Courses of Study

Semester VIII

B.Tech Mechanical Engineering

(Batch 2023 Onwards)

Department of Mechanical Engineering

Islamic University of Science and Technology, Kashmir

Table of Contents

Detailed Syllabus for 8th Semester

Total Credits = 15 *Total Hours Per Week = 24*

S.No	Course Code	Course Title	L	T	P	S	Hours Per Week	Credits
1	MEC461C	Major Project	0	0	18	0	18	9
2	MECXXXE	Discipline Centric Elective - III[1]	3	0	0	0	3	3
3	XXXXXXG	Generic Elective - III[2]	3	0	0	0	3	3

Notes:

[1] Discipline Centric Electives are offered to the students of the Department of Mechanical Engineering only. The credits corresponding to Discipline Centric Elective - III can alternatively be obtained through MOOCs platform, like NPTEL, subject to the approval of the Head of the Department.

[2] Generic Electives are offered to the students of the School of Engineering and Technology including the students of the Department of Mechanical Engineering. The credits corresponding to Generic Elective - III can alternatively be obtained through MOOCs platform, like NPTEL, or from the Minor Degree Course list subject to the approval of the Head of the Department.

Discipline Centric Elective - III

S.No	Course Code	Course Title	L	T	P	S	Hours Per Week	Credits
1	MEC455E	Gas Dynamics	3	0	0	0	3	3
2	MEC456E	Fatigue and Fracture Mechanics	3	0	0	0	3	3
3	MEC457E	Automotive Systems Engineering	3	0	0	0	3	3
4	MEC458E	Fundamentals of Tribology	3	0	0	0	3	3

Generic Elective - III

S.No	Course Code	Course Title	L	T	P	S	Hours Per Week	Credits
1	MEC452G	Optimization Techniques in Engineering	3	0	0	0	3	3
2	MEC453G	Renewable Energy Engineering	3	0	0	0	3	3
3	MEC454G	Design of Experiments	3	0	0	0	3	3
4	MEC455G	Welding Technology	3	0	0	0	3	3

MEC455E Gas Dynamics 3-0-0-0

Course Objectives: This course will enable students to:

1. Develop an understanding of Navier-Stokes equations for viscous compressible fluid flow and important dimensionless numbers relevant to the flow.
2. Provide knowledge of compressible flow phenomena like shocks, expansion waves.
3. Develop an understanding of 1D and Quasi 1D flows with effects of friction, heat transfer and area change.
4. Acquire knowledge of moving shock wave and reflection phenomenon, shock tubes and 2D irrotational compressible flow.

Course Outcomes: At the end of this course, a student will be able to:

1. Capability to formulate and solve viscous fluid flow problems.
2. Ability to analyze compressible flows involving shock waves, expansion waves.
3. Capability to analyze 1D and Quasi 1D compressible flow through nozzle and diffusers
4. Capability to formulate 2D compressible potential flow.

Module I

Introduction to Compressible flow and its applications: Review of Basic Equation in Differential and Integral Form (Mass, Momentum and Energy) for a viscous compressible flow and equations of states. Review of concepts of speed of sound in a stationary compressible medium and the Mach. No Basic differential equations for an inviscid compressible flow Dynamic similarity parameters in a compressible viscous flow.

Module II

Steady One Dimensional Flow Model: Basic Equations, Normal Shock Waves (Stationary), Oblique Shock Waves, Reflection & Interaction of Oblique Shock Waves, Expansion Waves Adiabatic Flow in a Constant area passage with friction, frictionless flow in a constant area passage with heat addition/removal.

Module III

Quasi-ID Steady Flows: Adiabatic Flow in a variable area passage without friction, Convergent-divergent nozzles and their operating characteristics. Convergent-divergent, Supersonic Diffusers, Generalized Quasi-ID Flow Governing Equations.

Module IV

Unsteady wave motion: Moving normal shocks, reflected shock waves, Physical aspects of wave propagation, Basic elements of acoustic theory. Finite (Non-Linear) waves, Shock-tube relations, Finite compression waves.

Pre-requisites: Fluid Mechanics

Text Books:

1. S. M. Yahya Compressible Flow, Wiley Eastern, New Delhi.
2. Oosthuizen P.H., Carscallen W.E., Compressible Fluid Flow, McGraw Hill Education (India).
3. Zucrow & Hoffman, Gas Dynamics, John Wiley and Sons.
4. Shapiro, Dynamics & Theordynamics-Vol-1, Ronald Press New York.
5. Anderson Jr J.D., Modern Compressible Flow with Historical Perspective, McGraw Hill.

Reference Books: NA

Online Resources:

1. Gas Dynamics by Dr. T.M. Muruganandam (IIT Madras), NPTEL Course (https://archive.nptel.ac.in/courses/101/106/101106044/)

MEC456E Fatigue and Fracture Mechanics 3-0-0-0

Course Objectives: This course will enable students to:

1. Understand the basics of fatigue of structures.
2. Comprehend the fracture mechanics.
3. Acquire the knowledge of fatigue design and testing.

Course Outcomes: At the end of this course, a student will be able to:

1. Evaluate the fatigue of structures.
2. Estimate the fatigue life of materials.
3. Determine the strength of cracked bodies.
4. Identify the mechanism of fracture and crack growth in different types of materials
5. Distinguish safe life and fail safe design.

Module I

Introduction: Fatigue of Structures, S.N. curves, Endurance limit, Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams, Notches and stress concentrations, Neuber's stress concentration factors, plastic stress concentration factors – Notched S-N curves.

Module II

Statistical Aspects of Fatigue Behaviour: Low cycle and high cycle fatigue, Coffin-Manson's relation, Transition life, Cyclic Strain hardening and softening, Analysis of load histories, Cycle counting techniques, Cumulative damage, Miner's theory, other theories.

Module III

Physical Aspects of Fatigue: Phase in fatigue life, Crack initiation, Crack growth, Final fracture, Dislocations, Fatigue fracture surfaces.

Module IV

Fracture Mechanics: Strength of cracked bodies, potential energy and surface energy, Griffith's theory, Irwin – Orwin extension of Griffith's theory to ductile materials, Stress analysis of cracked bodies, Effect of thickness on fracture toughness, Stress intensity factors for typical geometries.

Module V

Fatigue Design and Testing: Safe life and fail safe design philosophies, Importance of Fracture Mechanics in aerospace structure, Application to composite materials and structures.

Pre-requisites: Mechanics of Deformable Bodies, Engineering Material and Applications

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Text Books:

1. F. C. Campbell, Fatigue and Fracture: Understanding the Basics, ASM International, 2012.
2. D. Brock, Elementary Engineering Fracture Mechanics, Noordhoff International Publishing Co., 1st edition, 1982.

Reference Books:

1. C.G.Sih, Mechanics of Fracture, Springer, 1st edition, 1991.

Online Resources:

1. Fracture Mechanics by Prof. K. Ramesh (IIT Madras), NPTEL Course (https://archive.nptel.ac.in/courses/112/106/112106065/).

MEC457E Automotive System Engineering 3-0-0-0

Course Objectives: This course will enable students to:

1. Learn about the working of conventional vehicles.
2. Learn about construction and operation of BEVs.
3. Learn about construction and operation of FCEVs.

Course Outcomes: At the end of this course, a student will be able to:

1. Explain the working of conventional engines: SI and CI
2. Describe the charging process in conventional engines
3. Explain the working of the powertrain in conventional engines
4. Describe the construction and working of BEVs
5. Describe the construction and working of FCEVs

Module I

Introduction: Introduction to IC Engines, classification and major applications, engine performance parameters, comparison of Otto, Diesel and Dual cycles, two-stroke engines-operation, advantages and disadvantages, scavenging, fuel-air cycles and their significance, actual cycles, various losses encountered in SI and CI engines.

Module II

Fuel Injection Systems: Mixture requirement in SI engines, carburetion, fuel injection in CI and SI engines, supercharging and turbocharging, types of combustion chambers in SI and CI engines, combustion in SI engines, effect of engine variables on detonation, combustion in CI engines, effect of engine variables on delay period, comparison of knock in SI and CI engines, conventional fuels for SI and CI engines-requirements and their knock rating, alternative fuels and fuel additives.

Module III

Power Transmission: Power transmission in conventional systems, requirements of Transmission System; different types of wheel drives, gear box; types of gear boxes, freewheel unit, overdrive units, operation of differential. Clutches: types, construction and operation. Braking system: mechanical and hydraulic, pneumatic

Module IV

Battery Powered Electric Vehicles: introduction to BEVS, current technological and market status – global and local, construction of BEVs, types of batteries, power train structure, performance parameters, economics of BEVs.

Module V

Fuel Cell Powered Electric Vehicles: introduction to FCEVs, current technological and market status, construction of FCEVs, types of fuel cells, power train structure, performance parameters, economics of FCEVs.

Pre-requisites: Engineering Thermodynamics, Applied Thermodynamics

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Text Books:

1. V. Ganesan, Internal Combustion Engines, McGraw Hill Education.
2. I. Hussain., Electric and Hybrid Vehicles Design Fundamentals, CRC Press

Reference Books:

1. J. B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Education.

Online Resources:

1. Fundamentals of Automotive Systems by Prof. C.S. Shankar Ram (IIT Madras), NPTEL Course (https://archive.nptel.ac.in/courses/107/106/107106088/).

MEC458E Fundamentals of Tribology 3-0-0-0

Course Objectives: This course will enable students to:

1. Introduce tribology as an important design consideration that affects the performance of various machine components in relative motion and in contact
2. Understand the importance of friction and wear while designing components for functional applications
3. Recognize the importance of lubrication in machine components and in the design of various types of bearings

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Course Outcomes: At the end of this course, a student will be able to:

1. Explain the importance of tribology through various historical development
2. Analyze the nature of surfaces and the equipment used to measure surface roughness.
3. Define the laws of friction and the concept of friction in metals and alloys.
4. Define the concept of wear, analysis of wear, techniques to control the wear and measurement technique to analyze friction and wear.
5. Explain the concept of lubrication and the use of lubricants for various tribological applications

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Module I

Introduction: Definition and History of Tribology, Industrial significance of Tribology. Factors affecting tribological phenomena. Applications and examples from real world problems. Origin and significance of Micro/ Nano tribology.

Module II

Solid Surface Characterization: The nature of surfaces, Engineering surface, Physico-Chemical Characteristics of Surface Layers: deformed layer, chemically reacted layer, physisorbed layer, chemisorbed layer, Methods of characterization of surface layer. Analysis of surface roughness: surface roughness parameters, statistical analysis, fractal characterization and practical consideration in measurement of surface roughness. Measurement of surface roughness: Contact and non-contact methods.

Module III

Friction: Introduction, Solid-Solid contact: rules of sliding friction, basic mechanism of sliding friction, other mechanisms of sliding friction, friction transition during sliding, static friction, stick slip, rolling friction. Liquid- Mediated contact. Friction of materials: metals and alloys, ceramics, polymers, solid lubricants.

Module IV

Introduction to Wear: Wear, Types of wear, Adhesive wear and its mathematical model, abrasive wear and its mathematical model, two body & three abrasive wear, corrosive wear model, erosive wear model, cavitation wear, wear, delamination wear, pitting wear, wear coefficient and wear measurement, weight loss method and profilometric method, Pin- on- Disc tribometer, Pin-on-ring tribometer, wear coefficient of various materials, Wear of metals and alloys, wear of ceramics, wear of polymers.

Module V

Lubrication: Lubricants, types of lubricants, physical adsorption, Chemisorption, Self-lubrication Properties of materials, Solid lubrication, Lubrication in space, Food industry, etc, High temperature lubrication, Hydrodynamic lubrication, Various components of Reynolds equation, Somerfield number and its use in hydrodynamic lubrication.

Pre-requisites: Engineering Mechanics, Machine design and Manufacturing processes

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Text Books:

1. H. Czichos, A system approach to science and Technology of Friction, Lubrication and Wear Volume I, Tribology series, Elsevier Publications. 1978.
2. J. Glaeser, Marerials for Tribology, Tribology series Vol. 20, Elsevier Publications, 1992.
3. B. Bhushan, Introduction to Tribology, John Wiley & Sons,2013.

Reference Books:

1. Bharat Bhushan, Introduction to Tribology, John Wiley & Sons,2013.
2. A. Cameron "The principles of Lubrication", Longman, London, 2000.

Online Resources:

1. Introduction to Tribology by Dr. Harish Hirani (IIT Delhi), NPTEL Course (https://archive.nptel.ac.in/courses/112/102/112102015/).

MEC452G Optimization Techniques in Engineering 3-0-0-0

Course Objectives: This course will enable students to:

1. Get familiar with various numerical methods used for single objective optimization problems.
2. Formulate an engineering design problem as an optimization problem.
3. Apply a suitable method for arriving at an optimal solution.
4. Understand various traditional and nontraditional optimization algorithms.

Course Outcomes: At the end of this course, a student will be able to:

1. Understand different parameters involved in an optimization problem.
2. Apply optimization techniques to single variable problems.
3. Apply optimization techniques to multivariable problems.
4. Apply optimization techniques to constrained optimization problems.
5. Understand nontraditional optimization techniques.

Module I

Introduction to Optimization: Historical development, Engineering applications of optimization, Optimization problem formulation: Design variables, constraints, objective function and variable bounds, Classification of optimization algorithms.

Module II

Single Variable Optimization: Optimality criteria, Bracketing methods: Exhaustive search method and bounding phase method, Region-elimination methods: Interval halving method, Fibonacci search method and golden section search method, Gradient based methods: Newton-Raphson method, bisection method and secant method.

Module III

Multivariable Optimization: Optimality criteria, Unidirectional search, Direct search methods: Hooke-Jeeves pattern search method, Gradient-based methods: Cauchy's (steepest descent) method, Newton's method and Marquardt's method.

Module IV

Constrained Optimization: Kuhn-Tucker conditions, Transformation methods: Penalty function method and method of multipliers, Linearized search techniques: Cutting plane method, Generalized reduced gradient method, Integer programming.

Module V

Nontraditional Optimization: Genetic algorithms: Working principles, Differences and similarities between GAs and Traditional Methods, GAs for Constrained Optimization, Simulated annealing, Global optimization: Using the Steepest Descent Method, Using Genetic Algorithms, Using Simulated Annealing.

Pre-requisites: Numerical Methods for Engineers

Text Books:

1. K. Deb, Optimization for Engineering Design: Algorithms and Examples, PHI, 2nd Edition, 2012.
2. S. S. Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons, 4th Edition, 2009.

Reference Books:

1. J. Arora, Introduction to Optimum Design, AP, 4th Edition, 2016.
2. R. C. Johnson, Optimum Design of Mechanical Elements, Wiley, 2nd Edition, 1980.
3. D. E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Professional, 1st Edition, 1989.

Online Resources:

1. Optimization Methods in Engineering Design by Prof. Saroj Kumar Patel (NIT Rourkela), (https://youtube.com/playlist?list=PL7XCYAQpq_DPkyrj-LEi5Gn73Xx_u-J1Q)

MEC453G Renewable Energy Engineering 3-0-0-0

Course Objectives: This course will enable students to:

1. Acquire the knowledge of the global energy scenario-availability and utilization.
2. Impart knowledge about solar energy and its utilization.
3. Learn about wind energy and its utilization.
4. Learn about other non-conventional energy sources such as biomass, OTEC, geothermal.

Course Outcomes: At the end of this course, a student will be able to:

1. Explain the global energy scenario.
2. Explain utilization of various forms of solar energy
3. Explain the principles of solar energy in engineering applications.
4. Describe the methods of utilization of wind energy
5. Describe the utilization of other non-conventional sources of energy.

Module I

Introduction: Role of energy in the development of society, Energy demand and availability, Impact of energy use on the environment, Economic aspects, Global and Indian energy Scenario, Conventional and Non-Conventional Sources,

Module II

Solar Energy: Solar energy as an alternative source, solar energy measurement devices, estimation of direct and diffuse radiation Solar energy collectors and their types, analysis of flat plate collectors for air and water heaters.

Module III

Utilization of Solar Energy: Solar heating and cooling of buildings, solar refrigeration, solar ponds and solar stills, solar energy storage, electricity generation from solar energy: principles of photovoltaic solar cells.

Module IV

Wind Energy Resources: Global wind circulations; Indian sites for wind power; Aerodynamic design of wind turbine, Darrieus rotor design, propeller type rotor design, blade loads, Governor and Yaw control; Economics of wind power.

Module V

Other Non-Conventional Sources of Energy: Biomass Conversions, MHD (Magneto-Hydrodynamic) Power generation system; Geothermal Energy; Energy from Ocean (Ocean Thermal Energy Technology and Energy from Tides).

Pre-requisites: NA

Text Books:

1. B. H. Khan, Non-Conventional Energy Resources, McGraw Hill Education (India). 2nd edition, 2017.

Reference Books:

1. S. P. Sukhatme and J. K. Nayak, Solar Energy, McGraw Hill Education (India). 4th edition, 2017.
2. J. Twidell and T. Weir, Renewable Energy Resources, Routledge, 3rd edition, 2015.

3. J. A. Duffie and W.A Beckman, Solar Engineering of Thermal Processes, Wiley.

Online Resources:

1. Physics of Renewable energy system by Prof. Amreesh Chandra, IIT Kharagpur, NPTEL course.(Physics of Renewable Energy Systems - Course)
2. Non-Conventional energy by Prof. Prathap Haridoss, IIT Madras, NPTEL course (Non-conventional energy Resources - Course).

MEC454G Design of Experiments 3-0-0-0

Course Objectives: This course will enable students to:

1. Develop understanding of Design of Experiments (DoEs).
2. Design and conduct linear experimental designs and optimization.
3. Design and conduct non-linear experimental designs and optimization.
4. Provide an overview of Taguchi's robust design methodology.

Course Outcomes: At the end of this course, a student will be able to:

1. Explain the fundamentals of Design of Experiments (DoEs).
2. Design and conduct experiments for developing linear models and analyze the resulting data to obtain valid conclusions and optimize the system.
3. Choose optimal designs for developing nonlinear models efficiently and effectively, and analyze the resulting data to obtain valid conclusions and optimize the system.
4. Explain and construct a design matrix for conducting experiments for linear and nonlinear models.
5. Explain and apply Taguchi's robust design methodology for mechanical engineering problems.

Module I

Introduction to Design and Analysis of Experiments: Basic Principles of Design and Analysis of Experiments, Guidelines for Designing Experiments, model of a system, types of experimental design (first-order and second-order model), basic statistical concepts, single factor experiments.

Module II

Linear Experimental Designs and Optimization: Basic definition and principles, $\mathbf{2^k}$ full factorial design, a geometrical representation, standard order form, first order response surface model, estimation of main and interaction effects, statistical analysis, estimation of parameters and model adequacy test, $\mathbf{2^{k-p}}$ fractional factorial design, steps to construct fractional factorial design, first order response surface model, estimation of main and interaction effects, statistical analysis, estimation of parameters and model adequacy test, screening designs

Module III

Non-linear Experimental Designs and Optimization: Basic definition and principles, 3^k full factorial design, central composite designs, Box-Behnken design, estimation of linear and nonlinear effects, a second order response surface model, sequential approach.

Module IV

Taguchi Design : Introduction to Taguchi design, orthogonal arrays (OA), properties of OA, design of OA, Concept of S/N ratio.

Module V

Software Practice: Introduction to software used for design and analysis of experiments, systematic analysis and steps involved in software for the analysis of factorial design, fractional factorials method, Taguchi method and response surface methodology, case studies and examples.

Pre-requisites: NA

Text Books:

1. D. C. Montgomery, Design and analysis of experiments, John wiley and sons.
2. R. K. Roy, Design of experiments using the Taguchi approach: 16 steps to product and process improvement, John Wiley & Sons, 2001.

Reference Books:

1. K. Hinkelmann and O. Kempthorne, Introduction to experimental design, Vol. 1, John Wiley & Sons.
2. A. Dean and D. Voss. Design and analysis of experiments, Springer.
3. J. Antony, Design of Experiments for Engineers and Scientists, 2nd Edition, Elsevier Inc., 2014.

Online Resources:

1. Design and Analysis of Experiments By Prof. Jhareswar Maiti (IIT Kharagpur), NPTEL Course (https://onlinecourses.nptel.ac.in/noc21_mg48/preview)

MEC455G Welding Technology 3-0-0-0

Course Objectives: This course will enable students to:

1. Acquaint themselves with the exciting world of welding sciences.
2. Acquire knowledge on classification and principles of different welding techniques.
3. Explain the concepts of welding metallurgy and different thermal phenomena involved in welding processes.

Course Outcomes: At the end of this course, a student will be able to:

1. Explain different types of welding techniques and their applications.
2. Describe the welding process and its metallurgical and thermal implications.
3. Discuss the microstructure of various zones and hence comprehend their significance.
4. Apply various destructive and non destructive techniques in testing of weldments.
5. Inspect the welds and provide remedies in case of any defects.

Module I

Introduction to welding and joining processes: Introduction to consolidation processes, Classification of welding processes, some common concerns, types of fusion welds and types of joints, Design considerations, Heat effects, Weld ability and join ability. Welding terms and definitions, welding positions, elements of and construction of welding symbols.

Module II

Welding Metallurgy (Physical Metallurgy and Solidification of Weld Metal): Fundamentals of physical metallurgy: Need, phase diagrams: Fe-C, Al-Cu, Cu-Zn system, phase transformations in FeC system, TTT diagram, CCT diagram, carbon equivalent, Schaffer diagram, relevance of above in welding. Solidification of weld metal: Principle of solidification of weld metal, modes of solidification, effect of welding parameters on weld structure, grain refinement principle of weld metal, method of weld metal refinement, inoculation, arc pulsation, external excitation

Module III

Chemical, Metallurgical, and Mechanical testing of weldment: Comparison of destructive and non-destructive tests, chemical tests, forms of corrosion, testing for corrosion resistance, metallographic tests.

Module IV

Advanced Welding Processes: Atomic hydrogen, ultrasonic welding (USW), Plasma arc welding (PAW), laser beam welding (LBW), and Electron beam welding (EBW). Wire-feed based WAM: Wire and Laser Additive Manufacturing (WLAM), Electron Beam Freeform Fabrication (EBF3), Wire and Arc Additive Manufacturing (WAAM).

Module V

Weldment Inspection: Codes governing welding inspection: Structural welding code; ASME boiler and pressure vessel code, spot examination of welded joints, duties of the inspector, ASTM standards, API standards. Visual and liquid penetrant inspection, Magnetic particle and Radiographic inspection, Ultrasonic inspection and Eddy current inspection, acoustic emissions, proof tests and leak tests.

Pre-requisites: Manufacturing Processes I, Manufacturing Processes II

Text Books:

1. J. Larry and L. Jeffus, Welding Principles and Application, 5th edition, Delmer Publications

Reference Books:

1. R. S. Parmer., Welding Engineering and Technology, Khanna Publishers, 1997

Online Resources:

1. Advances in Welding and Joining Technologies by Prof. Swarup Bag (IIT Guwahati), NPTEL Course (https://nptel.ac.in/courses/112103244).
