Pimpri Chinchwad Education Trust's

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

SECTOR NO. 26, PRADHIKARAN, NIGDI, PUNE 411044

An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune

DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum Structure and Syllabus

of

Honor in AI-ML based Reliability Engineering

(Approved by BoS Mechanical Engineering)

(Course 2020)

Effective from Academic Year 2023-24

Institute Vision

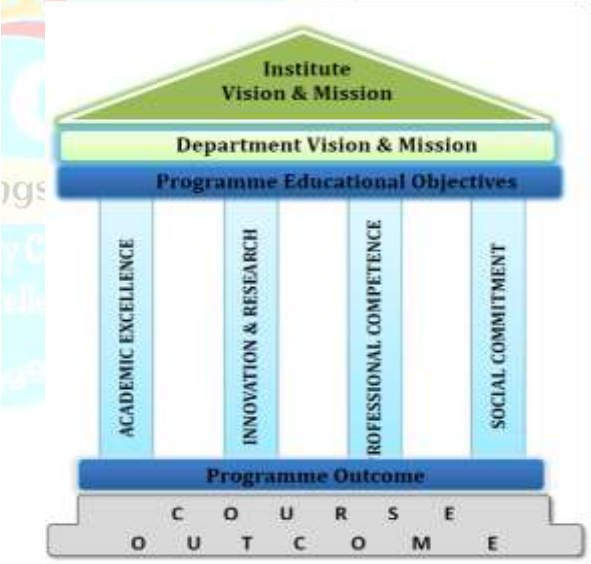
To be one of the top 100 Engineering Institutes of India in coming five years by offering exemplarily Ethical, Sustainable and Value Added Quality Education through a matching ecosystem for building successful careers.

Institute Mission

1. Serving the needs of the society at large through establishment of a state-of-art Engineering Institute.
2. Imparting right Attitude, Skills and Knowledge for self-sustenance through Quality Education.
3. Creating globally competent and Sensible engineers, researchers and entrepreneurs with ability to think and act independently in demanding situations.

Quality Policy

We at PCCOE are committed to impart Value Added Quality Education to satisfy the applicable requirements, needs and expectations of the Students and Stakeholders. We shall strive for academic excellence, professional competence and social commitment in fine blend with innovation and research. We shall achieve this by establishing and strengthening state-of- the-art Engineering and Management Institute through continual improvement in effective implementation of Quality Management System.



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Preface

Looking at Global Scenario to enhance the employability skills and impart deep knowledge in emerging/ multidisciplinary areas, an additional avenue is provided to passionate learners through the Minors and Honors Degree Scheme in academic structure.

For Honors degree program, student has to earn additional 20 credits in emerging area of one's own domain.

Objectives of Honors Degree

- To enable students to pursue allied academic interest in contemporary areas.
- To provide effective yet flexible options for students to achieve basic to intermediate level competence in the contemporary area.
- To enhance the employability skills with different combinations of competencies and flavors.
- To provide an academic mechanism for fulfilling demand of specialized areas from industries for higher order skill jobs.
- To provide a strong foundation to students aiming to pursue research/ higher studies in the Contemporary field of study.

Preface of Honor in AI-ML based Reliability Engineering

The Honor in AI-ML based Reliability Engineering is a multidisciplinary program focuses on the use of machine learning techniques, statistical modeling techniques, management systems, reliability testing methods and condition-based and preventive technologies to identify, manage and eliminate failures leading to losses in system function. This Honor program aims to mold the next generation reliability professionals who can develop reliable systems/ products and optimize the maintenance strategies and life cycle cost. This program also aims to create a sound foundation and detailed technical knowledge in statistical methods used for failure and repair data analysis, system reliability modeling, reliability allocations, probabilistic approaches, handbook-based reliability analysis, reliability and life testing, accelerated life testing, and design of experiments, etc.

The Honor program in AI-ML based Reliability Engineering help students in developing analytical, experimentation, and investigative skills to solve complex engineering, and reliability problems. The Honor consists of three courses (1. AI-ML for Reliability Modeling, 2. Product Design for Reliability, 3. Reliability Testing) 4. Seminar and one integrated project. The courses and integrated project are distributed in semester V to VIII. There is no need of any special pre-requisites for opting this Honor, however, it is preferred that the students should have basic understanding of statistics and probability. The students will develop the diverse knowledge, skills, abilities, and dispositions needed to succeed as reliability professional in a broad range of public or private industries. The Honor course will also help students to get an opportunity to work in nationally and internationally recognized universities/ institutes.

Objectives:

This program aims to:

- Explain the applications of probability distributions, statistical techniques and data science using AI- ML approaches to develop reliability and maintainability models for a data set.
- Acquaint students with different system reliability, availability, and maintainability; apply reinforced and deep learning modeling and analysis tools and techniques.
- Impact the basic and understanding of system reliability modeling and analysis techniques
- Introduce basic concepts of reliability testing, accelerated life testing (ALT), highly accelerated life testing (HALT), and reliability growth testing and develop skills to select suitable methods.

Course Outcomes:

At the successful completion of this Honor program, students will be able to:

- Use probability distributions and statistical methods to develop reliability models using AI-ML and draw practical inferences.
- Develop reliability, availability, and maintainability models for complex and safety-critical systems and analyze the systems for identifying critical components and other metrics.
- Apply methods such as failure modes and effects analysis, fault tree analysis, etc., and reliability allocation techniques to design a new product and systems.
- Investigate the performance and life of the components/ systems using accelerated life testing, and highly accelerated life testing using reinforced and deep learning models.

INDEX

LIST OF ABBREVIATIONS IN CURRICULUM STRUCTURE

Sr. No.	Abbreviation	Type of Course
1.	L	Lecture
2.	P	Practical
3.	T	Tutorial
4.	H	Hours
5.	CR	Credits
6.	IE1	Internal Evaluation 1
7.	IE2	Internal Evaluation 2
8.	ETE	End Term Evaluation
9.	TW	Term Work
10.	OR	Oral
11.	PR	Practical
12.	PROJ	Project

CREDIT DISTRIBUTION: SEMESTER WISE						
1 Lecture hour = 1 Credit 2 Lab Hours = 1 Credit 1 Tutorial Hour = 1 Credit						
Sr. No.	**Course Title**	**Credits/Semester**				
		5	**6**	**7**	**8**	Total
1.	AI-ML for Reliability Modeling	3	0	0	0	3
2.	AI-ML for Reliability Modeling Lab	1	0	0	0	1
3.	Product Design for Reliability	0	4	0	0	4
4.	Product Design for Reliability Lab	0	1	0	0	1
5.	Reliability Testing	0	0	3	0	3
6.	Reliability Testing Lab	0	0	1	0	1
7.	Seminar/ Mini-Project/ Internship	0	0	2	0	2
8.	Integrated Project	0	0	0	5	5
	Total	**4**	**5**	**6**	**5**	**20**

Curriculum structure

AI-ML BASED RELIABILITY ENGINEERING

Honor in Mechanical Engineering

Curriculum Structure

AI-ML Based RELIABILITY ENGINEERING

Honor in Mechanical Engineering

Semester	Course Code	Course Name	Teaching Scheme					Evaluation Scheme						
			L	P	T	H	CR	IE	MTE	ETE	TW	PR	OR	Total
V	HME5973	AI-ML for Reliability Modeling	3	-	-	3	3	20	30	50		-	-	100
V	HME5974	AI-ML for Reliability Modeling Lab	-	2	-	2	1	-	-	-	25	-	-	25
VI	HME6973	Product Design for Reliability	3	-	1	4	4	20	30	50	-	-	-	100
VI	HME6974	Product Design for Reliability Lab	-	2	-	2	1	-	-	-	50	-	-	50
VII	HME7969	Reliability Testing	3	-	-	3	3	20	30	50	-	-	-	100
VII	HME7970	Reliability Testing Lab	-	2	-	2	1	-	-	-	25	-	-	25
VII	HME7971	Seminar/ Mini-Project/ Internship	-	4	-	4	2	-	-	-	-	-	50	50
VIII	HME8977	Integrated Project	-	10	-	10	5	50	-	-	50	-	50	150
			9	20	1	30	**20**	110	90	150	150	-	100	**600**

Abbreviations are: L-Lecture, P-Practical, T-Tutorial, H- Hours, IE- Internal Evaluation, MTE- Mid Term Evaluation, ETE- End Term Evaluation, TW –Termwork, PR-Practical, OR - Oral

Course Syllabus

AI-ML based Reliability Engineering

Semester - V

Program:	Honor in AI-ML Based Reliability Engineering				Semester: V		
Course:	AI-ML for Reliability Modeling				Code: HME5973		
Teaching Scheme				Evaluation Scheme			
Lecture	Practical	Hours	Credit	IE	MTE	ETE	Total
3	-	3	3	20	30	50	100

Prior knowledge of:

a. Basics of probability and statistics
b. Fundamentals of Mechanical Engineering…….are essential

Course Objectives:

1. To impart a basic understanding of probability, statistical, and AI-ML techniques used in reliability engineering.
2. To make the learner aware of applications of probability distributions and machine learning methods in modeling and analyzing failure data.
3. To apply AI-ML techniques for information retrieval
4. To be able to select suitable data collection and preprocessing techniques.

Course Outcomes:

The students will be able to,

1. Apply the AI-ML and statistical methods for reliability data analysis.
2. Select suitable/ significant features using a suitable method.
3. Use the probability distributions for analyzing components and systems.
4. Develop classification and regression models for a given mechanical engineering data set.
5. Select suitable method for failure data collection and apply suitable techniques to refine data.
6. Evaluate the performance of the machine learning models and optimize the model

Detailed Syllabus

Unit	Description	Duration (H)
1	**Reliability Engineering in the 21st Century** Concept of failure; Definitions; Product life cycle phases; Consequences of failure; Suppliers. **Need of AI-ML in Reliability:** Comparison of AI, ML and data science; Approaches to AI; Approaches to ML: supervised, unsupervised and reinforcement learning.	7
2	**Feature Extraction and Selection** **Statistical features:** Reliability; CDF; PDF; MTTF, MTBF, t_{med}, mode, Moments of time to failure; Hazard rate; Bathtub curve; Conditional reliability; Percentiles product life. **Feature selection:** Principal component analysis; Ranking; Greedy forward & backward.	8
3	**Probability Distributions in Reliability** **Discrete Probability Distributions:** Binomial; and Poisson. **Continuous Probability Distributions:** Weibull; Exponential; Gaussian; Lognormal; Estimation of reliability metric such as life of the component, warranty period, reliable life, etc. Concept of the confidence interval	7
4	**Classification & Regression** **Classification Models:** Random Forest; Logistic regression; Decision tree; SVM; K-NN; K-Means, Naive Bayes. **Regression Models –** Linear; Neural network; Lasso; Gaussian; and polynomial regression. Concept of overfitting and underfitting	8
5	**Reliability Data** **Data sources and collection methods:** Primary data; Secondary data; Reliability of data; Suitability and adequacy of data; Data collection methods. **Categories of data –** Qualitative vs. quantitative; Grouped vs. non-grouped data; Complete vs. censored data; Static life estimation; Data preprocessing; Pareto analysis.	7
6	**Development of ML Models** Problem identification; Steps in ML modeling; Data collection and pre-processing; Model Selection; Model training, testing, K-fold cross-validation; Model evaluation: confusion matrix; Hyper parameter Tuning, Predictions.	8
	Total	45

Text Books:

1. An Introduction to Reliability and Maintainability Engineering by C. E. Ebeling, Waveland Press inc., 2019.
2. Reliability Engineering by K. C. Kapur, and M. Pecht, Wiley, 2014.
3. Reliability Engineering by K. K. Agarawal, Springer International Edition, 2012.
4. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
5. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
6. Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015

Reference books:

1. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill, 2017.
2. Reliability Engineering and Risk Analysis – A practical Guide by M. Modarres, K. Kaminsky, and V. Krivstov, CRC Press, Taylor and Francis Group, 2017.
3. Practical Reliability Engineering by P. D. T. O'Conner, John Wiley and Sons, 2012.
4. Life cycle reliability engineering by G. Yang, John Wiley and Sons, 2007.
5. Engineering Maintainability by B. S. Dhillon, Prentice Hall of India, 1999.
6. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
7. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
8. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
9. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
10. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH

Program:	Honor in AI-ML Based Reliability Engineering			Semester: V				
Course:	AI-ML for Reliability Modeling Lab			Code: HME5974				
Teaching Scheme				Evaluation Scheme				
Lecture	Practical	Hours	Credit	IE	MTE	ETE	TW	Total
-	2	2	1	-	-	-	25	25

Prior knowledge of:

a. Basics of probability and statistics
b. Fundamentals of Mechanical Engineering…….are essential

Course Objectives:

1. To impart a basic understanding of probability, statistical, and AI-ML techniques used in reliability engineering.
2. To make the learner aware of applications of probability distributions and machine learning methods in modeling and analyzing failure data.
3. To be able to select suitable data collection and preprocessing techniques.
4. To apply AI-ML techniques for model development and evaluation

Course Outcomes:

The students will be able to,

1. Apply the AI-ML and statistical methods for reliability data analysis.
2. Use the probability distributions for analyzing components and systems.
3. Develop classification and regression models for a given mechanical engineering data set and evaluate its performance.
4. Select suitable method for failure data collection and apply suitable techniques to refine data.
5. Evaluate the performance of the machine learning models and optimize the model
6. Analyze field failure and goodness-of-fit test to reliability tests data using a suitable method and software package.

Detailed Syllabus: (24 Hours)

Miniature commitment or Assignments:

Group A – (Any three problems for a failure data set using a suitable software package/ programming language)

1. Reliability data collection, sorting, classification, Pareto analysis/ bar chart plotting (paper clips experiments).
2. Plotting reliability characteristics for a given data set (Use data from paper clips experiments).
3. Select best-fit probability distributions for reliability modeling (Use data from paper clips experiments).
4. Parameter estimation using probability plotting papers, rank regression, and maximum Likelihood Estimation.
5. Feature extraction and selection for a reliability data.
6. Development of machine learning model and its evaluation for a given reliability data.

Group B – Goodness-of-fit Tests and Parameter Estimation (Mandatory)

1. Regression modeling and goodness-of-fit tests/ Classifications models and confusion matrix/ Parameter estimation and Concept of the confidence interval.

Group B (Mandatory)

One mini project based on the above contents and using mechanical engineering application dataset.

Text Books:

1. An Introduction to Reliability and Maintainability Engineering by C. E. Ebeling, Waveland Press inc., 2019.
2. Reliability Engineering by K. C. Kapur, and M. Pecht, Wiley, 2014.
3. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
4. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
5. Parag Kulkarni and Prachi Joshi, “Artificial Intelligence – Building Intelligent Systems”, PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015

Reference books:

1. Reliability Engineering and Risk Analysis – A practical Guide by M. Modarres, K. Kaminsky, and V. Krivstov, CRC Press, Taylor and Francis Group, 2017.
2. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
3. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
4. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
5. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
6. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH

Course Syllabus

AI-ML based Reliability Engineering

Semester - VI

Program:	Honor in AI-ML Based Reliability Engineering			Semester: VI					
Course:	Product Design for Reliability			Code: HME6973					
Teaching Scheme				Evaluation Scheme					
Lecture	Tutorial	Hours	Credit	IE	MTE	ETE	TW	OR	Total
3	1	4	4	20	30	50	-	-	100

Prior knowledge of:

a. Statistical methods used in reliability
b. Statistical methods for reliability modeling…….are essential

Course Objectives:

1. To explain the product development process and best practices for reliability.
2. To familiarize students with methods used for system reliability modeling and allocation.
3. To apply reinforced and deep learning models.
4. To be able to understand the stress-strength model and probabilistic approach in design.
5. To be able to select system reliability, maintainability, availability, and LCC method for modeling.
6. To impart a basic understanding of handbook-based reliability predictions.

Course Outcomes:

The students will be able to,

1. Demonstrate the product development process and apply the FMEA at different stages of the product life cycle.
2. Select a suitable method for system reliability modeling and reliability allocation.
3. Use reinforced and deep learning models for product performance analysis.
4. Use stress-strength models and probabilistic approaches in design and solve reliability problems.
5. Develop maintainability, availability, and LCC models for reliability improvements and optimization.
6. Apply handbook-based methods to predict the reliability of electronic components.

Detailed Syllabus

Unit	Description	Duration (H)
1	**Product Development and FMEA** Reliability objectives; Product requirements and constraints; Product life cycle conditions; Reliability capability; Parts selection and management; Design review; product qualification. FMEA; FMECA; FMMEA; Criticality assessment – RPN, and MIL-STD-1629; RCA.	10
2	**System Reliability Modeling and Allocation** Reliability Block Diagrams; FTA; Cut-sets and tie sets; Monte Carlo Simulation; Markov Chains. **Reliability Allocation methods –** Equal allocation, Weighting factor; Optimization.	10
3	**Reinforced and Deep Learning Models for Product Design** **Reinforced learning (RL);** Algorithms: value-based, policy-based, model-based; Positive vs Negative RL; Models: Markov Decision Process, Q Learning. **Deep Learning:** Artificial Neural Network, Convolution Neural Network.	10
4	**Probabilistic Design for Reliability** Probabilistic design models; Steps for probabilistic design; Factor of safety and variability; **Product Warranty Analysis:** Warranties, Warranty returns information, Warranty policies, and Warranty cost analysis. Physics-of-Failure (PoF) models for reliability prediction	10
5	**Maintainability, Availability, and Life Cycle Costing** **Maintainability:** Types of maintenance; Repair time distribution; Stochastic processes; TPM; RCM; Condition-based maintenance. **Availability:** Inherent, achieved, and operational availability, Steady-state availability. **Life Cycle Costing (LCC):** LCC break-up; LCC models. Reliability Improvement Methods.	10
6	**Handbook-Based Reliability Predictions** What is handbook-based reliability prediction, Handbook-based reliability prediction methods – FIDES, 217+, Bellcore/ Telcordia SR-332, ANSI/ VITA51.1, NSWC-11, GJB/z 299.	10
	Total	60

Text Books:

1. An Introduction to Reliability and Maintainability Engineering by C. E. Ebeling, Waveland Press inc., 2019.
2. Reliability Engineering by K. C. Kapur, and M. Pecht, Wiley, 2014.
3. Reliability Engineering by K. K. Agarawal, Springer International Edition, 2012.
4. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.

Reference books:

1. Reliability Engineering: Theory and Practice by A. Birolini, Springer International Edition, 2017.
2. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill, 2017.
3. Reliability Engineering and Risk Analysis – A practical Guide by M. Modarres, K. Kaminsky, and V. Krivstov, CRC Press, Taylor and Francis Group, 2017.
4. Reliability Engineering by L. S. Shrinath, East-West Press, New Delhi, 2005.
5. Practical Reliability Engineering by P. D. T. O'Conner, John Wiley and Sons, 2012.
6. Life cycle reliability engineering by G. Yang, John Wiley, and Sons, 2007.
7. Maintenance, Replacement, and Reliability: Theory and Applications by A. K. S. Jardine, and H. C. Tsang, Taylor and Francis, 2006.
8. Engineering Maintainability by B. S. Dhillon, Prentice Hall of India, 1999.
9. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.

Tutorials (to be performed in a group of 3-4 students)

1. FMEA analysis using MIL-STD-1629.
2. Root cause analysis.
3. Group case study on ARINC/ AGREE/ Feasibility of objectives/ Aggarwal's method/ and Integrated factor.
4. Optimal reliability allocations
5. Artificial Neural Network
6. Convolution Neural Network.
7. Markov chains
8. Ishikawa diagram/ NFF/ CCF & CMF/ FRACAS.
9. TPM/ RCM/ Condition-based maintenance.
10. Physics of failure models

Program:	Honor in AI-ML Based Reliability Engineering					Semester: VI			
Course:	Product Design for Reliability Lab					Code: HME6974			
Teaching Scheme				Evaluation Scheme					
Lecture	Practical	Hours	Credit	IE	MTE	ETE	TW	OR	Total
-	2	2	1	-	-	-	50	-	50

Prior knowledge of:

a. Statistical methods used in reliability
b. Statistical methods for reliability modeling…….are essential

Course Objectives:

1. To explain the product development process and best practices for reliability.
2. To familiarize students with methods used for system reliability modeling and allocation.
3. To be able to select system reliability, maintainability, availability, and LCC method for modeling.
4. To study reinforced and deep learning models.
5. To impart a basic understanding of handbook-based reliability predictions.
6. To introduce the concept of design for six sigma, process control and process capability.

Course Outcomes:

The students will be able to,

1. Demonstrate the product development process and apply the FMEA at different stages of the product life cycle.
2. Select a suitable method for system reliability modeling and reliability allocation.
3. Develop maintainability, availability, and LCC models for reliability improvements and optimization.
4. Use reinforced and deep learning models for product performance analysis.
5. Apply handbook-based methods and stress-strength models for reliability predictions.
6. Apply the concept of six sigma, process control and process capability for component design/ system selection.

Detailed Syllabus: (24 Hours)

Miniature commitment or Assignments:

Group A – (Any four case studies on following topics using suitable software package/ programming language)

1. Failure modes and effects analysis (FMEA)/ FMECA/ FMMEA)
2. Reliability block diagrams/ fault tree analysis
3. Markov chains
4. Monte Carlo simulation
5. Warranty data analysis
6. Artificial Neural Network
7. Convolution Neural Network.
8. Handbook-based reliability predictions
9. Design for six sigma
10. Process control and process capability

Group B (Mandatory)

One mini project based on one of the following topics and using mechanical engineering application dataset.

1. Process Control and Process Capability - X-bar/ R-chart/ S-chart/ p-chart/ np-chart/ c-chart/ u-chart.
2. Life cycle costing
3. Ishikawa diagram/ NFF/ CCF & CMF/ FRACAS.
4. TPM/ RCM/ Condition-based maintenance.
5. FIDES, 217+, or Bellcore/ Telcordia SR-332, or ANSI/ VITA51.1, or NSWC-11, or GJB/z 299

Text Books:

1. An Introduction to Reliability and Maintainability Engineering by C. E. Ebeling, Waveland Press inc., 2019.
2. Reliability Engineering by K. C. Kapur, and M. Pecht, Wiley, 2014.
3. Reliability Engineering by K. K. Agarawal, Springer International Edition, 2012.

Reference books:

1. Reliability Engineering: Theory and Practice by A. Birolini, Springer International Edition, 2017.
2. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill, 2017.
3. Reliability Engineering and Risk Analysis – A practical Guide by M. Modarres, K. Kaminsky, and V. Krivstov, CRC Press, Taylor and Francis Group, 2017.
4. Reliability Engineering by L. S. Shrinath, East-West Press, New Delhi, 2005.
5. Practical Reliability Engineering by P. D. T. O'Conner, John Wiley and Sons, 2012.
6. Life cycle reliability engineering by G. Yang, John Wiley, and Sons, 2007.
7. Maintenance, Replacement, and Reliability: Theory and Applications by A. K. S. Jardine, and H. C. Tsang, Taylor and Francis, 2006.
8. Engineering Maintainability by B. S. Dhillon, Prentice Hall of India, 1999.

Course Syllabus

AI-ML based Reliability Engineering

Semester - VII

Program:	Honor in AI-ML Based Reliability Engineering			Semester: VII				
Course:	Reliability Testing			Code: HME7969				
Teaching Scheme				Evaluation Scheme				
Lecture	Practical	Hours	Credit	IE	MTE	ETE	TW	Total
3	-	3	3	20	30	50	-	100

Prior knowledge of:

a. Statistical methods used in reliability and maintainability
b. Design for reliability
c. Quality, reliability,
d. Maintainability…….are essential

Course Objectives:

1. To introduce basic concepts of reliability testing, and accelerated life testing (ALT), and highly accelerated life testing (HALT).
2. To expose students to the concepts of design of experiments and analysis of variance.
3. To impact the basic understanding of non-destructive testing methods.
4. To explain the concept and approaches of reliability management

Course Outcomes:

The students will be able to,

1. Explain basic concepts of reliability and life testing.
2. Use suitable methods to solve problems on ALT, HALT, and HASS.
3. Develop machine and deep learning models for reliability test data.
4. Perform design of experiments and analysis of variance.
5. Select a suitable non-destructive technique for a given application.
6. Demonstrate the need for a reliability management program and safety audits.

Detailed Syllabus:

Unit	Description	Duration (H)
1	**Reliability Testing and Predictions** Product testing; Objectives of life tests; Reliability tests; Product screening and burn-in; Reliability growth testing; Acceptance and qualification test; Sequential tests; Storage/ transportation/ shipment/ operation/ environmental tests; Applications of AI-ML models for data modeling and predictions.	7
2	**Accelerated Life Testing (ALT)** Basic concepts, Methods; Temperature stress and failure rates; Stress combinations in ALT; Step-stress methods; Accelerated cycling, Constant accelerated stress model; Cumulative damage model; Applications of deep-learning models.	8
3	**Highly Accelerated Life Testing (HALT)** Concept; Goals, Plan, Stress levels for HALT, highly accelerated stress screening (HASS), Equipment used; Precautions to be taken; Applications of ML and DL models.	7
4	**Design of Experiments (DoE)** **Fundamentals of DoE;** Terms used in DoE – factors, levels, blocks, center point, repetitions, replications, etc.; Types of DoEs **Analysis of variance (ANOVA):** Principle of ANOVA; Types: one-way and two-way ANOVA.	8
5	**Non-Destructive Testing (NDT)** Comparison of destructive and non-destructive testing; the scope of NDT; Classification - Liquid penetrant testing, Eddy current tests, Ultrasonic testing, Radiography, Magnetic particle method.	7
6	**Reliability Management** Reliability program, Management objectives, policies and decisions; Reliability groups; Data acquisition, and analysis; Managing people by reliability; **Safety –** Environment; Auditory and visual warning devices; Safety and maintainability design; Electrical, mechanical, and other hazards; Safety audit; Planning for safety.	8
	Total	45

Text Books:

1. Reliability Engineering and Life Testing by V. N. A. Naikan, PHI Learning, 2008.
2. Accelerated Testing and Validation by A. Porter, Elsevier, 2012.
3. Accelerated Reliability and Durability Testing Technology by L. M. Klyatis, Wiley, 2012.
4. An Introduction to Reliability and Maintainability Engineering by C. E. Ebeling, Waveland Press inc., 2019.

Reference books:

1. Reliability Engineering: Theory and Practice by A. Birolini, Springer International Edition, 2017.
2. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill, 2017.
3. Reliability Engineering and Risk Analysis – A practical Guide by M. Modarres, K. Kaminsky, and V. Krivstov, CRC Press, Taylor and Francis Group, 2017.
4. Reliability Engineering by L. S. Shrinath, East-West Press, New Delhi, 2005.
5. Practical Reliability Engineering by P. D. T. O'Conner, John Wiley and Sons, 2012.
6. Life cycle reliability engineering by G. Yang, John Wiley, and Sons, 2007.
7. Maintenance, Replacement, and Reliability: Theory and Applications by A. K. S. Jardine, and H. C. Tsang, Taylor and Francis, 2006.
8. Engineering Maintainability by B. S. Dhillon, Prentice Hall of India, 1999.

Program:	Honor in AI-ML Based Reliability Engineering					Semester: VII		
Course:	Reliability Testing Lab					Code: HME7970		
Teaching Scheme				Evaluation Scheme				
Lecture	Practical	Hours	Credit	IE	MTE	ETE	TW	Total
-	2	2	1	-	-	-	25	25

Prior knowledge of:

a. Statistical methods used in reliability and maintainability
b. Design for reliability
c. Quality, reliability, and maintainability
d. System reliability modeling…….are essential

Course Objectives:

1. To introduce basic concepts of reliability testing, and ALT, and HALT.
2. Develop machine and deep learning models for reliability test data.
3. To expose students to the concepts of design of experiments and analysis of variance.
4. To impact the basic understanding of non-destructive testing methods.
5. To explain the concept and approaches of reliability management

Course Outcomes:

The students will be able to,

1. Use suitable methods to solve problems on ALT, HALT, and HASS.
2. Develop machine learning and deep learning models for test data modeling and analysis.
3. Perform design of experiments and analysis of variance.
4. Select a suitable non-destructive technique for a given application.
5. Demonstrate the need of a reliability management program and safety audits.

Detailed Syllabus: (24 Hours)

Miniature commitment or Assignments:

Group A – (Any two problems for reliability tests data set using suitable software package)

1. Life testing with censoring
2. Life testing with replacement
3. Life testing without replacement

Group B – (Any two problems for a failure data set using a suitable software package/ tool)

1. Accelerated life testing with ML models
2. Highly accelerated life testing/ HASS with DL models
3. Design of experiments/ analysis of variance
4. Non-destructive testing

Text Books:

1. Reliability Engineering and Life Testing by V. N. A. Naikan, PHI Learning, 2008.
2. Accelerated Testing and Validation by A. Porter, Elsevier, 2012.
3. Accelerated Reliability and Durability Testing Technology by L. M. Klyatis, Wiley, 2012.
4. An Introduction to Reliability and Maintainability Engineering by C. E. Ebeling, Waveland Press inc., 2019.

Reference books:

1. Reliability Engineering: Theory and Practice by A. Birolini, Springer International Edition, 2017.
2. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill, 2017.
3. Reliability Engineering and Risk Analysis – A practical Guide by M. Modarres, K. Kaminsky, and V. Krivstov, CRC Press, Taylor and Francis Group, 2017.
4. Reliability Engineering by L. S. Shrinath, East-West Press, New Delhi, 2005.
5. Practical Reliability Engineering by P. D. T. O'Conner, John Wiley and Sons, 2012.
6. Life cycle reliability engineering by G. Yang, John Wiley, and Sons, 2007.
7. Maintenance, Replacement, and Reliability: Theory and Applications by A. K. S. Jardine, and H. C. Tsang, Taylor and Francis, 2006.
8. Engineering Maintainability by B. S. Dhillon, Prentice Hall of India, 1999.

Program:	Honors in AI-ML Based Reliability Engineering			Semester: VII			
Course:	Seminar/ Mini-Project/ Internship			Code: HME7971			
Teaching Scheme				Evaluation Scheme			
Lecture	Practical	Hours	Credit	IE	TW	OR	Total
-	4	4	2	-	-	50	50

Prior knowledge of:

a. Basics of Mechanical Engineering
b. Statistical Methods for Reliability Modeling
c. Product Design for Reliability
d. Reliability Testing
e. Basics of suitable software packages used for the analysis of failure data. …….are essential

Course Objectives:

Students are expected to study,

1. To study advanced topics of AI-ML based reliability, availability, maintainability, and safety (RAMS) used in the product life-cycle design.
2. To use standards for conducting various activities in RAMS.
3. To conduct case studies based on the various phases in system design, analysis, and implementation of real-time applications/ case study using available platforms.

Course Outcomes:

The students will be able to,

1. Select an advanced topic for the seminar in the domain of RAMS.
2. Conduct a case study using AI-ML-DL based reliability models based on the real-time data/ laboratory data
3. Write a technical report based on the seminar.
4. Defend the case study and the obtained results presented in the technical seminars.

Guidelines: Total: 24 h (contact) + 24 h (non-contact/implementation)

1. Topic for the seminar/ mini-project or the industry for internship should be selected based on any topics covered in this honors course.
2. It is expected to carry out the work at the individual level under the guidance of the allocated guide.
3. Students can choose the topic/ industry considering their implementation in the Integrated Project/ Major Project.
4. A case study should be included in the report. Use of suitable software/ programming language is compulsory.
5. The report of the work should be submitted in compliance with the term work associated with the subject.
6. Paper publication associated with the project as a research outcome is appreciable.
7. Seminar based on the work carried out in the industry/ laboratory is mandatory.
8. Students are motivated to use relevant standards such as IEEE, IEC, ASME, etc.

Contents of the Seminar report

The seminar report includes the following:

- Abstract/Summary
- Introduction: Background, motivation, and Scope
- Literature review: should be based on at least five research papers published during the last 5 years:
- Methodology (if any)
- Case study
- Conclusion
- References

Sr. No.	Activity	Duration (H)
1	Week 1, 2, & 3: guide allotment, Finalization of topic and platform, Planning of the work, Literature review, identifying a problem, and formulating the problem for the seminar	12
2	Week 4, 5, & 6: Methodology finalization, finalizing project proposal, Review 1 for finalization of topic and specification.	12
3	Week 7, 8, & 9: Data analysis using suitable software/ programming language, Review 2 to understand the progress of the project	12
4	Week 10, 11, & 12: Report writing, and publication or copyright planning and execution, Submission, and term work compliances.	12
	Total	48

Course Syllabus

AI-ML based Reliability Engineering

Semester - VIII

Program:	Honor in AI-ML Based Reliability Engineering			Semester: VIII			
Course:	Integrated Project			Code: HME8977			
Teaching Scheme				Evaluation Scheme			
Lecture	Practical	Hours	Credit	IE	TW	OR	Total
-	10	10	5	50	50	50	150

Prior knowledge of:

a. Basics of Mechanical Engineering
b. Statistical Methods for Reliability Modeling
c. Product Design for Reliability
d. Reliability Testing
e. Basics of suitable software packages used for the analysis of failure data. …….are essential

Course Objectives:

Students are expected to study,

1. Reliability and maintainability in product design and development processes.
2. Various activities are involved in the project and its planning to channelize the work.
3. Building, designing, analysis, and implementation of real-time applications using available platforms.

Course Outcomes:

The students will be able to,

1. Understand, plan, and execute a project based on an advanced topics on AI-ML based Reliability Engineering.
2. Design/ simulate a real-time application
3. Write a technical report based on the project.
4. Deliver technical seminars based on the project work carried out.
5. Understand publication and copyright process of research.

Guidelines: Total: 24 h (contact) + 72 h (non-contact/implementation)

1. A group of 3 to 4 students needs to design and demonstrate the project under the guidance of the allocated guide.
2. Students can choose the project considering their implementation in Major Project.
3. The hardware implementation and or software simulation is compulsory.
4. Project Report should be submitted in compliance with term work associated with the subject.
5. Paper publication associated with the project as research outcome is appreciable.
6. Project work preferably should be completed in the laboratory/ industry.

Detailed Syllabus

Sr. No.	Activity	Duration (H)
1	Semester VIII (week 1 & 2): Project guide allotment, Finalization of topic and platform, Planning of the work, Literature review, identifying a problem, and formulating the problem for the project	20
2	Semester VIII (week 3 & 4): Methodology finalization, finalizing project proposal, Review 1 for finalization of topic and specification.	20
3	Semester VIII (week 5 & 6): Simulation of Ideas on appropriate software tools and finalization of hardware platform	20
4	Semester VIII (week 7 & 8): Understanding platform implementation and related software flow and execute the block-level design, Review 2 to understand the progress of the project	20
5	Semester VIII (week 9 & 10): Project Report writing and publication or copyright planning and execution.	20
6	Semester VIII (week 11 & 12): Demonstration of Project work and Final Review for submission and term work compliances.	20
	Total	120