ENRE - RELIABILITY ENGINEERING

ENRE447 Fundamentals of Reliability Engineering (3 Credits)
Provides a general survey of the techniques of reliability engineering with a focus on theoretical basis and quantitative methods, with frequent examples of application. Topics include mathematical definition of reliability, probabilistic models to represent failure phenomena, statistical life models for non-repairable components, reliability data analysis, failure modes and effects analysis, risk analysis, and system reliability models including fault trees, event trees. Students will learn how to apply these techniques to problems related to engineering systems, with example cases for process plants, energy systems and infrastructure.
Prerequisite: Minimum grade of C- in MATH141 and MATH246.
Restriction: Must be in Mechanical Engineering, Aerospace Engineering, Civil Engineering, or Fire Protection Engineering; or must be in the Nuclear Engineering minor; or permission of department.

ENRE489 Special Topics in Reliability Engineering (3 Credits)
Selected topics of current importance in reliability engineering.
Prerequisite: Permission of ENGR-Mechanical Engineering department.
Repeatable to: 6 credits if content differs.

ENRE600 Fundamentals of Failure Mechanisms (3 Credits)
Advanced failure mechanisms in reliability engineering wiil be taught from a basic materials and defects point of view. The methods of predicting the physics of failure of devices, materials, components and systems are reviewed. The main emphasis will be given to basic degradation mechanisms through understanding the physics, chemistry, and mechanics of such mechanisms. Mechanical failures are introduced through understanding fatigue, creep and yielding in materials, devices and components. The principles of cumulative damage and mechanical yielding theory are taught. The concepts of reliability growth, accelerated life testing, environmental testing are introduced. Physical, chemical and thermal related failures are introduced through a basic understanding of degradation mechanisms such as diffusion, electromigration, defects and defect migration. The failure mechanisms in basic material types will be taught. Failure mechanisms observed in real electronic devices and electronic packaging will also be presented. Problems related to manufacturing, and microelectronics will be analyzed. Mechanical failures are emphasized from the point of view of complex fatigue theory.
Cross-listed with: ENMA626.
Restriction: Permission of ENGR-Mechanical Engineering.
Credit Only Granted for: ENMA626, ENMA698M, ENMA698R, or ENRE600.

ENRE602 Principles of Reliability Analysis (3 Credits)
Principal methods of reliability analysis, including fault tree and reliability block diagrams; Failure Mode and Effects Analysis (FMEA); event tree construction and evaluation; reliability data collection and analysis; methods of modeling systems for reliability analysis. Focus on problems related to process industries, fossil-fueled power plant availability, and other systems of concern to engineers.

ENRE640 Collection and Analysis of Reliability Data (3 Credits)
Reliability data collection and analysis is of high (practical) importance in many essential engineering tasks including but not limited to: design alternatives evaluation, failure root cause analysis, early detection of field reliability problems, warranty reserve allocation, and others. The course teaches nonparametric and parametric statistical procedures of reliability data analysis for both non-repairable and repairable systems. It covers test data analysis (including accelerated and degradation testing), field data analysis (including warranty data and connected fleets data). Machine learning methods in reliability data analysis are discussed as well, along with special topics on condition-based maintenance and prognostics.
Prerequisite: ENRE602.

ENRE641 Probabilistic Physics of Failure and Accelerated Testing (3 Credits)
Models for life testing at constant stress. Graphical and analytical methods. Test plans for accelerated testing. Competing failure modes and size effects. Models and data analyses for step and time varying stresses. Optimizing of test plans.

ENRE642 Reliability Engineering Management (3 Credits)
Unifying systems perspective of reliability engineering management. Design, development and management of organizations and reliability programs including: management of systems evaluation and test protocols, development of risk management-mitigation processes, and management of functional tasks performed by reliability engineers.

ENRE645 Human Reliability Analysis (3 Credits)
Methods of solving practical human reliability problems, cognitive and behavioral modeling, task analysis, performance shaping factors, error classification, distribution of human performance and uncertainty bounds, sources of human error probability data, human error risk mitigation, examples and case studies.

ENRE648 Special Problems in Reliability Engineering (1-6 Credits)
For students who have definite plans for individual study of approved problems. Credit given according to extent of work.
Repeatable to: 6 credits if content differs.

ENRE655 Machine Learning Algorithms for Reliability Engineering (3 Credits)
Students learn representative machine learning algorithms with applications to reliability engineering. This course will cover model-based methods for reliability analysis, reliability model parameter estimation with both maximum likelihood approaches and Bayesian approaches, model selection, and model-based methods for health monitoring and reliability prediction. This course will also cover data-driven methods for reliability analysis, including neural networks, deep neural networks, random forest, support vector machines. Lastly, this course will cover topics on decision optimization based on reliability analysis, focusing on the Markov decision process and reinforcement learning.
Prerequisite: ENRE602.

ENRE670 Probabilistic Risk Assessment (3 Credits)
Why study risk, sources of risk, overview of Risk Assessment and Risk Management, relation to System Safety and Reliability Engineering; measures, representation, communication, and perception of risk; overview of use of risk assessment results in decision making; overview of Probabilistic Risk Assessment (PRA) process; detailed converge of PRA methods including (1) methods for risk scenario development such as identification of initiators, event sequence diagrams, event trees, causal modeling (fault trees, influence diagrams, and hybrid methods), and simulation approaches; (2) methods of risk scenario likelihood assessment, including quantitative and qualitative approaches, as well as uncertainty modeling and analysis. Also covers methods for risk modeling of system hardware behavior, physical phenomena, human behavior, software behavior, organizational environment, and external physical environment. Additional core topics include risk model integration and quantification (Boolean-based, binary decsion diagram, Bayesian belief networks, and hybrid methods), simulation-based Dynamic PRA methods (discrete and continuous) and several examples of large scale PRAs for space missions, nuclear power, aviation and medical systems.
Prerequisite: ENRE602.

ENRE671 Risk Assessment in Engineering (3 Credits)
Introduction to risk management and decision-making, including uncertainty propagation, importance ranking, risk acceptance criteria, decision analysis and other decsion-making techniques, risk communication.
Prerequisite: ENRE670.

ENRE682 Software Reliability and Integrity (3 Credits)
Defining software reliability, initiatives and standards on software reliability, inherent characteristics of software which determine reliability, types of software errors, structured design, overview of software reliability models, software fault tree analysis, software redundancy, automating tools for software reliability protypes and real time software reliability.

ENRE684 Information Security (3 Credits)
This course is divided into three major components: overview, detailed concepts and implementation techniques. The topics to be covered are: general security concerns and concepts from both a technical and management point of view, principles of security, architectures, access control and multi-level security, trojan horses, covert channels, trap doors, hardware security mechanism, security models, security kernels, formal specifications and verification, networks and distribution systems and risk analysis.
Jointly offered with: ENME442.
Credit Only Granted for: ENME442 or ENRE684.

ENRE695 Design for Reliability (3 Credits)
Reliability is the ability of a product or system to perform as intended (i.e., without failure and within specified performance limits) for a specified time, in its life-cycle conditions. Knowledge of reliability concepts and principles, as well as risk assessment, mitigation and management strategies prepares engineers to contribute effectively to product development and life cycle management. This course teaches the fundamental knowledge and skills in reliability as it pertains to the design, manufacture, and use of electrical, mechanical, and electro-mechanical products. Topics cover the suitability of the supply chain members to contribute towards development, manufacturing, distribution and support of reliable products; efficient and cost-effective design and manufacture of reliable products; process capability and process control; derating, uprating, FMMEA, reliability prediction and reliability allocation; how to plan and implement product testing to assess reliability; how to analyze degradation, failure, and return data to estimate fundamental reliability parameters; root cause analysis; and reliability issues associated with warranties, regulatory requirements, and liabilities.
Cross-listed with: ENME695.
Credit Only Granted for: ENME695 or ENRE695.

ENRE770 Life Cycle Cost and System Sustainment Analysis (3 Credits)
This course melds elements of traditional engineering economics with manufacturing process and sustainment modeling, and life cycle cost management concepts to form a practical foundation for predicting the cost of products and systems. Various manufacturing cost analysis will be presented including: process-flow, parametric, cost of ownership, and activity based costing. The effects of learning curves, data uncertainty, test and rework processes, and defects will be considered. Aspects of system sustainment including the impact on the life cycle (and life cycle costs) of reliability, maintenance, environment impact, and obsolescence will be treated.
Credit Only Granted for: ENME770 or ENRE770.

ENRE798 Master's Non-Thesis Research (1-6 Credits)

ENRE799 Master's Thesis Research (1-6 Credits)

ENRE898 Pre-Candidacy Research (1-8 Credits)

ENRE899 Doctoral Dissertation Research (1-8 Credits)