.94	-0.0896	0.0020	6389.23	-587.15	12.49	-0.0919	0.0020
0.35	6573.84	-782.44	33.82	-0.1190	0.0051	6226.28	-773.75	32.06	-0.1243	0.0051
0.40	6708.55	-927.22	56.45	-0.1382	0.0084	6235.35	-917.13	52.52	-0.1471	0.0084
0.45	6847.46	-1029.54	83.90	-0.1504	0.0123	6217.32	-1016.84	76.28	-0.1636	0.0123
0.50	6788.47	-1101.09	120.21	-0.1622	0.0177	5973.54	-1083.72	105.98	-0.1814	0.0177
0.55	6708.34	-1159.80	169.00	-0.1729	0.0252	5685.66	-1139.19	143.59	-0.2004	0.0253
0.60	6874.01	-1209.75	229.38	-0.1760	0.0334	5629.20	-1191.00	188.44	-0.2116	0.0335
0.65	7207.23	-1241.82	292.60	-0.1723	0.0406	5735.91	-1225.78	233.78	-0.2137	0.0408
0.70	7404.91	-1260.77	348.73	-0.1703	0.0471	5713.66	-1242.05	270.35	-0.2174	0.0473
0.75	7412.00	-1279.46	403.46	-0.1726	0.0544	5503.25	-1255.03	301.25	-0.2281	0.0547
0.80	7471.00	-1299.89	468.58	-0.1740	0.0627	5336.52	-1276.83	336.91	-0.2393	0.0631
0.85	7689.24	-1314.03	532.60	-0.1709	0.0693	5342.05	-1297.64	372.79	-0.2429	0.0698
0.90	7860.83	-1317.49	575.76	-0.1676	0.0732	5337.60	-1301.25	394.21	-0.2438	0.0739
0.95	7812.71	-1316.62	605.38	-0.1685	0.0775	5143.34	-1294.27	402.22	-0.2516	0.0782
1.00	7689.51	-1319.25	637.13	-0.1716	0.0829	4892.29	-1295.06	409.49	-0.2647	0.0837
1.05	7734.70	-1324.58	676.35	-0.1713	0.0874	4815.60	-1308.26	425.80	-0.2717	0.0884
1.10	7911.45	-1325.75	709.94	-0.1676	0.0897	4887.09	-1315.91	443.88	-0.2693	0.0908
1.15	7987.22	-1323.47	728.02	-0.1657	0.0911	4894.79	-1311.09	452.00	-0.2679	0.0923
1.20	7915.36	-1322.58	732.91	-0.1671	0.0926	4799.50	-1307.72	450.65	-0.2725	0.0939
1.25	7889.17	-1326.50	725.21	-0.1681	0.0919	4781.57	-1316.54	446.19	-0.2753	0.0933
1.30	8013.00	-1330.17	704.38	-0.1660	0.0879	4915.53	-1325.97	439.09	-0.2698	0.0893
1.35	8129.65	-1329.53	675.79	-0.1635	0.0831	5028.89	-1322.74	425.24	-0.2630	0.0846
1.40	8085.00	-1327.55	654.33	-0.1642	0.0809	4967.07	-1314.08	409.34	-0.2646	0.0824
1.45	7968.38	-1328.98	644.96	-0.1668	0.0809	4831.07	-1314.04	398.60	-0.2720	0.0825
1.50	7953.33	-1332.17	632.72	-0.1675	0.0796	4809.39	-1322.92	390.44	-0.2751	0.0812
1.55	8002.41	-1334.54	603.27	-0.1668	0.0754	4864.91	-1325.45	374.70	-0.2725	0.0770
1.60	7943.76	-1338.79	586.13	-0.1685	0.0738	4782.59	-1321.99	361.04	-0.2764	0.0755
1.65	7883.72	-1343.35	606.87	-0.1704	0.0770	4661.67	-1328.15	367.63	-0.2849	0.0789
1.70	8007.10	-1340.36	604.67	-0.1674	0.0755	4791.25	-1340.25	371.10	-0.2797	0.0775
1.75	8134.01	-1327.95	527.37	-0.1633	0.0648	5043.13	-1332.81	335.67	-0.2643	0.0666
1.80	8017.19	-1316.68	418.81	-0.1642	0.0522	5107.66	-1316.06	274.12	-0.2577	0.0537
1.85	7748.63	-1315.71	334.21	-0.1698	0.0431	5018.54	-1312.36	222.53	-0.2615	0.0443
1.90	7602.99	-1323.44	267.25	-0.1741	0.0352	5058.39	-1324.80	182.94	-0.2619	0.0362
1.95	7583.35	-1334.70	192.35	-0.1760	0.0254	5237.75	-1335.42	136.81	-0.2550	0.0261
2.00	7512.79	-1343.43	141.10	-0.1788	0.0188	5306.50	-1338.89	102.74	-0.2523	0.0194

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 REAR SUSPENSION TIRE FORCES

TRAILING TANDEM AXLE

	LEFT SIDE					RIGHT SIDE				
TIME (SEC)	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y
0.0	9947.60	-0.0	0.0	0.0	0.0	9947.60	-0.0	0.0	0.0	0.0
0.05	9947.97	-0.02	0.51	-0.0000	0.0001	9947.28	0.05	0.51	0.0000	0.0001
0.10	9951.49	0.37	-2.22	0.0000	-0.0002	9949.40	0.59	-2.22	0.0001	-0.0002
0.15	9986.45	3.30	-7.79	0.0003	-0.0008	9964.87	3.79	-7.78	0.0004	-0.0008
0.20	10025.63	11.77	-6.62	0.0012	-0.0007	9942.15	12.68	-6.56	0.0013	-0.0007
0.25	9993.27	-473.49	7.33	-0.0474	0.0007	9814.40	-467.38	7.20	-0.0476	0.0007
0.30	9774.61	-1433.30	32.86	-0.1466	0.0034	9453.65	-1418.28	31.80	-0.1500	0.0034
0.35	9585.97	-2134.89	63.36	-0.2227	0.0066	9113.79	-2112.98	60.28	-0.2318	0.0066
0.40	9662.62	-2639.06	99.25	-0.2731	0.0103	9019.20	-2614.30	92.73	-0.2899	0.0103
0.45	9812.44	-2965.28	144.41	-0.3022	0.0147	8953.52	-2937.37	131.96	-0.3281	0.0147
0.50	9729.37	-3169.21	201.17	-0.3257	0.0207	8618.27	-3133.48	178.54	-0.3636	0.0207
0.55	9577.07	-3317.94	272.31	-0.3464	0.0284	8186.86	-3277.27	233.36	-0.4003	0.0285
0.60	9732.13	-3440.92	361.10	-0.3536	0.0371	8041.02	-3408.36	299.30	-0.4239	0.0372
0.65	10166.21	-3508.11	461.63	-0.3451	0.0454	8158.13	-3489.36	371.91	-0.4277	0.0456
0.70	10481.66	-3521.84	559.32	-0.3360	0.0534	8155.83	-3503.71	437.27	-0.4296	0.0536
0.75	10531.84	-3526.30	657.91	-0.3348	0.0625	7888.17	-3498.90	495.54	-0.4436	0.0628
0.80	10598.59	-3540.91	766.92	-0.3341	0.0724	7633.16	-3519.45	555.98	-0.4611	0.0728
0.85	10879.63	-3549.63	879.83	-0.3263	0.0809	7603.09	-3548.30	619.47	-0.4667	0.0815
0.90	11151.09	-3527.30	975.79	-0.3163	0.0875	7596.05	-3533.82	670.26	-0.4652	0.0882
0.95	11139.93	-3495.55	1051.74	-0.3138	0.0944	7348.52	-3491.64	760.21	-0.4751	0.0953
1.00	10978.57	-3477.15	1124.34	-0.3167	0.1024	6985.28	-3470.44	722.69	-0.4968	0.1035
1.05	11011.92	-3473.44	1211.95	-0.3154	0.1101	6821.02	-3488.36	759.13	-0.5114	0.1113
1.10	11260.63	-3460.39	1306.46	-0.3073	0.1160	6874.57	-3498.63	807.32	-0.5089	0.1174
1.15	11421.73	-3433.80	1385.14	-0.3006	0.1213	6880.29	-3472.42	845.36	-0.5047	0.1229
1.20	11372.81	-3411.11	1440.50	-0.2999	0.1267	6743.62	-3445.39	866.23	-0.5109	0.1285
1.25	11351.48	-3403.52	1486.55	-0.2998	0.1310	6670.78	-3450.52	886.83	-0.5173	0.1329
1.30	11545.74	-3399.61	1537.30	-0.2944	0.1331	6789.29	-3464.48	918.68	-0.5103	0.1353
1.35	11776.24	-3382.18	1586.69	-0.2872	0.1347	6912.25	-3446.25	947.45	-0.4986	0.1371
1.40	11791.28	-3361.62	1627.64	-0.2851	0.1380	6825.01	-3410.87	959.41	-0.4998	0.1406
1.45	11661.91	-3350.52	1667.50	-0.2873	0.1430	6616.32	-3395.92	964.46	-0.5133	0.1458
1.50	11645.95	-3348.24	1713.24	-0.2875	0.1471	6526.12	-3408.82	979.83	-0.5223	0.1501
1.55	11753.57	-3342.58	1761.05	-0.2844	0.1498	6543.22	-3409.53	1001.77	-0.5211	0.1531
1.60	11739.29	-3334.70	1820.80	-0.2841	0.1551	6406.28	-3386.86	1016.73	-0.5287	0.1587
1.65	11673.66	-3332.17	1906.26	-0.2854	0.1633	6209.27	-3388.09	1038.90	-0.5456	0.1673
1.70	11852.11	-3329.01	1987.43	-0.2809	0.1677	6302.73	-3423.11	1084.17	-0.5431	0.1720
1.75	12115.23	-3311.03	1998.69	-0.2733	0.1650	6575.82	-3420.95	1113.93	-0.5202	0.1694
1.80	12071.29	-3287.78	1933.62	-0.2724	0.1602	6650.36	-3382.60	1094.72	-0.5086	0.1646
1.85	11748.45	-3280.13	1851.24	-0.2792	0.1576	6516.82	-3365.78	1056.06	-0.5165	0.1621
1.90	11545.24	-3289.37	1801.15	-0.2849	0.1560	6500.61	-3389.06	1043.84	-0.5213	0.1606
1.95	11565.78	-3301.72	1785.74	-0.2855	0.1544	6655.01	-3404.95	1058.76	-0.5116	0.1591
2.00	11547.72	-3307.46	1800.66	-0.2864	0.1559	6706.72	-3399.28	1079.00	-0.5068	0.1609

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.09.2

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 REAR SUSPENSION - BRAKE SUMMARY

LEADING TANDEM AXLE

TIME (SEC)	TREADLE PRESSURE (PSI)	LEFT SIDE BRAKE PRESSURE (PSI)	LEFT SIDE BRAKE TORQUE (IN-LB)	LEFT SIDE TIRE BRAKE FORCE (LB)	LEFT SIDE WHEEL SLIP	LEFT SIDE ANGULAR WHEEL VEL. (RAD/SEC)	LEFT SIDE ANGULAR WHEEL ACCEL. (RAD/S**2)	RIGHT SIDE BRAKE PRESSURE (PSI)	RIGHT SIDE BRAKE TORQUE (IN-LB)	RIGHT SIDE TIRE BRAKE FORCE (LB)	RIGHT SIDE WHEEL SLIP	RIGHT SIDE ANGULAR WHEEL VEL (RAD/SEC)	RIGHT SIDE ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	-0.02	0.0000	26.14	0.00	0.0	0.0	0.05	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.37	-.0000	26.14	-0.02	0.0	0.0	0.59	-.0000	26.14	-0.03
0.15	30.00	0.16	161.07	0.55	-.0000	26.13	-0.41	0.16	161.07	1.05	-.0000	26.13	-0.43
0.20	30.00	3.18	3175.51	-100.56	0.0024	26.05	-2.70	3.18	3175.51	-99.24	0.0024	26.05	-2.76
0.25	30.00	9.08	9083.05	-346.48	0.0082	25.84	-4.92	9.08	9083.05	-342.98	0.0083	25.83	-5.08
0.30	30.00	14.41	14413.03	-593.29	0.0141	25.55	-5.73	14.41	14413.03	-587.15	0.0145	25.53	-6.02
0.35	30.00	18.38	18384.68	-782.44	0.0188	25.26	-6.08	18.38	18384.68	-773.75	0.0196	25.22	-6.50
0.40	30.00	21.34	21344.23	-927.22	0.0218	24.97	-6.17	21.34	21344.23	-917.13	0.0232	24.91	-6.65
0.45	30.00	23.55	23549.72	-1029.54	0.0237	24.65	-6.49	23.55	23549.72	-1016.84	0.0258	24.57	-7.10
0.50	30.00	25.19	25193.21	-1101.09	0.0256	24.31	-6.96	25.19	25193.21	-1083.72	0.0286	24.19	-7.79
0.55	30.00	26.42	26417.89	-1159.80	0.0273	23.97	-7.05	26.42	26417.89	-1139.19	0.0316	23.81	-8.03
0.60	30.00	27.33	27330.53	-1209.75	0.0278	23.65	-6.82	27.33	27330.53	-1191.00	0.0334	23.44	-7.72
0.65	30.00	28.01	28010.60	-1241.82	0.0272	23.33	-6.90	28.01	28010.60	-1225.78	0.0337	23.08	-7.66
0.70	30.00	28.52	28517.44	-1260.77	0.0269	22.98	-7.19	28.52	28517.44	-1242.05	0.0343	22.70	-8.09
0.75	30.00	28.90	28895.07	-1279.46	0.0273	22.63	-7.19	28.90	28895.07	-1255.03	0.0360	22.30	-8.36
0.80	30.00	29.18	29176.49	-1299.89	0.0275	22.30	-6.88	29.18	29176.49	-1276.83	0.0378	21.92	-7.58
0.85	30.00	29.39	29386.20	-1314.03	0.0270	21.99	-6.70	29.39	29386.20	-1297.64	0.0384	21.57	-7.49
0.90	30.00	29.54	29542.49	-1317.49	0.0265	21.66	-6.91	29.54	29542.49	-1301.25	0.0385	21.21	-7.68
0.95	30.00	29.66	29658.98	-1316.62	0.0266	21.31	-7.22	29.66	29658.98	-1294.27	0.0397	20.83	-8.29
1.00	30.00	29.75	29745.74	-1319.25	0.0271	20.96	-7.30	29.75	29745.74	-1295.06	0.0418	20.43	-8.46
1.05	30.00	29.81	29810.44	-1324.58	0.0270	20.62	-7.20	29.81	29810.44	-1308.26	0.0429	20.06	-7.98
1.10	30.00	29.86	29858.63	-1325.75	0.0265	20.27	-7.26	29.86	29858.63	-1315.91	0.0425	19.70	-7.73
1.15	30.00	29.89	29894.53	-1323.47	0.0262	19.91	-7.45	29.89	29894.53	-1311.09	0.0423	19.32	-8.04
1.20	30.00	29.92	29921.27	-1322.58	0.0264	19.54	-7.56	29.92	29921.27	-1307.72	0.0430	18.94	-8.27
1.25	30.00	29.94	29941.28	-1326.50	0.0265	19.18	-7.42	29.94	29941.28	-1316.54	0.0435	18.57	-7.89
1.30	30.00	29.96	29956.13	-1330.17	0.0262	18.84	-7.28	29.96	29956.13	-1325.97	0.0426	18.22	-7.48
1.35	30.00	29.97	29967.18	-1329.53	0.0258	18.48	-7.34	29.97	29967.18	-1322.74	0.0415	17.87	-7.66
1.40	30.00	29.98	29975.43	-1327.55	0.0259	18.12	-7.45	29.98	29975.43	-1314.08	0.0418	17.50	-8.09
1.45	30.00	29.98	29981.56	-1328.98	0.0263	17.76	-7.40	29.98	29981.56	-1314.04	0.0429	17.12	-8.11
1.50	30.00	29.99	29986.14	-1332.17	0.0264	17.42	-7.26	29.99	29986.14	-1322.92	0.0434	16.77	-7.70
1.55	30.00	29.99	29989.56	-1334.54	0.0263	17.07	-7.15	29.99	29989.56	-1325.45	0.0430	16.41	-7.58
1.60	30.00	29.99	29992.09	-1338.79	0.0266	16.72	-6.95	29.99	29992.09	-1321.99	0.0436	16.05	-7.75
1.65	30.00	29.99	29994.00	-1343.35	0.0269	16.39	-6.74	29.99	29994.00	-1328.15	0.0450	15.70	-7.47
1.70	30.00	30.00	29995.39	-1340.36	0.0264	16.08	-6.89	30.00	29995.39	-1340.25	0.0442	15.39	-6.89
1.75	30.00	30.00	29996.44	-1327.95	0.0258	15.73	-7.48	30.00	29996.44	-1332.81	0.0417	15.07	-7.25
1.80	30.00	30.00	29997.22	-1316.68	0.0259	15.34	-8.02	30.00	29997.22	-1316.06	0.0407	14.70	-8.05
1.85	30.00	30.00	29997.83	-1315.71	0.0268	14.95	-8.07	30.00	29997.83	-1312.36	0.0413	14.32	-8.23
1.90	30.00	30.00	29998.21	-1323.44	0.0275	14.57	-7.70	30.00	29998.21	-1324.80	0.0414	13.96	-7.63
1.95	30.00	30.00	29998.52	-1334.70	0.0278	14.22	-7.16	30.00	29998.52	-1335.42	0.0403	13.62	-7.13
2.00	30.00	30.00	29998.82	-1343.43	0.0282	13.87	-6.75	30.00	29998.82	-1338.89	0.0398	13.29	-6.97

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 1 REAR SUSPENSION - BRAKE SUMMARY
TRAILING TANDEM AXLE

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	-0.02	0.0000	26.14	0.00	0.0	0.0	0.05	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.37	-.0000	26.14	-0.02	0.0	0.0	0.59	-.0000	26.14	-0.03
0.15	30.00	0.16	0.0	3.30	-.0001	26.14	-0.16	0.16	0.0	3.79	-.0001	26.13	-0.18
0.20	30.00	3.18	0.0	11.77	-.0003	26.12	-0.56	3.18	0.0	12.68	-.0003	26.12	-0.60
0.25	30.00	9.08	15282.68	-473.49	0.0112	25.76	-13.49	9.08	15267.26	-467.38	0.0113	25.75	-13.74
0.30	30.00	14.41	34545.36	-1433.30	0.0347	25.02	-13.19	14.41	34509.41	-1418.28	0.0355	24.99	-13.82
0.35	30.00	18.38	48065.84	-2134.89	0.0527	24.39	-11.65	18.38	48027.03	-2112.98	0.0549	24.31	-12.61
0.40	30.00	21.34	57446.95	-2639.06	0.0647	23.87	-9.76	21.34	57421.92	-2614.30	0.0687	23.75	-10.88
0.45	30.00	23.55	63269.95	-2965.28	0.0716	23.45	-7.95	23.55	63288.19	-2937.37	0.0777	23.26	-9.32
0.50	30.00	25.19	67638.31	-3169.21	0.0772	23.03	-8.54	25.19	67697.63	-3133.48	0.0861	22.76	-10.38
0.55	30.00	26.42	70564.13	-3317.94	0.0821	22.62	-8.35	26.42	70675.69	-3277.27	0.0948	22.25	-10.55
0.60	30.00	27.33	72468.38	-3440.92	0.0837	22.29	-6.99	27.33	72642.75	-3408.36	0.1004	21.82	-8.95
0.65	30.00	28.01	73165.06	-3508.11	0.0817	22.02	-5.43	28.01	73439.44	-3489.36	0.1013	21.47	-6.97
0.70	30.00	28.52	73869.94	-3521.84	0.0796	21.74	-6.44	28.52	74214.19	-3503.71	0.1017	21.11	-8.11
0.75	30.00	28.90	74228.38	-3526.30	0.0793	21.42	-7.07	28.90	74646.75	-3498.90	0.1051	20.70	-9.36
0.80	30.00	29.18	74345.69	-3540.91	0.0791	21.12	-6.65	29.18	74845.81	-3519.45	0.1092	20.29	-8.85
0.85	30.00	29.39	74291.75	-3549.63	0.0773	20.85	-6.11	29.39	74877.00	-3548.30	0.1105	19.95	-7.55
0.90	30.00	29.54	73821.00	-3527.30	0.0749	20.58	-6.06	29.54	74525.13	-3533.82	0.1102	19.63	-7.41
0.95	30.00	29.66	73609.69	-3495.55	0.0743	20.26	-7.07	29.66	74392.44	-3491.64	0.1125	19.25	-9.11
1.00	30.00	29.75	73359.69	-3477.15	0.0750	19.93	-7.36	29.75	74226.94	-3470.44	0.1177	18.81	-9.73
1.05	30.00	29.81	73085.19	-3473.44	0.0747	19.61	-6.89	29.81	74041.69	-3488.36	0.1211	18.42	-8.44
1.10	30.00	29.86	72591.19	-3460.39	0.0728	19.31	-6.35	29.86	73669.25	-3498.63	0.1205	18.09	-7.07
1.15	30.00	29.89	72316.38	-3433.80	0.0712	18.99	-6.97	29.89	73465.50	-3472.42	0.1195	17.77	-7.84
1.20	30.00	29.92	72050.25	-3411.11	0.0710	18.64	-7.42	29.92	73268.25	-3445.39	0.1210	17.39	-8.66
1.25	30.00	29.94	71794.88	-3403.52	0.0710	18.31	-7.18	29.94	73081.75	-3450.52	0.1225	17.03	-7.97
1.30	30.00	29.96	71547.94	-3399.61	0.0697	18.00	-6.78	29.96	72898.44	-3464.48	0.1209	16.73	-6.88
1.35	30.00	29.97	71186.81	-3382.18	0.0680	17.68	-6.76	29.97	72616.69	-3446.25	0.1181	16.45	-7.08
1.40	30.00	29.98	70978.94	-3361.62	0.0675	17.34	-7.25	29.98	72458.63	-3410.87	0.1184	16.10	-8.39
1.45	30.00	29.98	70788.75	-3350.52	0.0680	17.00	-7.33	29.98	72323.25	-3395.92	0.1216	15.72	-8.79
1.50	30.00	29.99	70613.00	-3348.24	0.0681	16.67	-7.03	29.99	72205.50	-3408.82	0.1237	15.36	-7.90
1.55	30.00	29.99	70368.94	-3342.58	0.0674	16.35	-6.72	29.99	72040.06	-3409.53	0.1234	15.04	-7.47
1.60	30.00	29.99	70228.88	-3334.70	0.0673	16.02	-6.76	29.99	71952.06	-3386.86	0.1252	14.68	-8.34
1.65	30.00	29.99	70100.88	-3332.17	0.0676	15.70	-6.58	29.99	71882.50	-3388.09	0.1292	14.31	-8.12
1.70	30.00	30.00	69980.44	-3329.01	0.0665	15.41	-6.45	30.00	71819.56	-3423.11	0.1286	14.03	-6.30
1.75	30.00	30.00	69870.75	-3311.03	0.0647	15.10	-7.05	30.00	71752.56	-3420.95	0.1232	13.78	-6.25
1.80	30.00	30.00	69744.19	-3287.78	0.0645	14.73	-7.86	30.00	71668.13	-3382.60	0.1205	13.48	-7.88
1.85	30.00	30.00	69688.06	-3280.13	0.0661	14.34	-8.09	30.00	71638.56	-3365.78	0.1223	13.11	-8.61
1.90	30.00	30.00	69646.38	-3289.37	0.0675	13.97	-7.55	30.00	71623.94	-3389.06	0.1235	12.76	-7.46
1.95	30.00	30.00	69614.06	-3301.72	0.0676	13.63	-6.89	30.00	71612.56	-3404.95	0.1212	12.47	-6.68
2.00	30.00	30.00	69580.38	-3307.46	0.0678	13.31	-6.53	30.00	71602.88	-3399.28	0.1200	12.18	-6.93

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 1 REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY
LEADING TANDEM AXLE

TIME (SEC)	LEFT SIDE: TIRE SIDESLIP ANGLE (DEG)	LEFT SIDE: TIRE LATERAL FORCE (LB)	LEFT SIDE: MU-Y	LEFT SIDE: ALIGNING TORQUE (IN-LB)	RIGHT SIDE: TIRE SIDESLIP ANGLE (DEG)	RIGHT SIDE: TIRE LATERAL FORCE (LB)	RIGHT SIDE: MU-Y	RIGHT SIDE: ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	-0.0003	0.3084	0.0000	0.0	-0.0003	0.3084	0.0000	0.0
0.10	0.0026	-3.1785	-0.0005	0.0	0.0026	-3.1785	-0.0005	0.0
0.15	0.0088	-10.5868	-0.0016	0.0	0.0088	-10.5696	-0.0016	0.0
0.20	0.0107	-12.9823	-0.0019	0.0	0.0108	-12.8767	-0.0019	0.0
0.25	0.0041	-4.9689	-0.0007	0.0	0.0041	-4.8763	-0.0007	0.0
0.30	-0.0108	12.9372	0.0020	0.0	-0.0108	12.4866	0.0020	0.0
0.35	-0.0284	33.8232	0.0051	0.0	-0.0285	32.0566	0.0051	0.0
0.40	-0.0465	56.4507	0.0084	0.0	-0.0465	52.5209	0.0084	0.0
0.45	-0.0677	83.8965	0.0123	0.0	-0.0678	76.2824	0.0123	0.0
0.50	-0.0979	120.2147	0.0177	0.0	-0.0981	105.9837	0.0177	0.0
0.55	-0.1392	168.9959	0.0252	0.0	-0.1396	143.5894	0.0253	0.0
0.60	-0.1844	229.3791	0.0334	0.0	-0.1850	188.4391	0.0335	0.0
0.65	-0.2244	292.5996	0.0406	0.0	-0.2252	233.7829	0.0408	0.0
0.70	-0.2603	348.7300	0.0471	0.0	-0.2615	270.3503	0.0473	0.0
0.75	-0.3008	403.4631	0.0544	0.0	-0.3025	301.2483	0.0547	0.0
0.80	-0.3466	468.5833	0.0627	0.0	-0.3489	336.9087	0.0631	0.0
0.85	-0.3828	532.6018	0.0693	0.0	-0.3857	372.7869	0.0698	0.0
0.90	-0.4048	575.7576	0.0732	0.0	-0.4082	394.2056	0.0739	0.0
0.95	-0.4282	605.3816	0.0775	0.0	-0.4322	402.2170	0.0782	0.0
1.00	-0.4579	637.1326	0.0829	0.0	-0.4626	409.4915	0.0837	0.0
1.05	-0.4833	676.3469	0.0874	0.0	-0.4887	425.8035	0.0884	0.0
1.10	-0.4959	709.9392	0.0897	0.0	-0.5020	443.8787	0.0908	0.0
1.15	-0.5037	728.0190	0.0911	0.0	-0.5103	451.9971	0.0923	0.0
1.20	-0.5117	732.9055	0.0926	0.0	-0.5189	450.6538	0.0939	0.0
1.25	-0.5080	725.2090	0.0919	0.0	-0.5157	446.1892	0.0933	0.0
1.30	-0.4858	704.3784	0.0879	0.0	-0.4937	439.0913	0.0893	0.0
1.35	-0.4594	675.7886	0.0831	0.0	-0.4673	425.2373	0.0846	0.0
1.40	-0.4473	654.3335	0.0809	0.0	-0.4554	409.3418	0.0824	0.0
1.45	-0.4473	644.9644	0.0809	0.0	-0.4560	398.6040	0.0825	0.0
1.50	-0.4396	632.7168	0.0796	0.0	-0.4487	390.4443	0.0812	0.0
1.55	-0.4166	603.2661	0.0754	0.0	-0.4257	374.7031	0.0770	0.0
1.60	-0.4078	586.1335	0.0738	0.0	-0.4172	361.0388	0.0755	0.0
1.65	-0.4254	606.8735	0.0770	0.0	-0.4358	367.6260	0.0789	0.0
1.70	-0.4173	604.6660	0.0755	0.0	-0.4280	371.1038	0.0775	0.0
1.75	-0.3583	527.3655	0.0648	0.0	-0.3678	335.6733	0.0666	0.0
1.80	-0.2887	418.8057	0.0522	0.0	-0.2966	274.1189	0.0537	0.0
1.85	-0.2384	334.2051	0.0431	0.0	-0.2451	222.5332	0.0443	0.0
1.90	-0.1943	267.2537	0.0352	0.0	-0.1999	182.9387	0.0362	0.0
1.95	-0.1402	192.3530	0.0254	0.0	-0.1444	136.8138	0.0261	0.0
2.00	-0.1038	141.1049	0.0188	0.0	-0.1070	102.7450	0.0194	0.0

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.14.2

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY

TRAILING TANDEM AXLE

TIME (SEC)	LEFT SIDE: TIRE SIDESLIP ANGLE (DEG)	LEFT SIDE: TIRE LATERAL FORCE (LB)	LEFT SIDE: MU-Y	LEFT SIDE: ALIGNING TORQUE (IN-LB)	RIGHT SIDE: TIRE SIDESLIP ANGLE (DEG)	RIGHT SIDE: TIRE LATERAL FORCE (LB)	RIGHT SIDE: MU-Y	RIGHT SIDE: ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	-0.0004	0.5101	0.0001	0.0	-0.0004	0.5101	0.0001	0.0
0.10	0.0018	-2.2165	-0.0002	0.0	0.0018	-2.2161	-0.0002	0.0
0.15	0.0065	-7.7925	-0.0008	0.0	0.0065	-7.7761	-0.0008	0.0
0.20	0.0055	-6.6180	-0.0007	0.0	0.0055	-6.5638	-0.0007	0.0
0.25	-0.0061	7.3328	0.0007	0.0	-0.0061	7.2034	0.0007	0.0
0.30	-0.0279	32.8619	0.0034	0.0	-0.0279	31.7968	0.0034	0.0
0.35	-0.0548	63.3595	0.0066	0.0	-0.0548	60.2795	0.0066	0.0
0.40	-0.0851	99.2475	0.0103	0.0	-0.0852	92.7312	0.0103	0.0
0.45	-0.1220	144.4148	0.0147	0.0	-0.1222	131.9586	0.0147	0.0
0.50	-0.1714	201.1723	0.0207	0.0	-0.1717	178.5374	0.0207	0.0
0.55	-0.2357	272.3096	0.0284	0.0	-0.2363	233.3632	0.0285	0.0
0.60	-0.3076	361.0972	0.0371	0.0	-0.3086	299.3035	0.0372	0.0
0.65	-0.3764	461.6267	0.0454	0.0	-0.3779	371.9055	0.0456	0.0
0.70	-0.4424	559.3176	0.0534	0.0	-0.4444	437.2668	0.0536	0.0
0.75	-0.5178	657.9089	0.0625	0.0	-0.5208	495.5439	0.0628	0.0
0.80	-0.5998	766.9194	0.0724	0.0	-0.6038	555.9812	0.0728	0.0
0.85	-0.6704	879.8315	0.0809	0.0	-0.6754	619.4673	0.0815	0.0
0.90	-0.7254	975.7896	0.0875	0.0	-0.7315	670.2610	0.0882	0.0
0.95	-0.7826	1051.7405	0.0944	0.0	-0.7899	700.2063	0.0953	0.0
1.00	-0.8490	1124.3376	0.1024	0.0	-0.8576	722.6875	0.1035	0.0
1.05	-0.9123	1211.9463	0.1101	0.0	-0.9226	759.1316	0.1113	0.0
1.10	-0.9618	1306.4648	0.1160	0.0	-0.9735	807.3215	0.1174	0.0
1.15	-1.0053	1385.1353	0.1213	0.0	-1.0185	845.3557	0.1229	0.0
1.20	-1.0500	1440.5046	0.1267	0.0	-1.0648	866.2251	0.1285	0.0
1.25	-1.0856	1486.5483	0.1310	0.0	-1.1021	886.8340	0.1329	0.0
1.30	-1.1038	1537.3040	0.1331	0.0	-1.1217	918.6760	0.1353	0.0
1.35	-1.1169	1586.6938	0.1347	0.0	-1.1363	947.4541	0.1371	0.0
1.40	-1.1443	1627.6428	0.1380	0.0	-1.1653	959.4126	0.1406	0.0
1.45	-1.1853	1667.4973	0.1430	0.0	-1.2084	964.4624	0.1458	0.0
1.50	-1.2195	1713.2361	0.1471	0.0	-1.2446	979.8293	0.1501	0.0
1.55	-1.2420	1761.0466	0.1498	0.0	-1.2692	1001.7715	0.1531	0.0
1.60	-1.2858	1820.7981	0.1551	0.0	-1.3156	1016.7314	0.1587	0.0
1.65	-1.3537	1906.2588	0.1633	0.0	-1.3870	1038.9019	0.1673	0.0
1.70	-1.3901	1987.4297	0.1677	0.0	-1.4260	1084.1687	0.1720	0.0
1.75	-1.3676	1998.6919	0.1650	0.0	-1.4043	1113.9312	0.1694	0.0
1.80	-1.3279	1933.6213	0.1602	0.0	-1.3646	1094.7175	0.1646	0.0
1.85	-1.3062	1851.2378	0.1576	0.0	-1.3434	1056.0583	0.1621	0.0
1.90	-1.2933	1801.1511	0.1560	0.0	-1.3311	1043.8367	0.1606	0.0
1.95	-1.2799	1785.7441	0.1544	0.0	-1.3188	1058.7588	0.1591	0.0
2.00	-1.2926	1800.6624	0.1559	0.0	-1.3337	1078.9968	0.1609	0.0

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.17.2

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 1 REAR SUSPENSION - UNSPRUNG MASS SUMMARY

LEADING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0	0.00	0.0000	0.0	0.00
0.05	0.0000	-0.0000	0.0000	-0.0017	-1.9	0.0000	-0.0011	0.03	-0.0000	-0.0012	-0.25
0.10	0.0000	-0.0000	0.0011	0.0023	43.3	-0.0005	-0.0391	-14.76	-0.0000	0.0132	-7.31
0.15	0.0002	-0.0009	0.0032	-0.0463	308.9	-0.0047	-0.1914	-94.12	-0.0008	-0.0445	-53.45
0.20	0.0002	-0.0046	-0.0314	-0.1059	839.6	-0.0170	-0.6991	-780.09	-0.0060	-0.4514	-677.86
0.25	0.0001	-0.0108	-0.0541	-0.1811	1621.3	-0.0188	-0.4269	-909.75	0.0033	-0.1264	-735.24
0.30	-0.0009	-0.0203	-0.0863	-0.1762	2471.2	-0.0045	-0.2035	-848.28	0.0291	0.1471	-584.34
0.35	-0.0020	-0.0304	-0.0587	-0.2212	3422.2	0.0059	-0.6571	-806.49	0.0522	-0.2830	-442.87
0.40	-0.0014	-0.0415	-0.0303	-0.2471	4541.3	-0.0050	-1.1598	-920.68	0.0562	-0.7005	-439.52
0.45	-0.0007	-0.0554	-0.0578	-0.2968	5880.6	-0.0167	-0.8349	-1027.68	0.0623	-0.2805	-406.81
0.50	-0.0020	-0.0718	-0.0940	-0.3581	7441.0	-0.0086	-0.3315	-974.19	0.0913	0.2741	-190.84
0.55	-0.0038	-0.0902	-0.0726	-0.3828	9076.7	0.0018	-0.6909	-903.78	0.1233	-0.0765	49.15
0.60	-0.0035	-0.1100	-0.0212	-0.4033	10703.5	-0.0139	-1.5540	-1037.10	0.1290	-0.9391	82.86
0.65	-0.0014	-0.1303	-0.0150	-0.4055	12380.2	-0.0485	-1.7444	-1312.32	0.1163	-1.0983	-21.52
0.70	-0.0005	-0.1500	-0.0564	-0.3843	14141.8	-0.0702	-1.1399	-1480.88	0.1174	-0.4675	-11.45
0.75	-0.0014	-0.1694	-0.0764	-0.3972	15951.2	-0.0720	-0.8001	-1494.77	0.1390	-0.1181	157.66
0.80	-0.0020	-0.1895	-0.0480	-0.4077	17711.8	-0.0780	-1.1819	-1543.95	0.1558	-0.5550	285.98
0.85	-0.0010	-0.2087	-0.0260	-0.3507	19315.5	-0.0999	-1.5034	-1717.43	0.1544	-0.9137	272.75
0.90	-0.0001	-0.2246	-0.0530	-0.2918	20871.8	-0.1182	-1.0653	-1857.88	0.1559	-0.4929	286.51
0.95	-0.0012	-0.2378	-0.0892	-0.2434	22319.5	-0.1139	-0.4260	-1820.79	0.1786	0.0774	466.75
1.00	-0.0029	-0.2493	-0.0784	-0.2242	23530.3	-0.1008	-0.5091	-1718.54	0.2070	-0.1044	688.28
1.05	-0.0032	-0.2602	-0.0388	-0.2127	24506.6	-0.1043	-1.1065	-1748.20	0.2156	-0.7722	752.24
1.10	-0.0021	-0.2697	-0.0306	-0.1656	25339.1	-0.1220	-1.2589	-1887.15	0.2076	-0.9707	688.73
1.15	-0.0016	-0.2760	-0.0588	-0.0894	26000.4	-0.1305	-0.8021	-1950.33	0.2062	-0.6093	680.89
1.20	-0.0023	-0.2784	-0.0701	-0.0101	26345.3	-0.1239	-0.5635	-1897.33	0.2159	-0.4918	757.16
1.25	-0.0026	-0.2777	-0.0434	0.0213	26484.2	-0.1225	-0.9710	-1887.58	0.2177	-0.9154	769.55
1.30	-0.0015	-0.2768	-0.0231	0.0071	26765.5	-0.1378	-1.3590	-2008.45	0.2044	-1.1942	664.23
1.35	-0.0004	-0.2770	-0.0449	-0.0201	27349.4	-0.1534	-1.0803	-2128.91	0.1944	-0.8256	588.73
1.40	-0.0008	-0.2785	-0.0751	-0.0396	28012.3	-0.1516	-0.5432	-2111.71	0.2033	-0.3205	661.02
1.45	-0.0019	-0.2802	-0.0713	-0.0305	28499.1	-0.1406	-0.5184	-2024.86	0.2196	-0.3735	788.23
1.50	-0.0022	-0.2809	-0.0450	-0.0008	28860.1	-0.1396	-0.9077	-2019.28	0.2240	-0.7689	820.92
1.55	-0.0017	-0.2803	-0.0510	0.0041	29355.2	-0.1456	-0.8499	-2065.25	0.2228	-0.6057	812.46
1.60	-0.0023	-0.2822	-0.0743	-0.0937	30087.8	-0.1421	-0.5080	-2035.40	0.2341	-0.2476	902.86
1.65	-0.0032	-0.2876	-0.0565	-0.0896	30549.0	-0.1363	-0.7926	-1991.23	0.2444	-0.7212	981.50
1.70	-0.0021	-0.2876	-0.0148	0.1057	30558.2	-0.1489	-1.3665	-2092.75	0.2298	-1.4001	864.11
1.75	-0.0003	-0.2770	-0.0297	0.2860	30464.0	-0.1675	-1.1312	-2236.84	0.2069	-1.1838	686.54
1.80	-0.0004	-0.2610	-0.0782	0.3333	30180.1	-0.1622	-0.3056	-2190.82	0.2060	-0.4917	682.47
1.85	-0.0021	-0.2449	-0.0834	0.3122	29406.9	-0.1373	-0.0731	-1995.04	0.2194	-0.4598	787.68
1.90	-0.0027	-0.2284	-0.0449	0.3462	28256.1	-0.1226	-0.5835	-1882.76	0.2176	-1.0297	771.10
1.95	-0.0019	-0.2106	-0.0424	0.3329	27246.2	-0.1214	-0.7704	-1874.33	0.2029	-1.0717	655.67
2.00	-0.0019	-0.1976	-0.0609	0.1721	26577.4	-0.1161	-0.5821	-1832.25	0.1964	-0.8108	606.27

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTICNS EXERCISED)
TRAILER NO. 1 REAR SUSPENSION - UNSPRUNG MASS SUMMARY
TRAILING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	-0.0000	0.0	-0.00	-0.0000	0.0	-0.00
0.05	0.0000	-0.0001	0.0000	-0.0027	-2.5	0.0000	-0.0007	0.11	-0.0000	-0.0015	-0.33
0.10	0.0000	-0.0002	0.0014	-0.0034	38.2	-0.0007	-0.0335	-15.52	-0.0000	0.0150	-6.70
0.15	0.0002	-0.0017	0.0055	-0.0692	278.6	-0.0062	-0.1555	-94.87	-0.0005	-0.0238	-41.36
0.20	0.0004	-0.0070	-0.0233	-0.1464	754.7	-0.0165	-0.5885	-651.04	-0.0004	-0.3677	-510.90
0.25	-0.0002	-0.0153	-0.0770	-0.2301	1461.0	-0.0231	-0.6863	-853.03	0.0082	-0.4183	-607.35
0.30	-0.0027	-0.0280	-0.1139	-0.2352	2201.3	-0.0055	-0.5157	-662.58	0.0425	-0.2042	-285.78
0.35	-0.0053	-0.0413	-0.0827	-0.2974	3037.1	0.0117	-0.9210	-492.82	0.0786	-0.5974	31.80
0.40	-0.0055	-0.0565	-0.0350	-0.3377	4013.8	0.0011	-1.1871	-551.00	0.0900	-0.7878	145.63
0.45	-0.0051	-0.0755	-0.0593	-0.4082	5170.5	-0.0158	-0.8175	-664.55	0.0991	-0.3370	236.52
0.50	-0.0068	-0.0978	-0.1088	-0.4845	6520.0	-0.0080	-0.4701	-589.11	0.1376	0.0517	551.95
0.55	-0.0096	-0.1227	-0.0892	-0.5137	7931.0	0.0073	-0.8515	-462.71	0.1853	-0.3238	931.85
0.60	-0.0098	-0.1495	-0.0186	-0.5521	9311.1	-0.0098	-1.4817	-593.05	0.2002	-0.9654	1051.62
0.65	-0.0073	-0.1777	0.0026	-0.5771	10704.9	-0.0567	-1.4875	-956.44	0.1857	-0.9552	942.32
0.70	-0.0057	-0.2062	-0.0466	-0.5587	12158.3	-0.0922	-0.9791	-1229.71	0.1843	-0.4224	935.73
0.75	-0.0066	-0.2345	-0.0812	-0.5776	13651.7	-0.0996	-0.8165	-1285.35	0.2119	-0.2543	1154.03
0.80	-0.0076	-0.2632	-0.0504	-0.5771	15108.2	-0.1077	-1.1794	-1348.94	0.2383	-0.6650	1359.47
0.85	-0.0065	-0.2912	-0.0159	-0.5318	16402.7	-0.1366	-1.3522	-1575.71	0.2404	-0.8825	1375.14
0.90	-0.0052	-0.3162	-0.0440	-0.4716	17635.7	-0.1649	-0.9336	-1795.38	0.2418	-0.4805	1387.86
0.95	-0.0062	-0.3376	-0.0956	-0.3889	18795.1	-0.1639	-0.4964	-1786.04	0.2708	-0.0895	1616.63
1.00	-0.0087	-0.3558	-0.0912	-0.3514	19770.4	-0.1464	-0.6675	-1650.48	0.3121	-0.3471	1937.34
1.05	-0.0094	-0.3734	-0.0392	-0.3594	20509.8	-0.1475	-1.1165	-1661.16	0.3295	-0.8795	2070.37
1.10	-0.0081	-0.3909	-0.0193	-0.3330	21060.9	-0.1703	-1.1262	-1840.39	0.3212	-0.9491	2005.37
1.15	-0.0072	-0.4051	-0.0523	-0.2294	21443.9	-0.1851	-0.7411	-1955.05	0.3177	-0.6411	1978.83
1.20	-0.0080	-0.4133	-0.0733	-0.1111	21581.8	-0.1788	-0.6358	-1905.83	0.3296	-0.6312	2071.41
1.25	-0.0085	-0.4179	-0.0428	-0.1007	21534.4	-0.1752	-0.9949	-1879.96	0.3340	-1.0202	2103.34
1.30	-0.0072	-0.4245	-0.0109	-0.1709	21550.6	-0.1939	-1.2291	-2027.50	0.3174	-1.1824	1972.35
1.35	-0.0055	-0.4340	-0.0318	-0.2013	21806.0	-0.2173	-0.9550	-2210.50	0.3018	-0.8204	1851.30
1.40	-0.0057	-0.4432	-0.0757	-0.1669	22194.7	-0.2192	-0.5936	-2223.48	0.3109	-0.4554	1924.05
1.45	-0.0073	-0.4504	-0.0787	-0.1334	22489.9	-0.2050	-0.6635	-2113.55	0.3335	-0.5868	2100.27
1.50	-0.0078	-0.4570	-0.0452	-0.1430	22641.8	-0.2011	-0.9565	-2084.34	0.3427	-0.9120	2169.82
1.55	-0.0073	-0.4650	-0.0459	-0.1919	22836.6	-0.2081	-0.8227	-2139.52	0.3419	-0.7085	2164.26
1.60	-0.0079	-0.4758	-0.0768	-0.2456	23252.3	-0.2053	-0.5924	-2116.77	0.3561	-0.4328	2276.97
1.65	-0.0091	-0.4876	-0.0608	-0.2081	23487.6	-0.1971	-0.9165	-2054.59	0.3723	-0.9237	2400.47
1.70	-0.0080	-0.4955	-0.0037	-0.0999	23218.2	-0.2110	-1.2783	-2165.00	0.3558	-1.4482	2268.55
1.75	-0.0055	-0.4952	-0.0118	0.0978	22759.5	-0.2373	-0.9689	-2369.07	0.3231	-1.1463	2014.76
1.80	-0.0052	-0.4852	-0.0763	0.2947	22261.5	-0.2355	-0.3822	-2352.51	0.3169	-0.5939	1968.63
1.85	-0.0073	-0.4685	-0.0947	0.3460	21511.8	-0.2032	-0.3294	-2100.10	0.3338	-0.6937	2100.35
1.90	-0.0084	-0.4516	-0.0481	0.3010	20374.1	-0.1784	-0.7107	-1908.03	0.3342	-1.1869	2100.69
1.95	-0.0076	-0.4393	-0.0356	0.1847	19169.5	-0.1727	-0.7409	-1864.16	0.3145	-1.1406	1947.27
2.00	-0.0074	-0.4327	-0.0581	0.0619	18277.3	-0.1659	-0.6107	-1810.58	0.3033	-0.9126	1860.27

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

BRAKE MODEL TEMPERATURES --- AXLE 2

TIME (SEC)	LEFT SIDE: INTERFACE TEMP (DEG-F)	LEFT SIDE: DRUM TEMP (DEG-F)	LEFT SIDE: LINING TEMP (DEG-F)	LEFT SIDE: BRAKE TORQUE (IN-LB)	RIGHT SIDE: INTERFACE TEMP (DEG-F)	RIGHT SIDE: DRUM TEMP (DEG-F)	RIGHT SIDE: LINING TEMP (DEG-F)	RIGHT SIDE: BRAKE TORQUE (IN-LB)
0.0	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.05	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.10	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.15	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.20	70.00	70.00	70.00	0.0	70.00	70.00	70.00	0.0
0.25	74.26	70.00	70.00	15282.68	74.81	70.00	70.00	15267.26
0.30	84.91	70.00	70.01	34545.36	85.47	70.00	70.01	34509.41
0.35	96.42	70.00	70.01	48065.84	96.84	70.01	70.02	48027.03
0.40	107.55	70.05	70.03	57446.95	107.78	70.06	70.03	57421.92
0.45	122.74	70.34	70.06	63269.95	122.60	70.35	70.06	63288.19
0.50	131.70	70.74	70.08	67638.31	131.27	70.76	70.08	67697.63
0.55	139.73	71.34	70.10	70564.13	138.97	71.37	70.10	70675.69
0.60	146.96	72.15	70.13	72468.38	145.82	72.18	70.13	72642.75
0.65	156.58	73.70	70.18	73165.06	154.84	73.73	70.18	73439.44
0.70	162.24	74.95	70.22	73869.94	160.10	74.96	70.21	74214.19
0.75	167.32	76.33	70.25	74228.38	164.77	76.33	70.25	74646.75
0.80	171.93	77.83	70.29	74345.69	168.91	77.80	70.29	74845.81
0.85	176.15	79.43	70.33	74291.75	172.64	79.36	70.33	74877.00
0.90	181.83	81.96	70.39	73821.00	177.64	81.83	70.39	74525.13
0.95	185.20	83.72	70.44	73609.69	180.56	83.53	70.43	74392.44
1.00	188.24	85.51	70.48	73359.69	183.12	85.26	70.47	74226.94
1.05	191.03	87.33	70.53	73085.19	185.39	87.00	70.52	74041.69
1.10	194.83	90.07	70.60	72591.19	188.49	89.63	70.58	73669.25
1.15	197.10	91.91	70.65	72316.38	190.35	91.38	70.63	73465.50
1.20	199.16	93.74	70.70	72050.25	192.01	93.11	70.67	73268.25
1.25	201.04	95.56	70.75	71794.88	193.49	94.82	70.72	73081.75
1.30	202.78	97.36	70.80	71547.94	194.87	96.51	70.77	72898.44
1.35	205.16	100.02	70.87	71186.81	196.77	98.99	70.84	72616.69
1.40	206.56	101.76	70.92	70978.94	197.88	100.61	70.89	72458.63
1.45	207.82	103.47	70.98	70788.75	198.83	102.20	70.94	72323.25
1.50	208.98	105.15	71.03	70613.00	199.64	103.75	70.99	72205.50
1.55	210.54	107.62	71.11	70368.94	200.74	106.02	71.06	72040.06
1.60	211.45	109.23	71.16	70228.88	201.34	107.49	71.11	71952.06
1.65	212.28	110.80	71.22	70100.88	201.83	108.92	71.16	71882.50
1.70	213.06	112.33	71.27	69980.44	202.27	110.32	71.21	71819.56
1.75	213.77	113.83	71.33	69870.75	202.73	111.68	71.26	71752.56
1.80	214.60	116.02	71.41	69744.19	203.31	113.66	71.34	71668.13
1.85	215.00	117.44	71.46	69688.06	203.54	114.93	71.39	71638.56
1.90	215.30	118.82	71.52	69646.38	203.69	116.17	71.44	71623.94
1.95	215.55	120.17	71.57	69614.06	203.81	117.38	71.49	71612.56
2.00	215.83	122.14	71.65	69580.38	203.95	119.12	71.56	71602.88

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 2 SPRUNG MASS POSITION

TIME (SEC)	FORWARD (FT)	LATERAL (FT)	VERTICAL (FT)	ROLL (DEG)	PITCH (DEG)	HEADING (DEG)	TURN RADIUS (FT)	SIDE SLIP (DEG)	ARTICULATION ANGLE (DEG)
0.0	-60.8718	0.0	0.0	0.0	0.0	0.0	************	0.0	0.0
0.05	-58.5619	-0.0000	0.0000	0.0000	0.0000	-0.0000	************	-0.0000	0.0000
0.10	-56.3624	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	************	-0.0000	0.0003
0.15	-54.1659	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	************	-0.0000	0.0011
0.20	-51.9762	-0.0000	0.0000	0.0000	-0.0007	-0.0000	************	0.0000	0.0031
0.25	-49.7950	-0.0000	0.0001	0.0001	-0.0066	-0.0000	-167816.1875	-0.0003	0.0073
0.30	-47.6217	-0.0000	0.0008	0.0006	-0.0182	-0.0002	-55264.2773	-0.0016	0.0149
0.35	-45.4564	-0.0002	0.0042	0.0024	-0.0200	-0.0010	-27970.6953	-0.0042	0.0273
0.40	-43.3023	-0.0005	0.0083	0.0058	-0.0161	-0.0027	-17092.8750	-0.0083	0.0464
0.45	-41.1650	-0.0010	0.0088	0.0107	-0.0234	-0.0056	-11637.6758	-0.0142	0.0740
0.50	-39.0506	-0.0019	0.0066	0.0163	-0.0325	-0.0101	-8583.7266	-0.0221	0.1121
0.55	-36.9643	-0.0034	0.0059	0.0216	-0.0262	-0.0161	-6612.0469	-0.0322	0.1624
0.60	-34.9084	-0.0054	0.0073	0.0259	-0.0195	-0.0238	-5443.6406	-0.0446	0.2266
0.65	-32.8835	-0.0082	0.0082	0.0286	-0.0294	-0.0331	-5001.5352	-0.0581	0.3058
0.70	-30.8894	-0.0118	0.0084	0.0288	-0.0396	-0.0438	-5181.8242	-0.0703	0.4001
0.75	-28.9255	-0.0161	0.0087	0.0257	-0.0335	-0.0553	-5918.1797	-0.0796	0.5101
0.80	-26.9917	-0.0209	0.0081	0.0189	-0.0246	-0.0668	-7930.0391	-0.0850	0.6361
0.85	-25.0873	-0.0262	0.0067	0.0091	-0.0272	-0.0774	-17892.7305	-0.0847	0.7764
0.90	-23.2119	-0.0315	0.0066	-0.0030	-0.0316	-0.0865	23092.8867	-0.0764	0.9290
0.95	-21.3655	-0.0366	0.0082	-0.0168	-0.0299	-0.0930	6059.7344	-0.0588	1.0923
1.00	-19.5485	-0.0411	0.0091	-0.0316	-0.0304	-0.0957	3364.1870	-0.0317	1.2655
1.05	-17.7617	-0.0445	0.0083	-0.0462	-0.0347	-0.0938	2318.4480	0.0042	1.4481
1.10	-16.0052	-0.0465	0.0074	-0.0588	-0.0332	-0.0867	1750.9490	0.0481	1.6390
1.15	-14.2796	-0.0468	0.0075	-0.0686	-0.0274	-0.0740	1398.8762	0.0998	1.8365
1.20	-12.5859	-0.0449	0.0079	-0.0757	-0.0287	-0.0551	1176.5242	0.1578	2.0397
1.25	-10.9248	-0.0408	0.0082	-0.0807	-0.0349	-0.0297	1028.9216	0.2201	2.2480
1.30	-9.2962	-0.0340	0.0085	-0.0844	-0.0348	0.0027	917.6680	0.2850	2.4615
1.35	-7.6993	-0.0246	0.0085	-0.0876	-0.0298	0.0422	827.4614	0.3518	2.6794
1.40	-6.1335	-0.0123	0.0077	-0.0912	-0.0293	0.0888	751.9639	0.4202	2.9009
1.45	-4.5985	0.0029	0.0072	-0.0956	-0.0318	0.1426	685.1323	0.4900	3.1256
1.50	-3.0939	0.0212	0.0078	-0.1006	-0.0311	0.2036	622.5801	0.5620	3.3534
1.55	-1.6180	0.0426	0.0085	-0.1059	-0.0302	0.2716	566.4561	0.6374	3.5844
1.60	-0.1672	0.0673	0.0084	-0.1107	-0.0325	0.3462	522.1958	0.7158	3.8210
1.65	1.2556	0.0954	0.0079	-0.1136	-0.0332	0.4274	485.2156	0.7964	4.0638
1.70	2.6423	0.1268	0.0078	-0.1138	-0.0298	0.5146	451.2654	0.8793	4.3107
1.75	3.9914	0.1617	0.0080	-0.1114	-0.0289	0.6075	420.3301	0.9653	4.5586
1.80	5.3059	0.2001	0.0081	-0.1081	-0.0332	0.7064	394.2637	1.0534	4.8041
1.85	6.5890	0.2419	0.0083	-0.1060	-0.0355	0.8117	373.0693	1.1418	5.0442
1.90	7.8429	0.2870	0.0085	-0.1068	-0.0324	0.9232	354.1860	1.2292	5.2788
1.95	9.0714	0.3353	0.0081	-0.1107	-0.0296	1.0405	333.5405	1.3163	5.5100
2.00	10.2753	0.3867	0.0075	-0.1170	-0.0299	1.1634	309.4231	1.4065	5.7412

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 2 SPRUNG MASS VELOCITY (BODY AXES)

TIME (SEC)	FORWARD (FT/SEC)	LATERAL (FT/SEC)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	PITCH (DEG/SEC)	HEADING (DEG/SEC)	ARTICULATION RATE (DEG/SEC)
0.0	44.00	0.0	0.0	0.0	0.0	0.0	0.0
0.05	44.00	-0.00	-0.00	0.00	0.00	-0.00	0.00
0.10	44.00	-0.00	-0.00	0.00	-0.00	-0.00	0.01
0.15	44.00	-0.00	-0.00	0.00	-0.00	-0.00	0.03
0.20	43.97	0.00	0.00	-0.00	-0.03	0.00	0.06
0.25	43.86	-0.00	0.01	0.00	-0.12	-0.00	0.11
0.30	43.60	-0.00	0.04	0.02	-0.09	-0.01	0.19
0.35	43.19	-0.00	0.09	0.05	0.17	-0.02	0.31
0.40	42.72	-0.01	0.06	0.08	0.08	-0.05	0.46
0.45	42.28	-0.01	-0.04	0.11	-0.16	-0.07	0.65
0.50	41.82	-0.02	-0.05	0.11	0.05	-0.10	0.88
0.55	41.32	-0.02	0.01	0.10	0.31	-0.14	1.14
0.60	40.81	-0.03	0.03	0.07	0.06	-0.17	1.43
0.65	40.29	-0.04	0.00	0.03	-0.21	-0.20	1.74
0.70	39.76	-0.05	-0.01	-0.03	0.04	-0.23	2.04
0.75	39.18	-0.05	-0.01	-0.10	0.32	-0.23	2.36
0.80	38.56	-0.06	-0.03	-0.17	0.15	-0.22	2.67
0.85	37.94	-0.06	-0.03	-0.22	-0.04	-0.20	2.94
0.90	37.32	-0.05	0.01	-0.26	0.07	-0.16	3.16
0.95	36.68	-0.04	0.03	-0.29	0.13	-0.10	3.37
1.00	36.04	-0.02	-0.01	-0.30	0.02	-0.01	3.56
1.05	35.41	0.00	-0.03	-0.28	0.03	0.09	3.74
1.10	34.80	0.03	-0.01	-0.23	0.20	0.20	3.89
1.15	34.18	0.06	0.01	-0.17	0.16	0.31	4.01
1.20	33.56	0.09	0.00	-0.12	-0.03	0.44	4.12
1.25	32.95	0.13	-0.00	-0.08	0.00	0.58	4.22
1.30	32.34	0.16	-0.00	-0.07	0.17	0.72	4.32
1.35	31.71	0.19	-0.01	-0.07	0.16	0.86	4.40
1.40	31.07	0.23	-0.02	-0.08	0.04	1.00	4.46
1.45	30.44	0.26	-0.00	-0.09	0.06	1.15	4.53
1.50	29.80	0.29	0.02	-0.10	0.13	1.29	4.59
1.55	29.17	0.32	0.01	-0.10	0.07	1.43	4.67
1.60	28.55	0.36	-0.01	-0.08	0.03	1.56	4.80
1.65	27.95	0.39	-0.01	-0.03	0.12	1.69	4.91
1.70	27.37	0.42	0.00	0.03	0.15	1.80	4.96
1.75	26.79	0.45	0.00	0.06	0.04	1.92	4.95
1.80	26.20	0.48	0.00	0.06	-0.01	2.04	4.86
1.85	25.58	0.51	0.00	0.02	0.10	2.17	4.75
1.90	24.94	0.54	-0.00	-0.05	0.17	2.29	4.65
1.95	24.29	0.56	-0.01	-0.10	0.10	2.40	4.62
2.00	23.66	0.58	-0.01	-0.14	0.07	2.51	4.64

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TIME	TRAILER NO. 2 SPRUNG MASS ACCELERATION (BODY AXES)						INERTIAL ACCEL. ALONG BODY AXES	
(SEC)	FORWARD (FT/SEC**2)	LATERAL (FT/SEC**2)	VERTICAL (FT/SEC**2)	ROLL (DEG/SEC**2)	PITCH (DEG/SEC**2)	HEADING (DEG/SEC**2)	LONGITUDINAL (FT/SEC**2)	LATERAL (FT/SEC**2)
0.0	0.0000	0.0000	0.0000	-0.0000	0.0001	-0.0000	0.0000	0.0000
0.05	-0.0005	-0.0002	-0.0000	0.0041	0.0002	-0.0013	-0.0005	-0.0002
0.10	-0.0096	-0.0004	-0.0007	0.0073	-0.0071	-0.0038	-0.0096	-0.0005
0.15	-0.1057	0.0010	-0.0382	-0.0241	-0.3874	0.0062	-0.1057	0.0009
0.20	-1.1297	-0.0010	-3.4643	0.0144	-26.0731	-0.0015	-1.1297	-0.0009
0.25	-3.3421	-0.0108	-7.9812	0.2031	-57.9839	-0.0699	-3.3422	-0.0118
0.30	-6.8148	-0.0288	-6.8476	0.4957	-49.7507	-0.2089	-6.8149	-0.0350
0.35	-8.9938	-0.0501	-7.5844	0.6791	-51.9183	-0.3787	-8.9936	-0.0674
0.40	-9.0974	-0.0735	-9.6758	0.6074	-60.7459	-0.5126	-9.0973	-0.1077
0.45	-8.6987	-0.1002	-9.4148	0.2943	-55.8640	-0.5846	-8.6986	-0.1545
0.50	-9.2730	-0.1283	-7.2045	-0.1330	-46.9265	-0.6249	-9.2731	-0.2045
0.55	-10.1336	-0.1593	-6.9334	-0.4401	-54.4421	-0.6445	-10.1336	-0.2580
0.60	-10.1458	-0.1830	-8.2937	-0.6533	-62.9212	-0.6425	-10.1458	-0.3039
0.65	-10.0470	-0.1784	-8.5038	-0.9991	-54.8159	-0.5718	-10.0471	-0.3201
0.70	-10.9398	-0.1401	-7.9487	-1.4303	-46.7267	-0.3184	-10.9400	-0.2966
0.75	-11.9957	-0.0873	-8.2246	-1.5207	-53.6443	0.0458	-11.9960	-0.2465
0.80	-12.2093	-0.0210	-8.3758	-1.2424	-60.3426	0.3297	-12.2096	-0.1714
0.85	-12.1234	0.0711	-7.5000	-0.9250	-55.2880	0.6083	-12.1236	-0.0619
0.90	-12.4235	0.1850	-7.2083	-0.7156	-51.4389	1.0385	-12.4236	0.0810
0.95	-12.7216	0.3028	-8.2935	-0.4405	-55.8993	1.5124	-12.7216	0.2421
1.00	-12.4832	0.4086	-8.8785	0.1084	-56.8632	1.8307	-12.4832	0.4025
1.05	-12.1545	0.4977	-8.0516	0.8093	-51.8452	2.0232	-12.1545	0.5523
1.10	-12.1380	0.5770	-7.4404	1.2003	-52.4832	2.2060	-12.1381	0.6962
1.15	-12.2534	0.6428	-7.8752	1.1478	-58.2566	2.3962	-12.2537	0.8300
1.20	-12.0245	0.6828	-8.1864	0.8981	-57.1360	2.5925	-12.0252	0.9412
1.25	-11.9989	0.6943	-7.9907	0.5911	-51.5716	2.7354	-12.0002	1.0264
1.30	-12.2726	0.6901	-8.0929	0.2256	-52.5199	2.7821	-12.2746	1.0957
1.35	-12.5188	0.6790	-8.3296	-0.1010	-57.1344	2.7957	-12.5218	1.1554
1.40	-12.5004	0.6646	-7.9438	-0.2570	-56.1297	2.8381	-12.5044	1.2094
1.45	-12.5238	0.6518	-7.5170	-0.2161	-53.0273	2.8191	-12.5290	1.2624
1.50	-12.5842	0.6493	-7.9171	-0.0258	-54.6870	2.7089	-12.5907	1.3205
1.55	-12.4075	0.6549	-8.4581	0.2865	-56.5790	2.6367	-12.4156	1.3812
1.60	-12.0180	0.6505	-8.2204	0.8177	-54.0378	2.5539	-12.0277	1.4275
1.65	-11.6341	0.6420	-7.7723	1.2550	-52.7496	2.3711	-11.6455	1.4642
1.70	-11.3877	0.6393	-7.8835	1.1809	-56.0397	2.2299	-11.4009	1.5003
1.75	-11.4591	0.6308	-8.1249	0.5001	-57.4025	2.3285	-11.4742	1.5275
1.80	-11.9181	0.5983	-8.0153	-0.4431	-53.9269	2.5062	-11.9353	1.5318
1.85	-12.5278	0.5429	-7.9941	-1.0943	-52.3002	2.4806	-12.5471	1.5114
1.90	-12.8444	0.4888	-8.2448	-1.2010	-55.1289	2.3071	-12.8658	1.4858
1.95	-12.7692	0.4610	-8.1793	-0.8679	-56.5117	2.1894	-12.7926	1.4800
2.00	-12.3598	0.4717	-7.7520	-0.0912	-54.5906	2.0918	-12.3853	1.5089

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 2 FRONT AXLE TIRE FORCES

	LEFT SIDE					RIGHT SIDE				
TIME (SEC)	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y
0.0	4325.00	-0.0	0.0	0.0	0.0	4325.00	-0.0	0.0	0.0	0.0
0.05	4324.97	0.00	-0.06	0.0000	-0.0000	4325.02	0.00	-0.06	0.0000	-0.0000
0.10	4324.84	0.07	-0.16	0.0000	-0.0000	4325.15	0.07	-0.16	0.0000	-0.0000
0.15	4325.26	0.71	0.26	0.0002	0.0001	4324.99	0.71	0.26	0.0002	0.0001
0.20	4332.56	9.28	-0.15	0.0021	-0.0000	4332.55	9.28	-0.15	0.0021	-0.0000
0.25	4393.97	33.83	-3.25	0.0077	-0.0007	4397.52	33.78	-3.25	0.0077	-0.0007
0.30	4548.82	-259.06	-9.78	-0.0569	-0.0021	4561.70	-259.59	-9.81	-0.0569	-0.0021
0.35	4740.97	-649.99	-18.36	-0.1371	-0.0039	4769.11	-651.23	-18.47	-0.1366	-0.0039
0.40	4892.64	-893.94	-26.80	-0.1827	-0.0055	4940.43	-895.48	-27.07	-0.1813	-0.0055
0.45	4960.80	-960.08	-34.11	-0.1935	-0.0069	5030.98	-961.75	-34.60	-0.1912	-0.0069
0.50	4912.78	-994.43	-40.79	-0.2024	-0.0083	5006.41	-996.29	-41.58	-0.1990	-0.0083
0.55	4807.72	-1014.74	-47.15	-0.2111	-0.0098	4923.57	-1016.63	-48.32	-0.2065	-0.0098
0.60	4811.20	-1042.31	-52.11	-0.2166	-0.0108	4944.68	-1043.76	-53.62	-0.2111	-0.0108
0.65	4959.88	-1066.85	-52.30	-0.2151	-0.0105	5101.08	-1067.42	-53.87	-0.2093	-0.0106
0.70	5074.76	-1068.11	-44.02	-0.2105	-0.0087	5206.30	-1067.83	-45.28	-0.2051	-0.0087
0.75	5028.11	-1058.68	-30.16	-0.2106	-0.0060	5133.05	-1057.72	-30.91	-0.2061	-0.0060
0.80	4922.31	-1060.93	-14.66	-0.2155	-0.0030	4989.71	-1059.16	-14.97	-0.2123	-0.0030
0.85	4908.43	-1071.96	6.18	-0.2184	0.0013	4924.02	-1069.12	6.11	-0.2171	0.0012
0.90	4991.96	-1076.44	35.79	-0.2156	0.0072	4939.09	-1072.62	35.35	-0.2172	0.0072
0.95	5099.41	-1075.71	69.27	-0.2109	0.0136	4969.32	-1071.34	67.49	-0.2156	0.0136
1.00	5183.52	-1078.44	99.28	-0.2081	0.0192	4978.62	-1073.87	95.35	-0.2157	0.0192
1.05	5210.64	-1082.35	124.70	-0.2077	0.0239	4938.25	-1077.66	118.16	-0.2182	0.0239
1.10	5175.81	-1082.96	148.42	-0.2092	0.0287	4843.99	-1078.13	138.80	-0.2226	0.0287
1.15	5152.95	-1084.15	171.02	-0.2104	0.0332	4771.41	-1079.62	158.09	-0.2263	0.0331
1.20	5212.84	-1089.68	190.92	-0.2090	0.0366	4792.23	-1085.76	174.95	-0.2266	0.0365
1.25	5302.40	-1091.13	206.27	-0.2058	0.0389	4853.77	-1087.49	187.79	-0.2241	0.0387
1.30	5321.41	-1086.13	217.78	-0.2041	0.0409	4853.09	-1082.23	196.95	-0.2230	0.0406
1.35	5274.00	-1082.02	228.68	-0.2052	0.0434	4787.88	-1077.81	205.14	-0.2251	0.0428
1.40	5241.10	-1083.09	239.51	-0.2067	0.0457	4735.92	-1078.95	212.97	-0.2278	0.0450
1.45	5254.13	-1084.00	247.79	-0.2063	0.0472	4730.90	-1080.23	218.41	-0.2283	0.0462
1.50	5288.90	-1083.73	253.44	-0.2049	0.0479	4749.04	-1080.23	221.35	-0.2275	0.0466
1.55	5326.13	-1085.34	258.74	-0.2038	0.0486	4769.11	-1081.90	223.71	-0.2269	0.0469
1.60	5343.89	-1089.10	258.82	-0.2038	0.0484	4777.36	-1085.90	221.43	-0.2273	0.0463
1.65	5318.40	-1092.63	251.37	-0.2054	0.0473	4756.68	-1089.77	212.76	-0.2291	0.0447
1.70	5274.22	-1096.32	243.64	-0.2079	0.0462	4726.36	-1093.82	204.04	-0.2314	0.0432
1.75	5272.69	-1097.57	244.68	-0.2082	0.0464	4735.48	-1095.21	202.78	-0.2313	0.0428
1.80	5319.65	-1093.44	252.87	-0.2055	0.0475	4787.24	-1090.93	207.20	-0.2279	0.0433
1.85	5351.14	-1085.09	261.60	-0.2028	0.0489	4819.09	-1082.24	211.30	-0.2246	0.0438
1.90	5329.68	-1079.45	270.15	-0.2025	0.0507	4790.50	-1076.27	214.49	-0.2247	0.0448
1.95	5289.73	-1079.55	280.21	-0.2041	0.0530	4732.72	-1076.24	218.20	-0.2274	0.0461
2.00	5270.23	-1084.86	284.52	-0.2058	0.0540	4696.38	-1081.95	216.42	-0.2304	0.0461

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 2 REAR SUSPENSION TIRE FORCES
LEADING TANDEM AXLE

TIME (SEC)	LEFT SIDE VERTICAL (LB)	LEFT SIDE LONG. (LB)	LEFT SIDE LATERAL (LB)	LEFT SIDE MU-X	LEFT SIDE MU-Y	RIGHT SIDE VERTICAL (LB)	RIGHT SIDE LONG. (LB)	RIGHT SIDE LATERAL (LB)	RIGHT SIDE MU-X	RIGHT SIDE MU-Y
0.0	2162.50	-0.0	0.0	0.0	0.0	2162.50	-0.0	0.0	0.0	0.0
0.05	2162.50	0.00	0.00	0.0000	0.0000	2162.50	0.00	0.00	0.0000	0.0000
0.10	2162.49	0.07	0.03	0.0000	0.0000	2162.48	0.07	0.03	0.0000	0.0000
0.15	2162.01	-2.03	-0.03	-0.0009	-0.0000	2162.12	-2.03	-0.03	-0.0009	-0.0000
0.20	2142.78	-102.30	-0.05	-0.0477	-0.0000	2142.88	-102.29	-0.05	-0.0477	-0.0000
0.25	2058.47	-333.31	0.34	-0.1619	0.0002	2058.13	-333.35	0.34	-0.1620	0.0002
0.30	1973.05	-563.54	1.30	-0.2856	0.0007	1972.62	-563.74	1.30	-0.2858	0.0007
0.35	2126.17	-763.16	2.69	-0.3589	0.0013	2127.92	-763.84	2.69	-0.3590	0.0013
0.40	2375.94	-914.24	3.80	-0.3848	0.0016	2383.94	-915.52	3.81	-0.3840	0.0016
0.45	2312.25	-1004.37	3.65	-0.4344	0.0016	2331.66	-1006.65	3.68	-0.4317	0.0016
0.50	2090.02	-1076.21	2.48	-0.5149	0.0012	2124.29	-1079.80	2.52	-0.5083	0.0012
0.55	2137.67	-1163.71	1.51	-0.5444	0.0007	2185.59	-1166.45	1.54	-0.5337	0.0007
0.60	2290.64	-1208.22	1.49	-0.5275	0.0006	2347.94	-1210.23	1.53	-0.5154	0.0006
0.65	2216.25	-1219.28	1.21	-0.5502	0.0005	2279.72	-1222.35	1.25	-0.5362	0.0005
0.70	2101.41	-1242.58	-0.40	-0.5913	-0.0002	2167.74	-1244.95	-0.41	-0.5743	-0.0002
0.75	2192.07	-1273.88	-1.79	-0.5811	-0.0008	2252.51	-1273.13	-1.83	-0.5652	-0.0008
0.80	2282.29	-1273.83	-1.37	-0.5581	-0.0006	2325.24	-1271.92	-1.40	-0.5470	-0.0006
0.85	2196.23	-1268.95	-0.95	-0.5778	-0.0004	2215.52	-1266.31	-0.96	-0.5716	-0.0004
0.90	2152.03	-1287.37	-1.57	-0.5982	-0.0007	2143.94	-1282.90	-1.57	-0.5984	-0.0007
0.95	2268.82	-1304.53	-2.51	-0.5750	-0.0011	2229.60	-1299.14	-2.46	-0.5827	-0.0011
1.00	2326.53	-1298.45	-3.40	-0.5581	-0.0015	2254.27	-1291.97	-3.29	-0.5731	-0.0015
1.05	2246.51	-1296.37	-4.19	-0.5771	-0.0019	2142.09	-1288.12	-3.99	-0.6013	-0.0019
1.10	2232.75	-1311.67	-5.68	-0.5875	-0.0025	2101.55	-1304.33	-5.35	-0.6207	-0.0025
1.15	2321.06	-1318.54	-10.03	-0.5681	-0.0043	2174.37	-1313.21	-9.41	-0.6040	-0.0043
1.20	2328.91	-1311.88	-16.89	-0.5633	-0.0073	2177.23	-1305.71	-15.81	-0.5997	-0.0073
1.25	2262.21	-1311.51	-23.87	-0.5797	-0.0106	2109.91	-1304.87	-22.30	-0.6184	-0.0106
1.30	2275.92	-1319.33	-32.30	-0.5797	-0.0142	2128.51	-1314.74	-30.27	-0.6177	-0.0142
1.35	2330.82	-1316.60	-43.18	-0.5649	-0.0185	2194.18	-1312.54	-40.76	-0.5982	-0.0186
1.40	2296.25	-1308.60	-52.55	-0.5699	-0.0229	2166.74	-1302.88	-49.75	-0.6013	-0.0230
1.45	2240.85	-1310.71	-59.67	-0.5849	-0.0266	2112.06	-1304.76	-56.46	-0.6178	-0.0267
1.50	2276.69	-1318.83	-69.41	-0.5793	-0.0305	2152.23	-1314.60	-65.91	-0.6108	-0.0306
1.55	2321.90	-1318.16	-81.18	-0.5677	-0.0350	2205.65	-1313.90	-77.51	-0.5957	-0.0351
1.60	2284.22	-1316.89	-88.79	-0.5765	-0.0389	2169.44	-1311.38	-84.81	-0.6045	-0.0391
1.65	2247.24	-1324.52	-94.81	-0.5894	-0.0422	2134.90	-1320.13	-90.64	-0.6184	-0.0425
1.70	2276.43	-1332.90	-106.62	-0.5855	-0.0468	2184.11	-1331.04	-103.00	-0.6094	-0.0472
1.75	2283.00	-1329.06	-121.73	-0.5822	-0.0533	2222.89	-1327.66	-119.41	-0.5973	-0.0537
1.80	2221.59	-1320.74	-133.80	-0.5945	-0.0602	2188.97	-1318.93	-132.90	-0.6025	-0.0607
1.85	2188.40	-1318.07	-146.65	-0.6023	-0.0670	2181.43	-1316.91	-147.47	-0.6037	-0.0676
1.90	2220.50	-1317.51	-163.79	-0.5933	-0.0738	2241.99	-1316.77	-166.96	-0.5873	-0.0745
1.95	2229.29	-1314.65	-177.81	-0.5897	-0.0798	2266.87	-1313.11	-182.68	-0.5793	-0.0806
2.00	2193.32	-1318.15	-185.22	-0.6010	-0.0844	2227.73	-1315.93	-190.21	-0.5907	-0.0854

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 2 REAR SUSPENSION TIRE FORCES
TRAILING TANDEM AXLE

	LEFT SIDE					RIGHT SIDE				
TIME (SEC)	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y
0.0	2162.50	-0.0	0.0	0.0	0.0	2162.50	-0.0	0.0	0.0	0.0
0.05	2162.50	0.00	0.00	0.0000	0.0000	2162.50	0.00	0.00	0.0000	0.0000
0.10	2162.48	0.07	0.01	0.0000	0.0000	2162.49	0.07	0.01	0.0000	0.0000
0.15	2161.92	-2.03	-0.04	-0.0009	-0.0000	2162.06	-2.03	-0.04	-0.0009	-0.0000
0.20	2126.21	-101.89	-0.03	-0.0479	-0.0000	2126.27	-101.89	-0.03	-0.0479	-0.0000
0.25	1991.83	-329.53	0.20	-0.1654	0.0001	1991.69	-329.58	0.20	-0.1655	0.0001
0.30	1858.58	-556.07	0.46	-0.2992	0.0002	1859.51	-556.41	0.46	-0.2992	0.0002
0.35	1975.98	-757.53	0.18	-0.3834	0.0001	1981.72	-758.60	0.18	-0.3828	0.0001
0.40	2197.25	-910.18	-1.70	-0.4142	-0.0008	2214.13	-912.13	-1.71	-0.4120	-0.0008
0.45	2111.71	-995.69	-4.83	-0.4715	-0.0023	2145.16	-999.21	-4.91	-0.4658	-0.0023
0.50	1873.46	-1064.25	-8.16	-0.5681	-0.0044	1925.02	-1069.81	-8.38	-0.5557	-0.0044
0.55	1907.61	-1159.01	-12.66	-0.6076	-0.0066	1978.38	-1163.54	-13.13	-0.5881	-0.0066
0.60	2048.33	-1205.16	-17.58	-0.5884	-0.0086	2136.99	-1208.72	-18.33	-0.5656	-0.0086
0.65	1965.50	-1210.10	-20.74	-0.6157	-0.0106	2065.30	-1215.54	-21.79	-0.5886	-0.0105
0.70	1845.50	-1233.55	-23.56	-0.6684	-0.0128	1949.61	-1238.20	-24.88	-0.6351	-0.0128
0.75	1931.22	-1272.19	-27.02	-0.6587	-0.0140	2032.71	-1272.00	-28.43	-0.6258	-0.0140
0.80	2018.45	-1270.70	-27.16	-0.6295	-0.0135	2103.50	-1268.82	-28.29	-0.6032	-0.0134
0.85	1933.49	-1261.12	-23.52	-0.6522	-0.0122	1989.00	-1258.44	-24.18	-0.6327	-0.0122
0.90	1892.08	-1282.43	-19.37	-0.6778	-0.0102	1911.90	-1276.67	-19.56	-0.6678	-0.0102
0.95	2013.03	-1304.58	-13.79	-0.6481	-0.0069	1991.36	-1296.74	-13.64	-0.6512	-0.0068
1.00	2078.43	-1295.92	-4.26	-0.6235	-0.0020	2006.83	-1286.17	-4.11	-0.6409	-0.0020
1.05	2007.60	-1291.12	7.41	-0.6431	0.0037	1884.31	-1278.21	6.95	-0.6783	0.0037
1.10	2003.78	-1309.39	19.96	-0.6535	0.0100	1833.00	-1296.90	18.27	-0.7075	0.0100
1.15	2105.41	-1318.53	33.74	-0.6263	0.0160	1891.86	-1308.35	30.34	-0.6916	0.0160
1.20	2128.01	-1309.76	46.57	-0.6155	0.0219	1879.50	-1297.25	41.19	-0.6902	0.0219
1.25	2074.88	-1308.78	58.69	-0.6308	0.0283	1798.28	-1294.20	50.96	-0.7197	0.0283
1.30	2105.40	-1319.15	73.76	-0.6266	0.0350	1799.79	-1307.18	63.19	-0.7263	0.0351
1.35	2181.38	-1316.87	90.73	-0.6037	0.0416	1844.20	-1305.27	76.92	-0.7078	0.0417
1.40	2164.42	-1307.36	105.42	-0.6040	0.0487	1799.01	-1291.47	87.92	-0.7179	0.0489
1.45	2124.08	-1309.96	120.97	-0.6167	0.0570	1729.15	-1292.58	98.86	-0.7475	0.0572
1.50	2182.09	-1319.99	142.53	-0.6049	0.0653	1747.07	-1305.67	114.63	-0.7473	0.0656
1.55	2252.75	-1319.13	165.00	-0.5856	0.0732	1774.98	-1303.81	130.66	-0.7345	0.0736
1.60	2232.35	-1316.99	182.94	-0.5900	0.0820	1721.45	-1297.38	141.87	-0.7537	0.0824
1.65	2210.74	-1325.26	201.46	-0.5995	0.0911	1671.50	-1306.47	153.27	-0.7816	0.0917
1.70	2264.48	-1334.74	223.48	-0.5894	0.0987	1696.14	-1320.21	168.54	-0.7784	0.0994
1.75	2296.17	-1330.76	240.76	-0.5796	0.1049	1709.79	-1315.19	180.61	-0.7692	0.1056
1.80	2251.25	-1322.31	251.89	-0.5874	0.1119	1659.35	-1303.51	187.16	-0.7856	0.1128
1.85	2238.72	-1320.58	268.99	-0.5899	0.1202	1631.15	-1302.76	197.71	-0.7987	0.1212
1.90	2304.23	-1320.75	296.87	-0.5732	0.1288	1658.29	-1304.18	215.69	-0.7865	0.1301
1.95	2342.97	-1317.73	324.48	-0.5624	0.1385	1653.22	-1297.47	231.31	-0.7848	0.1399
2.00	2325.14	-1321.28	348.14	-0.5683	0.1497	1595.94	-1297.32	241.60	-0.8129	0.1514

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.07.3

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 2 FRONT SUSPENSION - BRAKE SUMMARY

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	0.00	-.0000	26.14	-0.00	0.0	0.0	0.00	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.07	-.0000	26.14	-0.00	0.0	0.0	0.07	-.0000	26.14	-0.00
0.15	30.00	0.16	0.0	0.71	-.0000	26.14	-0.03	0.16	0.0	0.71	-.0000	26.14	-0.03
0.20	30.00	3.18	0.0	9.28	-.0002	26.12	-0.44	3.18	0.0	9.28	-.0002	26.12	-0.44
0.25	30.00	9.08	0.0	33.83	-.0008	26.07	-1.61	9.08	0.0	33.78	-.0008	26.07	-1.61
0.30	30.00	14.41	8826.06	-259.06	0.0059	25.75	-8.47	14.41	8826.06	-259.59	0.0059	25.75	-8.45
0.35	30.00	18.38	16769.38	-649.99	0.0141	25.30	-8.58	18.38	16769.38	-651.23	0.0141	25.31	-8.52
0.40	30.00	21.34	20672.11	-893.94	0.0188	24.91	-6.17	21.34	20672.11	-895.48	0.0187	24.91	-6.09
0.45	30.00	23.55	21774.86	-960.08	0.0199	24.60	-5.62	23.55	21774.86	-961.75	0.0197	24.61	-5.54
0.50	30.00	25.19	22596.60	-994.43	0.0208	24.33	-5.92	25.19	22596.60	-996.29	0.0205	24.34	-5.83
0.55	30.00	26.42	23208.94	-1014.74	0.0217	24.03	-6.39	26.42	23208.94	-1016.63	0.0213	24.05	-6.30
0.60	30.00	27.33	23665.26	-1042.31	0.0223	23.70	-6.16	27.33	23665.26	-1043.76	0.0217	23.72	-6.09
0.65	30.00	28.01	24005.30	-1066.85	0.0221	23.39	-5.79	28.01	24005.30	-1067.42	0.0215	23.42	-5.76
0.70	30.00	28.52	24258.71	-1068.11	0.0217	23.11	-6.33	28.52	24258.71	-1067.83	0.0211	23.13	-6.34
0.75	30.00	28.90	24447.53	-1058.68	0.0217	22.78	-7.22	28.90	24447.53	-1057.72	0.0212	22.80	-7.27
0.80	30.00	29.18	24588.24	-1060.93	0.0222	22.40	-7.45	29.18	24588.24	-1059.16	0.0219	22.42	-7.53
0.85	30.00	29.39	24693.09	-1071.96	0.0225	22.02	-7.17	29.39	24693.09	-1069.12	0.0224	22.04	-7.30
0.90	30.00	29.54	24771.23	-1076.44	0.0222	21.68	-7.14	29.54	24771.23	-1072.62	0.0224	21.68	-7.32
0.95	30.00	29.66	24829.48	-1075.71	0.0217	21.32	-7.31	29.66	24829.48	-1071.34	0.0222	21.31	-7.52
1.00	30.00	29.75	24872.87	-1078.44	0.0214	20.95	-7.28	29.75	24872.87	-1073.87	0.0222	20.93	-7.50
1.05	30.00	29.81	24905.21	-1082.35	0.0214	20.59	-7.17	29.81	24905.21	-1077.66	0.0225	20.56	-7.40
1.10	30.00	29.86	24929.31	-1082.96	0.0215	20.24	-7.20	29.86	24929.31	-1078.13	0.0229	20.20	-7.43
1.15	30.00	29.89	24947.26	-1084.15	0.0217	19.88	-7.19	29.89	24947.26	-1079.62	0.0233	19.83	-7.40
1.20	30.00	29.92	24960.63	-1089.68	0.0215	19.52	-6.96	29.92	24960.63	-1085.76	0.0233	19.46	-7.14
1.25	30.00	29.94	24970.64	-1091.13	0.0212	19.18	-6.91	29.94	24970.64	-1087.49	0.0231	19.11	-7.08
1.30	30.00	29.96	24978.06	-1086.13	0.0210	18.84	-7.17	29.96	24978.06	-1082.23	0.0230	18.76	-7.35
1.35	30.00	29.97	24983.58	-1082.02	0.0211	18.47	-7.37	29.97	24983.58	-1077.81	0.0232	18.38	-7.58
1.40	30.00	29.98	24987.70	-1083.09	0.0213	18.10	-7.33	29.98	24987.70	-1078.95	0.0235	18.00	-7.53
1.45	30.00	29.98	24990.77	-1084.00	0.0212	17.74	-7.30	29.98	24990.77	-1080.23	0.0235	17.63	-7.48
1.50	30.00	29.99	24993.06	-1083.73	0.0211	17.38	-7.32	29.99	24993.06	-1080.23	0.0234	17.26	-7.48
1.55	30.00	29.99	24994.77	-1085.34	0.0210	17.01	-7.24	29.99	24994.77	-1081.90	0.0234	16.89	-7.41
1.60	30.00	29.99	24996.04	-1089.10	0.0210	16.66	-7.07	29.99	24996.04	-1085.90	0.0234	16.52	-7.22
1.65	30.00	29.99	24996.99	-1092.63	0.0212	16.31	-6.90	29.99	24996.99	-1089.77	0.0236	16.17	-7.04
1.70	30.00	30.00	24997.69	-1096.32	0.0214	15.98	-6.73	30.00	24997.69	-1093.82	0.0238	15.83	-6.85
1.75	30.00	30.00	24998.21	-1097.57	0.0214	15.64	-6.67	30.00	24998.21	-1095.21	0.0238	15.49	-6.78
1.80	30.00	30.00	24998.60	-1093.44	0.0212	15.31	-6.87	30.00	24998.60	-1090.93	0.0235	15.15	-6.99
1.85	30.00	30.00	24998.91	-1085.09	0.0209	14.96	-7.26	30.00	24998.91	-1082.24	0.0231	14.80	-7.40
1.90	30.00	30.00	24999.09	-1079.45	0.0209	14.60	-7.53	30.00	24999.09	-1076.27	0.0231	14.42	-7.68
1.95	30.00	30.00	24999.25	-1079.55	0.0210	14.22	-7.53	30.00	24999.25	-1076.24	0.0234	14.04	-7.69
2.00	30.00	30.00	24999.41	-1084.86	0.0212	13.85	-7.28	30.00	24999.41	-1081.95	0.0237	13.66	-7.42

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 2 REAR SUSPENSION - BRAKE SUMMARY
LEADING TANDEM AXLE

		LEFT SIDE						RIGHT SIDE						
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	0.00	-.0000	26.14	-0.00	0.0	0.0	0.00	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.07	-.0000	26.14	-0.00	0.0	0.0	0.07	-.0000	26.14	-0.00
0.15	30.00	0.16	161.07	-2.03	0.0000	26.13	-0.28	0.16	161.07	-2.03	0.0000	26.13	-0.28
0.20	30.00	3.18	3175.51	-102.30	0.0025	26.05	-2.62	3.18	3175.51	-102.29	0.0025	26.05	-2.62
0.25	30.00	9.08	9083.05	-333.31	0.0083	25.83	-5.54	9.08	9083.05	-333.35	0.0083	25.83	-5.54
0.30	30.00	14.41	14413.03	-563.54	0.0147	25.52	-7.15	14.41	14413.03	-563.74	0.0147	25.52	-7.14
0.35	30.00	18.38	18384.68	-763.16	0.0185	25.19	-7.00	18.38	18384.68	-763.84	0.0185	25.19	-6.97
0.40	30.00	21.34	21344.23	-914.24	0.0198	24.88	-6.78	21.34	21344.23	-915.52	0.0198	24.88	-6.72
0.45	30.00	23.55	23549.72	-1004.37	0.0224	24.54	-7.69	23.55	23549.72	-1006.65	0.0222	24.55	-7.58
0.50	30.00	25.19	25193.21	-1076.21	0.0265	24.19	-8.15	25.19	25193.21	-1079.80	0.0262	24.20	-7.97
0.55	30.00	26.42	26417.89	-1163.71	0.0280	23.87	-6.87	26.42	26417.89	-1166.45	0.0275	23.89	-6.74
0.60	30.00	27.33	27330.53	-1208.22	0.0272	23.58	-6.90	27.33	27330.53	-1210.23	0.0265	23.61	-6.80
0.65	30.00	28.01	28010.60	-1219.28	0.0283	23.24	-7.97	28.01	28010.60	-1222.35	0.0276	23.27	-7.83
0.70	30.00	28.52	28517.44	-1242.58	0.0304	22.90	-8.06	28.52	28517.44	-1244.95	0.0296	22.93	-7.95
0.75	30.00	28.90	28895.07	-1273.88	0.0299	22.59	-7.46	28.90	28895.07	-1273.13	0.0291	22.62	-7.49
0.80	30.00	29.18	29176.49	-1273.83	0.0287	22.25	-8.13	29.18	29176.49	-1271.92	0.0282	22.27	-8.22
0.85	30.00	29.39	29386.20	-1268.95	0.0297	21.86	-8.85	29.39	29386.20	-1266.31	0.0294	21.88	-8.98
0.90	30.00	29.54	29542.49	-1287.37	0.0308	21.48	-8.34	29.54	29542.49	-1282.90	0.0308	21.49	-8.56
0.95	30.00	29.66	29658.98	-1304.53	0.0296	21.15	-7.80	29.66	29658.98	-1299.14	0.0300	21.14	-8.06
1.00	30.00	29.75	29745.74	-1298.45	0.0287	20.79	-8.29	29.75	29745.74	-1291.97	0.0295	20.78	-8.60
1.05	30.00	29.81	29810.44	-1296.37	0.0297	20.42	-8.55	29.81	29810.44	-1288.12	0.0310	20.38	-8.94
1.10	30.00	29.86	29858.63	-1311.67	0.0302	20.06	-7.93	29.86	29858.63	-1304.33	0.0320	20.01	-8.28
1.15	30.00	29.89	29894.53	-1318.54	0.0292	19.73	-7.69	29.89	29894.53	-1313.21	0.0311	19.67	-7.94
1.20	30.00	29.92	29921.27	-1311.88	0.0290	19.37	-8.07	29.92	29921.27	-1305.71	0.0309	19.31	-8.36
1.25	30.00	29.94	29941.28	-1311.51	0.0299	19.01	-8.13	29.94	29941.28	-1304.87	0.0318	18.93	-8.45
1.30	30.00	29.96	29956.13	-1319.33	0.0298	18.67	-7.80	29.96	29956.13	-1314.74	0.0318	18.59	-8.02
1.35	30.00	29.97	29967.18	-1316.60	0.0291	18.32	-7.95	29.97	29967.18	-1312.54	0.0308	18.24	-8.15
1.40	30.00	29.98	29975.43	-1308.60	0.0293	17.95	-8.35	29.98	29975.43	-1302.88	0.0310	17.86	-8.63
1.45	30.00	29.98	29981.56	-1310.71	0.0301	17.57	-8.27	29.98	29981.56	-1304.76	0.0318	17.48	-8.55
1.50	30.00	29.99	29986.14	-1318.83	0.0298	17.22	-7.89	29.99	29986.14	-1314.60	0.0314	17.11	-8.09
1.55	30.00	29.99	29989.56	-1318.16	0.0292	16.87	-7.93	29.99	29989.56	-1313.90	0.0307	16.76	-8.13
1.60	30.00	29.99	29992.09	-1316.89	0.0297	16.50	-8.00	29.99	29992.09	-1311.38	0.0311	16.39	-8.26
1.65	30.00	29.99	29994.00	-1324.52	0.0303	16.16	-7.64	29.99	29994.00	-1320.13	0.0318	16.03	-7.85
1.70	30.00	30.00	29995.39	-1332.90	0.0301	15.83	-7.24	30.00	29995.39	-1331.04	0.0314	15.70	-7.33
1.75	30.00	30.00	29996.44	-1329.06	0.0300	15.50	-7.43	30.00	29996.44	-1327.66	0.0308	15.37	-7.49
1.80	30.00	30.00	29997.22	-1320.74	0.0306	15.15	-7.83	30.00	29997.22	-1318.93	0.0310	15.02	-7.91
1.85	30.00	30.00	29997.83	-1318.07	0.0310	14.80	-7.95	30.00	29997.83	-1316.91	0.0311	14.67	-8.01
1.90	30.00	30.00	29998.21	-1317.51	0.0306	14.44	-7.98	30.00	29998.21	-1316.77	0.0302	14.31	-8.02
1.95	30.00	30.00	29998.52	-1314.65	0.0304	14.07	-8.12	30.00	29998.52	-1313.11	0.0298	13.93	-8.19
2.00	30.00	30.00	29998.82	-1318.15	0.0309	13.70	-7.95	30.00	29998.82	-1315.93	0.0304	13.56	-8.06

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.10.3
SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 2 REAR SUSPENSION - BRAKE SUMMARY
TRAILING TANDEM AXLE

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	0.00	-.0000	26.14	-0.00	0.0	0.0	0.00	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.07	-.0000	26.14	-0.00	0.0	0.0	0.07	-.0000	26.14	-0.00
0.15	30.00	0.16	161.07	-2.03	0.0000	26.13	-0.28	0.16	161.07	-2.03	0.0000	26.13	-0.28
0.20	30.00	3.18	3175.51	-101.89	0.0025	26.05	-2.64	3.18	3175.51	-101.89	0.0025	26.05	-2.64
0.25	30.00	9.08	9083.05	-329.53	0.0085	25.83	-5.72	9.08	9083.05	-329.58	0.0085	25.83	-5.72
0.30	30.00	14.41	14413.03	-556.07	0.0154	25.50	-7.50	14.41	14413.03	-556.41	0.0154	25.50	-7.48
0.35	30.00	18.38	18384.68	-757.53	0.0197	25.16	-7.27	18.38	18384.68	-758.60	0.0197	25.16	-7.22
0.40	30.00	21.34	21344.23	-910.18	0.0213	24.84	-6.98	21.34	21344.23	-912.13	0.0212	24.85	-6.88
0.45	30.00	23.55	23549.72	-995.69	0.0243	24.50	-8.11	23.55	23549.72	-999.21	0.0240	24.51	-7.94
0.50	30.00	25.19	25193.21	-1064.25	0.0292	24.12	-8.72	25.19	25193.21	-1069.81	0.0286	24.14	-8.45
0.55	30.00	26.42	26417.89	-1159.01	0.0313	23.79	-7.09	26.42	26417.89	-1163.54	0.0303	23.82	-6.87
0.60	30.00	27.33	27330.53	-1205.16	0.0303	23.50	-7.04	27.33	27330.53	-1208.72	0.0291	23.54	-6.87
0.65	30.00	28.01	28010.60	-1210.10	0.0317	23.16	-8.41	28.01	28010.60	-1215.54	0.0303	23.21	-8.15
0.70	30.00	28.52	28517.44	-1233.55	0.0344	22.80	-8.49	28.52	28517.44	-1238.20	0.0327	22.86	-8.27
0.75	30.00	28.90	28895.07	-1272.19	0.0339	22.49	-7.54	28.90	28895.07	-1272.00	0.0322	22.55	-7.55
0.80	30.00	29.18	29176.49	-1270.70	0.0324	22.16	-8.27	29.18	29176.49	-1268.82	0.0311	22.21	-8.36
0.85	30.00	29.39	29386.20	-1261.12	0.0336	21.77	-9.23	29.39	29386.20	-1258.44	0.0326	21.81	-9.35
0.90	30.00	29.54	29542.49	-1282.43	0.0349	21.39	-8.58	29.54	29542.49	-1276.67	0.0344	21.41	-8.85
0.95	30.00	29.66	29658.98	-1304.58	0.0334	21.07	-7.80	29.66	29658.98	-1296.74	0.0335	21.07	-8.17
1.00	30.00	29.75	29745.74	-1295.92	0.0321	20.72	-8.42	29.75	29745.74	-1286.17	0.0330	20.70	-8.88
1.05	30.00	29.81	29810.44	-1291.12	0.0331	20.34	-8.80	29.81	29810.44	-1278.21	0.0349	20.30	-9.41
1.10	30.00	29.86	29858.63	-1309.39	0.0336	19.99	-8.04	29.86	29858.63	-1296.90	0.0364	19.92	-8.64
1.15	30.00	29.89	29894.53	-1318.53	0.0322	19.66	-7.69	29.89	29894.53	-1308.35	0.0356	19.58	-8.17
1.20	30.00	29.92	29921.27	-1309.76	0.0317	19.32	-8.17	29.92	29921.27	-1297.25	0.0355	19.21	-8.77
1.25	30.00	29.94	29941.28	-1308.78	0.0325	18.96	-8.26	29.94	29941.28	-1294.20	0.0371	18.83	-8.96
1.30	30.00	29.96	29956.13	-1319.15	0.0323	18.62	-7.80	29.96	29956.13	-1307.18	0.0374	18.48	-8.38
1.35	30.00	29.97	29967.18	-1316.87	0.0311	18.28	-7.94	29.97	29967.18	-1305.27	0.0364	18.13	-8.49
1.40	30.00	29.98	29975.43	-1307.36	0.0311	17.92	-8.41	29.98	29975.43	-1291.47	0.0370	17.75	-9.17
1.45	30.00	29.98	29981.56	-1309.96	0.0318	17.54	-8.30	29.98	29981.56	-1292.58	0.0385	17.35	-9.13
1.50	30.00	29.99	29986.14	-1319.99	0.0311	17.20	-7.84	29.99	29986.14	-1305.67	0.0385	16.99	-8.52
1.55	30.00	29.99	29989.56	-1319.13	0.0301	16.85	-7.88	29.99	29989.56	-1303.81	0.0378	16.63	-8.61
1.60	30.00	29.99	29992.09	-1316.99	0.0304	16.49	-7.99	29.99	29992.09	-1297.38	0.0388	16.26	-8.93
1.65	30.00	29.99	29994.00	-1325.26	0.0309	16.15	-7.60	29.99	29994.00	-1306.47	0.0402	15.89	-8.50
1.70	30.00	30.00	29995.39	-1334.74	0.0303	15.83	-7.15	30.00	29995.39	-1320.21	0.0401	15.56	-7.85
1.75	30.00	30.00	29996.44	-1330.76	0.0298	15.50	-7.35	30.00	29996.44	-1315.19	0.0396	15.23	-8.09
1.80	30.00	30.00	29997.22	-1322.31	0.0302	15.16	-7.75	30.00	29997.22	-1303.51	0.0404	14.88	-8.65
1.85	30.00	30.00	29997.83	-1320.58	0.0304	14.81	-7.84	30.00	29997.83	-1302.76	0.0411	14.51	-8.68
1.90	30.00	30.00	29998.21	-1320.75	0.0295	14.46	-7.83	30.00	29998.21	-1304.18	0.0405	14.16	-8.62
1.95	30.00	30.00	29998.52	-1317.73	0.0290	14.09	-7.97	30.00	29998.52	-1297.47	0.0404	13.78	-8.94
2.00	30.00	30.00	29998.82	-1321.28	0.0293	13.72	-7.80	30.00	29998.82	-1297.32	0.0419	13.40	-8.95

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 2 FRONT SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	0.0001	-0.0645	-0.0000	0.0	0.0001	-0.0645	-0.0000	0.0
0.10	0.0001	-0.1648	-0.0000	0.0	0.0001	-0.1648	-0.0000	0.0
0.15	-0.0002	0.2632	0.0001	0.0	-0.0002	0.2632	0.0001	0.0
0.20	0.0001	-0.1513	-0.0000	0.0	0.0001	-0.1513	-0.0000	0.0
0.25	0.0027	-3.2491	-0.0007	0.0	0.0027	-3.2517	-0.0007	0.0
0.30	0.0077	-9.7792	-0.0021	0.0	0.0077	-9.8070	-0.0021	0.0
0.35	0.0140	-18.3629	-0.0039	0.0	0.0140	-18.4730	-0.0039	0.0
0.40	0.0197	-26.8003	-0.0055	0.0	0.0197	-27.0662	-0.0055	0.0
0.45	0.0248	-34.1064	-0.0069	0.0	0.0248	-34.5997	-0.0069	0.0
0.50	0.0299	-40.7850	-0.0083	0.0	0.0299	-41.5837	-0.0083	0.0
0.55	0.0353	-47.1496	-0.0098	0.0	0.0354	-48.3221	-0.0098	0.0
0.60	0.0390	-52.1127	-0.0108	0.0	0.0391	-53.6159	-0.0108	0.0
0.65	0.0380	-52.2970	-0.0105	0.0	0.0381	-53.8710	-0.0106	0.0
0.70	0.0313	-44.0241	-0.0087	0.0	0.0313	-45.2757	-0.0087	0.0
0.75	0.0216	-30.1624	-0.0060	0.0	0.0217	-30.9103	-0.0060	0.0
0.80	0.0107	-14.6569	-0.0030	0.0	0.0108	-14.9674	-0.0030	0.0
0.85	-0.0045	6.1774	0.0013	0.0	-0.0045	6.1065	0.0012	0.0
0.90	-0.0258	35.7899	0.0072	0.0	-0.0258	35.3518	0.0072	0.0
0.95	-0.0490	69.2742	0.0136	0.0	-0.0489	67.4857	0.0136	0.0
1.00	-0.0690	99.2792	0.0192	0.0	-0.0690	95.3545	0.0192	0.0
1.05	-0.0863	124.6992	0.0239	0.0	-0.0862	118.1589	0.0239	0.0
1.10	-0.1034	148.4216	0.0287	0.0	-0.1033	138.8007	0.0287	0.0
1.15	-0.1196	171.0246	0.0332	0.0	-0.1194	158.0858	0.0331	0.0
1.20	-0.1320	190.9231	0.0366	0.0	-0.1316	174.9465	0.0365	0.0
1.25	-0.1402	206.2703	0.0389	0.0	-0.1394	187.7853	0.0387	0.0
1.30	-0.1475	217.7821	0.0409	0.0	-0.1463	196.9520	0.0406	0.0
1.35	-0.1563	228.6815	0.0434	0.0	-0.1544	205.1450	0.0428	0.0
1.40	-0.1647	239.5101	0.0457	0.0	-0.1621	212.9684	0.0450	0.0
1.45	-0.1700	247.7912	0.0472	0.0	-0.1664	218.4087	0.0462	0.0
1.50	-0.1727	253.4354	0.0479	0.0	-0.1680	221.3549	0.0466	0.0
1.55	-0.1751	258.7351	0.0486	0.0	-0.1691	223.7109	0.0469	0.0
1.60	-0.1746	258.8164	0.0484	0.0	-0.1671	221.4276	0.0463	0.0
1.65	-0.1703	251.3690	0.0473	0.0	-0.1612	212.7632	0.0447	0.0
1.70	-0.1665	243.6435	0.0462	0.0	-0.1556	204.0396	0.0432	0.0
1.75	-0.1673	244.6798	0.0464	0.0	-0.1543	202.7816	0.0428	0.0
1.80	-0.1713	252.8740	0.0475	0.0	-0.1560	207.1999	0.0433	0.0
1.85	-0.1762	261.6001	0.0489	0.0	-0.1580	211.3049	0.0438	0.0
1.90	-0.1827	270.1516	0.0507	0.0	-0.1614	214.4909	0.0448	0.0
1.95	-0.1909	280.2104	0.0530	0.0	-0.1662	218.2017	0.0461	0.0
2.00	-0.1946	284.5151	0.0540	0.0	-0.1661	216.4165	0.0461	0.0

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 2 REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY
LEADING TANDEM AXLE

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	-0.0000	0.0046	0.0000	0.0	-0.0000	0.0046	0.0000	0.0
0.10	-0.0000	0.0319	0.0000	0.0	-0.0000	0.0319	0.0000	0.0
0.15	0.0000	-0.0275	-0.0000	0.0	0.0000	-0.0275	-0.0000	0.0
0.20	0.0000	-0.0468	-0.0000	0.0	0.0000	-0.0468	-0.0000	0.0
0.25	-0.0003	0.3441	0.0002	0.0	-0.0003	0.3440	0.0002	0.0
0.30	-0.0012	1.3029	0.0007	0.0	-0.0012	1.3026	0.0007	0.0
0.35	-0.0023	2.6920	0.0013	0.0	-0.0023	2.6940	0.0013	0.0
0.40	-0.0029	3.8001	0.0016	0.0	-0.0029	3.8125	0.0016	0.0
0.45	-0.0028	3.6534	0.0016	0.0	-0.0028	3.6834	0.0016	0.0
0.50	-0.0021	2.4773	0.0012	0.0	-0.0021	2.5172	0.0012	0.0
0.55	-0.0013	1.5081	0.0007	0.0	-0.0013	1.5413	0.0007	0.0
0.60	-0.0012	1.4888	0.0006	0.0	-0.0012	1.5253	0.0006	0.0
0.65	-0.0010	1.2139	0.0005	0.0	-0.0010	1.2479	0.0005	0.0
0.70	0.0003	-0.3963	-0.0002	0.0	0.0003	-0.4086	-0.0002	0.0
0.75	0.0015	-1.7851	-0.0008	0.0	0.0015	-1.8333	-0.0008	0.0
0.80	0.0011	-1.3721	-0.0006	0.0	0.0011	-1.3971	-0.0006	0.0
0.85	0.0008	-0.9496	-0.0004	0.0	0.0008	-0.9574	-0.0004	0.0
0.90	0.0013	-1.5748	-0.0007	0.0	0.0013	-1.5682	-0.0007	0.0
0.95	0.0020	-2.5062	-0.0011	0.0	0.0020	-2.4622	-0.0011	0.0
1.00	0.0026	-3.3993	-0.0015	0.0	0.0026	-3.2937	-0.0015	0.0
1.05	0.0034	-4.1861	-0.0019	0.0	0.0034	-3.9927	-0.0019	0.0
1.10	0.0046	-5.6846	-0.0025	0.0	0.0046	-5.3538	-0.0025	0.0
1.15	0.0078	-10.0344	-0.0043	0.0	0.0078	-9.4094	-0.0043	0.0
1.20	0.0131	-16.8918	-0.0073	0.0	0.0131	-15.8136	-0.0073	0.0
1.25	0.0190	-23.8703	-0.0106	0.0	0.0191	-22.3043	-0.0106	0.0
1.30	0.0256	-32.2960	-0.0142	0.0	0.0256	-30.2746	-0.0142	0.0
1.35	0.0334	-43.1759	-0.0185	0.0	0.0335	-40.7602	-0.0186	0.0
1.40	0.0412	-52.5470	-0.0229	0.0	0.0414	-49.7511	-0.0230	0.0
1.45	0.0480	-59.6721	-0.0266	0.0	0.0482	-56.4645	-0.0267	0.0
1.50	0.0549	-69.4117	-0.0305	0.0	0.0552	-65.9140	-0.0306	0.0
1.55	0.0630	-81.1754	-0.0350	0.0	0.0633	-77.5052	-0.0351	0.0
1.60	0.0701	-88.7931	-0.0389	0.0	0.0705	-84.8128	-0.0391	0.0
1.65	0.0760	-94.8103	-0.0422	0.0	0.0765	-90.6382	-0.0425	0.0
1.70	0.0844	-106.6192	-0.0468	0.0	0.0850	-102.9989	-0.0472	0.0
1.75	0.0961	-121.7262	-0.0533	0.0	0.0968	-119.4076	-0.0537	0.0
1.80	0.1085	-133.7967	-0.0602	0.0	0.1094	-132.9049	-0.0607	0.0
1.85	0.1208	-146.6463	-0.0670	0.0	0.1218	-147.4733	-0.0676	0.0
1.90	0.1329	-163.7926	-0.0738	0.0	0.1342	-166.9634	-0.0745	0.0
1.95	0.1437	-177.8105	-0.0798	0.0	0.1452	-182.6761	-0.0806	0.0
2.00	0.1522	-185.2199	-0.0844	0.0	0.1539	-190.2127	-0.0854	0.0

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 2 REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY
TRAILING TANDEM AXLE

TIME (SEC)	LEFT SIDE TIRE SIDESLIP ANGLE (DEG)	LEFT SIDE TIRE LATERAL FORCE (LB)	LEFT SIDE MU-Y	LEFT SIDE ALIGNING TORQUE (IN-LB)	RIGHT SIDE TIRE SIDESLIP ANGLE (DEG)	RIGHT SIDE TIRE LATERAL FORCE (LB)	RIGHT SIDE MU-Y	RIGHT SIDE ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	-0.0000	0.0029	0.0000	0.0	-0.0000	0.0029	0.0000	0.0
0.10	-0.0000	0.0124	0.0000	0.0	-0.0000	0.0124	0.0000	0.0
0.15	0.0000	-0.0425	-0.0000	0.0	0.0000	-0.0425	-0.0000	0.0
0.20	0.0000	-0.0296	-0.0000	0.0	0.0000	-0.0296	-0.0000	0.0
0.25	-0.0002	0.1999	0.0001	0.0	-0.0002	0.1999	0.0001	0.0
0.30	-0.0004	0.4613	0.0002	0.0	-0.0004	0.4615	0.0002	0.0
0.35	-0.0002	0.1760	0.0001	0.0	-0.0002	0.1765	0.0001	0.0
0.40	0.0014	-1.6978	-0.0008	0.0	0.0014	-1.7106	-0.0008	0.0
0.45	0.0041	-4.8297	-0.0023	0.0	0.0041	-4.9053	-0.0023	0.0
0.50	0.0078	-8.1590	-0.0044	0.0	0.0078	-8.3814	-0.0044	0.0
0.55	0.0120	-12.6639	-0.0066	0.0	0.0120	-13.1293	-0.0066	0.0
0.60	0.0155	-17.5810	-0.0086	0.0	0.0155	-18.3341	-0.0086	0.0
0.65	0.0190	-20.7435	-0.0106	0.0	0.0190	-21.7855	-0.0105	0.0
0.70	0.0230	-23.5623	-0.0128	0.0	0.0230	-24.8770	-0.0128	0.0
0.75	0.0252	-27.0235	-0.0140	0.0	0.0252	-28.4262	-0.0140	0.0
0.80	0.0242	-27.1594	-0.0135	0.0	0.0242	-28.2868	-0.0134	0.0
0.85	0.0219	-23.5208	-0.0122	0.0	0.0219	-24.1828	-0.0122	0.0
0.90	0.0184	-19.3658	-0.0102	0.0	0.0184	-19.5600	-0.0102	0.0
0.95	0.0123	-13.7921	-0.0069	0.0	0.0123	-13.6400	-0.0068	0.0
1.00	0.0037	-4.2561	-0.0020	0.0	0.0037	-4.1094	-0.0020	0.0
1.05	-0.0066	7.4062	0.0037	0.0	-0.0066	6.9531	0.0037	0.0
1.10	-0.0180	19.9633	0.0100	0.0	-0.0180	18.2725	0.0100	0.0
1.15	-0.0289	33.7364	0.0160	0.0	-0.0289	30.3433	0.0160	0.0
1.20	-0.0394	46.5721	0.0219	0.0	-0.0395	41.1892	0.0219	0.0
1.25	-0.0510	58.6940	0.0283	0.0	-0.0511	50.9617	0.0283	0.0
1.30	-0.0631	73.7552	0.0350	0.0	-0.0633	63.1938	0.0351	0.0
1.35	-0.0750	90.7302	0.0416	0.0	-0.0752	76.9214	0.0417	0.0
1.40	-0.0878	105.4201	0.0487	0.0	-0.0881	87.9158	0.0489	0.0
1.45	-0.1026	120.9717	0.0570	0.0	-0.1030	98.8642	0.0572	0.0
1.50	-0.1177	142.5349	0.0653	0.0	-0.1182	114.6316	0.0656	0.0
1.55	-0.1320	164.9986	0.0732	0.0	-0.1327	130.6644	0.0736	0.0
1.60	-0.1477	182.9443	0.0820	0.0	-0.1485	141.8743	0.0824	0.0
1.65	-0.1642	201.4590	0.0911	0.0	-0.1652	153.2727	0.0917	0.0
1.70	-0.1778	223.4810	0.0987	0.0	-0.1791	168.5355	0.0994	0.0
1.75	-0.1890	240.7569	0.1049	0.0	-0.1904	180.6068	0.1056	0.0
1.80	-0.2016	251.8883	0.1119	0.0	-0.2033	187.1647	0.1128	0.0
1.85	-0.2165	268.9871	0.1202	0.0	-0.2184	197.7126	0.1212	0.0
1.90	-0.2322	296.8723	0.1288	0.0	-0.2344	215.6913	0.1301	0.0
1.95	-0.2496	324.4839	0.1385	0.0	-0.2521	231.3148	0.1399	0.0
2.00	-0.2698	348.1406	0.1497	0.0	-0.2728	241.5997	0.1514	0.0

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 2 FRONT SUSPENSION - UNSPRUNG MASS SUMMARY

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	0.0	0.0000	0.0	0.0003	0.1	-0.0000	-0.0001	-0.01	0.0000	0.0001	0.01
0.10	0.0	0.0000	0.0	0.0001	0.5	-0.0000	-0.0000	-0.05	0.0000	-0.0003	0.02
0.15	0.0000	-0.0000	0.0001	-0.0012	-1.9	-0.0000	-0.0015	-0.14	-0.0000	-0.0023	-0.47
0.20	0.0001	-0.0000	0.0033	0.0022	-0.5	-0.0017	-0.0711	-18.02	-0.0017	-0.0691	-17.97
0.25	0.0006	0.0003	0.0162	0.0104	8.3	-0.0114	-0.2854	-107.62	-0.0112	-0.2812	-106.08
0.30	0.0020	0.0011	0.0321	0.0216	16.3	-0.0299	-0.4487	-263.06	-0.0295	-0.4485	-260.38
0.35	0.0039	0.0024	0.0317	0.0314	0.6	-0.0541	-0.4678	-453.44	-0.0540	-0.4811	-453.58
0.40	0.0054	0.0042	0.0209	0.0377	-58.7	-0.0745	-0.3735	-606.69	-0.0754	-0.4046	-616.26
0.45	0.0062	0.0061	0.0021	0.0414	-160.6	-0.0853	-0.1116	-674.49	-0.0882	-0.1558	-699.59
0.50	0.0059	0.0082	-0.0191	0.0421	-284.2	-0.0827	0.2131	-632.81	-0.0879	0.1665	-676.16
0.55	0.0051	0.0102	-0.0173	0.0371	-401.4	-0.0715	0.1858	-546.92	-0.0789	0.1454	-607.25
0.60	0.0051	0.0118	0.0129	0.0261	-496.0	-0.0696	-0.2114	-557.68	-0.0787	-0.2418	-631.59
0.65	0.0064	0.0126	0.0281	0.0019	-564.0	-0.0846	-0.3957	-687.43	-0.0951	-0.4161	-771.17
0.70	0.0075	0.0118	0.0033	-0.0324	-599.5	-0.0991	-0.0981	-780.94	-0.1104	-0.1019	-869.55
0.75	0.0071	0.0095	-0.0257	-0.0560	-569.2	-0.0957	0.2224	-733.83	-0.1066	0.2520	-816.74
0.80	0.0059	0.0063	-0.0225	-0.0771	-445.7	-0.0827	0.1809	-634.33	-0.0913	0.2415	-697.94
0.85	0.0055	0.0017	-0.0018	-0.1056	-260.0	-0.0775	-0.0447	-608.75	-0.0827	0.0318	-644.75
0.90	0.0059	-0.0043	0.0090	-0.1329	-46.8	-0.0837	-0.1846	-666.60	-0.0850	-0.1000	-671.25
0.95	0.0065	-0.0112	0.0082	-0.1387	197.5	-0.0941	-0.2232	-750.19	-0.0908	-0.1232	-718.33
1.00	0.0070	-0.0179	0.0017	-0.1284	483.7	-0.1030	-0.1595	-815.48	-0.0944	-0.0464	-740.87
1.05	0.0070	-0.0240	-0.0105	-0.1146	782.3	-0.1062	0.0205	-829.31	-0.0920	0.1279	-710.95
1.10	0.0064	-0.0294	-0.0174	-0.0993	1039.0	-0.1021	0.1287	-789.98	-0.0830	0.2125	-634.83
1.15	0.0059	-0.0339	-0.0060	-0.0810	1226.7	-0.0976	-0.0088	-763.54	-0.0748	0.0487	-581.79
1.20	0.0062	-0.0374	0.0101	-0.0616	1352.1	-0.1017	-0.1959	-808.17	-0.0765	-0.1581	-608.67
1.25	0.0070	-0.0400	0.0072	-0.0428	1437.9	-0.1112	-0.1516	-879.26	-0.0843	-0.1243	-667.40
1.30	0.0071	-0.0417	-0.0092	-0.0327	1504.4	-0.1145	0.0388	-892.85	-0.0864	0.0611	-671.32
1.35	0.0066	-0.0433	-0.0153	-0.0343	1562.9	-0.1095	0.1099	-848.93	-0.0803	0.1313	-618.86
1.40	0.0062	-0.0450	-0.0075	-0.0355	1630.2	-0.1045	0.0323	-814.88	-0.0740	0.0615	-574.57
1.45	0.0062	-0.0467	-0.0001	-0.0329	1727.2	-0.1049	-0.0540	-823.74	-0.0726	-0.0125	-568.59
1.50	0.0064	-0.0481	0.0018	-0.0318	1853.0	-0.1089	-0.1001	-857.78	-0.0742	-0.0511	-583.80
1.55	0.0067	-0.0497	0.0012	-0.0317	1985.8	-0.1136	-0.1054	-894.80	-0.0764	-0.0573	-601.36
1.60	0.0068	-0.0506	-0.0038	-0.0086	2120.6	-0.1168	-0.0333	-915.50	-0.0771	0.0151	-601.96
1.65	0.0066	-0.0502	-0.0105	0.0156	2237.2	-0.1160	0.0670	-902.37	-0.0740	0.0994	-572.15
1.70	0.0063	-0.0490	-0.0086	0.0222	2286.3	-0.1122	0.0549	-873.63	-0.0692	0.0531	-537.69
1.75	0.0063	-0.0480	0.0020	0.0098	2237.0	-0.1113	-0.0611	-874.04	-0.0692	-0.0970	-547.07
1.80	0.0067	-0.0476	0.0063	0.0003	2135.8	-0.1154	-0.1059	-909.54	-0.0752	-0.1456	-597.71
1.85	0.0070	-0.0475	-0.0023	-0.0087	2065.9	-0.1191	-0.0145	-932.28	-0.0803	-0.0301	-629.70
1.90	0.0068	-0.0481	-0.0119	-0.0276	2073.7	-0.1173	0.0800	-911.56	-0.0784	0.0942	-606.70
1.95	0.0064	-0.0496	-0.0118	-0.0434	2157.3	-0.1124	0.0724	-873.97	-0.0720	0.1141	-555.76
2.00	0.0061	-0.0512	-0.0062	-0.0289	2322.0	-0.1100	0.0030	-859.54	-0.0666	0.0748	-515.59

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.17.3

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 2 REAR SUSPENSION - UNSPRUNG MASS SUMMARY

LEADING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0	0.00	0.0000	0.0	0.00
0.05	0.0	-0.0000	0.0	-0.0000	-0.0	0.0000	0.0000	0.00	-0.0000	-0.0000	-0.00
0.10	-0.0000	-0.0000	-0.0000	0.0000	-0.5	0.0000	0.0003	0.04	-0.0000	0.0000	-0.03
0.15	-0.0000	0.0000	-0.0002	0.0003	-0.8	0.0000	0.0010	-3.30	0.0000	0.0012	-3.37
0.20	-0.0001	0.0000	-0.0169	-0.0004	0.1	0.0002	-0.1725	-334.35	0.0002	-0.1723	-334.34
0.25	-0.0008	-0.0000	-0.0707	-0.0010	-2.8	0.0088	-0.6911	-737.71	0.0088	-0.6945	-737.99
0.30	-0.0016	-0.0000	-0.0585	0.0011	-23.5	0.0216	-1.0665	-685.84	0.0212	-1.0799	-688.18
0.35	-0.0003	0.0001	-0.0029	0.0065	-80.1	0.0015	-1.7698	-826.51	0.0002	-1.7996	-834.63
0.40	0.0021	0.0007	-0.0230	0.0153	-181.8	-0.0312	-1.3295	-1032.92	-0.0342	-1.3754	-1051.48
0.45	0.0018	0.0017	-0.0946	0.0241	-318.9	-0.0211	-0.4326	-977.59	-0.0266	-0.4883	-1010.46
0.50	-0.0003	0.0030	-0.0786	0.0270	-469.9	0.0098	-0.7543	-800.68	0.0016	-0.8109	-849.90
0.55	0.0001	0.0042	-0.0207	0.0216	-614.0	0.0057	-1.4769	-833.85	-0.0050	-1.5276	-898.60
0.60	0.0016	0.0051	-0.0399	0.0133	-735.0	-0.0129	-1.1451	-947.97	-0.0258	-1.1840	-1025.10
0.65	0.0010	0.0056	-0.0832	0.0096	-810.0	-0.0032	-0.6556	-890.12	-0.0173	-0.6710	-974.87
0.70	-0.0001	0.0059	-0.0592	-0.0001	-808.6	0.0116	-1.0838	-805.38	-0.0025	-1.0663	-890.06
0.75	0.0006	0.0055	-0.0274	-0.0200	-713.4	0.0001	-1.4627	-878.00	-0.0123	-1.4092	-952.01
0.80	0.0015	0.0040	-0.0550	-0.0381	-526.9	-0.0118	-1.0325	-948.55	-0.0207	-0.9460	-1001.67
0.85	0.0006	0.0019	-0.0783	-0.0452	-254.7	-0.0018	-0.7943	-888.02	-0.0058	-0.6777	-911.59
0.90	0.0000	-0.0006	-0.0489	-0.0520	86.0	0.0027	-1.2579	-864.01	0.0048	-1.1196	-850.89
0.95	0.0009	-0.0033	-0.0320	-0.0583	475.8	-0.0136	-1.4375	-963.25	-0.0045	-1.2842	-908.09
1.00	0.0014	-0.0063	-0.0612	-0.0591	894.9	-0.0226	-1.0163	-1016.04	-0.0062	-0.8572	-916.42
1.05	0.0005	-0.0092	-0.0729	-0.0553	1305.9	-0.0140	-0.9129	-963.74	0.0097	-0.7662	-821.05
1.10	0.0002	-0.0116	-0.0461	-0.0405	1665.7	-0.0132	-1.2723	-961.48	0.0167	-1.1495	-781.40
1.15	0.0009	-0.0131	-0.0402	-0.0179	1961.0	-0.0257	-1.2752	-1036.38	0.0091	-1.1759	-827.07
1.20	0.0010	-0.0135	-0.0634	-0.0046	2194.5	-0.0284	-0.9543	-1051.35	0.0100	-0.8786	-820.65
1.25	0.0004	-0.0136	-0.0630	0.0017	2368.1	-0.0214	-1.0167	-1009.42	0.0195	-0.9599	-763.80
1.30	0.0005	-0.0132	-0.0426	0.0145	2511.8	-0.0242	-1.2812	-1028.07	0.0184	-1.2276	-771.65
1.35	0.0011	-0.0123	-0.0482	0.0195	2659.7	-0.0326	-1.1465	-1077.57	0.0117	-1.0894	-811.73
1.40	0.0008	-0.0116	-0.0669	0.0057	2811.0	-0.0295	-0.9103	-1057.93	0.0165	-0.8538	-781.86
1.45	0.0003	-0.0115	-0.0578	0.0013	2968.0	-0.0234	-1.0824	-1022.47	0.0246	-1.0183	-734.12
1.50	0.0006	-0.0112	-0.0410	0.0131	3158.7	-0.0295	-1.2949	-1059.92	0.0209	-1.2161	-757.21
1.55	0.0011	-0.0104	-0.0517	0.0117	3371.7	-0.0372	-1.1191	-1105.25	0.0157	-1.0423	-787.63
1.60	0.0008	-0.0102	-0.0652	-0.0024	3545.1	-0.0337	-0.9498	-1083.50	0.0213	-0.8973	-753.13
1.65	0.0004	-0.0101	-0.0541	0.0154	3654.8	-0.0297	-1.1131	-1060.52	0.0266	-1.0808	-722.59
1.70	0.0008	-0.0084	-0.0440	0.0509	3720.4	-0.0346	-1.2046	-1090.42	0.0217	-1.1874	-752.48
1.75	0.0010	-0.0055	-0.0567	0.0571	3737.2	-0.0368	-0.9983	-1102.67	0.0183	-1.0029	-771.80
1.80	0.0006	-0.0030	-0.0643	0.0444	3707.9	-0.0298	-0.9311	-1060.47	0.0237	-0.9415	-739.38
1.85	0.0004	-0.0008	-0.0510	0.0498	3716.3	-0.0266	-1.1576	-1042.51	0.0259	-1.1344	-727.20
1.90	0.0008	0.0018	-0.0446	0.0477	3834.6	-0.0327	-1.2317	-1079.54	0.0201	-1.1676	-762.23
1.95	0.0010	0.0033	-0.0572	0.0111	4027.4	-0.0359	-1.0472	-1097.54	0.0165	-0.9693	-770.44
2.00	0.0006	0.0031	-0.0605	-0.0108	4238.9	-0.0327	-1.0318	-1078.57	0.0244	-0.9480	-735.03

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 2 REAR SUSPENSION - UNSPRUNG MASS SUMMARY
TRAILING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	-0.0000	0.0	0.00	-0.0000	0.0	0.00
0.05	0.0	-0.0000	0.0	-0.0000	-0.0	0.0000	0.0000	0.00	-0.0000	-0.0000	-0.00
0.10	-0.0000	0.0000	-0.0000	0.0001	-0.4	0.0000	0.0003	0.04	-0.0000	0.0001	-0.03
0.15	-0.0000	0.0000	-0.0003	0.0002	-0.7	0.0000	-0.0004	-2.50	0.0000	-0.0003	-2.58
0.20	-0.0003	0.0000	-0.0231	-0.0004	-0.0	0.0002	-0.2472	-314.56	0.0002	-0.2470	-314.55
0.25	-0.0013	-0.0000	-0.0802	-0.0000	-2.2	0.0078	-0.8054	-671.49	0.0077	-0.8081	-671.73
0.30	-0.0026	0.0001	-0.0662	0.0041	-19.5	0.0207	-1.1595	-573.56	0.0203	-1.1709	-575.78
0.35	-0.0017	0.0005	-0.0085	0.0129	-68.2	0.0008	-1.8397	-679.09	-0.0005	-1.8652	-686.97
0.40	0.0005	0.0014	-0.0272	0.0253	-154.9	-0.0317	-1.3830	-859.50	-0.0347	-1.4223	-877.65
0.45	-0.0000	0.0029	-0.0978	0.0316	-275.4	-0.0215	-0.4728	-784.68	-0.0269	-0.5235	-817.20
0.50	-0.0022	0.0045	-0.0809	0.0331	-416.0	0.0095	-0.7843	-593.23	0.0014	-0.8368	-642.17
0.55	-0.0020	0.0062	-0.0225	0.0350	-543.4	0.0055	-1.5023	-615.73	-0.0052	-1.5441	-679.93
0.60	-0.0005	0.0078	-0.0412	0.0275	-637.6	-0.0131	-1.1654	-721.86	-0.0259	-1.1949	-798.32
0.65	-0.0011	0.0089	-0.0841	0.0143	-695.9	-0.0034	-0.6688	-657.84	-0.0174	-0.6811	-742.26
0.70	-0.0023	0.0093	-0.0600	0.0034	-689.7	0.0115	-1.0937	-568.57	-0.0026	-1.0739	-653.04
0.75	-0.0016	0.0091	-0.0279	-0.0133	-584.5	0.0000	-1.4715	-637.94	-0.0123	-1.4135	-711.57
0.80	-0.0008	0.0077	-0.0554	-0.0416	-393.8	-0.0119	-1.0362	-705.84	-0.0208	-0.9520	-758.91
0.85	-0.0016	0.0051	-0.0786	-0.0590	-139.0	-0.0018	-0.7933	-643.23	-0.0059	-0.6859	-667.22
0.90	-0.0023	0.0020	-0.0491	-0.0669	175.6	0.0028	-1.2556	-617.79	0.0047	-1.1272	-605.18
0.95	-0.0014	-0.0017	-0.0322	-0.0812	533.5	-0.0135	-1.4319	-715.87	-0.0046	-1.2938	-661.49
1.00	-0.0009	-0.0061	-0.0613	-0.0933	900.6	-0.0226	-1.0065	-767.64	-0.0063	-0.8701	-669.31
1.05	-0.0018	-0.0107	-0.0730	-0.0898	1250.0	-0.0139	-0.9026	-714.71	0.0096	-0.7788	-573.44
1.10	-0.0021	-0.0150	-0.0462	-0.0816	1545.2	-0.0131	-1.2597	-711.90	0.0165	-1.1641	-533.48
1.15	-0.0014	-0.0189	-0.0403	-0.0717	1755.7	-0.0255	-1.2583	-786.19	0.0089	-1.1946	-579.13
1.20	-0.0013	-0.0220	-0.0634	-0.0559	1894.4	-0.0283	-0.9382	-800.88	0.0098	-0.8966	-572.50
1.25	-0.0019	-0.0246	-0.0630	-0.0489	1981.3	-0.0212	-1.0009	-758.80	0.0193	-0.9777	-515.47
1.30	-0.0018	-0.0271	-0.0426	-0.0560	2020.1	-0.0240	-1.2589	-776.92	0.0182	-1.2521	-523.57
1.35	-0.0012	-0.0300	-0.0482	-0.0555	2035.0	-0.0323	-1.1229	-826.10	0.0114	-1.1156	-563.79
1.40	-0.0015	-0.0325	-0.0669	-0.0489	2072.6	-0.0293	-0.8937	-806.70	0.0163	-0.8734	-533.53
1.45	-0.0020	-0.0351	-0.0578	-0.0608	2134.9	-0.0232	-1.0635	-771.12	0.0244	-1.0405	-485.80
1.50	-0.0017	-0.0386	-0.0410	-0.0799	2188.8	-0.0292	-1.2660	-807.87	0.0206	-1.2489	-509.51
1.55	-0.0012	-0.0425	-0.0517	-0.0708	2239.9	-0.0369	-1.0940	-853.15	0.0154	-1.0719	-539.92
1.60	-0.0015	-0.0455	-0.0652	-0.0536	2300.8	-0.0335	-0.9354	-831.96	0.0211	-0.9168	-504.80
1.65	-0.0019	-0.0480	-0.0541	-0.0532	2315.3	-0.0295	-1.0932	-808.74	0.0263	-1.1064	-474.47
1.70	-0.0016	-0.0506	-0.0440	-0.0490	2229.1	-0.0342	-1.1745	-837.90	0.0213	-1.2235	-505.08
1.75	-0.0013	-0.0523	-0.0567	-0.0200	2085.0	-0.0365	-0.9759	-850.36	0.0180	-1.0316	-524.17
1.80	-0.0017	-0.0529	-0.0643	-0.0114	1949.4	-0.0296	-0.9158	-808.63	0.0234	-0.9633	-491.27
1.85	-0.0020	-0.0541	-0.0510	-0.0483	1831.8	-0.0263	-1.1285	-789.94	0.0255	-1.1704	-479.82
1.90	-0.0015	-0.0575	-0.0446	-0.0815	1742.6	-0.0323	-1.1924	-826.11	0.0196	-1.2141	-515.68
1.95	-0.0014	-0.0614	-0.0572	-0.0751	1741.9	-0.0355	-1.0225	-844.70	0.0182	-1.0018	-523.30
2.00	-0.0017	-0.0649	-0.0605	-0.0750	1836.7	-0.0324	-1.0148	-826.29	0.0241	-0.9736	-487.33

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 SPRUNG MASS POSITION

TIME (SEC)	FORWARD (FT)	LATERAL (FT)	VERTICAL (FT)	ROLL (DEG)	PITCH (DEG)	HEADING (DEG)	TURN RADIUS (FT)	SIDE SLIP (DEG)	ARTICULATION ANGLE (DEG)
0.0	-96.3765	0.0	0.0	0.0	0.0	0.0	************	0.0	0.0
0.05	-94.0666	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	************	-0.0000	-0.0000
0.10	-91.8671	-0.0000	0.0000	0.0000	-0.0000	-0.0000	************	-0.0000	-0.0000
0.15	-89.6706	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	************	0.0000	-0.0000
0.20	-87.4809	0.0000	-0.0000	-0.0000	-0.0012	0.0000	************	0.0000	-0.0000
0.25	-85.2997	0.0000	-0.0000	-0.0000	-0.0085	0.0000	************	-0.0000	-0.0000
0.30	-83.1264	0.0000	-0.0000	0.0000	-0.0202	-0.0000	************	-0.0000	-0.0002
0.35	-80.9611	-0.0000	0.0000	0.0000	-0.0261	-0.0000	************	0.0000	-0.0010
0.40	-78.8070	0.0000	0.0000	-0.0000	-0.0244	0.0000	************	0.0001	-0.0027
0.45	-76.6697	0.0000	-0.0000	-0.0001	-0.0282	0.0001	326472.8750	0.0003	-0.0057
0.50	-74.5554	0.0000	-0.0000	-0.0003	-0.0354	0.0002	219805.6250	0.0006	-0.0103
0.55	-72.4690	0.0001	0.0000	-0.0005	-0.0342	0.0004	197834.2500	0.0010	-0.0165
0.60	-70.4131	0.0001	0.0000	-0.0006	-0.0313	0.0007	289142.0625	0.0013	-0.0244
0.65	-68.3882	0.0002	-0.0000	-0.0003	-0.0363	0.0009	************	0.0012	-0.0339
0.70	-66.3941	0.0003	-0.0000	0.0003	-0.0398	0.0010	-116035.7500	0.0006	-0.0448
0.75	-64.4302	0.0003	0.0000	0.0012	-0.0356	0.0008	-50063.1250	-0.0008	-0.0561
0.80	-62.4964	0.0003	0.0000	0.0023	-0.0350	0.0002	-27777.8750	-0.0032	-0.0670
0.85	-60.5920	0.0001	-0.0000	0.0034	-0.0405	-0.0010	-18640.0117	-0.0069	-0.0765
0.90	-58.7166	-0.0003	-0.0000	0.0045	-0.0400	-0.0028	-14344.9727	-0.0115	-0.0837
0.95	-56.8702	-0.0009	0.0000	0.0052	-0.0353	-0.0055	-11855.5625	-0.0169	-0.0875
1.00	-55.0532	-0.0017	-0.0000	0.0054	-0.0375	-0.0089	-10414.5938	-0.0227	-0.0868
1.05	-53.2663	-0.0028	-0.0000	0.0051	-0.0416	-0.0130	-9898.3125	-0.0285	-0.0808
1.10	-51.5099	-0.0043	0.0000	0.0044	-0.0382	-0.0178	-10173.4492	-0.0336	-0.0685
1.15	-49.7843	-0.0059	0.0000	0.0034	-0.0354	-0.0231	-11354.2656	-0.0374	-0.0509
1.20	-48.0906	-0.0078	-0.0000	0.0021	-0.0397	-0.0286	-14089.1406	-0.0395	-0.0266
1.25	-46.4295	-0.0099	-0.0000	0.0006	-0.0411	-0.0341	-20383.8828	-0.0396	0.0044
1.30	-44.8009	-0.0120	0.0000	-0.0009	-0.0366	-0.0393	-43677.2422	-0.0377	0.0420
1.35	-43.2039	-0.0142	0.0000	-0.0022	-0.0367	-0.0440	132536.0625	-0.0337	0.0861
1.40	-41.6382	-0.0163	-0.0000	-0.0034	-0.0412	-0.0479	25383.8203	-0.0278	0.1367
1.45	-40.1031	-0.0183	-0.0000	-0.0043	-0.0397	-0.0509	14001.1914	-0.0200	0.1935
1.50	-38.5984	-0.0200	0.0000	-0.0052	-0.0359	-0.0527	9336.5586	-0.0108	0.2564
1.55	-37.1224	-0.0215	-0.0000	-0.0059	-0.0385	-0.0533	6747.3477	0.0002	0.3246
1.60	-35.6715	-0.0227	-0.0000	-0.0066	-0.0414	-0.0523	5196.9961	0.0129	0.3985
1.65	-34.2486	-0.0235	-0.0000	-0.0075	-0.0378	-0.0497	4137.2539	0.0273	0.4771
1.70	-32.8616	-0.0238	0.0000	-0.0084	-0.0360	-0.0453	3319.5142	0.0437	0.5599
1.75	-31.5122	-0.0235	-0.0000	-0.0093	-0.0400	-0.0390	2715.7888	0.0625	0.6465
1.80	-30.1974	-0.0227	-0.0000	-0.0101	-0.0404	-0.0305	2308.0623	0.0835	0.7369
1.85	-28.9139	-0.0211	0.0000	-0.0106	-0.0364	-0.0198	2022.0466	0.1062	0.8315
1.90	-27.6594	-0.0188	0.0000	-0.0106	-0.0375	-0.0071	1800.4709	0.1303	0.9302
1.95	-26.4303	-0.0158	-0.0000	-0.0101	-0.0413	0.0078	1629.7432	0.1554	1.0327
2.00	-25.2255	-0.0119	-0.0000	-0.0092	-0.0392	0.0247	1500.5786	0.1810	1.1387

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 3 SPRUNG MASS VELOCITY (BODY AXES)

TIME (SEC)	FORWARD (FT/SEC)	LATERAL (FT/SEC)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	PITCH (DEG/SEC)	HEADING (DEG/SEC)	ARTICULATION RATE (DEG/SEC)
0.0	44.00	0.0	0.0	0.0	0.0	0.0	0.0
0.05	44.00	-0.00	-0.00	0.00	-0.00	-0.00	-0.00
0.10	44.00	-0.00	-0.00	0.00	0.00	-0.00	-0.00
0.15	44.00	0.00	-0.00	-0.00	-0.00	0.00	-0.00
0.20	43.97	0.00	-0.00	-0.00	-0.07	0.00	0.00
0.25	43.82	-0.00	-0.01	0.00	-0.21	0.00	-0.00
0.30	43.52	-0.00	-0.01	0.00	-0.07	-0.00	-0.01
0.35	43.12	0.00	-0.02	-0.00	0.14	0.00	-0.02
0.40	42.64	0.00	-0.02	-0.00	0.17	0.00	-0.05
0.45	42.13	0.00	-0.02	-0.00	0.01	0.00	-0.08
0.50	41.65	0.00	-0.03	-0.00	0.08	0.00	-0.11
0.55	41.20	0.00	-0.02	-0.00	0.25	0.00	-0.14
0.60	40.76	0.00	-0.02	0.00	0.13	0.01	-0.18
0.65	40.30	0.00	-0.03	0.01	0.02	0.00	-0.21
0.70	39.80	0.00	-0.03	0.02	0.18	-0.00	-0.22
0.75	39.26	-0.00	-0.02	0.02	0.25	-0.01	-0.23
0.80	38.65	-0.00	-0.03	0.02	0.08	-0.02	-0.21
0.85	38.00	-0.00	-0.03	0.02	0.07	-0.03	-0.17
0.90	37.32	-0.01	-0.02	0.02	0.25	-0.05	-0.11
0.95	36.65	-0.01	-0.02	0.01	0.20	-0.06	-0.03
1.00	35.99	-0.01	-0.02	-0.00	0.05	-0.08	0.07
1.05	35.36	-0.02	-0.03	-0.01	0.15	-0.09	0.18
1.10	34.75	-0.02	-0.02	-0.02	0.27	-0.10	0.30
1.15	34.16	-0.02	-0.02	-0.02	0.13	-0.11	0.42
1.20	33.57	-0.02	-0.02	-0.03	0.06	-0.11	0.55
1.25	32.97	-0.02	-0.02	-0.03	0.21	-0.11	0.69
1.30	32.35	-0.02	-0.02	-0.03	0.23	-0.10	0.82
1.35	31.73	-0.02	-0.02	-0.02	0.08	-0.09	0.95
1.40	31.10	-0.02	-0.02	-0.02	0.11	-0.07	1.07
1.45	30.45	-0.01	-0.02	-0.02	0.25	-0.05	1.20
1.50	29.80	-0.01	-0.02	-0.01	0.18	-0.02	1.31
1.55	29.15	0.00	-0.02	-0.01	0.06	0.00	1.42
1.60	28.52	0.01	-0.02	-0.02	0.17	0.04	1.52
1.65	27.91	0.01	-0.02	-0.02	0.25	0.07	1.62
1.70	27.32	0.02	-0.02	-0.02	0.12	0.11	1.70
1.75	26.76	0.03	-0.02	-0.02	0.08	0.15	1.77
1.80	26.20	0.04	-0.02	-0.01	0.22	0.19	1.85
1.85	25.63	0.05	-0.02	-0.01	0.21	0.23	1.93
1.90	25.03	0.06	-0.02	0.01	0.07	0.28	2.01
1.95	24.37	0.07	-0.02	0.02	0.13	0.32	2.09
2.00	23.69	0.07	-0.02	0.02	0.24	0.36	2.16

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TIME	TRAILER NO. 3 SPRUNG MASS ACCELERATION (BODY AXES)						INERTIAL ACCEL. ALONG BODY AXES	
(SEC)	FORWARD (FT/SEC**2)	LATERAL (FT/SEC**2)	VERTICAL (FT/SEC**2)	ROLL (DEG/SEC**2)	PITCH (DEG/SEC**2)	HEADING (DEG/SEC**2)	LONGITUDINAL (FT/SEC**2)	LATERAL (FT/SEC**2)
0.0	0.0000	0.0000	0.0	-0.0000	-0.0000	0.0	0.0000	0.0000
0.05	-0.0010	-0.0000	-0.0000	0.0000	-0.0001	-0.0000	-0.0010	-0.0000
0.10	-0.0020	-0.0000	0.0000	0.0000	-0.0002	-0.0000	-0.0020	-0.0000
0.15	-0.0567	0.0000	-0.0006	-0.0005	-0.1925	0.0002	-0.0567	0.0000
0.20	-1.4926	0.0000	-0.0505	0.0000	-2.9339	0.0002	-1.4926	0.0000
0.25	-4.5011	-0.0001	-0.0495	0.0022	-19.9456	-0.0008	-4.5011	-0.0001
0.30	-7.0705	-0.0001	0.0938	0.0006	-92.9412	-0.0008	-7.0705	-0.0001
0.35	-8.8931	0.0006	0.2555	-0.0124	-93.4938	0.0040	-8.8932	0.0006
0.40	-9.9883	0.0022	0.2509	-0.0335	-101.2686	0.0160	-9.9884	0.0026
0.45	-9.9278	0.0041	0.1539	-0.0390	-99.6940	0.0298	-9.9278	0.0053
0.50	-9.1438	0.0052	0.2141	-0.0070	-92.9053	0.0347	-9.1438	0.0076
0.55	-8.6589	0.0047	0.2912	0.0555	-96.3216	0.0225	-8.6590	0.0082
0.60	-8.8146	0.0016	0.2158	0.1228	-101.7016	-0.0102	-8.8147	0.0054
0.65	-9.4092	-0.0046	0.1827	0.1590	-96.8712	-0.0567	-9.4092	-0.0021
0.70	-10.2827	-0.0133	0.2709	0.1293	-93.4330	-0.1062	-10.2828	-0.0136
0.75	-11.4248	-0.0253	0.2636	0.0737	-99.2598	-0.1599	-11.4249	-0.0302
0.80	-12.4954	-0.0407	0.1793	0.0430	-100.5602	-0.2256	-12.4954	-0.0522
0.85	-13.1960	-0.0544	0.2218	-0.0232	-94.4149	-0.2834	-13.1960	-0.0743
0.90	-13.4440	-0.0629	0.2865	-0.1371	-95.2499	-0.3020	-13.4441	-0.0923
0.95	-13.2070	-0.0681	0.2117	-0.1911	-101.0282	-0.2974	-13.2071	-0.1067
1.00	-12.7340	-0.0687	0.1671	-0.1789	-98.3532	-0.2948	-12.7341	-0.1161
1.05	-12.2543	-0.0611	0.2516	-0.1683	-93.5491	-0.2631	-12.2544	-0.1166
1.10	-11.8993	-0.0464	0.2586	-0.1474	-97.7546	-0.1856	-11.8995	-0.1080
1.15	-11.6563	-0.0268	0.1608	-0.1149	-101.1130	-0.0950	-11.6564	-0.0915
1.20	-11.6916	-0.0035	0.1764	-0.0885	-95.9411	-0.0003	-11.6917	-0.0685
1.25	-11.9899	0.0202	0.2619	-0.0296	-94.2957	0.1066	-11.9900	-0.0421
1.30	-12.2562	0.0429	0.2121	0.0376	-99.8482	0.2084	-12.2563	-0.0136
1.35	-12.4262	0.0647	0.1343	0.0438	-99.6818	0.2971	-12.4263	0.0164
1.40	-12.6644	0.0828	0.1986	0.0324	-94.3239	0.3799	-12.6645	0.0449
1.45	-12.9065	0.0963	0.2485	0.0427	-96.2036	0.4495	-12.9066	0.0704
1.50	-12.8634	0.1087	0.1635	0.0076	-100.8075	0.5121	-12.8634	0.0961
1.55	-12.6049	0.1215	0.1311	-0.0636	-97.5161	0.5859	-12.6049	0.1234
1.60	-12.3608	0.1323	0.2134	-0.0689	-94.0695	0.6509	-12.3609	0.1499
1.65	-11.9866	0.1431	0.2135	-0.0348	-98.3903	0.6978	-11.9867	0.1772
1.70	-11.3778	0.1582	0.1266	-0.0350	-100.3796	0.7632	-11.3778	0.2091
1.75	-10.8928	0.1737	0.1414	-0.0019	-95.5469	0.8395	-10.8929	0.2427
1.80	-10.9896	0.1828	0.2107	0.1113	-95.1807	0.8602	-10.9898	0.2703
1.85	-11.6125	0.1852	0.1695	0.1996	-100.0254	0.8316	-11.6128	0.2902
1.90	-12.4670	0.1831	0.1083	0.2160	-98.8067	0.8136	-12.4673	0.3040
1.95	-13.2906	0.1751	0.1565	0.1972	-94.4036	0.7832	-13.2910	0.3103
2.00	-13.7286	0.1626	0.1930	0.1252	-96.9748	0.7196	-13.7291	0.3100

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 FRONT AXLE TIRE FORCES

LEADING TANDEM AXLE

	LEFT SIDE					RIGHT SIDE				
TIME (SEC)	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y
0.0	2162.50	-0.0	0.0	0.0	0.0	2162.50	-0.0	0.0	0.0	0.0
0.05	2162.50	0.01	-0.00	0.0000	-0.0000	2162.50	0.01	-0.00	0.0000	-0.0000
0.10	2162.50	0.02	-0.00	0.0000	-0.0000	2162.50	0.02	-0.00	0.0000	-0.0000
0.15	2162.56	-2.52	0.00	-0.0012	0.0000	2162.55	-2.52	0.00	-0.0012	0.0000
0.20	2183.01	-100.96	0.00	-0.0462	0.0000	2183.01	-100.96	0.00	-0.0462	0.0000
0.25	2300.46	-339.86	-0.02	-0.1477	-0.0000	2300.47	-339.86	-0.02	-0.1477	-0.0000
0.30	2511.88	-599.33	-0.01	-0.2386	-0.0000	2511.91	-599.33	-0.01	-0.2386	-0.0000
0.35	2606.78	-783.23	0.11	-0.3005	0.0000	2606.70	-783.22	0.11	-0.3005	0.0000
0.40	2600.49	-923.34	0.40	-0.3551	0.0002	2600.03	-923.30	0.40	-0.3551	0.0002
0.45	2648.47	-1046.26	0.71	-0.3950	0.0003	2647.41	-1046.19	0.71	-0.3952	0.0003
0.50	2739.10	-1140.45	0.80	-0.4164	0.0003	2737.47	-1140.39	0.80	-0.4166	0.0003
0.55	2730.22	-1203.11	0.50	-0.4407	0.0002	2728.39	-1203.09	0.50	-0.4410	0.0002
0.60	2694.94	-1253.97	-0.27	-0.4653	-0.0001	2693.76	-1254.06	-0.27	-0.4655	-0.0001
0.65	2756.46	-1291.06	-1.41	-0.4684	-0.0005	2757.13	-1291.29	-1.41	-0.4683	-0.0005
0.70	2803.12	-1301.21	-2.66	-0.4642	-0.0009	2806.67	-1301.53	-2.66	-0.4637	-0.0009
0.75	2750.06	-1301.65	-4.10	-0.4733	-0.0015	2757.44	-1302.10	-4.12	-0.4722	-0.0015
0.80	2736.47	-1309.72	-5.84	-0.4786	-0.0021	2748.42	-1310.19	-5.87	-0.4767	-0.0021
0.85	2802.73	-1312.76	-7.01	-0.4684	-0.0025	2818.62	-1313.11	-7.06	-0.4659	-0.0025
0.90	2801.75	-1308.99	-7.03	-0.4672	-0.0025	2819.81	-1309.29	-7.08	-0.4643	-0.0025
0.95	2742.51	-1316.70	-6.48	-0.4801	-0.0024	2761.22	-1316.90	-6.53	-0.4769	-0.0024
1.00	2766.23	-1333.79	-5.28	-0.4822	-0.0019	2783.48	-1333.73	-5.33	-0.4792	-0.0019
1.05	2820.32	-1340.04	-2.77	-0.4751	-0.0010	2833.11	-1339.84	-2.81	-0.4729	-0.0010
1.10	2785.52	-1341.37	0.50	-0.4815	0.0002	2792.12	-1341.13	0.47	-0.4803	0.0002
1.15	2752.32	-1350.93	4.01	-0.4908	0.0015	2751.86	-1350.57	3.97	-0.4908	0.0014
1.20	2806.65	-1356.17	7.98	-0.4832	0.0028	2797.86	-1355.77	7.91	-0.4846	0.0028
1.25	2831.63	-1347.82	11.63	-0.4760	0.0041	2814.65	-1347.45	11.51	-0.4787	0.0041
1.30	2780.72	-1342.92	14.30	-0.4829	0.0051	2757.20	-1342.55	14.14	-0.4869	0.0051
1.35	2782.21	-1346.84	16.54	-0.4841	0.0059	2753.18	-1346.59	16.34	-0.4891	0.0059
1.40	2838.87	-1343.66	18.20	-0.4733	0.0064	2805.52	-1343.51	17.97	-0.4789	0.0064
1.45	2824.19	-1335.16	18.62	-0.4728	0.0066	2788.91	-1334.93	18.37	-0.4787	0.0066
1.50	2776.87	-1336.75	18.44	-0.4814	0.0066	2741.05	-1336.52	18.20	-0.4876	0.0066
1.55	2807.59	-1343.76	18.04	-0.4786	0.0064	2771.80	-1343.60	17.81	-0.4847	0.0064
1.60	2843.09	-1342.97	16.64	-0.4724	0.0059	2808.73	-1342.71	16.43	-0.4780	0.0059
1.65	2799.18	-1344.14	14.60	-0.4802	0.0052	2766.99	-1343.70	14.41	-0.4856	0.0052
1.70	2775.16	-1354.97	12.56	-0.4883	0.0045	2745.09	-1354.52	12.36	-0.4934	0.0045
1.75	2821.15	-1362.46	9.37	-0.4829	0.0033	2795.07	-1362.01	9.15	-0.4873	0.0033
1.80	2824.03	-1357.80	4.60	-0.4808	0.0016	2804.33	-1357.23	4.35	-0.4840	0.0015
1.85	2771.83	-1350.65	-0.51	-0.4873	-0.0002	2759.24	-1350.04	-0.86	-0.4893	-0.0003
1.90	2778.72	-1343.78	-6.51	-0.4836	-0.0023	2775.85	-1343.25	-7.01	-0.4839	-0.0025
1.95	2818.55	-1331.17	-14.23	-0.4723	-0.0050	2829.76	-1330.57	-15.01	-0.4702	-0.0053
2.00	2786.77	-1321.10	-21.73	-0.4741	-0.0078	2812.59	-1320.35	-22.89	-0.4694	-0.0081

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 3 FRONT AXLE TIRE FORCES
TRAILING TANDEM AXLE

	LEFT SIDE					RIGHT SIDE				
TIME (SEC)	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y
0.0	2162.50	-0.0	0.0	0.0	0.0	2162.50	-0.0	0.0	0.0	0.0
0.05	2162.50	0.01	-0.00	0.0000	-0.0000	2162.50	0.01	-0.00	0.0000	-0.0000
0.10	2162.50	0.02	-0.00	0.0000	-0.0000	2162.50	0.02	-0.00	0.0000	-0.0000
0.15	2162.48	-2.52	0.00	-0.0012	0.0000	2162.48	-2.52	0.00	-0.0012	0.0000
0.20	2167.07	-100.59	0.00	-0.0464	0.0000	2167.06	-100.59	0.00	-0.0464	0.0000
0.25	2237.82	-337.07	-0.02	-0.1506	-0.0000	2237.84	-337.08	-0.02	-0.1506	-0.0000
0.30	2397.15	-596.07	-0.02	-0.2487	-0.0000	2397.19	-596.07	-0.02	-0.2487	-0.0000
0.35	2460.33	-780.54	0.10	-0.3172	0.0000	2460.26	-780.52	0.10	-0.3173	0.0000
0.40	2427.31	-921.34	0.43	-0.3796	0.0002	2426.80	-921.28	0.43	-0.3796	0.0002
0.45	2455.78	-1046.27	0.88	-0.4260	0.0004	2454.48	-1046.17	0.88	-0.4262	0.0004
0.50	2532.06	-1141.56	1.19	-0.4508	0.0005	2529.84	-1141.46	1.19	-0.4512	0.0005
0.55	2512.47	-1203.44	1.12	-0.4790	0.0004	2509.70	-1203.39	1.12	-0.4795	0.0004
0.60	2469.17	-1255.31	0.47	-0.5084	0.0002	2466.90	-1255.42	0.47	-0.5089	0.0002
0.65	2524.58	-1294.73	-0.78	-0.5129	-0.0003	2524.31	-1295.05	-0.78	-0.5130	-0.0003
0.70	2566.39	-1304.35	-2.50	-0.5082	-0.0010	2569.71	-1304.80	-2.51	-0.5078	-0.0010
0.75	2509.36	-1303.72	-4.77	-0.5195	-0.0019	2517.74	-1304.34	-4.78	-0.5181	-0.0019
0.80	2492.37	-1313.29	-7.75	-0.5269	-0.0031	2507.13	-1313.96	-7.80	-0.5241	-0.0031
0.85	2555.30	-1317.21	-10.87	-0.5155	-0.0043	2576.95	-1317.74	-10.97	-0.5114	-0.0043
0.90	2551.13	-1311.89	-13.24	-0.5142	-0.0052	2578.55	-1312.37	-13.38	-0.5090	-0.0052
0.95	2489.19	-1319.34	-14.97	-0.5300	-0.0060	2520.60	-1319.66	-15.17	-0.5236	-0.0060
1.00	2510.15	-1338.13	-16.47	-0.5331	-0.0066	2544.06	-1338.03	-16.70	-0.5259	-0.0066
1.05	2561.35	-1344.12	-16.95	-0.5248	-0.0066	2595.45	-1343.80	-17.19	-0.5178	-0.0066
1.10	2524.49	-1344.18	-15.87	-0.5325	-0.0063	2555.65	-1343.75	-16.09	-0.5258	-0.0063
1.15	2489.95	-1354.67	-13.91	-0.5441	-0.0056	2516.10	-1353.94	-14.09	-0.5381	-0.0056
1.20	2542.94	-1361.15	-11.41	-0.5353	-0.0045	2562.98	-1360.21	-11.54	-0.5307	-0.0045
1.25	2567.41	-1351.75	-8.14	-0.5265	-0.0032	2579.91	-1350.81	-8.21	-0.5236	-0.0032
1.30	2517.34	-1346.23	-4.32	-0.5348	-0.0017	2521.36	-1345.26	-4.36	-0.5335	-0.0017
1.35	2520.05	-1351.44	-0.36	-0.5363	-0.0001	2515.92	-1350.52	-0.39	-0.5368	-0.0002
1.40	2578.33	-1348.42	3.69	-0.5230	0.0014	2566.49	-1347.61	3.66	-0.5251	0.0014
1.45	2566.39	-1338.67	7.83	-0.5216	0.0031	2547.05	-1337.84	7.76	-0.5253	0.0030
1.50	2522.41	-1340.41	12.21	-0.5314	0.0048	2495.76	-1339.63	12.08	-0.5368	0.0048
1.55	2556.96	-1348.44	17.16	-0.5274	0.0067	2522.62	-1347.80	16.93	-0.5343	0.0067
1.60	2597.29	-1347.01	22.33	-0.5186	0.0086	2554.67	-1346.33	21.96	-0.5270	0.0086
1.65	2558.66	-1347.33	27.50	-0.5266	0.0107	2507.62	-1346.53	26.93	-0.5370	0.0107
1.70	2540.36	-1358.89	33.50	-0.5349	0.0132	2479.97	-1358.24	32.66	-0.5477	0.0132
1.75	2593.69	-1366.79	40.35	-0.5270	0.0156	2522.59	-1366.34	39.15	-0.5416	0.0155
1.80	2604.63	-1361.24	46.39	-0.5226	0.0178	2523.78	-1360.78	44.78	-0.5392	0.0177
1.85	2559.67	-1353.91	51.44	-0.5289	0.0201	2471.44	-1353.66	49.41	-0.5477	0.0200
1.90	2574.88	-1347.60	57.06	-0.5234	0.0222	2479.72	-1348.08	54.57	-0.5436	0.0220
1.95	2624.76	-1334.60	62.58	-0.5085	0.0238	2523.58	-1335.26	59.62	-0.5291	0.0236
2.00	2601.44	-1323.84	66.41	-0.5089	0.0255	2497.95	-1324.21	63.05	-0.5301	0.0252

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 3 REAR SUSPENSION TIRE FORCES
LEADING TANDEM AXLE

TIME (SEC)	LEFT SIDE VERTICAL (LB)	LEFT SIDE LONG. (LB)	LEFT SIDE LATERAL (LB)	LEFT SIDE MU-X	LEFT SIDE MU-Y	RIGHT SIDE VERTICAL (LB)	RIGHT SIDE LONG. (LB)	RIGHT SIDE LATERAL (LB)	RIGHT SIDE MU-X	RIGHT SIDE MU-Y
0.0	2162.50	-0.0	0.0	0.0	0.0	2162.50	-0.0	0.0	0.0	0.0
0.05	2162.50	0.01	0.00	0.0000	0.0000	2162.50	0.01	0.00	0.0000	0.0000
0.10	2162.50	0.02	0.00	0.0000	0.0000	2162.50	0.02	0.00	0.0000	0.0000
0.15	2162.52	-2.52	-0.00	-0.0012	-0.0000	2162.52	-2.52	-0.00	-0.0012	-0.0000
0.20	2157.77	-100.31	-0.00	-0.0465	-0.0000	2157.77	-100.31	-0.00	-0.0465	-0.0000
0.25	2086.80	-327.55	0.00	-0.1570	0.0000	2086.79	-327.55	0.00	-0.1570	0.0000
0.30	1926.88	-552.73	0.01	-0.2869	0.0000	1926.87	-552.73	0.01	-0.2869	0.0000
0.35	1868.65	-741.08	-0.02	-0.3966	-0.0000	1868.69	-741.08	-0.02	-0.3966	-0.0000
0.40	1901.84	-885.30	-0.09	-0.4655	-0.0000	1901.91	-885.29	-0.09	-0.4655	-0.0000
0.45	1868.21	-983.67	-0.18	-0.5265	-0.0001	1868.13	-983.60	-0.18	-0.5265	-0.0001
0.50	1792.51	-1074.12	-0.18	-0.5992	-0.0001	1791.92	-1073.97	-0.18	-0.5993	-0.0001
0.55	1818.86	-1165.25	-0.03	-0.6406	-0.0000	1817.54	-1165.06	-0.03	-0.6410	-0.0000
0.60	1861.31	-1210.69	0.25	-0.6505	0.0001	1859.45	-1210.58	0.25	-0.6510	0.0001
0.65	1798.36	-1222.02	0.56	-0.6795	0.0003	1796.72	-1222.08	0.56	-0.6802	0.0003
0.70	1756.37	-1247.70	0.75	-0.7104	0.0004	1756.12	-1248.09	0.75	-0.7107	0.0004
0.75	1815.91	-1270.68	0.79	-0.6997	0.0004	1818.06	-1271.33	0.79	-0.6993	0.0004
0.80	1824.39	-1258.89	0.80	-0.6900	0.0004	1829.35	-1259.71	0.80	-0.6886	0.0004
0.85	1750.90	-1250.09	0.79	-0.7140	0.0004	1758.83	-1251.20	0.79	-0.7114	0.0004
0.90	1756.03	-1271.20	0.62	-0.7239	0.0004	1766.87	-1272.25	0.63	-0.7201	0.0004
0.95	1819.59	-1282.57	0.50	-0.7049	0.0003	1832.21	-1283.33	0.50	-0.7004	0.0003
1.00	1790.96	-1275.74	0.60	-0.7123	0.0003	1803.64	-1276.45	0.61	-0.7077	0.0003
1.05	1737.11	-1286.74	0.76	-0.7407	0.0004	1748.66	-1287.24	0.76	-0.7361	0.0004
1.10	1783.62	-1310.91	1.01	-0.7350	0.0006	1792.68	-1310.84	1.01	-0.7312	0.0006
1.15	1824.03	-1309.17	1.41	-0.7177	0.0008	1829.37	-1308.85	1.42	-0.7155	0.0008
1.20	1768.95	-1298.40	1.58	-0.7340	0.0009	1770.47	-1297.92	1.58	-0.7331	0.0009
1.25	1750.34	-1307.79	1.63	-0.7472	0.0009	1747.82	-1306.98	1.63	-0.7478	0.0009
1.30	1813.55	-1314.39	1.92	-0.7248	0.0011	1806.50	-1313.40	1.91	-0.7270	0.0011
1.35	1815.17	-1300.32	1.98	-0.7164	0.0011	1804.51	-1299.26	1.97	-0.7200	0.0011
1.40	1755.96	-1294.18	1.54	-0.7370	0.0009	1743.14	-1293.04	1.53	-0.7418	0.0009
1.45	1775.20	-1305.63	1.05	-0.7355	0.0006	1760.67	-1304.59	1.04	-0.7410	0.0006
1.50	1828.05	-1305.14	0.40	-0.7140	0.0002	1812.55	-1304.17	0.40	-0.7195	0.0002
1.55	1793.74	-1296.44	-0.72	-0.7228	-0.0004	1778.40	-1295.29	-0.72	-0.7283	-0.0004
1.60	1753.95	-1303.88	-2.01	-0.7434	-0.0011	1738.82	-1302.67	-2.00	-0.7492	-0.0011
1.65	1800.62	-1318.92	-3.40	-0.7325	-0.0019	1785.65	-1317.85	-3.37	-0.7380	-0.0019
1.70	1825.36	-1318.93	-5.12	-0.7226	-0.0028	1811.16	-1317.76	-5.08	-0.7276	-0.0028
1.75	1773.06	-1318.55	-6.86	-0.7437	-0.0039	1759.58	-1317.16	-6.81	-0.7486	-0.0039
1.80	1765.58	-1328.52	-8.65	-0.7525	-0.0049	1753.01	-1327.33	-8.60	-0.7572	-0.0049
1.85	1816.41	-1326.23	-10.99	-0.7301	-0.0061	1806.74	-1325.43	-10.94	-0.7336	-0.0061
1.90	1802.34	-1307.32	-13.42	-0.7253	-0.0074	1797.07	-1306.66	-13.39	-0.7271	-0.0075
1.95	1749.87	-1297.07	-15.63	-0.7412	-0.0089	1749.67	-1296.71	-15.65	-0.7411	-0.0089
2.00	1771.16	-1300.36	-18.96	-0.7342	-0.0107	1779.12	-1300.60	-19.07	-0.7310	-0.0107

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 REAR SUSPENSION TIRE FORCES

TRAILING TANDEM AXLE

TIME (SEC)	LEFT SIDE VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y	RIGHT SIDE VERTICAL (LB)	LONG. (LB)	LATERAL (LB)	MU-X	MU-Y
0.0	2162.50	-0.0	0.0	0.0	0.0	2162.50	-0.0	0.0	0.0	0.0
0.05	2162.50	0.01	0.00	0.0000	0.0000	2162.50	0.01	0.00	0.0000	0.0000
0.10	2162.50	0.02	0.00	0.0000	0.0000	2162.50	0.02	0.00	0.0000	0.0000
0.15	2162.45	-2.52	-0.00	-0.0012	-0.0000	2162.45	-2.52	-0.00	-0.0012	-0.0000
0.20	2141.83	-99.94	-0.00	-0.0467	-0.0000	2141.82	-99.94	-0.00	-0.0467	-0.0000
0.25	2024.17	-324.16	0.00	-0.1601	0.0000	2024.16	-324.16	0.00	-0.1601	0.0000
0.30	1812.16	-544.73	0.00	-0.3006	0.0000	1812.16	-544.73	0.00	-0.3006	0.0000
0.35	1722.21	-731.53	-0.01	-0.4248	-0.0000	1722.25	-731.54	-0.01	-0.4248	-0.0000
0.40	1728.67	-876.57	-0.04	-0.5071	-0.0000	1728.66	-876.54	-0.04	-0.5071	-0.0000
0.45	1675.54	-972.55	-0.01	-0.5804	-0.0000	1675.19	-972.44	-0.01	-0.5805	-0.0000
0.50	1585.43	-1061.27	0.13	-0.6694	0.0001	1584.34	-1061.03	0.13	-0.6697	0.0001
0.55	1600.99	-1157.13	0.39	-0.7228	0.0002	1598.97	-1156.85	0.39	-0.7235	0.0002
0.60	1635.36	-1203.70	0.69	-0.7360	0.0004	1632.77	-1203.54	0.69	-0.7371	0.0004
0.65	1566.21	-1210.38	0.80	-0.7728	0.0005	1564.18	-1210.49	0.80	-0.7739	0.0005
0.70	1519.40	-1237.69	0.61	-0.8146	0.0004	1519.40	-1238.31	0.61	-0.8150	0.0004
0.75	1575.11	-1266.62	0.05	-0.8041	0.0000	1578.47	-1267.67	0.05	-0.8031	0.0000
0.80	1580.35	-1251.79	-0.85	-0.7921	-0.0005	1588.01	-1253.21	-0.85	-0.7892	-0.0005
0.85	1504.09	-1238.82	-1.96	-0.8236	-0.0013	1516.54	-1240.81	-1.98	-0.8182	-0.0013
0.90	1506.73	-1264.59	-3.50	-0.8393	-0.0023	1524.28	-1266.62	-3.54	-0.8310	-0.0023
0.95	1567.89	-1278.32	-5.30	-0.8153	-0.0034	1589.97	-1279.96	-5.37	-0.8050	-0.0034
1.00	1537.29	-1266.03	-6.63	-0.8235	-0.0043	1561.82	-1267.83	-6.74	-0.8118	-0.0043
1.05	1481.94	-1276.21	-7.71	-0.8612	-0.0052	1507.20	-1277.86	-7.84	-0.8478	-0.0052
1.10	1526.78	-1306.24	-9.01	-0.8556	-0.0059	1552.03	-1306.96	-9.16	-0.8421	-0.0059
1.15	1565.84	-1303.18	-9.82	-0.8323	-0.0063	1589.43	-1303.50	-9.96	-0.8201	-0.0063
1.20	1510.53	-1287.77	-9.73	-0.8525	-0.0064	1530.29	-1287.96	-9.85	-0.8416	-0.0064
1.25	1492.01	-1300.21	-9.47	-0.8715	-0.0063	1507.20	-1299.73	-9.56	-0.8624	-0.0063
1.30	1555.18	-1310.77	-9.02	-0.8428	-0.0058	1565.65	-1309.76	-9.08	-0.8366	-0.0058
1.35	1557.64	-1292.86	-7.79	-0.8300	-0.0050	1562.62	-1291.68	-7.81	-0.8266	-0.0050
1.40	1500.11	-1284.58	-6.16	-0.8563	-0.0041	1499.43	-1283.09	-6.15	-0.8557	-0.0041
1.45	1521.02	-1300.69	-4.49	-0.8551	-0.0030	1515.17	-1299.06	-4.47	-0.8574	-0.0030
1.50	1575.91	-1300.74	-2.49	-0.8254	-0.0016	1564.93	-1298.98	-2.47	-0.8301	-0.0016
1.55	1544.34	-1287.92	-0.18	-0.8340	-0.0001	1527.98	-1285.63	-0.18	-0.8414	-0.0001
1.60	1507.60	-1296.16	2.41	-0.8598	0.0016	1485.31	-1293.42	2.37	-0.8708	0.0016
1.65	1557.91	-1315.12	5.68	-0.8442	0.0036	1528.46	-1312.38	5.57	-0.8586	0.0036
1.70	1586.94	-1313.17	9.30	-0.8275	0.0059	1549.67	-1309.88	9.09	-0.8453	0.0059
1.75	1538.82	-1310.17	12.88	-0.8514	0.0084	1493.89	-1305.90	12.51	-0.8742	0.0084
1.80	1536.10	-1323.22	17.34	-0.8614	0.0113	1482.55	-1318.99	16.74	-0.8897	0.0113
1.85	1593.04	-1322.90	22.68	-0.8304	0.0142	1530.15	-1319.14	21.80	-0.8621	0.0142
1.90	1584.41	-1301.26	27.04	-0.8213	0.0171	1515.03	-1296.99	25.88	-0.8561	0.0171
1.95	1536.29	-1290.56	30.68	-0.8400	0.0200	1463.27	-1286.17	29.26	-0.8790	0.0200
2.00	1563.80	-1296.96	35.40	-0.8294	0.0226	1486.50	-1293.54	33.70	-0.8702	0.0227

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 3 FRONT SUSPENSION - BRAKE SUMMARY
LEADING TANDEM AXLE

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	0.01	-.0000	26.14	-0.00	0.0	0.0	0.01	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.02	-.0000	26.14	-0.00	0.0	0.0	0.02	-.0000	26.14	-0.00
0.15	30.00	0.16	161.07	-2.52	0.0001	26.14	-0.26	0.16	161.07	-2.52	0.0001	26.14	-0.26
0.20	30.00	3.18	3175.51	-100.96	0.0024	26.05	-2.68	3.18	3175.51	-100.96	0.0024	26.05	-2.68
0.25	30.00	9.08	9083.05	-339.86	0.0076	25.82	-5.23	9.08	9083.05	-339.86	0.0076	25.82	-5.23
0.30	30.00	14.41	14413.03	-599.33	0.0123	25.53	-5.44	14.41	14413.03	-599.33	0.0123	25.53	-5.44
0.35	30.00	18.38	18384.68	-783.23	0.0155	25.23	-6.05	18.38	18384.68	-783.22	0.0155	25.23	-6.05
0.40	30.00	21.34	21344.23	-923.34	0.0183	24.88	-6.35	21.34	21344.23	-923.30	0.0183	24.88	-6.35
0.45	30.00	23.55	23549.72	-1046.26	0.0203	24.52	-5.70	23.55	23549.72	-1046.19	0.0203	24.52	-5.70
0.50	30.00	25.19	25193.21	-1140.45	0.0214	24.22	-5.09	25.19	25193.21	-1140.39	0.0214	24.22	-5.09
0.55	30.00	26.42	26417.89	-1203.11	0.0227	23.93	-4.99	26.42	26417.89	-1203.09	0.0227	23.93	-4.99
0.60	30.00	27.33	27330.53	-1253.97	0.0240	23.64	-4.72	27.33	27330.53	-1254.06	0.0240	23.64	-4.71
0.65	30.00	28.01	28010.60	-1291.06	0.0241	23.37	-4.55	28.01	28010.60	-1291.29	0.0241	23.37	-4.54
0.70	30.00	28.52	28517.44	-1301.21	0.0239	23.09	-5.27	28.52	28517.44	-1301.53	0.0239	23.09	-5.25
0.75	30.00	28.90	28895.07	-1301.65	0.0244	22.76	-6.14	28.90	28895.07	-1302.10	0.0243	22.76	-6.11
0.80	30.00	29.18	29176.49	-1309.72	0.0246	22.40	-6.42	29.18	29176.49	-1310.19	0.0245	22.40	-6.39
0.85	30.00	29.39	29386.20	-1312.76	0.0241	22.03	-6.77	29.39	29386.20	-1313.11	0.0240	22.04	-6.75
0.90	30.00	29.54	29542.49	-1308.99	0.0241	21.65	-7.31	29.54	29542.49	-1309.29	0.0239	21.66	-7.30
0.95	30.00	29.66	29658.98	-1316.70	0.0247	21.24	-7.22	29.66	29658.98	-1316.90	0.0246	21.25	-7.21
1.00	30.00	29.75	29745.74	-1333.79	0.0248	20.85	-6.61	29.75	29745.74	-1333.73	0.0247	20.86	-6.61
1.05	30.00	29.81	29810.44	-1340.04	0.0245	20.50	-6.47	29.81	29810.44	-1339.84	0.0243	20.51	-6.48
1.10	30.00	29.86	29858.63	-1341.37	0.0248	20.14	-6.52	29.86	29858.63	-1341.13	0.0247	20.15	-6.53
1.15	30.00	29.89	29894.53	-1350.93	0.0253	19.78	-6.15	29.89	29894.53	-1350.57	0.0253	19.79	-6.16
1.20	30.00	29.92	29921.27	-1356.17	0.0249	19.44	-5.96	29.92	29921.27	-1355.77	0.0249	19.45	-5.98
1.25	30.00	29.94	29941.28	-1347.82	0.0245	19.11	-6.40	29.94	29941.28	-1347.45	0.0246	19.12	-6.42
1.30	30.00	29.96	29956.13	-1342.92	0.0249	18.75	-6.67	29.96	29956.13	-1342.55	0.0251	18.75	-6.69
1.35	30.00	29.97	29967.18	-1346.84	0.0249	18.38	-6.51	29.97	29967.18	-1346.59	0.0252	18.38	-6.52
1.40	30.00	29.98	29975.43	-1343.66	0.0244	18.03	-6.68	29.98	29975.43	-1343.51	0.0247	18.02	-6.69
1.45	30.00	29.98	29981.56	-1335.16	0.0243	17.66	-7.10	29.98	29981.56	-1334.93	0.0246	17.66	-7.11
1.50	30.00	29.99	29986.14	-1336.75	0.0248	17.27	-7.04	29.99	29986.14	-1336.52	0.0251	17.27	-7.05
1.55	30.00	29.99	29989.56	-1343.76	0.0246	16.90	-6.71	29.99	29989.56	-1343.60	0.0250	16.89	-6.72
1.60	30.00	29.99	29992.09	-1342.97	0.0243	16.54	-6.75	29.99	29992.09	-1342.71	0.0246	16.53	-6.77
1.65	30.00	29.99	29994.00	-1344.14	0.0247	16.18	-6.70	29.99	29994.00	-1343.70	0.0250	16.17	-6.72
1.70	30.00	30.00	29995.39	-1354.57	0.0251	15.83	-6.19	30.00	29995.39	-1354.52	0.0254	15.82	-6.21
1.75	30.00	30.00	29996.44	-1362.46	0.0249	15.51	-5.84	30.00	29996.44	-1362.01	0.0251	15.49	-5.86
1.80	30.00	30.00	29997.22	-1357.80	0.0248	15.20	-6.06	30.00	29997.22	-1357.23	0.0249	15.18	-6.09
1.85	30.00	30.00	29997.83	-1350.65	0.0251	14.86	-6.40	30.00	29997.83	-1350.04	0.0252	14.85	-6.43
1.90	30.00	30.00	29998.21	-1343.78	0.0249	14.51	-6.73	30.00	29998.21	-1343.25	0.0249	14.49	-6.76
1.95	30.00	30.00	29998.52	-1331.17	0.0243	14.14	-7.33	30.00	29998.52	-1330.57	0.0242	14.13	-7.36
2.00	30.00	30.00	29998.82	-1321.10	0.0244	13.75	-7.81	30.00	29998.82	-1320.35	0.0242	13.73	-7.85

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 3 FRONT SUSPENSION - BRAKE SUMMARY
TRAILING TANDEM AXLE

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	0.01	-.0000	26.14	-0.00	0.0	0.0	0.01	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.02	-.0000	26.14	-0.00	0.0	0.0	0.02	-.0000	26.14	-0.00
0.15	30.00	0.16	161.07	-2.52	0.0001	26.14	-0.26	0.16	161.07	-2.52	0.0001	26.14	-0.26
0.20	30.00	3.18	3175.51	-100.59	0.0024	26.05	-2.70	3.18	3175.51	-100.59	0.0024	26.05	-2.70
0.25	30.00	9.08	9083.05	-337.07	0.0078	25.82	-5.36	9.08	9083.05	-337.08	0.0078	25.82	-5.36
0.30	30.00	14.41	14413.03	-596.07	0.0128	25.52	-5.60	14.41	14413.03	-596.07	0.0128	25.52	-5.60
0.35	30.00	18.38	18384.68	-780.54	0.0163	25.20	-6.17	18.38	18384.68	-780.52	0.0163	25.20	-6.17
0.40	30.00	21.34	21344.23	-921.34	0.0195	24.84	-6.45	21.34	21344.23	-921.28	0.0195	24.84	-6.45
0.45	30.00	23.55	23549.72	-1046.27	0.0219	24.48	-5.70	23.55	23549.72	-1046.17	0.0219	24.48	-5.70
0.50	30.00	25.19	25193.21	-1141.56	0.0232	24.17	-5.03	25.19	25193.21	-1141.46	0.0232	24.17	-5.04
0.55	30.00	26.42	26417.89	-1203.44	0.0247	23.89	-4.97	26.42	26417.89	-1203.39	0.0247	23.88	-4.97
0.60	30.00	27.33	27330.53	-1255.31	0.0262	23.59	-4.65	27.33	27330.53	-1255.42	0.0262	23.59	-4.65
0.65	30.00	28.01	28010.60	-1294.73	0.0264	23.31	-4.38	28.01	28010.60	-1295.05	0.0264	23.31	-4.36
0.70	30.00	28.52	28517.44	-1304.35	0.0262	23.04	-5.12	28.52	28517.44	-1304.80	0.0261	23.04	-5.10
0.75	30.00	28.90	28895.07	-1303.72	0.0268	22.71	-6.04	28.90	28895.07	-1304.34	0.0267	22.71	-6.01
0.80	30.00	29.18	29176.49	-1313.29	0.0271	22.34	-6.25	29.18	29176.49	-1313.96	0.0270	22.34	-6.21
0.85	30.00	29.39	29386.20	-1317.21	0.0265	21.98	-6.55	29.39	29386.20	-1317.74	0.0263	21.98	-6.53
0.90	30.00	29.54	29542.49	-1311.89	0.0265	21.60	-7.18	29.54	29542.49	-1312.37	0.0262	21.60	-7.15
0.95	30.00	29.66	29658.98	-1319.34	0.0273	21.19	-7.10	29.66	29658.98	-1319.66	0.0270	21.20	-7.08
1.00	30.00	29.75	29745.74	-1338.13	0.0274	20.80	-6.40	29.75	29745.74	-1338.03	0.0271	20.81	-6.41
1.05	30.00	29.81	29810.44	-1344.12	0.0270	20.44	-6.27	29.81	29810.44	-1343.80	0.0267	20.46	-6.29
1.10	30.00	29.86	29858.63	-1344.18	0.0274	20.09	-6.38	29.86	29858.63	-1343.75	0.0271	20.10	-6.40
1.15	30.00	29.89	29894.53	-1354.67	0.0280	19.73	-5.97	29.89	29894.53	-1353.94	0.0277	19.74	-6.00
1.20	30.00	29.92	29921.27	-1361.15	0.0276	19.39	-5.72	29.92	29921.27	-1360.21	0.0273	19.40	-5.77
1.25	30.00	29.94	29941.28	-1351.75	0.0271	19.06	-6.22	29.94	29941.28	-1350.81	0.0270	19.07	-6.26
1.30	30.00	29.96	29956.13	-1346.23	0.0275	18.70	-6.52	29.96	29956.13	-1345.26	0.0275	18.71	-6.56
1.35	30.00	29.97	29967.18	-1351.44	0.0276	18.33	-6.29	29.97	29967.18	-1350.52	0.0276	18.33	-6.34
1.40	30.00	29.98	29975.43	-1348.42	0.0269	17.98	-6.46	29.98	29975.43	-1347.61	0.0270	17.98	-6.49
1.45	30.00	29.98	29981.56	-1338.67	0.0269	17.61	-6.94	29.98	29981.56	-1337.84	0.0270	17.61	-6.97
1.50	30.00	29.99	29986.14	-1340.41	0.0274	17.22	-6.86	29.99	29986.14	-1339.63	0.0276	17.22	-6.90
1.55	30.00	29.99	29989.56	-1348.44	0.0272	16.85	-6.49	29.99	29989.56	-1347.80	0.0275	16.85	-6.52
1.60	30.00	29.99	29992.09	-1347.01	0.0267	16.50	-6.56	29.99	29992.09	-1346.33	0.0271	16.49	-6.60
1.65	30.00	29.99	29994.00	-1347.33	0.0271	16.14	-6.55	29.99	29994.00	-1346.53	0.0276	16.13	-6.59
1.70	30.00	30.00	29995.39	-1358.89	0.0275	15.79	-6.00	30.00	29995.39	-1358.24	0.0282	15.77	-6.04
1.75	30.00	30.00	29996.44	-1366.79	0.0271	15.47	-5.63	30.00	29996.44	-1366.34	0.0279	15.45	-5.65
1.80	30.00	30.00	29997.22	-1361.24	0.0269	15.16	-5.90	30.00	29997.22	-1360.78	0.0278	15.14	-5.92
1.85	30.00	30.00	29997.83	-1353.91	0.0272	14.83	-6.25	30.00	29997.83	-1353.66	0.0282	14.80	-6.26
1.90	30.00	30.00	29998.21	-1347.80	0.0270	14.48	-6.54	30.00	29998.21	-1348.08	0.0280	14.45	-6.53
1.95	30.00	30.00	29998.52	-1334.80	0.0262	14.12	-7.16	30.00	29998.52	-1335.26	0.0272	14.08	-7.14
2.00	30.00	30.00	29998.82	-1323.84	0.0262	13.73	-7.68	30.00	29998.82	-1324.21	0.0273	13.69	-7.66

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 REAR SUSPENSION - BRAKE SUMMARY

LEADING TANDEM AXLE

		LEFT SIDE						RIGHT SIDE					
TIME (SEC)	TREADLE PRESSURE (PSI)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL. (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)	BRAKE PRESSURE (PSI)	BRAKE TORQUE (IN-LB)	TIRE BRAKE FORCE (LB)	WHEEL SLIP	ANGULAR WHEEL VEL (RAD/SEC)	ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	0.01	-.0000	26.14	-0.00	0.0	0.0	0.01	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.02	-.0000	26.14	-0.00	0.0	0.0	0.02	-.0000	26.14	-0.00
0.15	30.00	0.16	161.07	-2.52	0.0001	26.14	-0.26	0.16	161.07	-2.52	0.0001	26.14	-0.26
0.20	30.00	3.18	3175.51	-100.31	0.0024	26.05	-2.71	3.18	3175.51	-100.31	0.0024	26.05	-2.71
0.25	30.00	9.08	9083.05	-327.55	0.0081	25.81	-5.82	9.08	9083.05	-327.55	0.0081	25.81	-5.82
0.30	30.00	14.41	14413.03	-552.73	0.0148	25.47	-7.66	14.41	14413.03	-552.73	0.0148	25.47	-7.66
0.35	30.00	18.38	18384.68	-741.08	0.0204	25.10	-8.05	18.38	18384.68	-741.08	0.0204	25.10	-8.05
0.40	30.00	21.34	21344.23	-885.30	0.0240	24.73	-8.16	21.34	21344.23	-885.29	0.0240	24.73	-8.16
0.45	30.00	23.55	23549.72	-983.67	0.0271	24.35	-8.68	23.55	23549.72	-983.60	0.0271	24.35	-8.68
0.50	30.00	25.19	25193.21	-1074.12	0.0309	23.98	-8.25	25.19	25193.21	-1073.97	0.0309	23.98	-8.25
0.55	30.00	26.42	26417.89	-1165.25	0.0330	23.68	-6.79	26.42	26417.89	-1165.06	0.0330	23.68	-6.80
0.60	30.00	27.33	27330.53	-1210.69	0.0335	23.41	-6.78	27.33	27330.53	-1210.58	0.0335	23.41	-6.78
0.65	30.00	28.01	28010.60	-1222.02	0.0350	23.11	-7.84	28.01	28010.60	-1222.08	0.0350	23.10	-7.84
0.70	30.00	28.52	28517.44	-1247.70	0.0366	22.79	-7.82	28.52	28517.44	-1248.09	0.0366	22.79	-7.80
0.75	30.00	28.90	28895.07	-1270.68	0.0360	22.49	-7.61	28.90	28895.07	-1271.33	0.0360	22.49	-7.58
0.80	30.00	29.18	29176.49	-1258.89	0.0355	22.15	-8.84	29.18	29176.49	-1259.71	0.0355	22.15	-8.80
0.85	30.00	29.39	29386.20	-1250.09	0.0368	21.75	-9.75	29.39	29386.20	-1251.20	0.0366	21.75	-9.70
0.90	30.00	29.54	29542.49	-1271.20	0.0373	21.36	-9.11	29.54	29542.49	-1272.25	0.0371	21.36	-9.06
0.95	30.00	29.66	29658.98	-1282.57	0.0363	20.99	-8.85	29.66	29658.98	-1283.33	0.0361	21.00	-8.81
1.00	30.00	29.75	29745.74	-1275.74	0.0367	20.60	-9.38	29.75	29745.74	-1276.45	0.0364	20.61	-9.34
1.05	30.00	29.81	29810.44	-1286.74	0.0381	20.21	-9.01	29.81	29810.44	-1287.24	0.0379	20.22	-8.98
1.10	30.00	29.86	29858.63	-1310.91	0.0378	19.87	-7.97	29.86	29858.63	-1310.84	0.0376	19.88	-7.97
1.15	30.00	29.89	29894.53	-1309.17	0.0370	19.54	-8.13	29.89	29894.53	-1308.85	0.0368	19.55	-8.15
1.20	30.00	29.92	29921.27	-1298.40	0.0378	19.19	-8.71	29.92	29921.27	-1297.92	0.0377	19.19	-8.73
1.25	30.00	29.94	29941.28	-1307.79	0.0385	18.84	-8.31	29.94	29941.28	-1306.98	0.0385	18.84	-8.35
1.30	30.00	29.96	29956.13	-1314.39	0.0373	18.51	-8.03	29.96	29956.13	-1313.40	0.0374	18.51	-8.08
1.35	30.00	29.97	29967.18	-1300.32	0.0369	18.16	-8.73	29.97	29967.18	-1299.26	0.0371	18.16	-8.78
1.40	30.00	29.98	29975.43	-1294.18	0.0379	17.78	-9.04	29.98	29975.43	-1293.04	0.0382	17.77	-9.09
1.45	30.00	29.98	29981.56	-1305.63	0.0379	17.41	-8.51	29.98	29981.56	-1304.59	0.0382	17.41	-8.56
1.50	30.00	29.99	29986.14	-1305.14	0.0368	17.06	-8.54	29.99	29986.14	-1304.17	0.0370	17.05	-8.59
1.55	30.00	29.99	29989.56	-1296.44	0.0372	16.68	-8.97	29.99	29989.56	-1295.29	0.0375	16.67	-9.02
1.60	30.00	29.99	29992.09	-1303.88	0.0383	16.30	-8.62	29.99	29992.09	-1302.67	0.0386	16.30	-8.67
1.65	30.00	29.99	29994.00	-1318.92	0.0377	15.97	-7.91	29.99	29994.00	-1317.85	0.0380	15.96	-7.96
1.70	30.00	30.00	29995.39	-1318.93	0.0372	15.63	-7.91	30.00	29995.39	-1317.76	0.0375	15.62	-7.96
1.75	30.00	30.00	29996.44	-1318.55	0.0383	15.29	-7.93	30.00	29996.44	-1317.16	0.0385	15.28	-8.00
1.80	30.00	30.00	29997.22	-1328.52	0.0387	14.98	-7.46	30.00	29997.22	-1327.33	0.0390	14.96	-7.51
1.85	30.00	30.00	29997.83	-1326.23	0.0376	14.67	-7.57	30.00	29997.83	-1325.43	0.0378	14.66	-7.60
1.90	30.00	30.00	29998.21	-1307.32	0.0373	14.32	-8.47	30.00	29998.21	-1306.66	0.0374	14.31	-8.50
1.95	30.00	30.00	29998.52	-1297.07	0.0382	13.94	-8.96	30.00	29998.52	-1296.71	0.0382	13.92	-8.97
2.00	30.00	30.00	29998.82	-1300.36	0.0378	13.56	-8.80	30.00	29998.82	-1300.60	0.0376	13.54	-8.79

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 REAR SUSPENSION - BRAKE SUMMARY

TRAILING TANDEM AXLE

TIME (SEC)	TREADLE PRESSURE (PSI)	LEFT SIDE BRAKE PRESSURE (PSI)	LEFT SIDE BRAKE TORQUE (IN-LB)	LEFT SIDE TIRE BRAKE FORCE (LB)	LEFT SIDE WHEEL SLIP	LEFT SIDE ANGULAR WHEEL VEL. (RAD/SEC)	LEFT SIDE ANGULAR WHEEL ACCEL. (RAD/S**2)	RIGHT SIDE BRAKE PRESSURE (PSI)	RIGHT SIDE BRAKE TORQUE (IN-LB)	RIGHT SIDE TIRE BRAKE FORCE (LB)	RIGHT SIDE WHEEL SLIP	RIGHT SIDE ANGULAR WHEEL VEL (RAD/SEC)	RIGHT SIDE ANGULAR WHEEL ACCEL. (RAD/S**2)
0.0	0.0	0.0	0.0	-0.0	0.0	26.14	-0.0	0.0	0.0	-0.0	0.0	26.14	-0.0
0.05	15.75	0.0	0.0	0.01	-.0000	26.14	-0.00	0.0	0.0	0.01	-.0000	26.14	-0.00
0.10	30.00	0.0	0.0	0.02	-.0000	26.14	-0.00	0.0	0.0	0.02	-.0000	26.14	-0.00
0.15	30.00	0.16	161.07	-2.52	0.0001	26.14	-0.26	0.16	161.07	-2.52	0.0001	26.14	-0.26
0.20	30.00	3.18	3175.51	-99.94	0.0024	26.05	-2.73	3.18	3175.51	-99.94	0.0024	26.05	-2.73
0.25	30.00	9.08	9083.05	-324.16	0.0082	25.81	-5.98	9.08	9083.05	-324.16	0.0082	25.81	-5.98
0.30	30.00	14.41	14413.03	-544.73	0.0155	25.45	-8.04	14.41	14413.03	-544.73	0.0155	25.45	-8.04
0.35	30.00	18.38	18384.68	-731.53	0.0219	25.06	-8.51	18.38	18384.68	-731.54	0.0219	25.06	-8.51
0.40	30.00	21.34	21344.23	-876.57	0.0261	24.68	-8.58	21.34	21344.23	-876.54	0.0261	24.68	-8.58
0.45	30.00	23.55	23549.72	-972.55	0.0299	24.28	-9.21	23.55	23549.72	-972.44	0.0299	24.28	-9.21
0.50	30.00	25.19	25193.21	-1061.27	0.0345	23.89	-8.86	25.19	25193.21	-1061.03	0.0345	23.89	-8.87
0.55	30.00	26.42	26417.89	-1157.13	0.0372	23.58	-7.18	26.42	26417.89	-1156.85	0.0373	23.58	-7.19
0.60	30.00	27.33	27330.53	-1203.70	0.0379	23.30	-7.11	27.33	27330.53	-1203.54	0.0380	23.30	-7.12
0.65	30.00	28.01	28010.60	-1210.38	0.0398	22.99	-8.40	28.01	28010.60	-1210.49	0.0398	22.99	-8.39
0.70	30.00	28.52	28517.44	-1237.69	0.0419	22.66	-8.29	28.52	28517.44	-1238.31	0.0420	22.66	-8.26
0.75	30.00	28.90	28895.07	-1266.62	0.0414	22.37	-7.81	28.90	28895.07	-1267.67	0.0414	22.37	-7.76
0.80	30.00	29.18	29176.49	-1251.79	0.0408	22.03	-9.18	29.18	29176.49	-1253.21	0.0406	22.03	-9.11
0.85	30.00	29.39	29386.20	-1238.82	0.0424	21.62	-10.29	29.39	29386.20	-1240.81	0.0421	21.63	-10.19
0.90	30.00	29.54	29542.49	-1264.59	0.0432	21.22	-9.43	29.54	29542.49	-1266.62	0.0428	21.24	-9.33
0.95	30.00	29.66	29658.98	-1278.32	0.0420	20.87	-9.05	29.66	29658.98	-1279.96	0.0414	20.88	-8.97
1.00	30.00	29.75	29745.74	-1266.03	0.0424	20.48	-9.84	29.75	29745.74	-1267.83	0.0418	20.49	-9.75
1.05	30.00	29.81	29810.44	-1276.21	0.0443	20.08	-9.51	29.81	29810.44	-1277.86	0.0437	20.10	-9.43
1.10	30.00	29.86	29858.63	-1306.24	0.0441	19.74	-8.19	29.86	29858.63	-1306.96	0.0434	19.76	-8.16
1.15	30.00	29.89	29894.53	-1303.18	0.0429	19.42	-8.42	29.89	29894.53	-1303.50	0.0422	19.44	-8.41
1.20	30.00	29.92	29921.27	-1287.77	0.0439	19.07	-9.22	29.92	29921.27	-1287.96	0.0433	19.08	-9.21
1.25	30.00	29.94	29941.28	-1300.21	0.0449	18.71	-8.67	29.94	29941.28	-1299.73	0.0444	18.73	-8.70
1.30	30.00	29.96	29956.13	-1310.77	0.0434	18.39	-8.20	29.96	29956.13	-1309.76	0.0431	18.41	-8.25
1.35	30.00	29.97	29967.18	-1292.86	0.0427	18.04	-9.08	29.97	29967.18	-1291.68	0.0426	18.05	-9.14
1.40	30.00	29.98	29975.43	-1284.58	0.0441	17.66	-9.50	29.98	29975.43	-1283.09	0.0441	17.67	-9.57
1.45	30.00	29.98	29981.56	-1300.69	0.0440	17.30	-8.74	29.98	29981.56	-1299.06	0.0441	17.30	-8.82
1.50	30.00	29.99	29986.14	-1300.74	0.0425	16.96	-8.75	29.99	29986.14	-1298.98	0.0427	16.95	-8.84
1.55	30.00	29.99	29989.56	-1287.92	0.0429	16.58	-9.37	29.99	29989.56	-1285.63	0.0433	16.57	-9.48
1.60	30.00	29.99	29992.09	-1296.16	0.0443	16.20	-8.98	29.99	29992.09	-1293.42	0.0448	16.19	-9.12
1.65	30.00	29.99	29994.00	-1315.12	0.0435	15.87	-8.09	29.99	29994.00	-1312.38	0.0442	15.85	-8.22
1.70	30.00	30.00	29995.39	-1313.17	0.0426	15.54	-8.18	30.00	29995.39	-1309.88	0.0435	15.52	-8.34
1.75	30.00	30.00	29996.44	-1310.17	0.0438	15.21	-8.33	30.00	29996.44	-1305.90	0.0450	15.18	-8.53
1.80	30.00	30.00	29997.22	-1323.22	0.0444	14.89	-7.71	30.00	29997.22	-1318.99	0.0458	14.86	-7.91
1.85	30.00	30.00	29997.83	-1322.90	0.0428	14.59	-7.72	30.00	29997.83	-1319.14	0.0444	14.55	-7.90
1.90	30.00	30.00	29998.21	-1301.26	0.0423	14.25	-8.76	30.00	29998.21	-1296.99	0.0441	14.21	-8.96
1.95	30.00	30.00	29998.52	-1290.56	0.0433	13.87	-9.27	30.00	29998.52	-1286.17	0.0453	13.82	-9.48
2.00	30.00	30.00	29998.82	-1296.96	0.0427	13.49	-8.96	30.00	29998.82	-1293.54	0.0448	13.44	-9.13

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 FRONT SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY

LEADING TANDEM AXLE

TIME (SEC)	LEFT SIDE: TIRE SIDESLIP ANGLE (DEG)	LEFT SIDE: TIRE LATERAL FORCE (LB)	LEFT SIDE: MU-Y	LEFT SIDE: ALIGNING TORQUE (IN-LB)	RIGHT SIDE: TIRE SIDESLIP ANGLE (DEG)	RIGHT SIDE: TIRE LATERAL FORCE (LB)	RIGHT SIDE: MU-Y	RIGHT SIDE: ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	0.0000	-0.0001	-0.0000	0.0	0.0000	-0.0001	-0.0000	0.0
0.10	0.0000	-0.0005	-0.0000	0.0	0.0000	-0.0005	-0.0000	0.0
0.15	-0.0000	0.0048	0.0000	0.0	-0.0000	0.0048	0.0000	0.0
0.20	-0.0000	0.0028	0.0000	0.0	-0.0000	0.0028	0.0000	0.0
0.25	0.0000	-0.0187	-0.0000	0.0	0.0000	-0.0187	-0.0000	0.0
0.30	0.0000	-0.0150	-0.0000	0.0	0.0000	-0.0150	-0.0000	0.0
0.35	-0.0001	0.1080	0.0000	0.0	-0.0001	0.1080	0.0000	0.0
0.40	-0.0003	0.3997	0.0002	0.0	-0.0003	0.3997	0.0002	0.0
0.45	-0.0005	0.7143	0.0003	0.0	-0.0005	0.7140	0.0003	0.0
0.50	-0.0005	0.7964	0.0003	0.0	-0.0005	0.7959	0.0003	0.0
0.55	-0.0003	0.4982	0.0002	0.0	-0.0003	0.4978	0.0002	0.0
0.60	0.0002	-0.2657	-0.0001	0.0	0.0002	-0.2656	-0.0001	0.0
0.65	0.0009	-1.4098	-0.0005	0.0	0.0009	-1.4102	-0.0005	0.0
0.70	0.0017	-2.6586	-0.0009	0.0	0.0017	-2.6620	-0.0009	0.0
0.75	0.0027	-4.1045	-0.0015	0.0	0.0027	-4.1157	-0.0015	0.0
0.80	0.0038	-5.8437	-0.0021	0.0	0.0038	-5.8700	-0.0021	0.0
0.85	0.0045	-7.0128	-0.0025	0.0	0.0045	-7.0552	-0.0025	0.0
0.90	0.0045	-7.0296	-0.0025	0.0	0.0045	-7.0810	-0.0025	0.0
0.95	0.0043	-6.4797	-0.0024	0.0	0.0043	-6.5348	-0.0024	0.0
1.00	0.0034	-5.2832	-0.0019	0.0	0.0035	-5.3339	-0.0019	0.0
1.05	0.0018	-2.7669	-0.0010	0.0	0.0018	-2.8061	-0.0010	0.0
1.10	-0.0003	0.5048	0.0002	0.0	-0.0003	0.4714	0.0002	0.0
1.15	-0.0026	4.0139	0.0015	0.0	-0.0026	3.9726	0.0014	0.0
1.20	-0.0051	7.9767	0.0028	0.0	-0.0051	7.9069	0.0028	0.0
1.25	-0.0074	11.6262	0.0041	0.0	-0.0074	11.5120	0.0041	0.0
1.30	-0.0093	14.2960	0.0051	0.0	-0.0092	14.1364	0.0051	0.0
1.35	-0.0107	16.5434	0.0059	0.0	-0.0107	16.3401	0.0059	0.0
1.40	-0.0116	18.2044	0.0064	0.0	-0.0115	17.9697	0.0064	0.0
1.45	-0.0119	18.6172	0.0066	0.0	-0.0119	18.3742	0.0066	0.0
1.50	-0.0120	18.4379	0.0066	0.0	-0.0120	18.1975	0.0066	0.0
1.55	-0.0116	18.0434	0.0064	0.0	-0.0116	17.8132	0.0064	0.0
1.60	-0.0105	16.6420	0.0059	0.0	-0.0105	16.4343	0.0059	0.0
1.65	-0.0094	14.6017	0.0052	0.0	-0.0094	14.4076	0.0052	0.0
1.70	-0.0082	12.5589	0.0045	0.0	-0.0081	12.3595	0.0045	0.0
1.75	-0.0060	9.3656	0.0033	0.0	-0.0059	9.1504	0.0033	0.0
1.80	-0.0029	4.6022	0.0016	0.0	-0.0028	4.3450	0.0015	0.0
1.85	0.0003	-0.5095	-0.0002	0.0	0.0006	-0.8553	-0.0003	0.0
1.90	0.0042	-6.5086	-0.0023	0.0	0.0046	-7.0132	-0.0025	0.0
1.95	0.0091	-14.2311	-0.0050	0.0	0.0096	-15.0133	-0.0053	0.0
2.00	0.0141	-21.7290	-0.0078	0.0	0.0147	-22.8917	-0.0081	0.0

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 3 FRONT SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY
TRAILING TANDEM AXLE

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	0.0000	-0.0001	-0.0000	0.0	0.0000	-0.0001	-0.0000	0.0
0.10	0.0000	-0.0006	-0.0000	0.0	0.0000	-0.0006	-0.0000	0.0
0.15	-0.0000	0.0050	0.0000	0.0	-0.0000	0.0050	0.0000	0.0
0.20	-0.0000	0.0044	0.0000	0.0	-0.0000	0.0044	0.0000	0.0
0.25	0.0000	-0.0180	-0.0000	0.0	0.0000	-0.0180	-0.0000	0.0
0.30	0.0000	-0.0202	-0.0000	0.0	0.0000	-0.0202	-0.0000	0.0
0.35	-0.0001	0.1022	0.0000	0.0	-0.0001	0.1022	0.0000	0.0
0.40	-0.0003	0.4339	0.0002	0.0	-0.0003	0.4338	0.0002	0.0
0.45	-0.0006	0.8764	0.0004	0.0	-0.0006	0.8760	0.0004	0.0
0.50	-0.0008	1.1877	0.0005	0.0	-0.0008	1.1866	0.0005	0.0
0.55	-0.0008	1.1199	0.0004	0.0	-0.0008	1.1186	0.0004	0.0
0.60	-0.0003	0.4684	0.0002	0.0	-0.0003	0.4679	0.0002	0.0
0.65	0.0006	-0.7846	-0.0003	0.0	0.0006	-0.7845	-0.0003	0.0
0.70	0.0018	-2.5027	-0.0010	0.0	0.0018	-2.5059	-0.0010	0.0
0.75	0.0034	-4.7661	-0.0019	0.0	0.0034	-4.7822	-0.0019	0.0
0.80	0.0056	-7.7495	-0.0031	0.0	0.0056	-7.7960	-0.0031	0.0
0.85	0.0077	-10.8739	-0.0043	0.0	0.0077	-10.9681	-0.0043	0.0
0.90	0.0094	-13.2369	-0.0052	0.0	0.0094	-13.3838	-0.0052	0.0
0.95	0.0108	-14.9746	-0.0060	0.0	0.0108	-15.1720	-0.0060	0.0
1.00	0.0118	-16.4686	-0.0066	0.0	0.0118	-16.7047	-0.0066	0.0
1.05	0.0119	-16.9466	-0.0066	0.0	0.0119	-17.1928	-0.0066	0.0
1.10	0.0113	-15.8714	-0.0063	0.0	0.0113	-16.0940	-0.0063	0.0
1.15	0.0101	-13.9083	-0.0056	0.0	0.0101	-14.0857	-0.0056	0.0
1.20	0.0081	-11.4116	-0.0045	0.0	0.0081	-11.5362	-0.0045	0.0
1.25	0.0057	-8.1409	-0.0032	0.0	0.0057	-8.2149	-0.0032	0.0
1.30	0.0031	-4.3204	-0.0017	0.0	0.0031	-4.3572	-0.0017	0.0
1.35	0.0003	-0.3641	-0.0001	0.0	0.0003	-0.3872	-0.0002	0.0
1.40	-0.0026	3.6917	0.0014	0.0	-0.0026	3.6586	0.0014	0.0
1.45	-0.0055	7.8289	0.0031	0.0	-0.0055	7.7618	0.0030	0.0
1.50	-0.0087	12.2091	0.0048	0.0	-0.0087	12.0781	0.0048	0.0
1.55	-0.0121	17.1564	0.0067	0.0	-0.0121	16.9259	0.0067	0.0
1.60	-0.0155	22.3295	0.0086	0.0	-0.0155	21.9581	0.0086	0.0
1.65	-0.0194	27.5025	0.0107	0.0	-0.0194	26.9338	0.0107	0.0
1.70	-0.0238	33.5040	0.0132	0.0	-0.0237	32.6591	0.0132	0.0
1.75	-0.0280	40.3513	0.0156	0.0	-0.0280	39.1468	0.0155	0.0
1.80	-0.0321	46.3923	0.0178	0.0	-0.0320	44.7806	0.0177	0.0
1.85	-0.0362	51.4433	0.0201	0.0	-0.0360	49.4063	0.0200	0.0
1.90	-0.0399	57.0615	0.0222	0.0	-0.0397	54.5656	0.0220	0.0
1.95	-0.0430	62.5761	0.0238	0.0	-0.0426	59.6154	0.0236	0.0
2.00	-0.0460	66.4138	0.0255	0.0	-0.0455	63.0481	0.0252	0.0

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 3 REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY
LEADING TANDEM AXLE

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	-0.0000	0.0000	0.0000	0.0	-0.0000	0.0000	0.0000	0.0
0.10	-0.0000	0.0002	0.0000	0.0	-0.0000	0.0002	0.0000	0.0
0.15	0.0000	-0.0009	-0.0000	0.0	0.0000	-0.0009	-0.0000	0.0
0.20	0.0000	-0.0019	-0.0000	0.0	0.0000	-0.0019	-0.0000	0.0
0.25	-0.0000	0.0040	0.0000	0.0	-0.0000	0.0040	0.0000	0.0
0.30	-0.0000	0.0082	0.0000	0.0	-0.0000	0.0082	0.0000	0.0
0.35	0.0000	-0.0157	-0.0000	0.0	0.0000	-0.0157	-0.0000	0.0
0.40	0.0001	-0.0922	-0.0000	0.0	0.0001	-0.0922	-0.0000	0.0
0.45	0.0002	-0.1787	-0.0001	0.0	0.0002	-0.1787	-0.0001	0.0
0.50	0.0002	-0.1768	-0.0001	0.0	0.0002	-0.1768	-0.0001	0.0
0.55	0.0000	-0.0303	-0.0000	0.0	0.0000	-0.0303	-0.0000	0.0
0.60	-0.0002	0.2541	0.0001	0.0	-0.0002	0.2539	0.0001	0.0
0.65	-0.0006	0.5629	0.0003	0.0	-0.0006	0.5624	0.0003	0.0
0.70	-0.0008	0.7534	0.0004	0.0	-0.0008	0.7533	0.0004	0.0
0.75	-0.0008	0.7923	0.0004	0.0	-0.0008	0.7932	0.0004	0.0
0.80	-0.0008	0.8003	0.0004	0.0	-0.0008	0.8024	0.0004	0.0
0.85	-0.0008	0.7861	0.0004	0.0	-0.0008	0.7896	0.0004	0.0
0.90	-0.0006	0.6231	0.0004	0.0	-0.0006	0.6269	0.0004	0.0
0.95	-0.0005	0.4973	0.0003	0.0	-0.0005	0.5007	0.0003	0.0
1.00	-0.0006	0.6043	0.0003	0.0	-0.0006	0.6084	0.0003	0.0
1.05	-0.0008	0.7564	0.0004	0.0	-0.0008	0.7612	0.0004	0.0
1.10	-0.0010	1.0094	0.0006	0.0	-0.0010	1.0142	0.0006	0.0
1.15	-0.0014	1.4122	0.0008	0.0	-0.0014	1.4159	0.0008	0.0
1.20	-0.0016	1.5767	0.0009	0.0	-0.0016	1.5775	0.0009	0.0
1.25	-0.0017	1.6322	0.0009	0.0	-0.0017	1.6293	0.0009	0.0
1.30	-0.0019	1.9210	0.0011	0.0	-0.0019	1.9130	0.0011	0.0
1.35	-0.0020	1.9803	0.0011	0.0	-0.0020	1.9681	0.0011	0.0
1.40	-0.0016	1.5415	0.0009	0.0	-0.0016	1.5299	0.0009	0.0
1.45	-0.0011	1.0479	0.0006	0.0	-0.0011	1.0391	0.0006	0.0
1.50	-0.0004	0.4028	0.0002	0.0	-0.0004	0.3994	0.0002	0.0
1.55	0.0007	-0.7214	-0.0004	0.0	0.0007	-0.7153	-0.0004	0.0
1.60	0.0021	-2.0128	-0.0011	0.0	0.0021	-1.9957	-0.0011	0.0
1.65	0.0034	-3.4002	-0.0019	0.0	0.0034	-3.3728	-0.0019	0.0
1.70	0.0051	-5.1169	-0.0028	0.0	0.0051	-5.0791	-0.0028	0.0
1.75	0.0070	-6.8609	-0.0039	0.0	0.0070	-6.8126	-0.0039	0.0
1.80	0.0088	-8.6508	-0.0049	0.0	0.0088	-8.5958	-0.0049	0.0
1.85	0.0109	-10.9914	-0.0061	0.0	0.0109	-10.9433	-0.0061	0.0
1.90	0.0134	-13.4157	-0.0074	0.0	0.0134	-13.3919	-0.0075	0.0
1.95	0.0161	-15.6286	-0.0089	0.0	0.0161	-15.6479	-0.0089	0.0
2.00	0.0193	-18.9563	-0.0107	0.0	0.0193	-19.0713	-0.0107	0.0

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.14.4

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 REAR SUSPENSION - LATERAL TIRE FORCE AND MOMENT SUMMARY

TRAILING TANDEM AXLE

	LEFT SIDE				RIGHT SIDE			
TIME (SEC)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)	TIRE SIDESLIP ANGLE (DEG)	TIRE LATERAL FORCE (LB)	MU-Y	ALIGNING TORQUE (IN-LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	-0.0000	0.0000	0.0000	0.0	-0.0000	0.0000	0.0000	0.0
0.10	-0.0000	0.0001	0.0000	0.0	-0.0000	0.0001	0.0000	0.0
0.15	0.0000	-0.0006	-0.0000	0.0	0.0000	-0.0006	-0.0000	0.0
0.20	0.0000	-0.0002	-0.0000	0.0	0.0000	-0.0002	-0.0000	0.0
0.25	-0.0000	0.0041	0.0000	0.0	-0.0000	0.0041	0.0000	0.0
0.30	-0.0000	0.0033	0.0000	0.0	-0.0000	0.0033	0.0000	0.0
0.35	0.0000	-0.0142	-0.0000	0.0	0.0000	-0.0142	-0.0000	0.0
0.40	0.0000	-0.0405	-0.0000	0.0	0.0000	-0.0405	-0.0000	0.0
0.45	0.0000	-0.0142	-0.0000	0.0	0.0000	-0.0142	-0.0000	0.0
0.50	-0.0001	0.1263	0.0001	0.0	-0.0001	0.1263	0.0001	0.0
0.55	-0.0004	0.3948	0.0002	0.0	-0.0004	0.3943	0.0002	0.0
0.60	-0.0008	0.6948	0.0004	0.0	-0.0008	0.6937	0.0004	0.0
0.65	-0.0009	0.8047	0.0005	0.0	-0.0009	0.8037	0.0005	0.0
0.70	-0.0007	0.6113	0.0004	0.0	-0.0007	0.6113	0.0004	0.0
0.75	-0.0001	0.0465	0.0000	0.0	-0.0001	0.0466	0.0000	0.0
0.80	0.0010	-0.8457	-0.0005	0.0	0.0010	-0.8498	-0.0005	0.0
0.85	0.0024	-1.9622	-0.0013	0.0	0.0024	-1.9783	-0.0013	0.0
0.90	0.0042	-3.5036	-0.0023	0.0	0.0042	-3.5440	-0.0023	0.0
0.95	0.0061	-5.3002	-0.0034	0.0	0.0061	-5.3740	-0.0034	0.0
1.00	0.0078	-6.6325	-0.0043	0.0	0.0078	-6.7369	-0.0043	0.0
1.05	0.0094	-7.7080	-0.0052	0.0	0.0094	-7.8373	-0.0052	0.0
1.10	0.0106	-9.0141	-0.0059	0.0	0.0106	-9.1604	-0.0059	0.0
1.15	0.0113	-9.8203	-0.0063	0.0	0.0113	-9.9650	-0.0063	0.0
1.20	0.0116	-9.7284	-0.0064	0.0	0.0116	-9.8523	-0.0064	0.0
1.25	0.0114	-9.4691	-0.0063	0.0	0.0114	-9.5622	-0.0063	0.0
1.30	0.0105	-9.0203	-0.0058	0.0	0.0104	-9.0781	-0.0058	0.0
1.35	0.0090	-7.7906	-0.0050	0.0	0.0090	-7.8132	-0.0050	0.0
1.40	0.0074	-6.1576	-0.0041	0.0	0.0074	-6.1533	-0.0041	0.0
1.45	0.0053	-4.4911	-0.0030	0.0	0.0053	-4.4731	-0.0030	0.0
1.50	0.0028	-2.4902	-0.0016	0.0	0.0028	-2.4726	-0.0016	0.0
1.55	0.0002	-0.1848	-0.0001	0.0	0.0002	-0.1828	-0.0001	0.0
1.60	-0.0029	2.4067	0.0016	0.0	-0.0029	2.3714	0.0016	0.0
1.65	-0.0066	5.6784	0.0036	0.0	-0.0066	5.5725	0.0036	0.0
1.70	-0.0106	9.3017	0.0059	0.0	-0.0106	9.0870	0.0059	0.0
1.75	-0.0151	12.8813	0.0084	0.0	-0.0151	12.5123	0.0084	0.0
1.80	-0.0203	17.3367	0.0113	0.0	-0.0204	16.7449	0.0113	0.0
1.85	-0.0257	22.6772	0.0142	0.0	-0.0257	21.8026	0.0142	0.0
1.90	-0.0308	27.0391	0.0171	0.0	-0.0308	25.8847	0.0171	0.0
1.95	-0.0360	30.6752	0.0200	0.0	-0.0360	29.2567	0.0200	0.0
2.00	-0.0408	35.3953	0.0226	0.0	-0.0409	33.6982	0.0227	0.0

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES - PHASE 4. OUTPUT PAGE NO. 1.15.4

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 FRONT SUSPENSION - UNSPRUNG MASS SUMMARY

LEADING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0	0.00	0.0000	0.0	0.00
0.05	0.0	0.0000	0.0	0.0000	0.0	-0.0000	-0.0000	-0.00	-0.0000	-0.0000	-0.00
0.10	0.0	0.0000	0.0	0.0000	0.0	-0.0000	0.0000	-0.00	-0.0000	0.0000	-0.00
0.15	0.0000	-0.0000	0.0001	-0.0000	-0.0	-0.0000	-0.0013	-0.54	-0.0000	-0.0013	-0.55
0.20	0.0002	-0.0000	0.0095	0.0000	0.0	-0.0015	-0.0695	-27.53	-0.0015	-0.0694	-27.53
0.25	0.0012	0.0000	0.0350	0.0001	0.1	-0.0105	-0.1180	5.37	-0.0105	-0.1180	5.39
0.30	0.0030	0.0000	0.0828	-0.0000	-0.0	-0.0276	0.7738	480.38	-0.0276	0.7737	480.38
0.35	0.0040	-0.0000	0.0512	-0.0004	-0.4	-0.0350	0.9513	407.42	-0.0351	0.9512	407.36
0.40	0.0039	-0.0000	0.0491	-0.0009	-0.6	-0.0331	1.0119	410.17	-0.0331	1.0121	410.07
0.45	0.0043	-0.0001	0.0741	-0.0012	1.3	-0.0385	0.8955	357.88	-0.0385	0.8968	358.00
0.50	0.0051	-0.0001	0.0674	-0.0008	6.3	-0.0484	1.0005	274.50	-0.0483	1.0028	275.27
0.55	0.0051	-0.0002	0.0426	0.0002	12.5	-0.0476	1.1335	275.57	-0.0474	1.1357	277.18
0.60	0.0048	-0.0001	0.0521	0.0021	16.3	-0.0439	0.9647	300.28	-0.0436	0.9651	302.45
0.65	0.0053	0.0000	0.0696	0.0042	13.4	-0.0497	0.8768	251.45	-0.0495	0.8740	253.28
0.70	0.0058	0.0003	0.0540	0.0059	0.7	-0.0545	1.0978	212.98	-0.0544	1.0913	213.14
0.75	0.0053	0.0006	0.0422	0.0076	-19.6	-0.0498	1.1427	248.42	-0.0501	1.1343	245.92
0.80	0.0052	0.0010	0.0601	0.0082	-43.3	-0.0485	0.9217	255.73	-0.0492	0.9122	250.14
0.85	0.0058	0.0014	0.0642	0.0058	-71.2	-0.0546	0.9480	206.97	-0.0558	0.9367	197.89
0.90	0.0059	0.0016	0.0444	0.0026	-101.0	-0.0544	1.1593	209.25	-0.0560	1.1490	196.55
0.95	0.0053	0.0017	0.0466	-0.0001	-123.0	-0.0488	1.0761	252.35	-0.0507	1.0700	237.11
1.00	0.0055	0.0016	0.0649	-0.0049	-134.2	-0.0509	0.9031	233.94	-0.0530	0.9004	217.81
1.05	0.0060	0.0012	0.0564	-0.0098	-138.5	-0.0558	1.0372	196.39	-0.0578	1.0370	180.59
1.10	0.0057	0.0006	0.0411	-0.0115	-133.8	-0.0522	1.1555	224.60	-0.0541	1.1595	210.28
1.15	0.0053	-0.0000	0.0543	-0.0134	-119.2	-0.0490	0.9832	249.01	-0.0505	0.9900	237.27
1.20	0.0057	-0.0007	0.0651	-0.0153	-99.4	-0.0540	0.9220	209.24	-0.0551	0.9305	200.87
1.25	0.0060	-0.0015	0.0487	-0.0132	-73.7	-0.0562	1.1071	192.80	-0.0567	1.1183	188.48
1.30	0.0055	-0.0021	0.0435	-0.0103	-42.2	-0.0513	1.1044	230.66	-0.0513	1.1164	230.66
1.35	0.0054	-0.0026	0.0611	-0.0091	-12.6	-0.0515	0.9242	228.20	-0.0510	0.9346	231.99
1.40	0.0059	-0.0030	0.0604	-0.0057	14.1	-0.0569	0.9866	186.33	-0.0560	0.9970	193.39
1.45	0.0058	-0.0031	0.0434	-0.0017	42.3	-0.0556	1.1445	197.36	-0.0543	1.1552	207.45
1.50	0.0054	-0.0032	0.0495	-0.0004	68.9	-0.0512	1.0344	230.60	-0.0496	1.0438	243.12
1.55	0.0056	-0.0032	0.0640	0.0010	93.9	-0.0543	0.9166	205.89	-0.0525	0.9269	220.38
1.60	0.0060	-0.0031	0.0532	0.0036	125.4	-0.0578	1.0633	178.87	-0.0557	1.0767	195.85
1.65	0.0056	-0.0029	0.0424	0.0035	162.5	-0.0539	1.1319	209.69	-0.0514	1.1459	229.68
1.70	0.0054	-0.0027	0.0564	0.0042	200.2	-0.0520	0.9652	224.11	-0.0491	0.9798	247.08
1.75	0.0058	-0.0024	0.0625	0.0090	243.8	-0.0567	0.9497	186.80	-0.0534	0.9675	213.00
1.80	0.0059	-0.0018	0.0470	0.0117	292.8	-0.0575	1.1155	181.63	-0.0537	1.1329	211.35
1.85	0.0054	-0.0012	0.0463	0.0129	333.5	-0.0531	1.0747	215.82	-0.0490	1.0872	248.17
1.90	0.0055	-0.0003	0.0620	0.0201	364.1	-0.0543	0.9243	205.05	-0.0501	0.9344	238.39
1.95	0.0060	0.0009	0.0576	0.0259	390.0	-0.0588	1.0175	170.86	-0.0546	1.0249	203.61
2.00	0.0058	0.0022	0.0434	0.0234	402.8	-0.0563	1.1443	190.90	-0.0524	1.1451	221.41

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)

TRAILER NO. 3 FRONT SUSPENSION - UNSPRUNG MASS SUMMARY

TRAILING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	-0.0000	0.0	-0.00	-0.0000	0.0	-0.00
0.05	0.0	0.0000	0.0	0.0000	0.0	-0.0000	-0.0000	-0.00	-0.0000	-0.0000	-0.00
0.10	0.0	0.0000	0.0	0.0000	0.0	-0.0000	0.0000	-0.00	-0.0000	0.0000	-0.00
0.15	-0.0000	-0.0000	-0.0000	-0.0000	-0.0	-0.0000	-0.0027	0.25	-0.0000	-0.0027	0.25
0.20	0.0000	-0.0000	0.0036	0.0000	0.0	-0.0017	-0.1407	-8.51	-0.0017	-0.1406	-8.51
0.25	0.0006	0.0000	0.0248	0.0001	0.1	-0.0107	-0.2407	68.92	-0.0107	-0.2407	68.93
0.30	0.0019	0.0000	0.0759	-0.0000	0.0	-0.0285	0.6915	591.00	-0.0285	0.6914	591.00
0.35	0.0026	-0.0000	0.0450	-0.0004	-0.4	-0.0357	0.8769	553.43	-0.0357	0.8767	553.36
0.40	0.0023	-0.0000	0.0450	-0.0011	-0.7	-0.0336	0.9629	582.91	-0.0336	0.9630	582.80
0.45	0.0025	-0.0001	0.0709	-0.0016	0.6	-0.0389	0.8572	550.17	-0.0389	0.8582	550.27
0.50	0.0032	-0.0002	0.0650	-0.0015	4.5	-0.0486	0.9723	481.55	-0.0486	0.9742	482.28
0.55	0.0031	-0.0002	0.0408	-0.0003	9.6	-0.0479	1.1125	493.56	-0.0477	1.1144	495.14
0.60	0.0027	-0.0002	0.0507	0.0020	12.9	-0.0440	0.9489	526.42	-0.0438	0.9493	528.58
0.65	0.0031	-0.0000	0.0686	0.0049	10.4	-0.0498	0.8649	483.65	-0.0496	0.8624	485.51
0.70	0.0036	0.0003	0.0533	0.0076	-0.2	-0.0546	1.0885	449.68	-0.0545	1.0831	449.93
0.75	0.0031	0.0007	0.0416	0.0101	-16.7	-0.0498	1.1353	488.48	-0.0501	1.1286	486.10
0.80	0.0029	0.0013	0.0597	0.0122	-34.9	-0.0486	0.9155	498.27	-0.0493	0.9086	492.86
0.85	0.0035	0.0019	0.0639	0.0119	-53.7	-0.0547	0.9424	451.34	-0.0558	0.9352	442.55
0.90	0.0036	0.0024	0.0442	0.0089	-72.1	-0.0544	1.1545	455.00	-0.0560	1.1484	442.62
0.95	0.0030	0.0028	0.0464	0.0059	-83.5	-0.0488	1.0721	499.16	-0.0507	1.0700	484.20
1.00	0.0032	0.0030	0.0648	0.0031	-82.5	-0.0510	0.8990	481.49	-0.0530	0.9015	465.72
1.05	0.0037	0.0031	0.0563	-0.0021	-72.1	-0.0558	1.0335	444.51	-0.0578	1.0385	429.08
1.10	0.0034	0.0028	0.0410	-0.0073	-56.7	-0.0522	1.1533	473.23	-0.0540	1.1600	459.11
1.15	0.0030	0.0024	0.0543	-0.0098	-35.6	-0.0490	0.9814	498.00	-0.0505	0.9905	486.40
1.20	0.0034	0.0018	0.0650	-0.0119	-8.8	-0.0540	0.9204	458.47	-0.0551	0.9311	450.24
1.25	0.0037	0.0012	0.0487	-0.0145	19.5	-0.0562	1.1072	442.30	-0.0567	1.1175	437.93
1.30	0.0032	0.0004	0.0435	-0.0151	45.1	-0.0513	1.1057	480.40	-0.0513	1.1146	480.14
1.35	0.0031	-0.0003	0.0610	-0.0140	66.4	-0.0515	0.9256	478.04	-0.0510	0.9328	481.55
1.40	0.0036	-0.0010	0.0604	-0.0135	82.7	-0.0569	0.9890	436.31	-0.0560	0.9943	442.97
1.45	0.0035	-0.0017	0.0434	-0.0132	93.8	-0.0555	1.1482	447.49	-0.0543	1.1513	456.99
1.50	0.0031	-0.0023	0.0495	-0.0131	99.2	-0.0512	1.0385	480.80	-0.0497	1.0396	492.67
1.55	0.0033	-0.0030	0.0640	-0.0144	100.1	-0.0543	0.9217	456.18	-0.0525	0.9217	469.91
1.60	0.0037	-0.0038	0.0532	-0.0150	101.3	-0.0578	1.0694	429.26	-0.0557	1.0704	445.31
1.65	0.0033	-0.0045	0.0424	-0.0154	105.0	-0.0539	1.1382	460.11	-0.0514	1.1396	479.16
1.70	0.0031	-0.0053	0.0564	-0.0182	106.9	-0.0519	0.9726	474.60	-0.0491	0.9724	496.51
1.75	0.0035	-0.0063	0.0625	-0.0196	104.8	-0.0566	0.9591	437.45	-0.0535	0.9580	462.29
1.80	0.0036	-0.0072	0.0470	-0.0156	102.8	-0.0574	1.1245	432.29	-0.0538	1.1238	460.65
1.85	0.0031	-0.0078	0.0463	-0.0126	97.5	-0.0530	1.0831	466.40	-0.0490	1.0787	497.55
1.90	0.0032	-0.0085	0.0620	-0.0131	76.4	-0.0542	0.9352	455.79	-0.0502	0.9233	487.62
1.95	0.0036	-0.0090	0.0576	-0.0088	39.1	-0.0587	1.0290	421.69	-0.0547	1.0133	452.75
2.00	0.0035	-0.0092	0.0434	-0.0021	-2.4	-0.0562	1.1527	441.49	-0.0525	1.1366	470.78

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 3 REAR SUSPENSION - UNSPRUNG MASS SUMMARY
LEADING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0	0.00	0.0000	0.0	0.00
0.05	0.0	-0.0000	0.0	-0.0000	-0.0	0.0000	0.0000	0.00	0.0000	0.0000	0.00
0.10	0.0	-0.0000	0.0	-0.0000	-0.0	0.0000	-0.0000	0.00	0.0000	-0.0000	0.00
0.15	0.0000	0.0000	0.0000	0.0000	0.0	0.0000	0.0027	-0.25	0.0000	0.0027	-0.25
0.20	-0.0000	0.0000	-0.0036	-0.0000	0.0	0.0017	0.1416	8.82	0.0017	0.1417	8.82
0.25	-0.0006	-0.0000	-0.0245	-0.0000	0.0	0.0109	0.2442	-59.63	0.0109	0.2441	-59.63
0.30	-0.0020	-0.0000	-0.0773	0.0000	-0.1	0.0289	-0.7606	-578.20	0.0289	-0.7606	-578.21
0.35	-0.0026	0.0000	-0.0438	0.0001	-0.1	0.0361	-0.9171	-540.68	0.0361	-0.9170	-540.69
0.40	-0.0023	0.0000	-0.0435	-0.0000	1.0	0.0337	-0.9723	-572.32	0.0337	-0.9715	-572.19
0.45	-0.0025	-0.0000	-0.0705	-0.0006	4.4	0.0392	-0.8754	-538.01	0.0393	-0.8737	-537.45
0.50	-0.0032	-0.0000	-0.0640	-0.0012	9.6	0.0489	-1.0192	-469.81	0.0491	-1.0171	-468.55
0.55	-0.0031	-0.0001	-0.0395	-0.0013	14.3	0.0476	-1.1556	-486.04	0.0478	-1.1544	-484.14
0.60	-0.0026	-0.0002	-0.0508	-0.0005	14.5	0.0438	-0.9639	-518.39	0.0441	-0.9652	-516.43
0.65	-0.0032	-0.0002	-0.0683	0.0013	6.5	0.0502	-0.8811	-470.92	0.0504	-0.8860	-470.01
0.70	-0.0036	-0.0000	-0.0513	0.0034	-11.0	0.0550	-1.1248	-437.28	0.0548	-1.1329	-438.72
0.75	-0.0031	0.0002	-0.0405	0.0048	-35.8	0.0501	-1.1601	-477.56	0.0494	-1.1704	-482.39
0.80	-0.0029	0.0004	-0.0604	0.0052	-65.1	0.0497	-0.9184	-480.72	0.0485	-0.9300	-489.51
0.85	-0.0036	0.0007	-0.0633	0.0055	-96.3	0.0568	-0.9592	-426.19	0.0551	-0.9707	-439.16
0.90	-0.0036	0.0010	-0.0419	0.0047	-124.0	0.0565	-1.1897	-430.68	0.0543	-1.1986	-447.29
0.95	-0.0030	0.0011	-0.0459	0.0018	-142.4	0.0507	-1.0920	-475.87	0.0483	-1.0968	-494.67
1.00	-0.0032	0.0011	-0.0656	-0.0009	-149.0	0.0536	-0.9107	-452.78	0.0511	-0.9108	-472.06
1.05	-0.0037	0.0010	-0.0552	-0.0030	-143.2	0.0586	-1.0699	-414.56	0.0563	-1.0656	-432.64
1.10	-0.0034	0.0008	-0.0390	-0.0057	-126.6	0.0541	-1.1992	-450.86	0.0521	-1.1913	-466.06
1.15	-0.0029	0.0005	-0.0544	-0.0071	-101.6	0.0502	-1.0067	-480.13	0.0488	-0.9957	-491.18
1.20	-0.0034	0.0002	-0.0656	-0.0068	-67.8	0.0554	-0.9457	-439.65	0.0546	-0.9316	-445.67
1.25	-0.0037	-0.0002	-0.0471	-0.0078	-28.6	0.0570	-1.1547	-428.55	0.0569	-1.1399	-428.96
1.30	-0.0031	-0.0006	-0.0420	-0.0080	9.5	0.0508	-1.1483	-476.64	0.0515	-1.1347	-471.48
1.35	-0.0031	-0.0009	-0.0615	-0.0052	44.9	0.0506	-0.9462	-477.58	0.0519	-0.9332	-467.48
1.40	-0.0036	-0.0011	-0.0604	-0.0034	78.6	0.0561	-1.0151	-435.36	0.0579	-1.0031	-421.02
1.45	-0.0035	-0.0013	-0.0417	-0.0029	107.9	0.0541	-1.1889	-452.00	0.0563	-1.1790	-434.12
1.50	-0.0030	-0.0014	-0.0487	-0.0008	133.0	0.0489	-1.0667	-491.60	0.0516	-1.0576	-470.89
1.55	-0.0033	-0.0014	-0.0645	0.0006	158.5	0.0520	-0.9361	-466.69	0.0550	-0.9261	-443.44
1.60	-0.0037	-0.0014	-0.0527	-0.0000	186.5	0.0556	-1.0970	-439.90	0.0589	-1.0860	-413.95
1.65	-0.0033	-0.0013	-0.0409	0.0006	217.1	0.0509	-1.1749	-476.82	0.0546	-1.1629	-447.97
1.70	-0.0030	-0.0013	-0.0561	0.0016	250.5	0.0484	-0.9953	-495.98	0.0524	-0.9824	-464.15
1.75	-0.0035	-0.0012	-0.0628	0.0009	284.4	0.0531	-0.9760	-459.01	0.0575	-0.9636	-424.15
1.80	-0.0036	-0.0011	-0.0461	0.0027	316.3	0.0536	-1.1534	-456.40	0.0563	-1.1420	-418.90
1.85	-0.0031	-0.0009	-0.0452	0.0069	343.3	0.0485	-1.1092	-495.45	0.0535	-1.1007	-456.58
1.90	-0.0032	-0.0005	-0.0620	0.0081	357.8	0.0498	-0.9429	-485.04	0.0547	-0.9407	-446.61
1.95	-0.0037	-0.0000	-0.0575	0.0107	355.6	0.0547	-1.0340	-447.35	0.0593	-1.0367	-411.18
2.00	-0.0035	0.0007	-0.0424	0.0180	347.0	0.0525	-1.1658	-465.26	0.0566	-1.1686	-432.83

SAMPLE RUN - TRIPLES BRAKING IN A TURN. (VARIOUS OPTIONS EXERCISED)
TRAILER NO. 3 REAR SUSPENSION - UNSPRUNG MASS SUMMARY
TRAILING TANDEM AXLE

	AXLE MOTION					DYNAMIC SUSPENSION MOTIONS AND FORCES					
	POSITION		VELOCITY			LEFT SIDE			RIGHT SIDE		
TIME (SEC)	VERTICAL (FT)	ROLL (DEG)	VERTICAL (FT/SEC)	ROLL (DEG/SEC)	AUXILIARY ROLL TORQUE (IN-LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)	SUSP. DEFLECT. (IN)	SUSP. VELOCITY (IN/SEC)	SUSP. FORCE (LB)
0.0	0.0	0.0	0.0	0.0	0.0	-0.0000	0.0	-0.00	-0.0000	0.0	-0.00
0.05	0.0	-0.0000	0.0	-0.0000	-0.0	0.0000	0.0000	0.00	0.0000	0.0000	0.00
0.10	0.0	0.0000	0.0	0.0000	-0.0	0.0000	-0.0000	0.00	0.0000	-0.0000	0.00
0.15	-0.0000	0.0000	-0.0001	0.0000	0.0	0.0000	0.0013	0.55	0.0000	0.0013	0.55
0.20	-0.0002	-0.0000	-0.0096	-0.0000	0.0	0.0016	0.0704	27.83	0.0016	0.0704	27.84
0.25	-0.0012	-0.0000	-0.0347	-0.0000	0.0	0.0107	0.1215	3.91	0.0107	0.1215	3.91
0.30	-0.0030	0.0000	-0.0842	0.0000	-0.1	0.0280	-0.8428	-467.58	0.0280	-0.8429	-467.60
0.35	-0.0039	0.0000	-0.0500	0.0000	-0.1	0.0354	-0.9915	-394.67	0.0354	-0.9914	-394.69
0.40	-0.0039	-0.0000	-0.0476	-0.0002	0.8	0.0332	-1.0213	-399.58	0.0332	-1.0206	-399.47
0.45	-0.0043	-0.0000	-0.0737	-0.0010	3.6	0.0388	-0.9137	-345.72	0.0389	-0.9123	-345.18
0.50	-0.0052	-0.0001	-0.0664	-0.0016	8.0	0.0486	-1.0474	-262.77	0.0488	-1.0456	-261.53
0.55	-0.0051	-0.0002	-0.0413	-0.0016	12.1	0.0474	-1.1767	-268.06	0.0476	-1.1757	-266.17
0.60	-0.0047	-0.0002	-0.0521	-0.0003	12.1	0.0437	-0.9797	-292.26	0.0439	-0.9809	-290.29
0.65	-0.0053	-0.0002	-0.0693	0.0022	5.1	0.0501	-0.8932	-238.73	0.0502	-0.8974	-237.78
0.70	-0.0058	-0.0000	-0.0520	0.0048	-10.4	0.0549	-1.1340	-200.57	0.0547	-1.1413	-201.95
0.75	-0.0053	0.0003	-0.0410	0.0069	-32.2	0.0500	-1.1673	-237.49	0.0494	-1.1762	-242.22
0.80	-0.0052	0.0007	-0.0608	0.0082	-56.8	0.0496	-0.9243	-238.16	0.0485	-0.9339	-246.80
0.85	-0.0058	0.0011	-0.0636	0.0089	-82.4	0.0567	-0.9640	-181.77	0.0551	-0.9732	-194.56
0.90	-0.0059	0.0015	-0.0421	0.0091	-103.3	0.0564	-1.1939	-184.89	0.0543	-1.1999	-201.26
0.95	-0.0053	0.0020	-0.0461	0.0068	-113.1	0.0506	-1.0957	-229.06	0.0483	-1.0972	-247.57
1.00	-0.0055	0.0022	-0.0657	0.0027	-112.0	0.0535	-0.9134	-205.17	0.0511	-0.9111	-224.22
1.05	-0.0060	0.0023	-0.0553	0.0007	-100.3	0.0586	-1.0723	-166.37	0.0563	-1.0655	-184.22
1.10	-0.0057	0.0023	-0.0390	-0.0008	-76.0	0.0541	-1.2016	-202.27	0.0521	-1.1906	-217.17
1.15	-0.0053	0.0021	-0.0544	-0.0048	-44.3	0.0502	-1.0081	-231.18	0.0488	-0.9956	-242.02
1.20	-0.0058	0.0018	-0.0656	-0.0079	-10.2	0.0554	-0.9458	-190.37	0.0546	-0.9325	-196.36
1.25	-0.0060	0.0014	-0.0471	-0.0081	27.3	0.0570	-1.1549	-179.10	0.0569	-1.1403	-179.47
1.30	-0.0055	0.0010	-0.0420	-0.0090	64.8	0.0508	-1.1482	-227.05	0.0515	-1.1353	-221.86
1.35	-0.0054	0.0005	-0.0616	-0.0103	94.8	0.0506	-0.9447	-227.78	0.0519	-0.9351	-217.86
1.40	-0.0060	-0.0000	-0.0604	-0.0098	117.6	0.0561	-1.0131	-185.44	0.0579	-1.0054	-171.38
1.45	-0.0058	-0.0005	-0.0417	-0.0090	135.9	0.0541	-1.1870	-202.02	0.0563	-1.1811	-184.43
1.50	-0.0053	-0.0010	-0.0487	-0.0094	148.2	0.0490	-1.0640	-241.53	0.0516	-1.0605	-221.21
1.55	-0.0056	-0.0014	-0.0645	-0.0099	156.4	0.0521	-0.9327	-216.52	0.0550	-0.9297	-193.80
1.60	-0.0060	-0.0020	-0.0527	-0.0115	165.1	0.0556	-1.0932	-189.67	0.0589	-1.0899	-164.32
1.65	-0.0056	-0.0026	-0.0409	-0.0138	173.0	0.0510	-1.1702	-226.49	0.0546	-1.1677	-198.40
1.70	-0.0053	-0.0033	-0.0561	-0.0139	179.4	0.0484	-0.9902	-245.58	0.0524	-0.9876	-214.63
1.75	-0.0058	-0.0040	-0.0628	-0.0141	186.8	0.0531	-0.9711	-208.60	0.0575	-0.9686	-174.62
1.80	-0.0059	-0.0047	-0.0461	-0.0168	189.1	0.0536	-1.1470	-205.87	0.0583	-1.1485	-169.47
1.85	-0.0054	-0.0056	-0.0452	-0.0156	177.8	0.0486	-1.1018	-244.80	0.0534	-1.1082	-207.28
1.90	-0.0055	-0.0062	-0.0620	-0.0086	157.3	0.0498	-0.9374	-234.49	0.0546	-0.9463	-197.20
1.95	-0.0060	-0.0065	-0.0575	-0.0064	127.7	0.0547	-1.0284	-196.82	0.0592	-1.0425	-161.74
2.00	-0.0058	-0.0069	-0.0424	-0.0087	80.9	0.0526	-1.1571	-214.47	0.0565	-1.1775	-183.64

APPENDIX C

INPUT PARAMETER REFERENCE LIST

HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITRAILERS, DOUBLES, AND TRIPLES COMBINATIONS - PHASE 4

Parameter Name	Description	Engineering Units	Format*	Program Symbol	Options Available	User Manual Section	Comments
Title Line	User Identification of Run	———	20A4	HEAD		3.1, 3.2	First line of input list
Simulation Operation Parameters							
Vehicle Configuration	Number of Trailers	———	I2	NVEH		3.2	Zero=Truck or bobtail tractor; 3 max.
Initial Velocity	Vehicle speed at beginning of simulation	ft/sec	F15.3	VEL		3.2	
Steer Input Table	Number of lines in table Pos. - Path-Follwer Table	——— ft. long., ft. lat.	I3 2F10.2	ISTEER XP,YP		3.2 3.2, App. G	Zero lines=Straight ahead Max. of 25 lines
	Neg. - Steer Angle Table (Front Wheels or Steering Wheel)	sec, LW deg., RW deg.	3F10.2	TURNX, TURNY	side-to-side	3.2	
End of Preview Interval	Driver's view distance ahead (in time)	sec	F10.4	TFF		3.2, App. G	Typ. 1-3 sec } Appear only with path-follower model
Driver Transport Lag	Pure time lag in driver model	sec	F10.4	TAUMEM		3.2, App. G	1 sec. max. } Appear only with path-follower model
Treadle Pressure Table	Number of lines in table Time-pressure table entries	 sec, psi	I2 2F10.2	NTP XTP,YTP		3.2	Maximum of 10 lines
Max. Simulation Time	Length of time of simulation run	sec	F15.3	TIMF		3.2	
Time Increment of Output	Simulation time interval of print-out lines	sec	F15.3	TINC		3.2	
Road Key	Choice of following road options Neg. - User written road sub-routine call		I2	IROAD		App. H	May be used for rough roads, etc.
	Zero - Flat, horizontal road		I2	IROAD			
	Pos. - Planar road w/downgrade & cross-slope	-, %, %	I2, 2F10.2	IROAD, DZDXO, DZDYO			

*All formats begin in Column 1, additional columns may be used for users' comments, labels, etc.

Output Page Option Keys	Eight digits key for eight page types (0=no print, 1=print) as follows: -Sprung Mass Position Page -Sprung Mass Velocity Page -Sprung Mass Acceleration Page -Tire Forces Page -Brake Summary Page -Lateral Pages -Unsprung Mass Page -Brake Model Temperatures		8I1				
Truck/Tractor/Trailer Parameters							
Wheelbase	Center-to-center distance, front-to-rear suspensions on trucks/tractors/full trailers; kingpin to center of rear suspension on semitrailers	in.	F15.3	WHBS		3.3.1, 3.4.1, 3.5.1	
Base Vehicle Curb Wt. on FA	Front axle curb weight on trucks/tractors/full trailers w/o payload or hitch load	lb	F15.3	SNL(_,1)		3.3.1, 3.5.1	Payload may be included in base vehicle
Base Vehicle Kingpin Static Load	Weight at kingpin of semitrailer w/o payload or hitch loads	lb	F15.3	SNL(_,1)		3.4.1	Payload may be included in base vehicle
Base Vehicle Curb Wt. on RA	Rear axle curb weight w/o payload or hitch loads	lb	F15.3	SNL(_,2)		3.3.1, 3.4.1, 3.5.1	Payload may be included in base vehicle
Sprung Mass CG Height	Distance above ground (at final load conditions)	in.	F15.3	DELTA		3.3.1	
Sprung Mass	Moment of inertia properties of sprung mass only					3.3.1	
-Roll Moment of Inertia		in-lb-sec^2	F15.3	VJ(_,1)			
-Pitch Moment of Inertia		in-lb-sec^2	F15.3	VJ(_,2)			
-Yaw Moment of Inertia		in-lb-sec^2	F15.3	VJ(_,3)			

Payload Weight		lb	F15.3	PW		3.3.1,3.4.1	May be lumped with base vehicle
-Dist. Ahead of Rear Susp.	Long. location ahead of rear susp.	in.	F15.3	PX		3.3.1,3.4.1	
-CG Height	Height above ground (at full load condition)	in.	F15.3	PZ		3.3.1,3.4.1	
-Roll Moment of Inertia	Payload moment of inertia properties	in-lb-sec^2	F15.3	PJ(_,1)		3.3.1,3.4.1	Entries only when payload is not zero
-Pitch Moment of Inertia	" " " " "	in-lb-sec^2	F15.3	PJ(_,2)		3.3.1,3.4.1	
-Yaw Moment of Inertia	" " " " "	in-lb-sec^2	F15.3	PJ(_,3)		3.3.1,3.4.1	
Fifth Wheel Location	Long. distance ahead of rear susp.	in.	F15.3	BB1		3.3.1	
Fifth Wheel Height	Height above ground at pitch articulation	in.	F15.3	D		3.3.1	Entries in tractor parameters only when trailers are specified in configuration
Tractor Frame Stiffness	Frame torsional stiffness (Typ. 20,000-250,000)	in-lb/deg	F15.3	MC5		3.3.1	
Tractor Frame Torsional Axis Height	Height above ground	in.	F15.3	HFRAM		3.3.1	
Dolly Key	Choice of converter (1) or fixed (2) dolly	————	I2	KDOLLY		3.5.1	
Dist. from Turntable Center to Pintle Hook	Length of dolly tongue	in.	F15.3	APHI		3.5.1	Entries only with a full trailer (enter preceding full trailer wheelbase)
Turntable Location	Dist. ahead of dolly susp. center	in.	F15.3	BB1		3.5.1	
Turntable Height Above Ground	Height of pitch articulation on dolly	in.	F15.3	D		3.5.1	
Location of Pintle Hook	Dist. behind rear susp. of towing vehicle	in.	F15.3	A3		3.4.1,3.5.1	Entries for trailer towing a full trailer
Height of Pintle Hook	Dist. above ground on towing veh.	in.	F15.3	PH		3.4.1,3.5.1	
<u>Suspension and Axle Parameters</u>							
Suspension Key	Choice of single (0), four-spring tandem (1), or walking-beam tandem (2)	————	I2	KEY		3.3.4.2	

Tandem Separation	Center-to-center dist. between tandem axles	in.	F15.3	TD		3.3.4.2	Entries only if tandem axles are specified
Static Load Transfer	Percent load on leading tandem axle	%	F15.3	FSPLIT		3.3.4.2	
Dynamic Load Transfer	Percent of tandem axle brake torque acting to transfer load onto leading tandem axle	%	F15.3	FSHIFT		3.3.4.2	
Suspension Spring Rate	Stiffness of each susp. spring (L&R)	lb/in	F15.3	K(_,_,_,1&2)	Side-to-side table lookup	3.3.2	Serial entry of this data set when tandem axles are specified (leading tandem, trailing tandem)
Suspension Viscous Damping	Shock absorber damping coefficients (L&R)	lb-sec²/in	F15.3	C(_,_,_,1&2)	Side-to-side table lookup	3.3.2	
Coulomb Friction	One-half the force hysteresis in each spring (L&R)	lb	F15.3	CF(_,_,_,1&2)	Side-to-side	3.3.2	
Axle Roll Moment of Inertia	Roll inertia properties of total unsprung mass	in-lb-sec²	F15.3	IA		3.3.2	
Roll Center Height	Height of roll center above ground	in.	F15.3	RCI		3.3.2	
Roll Steer Coeff.	Axle roll steer effects	deg steer/deg roll	F15.3	RST		3.3.2	
Auxiliary Roll Stiffness	Roll stiffness not due to spring forces	in-lb/deg	F15.3	KRS		3.3.2	
Lat. Dist. between Susp. Springs	Suspension lateral spacing	in.	F15.3	SYI		3.3.2	
Track Width	Center-to-center dist. between wheel sets	in.	F15.3	TRA		3.3.2, 3.3.4.1	
Unsprung Weight	Total weight of axle, brakes, wheels, etc.	lb	F15.3	ASW		3.3.2	
Steering Gear Ratio	Deg. steering wheel/deg. road wheel	deg/deg	F10.2	GRATIO		3.3.2	Entered only for truck/tractor front axle
<u>Tire and Wheel Parameters</u>							
Dual Tire Separation	Center-to-center dist. between tires in a dual set	in.	F15.3	DTS	Side-to-side	3.3.5	Deleted on truck/tractor front axle
Cornering Stiffness	Initial slope of tire lateral force-slip angle curve at loaded cond.	lb/deg	F15.3	CALF	Side-to-side, table lookup	3.3.3,3.3.5	Data on per tire basis

Long. Stiffness	Initial slope of tire brake force-slip curve at loaded condition	lb/slip	F15.3	CS	Side-to-side, Table lookup	3.3.3,3.3.5	Data on per tire basis
Camber Stiffness	Initial slope of tire lateral force-camber angle curve at loaded cond.	lb/deg	F15.3	CAM	Side-to-side	3.3.3,3.3.5	Data on per tire basis
Aligning Moment	Initial slope of tire aligning moment-slip angle curve at loaded condition	in-lb/deg	F15.3	CAT	Side-to-side	3.3.3,3.3.5	Data on per tire basis
Tire Spring Rate	Force-deflection rate at loaded condition	lb/in	F15.3	KT	Side-to-side	3.3.3,3.3.5	Data on per tire basis
Tire Loaded Radius	Tire radius at loaded condition	in.	F15.3	SRAD	Side-to-side	3.3.3,3.3.5	
Polar Moment of Inertia	Spin inertia of wheel assembly	in-lb-sec^2	F15.3	WHEELI	Side-to-side	3.3.3,3.3.5	Use one-half of total for a dual wheel set
<u>Brake Parameters</u>							
Time Lag	Time from treadle valve motion to beginning of pressure rise at brake	sec.	F10.2	TQ(_,_,_,_,1)	Side-to-side	3.3.6	Entries deleted if no
Rise Time	First-order time constant of pressure rise at brake	sec.	F10.2	TQ(_,_,_,_,2)	Side-to-side	3.3.6	lines in treadle pressure table
Brake Torque	Torque-pressure coefficient of brake	in-lb/psi	F10.2	BTQ	Side-to-side, Table lookup	3.3.6	Max. of 10 lines
Global Brake Hysteresis Key	=0=> No brake hysteresis >0=> Brake hysteresis		I1	KHYST		3.3.6	Entered only for 1st axle on vehicle
Hysteresis Parameters			10F8.2			3.3.6	Entered for each axle on vehicle only if KHYST>0
Global Brake Proportioning Key	=0=> No brake proportioning >0=> Brake proportioning		I1	KPROP		3.3.6	Entered for each axle on vehicle
Brake Proportioning Data						3.3.6	Entered for each axle on vehicle only if KPROP>0

<u>Antilock Parameters</u>							
Vehicle Antilock Key	Vehicle antilock key, 0-no antilock, 01-indicates antilocks used	————	I2	ILOCK		3.6, App. D	
Antilock Parameters	See Appendix D						
<u>Rerun Parameter</u>							
Rerun	Key at end of data input list 00 - ends simulation run 01 - indicates another run follows	————	I2	RERUN		3.7	Last line of input list

APPENDIX D

ANTILOCK SIMULATION

The documentation presented in this appendix represents the most recent version of the HSRI antilock program. The simulation concentrates on the three areas common to most antilock systems: (1) wheel speed sensor, (2) control logic module, and (3) pressure modulator. Axle-by-axle systems are allowed for, as well as four side-to-side options: (1) worst wheel, (2) best wheel, (3) average wheel, and (4) independent wheel.

A block diagram showing the relationship between the antilock elements and the main program is shown in Figure D-1. The wheel speed signal, ω. is received from the main program and processed by the wheel sensor wherein an effective time delay occurs resulting in delayed wheel speed and acceleration signals ω_d and $\dot{\omega}_d$. These signals, along with vehicle velocity, $\dot{x}$, vehicle acceleration, $\ddot{x}$, and feedback from the pressure modulator, are input to the control logic module. The control logic module outputs and ON/OFF solenoid command signal to the pressure modulator which in turn generates the brake pressure, P, returned to the main program.

A complete description of the antilock simulation and explanation of its use is presented in the following sections.

D.1 <u>User Dictionary of Variables/Parameters</u>. In order to offer much greater flexibility to the program user as regards variable and parameter programming choices, a table or dictionary of such variables/parameters has been added. This dictionary, as shown in Figure D-2, is simply a listing of various variables and parameters which might be considered to be of some importance or interest to an antilock system. A user selects, for programming purposes, a particular variable/parameter by referring to its variable I.D. numeral shown in Table D-1.and Figure D-3. If a user has need for additional variables or parameters not included in the dictionary, they can be added by rather simple additions to the FORTRAN code.

The purpose of the dictionary is to allow the program user to select, from a wide variety of possible antilock variables/ parameters, only those which are of interest to the particular

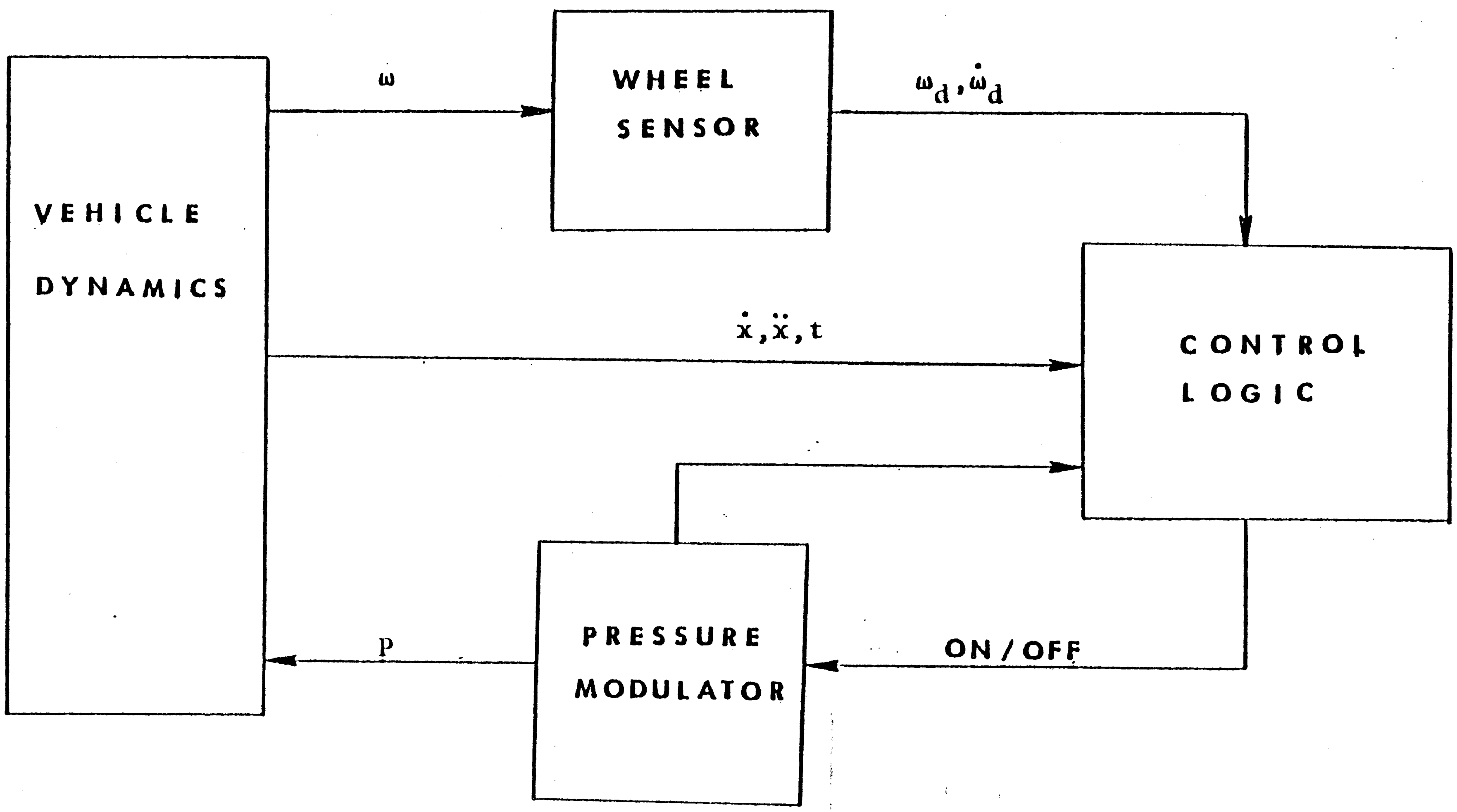


Figure D-1. Antilock block diagram.

DICTIONARY OF ANTI-LOCK VARIABLES/PARAMETERS AVAILABLE TO USER.

VARIABLE I.D.	DESCRIPTION	VARIABLE I.D.	DESCRIPTION
1	1.0	45	WMAX1
2	TIME	46	WMAX2
3	OMEGA	47	TWMAX1
4	OMEGADOT	48	TWMAX2
5	XDOT	49	WMIN
6	XDDOT	50	TWMIN
7	POFF1	51	TPMAX2
8	POFF2	52	TPMIN2
9	PON1	53	GPV1
10	PON2	54	GPV2
11	TOFF1	55	GPV3
12	TON1	56	GPV4
13	XDOFF	57	GPV5
14	XDON	58	FOS4
15	WOFF	59	FOS5
16	WON	60	OMEGDIF
17	WDOFF		
18	WDON		
19	WDMAX		
20	WDMIN		
21	TPMAX1		
22	TPMIN1		
23	WLOCK		
24	TLOCK		
25	SLON		
26	SLOFF		
27	PMAX1		
28	PMAX2		
29	PMIN1		
30	PMIN2		
31	PO		
32	ON		
33	TMOD		
34	SLIP		
35	P		
36	CYCNT		
37	SQUARE		
38	SQUARN		
39	TOFF2		
40	TON2		
41	FOS1		
42	FOS2		
43	FOS3		
44	GPCNT		

Figure D-2

Table D-1. Variable/Parameter Definitions

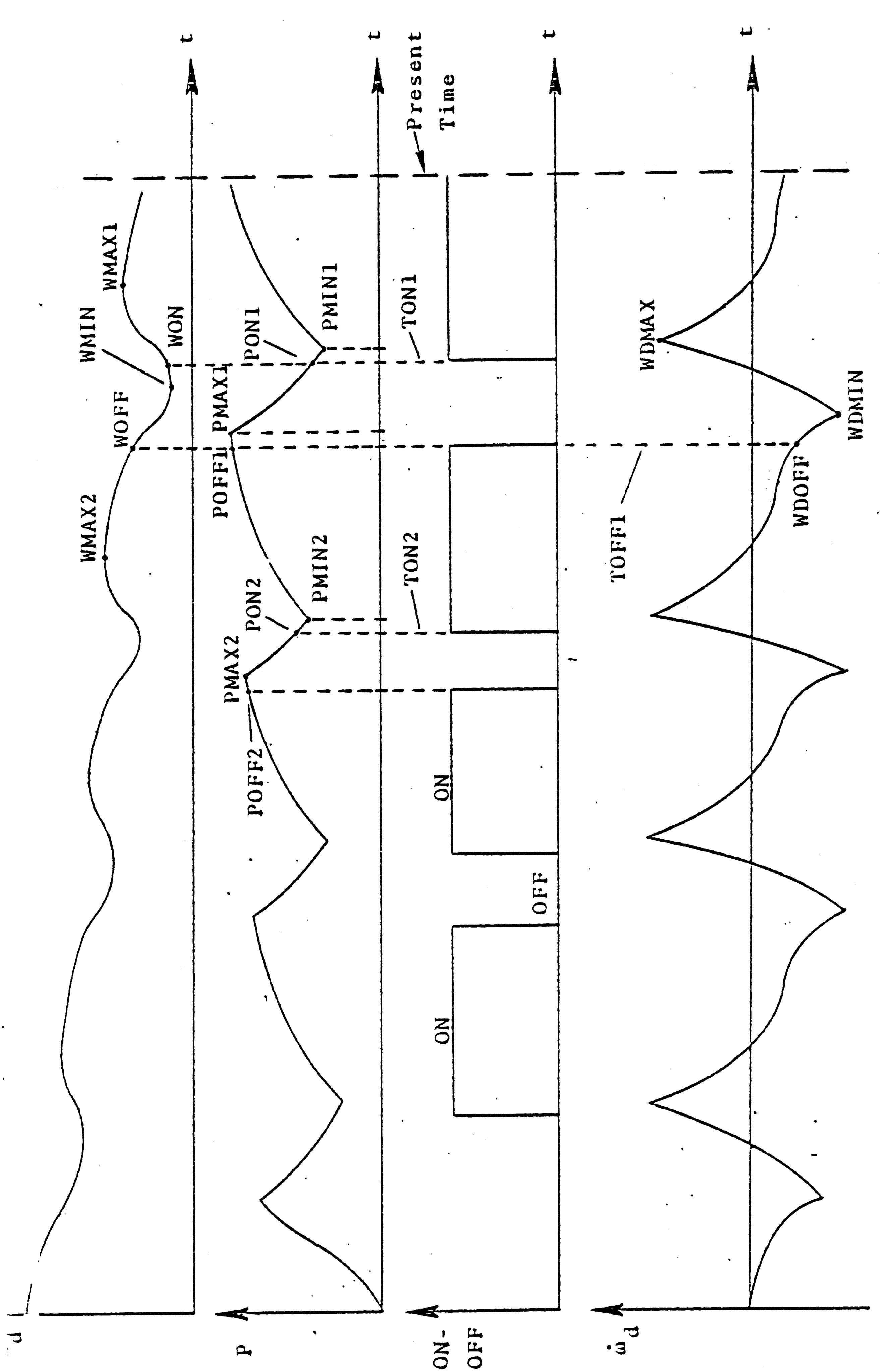
Symbol	I.D. Code	Definition	Units
1.0	1	Constant; Unity Parameter	
TIMF	2	Time in simulation	(sec)
OMEGA	3	Wheel speed at tire-road interface (expressed as an equivalent translational velocity)	(ft/sec)
OMEGADOT	4	Wheel acceleration at tire-road interface (expressed as an equivalent translational acceleration)	(ft/sec^2)
XDOT	5	Vehicle velocity	(ft/sec)
XDDOT	6	Vehicle acceleration	(ft/sec^2)
POFF1	7	Brake pressure at last "OFF" signal	(psi)
POFF2	8	Brake pressure at "OFF" signal in next to last cycle	(psi)
PON1	9	Brake pressure at last "ON" signal	(psi)
PON2	10	Brake pressure at "ON" signal in next to last cycle	(psi)
TOFF1	11	Time at last "OFF" signal	(sec)
TON1	12	Time at last "ON" signal	(sec)
XDOFF	13	Vehicle velocity at last "OFF" signal	(ft/sec)
XDON	14	Vehicle velocity at last "ON" signal	(ft/sec)
WOFF	15	Wheel speed at last "OFF" signal	(ft/sec)
WON	16	Wheel speed at last "ON" signal	(ft/sec)
WDOFF	17	Wheel acceleration at last "OFF" signal	(ft/sec^2)
WDON	18	Wheel acceleration at last "ON" signal	(ft/sec^2)
WDMAX	19	Maximum wheel acceleration in last cycle	(ft/sec^2)
WDMIN	20	Minimum wheel acceleration in last cycle	(ft/sec^2)

Table D-1 (Cont.)

Symbol	I.D. Code	Definition	Units
TPMAX1	21	Time of maximum pressure in last cycle	(sec)
TPMIN1	22	Time of minimum pressure in last cycle	(sec)
WLOCK	23	Parameter having value 1.0 if wheel is locked; otherwise having value of 0.0	
TLOCK	24	Time ramp beginning at start of any wheel lock	(sec)
SLON	25	Wheel slip at last "ON" signal	
SLOFF	26	Wheel slip at last "OFF" signal	
PMAX1	27	Maximum pressure from last cycle	(psi)
PMAX2	28	Maximum pressure from cycle before last	(psi)
PMIN1	29	Minimum pressure from last cycle	(psi)
PMIN2	30	Minimum pressure from cycle before last	(psi)
PD	31	Treadle pressure	(psi)
ON	32	Parameter having value of 1.0 during "ON" signal; otherwise 0.0	
TMOD	33	Time of modulation for the pulse-width modulated square wave	(sec)
SLIP	34	Wheel slip	
P	35	Brake pressure	(psi)
CYCNT	36	Cycle counter beginning at 0 and incrementing its count by 1 every "OFF" signal	
SQUARE	37	Pulse-width modulated square wave having value 1.0 or 0.0	
SQUARN	38	SQUARE - 1.0	
TOFF2	39	Time of "OFF" signal in cycle before last	(sec)
TON2	40	Time of "ON" signal in cycle before last	(sec)
FOS1	41	First one-shot variable having value 1.0 during one-shot firing; otherwise having value of 0.0	

Table D-1 (Cont.)

Symbol	I.D. Code	Definition	Units
FOS2	42	Second one-shot variable	
FOS3	43	Third one-shot variable	
GPCNT	44	General purpose counter	
WMAX1	45	Maximum wheel speed in last cycle	(ft/sec)
WMAX2	46	Maximum wheel speed in cycle before last	(ft/sec)
TWMAX1	47	Time of maximum wheel speed in last cycle	(sec)
TWMAX2	48	Time of maximum wheel speed in cycle before last	(sec)
WMIN	49	Minimum wheel speed in last cycle	(ft/sec)
TWMIN	50	Time of minimum wheel speed in last cycle	(sec)
TPMAX2	51	Time of maximum brake pressure in cycle before last	(sec)
TPMIN2	52	Time of minimum brake pressure in cycle before last	(sec)
GPV1	53	First general purpose variable	
GPV2	54	Second general purpose variable	
GPV3	55	Third general purpose variable	
GPV4	56	Fourth general purpose variable	
GPV5	57	Fifth general purpose variable	
FOS4	58	Fourth one-shot variable	
FOS5	59	Fifth one-shot variable	
IMEGDIF	60	Side-to-side wheel speed difference indicator having the value 1.0 (otherwise 0.0) when the same axle side-to-side wheel speed difference (ft/sec) is greater than the input parameter, WWDIF.	



t
Present Time
WMAX1
WMIN
WON
WOFF
WMAX2
PMIN1
PON1
PMAX1
POFF1
PMIN2
PON2
PMAX2
POFF2
TON1
TOFF1
TON2
ON
OFF
ON
WDMAX
WDMIN
WDOFF
P
ON-
OFF

Figure D-3

system he is attempting to simulate. Those familiar with the previous antilock simulation may recall that such variable/parameter choices were fixed and limited to wheel speed, acceleration, and four or five other variables. Thus, the present approach should eliminate most problems where the user was handicapped with the previous program because a particular variable or parameter was not available.

Within the antilock variables/parameters are stored in an array of dimension 60 called VARIB(J), J=1,60. Therefore, VARIB(1) contains the constant 1.0, VARIB(2) contains the present value of the time, t, and so on as defined in Table D-1.

D.2. General Expression Form. Throughout the remainder of this discussion a particular algebraic expression will be encountered repeatedly. It would therefore be helpful beforehand to define each term in the expression and then discuss its purpose. The expression referred to is of the general form:

$$C_1x_1 + C_2x_2 + C_3x_3 + C_4x_4y_4 + C_5x_5y_5 \qquad \text{(D-1)}$$

The C_i $(i=1,\ldots,5)$ are constant coefficients for each term. Any of these coefficients may be adaptive to as many as two different variables. This adaptive feature will be discussed in detail in Section D-4. The x_i, $(i=1,\ldots,5)$ and y_i, $(i=4,5)$ are variables or parameters available in the user dictionary. Note that the fourth and fifth terms are quadratic in form. During execution of the program the x_i and y_i, which the user has selected from the dictionary to form some relationship, are actually assigned values from the array VARIB(J).

The purpose of these expressions is to allow the user to form various algebraic relationships between the variables and parameters available in the dictionary, subject to the form of the general expression (D-1). A form of this general expression appears in almost every section of the program from control logic inequality expressions to evaluation of one-shot conditions. Only those terms necessary to form a desired expression are required. Some simple examples illustrating the use of these general expressions are presented in the following sections.

D.3. Wheel Sensor Module. The primary effect of a wheel sensor is a phase shift and/or time delay between the actual wheel rate and the derived wheel rate. This input-output relationship can often be described adequately by transfer functions of various order and/or transport time delay expressions. The present version assumes a general first-order filter of the form $1/\tau_{\omega}p + 1$ relating actual wheel rate to derived wheel rate, where τ_{ω} is the time constant of the filter and p is an operator denoting differentiation with respect to time.

Many antilock systems make use of wheel acceleration derived from the output of the wheel sensor. This normally involves additional delays along with a differentiation process. The assumed transfer function here was taken as $p/\tau_{\omega d}p + 1$ relating derived wheel rate to derived wheel acceleration. The derived wheel acceleration calculation normally takes place within the electronic control unit. However, since it, along with wheel rate, is a primary input to the control unit logic, it is included here within the wheel sensor module so that the control unit can be characterized by logical or decision-making processes only. The wheel sensor module can then be described by the input-output relationships shown in Figure D-4.

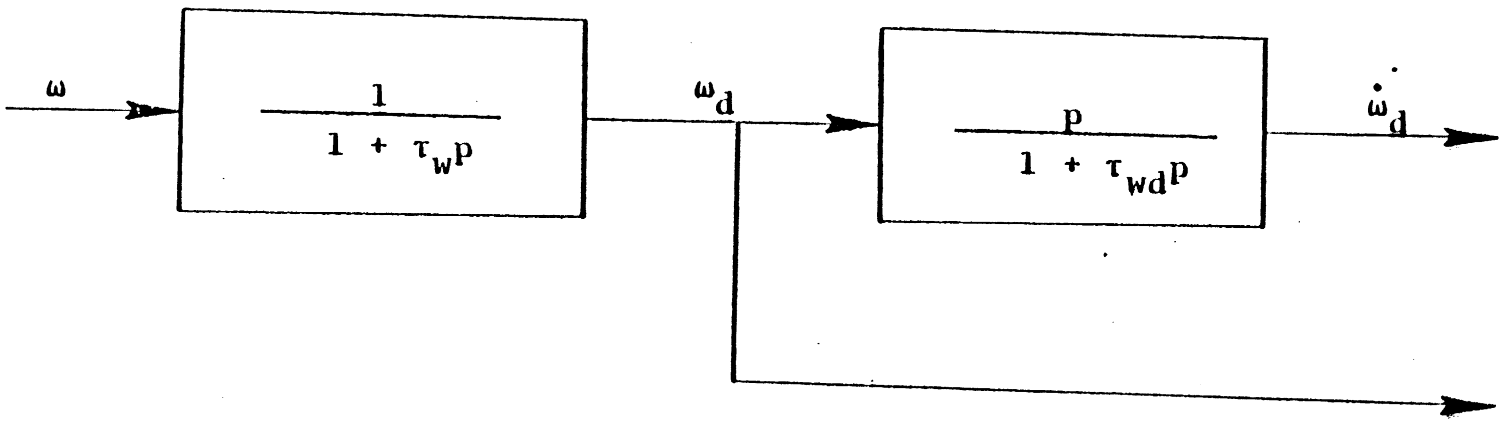


Figure D-4. Wheel sensor module.

The delayed wheel speed and acceleration signals, ω_d and $\dot{\omega}_d$, are used as the primary inputs to the control logic module. The assumed wheel sensor and derivative circuit input-output relationships are therefore described by two input parameters, τ_ω and $\tau_{\omega d}$, which represent the first-order filter time constants of the wheel sensor and its derivative circuit. The variables, ω_d and $\dot{\omega}_d$, appear in the user dictionary as OMEGA and OMEGADOT, I.D. codes 3 and 4. (The symbols ω and $\dot{\omega}$ are used interchangeably throughout this section for ω_d and $\dot{\omega}_d$.)

Other variables are provided as possible inputs to the control logic module, however, no similar operations are attempted on these other input variables.

D.4. Control Logic Module. The control logic is characterized by a set of eight inequality expressions which the user forms as conditions for generating "ON" and "OFF" signals. Associated with each arithmetic inequality expression is a logical variable. These logical variables, reflecting the state or polarity of the inequality expressions, are logically combined to generate the "ON" and "OFF" signals. "ON" is defined here as air being applied to, or "ON," the brake air chambers. Figure D-5 summarizes the overall structure of the control logic module.

Inequality Expressions.

Each of the eight arithmetic inequalities has the general form:

$$F_i \triangleq c_{i1}v_{i1} + c_{i2}v_{i2} + c_{i3}v_{i3} + c_{i4}v_{i4}w_{i4} + c_{i5}v_{i5}w_{i5} \geq 0 \quad , \quad i=1,8 \tag{D-2}$$

where

Inequality Expression	Logical Variable	Logical Operator	Solenoid Command
$F_1 \geq 0$	L_1	OP_{12}	OFF
$F_2 \geq 0$	L_2	OP_{23}	
$F_3 \geq 0$	L_3	OP_{34}	
$F_4 \geq 0$	L_4	⋮	
⋮	⋮		ON
$F_8 \geq 0$	L_8	OP_{78}	

Figure D-5. Control logic module.

c_{ij} , (j=1,5) are the constant coefficients of each term.

v_{ij}, w_{ik} , (j=1,5; k=4,5) are the variables/ parameters selected from the user dictionary.

The first four inequalities, F_1 through F_4, are used for generating the "OFF" signal; the last four inequalities for the "ON" signal.

As an example, suppose the condition

$$\dot{\omega} \leq -100 \text{ ft/sec}^2*$$

or

$$-\dot{\omega} - 100 \geq 0$$

was used as the first "OFF" condition. Then F_1 would become

$$F_1 \triangleq (-1.0)\dot{\omega} + (-100.)1.0 \geq 0 \quad ,$$

with -1.0 and -100. required as c_{11} and c_{12}. OMEGADOT, ($\dot{\omega}$), would be selected from the user dictionary for v_{11} and the unity parameter, 1.0, would be selected as v_{12}. As will be described in detail in Section D.7 , five numbers would be required as program input for forming this expression: (a) the number of terms involved in the expression, (2); (b) two coefficients, (-1.0) and (-100.); and (c) two variable I.D. codes from the user dictionary, '4' and '1' for OMEGADOT and the unity parameter, respectively.

*See definition of OMEGADOT in Table D-1.

A simple description of the sequence of operations taking place within the antilock control logic module is as follows:

During a braking maneuver, the variables/parameters selected by the user are substituted in the user-defined inequality expressions. These expressions are evaluated, and based upon their polarity, OFF signals or ON signals are sent to the pressure modulator. At the beginning of the braking maneuver, evaluation of the inequalities associated with generating the "OFF" signal takes place until an "OFF" signal is generated. Attention then is focused on the inequalities associated with generating an "ON" signal until an "ON" signal is generated. This sequence continues until either the treadle valve pressure demanded by the driver falls to near zero, or until the vehicle velocity decreases to below some cut-off velocity.

Logical Variables

Each of the eight inequalities has assigned to it a logical variable that is defined as TRUE if the inequality is satisfied as shown; FALSE if not. In other words, if $F_i \geq 0$, then the logical variable L_i associated with F_i assumes the value TRUE. If $F_i < 0$, then L_i assumes the value FALSE. Since there are four inequalities for the generation of the "OFF" signal, there are four logical variables associated with the "OFF" signal. The purpose of these logical variables is to facilitate the generation of an "OFF" signal by allowing them to be "AND"-ed and "OR"-ed together by the program user. If, for example, the user had decided that F_1 and F_2 must be satisfied or else F_3 or F_4 be satisfied (F_1, F_2, F_3, and F_4 having been previously defined by the data set selected by the user), the proper "OFF" signal would be defined by the following expression:

$$\text{OFF} = (L_1 \text{ AND } L_2) \quad \text{OR} \quad (L_3 \text{ OR } L_4) \ .$$

The same discussion applies to the "ON" signal and associated logical variables L_5, L_6, L_7, and L_8.

The user specifies the logical operations between L_1 and L_2, L_3, and L_4, and between the bracketed expressions by means of three logical operator switches, OP_{12}, OP_{34}, and OP_{23}, respectively. Input values of 0 imply logical "OR" operations; values of 1 imply logical "AND" operations. The same rules apply to logical variables L_5, L_6, L_7, L_8 and their logical operator switches OP_{56}, OP_{78}, and OP_{67}. The general forms of these logical equations are:

$$OFF = (L_1 \; OP_{12} \; L_2) \; OP_{23} \; (L_3 \; OP_{34} \; L_4) \tag{D-3}$$

and

$$ON = (L_5 \; OP_{56} \; L_6) \; OP_{67} \; (L_7 \; OP_{78} \; L_8) \tag{D-4}$$

The user is required to input data only for the number of inequality expressions needed. The details relating to data input for the inequality expressions and logical operators are explained in Section D.7 .

Time Delays

Four programmable time delays are available in the control logic. The first time delay, τ_1, is the delay between the evaluations of F_1 and the evaluations of either F_2, F_3, or F_4. The second time delay, τ_2, is the delay between the time of generation of the "OFF" signal and the time that F_5 may be evaluated in the generation of the next "ON" signal. τ_3 is the delay between the time of evaluation of F_5 and the time of evaluation of either F_6, F_7, or F_8. τ_4 is the delay between the time of generation of the "ON" signal and the time that F_1 may be evaluated in the generation of the next "OFF" signal. For time delay effects other than those described here, the one-shot variables (Section D.6) may be employed.

Example

A brief example covering the above outlined features should prove helpful. Consider an antilock system which generates an "OFF" signal subject to the following laws:

1) $\dot{\omega} \leq -50 \text{ ft/sec}^2$

and 2) at a time .05 second after (1) is satisfied, $\omega \leq .9\,\dot{x}$ must also be satisfied.

Suppose the corresponding "ON" signal must satisfy the following requirements

3) $\dot{\omega} \geq -.5 \text{ ft/sec}^2$

and 4) at a time .02 second after (3) is satisfied, $\omega \geq .8\,\dot{x}$ must also be satisfied.

Suppose also that once the "ON" signal is generated during any cycle, the test for the next "OFF" signal must not take place for at least 0.1 second, guaranteeing a certain amount of brake on-time.

Rewriting (1) as

$$F_1 = -\dot{\omega} - 50 \geq 0$$

$$c_{11} = -1.0$$

$$c_{12} = -50.$$

The variable I.D. codes for v_{11} and v_{12} would be "4" and "1," corresponding to OMEGADOT and the unity parameter from the user dictionary.

Similarly, for (2),

$$F_2 = -\omega + .9\,\dot{x} \geq 0$$

$$c_{21} = -1.0$$

$$c_{22} = .90$$

The variable I.D. codes for v_{21} and v_{11} would be "3" and "5".

Since F_3 and F_4 are not required, no input for these expressions would be needed. OP_{12} should be entered as 1 since OFF = L_1 AND L_2. OP_{23} and OP_{24} have no meaning here and can therefore be either 0 or 1. The time delay between F_1 and F_2 implies $\tau_1 = 0.05$. Since there is no time delay specified between the generation of the "OFF" signal and the evaluation for the next "ON" signal, $\tau_2 = 0.0$.

Similarly, for the "ON" criteria, (3) may be rewritten as

$$F_5 = \dot{\omega} + 5 \geq 0$$

$c_{51} = 1.0$

$c_{52} = 5.0$

With variable I.D. codes for v_{51} and v_{52} of "4" and "1".

Likewise

$$F_6 = \omega - .8\,\dot{x} \geq 0$$

$c_{61} = 1.0$

$c_{62} = -.8$

With variable I.D. codes for v_{61} and v_{62} of "3" and "5".

Since F_7 and F_8 are not required, no input for these expressions would be needed. OP_{56} should be entered as 1 for the required "AND" operation, while OP_{67} and OP_{78} are meaningless here and can be either 0 or 1. The time delay between F_5 and F_6 requires $\tau_3 = 0.02$. The time delay between the "ON" signal and the test for the next "OFF" signal requires $\tau_4 = 0.10$.

Adaptive Coefficients

Many antilock systems possess adaptive capabilities for changing coefficients involved in their control logic. For this reason, and increased programming flexibility, an adaptive coefficient feature is provided for in this program. Each coefficient, C_{ij}, involved in the inequality expressions may be altered to change its value as a function of one or two dictionary variables in the manner shown in Figures D-6 and D-7.

In Figure D-6, the value of C_{ij} is A_0 (its initial value), if $u_{ij} < b_1$. If u_{ij}, the adaptive variable, is <u>greater than</u> its breakpoint value of b_1, C_{ij} is equal to A_1.

If two adaptive variables are involved, as illustrated in Figure D-7,

$$C_{ij} = \begin{cases} A_0 & \text{if} \quad u_{ij} \leq b_1 \quad \text{and} \quad z_{ij} \leq b_2 \\ A_1 & \text{if} \quad u_{ij} > b_1 \quad \text{and} \quad z_{ij} \leq b_2 \\ A_2 & \text{if} \quad z_{ij} > b_2 \end{cases} \tag{D-5}$$

By including an additional numerical switch in the input, the two adaptive variable case may be altered to:

$$C_{ij} = \begin{cases} A_0 & \text{if} \quad u_{ij} \leq b_1 \\ A_1 & \text{if} \quad u_{ij} > b_1 \quad \text{and} \quad z_{ij} \leq b_2 \\ A_2 & \text{if} \quad u_{ij} > b_1 \quad \text{and} \quad z_{ij} > b_2 \end{cases} \tag{D-6}$$

as illustrated in Figure D-8.

The details of the numerical input format are explained in Section D.7.

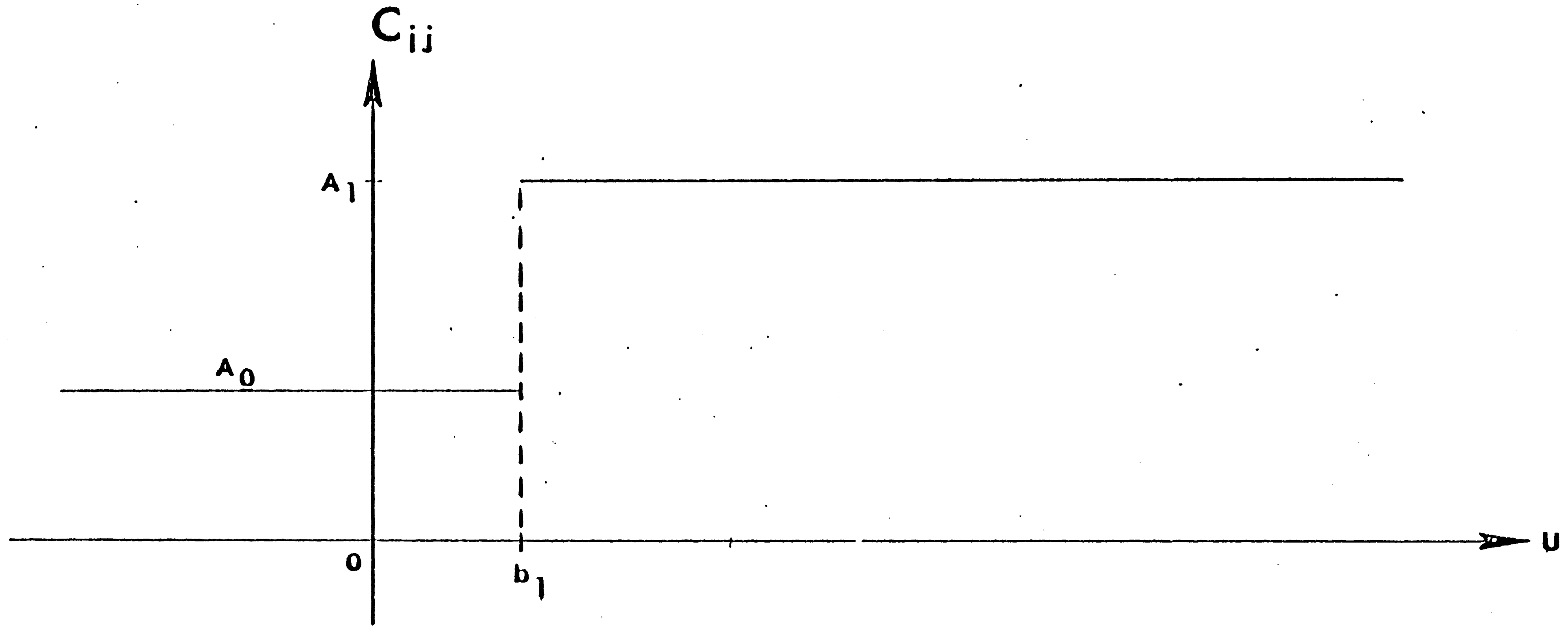


Figure D-6.

$$C_{ij} = \begin{cases} A_0 \ , \text{ if } u_{ij} \le b_1 \text{ and } z_{ij} \le b_2 \\ A_1 \ , \text{ if } u_{ij} > b_1 \text{ and } z_{ij} \le b_2 \\ A_2 \ , \text{ if } z_{ij} > b_2 \end{cases}$$

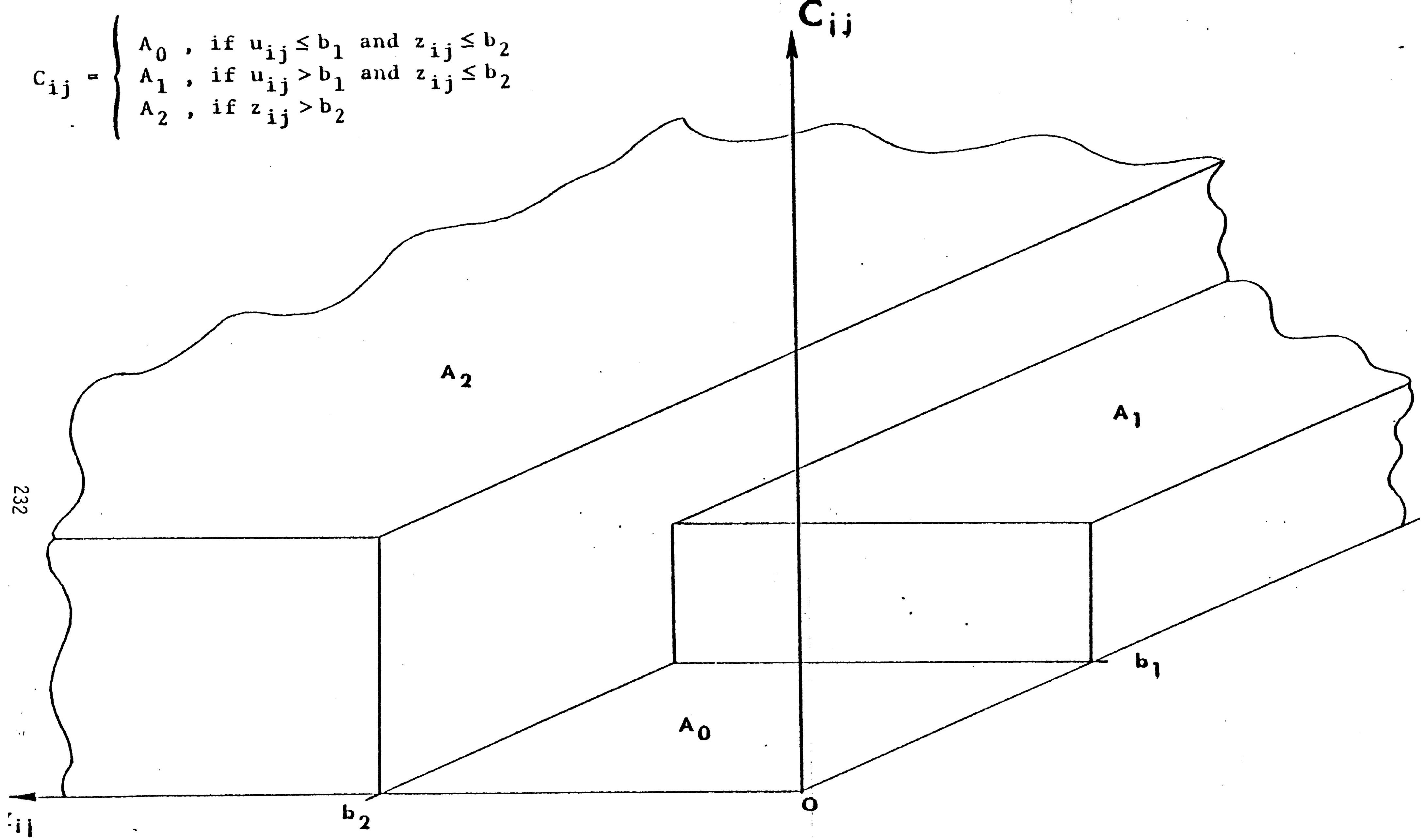


Figure D-7. Adaptive coefficient feature.

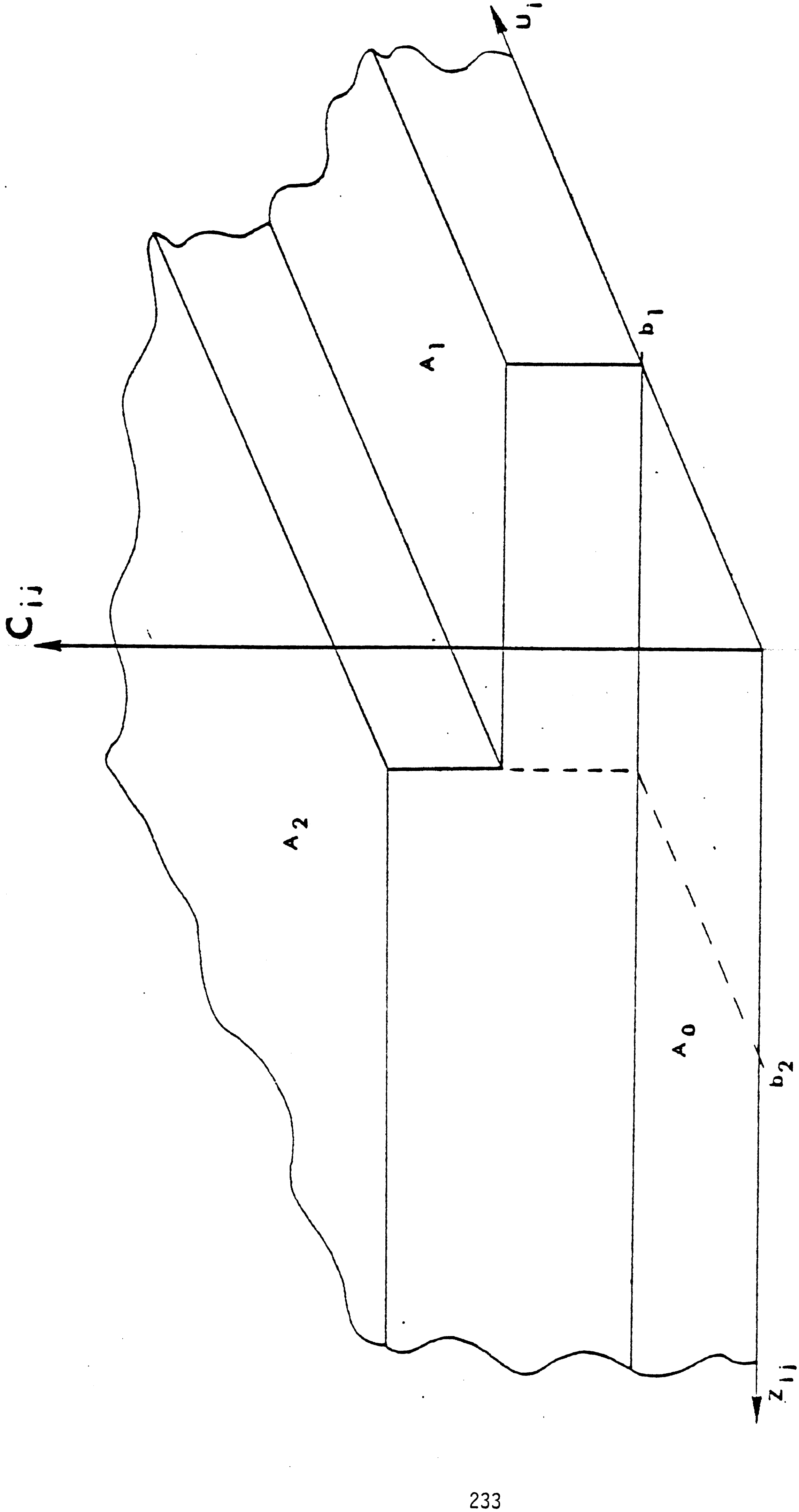


Figure D-8.

Side-to-Side Options

Three different side-to-side options per axle are available. One antilock system is allowed for each axle with the same pressure being returned to both sides for each of the available options. These are summarized below:

OPTION 1 - Worst Wheel. The wheel having the lowest rotational rate (omega) for a given axle is selected by the control logic as its input. The same pressure is returned to both sides based on this input.

OPTION 2 - Best Wheel. Same as Option 1 except that the wheel with the highest rotational rate is selected as input.

OPTION 3 - Average Wheel. Both wheel rates are averaged by the control logic module and used as input. The same pressure is returned to both sides.

See Section D.7 for the numerical input and format required for each option.

Logic Sampling Rate Control

The program user is asked to specify a logic sampling period, TSMPLE, which controls the rate at which the antilock logic is interrogated. If TSMPLE is specified to be less than or equal to the digital simulation time step, then no sampling rate control is in effect. If, however, a logic sampling period greater than the digital simulation time step is called for, all control logic and special option features pertaining to the control logic module are interrogated at time intervals set by the logic sampling period, TSMPLE. Wheel sensor computations and pressure modulator activities are not affected.

For vehicle velocities less than 7 ft/sec, the antilock simulation is inactivated and line pressures will follow the treadle pressure.

D.5. Pressure Modulator. The pressure modulator valve is simulated by two time delays and several programmable rise and fall rates for both exponential and linear characteristics. The programmable rise and fall rates make possible the simulation of relatively complex pressure modulator activity including designs involving pneumatic logic or pulse-width modulators.

Time Delays

The input received by the pressure modulator is simply the "ON" and "OFF" signals generated in the control logic module. Once a control signal is received there is normally a time delay before actual pressure reduction or increase takes place. These time lags are denoted in the simulation as τ_{ON} and τ_{OFF} and are program inputs specified by the user.

Exponential Fall and Rise Rates

The pressure rise is defined to be exponential in time with the upper pressure limit set by the treadle valve output or by a programmable limit PDRSE offered as a special option and explained in Section D.6. Likewise, the pressure fall is exponential in time with its lower limit as zero pressure or by a programmable lower limit, PDFALL, offered as a special option and defined in Section D.6. As many as three pressure fall rates and three rise rates can be programmed. The fall and rise rates referred to are defined as the inverse of the time constants associated with the exponential pressure rise and fall.

The three exponential fall rates are denoted as PFE_i, (i=1,3); the three exponential rise rates are defined as PRE_i, (i=1,3). For reasons of flexibility these fall and rise rates are defined to be functions of variables denoted as ε_1 and ε_2, respectively. ε_1 and ε_2 are defined by the general form expressions:

$$\varepsilon_1 \triangleq H_1 v_1 + H_2 v_2 + H_3 v_3 + H_4 v_4 w_4 + H_5 v_5 w_5$$

$$\varepsilon_2 \triangleq G_1 v_1 + G_2 v_2 + G_3 v_3 + G_4 v_4 w_4 + G_5 v_5 w_5$$

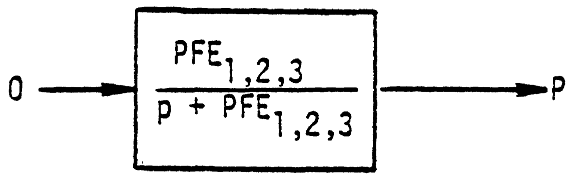
where H_i and G_i, (i=1,5) are the constant coefficients of each term, and v_j and w_k, (j=1,5; k=4,5) are variables/parameters available in the user dictionary.

These relationships are shown in Figures D-9 and D-10. The break-points X_1, X_2, X_3, and X_4 along the ε_1 and ε_2 axes separate the fall and rise rate regions.

In terms of transfer function notation, the above relationships can be expressed as:

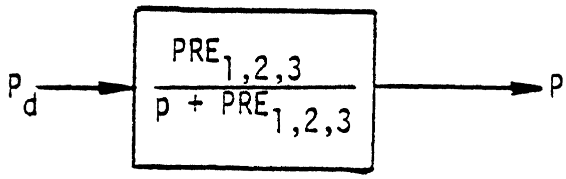
<u>Pressure Fall:</u>

PDFALL or



<u>Pressure Rise:</u>

PDRISE or



where $PFE_{1,2,3}$ and $PRE_{1,2,3}$ defined above are functions of ε_1 and ε_2, respectively, and p is an operator denoting differentiation with respect to time.

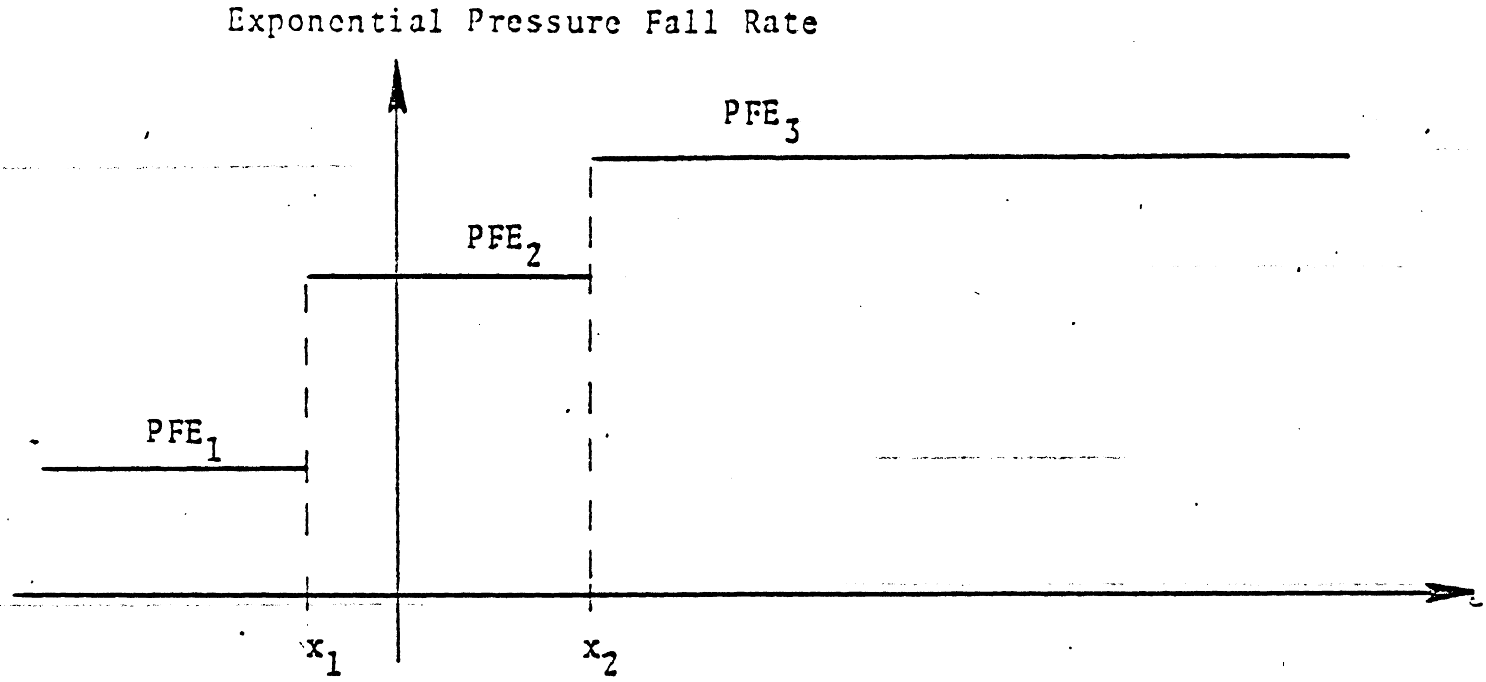


Figure D-9.

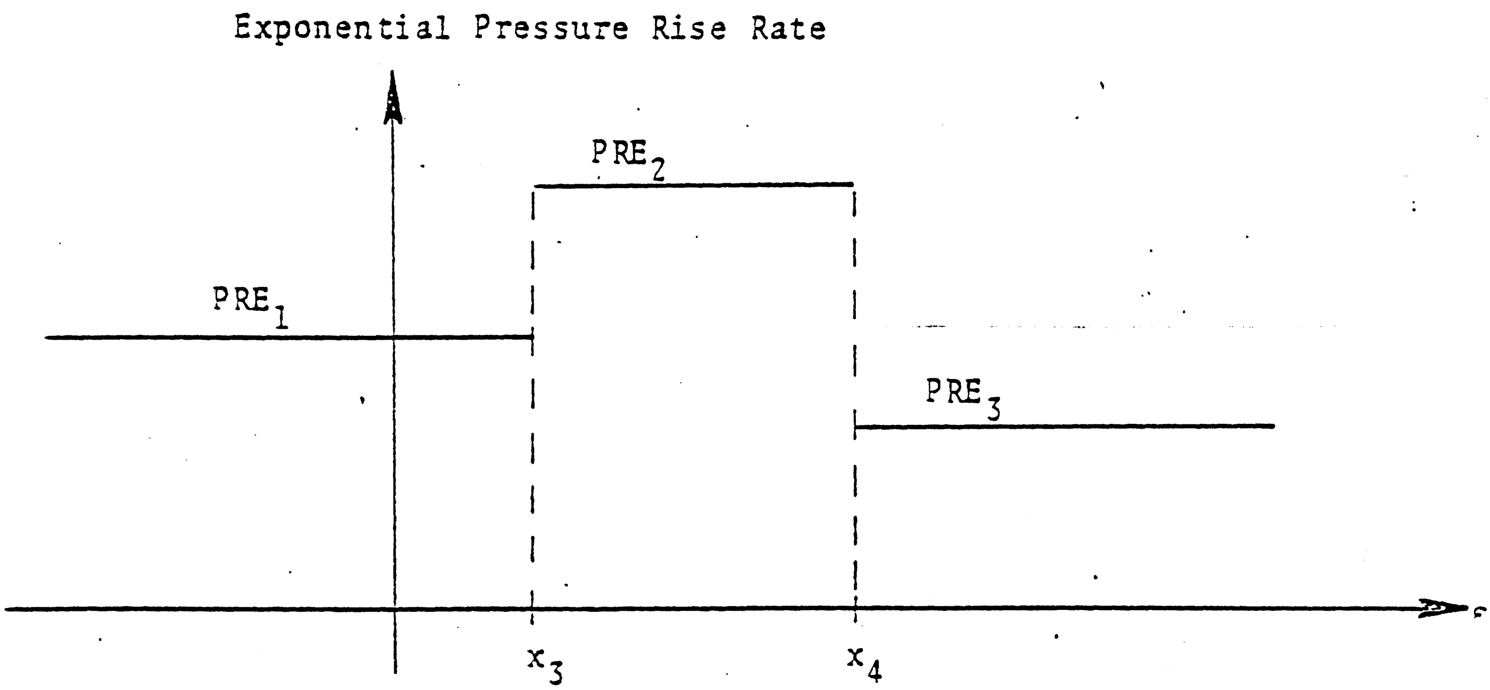


Figure D-10.

Linear Fall and Rise Rates

The pressure fall and rise, under this option, is linear in time with an upper limit as treadle pressure, P_d, and a lower limit as zero pressure. Three fall rates and three rise rates may be specified as in the exponential case. The linear fall and rise rates are denoted as PFL_i and PRL_i , (i=1,3), respectively. Again, for programming flexibility, the linear fall and rise rates are defined as functions of variables denoted as ε_3 and ε_4, respectively. ε_3 and ε_4 are defined by the general form expressions:

$$\varepsilon_3 \triangleq R_1 v_1 + R_2 v_2 + R_3 v_3 + R_4 v_4 w_4 + R_5 v_5 w_5$$

$$\varepsilon_4 \triangleq S_1 v_1 + S_2 v_2 + S_3 v_3 + S_4 v_4 w_4 + S_5 v_5 w_5$$

where R_j and S_j , (j=1,5) are the constant coefficients of each term, and v_j w_k , (j=1,5; k=4,5) are variables/parameters available in the user dictionary. These relationships are illustrated in Figures D-11 and D-12. The pressure returned is given simply by the following two equations:

$$P(t-t_o) = [PFL_i(\varepsilon_3)] \cdot (t-t_o) + P(t_o) \quad ; \quad \text{(fall)}$$

$$P(t-t_o) = [PRL_i(\varepsilon_4)] \cdot (t-t_o) + P(t_o) \quad ; \quad \text{(rise)}$$

X_5, X_6, X_7, and X_8 are the associated break-points similar to the exponential case.

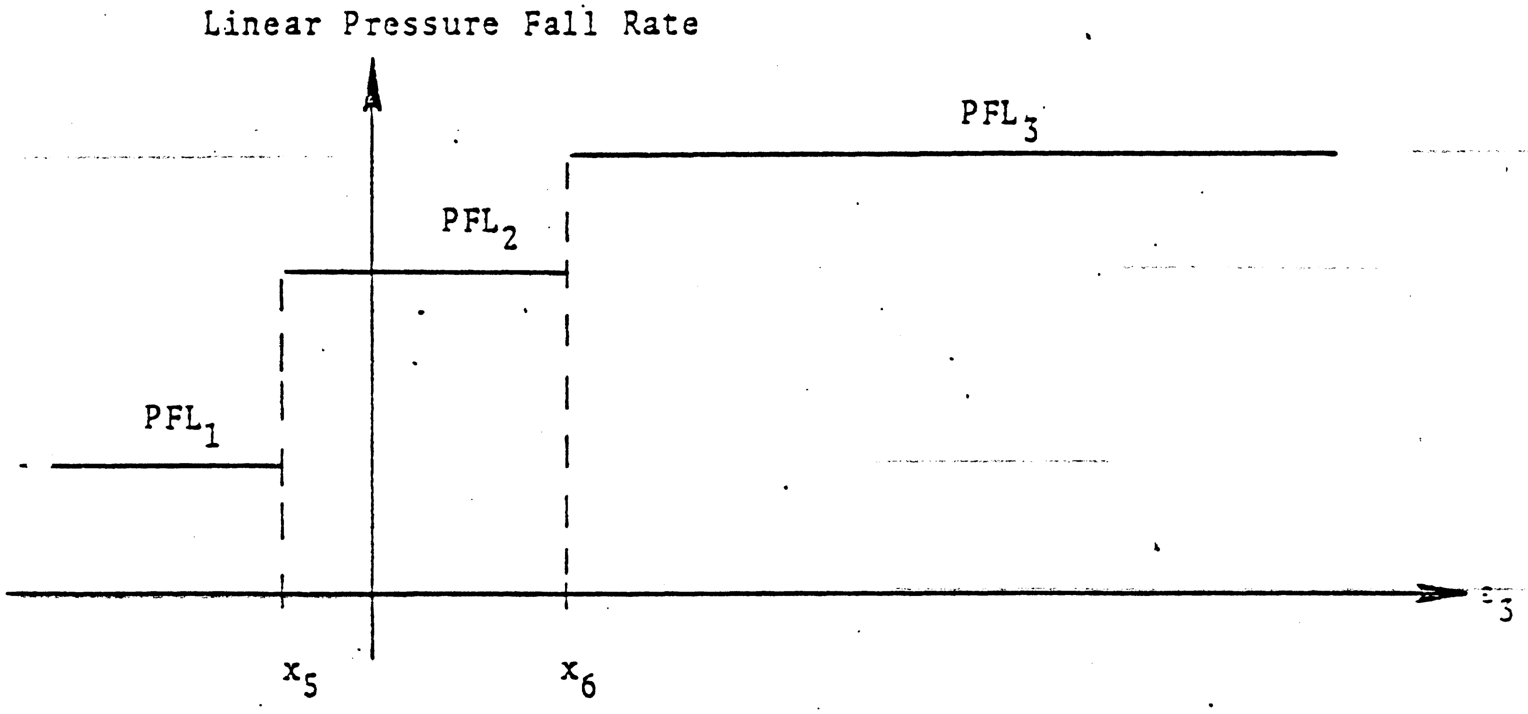


Figure D-11

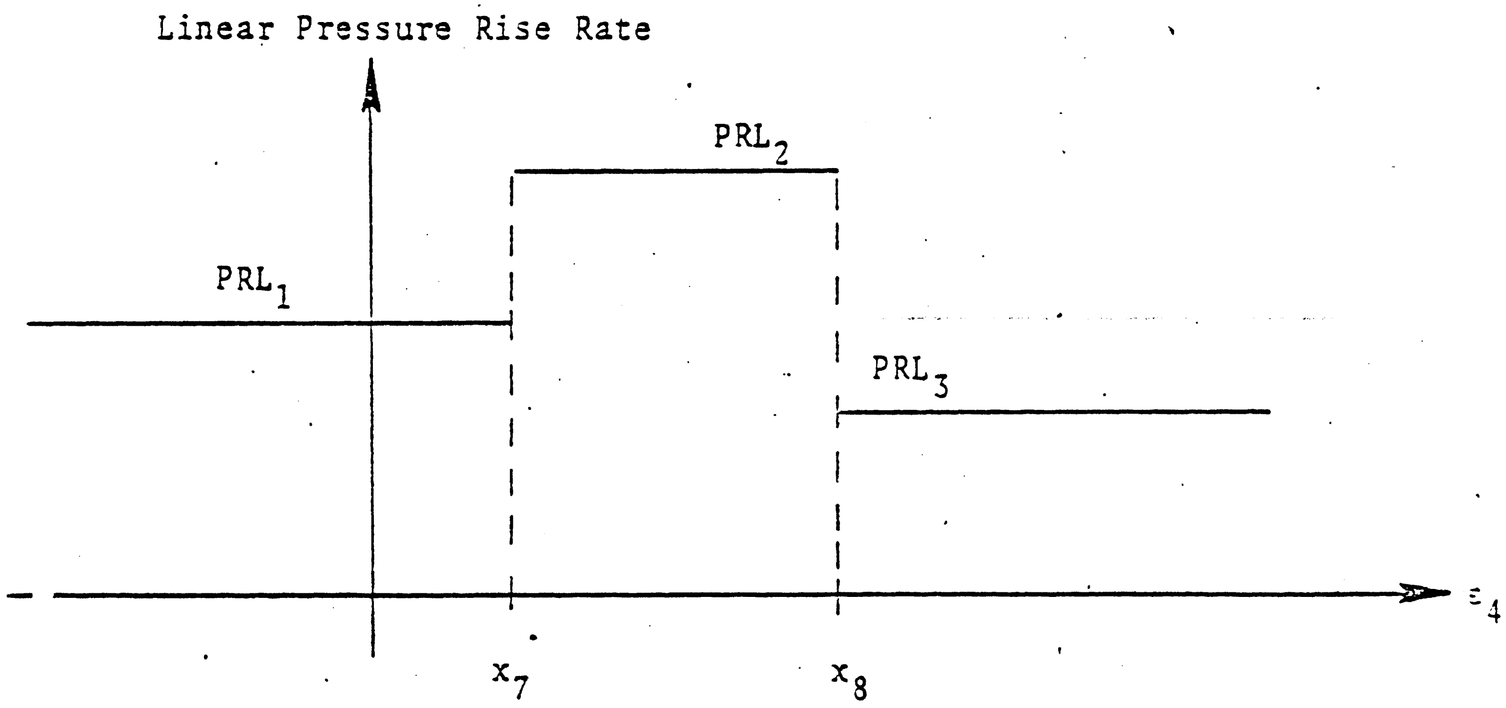


Figure D-12

Pressure Modulator Key

A pressure modulator key, IPKEY, is read during input just prior to any data related to the pressure modulator. The value of this key distinguishes for the program whether exponential, linear, or both exponential and linear characteristics will be computed. The following key defines the IPKEY values required for each case:

$$\text{IPKEY} = \begin{cases} 0 \quad , & \text{exponential} \\ 1 \quad , & \text{linear} \\ 2 \quad , & \text{exponential and linear} \end{cases}$$

The exponential and linear option (IPKEY=2) returns a pressure representing the summation of the exponential and linear pressure computations.

Finally, all coefficients appearing in the general form expressions for the pressure modulator possess the adaptive coefficient feature.

Example

Consider the following example of a certain pressure modulator having only exponential pressure fall and rise characteristics:

1) "ON" delay = "OFF" delay = 0.05 seconds.

2) The exponential pressure rise rate assumes an approximate value of $(0.2)^{-1} = 5.0$ for differences between treadle valve output pressure and line pressure of 50 psi or more, and an approximate exponential rise rate of $(0.33)^{-1} = 3.0$ for pressure differences of less than 50 psi.

3) The exponential pressure fall rate is approximately constant for all line pressure values with a fall rate equal to $(0.25)^{-1} = 4.0$.

This could be simulated by the following choice of input parameters:

$IPKEY = 0$

$\tau_{ON} = 0.05$

$\tau_{OFF} = 0.05$

$H_1 = 1.0 \quad \} \Rightarrow \quad \varepsilon_1 = 1.0$

$G_1 = -1.0 \; , \; G_2 = 1.0 \quad \} \Rightarrow \quad \varepsilon_2 = P_d - P$

Variable I.D. code for P_d = 31.

Variable I.D. code for P = 35.

See User Diectionary

$X_1 = X_2 = 0.0$

$PFE_1 = PFE_2 = PFE_3 = 4.0$

$X_3 = 0.0 \; , \; X_4 = 50.0$

$PRE_1 = PRE_2 = 3.0 \; , \; PRE_3 = 5.0$

The number of terms required for ε_1, (1 term) and ε_2 (2 terms) would also be required as input as explained in Section D.7.

D.6. Special Options. Five special options have been included in the model in order to facilitate simulation of certain features displayed in some actual antilock systems while also providing increased programming flexibility. The five options referred to are: (1) treadle pressure modulation/programming, (2) pulse-width modulated square wave, (3) five programmable one-shots, (4) general purpose counter, and (5) general purpose variables. Each of these options will be explained in the following sections.

Treadle Pressure Modulation/Programming

Most pressure valves operating without antilock interruption, and many under antilock cycling, follow or are limited above by the treadle pressure application; while similarly, the output pressure of these valves fall to treadle pressure or zero pressure when treadle pressure is decreased or removed. However, in some valves, during antilock cycling, pressure may rise to some limiting pressure less than treadle and/or fall to some pressure greater than zero. Such treadle modulation or programming of demanded pressure is a feature which is allowed for under this option.

Prior to any input for this option, a key, IPDKEY, for treadle pressure modulation, is read. A value of -1 or less negates the use of this option, while values greater than or equal to 0 activate the option. Variables PDFALL and PDRISE become the demanded pressure during pressure fall and rise periods, respectively. These variables are defined by the following general form expressions:

$$\text{PDFALL} \triangleq V_1 v_1 + V_2 v_2 + V_3 v_3 + V_4 v_4 w_4 + V_5 v_5 w_5$$

$$\text{PDRISE} \triangleq W_1 v_1 + W_2 v_2 + W_3 v_3 + W_4 v_4 w_4 + W_5 v_5 w_5$$

where,

> V_j and W_j , (j=1,5) are constant coefficients for each term. The adaptive coefficient feature is provided for these coefficients.
>
> v_j, w_k , (j=1,5; k=4,5) are variables/parameters selected from the user dictionary.

As an example, suppose an antilock system operated so as to always rise to the maximum pressure attained in the previous cycle rather than to treadle pressure. PDRSE would then be defined as simply

$$\text{PDRSE} = (1.0)\ \text{POFF1}$$

where 1.0 is W_1 and POFF1, the maximum pressure from the last cycle, is selected from the user dictionary for v_1. In this case, the coefficient, 1.0, and the variable I.D. code for POFF1, 7, would be required as input for the option.

Pulse-Width Modulated Square Wave

A time, or pulse-width, modulated square wave is provided as an option for general use. This option was motivated by a particular antilock system known to possess such a feature for purposes of treadle pressure modulation. The square wave generated under this option can be used in any portion of the program and is available in the user dictionary under the name SQUARE. Figure D-13 illustrates the parameter and variable relationships which define the square wave. The period of the suqare wave, PERIOD, is constant. The amount of time modulation, represented by TMOD, may be variable and programmable. This is accomplished in the program by allowing the ratio, TMOD/PERIOD, to be a tabular function of a variable, ε_5, as shown in Figure D-14. ε_5 is defined as a general form expression:

$$\varepsilon_5 = PW_1 v_1 + PW_2 v_2 + PW_3 v_3 + PW_4 v_4 w_4 + PW_5 v_5 w_5$$

where

PW_i , (i=1,5) are constant coefficients for each term. The adaptive coefficient feature is provided for these coefficients.

v_i, w_k , (i=1,5; k=4,5) are variables/parameters selected from the user dictionary.

Note that the FZ_i values in the TMOD/PERIOD table should not be greater than 1.0 or less than 0.0. Values of 1.0 ideally signify 100% modulation; values of 0.0, no modulation. (In

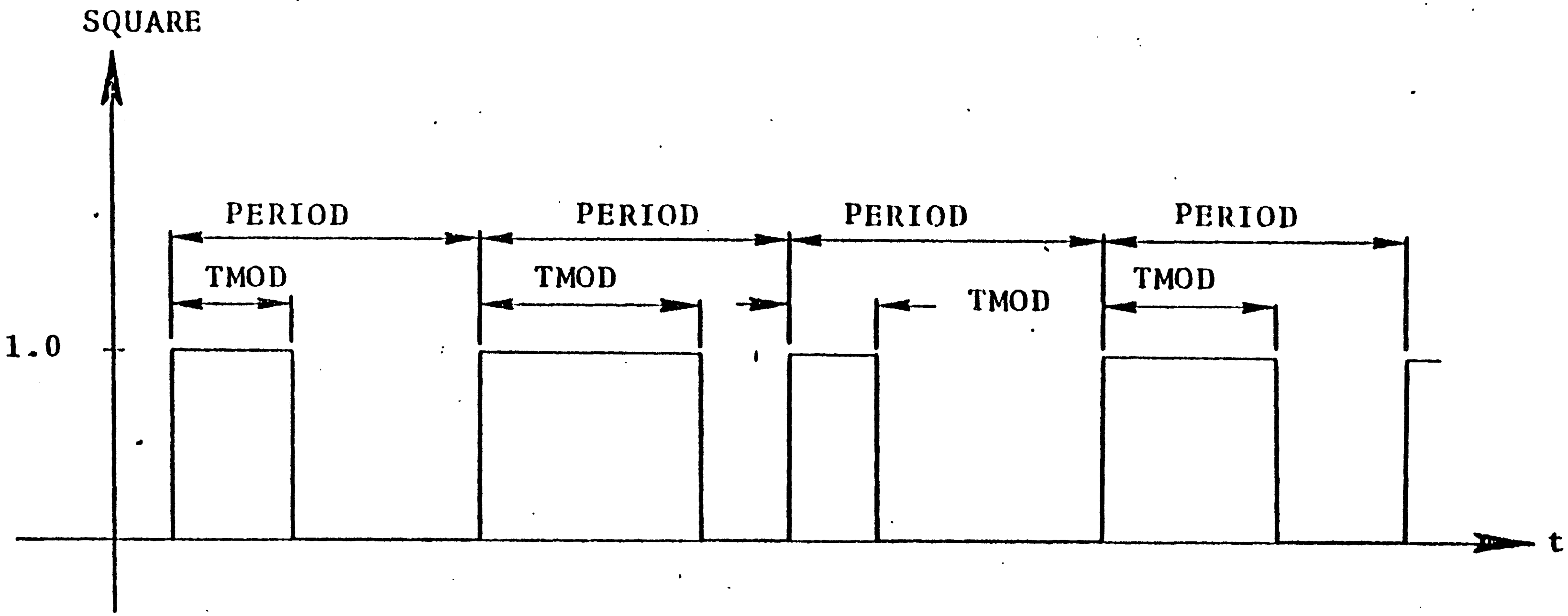


Figure D-13. Pulse-width modulated square wave.

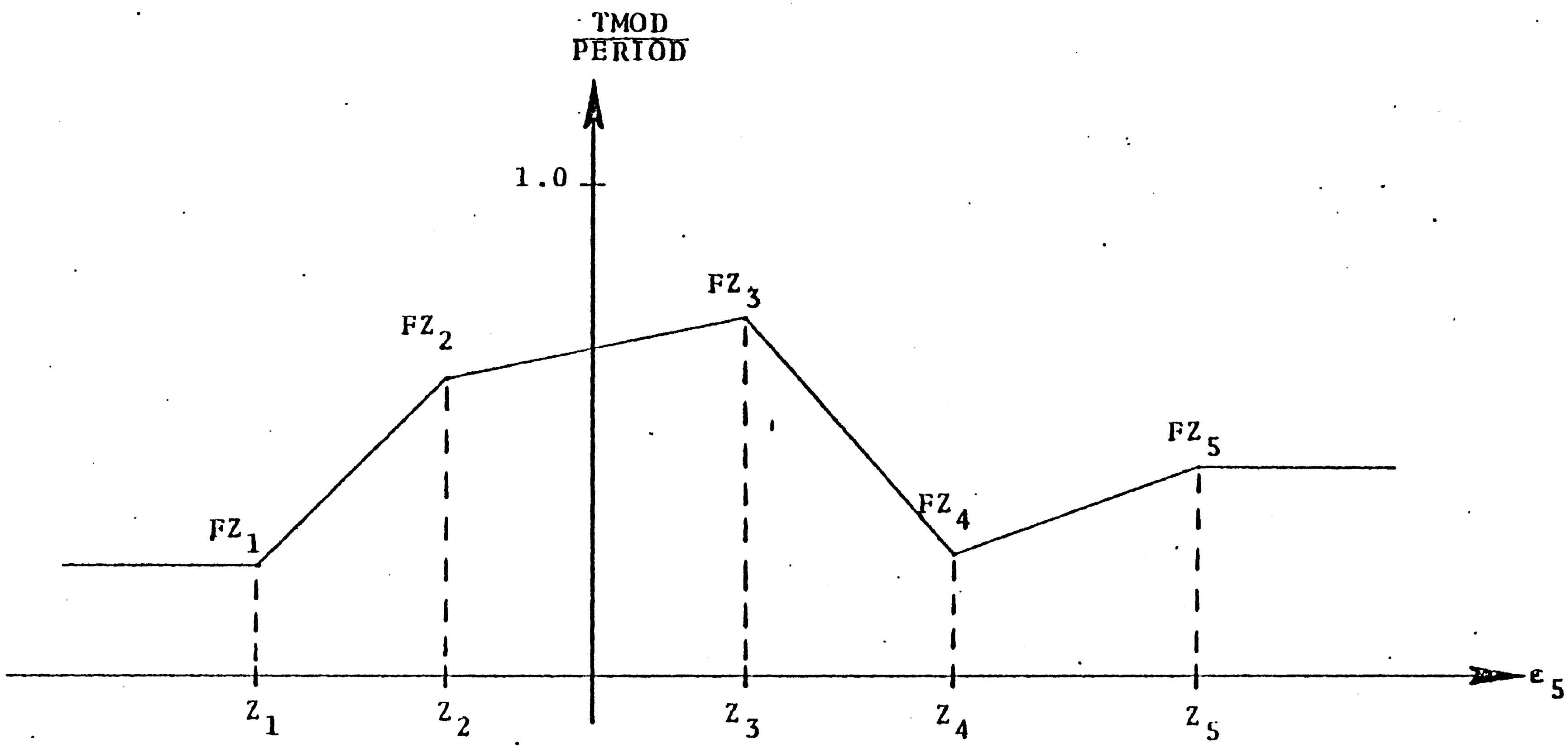


Figure D-14. Pulse-width table.

actuality, the degree of modulation attainable depends on the simulation time step used and the period chosen for the square wave.)

Input data required for this option includes: (a) five pairs of FZ_i and Z_i, (b) PERIOD, and (c) coefficient values and variable I.D. codes used in the general form expression for ε_5. As before, a key for the pulse-width modulation option, IPWMKY, is read prior to any input for this option. IPWMKY values greater than or equal to 0 enable the option.

If desired, two additional sets of FZ_i values may be input. Each set is associated with a specific variable/parameter chosen by the user from the dictionary and a break-point for that variable/parameter. If the specified variable exceeds the break-point value for the given FZ_i set, that FZ_i set replaces the original or previous set used by the program. The purpose of this is to allow for some adaptive capability within the FZ_i table, if desired. The details of the numerical input for this adaptive option are explained in Section D.7.

<u>One-Shots</u>

Three programmable one-shots are provided under this option and can be used for several different purposes. Two common uses are: (1) simulating time delay effects and (2) as auxiliary binary variables for use in any general purpose expressions. The three one-shots, as defined in this document, are binary variables having the numerical value of 1.0 or 0.0. These are available in the user dictionary under the names FOS1, FOS2, and FOS3.

The one-shots used in the program operate according to the following rule: If a trigger or input condition (inequality) changes from <u>negative</u> to <u>positive</u>, the one-shot will change its value from 0.0 to 1.0 for a fixed length of time, specified by the user, then return to 0.0. During a one-shot firing (1.0

value), the trigger input is disabled and cannot effect recurrent firings from this state. The one-shot is reset for another firing by two necessary occurrences: (1) the time duration of the present one-shot firing has been exceeded, followed by or concurrent with, (2) the trigger condition being negative. A trigger condition value of 0.0 is interpreted by the program as <u>positive</u>. See Figure D-15.

The one-shot can also be reset by a clear command which is programmed similarly as the trigger condition. It may be used to override any current trigger command to clear or reset the one-shot. The one-shot is reset whenever the clear condition is positive or zero. The clear condition is always evaluated after the trigger condition at each program time step.

The trigger condition is defined by the general form expression:

$$OS_1v_1 + OS_2v_2 + OS_3v_3 + OS_4v_4w_4 + OS_5v_5w_5 \geq 0$$

where

OS_i (i=1,5) are constant coefficients for each term and possess the adaptive coefficient feature.

v_i, w_k (i=1,5; k-4,5) are variables/parameters from the user dictionary.

The clear condition is defined by the general form expression:

$$RIDCL_1V_1 + RIDCL_2V_2 + RIDCL_3V_3 + RIDCL_4V_4W_4 + RIDCL_5V_5W_5 \geq 0$$

where

$RIDCL_i$ (i=1,5) are constant coefficients for each term and possess the adaptive coefficient feature.

V_i, W_k (i-1,5; K=4,5) are variables/parameters from the user dictionary.

Each one-shot trigger and clear command is programmable by a general form expression as shown above. The one-shot time durations are denoted as TOS1,.....,TOS5 and are required as input for each one-shot used.

<u>General Purpose Counter</u>

This option allows the user to generate a count sequence by incrementing a counter by 1 every digital time step, if a particular inequality expression is greater than or equal to 0. The variable

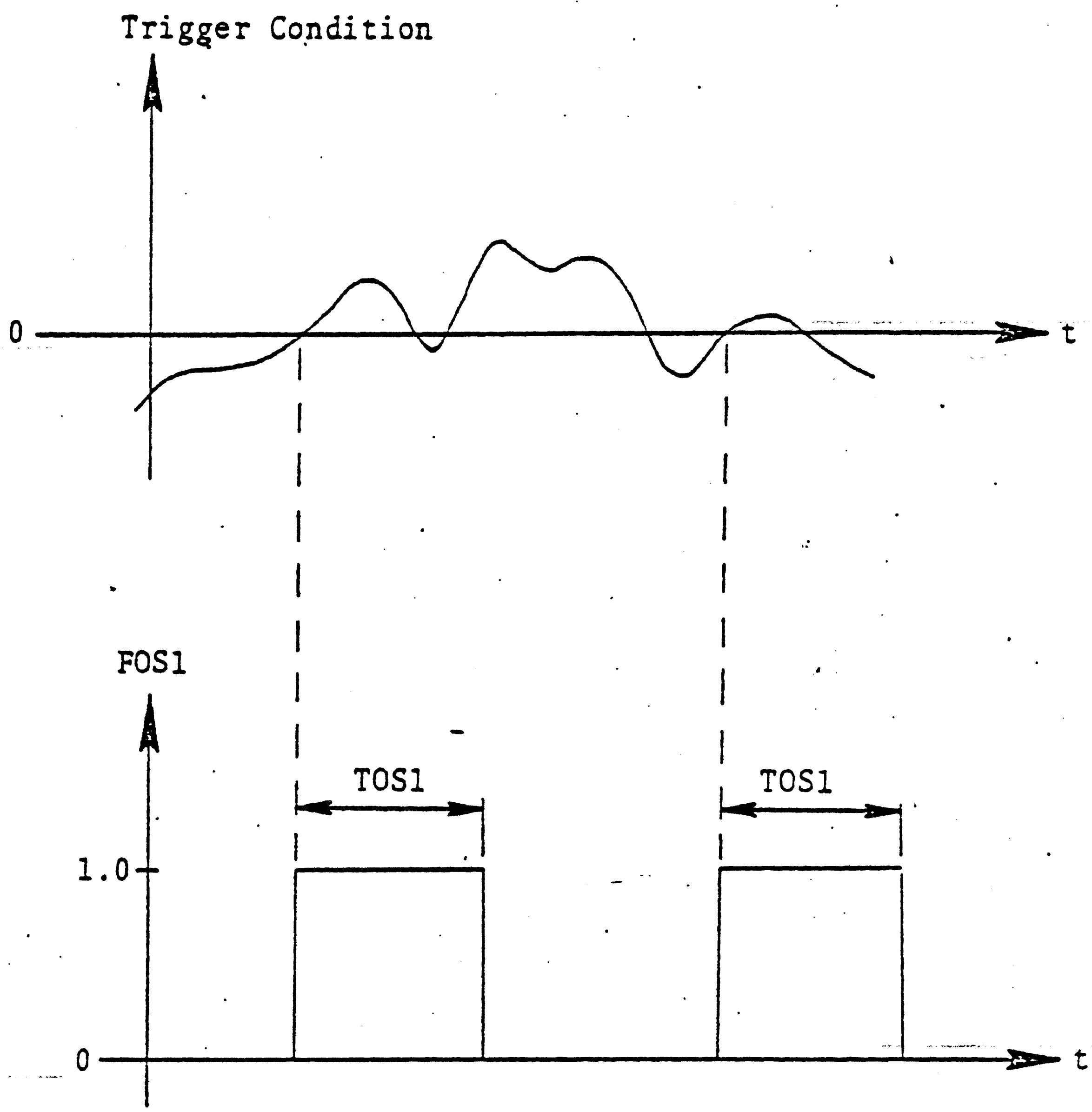


Figure D-15. One-shot operation. (Clear condition < 0) containing the count is called GPCNT and is in the user dictionary with the I.D. code 44. The general form expression is given by

$$GP_1v_1 + GP_2v_2 + GP_3v_3 + GP_4v_4w_4 + GP_5v_5w_5 > 0$$

where

GP_i (i=1,5) are constant coefficients for each term and can be adaptive.

v_i, w_k (i=1,5; k-4,5) are variables/parameters from the user dictionary.

If the above inequality is satisfied, the GPCNT count is incremented <u>each time step</u>. If only a one count increment is desired whenever a particular condition is satisfied, then a one-shot could be fired for a time period equal to or less than the digital time step, with the general purpose counter incrementing itself every one-shot firing.

The above discussion applies whenever the logic sampling period is specified as less than or equal to the digital simulation time step. If the user specifies a larger logic sampling period (slower sampling rate), then the general purpose counter will be incremented only each <u>logic sampling period</u>.

The counter can be reset to zero by allowing the inequality expression to become less than or equal to -10,000.

<u>General Purpose Variables</u>

This option allows the program user to define new dictionary variables as linear combinations and products of any other variables available in the dictionary. Each general purpose variable is defined by a general form expression:

$$GPV = GPVV_1v_1 + GPVV_2v_2 + GPVV_3v_3 + GPVV_4v_4w_4 + GPVV_5v_5w_5$$

where

GPV is the general purpose variable

$GPVV_i$ (i=1,5) are constant coefficients for each term and possess the adaptive coefficient feature.

D.7. <u>Input Data Format - General Form Expressions</u>. The most frequently occurring form enountered by the program user is the general form expression which appears in almost every program segment and special option. As discussed in Section D.2, it has the form

$$C_1x_1 + C_2x_2 + C_3x_3 + C_4x_4y_4 + C_5x_5y_5$$

where

C_i (i=1,5) are the constant coefficients of each term.

x_i, y_k (i=1,5; k-4,5) are variables/parameters available in the user dictionary.

The user defines a given general form expression for the program by inputting three different pieces of information: (1) the number of terms in the expression required (1 to 5), (2) the variable I.D. codes corresponding to the x_i, y_k from the user dictionary for each variable/parameter used in constructing the expression, and (3) the coefficients of each term, C_i, used in the expression. The following data input sequence is what would be required for defining a general form expression:

NT	, number of terms	; I1 format
(I.D. code of x_1)		; F10.4 format
(I.D. code of x_2)		; F10.4 format
(I.D. code of x_3)		; F10.4 format
(I.D. code of x_4),(I.D. code of y_4)		; 2F10.4 format
(I.D. code of x_5),(I.D. code of y_5)		; 2F10.4 format
Coefficient of x_1		; F10.4 format
Coefficient of x_2		; F10.4 format
Coefficient of x_3		; F10.4 format
Coefficient of x_4y_4		; F10.4 format
Coefficient of x_5y_5		; F10.4 format

If NT is 5, the above format is used. If NT = M < 5, only M I.D. code cards and M coefficient cards are required. Note that the second fields of the I.D. code cards are used only for the 4th and 5th terms. The 4th and 5th terms allow for quadratic representations, but can be linear if one of the two variable I.D. codes is selected as 1.0 (unity parameter).

Constant terms are represented by the unity parameter, 1.0, and the desired constant coefficient.

As an example, consider the general form expression, $\dot{x} - \omega - 10$. The required input for this would be:

3	number of terms required; I1 format
5. 3. 1.	variable I.D. codes from the user dictionary corresponding to $\dot{x}$, ω, and the constant; F10.4 format
1. -1. -10.	the C_i coefficients for each of the terms; F10.4 format

<u>Adaptive Coefficient Input Format</u>

As explained in Section D.4, an adaptive coefficient feature exists to allow the coefficients appearing in the general form expressions to change value as a function of one or two variables from the user dictionary and their associated break-points. The third and fourth fields (columns 21-30, 31-40) of each variable I.D. input card are used to identify the variable(s) to which the corresponding term's coefficient is adaptive. Similarly, the fourth and fifth fields (columns 31-40, 41-50) of each coefficient card are used for specifying their associated break-points. The alternate coefficients are specified in the second and third fields (columns 11-20, 21-30) of each coefficient card. Consider the example from the previous section and suppose it was desired to alter the coefficient of $\dot{x}$, i.e., 1., to values of .5, and .2 according to the following rule:

$$\text{Coefficient of } \dot{x} = \begin{cases} 1.0 & \text{initial or nominal value} \\ 0.5 & \text{whenever } \dot{\omega} > 25 \text{ and} \\ & t \leq 2.0 \\ 0.2 & \text{if } t > 2.0 \end{cases}$$

The input required would now become:

3

5. , ; 4. , 2. ,

3.

1.

1. , 0.5 , 0.2 , 25. , 2.0 ,

-1.

-10.

where the numbers 4. and 2. are the I.D. codes for $\dot{\omega}$ and t, respectively, and occur on the I.D. card for $\dot{x}$ in fields 3 and 4.

If only one adaptive variable is required, then field 4 of the I.D. code card and fields 3 and 5 of the coefficient card should not be used. Negative I.D. codes are permitted for the adaptive variables. This will cause the program to invert the sign of the adaptive variable. It would be used if one found it more convenient to have the adaptive condition, $u_{ij} > b_1$, interpreted as

$$-u_{ij} > -b_1 \quad , \quad (u_{ij} < b_1).$$

Reference was made in Section D.4 to a numerical switch which allows the adaptive coefficient feature to be defined by Equation (D-6) rather than by Equation (D-5). If this optional definition is desired, any negative number should be entered in field 2 (columns 11-20) of the variable I.D. card. Normally, this field is not used except when 4 or 5 terms are needed in a general form expression. In the case of a 4th or 5th term <u>and</u> the optional definition, the <u>negative</u> of the variable I.D. code should be used in field 2.

<u>Pulse-Width Modulation Table - Adaptive Capability</u>

The adaptive capability for the FZ_i table is implemented by the following numerical input procedure: If field 6 (column 51-60) of the first FZ_i card is non-zero, two more FZ_i cards are read. Each of these cards maintain the same five fields for the alternate FZ_i input. However, two additional fields are included (columns 51-60, 61-70) and are used to specify the adaptive variable I.D. code and its associated break-point for that card (alternate table). The second alternate card takes precedence over the first alternate in the event both break-points are exceeded. The following sample input is an example:

Z_i card:	-30.	-10.	0.	10.	50.		
1st FZ_i card:	0.	.10	.20	.50	.90	99.	
1st alternate FZ_i card:	0.	.05	.10	.25	.45	5.	50.
2nd alternate FZ_i card:	0.	.025	.05	.12	.22	5.	70.

The number 99. in field 6 for the 1st FZ_i card simply causes the next two cards to be read. Both alternate cards are adaptive in this case to the same variable, vehicle velocity (I.D. code 5; field 6). The respective break-points are 50. ft/sec and 70. ft/sec. The effect of this input is to cause the program to use table 3 for speeds above 70 ft/sec, table 2 for speeds between 70 ft/sec and 50 ft/sec, and table 1 for speeds less than 50 ft/sec. The adaptive variables do not have to be the same, as in the example.

Antilock Input Stream

Before any input data for the antilock subroutine is read, a key parameter (ILOCK) is read to indicate whether or not any wheel of the vehicle possesses an antilock system (see Section 3.6 of the Users Manual). If any or all wheels do, the key parameter (ILOCK) in the input stream should be set to 01 (I2 format). If no antilock system at all is desired, ILOCK should be set to 0. No antilock data should follow ILOCK if ILOCK is 0. For ILOCK set to 01, the following table number and input parameter discussion applies for each wheel on the vehicle train.

A table number not currently in use for a tire, spring, or other antilock table, causes the program to read antilock data for the specified table number. Subsequent wheels on the vehicle train requiring the same antilock data as one previously read, need only enter the same table number. An entry of 0 for any antilock table number implies no antilock system for that wheel.

The following example illustrates the antilock table number usage for a tractor-trailer with tandem rear suspensions on the tractor and trailer. Following an 01 ILOCK entry indicating antilock systems on the vehicle train:

0 0	No antilock on the tractor front axle (left and right wheels)
05	New table number of tractor rear suspension, front tandem axle, left side
. . . .	Antilock data for front tandem axle, left side
05	Same antilock data requested for front tandem, right side
05 05	Same antilock data requested for rear tandem, left and right sides
06	New table number for trailer rear suspensions, front tandem, left side
. . . .	Antilock data for trailer front tandem, left side
06	Same antilock data requested for trailer front tandem, right side
0 0	No antilock data for trailer rear tandem axle, left and right wheels

The numerical inputs for OPTION, the side-to-side option key, are as follows:

OPTION

01 => Worst Wheel

02 => Best Wheel

03 => Average Wheel

04 => Independent Wheel
(I2 format)

The following list defines all the input parameters available for each antilock system used. The parameters required should be entered in the order given below.

It should be noted that this complete listing is presented to define the order and format of any required input data. The program, however, requires only that amount of input data needed to define a particular system.

Input	Description	Format
ILOCK	global antilock key	I2
TN_1	Table number entry for 1st wheel (front axle, left side)	I2
$OPTION_1$	side-to-side option, 1st wheel	I2
WWDIF	side-to-side wheel speed difference operator (see variable I.D. 60 definition)	F10.2
$NOFF_1$	No. of 'OFF' <u>inequalities</u> to follow	I1
M1	No. of terms in 1st inequality	I1
ID_1 . . . ID_{M1}	M1 variable I.D. code cards for logic inequality 1	4F10.4
$C_{1,1}$ . . . $C_{1,M1}$	M1 coefficient cards	5F10.4
M_2	No. of terms in 2nd inequality	I1
ID_1 . . . ID_{M2}	M2 variable I.D. code cards for logic inequality 2	4F10.4
$C_{2,1}$ . . . $C_{2,M2}$	M2 coefficient cards	5F10.4
M_3	No. of terms in 3rd inequality	I1
. . . .	. . . .	

For $NOFF_1$ inequality expressions, $NOFF_1 \leq 4$.

NON_1	No. of 'ON' inequalities to follow	I1
M5	No. of terms in 5th inequality	I1
ID_1 . . . ID_{M5}	M5 variable I.D. code cards for logic inequality 5	4F10.4
$C_{5,1}$ . . . $C_{5,M5}$	M5 coefficient cards	5F10.4
M6	No. of terms in 6th inequality	I1
. . . . . .	. . . . . .	

For NON_1 inequality expressions, $NON_1 \leq 4$.

$\tau_1, \tau_2, \tau_3, \tau_4$	Logic time delays	4F10.4
IPKEY	Pressure modulator key	I1
N1	No. of terms in ε_1 expression (IPKEY=0,2)	I1
ID_1 . . . ID_{N1}	N1 variable I.D. code cards	4F10.4
H_1 . . . H_{N1}	N1 coefficient cards	5F10.4

N2	No. of terms in the ε_2 expressions	I1
ID_1 . . . ID_{N2}	N2 variable I.D. code cards	4F10.4
G_1 . . . G_{N2}	N2 coefficient cards	5F10.4
X_1 X_2	ε_1 break-points	2F10.4
X_3 X_4	ε_2 break-points	2F10.4
PFE1 PFE2 PFE3	exponential fall rates	3F10.4
PRE1 PRE2 PRE3	exponential rise rates	3F10.4
N3	No. of terms in ε_3 expression (IPKEY=1,2)	I1
ID_1 . . . ID_{N3}	N3 variable I.D. code cards	4F10.4
R_1 . . . R_{N3}	N3 coefficient cards	5F10.4
N4	No. of terms in ε_4 expression	I1
ID_1 . . . ID_{N4}	N4 variable I.D. code cards	4F10.4

$S_1 \ldots S_{N4}$	N4 coefficient cards	5F10.4
X_5 X_6	ε_3 break-points	2F10.4
X_7 X_8	ε_4 break-points	2F10.4
PFL1 PFL2 PFL3	linear fall rates	3F10.4
PRL1 PRL2 PRL3	linear rise rates	3F10.4
τ_{ON}, τ_{OFF}	pressure modulator time delays	2F10.4
τ_W, τ_{WD}	wheel rate, acceleration time constants	2F10.4
OP_{12}, OP_{23}, OP_{34}	logical operator switches	3I1
OP_{56}, OP_{67}, OP_{78}	logical operator switches	3I1
IPDKEY	treadle pressure modulator key	I2
N5	No. of terms for PDRISE	I1
$ID_1 \ldots ID_{N5}$	N5 variable I.D. code cards	4F10.4
$W_1 \ldots W_{N5}$	N5 coefficient cards	5F10.4
N6	No. of terms in PDFALL expression	I1
$ID_1 \ldots ID_{N6}$	N6 variable I.D. code cards	4F10.4

V_1 . . . V_{N6}	N6 coefficient cards	5F10.4
IPWMKY	pulse-width modulation key	I2
PERIOD	period of pulse-width modulated square wave	F10.4
N7	No. of terms in ε_5 expression	I1
ID_1 . . . ID_{N7}	N7 variable I.D. code cards	4F10.4
PW_1 . . . PW_{N7}	N7 coefficient cards	5F10.4
Z_1, Z_2, Z_3, Z_4, Z_5	$\frac{TMOD}{PERIOD}$ table break-points	5F10.4
$FZ_1, FZ_2, FZ_3, FZ_4, FZ_5$	$\frac{TMOD}{PERIOD}$ table input	6F10.4
	alternate/adaptive FZ_i input (see Section)	7F10.4 7F10.4
IOSKEY	one-shot option key	I2
N1	No. of terms for 1st one-shot expression	I1
ID_1 . . . ID_{N1}	N1 variable I.D. code cards	4F10.4

OS_1 . . . OS_{N1}	N1 coefficient cards	5F10.4
NC1	no. of terms for 1st one-shot 'clear' expression	I1
ID_1 . . . ID_{NC1}	NC1 variable I.D. code cards	4F10.4
$RIDCL_1$ . . . $RIDCL_{NC1}$	NC1 coefficient cards	5F10.4
TOS_1	time duration of 1st one-shot	F10.4
N2	no. of terms in 2nd one-shot expression	I1
ID_1 . . . ID_{N2}	N2 variable I.D. code cards	4F10.4
OS_1 . . . OS_{N2}	N2 coefficient cards	5F10.4
NC2	no. of terms for 2nd one-shot 'clear' expression	I1
ID_1 . . . ID_{N2}	NC2 variable I.D. code cards	4F10.4
$RIDCL_1$ . . . $RIDCL_{NC2}$	NC2 coefficient cards	5F10.4

TOS2	time duration of 2nd one-shot expression	F10.4
N3	no. of terms in 3rd one-shot expression	I1
ID_1 . . . ID_{N3}	N3 variable I.D. code cards	4F10.4
OS_1 . . . OS_{N3}	N3 coefficient cards	5F10.4
NC3	no. of terms for 3rd one-shot 'clear' expression	I1
ID_1 . . . ID_{NC3}	NC3 variable I.D. code cards	4F10.4
$RIDCL_1$ . . . $RIDCL_{NC3}$	NC3 coefficient cards	5F10.4
TOS3	time duration of 3rd one-shot	F10.4
N4	no. of terms for 4th one-shot expression	I1
ID_1 . . . ID_{N4}	N4 variable I.D. code cards	4F10.4
OS_1 . . . OS_{N4}	N4 coefficient cards	5F10.4

NC4	no. of terms for 4th one-shot 'clear' expression	I1
ID_1 . . . ID_{NC4}	NC4 variable I.D. code cards	4F10.4
$RIDCL_1$ . . . $RIDCL_{NC4}$	NC4 coefficient cards	5F10.4
TOS4	time duration of 4th one-shot	F10.4
N5	no. of terms for 5th one-shot expression	I1
ID_1 . . . ID_{N5}	N5 variable I.D. code cards	4F10.4
OS_1 . . . OS_{N5}	N5 coefficient cards	5F10.4
NC5	no. of terms for 5th one-shot 'clear' expression	I1
ID_1 . . . ID_{NC5}	NC5 variable I.D. code cards	4F10.4
$RIDCL_1$ . . . $RIDCL_{NC5}$	NC5 coefficient cards	5F10.4
TOS5	time duration of 5th one-shot	F10.4

IGPKEY	general purpose counter key	I2
NG	no. of terms in general purpose counter expression	I1
ID_1 . . . ID_{NG}	NG variable I.D. code cards	4F10.4
GP_1 . . . GP_{NG}	NG coefficient cards	5F10.4
IGPVKY	general purpose variable option key	I2
NV_1	no. of terms in first general purpose expression	I1
ID_1 . . . ID_{NV1}	NV1 variable I.D. code cards	4F10.4
GPV_1 . . . GPV_{NV1}	NV1 coefficient cards	5F10.4
NV2	no. of terms in 2nd general purpose expression	I1
ID_2 . . . ID_{NV2}	NV2 variable I.D. code cards	4F10.4
GPV_1 . . . GPV_{NV2}	NV2 coefficient cards	5F10.4
NV3	no. of terms in 3rd general purpose expression	I1

ID_3 . . . ID_{NV3}	NV3 variable I.D. code cards	4F10.4
GPV_3 . . . GPV_{NV3}	NV3 coefficient cards	5F10.0
NV4	no. of terms in 4th general purpose variable expression	I1
ID_1 . . . ID_{NV4}	NV4 variable I.D. code cards	4F10.4
GPV_1 . . . GPV_{NV4}	NV4 coefficient cards	5F10.4
NV5	no. of terms in 5th general purpose variable expression	I1
ID_1 . . . ID_{NV5}	NV5 variable I.D. code cards	4F10.4
GPV_1 . . . GPV_{NV5}	NV5 coefficient cards	5F10.4
TSMPLE	control logic sampling period	F10.4
TN_2	Table number entry for 2nd wheel (front axle, right side)	I2
$OPTION_2$	OPTION for 2nd wheel	I2

{ Same input format as for wheel 1 }

TN_3	Table number entry for 3rd wheel	I2
$OPTION_3$	OPTION for 3rd wheel	I2
	{ Same input format as for wheel 1 }	

.
.
.

End of antilock input

The following section provides two example problems and their associated input lists.

Example Problems

EXAMPLE 1.

Suppose an antilock system possesses the following features: (1) a wheel sensor time delay effect of 10 ms. and another 20 ms. delay in the derivation of wheel acceleration; (2) control logic which generates an "OFF" signal once the wheel acceleration falls below -50.0 ft/sec^2 and an "ON" signal for wheel accelerations greater than -10.0 ft/sec^2; (3) pressure modulator time delays of 40 ms. for "OFF" signals and 60 ms. for "ON" signals. The supposed exponential pressure rates are functions of wheel acceleration defined as follows:

$$\text{Pressure Fall Rate} \equiv \begin{cases} (0.1)^{-1} = 10.0 \text{ for } \dot{\omega} \leq -100 \text{ ft/sec}^2 \\ (0.2)^{-1} = 5.0 \text{ for } \dot{\omega} > -100 \text{ ft/sec}^2 \end{cases}$$

$$\text{Pressure Rise Rate} \equiv \begin{cases} (0.2)^{-1} = 5.0 \text{ for } \dot{\omega} \leq 50 \text{ ft/sec}^2 \\ (0.1)^{-1} = 10.0 \text{ for } \dot{\omega} > 50 \text{ ft/sec}^2 \end{cases}$$

The following choice of input parameters would describe the above antilock system:

$\tau_\omega = 0.01$

$\tau_{\omega d} = 0.02$

$C_{11} = -1.0$

$\rightarrow F_1 = -\dot{\omega} - 50.0 \geq 0$

$C_{12} = -50.0$

$C_{51} = 1.0$

$\rightarrow F_5 = \dot{\omega} + 10.0 \geq 0$

$C_{52} = 10.0$

I.D. Code for $\dot{\omega}$ = 4.

I.D. Code for 1.0 = 1.

$\tau_1 = \tau_3 = \tau_4 = 0.0$

$\tau_2 = 0.2$

$H_1 = 1.0$

$\rightarrow \varepsilon_1 = \dot{\omega} + 100$

$H_2 = 100.0$

$X_1 = -10000.0$

$X_2 = 0.0$

PFE1 = 10.0

PFE2 = 5.0

$G_1 = 1.0$

$\rightarrow \varepsilon_2 = \dot{\omega} - 50.0$

$G_2 = -50.0$

$X_3 = -10000.0$

$X_4 = 0.0$

PRE1 = 5.0

PRE2 = 10.0

$OP_{12} = OP_{23} = OP_{34} = OP_{56} = OP_{67} = OP_{78}$ = either 0 or 1

$\tau_{ON} = 0.06$

$\tau_{OFF} = 0.04$

The following input list would be required:

01				ILOCK
01				TN_1
01				worst-wheel side-to-side option
0.0				WWDIF
1				NOFF1
2				M1
4.				I.D. code for $\dot{\omega}$
1.				I.D. code for 1.0
-1.				1st term coefficient, C_{11}
-50.				2nd term coefficient, C_{12}
1				NON_1
2				M5
4.				I.D. code for $\dot{\omega}$
1.				I.D. code for 1.0
1.				1st term coefficient, C_{51}
10.				2nd term coefficient, C_{52}
0.	0.	0.	0.	τ_i
0				IPKEY
2				N1
4.				I.D. for $\dot{\omega}$
1.				I.D. for 1.0
1.		ε_1		1st term coefficient for ε_1
100.				2nd term coefficient for ε_1
2				N2
4.				I.D. for $\dot{\omega}$
1.		ε_2		I.D. for 1.0
1.				1st term coefficient for ε_2
-50.				2nd term coefficient for ε_2
-10000.		0.		X_1, X_2
-10000.		0.		X_3, X_4

10.	10.	5.	PFE1, PFE2, PFE3
5.	5.	10.	PRE1, PRE2, PRE3
.06	.04		τ_{ON}, τ_{OFF}
.01	.02		τ_W, τ_{WD}
000			OP_{12}, OP_{23}, OP_{34}
000			OP_{56}, OP_{67}, OP_{78}
-1			IPDKEY
-1			IPWMKY
-1			IOSKEY
-1			IGPKEY
-1			IGPVKY
.0001			TSMPLE
01			TN_2
01			TN_3
⋮			⋮

EXAMPLE 2.

Simulation of an antilock system having the following features:

Wheel Sensor: τ_ω , $\tau_{\omega d}$ = .010 seconds

Control Logic:

OFF signal given by

$$F_1 = \dot{x} - \omega - 14 \geq 0, \quad \text{for } \dot{X} > 50 \text{ ft/sec}$$
$$= \dot{x} - \omega - 11 \geq 0, \quad \text{for } \dot{X} \leq 50$$

<u>AND</u>

$$F_2 = -\dot{\omega} - 12 \geq 0$$

<u>OR</u>

$$F_3 = \text{SLIP} - .50 \geq 0$$

ON signal generated when

$$F_5 = -\dot{x} + \omega + 10 \geq 0$$

<u>AND</u>

$$F_6 = \dot{\omega} - 20. \geq 0$$

<u>OR</u>

$$F_7 = \dot{\omega} - 250. \geq 0$$

Pressure Modulator:

a) τ_{ON} = .015 sec. ; τ_{OFF} = .010 sec.

b) One exponential fall rate of 14. sec^{-1}.

c) One exponential rise rate of 14. sec^{-1}.
and one linear rise rate of 45. sec^{-1}.

The exponential and linear pressure rise regions are determined by a decaying time ramp from the maximum pressure in the previous cycle. For pressure below this time ramp, the pressure rise is exponential; for pressure greater than the time ramp, the pressure rise is linear (see Figure D-16). The decaying time ramp can be written as

$$\text{PMAX1} - 85.\ (t - \text{TPMAX1})$$

where

PMAX1 is the maximum pressure in the last cycle

t is time

TPMAX1 is the time of the maximum pressure in the last cycle

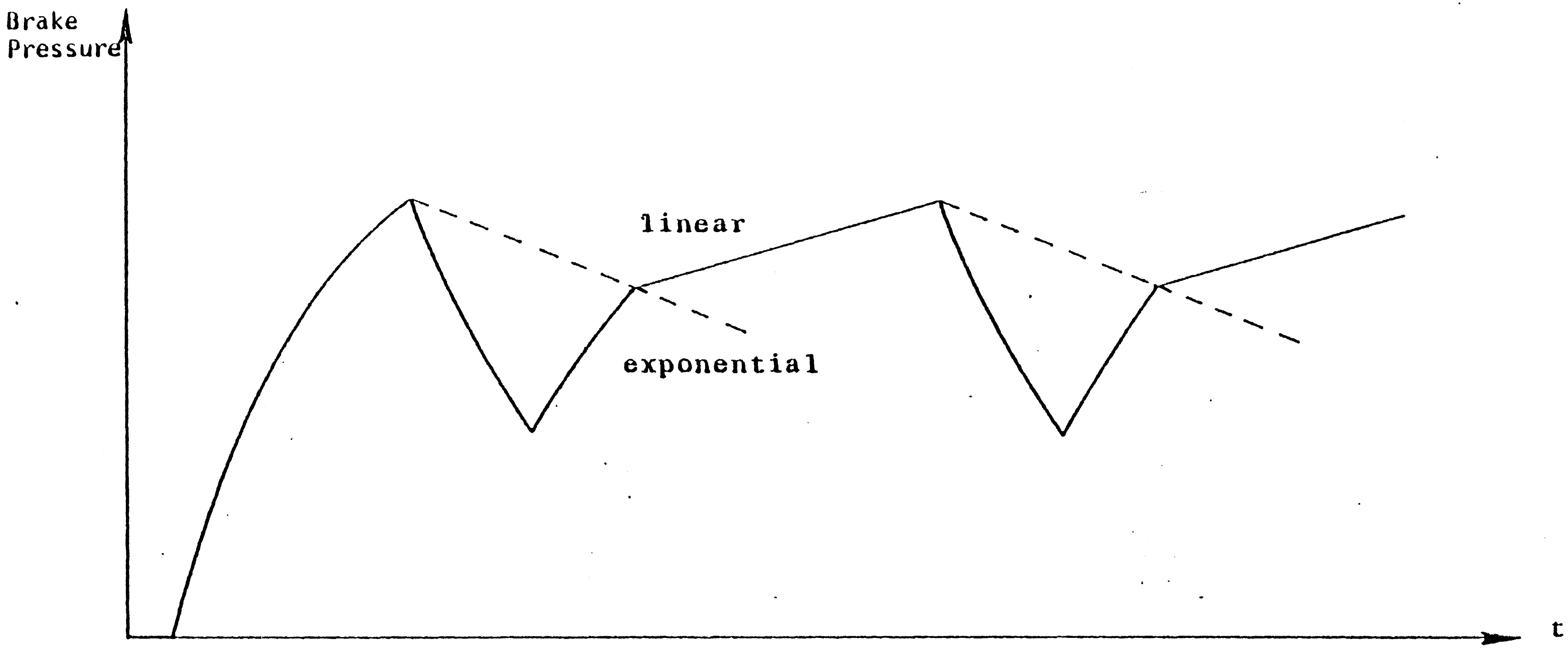
and 85. is the rate of decay. (psi/sec)

By subtracting the above expression from brake pressure, P, the ε_2 and ε_4 general expressions become:

$$\varepsilon_2 = P - \text{PMAX1} + 85\ T - 85\ \text{TPMAX1}$$

and

$$\varepsilon_4 = P - \text{PMAX1} + 85\ T - 85\ \text{TPMAX1},$$



PRESSURE MODULATOR CHARACTERISTIC --- SYSTEM #2.

Figure D-16.

the switching point occurring at $\varepsilon_2 = \varepsilon_4 = 0$. Therefore, the desired rise characteristic can be simulated by the following set of pressure inputs:

$$X_3 = X_4 = X_7 = X_8 = 0$$

PRE1 = PRE2 = 14. , PRE3 = 0

PRL1 = PRL2 = 0. , PRL3 = 45.

The following input list would be required:

01	ILOCK
01	TN_1
01	$OPTION_1$
0.0	WWDIF
3	$NOFF_1$
3	M1
5.	
3.	
1. , , 5. , ,	
1.	C_{11}
-1.	C_{12}
-11. , -14. , , 50., ,	C_{13}
2	M2
4.	
1.	
-1.	C_{21}
-120.	C_{22}
2	M3
34.	
1.	
1.	C_{31}
-.50	C_{32}
3	NON_1
3	M5
5.	
3.	
1.	

-1.				C_{51}
1.				C_{52}
10.				C_{53}
2				M6
4.				
1.				
1.				C_{61}
-20.				C_{62}
2				M7
4.				
1.				
1.				C_{71}
-250.				C_{72}
0.	0.	0.	0.	τ_i
2				IPKEY
1				N1
1.				ε_1
5.				
4				N2
35.				ε_2
27.				
2.				
21.	1.			
1.				
-1.				
85.				
85.				

0.	0.			X_1, X_2
0.	0.			X_3, X_4
14.	14.	14.		PFE1, PFE2, PFE3
14.	14.	0.		PRE1, PRE2, PRE3
1				N3
1.			ε_3	
5.				
4				N4
35.			ε_4	
27.				
2.				
21.	1.			
1.				
-1.				
85.				
85.				
0.	0.			X_5, X_6
0.	0.			X_7, X_8
0.	0.	0.		PFL1, PFL2, PFL3
0.	0.	45.		PRL1, PRL2, PRL3
.015	.010			τ_{ON}, τ_{OFF}
.010	.010			τ_{ω} , $\tau_{\omega D}$
100				OP_{12}, OP_{23}, OP_{34}
100				OP_{56}, OP_{67}, OP_{78}
-1				IPDKEY
-1				IPWMKY
-1				IOSKEY

-1	IGPKEY
-1	IGPVKY
.0001	TSMPLE
01	TN_2
01	TN_3
.	.
.	.
.	.
.	.

Output-Echo Format

Figures D-17 through D-20 show an example of the kind of output-echo produced by the antilock subroutine. The first output page is simply the user dictionary of variables/parameters. The succeeding pages represent a computer echo of the antilock input. The "First" and "Second Adaptive Value" columns refer to the alternate coefficients available with the adaptive coefficient feature. The "First" and "Second Adaptive Variable" columns echo the variable I.D. codes for the two adaptive variables, while the columns labeled "First" and "Second Break-Point" contain their associated break-points. If the secondary adaptive coefficient definition (Figure D-8) is used, the word "AND" appears between the First and Second Adaptive Variable columns in the output echo for that coefficient. Any input not associated with a general form expression is listed under "Non-Adaptive Antilock Parameters."

```
DICTIONARY OF ANTI-LOCK VARIABLES/PARAMETERS AVAILABLE TO USER.

VARIABLE I.D.        DESCRIPTION           VARIABLE I.D.        DESCRIPTION
-------------        -----------           -------------        -----------

   1 ...................... 1.0               45 ...................... WMAX1
   2 ...................... TIME              46 ...................... WMAX2
   3 ...................... OMEGA             47 ...................... TWMAX1
   4 ...................... OMEGADOT          48 ...................... TWMAX2
   5 ...................... XDOT              49 ...................... WMIN
   6 ...................... XDDOT             50 ...................... TWMIN
   7 ...................... POFF1             51 ...................... TPMAX2
   8 ...................... POFF2             52 ...................... TPMIN2
   9 ...................... PON1              53 ...................... GPV1
  10 ...................... PON2              54 ...................... GPV2
  11 ...................... TOFF1             55 ...................... GPV3
  12 ...................... TON1              56 ...................... GPV4
  13 ...................... XDOFF             57 ...................... GPV5
  14 ...................... XDON              58 ...................... FOS4
  15 ...................... WOFF              59 ...................... FOS5
  16 ...................... WON               60 ...................... OMEGDIF
  17 ...................... WDOFF
  18 ...................... WDON
  19 ...................... WDMAX
  20 ...................... WDMIN
  21 ...................... TPMAX1
  22 ...................... TPMIN1
  23 ...................... WLOCK
  24 ...................... TLOCK
  25 ...................... SLON
  26 ...................... SLOFF
  27 ...................... PMAX1
  28 ...................... PMAX2
  29 ...................... PMIN1
  30 ...................... PMIN2
  31 ...................... PD
  32 ...................... ON
  33 ...................... TMOD
  34 ...................... SLIP
  35 ...................... P
  36 ...................... CYCNT
  37 ...................... SQUARE
  38 ...................... SQUARN
  39 ...................... TOFF2
  40 ...................... TON2
  41 ...................... FOS1
  42 ...................... FOS2
  43 ...................... FOS3
  44 ...................... GPCNT
```

Figure D-17. Antilock Output Echo

** TI- SU TIN PUT AME .. TABL. --- ..LE 1. ***

SYMBOL	DESCRIPTION	INITIAL VALUE	FIRST ADAPTIVE VALUE	SECOND ADAPTIVE VALUE	INITIAL VALUE VARIABLE	FIRST ADAPTIVE VARIABLE	SECOND ADAPTIVE VARIABLE	FIRST BREAK-PT	SECOND BREAK-PT
INEQUALITY EXPRESSION: 1									
C(1)	COEFFICIENT(1)	-1.0000			3				
C(2)	COEFFICIENT(2)	1.0000			45				
C(3)	COEFFICIENT(3)	-20.0000	-10.0000		2	6		-16.000	
C(4)	COEFFICIENT(4)	20.0000	10.0000		47, 1	6		-16.000	
C(5)	COEFFICIENT(5)	-4.0000	-7.0000		1, 1	36		0.500	
INEQUALITY EXPRESSION: 2									
C(1)	COEFFICIENT(1)	-1.0000			4				
C(2)	COEFFICIENT(2)	-70.0000			1				
INEQUALITY EXPRESSION: 3									
C(1)	COEFFICIENT(1)	1.0000			42				
C(2)	COEFFICIENT(2)	-0.1000			1				
C(3)	COEFFICIENT(3)	1000.0000			23				
INEQUALITY EXPRESSION: 5									
C(1)	COEFFICIENT(1)	1.0000			3				
C(2)	COEFFICIENT(2)	-1.0000			45				
C(3)	COEFFICIENT(3)	20.0000	10.0000		2	6		-16.000	
C(4)	COEFFICIENT(4)	-20.0000	-10.0000		47, 1	6		-16.000	
C(5)	COEFFICIENT(5)	7.0000			1, 1				
INEQUALITY EXPRESSION: 6									
C(1)	COEFFICIENT(1)	1.0000			4				
C(2)	COEFFICIENT(2)	-20.0000			1				
INEQUALITY EXPRESSION: 7									
C(1)	COEFFICIENT(1)	1.0000			42				
C(2)	COEFFICIENT(2)	-0.1000			1				

EPSILION 1:

Figure D-18. Antilock output echo.

```
 )              OEP     ERT            5 - 00

EPSILION 2:

  G(1)          COEFFICIENT(1)        1.0000                    35
  G(2)          COEFFICIENT(2)       -1.0000                    27
  G(3)          COEFFICIENT(3)      200.0000   100.0000          2        36          1.500
  G(4)          COEFFICIENT(4)     -200.0000  -100.0000         21,  1    36          1.500

EPSILION 3:

  R(1)          COEFFICIENT(1)        5.0000                     1

EPSILION 4:

  S(1)          COEFFICIENT(1)        1.0000                    35
  S(2)          COEFFICIENT(2)       -1.0000                    27
  S(3)          COEFFICIENT(3)      200.0000   100.0000          2        36          1.500
  S(4)          COEFFICIENT(4)     -200.0000  -100.0000         21,  1    36          1.500

ONE-SHOT 1:

OS1(1)          COEFFICIENT(1)       -1.0000                     3
OS1(2)          COEFFICIENT(2)        1.0000                    45
OS1(3)          COEFFICIENT(3)      -20.0000   -10.0000          2         6        -16.000
OS1(4)          COEFFICIENT(4)       20.0000    10.0000         47,  1     6        -16.000
OS1(5)          COEFFICIENT(5)       -6.0000                     1,  1

ONE-SHOT 2:

OS2(1)          COEFFICIENT(1)        0.0                        1
OS2(2)          COEFFICIENT(2)       -0.1000                     1
OS2(3)          COEFFICIENT(3)       50.0000                    41
OS2(4)          COEFFICIENT(4)        1.0000                    41,  4

** NON-ADAPTIVE ANTI-LCCK PARAMETERS. **

 TAU1           LOGIC TIME DELAY       0.0
 TAU2               "                  0.0
 TAU3               "                  0.0
 TAU4               "                  0.0
 X1             EPSILON 1 BREAK-PT     0.0
 X2                 "                 50.0000
 X3             EPSILON 2 BREAK-PT    -5.0000
 X4                 "                  2.5000
 PFE1     EXP. PRESSURE FALL RATE     12.5000
 PFE2               "                 12.5000
 PFE3               "                 12.5000
 PRE1     EXP. PRESSURE RISE RATE     14.0000
 PRE2               "                 14.0000
 PRE3               "                  0.0
 X5             EPSILON 3 BREAK-PT     0.0
 X6                 "                 50.0000
 X7             EPSILON 4 BREAK-PT     - 0000
```

Figure D-19. Antilock output echo

```
X0                              "                        2.5000
PFL1       LIN. PRESSURE FALL RATE                       0.0
PFL2                            "                        0.0
PFL3                            "                        0.0
PRL1       LIN. PRESSURE RISE RATE                       0.0
PRL2                            "                        0.0
PRL3                            "                       40.0000
TAUON      PRESSURE-ON TIME DELAY                        0.0150
TAUOFF     PRESSURE-OFF TIME DELAY                       0.0100
TAUW       TIME CONSTANT-WHEEL RATE                      0.0100
TAUWD      TIME CONSTANT-WHEEL ACCEL.                    0.0100
OP12       LOGICAL OPERATOR SWITCH                            1
OP23                            "                             0
OP34                            "                             0
OP56       LOGICAL OPERATOR SWITCH                            1
OP67                            "                             0
OP78                            "                             0
TOS1       ONE-SHOT TIME DURATION                        0.0200
TOS2       ONE-SHOT TIME DURATION                        0.0200
TSAMPLE    ANTI-LOCK SAMPLING RATE                       0.0010
OPTION     SIDE-TO-SIDE                                       1
```

Figure D-20. Antilock output echo.

Examples of the use of the antilock program and example data can be found in References [16, 19, 20, 21, 22, 25, 28].

APPENDIX E

THE EQUATIONS OF MOTION

To explain the equations of motion of the system, it is convenient to describe several subsystems and their interconnections. These subsystems are described in an orthogonal coordinate system which will be defined first.

E.1 The Coordinate Systems

The coordinates systems used are unchanged from the Phase II HSRI/MVMA program [2],* and details can be found in Section 4.1.2 of this manual. To briefly summarize:

Each sprung mass has a set of body axes fixed to the sprung mass origin at the sprung mass center designated as x, y, z, where x goes toward the front, y goes to the right, and z goes down.

A second set of axes is the inertial set designated as X, Y, Z. These are fixed and never change direction. In the initial condition for any simulation run, the sprung mass c.g. of the truck/tractor is at the origin of X, Y, Z, facing in the X direction.

A third set of axes, called the yaw plane system, is required. These are designated as $\bar{x}$, $\bar{y}$, $\bar{z}$, and have an origin which follows the sprung mass c.g. The direction of $\bar{z}$ remains normal to the road, and $\bar{x}$ and $\bar{y}$ follow the rotation of the vehicle around the $\bar{z}$ axis. Thus, $\bar{x}$ faces along the projection of x in the road plane.

There is frequent need to rotate forces and moments from one coordinate system to another. These are done using the "A" matrix, which rotates vectors between body and inertial, and the "BZ" matrix, which rotates vectors between body and yaw plane. The cosine and sine of the yaw angle, ψ, is used to go between the yaw plane and inertial systems.

---

*Numbers in brackets designate references appearing in Section 6.0.

E.2 General Equations

Each sprung mass has body axes x, y, z. All forces are rotated into these directions, resulting in ΣF_x, ΣF_y, ΣF_z which in the computer code are called FSUM(1), FSUM(2), and FSUM(3). As is typical in the vehicle dynamics literature, the velocity in the x direction is u, the velocity in the y direction is v, and the velocity in the z direction is w. The rotation rate about the x axis is p, the rotation rate about the y axis is q, and the rotation rate about the z axis is r.

The translational equations of motion are then:

$$M(\dot{u} - vr + wq) = \Sigma F_x$$

$$M(\dot{v} + ur - wp) = \Sigma F_y$$

$$M(\dot{w} + uq - vp) = \Sigma F_z$$

where M is the sprung mass and the dot indicates differentiation with respect to time. In the computer program these equations are solved for $\dot{u}$, $\dot{v}$, and $\dot{w}$ at the beginning of each integration time step.

There are also the equations of rotational motion about each body axis. All moments on the sprung mass are rotated into the x, y, and z directions, thus resulting in ΣM_x, ΣM_y, and ΣM_z which in the computer code are called TSUM(1), TSUM(2), and TSUM(3). The equations of rotational motion are Euler's equations with zero cross-products of inertia, namely:

$$I_{xx}\dot{p} + qr(I_{zz}-I_{yy}) = \Sigma M_x$$

$$I_{yy}\dot{q} + pr(I_{xx}-I_{zz}) = \Sigma M_y$$

$$I_{zz}\dot{r} + pq(I_{yy}-I_{xx}) = \Sigma M_z$$

where p is the rotation rate about x, q about y, and r about z. The program solves for $\dot{p}$, $\dot{q}$, and $\dot{r}$ at the beginning of each integration time step.

The accelerations of the sprung mass motions depend on the forces FSUM(I) and the moments TSUM(I). Each of those forces and moments will be discussed in the next sections.

E.3 Forces on the Sprung Mass

There are several forces on the sprung mass. These forces are applied either through the suspensions or the fifth wheel (pintle hook). Consider first the suspension forces.

E.3.1 Suspension Forces. There are suspension forces in the x, y, and z directions. The force in the z direction is the most straightforward. For a single axle, the calculations are unchanged from Phase II [2], i.e., the force, SF, in the z direction is the deflection of the spring times the spring rate plus the force of coulomb and viscous friction. Some notes:

1) Tension is positive. Zero force is at static equilibrium. Thus the preload in the spring, which is the weight on that spring at static equilibrium, drops out of the calculations.

2) The springs may be made nonlinear by using a table lookup.

3) The coulomb friction break-point is set based on the masses, coulomb friction, and integration time step. Details of the theory are presented in [40].

4) Suspension force calculations take place in subroutine LINE.

For tandem axles, the SF use the same algorithms as the single axle. But, if braking occurs, suspension force is added to the lead axle and subtracted from the trailing axle according to the rule

SF(LEAD) = SF(LEAD) + FSHIFT*BTORQ/TD

SF(TRAIL) = SF(TRAIL) - FSHIFT*BTORQ/TD

where

> BTORQ is the total brake torque of all four brakes on the tandem set, FSHIFT comes from the dynamic load transfer and TD is the fore-aft separation distance of the tandem axles.

The load transfer calculations are found in subroutine LINE.

The lateral and longitudinal suspension forces are also calculated using the Phase II [2] procedure. To explain briefly, the lateral forces at the suspensions may be viewed as constraint forces which hold sprung and unsprung masses together. To calculate these forces, the following procedure is used:

1) The sprung and unsprung masses are assumed to move as a unit with yawing but not in rolling or pitching. Thus an estimated acceleration for the vehicle can be calculated using the entire mass and the known forces at the tire-road interface.

2) The unsprung mass acceleration is assumed to be a simple function of the gross acceleration calculated in (1). Then, since the yaw plane forces on the tires are known, the yaw plane constraint forces can be found.

3) These yaw plane constraint forces are applied to the sprung mass in the full blown equations of motion.

The user should note that the purpose of the method is to avoid dynamic coupling which requires matrix inversions each Δt. The height of the constraint point is the roll center height given as an input parameter. Finally, the accuracy of the method is quite good. (See [41] for details.)

E.3.2 <u>The Forces at the Fifth Wheel</u>. The PHASE 4 -simulation, like Phase II [2], uses a spring-dashpot for the fifth wheel and pintle hook connection. Two advantages accrue:

1) removal of dynamic coupling

2) the ability to simulate roll compliance at the hitch.

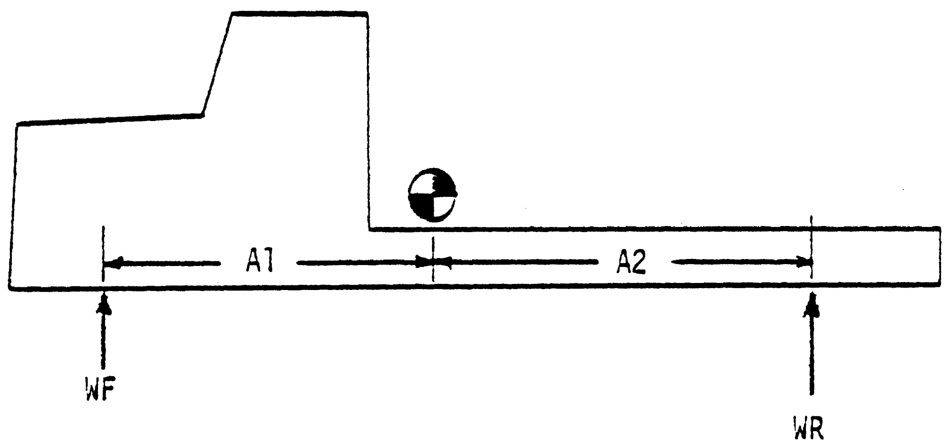
The method works as follows. At each integration time step the position of the tractor fifth wheel, a point located on the tractor, is calculated and the position of the trailer fifth wheel, a point on the trailer, is calculated. A force is assumed to act along the line between these points. The magnitude of the force is assumed to be a spring rate, PIN, times the distance between the points plus a damping rate, CFW, times the relative velocity between the points.

APPENDIX F
PARAMETER ESTIMATION METHOD

This appendix describes simplified methods for estimating the mass moments of inertia for heavy vehicles with as little user time and energy as possible.

In the simulation program, the static loads on the tires are entered, along with the unsprung weights and the wheelbase. Note that the fore-aft mass center location is implicitly input by the user.

From this same data, one may find the total weight supported by the front and rear suspensions. Referring to these as WF and WR, and locating the mass center leads to the vehicle representation shown in the figure below.



Schematic diagram of sprung mass

It is obvious that for conventional vehicles one must expect the sprung mass pitch moment of inertia, I_{yy}, to be limited by

$$I_{yy} < \frac{1}{g}(WF \cdot A1^2 + WR \cdot A2^2) \tag{1}$$

Since one expects (at least in the unloaded condition)

$$A2 > A1 \tag{2}$$

we were led to try the formulation

$$I_{yy} = \frac{1}{g}([WF + a \cdot WR]A1^2 + WR(1-a)A2^2) \tag{3}$$

A comparison between empirical data and computed results has led to the conclusion that the value a = .4 leads to reasonable pitch inertia values for unloaded vehicles. Furthermore, even in the case of loaded vehicles, Equation (3) leads to very reasonable results.

Given the pitch inertia from Equation (3), empirical data has shown it reasonable to assume that the sprung mass yaw moment of inertia, I_{zz}, is equal to the pitch inertia, and the roll inertia may be related to the pitch and yaw inertias by a multiple of the vehicle dimensions. In particular

$$I_{zz} = I_{yy} \tag{4}$$

$$I_{xx} = 2 \left[\frac{\text{(TRACK)}}{\text{(Total Length)}}\right]^2 I_{yy} \tag{5}$$

APPENDIX G

PATH-FOLLOWER, CLOSED-LOOP DRIVER MODEL

Section 3.2 of the Users Manual explains the input requirements for the closed-loop driver model. This appendix will outline the manner in which the model works and demonstrate its use in simulating a closed-loop double lane-change maneuver with a tractor-trailer.

The driver model is based on a technique, discussed more completely in Reference [34] which selects a steering control at each point in time by minimizing the current preview error (squared error). Referring to Figure G-1, the solid line shows the desired path trajectory input by the program user (table values), and the dashed line the estimated trajectory of the vehicle using the current steering control. The preview interval (user input), over which the path estimates are made, extends from the current vehicle position, time t, to the end of the interval, time t + T. This interval is divided into ten equal parts and position errors, ε_i, between the desired and estimated trajectories are calculated for each. The current steering control is then selected to minimize the sum of the squares,

$$\sum_{i=1}^{10} \varepsilon_i^2 .$$

Estimates of the vehicle position over the preview interval (t, t+T) are obtained from an internal linear model representation of the truck/tractor vehicle.

Example Usage

The following discussion demonstrates the use of the driver model in simulating a closed-loop double lane-change maneuver measured on an actual tractor-trailer. The input data describing the experimentally measured vehicle path, and the necessary driver model parameters are shown in Table G-1. The format corresponds to the requirements discussed in the Users Manual, Section 3.2.

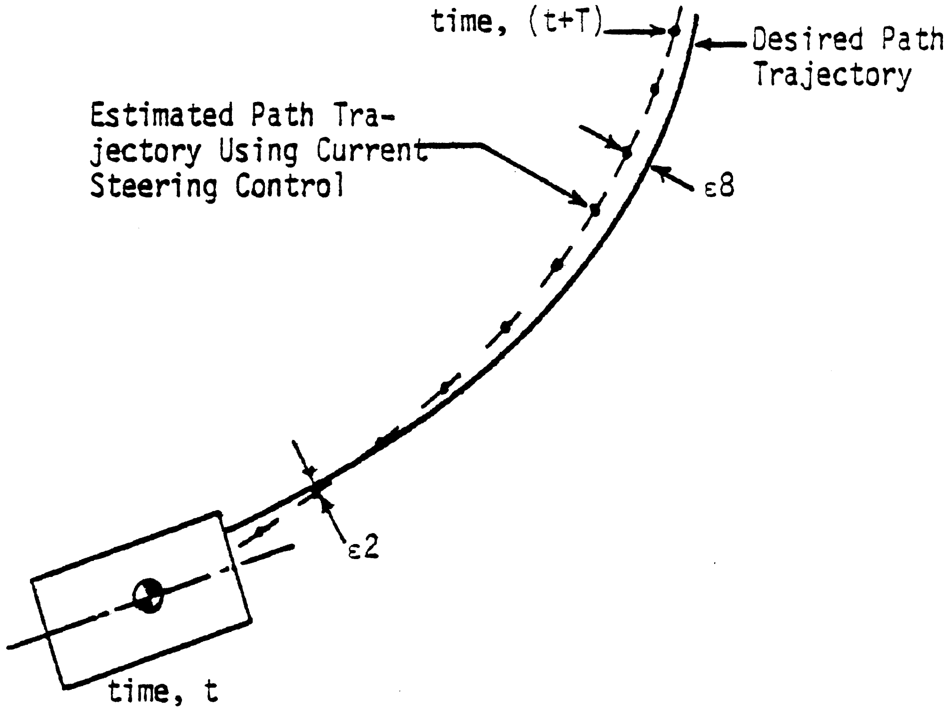


Figure G.1. Closed-loop steering model.

Table G-1

-16		Closed-loop key (- sign) 16 points in path table.
0.0	0.0	x-y path table
70.0	0.0	
85.0	-1.0	
100.0	-4.2	
115.0	-6.7	
130.0	-9.0	
145.0	-10.7	
160.0	-11.3	
175.0	-11.3	
190.0	-10.3	
205.0	-8.7	
220.0	-6.2	
235.0	-3.3	
250.0	-1.3	
265.0	0.0	
900.0	0.0	
0.0		Transport lag
1.10		Preview interval

The two driver model parameters following the path table input are the driver transport lag and the preview interval parameter, T, discussed above. In this example, the driver transport lag was selected as zero and the preview interval parameter value varied to find the best match between simulated and measured responses for the maneuver.

Simulation results for this data set are shown in Figure G-2, along with corresponding measured vehicle responses. The first time history is tractor lateral acceleration (simulated and measured), followed by tractor yaw rate and front-wheel steering angle. Excellent agreement between the simulated and measured responses is demonstrated in Figure G-2 even though estimates of tire cornering stiffness had to be used in this case.

Very similar responses can be obtained for non-zero driver transport lags (more accurate representations of human operator limitations) by increasing the value of the preview interval parameter. For example, a transport lag of 0.25 seconds would require an increase of the preview interval parameter value from 1.1 to about 1.5 in order to obtain responses similar to those shown in Figure G-2. The principal effect would be somewhat decreased damping in each of the simulated time histories responses.

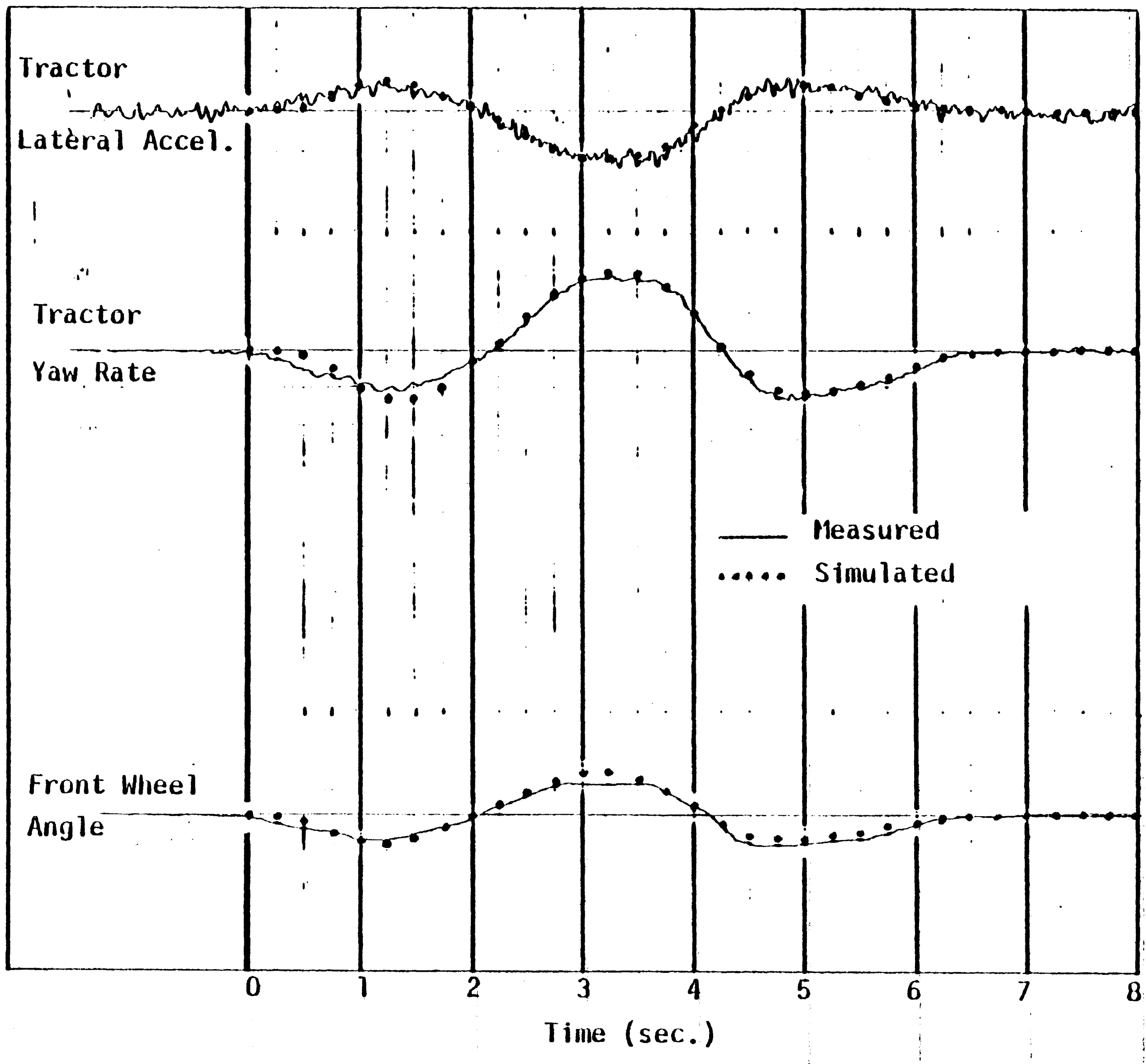


Figure G.2. Path-follower replication of an actual maneuver.

APPENDIX H

USER-WRITTEN ROAD SUBROUTINE

Entry of a negative value for the road key, IROAD, referred to in Section 3.2 of the Users Manual, allows the program user to define an alternate road surface for use in the simulation. By entering code (e.g., FORTRAN) in SUBROUTINE ROAD, which calculates the road elevations, Z, at each wheel as a function of X and Y inertial coordinates, the user is free to define nearly any road surface desired. The only restrictions are that (1) the complete vehicle train starts from a flat or horizontal surface and (2) all gradients (cross-slopes, downgrades) encountered by the vehicle train during the simulation remain less than about 0.10 (rise/ run).

The vehicle train is assumed to start at time zero pointing in a straight line along the X inertial coordinate axis as shown in Figure H-1. Since the vehicle train starts from a flat horizontal plane, the code defining the road surface must guarantee that the road surface elevation is zero for negative values of the inertial X-coordinate.

The user-written subroutine (SUBROUTINE ROAD) must use the following FORTRAN format (or alternate equivalent):

```
SUBROUTINE ROAD(X,Y,Z,T)

     Codes for the calculation of road elevation, Z
     (in feet) as a function of X, Y (in feet) inertial
     coordinates—supplied by the main calling program.

RETURN

ENTRY ROADDZ(X,Y,DZDX,DZDY)

     Code for the calculation of road gradients
     dz/dx(DZDX) and dz/dy(DZDY) consistent with the
     elevation definition above.

RETURN

END
```

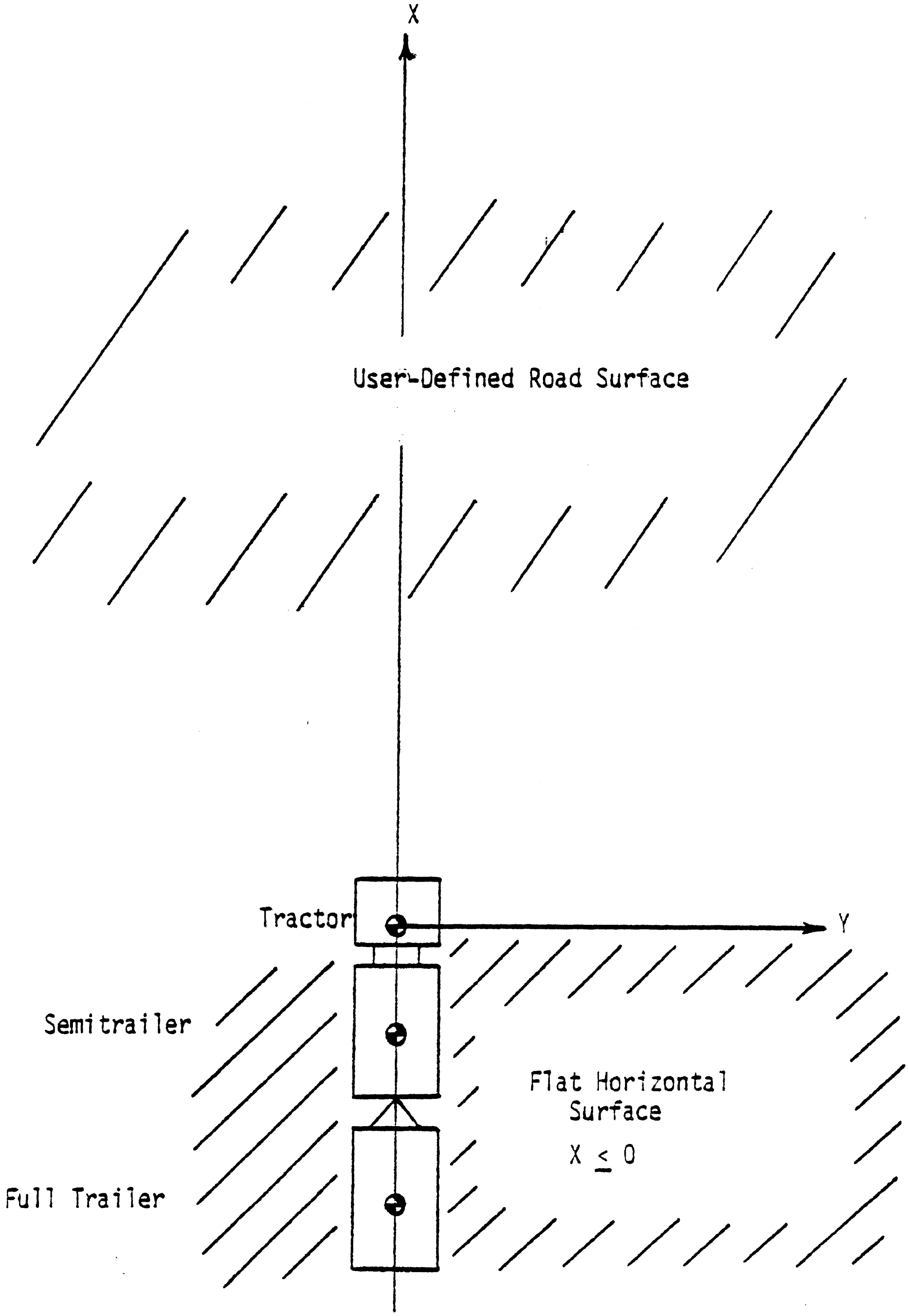


Figure H-1. Vehicle position at zero time.

The argument list for SUBROUTINE ROAD is defined as

X forward inertial coordinate of the wheel, supplied by the calling program

Y lateral inertial coordinate of the wheel, supplied by the calling program

Z vertical road elevation (in feet) calculated by the user code using X and Y—returned to the calling program

T simulation time supplied by the calling program for possible use in the subroutine calculations.

The argument list for ENTRY ROADDZ is:

X same as above

Y same as above

DZDX user=calculated gradient (dz/dx) of the road surface along the X inertial coordinate direction

DZDY user-calculated gradient (dz/dy) of the road surface along the Y inertial coordinate direction.

The DZDX and DZDY calculations should be consistent with the definition of $Z = f(X,Y)$. For example, if $Z = X^2Y + Y^2$ in ROAD,

$$DZDX = 2XY$$
$$DZDY = X^2 + 2Y$$

should be calculated in ROADDZ. The derivatives are used to establish the yaw plane coordinate system in the simulation procedure. In the case of a rough, but essentially horizontal road, the derivatives may be arbitrarily set to zero.

Example Road

The following code should be used to describe a super-elevated, 500-foot circular roadway (cone): The roadway is horizontal for values of $X \leq 0$. The super-elevation, E, is increased linearly between X=0 and X=200 to a maximum value of 0.08. For values of X > 200, the super-elevation is fixed at 0.08 (Figure H-2). R is the actual radius (calculated) of the (X,Y) point supplied by the calling program.

```
SUBROUTINE ROAD(X,Y,Z,T)
R = SQRT(X**2 + (Y+500)**2)
E = 0.08 * X/200.
IF(X.GT. 200.) E = 0.08
IF(X.LT. 0.)   E = 0.0
Z = E * (500-R)
RETURN
ENTRY ROADDZ(X,Y,DZDX,DZDY)
DZDX = - E * X/R
DZDY = - E * (Y+500)/R
RETURN
END
```

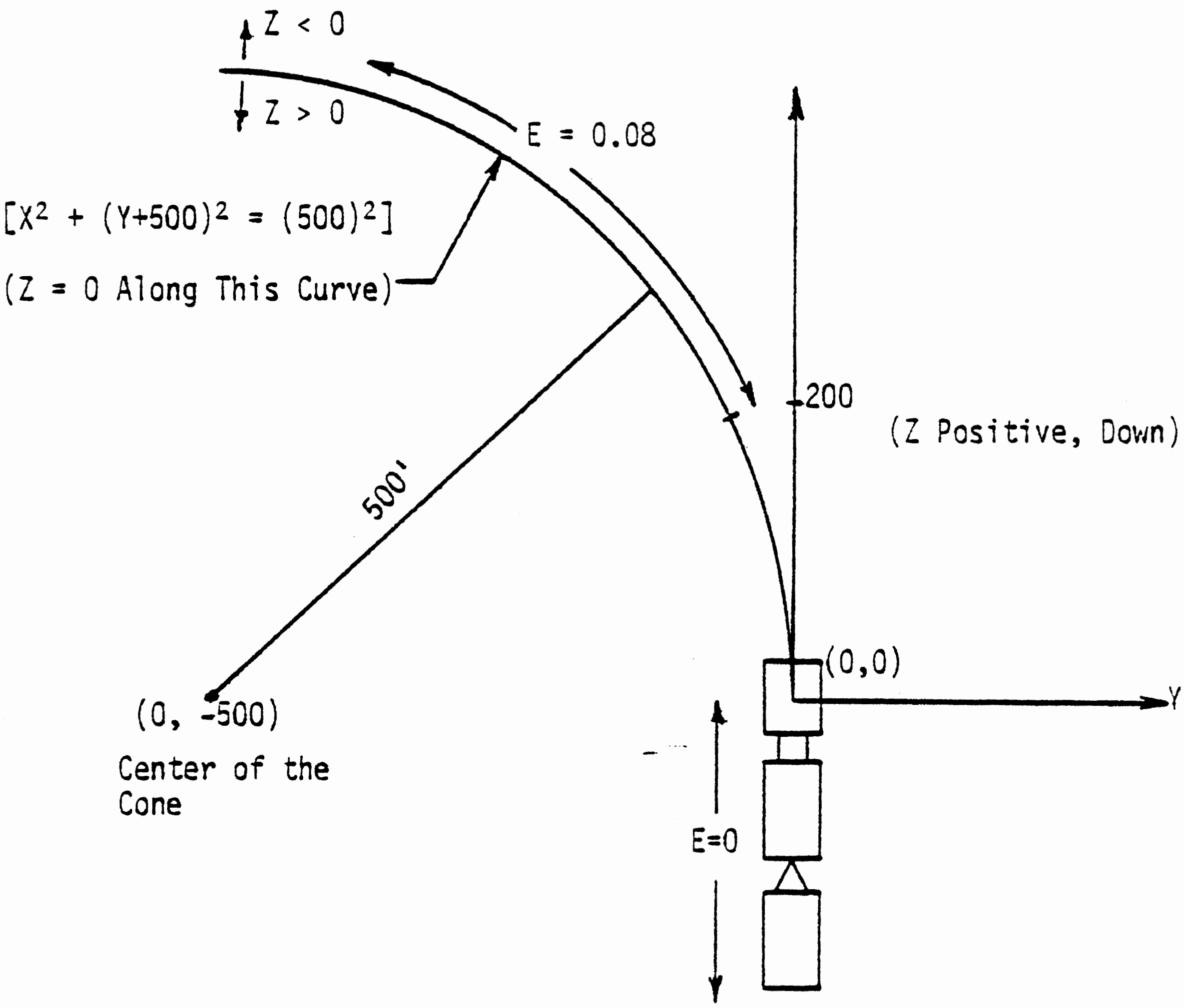


Figure H-2. Circular super-elevated roadway example.

APPENDIX I

TIRE, BRAKE, SUSPENSION, FRAME COMPLIANCE, AND STEERING SYSTEM OPTIONS

This appendix contains eight sub-appendices I.1 through I.8 which document and explain various model options which are available in the PHASE 4 computer program.

I.1 A Semi-Empirical Tire Model

The original Phase II directional response model contained a semi-empirical tire model employing a simplified theory incorporating an "adhesion" region and a "sliding" region in the tire contact patch. However, the T3DRS:V1 program as delivered to FHWA did not include any theoretically based representation of the tire traction field. The conceptual tire model outlined herein is intended to provide the capability for using a limited number of readily obtained (or estimated) parameters in computing the shear forces and aligning moment produced in braking and/or steering maneuvers.

The parameters used in specifying a tire are defined in Table I.1.1. The main advantage of this set of parameters over those used in the Phase II model is that μ_p, S_p, and μ_s can be read directly from a desired μ-slip curve.

The partial derivatives specified in the list of parameters are included to provide a means for fitting particular trends observed in test data.

The derivation of the equations for the tire model is detailed, but straightforward (once the assumptions are understood). The primary assumptions are:

1) the contact patch can be divided into a sliding region and an adhesion region,

2) the shear force generated in the adhesion region depends upon elastic properties of the tire, and

3) the shear force generated in the sliding region depends upon the frictional properties of the tire-road interface.

Table I.1.1

Symbols	Definitions
μ_p	maximum friction value for a μ-slip curve obtained at F_{z_o} and V_o
S	instantaneous value of slip
S_p	value of slip at maximum of μ-slip curve
μ_s	friction value for a locked wheel for a μ-slip curve obtained at F_{z_o} and V_o
C_α	nominal cornering stiffness
X_p	nominal pneumatic trail
C_y	lateral deflection stiffness
F_{z_o}	nominal vertical load
V_o	nominal velocity
$\partial C_\alpha/\partial F_z$	rate of change of C_α with respect to load
$\partial \mu_p/\partial F_z$	rate of change of μ_p with respect to load
$\partial \mu_s/\partial F_z$	rate of change of μ_s with respect to load
$\partial S_p/\partial F_z$	rate of change of S_p with respect to load
$\partial X_p/\partial F_z$	rate of change of X_p with respect to load
$\partial C_y/\partial F_z$	rate of change of C_y with respect to load
$\partial C_\alpha/\partial V$	rate of change of C_α with respect to velocity
$\partial \mu_p/\partial V$	rate of change of μ_p with respect to velocity
$\partial \mu_s/\partial V$	rate of change of μ_s with respect to velocity
$\partial S_p/\partial V$	rate of change of S_p with respect to velocity
$\partial X_p/\partial V$	rate of change of X_p with respect to velocity
$\partial C_y/\partial V$	rate of change of C_y with respect to velocity

The conceptual model is implemented on the computer as follows. If the partial derivatives are non-zero, then μ_p', S_p', μ_s', C_α', X_p', and C_y' are calculated accordingly at each time step, that is,

$$\mu_p' = \mu_p + \frac{\partial \mu_p}{\partial F_z} (F_z - F_{z_o}) + \frac{\partial \mu_p}{\partial V} (V - V_o)$$

$$S_p' = S_p + \frac{\partial S_p}{\partial F_z} (F_z - F_{z_o}) + \frac{\partial S_p}{\partial V} (V - V_o)$$

$$\mu_s' = \mu_s + \frac{\partial \mu_s}{\partial F_z} (F_z - F_{z_o}) + \frac{\partial \mu_s}{\partial V} (V - V_o)$$

$$C_\alpha' = C_\alpha + \frac{\partial C_\alpha}{\partial F_z} (F_z - F_{z_o}) + \frac{\partial C_\alpha}{\partial V} (V - V_o)$$

$$X_p' = X_p + \frac{\partial X_p}{\partial F_z} (F_z - F_{z_o}) + \frac{\partial X_p}{\partial V} (V - V_o)$$

and $$C_y' = C_y + \frac{\partial C_y}{\partial F_z} (F_z - F_{z_o}) + \frac{\partial C_y}{\partial V} (V - V_o)$$

These parameters are then employed to compute the auxiliary quantities μ and C_s using the following equations:

$$a = (1 - S_p')^2 \, (1 + S_p')$$

$$b = (1 - S_p')(\mu_s'(S_p' + 2) - \mu_p'(2S_p' + 1))$$

$$c = (\mu_s' - \mu_p')\mu_s'$$

$$B = - \frac{b + \sqrt{b^2 - 4ac}}{2a}$$

$$A = \mu_s' + B$$

$$C = \mu_s' + B(1 - S_p')$$

$$C_s = \frac{C^2 F_{z_o} \ (1-S_p')}{4 \ S_p'(C-\mu_p')}$$

$$\mu = A - BS$$

Once these preliminary calculations are performed, then the fraction (X_s/ℓ) is calculated, where the quantity X_s is the distance from the front of the contact patch to the point where sliding starts and the quantity ℓ is the length of the contact patch. The expressions used for this calculation are:

$$D_T = \left((C_s S)^2 + (C_\alpha' \ \tan\alpha)^2\right)^{1/2}$$

and

$$\frac{X_s}{\ell} = \frac{\mu F_z \ (1-S)}{2D_T}$$

If $X_s/\ell > 1.0$, X_s/ℓ is set equal to 1.0 (note that $X_s/\ell > 1.0$ means that there is no sliding region). Under these conditions, the tire longitudinal force, F_x (positive in the braking direction), is given by:

$$F_x = \frac{C_s S}{1-S} \qquad \text{where } S \text{ is the longitudinal slip}$$

and the lateral force, F_y, is given by:

$$F_y = \frac{-C_\alpha' \ \tan\alpha}{1-S} \qquad \text{where } \alpha \text{ is the slip angle.}$$

If $X_s/\ell < 1.0$, the force components from the adhesion region are:

$$F_{x_a} = C_s S \left(\frac{\mu F_z}{2D_T}\right)^2 (1-S)$$

$$F_{y_a} = -C_\alpha' \tan\alpha \left(\frac{\mu F_z}{2D_T}\right)^2 (1-S)$$

and the force components from the sliding region are obtained as follows:

$$F_{T_s} = \mu F_z(1 - X_s/\ell)$$

$$S_T = (S^2 + \tan^2 \alpha)^{1/2}$$

$$F_{x_s} = F_{T_s}(S/S_T)$$

$$F_{y_s} = -F_{T_s}(\tan \alpha/S_T)$$

And, finally in total

$$F_x = F_{x_a} + F_{x_s}$$

$$F_y = F_{y_a} + F_{y_s}$$

The aligning torque is difficult to predict accurately using a simple theoretical model. However, reasonably accurate results can be obtained using empirically obtained values of X_p and C_y. In this approach, the aligning torque, A_T, is approximated as follows:

$$A_T \doteq - F_y X_p' \left(\frac{X_s}{\ell}\right) + F_y F_x C_y'$$

The simplified tire model described here differs from previous versions in two main respects: (1) aligning torque is approximated even in the case of combined longitudinal and lateral slip and (2) the resultant force produced by the sliding portion of the contact patch opposes the direction of sliding.

I.2 Brake Model

The brake model option is included for use in research studies requiring detailed investigations of the influences of the properties of foundation brakes. (It should be emphasized that for applications not requiring a comprehensive examination of the brakes, brake performance may be represented by a pressure-input/torque-output table (see Section 3.3.6).) The brake model consists of two primary parts: (1) a heat flow analysis for brake temperatures and (2) a semi-empirical model for representing an instantaneous brake factor.

Figure I.2-1 shows the relationship of the semi-empirical model for the brake factor to (1) the actuation effort and (2) the calculations of brake temperatures and wheel speed. Empirical results from brake tests indicate that the instantaneous torque produced by a brake during a stop is primarily a function of pressure, but it may be strongly influenced by temperature and sliding velocity effects. Hence, the concept of an instantaneous brake factor has been employed to represent the in-stop fade and recovery typical of certain types of drum brakes. In this representation (Figure I.2-1), brake torque, T_B, is a function of (1) the pressure in the air chamber, P, (2) the wheel speed, ω, and (3) the temperature distribution throughout the brake, $\vec{\theta}$.

The details of the conceptual models implemented for computing brake temperatures and brake fade are presented in the following sections, I.2.1 and I.2.2, respectively.

I.2.1 Brake Temperature. Temperature calculations were first introduced into the Phase I straight-line braking program to provide a means for predicting in-stop fade. In that case, the interface temperature between the drum and lining was calculated using specially developed numerical methods for solving classical heat flow equations applied to a simplified model of the brake drum [11]. Later, work in studying inertia dynamometer results employed a finite element model of the actual brake drum to compute temperatures throughout the drum [15]. In addition, simplified lumped parameter models of the brake

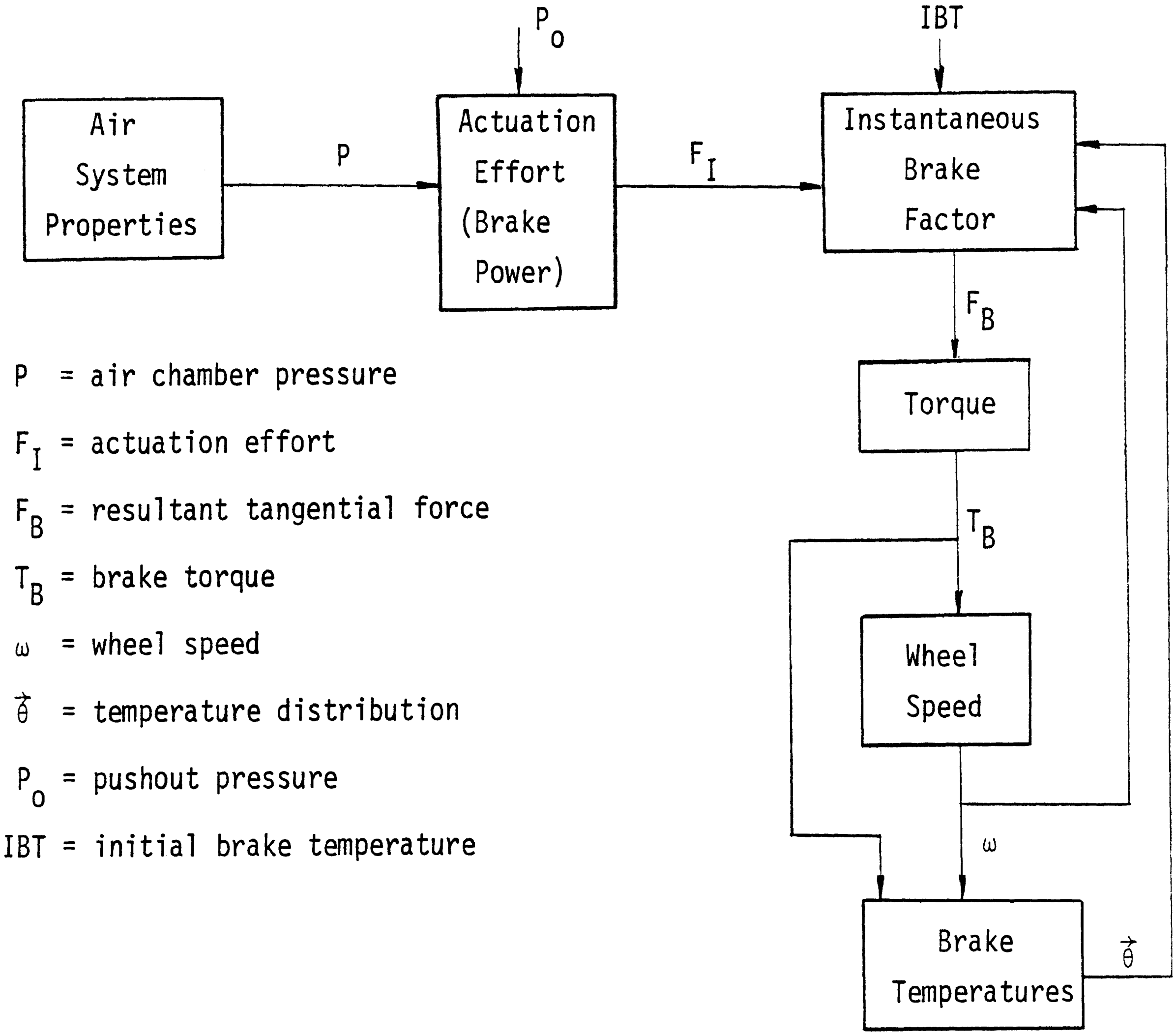


Figure I.2-1. Elements of the brake representation.

have been developed to make temperature calculations for use in studies incorporating antilock system hardware with vehicle models [19].

The past work has been reviewed with the intention of selecting a conceptual model suitable for anticipated applications of the computer simulation in studies of downhill speed control, fade and recovery tests, and in-stop fade. The following lumped parametric model has been selected to provide first-order estimates of temperatures at the drum/lining interface and within the drum and the lining.

Figure I.2-2 illustrates the form of the model using an electrical circuit analogy to represent the heat flow process. The symbols used in Figure I.2-2 are defined in Table I.2.1. The basic equations to be solved by the computerized model follow Table I.2.1.

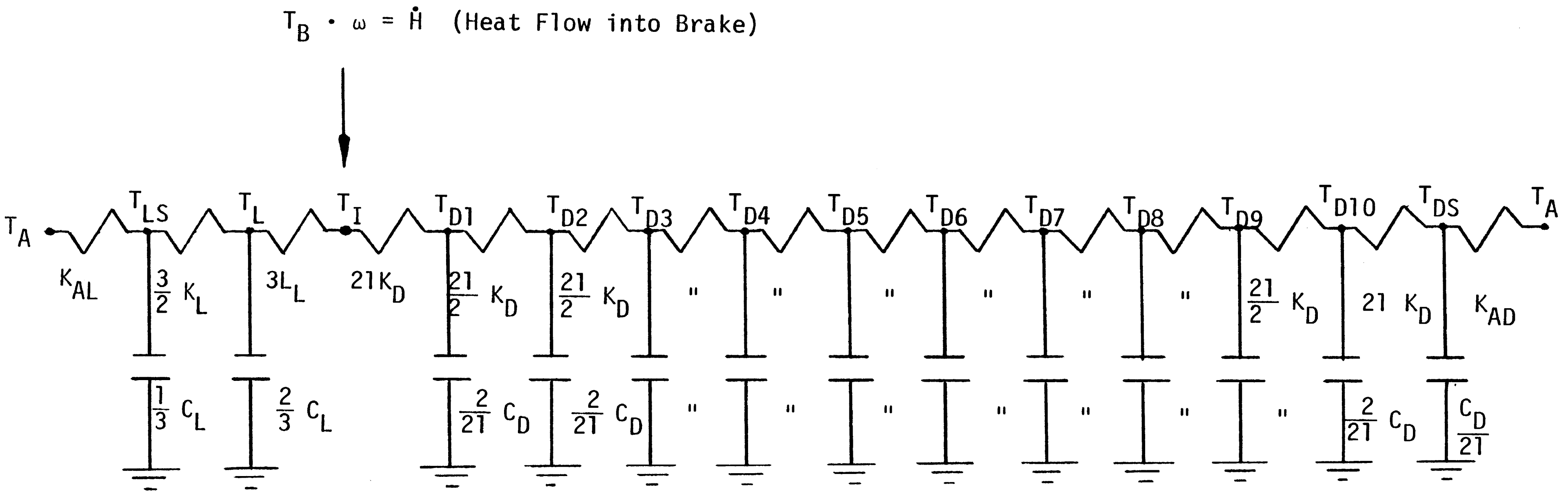


Figure I.2-2. 10-1/2 Node lumped mass brake temperature model.

Table I.2.1

Symbol	Definition
K_{AL}	heat convection coefficient for the lining
K_L	heat conduction coefficient for the lining
C_L	thermal capacity of the lining
C_D	thermal capacity of the drum
K_D	heat conduction coefficient for the drum
K_{AD}	heat convection coefficient for the drum
$\dot{H}$	heat flow into the brake
T_B	brake torque
ω	wheel (drum) speed
T_{LS}	lining exterior surface temperature
T_L	internal lining temperature at a point 1/3 of the distance from the interface to the exterior surface of the lining
T_I	interface temperature
T_{Di}	internal drum temperature at the i^{th} location between the interface and the exterior surface of the drum ($i = 1$ to 10)
T_{DS}	drum exterior surface temperature
T_A	ambient air temperature

Note: T_I, T_L, T_{D5}, and T_B are printed out on the "Brake Model Temperature" page if the brake model option is employed.

EQUATIONS AND ADDITIONAL SYMBOL DEFINITIONS

Auxiliary Calculations

$$K_D = \frac{K_d \, \pi \, D_D \, w_\ell}{t_D}$$

where

K_d = conductivity of the drum material

D_D = diameter of the drum

w_ℓ = width of the lining

t_D = thickness of the drum

$$K_L = \frac{K_\ell \, \pi \, D_D \, w_\ell \, f_\ell}{t_\ell}$$

where

K_ℓ = conductivity of the lining material

f_ℓ = the ratio of lining length to drum circumference

t_ℓ = thickness of the lining

$$C_D = C_d \, \rho_d \, V_d$$

where

C_d = specific heat of the drum material

ρ_d = density of the drum material

V_d = effective volume of the drum

($V_d \doteq \pi D_D \, w_\ell \, T_D$)

$$C_L = C_\ell \, \rho_\ell \, V_\ell$$

where

C_ℓ = specific heat of the lining material

ρ_ℓ = density of the lining material

V_ℓ = effective volume of the lining ($V_\ell \doteq \pi D_D \, w_\ell \, f_\ell \, t_\ell$)

$$K_{AD} = (K_{ADO} + K_{ADV}\, V)\pi\, D_D\, w_\ell$$

where

K_{ADO} = empirically evaluated convective heat transfer coefficient for the drum

V = velocity of the vehicle

K_{ADV} = velocity sensitivity (empirically evaluated)

$$K_{AL} = (K_{ALO} + K_{ALV}\, V)\pi\, D_D\, w_\ell\, f_\ell$$

where

K_{ALO} = empirically evaluated convective heat transfer coefficient for the lining

K_{ALV} = velocity sensitivity (empirically evaluated)

Basic Equations

$$T_I = [\dot{H} + 21K_D\, T_{D1} + 3K_L\, T_L]/[21K_D + 3K_L] \tag{I.2.1}$$

and the matrix equation,

$$M\, \dot{\overline{\theta}} = S\, \overline{\theta} + \overline{c}\, T_I + \overline{d}\, T_A \tag{I.2.2}$$

where

$$\overline{\theta} = \begin{bmatrix} T_{D1} \\ T_{D2} \\ \cdot \\ \cdot \\ \cdot \\ T_{D10} \\ T_{DS} \\ T_L \\ T_{LS} \end{bmatrix}_{13x1}, \quad \overline{c} = \begin{bmatrix} 21K_D \\ 0 \\ 0 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ 0 \\ 3K_L \\ 0 \end{bmatrix}_{13x1}, \quad \overline{d} = \begin{bmatrix} 0 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ 0 \\ K_{AD} \\ 0 \\ K_{AL} \end{bmatrix}_{13x1}$$

and,

$$M = \begin{bmatrix} \frac{2}{21} C_D & & & & & \\ & \ddots & & & 0 & \\ & & \frac{2}{21} C_D & & & \\ & & & \frac{C_D}{21} & & \\ & 0 & & & \frac{2}{3} C_L & \\ & & & & & \frac{C_L}{3} \end{bmatrix}_{13\text{x}13}$$

$$S = \begin{bmatrix} -\frac{63}{2} K_D & \frac{21}{2} K_D & 0 & 0 & \cdots & & & & & \\ \frac{21}{2} K_D & -21 K_D & \frac{21}{2} K_D & 0 & & & & & \bigcirc & \\ 0 & \frac{21}{2} K_D & -21 K_D & \frac{21}{2} K_D & 0 & & & & & \\ \vdots & & \ddots & \ddots & \ddots & \ddots & & & & \\ & & & & & \frac{21}{2} K_D & -\frac{63}{2} K_D & 21 K_D & 0 & 0 \\ & & & & & 0 & 21 K_D & (-21 K_D - K_{AD}) & 0 & 0 \\ & \bigcirc & & & & 0 & 0 & 0 & -\frac{9}{2} K_L & \frac{3}{2} K_L \\ & & & & & 0 & 0 & 0 & \frac{3}{2} K_L & (-\frac{3}{2} K_L - K_{AL}) \end{bmatrix}_{13x13}$$

I.2.2 Brake Fade (Torque Characteristics). The torque characteristics of commercial vehicle brakes have been studied in several projects supported by MVMA. Even though a variety of useful results have been acquired [11,15], a complete understanding of the development of instantaneous brake torque as influenced by pressure, temperature, sliding velocity, work history, temperature gradients, and other factors has not been obtained.

Recent research work [15] has been directed at treating brake effectiveness as an empirically derived function of pressure, interface temperature, and sliding velocity. However, the empirical expressions derived in the recent work appear to be unduly complex and too difficult to obtain to be useful for including in the simulation model now. Possibly a comprehensive empirical approach would be feasible in the future if large amounts of brake data were gathered into digital files suitable for computer processing.

The conceptual approach taken in PHASE 4 is based on an instantaneous brake factor, B_F, that is represented by the following equation:

$$B_F = B_{F_o} + C_V\,(\omega\, D_D/2) + C_T\,(T_I - T_L) + C_F\,(F_I/A\ell) \qquad \text{(I.2.3)}$$

where

B_{F_o} = the nominal brake factor

C_V = the rate of change of brake factor with sliding velocity

C_T = the rate of change of brake factor with temperature gradient

C_F = the rate of change of brake factor with pressure

ω = wheel speed (drum rotational velocity)

D_D = drum diameter

T_I = interface temperature

T_L = lining temperature

F_I = actuation effort

A_ℓ = area of the lining

The input variables needed for computing B_F are ω, T_I, T_L, and F_I. The wheel speed, ω, and the temperatures, T_I and T_L, are available from calculations performed in other parts of the computerized model. (See Figure I.2-1.) The actuation effort, F_I, is determined by the following equations, one for a wedge brake and the other for a cam brake:

<u>For a Wedge Brake</u>:

$$F_I = A_c(P-P_o)\,\frac{1}{2}\cot(\alpha/2) \tag{I.2.4}$$

where

A_c = area of the air chamber

P = line pressure

P_o = the pushout pressure of the brake

α = included wedge angle

(the calculation is for one wedge of a dual wedge brake)

<u>For a Cam Brake</u>:

$$F_I = A_c(P-P_o)S_\ell \tag{I.2.5}$$

where

S_ℓ = slack adjuster arm length

The brake torque, T_B, is determined by the actuation effort, F_I, brake factor, B_F, drum diameter, D_D, and lining fade using the following equation:

$$T_B = F_I\,B_F(D_D/2)\,G(T_L) \tag{I.2.6}$$

where

$G(T_L)$ is a table representing the influence of lining tempera-ure on brake torque. (For example, $G(T_L)$ may be chosen to make the brake torque fade completely above some maximum lining temperature.)

The model represented by Equations (I.2.3) through (I.2.6) is easy to use for studying the in... .es of changes in "brake power" (air chamber area and wedge angle for wedge brakes or air chamber area and slack adjuster arm length for cam brakes), but the choice of parameters to represent the effects of changes in lining type is not obvious and may require considerable effort in analyzing dynamometer data. For example, Table I.2.2 lists empirically determined coefficients for a constant pressure stop from 60 mph of the same type of 15 x 6 dual wedge brake with a 10° wedge angle and type 16 air chamber but equipped with three different types of linings. Clearly, the evaluation of the influence of lining properties on in-stop fade is highly dependent upon the availability of appropriate test data.

Table I.2.2

Lining	B_{F_0}	C_V (sec/ft)	C_T (1/°F)
551-D	2.9	0.0029	-0.0011
E-84	4.6	-0.0015	-0.0102
MM8C5	6.8	-0.0003	-0.0143

Note: C_F is not included here because these results are for a single value of air pressure.

Procedures for processing brake test data are being developed. Given time histories of wheel speed and brake torque for a particular stop at a selected pressure level, the temperature model described in Section I.2.1 can be used to calculate temperature time histories. Using data points from all of these time histories, Equations (I.2.3) through (I.2.6) can be solved for values of B_{F_0}, C_V, and C_T that will cause the model to approximately match the test data. For example, Figure I.2-3 illustrates a rough fit obtained using torque, wheel speed, and temperature data corresponding to the three points designated by an "x" in

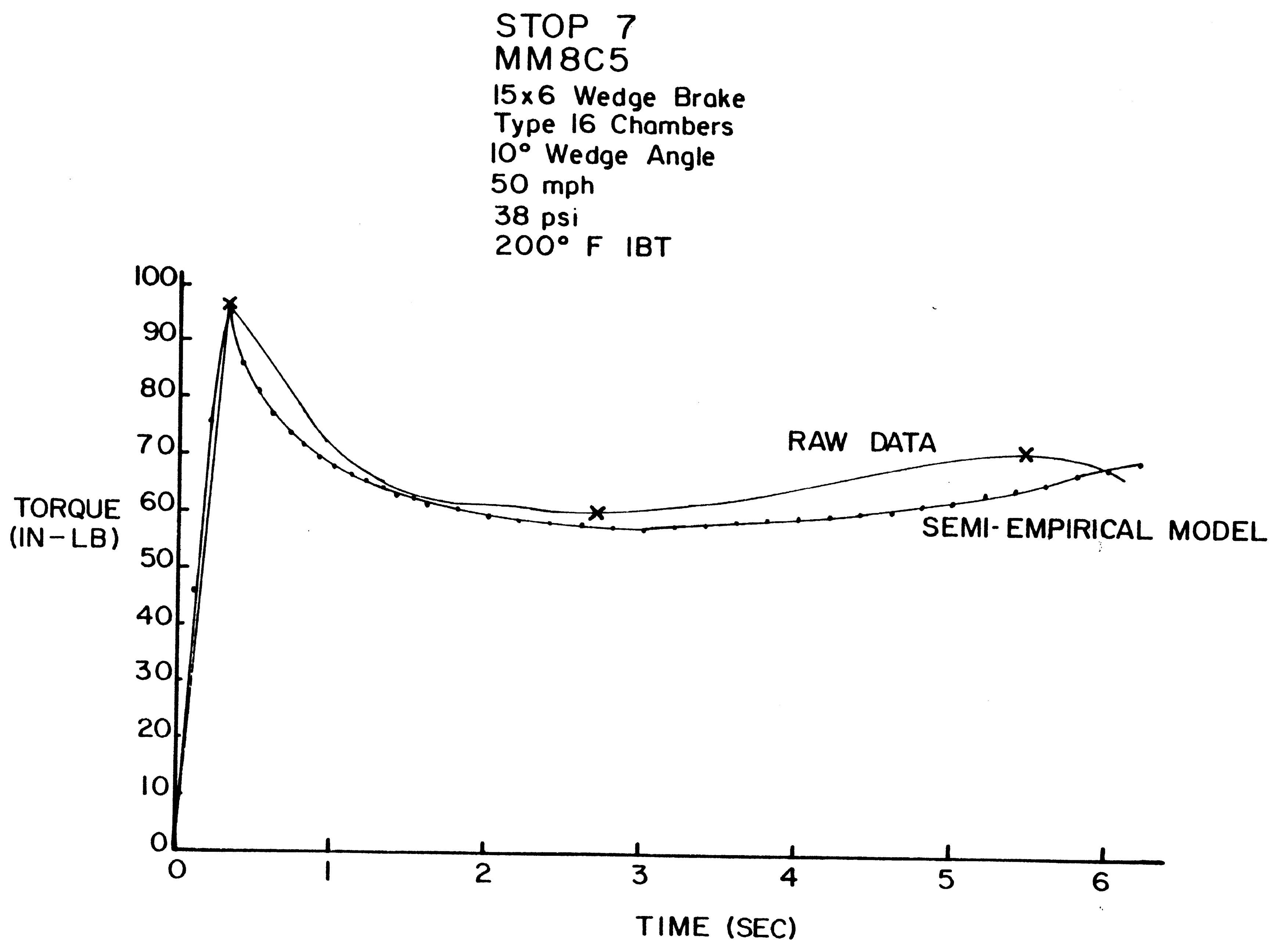

STOP 7
MM8C5
15x6 Wedge Brake
Type 16 Chambers
10° Wedge Angle
50 mph
38 psi
200° F IBT
TORQUE (IN-LB)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
TIME (SEC)
RAW DATA
SEMI-EMPIRICAL MODEL

Figure I.2-3

the figure. Nevertheless, the art and science of representing brake torque characteristics is not well developed, and until it is, the user of the computerized model will have to exercise ingenuity in representing brake performance.

I.3 Spring Envelope Option

The Spring Envelope option allows the PHASE 4 program user to accurately represent the kind of suspension force-deflection characteristics typically measured on heavy truck suspensions. Figure I.3-1 shows an example of a tandem suspension force-deflection measurement recently made at HSRI. References [18] and [39] contain additional sources of such measurements for a variety of heavy truck springs.

In order to use the Spring Envelope option, four kinds of data information are required as input for each spring:

1) a compression envelope table (force versus deflection),

2) an extension envelope table (force versus deflection),

3) a deflection constant for compression, β_c, which describes the rate at which the force-deflection characteristic approaches the compression envelope during spring compression, and

4) a deflection constant for extension, β_c, which describes the rate at which the force-deflection characteristic approaches the extension envelope during spring extension.

The compression and extension envelopes can be obtained directly from most spring force-deflection measurement plots. The compression and extension envelopes of the computer model represent hypothetical boundaries within which the suspension forces must remain during large amplitude deflections. Figure I.3-1 shows both envelopes as dashed lines superimposed on each plot of force-deflection measurements. Each pair of force-deflection envelope lines are input to the PHASE 4 program as simple force-deflection tables per spring.

The compression and extension deflection constants (β_c and β_e) which describe the rate of compression/extension, can also be obtained readily from most spring-force measurement plots. Referring to Figure I-3.2, β_c and β_e are defined as that amount of deflection needed to produce a 63 percent reduction in the difference between the present spring force and its approaching envelope during compression and extension stroking.

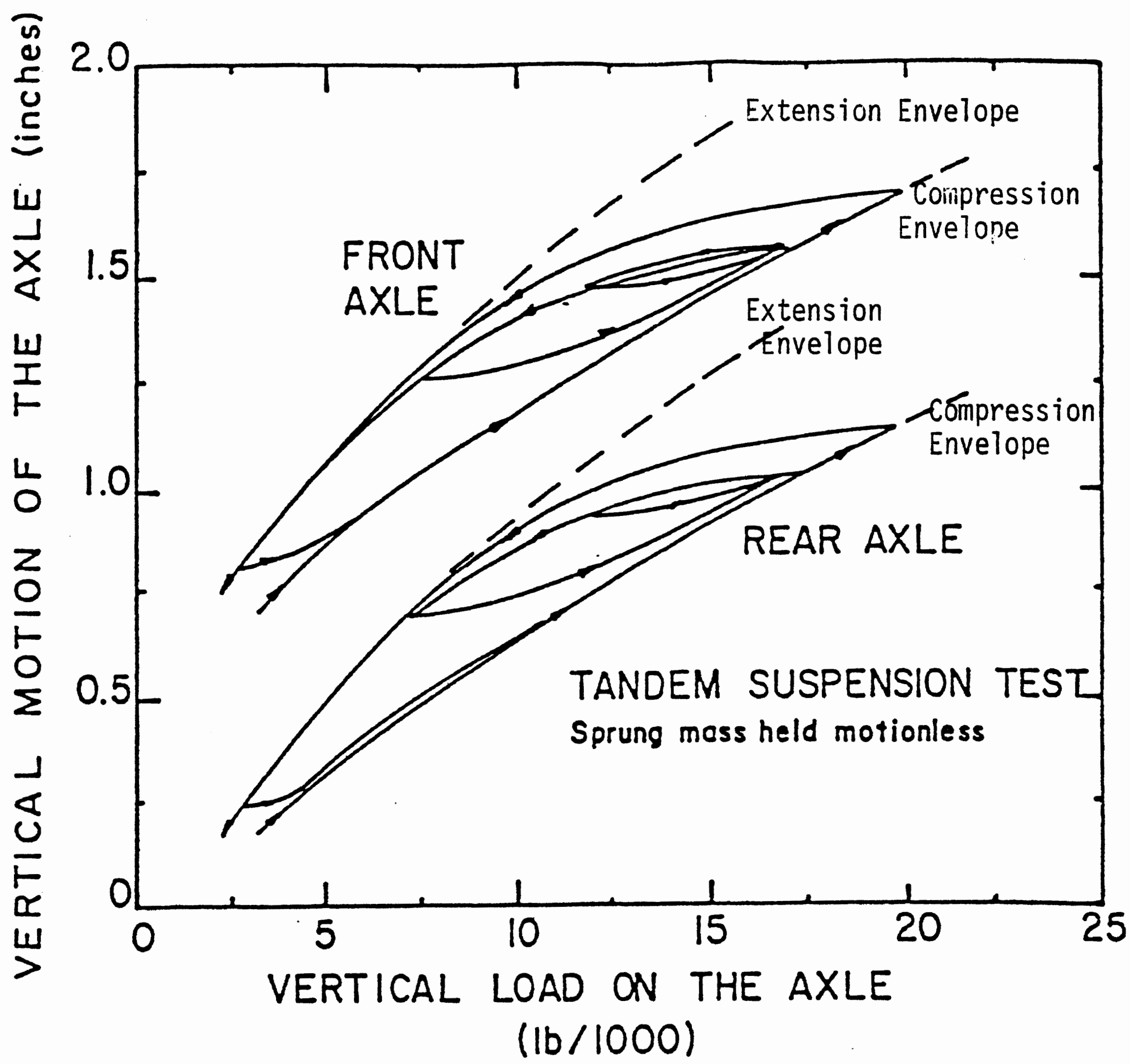


Figure I.3-1. Rear tandem suspension force-deflection measurement.

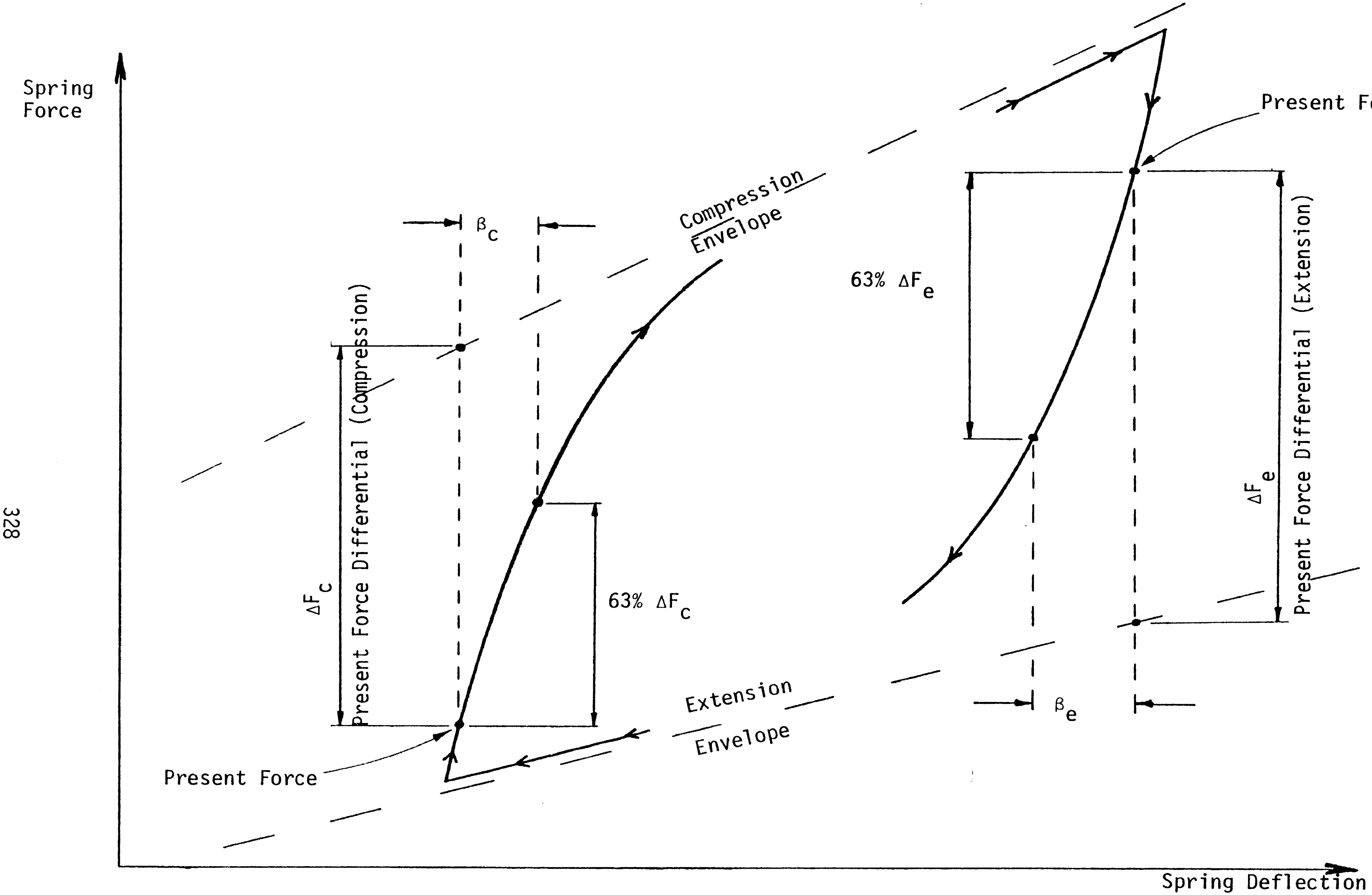


Figure I.3-2. Definition of compression/extension deflection constants, β_c and β_e.

The assumption here is that the spring force at any given deflection during stroking approaches its outer envelope in an exponential manner given by the relationship

$$F_i = F_{env_i} + (F_{i-1} - F_{env_i})e^{-\beta|\delta_i - \delta_{i-1}|} \tag{I.3.1}$$

where

- F_i is the spring force at the current simulation time step
- F_{i-1} is the spring force at the last simulation time step
- δ_i is the spring deflection at the current simulation time step
- δ_{i-1} is the spring deflection at the last simulation time step
- F_{env_i} is either the compression or extension envelope (depending upon whether the spring is compressing or extending) force corresponding to the current deflection, δ_i

and β is either β_c or β_e (again depending upon whether the spring is compressing or extending).

Clearly, no spring conforms perfectly to such an ideal representation as given by Equation (I.3.1). However, quite reasonable approximations to the kind of spring force-deflection characteristics typically measured for heavy truck suspensions can be obtained using this model. As an example, consider Figure I.3-3 which shows a comparison of spring force-deflection measurements for a multi-leaf front spring and spring force-deflection characteristics predicted by the spring envelope model using the following input data:

1) $F_{env_{compression}} = 1300\ \delta + 300$ (lb)

2) $F_{env_{extension}} = 1100\ \delta - 100$ (lb)

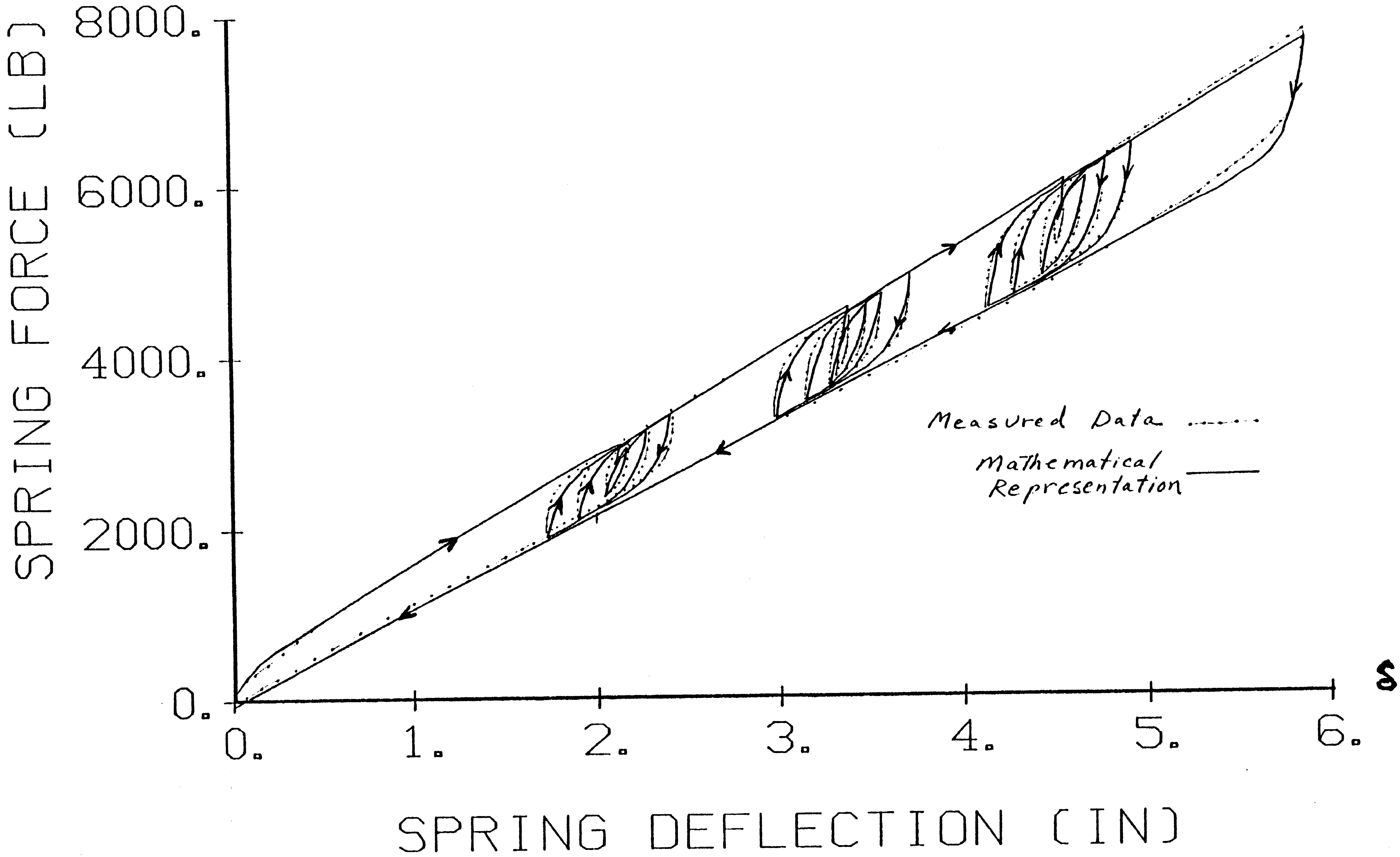


Figure I.3-3. Comparison of measured and simulated spring force-deflection characteristics.

3) β_c = 0.08 (in)

4) β_e = 0.076 (in)

The compression and extension envelopes, items (1) and (2) (shown here as equations rather than the tabular form used by the PHASE 4 program), were selected in this example as the straight-line asymtotes bounding the upper and lower portions of the measured data. The compression and extension parameters, β_c and β_e, were selected to give the best overall fit to the hysteresis loops during stroking.

The following data, as described here and in Section 3.3.2, would be required by the PHASE 4 program to represent the spring force-deflection characteristics shown in Figure I.3-3:

02	no. of points in compression envelope table
300. , 0.0 8100. , 6.0	force versus deflection compression envelope table
0.08	compression deflection constant, β_c
02	no. of points in extension envelope table
-100. , 0.0 6500. , 6.0	force versus deflection extension envelope table
0.076	extension deflection constant, β_e

Finally, Figure I.3-4 shows a suspension force-deflection time history computed by the PHASE 4/Spring Envelope program during a sinusoidal steer (lane change) maneuver. The plot shows both left and right suspension forces for a loaded tandem axle. Both force/deflection time histories start from the static initial condition of 7000 lb and 1.35 in. Each + and * are 0.1 second apart in time. The total time interval shown here is about 3.5 seconds.

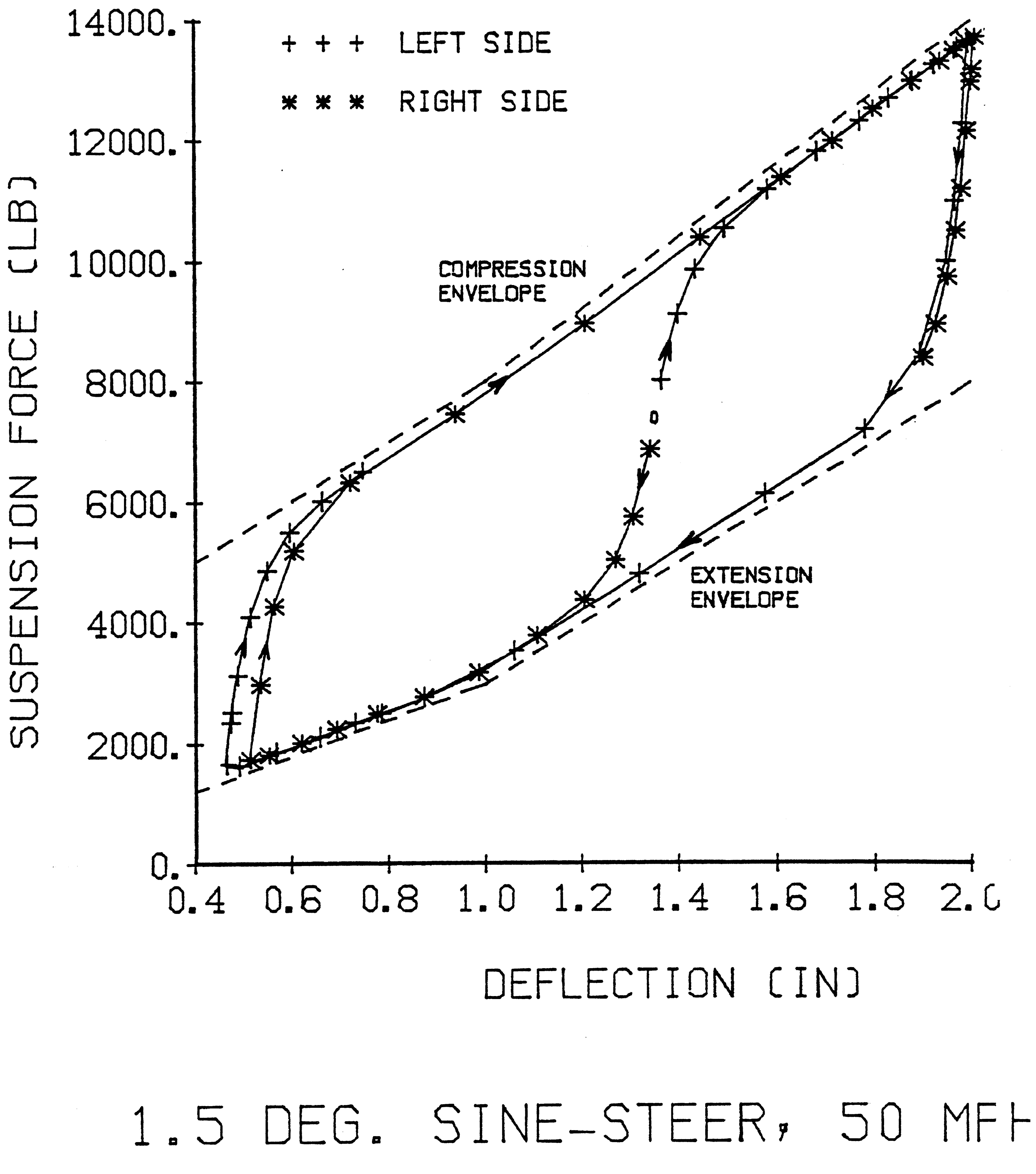


Figure I.3-4. PHASE 4 model calculation for a loaded tandem axle.

I.4 Torsional Compliance in the Tractor Frame

Previous work on torsional compliance treated the stiffnesses of both the tractor and trailer frames. As a result of that work, a special version of the Phase II model was developed for studying the influences of frame compliances and roll stiffnesses on the yaw stability of commercial vehicles.

The special model was employed in an NHTSA-sponsored study entitled "The Yaw Stability of Tractor-Semitrailers During Cornering." Examinations of the results of the NHTSA study [38] indicate that the torsional stiffnesses of the trailer frames for typical van and flat-bed trailers are not particularly important in determining yaw stability. Accordingly, only tractor frame compliance (in torsion) is considered in the following model.

The conceptual model is sketched in Figure I.4-1 using symbols defined in Table I.4.1

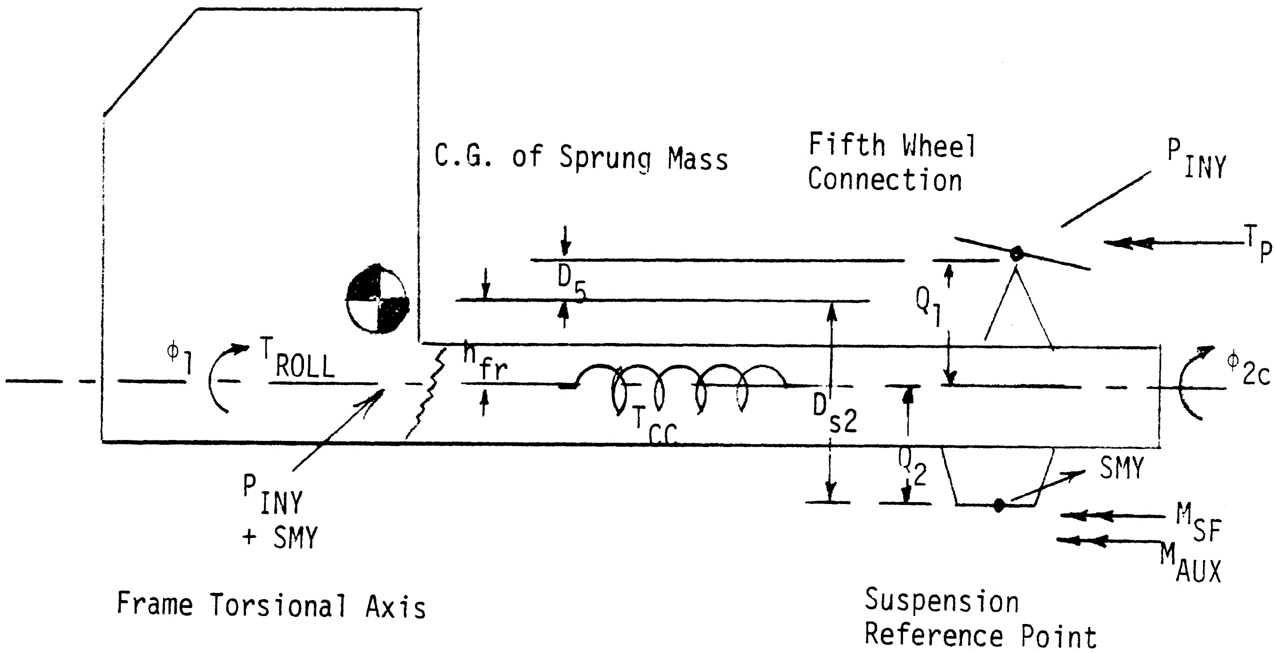


Figure I.4-1

Table I.4.1

Symbols	Definitions
ϕ_1	tractor sprung mass roll angle
h_{fr}	height of sprung mass c.g. above the frame torsional axis
T_{ROLL}	roll moment transmitted to the tractor sprung mass via the torsional frame
T_{CC}	effective stiffness of the tractor frame
Q_1	vertical distance between torsional axis and fifth wheel
Q_2	vertical distance between torsional axis and rear suspension reference point
P_{INY}	lateral force on the tractor at the fifth wheel
T_p	roll moment on the tractor from the trailer at the fifth wheel
T_{PT}	$(-T_p)$
ϕ_{2c}	roll angle at the fifth wheel
SMY	lateral force on the tractor sprung mass at the suspension reference point
M_{SF}	roll moment from the rear suspension of the tractor
M_{AUX}	roll moment due to auxiliary roll stiffness of the rear suspension of the tractor
D_5	height of the fifth wheel above the sprung mass c.g.
D_{s2}	height of the rear suspension reference point below the sprung mass c.g.

The equations describing this system are derived assuming that roll equilibrium exists about the frame torsional axis, that is,

$$T_{ROLL} = T_{CC}(\phi_{2c} - \phi_1) = T_p + (P_{INY})Q_1 - (SMY)Q_2 + M_{SF} + M_{AUX}$$

where $Q_1 = h_{fr} + D_5$

$$Q_2 = D_{s2} - h_{fr}$$

$$M_{AUX} = \sum_{i_{\text{rear axles}}} K_{RS_i}(\phi_{axle_i} - \phi_{2c})$$

where ϕ_{axle_i} is the roll angle of the i^{th} rear axle

and K_{RS_i} is the auxiliary roll stiffness of the i^{th} rear axle

The moment, T_{PT}, from the tractor on the trailer sprung mass is given by:

$$T_{PT} = -T_p = (P_{INY})Q_1 - (SMY)Q_2 + M_{SF} + M_{AUX} - T_{ROLL}$$

The following equations are used to approximate the influence of the articulation angle, Γ, measured from the trailer's longitudinal axis to the tractor's longitudinal axis:

$$\phi_{2c} \doteq \phi_2 \cos \Gamma$$

where ϕ_2 is the roll angle of the trailer's sprung mass,

$$T_{PT_{ROLL}} = T_{PT} \cos \Gamma \qquad \text{(acting on the trailer sprung mass in roll)}$$

$$T_{PT_{PITCH}} = T_{PT} \cos \Gamma \qquad \text{(acting on the trailer sprung mass in pitch)}$$

Note that the roll moment, T_R, transmitted to the tractor sprung mass through the torsionally compliant frame is the sum of the torsional moment and the moment due to a lateral force equal to P_{INY} + SMY, viz.,

$$T_R = T_{ROLL} - h_{fr} (P_{INY} + SMY)$$

The computerized model derived from this conceptual model uses a quasi-static technique in which the following sequence of calculations is employed:

1) At the end of an integration step, ϕ_{axle_i}, ϕ_1, ϕ_2, and Γ are available to compute ϕ_{2c}, T_{ROLL}, and M_{AUX}.

2) P_{INY}, SMY, and M_{SF} are evaluated as they were previously in T3DRS:V1 <u>except</u> ϕ_{2c} is used in place of ϕ_1 where appropriate.

3) T_R, $T_{PT_{ROLL}}$, and $T_{PT_{PITCH}}$ are then calculated for use in the next integration step.

With regard to T3DRS:V1, the change described here is approximately equivalent to removing the so-called "fifth wheel spring, MC5," and inserting a new spring, T_{CC}, between the rear suspension of the tractor and the tractor sprung mass. With respect to roll, the rear suspension of the tractor will be rigidly coupled to the trailer and elastically coupled to the tractor's sprung mass.

For the user of PHASE 4, the frame torsional compliance model requires two input parameters, the frame torsional stiffness and the height of the frame torsional axis above the ground under static conditions. The values of these parameters are "echoed" in the computer printout next to the labels "TRACTOR FRAME STIFFNESS" and "TRACTOR FRAME TORSIONAL AXIS HEIGHT." Note that these two parameters apply only to tractors (lead units) pulling one or more trailers, and should not be entered for truck or bob-tail tractor configurations (VEHICLE CONFIGURATION parameter = 00).

I.5 Steering System Model

The steering system on a heavy truck plays a significant role in its handling behavior as perceived by a driver. Though the steering control is input at the steering wheel, the forces and compliances in the system alter the steer angles obtained at the front wheels. The significance of the effect is seen in the fact that the steering system has been identified as a major source of understeer on heavy trucks. In truck performance studies, the actual steer angles obtained may be only half that expected from the steering-wheel angle and gear ratio, due to the action of these effects.

In order to allow the user of the simulation to replicate these effects and apply steering control to the simulation in the more familiar form of steering-wheel angle, a steering system model has been added as an option in the program.

The conceptual model outlined here is similar to a model developed by T.D. Gillespie. (Reference: T.D. Gillespie, "Front Brake Interactions with Heavy Vehicle Steering and Handling During Braking," SAE Paper No. 760025.) The work reported by Gillespie describes the addition of a quasi-static steering system model to the Phase II directional response program developed for MVMA.

Figure I.5-1 illustrates the distribution of compliances, torques, and angular displacements used in the conceptual model. As indicated in Figure I.5-1, the steering wheel steers the left front wheel through a gear and a compliant element. The right front wheel is steered by the left front wheel through a compliant tie rod linkage. Clearly, the equations for the model are extremely simple if the torques are known, viz.,

$$\delta_{lf} = \frac{\delta_{sw}}{N_G} + \left(\frac{M_{lf} + M_{rf}}{K_{ss}}\right) \tag{I.5.1}$$

$$\delta_{rf} = \delta_{lf} + \frac{M_{rf}}{K_{tr}} \tag{I.5.2}$$

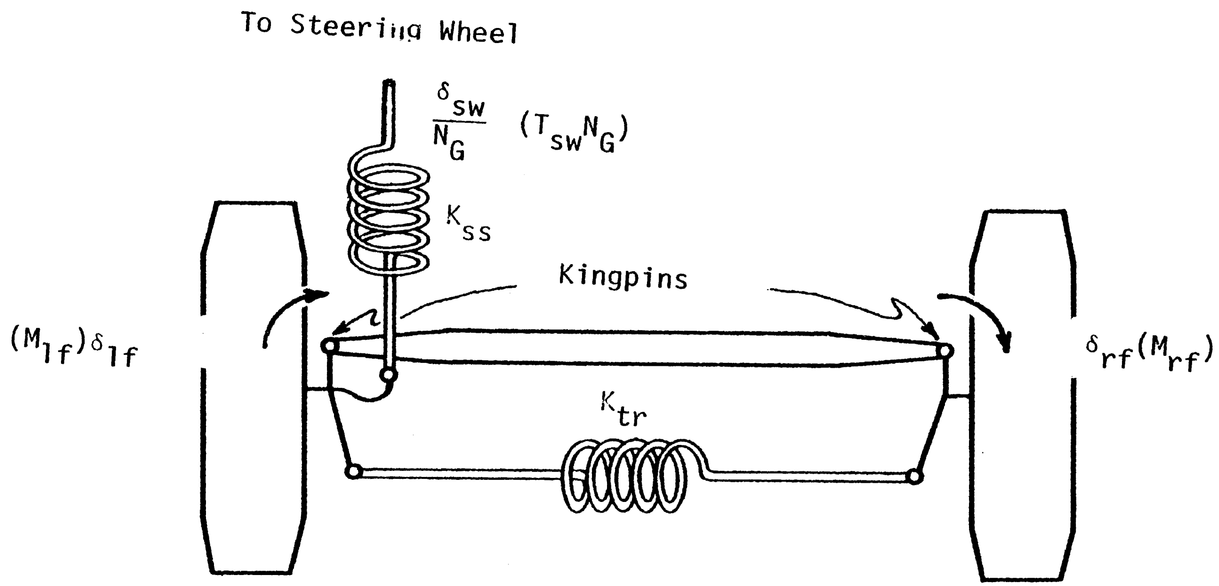


Figure I.5-1. Plan view of a truck steering system.

where

δ_{sw} = STEERING WHEEL ANGLE* (deg)

N_G = STEERING GEAR RATIO* (-)

T_{sw} = steering wheel torque (in-lb)

K_{ss} = STEERING STIFFNESS* (in-lb/deg)

M_{lf} = left front wheel torque (in-lb)

δ_{lf} = left front wheel angle (deg)

K_{tr} = TIE ROD STIFFNESS* (in-lb/deg)

δ_{rf} = right front wheel angle (deg)

M_{rf} = right front wheel torque (in-lb)

Typical values of K_{ss} and K_{tr} for heavy trucks range from 5,000 to 10,000 in-lb/deg and 10,000 to 20,000 in-lb/deg, respectively.

*Parameters required in the simulation input.

The torques developed at each kingpin are the result of the forces and moments exerted on the tires. The kingpin axis is assumed vertical in the model, hence the major components contributing to the torque are those shown in Figure I.5-2. By SAE convention, the forces and moments acting on a tire are measured at the center of tire contact, which lies vertically under the wheel axis at the lateral centerline of the tire. Longitudinal forces on the tires produce torques in proportion to the LATERAL OFFSET OF STEERING AXIS, y_m, between the center of the tire and the kingpin axis. The LATERAL OFFSET is defined as the distance measured at the ground plane and therefore depends on the location of the kingpin axis relative to the wheel and the kingpin inclination angle in the lateral direction. The offset is positive when the wheel center falls outside of the kingpin axis. Lateral forces produce torques in proportion to the longitudinal distance (often called the MECHANICAL TRAIL), x_m, between the center of the tire and the kingpin axis, as measured at the

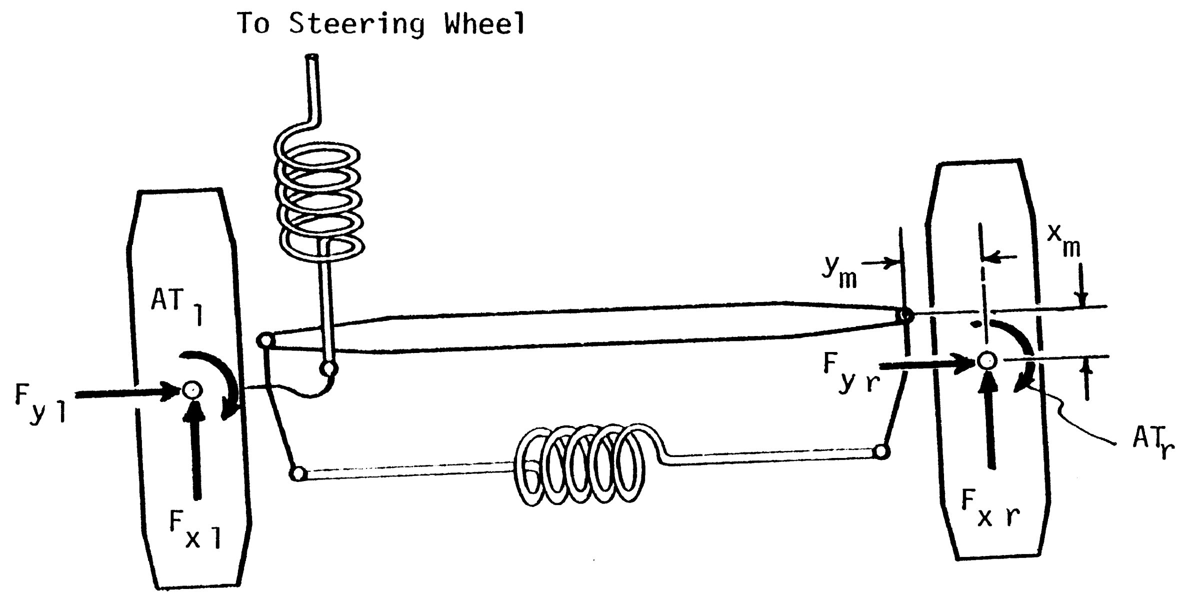


Figure I.5-2. Forces and moments in the truck steering system model.

ground plane. The MECHANICAL TRAIL derives from caster angle on the axle, and like the caster, is positive when the kingpin axis falls ahead of the tire center. The aligning torques translate directly as torques about the kingpin.

Using the convention for the positive forces and torques shown in the figures, the equations for the torques about each kingpin are:

$$M_{lf} = AT_l - F_{yl}\, x_m + F_{xl}\, y_m$$

$$M_{rf} = AT_r - F_{yr}\, x_m - F_{xr}\, y_m$$

where the subscripts r and l mean right and left sides of the vehicle, respectively;

AT = tire aligning torque (in-lb)

F_y = tire lateral force (lb)

F_x = tire longitudinal force (lb)

x_m = MECHANICAL TRAIL (due to caster angle and steering axis location) (in)

y_m = LATERAL OFFSET of the steering axis (due to kingpin inclination and location) (in)

During braking maneuvers, the reaction of the brake torque on the front axle is absorbed by the suspension springs. The forward roll of the axle associated with the wrap-up of the springs reduces the caster angle and hence the MECHANICAL TRAIL. The effect is modeled as a linear function of brake torque by the equation

$$x_m(t) = x_m + (T_{BL} + T_{BR})/K_w + R_t \cdot \theta$$

where

$x_m(t)$ = the instantaneous MECHANICAL TRAIL

x_m = initial MECHANICAL TRAIL (entered as input)

T_{BL}, T_{BR} = left and right brake torques

K_w = TORSIONAL WRAP-UP STIFFNESS

R_t = tire radius

θ = vehicle pitch angle

The TORSIONAL WRAP-UP STIFFNESS is defined as the total axle brake torque required to reduce the MECHANICAL TRAIL by one inch measured in the ground plane. The stiffness is always positive in sign. A reasonable value for this stiffness is not readily available, but can be estimated, knowing the front suspension stiffness and the length of the front springs, using the equation

$$K_w = \frac{2 \cdot K_s \cdot \ell^2}{4 \cdot R_t}$$

where

K_s = nominal stiffness of each front spring (lb/in)

ℓ = spring length (in)

R_t = tire radius

For example, on a front suspension with 50-inch front springs having a rate of 1200 lb/in and a tire radius of 20 inches

$$K_w = \frac{2 \cdot 1200 \text{ lb/in} \cdot 2500 \text{ in}^2}{4 \cdot 20 \text{ in}} = 75{,}000 \text{ in-lb/in}$$

The computerized model derived from this conceptual model operates using a quasi-static technique in which values of T_B, AT, F_y, and F_x from the previous time step in the digital calculation are used to compute front-wheel steer angle deviations for the "current" time. Thus the front-wheel steer angle at any time in the calculation is the attempted steer angle (steering-wheel angle divided by steering-gear ratio) plus the deviations at each wheel due to the steering model and due to roll steer effects.

Closed-Loop Operation with a Steering System

During closed-loop operation with a steering system, the PHASE 4 model assumes that the front-wheel angle, δ_{FW}, returned by the steering controller, is equal to the average of the left and right front wheel angles, δ_{lf} and δ_{rf}, or

$$\delta_{FW} = \frac{\delta_{1f} + \delta_{rf}}{2} \tag{I.5.3}$$

Since the left and right front wheel angles are related to the steering-wheel angle, δ_{sw}, and torques, M_{1f}, M_{rf}, by Equations (I.5.1) and (I.5.2), Equation (I.5.3) can be written as

$$\delta_{FW} = \left[\frac{\delta_{sw}}{N_G} + \delta_{1f} + \frac{M_{rf} + M_{1f}}{K_{ss}} + \frac{M_{rf}}{K_{tr}}\right]/2 \tag{I.5.4}$$

and, together with Equation (I.5.1), define the required closed-loop steering-wheel angle as

$$\delta_{sw} = N_G \left[\delta_{FW} - \left(\frac{M_{rf} + M_{1f}}{K_{ss}}\right) - \frac{M_{rf}}{2K_{tr}}\right] \tag{I.5.5}$$

The left and right front wheel angles then become

$$\delta_{1f} = \delta_{FW} - \frac{M_{rf}}{2K_{tr}} \tag{I.5.6}$$

$$\delta_{rf} = \delta_{FW} + \frac{M_{rf}}{2K_{tr}} \tag{I.5.7}$$

The steering-wheel angle calculated by Equation (I.5.5) and the front wheel angles, Equations (I.5.6), (I.5.7), appear on the Truck/Tractor Sprung Mass Velocity and Acceleration output pages during closed-loop operation with a steering system.

I.6 Brake Hysteresis Option

Brake torque-line pressure hysteresis characteristics are frequently encountered in heavy truck air brake systems, particularly in cam-type actuation mechanisms [11]. Although brake hysteresis may not be of significance under low level or normal braking conditions, moderate to large levels of hysteresis can be important under emergency braking conditions involving antiskid wheel cycling, leading to significant reduction in braking performance [22].

Brake torque measurements [11] have shown that torque-pressure hysteresis levels can depend on whether or not wheel lock occurs during a torque-pressure cycle. Figure I.6-1 illustrates this point.

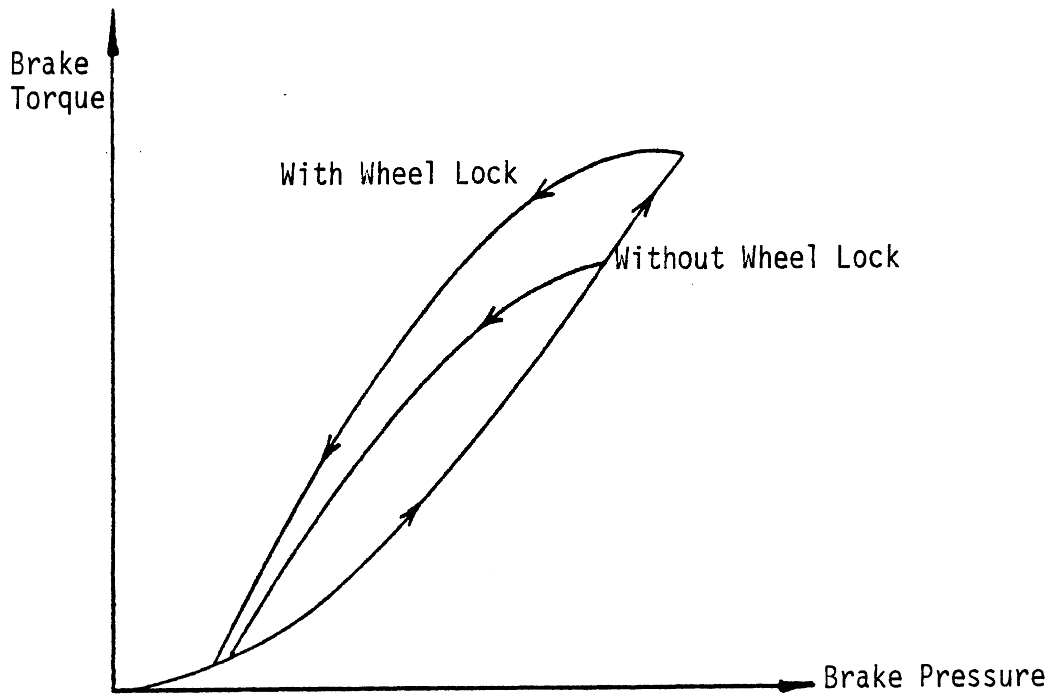


Figure I.6-1. Brake torque-pressure hysteresis characteristic.

In order to simulate this hysteresis behavior for both wheel lock and rolling wheel return loops, the PHASE 4 program employs a computer algorithm which reproduces the brake torque-pressure hysteresis characteristics shown in Figure I.6-2. Under this option, the nominal brake torque-pressure table (or linear brake torque coefficient representation) is modified by two basic parameters, HY and HYL, which act as simple multipliers of the nominal torque-pressure table during the pressure reduction return loop. HY acts during a rolling-wheel return; HYL acts during a locked-wheel return.

Three remaining parameters, RESID, RESBRK, and HY2 are used to adjust the hysteresis characteristic in the low pressure range of operation. RESID (in-lb) represents the residual brake torque at zero pressure ("y-intercept") during a return loop. RESBRK (psi) is the brake pressure level (break-point) below which the brake torque diminishes very rapidly during a return loop. And, HY2 (in-lb/psi) is the corresponding slope of brake torque to pressure below the RESBRK break-point value. These five parameters permit a versatile means of representing most brake torque-pressure hysteresis characteristics within the PHASE 4 program under this option.

To use the brake hysteresis option in the PHASE 4 program, a non-zero value for the global hysteresis key, KHYST, must first be entered immediately following the truck/tractor front axle BRAKE TORQUE parameter, Section 3.3.6. This key signals the program that the brake hysteresis option is in effect and that hysteresis parameters need to be read for each brake. Following this key and each subsequent BRAKE TORQUE parameter on the vehicle train, a line of ten brake hysteresis parameters (10F8.2 format) need to be entered. The first five parameters on this line correspond to the left side values of HY, HY2, RESBRK, RESID, and HYL. The next five for the corresponding right side values. If no right side values are entered, their values are equated internally to those values entered for the left side. Also, if no hysteresis characteristic is desired on a particular brake on the vehicle train, the line must still be entered but a simple 0.0 entry for HY will cause the program to ignore the hysteresis calculations for that brake.

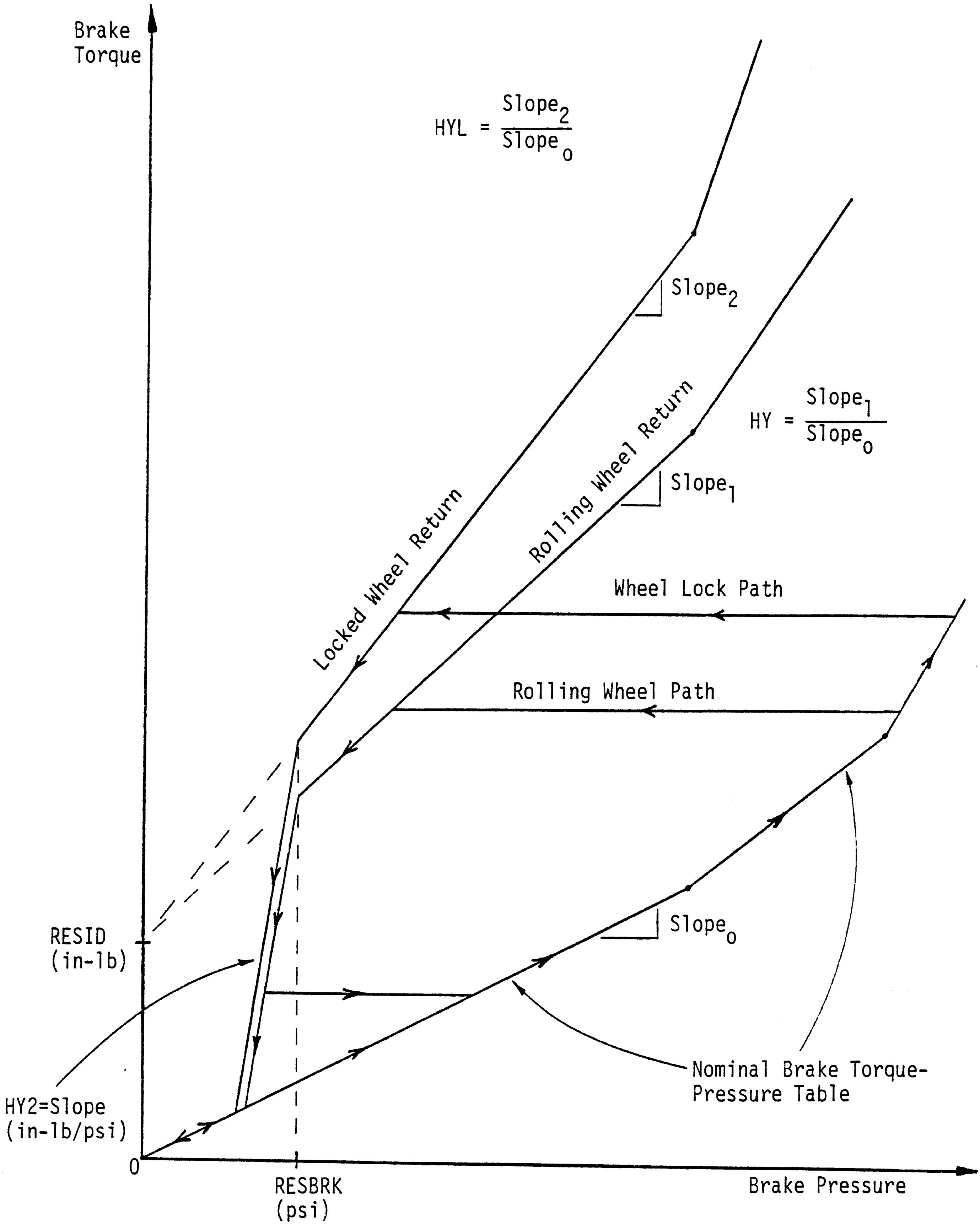


Figure I.6-2. Brake hysteresis algorithm and definition of input parameters: HY, HY2, RESBRK, RESID, and HYL.

I.7 Brake Proportioning Option

The brake proportioning option offered in the PHASE 4 program allows the user to proportion any brake on the vehicle train with any of the following "sensor" variables: (1) vertical tire load, (2) suspension deflection, or (3) vehicle deceleration. In addition, the brake proportioning program can simulate more conventional pressure-dependent proportioning valves.

Figure I.7-1 describes the basic features of the proportioning model. Two "valves" or user-defined tables (Treadle Table and Valve Table in Figure I.7-1) control the operating characteristics of the brake proportioning system. The Treadle Table accepts treadle pressure as input and generates the output pressure, P_{out}. P_{out} is then multiplied by a programmed gain factor, K. K is determined by the user-defined characteristics of the Valve Table and one of its three optional inputs: vertical load, suspension deflection, or vehicle deceleration. The product of P_{out} and K, P_b, is then used as input to the brake chamber pressure calculation, which in turn is then supplied to the brake torque table/or model.

The particular variable input to the Valve Table, V_{IPRO}, is selected by the numerical value entered for the proportioning key, IPRO (1, 2, or 3). If IPRO is entered as 0, brake proportioning is ignored for that brake.

Conventional brake proportioning values that are dependent upon demanded (treadle) pressure alone can be simulated by the following procedure. Define K (Valve Table) as unity (1.0) over a range of values encompassing all possible excursions by the selected input variable (vertical load, suspension deflection, or vehicle deceleration), and then define the desired pressure-dependent gain relationship using the Treadle Table.

If the suspension deflection proportioning option is selected (IPRO=2), one additional parameter must be specified: spring rest length, SPRINGØ , in inches. Since the PHASE 4 program internally calculates deflections from the static load condition, entry of the SPRINGØ parameter

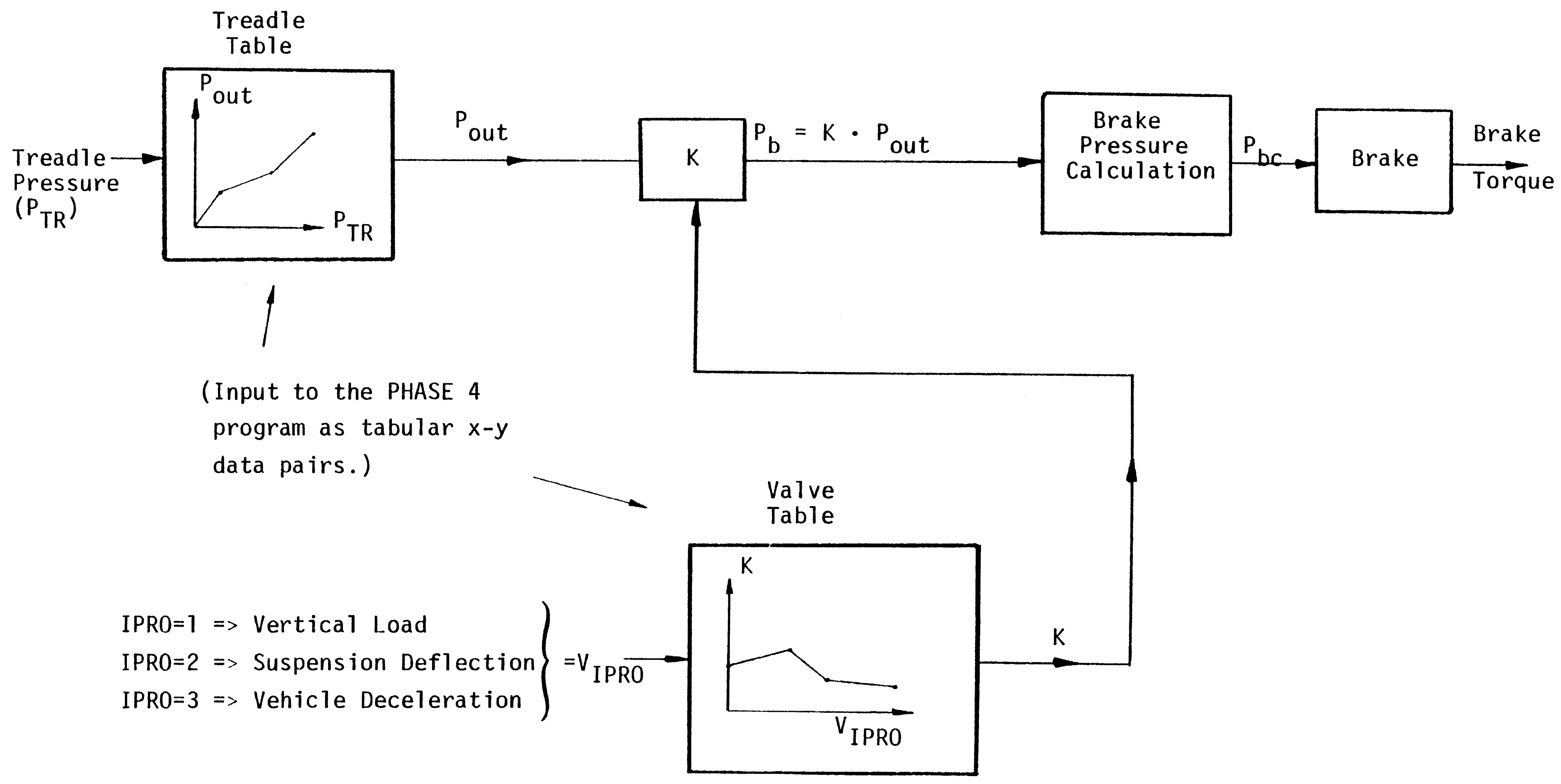
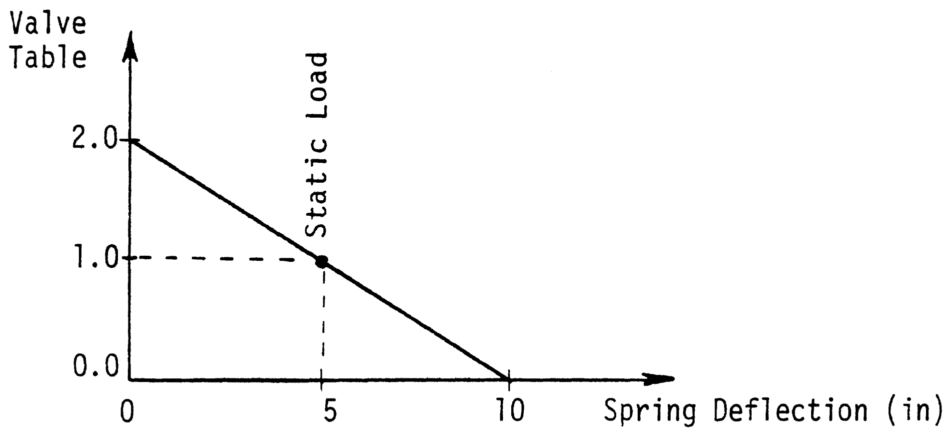


Figure I.7-1. Description of brake proportioning option.

permits the program user to design a deflection proportioning system using zero spring deflection (full compression) to SPRINGØ (rest length) as an x-abscissa variable, rather than deflection from the static load condition.

For example, consider a front tractor spring (stiffness = 1000 lb/in) at a static load of 5000 lb (one side) and rest length, SPRINGØ, specified as 10 inches. If the brake gains were previously selected to proportion the vehicle at the static load condition, the following Valve Table would provide near optimal proportioning for this brake at other load conditions (providing other brakes on the vehicle are likewise proportioned).



As explained in Section 3.3.6, the brake proportioning option is activated by entry of a non-zero value for the global brake proportioning key, KPROP (I1 format), immediately following the global brake hysteresis key, KHYST, entry. Brake proportioning data must then be entered for each brake on the vehicle train. Brake proportioning data follows the KPROP key for the truck/tractor front axle and any hysteresis input data for all remaining brakes on the vehicle. (If the hysteresis option is not in use, brake proportioning data follows each BRAKE TORQUE coefficient parameter.)

Entry of brake proportioning data for each brake (left and right) must conform in order and format to the following.

		Format
IPRO	0 => No proportioning, this brake 1 => Vertical load proportioning 2 => Suspension deflection proportioning 3 => Longitudinal deceleration proportioning	I1

- -

** The following data is entered only if IPRO > 0 **

- -

NT1	# of pairs in Treadle Table	I2
x_1, y_1 . . . x_{NT1}, y_{NT2}	Treadle Table	2F10.2 each line
NT2	# of pairs in Valve Table	I2
x_1, y_1 . . . x_{NT2}, y_{NT2}	Valve Table	2F10.2 each line
(SpringØ only if IPRO = 2)		**F10.2**

- -

Then,

Repeat for right side, same axle,

beginning with,

IPRO

.
.
.
.

I.8 Nonlinear Tire Aligning Torque Model

The nonlinear tire aligning torque model described here can only be used with the nonlinear tire table lookup option of the PHASE 4 program. The purpose of this model is to extend the applicability of the simplified linear tire aligning torque representation to a wider range of operating conditions. A typical passenger car tire plot of aligning torque, M_z, as a function of tire sideslip angle, α, in the presence of braking is shown in Figure I.8-1 [42]. Since few heavy truck tire measurements of a similar nature are available, it is assumed here that aligning torque characteristics of heavy truck tires behave similarly.

In order to reproduce this basic shape, and also account for changes due to vertical load and braking, the nonlinear aligning torque model used in the PHASE 4 program is calculated by the following equation:

$$M_z = \left[\frac{C_{at}}{\left.\frac{\partial \mu_y}{\partial \alpha}\right|_s N_s} - C_1 F_x \right] \cdot \left[\frac{1 - C_2 \alpha \frac{F_x}{N_s}}{1 + C_3 \alpha} \right] \cdot \left[1 + C_4 \frac{(N - N_s)}{N_s} \right] \cdot F_y$$

where

C_{at} is the linear aligning torque coefficient (in-lb/deg) (ALIGNING MOMENT input parameter)

$\left.\frac{\partial \mu_y}{\partial \alpha}\right|_s$ is the partial derivative of normalized cornering force with respect to sideslip angle evaluated at the static load condition (or C_α/N_s, linear cornering stiffness normalized by the static load)

N_s is the static tire load

F_x is the tire longitudinal traction force (positive for braking here)

N is the instantaneous vertical tire load

F_y is the tire lateral traction force

C_1 is the coefficient of brake force which describes the first-order influence of brake force on the pneumatic trail (in/lb)

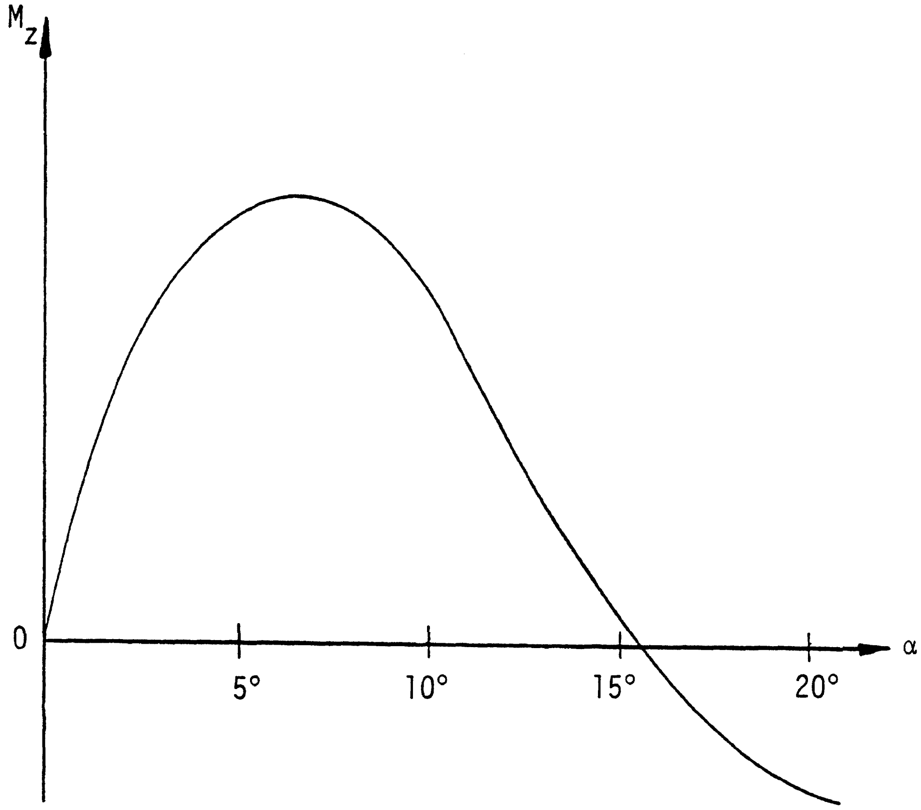


Figure I.8-1. Typical tire aligning torque measurement in the presence of braking.

C_2, C_3 are parameters whose ratio define the saturation level of aligning torque at large tire sideslip angles in the presence of longitudinal braking or traction. In the absence of braking or traction, C_3 determines the rate of decay of aligning torque for large slip angles $(rad)^{-1}$.

and C_4 is a sensitivity coefficient used to describe any additional aligning torque variations deriving from changes in vertical tire load (away from the static load condition) not already accounted for by accompanying F_y variations with load.

Figure I.8-2 further describes these parameters and how they influence the basic shape of the plot shown in Figure I.8-1. Figure I.8-2 shows two aligning torque curves: (a) one with no braking force present ($F_x = 0$) and (b) one with that amount of brake force to reduce the free-rolling pneumatic trail,

$$\frac{C_{at}}{\left.\frac{\partial \mu_y}{\partial \alpha}\right|_s N_s}$$

by one half.

The nonlinear tire aligning torque model is keyed in the PHASE 4 program, as explained in Section 3.3.3.1, by entry of a <u>negative</u> ALIGNING MOMENT coefficient, C_{at}, in conjunction with the nonlinear cornering stiffness lookup-table tire option. (The absolute value of the negative C_{at} entry, $|-C_{at}|$ is actually used in the nonlinear aligning torque calculation described above.) The next line (or card) entered should contain the four nonlinear aligning torque curve fit parameters C_1, C_2, C_3, and C_4, described above. The curve fit parameters are entered in (8F10.2) format, the first four for the left side tire, the second four for the right side. If no right side parameters are entered, they are equated internally to those values entered for the left side.

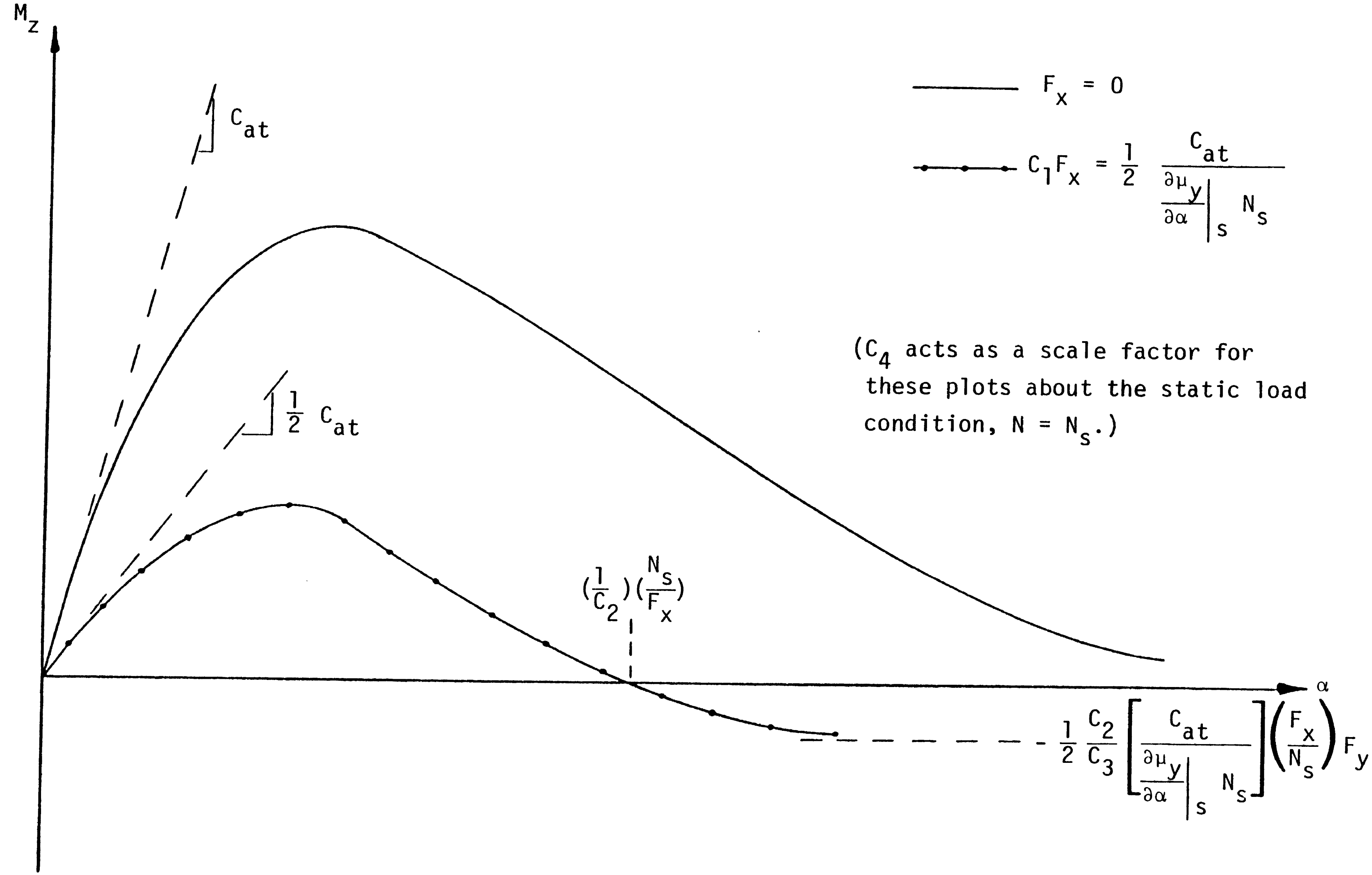


Figure I.8-2. Description and influence of nonlinear aligning torque model parameters: C_{at}, C_1, C_2, C_3, and C_4.