Final Report of the Forensic Engineering Curriculum Committee

January 29, 2000
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NOTE: Resource materials and recommended reading may be found in the "Journal" of the NAFE. An index of those papers is shown on the NAFE website ....."nafe.org"
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Introduction

In April 1997, the President of the National Academy of Forensic Engineers appointed the ad hoc Forensic Engineering Curriculum Committee. The committee's responsibility was to develop guidelines for university courses in forensic engineering. When approved by the Academy, the guidelines would then be made available to universities for helping in the development of new courses in forensic engineering or adding a forensic engineering component to existing courses. This report presents the finished work and recommendations of that committee.

Forensic Engineering

Forensic engineering is a highly specialized field of engineering practice requiring engineering expertise and knowledge of legal procedures. Forensic engineering can be defined as the application of the engineering sciences to the investigation of failures or other performance problems. Some forensic engineering projects or cases require sworn testimony in a court of law or legal proceeding. Thus, forensic engineers must work in both the engineering and legal arenas. From an engineering perspective, forensic engineering deals with the investigation and reconstruction of failures in buildings, structures, facilities, vehicles, and other engineered systems. From a legal perspective, forensic engineering is a fact-finding mission to learn the most probable cause or causes of a failure. Forensic engineering requires both scientific skills and high ethical standards. Forensic engineers must be expert in their field and impartial in the investigation process.

Need for Forensic Engineering Education?

There are at least four reasons why there are no formal forensic engineering degree programs offered at universities in this country. First, forensic engineering is not a standard engineering discipline like mechanical, electrical, or civil engineering. Forensic engineering encompasses many disciplines, and it is not easy to offer multi-disciplinary courses which cross traditional engineering boundaries. Second, forensic engineering is not a widely known field outside the profession. Third, universities have not seen the need to include failure analysis in traditional engineering programs. Finally, and most important, the demand for forensic engineers is not high when compared with standard engineering disciplines. Still, there exists a need for some form of university education in forensic engineering to help train engineers that are new to the profession.

1 Adapted from Guidelines for Failure Investigation by American Society of Civil Engineers, 1989
Several universities do offer a single, elective graduate course in forensic engineering. Four such courses are identified below:

a. ENGR 5340 - Advanced Topics in Engineering (Introduction to Forensic Engineering), University of Texas at Tyler.
b. CE 5805 - Failure Analysis and Condition Assessment in Civil and Mechanical Engineering, University of Colorado at Denver.
c. EE 595G - Medical Device Accidents and their Engineering Analysis, Purdue University.
d. TECH 525 - Applications in Forensic Engineering Technology, Purdue University.

A Formal Degree Program?

Due to the specialized nature of forensic engineering, any forensic engineering degree program should begin at the Masters Degree level. It is doubtful, however, that any university would be willing to commit the resources needed to develop a formal Masters Degree Program in Forensic Engineering. Most graduate faculty are involved in sponsored research, not engineering practice, and the demand for graduates is limited.

The best approach is to work within existing graduate degree programs already in place. For example, most universities today have graduate degree programs in interdisciplinary engineering where a student can structure a graduate program of special interest within two or more engineering departments. One of the main strengths of an interdisciplinary program is the ability to tailor the program to the needs and strengths of the individual student and their specific background. This is especially important in the field of forensic engineering where an electrical engineering student will have very different expertise compared to a mechanical engineering technology student. An interdisciplinary forensic engineering program would allow for both students to be trained equally well.

Prospective students should hold a baccalaureate degree in engineering, engineering technology, or other engineering science discipline that can lead to registration as a professional engineer. Although not required, several years engineering experience and qualification for the Fundamentals of Engineering (FE) examination would be a plus.
Capabilities of Graduates

Graduates of the program will not be experienced forensic engineers and will not be qualified immediately to take on complex investigative or litigation projects. Graduates will, however, understand the complex relationship that exists between engineering and the American legal system and know how to conduct forensic engineering investigations according to the scientific method and recommended engineering practice. Additionally, graduates will think critically and communicate with clarity and precision both orally and in writing. Furthermore, graduates will be employable in a forensic engineering setting with little on-the-job training required.

Recommended Plan of Study

The plan of study should consist of a minimum of 33 semester hours of graduate credit as described below and conform to the requirements of the graduate school of the university where the degree is awarded.

Core Courses (15 semester hours): A core of 15 semester hours in applied forensic engineering course work is required. Universities can meet this requirement by employing adjunct faculty who are practicing forensic engineers and using university faculty who are part-time consulting forensic engineers.

- FE 501 (3) Introduction to Forensic Engineering
- FE 502 (3) Product Liability
- FE 590 (3) Forensic Engineering Project
- FE 601 (3) Advanced Forensic Engineering Techniques
- FE 602 (3) Computer Applications in Forensic Engineering

Required Supporting Courses (nine semester hours): Nine semester hours in supporting course work are required. This requirement can be met with existing courses available at most universities.

- EG 520 or equiv (3) Engineering Ethics
- Math (6) Mathematical, statistical, or computer sciences beyond ordinary differential equations.

Elective Courses (nine semester hours): Nine semester hours in closely related engineering electives are required. Courses listed below are typical courses available at many universities. The list is not exhaustive. Others courses may also be available.
Methods of integrating the following and similar practical experiences into the plan of study should be considered:

- Court experience where expert engineering testimony is given.
- Deposition experience where expert engineering testimony is given.
- A relevant co-op or internship.
- Membership in at least one professional engineering society that can be related to forensic engineering.

**Descriptions of Core Courses**

**FE 501 - Introduction to Forensic Engineering (3).** This course is a survey of forensic engineering with particular emphasis on using engineering science and technology to investigate and reconstruct failures of engineered systems. Topics include qualifications of the forensic engineer, the scientific method, failure hypotheses, levels of confidence, physical evidence, field investigation techniques, examination and testing, codes and standards, and personnel safety. Other topics include ethics, the hired gun, junk science, the legal process, introduction to expert witness testimony, trial exhibits, Frye and Daubert decisions, bias, forensic engineering business practice, and engineering reports. By completing this course, the student will learn how to correctly conduct a forensic engineering investigation and how to properly prepare a forensic engineering report in accordance with current industry guidelines.

**FE 502 - Product Liability (3).** This course is a study of the interrelationships among the product manufacturer, the design engineer, and the consumer in a legal context. Topics include the legal framework of product liability, design and manufacturing defects, misrepresentation, evidentiary issues, consumer expectations, warranties, and the unreasonably dangerous product. Other topics include warnings and instructions, user errors, comparative fault, the cost of safety, the ethics of safety, risk assessment, regulatory agencies and statute laws, codes and standards, accident prevention, and safe product design. Fault-tree analysis and other evaluation methods will be studied.
FE 590 - Forensic Engineering Project (3). This course takes the student through the formal investigation of a forensic engineering problem under the direction of the student's graduate committee. An oral examination and project defense are required.

FE 601 - Advanced Forensic Engineering Techniques (3). This is an advanced course designed to explore current topics of interest in the field of forensic engineering. Topics vary from semester to semester, and the course may include several laboratory sessions. Topics could include vehicular accident reconstruction, nondestructive testing, expansive soil failure, forensic photography, photogrammetry, fire and explosion investigation, electrical contact accidents, vehicular fires and explosions, construction safety, applications of anthropology and medical science to forensic engineering, and other specialized topics. Patents, copyrights, trademarks, infringements and invalidations are also covered. By completing this course, the student can explore the many areas of forensic engineering that require a basic understanding of the underlying science and techniques learned in FE 501. (May be repeated for credit as topics change).

FE 602 - Computer Applications in Forensic Engineering (3). This is an advanced course designed to explore current computer software available to the practicing forensic engineer. Programs could include AutoCAD, PC Crash, FASTLite, BUILDSMOKE, PC Rect, PhotoShop, EDCRASH, EDSMAC, MiniCAD, Working Model, DynaCAM, COSMOS/M, and advanced applications of EXCEL and PowerPoint for courtroom presentations and trial exhibits. This course will use the computer lab to allow the student to integrate computer software with the basic techniques of forensic engineering investigation learned in FE 501 and FE 601.

(An alternative approach would be to combine the computer applications course (FE 602) with the advanced topics course (FE 601) and create a two-semester advanced topics sequence. This way, the student could take two semesters of courses without repeating anything or elect to take just one. The topics could change each semester while having the option of repeating every other semester.)

Qualifications of the Faculty

Full-time and adjunct faculty who teach core courses should be qualified to hold a member grade in the National Academy of Forensic Engineers.
Appendix

This appendix contains outlines of core courses in ABET format.
FE 501 - Introduction to Forensic Engineering

Catalog Data:  FE 501 Introduction to Forensic Engineering.  
Class 3, lab 0, credit 3. 
Prerequisites: Graduate standing or consent of the instructor.

This course is a survey of forensic engineering with particular emphasis on using engineering science and technology to investigate and reconstruct failures of engineered systems. Topics include qualifications of the forensic engineer, the scientific method, failure hypotheses, levels of confidence, physical evidence, field investigation techniques, examination and testing, codes and standards, and personnel safety. Other topics include ethics, the hired gun, junk science, the legal process, introduction to expert witness testimony, trial exhibits, Frye and Daubert decisions, bias, forensic engineering business practice, and engineering reports.


References:  
2. E-860, Standard Practice for Examining and Testing Items that may Become Involved in Products Liability Litigation.  

Coordinator:  Identify the responsible faculty member.

Goals:  To introduce students to the complex relationship between engineering and the American legal system. The course will also help students develop problem-solving and analytical skills through application of the scientific method to the many real-world cases studied.

Topics:  
1. Introduction, references, and plan of study.  
2. Qualifications of the Forensic Engineer.  
3. The investigation process.  
4. Planning the investigation.  
5. Site visit and analysis (including safety).  
6. Physical evidence.  
7. Examination and testing.  
8. The scientific method.  
9. Developing the failure hypothesis.  
10. Levels of confidence.  
11. Forensic engineering reports.  
12. The legal process.  

(0.5 hour)  
(0.5 hour)  
(2.0 hours)  
(2.0 hours)  
(3.0 hours)  
(2.0 hours)  
(1.0 hour)  
(2.0 hours)  
(1.0 hour)  
(1.0 hour)  
(2.0 hours)  
(1.0 hour)
13. Frye and Daubert decisions. (1.0 hour)
14. Expert witness testimony. (2.0 hour)
15. Trial exhibits. (3.0 hours)
16. Business practices. (2.0 hours)
17. Ethics and bias. (2.0 hours)
18. Case studies (including accident prevention). (15 hours)

Computer usage: Word Processing and Spreadsheet Software.

Laboratory: None.

Oral and written communication: There are 12 written assignments, each valued at 100 points, about 86% of the student's final grade. The written assignments require extensive reading and research of the texts and references. A formally-written paper, with in-class oral presentation, is also required. It is valued at 200 points, about 14% of the final grade. Formal abstracts are required and must be approved by the course coordinator. Papers are critically reviewed in accordance with the following criteria: originality, data collection, analysis, testing, literature search, format, grammar, scholarship, use of references, conclusions, and interest to the class. Collaboration among students is encouraged.

Calculus usage: None.

Library usage: Selected references are placed on library reserve. The research paper and class presentation may require the use of other library references.

Prepared by: __________ , Professor
Date: Oct 20, 1999

Approved by: __________ Chair, Curriculum Committee
Date: __________
FE 502 - Product Liability

Catalog Data:

FE 502 Product Liability.
Class 3, lab 0, credit 3.
Prerequisites: Graduate standing or consent of the instructor.

This course is a study of the interrelationships among the product manufacturer, the design engineer, and the consumer in a legal context. Topics include the legal framework of product liability, design and manufacturing defects, misrepresentation, evidentiary issues, consumer expectations, warranties, and the unreasonably dangerous product. Other topics include user errors, comparative fault, the cost of safety, the ethics of safety, risk assessment, regulatory agencies and statute laws, codes and standards, accident prevention, and safe product design. Fault-tree analysis and other evaluation methods will be studied.

Textbook:

References:

Coordinator: Identify the responsible faculty member.

Goals: To introduce students to the interrelationships that exist among product manufacturers, product design engineers, and consumers in a legal context.

Topics:
1. Introduction, references, and plan of study. (0.5 hour)
2. The legal framework of product liability. (1.5 hours)
3. Design and manufacturing defects.
5. Evidentiary issues.
6. Consumer expectations.
7. Warranties.
8. Warnings and instructions.
9. The unreasonably dangerous product.
10. User errors.
11. Comparative fault.
12. The cost of safety.
13. The ethics of safety.
15. Regulatory agencies.
17. Codes and standards.
18. Accident prevention. (2.0 hours)
19. Safe product design. (2.0 hours)
20. Fault-tree analysis. (6.0 hours)
21. Case studies. (11 hours)

Computer usage: Word Processing and Spreadsheet Software.

Laboratory: None.

Oral and written communication: There are four formally-written assignments, each valued at 100 points, about 40% of the student's final grade. The formal assignments require extensive reading and research of the texts and references. A formally-written paper, with in-class oral presentation, is also required. It is valued at 200 points, about 20% of the final grade. Formal abstracts are required and must be approved by the course coordinator. Papers are critically reviewed in accordance with the following criteria: originality, data collection, analysis, testing, literature search, format, grammar, scholarship, use of references, conclusions, and interest to the class. Collaboration among students is encouraged. There is one mid-term and one final examination. Each exam is valued at 200 points, about 20% of the student's final grade.

Calculus usage: None.

Library usage: Selected references are placed on library reserve. The research paper and class presentation may require the use of other library references.

Prepared by: ____________, Professor
Date: Oct 20, 1999

Approved by: ____________ Chair, Curriculum Committee
Date: ____________
FE 590 - Forensic Engineering Project

Catalog Data: FE 590 Forensic Engineering Project.  
Class 0, lab 0, credit 3.  
Prerequisites: FE 501 or FE 502.

This course takes the student through the formal investigation of a forensic engineering problem under the direction of the student's graduate committee. A formal written report, oral examination, and project defense are required.

Textbook: As specified by the student's graduate committee.

References: As specified by the student's graduate committee.

Coordinator: Identify the responsible faculty member.

Goals: To give the student first-hand, practical experience in the solution of a real-world forensic engineering problem.

Topics: As specified by the student's graduate committee.

Computer usage: As specified by the student's graduate committee.

Laboratory: As specified by the student's graduate committee.

Oral and written communication: A formal written report, oral examination, and project defense are required.

Calculus usage: As specified by the student's graduate committee.

Library usage: As specified by the student's graduate committee.

Prepared by: ____________ , Professor  Date: Oct 20, 1999

Approved by: ____________ Chair, Curriculum Committee  Date: ____________
FE 601 - Advanced Forensic Engineering Techniques

Catalog Data: FE 601 Advanced Forensic Engineering Techniques.
Class 3, lab arranged, credit 3.
Prerequisites: FE 501.

This is an advanced course designed to explore current topics of interest in the field of forensic engineering. Topics vary from semester to semester, and the course may include several arranged laboratory sessions. Topics may include vehicular accident reconstruction, nondestructive testing, expansive soil failure, photography techniques, photogrammetry, fire and explosion investigation, electrical contact accidents, vehicular fires and explosions, construction accidents, applications of anthropology and medical science to forensic engineering, and other specialized topics. Patents, copyrights, trademarks, infringements and invalidations are also covered. By completing this course, the student can explore the many areas of forensic engineering that require a basic understanding of the underlying science and techniques learned in FE 501. (May be repeated for credit as topics change).


References: As specified by the course instructor.

Coordinator: List the responsible faculty member.

Goals: To explore current topics of interest in the field of forensic engineering.

Topics: As specified by the course instructor.

Computer usage: As specified by the course instructor.

Laboratory: Arranged by the course instructor.

Oral and written communication: As specified by the course instructor.

Calculus usage: As specified by the course instructor.

Library usage: As specified by the course instructor.

Prepared by: ______________, Professor Date: Oct 20, 1999

Approved by: ______________ Chair, Curriculum Committee Date: __________
FE 602 - Computer Applications in Forensic Engineering

Catalog Data: FE 602 Computer Applications in Forensic Engineering.
Class 3, lab arranged, credit 3.
Prerequisites: FE 501.
Corequisites: FE 601.

This is an advanced course designed to explore current computer software available to the practicing forensic engineer. This course will use the computer lab to allow the student to integrate computer software with the basic techniques of forensic engineering investigation learned in FE 501 and FE 601.

Textbook: As specified by the course instructor depending upon current software.

References: As specified by the course instructor depending upon current software.

Coordinator: List the responsible faculty member.

Goals: To explore current computer software available to the practicing forensic engineer.

Topics:
1. Introduction, references, and plan of study. (1.0 hours)
2. EXCEL for analysis and trial exhibits. (2.0 hours)
3. PowerPoint for courtroom presentations and trial exhibits. (3.0 hours)
4. AutoCAD for courtroom presentations and trial exhibits. (3.0 hours)
5. Other methods of interest for trial exhibits. (3.0 hours)
6. Selected engineering software for analysis. (15 hours)
7. Case studies and class projects. (18 hours)

Computer usage: As specified by course instructor.

Laboratory: Computer lab.

Oral and written communication: Written and oral presentations of assigned computer projects are required.

Calculus usage: Engineering calculus as used in the selected engineering software.

Library usage: None.

Prepared by: ____________, Professor Date: Oct 20, 1999

Approved by: ____________ Chair, Curriculum Committee Date: ________