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DEVELOPMENT OF MICROCOMPUTER MODELS OF TRUCK BRAKING AND HANDLING

Final Report

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16. Abstract

This report provides general information on computer programs based on simplified models of truck braking and handling. The following simplified models are discussed: low- and high- speed offtracking, straight line braking, static roll, steady turn, mountain descent, rearward amplification. It includes an outline of a tutorial course explaining the utilization of these models, and the vehicle dynamics concepts involved. Instructions on the use of each of the computer models, and charts summarizing the performance signatures and measures evaluated by each model are provided.

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DEVELOPMENT OF MICROCOMPUTER MODELS OF TRUCK BRAKING AND HANDLING

1. INTRODUCTION

This report provides general information on computer programs prepared by The University of Michigan Transportation Research Institute (UMTRI) through support provided by The Motor Vehicle Manufacturers Association (MVMA).

These programs are based on simplified models of truck braking and handling behavior. They are menu-driven and user-friendly. The simplified models are programmed in Microsoft FORTRAN for use on an IBM PC or compatible computer with a minimum of 512 Kilobytes of random access memory (RAM). The models also require either a 8087 or a 80287 math coprocessor and a graphics board to execute properly.

For those who would like explanations of the vehicle dynamics concepts involved in these models, a tutorial course on the utilization of these models is available. A brief summary of the contents of that course is included in the next section (section 2).

The third section of this document contains copies of the explanatory material that accompanies each of the floppy disks containing the models. This material provides step by step instructions for operating the simplified models. It also contains example input data and resulting outputs for each of the models.

The concluding section of this report contains a chart summarizing the performance signatures and measures evaluated by each of the models.

2. SUMMARY OF TUTORIAL ON TRUCK BRAKING AND HANDLING

The following material outlines the contents of the presentations pertaining to each of the maneuvering situations included in the course.

2.1 Constant Deceleration Braking

1. Definition and Motivation

The vehicle is presumed to be decelerating uniformly after the initial braking transient is over. Braking pressure is nearly constant and the influence of fade is neglected. The purpose of the analysis is to examine the relationships between brake proportioning and the wheel loads that prevail during wheels-unlocked stops on surfaces with different levels of tire/road friction. Basically, the program calculates vehicle deceleration and the friction utilization at each axle.

2. Concepts and Principles

- load transfer at constant deceleration
  - -static axle loads
  - -equilibrium of forces during constant deceleration
  - -interaxle load transfer in tandem suspensions
- brake proportioning
- friction utilization
  - -relationship between braking force and vertical load at each axle
- braking efficiency
  - -relationship between the level of deceleration and the maximum friction level required at any axle

3. Vehicle Descriptors

- static loads
- axle and hitch locations
- c.g. heights
- brake proportioning (pressure vs. torque)
- interaxle load transfer
- tire radius

4. Performance Signatures and Measures

- signatures (empty and loaded)
  - -friction utilizations vs. pressure
  - -deceleration vs. pressure
  - -braking efficiency vs. deceleration
- measures
  - -braking efficiency at 0.2 and 0.4 g

2.2 Mountain Descent

1. Definition and Motivation

The vehicle is driven along a selected elevation profile at a selected velocity profile. The heat flow into each brake is determined, and brake temperatures are calculated.

2. Concepts and Principles

- sources of retardation
  - -foundation brakes
  - -rolling resistance

-aerodynamic drag

-engine drag and retarders

• the meaning of "bulk" temperature and its dependence upon heat flow

-heat flow into the brake

-cooling concepts

-thermal capacity

• the concept of brake proportioning

3. Vehicle Descriptors

• retardation from sources other than the brakes

• proportioning of braking effort

• cooling coefficients as a function of velocity

• thermal capacities

4. Performance Signatures and Measures

• signatures

-temperature profiles for the brakes

• measures

-maximum temperatures

2.3 Low-Speed Offtracking

1. Definition and Motivation

The vehicle is making a tight turn at nearly zero speed. The front axle follows a predetermined path. The tracking of the trailing axles is computed.

2. Concepts and Principles

- paths taken by "rear" axles

  -rear tires move tangent to their paths, that is, along a tractrix

  -explanation of the tractrix

  -graphical demonstration of the determination of tractrices

- paths taken by hitches

  -tractrices for articulated vehicles

- transient and steady-state motions

3. Vehicle Descriptors

- axle and hitch locations

- equivalent wheelbases for units with multiple-axle suspensions

4. Performance Signatures and Measures

- signatures

  -the paths of each axle and the rear of the vehicle

- measures

  -inward offtracking

  -outward swingout

2.4 High-Speed Offtracking

1. Definition and Motivation

The vehicle is performing a steady turn such as that required on an entrance or exit ramp. As in low-speed offtracking, the front axle follows a predetermined path radius. In this case, the vehicle is proceeding at highway speed. The tracking fidelity of the trailing axles is computed.

2. Concepts and Principles

- slip angles of tires and the generation of lateral forces
- the lateral forces required for steady turning
- geometric relationships pertaining to the steady-turning situation
- the factors corresponding to low-speed offtracking and those factors corresponding to the slip angles needed to generate lateral forces

3. Vehicle Descriptors

- axle and hitch locations
- tire cornering stiffnesses
- tire vertical loads
- equivalent wheelbases for units with multiple-axle suspensions

4. Performance Signatures and Measures

- signatures
  - -the paths of each axle and the rear of the vehicle
- measures
  - -outwards offtracking (swingout)
  - -the speed for zero offtracking for the rearmost axle set

2.5 Steady Turn, Roll

1. Definition and Motivation

The vehicle is performing a steady turn and it has reached an equilibrium amount of roll (if one exists for the lateral acceleration level involved). Calculations are made at increasing severities of turning until the level of lateral acceleration equivalent to the vehicle's "rollover threshold" is reached.

2. Concepts and Principles

- sprung and unsprung masses
- suspension roll center heights
- lateral translation of the centers of gravity of sprung and unsprung masses
- roll stiffness definitions and concepts
- saturation of roll stiffness after wheel liftoff
- concept of a "stiff" suspension
- hitches with and without roll coupling

3. Vehicle Descriptors

- c.g. heights of sprung and unsprung masses
- roll center heights
- tire vertical stiffnesses
- between tire track widths
- suspension roll stiffnesses
- sprung and unsprung weights

4. Performance Measures and Signatures

- signatures
  - -lateral acceleration vs. "roll" angle for each independently rolling unit
- measures
  - -rollover thresholds

2.6 Steady Turning, Handling

1. Definition and Motivation

The vehicle is again envisioned to be in a steady turn. The lateral acceleration is constant and the rolling motions have reached equilibrium as in the roll analysis. The objective of the calculation is to examine the steering gain in response to small perturbations in front-wheel angle. This program determines the stability margin of the vehicle. If the vehicle can be divergently unstable, the velocity and lateral acceleration levels corresponding to the transition to instability are calculated .

2. Concepts and Principles

Some examples:

- conditions for turning equilibrium
- the handling equation
- the influence of vertical load on cornering stiffness
- side-to-side load transfer
- perturbations about equilibrium conditions
- steering system stiffness and effective cornering stiffness
- multiple-axle suspensions and their influences on damping in yaw, damping in sideslip, and coupling coefficient
- effective wheelbase and understeer coefficient for articulated vehicles with multiple-axle suspensions

3. Vehicle Descriptors

- roll-related parameters
  - -c.g. heights
  - -roll center heights

-track widths

-suspension roll stiffnesses

-sprung and unsprung weights

- tracking-related parameters

-axle and hitch locations

- tire properties

-cornering stiffness

-influence of vertical load on cornering stiffness

- steering system properties

-steering compliances

- axle loads, c.g. locations

4. Performance Measures and Signatures

- Signatures

-steering gain as a function of lateral acceleration and velocity

-stability boundary if the vehicle is divergently unstable

-steering angle as a function of lateral acceleration at a selected velocity

- measures

-gain at 0.3 g and 55 mph

-instability speed at 0.3 g if it exists

2.7 Rearward Amplification

1. Definition and Motivation

Rearward amplification pertains to the motions of the rear units of articulated vehicles in response to the motion of the first unit. The lateral acceleration of the last unit may be larger than that of the first unit in rapid obstacle-avoidance maneuvers. Consequently, the rear unit may not follow the path of the front unit with adequate fidelity and the rear unit may be susceptible to early rollover. This phenomenon is quite complicated to analyze in detail, but first-order results can be obtained using frequency-domain techniques. The program computes the transfer function between the lateral accelerations of the first and last units.

2. Concepts and Principles

- transfer functions from c.g.'s to hitches
- transfer functions from hitches to c.g.'s
- simplified transfer functions for full trailers
- the importance of the frequency of the input motion
- the importance of the velocity of the vehicle

3. Vehicle Descriptors

- axle and hitch locations
- tire cornering stiffnesses
- c.g. locations and masses
- yaw moments of inertia (or assumption of uniform loading)

4. Performance Signatures and Measures

- signatures

  -plots of transfer function magnitude vs. frequency

- measures

  -maximum magnitude and the frequency at which it occurs

3. EXPLANATORY MATERIALS ACCOMPANYING THE SIMPLIFIED MODELS

3.1 Introduction and General Information

Introduction

The simplified models discussed in this manual were developed by The University of Michigan Transportation Research Institute (UMTRI). This document contains instructions for using the various computerized models and provides the specific information required for performing a calculation.

The equilibrium analyses used here are simplified procedures that have been programmed in FORTRAN for use on IBM PC and IBM compatible computers. The following simplified models were developed:

1) Low- and High-Speed Offtracking Model
2) Straight Line Braking Model
3) Static Roll Model
4) Steady Turn Model (Handling)
5) Mountain Descent Model
6) Rearward Amplification Model

Engineering and Computer Requirements

Throughout the simplified models, the English system of units is used. Masses and weights are in units of pounds, with a gravitational constant of 386 in/sec/sec assumed.

The simplified models are programmed in Microsoft FORTRAN for use on an IBM PC or compatible computer with a minimum of 512 Kilobytes of random access memory (RAM). The models also require either a 8087 or a 80287 microprocessor and a graphics board (discussed below) to execute properly.

Hardware and Default Information

All the models, Offtracking, Braking, Roll, Handling, Rearward Amplification, and Mountain Descent, are written to support any graphics board and any printer device. The

hardware configuration as well as the simulation increments are now read from a common file containing 10 lines called "HARDWARE.SET". Figure 1 shows a print-out of this file.

Figure 1. Hardware.Set

```
HARDWARE AND INCREMENTS CONFIGURATION
&HALOIBM.DEV&
04
&HALOEPSN.PRN&
01.0000          Offtracking, path increment (ft), low speed transient
01.0000          Braking, treadle pressure increment (psi)
0.001            Roll, roll angle increment (rad)
0.025            Handling, lateral acceleration increment (g's)
0.25             Rearward Amplification, steering frequency increment (rad/sec)
01.00            Mountain Descent, integration time step (sec)
```

The Hardware.Set file must be present on the disk to insure the proper functioning of the models. The contents of this file are as follows:

1) The first line is a comment line and may contain any information.

2) The second line specifies the graphics card existing in the computer to be used. Therefore, it is required to know this information beforehand. Furthermore, the specified graphics card file contained in this line must be present in the disk for proper function of the graphics.

3) The third line specifies the graphics mode. This can be obtained from the HALO reference manual. Some examples are:

Graphics Card	Mode
HALOHERC.DEV	00
HALOIBME.DEV	04

4) The fourth line specifies the printer device. This file must be also present otherwise failures while printing plots may occur.

5) The fifth line specifies the path increment in ft, for low speed transient offtracking. Default 1 ft.

6) The sixth line is the treadle pressure increment, psi, for the braking model. Default 1 psi.

7) The seventh line is the roll angle increment, rad, for the roll model. Default 0.001 rad.

8) The eight line is the lateral acceleration increment, g's for the handling model. Default 0.025 g's.

9) The ninth line is the steering frequency increment, rad/sec, for the rearward amplification model. Default 0.25 rad/sec.

10) Increment for Mountain Descent in seconds. Default 1 sec.

The contents of this file can be changed by using any editor program, but it should always contain 10 lines.

3.2 Explicit Directions for Each Model

The following subsections provide documentation to aid users in learning how the programs operate. Each subsection contains detailed instructions on the use of the model being discussed, as well as example input and output from that model. The sections each begin with a "Quick Reference Card" that lists the files necessary to run the model, and the key commands that are available in the model.

Quick Reference Card.

OFFTRACKING V2.0

A) General Information:

To Run The Program Type: OFFTRACK

Files required for proper function:
- OFFTRACK.EXE
- TRAILERS
-TRACTOR
- HALO****.DEV
-HALO++++.PRN
- HARDWARE.SET
**** =Name of the Graphics board,e.g,HERC
++++=Name of the printer device, e.g, EPSN.

B) General Commands:

1) EDIT-VIEW DATA:

PgUp=Page Up
PgDn=Page Down
↑=Upper Edit Field
↵ or ↓=Lower Edit Field
Ctrl →=Right Edit Field (column)
Ctrl ←=Left Edit Field (column)
End=Accept or Continue
Esc=Exit to Main menu
← =Scrolls cursor to left on current field
→ =Scrolls cursor to right on current field

2) CALCULATE:

End=OK or Accept
Esc=Exit to Main menu

3) PLOTS:

a) P or p followed by:
W or w = Wide print out
T or t = Tall print out

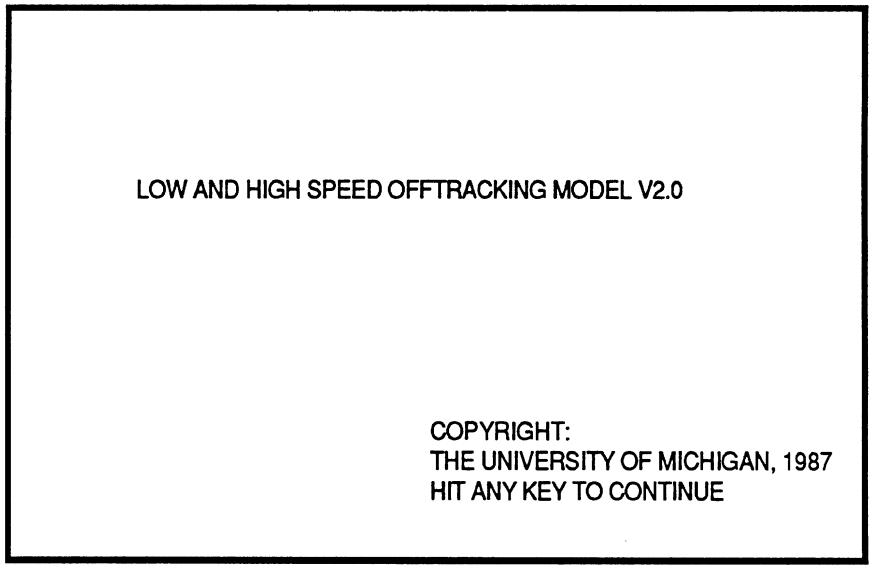
b) Any other key exits to Main menu.

1) RUNNING THE PROGRAM AND SELECTING NEW DATA

To start running the program insert the program disk in any drive and then type:

OFFTRACK

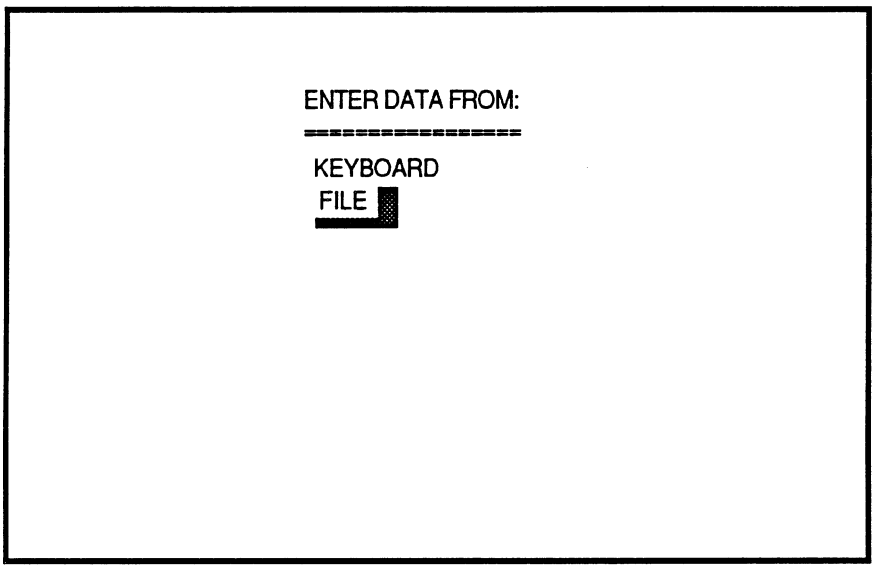
After few seconds the following message appears on the screen (see screen #1 below)



Screen #1

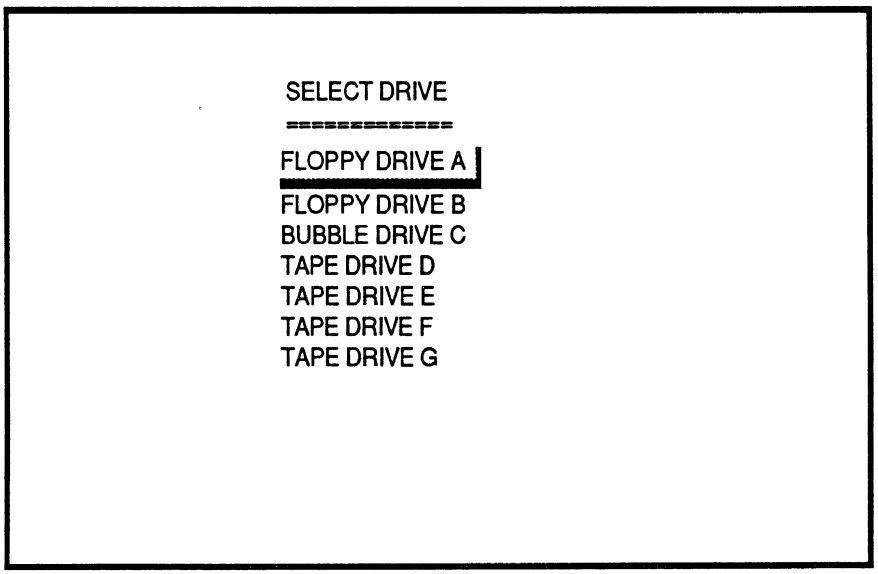
To continue simply hit any key on the keyboard.

The menu to select the source of input appears next, screen #2. Make your selection by pressing the up (↑) and down (↓) arrow keys and then **RETURN** (↵) or **End**.



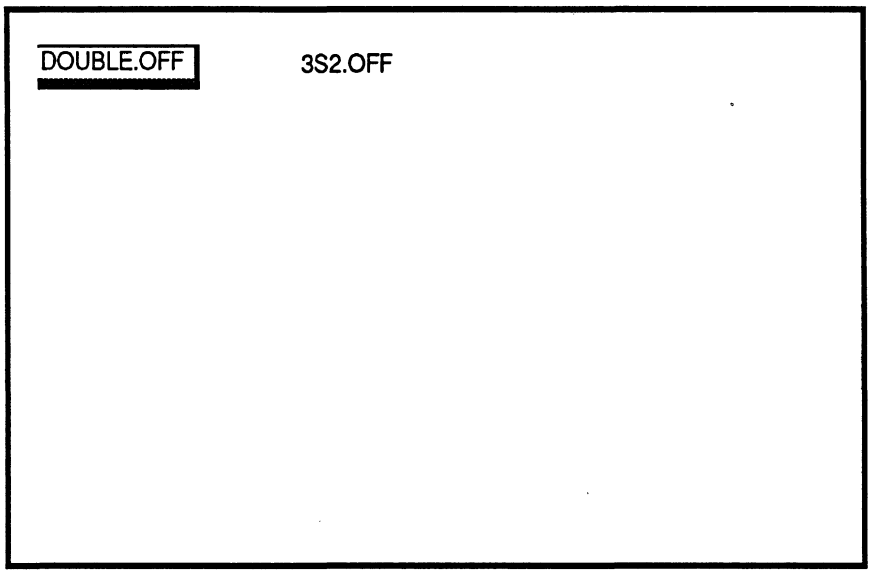
Screen #2

If your selection was "FILE", the following screen appears to enter the drive from which data will be entered.



Screen #3

One more time, make your selection and press the **End** key. All the files available on that drive will be listed on the screen so that you can select one to be read, see screen #4.



Screen #4

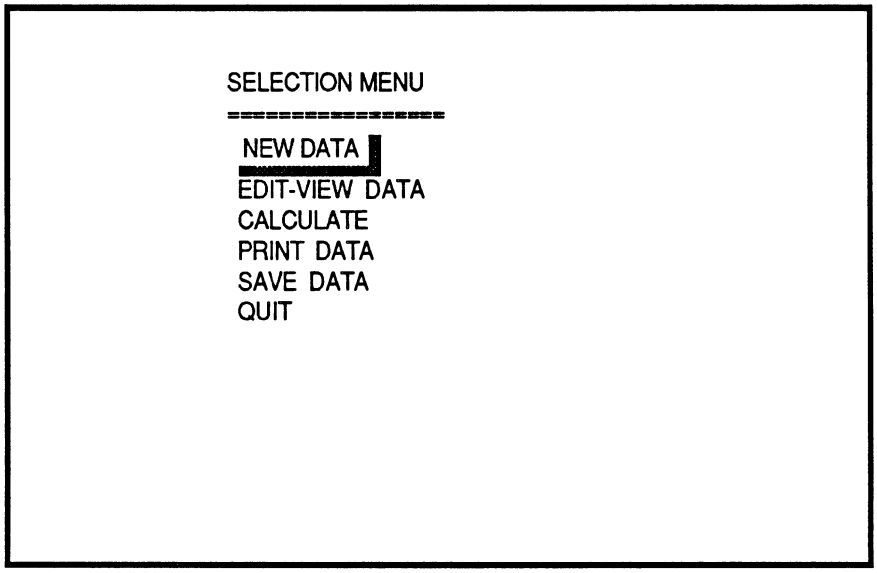
The file selection is made by pressing the following keys:

- **RETURN** key (↵) or the **Ctrl** plus the right arrow (→) key to select forward
- **Ctrl** plus the left arrow (←) key to select backwards, and
- **End** to complete the selection.

For "KEYBOARD" selection see the "EDIT-VIEW DATA" section.

2) EDIT-VIEW DATA

Once data has been read into memory, the main selection menu appears (screen #5.)



Screen #5

From this menu we could:

- Enter new data. This would return us to screen #2 (above.)
- Edit and view the current data set (explained in this section.)
- Calculate, which would further take us to another menu to select the type of calculation.
- Print data, that would send to the printer the current data set.
- Save data, which would allow us to save the current or modified data set into a file.
- Quit, that would return us to the operating system shell.

The way this program displays data is called "Page Editing", which shows the information for each unit on a screen page, see screen #6 and screen #7. We would have as many pages as number of units on the vehicle.

The controls for page editing are the following:

- Up arrow (↑) key, moves the cursor to the upper next position.
- Down arrow (↓) key, moves the cursor to the lower next position.
- **PgUp** key (page up), returns to the previous page.
- **PgDn** key (page down), advances one more page.
- **RETURN** key (↵), has the same function as the down arrow key.
- Right (→) and left (←) arrow keys, moves the text cursor on the current edit field. This is used to modify the current value.
- **Esc** key exits to the main menu at any point during the page editing session.

- **End** key, gets you out of the Edit mode if you are in the last page; otherwise, has no effect.

If you had selected to enter data from the keyboard, a prompt requesting the number of units appears first, and then the remaining data is entered by page editing.

```
LOW AND HIGH SPEED OFFTRACKING

-------------------------------------------------------------------------------

                    INFORMATION FOR UNIT #  1

WHEEL BASE = 144.000 INCHES

DISTANCE OF REAR ARTICULATION FROM FRONT SUSPENSION = 139.200 INCHES

FRONT SUSPENSION LOAD = 12000.0  LBS

TOTAL CORNERING STIFFNESS OF FRONT TIRES =  705.56  LBS/DEG

REAR SUSPENSION LOAD = 17000.0  LBS

TOTAL CORNERING STIFFNESS OF REAR TIRES = 1672.00  LBS/DEG

-------------------------------------------------------------------------------

      PgDn=PAGE DOWN   Esc=EXIT   End=PgDn
```

Screen #6

LOW AND HIGH SPEED OFFTRACKING

INFORMATION FOR UNIT # 2

WHEEL BASE = 432.000 INCHES

DISTANCE OF REAR ARTICULATION FROM FORWARD ARTICULATION = 466.000 INCHES

REAR SUSPENSION LOAD = 17000.0 LBS

TOTAL CORNERING STIFFNESS OF REAR TIRES = 1872.00 LBS/DEG

PgUp=PAGE UP PgDn=EXIT Esc=EXIT End=EXIT

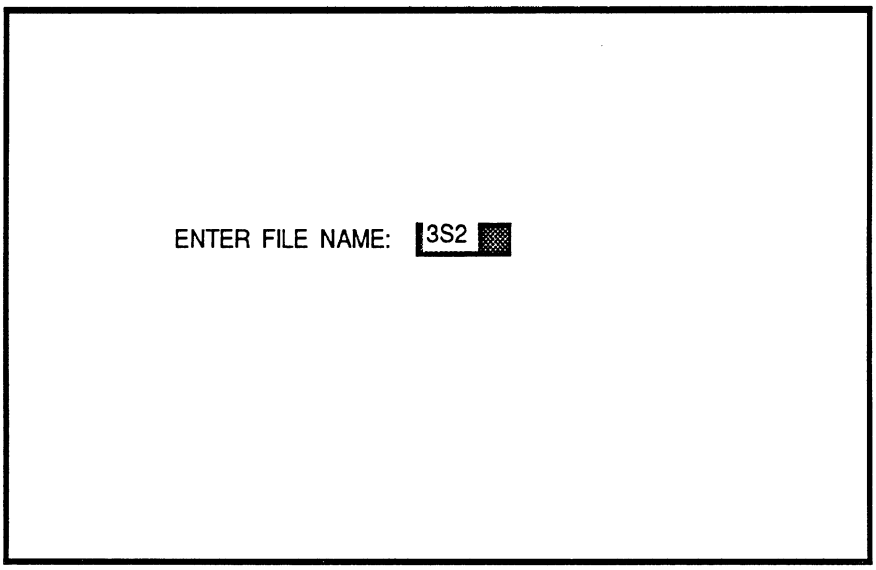
Screen #7

3) **PRINT DATA**

This option will allow the user to send the data set to the printer. A prompt appears to check whether the printer is connected and turned on. If so, just hit the **End** key. A sample data is included at the end of this documentation

4) **SAVE DATA**

Choosing this option allows the user to save a data set into a file. The computer prompts the user for the drive to where data will be stored, see screen #3, and then prompts for the file name, see screen #8.



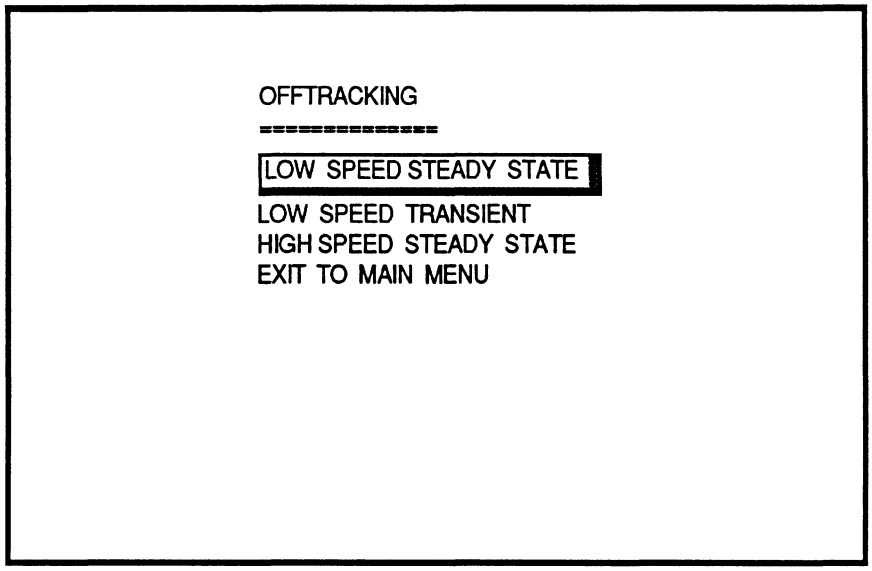
Screen #8

If the file already exists a message indicating so will be printed on the screen, allowing the user to either replace the old file with the new file, or enter a different name for the new file.

Note that the extension "OFF" is added to all the files. This is an identifier of files to this program.

5) CALCULATE

Selecting this option will display the following menu, see screen #9.



Screen #9

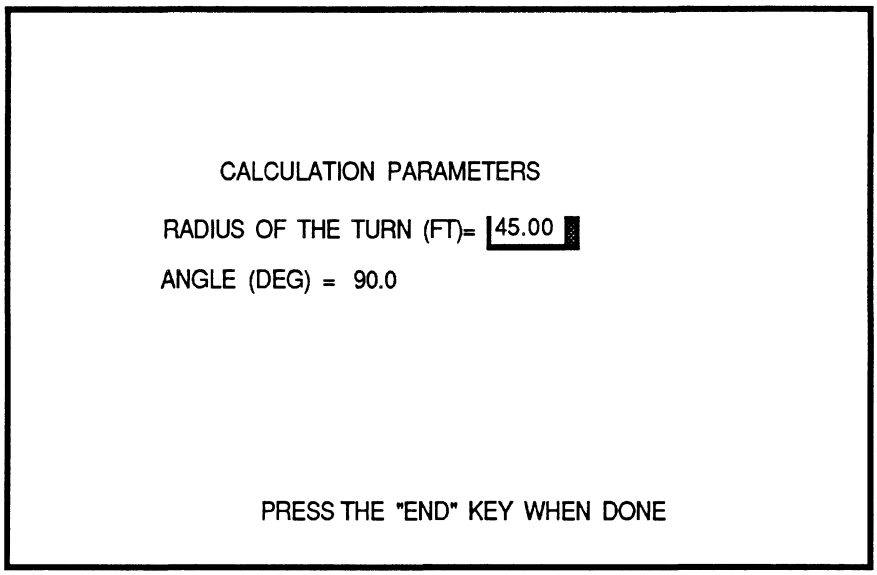
From this menu we can select the type of calculation to perform by just pressing the same controls explained on the previous menus (above.)

Low Speed Offtracking Steady State

The user will be prompted to enter the radius of the turn in ft, a default value of 1200 ft is given. The program checks the input for low magnitude turn radius and prints a warning message on the screen. The results will be displayed on the screen and an option to print the results will be asked for. If you wish to do so press the **End** key or **RETURN** (↵) key.

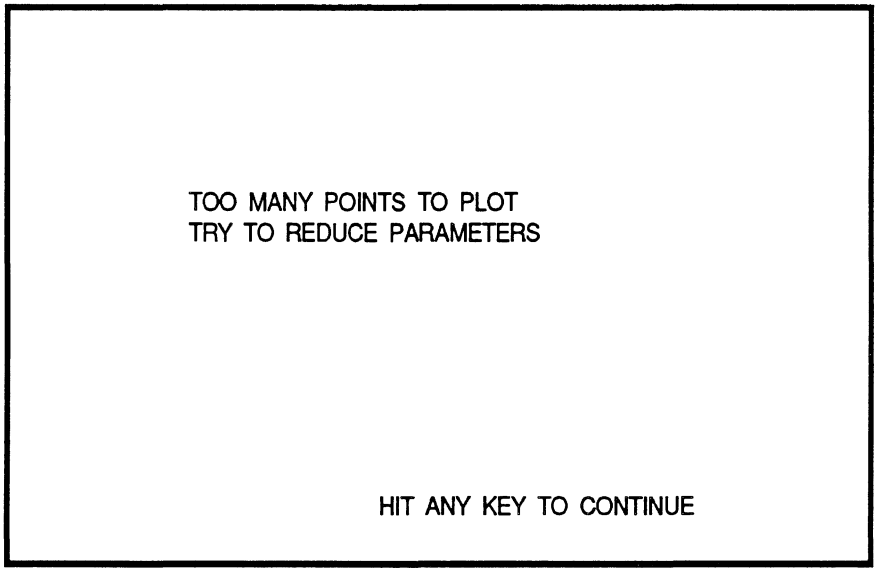
Low Speed Offtracking Transient

The user will be prompt to enter the calculation parameters, radius of the turn in ft, default is 45.0 ft, and angle in degrees, default is 90.0°, see screen #10. The path followed by the rear extremity point of the vehicle has been included in the results.



Screen #10

A default increment of 1 foot is given into the calculations. Therefore, if you entered a very large radius with a large angle a "BEEP" sound and a message will appear indicating that the number of points to plot are too many (see screen #11)



Screen #11

By pressing any key you will return to screen #10.

Once the proper parameters are set a message of "CALCULATING...." will appear on the screen. Once the calculations are completed, the user may print the chart displayed by typing a P (or p) followed by a W (or w) for a wide print-out, or a T (or t) for a tall print-out. To return to the OFFTRACKING menu, press any key.

High Speed Offtracking Steady State

The user is prompted to enter the radius of the turn, the speed in mph and g-level of the maneuver. The program checks the input for low magnitude turn radius and prints a warning message on the screen. The results are displayed on the screen and they may also be sent to the printer.

Exit to Main Menu

Selecting this option will return the user to screen #5 where further calculations may be made or the user may **QUIT** the program.

STEADY STATE RESULTS
LOW-SPEED OFFTRACKING

FILE NAME:C:TRSEMI-L.OFF

RADIUS OF THE TURN = 1200.00 FT

SUSP. NUM.	RADIUS (FT)
1	1200.00
2	1199.94
3	1199.40

REAR EXTREMITY SWING = 1199.40 FT

LOW-SPEED OFFTRACKING = .59583 FT

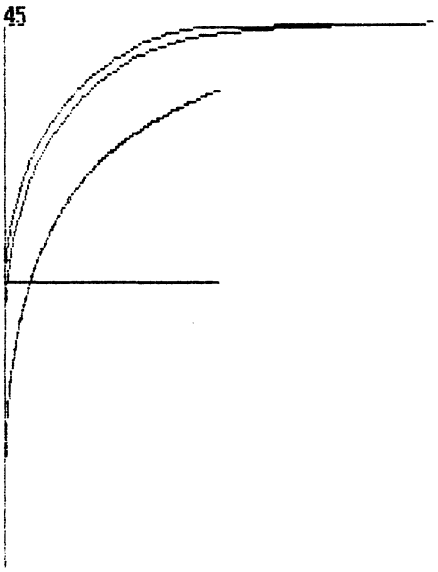
DO YOU WANT TO PRINT THE RESULTS ?Y

TRANSIENT LOW SPEED
OFFTRACKING
C:TRSEMI-L.OFF
MINIMUM RADIUS

SUSPENSION NUMBER	RADIUS (FEET)	ANGLE DEGREES
1	45	0
2	43.252	74.938
3	31.389	61.429

MAX OFFTRACKING=13.611FT

REAR SWING-OUT=.0018158FT



```
RADIUS OF THE TURN (FT) =  1200.00
FORWARD VELOCITY (MPH) =  55.00
G-LEVEL =    .1684


          Esc = EXIT     End = OK
```

STEADY STATE RESULTS
HIGH-SPEED OFFTRACKING

FILE NAME:C:TRSEMI-L.OFF

FORWARD VELOCITY = 55.00 MPH

RADIUS OF THE TURN = 1200.00 FT

SUSP. NUM.	RADIUS (FT)
1	1200.00
2	1200.26
3	1200.65

REAR EXTREMITY SWING = 1200.73 FT

HIGH-SPEED OFFTRACKING = -.73291 FT

Quick Reference Card.

BRAKING V2.0

A) General Information:

To Run The Program Type: BRAKING

Files required for proper function:
- BRAKING.EXE
-AXIS
- HALO****.DEV
-HALO++++.PRN
- HARDWARE.SET
**** =Name of the Graphics board,e.g,HERC
++++=Name of the printer device, e.g, EPSN.

B) General Commands:

1) EDIT-VIEW DATA:

PgUp=Page Up
PgDn=Page Down
↑=Upper Edit Field
↵ or ↓=Lower Edit Field
Ctrl →=Right Edit Field (column)
Ctrl ←=Left Edit Field (column)
End=Accept or Continue
Esc=Exit to Main menu
← =Scrolls cursor to left on current field
→ =Scrolls cursor to right on current field

2) PLOTS:

a) P or p followed by:
W or w = Wide print out
T or t = Tall print out

b) S or s : Enter new Axes limits. Esc will return to the Plot menu.

c) End exits to the Plot menu.

d) → and ←: Move the cross cursor rigth and left.

e) Ctrl→ or Ctrl ← move the cross cursor right and left at higher increments.

f) ↵ (RETURN key): Shifts the cross cursor among the different curves.

g)↑ and ↓ :Scroll the Y axis up and down

h) PgUp and PgDn: Scroll the X axis right and left.

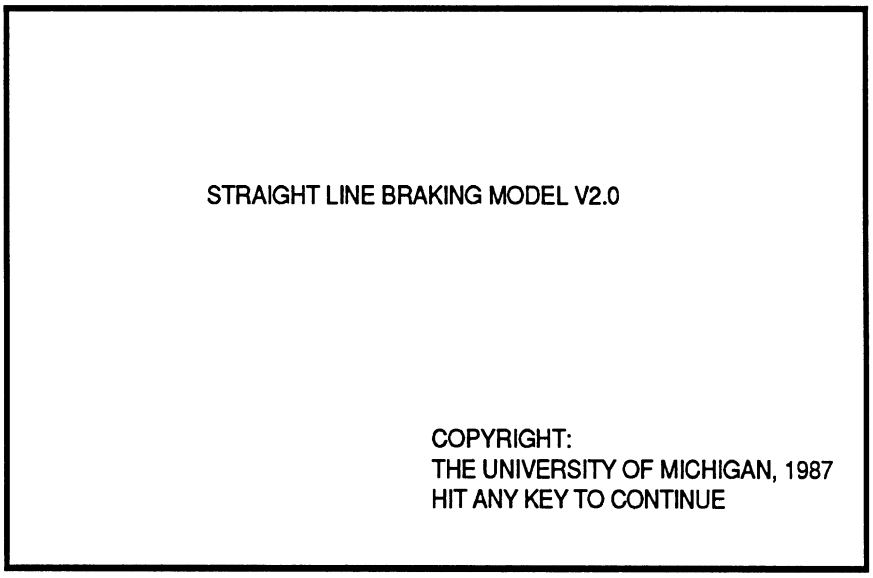
i) To zoom in or out: Hit the + or - keys (once or twice) followed by the axis to zoom (X or Y).

1) RUNNING THE PROGRAM AND SELECTING NEW DATA.

To start running the program insert the program disk in any drive and then type:

BRAKING

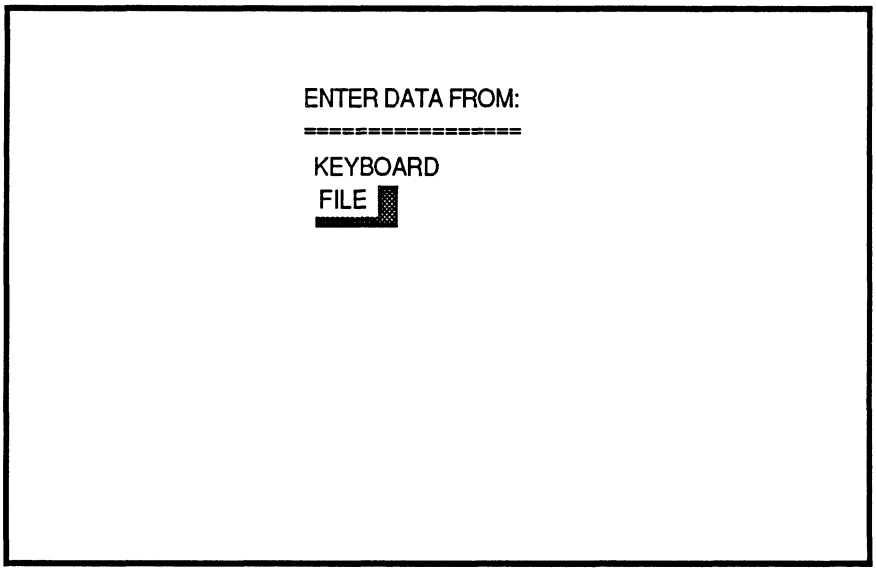
After few seconds the following message appears on the screen (see screen #1 below)



Screen #1

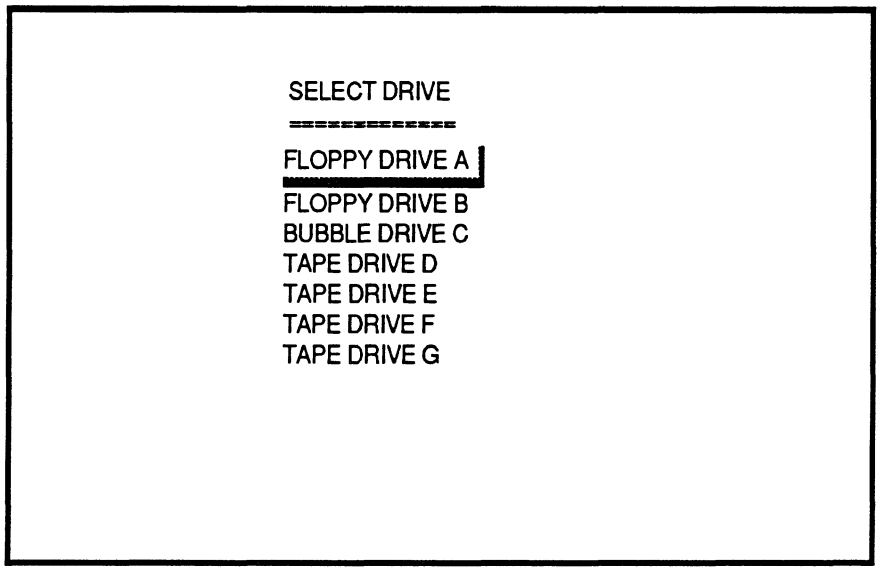
To continue simply hit any key on the keyboard.

The menu to select the source of input appears next, screen #2. Make your selection by pressing the up (↑) and down (↓) arrow keys and then **RETURN** (↵) or **End.**



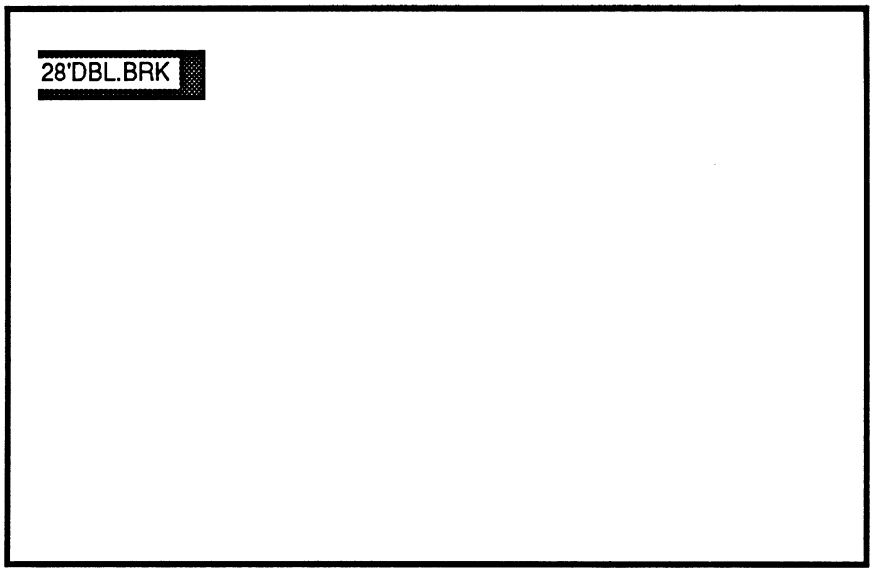
Screen #2

If your selection was "FILE", the following screen appears to enter the drive from which data will be entered.



Screen #3

One more time, make your selection and press the **End** key. All the files available on that drive will be listed on the screen so that you can select one to be read, see screen #4.



Screen #4

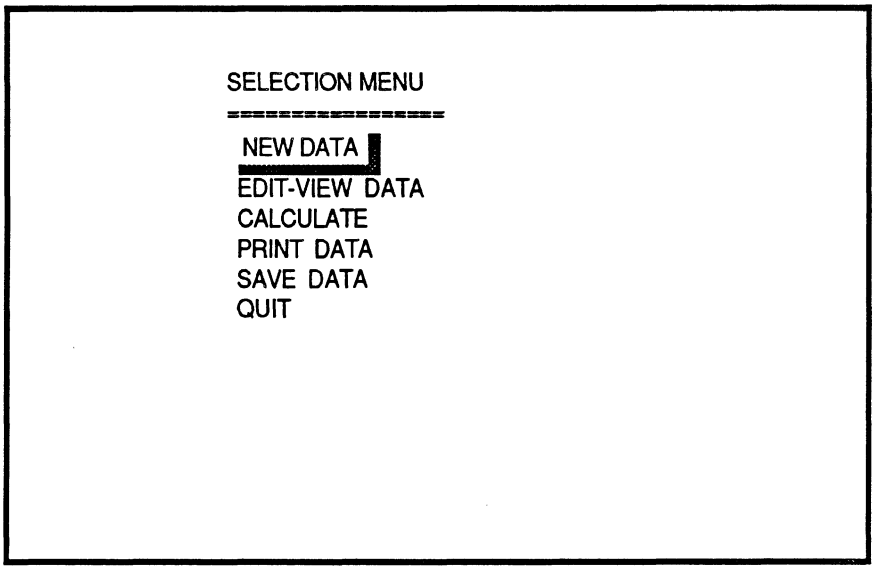
The file selection is made by pressing the following keys:

- **RETURN** key (↵) or the **Ctrl** plus the right arrow (→) key to select forward
- **Ctrl** plus the left arrow (←) key to select backwards, and
- **End** to complete the selection.

For "KEYBOARD" selection see the "EDIT-VIEW DATA" section.

2) EDIT-VIEW DATA

Once data has been read into memory, the main selection menu appears (screen #5.)



Screen #5

From this menu we could:

- Enter new data. This would return us to screen #2 (above.)
- Edit and view the current data set (explained in this section.)
- Calculate, which would further take us to another menu to select the type of calculation.
- Print data, that would send to the printer the current data set.
- Save data, which would allow us to save the current or modified data set into a file.
- Quit, that would return us to the operating system shell.

The way this program displays data is called "Page Editing", which shows the information for each unit on a screen page, see screen #6 and screen #7. We would have as many pages as number of units on the vehicle.

STRAIGHT LINE BRAKING MODEL

FILE NAME:A:28'DBL.BRK

Date: 9- 8-1986 Time:14:52:32

Information for Unit # 1

General Information

Total Weight = 16400.00 Lbs
Wheelbase = 120.000 inches
Distance of Rear Articulation from Front Suspension = 116.00 inches
Rear Articulation Height = 48.20 inches
Total C.G. Height = 40.00 inches

Suspension # 1 (Single)
Suspension Load = 10000.0 Lbs
Axle # 1
Radius of a Tire = 20.00 inches
Pushout Pressure = 7.00 PSI
Brake Key (1=Linear, 2=Non-linear) = 1
Brake Gain = 2000.00 in-lb/psi

Suspension # 2 (Single)
Suspension Load = 19000.0 Lbs
Axle # 1
Radius of a Tire = 20.00 inches
Pushout Pressure = 7.00 PSI
Brake Key (1=Linear, 2=Non-linear) = 1
Brake Gain = 3000.00 in-lb/psi

Screen #6

STRAIGHT LINE BRAKING MODEL

FILE NAME: A:28'DBL.BRK

Date: 9- 8-1993 Time: 11:52:32

Information for Unit # 2

General Information

Total Weight = 29600.00 Lbs
Wheelbase = 273.600 inches
Distance of Rear Articulation from Forward Articulation = 300.00 inches
Rear Articulation Height = 44.00 inches
Total C.G. Height = 78.36 inches
Unit Key (1 - Independent Unit, Dolly or Semi) = 1
(2 - Full Trailer - Fixed Dolly)

Suspension # 1 (Single)
Suspension Load = 17000.0 Lbs
Axle # 1
Radius of a Tire = 20.00 inches
Pushrout Pressure = 7.00 PSI
Brake Key (1=Linear, 2=Non-linear) = 1
Brake Gain = 3000.00 in-lb/psi

Screen #7

The controls for page editing are the following:

- Up arrow (↑) key, moves the cursor to the upper next position.
- Down arrow (↓) key, moves the cursor to the lower next position.
- **PgUp** key (page up), returns to the previous page.
- **PgDn** key (page down), advances one more page.
- **RETURN** key (↵), has the same function as the down arrow key.
- Right (→) and left (←) arrow keys, moves the text cursor on the current edit field. This is used to modify the current value.
- **Esc** key exits to the main menu at any point during the page editing session.
- **End** key, gets you out of the Edit mode if you are in the last page; otherwise, has no effect.

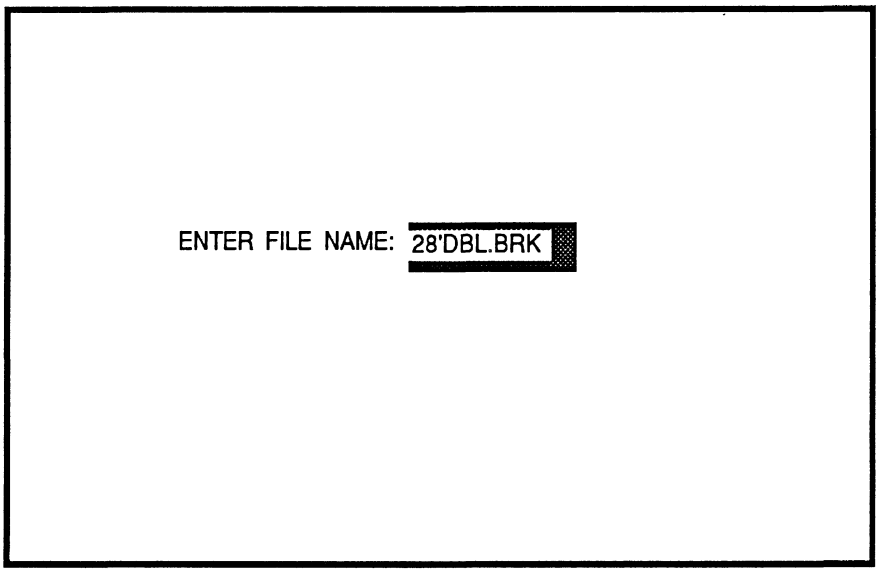
If you had selected to enter data from the keyboard, a prompt requesting the number of units appears first, and then the remaining data is entered by page editing.

3) **PRINT DATA**

This option will allow the user to send the data set to the printer. A prompt appears to check whether the printer is connected and turned on. If so, just hit the **End** key. A sample data set is included at the end of this documentation.

4) **SAVE DATA**

Choosing this option allows the user to save a data set into a file. The computer prompts the user for the drive to where data will be stored, see screen #3, and then prompts for the file name, see screen #8.



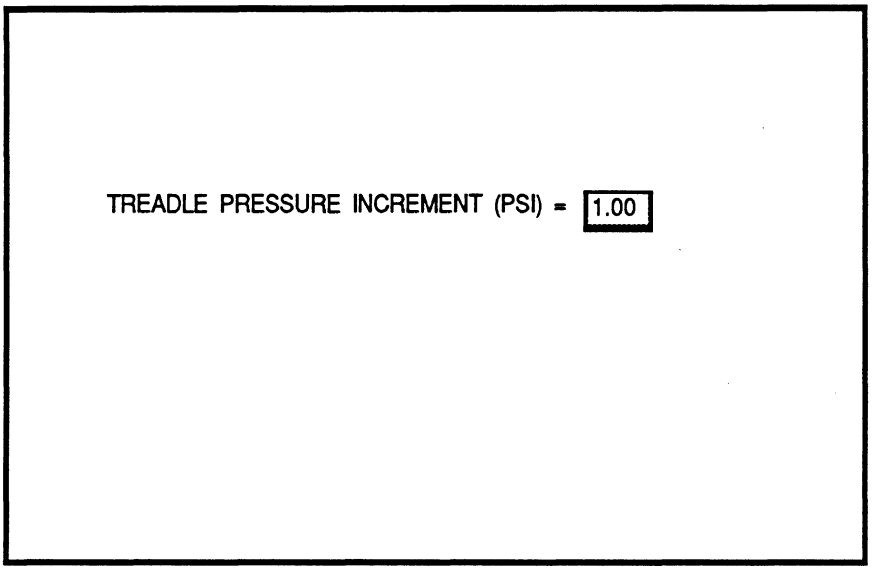
Screen #8

If the file already exists a message indicating so will be printed on the screen, allowing the user to either replace the old file with the new file, or enter a different name for the new file.

Note that the extension "OFF" is added to all the files. This is an identifier of files to this program.

5) CALCULATE

Selecting this option will display the following, see screen #9.



Screen #9

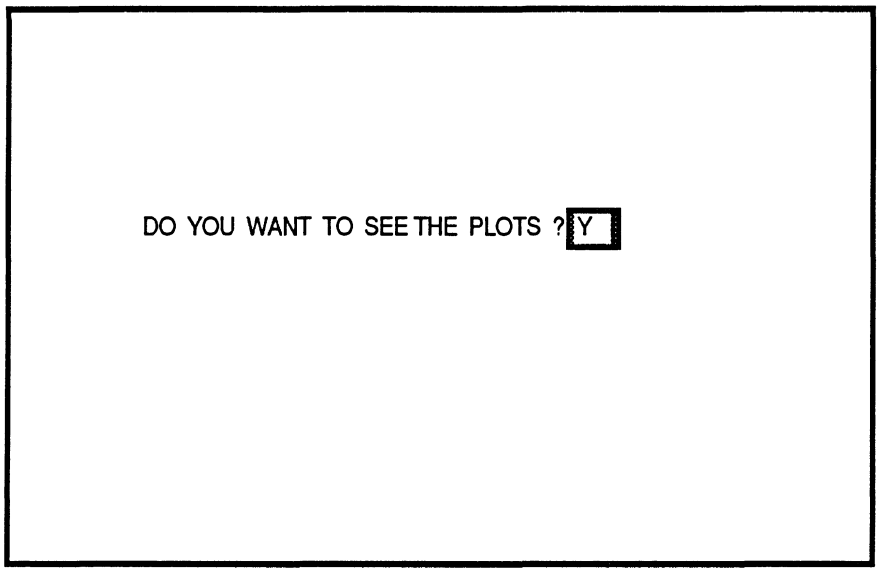
This will be the increment used for the computations. The default value is equal to 1.00 psi. Once you enter the desired number press the **End** key.

The following prompt will ask whether you want to print the results as they are calcualted or not. If the answer is "Y" or "y" then make sure that the printer in turned on. If the answer is "N" or "n" the results will appear on the screen only.

Calculations are stopped when either:

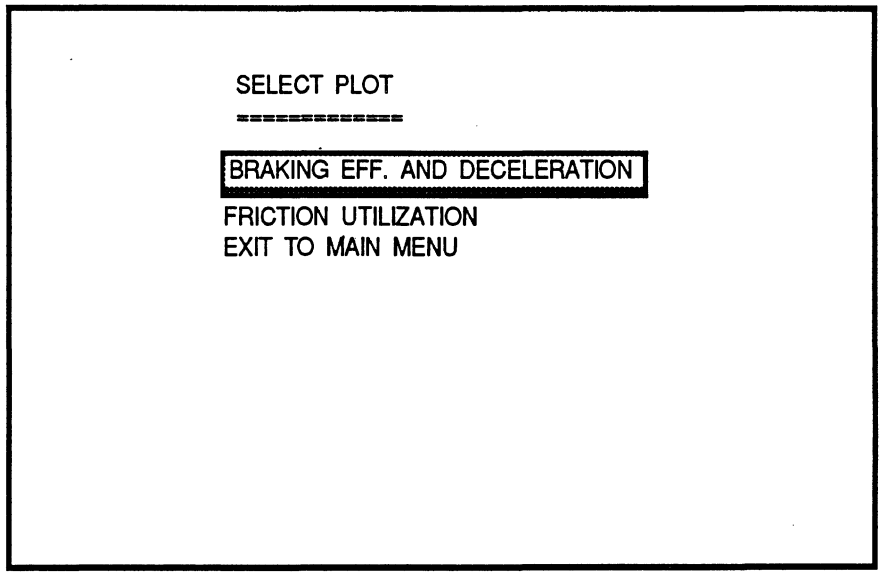
- the treadle pressure has exceeded a value of 100 psi, or
- A friction utilization for any axle of the vehicle is greater than 1.0.

After the calculations end the following screen appears.



Screen #10

If your answer is "yes" just press the **End** key, and the following menu will appear (Screen #11)



Screen #11

Once you have made your selection the plot will appear on the screen. Some examples are included on this documentation.

You still can play around with the plot. The following are the controls for the plot:

- Up arrow (↑) key, scrolls the "Y" axis upward.
- Down arrow (↓) key, scrolls the "Y" axis downward.
- **PgUp** key (page up), scrolls the "X" axis forward.
- **PgDn** key (page down), scrolls the "X" axis backward.
- **RETURN** key (↵), shifts the cross cursor among the different curves, and indicates on the lower view port the legend of the curve selected. The "Y" and "X" values at the position of the cursor are shown on the same port.
- Right (→) and left (←) arrow keys, move the cross cursor on the current curve right or left and updates its position on the lower view port.
- The + (plus) or - (minus) keys hit either once or twice and followed by the letter X or Y will zoom the respective axis up or down.
- **P** (or **p**), followed by a **W** (or **w**) for wide, or a **T** (or **t**) for tall,will print the current chart.
- **End** key, gets you out of the chart and sends you to the plot menu, screen #11.

Exit to Main Menu

Selecting this option will return the user to screen #5 where further calculations may be made or the user may **QUIT** the program.

Information for Unit # 3

General Information

[illegible] = 17500.00 Lbs
[illegible] = [illegible] inches
[illegible] Rear Articulation from Forward Articulation = 73.20 inches
[illegible] Articulation Height = 44.00 inches
[illegible] Width = 2[illegible].30 inches
[illegible] Independent Unit, Dolly or Semi) = 1
(2 = Full Trailer - Fixed Dolly)

Suspension # 1 (Single)
Suspension Load = 17000.0 Lbs
Axle # 1
Radius w/ a Tire = 20.00 inches
Pushout Pressure = 7.00 PSI
Brake Type (1=Linear, 2=Non-linear) = 1
Brake Gain = 3000.00 in-lb/psi

Information for Unit # 4

General Information

[illegible] = 17500.00 lbs
[illegible] = [illegible]3.20 inches
[illegible] Rear Articulation from Forward Articulation = 300.00 inches
[illegible] Articulation Height = 44.00 inches
[illegible] Width = 79.01 inches
[illegible] Independent Unit, Dolly or Semi) = 1
(2 = Full Trailer - Fixed Dolly)

Suspension # 1 (Single)
Suspension Load = 17000.0 lbs
Axle # 1
Radius w/ a Tire = 20.00 inches
Pushout Pressure = 7.00 PSI
Brake Type (1=Linear, 2=Non-linear) = 1
Brake Gain = 3000.00 in-lb/psi

STRAIGHT LINE BRAKING MODEL
FILE NAME:C:28 DBL.BRK

Treadle Pressure= .00 psi
Deceleration= .00000 gs
Braking Efficiency= .00000

No	Susp No	Axle No	Brake Force(Lbs)	Vertical Load(Lbs)	Friction Utilization
1	1	1	.00	10000.00	.0000
2	2	1	.00	19000.00	.0000
3	1	1	.00	17000.00	.0000
4	1	1	.00	17000.00	.0000
5	1	1	.00	17000.00	.0000

Treadle Pressure= 10.00 psi
Deceleration= .02625 gs
Braking Efficiency= .89919

No	Susp No	Axle No	Brake Force(Lbs)	Vertical Load(Lbs)	Friction Utilization
1	1	1	300.00	10276.51	.0292
2	2	1	450.00	18863.71	.0239
3	1	1	450.00	17117.10	.0263
4	1	1	450.00	16920.86	.0266
5	1	1	450.00	16821.82	.0268

Treadle Pressure= 20.00 psi
Deceleration= .11375 gs
Braking Efficiency= .94663

No	Susp No	Axle No	Brake Force(Lbs)	Vertical Load(Lbs)	Friction Utilization
1	1	1	1300.00	11198.19	.1161
2	2	1	1950.00	18409.40	.1059
3	1	1	1950.00	17507.42	.1114
4	1	1	1950.00	16657.07	.1171
5	1	1	1950.00	16227.91	.1202

Treadle Pressure= 30.00 psi
Deceleration= .20125 gs
Braking Efficiency= .91198

No	Susp No	Axle No	Brake Force(Lbs)	Vertical Load(Lbs)	Friction Utilization
1	1	1	2300.00	12119.88	.1898
2	2	1	3450.00	17955.10	.1921
3	1	1	3450.00	17897.75	.1928
4	1	1	3450.00	16393.28	.2105
5	1	1	3450.00	15633.99	.2207

Treadle Pressure= 40.00 psi
Deceleration= .28875 gs
Braking Efficiency= .87734

No	Susp No	Axle No	Brake Force(Lbs)	Vertical Load(Lbs)	Friction Utilization
1	1	1	3300.00	13041.57	.2530
2	2	1	4950.00	17500.79	.2828
3	1	1	4950.00	18288.08	.2707
4	1	1	4950.00	16129.49	.3069
5	1	1	4950.00	15040.07	.3291

Treadle Pressure= 50.00 psi
Deceleration= .37625 gs
Braking Efficiency= .8426?

[illegible]	Suspension No.	Axle No.	Brake Force(Lbs.)	Vertical Load(Lbs.)	Friction Utilization
[illegible]	1	1	4300.00	13963.26	.3080
[illegible]	2	1	6450.00	17046.49	.3784
[illegible]	1	1	6450.00	18678.41	.3453
[illegible]	1	1	6450.00	15865.70	.4065
[illegible]	1	1	6450.00	14446.15	.4465

Treadle Pressure= 60.00 psi
Deceleration= .46375 gs
Braking Efficiency= .80805

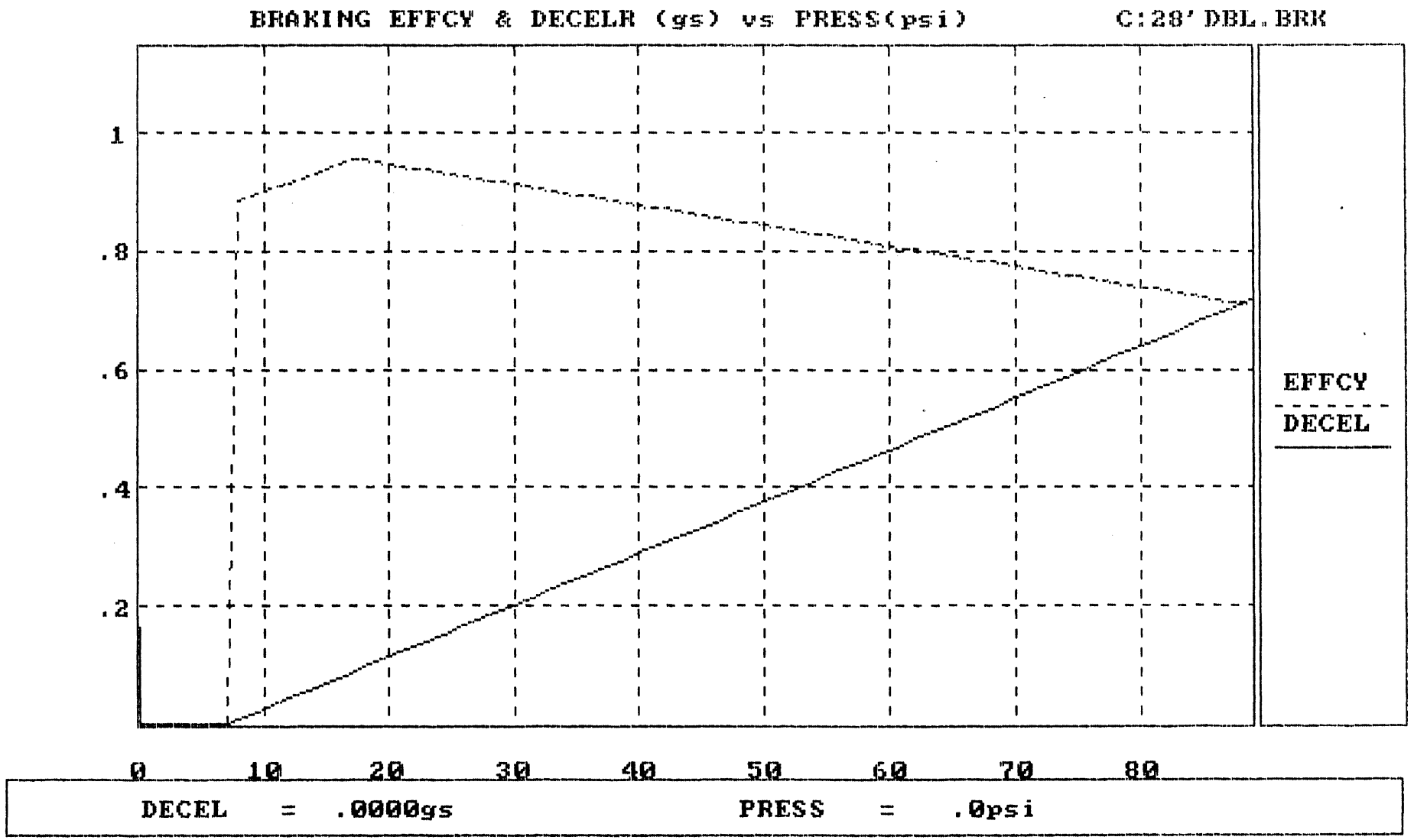
[illegible]	Suspension No.	Axle No.	Brake Force(Lbs.)	Vertical Load(Lbs.)	Friction Utilization
1	1	1	5300.00	14884.95	.3561
1	2	1	7950.00	16592.18	.4791
2	1	1	7950.00	19068.73	.4169
3	1	1	7950.00	15601.91	.5096
4	1	1	7950.00	13852.23	.5739

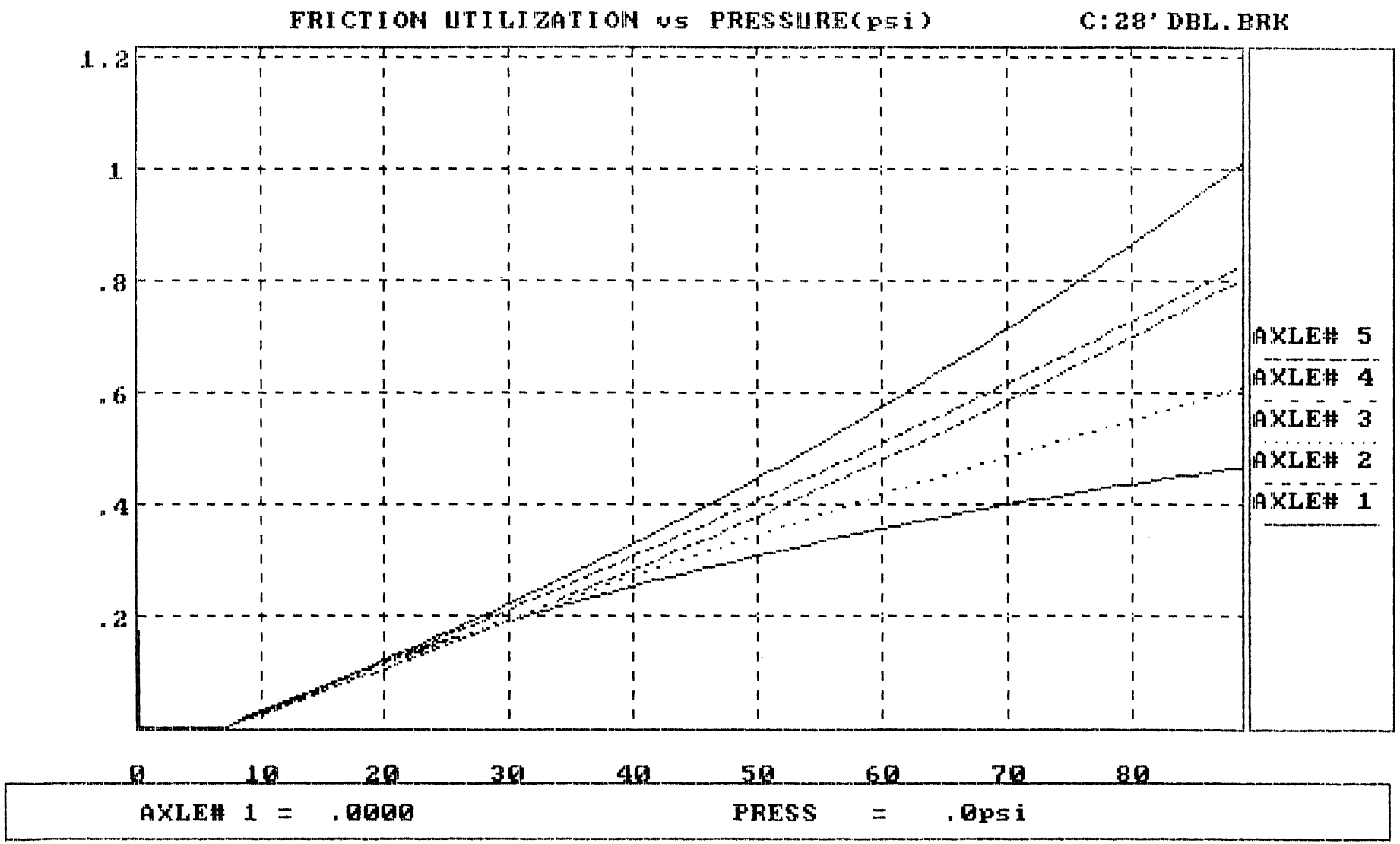
Treadle Pressure= 70.00 psi
Deceleration= .55125 gs
Braking Efficiency= .77340

[illegible]	Suspension No.	Axle No.	Brake Force(Lbs.)	Vertical Load(Lbs.)	Friction Utilization
[illegible]	1	1	6300.00	15806.63	.3986
[illegible]	2	1	9450.00	16137.88	.5856
[illegible]	1	1	9450.00	19459.06	.4856
[illegible]	1	1	9450.00	15338.12	.6161
[illegible]	1	1	9450.00	13258.31	.7128

Treadle Pressure= 80.00 psi
Deceleration= .63875 gs
Braking Efficiency= .73876

[illegible]	Suspension No.	Axle No.	Brake Force(Lbs.)	Vertical Load(Lbs.)	Friction Utilization
[illegible]	1	1	7300.00	16728.32	.4364
1	2	1	10950.00	15683.57	.6982
2	1	1	10950.00	19849.39	.5517
3	1	1	10950.00	15074.33	.7264
4	1	1	10950.00	12664.39	.8646


BRAKING EFFCY & DECELR (gs) vs PRESS(psi)
C:28' DBL.BRK
1
.8
.6
.4
.2
EFFCY
DECEL
0
10
20
30
40
50
60
70
80
DECEL = .0000gs
PRESS = .0psi


FRICTION UTILIZATION vs PRESSURE(psi)
C:28' DBL.BRK
1.2
1
.8
.6
.4
.2
0
10
20
30
40
50
60
70
80
AXLE# 5
AXLE# 4
AXLE# 3
AXLE# 2
AXLE# 1
AXLE# 1 = .0000
PRESS = .0psi

Quick Reference Card.

ROLL V2.0

A) General Information:

To Run The Program Type: ROLL

Files required for proper function:
- ROLL.EXE
-AXIS
- HALO****.DEV
-HALO++++.PRN
- HARDWARE.SET
**** =Name of the Graphics board,e.g,HERC
++++=Name of the printer device, e.g, EPSN.

B) General Commands:

1) EDIT-VIEW DATA:

PgUp=Page Up
PgDn=Page Down
↑=Upper Edit Field
↵ or ↓=Lower Edit Field
Ctrl →=Right Edit Field (column)
Ctrl ←=Left Edit Field (column)
End=Accept or Continue
Esc=Exit to Main menu
← =Scrolls cursor to left on current field
→ =Scrolls cursor to right on current field

2) PLOTS:

a) P or p followed by:
W or w = Wide print out
T or t = Tall print out

b) S or s : Enter new Axes limits. Esc will return to the Plot menu.

c) End exits to the Plot menu.

d) → and ← : Move the cross cursor rigth and left.

e) Ctrl→ or Ctrl ← move the cross cursor right and left at higher increments.

f) ↵ (RETURN key): Shifts the cross cursor among the different curves.

g)↑ and ↓ :Scroll the Y axis up and down

h) PgUp and PgDn: Scroll the X axis right and left.

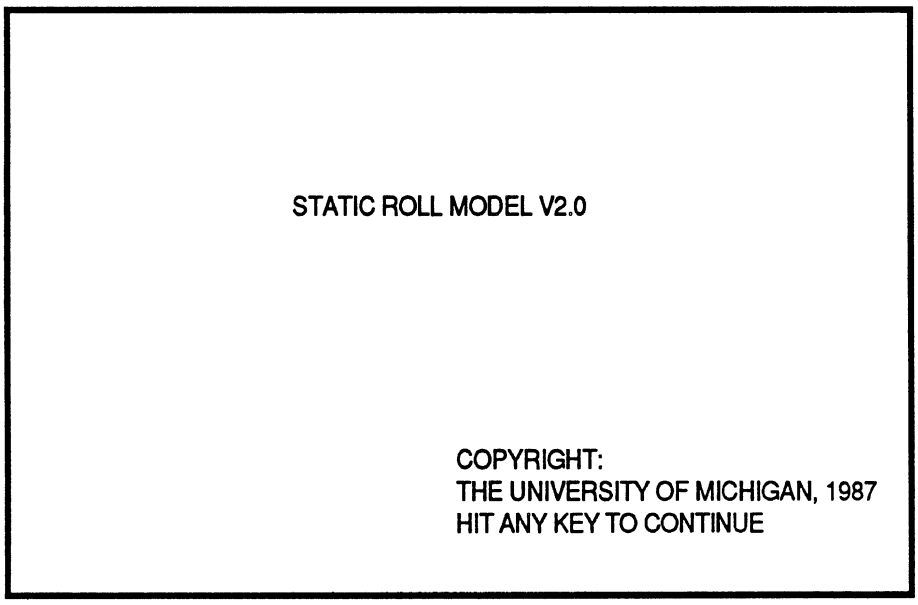
i) To zoom in or out: Hit the + or - keys (once or twice) followed by the axis to zoom (X or Y).

1) RUNNING THE PROGRAM AND SELECTING NEW DATA.

To start running the program insert the program disk in any drive and then type:

ROLL

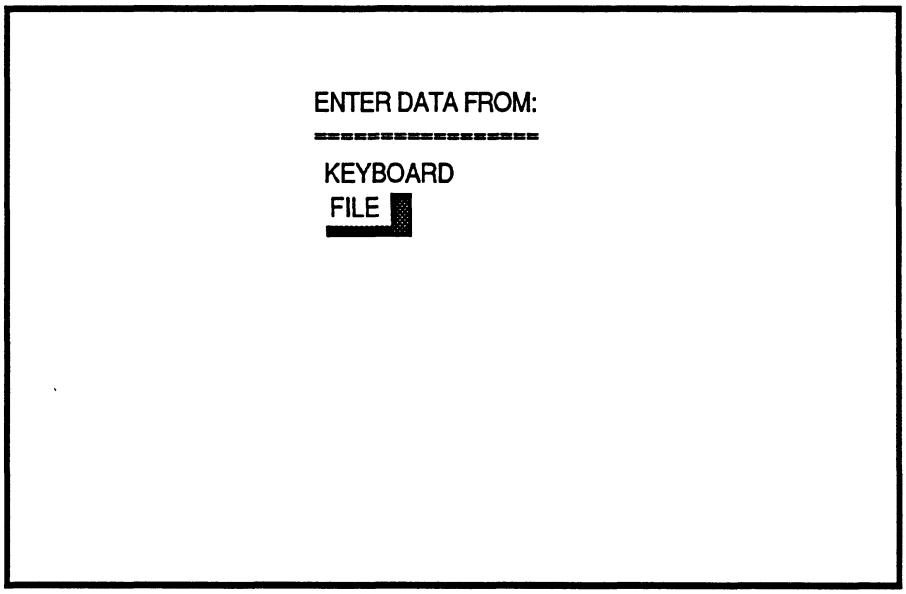
After few seconds the following message appears on the screen (see screen #1 below)



Screen #1

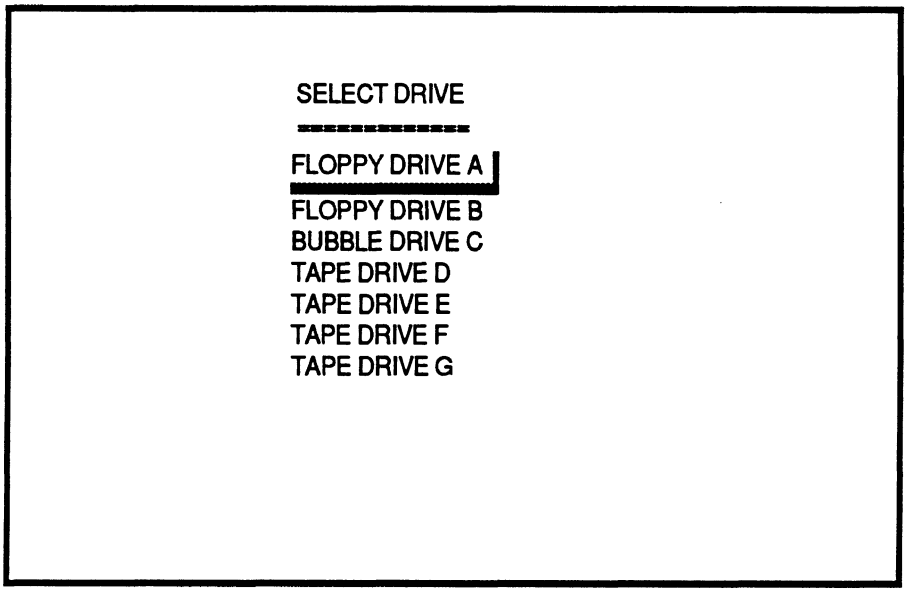
To continue simply hit any key on the keyboard.

The menu to select the source of input appears next, screen #2. Make your selection by pressing the up (↑) and down (↓) arrow keys and then **RETURN** (↵) or **End**.



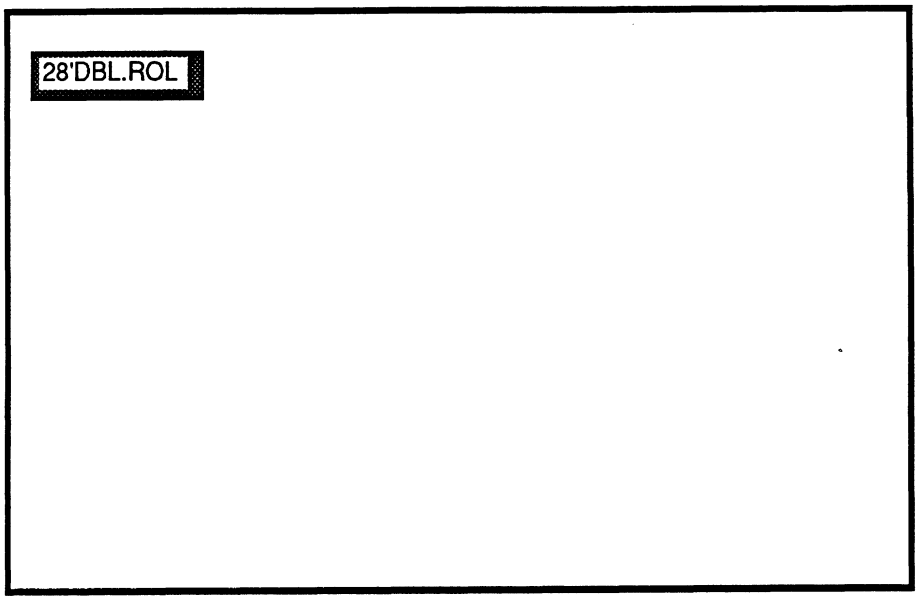
Screen #2

If your selection was "FILE", the following screen appears to enter the drive from which data will be entered.



Screen #3

One more time, make your selection and press the **End** key. All the files available on that drive will be listed on the screen so that you can select one to be read, see screen #4.



Screen #4

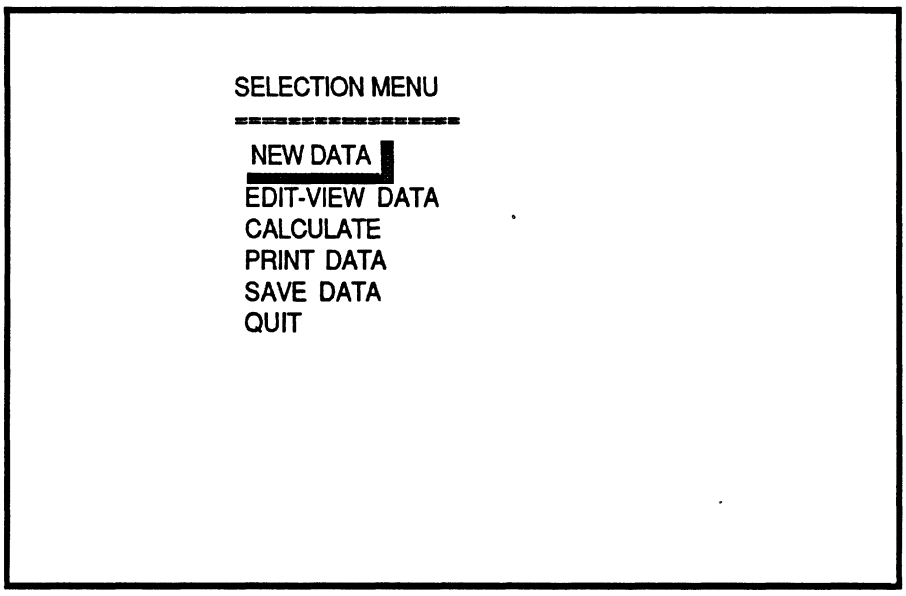
The file selection is made by pressing the following keys:

- **RETURN** key (↵) or the **Ctrl** plus the right arrow (→) key to select forward
- **Ctrl** plus the left arrow (←) key to select backwards, and
- **End** to complete the selection.

For "KEYBOARD" selection see the "EDIT-VIEW DATA" section.

2) EDIT-VIEW DATA

Once data has been read into memory, the main selection menu appears (screen #5.)



Screen #5

From this menu we could:

- Enter new data. This would return us to screen #2 (above.)
- Edit and view the current data set (explained in this section.)
- Calculate, which would further take us to another menu to select the type of calculation.
- Print data, that would send to the printer the current data set.
- Save data, which would allow us to save the current or modified data set into a file.
- Quit, that would return us to the operating system shell.

The way this program displays data is called "Page Editing", which shows the information for each unit on a screen page. We would have as many pages as number of units on the vehicle.

The controls for page editing are the following:

- Up arrow (↑) key, moves the cursor to the upper next position.
- Down arrow (↓) key, moves the cursor to the lower next position.
- **PgUp** key (page up), returns to the previous page.
- **PgDn** key (page down), advances one more page.
- **RETURN** key (↵), has the same function as the down arrow key.
- Right (→) and left (←) arrow keys, moves the text cursor on the current edit field. This is used to modify the current value.
- **Esc** key exits to the main menu at any point during the page editing session.
- **End** key, gets you out of the Edit mode if you are in the last page; otherwise, has no effect.

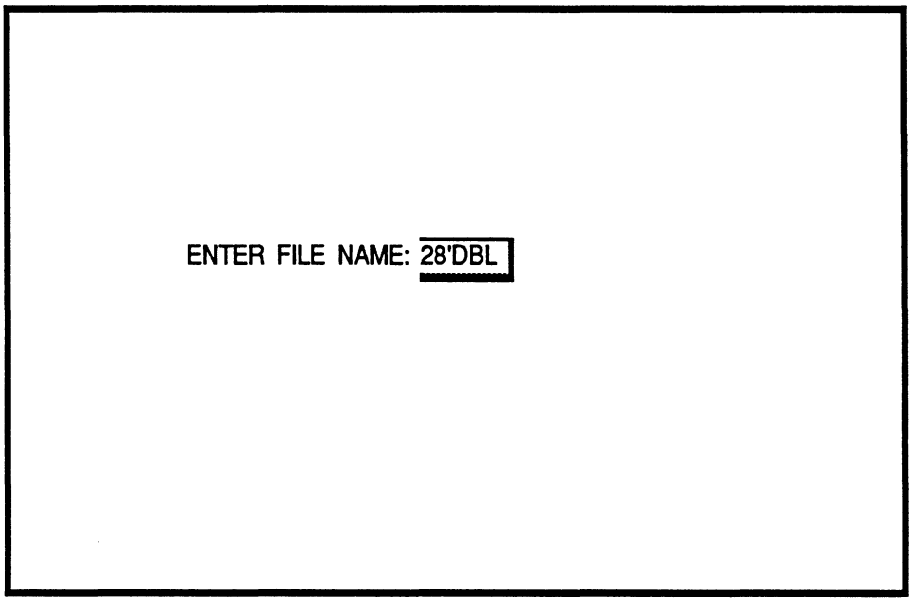
If you had selected to enter data from the keyboard, a prompt requesting the number of units appears first, and then the remaining data is entered by page editing.

3) **PRINT DATA**

This option will allow the user to send the data set to the printer. A prompt appears to check whether the printer is connected and turned on. If so, just hit the **End** key. A sample data set is included at the end of this documentation.

4) **SAVE DATA**

Choosing this option allows the user to save a data set into a file. The computer prompts the user for the drive to where data will be stored, see screen #3, and then prompts for the file name, see screen #6.



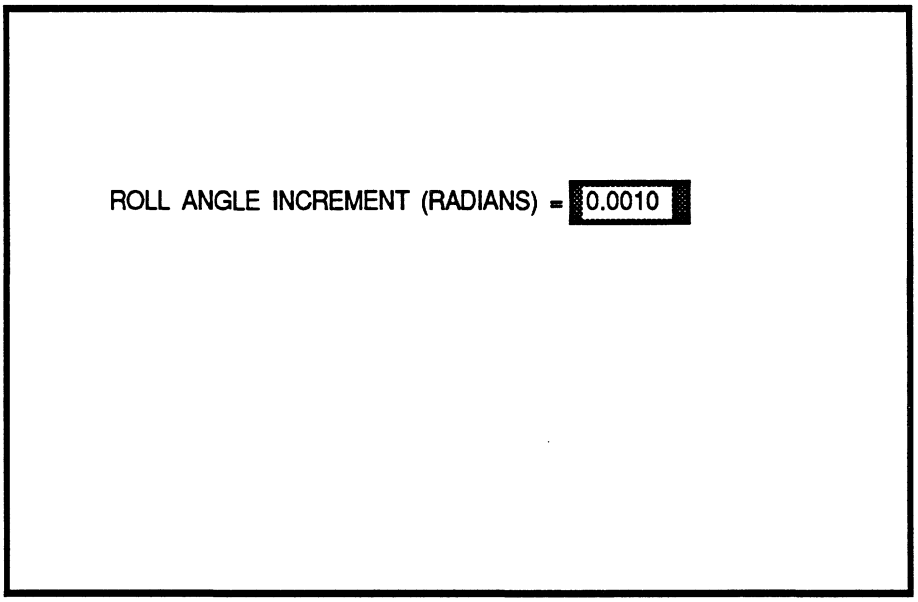
Screen #6

If the file already exists a message indicating so will be printed on the screen, allowing the user to either replace the old file with the new file, or enter a different name for the new file.

Note that the extension "ROL" is added to all the files. This is an identifier of files to this program.

5) **CALCULATE**

Selecting this option will display the following, see screen #7.



Screen #7

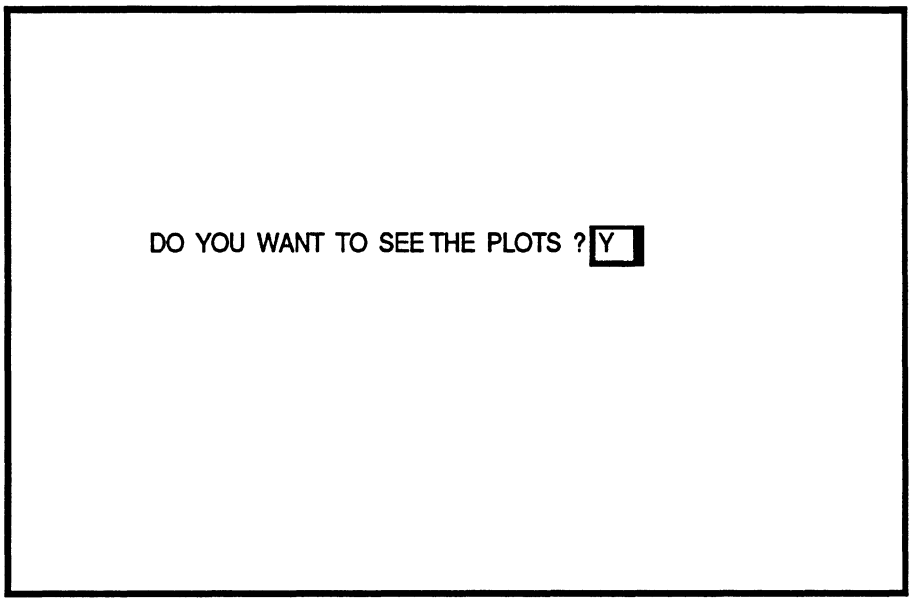
This will be the increment used for the computations. The default value is equal to 0.0010 radians. Once you enter the desired number press the **End** key.

The following prompt will ask whether you want to print the results as they are calcualted or not. If the answer is "Y" or "y" then make sure that the printer in turned on. If the answer is "N" or "n" the results will appear on the screen only.

Calculations are stopped when either:

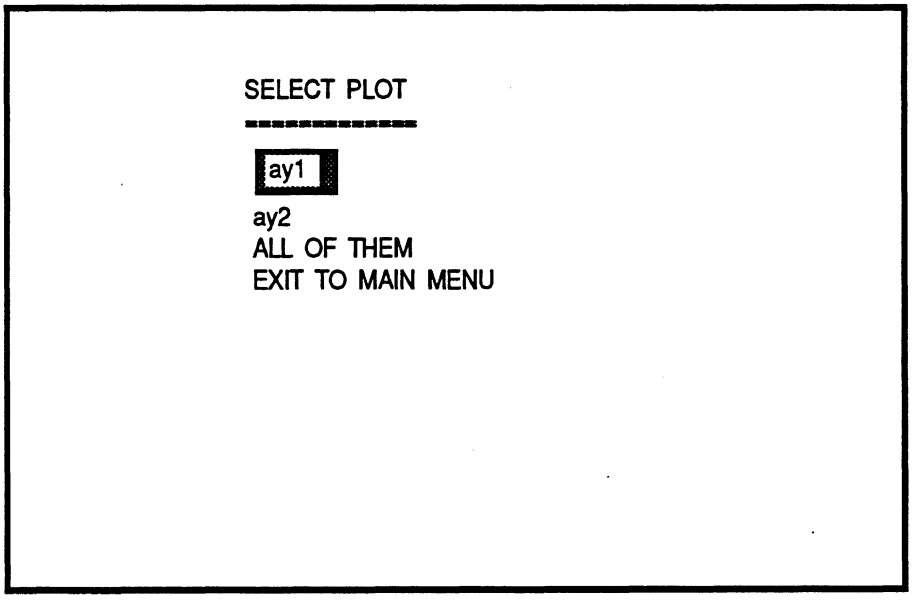
- All the axles have been liftoff the ground, or
- 0.02 radians after the accelerations for the roll units started decreasing.

After the calculations end the following screen appears.



Screen #8

If your answer is "yes" just press the **End** key, and the following menu will appear (Screen #9)



Screen #9

Once you have made your selection a plot will appear on the screen. Some examples are included at the end of this documentation.

"Ay1" is the lateral acceleration for the first roll unit, e.g., tractor semitrailer, straight truck.

"Ay2" is the lateral acceleration for the second roll unit, e.g., dolly-semitrailer, for a configuration of doubles.

If you have a triples you would obtain a third lateral acceleration, "ay3", corresponding to the third roll unit, i.e., the last dolly-semitrailer.

You can modify the form of the graph. The following keys are the controls for the graph:

- Up arrow (↑) key, scrolls the "Y" axis upward.
- Down arrow (↓) key, scrolls the "Y" axis downward.
- **PgUp** key (page up), scrolls the "X" axis forward.
- **PgDn** key (page down), scrolls the "X" axis backward.
- **RETURN** key (↵), shifts the cross cursor among the different curves, and indicates on the lower view port the legend of the curve selected. The "Y" and "X" values at the position of the cursor are shown on the same port.
- Right (→) and left (←) arrow keys, move the cross cursor on the current curve right or left and updates its position on the lower view port.
- The + (plus) or - (minus) keys hit either once or twice and followed by the letter X or Y will zoom the respective axis up or down.
- **P** (or **p**), followed by a **W** (or **w**) for wide, or a **T** (or **t**) for tall,will print the current chart.
- **End** key, gets you out of the chart and sends you to the plot menu, screen #9.

Exit to Main Menu

Selecting this option will return the user to screen #5 where further calculations may be made or the user may **QUIT** the program.

STATIC ROLL MODEL

FILE NAME:B:28'DBL.ROL

Date: 9-23-1986 Time:13:36:58

Information for Unit # 1 (Towing Unit)

General Information

Total Weight = 16200.00 Lbs
Total C.G. Height = 40.00 inches
Total Number of Axles = 2

Axles Information, Unit # 1

Axle # 1
Axle load = 10000.00 Lbs
Track Width of the Axle = 80.00 inches
Mass of the Axle = 1200.00 Lbs
Roll Center Height = 19.00 inches
Suspension Stiffness (per Spring) = 1200.00 Lbs/in
Spacing between Suspension Springs = 32.00 inches
Auxiliary Roll Stiffness = 8700.00 in-lb/deg
Tire Information
Total Number of Tires on the Axle = 2
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches

Axle # 2
Axle load = 19000.00 Lbs
Track Width of the Axle = 72.00 inches
Mass of the Axle = 2300.00 Lbs
Roll Center Height = 27.00 inches
Suspension Stiffness (per Spring) = 5500.00 Lbs/in
Spacing between Suspension Springs = 38.00 inches
Auxiliary Roll Stiffness = 11000.00 in-lb/deg
Tire Information
Total Number of Tires on the Axle = 4
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches

STATIC ROLL MODEL

FILE NAME:B:28'DBL.ROL

Date: 9-23-1986 Time:13:36:58

Information for Unit # 2 (Semitrailer)

General Information

Total Weight = 29600.00 Lbs
Total C.G. Height = 78.37 inches
Total Number of Axles = 1

Axles Information, Unit # 2

Axle # 1
Axle load = 17000.00 Lbs
Track Width of the Axle = 78.00 inches
Mass of the Axle = 1500.00 Lbs
Roll Center Height = 27.00 inches
Suspension Stiffness (per Spring) = 5500.00 Lbs/in
Spacing between Suspension Springs = 44.00 inches
Auxiliary Roll Stiffness = 11000.00 in-lb/deg
Tire Information
Total Number of Tires on the Axle = 4
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches

STATIC ROLL MODEL

FILE NAME:B:28'DBL.ROL

Date: 9-23-1986 Time:13:36:58

Information for Unit # 3 (Dolly)

General Information

Total Weight = 2500.00 Lbs
Total C.G. Height = 29.30 inches
Total Number of Axles = 1

Axles Information, Unit # 3

Axle # 1
Axle load = 17000.00 Lbs
Track Width of the Axle = 78.00 inches
Mass of the Axle = 1500.00 Lbs
Roll Center Height = 27.00 inches
Suspension Stiffness (per Spring) = 5500.00 Lbs/in
Spacing between Suspension Springs = 44.00 inches
Auxiliary Roll Stiffness = 11000.00 in-lb/deg
Tire Information
Total Number of Tires on the Axle = 4
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches

STATIC ROLL MODEL

FILE NAME:B:28'DBL.ROL

Date: 9-23-1986 Time:13:36:58

Information for Unit # 4 (Semitrailer)

General Information

Total Weight = 31500.00 Lbs
Total C.G. Height = 79.01 inches
Total Number of Axles = 1

Axles Information, Unit # 4

Axle # 1
Axle load = 17000.00 Lbs
Track Width of the Axle = 78.00 inches
Mass of the Axle = 1500.00 Lbs
Roll Center Height = 27.00 inches
Suspension Stiffness (per Spring) = 5500.00 Lbs/in
Spacing between Suspension Springs = 44.00 inches
Auxiliary Roll Stiffness = 11000.00 in-lb/deg

Tire Information
Total Number of Tires on the Axle = 4
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches

STATIC ROLL MODEL
FILE NAME:B:28'DBL.ROL

Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.00000	.00000	.00000	.00	.00000
1	2	.00000	.00000	.00000	.00	.00000
2	1	.00000	.00000	.00000	.00	.00000
3	1	.00000	.00000	.00000	.00	.00000
4	1	.00000	.00000	.00000	.00	.00000

Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.00821	.05727	.05000	1477.72	.27673
1	2	.01687	.05380	.05000	5464.47	.27673
2	1	.01660	.05423	.05000	5826.59	.27673
3	1	.01618	.05083	.05000	5677.84	.29651
4	1	.01618	.05083	.05000	5677.84	.29651

Axle # 1 of Unit # 2 has Lift Off

Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.01198	.08362	.07300	2157.47	.40381
1	2	.02462	.07856	.07300	7978.13	.40381
2	1	.02428	.07910	.07300	8506.83	.40381
3	1	.02362	.07421	.07300	8289.65	.43290
4	1	.02362	.07421	.07300	8289.65	.43290

Axle # 1 of Unit # 3 has Lift Off
Axle # 1 of Unit # 4 has Lift Off

Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.01222	.08604	.07500	2199.56	.40732
1	2	.02517	.08091	.07500	8155.37	.40732
2	1	.02655	.07867	.07500	8506.83	.40732
3	1	.02436	.07609	.07500	8516.77	.44374
4	1	.02436	.07609	.07500	8516.77	.44374

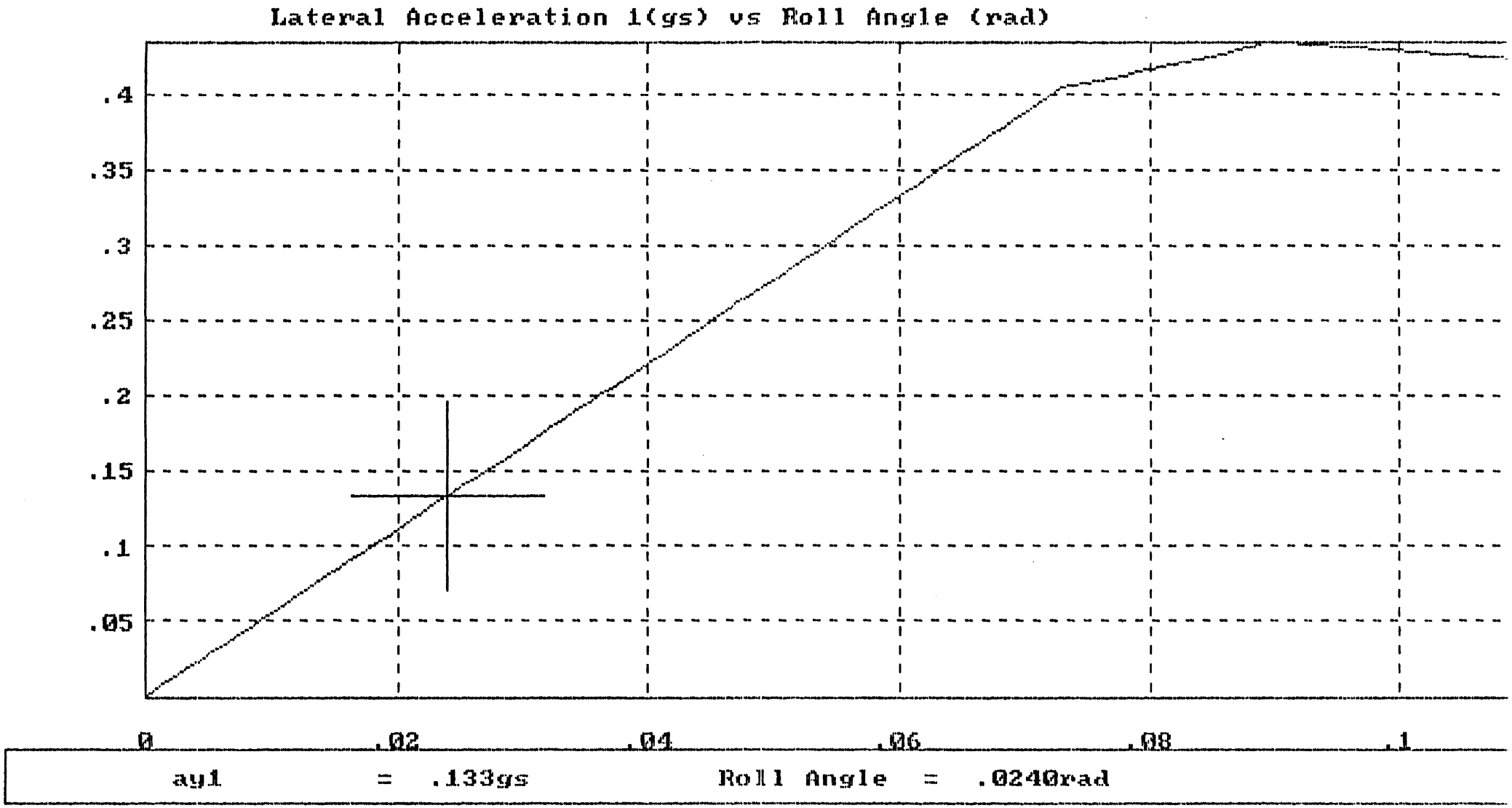
Axle # 2 of Unit # 1 has Lift Off

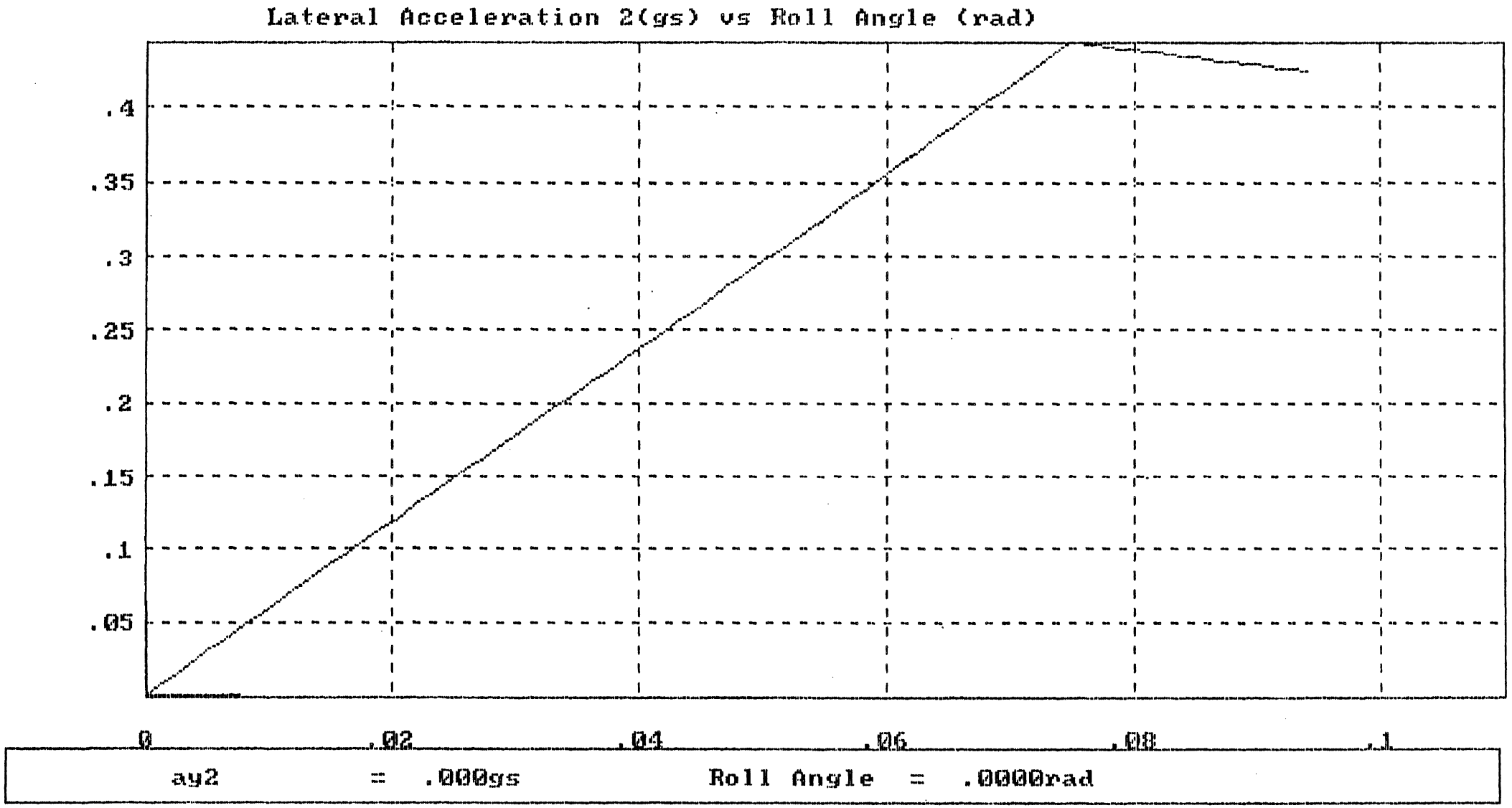
Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.01409	.10541	.09100	2540.15	.43326
1	2	.03028	.09860	.09100	9582.71	.43326
2	1	.04459	.07536	.09100	8506.83	.43326
3	1	.04036	.07609	.09100	8516.77	.42774
4	1	.04036	.07609	.09100	8516.77	.42774

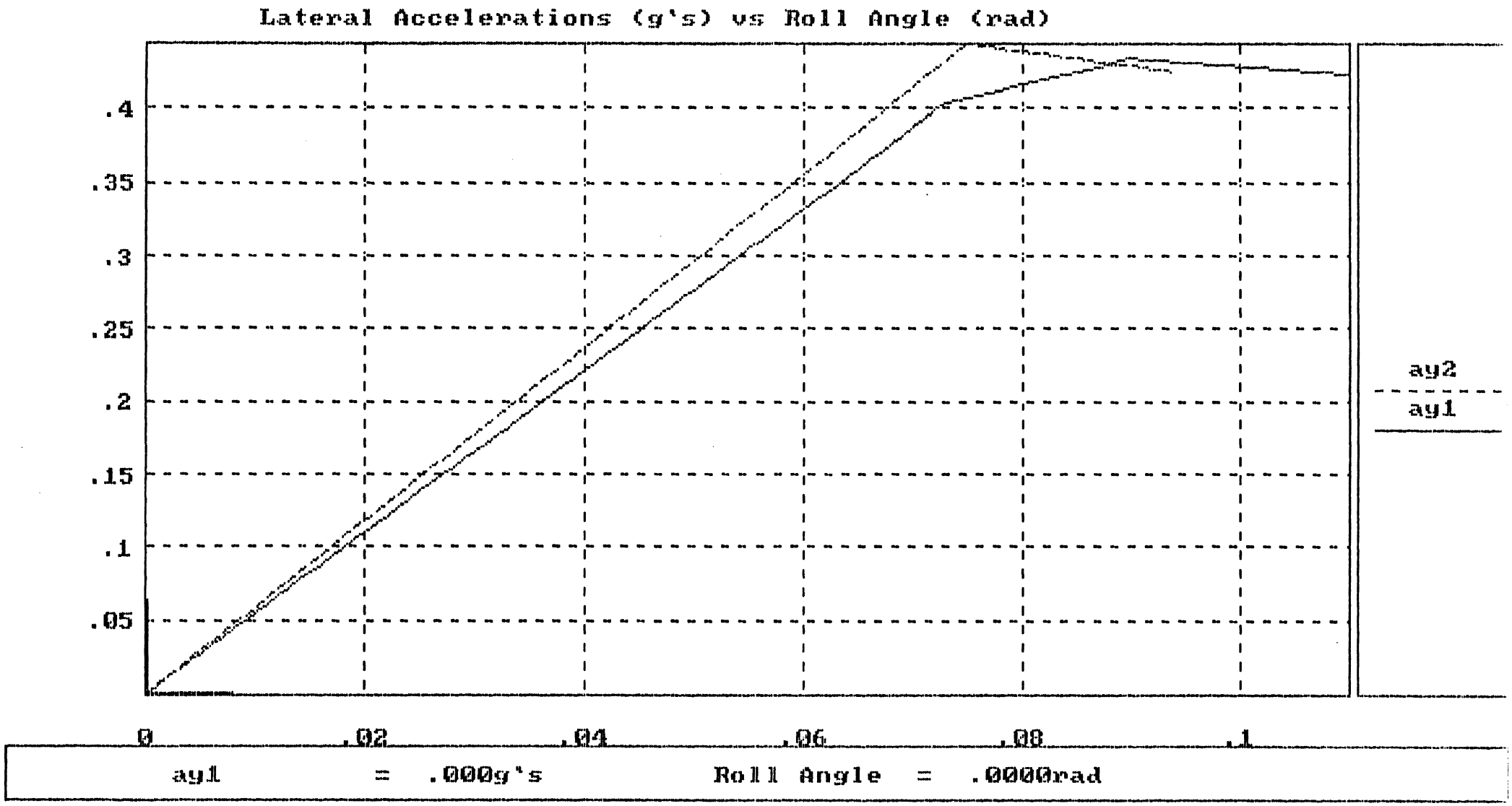
Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.01490	.11663	.10000	2681.56	.42826
1	2	.03956	.09813	.10000	9582.71	.42826
2	1	.05379	.07504	.10000	8506.83	.42826

Axle Liftoffs

Unit No	Axle No	Roll Angle (rad)	Lateral Acceleration (g's)
1	2	.09100	.43326
2	1	.07300	.40381
3	1	.07500	.44374
4	1	.07500	.44374


Lateral Acceleration 1(gs) vs Roll Angle (rad)
.4
.35
.3
.25
.2
.15
.1
.05
0
.02
.04
.06
.08
.1
ay1 = .133gs
Roll Angle = .0240rad


Lateral Acceleration 2(gs) vs Roll Angle (rad)
.4
.35
.3
.25
.2
.15
.1
.05
0
.02
.04
.06
.08
.1
ay2 = .000gs
Roll Angle = .0000rad


Lateral Accelerations (g's) vs Roll Angle (rad)
.4
.35
.3
.25
.2
.15
.1
.05
0
.02
.04
.06
.08
.1
ay2
ay1
ay1 = .000g's
Roll Angle = .0000rad

Steady Turn Model (Handling)

Quick Reference Card.

HANDLING V2.0

A) General Information:

To Run The Program Type: HANDLING

Files required for proper function:
- HANDLING.EXE
-AXIS
- HALO****.DEV
-HALO++++.PRN
- HARDWARE.SET
**** =Name of the Graphics board,e.g,HERC
++++=Name of the printer device, e.g, EPSN.

B) General Commands:

1) EDIT-VIEW DATA:

PgUp=Page Up
PgDn=Page Down
↑=Upper Edit Field
↵ or ↓=Lower Edit Field
Ctrl→=Right Edit Field (column)
Ctrl ←=Left Edit Field (column)
End=Accept or Continue
Esc=Exit to Main menu
← =Scrolls cursor to left on current field
→ =Scrolls cursor to right on current field

2) CALCULATE:

End=OK or Accept
Esc=Exit to Main menu

3) PLOTS:

a) P or p followed by:
W or w = Wide print out
T or t = Tall print out

b) S or s : Enter new Axes limits. Esc will return to the Plot menu.

c) End exits to the Plot menu.

d) → and ←: Move the cross cursor rigth and left.

e) Ctrl→ or Ctrl ← move the cross cursor right and left at higher increments.

f) ↵ (RETURN key): Shifts the cross cursor among the different curves.

g)↑ and ↓ :Scroll the Y axis up and down

h) PgUp and PgDn: Scroll the X axis right and left.

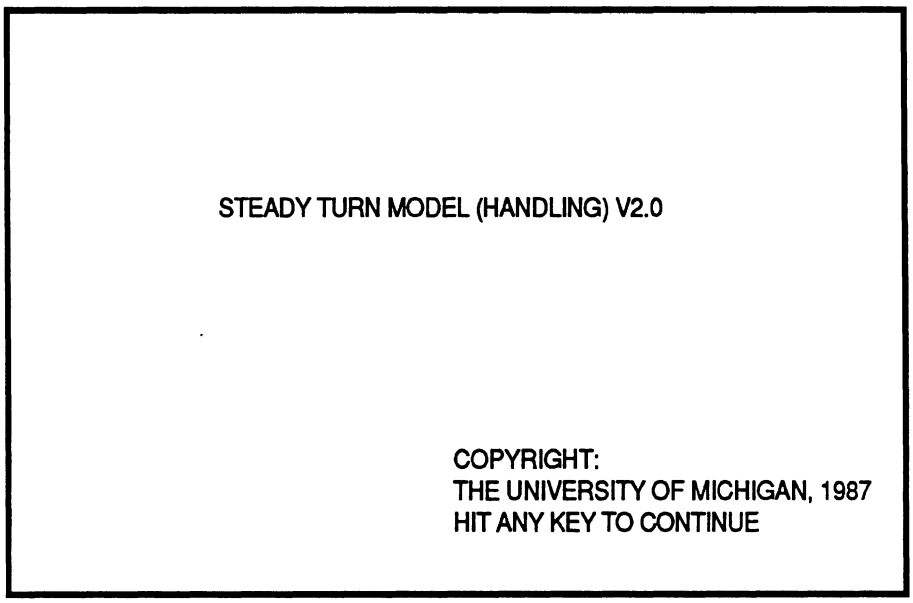
i) To zoom in or out: Hit the + or - keys (once or twice) followed by the axis to zoom (X or Y).

1) RUNNING THE PROGRAM AND SELECTING NEW DATA.

To start running the program insert the program disk in any drive and then type:

HANDLING

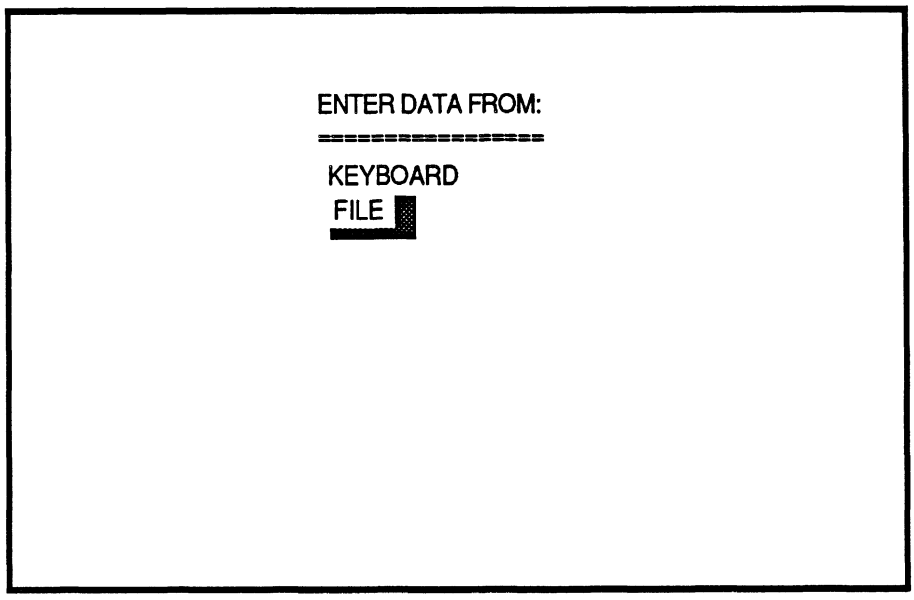
After few seconds the following message appears on the screen (see screen #1 below)



Screen #1

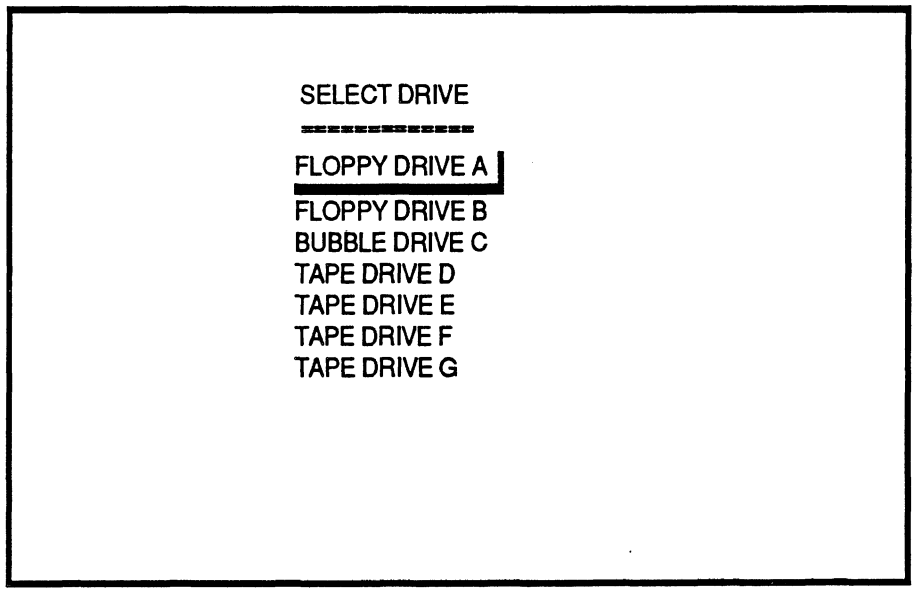
To continue simply hit any key on the keyboard.

The menu to select the source of input appears next, screen #2. Make your selection by pressing the up (↑) and down (↓) arrow keys and then **RETURN** (↵) or **End.**



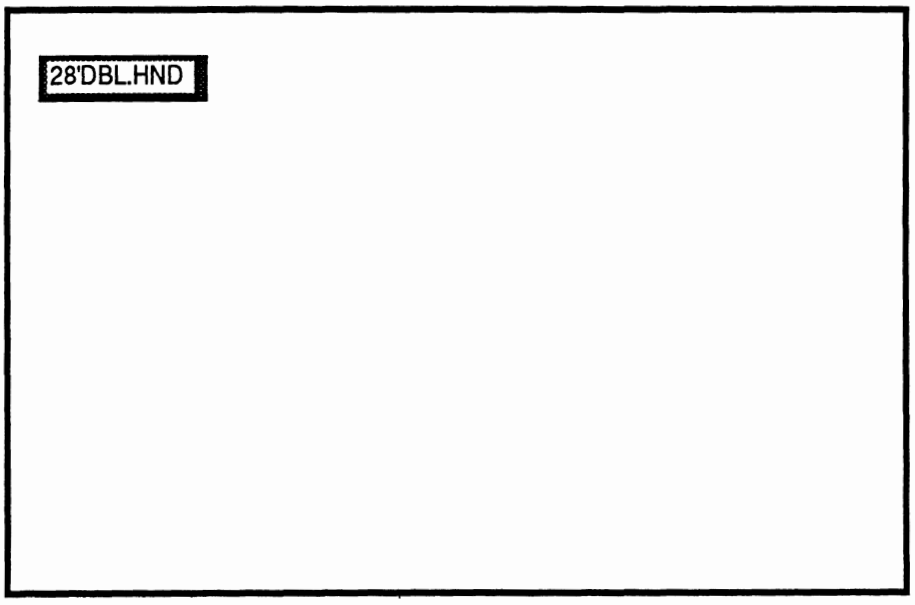
Screen #2

If your selection was "FILE", the following screen appears to enter the drive from which data will be entered.



Screen #3

One more time, make your selection and press the **End** key. All the files available on that drive will be listed on the screen so that you can select one to be read, see screen #4.



Screen #4

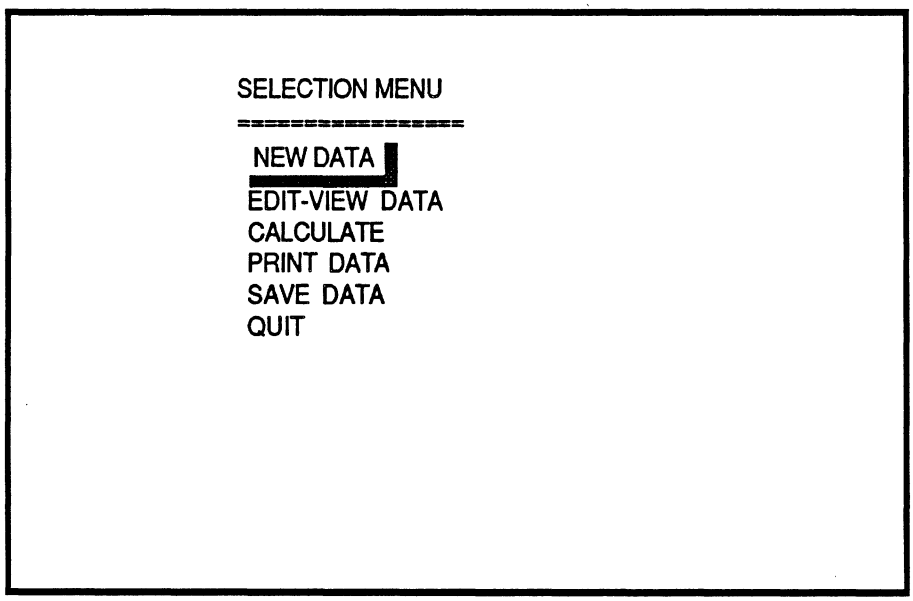
The file selection is made by pressing the following keys:

- **RETURN** key (↵) or the **Ctrl** plus the right arrow (→) key to select forward
- **Ctrl** plus the left arrow (←) key to select backwards, and
- **End** to complete the selection.

For "KEYBOARD" selection see the "EDIT-VIEW DATA" section.

2) EDIT-VIEW DATA

Once data has been read into memory, the main selection menu appears (screen #5.)



Screen #5

From this menu we could:

- Enter new data. This would return us to screen #2 (above.)
- Edit and view the current data set (explained in this section.)
- Calculate, which would further take us to another menu to select the type of calculation.
- Print data, that would send to the printer the current data set.
- Save data, which would allow us to save the current or modified data set into a file.
- Quit, that would return us to the operating system shell.

The way this program displays data is called "Page Editing", which shows the information for each unit on a screen page. We would have as many pages as number of units on the vehicle.

The controls for page editing are the following:

- Up arrow (↑) key, moves the cursor to the upper next position.
- Down arrow (↓) key, moves the cursor to the lower next position.
- **PgUp** key (page up), returns to the previous page.
- **PgDn** key (page down), advances one more page.
- **RETURN** key (↵), has the same function as the down arrow key.
- Right (→) and left (←) arrow keys, moves the text cursor on the current edit field. This is used to modify the current value.
- **Esc** key exits to the main menu at any point during the page editing session.
- **End** key, gets you out of the Edit mode if you are in the last page; otherwise, has no effect.

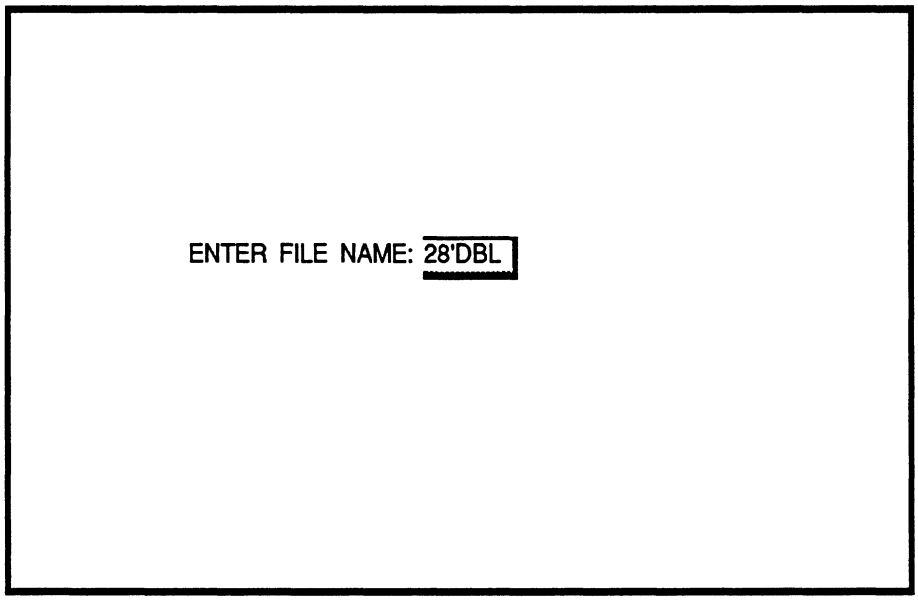
If you had selected to enter data from the keyboard, a prompt requesting the number of units appears first, and then the remaining data is entered by page editing.

3) **PRINT DATA**

This option will allow the user to send the data set to the printer. A prompt appears to check whether the printer is connected and turned on. If so, just hit the **End** key. A sample data set is included at the end of this documentation.

4) **SAVE DATA**

Choosing this option allows the user to save a data set into a file. The computer prompts the user for the drive to where data will be stored, see screen #3, and then prompts for the file name, see screen #6.



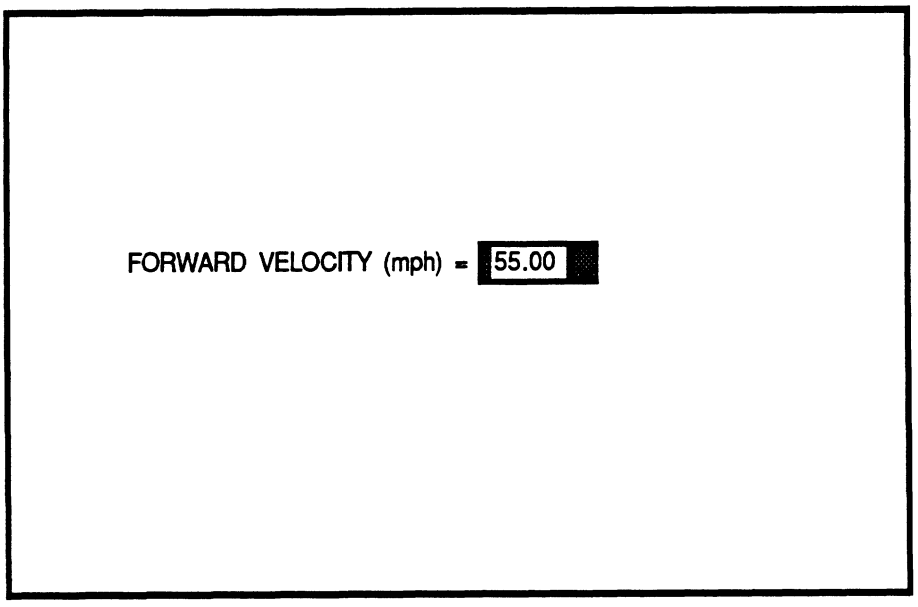
Screen #6

If the file already exists a message indicating so will be printed on the screen, allowing the user to either replace the old file with the new file, or enter a different name for the new file.

Note that the extension "HND" is added to all the files. This is an identifier of files to this program.

5) **CALCULATE**

Selecting this option will display the following, see screen #7.



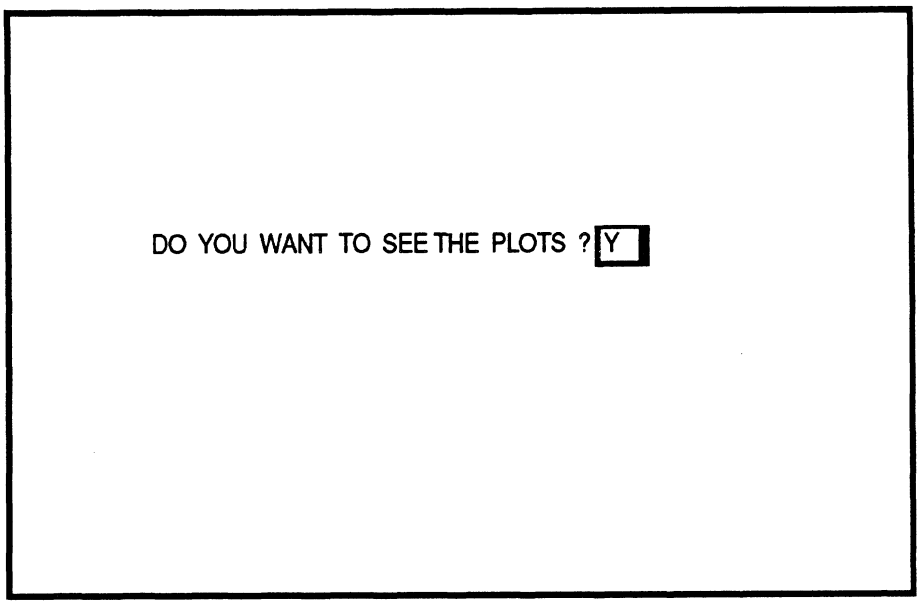
Screen #7

These will be the increments used for the computations. The default values are equal to 0.025 g's, and 55 mph. Once you enter the desired numbers press the **End** key.

The following prompt will ask whether you want to print the results as they are calculate or not. If the answer is "Y" or "y" then make sure that the printer is turned on. If the answer is "N" or "n" the results will appear on the screen only.

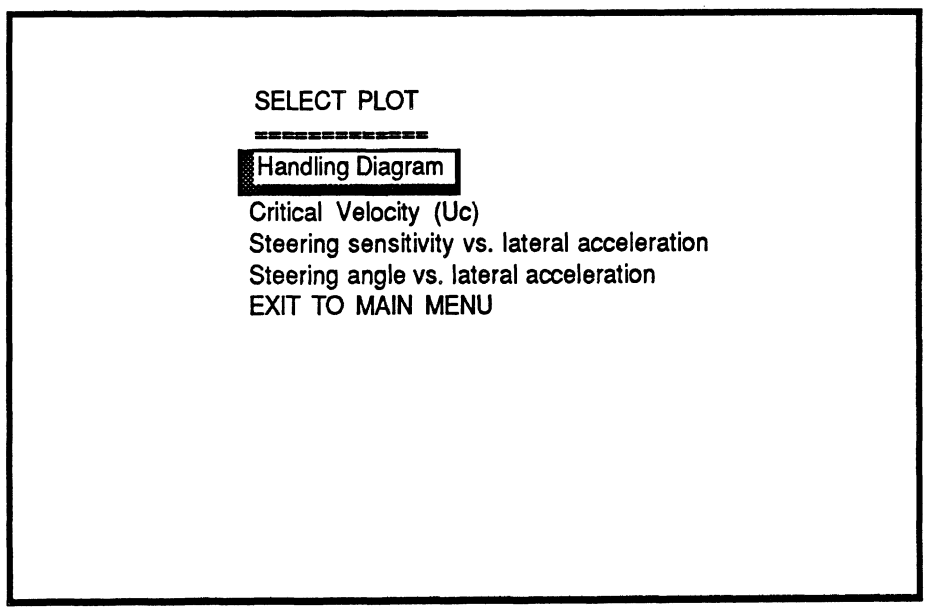
Calculations are stopped when an axle lifts off the ground.

After the calculations end the following screen appears.



Screen #8

If your answer is "yes" just press the **End** key, and the following menu will appear (Screen #9)



Screen #9

Once you have made your selection a plot will appear on the screen. Some examples are included at the end of this documentation.

The first plot is the handling diagram. Lateral acceleration is plotted versus (Lr*r/u-delta), where:

- Lr is the reference wheelbase (tractor wheelbase),
- r is the yaw rate,
- u is the forward velocity, and,
- delta is the steering angle.

The second plot (critical velocity) is only obtained if there is one, that is if the vehicle becomes unstable. A default value of 600 mph is given to indicate stability.

You can modify the form of the graph. The following keys are the controls for the graph:

- Up arrow (↑) key, scrolls the "Y" axis upward.
- Down arrow (↓) key, scrolls the "Y" axis downward.
- **PgUp** key (page up), scrolls the "X" axis forward.
- **PgDn** key (page down), scrolls the "X" axis backward.
- **RETURN** key (↵), shifts the cross cursor among the different curves, and indicates on the lower view port the legend of the curve selected. The "Y" and "X" values at the position of the cursor are shown on the same port.
- Right (→) and left (←) arrow keys, move the cross cursor on the current curve right or left and updates its position on the lower view port.
- The + (plus) or - (minus) keys hit either once or twice and followed by the letter X or Y will zoom the respective axis up or down.
- **P** (or **p**), followed by a **W** (or **w**) for wide, or a **T** (or **t**) for tall,will print the current chart.
- **End** key, gets you out of the chart and sends you to the plot menu, screen #9.

Exit to Main Menu

Selecting this option will return the user to screen #5 where further calculations may be made or the user may **QUIT** the program.

HANDLING MODEL

FILE NAME:A:28'DBL.HND

Date:11- 5-1987 Time:11:19:29

Information for Unit # 1 (Towing Unit)

General Information

Total Weight = 16400.00 Lbs
Total C.G. Height = 40.00 inches
Total Number of Axles = 2
Distance from C.G. to Rear Articulation Point = 58.32 inches

Steering System Information

Steering Gear Ratio = 30.00
Steering Stiffness = 11000.00 in-lb/deg
Tie Rod Stiffness = 11000.00 in-lb/deg
Mechanical Trail = 1.000
Aligning Moment per Tire = 1600.00 in-lb/deg

Axles Information, Unit # 1

Axle # 1

C.G - Axle Distance (negative if rear of CG) = 53.28 inches
Axle load = 10000.00 Lbs
Track Width of the Axle = 80.00 inches
Mass of the Axle = 1200.00 Lbs
Roll Center Height = 18.25 inches
Suspension Stiffness (per Spring) = 1400.00 Lbs/in
Spacing between Suspension Springs = 32.00 inches
Auxiliary Roll Stiffness = 8700.00 in-lb/deg

Tire Information

Total Number of Tires on the Axle = 2
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches
Nominal Load of the Tire = 6040.00 Lbs

Cornering Stiffness Table

Vertical Force (Lbs)	Cornering Stiffness (Lb/deg)
4000.00	654.08
5000.00	769.20
6000.00	853.11

Axle # 2

C.G - Axle Distance (negative if rear of CG) = -66.72 inches
Axle load = 19000.00 Lbs
Track Width of the Axle = 72.00 inches
Mass of the Axle = 2500.00 Lbs
Roll Center Height = 33.00 inches
Suspension Stiffness (per Spring) = 10600.00 Lbs/in
Spacing between Suspension Springs = 38.00 inches

Auxiliary Roll Stiffness = 30000.00 in-lb/deg

Tire Information
Total Number of Tires on the Axle = 4
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches
Nominal Load of the Tire = 6040.00 Lbs

Cornering Stiffness Table

Vertical Force (Lbs)	Cornering Stiffness (Lb/deg)
4000.00	654.08
5000.00	769.20
6000.00	853.11

Information for Unit # 2 (Semitrailer)

General Information

Total Weight = 29600.00 Lbs
Total C.G. Height = 78.37 inches
Total Number of Axles = 1
Distance from C.G. to Rear Articulation Point = 142.90 inches
Distance from C.G. to Front Articulation Point = 157.10 inches

Axles Information, Unit # 2

Axle # 1
C.G - Axle Distance (negative if rear of CG) = -116.50 inches
Axle load = 17000.00 Lbs
Track Width of the Axle = 78.00 inches
Mass of the Axle = 1500.00 Lbs
Roll Center Height = 27.00 inches
Suspension Stiffness (per Spring) = 8500.00 Lbs/in
Spacing between Suspension Springs = 44.00 inches
Auxiliary Roll Stiffness = 9000.00 in-lb/deg

Tire Information
Total Number of Tires on the Axle = 4
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches
Nominal Load of the Tire = 6040.00 Lbs

Cornering Stiffness Table

Vertical Force (Lbs)	Cornering Stiffness (Lb/deg)
4000.00	654.08
5000.00	769.20
6000.00	853.11

Information for Unit # 3 (Dolly)

General Information

Total Weight = 2500.00 Lbs
Total C.G. Height = 29.30 inches
Total Number of Axles = 1
Distance from C.G. to Rear Articulation Point = .00 inches

Distance from C.G. to Front Articulation Point = 73.20 inches

Axles Information, Unit # 3

Axle # 1
C.G - Axle Distance (negative if rear of CG) = .00 inches
Axle load = 17000.00 Lbs
Track Width of the Axle = 78.00 inches
Mass of the Axle = 1500.00 Lbs
Roll Center Height = 27.00 inches
Suspension Stiffness (per Spring) = 8500.00 Lbs/in
Spacing between Suspension Springs = 44.00 inches
Auxiliary Roll Stiffness = 9000.00 in-lb/deg

Tire Information
Total Number of Tires on the Axle = 4
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches
Nominal Load of the Tire = 6040.00 Lbs

Cornering Stiffness Table

Vertical Force (Lbs)	Cornering Stiffness (Lb/deg)
4000.00	654.08
5000.00	769.20
6000.00	853.11

Information for Unit # 4 (Semitrailer)

General Information

Total Weight = 31500.00 Lbs
Total C.G. Height = 79.01 inches
Total Number of Axles = 1
Distance from C.G. to Rear Articulation Point = .00 inches
Distance from C.G. to Front Articulation Point = 147.65 inches

Axles Information, Unit # 4

Axle # 1
C.G - Axle Distance (negative if rear of CG) = -125.95 inches
Axle load = 17000.00 Lbs
Track Width of the Axle = 78.00 inches
Mass of the Axle = 1500.00 Lbs
Roll Center Height = 27.00 inches
Suspension Stiffness (per Spring) = 8500.00 Lbs/in
Spacing between Suspension Springs = 44.00 inches
Auxiliary Roll Stiffness = 9000.00 in-lb/deg

Tire Information
Total Number of Tires on the Axle = 4
Vertical Stiffness of a Tire = 4500.00 Lbs/in
Radius of a Tire = 20.00 inches
Nominal Load of the Tire = 6040.00 Lbs

Cornering Stiffness Table

Vertical Force (Lbs)	Cornering Stiffness (Lb/deg)
4000.00	654.08
5000.00	769.20

6000.00	853.11

STEADY TURN MODEL
FILE NAME:A:28'DBL.HND

Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.00000	.00000	.00000	.00	.00000
1	2	.00000	.00000	.00000	.00	.00000
2	1	.00000	.00000	.00000	.00	.00000
3	1	.00000	.00000	.00000	.00	.00000
4	1	.00000	.00000	.00000	.00	.00000

*Reference Wheelbase (Lr) = 120.00 in
*Effective Wheelbase (Le) = 120.0000 in
*Rate of Change of Le = .0000 in/g
*Understeer Gradient (Ue) = .0618 rad/g
*Rate of Change of Ue = .0000 rad
*Critical Velocity = 600.0000 mph
*Steer Angle (delta) = .0000 rad
*Rate of Change of delta = .1113
*Force at the Fifth Wheel = .00 Lbs

Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.00120	.00641	.00595	215.54	.05000
1	2	.00333	.00492	.00595	1080.45	.05000
2	1	.00260	.00543	.00595	911.57	.05000
3	1	.00263	.00554	.00632	923.50	.05000
4	1	.00263	.00554	.00632	923.50	.05000

*Reference Wheelbase (Lr) = 120.00 in
*Effective Wheelbase (Le) = 120.0000 in
*Rate of Change of Le = -.1526 in/g
*Understeer Gradient (Ue) = .0613 rad/g
*Rate of Change of Ue = -.0221 rad
*Critical Velocity = 600.0000 mph
*Steer Angle (delta) = .0055 rad
*Rate of Change of delta = .1096
*Force at the Fifth Wheel = 630.19 Lbs

Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.00239	.01282	.01189	431.07	.10000
1	2	.00667	.00983	.01189	2160.91	.10000
2	1	.00519	.01087	.01189	1823.14	.10000
3	1	.00526	.01108	.01263	1847.01	.10000
4	1	.00526	.01108	.01263	1847.01	.10000

*Reference Wheelbase (Lr) = 120.00 in

*Effective Wheelbase (Le) = 120.0000 in
*Rate of Change of Le = .0763 in/g
*Understeer Gradient (Ue) = .0596 rad/g
*Rate of Change of Ue = -.0456 rad
*Critical Velocity = 600.0000 mph
*Steer Angle (delta) = .0109 rad
*Rate of Change of delta = .1045
*Force at the Fifth Wheel = 1260.38 Lbs

		Roll Angles (rad)			Load Transfer	Lateral Acceleration
Unit	Axle	Unsprung	Sprung	Total	(Lbs)	(g's)
1	1	.00359	.01923	.01784	646.61	.15000
1	2	.01000	.01475	.01784	3241.36	.15000
2	1	.00779	.01630	.01784	2734.72	.15000
3	1	.00789	.01662	.01895	2770.51	.15000
4	1	.00789	.01662	.01895	2770.51	.15000

*Reference Wheelbase (Lr) = 120.00 in
*Effective Wheelbase (Le) = 120.0000 in
*Rate of Change of Le = -.2289 in/g
*Understeer Gradient (Ue) = .0566 rad/g
*Rate of Change of Ue = -.0739 rad
*Critical Velocity = 600.0000 mph
*Steer Angle (delta) = .0159 rad
*Rate of Change of delta = .0950
*Force at the Fifth Wheel = 1890.57 Lbs

		Roll Angles (rad)			Load Transfer	Lateral Acceleration
Unit	Axle	Unsprung	Sprung	Total	(Lbs)	(g's)
1	1	.00479	.02565	.02379	862.14	.20000
1	2	.01334	.01967	.02379	4321.81	.20000
2	1	.01039	.02174	.02379	3646.29	.20000
3	1	.01052	.02215	.02527	3694.01	.20000
4	1	.01052	.02215	.02527	3694.01	.20000

*Reference Wheelbase (Lr) = 120.00 in
*Effective Wheelbase (Le) = 120.0000 in
*Rate of Change of Le = -.0763 in/g
*Understeer Gradient (Ue) = .0521 rad/g
*Rate of Change of Ue = -.1101 rad
*Critical Velocity = 600.0000 mph
*Steer Angle (delta) = .0203 rad
*Rate of Change of delta = .0795
*Force at the Fifth Wheel = 2520.76 Lbs

		Roll Angles (rad)			Load Transfer	Lateral Acceleration
Unit	Axle	Unsprung	Sprung	Total	(Lbs)	(g's)
1	1	.00599	.03206	.02973	1077.68	.25000
1	2	.01667	.02459	.02973	5402.26	.25000

2	1	.01299	.02717	.02973	4557.86	.25000
3	1	.01316	.02769	.03158	4617.51	.25000
4	1	.01316	.02769	.03158	4617.51	.25000

*Reference Wheelbase (Lr) = 120.00 in
*Effective Wheelbase (Le) = 120.0000 in
*Rate of Change of Le = .0000 in/g
*Understeer Gradient (Ue) = .0454 rad/g
*Rate of Change of Ue = -.1602 rad
*Critical Velocity = 600.0000 mph
*Steer Angle (delta) = .0237 rad
*Rate of Change of delta = .0547
*Force at the Fifth Wheel = 3150.95 Lbs

		Roll Angles (rad)			Load Transfer	Lateral Acceleration
Unit	Axle	Unsprung	Sprung	Total	(Lbs)	(g's)
1	1	.00718	.03847	.03568	1293.22	.30000
1	2	.02001	.02950	.03568	6482.72	.30000
2	1	.01558	.03260	.03568	5469.43	.30000
3	1	.01579	.03323	.03790	5541.02	.30000
4	1	.01579	.03323	.03790	5541.02	.30000

*Reference Wheelbase (Lr) = 120.00 in
*Effective Wheelbase (Le) = 120.0000 in
*Rate of Change of Le = -.1526 in/g
*Understeer Gradient (Ue) = .0357 rad/g
*Rate of Change of Ue = -.2327 rad
*Critical Velocity = 66.1754 mph
*Steer Angle (delta) = .0255 rad
*Rate of Change of delta = .0152
*Force at the Fifth Wheel = 3781.14 Lbs

		Roll Angles (rad)			Load Transfer	Lateral Acceleration
Unit	Axle	Unsprung	Sprung	Total	(Lbs)	(g's)
1	1	.00838	.04488	.04163	1508.75	.35000
1	2	.02334	.03442	.04163	7563.17	.35000
2	1	.01818	.03804	.04163	6381.00	.35000
3	1	.01842	.03877	.04422	6464.52	.35000
4	1	.01842	.03877	.04422	6464.52	.35000

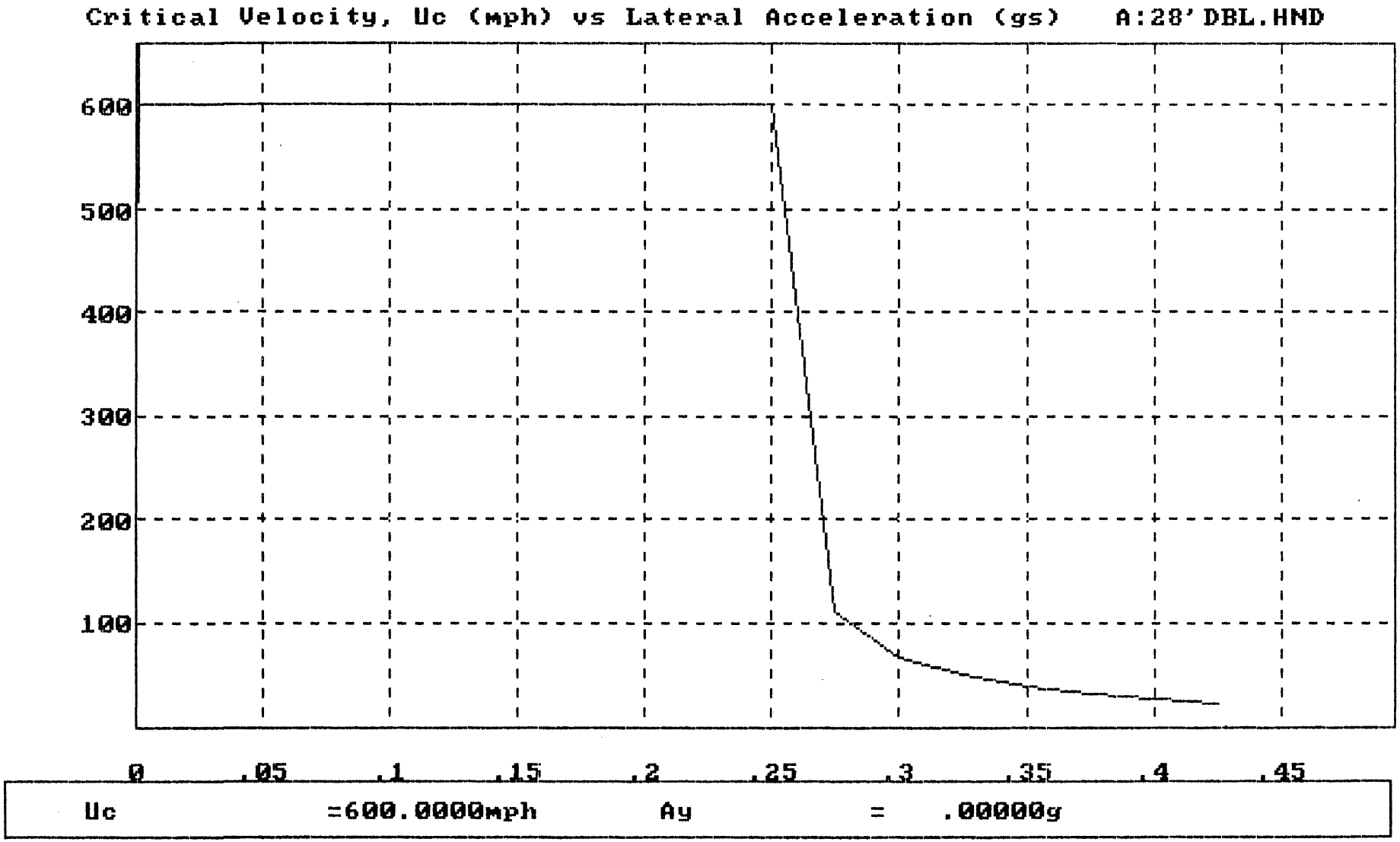
*Reference Wheelbase (Lr) = 120.00 in
*Effective Wheelbase (Le) = 120.0000 in
*Rate of Change of Le = -.1526 in/g
*Understeer Gradient (Ue) = .0214 rad/g
*Rate of Change of Ue = -.3461 rad
*Critical Velocity = 38.7166 mph
*Steer Angle (delta) = .0248 rad
*Rate of Change of delta = -.0503
*Force at the Fifth Wheel = 4411.33 Lbs

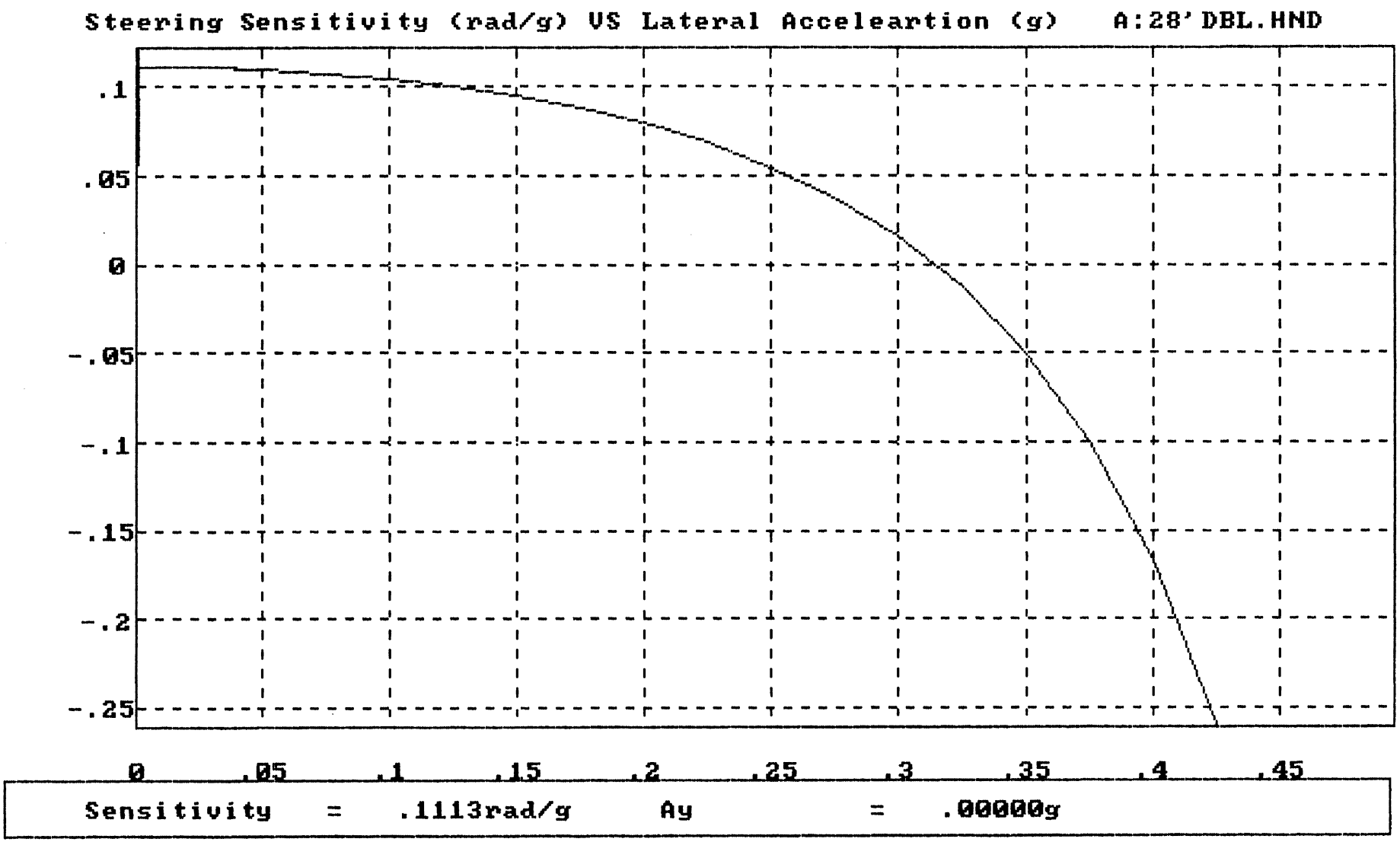
Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	1	.00958	.05129	.04757	1724.29	.40000
1	2	.02668	.03934	.04757	8643.62	.40000
2	1	.02078	.04347	.04757	7292.58	.40000
3	1	.02105	.04431	.05054	7388.02	.40000
4	1	.02105	.04431	.05054	7388.02	.40000

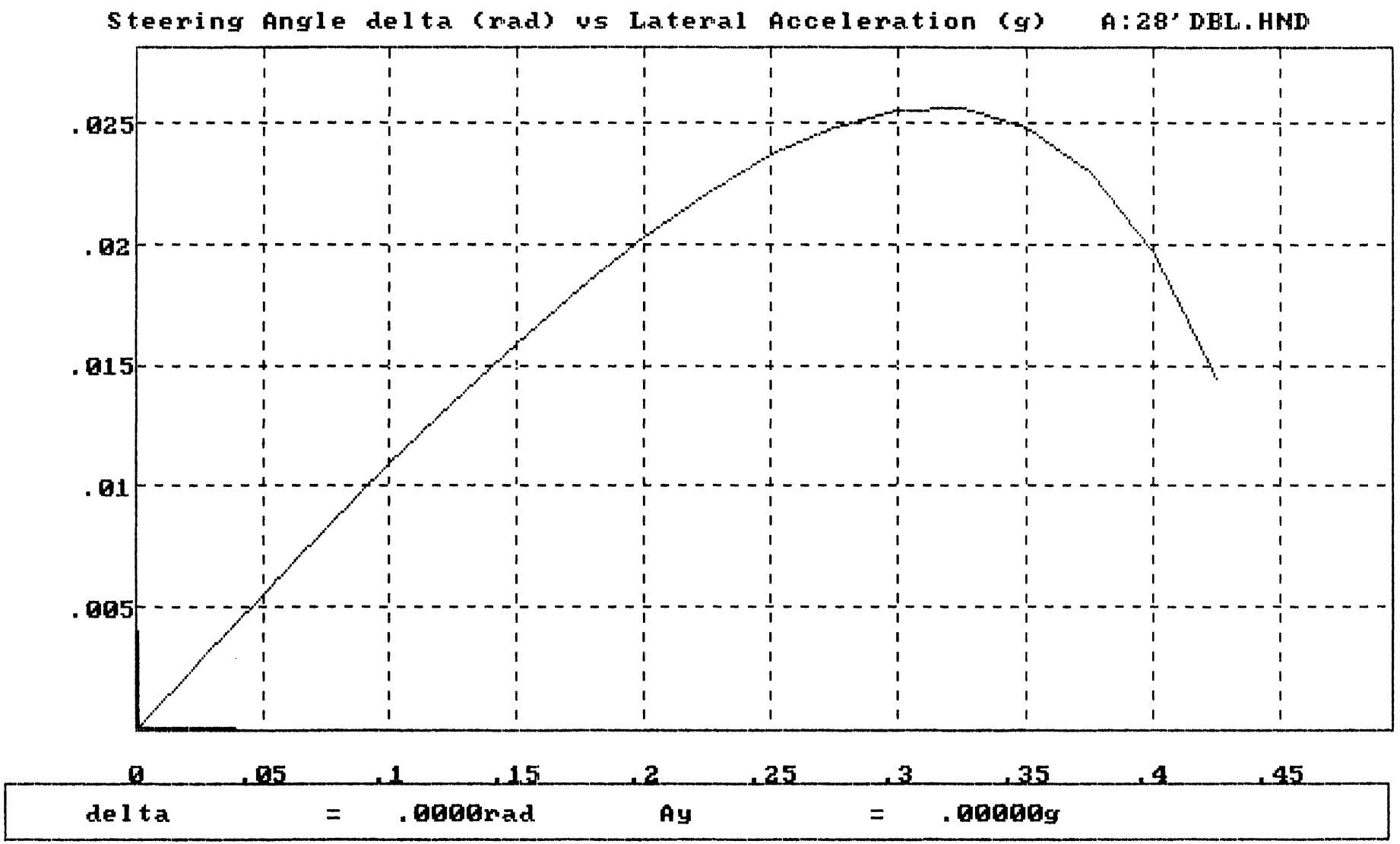
*Reference Wheelbase (Lr) = 120.00 in
*Effective Wheelbase (Le) = 120.0000 in
*Rate of Change of Le = .0000 in/g
*Understeer Gradient (Ue) = -.0002 rad/g
*Rate of Change of Ue = -.5393 rad
*Critical Velocity = 26.3144 mph
*Steer Angle (delta) = .0197 rad
*Rate of Change of delta = -.1666
*Force at the Fifth Wheel = 5041.52 Lbs

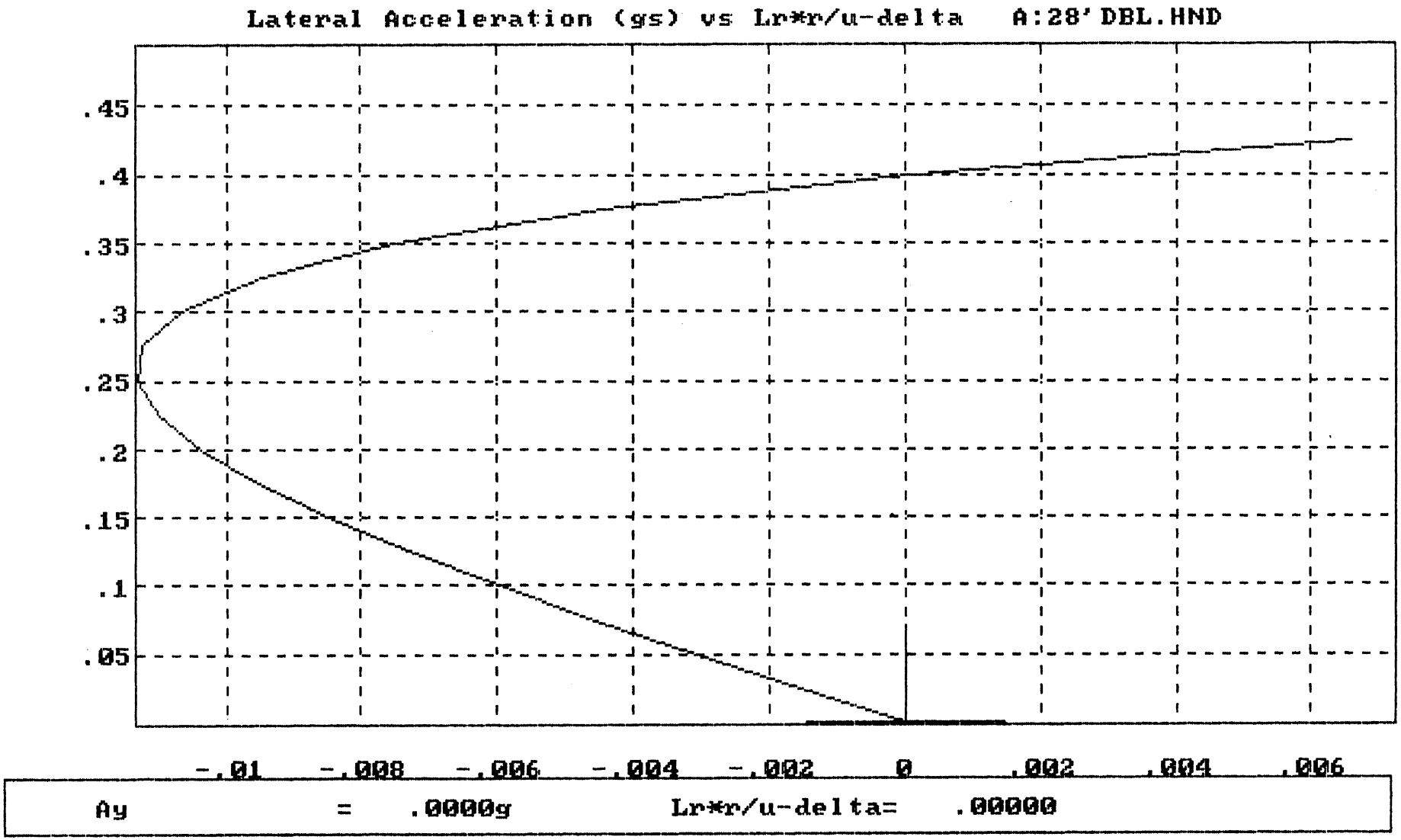
Axle # 2 of Unit # 1 has Lift Off

Unit	Axle	Roll Angles (rad) Unsprung	Sprung	Total	Load Transfer (Lbs)	Lateral Acceleration (g's)
1	2	.03001	.04426	.05352	9724.08	.45000


Critical Velocity, Uc (mph) vs Lateral Acceleration (gs) A:28' DBL.HND
600
500
400
300
200
100
0
.05
.1
.15
.2
.25
.3
.35
.4
.45
Uc =600.0000mph Ay = .00000g


Steering Sensitivity (rad/g) VS Lateral Acceleartion (g) A:28' DBL.HND
.1
.05
0
-.05
-.1
-.15
-.2
-.25
0
.05
.1
.15
.2
.25
.3
.35
.4
.45
Sensitivity = .1113rad/g Ay = .00000g


Steering Angle delta (rad) vs Lateral Acceleration (g) A:28' DBL.HND
.025
.02
.015
.01
.005
0
.05
.1
.15
.2
.25
.3
.35
.4
.45
delta = .0000rad Ay = .00000g


Lateral Acceleration (gs) vs Lr*r/u-delta A:28' DBL.HND
.45
.4
.35
.3
.25
.2
.15
.1
.05
-.01
-.008
-.006
-.004
-.002
0
.002
.004
.006
Ay = .0000g
Lr*r/u-delta= .00000

Quick Reference Card.

BRAKE TEMP, MOUNTAIN DESCENT V1.0

A) General Information:

To Run The Program Type: BRAKETEM

Files required for proper function:
- BRAKETEM.EXE
-AXIS
- HALO****.DEV
-HALO++++.PRN
- HARDWARE.SET
**** =Name of the Graphics board,e.g,HERC
++++=Name of the printer device, e.g, EPSN.

B) General Commands:

1) EDIT-VIEW DATA:

PgUp=Page Up
PgDn=Page Down
↑=Upper Edit Field
↵ or ↓=Lower Edit Field
Ctrl →=Right Edit Field (column)
Ctrl ←=Left Edit Field (column)
End=Accept or Continue
Esc=Exit to Main menu
← =Scrolls cursor to left on current field
→ =Scrolls cursor to right on current field

2) CALCULATE:

End=OK or Accept
Esc=Exit to Main menu

3) PLOTS:

a) P or p followed by:
W or w = Wide print out
T or t = Tall print out

b) S or s : Enter new Axes limits. Esc will return to the Plot menu.

c) End exits to the Plot menu.

d) → and ←: Move the cross cursor rigth and left.

e) Ctrl→ or Ctrl ← move the cross cursor right and left at higher increments.

f) ↵ (RETURN key): Shifts the cross cursor among the different curves.

g) ↑ and ↓ :Scroll the Y axis up and down

h) PgUp and PgDn: Scroll the X axis right and left.

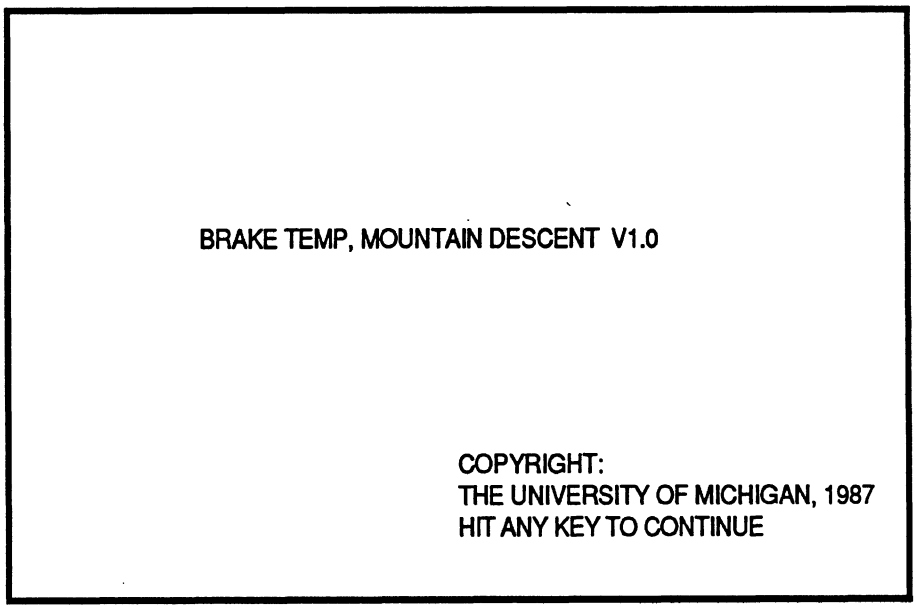
i) To zoom in or out: Hit the + or - keys (once or twice) followed by the axis to zoom (X or Y).

1) RUNNING THE PROGRAM AND SELECTING NEW DATA.

To start running the program insert the program disk in any drive and then type:

BRAKETEM

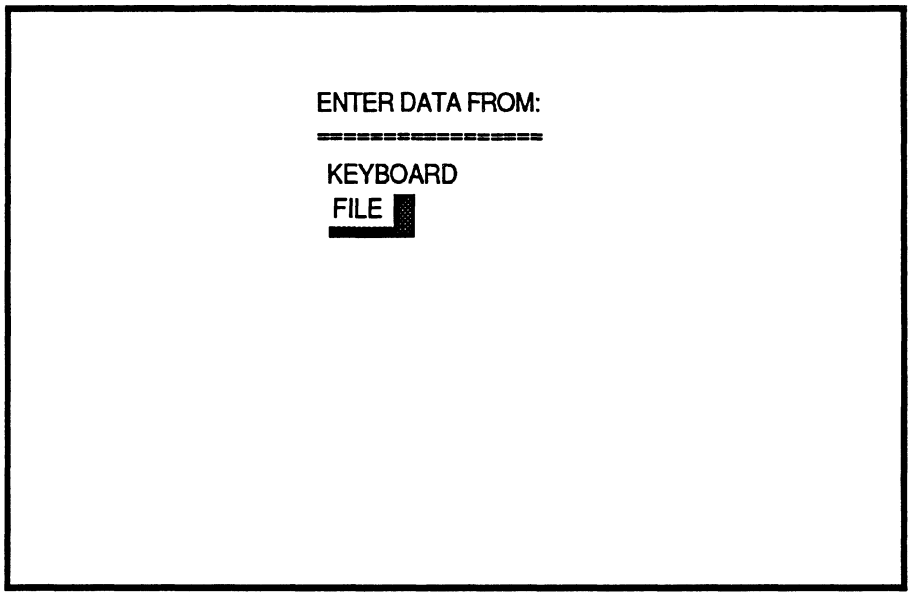
After few seconds the following message appears on the screen (see screen #1 below)



Screen #1

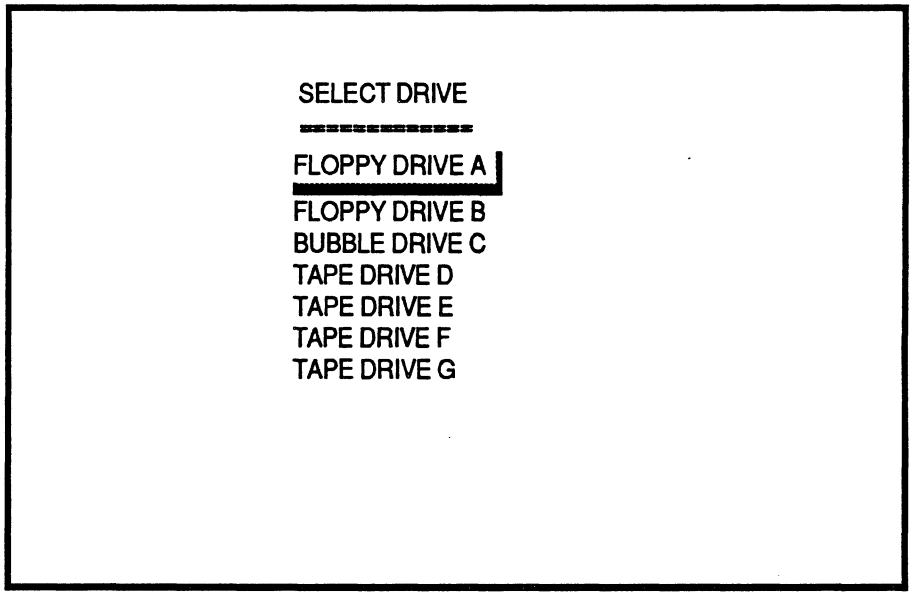
To continue simply hit any key on the keyboard.

The menu to select the source of input appears next, screen #2. Make your selection by pressing the up (↑) and down (↓) arrow keys and then **RETURN** (↵) or **End.**



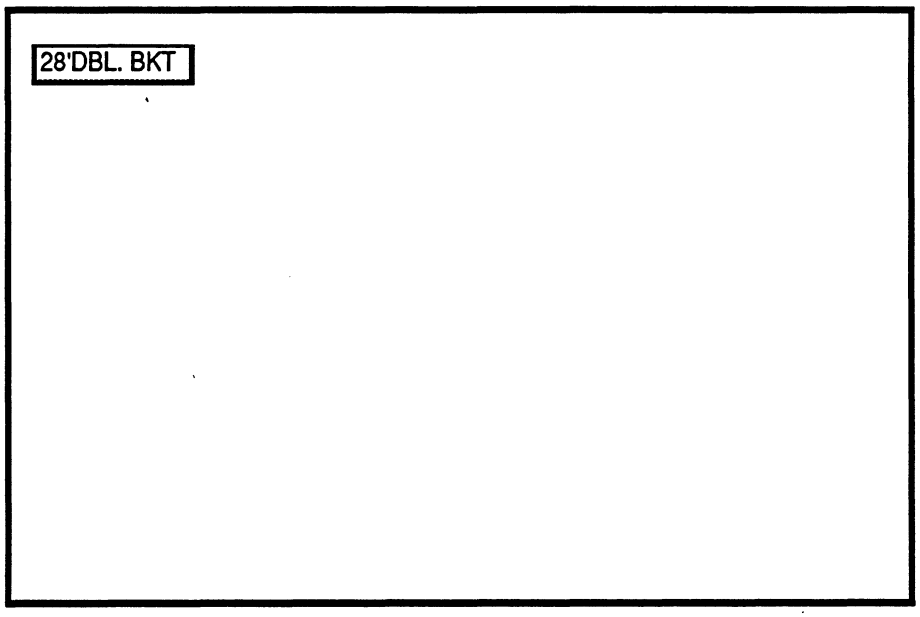
Screen #2

If your selection was "FILE", the following screen appears to enter the drive from which data will be entered.



Screen #3

One more time, make your selection and press the **End** key. All the files available on that drive will be listed on the screen so that you can select one to be read, see screen #4.



Screen #4

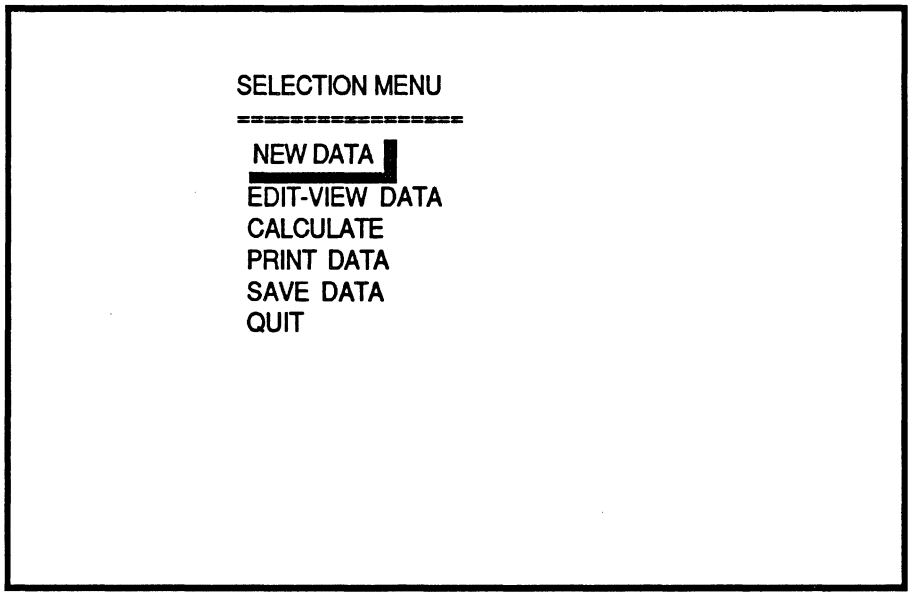
The file selection is made by pressing the following keys:

- **RETURN** key (↵) or the **Ctrl** plus the right arrow (→) key to select forward
- **Ctrl** plus the left arrow (←) key to select backwards, and
- **End** to complete the selection.

For "KEYBOARD" selection see the "EDIT-VIEW DATA" section.

2) EDIT-VIEW DATA

Once data has been read into memory, the main selection menu appears (screen #5.)



Screen #5

From this menu we could:

- Enter new data. This would return us to screen #2 (above.)
- Edit and view the current data set (explained in this section.)
- Calculate, which would further take us to another menu to select the type of calculation.
- Print data, that would send to the printer the current data set.
- Save data, which would allow us to save the current or modified data set into a file.
- Quit, that would return us to the operating system shell.

The way this program displays data is called "Page Editing", which shows the information for each unit on a screen page. We would have as many pages as number of units on the vehicle.

The controls for page editing are the following:

- Up arrow (↑) key, moves the cursor to the upper next position.
- Down arrow (↓) key, moves the cursor to the lower next position.
- **PgUp** key (page up), returns to the previous page.
- **PgDn** key (page down), advances one more page.
- **RETURN** key (↵), has the same function as the down arrow key.
- Right (→) and left (←) arrow keys, moves the text cursor on the current edit field. This is used to modify the current value.
- **Esc** key exits to the main menu at any point during the page editing session.
- **End** key, gets you out of the Edit mode <u>if you are in the last page</u>; otherwise, has no effect.

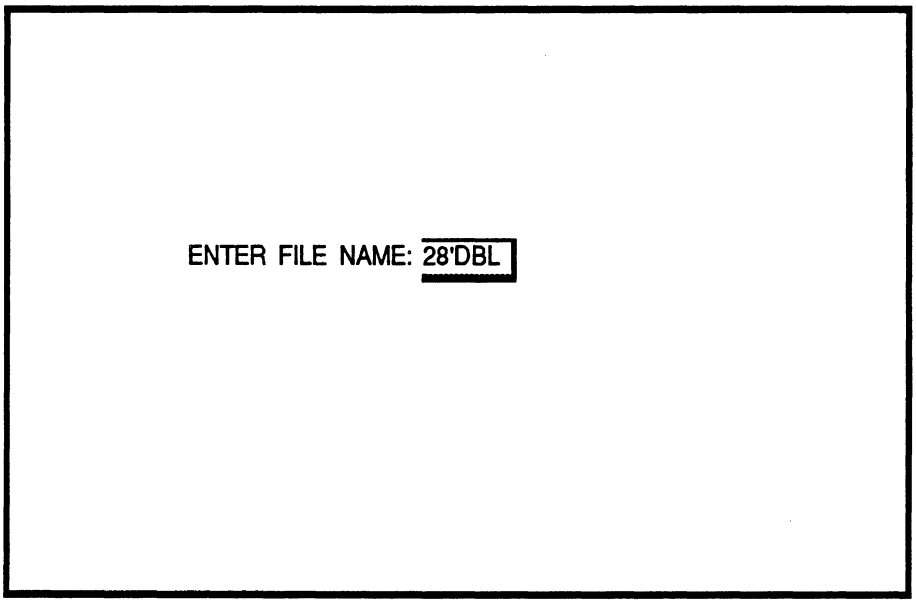
If you had selected to enter data from the keyboard, a prompt requesting the number of units appears first, and then the remaining data is entered by page editing.

3) **PRINT DATA**

This option will allow the user to send the data set to the printer. A prompt appears to check whether the printer is connected and turned on. If so, just hit the **End** key. A sample data set is included at the end of this documentation.

4) **SAVE DATA**

Choosing this option allows the user to save a data set into a file. The computer prompts the user for the drive to where data will be stored, see screen #3, and then prompts for the file name, see screen #6.



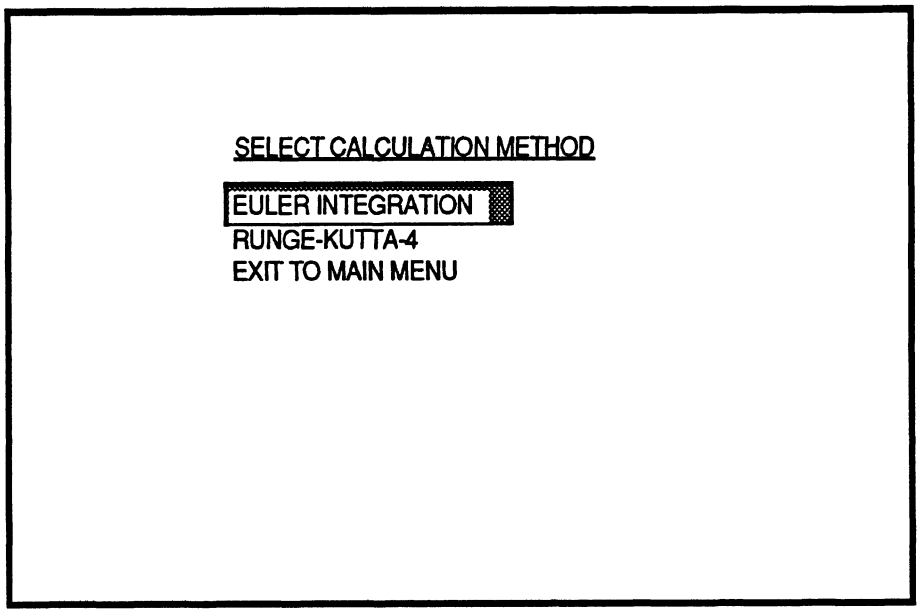
Screen #6

If the file already exists a message indicating so will be printed on the screen, allowing the user to either replace the old file with the new file, or enter a different name for the new file.

Note that the extension "BKT" is added to all the files. This is an identifier of files to this program.

5) CALCULATE

Selecting this option will display the following menu, see screen #7.

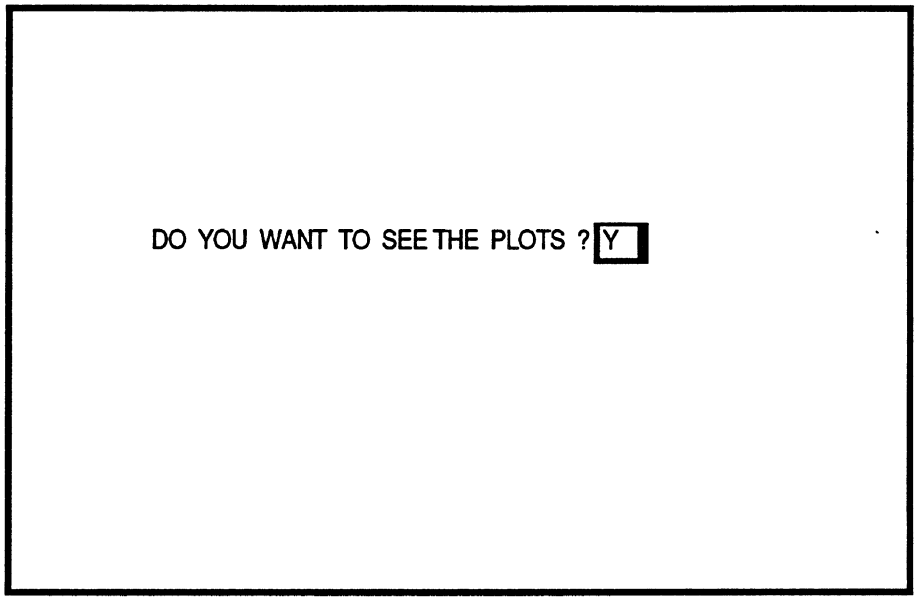


Screen #7

From this menu, the method of calculation to be performed may be selected by using the control explained for the previous menus (above).

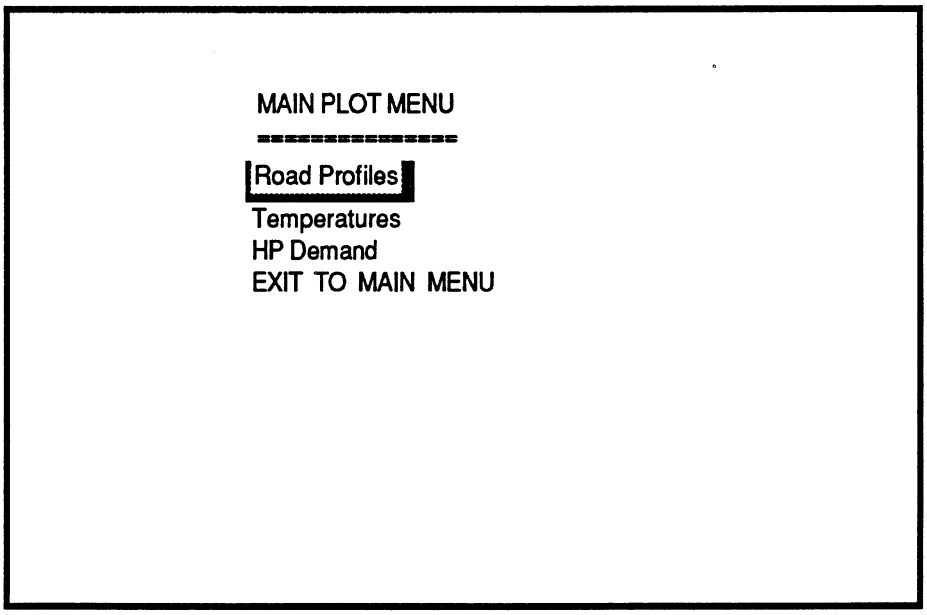
The following prompt will ask whether you want to print the results as they are calculate or not. If the answer is "Y" or "y" then make sure that the printer in turned on. If the answer is "N" or "n" the results will appear on the screen only.

After the calculations end the following screen appears.



Screen #8

If your answer is "yes" just press the **End** key, and the following menu will appear (Screen #9)



Screen #9

Once you have made your selection, another menu will appear to allow you to choose which variables are to be plotted. After the variables are chosen, a plot will appear on the screen. An example is included at the end of this documentation.

You can modify the form of the graph. The following keys are the controls for the graph:

- Up arrow (↑) key, scrolls the "Y" axis upward.
- Down arrow (↓) key, scrolls the "Y" axis downward.
- **PgUp** key (page up), scrolls the "X" axis forward.
- **PgDn** key (page down), scrolls the "X" axis backward.
- **RETURN** key (↵), shifts the cross cursor among the different curves, and indicates on the lower view port the legend of the curve selected. The "Y" and "X" values at the position of the cursor are shown on the same port.
- Right (→) and left (←) arrow keys, move the cross cursor on the current curve right or left and updates its position on the lower view port.
- The + (plus) or - (minus) keys hit either once or twice and followed by the letter X or Y will zoom the respective axis up or down.
- **P** (or **p**), followed by a **W** (or **w**) for wide, or a **T** (or **t**) for tall,will print the current chart.
- **End** key, gets you out of the chart and sends you to the plot menu, screen #9.

Exit to Main Menu

Selecting this option will return the user to screen #5 where further calculations may be made or the user may **QUIT** the program.

VEHICLE PARAMETERS

*Total Weight (lb) = 50000.00
*Frontal Area (Ft^2) = 100.00
*Total Number of Axles = 9
*Type of Tires : 2
(1 = BIAS PLY 2 = RADIALS)

ROAD AND AMBIENT PARAMETERS

*Ambient Temperature (F) = 90.00
*Air Drag Coefficient = .8500
*Road Surface Coefficient = 1.2000
*Number of Points in Road Profile = 10
*Number of Points in Aux. Retarding Table = 2

PgDn=PAGE DOWN Esc=EXIT End=PAGE DOWN

TOTAL AUXILIARY RETARDING POWER TABLE

VELOCITY (MPH)	RETARDING POWER (HP)
.00	.0000
40.00	100.0000

PgUp=PAGE UP PgDn=PAGE DOWN End=PgDn Esc=EXIT

BRAKE PARAMETERS

TO (F)	Thermal Capacity MCp (HP-HR/F)	Cooling Coefficients K1 (HP/F)	K2 (HP/F-mph)	PROPORTIONING
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556

PgUp=PAGE UP PgDn=PAGE DOWN End=PgDn Esc=EXIT

BRAKE PARAMETERS

TO (F)	Thermal Capacity MCp (HP-HR/F)	Cooling Coefficients K1 (HP/F)	K2 (HP/F-mph)	PROPORTIONING
100.00	.00813	.0100	.000208	.0556
100.00	.00813	.0100	.000208	.0556

PgUp=PAGE UP PgDn=PAGE DOWN End=PgDn Esc=EXIT

ROAD PROFILE

DISTANCE (MILES)	ELEVATION (FT)	VELOCITY (MPH)
.000	1700.00	50.00
.250	1615.52	49.00
.500	1531.04	48.00
.750	1446.56	47.00
1.000	1362.08	46.00
1.250	1277.60	45.00
1.500	1193.12	44.00
1.750	1108.64	43.00
2.000	1024.16	42.00
2.250	939.68	41.00

PgUp=PAGE UP PgDn=EXIT Esc=EXIT End=EXIT

MOUNTAIN DESCENT - BRAKE TEMP.
FILE NAME:C:DOUBLE.BKT
TIME HISTORY OF BRAKES TEMPERATURE

Time = .0000 sec
Distance = .000 Mi
Elevation = 1700.00 Ft
Velocity = 50.00 MPH
Acceleration = -.251E-02 gs
Decel. Demand = 443.1239 HP
Total to Brakes = 204.4392 HP

Axle No	Temp 1 (F)	Temp 2 (F)
1	100.0000	100.0000
Axle No	Temp 3 (F)	Temp 4 (F)
2	100.0000	100.0000
Axle No	Temp 5 (F)	Temp 6 (F)
3	100.0000	100.0000

Axle No	Temp 7 (F)	Temp 8 (F)
4	100.0000	100.0000
Axle No	Temp 9 (F)	Temp10 (F)
5	100.0000	100.0000
Axle No	Temp11 (F)	Temp12 (F)
6	100.0000	100.0000
Axle No	Temp13 (F)	Temp14 (F)
7	100.0000	100.0000
Axle No	Temp15 (F)	Temp16 (F)
8	100.0000	100.0000
Axle No	Temp17 (F)	Temp18 (F)
9	100.0000	100.0000

Time = 18.1818 sec
Distance = .250 Mi
Elevation = 1615.52 Ft
Velocity = 49.00 MPH
Acceleration = -.245E-02 gs
Decel. Demand = 433.9310 HP
Total to Brakes = 202.6926 HP

Axle No	Temp 1 (F)	Temp 2 (F)
1	106.8874	106.8874
Axle No	Temp 3 (F)	Temp 4 (F)
2	106.8874	106.8874
Axle No	Temp 5 (F)	Temp 6 (F)
3	106.8874	106.8874
Axle No	Temp 7 (F)	Temp 8 (F)
4	106.8874	106.8874
Axle No	Temp 9 (F)	Temp10 (F)
5	106.8874	106.8874
Axle No	Temp11 (F)	Temp12 (F)
6	106.8874	106.8874
Axle No	Temp13 (F)	Temp14 (F)
7	106.8874	106.8874
Axle No	Temp15 (F)	Temp16 (F)
8	106.8874	106.8874
Axle No	Temp17 (F)	Temp18 (F)

9	106.8874	106.8874

Time = 36.7385 sec
Distance = .500 Mi
Elevation = 1531.04 Ft
Velocity = 48.00 MPH
Acceleration = -.240E-02 gs
Decel. Demand = 424.7516 HP
Total to Brakes = 200.8127 HP

Axle No	Temp 1 (F)	Temp 2 (F)
1	113.6308	113.6308
Axle No	Temp 3 (F)	Temp 4 (F)
2	113.6308	113.6308
Axle No	Temp 5 (F)	Temp 6 (F)
3	113.6308	113.6308
Axle No	Temp 7 (F)	Temp 8 (F)
4	113.6308	113.6308
Axle No	Temp 9 (F)	Temp10 (F)
5	113.6308	113.6308
Axle No	Temp11 (F)	Temp12 (F)
6	113.6308	113.6308

Axle No	Temp13 (F)	Temp14 (F)
7	113.6308	113.6308
Axle No	Temp15 (F)	Temp16 (F)
8	113.6308	113.6308
Axle No	Temp17 (F)	Temp18 (F)
9	113.6308	113.6308

Time = 55.6859 sec
Distance = .750 Mi
Elevation = 1446.56 Ft
Velocity = 47.00 MPH
Acceleration = -.235E-02 gs
Decel. Demand = 415.5862 HP
Total to Brakes = 198.8022 HP

Axle No	Temp 1 (F)	Temp 2 (F)
1	120.2292	120.2292
Axle No	Temp 3 (F)	Temp 4 (F)
2	120.2292	120.2292
Axle No	Temp 5 (F)	Temp 6 (F)
3	120.2292	120.2292
Axle No	Temp 7 (F)	Temp 8 (F)
4	120.2292	120.2292
Axle No	Temp 9 (F)	Temp10 (F)
5	120.2292	120.2292
Axle No	Temp11 (F)	Temp12 (F)
6	120.2292	120.2292
Axle No	Temp13 (F)	Temp14 (F)
7	120.2292	120.2292
Axle No	Temp15 (F)	Temp16 (F)
8	120.2292	120.2292
Axle No	Temp17 (F)	Temp18 (F)
9	120.2292	120.2292

Time = 75.0407 sec
Distance = 1.000 Mi
Elevation = 1362.08 Ft
Velocity = 46.00 MPH

Acceleration = -.230E-02 gs
Decel. Demand = 406.4333 HP
Total to Brakes = 196.6614 HP

Axle No	Temp 1 (F)	Temp 2 (F)
1	127.0377	127.0377
Axle No	Temp 3 (F)	Temp 4 (F)
2	127.0377	127.0377
Axle No	Temp 5 (F)	Temp 6 (F)
3	127.0377	127.0377
Axle No	Temp 7 (F)	Temp 8 (F)
4	127.0377	127.0377
Axle No	Temp 9 (F)	Temp10 (F)
5	127.0377	127.0377
Axle No	Temp11 (F)	Temp12 (F)
6	127.0377	127.0377
Axle No	Temp13 (F)	Temp14 (F)
7	127.0377	127.0377
Axle No	Temp15 (F)	Temp16 (F)
8	127.0377	127.0377
Axle No	Temp17 (F)	Temp18 (F)
9	127.0377	127.0377

Time = 94.8209 sec
Distance = 1.250 Mi
Elevation = 1277.60 Ft
Velocity = 45.00 MPH
Acceleration = -.225E-02 gs
Decel. Demand = 397.2943 HP
Total to Brakes = 194.3941 HP

Axle No	Temp 1 (F)	Temp 2 (F)
1	133.6864	133.6864
Axle No	Temp 3 (F)	Temp 4 (F)
2	133.6864	133.6864
Axle No	Temp 5 (F)	Temp 6 (F)
3	133.6864	133.6864
Axle No	Temp 7 (F)	Temp 8 (F)
4	133.6864	133.6864
Axle No	Temp 9 (F)	Temp10 (F)
5	133.6864	133.6864
Axle No	Temp11 (F)	Temp12 (F)
6	133.6864	133.6864
Axle No	Temp13 (F)	Temp14 (F)
7	133.6864	133.6864
Axle No	Temp15 (F)	Temp16 (F)
8	133.6864	133.6864
Axle No	Temp17 (F)	Temp18 (F)
9	133.6864	133.6864

Time = 115.0457 sec
Distance = 1.500 Mi
Elevation = 1193.12 Ft
Velocity = 44.00 MPH
Acceleration = -.220E-02 gs
Decel. Demand = 388.1689 HP
Total to Brakes = 192.0018 HP

Axle No	Temp 1 (F)	Temp 2 (F)
1	140.5139	140.5139

Axle No	Temp 3 (F)	Temp 4 (F)
2	140.5139	140.5139
Axle No	Temp 5 (F)	Temp 6 (F)
3	140.5139	140.5139
Axle No	Temp 7 (F)	Temp 8 (F)
4	140.5139	140.5139
Axle No	Temp 9 (F)	Temp10 (F)
5	140.5139	140.5139
Axle No	Temp11 (F)	Temp12 (F)
6	140.5139	140.5139
Axle No	Temp13 (F)	Temp14 (F)
7	140.5139	140.5139
Axle No	Temp15 (F)	Temp16 (F)
8	140.5139	140.5139
Axle No	Temp17 (F)	Temp18 (F)
9	140.5139	140.5139

Time = 135.7353 sec
Distance = 1.750 Mi
Elevation = 1108.64 Ft
Velocity = 43.00 MPH
Acceleration = -.215E-02 gs

Decel. Demand = 379.0569 HP
Total to Brakes = 189.4866 HP

Axle No	Temp 1 (F)	Temp 2 (F)
1	147.1673	147.1673
Axle No	Temp 3 (F)	Temp 4 (F)
2	147.1673	147.1673
Axle No	Temp 5 (F)	Temp 6 (F)
3	147.1673	147.1673
Axle No	Temp 7 (F)	Temp 8 (F)
4	147.1673	147.1673
Axle No	Temp 9 (F)	Temp10 (F)
5	147.1673	147.1673
Axle No	Temp11 (F)	Temp12 (F)
6	147.1673	147.1673
Axle No	Temp13 (F)	Temp14 (F)
7	147.1673	147.1673
Axle No	Temp15 (F)	Temp16 (F)
8	147.1673	147.1673
Axle No	Temp17 (F)	Temp18 (F)
9	147.1673	147.1673

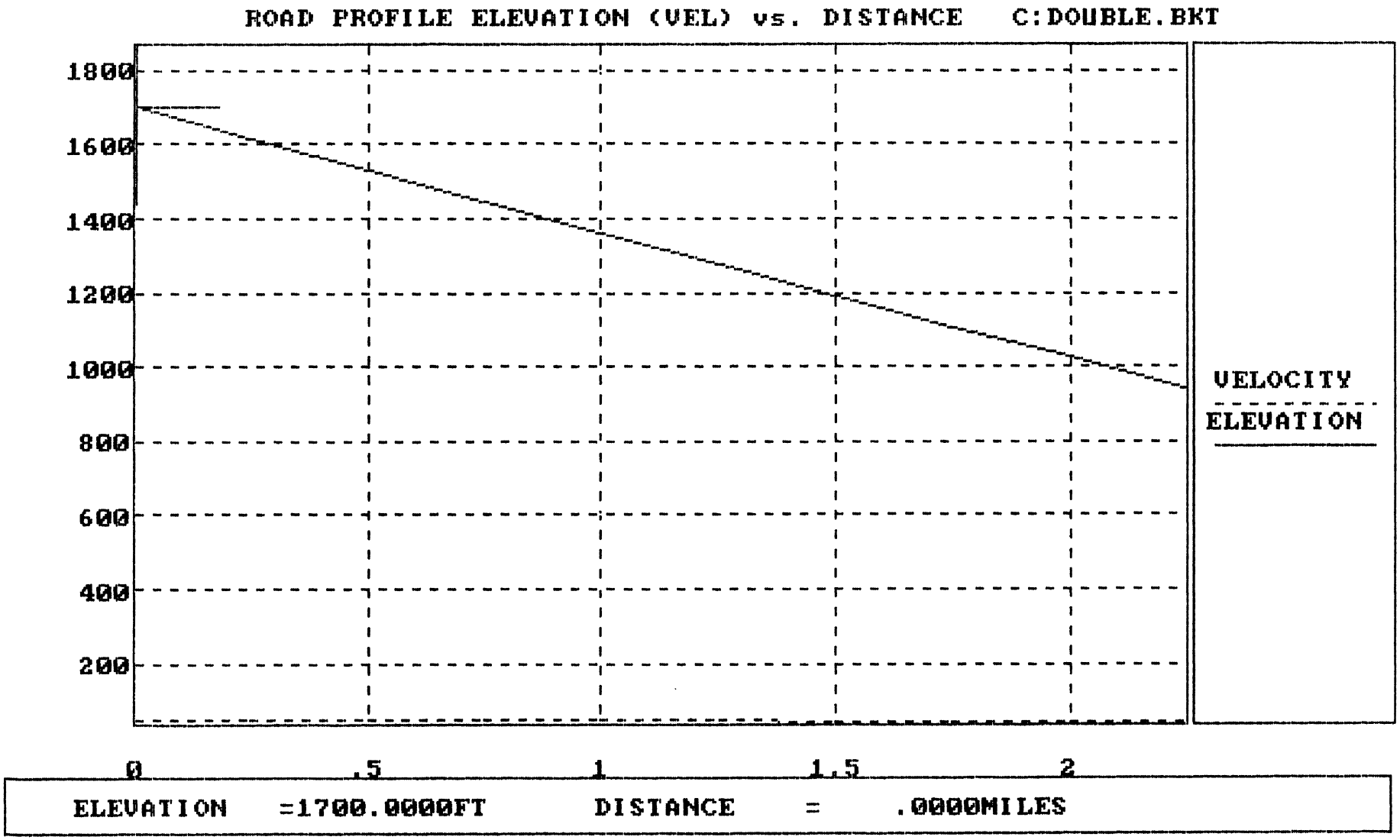
Time = 156.9118 sec
Distance = 2.000 Mi
Elevation = 1024.16 Ft
Velocity = 42.00 MPH
Acceleration = -.210E-02 gs
Decel. Demand = 369.9586 HP
Total to Brakes = 186.8509 HP

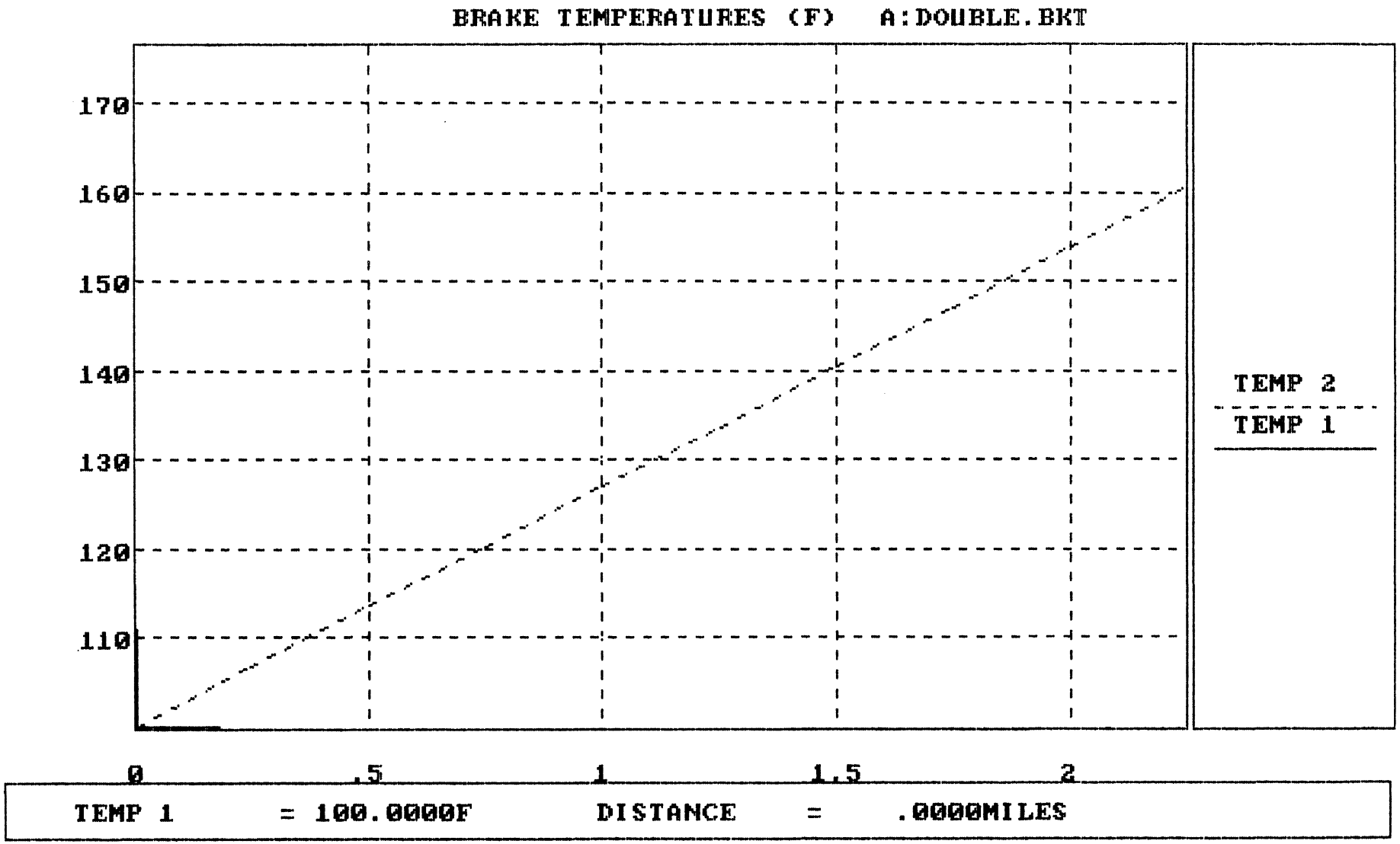
Axle No	Temp 1 (F)	Temp 2 (F)
1	153.9679	153.9679
Axle No	Temp 3 (F)	Temp 4 (F)
2	153.9679	153.9679
Axle No	Temp 5 (F)	Temp 6 (F)
3	153.9679	153.9679
Axle No	Temp 7 (F)	Temp 8 (F)
4	153.9679	153.9679

Axle No	Temp 9 (F)	Temp10 (F)
5	153.9679	153.9679
Axle No	Temp11 (F)	Temp12 (F)
6	153.9679	153.9679
Axle No	Temp13 (F)	Temp14 (F)
7	153.9679	153.9679
Axle No	Temp15 (F)	Temp16 (F)
8	153.9679	153.9679
Axle No	Temp17 (F)	Temp18 (F)
9	153.9679	153.9679

Time = 178.5985 sec
Distance = 2.250 Mi
Elevation = 939.68 Ft
Velocity = 41.00 MPH
Acceleration = -.210E-02 gs
Decel. Demand = 369.9586 HP
Total to Brakes = 186.8509 HP

Axle No	Temp 1 (F)	Temp 2 (F)
1	160.5804	160.5804
Axle No	Temp 3 (F)	Temp 4 (F)
2	160.5804	160.5804
Axle No	Temp 5 (F)	Temp 6 (F)
3	160.5804	160.5804
Axle No	Temp 7 (F)	Temp 8 (F)
4	160.5804	160.5804
Axle No	Temp 9 (F)	Temp10 (F)
5	160.5804	160.5804
Axle No	Temp11 (F)	Temp12 (F)
6	160.5804	160.5804
Axle No	Temp13 (F)	Temp14 (F)
7	160.5804	160.5804
Axle No	Temp15 (F)	Temp16 (F)
8	160.5804	160.5804
Axle No	Temp17 (F)	Temp18 (F)
9	160.5804	160.5804


ROAD PROFILE ELEVATION (VEL) vs. DISTANCE C:DOUBLE.BKT
1800
1600
1400
1200
1000
800
600
400
200
VELOCITY
ELEVATION
0
.5
1
1.5
2
ELEVATION =1700.0000FT DISTANCE = .0000MILES


BRAKE TEMPERATURES (F) A:DOUBLE.BKT
170
160
150
140
130
120
110
0
.5
1
1.5
2
TEMP 2
TEMP 1
TEMP 1 = 100.0000F DISTANCE = .0000MILES

Quick Reference Card.

REARWARD AMP. V2.0

A) General Information:

To Run The Program Type: REARWARD

Files required for proper function:
- REARWARD.EXE
-AXIS
- HALO****.DEV
-HALO++++.PRN
- HARDWARE.SET
**** =Name of the Graphics board,e.g,HERC
++++=Name of the printer device, e.g, EPSN.

B) General Commands:

1) EDIT-VIEW DATA:

PgUp=Page Up
PgDn=Page Down
↑=Upper Edit Field
↵ or ↓=Lower Edit Field
Ctrl →=Right Edit Field (column)
Ctrl ←=Left Edit Field (column)
End=Accept or Continue
Esc=Exit to Main menu
← =Scrolls cursor to left on current field
→ =Scrolls cursor to right on current field

2) CALCULATE:

End=OK or Accept
Esc=Exit to Main menu

3) PLOTS:

a) P or p followed by:
W or w = Wide print out
T or t = Tall print out

b) S or s : Enter new Axes limits. Esc will return to the Plot menu.

c) End exits to the Plot menu.

d) → and ←: Move the cross cursor rigth and left.

e) Ctrl→ or Ctrl ← move the cross cursor right and left at higher increments.

f) ↵ (RETURN key): Shifts the cross cursor among the different curves.

g)↑ and ↓ :Scroll the Y axis up and down

h) PgUp and PgDn: Scroll the X axis right and left.

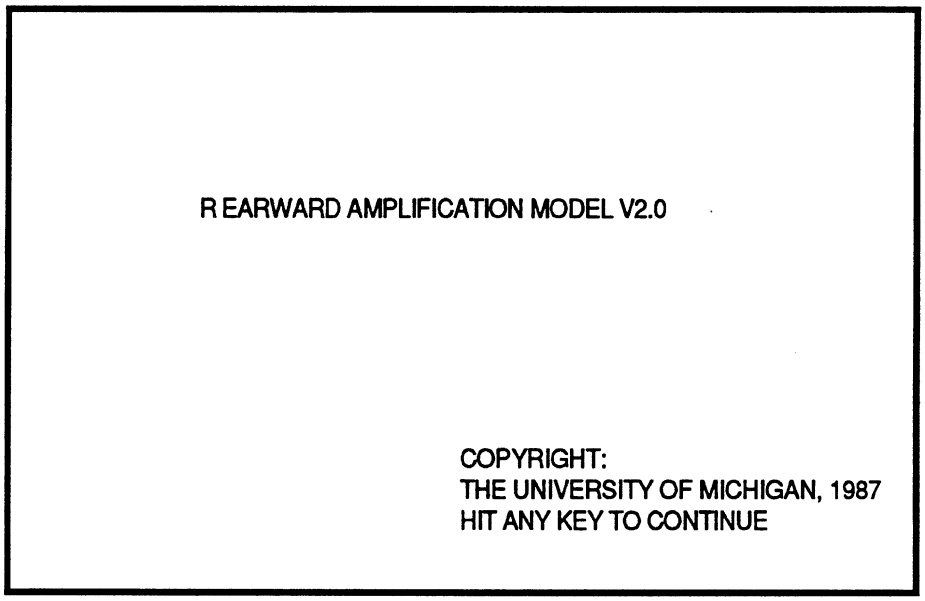
i) To zoom in or out: Hit the + or - keys (once or twice) followed by the axis to zoom (X or Y).

1) RUNNING THE PROGRAM AND SELECTING NEW DATA.

To start running the program insert the program disk in any drive and then type:

REARWARD

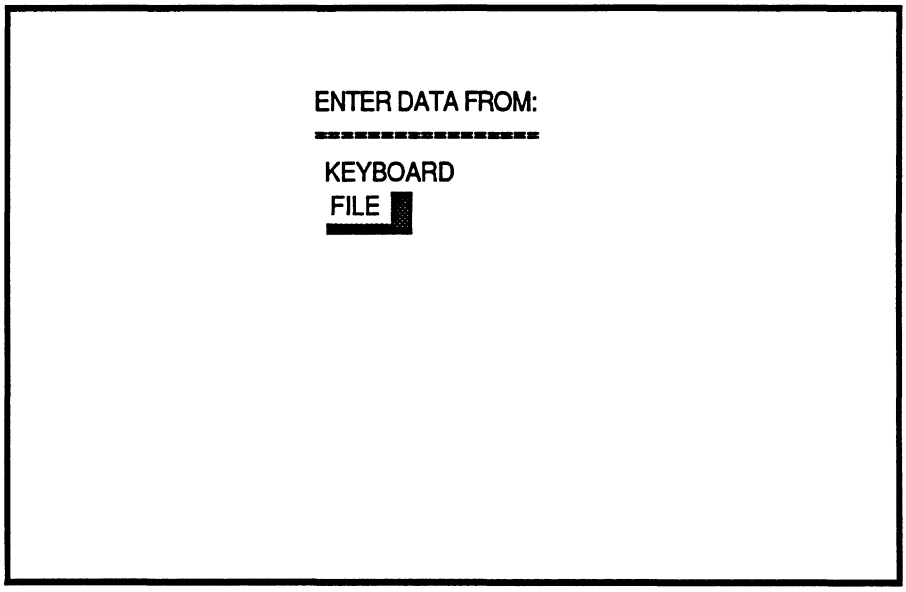
After a few seconds the following message appears on the screen (see screen #1 below)



Screen #1

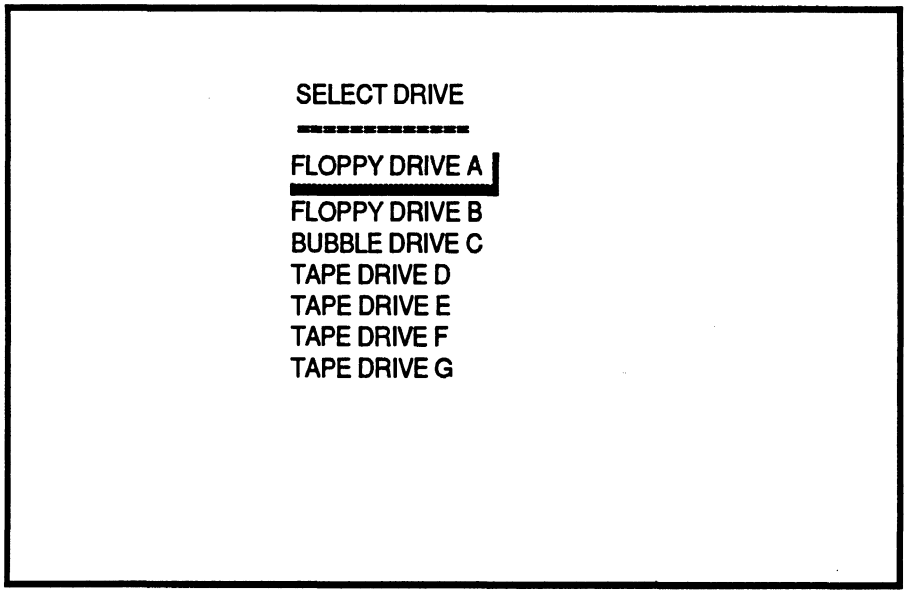
To continue simply hit any key on the keyboard.

The menu to select the source of input appears next, screen #2. Make your selection by pressing the up (↑) and down (↓) arrow keys and then **RETURN** (↵) or **End.**



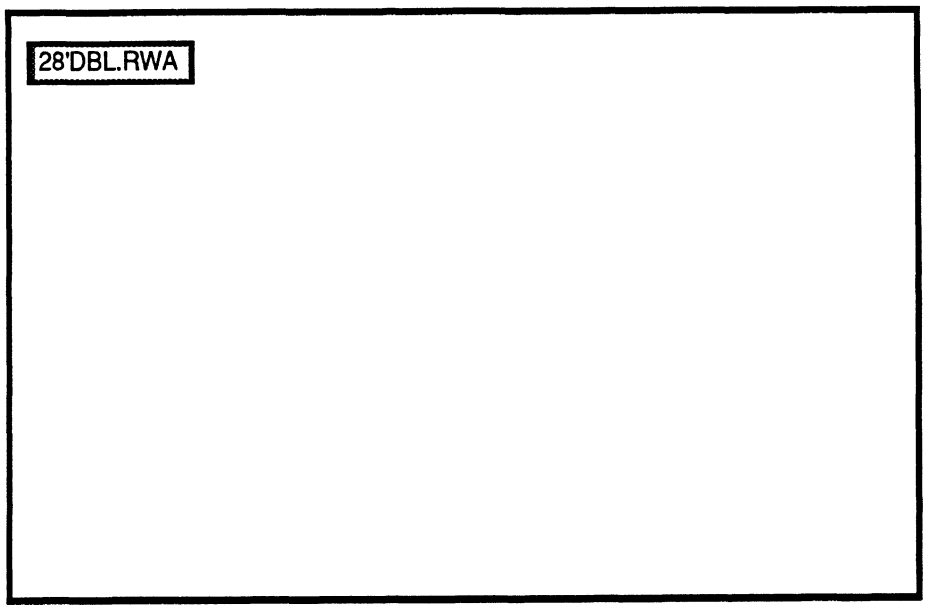
Screen #2

If your selection was "FILE", the following screen appears to enter the drive from which data will be entered.



Screen #3

One more time, make your selection and press the **End** key. All the files available on that drive will be listed on the screen so that you can select one to be read, see screen #4.



Screen #4

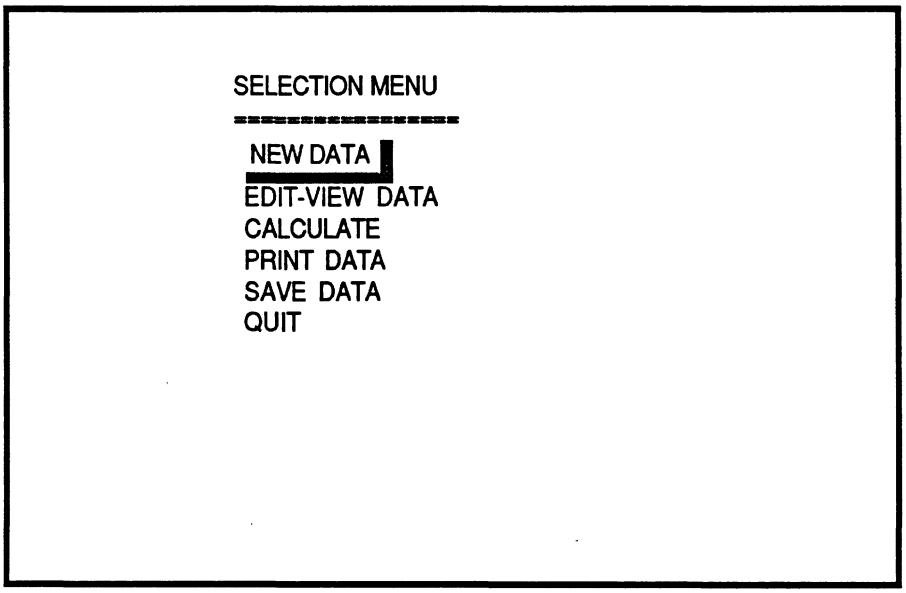
The file selection is made by pressing the following keys:

- **RETURN** key (↵) or the **Ctrl** plus the right arrow (→) key to select forward
- **Ctrl** plus the left arrow (←) key to select backwards, and
- **End** to complete the selection.

For "KEYBOARD" selection see the "EDIT-VIEW DATA" section.

2) EDIT-VIEW DATA

Once data has been read into memory, the main selection menu appears (screen #5.)



Screen #5

From this menu we could:

- Enter new data. This would return us to screen #2 (above.)
- Edit and view the current data set (explained in this section.)
- Calculate, which would further take us to another menu to select the type of calculation.
- Print data, that would send to the printer the current data set.
- Save data, which would allow us to save the current or modified data set into a file.
- Quit, that would return us to the operating system shell.

The way this program displays data is called "Page Editing", which shows the information for each unit on a screen page. We would have as many pages as number of units on the vehicle.

The controls for page editing are the following:

- Up arrow (↑) key, moves the cursor to the upper next position.
- Down arrow (↓) key, moves the cursor to the lower next position.
- **PgUp** key (page up), returns to the previous page.
- **PgDn** key (page down), advances one more page.
- **RETURN** key (↵), has the same function as the down arrow key.
- Right (→) and left (←) arrow keys, moves the text cursor on the current edit field. This is used to modify the current value.
- **Esc** key exits to the main menu at any point during the page editing session.
- **End** key, gets you out of the Edit mode if you are in the last page; otherwise, has no effect.

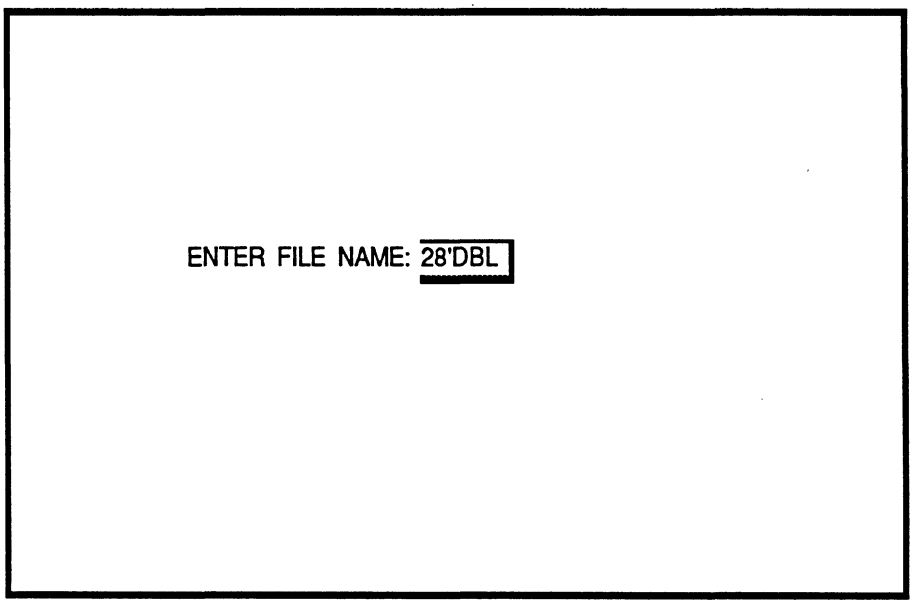
If you had selected to enter data from the keyboard, a prompt requesting the number of units appears first, and then the remaining data is entered by page editing.

3) **PRINT DATA**

This option will allow the user to send the data set to the printer. A prompt appears to check whether the printer is connected and turned on. If so, just hit the **End** key. A sample data set is included at the end of this documentation.

4) **SAVE DATA**

Choosing this option allows the user to save a data set into a file. The computer prompts the user for the drive to where data will be stored, see screen #3, and then prompts for the file name, see screen #6.



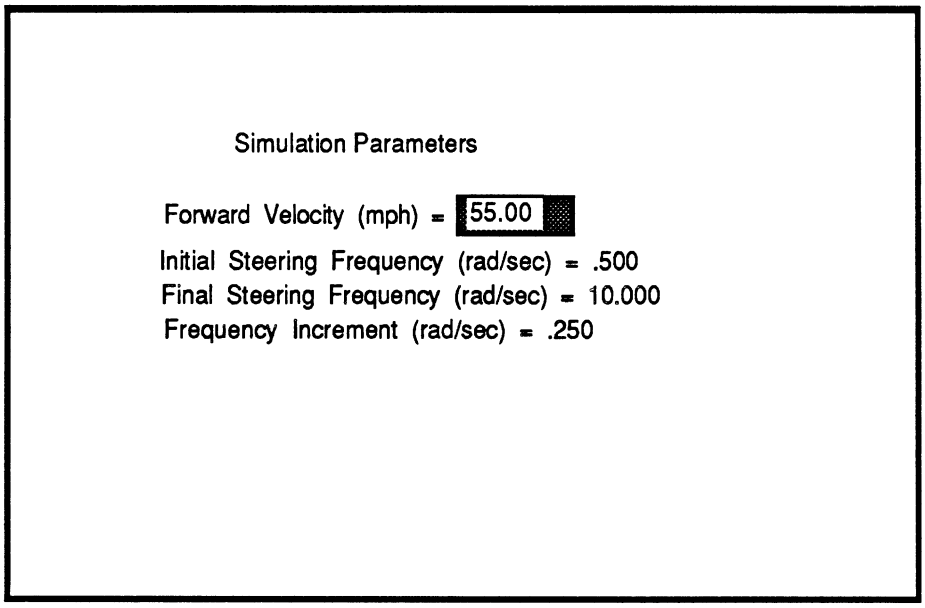
Screen #6

If the file already exists a message indicating so will be printed on the screen, allowing the user to either replace the old file with the new file, or enter a different name for the new file.

Note that the extension "RWA" is added to all the files. This is an identifier of files to this program.

5) **CALCULATE**

Selecting this option will display the following, see screen #7.

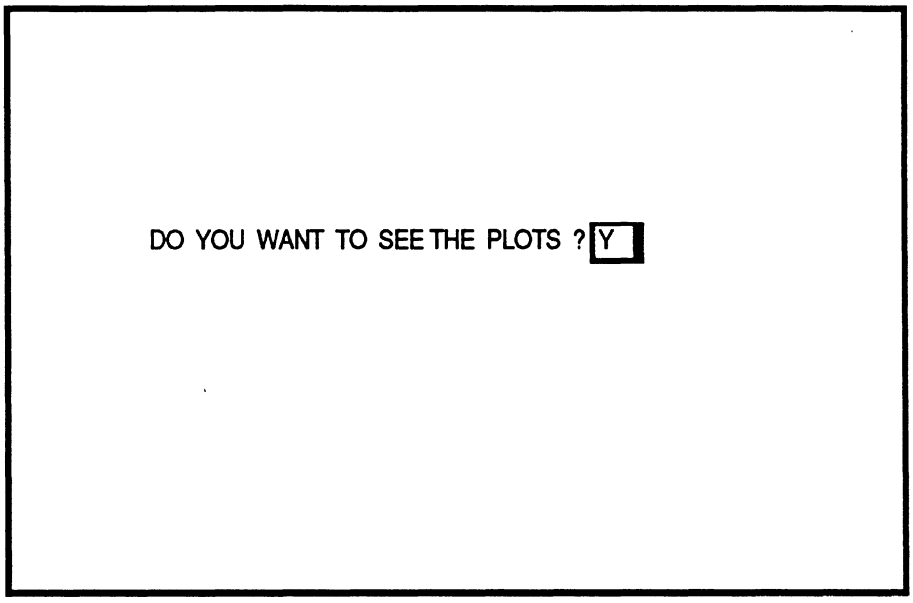


Screen #7

The default values are displayed above. Once you enter the desired numbers press the **End** key.

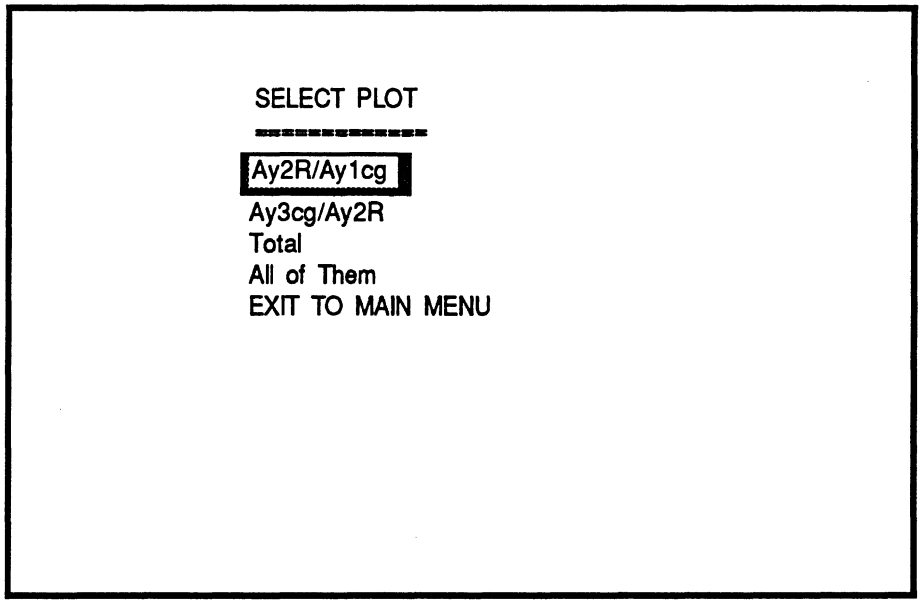
The following prompt will ask whether you want to print the results as they are calculated or not. If the answer is "Y" or "y" then make sure that the printer in turned on. If the answer is "N" or "n" the results will appear on the screen only.

After the calculations end the following screen appears.



Screen #8

If your answer is "yes" just press the **End** key, and the following menu will appear (Screen #9)

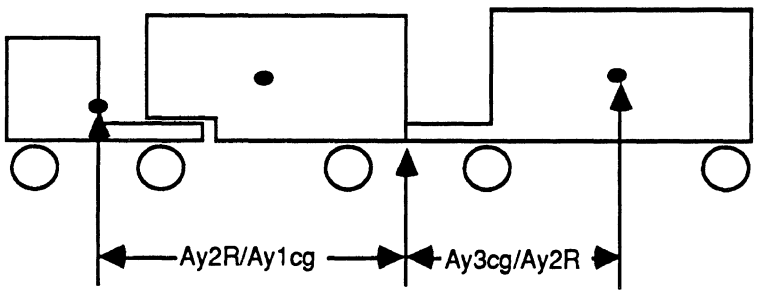


Screen #9

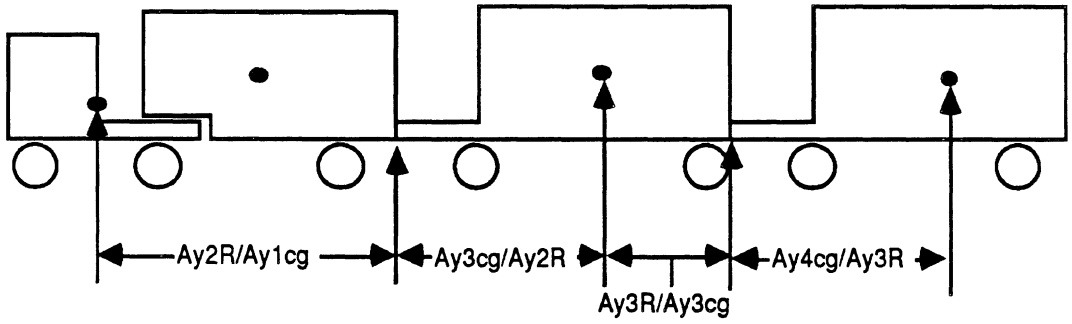
Once you have made your selection a plot will appear on the screen. Some examples are included at the end of this documentation. The above example corresponds to a 28 ft. double.

The diagram below depicts the terminology used in the program.

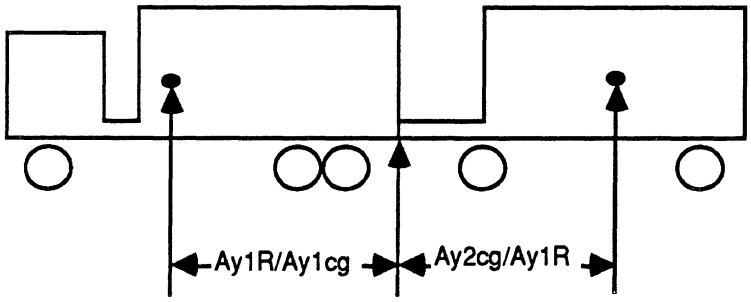
Double



Triple



Straight Truck-Full Trailer



The total transfer function is defined as the product of all the individual transfer functions, for example, for the above example (28'DBL.RWA file):

Total = (Ay3cg/Ay1cg) = (Ay2R/Ay1cg) * (Ay3cg/Ay2R)

It is assumed that the transfer function from the tractor C.G. to the semitrailer C.G., i.e., (Ay2cg/Ay1cg), is equal to 1.0

You can modify the form of the graph. The following keys are the controls for the graph:

- Up arrow (↑) key, scrolls the "Y" axis upward.
- Down arrow (↓) key, scrolls the "Y" axis downward.
- **PgUp** key (page up), scrolls the "X" axis forward.
- **PgDn** key (page down), scrolls the "X" axis backward.
- **RETURN** key (↵), shifts the cross cursor among the different curves, and indicates on the lower view port the legend of the curve selected. The "Y" and "X" values at the position of the cursor are shown on the same port.
- Right (→) and left (←) arrow keys, move the cross cursor on the current curve right or left and updates its position on the lower view port.
- The + (plus) or - (minus) keys hit either once or twice and followed by the letter X or Y will zoom the respective axis up or down.
- **P** (or **p**), followed by a **W** (or **w**) for wide, or a **T** (or **t**) for tall,will print the current chart.
- **End** key, gets you out of the chart and sends you to the plot menu, screen #9.

Exit to Main Menu

Selecting this option will return the user to screen #5 where further calculations may be made or the user may **QUIT** the program.

REARWARD AMPLIFICATION MODEL

FILE NAME:A:28'DBL.RWA

Date:10- 9-1986 Time:16: 1:38

Information for Unit # 2

General Information

Total Weight = 29600.00 Lbs
Yaw Moment of Inertia = 849799.00 in-lb-sec^2
Distance from C.G. to Front Articulation Point = 157.10 inches
Distance from C.G. to Rear Articulation Point = 142.98 inches
Total Number of Axles in the Unit = 1

Axles Information

Axle No	CG-Axle Distance (in)	Axle Cornering Stiffness (Lb/deg
1	116.50	2743.12

Information for Unit # 3

General Information

Total Weight = 34000.00 Lbs
Yaw Moment of Inertia = 1071143.00 in-lb-sec^2
Distance from C.G. to Front Articulation Point = 210.00 inches
Distance from C.G. to Rear Articulation Point = 172.80 inches
Total Number of Axles in the Unit = 2

Axles Information

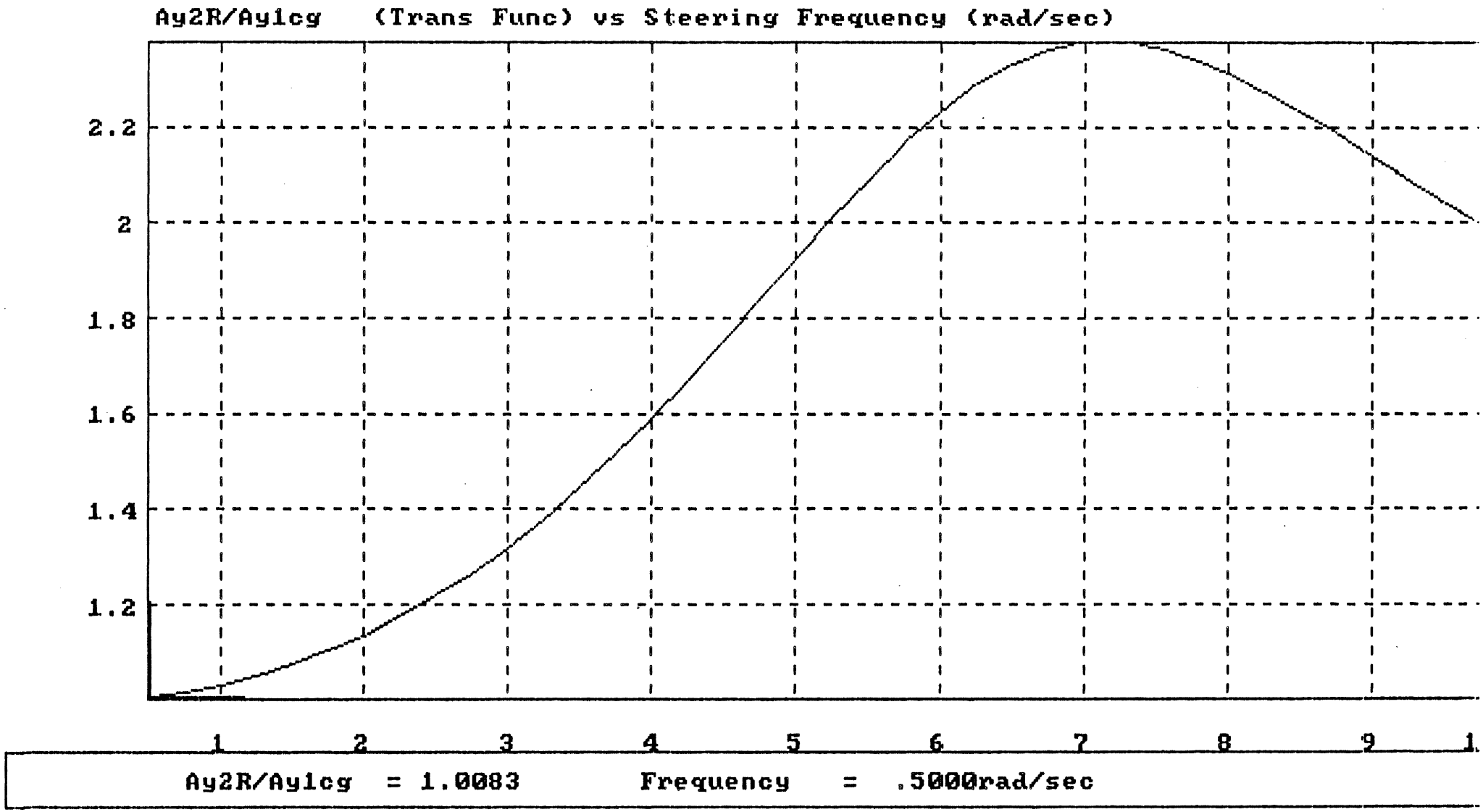
Axle No	CG-Axle Distance (in)	Axle Cornering Stiffness (Lb/deg)
1	136.80	2743.12
2	136.80	2743.12

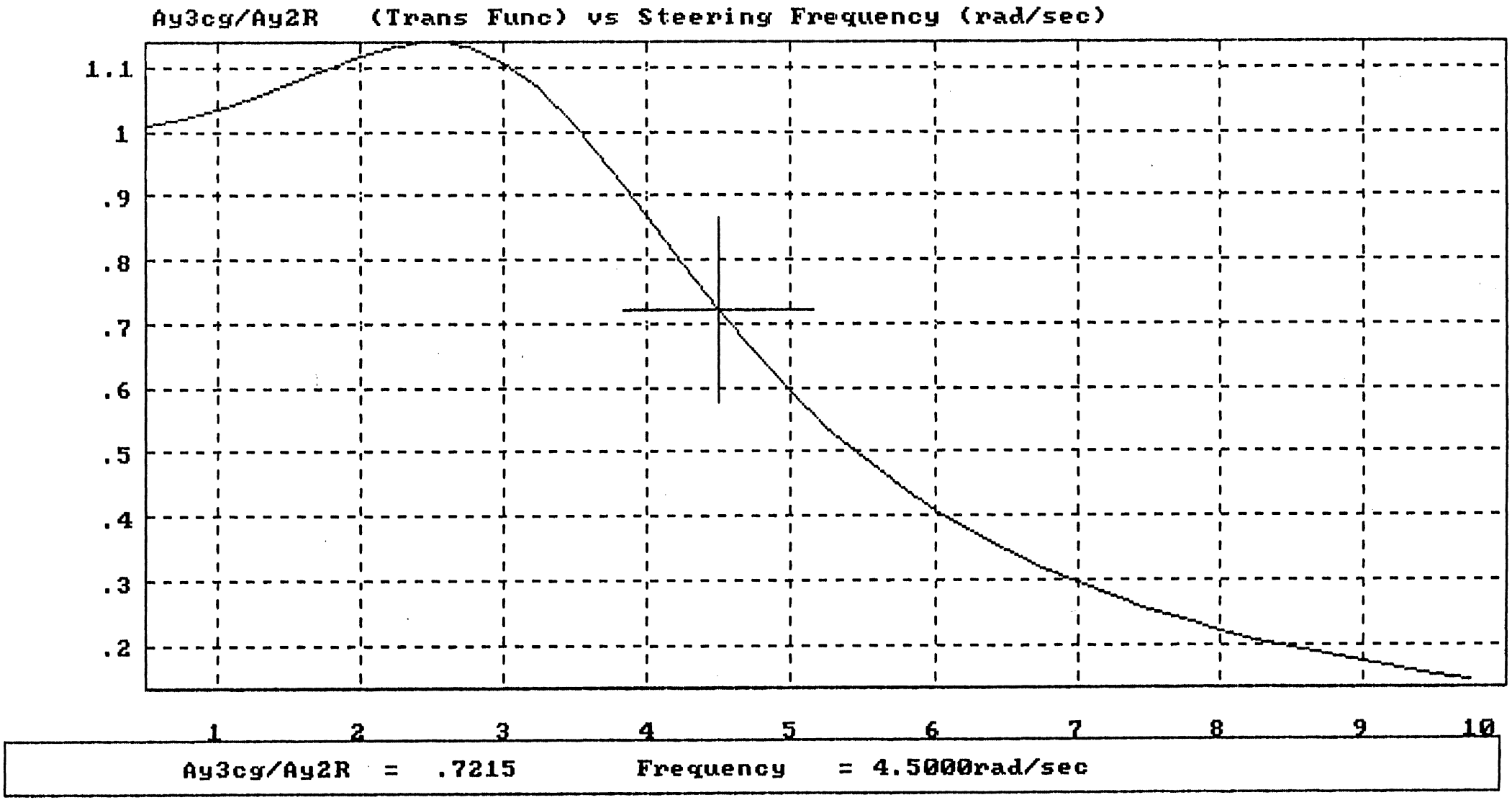
REARWARD AMPLIFICATION MODEL
FILE NAME:A:28'DBL.RWA

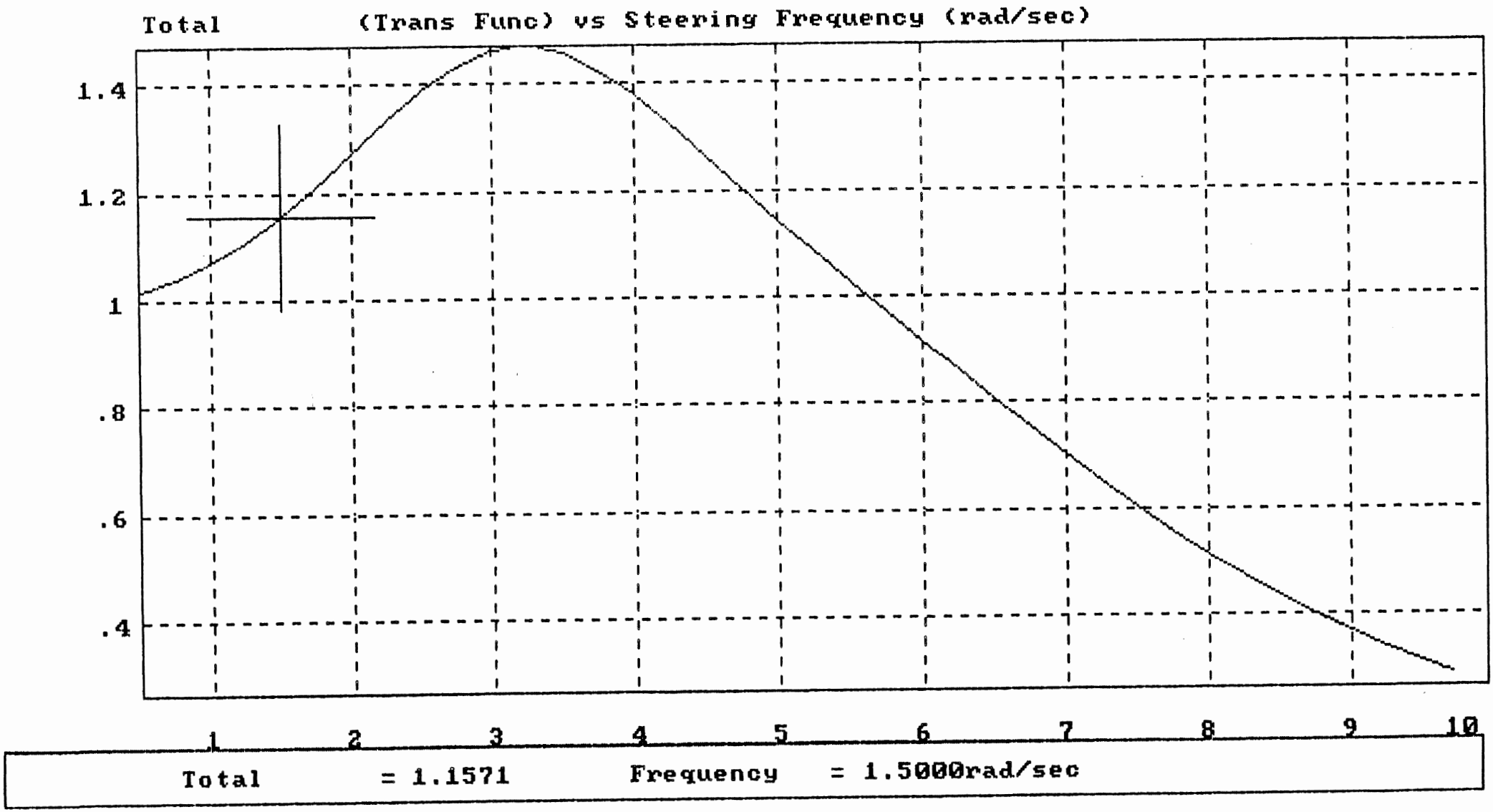
Transfer Functions

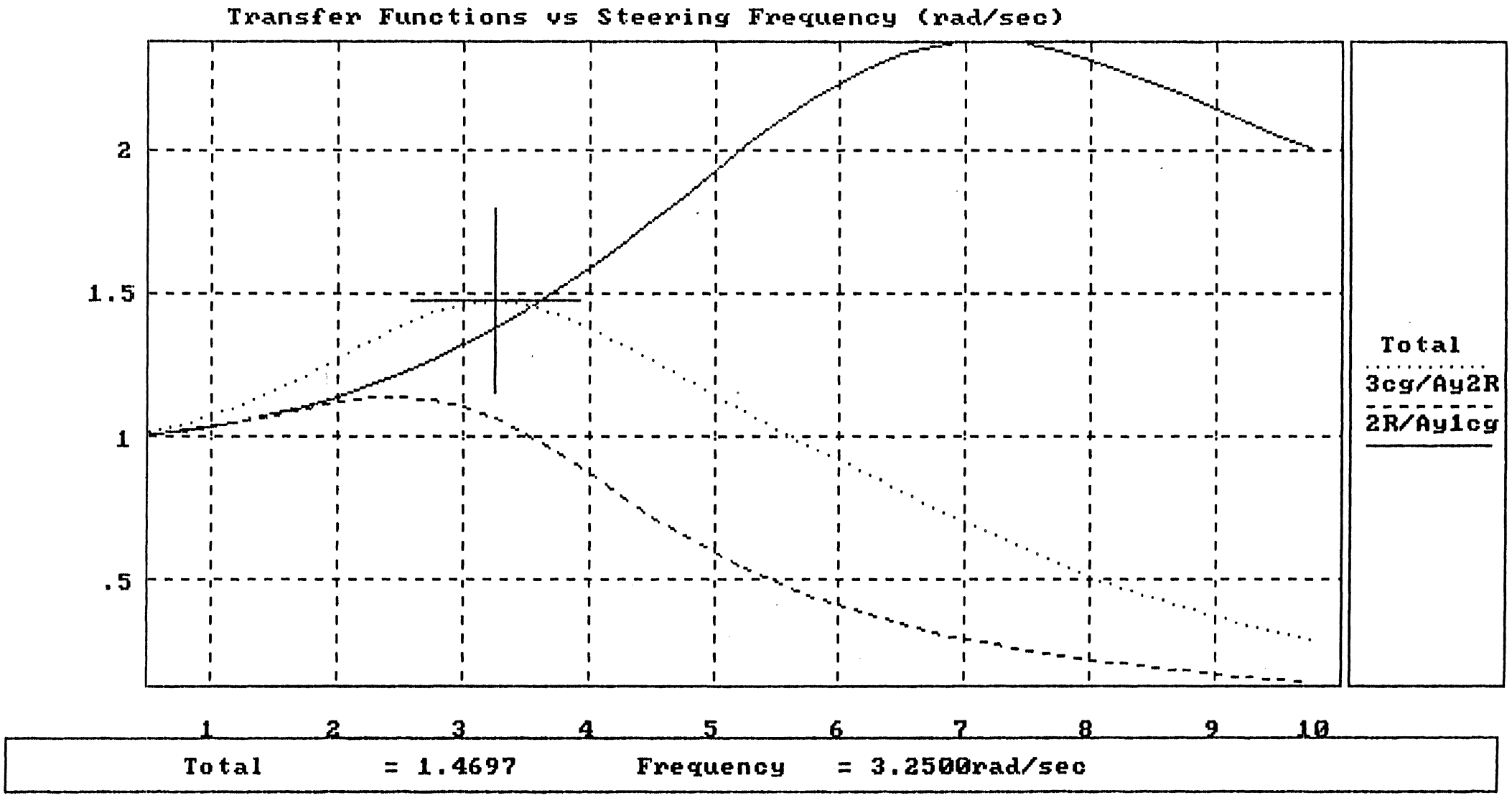
Freq(rad/sec)	Ay2R/Ay1cg	Ay3cg/Ay2R	Total
.5000	1.0083	1.0091	1.0175
.7500	1.0187	1.0203	1.0394
1.0000	1.0334	1.0355	1.0701
1.2500	1.0525	1.0542	1.1095
1.5000	1.0760	1.0753	1.1571
1.7500	1.1042	1.0973	1.2116
2.0000	1.1371	1.1175	1.2708
2.2500	1.1750	1.1328	1.3310
2.5000	1.2179	1.1388	1.3870
2.7500	1.2662	1.1314	1.4325
3.0000	1.3198	1.1073	1.4615
3.2500	1.3790	1.0658	1.4697
3.5000	1.4436	1.0089	1.4565
3.7500	1.5136	.9410	1.4243
4.0000	1.5887	.8674	1.3781
4.2500	1.6683	.7931	1.3230
4.5000	1.7515	.7215	1.2637
4.7500	1.8373	.6548	1.2030
5.0000	1.9239	.5940	1.1428
5.2500	2.0093	.5395	1.0839
5.5000	2.0911	.4908	1.0264
5.7500	2.1667	.4477	.9701
6.0000	2.2336	.4095	.9146
6.2500	2.2891	.3756	.8599
6.5000	2.3317	.3456	.8057
6.7500	2.3601	.3188	.7525
7.0000	2.3742	.2950	.7003
7.2500	2.3747	.2737	.6498
7.5000	2.3629	.2545	.6014
7.7500	2.3406	.2373	.5554
8.0000	2.3099	.2218	.5122
8.2500	2.2729	.2077	.4720
8.5000	2.2314	.1949	.4349
8.7500	2.1870	.1833	.4008
9.0000	2.1411	.1726	.3697
9.2500	2.0948	.1629	.3413
9.5000	2.0488	.1540	.3155
9.7500	2.0038	.1458	.2922
10.0000	1.9602	.1382	.2710

Max Total Transf. Function = 1.4697 at w = 3.250 rad/sec


Ay2R/Ay1cg (Trans Func) vs Steering Frequency (rad/sec)
2.2
2
1.8
1.6
1.4
1.2
1
2
3
4
5
6
7
8
9
Ay2R/Ay1cg = 1.0083
Frequency = .5000rad/sec


Ay3cg/Ay2R (Trans Func) vs Steering Frequency (rad/sec)
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
1
2
3
4
5
6
7
8
9
10
Ay3cg/Ay2R = .7215
Frequency = 4.5000rad/sec


Total (Trans Func) vs Steering Frequency (rad/sec)
1.4
1.2
1
.8
.6
.4
1
2
3
4
5
6
7
8
9
10
Total = 1.1571 Frequency = 1.5000rad/sec


Transfer Functions vs Steering Frequency (rad/sec)
2
1.5
1
.5
1
2
3
4
5
6
7
8
9
10
Total
3cg/Ay2R
2R/Ay1cg
Total = 1.4697 Frequency = 3.2500rad/sec

4. SUMMARY AND CONCLUDING REMARKS

The features of the simplified models are summarized in the following table. The amount of input information describing the vehicle depends upon the model involved. As can be seen by inspecting the table, a minimal amount of descriptive information is needed for some of the models. The models are designed to require as little input data as possible. Nevertheless, to use the entire set of models, pertinent information on the force and moment properties of tires, suspensions, and brakes are required as well as information on the layout of the vehicle.

The outputs of the models (see Table 1) are referred to as "performance signatures" (graphs and/or tables) and "performance measures" (numerics). These outputs are tailored to the maneuvers addressed by these simplified models. (The primary method for simplification is to consider the factors that are important in particular maneuvering situations.) The performance signatures and measures are the links to evaluating vehicle designs.

For example, one could set levels of the performance measures to use as performance targets. Then, the simplified models could be used to obtain first order estimates of whether preliminary designs (or existing vehicles) will meet these performance targets. If a design seems to fall short of desired levels of performance, one can use the models to study the influences of changes on the mechanical properties of the vehicle. The results of this process could be either changes in design or changes to more realistic levels of performance expectations. In any event, the ultimate goal is to develop a better understanding of the braking and handling performances of heavy trucks.

Table 1. Features of the Simplified Models

MODEL NAME	INPUTS	OUTPUTS, performance signatures and measures (graphs)	(numerics)
Low-speed offtracking	wheel and hitch locations	paths of each axle in turns of various radii	maximum offtracking
High-speed offtracking	the above plus tire cornering stiffnesses and axle loads	steady turn offtracking at various axles	steady turning offtracking at various g-levels
Constant deceleration braking	brake force characteristics as a function of treadle pressure, inertial properties, wheel and hitch locations	friction utilization and deceleration as a function of treadle pressure	Braking efficiencies at various g-levels
Steady turn,roll	suspension roll properties, axle loads, inertial properties, and tire vertical stiffnesses	roll angle versus lateral acceleration	rollover threshold
Handling in a steady turn	the above plus steering system properties, tire cornering stiffnesses, and geometric layout	handling diagram and stability space (if the vehicle is unstable without wheel liftoff), steering sensitivity diagrams	steering gain at various lateral acceleration and velocity levels, stability margin
Downhill descent	brake proportioning, thermal properties, velocity and elevation profiles	brake temperatures	maximum brake temperature
Obstacle avoidance (rearward amplification)	vehicle layout, inertial properties,tire cornering stiffnesses	rearward amplification versus frequency of steering excitation	maximum rearward amplification at low frequencies