NATIONAL ACCIDENT SAMPLING SYSTEM

TRAINING MATERIALS FOR
ACCIDENT RECONSTRUCTION

INSTRUCTOR'S MANUAL
Volume III

by:
Kenneth L. Campbell
Peter Cooley
Robert L. Hess
Robert E. Scott
Christopher B. Winkler

Edited by:
Kenneth L. Campbell
Thomas L. McDole

HIGHWAY SAFETY RESEARCH INSTITUTE
The University of Michigan
Ann Arbor, Michigan 48109

May 1979
2. Government Accession No.  
3. Recipient’s Catalog No.  
4. Title and Subtitle  
Training Materials for Accident Reconstruction  
Volume III, Instructor’s Manual  
5. Report Date  
May 1979  
6. Performing Organization Code  
7. Author(s)  
UM-HSRI-79-27-3  
9. Performing Organization Name and Address  
Highway Safety Research Institute  
The University of Michigan  
Ann Arbor, Michigan  
48109  
10. Work Unit No.  
11. Contract or Grant No.  
DOT-HS-8-01968  
12. Type of Report and Period Covered  
Course Materials  
13. Sponsoring Agency Name and Address  
National Highway Traffic Safety Administration  
Department of Transportation  
Washington, D.C.  
20590  
15. Supplementary Notes  
16. Abstract  
This Instructor's Manual is Volume III of the training materials developed by the staff of The University of Michigan's Highway Safety Research Institute for investigators in the National Highway Traffic Safety Administration (NHTSA) National Accident Sampling System (NASS). Volume I is a Reference Manual and Volume II is a Student Notebook. This volume contains lesson outlines.

The course was conducted for senior NASS investigators in May of 1979. A course evaluation was reported separately (Report No. UM-HSRI-79-81).

17. Key Words  
Accident Reconstruction  
Training Materials  
18. Distribution Statement  
19. Security Classif. (of this report)  
Unclassified  
20. Security Classif. (of this page)  
Unclassified  
21. No. of Pages  
25  
22. Price  

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# Daily Calendar

**MONDAY**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Instructor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30</td>
<td>1. Introduction</td>
<td>Campbell &amp; McDole</td>
</tr>
<tr>
<td>9:00</td>
<td>2. Review Exercises</td>
<td>McDole</td>
</tr>
<tr>
<td>9:45</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>10:00</td>
<td>3. Physics &amp; Dynamics</td>
<td>Hess</td>
</tr>
<tr>
<td>11:45</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>12:45</td>
<td>Lesson 3, cont.</td>
<td></td>
</tr>
<tr>
<td>2:45</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>3:00</td>
<td>9. Data Presentation</td>
<td>Cooley</td>
</tr>
<tr>
<td>4:45</td>
<td>End of Day</td>
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**TUESDAY**

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>8:30</td>
<td>5. Vehicle Force-Deflection</td>
<td>Campbell</td>
</tr>
<tr>
<td>9:30</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>9:45</td>
<td>4. Vehicle Dynamics</td>
<td>Winkler</td>
</tr>
<tr>
<td>11:45</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>12:45</td>
<td>10. Classroom Reconstruction</td>
<td>Hess</td>
</tr>
<tr>
<td>2:45</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>3:00</td>
<td>8. Vehicle Examination</td>
<td>Cooley</td>
</tr>
<tr>
<td>4:45</td>
<td>Dinner</td>
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</tr>
<tr>
<td>7:00</td>
<td>8L. Vehicle Examination Lab</td>
<td>Cooley @ HSRI</td>
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**WEDNESDAY**

<table>
<thead>
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<tbody>
<tr>
<td>8:30</td>
<td>Classical Reconstruction, cont.</td>
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</tr>
<tr>
<td>10:00</td>
<td>Break</td>
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<tr>
<td>10:15</td>
<td>Classical Reconstruction, cont.</td>
<td>Cooley</td>
</tr>
<tr>
<td>11:45</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>12:45</td>
<td>6. Skid Marks</td>
<td>Cooley</td>
</tr>
<tr>
<td>2:45</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>3:00</td>
<td>7. Scene Examination</td>
<td>Cooley</td>
</tr>
<tr>
<td>4:45</td>
<td>Dinner</td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>7L. Scene Examination Laboratory</td>
<td>Cooley @ HSRI</td>
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**THURSDAY**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>10:00</td>
<td>Break</td>
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<tr>
<td>10:15</td>
<td>Applications, cont.</td>
<td>Hess, Staff</td>
</tr>
<tr>
<td>11:45</td>
<td>Lunch</td>
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</tr>
<tr>
<td>12:45</td>
<td>Applications, cont.</td>
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</tr>
<tr>
<td>2:45</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>3:00</td>
<td>11E Exercises</td>
<td>Hess @ HSRI</td>
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<tr>
<td>4:00</td>
<td>Dinner</td>
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</tr>
<tr>
<td>7:00</td>
<td>CRASH Lab.</td>
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</tr>
<tr>
<td>Time</td>
<td>Event</td>
<td>Location</td>
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<tr>
<td>8:30</td>
<td>CRASH Lab, cont.</td>
<td>HSRI</td>
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<tr>
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<td>CRASH Lab Discussion</td>
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<tr>
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<td>Lunch</td>
<td>HSRI</td>
</tr>
<tr>
<td>12:45</td>
<td>Lunch</td>
<td>Chrysler Center</td>
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<tr>
<td>13:00</td>
<td>Collision Severity Measures</td>
<td>Chrysler Center</td>
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<tr>
<td>1:45</td>
<td>Break</td>
<td>HSRI</td>
</tr>
<tr>
<td>2:00</td>
<td>Final Examination</td>
<td>HSRI</td>
</tr>
<tr>
<td>3:30</td>
<td>Summary &amp; Closure</td>
<td>HSRI</td>
</tr>
<tr>
<td>4:00</td>
<td>Dismissal</td>
<td>HSRI</td>
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## Advanced Accident Reconstruction
### Lesson Schedule

<table>
<thead>
<tr>
<th>M</th>
<th>1 Introduction</th>
<th>2 Review Exercises</th>
<th>3 Physics and Dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.</td>
<td>5' Vehicle Force-Deflection</td>
<td>1' Vehicle Dynamics</td>
<td></td>
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<tr>
<td>W</td>
<td>Classical Reconstruction cont.</td>
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<tr>
<td>T</td>
<td>11 Applications</td>
<td></td>
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<tr>
<td>F</td>
<td>CRASH Lab cont.</td>
<td>12 CRASH Lab Discussion</td>
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<tr>
<td></td>
<td>4 Physics and Dynamics cont.</td>
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<tr>
<td></td>
<td>7 Classical Reconstruction</td>
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<tr>
<td></td>
<td>6 Skid Marks</td>
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<tr>
<td></td>
<td>10 Vehicle Examination</td>
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<tr>
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<td>11 Scene Exam. Lab.</td>
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<tr>
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<td>11E Exercises</td>
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<tr>
<td></td>
<td>12 CRASH Lab</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>13 Collision Severity Measures</td>
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<td></td>
<td>14 Final Examination</td>
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<td></td>
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<tr>
<td></td>
<td>15 Summary &amp; Closure</td>
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<td></td>
</tr>
</tbody>
</table>

Classes: M - Monday, T - Tuesday, W - Wednesday, T - Thursday, F - Friday
List of Lessons

Unit I. Course Overview
1. Course Introduction
2. Review Exercises

Unit II. Basic Principles
3. Physics and Dynamics
4. Vehicle Dynamics
5. Vehicle Force-Deflection Characteristics
6. Skid Marks and Analysis

Unit III. Data Collection and Documentation
7. Scene Inspection
7L. Scene Inspection Laboratory
8. Vehicle Inspection
8L. Vehicle Inspection Laboratory
9. Data Documentation

Unit IV. Reconstruction Techniques
10. Classical Reconstruction
11. Applications of Classical Accident Reconstruction
11E. Classical Reconstruction Exercises
11L. CRASH Laboratory
12. CRASH Laboratory Discussion
13. Collision Severity Measures

Unit V. Summation
14. Final Examination
15. Summary and Closure
Advanced Accident Reconstruction
Lesson Outline

Lesson No. 1, Introduction
Presented by: Kenneth L. Campbell
Thomas L. McDole
Highway Safety Research Institute

Description:
The introduction to the course. Presented will be the overall course organization, course objectives, lesson schedule, and calendar, distribution of lesson material, other course organizational information, and an overview of Accident Reconstruction.

Topics:
Welcome - T. McDole
Course Organization
Course Materials
Announcements
Word from Washington - S. Lee
Course Introduction - K. Campbell
Course Objectives
Overview of Accident Reconstruction

NOTES
Lesson No. 2, Review Exercises
Presented by: Thomas L. McDole

Description:

A review of the pre-course student mathematical exercises. The graded exercises will be returned to the student and problem areas will be discussed. The solutions to the problems will be presented and student's questions answered.

Topics:

Discussion of the graded pre-course exercises.
Lesson No. 3, Physics and Dynamics

Presented by: Robert L. Hess, Ph.D.

Description:

An introduction to the basic principles of physics and dynamics as they apply to accident reconstruction.

Topics:

Mathematical Background
- Coordinate systems
- Lines and points in a plane
- Vectors

Plane Kinematics of a Particle
- Vector position and displacement
- Velocity
- Momentum and Force

Plane Kinematics of a Rigid Body
- Angular Velocity
- Rotation
- Centroids
- Acceleration

Kinematics of a Body in Plane Motion
- Center of Mass
- Newton's Axiom
- Rectilinear Motion of a Rigid Body
- Plane Motion of a Rigid Body
- Vehicle Force System
Lesson Outline

Lesson No. 4, Vehicle Dynamics

Presented by: Christopher Winkler

Description:

An overview of three-dimensional real-world vehicle dynamics including vehicle handling, braking, and traction as they apply to accident causation and investigation.

Topics:

Definitions
  In-plane and out-of-plane motions
  Motor vehicle components which influence braking and handling

Tire traction and compliance

Handling
  Steady turning, normal and limit
  Directional response to steering
  Influence of wind and road disturbance

Braking
  Brake torque and force distribution
  The steady braking process
  Limit braking and directional stability
  Influence of road surface and tires

Accelerating
  Turning on a reduced friction surface
Lesson Outline

Lesson No. 5, Vehicle Force - Deflection Characteristics

Presented by: Kenneth L. Campbell

Description:

An overview of vehicle force-deflection characteristics as they apply to accident reconstruction. These characteristics are a measure of the energy required to crush the vehicle.

Topics:

Energy Considerations
   Energy Balance and Terms
   Estimating Energy Absorbed
   Considerations in Measuring Crush

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NOTES
Lesson Outline

Lesson No. 6, Skid Marks and Analysis
Presented by: Peter Cooley

Description:

A presentation on the practical aspects of describing and measuring skid and other pavement marks and on the estimating of changes of vehicular velocity based on skid distance and coefficient of friction.

Topics:

Importance of Tiremarks and Roadway Evidence
Overlapping Skidmarks
Curved Skidmarks
Skip Skids
Gaps in Skidmarks
Acceleration Marks
Variable Skidmarks
Tread Pattern Marks and Striations
Point of Impact
Tire Tread Imprints
Scuff Marks
Scratches
Gouges
Ruts
Furrows
Holes and Mounds
Debris
Speed from Skidmarks

NOTES
Advanced Accident Reconstruction

Lesson Outline

Lesson No. 7, Scene Inspection
Presented by: Peter Cooley

Description:

A presentation on the information available at an accident scene with techniques utilized to identify the scene elements necessary for accident reconstruction and to review methods of recording these data.

Topics:

Scene examination overview
Measurement Benchmarks
Measurement Equipment
Vehicle Final Rest Position
Roadway Examination
Road Characteristics
Traffic Controls
Off-road Features
Environmental Factors

NOTES
Lesson No. 7L, Scene Inspection Laboratory

Presented by: Peter Cooley

Description:

A laboratory session to accompany the presentation on Scene Inspection. Available will be several accident scenes for the student to observe, measure, and work.

Topics:

Observation of accident scenes

Relevant Roadway Features

Skid marks demonstration
Lesson No. 8, Vehicle Inspection

Presented by: Peter Cooley

Description:

A presentation to identify the vehicle-related data elements necessary for accident reconstruction and to review the methods utilized in observing, interpreting, and recording these data.

Topics:

I. General Vehicle Factors
II. On-scene Information
III. Vehicle Identification
IV. Tow Operator Practices and Storage
V. Exterior Damage Assessment
VI. Vehicle Exterior Examinations
VII. Vehicle Impact Orientations
VIII. Vehicle Field Forms

NOTES
Lesson Outline

Lesson No. 8L, Vehicle Inspection Laboratory
Presented by: Peter Cooley

Description:

A laboratory session to accompany the presentation on Vehicle Inspection. Available will be several accident-involved vehicles for the student to observe, measure, and record.

Topics:

Observe and measure accident involved vehicles.

NOTES
Lesson No. 9, Data Documentation

Presented by: Peter Cooley

Description:

A presentation to review the techniques available to the investigator for observing and recording the necessary data for accident reconstruction. Techniques to be covered include measurement techniques, marking and mapping techniques, photographic aids, and interviewing techniques.

Topics:

Investigator as an Observer
Field Data Recording Methods
Symbols for Documenting Crash Scene
Field Measurements
Sketching and Drawing To Scale
Photography

NOTES
Lesson Outline

Lesson No. 10, Classical Reconstruction

Presented by: Robert L. Hess

Description:

To provide an introduction to calculation used in accident reconstruction, to illustrate the steps necessary to perform a reconstruction, to provide an introduction to computer-assisted reconstruction calculations, and to illustrate the logic of various computer-oriented reconstruction programs and sub-programs.

Topics:

- Kinematic Equations of Motion Applied to Vehicle Trajectory
- Simplified Marguardt Equations
- Step-by-Step Integration
- Plots of Linear and Angular Velocity
- Trajectory Simulation
- Kinematic Equations Applied to Impact
Lesson No. 11, Applications of Classical Accident Reconstruction

Presented by: Robert L. Hess

Description:

A discussion of the application of classical, hand calculations to accident reconstruction and of the application of CRASH to crash configurations, of the sensitivity of CRASH results to certain input parameters and of operational problems encountered in using CRASH.
Advanced Accident Reconstruction

Lesson Outline

Lesson No. 11E, Classical Reconstruction Exercises

Presented by: Kenneth L. Campbell

Description:

A structured exercise laboratory session for the group solving of basic reconstruction problems.

NOTES
Advanced Accident Reconstruction
Lesson Outline

Lesson No. 11L, CRASH Lab.
Presented by: Robert L. Hess

Description:

A laboratory session devoted to individual or small group solution of reconstruction problems using CRASH and other problem solving techniques. Input data will come from either instructor generated problems or from student-generated data based on previous laboratory sessions.

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Advanced Accident Reconstruction

Lesson Outline

Lesson No. 12, CRASH Lab Discussion

Presented by: Robert L. Hess

Description:

A discussion of the CRASH Laboratory Session

NOTES
Lesson No. 13, Collision Severity Measures

Presented by: Kenneth L. Campbell

Description:

The need, definition, and uses of information on collision severity are described in order to instill a sense of "purpose" in the investigator.

Topics:

Need for Collision Severity
Definition of Collision Severity
A Model
Measures of Collision Severity
Applications
Examples

NOTES
Advanced Accident Reconstruction
Lesson Outline

Lesson No. 14, Final Examination
Presented by: Thomas L. McDole

Description:
A final course examination
Lesson No. 15, Summary and Closure

Presented by: Thomas L. McDole
Kenneth L. Campbell

Description:

Final class meeting, closing remarks, course evaluation, etc. as necessary to wrap-up the course.

NOTES