ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M.E. INDUSTRIAL SAFETY ENGINEERING

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES (PSOS)

PSO	Programme Specific Outcomes
PSO1	Apply principles of safety, risk analysis, and environmental management to design and implement effective industrial safety and health systems.
PSO2	Develop expertise in hazard identification, emergency response, and regulatory compliance to promote safe and sustainable industrial operations.

ANNA UNIVERSITY, CHENNAI

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E. Industrial Safety Engineering **Regulations:** 2025

Abbreviations:

BS– Basic Science (Mathematics)

ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**) & Emerging Technology (**ET**))

SD – Skill Development

SL – Self Learning

TCP – Total Contact Period(s)

L – Laboratory Course

T – Theory

LIT – Laboratory Integrated Theory

PW – Project Work

Semester I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	IS25101	Industrial Safety Management	T	3	0	0	3	3	ES (PC)
2.	IS25102	Industrial Safety, Health and Environment Acts	T	3	0	0	3	3	ES (PC)
3.	IS25103	Chemical Process Hazard and Risk Analysis	LIT	3	0	2	5	4	ES (PC)
4.	IS25104	Occupational Health and Industrial Hygiene	LIT	3	0	2	5	4	ES (PC)
5.	IS25105	Safety Audit	L	0	0	2	2	1	ES (PC)
6.	IS25106	Statistics and Probability for Safety and Risk Analysis	T	4	0	0	4	4	ES (PC)
7.	IS25107	Technical Seminar	-	0	0	2	2	1	SD
						Total	**24**	**20**	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	IS25201	Fire Engineering and Explosion Control	T	3	0	0	3	3	ES (PC)
2.	IS25202	Electrical Safety	T	3	0	0	3	3	ES (PC)
3.	IS25203	Safety in Process Industries	T	3	0	0	3	3	ES (PC)
4.		Programme Elective I	T	3	0	0	3	3	ES (PE)
5.	IS25204	System Simulation and Hazard Analysis	LIT	3	0	2	5	4	ES (PC)
6.	IS25205	Environmental Pollution and Control	LIT	3	0	2	5	4	ES (PC)
7.		Industry Oriented Course I	---	1	0	0	1	1	SD
8.		Self-Learning Course	---	-	-	-	-	1	-
						Total	**23**	**22**	

Semester III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	IS25301	Environmental and Social Governance	T	3	0	0	3	3	ES (PC)
2.		Programme Elective II	T	3	0	0	3	3	ES (PE)
3.		Programme Elective III	T	3	0	0	3	3	ES (PE)
4.		Programme Elective IV	T	3	0	0	3	3	ES (PE)
5.	IS25302	First Aid and Fire Fighting Training	L	0	0	2	2	1	ES (PC)
6.		Industry Oriented Course II	-	1	0	0	1	1	SD
7.	IS25303	Industrial Training	-	-	-	-	-	2	SD
8.	IS25304	Project Work I	-	0	0	12	12	6	SD
						Total	**27**	**22**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	IS25401	Project Work II	---	0	0	24	24	12	SD
						Total	**24**	**12**	

PROGRAMME ELECTIVE COURSES (PE)

S. No.	Course code	Course title	Periods Per Week			Total Contact Periods	Credits
			L	T	P		
1.	IS25001	International Safety Management System	3	0	0	3	3
2.	IS25002	Cybersecurity for Industrial Safety Systems	3	0	0	3	3
3.	IS25003	Asset Integrity and Reliability Engineering	3	0	0	3	3
4.	IS25004	Emergency Response and Disaster Management	3	0	0	3	3
5.	IS25005	ISO 45001 and ISO 14000	3	0	0	3	3
6.	IS25006	Human Factors Engineering and Ergonomics	3	0	0	3	3
7.	IS25007	Emerging Technologies in Safety	3	0	0	3	3
8.	IS25008	Safety in Construction	3	0	0	3	3
9.	IS25009	Safety in Oil and Gas	3	0	0	3	3
10.	IS25010	Behaviour-Based Safety	3	0	0	3	3
11.	IS25011	Optimization Techniques	3	0	0	3	3
12.	IS25012	Design of Experiments	3	0	0	3	3
13.	IS25013	Safety Economics and Cost-Benefit Analysis	3	0	0	3	3
14.	IS25014	Safety in Engineering Industries	3	0	0	3	3
15.	IS25015	Dock Safety	3	0	0	3	3

Semester I

IS25101	Industrial Safety Management	L	T	P	C
		3	0	0	3

Course Objectives:

- To provide foundational knowledge on the principles, history, and global evolution of industrial safety management systems.
- To develop skills for proactive planning, risk assessment, and systematic investigation of industrial accidents using contemporary tools and reporting methods.
- To enable learners to monitor, evaluate, and improve workplace safety performance using standardized metrics and audit methodologies.
- To foster capabilities in conducting safety training, promoting employee participation, and applying statistical techniques for safety data analysis and decision-making.

Fundamentals of Safety Management: Definitions and Evolution of Safety Management (India & Global); Elements of Industrial Safety; ILO Conventions and Country Ratifications; Overview of Modern Safety Concepts; Roles and Responsibilities: Safety Committee, Line & Staff Functions; Components of Safety Audit

Activity: Safety policy gap analysis based on ISO guidelines

Safety Planning and Risk Management: Planning for Productivity, Quality, and Safety; Budgeting for Safety; Hazard Identification and Risk Assessment Techniques; Safety Inspection, Sampling and Survey Methods; Performance Evaluation of Safety; Identification and Control of Unsafe Acts and Unsafe Conditions

Activity: Simulated hazard identification using a checklist

Accident Investigation and Prevention: Concepts of Reportable and Non-reportable Accidents; Statutory Reporting Procedures; Principles of Accident Prevention; Theories of Accident Causation; Incident Investigation Methodologies; Root Cause Analysis; Incident Cause Analysis Method (ICAM), Investigation Reporting Tools.

Activity: Case study analysis of a real-life industrial accident using Root Cause Analysis

Safety Performance Monitoring: Key Safety Metrics: Permanent/Partial Disabilities, Lost Time Injury, Frequency/Severity Rates; Near Miss Index, NCR, Safety Audit Reports; Safety Performance Indicators; Accident Trend Analysis; Safety Standards: IS 3786, ANSI Z16.1, OSHA Guidelines

Activity: Prepare a safety performance dashboard using sample data and suggest corrective measures

Safety Education, Training and Employee Participation: Identifying Training Needs: Safety Induction & Refresher; Training Methods: E-learning, Toolbox Talks, Simulations; Safety Motivation Tools; Worker Participation Programs; Suggestion Schemes and Competitions; Safety Campaigns; Performance Appraisal

Activity: Design a safety awareness campaign and conduct a mock training session with peer feedback

Data Analysis for Safety: Sampling Distributions; Hypothesis Testing, t-Test, F-Test, Chi-Square Test; Curve Fitting Techniques; Regression and Correlation, Simple, Multiple and Partial; Analysis of Variance (One-way and Two-way); Application of Statistical Tools in Safety Decisions

Activity: Use real or simulated safety incident data to perform hypothesis testing and regression analysis in Excel/SPSS

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Reese, C. D. (2016). Occupational health and safety management. CRC Press.
2. Neshuku, H. D. (2007). Industrial safety management. Jaico Publishing House.
3. Krishnan, N. V. (1997). Safety management in industry. Jaico Publishing House.
4. Bureau of Indian Standards. (n.d.). IS 3786: Method for computation of frequency and severity rates for industrial injuries. Bureau of Indian Standards.
5. Hughes, P., & Ferrett, E. (2020). Introduction to health and safety at work. Routledge.

E-Resources:

1. https://osha.gov/
2. https://ilo.org/
3. https://dgfasli.gov.in/
4. https://isafetytools.org/

	Description of CO	PO	PSO1	PSO2
CO1	Understand the principles, history, and evolution of industrial safety management systems, and apply them globally and locally in industry settings.	--	--	--
CO2	Develop skills for proactive safety planning, risk assessment, and systematic investigation of industrial accidents using contemporary tools and methods.	PO1 (3), PO2 (2)	3	3
CO3	Monitor and evaluate safety performance using standardized metrics and audit methodologies to improve workplace safety.	PO3 (2), PO2 (2)	2	3
CO4	Conduct safety training, promote employee participation, and apply statistical techniques for safety data analysis and decision-making.	PO2 (3), PO3 (2)	3	2

IS25102	Industrial Safety, Health and Environment Acts	L	T	P	C
		3	0	0	3

Course Objectives:

- To provide structured knowledge on Indian safety, health, and environmental regulations applicable to industries.
- To enable students to interpret and apply various provisions of the Factories Act, Environment Act, and associated rules.
- To introduce students to major rules governing hazardous materials, pressure vessels, and emergency planning.
- To expose students to globally relevant occupational health and safety standards and their impact on Indian industries.

Industrial Safety Framework and the Factories Act: Factories Act 1948: key definitions, safety, health & welfare provisions, Provisions for hazardous processes, penalties, employment conditions, Tamil Nadu Factories Rules 1950, overview, Tamil Nadu Safety Officer Rules 2005, appointment, duties, recent amendments

Activity:
Case Study: Apply Factories Act provisions to a real accident scenario.
Mock Compliance Audit: Prepare a checklist based on Section 41B and 41C.

Environmental Legislations and Waste Management Rules: Environment (Protection) Act 1986: objectives, powers, and scope, Air (Prevention & Control of Pollution) Act, 1981; Water (Prevention & Control of Pollution) Act, 1974; Noise Pollution (Regulation & Control) Rules, 2000; Biomedical Waste Rules, E-Waste Rules, Battery Waste Rules, Hazardous Waste Rules; Role of CPCB, SPCBs and obtaining statutory clearance (e.g., Consent to Operate)

Activity: Draft a pollution clearance application for a sample industry

Hazardous Substances, Process Safety & Specialized Rules: Manufacture, Storage, and Import of Hazardous Chemicals (MSIHC) Rules, 1989; Major Accident Hazard (MAH) Control Rules; Safety Reports, Notification Requirements, SDS, Onsite & Offsite Emergency Plans; Indian Boiler Act (Amendments), SMPV Rules, Gas Cylinder Rules; Petroleum Rules, Electricity Safety Provisions; Construction Workers Act (1996), Explosives Act (overview only)

Activity: Develop an emergency plan for a hazardous chemical scenario.

International Acts, Standards & Cross-Comparative Analysis: Occupational Safety & Health Act (OSHA, USA), HASAWA (UK); ISO 45001, ISO 14001, focus on legal conformity in safety and environment; NFPA (fire standards), OISD (oil industry safety), API Standards (overview); Role of ANSI and AERB in international benchmarking; Relevance and adaptation of global frameworks in Indian industries

Activity: Comparative Matrix: ISO 45001 vs OSHA, scope, penalties, audit systems.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. The Factories Act, 1948, Madras Book Agency.
2. The Environment (Protection) Act, 1986. (2020). Commercial Law Publishers.
3. Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India. MSIHC rules & hazardous waste rules.
4. Oil Industry Safety Directorate (OISD), American Petroleum Institute (API), & National Fire Protection Association (NFPA) OISD standards, API and NFPA guidelines (latest editions).
5. International Labour Organization (ILO) & International Organization for Standardization (ISO). ISO 45001 & ISO 14001 – Interpretation and implementation guides.

E-Resources:

1. https://labour.gov.in/ Ministry of Labour
2. https://cpcb.nic.in CPCB Waste Rules
3. https://osha.gov/ US OSHA etools
4. https://nfpa.org/ Fire Protection Codes
5. https://iso.org/ ISO 45001 & 14001 Codes

	Description of CO	PO	PSO1	PSO2
CO1	Understand the Indian safety, health, and environmental regulations and their application in industrial settings, particularly the Factories Act and Environment Protection Act.	--	--	--
CO2	Interpret and apply provisions of the Factories Act, Environment Act, and associated rules, focusing on hazardous materials and emergency planning.	PO3 (2), PO2 (2)	3	3
CO3	Develop an understanding of international safety and health standards (OSHA, ISO) and compare them with Indian standards, evaluating their impact on industry.	PO1 (3), PO3 (2)	2	3
CO4	Conduct safety audits and compliance checks based on legal provisions, and formulate risk management strategies in accordance with statutory regulations.	PO3 (2), PO2 (3)	3	3

IS25103	Chemical Process Hazard and Risk Analysis	L	T	P	C
		3	0	2	4

Course Objectives:

- To equip learners with analytical techniques to identify, evaluate, and mitigate hazards in industrial processes.
- To expose students to advanced mechanical and thermal hazard evaluation equipment.
- To enable learners to use tools and models for fault tree, event tree, and risk quantification.
- To impart competency in applying CPQRA techniques and real-time case evaluation using simulation software.

Fundamentals of Hazard Identification and Risk Assessment: Introduction to Hazards and Risks; Risk Monitoring; Risk Issues and Classifications; Hazard Assessment, Procedures and Methodologies; Safety Audit; Checklist Analysis; What-if Analysis; Safety Review; Preliminary Hazard Analysis (PHA); Hazard and Operability Study (HAZOP)

Activity: Perform a mock HAZOP study on a simplified process flow diagram (PFD) of a gas storage tank system.

Practical: Study and demonstration of fire extinguishers and a fire mock drill, including evacuation protocols.

Equipment Required:

- Fire Extinguishers (ABC, CO_2, Water, Foam types)
- Fire Drill Alarm System
- Evacuation Maps and Assembly Point Markers

Thermal and Mechanical Hazard Assessment: Applications of Advanced Equipment and Instruments: Thermo Calorimetry, Differential Scanning Calorimeter (DSC), Thermo Gravimetric Analyzer (TGA), Accelerated Rate Calorimeter (ARC); Principles of Operation, Controlling Parameters, Applications, and Advantages, Explosive Testing Techniques: Deflagration Test, Detonation Test, Ignition Test, Minimum Ignition Energy Test, BAM Friction and Impact Sensitivity Tests, Shock Sensitivity Test, Card Gap Test

Activity:
Interpret and compare sensitivity results of various chemicals using BAM test data and classify them based on reactivity index.

Practical:

- Measurement of friction sensitivity using BAM Friction Tester
- Measurement of impact sensitivity using BAM Fall Hammer
- Measurement of heat release using Bomb Calorimeter

Equipment Required:

- BAM Friction Tester
- BAM Fall Hammer
- Bomb Calorimeter

Risk Quantification Techniques: Fault Tree Analysis (FTA) and Event Tree Analysis (ETA), Logic Symbols and Gate Logic Representation, Methodology for FTA/ETA Development, Minimal Cut Set Ranking, Fire and Explosion Index (FEI), Fire and Toxicity Index (FETI), Hazard Analysis Techniques: HAZAN, Failure Mode and Effect Analysis (FMEA)

Activity:
Construct a fault tree for a hypothetical failure in a gas storage process and calculate its top event probability.

Practical:
• Measurement of flash point and fire point using Closed Cup Method
• Study and demonstration of smoke detection, alarm, and sprinkler system

Equipment Required:
• Pensky-Martens Closed Cup Tester
• Smoke Detection System and Sprinkler Demonstration Unit
• Fire Index Evaluation Charts

Chemical Process Quantitative Risk Analysis (CPQRA): CPQRA: Definition, Components, Techniques, Scope and Applications of CPQRA, Chemical Inventory Analysis, Estimation of Source Term, Gas/Vapour/Liquid Release, Two-phase Release, Heat Radiation, BLEVE, UVCE, Flash Fire, Toxic Effects, Plotting Damage Zones using Risk Software, Software Tools: ALOHA, MARPLOT, CAMEO

Activity:
Simulate a BLEVE scenario using ALOHA software and generate thermal radiation and toxicity dispersion maps.

Practical:
• Study of Fire Hydrant System and its components

Equipment Required:
• Fire Hydrant Model Trainer
• PC with ALOHA, CAMEO & MARPLOT Software
• BLEVE Simulation Case Sheets

Application of CPQRA: Consequence-Based and Frequency-Based CPQRA, Application of CPQRA to New and Existing Process Units, Intermediate Risk Characterization, Case Studies: Flixborough Disaster, Bhopal Gas Tragedy, Jaipur IOC Incident, Vizag Gas Leak, HPCL Refinery Fires, Application to Storage Terminals (LNG, Chlorine, Ammonia, Crude Oil)

Activity:
Perform a team-based case study presentation on the Jaipur IOC tank explosion and map the risk elements involved.

Practical:
• Measurement of earth resistance and ground resistivity using Wenner's method

Equipment Required:
- Earth Resistance Measurement Kit (Wenner Method)
- Case Study Documentation Boards
- Safety Engineering Reference Diagrams

Advanced Trends in Hazard Management: Internet of Things (IoT) in Hazard Detection and Monitoring, Real-time Leak and Temperature Monitoring via Sensors, Digital Twin Technology for Process Simulation and Risk Control, Environmental, Social, and Governance (ESG) Metrics for Safety, Predictive Analytics using AI/ML for Proactive Risk Alerts, Emerging Global Standards in Process Safety Performance Indicators

Activity:
Interpret sample real-time sensor data and generate alerts for a predictive fire risk management dashboard.

Practical:
- Study and demonstration of Personal Protective Equipment (PPE) used in high-risk process environments

Equipment Required:
- PPE Kit (Flame-retardant Suit, Helmet, Gloves, Respirator)
- IoT Sensors for Leak and Temp Detection (Demo Models)
- Predictive Dashboard Sheets (Sample Data)

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology and weightage:

Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Crowl, D. A., & Louvar, J. F. (2020). Chemical process safety: Fundamentals with applications (3rd ed.). Pearson.
2. Mannan, S. (2019). Lees' loss prevention in the process industries (Vols. 1–3). Elsevier.
3. Prabhakar, R. (2021). Process hazard analysis: A guide for engineers and managers. New Age International.
4. Khan, F. I. (2020). Green process engineering for sustainable chemical manufacturing. CRC Press.
5. Rao, C. S. (2018). Environmental pollution control engineering. New Age International.

E-Resources:

1. https://www.osha.gov – OSHA Technical Manuals
2. https://www.aiha.org – American Industrial Hygiene Association
3. https://cameochemicals.noaa.gov – CAMEO, ALOHA, MARPLOT
4. https://training.fema.gov – Fire Incident Command and Emergency Planning Modules

	Description of CO	PO	PSO1	PSO2
CO1	Understand and apply various hazard identification methodologies (PHA, HAZOP, safety audits) and risk assessment techniques in chemical processes, focusing on process safety management.	-	-	-
CO2	Analyze and quantify thermal, mechanical, and chemical hazards using advanced equipment (DSC, TGA, BAM) and process safety tools, including fault tree and event tree analysis (FTA/ETA).	PO3 (2), PO2 (3)	3	3
CO3	Utilize Chemical Process Quantitative Risk Analysis (CPQRA) techniques, including simulation tools (ALOHA, MARPLOT, CAMEO) for modeling, risk quantification, and mitigation strategies.	PO1 (3), PO3 (3)	3	3
CO4	Investigate real-world process safety incidents (e.g., Bhopal Gas Tragedy) and apply advanced technologies (IoT, AI/ML, digital twins) for proactive hazard monitoring and safety management.	PO3 (2), PO1 (3)	2	3

IS25104	Occupational Health and Industrial Hygiene	L	T	P	C
		3	0	2	4

Course Objectives:

- To provide in-depth knowledge of human physiology and the impact of occupational hazards on vital organs.
- To develop understanding of physical, chemical, biological, and ergonomic hazards in various work environments.
- To equip learners with competencies in occupational health surveillance, exposure evaluation, and mitigation strategies.
- To train students in practical assessment and instrumentation used in industrial hygiene and health monitoring.

Human Physiology and Occupational Pathology: Anatomy and Physiology of Lungs, Skin, Ear, and Eyes; Functions of Organs and Organ Systems; Effects of Hazards on Organs; Cardio-pulmonary Resuscitation; Audiometric Tests; Eye Tests; Vital Function Tests

Activity: Identify common organ-specific occupational diseases and create a hazard-organ impact chart

Practical: CPR demonstration and use of audiometry and vision screening instruments

Equipment Required:

- Audiometer (digital/manual)
- Vision Testing Chart (Snellen), Color Vision Plate

Physical Hazards and Industrial Noise: Noise – Components, Measurement, Sound Exposure Index, Hearing Conservation; OSHA & TLV Guidelines for Vibration, Ionizing & Non-Ionizing Radiation, Temperature Stress, Thermal Comfort, Wind Chill, Heat Index; Measurement Instruments and Calibration

Activity: Noise hazard zone mapping in a workshop layout

Practical:

- Measurement of Noise using Noise Level Meter
- Illumination using Lux Meter
- Vibration using Vibration Analyzer

Equipment Required:

- Sound Level Meter & Digital Lux Meter
- Hand-Arm/Whole-Body Vibration Analyzer

Chemical Hazards and Toxicology: Fumes, Mist, Vapour, Fog, Gases – Types and Toxicology; TLVs, Dose and Exposure Limits; Industrial Toxicology Basics; Comparison with OSHA Standards; Gas and Vapour Sampling; Measurement Procedures; Personal Sampling Techniques

Activity: Case study: Chemical exposure accident and hazard control breakdown

Practical:
Measurement of specific gas concentrations using Multi Gas Detector
Interpretation of Material Safety Data Sheets (MSDS)
Equipment Required:
Multi Gas Detector
MSDS samples
PPE samples for chemical handling (gloves, goggles, mask)

Biological and Ergonomic Hazards: Biohazard Classification – Bacteria, Fungi, Parasites, Viral Agents; COVID, SARS, Animal Care Hazards; Ergonomic Hazards – Musculoskeletal Disorders, CTS, Neck/Back Injuries; Laboratory & Animal Handling Programs

Activity: Ergonomic risk factor identification using photos and video samples

Practical:

- WBIT Testing for back strength
- Evaluation of working posture using RULA/REBA

Equipment Required:

- WBIT Tester or Manual Back Strength Tester
- Ergonomic Evaluation Forms (RULA/REBA templates)
- Adjustable chairs demo setup

Occupational Health Surveillance and Services: Occupational Health Units; Role of Health Examinations; Chronic Occupational Diseases (e.g., Pneumoconiosis, Siderosis, Anthracosis); Evaluation of Physiological Parameters – Shift Work, Fatigue, Stress, Personal Hygiene

Activity: Design a health surveillance plan for a specific industry (e.g., cement plant)

Practical:

- Measurement of Heart Rate using Pulse Oximeter
- Use of Questionnaire-based Stress Analysis Tool

Equipment Required:

- Pulse Oximeter (finger-type)
- Blood Pressure Monitor
- Standardized Stress Assessment Questionnaire
- Graph paper or software for stress trend plotting

Applied Occupational Toxicology and Exposure Evaluation: Sampling Strategies; Sample Collection Methods; Biological Monitoring; Indoor and Ambient Exposure; Threshold Effects; TLVs and Dose-Response; Measurement Considerations; System Toxicity Parameters; Work Capacity and Aerobic Tests

Activity: Create a sampling plan for chemical exposure in a paint industry

Practical:

- Dust Sampling using High Volume Sampler
- Toxicology Case Interpretation from Lab Report Data

Equipment Required:

- High Volume Air Sampler with filter papers
- Digital Flow Meter
- Particulate Filters & Sample Bags
- Laptop/software for plotting exposure trend lines

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology:

Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Plog, B. A., & Quinlan, P. J. (2021). Fundamentals of industrial hygiene (6th ed.). National Safety Council.
2. Reese, C. D. (2016). Occupational health and safety management. CRC Press.
3. Burgess, W. A. (2020). Recognition of health hazards in industry: A review of materials and processes. Wiley-Interscience.
4. Stricoff, R. S., & Walters, D. B. (2022). Industrial hygiene workbook: A practical guide. AIHA Press.
5. Krishnan, N. V. (1997). Safety management in industry. Jaico Publishing House.

E-Resources:

1. https://www.osha.gov
2. https://www.cdc.gov/niosh
3. https://www.ilo.org/
4. https://www.bis.gov.in/
5. https://openwho.org/

	Description of CO	PO	PSO1	PSO2
CO1	Understand the impact of occupational hazards on human physiology (lungs, skin, ears, eyes).	-	-	-
CO2	Evaluate and assess physical hazards (noise, vibration, thermal stress) using relevant measurement techniques.	PO3 (2), PO1 (3)	3	3
CO3	Apply toxicology principles to assess chemical hazards and use MSDS for safety.	PO1 (3), PO2 (3)	3	3
CO4:	Identify biological and ergonomic hazards and apply mitigation strategies like ergonomic evaluations.	PO3 (2), PO2 (3)	3	3

IS25105	Safety Audit	L	T	P	C
		0	0	2	1

Course Objectives:

- To Inculcate the Industrial Safety Environment to the students
- To Explore the Human Capital Management and Hazardous System

Description of The Course

- The students are expected to make a presentation on the state of Safety Audit from the observation from the Industry Safety Department.
- A faculty guide is to be allotted and the student will visit the industry to aware about the Importance of the Safety.
- Students are encouraged to prepare the Safety System Guidelines from your observation period of Inspection from the Industry Safety Department and contribute the same to the Environment Contribution.
- The students are advised to go through the below mentioned following heads of safety Measures to be audit and inspect at the time of visit. Depending on the requirements of the organizations, the audit can focus attention on the following aspects of a safety system and make sure that your level of expertise in the safety system.

Every safety audit as per 'The Code of Practice' on Occupational Safety & Health 'Indian Standard 14489:2018, ISO 45001:2018, EMS- ISO 14001:2015, NBC:2016 and other national and international standard applicable to each particular industry.

• Safety Management systems.

• Fire and Explosion prevention, protection and emergency management.

• Work injury prevention.

• Health hazards control.

• Evaluating emergency plan.

• First aid practices

• Management of health and safety

• Accidents and accident reporting

• Asbestos • Contractors

• Display screen equipment

• Electrical safety

• Emergency lighting

• Environmental protection

• Fire prevention and emergencies

• Hazardous substances

• Housekeeping and cleanliness

• Information and communication

• Kitchens, catering and food safety

• Lifts and lifting equipment

• Manual handling operations

• Noise

• Occupational health

• Personal protective equipment

• Plant rooms, machinery and equipment

• Risk assessment requirements

• Safety Policy

• Safety signs and notices

• Training

• Use of vehicles / vehicle safety

• Water services

• Welfare provision

• Working time

• Work at heights

• Workplace environment

• Accident prevention

• Identifying and correcting Regulatory Deficiencies

• Improvement of Employee Morale

• Identification and Elimination of Safety Hazards

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

	Description of Co	PO	PSO1	PSO2
CO1	Conduct safety audits based on ISO standards and assess the effectiveness of safety management systems.	PO1 (3), PO2 (2)	3	3
CO2	Manage industrial safety aspects such as fire/explosion prevention, emergency management, and health hazards.	PO1 (3), PO2 (3)	3	3
CO3	Audit environmental protection measures, including waste management and compliance with regulations.	PO1 (3), PO2 (3)	3	3
CO4	Prepare and present safety audit reports, identifying deficiencies and suggesting improvements.	PO2 (3), PO3 (2)	3	3

IS25106	Statistics and Probability for Safety and Risk Analysis	L	T	P	C
		4	0	0	4

Course Objectives:

- To introduce statistical and probabilistic tools applicable to safety and reliability engineering.
- To provide knowledge of distribution models for analyzing accident, failure, and hazard data.
- To apply hypothesis testing, correlation, and regression analysis for safety decision-making.
- To apply statistical design and time-series techniques to evaluate safety interventions and predict risks.

Probability Theory and Safety Fundamentals: Axioms and rules of probability, Conditional probability and independence, Bayes' theorem and its use in fault identification, Types of variables: discrete and continuous, Safety-related data: definitions, structure, examples.

Activity: Mini case analysis: Apply Bayes' Theorem to diagnose root cause probabilities.

Probability Distributions for Risk and Failure Modeling: Discrete distributions: Binomial, Poisson & Geometric; Continuous distributions: Normal, Exponential, Gamma & Weibull**;** Mean, variance, skewness, kurtosis**;** Applications in failure rate analysis and accident probability estimation

Activity: Think-pair-share: Identify appropriate distributions for different safety scenarios

Estimation and Regression Techniques in Safety: Point estimation and properties (unbiasedness, consistency, efficiency), Maximum Likelihood Estimation (MLE), Method of Moments, Simple Linear Regression and Multiple Regression, Safety metric modeling: injury frequency, exposure duration, etc.

Activity*:* Regression interpretation: Analyze regression output from historical accident database

Hypothesis Testing for Safety Decisions: Sampling distributions (mean, variance, proportion), *Z*, *t*, Chi-square, and *F* tests, Goodness-of-fit tests for safety data, Application examples: comparing accident rates before/after intervention, Use of p-values and confidence levels

Activity: PPE policy evaluation: Group-based statistical validation of before/after accident rates

Statistical Design of Experiments for Safety Interventions: Analysis of Variance (ANOVA): One-way and Two-way, Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design, Full Factorial Design (2^2, 2^3), Applications: assessing effect of lighting, noise, PPE type on human error

Activity: Analyze safety test outcomes using ANOVA framework.

Time Series Analysis and System Reliability: Time Series: trend, seasonality, cyclicity; Moving average, exponential smoothing methods; Introduction to Autoregressive (AR) models, Reliability concepts: MTBF, failure rate, hazard function, Reliability of series and parallel systems

Activity: Plot & forecast: Analyze 5-year accident trend data and apply smoothing

Weightage:

Continuous Assessment: 60%
End Semester Examinations: 40%

Assessment Methodology:

Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Montgomery, D. C., & Runger, G. C. (2020). *Applied statistics and probability for engineers* (7th ed.). Wiley.
2. Ross, S. M. (2021). *Introduction to probability and statistics for engineers and scientists* (6th ed.). Academic Press.
3. Modarres, M. (2006). *Risk analysis in engineering: Techniques, tools, and trends*. CRC Press.
4. Antony, J. (2014). *Design of experiments for engineers and scientists* (2nd ed.). Elsevier.
5. Stephans, R. A. (2004). *System safety for the 21st century*. Wiley.

E-Resources:

1. https://nptel.ac.in/courses/111105041
2. https://reliability.readthedocs.io/en/latest/
3. https://www.itl.nist.gov/div898/handbook/
4. https://www.osha.gov/data

	Description of CO	PO	PSO1	PSO2
CO1	Understand the principles, history, and evolution of industrial safety management systems, and apply them globally and locally in industry settings.	PO1 (3), PO3 (2)	3	2
CO2	Develop skills for proactive safety planning, risk assessment, and systematic investigation of industrial accidents using contemporary tools and methods.	PO1 (3), PO2 (2)	3	3
CO3	Monitor and evaluate safety performance using standardized metrics and audit methodologies to improve workplace safety.	PO3 (2), PO2 (2)	2	3
CO4	Conduct safety training, promote employee participation, and apply statistical techniques for safety data analysis and decision-making.	PO2 (3), PO3 (2)	3	2

Semester II

IS25201	Fire Engineering and Explosion Control	L	T	P	C
		3	0	0	3

Course Objectives:

- To provide fundamental knowledge on the physics and chemistry of fire, including properties of combustible materials and mechanisms of combustion and explosion.
- To impart understanding of various fire prevention, protection, and suppression systems used in industries and buildings for effective fire safety management.
- To develop the ability to analyse explosion protection methods and real-world fire and explosion case studies**,** enabling students to apply hazard prevention strategies in industrial practices.

Physics and Chemistry of Fire

Fire properties, solids, liquids, gases, combustion theory, explosion, vapour clouds, flash fire, jet fire, pool fire, auto-ignition, shock waves.

Activities*:* Conduct a quiz on combustion and fire properties and prepare a 3D model of fire triangle and tetrahedron

Physics and Chemistry of Fire – Part II

UVCE, BLEVE, Flixborough, Mexico disaster, Pasedena Texas, Piper Alpha, Bombay dock explosion, Mahul refinery explosion, Nagothane explosion, Vizag refinery disaster, fire accidents, industrial disasters.

Activities*:* Submit an assignment report on a major fire or explosion disaster and present a poster summarising industrial fire disasters

Fire Prevention and Protection

Ignition sources, fire triangle, fire tetrahedron, extinguishing principles, fire classes A B C D E, water, foam, DCP, CO_2, halon alternatives, extinguishers, hydrants, hoses, monitors, alarms, escape, rescue, first aid.

Activities*:* Watch a virtual demonstration of fire extinguishers and their use and conduct a quiz on classes of fire and extinguishing agents.

Industrial Fire Protection Systems

Sprinklers, hydrants, stand pipes, deluge systems, emulsifiers, selection criteria, maintenance, alarm systems, detection systems, CO_2 system, foam system, DCP system, halon system, halon replacement, smoke venting, inflammability index, tank farms, firefighting systems

Activities*:* Deliver a seminar on special suppression systems and prepare a model of an industrial sprinkler system layout.

Building Fire Safety

Fire-safe design, fire load, fire resistance, fire testing, structural protection, structural integrity, egress design, exit width, fire certificates, high-rise safety

Activities*:* Complete an assignment calculating exit width with egress layout design and watch a virtual demonstration on fire drills and evacuation.

Explosion Protection Systems

Explosion principles, detonation, blast waves, explosion parameters, containment, flame arrestors, isolation, suppression, venting, explosion relief, inert gases, rupture disc, CO_2 suppression, halon suppression, LPG hazards, ammonia hazards.

Activities*:* Present a poster on explosion protection methods and conduct a quiz on flame arrestors, rupture discs, and CO_2 suppression**.**

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Quiz - 10%, Assignments - 20%
Virtual Demonstration - 20%, Internal Examinations - 50%

References:

1. “Fire safety management”, 3rd edition – Danial E.DellaGiustina – 2014.
2. “Manual of fire safety “, N.Seghaprakash – 2011.
3. “A hand book of fire technology”, R. S. Gupta – 2010.
4. “Dust explosion and fire prevention handbook”, Nicholas P. Cheremisinoff – 2014.
5. “Industrial Fire Protection Handbook”, R.CraigSchrool – 2002.

E-Resources:

1. https://www.nfpa.org/Codes-and-Standards/All-Codes-and-Standards/List-of-Codes-and-Standards
2. https://www.osha.gov/etools/evacuation-plans-procedures
3. https://www.csb.gov/videos/
4. https://www.sfpe.org/publications/sfpehandbook

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain the physics and chemistry of fire, combustion, and explosion mechanisms	PO1 (2), PO3 (1)	2	1
CO2	Apply fire prevention, protection, and suppression techniques in industrial settings	PO1 (3), PO2 (3), PO3 (2)	3	2
CO3	Estimate parameters for explosion protection and assess hazards in industrial processes	PO1 (3), PO2 (3), PO3 (2)	3	2
CO4	Analyze real-world fire and explosion case studies and evaluate safety systems	PO1 (3), PO2 (3), PO3 (3), PO4 (2)	3	2

IS25202	Electrical Safety	L	T	P	C
		3	0	0	3

Course Objectives:

- To provide fundamental knowledge of basic electrical concepts, equipment, and standards relevant to electrical safety in industrial and domestic environments.
- To enable students to identify and analyse electrical hazards and implement appropriate protection, maintenance, and first aid measures to ensure safe operation.
- To develop understanding of hazardous area classifications and statutory requirements for the selection and installation of electrical equipment in compliance with national and international safety standards.

Basic Electrical Concepts and First Aid

Electrical concepts, electrostatics, electromagnetism, stored energy, electrical equipment, supply system, first aid, CPR.

Activities: Conduct a quiz on basic electrical concepts, electrostatics, and electromagnetism, and watch a virtual demonstration video on CPR and first aid for electrical shock victims

Electrical Standards and Statutory Requirements

Indian electricity act, statutory requirements, electrical inspectorate, international standards, electrical safety standards.

Activities: Prepare an assignment comparing Indian Electricity Acts with international standards**,** and deliver a seminar on statutory requirements from the Electrical Inspectorate**.**

Electrical Hazards – Part I

Electrical hazards, shocks, burns, insulation, current surges, fire, explosion, safety code, energy leakage.

Activities: Conduct a quiz on types of electrical hazards and safety codes, and present a poster on causes of electrical fires and explosions with preventive measures**.**

Electrical Hazards – Part II

Human resistance, electrical shock protection, PPE, static electricity, spark, arc, ignition, lightning, earthing.

Activities: Watch a virtual demonstration on earthing, lightning arrestors, and static electricity control, and submit an assignment on PPE requirements and human resistance to electricity.

Electrical Protection Systems and Maintenance

Electrical protection, preventive maintenance, fuses, circuit breakers, overload protection, earthing, grounding, ELCB, PPE, lock out

Activities: Prepare a model of a circuit breaker or fuse box layout, and conduct a quiz on ELCB, grounding systems, overload protection, and lockout procedures**..**

Hazardous Area Classification

Hazardous areas, electrical equipment classification, IS standards, NFPA, API, OSHA, temperature classification, gas grouping, barriers, isolators.

Activities: Deliver a seminar on hazardous area classification as per IS, NFPA, API, OSHA standards**,** and present a poster on temperature classification, gas grouping, and equipment selection for hazardous zones**.**

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (20%), Virtual demonstration (10%), Review of GATE & IES questions.

Assessment Methodology:

Quiz - 20%, Assignments - 20%, Virtual Demonstration - 10%
Internal Examinations - 50%

References:

1. “Electrician Theory”, 2018.
2. “Electrical safety handbook”, John Cadick, Mary Capelli-Schellpfeffer – 2012.
3. Electrical Safety: A Guide to the Causes and Prevention of Electric Hazards, Mohamed A. El-Sharkawi

E-Resources:

1. https://www.nfpa.org/education-and-research/research/electrical-safety
2. https://www.esfi.org/workplace-safety/
3. https://nptel.ac.in/courses/112107088

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain basic electrical concepts, electrostatics, electromagnetism, and first aid	PO1 (2), PO3 (1)	2	1
CO2	Apply electrical safety standards, statutory requirements, and first aid procedures	PO1 (3), PO2 (3), PO3 (2)	3	2
CO3	Estimate risks and protective measures for electrical hazards and human safety	PO1 (3), PO2 (3), PO3 (2)	3	2
CO4	Analyze electrical protection systems, hazardous area classifications, and maintenance	PO1 (3), PO2 (3), PO3 (3), PO4 (2)	3	2

IS25203	Safety in Process Industries	L	T	P	C
		3	0	0	3

Course Objectives:

- To provide fundamental knowledge on process design principles, pressure system design, and reactor safety applicable in chemical industries.
- To enable students to understand and analyse plant operations, maintenance, commissioning, and emergency planning for ensuring safe and efficient industrial practices.
- To develop the ability to evaluate storage systems and hazard assessments for various chemicals and gases, ensuring compliance with safety standards and environmental regulations.

Safety in Process Design – Part I

Process design, conceptual design, detailed design, inherently safer design, chemical reactors, batch reactors, reaction hazards, reactor safety, unit operations, utilities.

Activities: Quiz on process design concepts and reactor safety. Assignment evaluating reaction hazards in chemical processes.

Safety in Process Design – Part II

Pressure systems, vessel design, standards, pipes, valves, heat exchangers, machinery, overpressure protection, relief devices, flare, vent, pressure failures.

Activities: Seminar on pressure vessel design and relief devices. Poster presentation on flare and vent systems with failure cases.

Plant Commissioning and Inspection

Pressure systems, vessel design, standards, pipes, valves, heat exchangers, machinery, overpressure protection, relief devices, flare, vent, pressure failures.

Activities: Assignment on commissioning phases and documentation. Virtual demonstration on non-destructive testing and pipeline inspection.

Plant Operations

Operating discipline, procedures, inspection, emergency, permit system, start-up, shutdown, refinery operations, fired heaters, dryers, storage hazards, trip systems.

Activities: Quiz on operating procedures and emergency systems. Assignment on start-up, shutdown operations, and refinery hazards.

Plant Maintenance, Modification, and Emergency Planning

Maintenance management, isolation, purging, cleaning, confined space, permit

system, hot works, tank cleaning, repairs, plant modification, emergency planning, disaster, APELL.

Activities: Seminar on maintenance preparation and confined space safety**.** Poster presentation on plant modification controls and emergency planning.

Storages and Storage Safety

Storage safety, petroleum storage, tank layout, containment, venting, flame arrestors, LPG, LNG, hydrogen, toxic storages, ammonia, chlorine, underground storage, hazard assessment.

Activities: Quiz on storage layouts, venting systems, and fire safety. Assignment assessing LPG and LNG storage hazards and layouts.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (20%), Virtual demonstration (10%), Review of GATE & IES questions.

Assessment Methodology:

Quiz - 20%
Assignments - 20%
Virtual Demonstration - 10%
Internal Examinations - 50%

References:

1. “Accident Prevention Manual for Industrial Operations” NSC, Chicago, 1982.
2. “Quantitative Risk Assessment in Chemical Process Industries” American Institute of Chemical Industries, Centre for Chemical Process safety.
3. Carbide of Calcium Rules, Government of India.
4. Fawcett, H.h. and Wood, “Safety and Accident Prevention in Chemical Operations” Wiley inters, Second Edition.
5. GREEN, A.E., “High Risk Safety Technology”, John Wiley and Sons,. 1984.
6. Lees, F.P. “Loss Prevention in Process Industries” Butterworths and Company, 1996
7. Petroleum Act and Rules, Government of India.

E-Resources:

1. https://www.nfpa.org/education-and-research/research/fire-protection-research-foundation/projects-reports-storage-tanks
2. https://www.api.org/products-and-services/standards/important-standards-announcements

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain concepts of process design, inherently safer design, and unit operation hazards	PO1 (2), PO3 (1)	2	1
CO2	Apply safety standards for pressure systems, vessels, valves, relief devices, and plant commissioning	PO1 (3), PO2 (3), PO3 (2)	3	2
CO3	Estimate operational and storage hazards in plant operations, emergency planning, and maintenance	PO1 (3), PO2 (3), PO3 (3), PO4 (2)	3	2
CO4	Analyze plant safety systems, modification risks, storage layouts, and emergency strategies	PO1 (3), PO2 (3), PO3 (3), PO4 (2)	3	2

IS25204	System Simulation and Hazard Analysis	L	T	P	C
		3	0	2	4

Course Objectives:

- To provide fundamental knowledge on hazard identification, risk assessment techniques, and consequence analysis in process industries.
- To develop skills in using advanced instruments, explosive testing methods, and environmental measurements for effective hazard evaluation and control.
- To enable students to analyse past industrial accidents and apply risk quantification and safety management practices for preventing future incidents.

Hazard and Risk Assessment Fundamentals

Hazard, risk, societal risk, individual risk, voluntary risk, involuntary risk, technological risk, risk acceptance, risk estimation.

Activities: Quiz on hazard and risk concepts; Assignment on voluntary vs. involuntary risk analysis.

Practical: First aid study with PPE demonstration covering helmets, gloves, goggles, and safety kits.

Hazard Assessment Procedures and Techniques

Hazard assessment, safety audit, checklist analysis, what-if analysis, safety review, PHA, human error, HAZOP, warning systems.

Activities: Seminar on hazard assessment techniques; Poster presentation on HAZOP procedures.

Practical: Measurement of noise levels and environmental parameters including temperature, humidity, and illumination

Computer-Aided Instruments and Explosive Testing

Calorimetry, DSC, TGA, ARC, RC, RSST, explosive testing, deflagration, detonation, ignition test, sensitiveness tests, card gap test

Activities: Assignment on calorimetric instrument applications; Quiz on explosive testing methods.

Practical: Friction and impact testing of explosive materials with burst strength and auto ignition temperature tests.

Risk Analysis Quantification and Software Applications

Risk analysis, simulation, FTA, ETA, minimal cut set, FETI, HAZAN, FMEA, reliability, CISCON, HAMGARS, risk software.

Activities: Seminar on FTA, ETA, and FMEA methodologies; Poster on risk analysis software modules.

Practical: Exhaust gas analysis for SOx, NOx, COx, hydrocarbons, and air sampling with particle size measurement.

Consequence Analysis

Consequence analysis, chemical inventory, source term, BLEVE, pool fire, jet fire, dispersion, UVCE, flash fire, explosion effects, toxic effects.

Activities: Assignment on consequence analysis estimation methods; Quiz on chemical hazard identification.

Practical: Static charge testing on various materials and fire extinguisher operation for different fire types.

Credibility of Risk Assessment and Case Studies

Past accidents, case studies, Mexico, Flixborough, Bhopal, Seveso, Pasadena, Feyzin, Port Hudson, Rijnmond, Rasmussen, reactor safety.

Activities: Seminar on major industrial accident case studies; Poster on lessons learned from disasters.

Practical : Electrical safety tests including insulation resistance, earth resistance, continuity, and protection device sensitivity tests

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Mandated Activities:

Assignments, Quizzes, Presentation/Seminar, Realtime case simulation, Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Practical Lab-Work & Record	30%
Practical Examination & Viva voce	20%
Internal Examinations	50%

References:

1. Brown, D.B. System analysis and Design for safety, Prentice Hall, 1976.
2. Course Material Intensive Training Programme on Consequence Analysis, by Process Safety Centre, Indian Institute of Chemical Technology, Tarnaka and CLRI, Chennai.
3. Guidelines for Hazard Evaluation Procedures, Centre for Chemical Process safety, AICHE 1992
4. Hazop and Hazom, by Trevor A Klett, Institute of Chemical Engineering.
5. ILO- Major Hazard control- A practical Manual, ILO, Geneva, 1988.
6. Loss Prevention in Process Industries-Frank P. Less Butterworth-Hein UK 1990 (Vol.I, II and III)
7. Methodologies for Risk and Safety Assessment in Chemical Process Industries, Common wealth Science Council, UK
8. Quantitative Risk assessment in Chemical Industries, Institute of Chemical Industries, Centre for Chemical process safety.

E-Resources:

1. https://www.osha.gov/process-safety-management
2. https://www.aiche.org/ccps/resources/publications/books
3. https://www.hse.gov.uk/risk/index.htm

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain fundamental concepts of hazard, risk, societal vs. individual risks, and risk acceptance	PO1 (2), PO3 (1)	2	1
CO2	Apply hazard assessment procedures and techniques including HAZOP, PHA, safety audits, and human error analysis	PO1 (3), PO2 (3), PO3 (2)	3	2
CO3	Estimate risk using consequence analysis, FTA, ETA, FMEA, simulation, and risk software applications	PO1 (3), PO2 (3), PO4 (2)	3	2
CO4	Analyze industrial accident case studies, credibility of risk assessment, and implement safety measures	PO1 (3), PO3 (3), PO4 (2),	3	2

IS25205	Environmental Pollution and Control	L	T	P	C
		3	0	2	4

Course Objectives:

- To impart fundamental knowledge on various types of environmental pollution including air, water, and solid waste, along with their sources, effects, and control methods.
- To develop skills in measurement, analysis, and treatment techniques for pollutants using modern instruments and environmental monitoring methods.
- To familiarise students with environmental acts, rules, and pollution control strategies applicable to process industries for ensuring sustainable and compliant operations.

Air Pollution and Its Impact

Air pollutants, pollution sources, health effects, automobile pollution, clean coal, UV radiation, ozone depletion, deforestation, stack emissions, CFC, ambient air quality

Activities*:* Quiz on air pollutant classification and effects; Assignment on UV radiation and ozone depletion impacts.

Practical: Measurement of particulate and gaseous pollutants in the ambient air using High Volume Sampler.

Water Pollution and Treatment

Water pollutants, health hazards, sampling, water treatment, industrial effluents, advanced treatment, marine pollution, underwater pollution.

Activities*:* Seminar on water treatment technologies; Poster on water pollutant sampling and analysis techniques.

Practical: Measurement of moisture and temperature using Relative Humidity Meter.

Solid Waste Management

Solid waste, collection, disposal, health hazards, toxic waste, radioactive waste, incineration, recycling, hazardous waste, treatment options.

Activities*:* Assignment on hazardous waste management practices; Quiz on solid waste disposal methods and health hazards

Practical: Gaseous pollutants sampler for indoor/outdoor air quality monitoring.

Environmental Measurement and Control Techniques

Sampling, dust monitor, gas analyzer, particle size, lux meter, pH meter, GC, AAS, control equipment, scrubbers, precipitators, bag filters, gaseous emission control.

Activities*:* Seminar on environmental measurement instruments; Poster on pollution control equipment like scrubbers and precipitators.

Practical: Measurement of speed or velocity of air using Anemometer.

Environmental Acts and Rules

Environment Act, Water Act, Air Act, Hazardous Waste Rules, Bio-Medical Waste, ODS Rules, Batteries Rules, Noise Pollution, E-Waste Rules, Public Liability, EIA.

Activities*:* Assignment on key environmental acts and rules; Quiz on hazardous waste, e-waste, and noise pollution regulations.

Practical: (Study Experiment): Conduct a case study analysis of an industry's compliance with environmental acts and rules, preparing a report on how the Environment (Protection) Act, Water Act, and Air Act are implemented in their operations.

Pollution Control in Process Industries

Pollution control, cement industry, paper industry, petroleum products, textile, tanneries, thermal power, dyeing, pigments, eco-friendly energy.

Activities*:* Seminar on pollution control in process industries; Poster on eco-friendly energy alternatives for pollution reduction.

Practical : Measurement of Exhaust gas emission using Exhaust Gas Analyzer.

Weightage:
Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology:

Component	Weightage
Practical Lab-Work & Record	30%
Practical Examination & Viva voce	20%
Internal Examinations	50%

E-Resources:
1. Municipal Solid Waste Management - Course
2. https://onlinecourses.nptel.ac.in/noc25_ge17/preview?utm_source=chatgpt.com
3. Basic Environmental Engineering and Pollution Abatement - Course

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain air, water, and solid waste pollutants, sources, and their environmental and health impacts	PO1 (2), PO2 (1)	2	1
CO2	Apply measurement and monitoring techniques for air, water, and solid waste pollution using instruments and practical methods	PO2 (2), PO3 (2)	2	2
CO3	Estimate pollution load, efficiency of control devices, and treatment effectiveness in process industries	PO2 (3), PO4 (2)	3	2
CO4	Analyze environmental compliance with acts, rules, and industrial pollution control methods; recommend improvements	PO3 (3)	3	2

Semester III

IS25301	Environmental and Social Governance	L	T	P	C
		3	0	0	3

Course Objectives:

- To promote sustainable and responsible business practices considering social, environmental, and governance impacts.
- To evaluate ESG investment frameworks and decision-making criteria across sectors.
- To understand interconnections between market, environmental, and social factors in ESG implementation.
- To analyze ESG valuation and integration in financial and non-financial performance strategies.

ESG Foundations and Responsible Investing

Responsible investment; ESG vs. sustainable/socially responsible investments; Strengths and limitations of ESG frameworks; CSR and triple bottom line (TBL); ESG in decision-making; Benefits and challenges of ESG integration; ESG demonstrations in real-world investment processes.

Activity: Case study analysis of ESG disclosures by companies in sectors like energy, pharmaceuticals, or IT.

ESG Markets and Environmental Risk Factors

ESG market trends by geography, investor types, and asset classes; Role of regulations and policy; Investor demand and awareness; Environmental metrics and indicators – GHG emissions, water usage, energy efficiency, pollution, and waste; Climate risk adaptation and environmental impact assessments.

Activity: Analyze ESG scores of three companies using publicly available ESG rating data (e.g., CDP, MSCI, S&P ESG).

Social Impact, Inclusion, and Risk Factors

Social risk factors – labor, wages, DEI, occupational health and safety, community development; Impact of digitization and AI on social equity; Demographics, religion, culture, education, urbanization; Changing family structures; Social license to operate; Human rights and ethical sourcing in supply chains.

Activity: Role-play exercise: stakeholder negotiation on a factory's social compliance and community impact.

Corporate Governance and Ethical Accountability

Corporate governance principles; Board diversity, executive pay, shareholder rights; Ethics and compliance; Governance rating models; Roles and responsibilities of boards and committees; Corporate disclosures and transparency; Country-specific variations in governance practices.

Activity: Evaluate governance and board effectiveness using recent annual reports of Indian and international firms.

ESG Integration, Valuation, and Strategy Design

ESG integration strategies – screening, best-in-class, thematic investing, impact investing; Materiality mapping and ESG risk scoring; ESG indices and third-party evaluation tools; Designing ESG reports and implementation strategies; ESG valuation across asset classes.

Activity: Design an ESG strategy and reporting framework for a hypothetical SME in the manufacturing sector.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (10%), Quiz (10%), ESG Report Evaluation (15%), ESG Strategy Group Assignment (15%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	10%
Quizzes	10%
ESG Report Evaluation	15%
ESG Strategy Group Assignment	15%
Internal Examinations	50%

References:

1. John Hill, *Environmental, Social, and Governance (ESG) Investing: A Balanced Analysis of the Theory and Practice*, Academic Press, 2020.
2. Herman Bril, Georg Kell, *Sustainable Investing: A Path to a New Horizon*, Routledge, 2022.
3. Tensie Whelan, Carly Fink, *ESG and Financial Performance*, Harvard Business Review, 2020.
4. Jan Emblemsvåg, *Life-Cycle Thinking and Environmental Decision Making*, Springer, 2022.
5. Mervyn King & Leigh Roberts, *The Integrated Reporting Movement*, Wiley, 2016.

E-Resources:

1. https://www.msci.com/our-solutions/esg-investing
2. https://sasb.ifrs.org/
3. https://www.globalreporting.org/
4. https://www.cdp.net/en

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain ESG principles, responsible investing concepts, and triple bottom line frameworks	PO1 (2), PO3 (1)	2	1
CO2	Apply ESG evaluation metrics and frameworks to analyze environmental, social, and governance factors	PO2 (2), PO3 (2), PO5 (2)	2	2
CO3	Estimate ESG risk exposure, ratings, and integration impact on investment and business performance	PO2 (3), PO4 (2)	3	2
CO4	Analyze ESG integration strategies, valuation methods, and design ESG reporting frameworks for organizations	PO3 (3), PO4 (2), PO5 (2)	3	2

IS25302	First Aid and Fire Fighting Training	L	T	P	C
		0	0	2	1

Course Objectives:

- To equip students with life-saving first aid and CPR skills.
- To train learners in practical fire safety, evacuation techniques, and emergency preparedness.
- To ensure students can confidently operate fire extinguishers and basic rescue tools.
- To foster individual readiness in industrial and public safety scenarios.

First Aid Training

- Understanding basic principles of first aid
- Understanding the terminology, positioning, basic anatomy and physiology of the human body
- Being prepared at the workplace for patient and emergency scene assessment
- Treating life-threatening as well as common injuries using first aid principles
- Applying cardiopulmonary resuscitation (CPR) and choking procedures
- Treating bleeding, wounds as well as burns
- Treating head, spinal, chest, abdominal, pelvic, as well as fractures injuries
- Applying medical emergencies and shock management
- Applying emergency carry methods

Fire Fighting Training:

- Understand the pillars of a fire
- Identifying the type of fire
- Identify the type of mitigating measure for the type of fire
- To identify a usable fire extinguisher
- How to apply a fire extinguisher
- How to assist a burning victim
- Treatment of burn wounds
- Treatment of shock
- Evacuation procedure
- Practical exercises in using a fire extinguisher and evacuation

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology:

Component	Weightage
Continuous Skill Assessment	40%
Viva Voce	10%
Record Note Submission	20%
Final Practical Exam	30%
Total	**100%**

Execution Guidelines:

1. Training shall be conducted by certified in-house faculty or external fire safety trainers (e.g., Fire & Rescue Department, Red Cross).

2. Every student must attend all the sessions and complete the checklist-based skill validations.
3. Demonstrations and hands-on practice to be held in open/fire-safe zones or designated safety labs.
4. Proper PPE usage must be ensured during extinguisher and casualty handling practice.
5. A minimum of 1 fire drill and 2 emergency simulations should be included in the semester.

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Demonstrate life-saving first aid and CPR skills in workplace and emergency scenarios	PO1 (3), PO2 (3), PO3 (2)	3	2
CO2	Identify and classify different types of fires and hazards	PO1 (2), PO4 (1)	2	1
CO3	Operate fire extinguishers, fire suppression systems, and basic rescue tools safely	PO3 (3), PO5 (2)	3	2
CO4	Apply emergency evacuation procedures and manage injured victims during incidents	PO2 (3), PO3 (2), PO4 (2)	3	2

IS25303	Industrial Training	L	T	P	C
		0	0	0	2

Course Objectives:

- To provide students with advanced exposure to integrated safety management systems (SMS) across diverse industrial sectors.
- To strengthen student capability in applying theoretical models to real-world safety practices, hazard controls, and risk communication.
- To instill an understanding of industry-specific safety regulations, tools, audits, and emergency management protocols.
- To develop professionalism, interdisciplinary collaboration, and workplace safety culture awareness.

Guidelines:

1. Students must undergo **minimum 4 weeks** of industrial training at safety-sensitive facilities (manufacturing, construction, oil & gas, etc.).
2. Training must involve **exposure to real-time safety operations**, reporting systems, toolbox talks, safety data sheets, incident investigation processes, etc.
3. Each student will be assigned a **faculty mentor** to provide pre-training orientation, weekly check-ins, and progress review.
4. A **comprehensive internship report** must be submitted covering:
   - Company profile
   - Observed safety practices
   - Risk assessment techniques used
   - Incident reporting systems
   - Training programs (safety induction, mock drills)
   - Personal learning outcomes
5. Evaluation Components:
   - Training log & certificate (20%)
   - Report quality (30%)
   - Presentation & viva-voce (50%)

IS25304	Project Work I	L	T	P	C
		0	0	12	6

Course Objectives:

The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

Semester IV

IS25401	**Project Work II**	L	T	P	C
		0	0	24	12

Course Objectives:

The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.

Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

PROGRAMME ELECTIVE COURSES

IS25001	International Safety Management System	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the principles, structure, and requirements of the International Safety Management (ISM) Code for ensuring maritime and industrial operational safety.
- To develop skills in implementing, auditing, and maintaining safety management systems in compliance with international safety standards and regulations.
- To analyse case studies and best practices for effective integration of safety management systems to enhance organisational safety culture and performance.

ISO Standards Overview

ISO introduction, standard development, ISO 45001 structure, certification benefits, OH&S management system.

Activities*:* Quiz on ISO 45001 development and benefits; Assignment on OH&S management system

ISO 45001 Correspondence and Implementation

ISO correspondence, ISO 45001 vs ISO 14001 vs ISO 9001, legal requirements, implementation, risk assessment.

Activities*:* Seminar on ISO standard correspondences; Poster on ISO 45001 policy planning and risk assessment.

ISO 50001 Energy Management Systems

ISO 50001, energy management, objectives and targets, energy review, baseline, employee engagement, integration.

Activities*:* Assignment on ISO 50001 energy management policies and indicators; Quiz on continual improvement and compliance.

ISO 14001 Environmental Management Systems

ISO 14001, environmental management, risk assessment, legal requirements, quality management, customer satisfaction.

Activities*:* Seminar on ISO 14001 EMS and risk assessment; Poster on quality management integration and customer satisfaction.

ISO 9001 Quality Management Systems

ISO 9001, quality management, process approach, customer satisfaction, continual improvement, risk-based thinking.

Activities*:* Quiz on ISO 9001 principles and process approach; Assignment on leadership and continual improvement in quality management.

Environmental Impact Assessment and ISO 14040 Series

ISO 14040, LCA, eco-labeling, ISO 14020, EIA, audit methodology, continual improvement.

Activities*:* Seminar on LCA, eco-labelling, and EIA; Poster on audit methodology and continual improvement in EMS.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Mandated Activities with weightage: Assignments (20%), Quiz (20%), Virtual demonstration (10%), Review of GATE & IES questions.
Assessment Methodology: Quiz - 20% Assignments - 20% Virtual Demonstration - 10% Internal Examinations - 50%
References: 1. "ISO 14001:2004, Environmental Management Systems - Requirements with guidance for use", ISO, 2004. 2. "Guidelines on Occupational Health and Safety Management Systems (OSH-MS)" International Labour Organization: 2001. 3. "BS 8800: 2004 Occupational Health and Safety Management.
E-Resources: 1. The International Safety Management (ISM) Code 2. ISM Code: A comprehensive introduction

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain ISO standards (ISO 45001, 50001, 14001, 9001, 14040 series), structures, objectives, and management system benefits	PO1 (3), PO2 (2)	3	2
CO2	Apply ISO standards implementation, risk assessment, energy management, and continual improvement practices in organizational systems	PO3 (3), PO5 (3)	3	3
CO3	Estimate organizational performance, compliance levels, energy efficiency, environmental impacts, and quality metrics	PO2 (3), PO4 (3)	3	3
CO4	Analyze integration of ISO standards across OH&S, quality, environment, and energy management systems for strategic decision-making	PO4 (3), PO5 (3)	3	3

IS25002	Cybersecurity for Industrial Safety Systems	L	T	P	C
		3	0	0	3

Course Objectives:

- To introduce the fundamentals of cybersecurity as applied to industrial control and safety systems.
- To explore the vulnerabilities, threats, and risk assessment techniques for OT (Operational Technology) networks.
- To familiarize learners with international standards (ISA/IEC 62443, NIST, ISO) and cybersecurity frameworks.
- To develop an understanding of intrusion detection, mitigation strategies, and safety compliance in cyber-physical systems.
- To enable students to analyze real-world cyber incidents in safety-critical industries.

Introduction to Cybersecurity in Industrial Safety

Industrial Automation vs IT; OT systems and critical infrastructure; ICS, SCADA, PLC, DCS overview; Difference between IT Security & OT Security; Cyber-physical systems (CPS); Common threats: malware, phishing, ransomware, zero-day attacks.

Activity: Identify vulnerabilities in a typical industrial SCADA system architecture.

Industrial Network Architectures and Protocol Security

Industrial communication protocols (Modbus, Profibus, OPC UA, Ethernet/IP); Zones and conduits model; Purdue reference model for ICS; Secure network segmentation; Asset visibility and vulnerability management; Firewall placement in ICS.

Activity: Draw and annotate a secure ICS network architecture using the Purdue model.

Risk Assessment and Threat Modeling

Cybersecurity risk in process safety; Threat actors in OT – insiders, APTs, nation-state attacks; Consequence-based risk assessment; MITRE ATT&CK for ICS; Threat modeling with STRIDE, DREAD; Safety Integrity Levels (SIL) and cyber impact.

Activity: Perform a threat analysis for a simulated safety valve control system using STRIDE.

Standards and Cybersecurity Frameworks for Safety Systems

IEC 62443 family of standards; NIST Cybersecurity Framework; ISO/IEC 27001 & 27019 for energy and OT systems; Asset categorization; Cybersecurity policy design; Audit and compliance checklists; Incident response and recovery strategy.

Activity: Map security requirements of a real-world system to the relevant IEC 62443 clauses.

Intrusion Detection, Mitigation & Case Studies

Host- and network-based intrusion detection systems (IDS/NIDS); HoneyNets and anomaly detection; Patch management in industrial systems; Cyber drills and

playbooks; Case studies: Stuxnet, Triton, Colonial Pipeline, SolarWinds; Cyber hygiene in manufacturing.

Activity: Group presentation on one major OT cyberattack and its safety implications.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:
Assignments (20%), Quiz (10%), Case-Based Activity (15%), Flipped Classrooms (5%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	20%
Quizzes	10%
Case-Based Activities	15%
Flipped Classrooms	5%
Internal Examinations	50%

References:

1. Eric D. Knapp, Industrial Network Security: Securing Critical Infrastructure Networks for Smart Grid, SCADA, and Other Industrial Control Systems, Syngress, 2nd Ed., 2014.
2. Pascal Ackerman, Industrial Cybersecurity: Efficiently Secure Critical Infrastructure Systems, Packt, 2nd Ed., 2021.
3. ISA/IEC 62443 Standards – International Society of Automation, Latest Revision
4. NIST SP 800-82 Rev. 2, Guide to Industrial Control Systems Security, 2015
5. Andrew Ginter, SCADA Security: What's Broken and How to Fix It, 2016.

E-Resources:

1. https://ics-cert.us-cert.gov – U.S. CISA for ICS Threat Advisories
2. https://www.nist.gov – NIST Cybersecurity Framework
3. https://www.automation.com – Latest ICS Cybersecurity News
4. ISA.org – IEC 62443 Standards
5. https://attack.mitre.org/matrices/ics/ – MITRE ATT&CK for ICS Matrix

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain cybersecurity concepts and OT/IT differences	PO1 (3), PO2 (2)	3	2
CO2	Apply frameworks, threat modeling, and network segmentation	PO3 (3), PO5 (3)	3	3
CO3	Estimate cyber risks and vulnerability impacts	PO2 (3), PO4 (3)	3	3
CO4	Analyze real-world cyber incidents and mitigation strategies	PO4 (3), PO5 (3)	3	3

IS25003	Asset Integrity and Reliability Engineering	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the principles, methodologies, and tools for effective asset integrity and reliability management in industrial systems.
- To develop analytical skills for evaluating reliability parameters, failure data, and life cycle costs to support maintenance planning and decision-making.
- To apply advanced reliability prediction models and assessment techniques to optimise asset performance, ensure safety, and enhance operational efficiency.

Introduction to Asset Integrity Management

Asset integrity, inspection techniques, maintenance planning, performance optimization, ageing asset management.

Activities*:* Assignment on advanced inspection techniques; Seminar on maintenance optimization for ageing assets.

Asset Management and Risk Assessment

Asset management, risk assessment, inspection and maintenance, safety standards, incident analysis, safety culture.

Activities*:* Quiz on asset management and risk assessment; Poster on incident investigation and emergency planning.

Reliability Concepts and Failure Data Analysis

Reliability function, failure rate, MTBF, mortality curve, time to failure distributions, hazard plotting.

Activities*:* Assignment calculating reliability parameters; Quiz on failure distributions and plotting techniques.

Reliability Prediction Models

Reliability prediction, RBD, Bayes theorem, Markov analysis, fault tree, reliability testing.

Activities*:* Seminar on reliability prediction models and fault tree analysis; Assignment applying Markov analysis and cut/tie set methods.

Reliability and Life Cycle Cost Analysis

Life cycle cost, reliability allocation, replacement model, growth monitoring, non-parametric analysis.

Activities*:* Assignment on life cycle cost analysis and reliability allocation; Quiz on replacement models and reliability growth monitoring.

Reliability Assessment and Advanced Applications

Reliability assessment, asset integrity integration, maintenance planning, practical applications.

Activities*:* Seminar on comprehensive reliability assessment integration; Poster on reliability-based maintenance planning and case studies.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (20%), Virtual demonstration (10%), Review of GATE & IES questions.

Assessment Methodology:

Quiz - 20%
Assignments - 20%
Virtual Demonstration - 10%
Internal Examinations - 50%

References:

1. Safety, Health, and Asset Protection: Management Essentials, Second Edition 2nd Edition by Richard Lack
2. Guidelines for Asset Integrity Management By CCPS (Center for Chemical Process Safety) · 2017
3. Charles E. Ebeling, “An introduction to Reliability and Maintainability engineering”, TMH, 2000.
4. Roy Billington and Ronald N. Allan, “Reliability Evaluation of Engineering Systems”, Springer, 2007.
5. Srinath (2011) ‘Reliability Engineering’. Affiliated East-West Press Pvt Ltd, New Delhi.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc23_ge20/preview?utm
2. https://onlinecourses.nptel.ac.in/noc23_ce102/preview?utm
3. https://onlinecourses.nptel.ac.in/noc22_cs120/preview?utm

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain principles of asset integrity, inspection, and maintenance planning	PO1 (3), PO2 (2)	3	2
CO2	Apply risk assessment, reliability prediction models, and maintenance planning	PO3 (3), PO5 (3)	3	3
CO3	Estimate reliability parameters, life cycle costs, and failure probabilities	PO2 (3), PO4 (3)	3	3
CO4	Analyze reliability data, integrate asset integrity strategies, and optimize performance	PO4 (3), PO5 (3)	3	3

IS25004	Emergency Response and Disaster Management	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the fundamental concepts, types, and impacts of natural and man made disasters for effective disaster mitigation and management.
- To analyse technological, environmental, and pollution-related disasters and apply strategies for risk assessment and control.
- To develop skills in disaster preparedness, incident management, and the use of GIS and remote sensing for disaster response and planning.

Introduction to Disaster Management

Disaster management philosophy, mitigation, natural disasters, man-made disasters, global extremes.

Activities*:* Assignment on classification of disasters; Quiz on disaster management philosophies and mitigation concepts

Technological and Environmental Disasters

Technological disasters, APELL, emergency planning, industrial accidents, epidemics, war impacts.

Activities*:* Poster on technological disasters and APELL; Seminar on onsite and offsite emergency planning.

Pollution and Environmental Issues

Pollution aspects, marine pollution, toxic waste, global warming, EIA, green policies.

Activities*:* Assignment on pollution aspects and environmental issues; Quiz on eco-friendly products and green policies.

Disaster Repercussions and Impact

Disaster repercussions, economic damage, ecosystem loss, natural disasters, man-made disasters.

Activities*:* Poster on repercussions of disasters; Seminar on impacts of natural and man-made disasters.

Incident Management Systems

Incident management, disaster cycle, command system, crisis response, cleanup, restoration.

Activities*:* Assignment on disaster management cycle and incident command system; Quiz on early warning systems and crisis management.

Disaster Preparedness and GIS Applications

Disaster preparedness, training, GIS, remote sensing, awareness programmes.

Activities*:* Poster on GIS and remote sensing in disaster management; Seminar on training, drills, and awareness programmes.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Mandated Activities with weightage: Assignments (20%), Quiz (20%), Virtual demonstration (10%), Review of GATE & IES questions.
Assessment Methodology: Quiz - 20% Assignments - 20% Virtual Demonstration - 10% Internal Examinations - 50%
References: 1. Gilbert, M. Masters., “Introduction to Environmental Engineering and Science”, 3rd edition 2008. 2. Miller, G. Tylor., “Environmental Science”,14th edition 2012. 3. G. Tylor, Miller., “Environmental Science sustaining the earth”, 2005. 4. Bagad Vilas. “Principles of Environmental Science and Engineering”, 2004. 5. Sivakumar.R., “Principles of Environmental Science and Engineering”, 2005.
E-Resources: 1. https://www.undrr.org/publications 2. https://training.fema.gov/is/ 3. 404 | NASA Earthdata

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain disaster management concepts, philosophies, and types of disasters	PO1 (3), PO2 (2)	3	2
CO2	Apply disaster preparedness, mitigation strategies, and incident management systems	PO3 (3), PO4 (3)	3	3
CO3	Estimate environmental, economic, and societal impacts of disasters	PO2 (3), PO4 (3)	3	3
CO4	Analyze disaster data, incident responses, and GIS/remote sensing applications	PO4 (3), PO5 (3)	3	3

IS25005	ISO 45001 and ISO 14000	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the principles, structure, and implementation requirements of ISO 45001, ISO 14001, and related standards for occupational health, safety, and environmental management.
- To analyse planning, operational control, performance evaluation, and continual improvement processes in OH&S and EMS frameworks.
- To develop competency in environmental impact assessment, eco-labelling, and auditing procedures for effective industrial safety and environmental management practices.

Introduction to OH&S Management Systems

ISO 45001, OHSMS, PDCA cycle, leadership, OH&S policy, worker participation.

Activities*:* Assignment on ISO 45001 development and PDCA cycle; Quiz on leadership, OH&S policy, and worker participation.

Planning in OH&S Management

Assignment on hazard identification and risk assessment; Quiz on OH&S objectives and planning actions.

Activities*:* Poster on technological disasters and APELL; Seminar on onsite and offsite emergency planning.

Operation and Emergency Preparedness

Assignment on operational planning and emergency preparedness; Quiz on management of change and procurement.

Activities*:* Assignment on pollution aspects and environmental issues; Quiz on eco-friendly products and green policies.

Performance Evaluation and Improvement

ISO 14001, EMS, environmental policy, documentation, ISO 19011, auditing.

Activities*:* Assignment on performance evaluation and internal audit; Quiz on incident management and certification benefits.

ISO 14001 and Environmental Auditing

Incident management, disaster cycle, command system, crisis response, cleanup, restoration.

Activities*:* Assignment on ISO 14001 documentation and ISO 19011 auditing; Quiz on audit principles and auditor competence.

Environmental Impact Assessment and Eco-labelling

ISO 14040, LCA, eco-labelling, ISO 14020, EIA methodology, environmental assessment.

Activities*:* Assignment on LCA stages and eco-labelling principles; Quiz on EIA methodology and environmental benefits.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (20%), Virtual demonstration (10%), Review of GATE & IES questions.

Assessment Methodology:

Quiz - 20%
Assignments - 20%
Virtual Demonstration - 10%
Internal Examinations - 50%

References:

1.ISO 45001: 2018 –Occupational Health and safety management systems Requirements with guidance for use
2. ISO14001:2004, Environmental Management Systems Requirements with Guidance for Use" ,ISO, 2004.
3. "Guidelines on Occupational Health and Safety Management Systems (OSH-MS)" International Labour Organization, 2001.
4. "BS 8800: 2004 Occupational Health and Safety Management Systems-Guide" BSI, UK, 2004.
5. "ISO 19011:2011 Guidelines for Auditing Management Systems", ISO, 2011.
6. "ISO 14040:2006 Environmental Management- Life Cycle Assessment – Principles and Framework" ISO,2006.
7. "ISO 14025:2006 Environmental Labels and Declarations -Type III Environmental Declarations Principles andProcedures", ISO,2006.
8. "ISO 14021:1999 Environmental Labels and Declarations - Self Declared Environmental Claims (Type II environmental labelling)", ISO, 1999.
9. "ISO 14020:2000 Environmental Labels and Declarations-General Principles", ISO, 2000.

E-Resources:

1. ISO 45001:2018 - Occupational health and safety management systems
2. ISO - ISO 14000 family — Environmental management

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain OH&S & ISO 45001 principles and PDCA cycle	PO1 (3), PO2 (2)	3	2
CO2	Apply risk assessment, OH&S planning, and emergency preparedness	PO3 (3), PO4 (3)	3	3
CO3	Estimate audit outcomes and EMS compliance	PO2 (3), PO4 (3)	3	3
CO4	Analyze environmental impacts, LCA, and eco-labelling	PO4 (3), PO5 (3)	3	3

IS25006	Human Factors Engineering and Ergonomics	L	T	P	C
		3	0	0	3

Course Objectives:

- To introduce the core concepts and domains of ergonomics in industrial systems.
- To study human behavior, motivation, and learning in safety-critical environments.
- To apply anthropometric data in work system and product design.
- To analyze and improve human-machine interaction and task efficiency.

Foundations of Ergonomics and Anatomy

Introduction to ergonomics; Types and areas of ergonomics (physical, cognitive, organizational); Historical overview; Work posture and body mechanics; Spine and pelvis anatomy; Posture stability and balance; Risk factors for musculoskeletal disorders (MSDs); Cost-effectiveness of ergonomic interventions; Current research directions.

Activity: Conduct a workstation ergonomic audit in a lab/office and map risk factors using an RULA or REBA template.

Human Behavior and Motivation in Work Design

Individual differences; Fitting the man to the job; Methods of personality and motivation assessment; Accident proneness; Motivation theories; Job satisfaction and enrichment; Attitude formation and change; Learning theories (Classical/Operant); Frustration, conflict, and adaptation.

Activity:

Use a personality trait inventory (e.g., Big Five/MBTI) among peers and correlate with task preferences or ergonomics risk perception.

Anthropometry and Ergonomic Workstation Design

Anthropometry basics – percentiles, variability; Designing for standing/sitting postures; Guidelines for work height, reach, and clearance; Design for special populations (elderly, disabled); Visual display principles; Cost-benefit considerations in ergonomics.

Activity:

Design a seating workstation layout using anthropometric percentile data and prepare a one-page layout justification.

Man–Machine Systems and Human-System Interaction

Man as sensor/controller/information processor; Cognitive ergonomics; Virtual environments and simulation in HFE; Design of controls and displays; Ergonomics in manual material handling; Biomechanics; Prevention of cumulative trauma disorders (CTDs); Cognitive overload and fatigue issues.

Activity:

Redesign a basic machine control panel using display-control compatibility principles and simulate its use with user feedback.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (20%), Case-Based Activity (10%), Review of GATE & IES questions.

Assessment Methodology:

Assessment Component	Weightage
Internal Examinations	50%
Assignments	20%
Quizzes	20%
Seminar/Case Study	10%

References:

1. Mark S. Sanders and Ernest J. McCormick, *Human Factors in Engineering and Design*, 7th Edition, McGraw Hill Education, 2013.
2. Waldemar Karwowski, *International Encyclopedia of Ergonomics and Human Factors*, 2nd Edition, CRC Press, 2006.
3. R.S. Bridger, *Introduction to Human Factors and Ergonomics*, 3rd Edition, CRC Press, 2017.
4. S. Kumar, *Biomechanics in Ergonomics*, 2nd Edition, CRC Press, 2007.
5. *Ergonomics: Foundational Principles, Applications, and Technologies*. By Pamela McCauley-Bush, CRC Press, 2020.

E-Resources:

1. Occupational Safety and Health Administration (OSHA) Ergonomics Portal: https://www.osha.gov/ergonomics
2. NIOSH (National Institute for Occupational Safety and Health) Ergonomic Tools: https://www.cdc.gov/niosh/topics/ergonomics/
3. Ergoweb Knowledge Base (HFE tools, cases, and best practices): https://ergoweb.com/
4. ScienceDirect Journals – Search for recent HFE papers: https://www.sciencedirect.com/
5. IIT Madras NPTEL Course on Ergonomics: https://nptel.ac.in/courses/110/106/110106147/

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain ergonomics principles, human anatomy, and work posture risk factors	PO1 (3), PO2 (2)	3	2
CO2	Apply anthropometric data and ergonomic methods to design safe workstations and tools	PO3 (3), PO4 (3)	3	3
CO3	Estimate risk levels of musculoskeletal and cognitive workload using assessment tools	PO2 (3), PO4 (3)	3	3
CO4	Analyze human-system interaction and optimize control, display, and cognitive workload	PO4 (3), PO5 (3)	3	3

IS25007	Emerging Technologies in Safety	L	T	P	C
		3	0	0	3

Course Objectives:

- To introduce emerging digital technologies that enhance safety, risk prediction, and control in industrial environments.
- To explore the applications of AI, IoT, data analytics, and AR/VR in occupational health and safety.
- To develop skills to assess and integrate modern technologies into traditional safety frameworks.
- To analyze current and future trends in intelligent safety systems and smart environments.

Digital Transformation in Safety Engineering

Industry 4.0 and Safety 5.0; Role of digital technologies in EHS; Overview of smart safety systems; Human-machine collaboration; Safety automation basics; Predictive vs reactive safety systems.

Activity: Map traditional vs digital safety approaches in a real-life industry case.

Internet of Things (IoT) and Smart Wearables for Safety

IoT architecture for safety monitoring; Real-time data acquisition; Connected PPE (smart helmets, vests); Smart gas leak detectors, thermal sensors; Worker location tracking; Emergency alert systems.

Activity: Create a sample design for an IoT-enabled safety alert system in a confined space operation.

Artificial Intelligence and Data Analytics in Risk Management

Machine learning in hazard prediction; Safety data collection and cleaning; Safety incident prediction models; Behavior-based AI alerts; Video analytics for PPE compliance and unsafe acts detection.

Activity: Case study analysis: Use open data or mock dataset to train a simple hazard classification model using Excel/Python.

Augmented and Virtual Reality in Safety Training

Basics of AR/VR in safety; Immersive training simulations for fire, evacuation, chemical spills; Gamification for safety awareness; Virtual safety audits; Human factors and VR interface design.

Activity: Explore a freely available AR/VR demo and critique its usefulness for safety training.

Drones, Robotics, and Advanced Monitoring Systems

Drones in hazardous inspection (height, tanks, confined spaces); Robot-assisted fire rescue and bomb disposal; Real-time monitoring using digital twins; Edge computing for fast safety response; Ethical and legal aspects of autonomous safety systems.

Activity: Design a conceptual model for drone use in fire detection inside a large factory.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Case-Based Activity (15%), Flipped Classrooms (5%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	20%
Quizzes	10%
Case-Based Activities	15%
Flipped Classrooms	5%
Internal Examinations	50%

References:

1. Andrew Hopkins, Learning from High Reliability Organizations, Routledge, 2022.
2. Charles A. Harper, Handbook of Safety and Health for the Service Industry, Wiley, 2020.
3. Pascal Ackerman, Industrial Cybersecurity: Efficiently Secure Critical Infrastructure Systems, Packt, 2nd Ed., 2021.
4. A. K. Sethi, Industrial Safety and Health Management, McGraw-Hill, Latest Edition.
5. Nitin Upadhyay, Digital Safety in Smart Manufacturing, Springer, 2023.

E-Resources:

1. https://www.osha.gov/ – OSHA Updates and Digital Initiatives
2. https://www.nist.gov/cyberframework – NIST Frameworks for Safety and Cyber
3. https://www.safetyandhealthmagazine.com/ – Trends and Technology Columns
4. https://www.hse.gov.uk/research – HSE Research Reports
5. Coursera/NPTEL: *IoT, AI for Industrial Systems, AR/VR for Training*

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain Industry 4.0, Safety 5.0, and digital safety transformation concepts	PO1 (3), PO2 (2)	3	2
CO2	Apply IoT, smart wearables, AR/VR, and AI-based tools for safety monitoring and training	PO3 (3), PO5 (3)	3	3
CO3	Estimate risks, predict hazards, and analyze safety data using digital technologies	PO2 (3), PO4 (3)	3	3
CO4	Analyze advanced monitoring systems, drones, robotics, and human-machine collaboration	PO4 (3), PO5 (3)	3	3

IS25008	Safety in Construction	L	T	P	C
		3	0	0	3

Course Objectives:

- To ensure the health, well-being, and physical integrity of workers, and to prevent accidents, injuries, and fatalities in construction sites by fostering awareness, risk control, and safe practices across construction activities.

Accident Causes and Management Systems

Problems impeding safety in construction industry; Types and causes of site accidents; Human and organizational factors; Accident case studies; Building and Other Construction Workers Act & Central Rules, 1998; Permit-to-work; Safety audits; Project HSE Plan; Contractual clauses, compensation, quality assurance, personal protective equipment (PPE); Education and training.

Activity: Analyze a construction accident investigation report and identify root causes using fault tree.

Hazards of Construction and Prevention

Excavation, trenching, and tunneling hazards; Scaffolding risks; Erection and dismantling of structures; Blasting and pile boring hazards; Soil instability; Exposure to contaminants; Working in confined zones; Demolition safety – cordoning, dismantling, clearance protocols; Housekeeping and site layout risks.

Activity: Prepare a hazard risk register for activities such as excavation, tunneling, and scaffolding.

Fall Prevention and Fall Protection

OSHA 3146 provisions on fall protection; Design and inspection of scaffolds; Guardrails, handrails, toe boards, and ramps; Safety harnesses, full arrest systems, lifelines, and ladders; Use of safety nets and PPE; Fall monitoring systems; Access control on fragile roofs and high-rise edges.

Activity: Design a fall protection plan (FPP) for a multi-storey residential building site.

Safety in Huge Structures

Working at elevated civil structures – dams, bridges, tanks, retaining walls, towers, chimneys; Critical risks in demolition and high-rise construction; Failure modes in formwork, foundation works, and large concrete structures; Pre-demolition safety, safety documentation, escape zones, structural collapse response, site-specific fire hazards and refuge areas.

Activity: Perform a visual audit and risk mapping exercise of a bridge or multi-floor construction site.

Construction Machinery and Lifting Equipment Safety

Inspection and monitoring of cranes, hoists, pulley blocks, concrete mixers, loaders, trucks, conveyors, and other mechanized equipment; Manual and mechanical handling; Scaffolding, lifting procedures, signaling, ground stability; Use of electrical tools and machinery hazards; Mobile crane zone safety and permit procedures.

Activity: Conduct a mock inspection of construction machinery checklist and identify non-compliances.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Case-Based Activity (15%), Mini Safety Audit (5%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	20%
Quizzes	10%
Case-Based Activities	15%
Mini Safety Audit	5%
Internal Examinations	50%

References:

1. Jimmie Hinze, *Construction Safety*, Prentice Hall, 2nd Edition, 2011.
2. Richard J. Coble, *Construction Safety and Loss Control*, Wiley, 3rd Edition, 2000.
3. Arun Prasad, *Construction Safety Handbook*, Himalaya Publishing House, Latest Edition.
4. V.J. Davies and K. Tomasin, *Construction Safety Planning*, Thomas Telford, 1996.
5. National Building Code of India, BIS, Part 7 – Construction Practices and Safety.

E-Resources:

1. https://www.osha.gov/construction – OSHA Construction Safety
2. https://www.hse.gov.uk/construction – UK HSE Construction Portal
3. https://nptel.ac.in/courses/105/107/105107211 – NPTEL: Construction Technology and Management
4. https://cpwd.gov.in – CPWD Safety Manual (India)
5. https://www.ilo.org/safework – ILO Guidelines on Construction Safety

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain causes of construction accidents, accident management systems, and regulatory requirements	PO1 (3), PO2 (2)	3	2
CO2	Apply hazard identification, risk assessment, and fall prevention measures in construction sites	PO3 (3), PO5 (3)	3	3
CO3	Estimate risks in elevated structures and critical construction operations using inspection and audit data	PO2 (3), PO4 (3)	3	3
CO4	Analyze machinery, lifting equipment, and high-risk site operations to optimize safety management	PO4 (3), PO5 (3)	3	3

IS25009	Safety in Oil and Gas	L	T	P	C
		3	0	0	3

Course Objectives:

- Prevent accidents, injuries, and occupational illnesses in oil and gas industries.
- Improve safety and risk management practices in upstream and downstream operations.
- Equip learners with fire safety knowledge and emergency response systems in hydrocarbon environments.
- Impart understanding of applicable legal frameworks and disaster preparedness in the oil and gas sector.

Petroleum Products and Fire Hazards

Flash points; Classification of petroleum products – Classes A, B, C & Excluded; LEL & UEL; Static electricity; Earthing and bonding; Flameproof enclosures; ATEX classification; Petroleum-related fire case studies – Jaipur Fire, MB Lal Committee Recommendations, BP Texas incident, Hazira Fire incident.

Activity: Simulation-based evaluation of flash point classification using safety data sheets (SDS).

Upstream and Downstream Operations

Drilling, extraction, and transportation processes; Construction and safety of pipeline installations; Onshore and offshore maintenance; Associated hazards in crude transport and storage; Case insights from failures in pipeline integrity.

Activity: Analyze pipeline failure case and map risk elements across upstream/downstream stages.

Safe Handling of Hydrocarbons and Fire Protection

Boil over phenomena; Gas/vapor detection (HCD); Remote-operated shutoff valves (ROSOV); Types of firefighting foam – AFFF, AR-AFFF, Rim Seal; Equipment: Foam monitors, foam pourers, MFGs, HVLRs; Medium expansion foam systems; Design layout of fire protection.

Activity: Design a safety layout showing fire equipment placements for a hydrocarbon storage site.

Disaster Management Planning in Oil and Gas

Components of Disaster Management Plan (DMP); Risk assessment and consequence modeling; Mutual aid systems; On-site and off-site emergency drills; Key elements of Quantitative Risk Assessment (QRA); Legislation: Disaster Management Act, 2005.

Activity: Prepare an emergency response plan (ERP) for a simulated petroleum depot fire.

Legal Framework and Industry Regulations

Oil Industry Safety Directorate (OISD) standards – OISD-STD-105, 118, 144, 244; Interpretation of Petroleum Rules (2002); Jaipur fire regulation implications; Legal procedures in audits, permits, and safety compliance.

Activity: Compare OISD guidelines and international NFPA standards for petrochemical installations.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:
Assignments (20%), Quiz (10%), Case-Based Activity (15%), Flipped Classroom (5%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	20%
Quizzes	10%
Case-Based Activities	15%
Flipped Classroom Tasks	5%
Internal Examinations	50%

References:

1. Oil & Gas Industry Safety: Safety induction and emergency training – HSE UK, 2017.
2. Loss Prevention in the Process Industries by Frank P. Lees, Elsevier, 4th Edition, 2021.
3. Lessons from Process Accident Case Studies by Mannan & Lees, Elsevier, 2013.
4. Handbook of Fire Protection Engineering by P.J. DiNenno, NFPA, 5th Ed., 2022.
5. Petroleum Rules and OISD Standards Compilation – Government of India, Ministry of Petroleum.

E-Resources:

1. https://www.hse.gov.uk/offshore/ – HSE Offshore Safety Portal
2. https://www.osid.gov.in/ – Oil Industry Safety Directorate (OISD)
3. https://www.nfpa.org/ – National Fire Protection Association
4. MIT Open Course Ware – Process Safety Lectures

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain petroleum product hazards, flash points, classification, and fire case studies	PO1 (3), PO2 (2)	3	2
CO2	Apply safe handling, hydrocarbon fire protection systems, and upstream/downstream operational safety	PO3 (3), PO5 (3)	3	3
CO3	Estimate risk factors in pipelines, storage facilities, and fire scenarios using consequence modeling	PO2 (3), PO4 (3)	3	3
CO4	Analyze disaster management plans, legal frameworks, and compliance standards in oil and gas operations	PO4 (3), PO5 (3)	3	3

IS25010	Behaviour - Based Study	L	T	P	C
		3	0	0	3

Course Objectives:

- To promote workplace safety by emphasizing human behavior and its role in accident prevention.
- To understand psychological and organizational factors influencing unsafe behavior.
- To learn behavior-based safety models and their applications through real-world examples.
- To encourage a proactive safety culture by understanding perceptions, attitudes, and motivations toward safety.

Foundations of Behaviour-Based Safety (BBS)

Overview of BBS; Psychology of Behavior-Based Management; Role of Behavior in Risk Management; Leadership and BBS Implementation; Behavior-Based Safety Programs; ABC Model (Antecedent-Behavior-Consequence); Case Studies on BBS Implementation

Activity: Conduct a mock ABC analysis using recent incident data from a selected industrial case.

Human Behavioural Characteristics in Safety

Organizational Behavior and its Impact on Safety; Human Factors Contributing to Accidents; Psychological Aspects of Safety; Safety Culture System; Individual Differences in Risk Perception; Behavior Function of Self and Situation; Role of Management in Influencing Risk Attitudes

Activity: Roleplay-based simulation to analyze differences in risk perception among diverse teams.

Safety Culture and Behavioural Motivation

Safety Culture vs. Safety Climate – Definitions and Importance; Process Safety Management and its Behavioral Dimensions; Theories of Motivation in Safety (e.g., Maslow, Herzberg); Perception of Danger and Risk Acceptance; Role of Supervisors and Leaders in Motivating Safe Behavior; Reporting Culture

Activity: Audit an existing safety climate questionnaire and suggest improvement based on behavioral theories.

BBS Models, Theories and Psychology

ABC Model in Depth; Iceberg Theory; Leading & Lagging Indicators; Bradley Curve; Hierarchy of Control in Behavior; Barriers to BBS: Fatigue, Frustration, Rush, Complacency; Human Psychology: Cognition, Concern, Commitment; Neuroscience and BBS; Safety Leadership and Emotional Intelligence

Activity: Group presentation on applying the Bradley Curve in developing a long-term BBS strategy for a high-risk industry.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (20%), Case-Based Activity (10%), Review of GATE & IES questions.

Assessment Methodology:

Assessment Component	Weightage
Internal Examinations	50%
Assignments	20%
Quizzes	20%
Seminar/Case Study	10%

References:

1. William E. Hollins, *Behaviour Based Safety Analysis*, Waveland Press, 2020.
2. W. Fisher, C. Piazza & H. Roane, *Handbook of Applied Behavior Analysis*, 2nd Ed., Guilford Press, 2022.
3. Christopher Wickens & Lee John, *An Introduction to Human Factors in Engineering*, CRC Press, 2019.
4. rause, T. R., *The Behavior-Based Safety Process: Managing Involvement for an Injury-Free Culture*, Wiley-Interscience, 2004.
5. C. Geller, *The Psychology of Safety Handbook*, CRC Press, 2001.

E-Resources:

1. American Society of Safety Professionals (ASSP) – BBS Resources: https://www.assp.org/
2. National Safety Council (NSC) – Behavioral Safety Articles: https://www.nsc.org/
3. SafeStart International – Behavior-Based Safety Solutions: https://safestart.com/
4. OSHA Behavioural Safety Toolbox Talks: https://www.osha.gov/safety-management
5. NPTEL (IIT Kharagpur) – Human Behavior and Industrial Safety Module: https://nptel.ac.in/courses/109/105/109105112/

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain the foundations of BBS, ABC model, and behavioral psychology in safety	PO1 (3), PO2 (2)	3	2
CO2	Apply behavioral analysis and human factors concepts to identify and mitigate safety risks	PO3 (3), PO5 (3)	3	3
CO3	Estimate safety performance indicators and evaluate risk perception using BBS tools and models	PO2 (3), PO4 (3)	3	3
CO4	Analyze safety culture, motivational factors, and behavioral interventions to enhance industrial safety	PO4 (3), PO5 (3)	3	3

IS25011	Optimization Techniques	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the structure and classification of optimization problems, including linear, non-linear, and multi-objective cases.
- To explore decision-making tools and model-based optimization methods for engineering systems.
- To apply advanced non-traditional and metaheuristic optimization techniques to real-world problems.
- To develop optimization models using software tools and evaluate their impact in safety, logistics, production, and project management.

Introduction to Optimization

Classification of optimization problems; design vector, design constraints; objective function and constraint surfaces; parametric linear programming; multi-level optimization.

Activity: Identify optimization scenarios in industrial safety, logistics, or engineering design.

Decision Analysis and Multi-Objective Techniques

Decision Trees, Utility Theory, Game Theory, Multi-Objective Optimization; Goal Programming; Analytic Hierarchy Process (AHP); Analytic Network Process (ANP); Fuzzy MCDM techniques (Intro to Fuzzy AHP & TOPSIS).

Activity: Case-based decision-making for supplier selection or safety audit prioritization using AHP.

Classical Non-Linear Optimization

Unconstrained and constrained non-linear problems; KKT Conditions; Quadratic Programming; Convex & Non-convex optimization; Geometric and Separable programming; penalty and barrier function methods.

Activity: Solve a plant layout or safety investment problem using constrained optimization with Excel Solver or Python.

Metaheuristic Optimization I – Nature-Inspired Techniques

Genetic Algorithms; Simulated Annealing; Evolutionary Programming; Differential Evolution; Application to scheduling, routing, and energy optimization problems.

Activity: GA for machine/job scheduling using Python or MATLAB.

Metaheuristic Optimization II – Swarm & Intelligent Systems

Particle Swarm Optimization (PSO); Ant Colony Optimization (ACO); Firefly Algorithm; Artificial Bee Colony; Comparison of performance with traditional methods.

Activity: Implement PSO or ACO for network routing or risk reduction optimization.

Advanced Optimization for Industry 5.0 Applications

Optimization under uncertainty; Reinforcement Learning basics for optimization; Introduction to MILP solvers (CPLEX/Gurobi); Applications in safety system reliability, resource allocation, predictive maintenance, and energy systems.

Activity: Model an industrial optimization scenario using Python with Pyomo or Gurobi.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Case-Based Activity (15%), Mini Safety Audit (5%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	20%
Quizzes	10%
Case-Based Activities	15%
Mini Safety Audit	5%
Internal Examinations	50%

References:

1. Christos H. Papadimitriou & Kenneth Steiglitz, *Combinatorial Optimization*, PHI, 2006.
2. Ravindran, Philips & Solberg, *Operations Research – Principles and Practice*, John Wiley India, 2006.
3. S. S. Rao, *Engineering Optimization: Theory and Practice*, Wiley, 2017.
4. Deb Kalyanmoy, *Optimization for Engineering Design*, PHI, 2003.
5. Hamdy Taha, *Operations Research: An Introduction*, Pearson, 2020.

E-Resources:

1. https://ocw.mit.edu/courses/find-by-topic/#cat=engineering&subcat=mechanicalengineering&spec=optimization
2. https://nptel.ac.in/courses/111/105/111105039/
3. https://www.gurobi.com/resource-center/
4. https://www.pyomo.org/
5. https://www.khanacademy.org/math/optimization

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamental and advanced optimization concepts, problem types, and classical/non-linear methods	PO1 (3), PO2 (2)	3	2
CO2	Apply multi-objective, metaheuristic, and decision analysis techniques to solve industrial safety or engineering problems	PO3 (3), PO5 (3)	3	3
CO3	Estimate optimal solutions, evaluate constraints, and assess trade-offs in safety, energy, and resource optimization scenarios	PO2 (3), PO4 (3)	3	3

CO4	Analyze and compare optimization strategies, including classical, metaheuristic, and AI-based methods for complex industrial systems	PO4 (3), PO5 (3)	3	3

IS25012	Design of Experiments	L	T	P	C
		3	0	0	3

Course Objectives:

- To impart knowledge on principles and structured steps in designing statistically sound experiments.
- To build analytical skills in single-factor and factorial experiments with post hoc testing.
- To equip students in advanced design types such as nested, split plot, and response surface methodology.
- To develop expertise in applying Taguchi's methods for parameter optimization in engineering processes.

Fundamentals of Experimental Design

Importance and applications of experiments; terminology; types of experiments; experimental strategies; basic principles of design; steps in experimentation; sampling and sample size determination; normal probability plots; linear regression models; ANOVA basics.

Activity: Design a basic experiment using a randomization plan and explain the steps involved.

Single Factor Experiments

Completely randomized design, randomized block design, Latin square design; hypothesis testing; model adequacy checking; estimation of model parameters; post hoc comparisons – t-tests, Duncan's test, Tukey's HSD.

Activity: Conduct data analysis using R or Minitab for single-factor CRD and interpret ANOVA results.

Multifactor Experimental Designs

Two-factor and three-factor full factorial designs; interaction effects; randomized block factorial design; experiments with random factors; expected mean squares; approximate F-tests; nested and mixed models.

Activity: Create a 2^2 factorial design layout and analyze for interaction effects using statistical software.

Special Experimental Designs

Blocking and confounding in 2^k factorial designs; two-level fractional factorial designs; split-plot and nested designs; Random effects models; Introduction to Response Surface Designs (RSM) and central composite design (CCD); rotatability.

Activity: Simulate a split-plot design using Minitab or Python for an industrial baking or mixing process.

Taguchi and Robust Design Methods

Orthogonal arrays, Signal-to-noise ratios (S/N); control and noise factors; parameter design; multilevel experiments; multi-response optimization; Taguchi's loss function; Introduction to Shainin DOE.

Activity: Use Taguchi L9 or L18 orthogonal arrays to identify optimum factor levels in a real-time product (e.g., strength of welded joints).

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Case-Based Activity (15%), Mini Safety Audit (5%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	20%
Quizzes	10%
Case-Based Activities	15%
Mini Safety Audit	5%
Internal Examinations	50%

References:

1. Montgomery D.C., *Design and Analysis of Experiments*, Wiley India, 2017.
2. Antony J., *Design of Experiments for Engineers and Scientists*, Elsevier, 2014.
3. Angela M. Dean, Daniel Voss, *Design and Analysis of Experiments*, Springer, 2020.
4. Ross P.J., *Taguchi Techniques for Quality Engineering*, McGraw-Hill, 2005.
5. Ranjit Roy, *A Primer on the Taguchi Method*, Society of Manufacturing Engineers, 2010.

E-Resources:

1. https://nptel.ac.in/courses/111/105/111105039/
2. https://ocw.mit.edu/courses/find-by-topic/#cat=mathematics&subcat=statistics&spec=experimentaldesign
3. https://www.minitab.com/en-us/resources/
4. https://asq.org/quality-resources/design-of-experiments

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain principles, terminology, and structured steps of experimental design	PO1 (3), PO2 (2)	3	2
CO2	Apply single-factor, factorial, nested, and split-plot experimental designs to practical problems	PO3 (3), PO5 (3)	3	3
CO3	Estimate model parameters, interaction effects, and optimal factor levels using ANOVA, RSM, and Taguchi methods	PO2 (3), PO4 (3)	3	3
CO4	Analyze experimental results, interpret interactions, and evaluate robustness of designs for process optimization	PO4 (3), PO5 (3)	3	3

IS25013	Safety Economics and Cost-Benefit Analysis	L	T	P	C
		3	0	0	3

Course Objectives:

- To impart knowledge on principles and structured steps in designing statistically sound experiments.
- To build analytical skills in single-factor and factorial experiments with post hoc testing.
- To equip students in advanced design types such as nested, split plot, and response surface methodology.
- To develop expertise in applying Taguchi's methods for parameter optimization in engineering processes.

Fundamentals of Experimental Design

Importance and applications of experiments; terminology; types of experiments; experimental strategies; basic principles of design; steps in experimentation; sampling and sample size determination; normal probability plots; linear regression models; ANOVA basics.

Activity: Design a basic experiment using a randomization plan and explain the steps involved.

Single Factor Experiments

Completely randomized design, randomized block design, Latin square design; hypothesis testing; model adequacy checking; estimation of model parameters; post hoc comparisons – t-tests, Duncan's test, Tukey's HSD.

Activity: Conduct data analysis using R or Minitab for single-factor CRD and interpret ANOVA results.

Multifactor Experimental Designs

Two-factor and three-factor full factorial designs; interaction effects; randomized block factorial design; experiments with random factors; expected mean squares; approximate F-tests; nested and mixed models.

Activity: Create a 2^2 factorial design layout and analyze for interaction effects using statistical software.

Special Experimental Designs

Blocking and confounding in 2^k factorial designs; two-level fractional factorial designs; split-plot and nested designs; Random effects models; Introduction to Response Surface Designs (RSM) and central composite design (CCD); rotatability.

Activity: Simulate a split-plot design using Minitab or Python for an industrial baking or mixing process.

Taguchi and Robust Design Methods

Orthogonal arrays, Signal-to-noise ratios (S/N); control and noise factors; parameter design; multilevel experiments; multi-response optimization; Taguchi's loss function; Introduction to Shainin DOE.

Activity: Use Taguchi L9 or L18 orthogonal arrays to identify optimum factor levels in a real-time product (e.g., strength of welded joints).

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Case-Based Activity (15%), Mini Safety Audit (5%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	20%
Quizzes	10%
Case-Based Activities	15%
Mini Safety Audit	5%
Internal Examinations	50%

References:

1. Montgomery D.C., *Design and Analysis of Experiments*, Wiley India, 2017.
2. Antony J., *Design of Experiments for Engineers and Scientists*, Elsevier, 2014.
3. Angela M. Dean, Daniel Voss, *Design and Analysis of Experiments*, Springer, 2020.
4. Ross P.J., *Taguchi Techniques for Quality Engineering*, McGraw-Hill, 2005.
5. Ranjit Roy, *A Primer on the Taguchi Method*, Society of Manufacturing Engineers, 2010.

E-Resources:

1. https://nptel.ac.in/courses/111/105/111105039/
2. https://ocw.mit.edu/courses/find-by-topic/#cat=mathematics&subcat=statistics&spec=experimentaldesign
3. https://www.minitab.com/en-us/resources/
4. https://asq.org/quality-resources/design-of-experiments

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain principles and steps of experimental design	-	-	-
CO2	Apply single-factor and factorial experiments	PO3 (3), PO5 (3)	3	3
CO3	Estimate model parameters and optimal factor levels	PO2 (3), PO4 (3)	3	3
CO4	Analyze results and evaluate robustness of designs	PO4 (3), PO5 (3)	3	3

IS25014	Safety in Engineering Industries	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand hazards associated with various engineering operations and machinery.
- To develop knowledge of machine guarding principles and protection systems.
- To ensure workplace safety in processes such as welding, cutting, forming, and hot working.
- To build competency in identifying, assessing, and mitigating industrial mechanical risks.

Safety in Metal Working Machinery and Wood Working Machines

General safety rules, PPE, inspections; Machining operations – lathes, milling, boring, grinding, drilling, CNC and manual machines; Types of machinery and safety features; Woodworking safety – saws, presses, and hazards.

Activity: Hazard identification from standard machine layout drawings.

Principles of Machine Guarding

Zero Mechanical State (ZMS); Types of guards – fixed, interlocked, adjustable, trip guards; Guarding construction – design and materials; Safety devices – emergency stops, light curtains, two-hand controls; Guard inspection and authorization for access.

Activity: Safety audit of workshop tools and creation of guard compliance checklist.

Safety in Welding and Gas Cutting

Gas welding, arc welding, resistance welding, brazing, soldering hazards; Personal protective equipment (PPE); Flashback arrestors and cylinder handling; Fire hazards and fumes; Safety in electrical welding and maintenance practices.

Activity: Create a welding risk matrix and develop safe operating procedures (SOPs).

Safety in Cold Forming and Hot Working of Metals

Hazards in forging, hot rolling, extrusion, press braking, hammering; Machine guarding in hot metal processes; Auxiliary systems – hydraulic and pneumatic; Safety in induction furnaces and reheating furnaces; Emergency preparedness in foundries.

Activity: Develop a visual process flow hazard mapping for forging or rolling mills.

Safety in Finishing, Inspection, and Testing Units

Surface finishing – polishing, buffing, pickling, coating; Safety during inspection and testing (NDT, hydraulic, pneumatic, ultrasonic); High-pressure vessels; Painting booths and fume extraction; Ergonomic concerns in final assembly and packing.

Activity: Observation-based ergonomic checklist for inspection benches and finishing lines.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Case-Based Activity (15%), Flipped Classrooms (5%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	20%
Quizzes	10%
Case-Based Activities	15%
Flipped Classrooms	5%
Internal Examinations	50%

References:

1. John R. Ridley & Dick Pearce, Health and Safety in Engineering Workshops, Elsevier, 3rd Edition.
2. A. K. Sethi, Industrial Safety and Environment, McGraw-Hill, Latest Edition.
3. R.K. Jain, Production Technology, Khanna Publishers, 2022.
4. David L. Goetsch, Occupational Safety and Health for Technologists, Engineers, and Managers, Pearson, 9th Edition.
5. Bureau of Indian Standards, IS: Standard Codes on Machine Guarding and Safety in Welding.

E-Resources:

1. https://www.osha.gov/machine-guarding
2. https://www.ilo.org/safework
3. https://nptel.ac.in/courses/110/105/110105094
4. https://webstore.ansi.org

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain safety principles in metal and wood working machinery	-	-	-
CO2	Apply machine guarding, welding, and operational safety practices	PO3 (3), PO5 (3)	3	3
CO3	Estimate hazards, risk levels, and protective measures in workshop setups	PO2 (3), PO4 (3)	3	3
CO4	Analyze process flow, inspections, and safety compliance for improvement	PO4 (3), PO5 (3)	3	3

IS25015	Dock Safety	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the statutory framework and safety codes applicable to dock operations.
- To gain knowledge of onboard hazards and safe cargo handling practices.
- To examine safe use, maintenance, and testing of lifting appliances and transport equipment.
- To prepare students to handle dock-related emergencies, hazardous cargo, and SHW regulations.

History of Safety Legislation

History and evolution of dock safety laws in India; Dock Workers (Safety, Health and Welfare) Act 1986; Heavy packages rules under the Dock Regulations; Handling of hazardous chemicals – 1989 environment rules; Interpretation of legal terms; Responsibilities of dock owners, supervisors, and contractors.

Activity: Create a compliance checklist based on the Dock Workers (SHW) Rules, 1990.

Working on Board the Ship

Types of ships and hazards; Hatch covers – types, construction, mechanical vs manual; Safe means of access; Hazards in holds and decks; Cargo operations; Chipping, painting, lighting; Risks of oil, chemical and flammable liquid transport; Handling of internal combustion-powered trucks; Hazardous cargo ship management.

Activity: Risk identification exercise using ship deck layout diagrams.

Lifting Appliances

Rigging and maintenance of derricks, portainers, transtainers, gantries; Container handling and stacking; Use of synthetic and natural fibre ropes, chains, hooks, gears; Gear testing, reexamination requirements.

Activity: Video-based case study on container crane failure and lessons learned.

Transport Equipment

Forklifts, top lift trucks, mobile equipment on the dock; Loading/unloading of wheeled cargo; Stacking inside containers; Safe operation of road/rail dock vehicles; Testing and maintenance; Storage of cargo in containers and dock yards

Activity: Design of a safe material movement path layout for dock operations.

Emergency Preparedness and SHW Rules

Dock safety code for fire, oil spill, chemical leak emergencies; Dangerous goods rules, 1989; Preparation of Emergency Response Plan (ERP); Entry and hot work in hazardous cargo ships; Responsibilities under Dock Workers (Safety, Health and

Welfare) Rules, 1990 – permit-to-work system, notification and documentation of incidents.

Activity: Prepare an ERP template for a hazardous cargo incident scenario.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Case-Based Activity (15%), Flipped Classrooms (5%), Review of GATE & IES questions.

Assessment Methodology:

Component	Weightage
Assignments	20%
Quizzes	10%
Case-Based Activities	15%
Flipped Classrooms	5%
Internal Examinations	50%

References:

1. Dock Workers (Safety, Health and Welfare) Rules, Ministry of Labour, Govt. of India, Latest Edition.
2. IS 15859: Safety Code for Docks, BIS Standards, 2016.
3. Alan Veasey, *Port and Terminal Management*, Lloyd's Practical Shipping Guides, 2020.
4. International Maritime Organization (IMO), *Code of Practice for Safe Loading and Handling of Cargo*, 2018.
5. Bureau of Indian Standards, *Manual Handling, Rigging and Gear Testing Guidelines*, Latest.

E-Resources:

1. https://dgfasli.gov.in – DGFASLI Guidelines for Dock Workers
2. https://imo.org – Maritime Safety Codes and Conventions
3. https://ilo.org/safework – ILO Tools for Dock and Port Safety
4. https://osha.gov – Shipyard & Dock Safety e-Tools

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain the evolution of dock safety laws, types of ships, lifting appliances, transport equipment, and emergency preparedness	-	-	-
CO2	Apply Dock Workers (SHW) Rules, safe cargo handling, lifting, and emergency procedures	PO3 (3), PO5 (3)	3	3
CO3	Estimate risks associated with heavy packages, hazardous cargo, lifting appliances, and dock transport equipment	PO2 (3), PO4 (3)	3	3
CO4	Analyze responsibilities, ship layouts, lifting operations, dock yard designs, and ERP plans for improvement	PO4 (3), PO5 (3)	3	3