B.E- MECHANICAL ENGINEERING (Honours)

S.No	Course Code	Title of the Course	Credits
1	H20ME001/H22ME001	Automation in Manufacturing	3
2	H20ME002/H22ME002	Advanced Materials and Processes	3
3	H20ME003/H22ME003	Industrial Safety Engineering	3
4	H20ME004/H22ME004	Surface Engineering for Corrosion and Wear Resistance Applications	3
5	H20ME005/H22ME005	Mathematical Modeling of Manufacturing Processes	3
6	H20ME006/H22ME006	Work System Design	3
7	H20ME007/H22ME007	Sustainability Through Green Manufacturing Systems: An Applied Approach	3
8	H20ME008/H22ME008	Functional and Conceptual Design	3
9	H20ME009/H22ME009	Weldability of Metals: Mechanisms, Weld Defects & Prevention.	2
10	H20ME010/H22ME010	Design for Quality, Manufacturing and Assembly	2
11	H20ME011/H22ME011	Dealing With Materials Data: Collection, Analysis, and Interpretation	3
12	H20ME012/H22ME012	Manufacturing Strategy	2
13	H20ME013/H22ME013	Knowledge Management	2
14	H20ME014/H22ME014	Design Thinking - A Primer	1
15	H20ME015/H22ME015	Innovation by Design	1
16	H20ME016/H22ME016	Understanding Design	1
17	H20ME017/H22ME017	Structural Analysis of Nano materials	1

18	H20ME018/H22ME018	Mechanical Measurement Systems	2
19	H20ME019/H22ME019	Patent Drafting for Beginners	1
20	H20ME020/H22ME020	Heat Exchangers: Fundamentals and Design Analysis	3
21	H20ME021/H22ME021	Solar Energy Engineering and Technology	3
22	H20ME022/H22ME022	Advanced Fluid Mechanics	3
23	H20ME023/H22ME023	Aircraft Propulsion	3
24	H20ME024/H22ME024	Energy Conservation and waste heat recovery	3
25	H20ME025/H22ME025	Fluidization Engineering	3
26	H20ME026/H22ME026	CFD using Finite Volume Method	3
27	H20ME027/H22ME027	Fundamentals of Convective Heat Transfer	3
28	H20ME028/H22ME028	Dynamic behavior of Materials	3
29	H20ME029/H22ME029	System design for Sustainability	3
30	H20ME030/H22ME030	Computational Continuum Mechanics	3
31	H20ME031/H22ME031	Engineering Fracture Mechanics	3
32	H20ME032/H22ME032	Numerical Methods for Engineers	3
33	H20ME033/H22ME033	Robotics and Control: Theory and Practice	2
34	H20ME034/H22ME034	Acoustic materials and Metamaterials	2
35	H20ME035/H22ME035	MATLAB Programming for Numerical Computation	2
36	H20ME036/H22ME036	Ergonomics in Automotive design	1
37	H20ME037/H22ME037	Foundations of Cognitive Robotics	1
38	H20ME038/H22ME038	Theory of Rectangular Plates	1
39	H20ME039/H22ME039	Elements Of Mechanical Vibration	3
40	H20ME040/H22ME040	Aircraft Stability and Control	3
41	H20ME041/H22ME041	Introduction To Aircraft Design	3

42	H20ME042/H22ME042	Space Flight Mechanics	3
43	H20ME043/H22ME043	Vibration And Structural Dynamics	2
44	H20ME044/H22ME044	Smart Structures	3
45	H20ME045/H22ME045	Understanding Incubation and Entrepreneurship	3
46	H20ME046/H22ME046	Design, Technology, and Innovation	2
47	H20ME047/H22ME047	Social Innovation in Industry 4.0	3
48	H20ME048/H22ME048	Experimental Modal Analysis	3
49	H20ME049/H22ME049	Mechanical Behavior of Polymers and Composites	3
50	H20ME050/H22ME050	Sustainable Power Generation Systems	3

H20ME001

AUTOMATION IN MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Explain the design and development of automated systems in the manufacturing. (BL-2)
2. Describe working of various blocks of automated system. (BL-2)
3. Illustrate the principle of operation and construction details of sensors/transducers, actuators, drives and mechanisms, hydraulic and pneumatic systems for automation. (BL-3)
4. Summarize the microprocessor technology, programming and CNC technology. (BL-2)
5. Use automation principles for manufacturing industrial applications. (BL-3)

UNIT- I

Introduction: Importance of automation in the manufacturing industry. Use of mechatronics, systems required.
Design of an automated system: Building blocks of an automated system, working principle and examples.

UNIT- II

Fabrication: Fabrication or selection of various components of an automated system, specifications of various elements, use of design data books and catalogues.
Sensors: Study of various sensors required in a typical automated system for manufacturing, construction and principle of operation of sensors.

UNIT- III

Microprocessor technology: Signal conditioning and data acquisition, use of microprocessor or micro controllers, configurations, working.
Drives: Electrical drives, types, selection criteria, construction and operating principle.

UNIT - IV

Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.
Hydraulic systems: Hydraulic power pack, pumps, valves, designing of hydraulic circuits.

UNIT –V

Pneumatic systems: Configurations, compressors, valves, distribution and conditioning.
CNC technology: Basic elements, interpolators and programming.

Text Books:

1. Boltan, W., “Mechatronics: electronic control systems in mechanical and electrical engineering”, Longman, Singapore, 1999.
2. Groover, M.P., “Automation, Production Systems, and Computer-Integrated Manufacturing”, Prentice Hall, 2001.
3. Gaonkar, R.S., “Microprocessor architecture, programming, and applications with the 8085”, Penram International Publishing (India), Delhi, 2000.

Suggested Reading:

1. Regtien, P. P. L., “Sensors for mechatronics”, Elsevier, USA, 2012.
2. Parr, A. A., “Hydraulics and pneumatics”, Elsevier, 1999.

Handbooks:

1. Smid, P., “CNC Programming Handbook”, Industrial Press, New York, USA, 2008.
2. Rothbart, H. A., “CAM Design Handbook”, McGraw-Hill, 2004.
3. Norton, R. L., “Cam Design and Manufacturing Handbook”, Industrial press Inc, 2002.

H20ME002

ADVANCED MATERIALS AND PROCESSES

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the classification of structural and functional materials. (BL-2)
2. Learn the processing and applications of bulk metallic glasses. (BL-1)
3. Identify the use of various materials. (BL-2)
4. Design materials based on applications. (BL-3)
5. Understand the importance of shape memory alloys and super alloys. (BL-2)

UNIT – I
Introduction: Metastable and functional alloys.
Bulk metallic glasses: Fundamental concepts, mechanical and functional properties.

UNIT - II
Shape memory alloys, Pseduelasticity, shape memory alloys applications and case studies.

UNIT - III
Introduction to high temperature materials.
Super alloys: Alloy design, microstructure and properties.

UNIT - IV
Nano-materials.

UNIT - V
Soft and hard magnetic materials, non-equilibrium processes, single crystal growth, rapid solidification, inert gas condensation and advanced functional alloys.

Text Books:

1. Leonardo Lecce and Antonio Concilio, “Shape Memory Alloy Engineering: For Aerospace, Structural and Biomedical Applications”, Butterworth-Heinemann, 2014.
2. Helmi A. Youssef, “Machining of Stainless Steels and Super Alloys: Traditional and Nontraditional Techniques”, Wiley, 2016.
3. Guozhong Cao and Ying , “Nanostructures and Nanomaterials: Synthesis, Properties, and Applications”, World Scientific Publishing Company, 2010.

Suggested Reading:

1. Mark J. Mezger, Kay J. Tindle, “Energetic Materials: Advanced Processing Technologies for Next Generation Materials”, CRC Press, 2017.
2. C. Suryanarayana and A. Inoue, “Bulk Metallic Glasses”, CRC Press; 2 edition, 2017.

H20ME003

INDUSTRIAL SAFETY ENGINEERING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Identify the causes for industrial accidents and suggest preventive measures for safety. (BL-2)
2. Use the concepts of engineering systems safety, dimensions of engineering systems safety.(BL-3)
3. Apply the principles of safety design and carry out analysis. (BL-3)
4. Design for engineering systems safety and control for safety. (BL-3)
5. Integrate safety with other operational goals such as quality and reliability. (BL-5)

UNIT - I

Introduction: key concepts, terminologies, and safety quantification, safety by design, hazard identification techniques (e.g., HAZOP, FMEA, etc.) .

UNIT - II

Fault tree and event tree analysis (qualitative & quantitative) and Bow-tie and quantitative risk assessment (QRA) .

UNIT - III

Safety function deployment, safety vs reliability, quantification of basic events (repair to failure, repair- failure-repair, and combined processes).

UNIT - IV

Systems safety quantification (e.g., truth tables, structure functions, minimal cut sets), human error analysis and safety.

UNIT – V

Accident investigation and analysis, application of virtual reality, OSHAS 18001 and OSHMS.

Text Books:

1. Komamoto and Henley, “Probabilistic Risk Assessment for Engineering and Scientists”, IEEE Press, 1995.
2. Heinrich et al., “Industrial Accident Prevention”, McGraw Hill, 1980.
3. Petersen D, “Techniques for safety management - A systems approach”, ASSE 1998.

Suggested Reading:

1. H. P. Garg, “Maintenance Engineering”, S. Chand and Company, Year 2010.
2. Tyler G. Hicks and T. W. Edwards, “Pump Application Engineering", McGraw-Hill, 1971.

H20ME004

SURFACE ENGINEERING FOR CORROSION AND WEAR RESISTANCE APPLICATIONS

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the degradation of engineering materials through wear and corrosion. (BL-2)
2. Develop wear and corrosion resistant materials. (BL-6)
3. Analyze the role of microstructure in controlling the surface dependent failure of components. (BL-3)
4. Apply advanced surface modification techniques to protect engineering components. (BL-4)
5. Evaluate various surface engineering techniques. (BL-5)

UNIT - I

Introduction: Materials, surface, thermodynamics of surface, surface dependent engineering properties, Common surface initiated engineering failure, mechanism of surface degradation, role of microstructure and materials behavior in controlling the surface dependent failure of components, importance of surface engineering, classification and scope of surface engineering of materials, surface modification and coating techniques.

UNIT - II

Conventional surface modification methods: Age hardening, induction hardening, carburizing, nitriding, and diffusion assisted surface alloying.

Advanced surface modification methods: Laser, plasma and electron beam assisted surface modification, surface coating by chemical/electro-chemical routes electro/electroless deposition, anodizing, micro-arc oxidation.

UNIT-III

Surface coating by physical routes: Physical vapor deposition, pulsed laser deposition, cathodic arc evaporation.

Surface coating by chemical routes: Chemical vapor deposition, laser assisted chemical vapor deposition.

UNIT- IV

Hot dipping: Galvanizing, tinning, aluminizing, babitting.

Thermal spraying: Ame spraying, HVOF spraying, wire arc spraying, kinetic spraying.

UNIT-V

Special coating techniques: Weld overlaying, laser surface cladding, surface characterization and testing.

Text Books:

1. J R Davis, “Surface Engineering for Corrosion and Wear Resistance”, ASM International, 2001.
2. Manish Roy “Surface Engineering for Enhanced Performance against wear”, Springer Science & Business Media, 2013.
3. K. Holmberg, A. Matthews, “Coatings Tribology: Properties, Techniques and Applications in Surface Engineering” , Elsevier,1994.

Suggested Reading:

1. Tadeusz Burakowski, Tadeusz Wierzchon, “Surface engineering in metals”, CRC Press, 1999.
2. Jamal Takadoum, “Surface Engineering: Enhancing life of Tribological component”, Springer, 2017.
3. London A W Batchelor, “Materials Degradation and its control by surface engineering”, Imperial College Press, 2006.

H20ME005

MATHEMATICAL MODELING OF MANUFACTURING PROCESSES

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the basic mechanism such as heat and mass transport with associated fluid flow including metallurgical transformation, distortion and residual stress generation in different manufacturing processes. (BL-2)
2. Explain the analysis, numerical simulation at different scale and experimentation for different types of manufacturing processes. (BL-4)
3. Develop the computational models for a manufacturing process relies on mathematical expression of the governing mechanism. (BL-6)
4. Understand the most general to advanced manufacturing processes based on scientific principle. (BL-2)
5. Develop physics based computational model of manufacturing process using standard commercial package. (BL-6)

UNIT – I
Introduction to manufacturing processes, physics of manufacturing processes.

UNIT – II
Conventional machining, non-conventional machining.

UNIT - III
Metal forming, welding.

UNIT – IV
Casting and powder metallurgy, coating and additive manufacturing.

UNIT - V
Heat treatment, micro/nano scale manufacturing, processing of non-metallic materials.

Text Books:

1. A Ghosh and A K Mallik, “Manufacturing Science”, East-West Press Pvt Ltd,2nd Ed., 2010.
2. D A Brandt, J C Warner, “Metallurgy Fundamentals”, Goodheart- Willcox, 2009.
3. C Lakshmana Rao and Abhijit P Deshpande, “Modelling of Engineering Materials”, Ane Books Pvt. Ltd., New Delhi, India, 2010.

Suggested Reading:

1. J. Chakrabarty, “Theory of plasticity”, 3rd Eds, Elsevier India, 2009.
2. Norman Y Zhou, “Micro joining and Nanoioining”, Woodhead publishing, 2008.

H20ME006

WORK SYSTEM DESIGN

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Scientifically establish the time required for a qualified worker to carry out a work element at a defined rate of working. (BL-5)
2. Apply ergonomic aspects of work system design. (BL-3)
3. Carry out systematic examination of the methods of doing work with an aim of finding the means of effective and efficient use of resources. (BL-3)
4. Establishing standards of performance for the work being carried out. (BL-5)
5. Carry out in-depth analysis of all the elements, factors, resources and relationships affectingthe efficiency and effectiveness of the work being studied. (BL-3)

UNIT- I
Work system design: Introduction, concept of productivity, measurement of productivity, productivity measures, productivity measurement models, factors influencing productivity, causes of low productivity, productivity improvement techniques, numerical problems on productivity, case study on productivity.

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UNIT -II
Work study: Basic concept, steps involved in work study, concept of work content, techniques of work study, human aspects of work study
Method study: Basic concept, steps involved in method study, recording techniques, operation process charts, examples.
Flow process charts: Examples, two-handed-process charts, multiple activity charts, flow diagrams.

UNIT-III
String diagrams, principles of motion economy, micro-motion study, therbligs, SIMO charts, memo-motion study, cycle graph and chrono-cycle graph, critical examination techniques, development and selection of new method, installation and maintenance of improved methods.

UNIT- IV
Work measurement: Basic concept, techniques of work measurement, steps involved in time study, steps and equipment of time study, performance rating.
Performance rating: Examples, allowances, computation of standard time-I, computation of standard time-II, case study.

UNIT – V
Work sampling: Basics, procedure of work sampling study, numerical problems on work sampling, introduction to synthetic data and PMTS, introduction to MTM and MOST.
Ergonomics: Basic concept, industrial ergonomics, anthropometry, man-machine system-1&2.
Case studies: Office chair, tower crane cabin, car seat, computer system, assembly line.

Text Books:

1. M. Telsang, "Industrial Engineering and Production Management", S. Chand and Company Ltd, 2015.
2. Ralph M. Barnes, Wiley "Motion and Time Study Design and Measurement of Work", The University of California, 2005.
3. Groover M.P., "Work Systems: The Methods, Measurement & Management of Work", Prentice Hall, 2000.

Suggested Reading:

1. Alexander D., The practice and Management of industrial ergonomics, Prentice Hall, 2006.
2. Konz S., and Johnson S., Work Design and Industrial Ergonomics, Holcomb Hathaway Publishers, 2001.

H20ME007

SUSTAINABILITY THROUGH GREEN MANUFACTURING SYSTEMS: AN APPLIED APPROACH

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the over view of the sustainability through green manufacturing systems. (BL-2)
2. Analyze the various methodologies and its applications in improving the eco-efficiency. (BL-4)
3. Suggest ways to conserve energy and natural sources and to ensure that they have minimal impact on the environment and society. (BL-6)
4. Apply sustainable aspects of management methodologies such as lean manufacturing, green supply chain management and product life cycle management. (BL-3)
5. Carry out simulation of the manufacturing systems and use modern tools that are used in the virtual environment. (BL-3)

UNIT - I

Introduction: Concept of sustainability, manufacturing, operations, processes, practices, resources in manufacturing, simulation models for manufacturing, validation, verification, output analysis, conceptsof optimization, numerical optimization through simulation.

UNIT - II

Life cycle analysis: Remanufacture and disposal, tools for LCA, optimization for achieving sustainability in unit manufacturing, green manufacturing.

UNIT - III

Green manufacturing techniques: Dry and near-dry machining, edible oil based cutting fluids, cryogenic machining for eco-efficiency.

UNIT - IV

Implementation of lean methods: Validating requirements, green supply chain and carbon footprints in transportation.

Product life cycle management: Energy and mass, work pool and throughput.

UNIT - V

Modern approaches for sustainable manufacturing, toxic substances in industry, and need of renewable sources, simulation for sustainable manufacturing, building a smart green factory, simulation techniques.

Text Books:

1. Nylund, Hasse, “Impacts of Product Lifecycle and Production System Design on Competitive and Sustainable Production”, McGraw Hills Publication, 2013.
2. David A. Dornfeld “Green Manufacturing: Fundamentals and Applications” Springer, 2012.
3. Mrityunjay Singh Tatsuki Ohji Rajiv Asthana “Green and Sustainable Manufacturing of Advanced Material” , Elsevier, 2015.

Suggested Reading:

1. Bin Chang, “Systems Analysis for Sustainable Engineering: Theory and Applications (Green Manufacturing & Systems Engineering)”, McGraw-Hill Education, 2010.
2. Jiri Klemes , Ferenc Friedler, “Sustainability in the Process Industry: Integration and Optimization (Green Manufacturing & Systems Engineering)”, McGraw-Hill Education, 2010.

H20ME008

FUNCTIONAL AND CONCEPTUAL DESIGN

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Learn the importance of system design process in product design. (BL- 1)
2. Identify various steps involved in the design process. (BL-2)
3. Learn the importance of function and form in the design process. (BL-1)
4. Apply the systematic design process for product development. (BL-3)
5. Apply the concept development tools in the design process. (BL-3)

UNIT - I
Overview of the design process: How engineering design is different from conventional design.
Steps in design process: Understanding the opportunity, mission statement.

UNIT - II
Customer need identification: Like/Dislike method, affinity diagram.
Product specifications: Design metrics, bench marking, QFD, HOQ and examples.

UNIT - III
Functional design: Functional decomposition, FAST, function structure, function tree, functional decomposition, examples.

UNIT - IV
Product architecture: Portfolio architecture, unshared, modular, customizable architectures, choosing portfolio architecture, module heuristics.

UNIT - V
Concept development: Converting functions to concepts, concept development tools- intuitive and logical methods, brainstorming, 6-3-5, TRIZ.
Concept selection: Concept screening, scoring and ranking.

Text Books:

1. Kevin Otto & Krisitn Wood, “Product Design”, Pearson Education, 2010.
2. D.G. Ullman, “The Mechanical Design Process”, McGraw- Hill, 2015.
3. G. Pahl and W.Beitz, “Engineering Design- A systematic Approach”, Springer, 2007.

Suggested Reading:

1. Michael Joseph French, “Conceptual Design for Engineers”, Springer; 3rd edition, 2013.
2. Clive L. Dym, “Engineering Design: A Project-Based Introduction”, Wiley; 4^{th} edition, 2013.

H20ME009

WELDABILITY OF METALS: MECHANISMS, WELD DEFECTS & PREVENTION

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, students are able to

1. Recall various aspects related with weldability of various metal systems of commercial importance. (BL-1)
2. Analyze weldability factors affecting weldability of metals, weldability of plain carbon steel, alloy steel and stainless steels. (BL-4)
3. Understand discontinuities in metal systems like ferrous and non-ferrous metals. (BL-2)
4. Understand weldability of pre-coated steel-I, II and stainless steel. (BL-2)
5. Apply the concepts of weldability to martensitic stainless Steel-I, II, ferritic stainless steel and austenitic stainless steel. (BL-3)

UNIT - I
Understanding weldability, introduction, metal properties & weldability, weldability of work hardenable metals.

UNIT - II
Weldability of work hardenable & precipitation strengthened metals, weldability of precipitation strengthened metals, weldability of metals strengthened by grain refinement, dispersion hardening and transformation hardening, weldability of transformation hardening metals, weldability of metals, combination of strengthening mechanisms.

UNIT - III
Weldability consideration, weldability of carbon and alloy steels, weldability of low carbon steel and mild steel, weldability of medium carbon steel and high carbon steel, weldability of carbon and welding processes, weldability of carbon steel and radiation welding and thermal cutting.

UNIT - IV
Weldability of high strength low alloy steels, weldability of Q & T steels, weldability of HTLA steel, weldability of Cr-Mo steel.

UNIT - V
Weldability of pre-coated steel, weldability of stainless steel, weldability of martensitic stainless steel, weldability of martensitic stainless steel, weldability of ferritic stainless steel, weldability of austenitic stainless steel, weldability of PH stainless steel

Text Books:

1. John C. Lippold**, "**Welding Metallurgy and Weldability", Wiley India Publications, 2014.
2. Larry Jeffus, "Welding: Principles and Applications" , Cengage Learning Publications, 2011.
3. Stout "Weldability of Steels", Amer Welding Society Publishers 3rd edition, 1978.

Suggested Reading:

1. Damian J. Kotecki John C. Lippold, "Welding Metallurgy and Weldability of Stainless Steels", Wiley Publications India, 2011.
2. "Welding Handbook: Metals and Their Weldability (Vol. 4)"**,** American Welding Society, 1982.

H20ME010

DESIGN FOR QUALITY, MANUFACTURING AND ASSEMBLY.

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

.**Outcomes:** At the end of the course, the students are able to

1. Recall the concepts such as quality, robustness, six sigma and orthogonal array. (BL-1)
2. Understand the limitations of a design from manufacturing and assembly perspective. (BL-2)
3. Suggest techniques to produce high quality products at low cost. (BL-4)
4. Design teams in simplifying product structure to reduce manufacturing & assembly costs and quantify improvements. (BL-4)
5. Interpret the reasons for variability, mathematically represent, formulate and control it. (BL-6)

UNIT - I

Introduction: Discussion on quality**,** measuring quality, quality loss function, discussion on robustness, six sigma concepts.

UNIT - II

Quantifying robustness: Signal to noise ratio, problem formulation using SNR, design of experiment discussions, orthogonal array, linear graphs, triangular tables, finding optimum combinations, case studies.

UNIT – III

Design for manufacturing: Over the wall design, most influential phase in design, best practices in injection molding and sheet metal working, design for additive manufacturing, single point and multipoint tools.

UNIT – IV

Design for assembly: Boothroyd Dewhurst method, theoretical minimum number of parts, Xerox producibility index (XPI) method.

UNIT – V

Do's and dont's in manual assembly, assembly time estimation, design for robotic assembly considerations, design for sustainability.

Text Books:

1. J. M. Juran, "Juran on Quality by Design: The New Steps for Planning Quality into Goods and Services", McGraw-Hill Education, 1992.
2. Daniel E. Whitney, "Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development", Oxford University Press, 2004.
3. Geoffrey Boothroyd, Peter Dewhurst, "Product Design for Manufacture and Assembly (Manufacturing Engineering and Materials Processing)", CRC Press, 3/e , 2010.

Suggested Reading:

1. James Bralla, "Design for Manufacturability Handbook", McGraw-Hill Education, 2/ e,1998
2. David M. Anderson , "Design for Manufacturability: How to Use Concurrent Engineering to Rapidly Develop Low-Cost, High-Quality Products for Lean Production", Productivity Press, 1/e, 2014.

H20ME011

DEALING WITH MATERIALS DATA: COLLECTION, ANALYSIS AND INTERPRETATION

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Recall the basics of the probability and statistics. (BL-1)
2. Describe data collection, descriptive analysis, error and report presentation. (BL-5)
3. Understand the experimental data processing and probability distributions using R. (BL-2)
4. Understand the graphical data handling, data fitting and hands-on sessions using R programming language. (BL-2)
5. Apply the concept design of experiments, hypnosis testing, Bayesian inference and R for different case study. (BL-3)

UNIT - I
Introduction, basic probability and statistics, basic R.

UNIT – II
Presenting data, inaccuracies and error and its propagation, R for descriptive data analysis.

UNIT – III
Probability distributions, probability distributions using R, processing of experimental data using R.

UNIT - IV
Fitting functions to data, regression, testing significance of fit, R for graphical handling of data and fitting .

UNIT – V
Basics of design of experiments, Bayesian inference and its uses, case studies using R.

Text Books:

1. John I Mc Cool, Using the Weibull Distribution: Reliability, Modeling, and Inference", Wiley, 2012
2. Douglas C. Montgomery and George C. Runger , "Applied Statistics and Probability for Engineers", Springer, 2016.
3. John I. McCool, Schumacker and Sara Tomek, "Understanding Statistics Using R", Springer, 2013.

Suggested Reading:

1. Herman J C Berendsen, "A student's guide to data and error analysis", Cambridge University Press, 2011.
2. Gareth James , Daniela Witten, " An Introduction to Statistical Learning: with Applications in R", Springer, 2013.

H20ME012

MANUFACTURING STRATEGY

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the process of formulation of manufacturing strategy. (BL-2)
2. Apply various tools and techniques for making a world class organization like Toyota production System.(BL-3)
3. Analyze manufacturing functions to gain competitive advantage. (BL-4)
4. Understand the concepts of total quality management and manufacturing excellence. (BL-2)
5. Apply Deming's approach to improve quality in industry. (BL-3)

UNIT-I

Introduction: Manufacturing output, operations systems, operations strategy, functional strategy within context of a firm functional dominance within corporate strategy, concept of world class manufacturing organization, 6 Ps of manufacturing, skinners' view and Hayes and Wheelwright framework of manufacturing strategy, alternative paradigm of manufacturing strategy

UNIT-II

Generic manufacturing strategies: Developing a manufacturing strategy, understanding markets, the concept of order winners and qualifiers, basic characteristics and specific dimensions of order winners and qualifiers, some specific order winners and qualifiers-I,II &III, some specific order winners and qualifiers (Non operation related criteria.

UNIT-III

Developing an operations strategy: Methodology, Roth and Miller classification, enlightened view of manufacturing.

Manufacturing strategy taxonomy: Some evidences from China, quality management, manufacturing excellence, and total quality management.

UNIT-IV

Deming's approach to quality, business excellence awards, process choice and 3 dimensional view, product profiling, critical success factors for world class manufacturing, value added engineering, total employee involvement, HR theories for operations strategy, flexible manufacturing system.

UNIT-V

Concept of focus WRT manufacturing strategy, Toyota production system, world class manufacturing and India, achieving world class status.

Text Books:

1. John Miltenburg¸"Manufacturing Strategy: How to Formulate and Implement a Winning Plan", Productivity Press, 2017.
2. Danny Samson ,"Manufacturing & Operations Strategy", Prentice Hall publication, 1993.
3. Terry Hill and Alex Hill, **"**Manufacturing Operations Strategy" Palgrave Macmillan publication, 2009.

Suggested Readings:

1. Taiichi Ohno, "Evolution of Toyota Production System", Kindle Edition, 2017.
2. Richard J. Schonberger, "World class Manufacturing", Free Press, 2008.

H20ME013

KNOWLEDGE MANAGEMENT

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, students are able to

1. Use the current theories, practices, tools and techniques in knowledge management. (BL-3)
2. Understand the role and use of knowledge in organizations and institutions. (BL-2)
3. Apply fundamental concepts of knowledge and its creation, acquition, representation, dissemination, use and re-use. (BL-3)
4. Perform exchange of knowledge, knowledge codification and system development, its testing. (BL-3)
5. Recommend appropriate KM tools and portals, by considering ethical, managerial and legal issues in knowledge management. (BL-5)

UNIT - I

Introducing the concept of knowledge management (KM): Why KM, KM system life cycle, and aligning KM and business strategy.

KM cycle: Knowledge creation, capturing tacit knowledge, types of knowledge and its implications for KM.

UNIT - II

Knowledge codication and system development: Codication, system testing and deployment, knowledge transfer and knowledge sharing, the role of culture and structure.

UNIT – III

Analysis design and development: Knowledge infrastructure, knowledge audit, knowledge team, analysis, design and development of KM system.

UNIT - IV

KM tools and portals: Inferences from data, data mining and knowledge portals.

Evaluation of KM effectiveness: Tools and metrics, ethical, legal and managerial issues.

UNIT – V

KM experiences form Indian companies, KM innovation and learning organization, the future of KM.

Text Books:

1. Awad, E.M, "Knowledge Management" Pearson India, Delhi, 2007.
2. Fernandez I. B. and Sabherwal.R, "Knowledge Management: System and Resources", PHI Delhi, 2010.
3. Kimiz Dalkir, "Knowledge Management in Theory and Practice" Elsevier, 2005.

Suggested Reading:

1. Tiwana Amrit, "The Knowledge Management Toolkit", Prentice Hall PTR, 1999.
2. Dr.Tiny Neeraja, Dr.Jayam & Dr Tanu, "Knowledge Management", 2014.

H20ME014

DESIGN THINKING - A PRIMER

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Understand the basic concept of design thinking. (BL-2)
2. Recall the step involved in design thinking. (BL-1)
3. Apply the principles of design thinking by observing, interviewing or just experiencing a situation.(BL-3)
4. Improve the situation of the humans by solving problems facing them. (BL-5)
5. Analyze problems using brain storming, 5 why's. (BL-3)

UNIT-I
Design thinking: Introduction, history, discussion and case study.

UNIT-II
Empathize phase: Customer journey mapping.

UNIT-III
Analyze phase: 5-Whys, 5 whys-IIT stadium levels and solve-workshop I & II.

UNIT-IV
Solve phase: Ideation, free brainstorming.

UNIT-V
Make/Test phase: Customer reactions to prototype, finale and appeal for proposals.

Text Books:

1. Prof. Karl Ulrich, "Design: Creation of Artifacts in Society", University of Pennsylvania, 2011.
2. Tim Brown, "Change by Design" Harper Business Publication, 2013.
3. Idris Mootee "Design Thinking for Strategic Innovation", Adams Media publications, 2014.

Suggested Reading:

1. Bryan Lawson, "How Designer's Think: The design process demystified", Architectural Press, 2005.
2. Brown, Dan M, "Designing Together", New Riders, 2013.

H20ME015

INNOVATION BY DESIGN

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Find solutions to present day problems and challenges through innovation. (BL-4)
2. Formulate a design enabled by innovation. (BL-6)
3. Gain knowledge on the journey of a design idea from the identification of a problem to a final solution. (BL-2)
4. Learn the importance of innovation process requiring empathy, meticulous effort, constant user interaction and effective collaboration. (BL-1)
5. Apply innovation to have positive impact on a large community of users. (BL-3)

UNIT-I

Introduction: The seven concerns, design thinking & collaboration, challenges to innovation, understanding users, arriving at design insights, prototyping for user feedback.

First C: The cause: Crossing the first pitfall, trial and error, user feedback for development, new users, new needs to meet.

UNIT-II

Second C: The context: The basic need, ingenious attempts, further insights, the working rig, concepts generation, experiencing the product.

Third C: The comprehension: Understanding constraints, positioning the product, exploring possibilities, understanding the technology.

UNIT-III

Fourth C: The check: The check and the cause, the product, the users and the context, the prototyping, user needs.

UNIT-IV

Fifth C: The conception: Synchronic studies, one product, many problems, concept clusters, from idea to product, prototyping, materials and technologies, collaborative efforts.

UNIT-V

Sixth C: The drafting: Recap, the manufacturing challenge, the user feedback, the iterative Process.

Seventh C: The connection: The seed for innovation, pinnacle for innovation, the Innovation timeline, the innovation, champions, the Innovation templates, the Serial Innovation.

Suggested References:

1. 7C's Link: http://www.idc.iitb.ac.in/~chakku/chakku7Cs.pdf
2. Collaborative Model For Innovation Link: http://www.idc.iitb.ac.in/~chakku/collaborative_model_for_innovation.pdf
3. Pitfalls in the Innovation process Link: http://www.idc.iitb.ac.in/~chakku/Pitfalls_in_the_innovation_process.pdf
4. Innovation By Design – Collaboration is the key to cross the Pitsfalls in the Innovation Process Link: http://www.idc.iitb.ac.in/~chakku/Innovation_by_Design.pdf

H20ME016

UNDERSTANDING DESIGN

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Understand the discipline of design and its multidisciplinary nature. (BL-2)
2. Translate ideas and needs into all the objects that surround us. (BL-2)
3. Understand the relevance and value of design and how it impacts society, industry and the environment. (BL-2)
4. Differentiate between good and bad design. (BL-4)
5. To analyze design as process and product. (BL-5)

UNIT-I

An introduction to design, users and context: The many notions of design, design as a process and a product, the evolution of design, design engages with many disciplines, design is concerned with the user, good design, bad design, users and contexts, multiple users, differing contexts, understanding user experience, design for a meaningful impact.

UNIT-II

Design and society: Community and collaboration, understanding contexts, knowledge and access, function, context and consequences.

UNIT-III

Design and sustainability: Sustainability practices in daily life, the perspective of engineering understanding embodied energy, the users role in sustainability, framing the world as future.

UNIT-IV

Design and industry and design and collaboration: Understanding varied user needs, pushing the boundaries of mass production, breaking familiar assumptions, design & collaboration, collaborating with unlikely partners, principles of collaboration, design thinking .

UNIT-V

Innovation by design: Facilitating the reach of a traditional craft, pitfalls of innovation, the seven concerns of innovation, a little design goes a long way.

Text Books:

1. Ansell, C & Torfing J, “Public Innovation through Collaboration and Design”, London and New York, Routledge, 2014.
2. Antonneli, Paola, “Humble Masterpieces: everyday marvels of Design”, Harper Collins Publishers, 2005.
3. Baxter, Mike, “Product Design”, London Glasgow New York, Chapman & Hall, 1995.

Suggested Reading:

1. Doordan, Dennis, “Design History: An Anthology”, Cambridge, London, MIT Press, 2000.
2. Heskett, John, “Design: a very short introduction” , Oxford University Press, 2002.

H20ME017

STRUCTURAL ANALYSIS OF NANO MATERIALS

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, students are able to

1. Understand the properties of nano materials. (BL-2)
2. Study the crystal structure of materials and their defects. (BL-1)
3. Have a detailed knowledge of the structure from the atomic/molecular level. (BL-2)
4. Investigate the structure-property relationship of nano materials. (BL-4)
5. Achieve relevant improvements in current state-of-the art materials. (BL-3)

UNIT-I

Introduction: Fundamental concepts of atomic structure and interatomic bonding, structure of materials, defects in structure of materials.

UNIT-II

Phase diagram: Determination of phases, transformation of phases.

UNIT-III

Basic properties: Metals, ceramics, polymers, selection of nano materials, structure property relationship of advanced nano materials.

UNIT-IV

Qualitative analysis by diffraction, quantitative analysis by diffraction.

UNIT-V

Microscopic structural analysis of nano materials-I, microscopic structural analysis of nano materials-II.

Text Books:

1. Cullity, B.D., Stock, S.R. and Stock, S, “Elements of X-Ray diffraction”, Prentice Hall, 3\e, New Jersey, 2013.
2. Phillips, R., “Crystal Defects and Microstructures”, Cambridge university press, Cambridge, UK, 2015.
3. Wang, Z.L.,” Characterization of Nano Phase Materials” , Wiley-VCH, Weinheim, Germany, 2008.

Suggested Reading:

1. Allen, S.M., Thomas, E.L., “The structure of materials”, John Wiley & Sons, US, 2011.
2. Hideo Hosono, Yoshinao Mishima, “Nanomaterials: Research Towards Applications”, Elsevier Science, 2006.

H20ME018

MECHANICAL MEASUREMENT SYSTEMS

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the various characteristics of instrument. (BL-2)
2. Analyze the generalized model of a measuring system. (BL-4)
3. Understand the frequency response of a measuring system. (BL-2)
4. Evaluate measuring methods and devices for displacement, pressure and temperature measurement. (BL-5)
5. Understand the various thermo physical properties of measurement. (BL-2)

UNIT-I

Basic concepts of measurement, functional elements of instruments, classification of measuring instruments, methods of correction for interfering and modifying inputs.

UNIT-II

Static characteristics of measuring instruments, loading effect and impedance matching, statistical analysis, Chi-square test, least square method, uncertainty analysis, problem solving, generalized model of a measuring system, zero and first order system.

UNIT-III

First order system- ramp response, impulse response, frequency response, second order system- step response, ramp response, impulse and frequency response, higher order systems, compensation, transducers, flow measurement, temperature measurement.

UNIT-IV

Strain gauges, piezoelectric transducers pressure measurement, force and torque measurement, displacement and acceleration measurement.

UNIT-V

Sound measurement, thermophysical properties measurement, flow visualization, air pollution sampling and measurement, problem solving.

Text Books:

1. Venkateshan, S.P., “Mechanical measurements”, John Wiley & Sons, 2015.
2. Fridman, A.E., “The quality of measurements: a metrological reference”, Springer Science & Business Media, 2011.
3. Bewoor, A.K. and Kulkarni, V.A., “Metrology and measurement”, McGraw-Hill Education, 2009.

Suggested Reading:

1. R.K. Rajput, “Mechanical Measurements and Instrumentation”, S.K. Kataria & Sons, 2013.
2. Dr. D.S. Kumar, “Mechanical Measurements & Control”, Metropolitan Book Co. (P) Ltd, 2015.

H20ME019

PATENT DRAFTING FOR BEGINNERS

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Understand the concept of various patent classification and the limits of patentability search. (BL-2)
2. Apply the various forms and punctuation of claim. (BL-3)
3. Analyze the claim with combo pen with marker. (BL-4)
4. Understand the various evolutions of patient specifications. (BL-2)
5. Apply the concept of amendments to claim. (BL-3)

UNIT- I

Invention as a solution to an unsolved problem: Patent classification, technical advance, getting working disclosure, searching with a disclosure, patentability search, reasons for ordering patentability search ,limits of patentability search, patentability search report, identifying the inventive concept.

UNIT- II

Drafting a claim: Problem solution statement, problem solution to claim, provisions relating to claim, structure of claims, form and punctuation of claim, omnibus claims, cooperation.

UNIT- III

Types and arrangement of claims: Dependent claims, apparatus claims, process claims, claim drafting best practices, amendment to claim, claim analysis combo pen with marker.

UNIT - IV

Structure of the patent specification: Introduction to specification drafting, enabling disclosure, best methods.

UNIT-V

Parts of the specifications, parts of the application, detailed description, evolution of patent specifications.

Text Books:

1. Jeffrey G. Sheldon, "How to Write a Patent Application", Third Edition, Practicing Law Institute, 2016.
2. Richard Susskind, "Tomorrows Lawyers", Oxford Publishers, 2013.
3. Nicholas J McBride, "Letters to a Law Student", 3/e, Pearson publishers, 2013.

Suggested Reading:

1. Williams Glanville, "Learning the Law", Indian Economy Reprint, 2013.
2. Pankaj Kumar Tripathi," Law of Evidence", PVP publications, 2019.

H20ME020

HEAT EXCHANGERS: FUNDAMENTALS AND DESIGN ANALYSIS

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Evaluate the effectiveness of heat exchanger. (BL-5)
2. Discuss the tubular and compact heat exchangers. (BL-2)
3. Analyze the plate fin and direct contact heat exchangers. (BL-4)
4. Analyze the heat pipes and micro scale heat exchangers. (BL-4)
5. Understand the concept of phase change heat transfer. (BL-2)

UNIT-I

Background, application, classification, common terminologies introduction to thermal and hydraulic aspects, pressure drop and heat transfer, sizing and rating. F-LMTD and -NTU method.

UNIT-II

Tubular Heat Exchangers: Different designs, brief description of shell and tube heat exchangers, special types, compact heat exchangers, enhancement of heat transfer, extended surface or fin, fundamental of extended surface heat transfer, fin tube heat exchanger.

UNIT-III

Plate Fin Heat Exchangers (PFHE): Types, construction, fabrication, design, application, multi stream PFHE, multi stream PFHE continued, direct contact heat exchangers, types, application, simple analysis, regenerators, types of regenerators, construction, application, theory of regenerator, NTU and method.

UNIT-IV

Heat pipes: Construction, working principle, application, analysis, special heat pipes, micro scale heat exchangers and heat sinks, heat transfer and fluid flow through narrow conduits, special design considerations.

UNIT-V

Phase change HEX: Phase change heat transfer, introduction to evaporators and condensers, phase change HEX, phase change heat transfer, introduction to evaporators and condensers, heat exchanger testing, steady state and dynamic methods.

Text Books:

1. R. K. Shah, Dusan P. Sekulic, "Fundamentals of Heat Exchanger Design", John Wiley & Sons, 2003.
2. Kuppan Thulukkanam, "Heat Exchanger Design Handbook" ,Taylor & Francis, 2000.

Suggested Reading:

1. Sadik Kakac, Hongtan Liu, "Heat Exchangers: Selection, Rating, and Thermal Design", 3/e ,CRC-Press, 1998.
2. Randall F. Barron, Gregory F. Nellis, "Cryogenic Heat Transfer", 2/e, CRC Press, 2016.

H20ME021

SOLAR ENERGY ENGINEERING AND TECHNOLOGY

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the need of energy conversion and the energy measuring devices. (BL-2)
2. Estimate total solar radiation and maximum power generation from PV cells. (BL-5)
3. Design of grid-connected PV system. (BL-6)
4. Classify the solar collectors and evaluate their performance. (BL-2)
5. Explain the various methods of energy storage and applications of solar energy. (BL-2)

UNIT-I

Energy scenario, overview of solar energy conversion devices and applications, physics of propagation of solar radiation from the sun to earth. sun-earth geometry, extra-terrestrial and terrestrial radiation, solar energy measuring instruments.

UNIT-II

Estimation of solar radiation under different climatic conditions, estimation of total radiation, fundamentals of solar PV cells, principles and performance analysis, modules, arrays, theoretical maximum power generation from PV cells, PV standalone system components, standalone PV-system design.

UNIT-III

Components of grid-connected PV system, solar power plant design and performance analysis, fundamentals of solar collectors, Snails law, Bougers law, physical significance of transmissivity – absorptivity product.

UNIT-IV

Performance analysis of liquid flat plate collectors and testing, performance analysis of solar air heaters and testing, solar thermal power generation (Solar concentrators).

UNIT-V

Thermal energy storage (sensible, latent and thermochemical) and solar pond, applications, solar refrigeration, passive architecture, solar distillation, and emerging technologies.

Text Books:

1. G. N. Tiwari, "Solar Energy, Fundamentals, Design, Modeling and Applications", Narosa, 2002.
2. S. P. Sukhatme and J. K. Nayak, "Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw Hill, 2006.
3. C. S. Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", Prentice Hall India, 2/e, 2011.

Suggested Reading:

1. J. A. Duffie and W. A. Beckman, "Solar Engineering of Thermal Processes", John Wiley, 2006.
2. D. Y. Goswami, F. Kreith and J. F. Kreider, "Principles of Solar Engineering", Taylor and Francis, 1999.

H20ME022 **ADVANCED FLUID MECHANICS**

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the concept of Kinematics and Dynamics of Fluid Mechanics. (BL-2)
2. Derive the Navier-stokes equation and apply it to steady flow problems. (BL-5)
3. Solve the Navier-stokes equation for the Unsteady Flows. (BL-3)
4. Understand the Concept of Boundary Layer theory in Turbulent cases. (BL-2)
5. Discuss the Compressible flows and potential flow, flow past immersed bodies. (BL-2)

UNIT-1.

Brief recapitulation of some preliminary concepts of Fluid Mechanics : Fluid Kinematics. Dynamics of Inviscid Flows and Reynolds Transport Theorem, Dynamics of viscous flows.

UNIT-2.

Derivation of Navier- Stokes equation. Some exact solutions of Navier-Stokes equation-Steady Flows, Practical Applications.

UNIT-3.

Some exact solutions of Navier-Stokes equation-Unsteady Flows.

UNIT-4.

Introduction to turbulence, Boundary Layer theory.

UNIT-5.

Potential flow and flow past immersed bodies, Compressible flows

Test Books:

1. Fluid Mechanics: by Pijush K. Kundu, Ira M. Cohen, David R Dowling, Academic Press.
2. Introduction to Fluid Mechanics and Fluid Machines: by S. K. Som, Gautam Biswas and Suman Chakraborty, McGraw-Hill Education.

Suggested Reading:

1. Fluid Mechanics: by F. M White, McGraw-Hill Education.
2. Introduction to Fluid Mechanics by R. Fox and A. MacDonald, John Wiley and Sons.

H20ME023

AIRCRAFT PROPULSION

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Study of gas turbines and aircraft propulsion. (BL-2)
2. Compare the ideal and real cycle analysis. (BL-2)
3. Evaluate the performance of aircraft engine and study of engine components. (BL-5)
4. Study of different compressors and turbines. (BL-2)
5. Identify turbine cooling methods and study of blade and cascade theory. (BL-3)

UNIT-I

Introduction to gas turbines and aircraft propulsion: Turbomachines-Introduction, classification, components of gas turbine power plant, various aircraft engines, engine performance parameters.

UNIT-II

Ideal and real cycle analysis: Air standard ideal Brayton cycle, non-ideal Brayton cycle, Brayton cycle with reheater, Brayton cycle with intercooler, real Brayton cycle with stagnation conditions, polytropic efficiency of compressor and turbine, aircraft engine intake, intake efficiency, propelling nozzle, nozzle efficiency.

UNIT-III

Engine performance and engine components: Turbojet engine, turbofan engine, ramjet engine, thrust augmentation and engine parameters for aircrafts.

UNIT-IV

Centrifugal compressor: Velocity diagram, work done, thermodynamic analysis, stage efficiency and degree of reaction.
Axial flow compressor: Velocity diagram, work done, degree of reaction, free vortex condition.
Axial turbine: Velocity diagram, work done and degree of reaction.
Radial turbine: Velocity diagram, H-S diagram, stage efficiency, degree of reaction.

UNIT-V

Blade design, cascade theory and turbine cooling methods: Cascade theory and blade design, cascade variables and turbine cascade, velocity diagrams of turbine cascade, compressor cascade, turbine cooling methods.

Text Books:

1. G. F. C. Rogers and Y. R. Mayhew, “Engineering Thermodynamics Work and Heat Transfer”, 4/e., Pearson, 2001.
2. H. I. H Saravanamuttoo, G. F. C. Rogers and H. Cohen, “Gas Turbine Theory”, 4/e., Pearson, 2003.

H20ME024

ENERGY CONSERVATION AND WASTE HEAT RECOVERY

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Define the waste heat and the importance of its recovery. (BL-1)
2. Explain different types of power cycles to extract waste heat. (BL-2)
3. Analyse heat exchanger with specialized heat exchange techniques for effective recovery. (BL-4)
4. Illustrate various techniques of direct energy conversion systems. (BL-2)
5. Discuss the various energy storage techniques. (BL-2)

UNIT-I

Introduction to waste heat, importance of waste heat recovery, review of thermodynamics – introduction to first and second laws, entropy, entropy generation, first and second law efficiency.

UNIT-II

Power plant cycles - energy cascading, Rankine cycle, modification of Rankine cycle, examples of gas turbine cycle, combined cycle, combined gas turbine-steam turbine power plant, heat recovery steam generators.

UNIT-III

Thermodynamic cycles for low temperature application, cogenerations, introduction to heat exchangers, analysis – LMTD and ε-NTU method, problem solving, special heat exchangers for waste heat recovery, synthesis of heat exchanger, network, heat pipes & vapour chambers.

UNIT-IV

Direct conversion technologies – thermoelectric generators, thermionic conversion, thermo-PV, magneto hydro dynamics, heat pump, heat recovery from incinerators.

UNIT-V

Energy storage – introduction, energy storage techniques – pumped hydro, compressed air, flywheel, superconducting magnetic storage, thermal storage (sensible & latent), battery, chemical energy storage, fuel cells, energy economics.

Reference Books:

1. Nikolai V. Khartchenko, “Advance Energy Systems”, Taylor and Francis Publishing,2000
2. M.M.El-Wakil, Powerplant Technology, Tata McGraw Hill ,2013
3. Rajmohan Gupta, “Steam Turbine”, Oxford & IBH Publishing Co. Pvt. Ltd.

Suggested Reading:

1. Ganesan, “Gas Turbine”, McGraw Hil,2013l
2. Practical Heat Recovery – Boyen J.L. John Wiley, New York, USA1976.

H20ME025

FLUIDIZATION ENGINEERING

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the phenomenon of fluidization and characteristics of solids. (BL-2)
2. Analyse the fluidization parameters. (BL-4)
3. Measure the power consumption of gas pumping in fluidised beds and understand the concept of bubbling fluidization. (BL-5)
4. Understand the entrainment characteristics and attrition in fluidized beds. (BL-2)
5. Study the phenomena of mass transfer and heat transfer in fluidized bed. (BL-2)

UNIT-I

Introduction: The phenomenon of fluidization, advantages and disadvantages of fluidized beds, industrial applications of fluidized beds

Characteristics of solids: Classification of solids, flow characteristics and its outline in the different types of fluidization.

UNIT-II

Flow pattern of fluidization system: Flow pattern, flow pattern transition, flow pattern map, frictional pressure drop and its model to analyse, solid movement, mixing, segregation and staging.

UNIT-III

Gas distribution: Type of gas distributors in small and large scale industries, design of distributor.

Bubbling fluidized beds: Gas dispersion and gas interchange in bubbling beds, mixing characteristics.

UNIT-IV

Entrainment and elutriation from fluidized beds: Entrainment characteristics, fast fluidization condition, elutriation condition.

Attrition: Attrition mechanism and its analysis by model.

UNIT-V

Mass transfer phenomena: Particle to gas mass transfer phenomena and its analysis by model in two and three phase system and modelling.

Heat transfer phenomena: Heat transfer between fluidized beds, surfaces and modelling.

Design of fluidized bed reactors: Design for physical operation, catalytic and non-catalytic systems.

Text Books:

1. D. Kunii and O. Levenspiel, “Fluidization Engineering”, Butterworth, 1991.
2. D. Gidaspow, “Multiphase Flow and Fluidization: Continuum and Kinetic Theory Description”, Elsevier Science & Technology Books, 1993.

Suggested Reading:

1. L.G. Gibilaro, “Fluidization-Dynamics”, Butterworth-Heinemann, 2001
2. S. K. Majumder, “Hydrodynamics and Transport Processes of Inverse Bubbly Flow”, Elsevier,1/e, Amsterdam (2016).

H20ME026

COMPUTATIONAL FLUID DYNAMICS USING FINITE VOLUME METHOD

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Describe and develop mathematical models for flow phenomena. (BL-1)
2. Classify PDE for fluid flow and heat transfer applications. (BL-2)
3. Apply Finite Volume Method for fluid flow and heat transfer problems. (BL-3)
4. Test the discretized equations for stability and solve the system of linear equations. (BL-4)
5. Implementation of different types of meshes. (BL-5)

UNIT-I
Review of governing equations: Continuity, momentum and energy equations, steady and unsteady flows, classification of governing equations, elliptic, parabolic and hyperbolic equations, their significance.

UNIT-II
Overview of numerical solution methods: Finite difference, finite element and finite volume methods, their merits and demerits, steady diffusion equation on structured meshes.

UNIT-III
Structured and Unstructured meshes: Unsteady diffusion equation on structured meshes, diffusion in unstructured meshes.

UNIT-IV
Convection and diffusion: Mathematical formulation, discretization, various methods to solve them, higher-order schemes, their effect on convergence.

UNIT-V
Convection and diffusion on unstructured meshes: Their stability, linear system solvers, iterative methods.
Incompressible flow field calculation: SIMPLE algorithm, types of grids, staggered and co-located formulation, need of staggered grids.

Text Books:

1. Suhas V. Patankar, “Numerical Heat Transfer and Fluid Flow”, Hemisphere, New York, 1980.
2. H. K. Versteeg and W. Malalasekra,“An Introduction to Computational Fluid Dynamics - The Finite Volume Method”, Pearson Education, 2017.
3. T. J. Chung, “Computational Fluid Dynamics”, Cambridge University Press, 2010.

Suggested Reading:

1. F. Moukalled, L. Mangani, M. Darwish, “The Finite Volume Method in Computational Fluid Dynamics”, Springer, 2015.
2. J. H. Ferziger and M. Peric, “Computational Methods for Fluid Dynamics”, Springer, 2002.

H20ME027

FUNDAMENTALS OF CONVECTIVE HEAT TRANSFER

Instruction	3	Hour per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Derive the governing equations of incompressible fluid heat flow. (BL-5)
2. Study the different solutions and methods for the laminar external flow and heat transfer over a flat plate. (BL-2)
3. Understand the concepts of laminar fluid and heat transfer through the internal cross sections of different channels. (BL-1)
4. Understand the concepts of natural convective heat transfer on flow past vertical plate at different at conditions and positions. (BL-1)
5. Discuss the governing equations of turbulent convection of the heat and mass transfer and their analogies. (BL-2)

UNIT-I

Governing equations: Continuity, momentum and energy equations and their derivations in different coordinate systems, boundary layer approximations to momentum and energy.

UNIT-II

Laminar external flow and heat transfer: Similarity solutions for flat plate (Blasius solution), flows with pressure gradient (Falkner-Skan and Eckert solutions), flow with transpiration, integral method solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature (Duhamel's method), flows with pressure gradient (von Karman-Pohlhausen method).

UNIT-III

Laminar internal flow and heat transfer: Exact solutions to N-S equations for flow through channels and circular pipe, fully developed forced convection in pipes with different wall boundary conditions, forced convection in the thermal entrance region of ducts and channels (Graetz solution), heat transfer in the combined entrance region, integral method for internal flows with different wall boundary conditions.

UNIT-IV

Natural convection heat transfer: Governing equations for natural convection, Boussinesq approximation, dimensional analysis, similarity solutions for laminar flow past a vertical plate with constant wall temperature and heat flux conditions, integral method for natural convection flow past vertical plate, effects of inclination, natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures.

UNIT-V

Turbulent convection: Governing equations for averaged turbulent flow field (RANS), analogies between heat and Mass transfer (Reynolds, Prandtl-Taylor and von Karman Analogies),turbulence models (Zero, one and two equation models), turbulent flow and heat transfer across flat plate and circular tube, turbulent natural convection heat transfer, empirical correlations for different configurations.

Text Books:

1. W.Kays, M. Crawford and B. Weigand, "Convective Heat and Mass Transfer", 4/e, McGraw Hill International, 2005.
2. S. Kakac and Y.Yener, "Convective Heat Transfer", 2/e, CRC Press, 1995.
3. A. Bejan, "Convection Heat Transfer", 3/e, John Wiley, 2004.

Suggested Readings:

1. F.P. Incropera and D. Dewitt, "Fundamentals of Heat and Mass Transfer", 7/e, John Wiley, 2011.
2. H. Schlichting and K. Gersten, "Boundary Layer Theory", 8/e, Springer-Verlag, 2000.

H20ME028

DYNAMIC BEHAVIOR OF MATERIALS

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand about dynamic deformation, failure, and elastic waves. (BL-2)
2. Differentiate plastic waves and shockwaves due to uniaxial and combined stress. (BL-4)
3. Apply experimental techniques for dynamic deformation in metals. (BL-3)
4. Analyze plastic deformation of metals at high strain rates. (BL-4)
5. Assess dynamic fracture. (BL-5)

UNIT-I
Introduction: Dynamic deformation and failure, Introduction to waves: elastic waves, types of elastic waves, reflection, refraction and interaction of waves.

UNIT-II
Plastic waves and shock waves: Plastic waves of uniaxial stress, uniaxial strain and combined stress, Taylor's experiments, shock waves, shock wave induced phase transformation, explosive-material interaction and detonation.

UNIT-III
Experimental techniques for dynamic deformation: Intermediate strain rate tests, split Hopkinson pressure bar, expanding ring test, gun systems, Review of mechanical behavior of materials (especially metals), elastic and plastic deformation of metals, dislocation mechanics.

UNIT-IV
Plastic deformation of metals at high strain rates: Empirical constitutive equations, relationship between dislocation velocity and applied stress, physically based constitute equations, Plastic deformation in shock waves, strengthening due to shock wave propagation, dislocation generation, point defect generation and deformation twinning, strain localization/shear bands, constitutive models, metallurgical aspects.

UNIT-V
Dynamic fracture: Fundamentals of fracture mechanics, limiting crack speed, crack branching and dynamic fracture toughness, spalling and fragmentation, dynamic deformation of materials other than metals, polymers, ceramics, composites, applications, armor applications, explosive welding and forming.

Textbooks:

1. Marc A. Meyers, "Dynamic Behavior of Materials", John Wiley & Sons, New York, 1994 .
2. L.B. Freund, "Dynamic Fracture Mechanics", Cambridge, 1990.
3. Y. Bai B. Dodd, "Adiabatic Shear Localization", Pergamon, Oxford, UK, 1992.

Suggested Reading:

1. G.E. Dieter, "Mechanical Metallurgy", Mc Graw Hill, 1986
2. J.W. Swegle, D.E. Grady, in Shock Waves in Condensed Matter, Springer, 1985,

H20ME029

SYSTEM DESIGN FOR SUSTAINABILITY

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand sustainability, its development and evolution. (BL-2)
2. Identify the strategies and software tools for product life cycle design. (BL-2)
3. Understand the transition path and challenges in sustainable product service system. (BL-2)
4. Use the tools for designing product-service system for eco-efficiency. (BL-3)
5. Design for social equity and cohesion by following design criteria and guidelines. (BL-6)

UNIT-I

Sustainability: Definition of sustainability, the need for sustainable development, evolution of sustainability within design.

UNIT-II

Product life cycle design: Methods, strategies and software tools.

UNIT-III

Sustainable product: Service system design: Definition, types, examples, Sustainable product service system – transition path and challenges.

UNIT-IV

Designing for sustainable product-service system: Methods and tools, other design for sustainability, tools and approaches .

UNIT-V

Design for sustainability: Engineering design criteria and guidelines.

Text Books:

1. Vezzoli, C., Kohtala, C., Srinivasan, A., Xin, L., Fusakul, M., Sateesh, D. and Diehl,. "Product-service system design for sustainability". J.C.Routledge,2017
2. Peter Stansinoupolos (Author), Michael H Smith (Author), Karlson Hargroves (Author), " Whole System Design: An Integrated Approach to Sustainable Engineering": Paperback ,2008.
3. Jane Penty. "Product Design and Sustainability: Strategies, Tools and Practice" Routledg, 1/e, 2019.

H20ME03
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COMPUTATIONAL CONTINUUM MECHANICS

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Summarize the concepts of tensors, kinematics and kinetics. (BL-2)
2. Apply concepts of tensors to set up the constitutive relations for nonlinear finite element analysis of a simple hyperelastic material. (BL-3)
3. Analyze linearization of the weak form of the equilibrium equations. (BL-4)
4. Discuss discretization to obtain the finite element equations, in particular, the tangent matrices and residual vectors. (BL-2)
5. Compare the Newton-Raphson solution procedure along with line search and arc length methods to enhance the solution procedure. (BL-5)

UNIT-I
Introduction - Origins of nonlinearity.
Mathematical preliminaries -1: Tensors and tensor algebra.
Mathematical preliminaries -2: Linearization and directional derivative, tensor analysis.

UNIT-II
Kinematics - 1: Deformation gradient, polar decomposition, area and volume change.
Kinematics - 2: Linearized kinematics, material time derivative, rate of deformation and spin tensor.

UNIT-III
Kinetics - 1: Cauchy stress tensor, equilibrium equations, principle of virtual work.
Kinetics - 2: Work conjugacy, different stress tensors, stress rates.

UNIT-IV
Hyperelasticity - 1: Lagrangian and Eulerian elasticity tensor.
Hyperelasticity - 2: Isotropic hyperelasticity, compressible Neo-Hookean material.

UNIT-V
Linearization : Lineation of internal virtual work, linearization of external virtual work.
Discretization: Discretization of linearized equilibrium equations - material and geometric tangent matrices.
Solution Procedure: Newton-Raphson procedure, line search and arc length method.

Text Books:

1. J, Bonet A. J. Gil and R. D. Wood, "Nonlinear Solid Mechanics for Finite Element Analysis: Statics" ,Cambridge University Press, 2016.
2. K.-J. Bathe ,"Finite Element Procedures", Prentice-Hall India, New Delhi, 1996.
3. A. F. Bower, "Applied Mechanics of Solids , CRC Press, Boca Raton, 2010. (Also accessible through authors website: http://solidmechanics.org/)

Suggested Readings:

1. Ahmed A. Shabana , "Computational Continuum Mechanics" , Wiley 2018.
2. FY Cheng, FZizhi,"Computational Mechanics in Structural Engineering: Recent Developments", Elsevier Science; 2/e,1999.

H20ME031

ENGINEERING FRACTURE MECHANICS

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of fracture mechanics. (BL-2)
2. Analyze different modes of failure under the presence of crack. (BL-4)
3. Develop crack growth models. (BL-3)
4. Identify the relationship between crack propagation and stress intensity factor systems. (BL-3)
5. Examine advanced Fracture mechanics. (BL-4)

UNIT-I
Introduction to fracture mechanics: LEFM and EPFM, fatigue crack growth model, crack growth and fracture mechanisms, energy release rate, elastic strain energy, fracture strength by Griffith, energy release rate, utility of energy release rate

UNIT-II
Crack-tip stress and displacement fields: Review of theory of elasticity, Airy's stress function for mode-I, Westergaard solution of stress field for mode-I ,displacement field for mode-I ,relation between KI and G_I, stress field in mode-II, generalized Westergaard approach ,William's Eigen function approach, multi-parameter stress field equations and validation.

UNIT-III
SIF's, plastic zone modeling, fracture toughness testing : Evaluation of SIF for various geometries ,SIF for embedded cracks ,SIF for surface cracks, modeling of plastic deformation ,Irwin's model , Dugdale model , fracture toughness testing, plane strain fracture toughness testing ,plane stress fracture toughness testing.

UNIT-IV
Crack initiation and life estimation: Paris law and Sigmoidal curve, crack closure, crack growth models.

UNIT-V
Advanced fracture mechanics: J-Integral, HRR field and CTOD, FAD and mixed mode fracture, crack arrest and repair methodologies.

Text Books:

1. David Broek , "Elementary Engineering Fracture Mechanics", Kluwer Academic Publishers , The Hague – 1984.
2. Prashant Kumar., "Elements of fracture mechanics", Mc Graw Hill Education (India) Private Limited, New Delhi - 2014.
3. T.L. Anderson, "Fracture Mechanics - Fundamentals and Applications", 3/e, Taylor and Francis Group, 2005.

Suggested reading:

1. R.N.L.Smith, "Basic Fracture Mechanics", Butterworth Heinemann Publications, 1991.
2. K. Ramesh," e-Book on Engineering Fracture Mechanics", IIT Madras, 2007.
   URL: http://apm.iitm.ac.in/smlab/kramesh/book_4.htm

H20ME032

NUMERICAL METHODS FOR ENGINEERS

Instruction	3 hours per week
Course Duration	12 weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand the of calculation and interpretation of errors in numerical method. (BL-2)
2. Analyze numerical solution of a system of linear equations . (BL-4)
3. Examine the roots of polynomial equations using numerical analysis . (BL-4)
4. Apply numerical differentiation, integration and regression methods. (BL-3)
5. Solve numerically on the ordinary differential equations using different methods . (BL-3)

UNIT-I
Introduction : Motivation and applications computation and error analysis accuracy and precision, truncation and round-off errors, binary number system, error propagation.

UNIT-II
Linear systems and equations: Matrix representation, Cramer's rule, Gauss Elimination, Matrix Inversion, LU decomposition, iterative methods, relaxation methods, Eigen values.

UNIT-III
Algebraic equations: Bracketing methods, bisection, Reguli-Falsi, open methods and optimization open methods, secant, fixed point iteration, Newton-Raphson, multivariate Newton's method.

UNIT-IV
Numerical differentiation ,integration, regression and curve fitting : Numerical differentiation, higher order formulae , integration and integral equations trapezoidal rules, Simpson's rules, quadrature regression linear regression, least squares, total least squares, interpolation and curve fitting interpolation, Newton's difference formulae, cubic splines.

UNIT-V
ODEs initial value problems and boundary value problems: Euler's methods, Runge-Kutta methods, predictor-corrector methods, extension to multi-variable systems, adaptive step size, stiff ODEs, boundary value problems shooting method, finite differences, over/under relaxation(SOR).

Text Books:

1. Gupta S.K , "Numerical Methods for Engineers", New Age International, 1995.
2. Chapra S.C. and Canale R.P, "Numerical Methods for Engineers", 5/e., McGraw Hill, 2006.
3. Froberg C. E., "Introduction to Numerical Analysis", 2/e, Addison Wesley, 1970.

Suggested Reading:

1. Jain M.K., IyengarS.R.K., "Numerical methods for Scientific and Engineering Computation", 3/e, New Age International (P) Ltd, 1996.
2. Phillips G.M., Taylor P.J., "Theory and Applications of Numerical Analysis", 2/e, Academic Press, 1996.

H20ME033

ROBOTICS AND CONTROL : THEORY AND PRACTICE

Instruction	3 hours per week
Course Duration	8 weeks
Credits	2

Outcomes: At the end of the course, the students are able to

1. Understand the spatial transformations associated with rigid body motions. (BL-2)
2. Develop skill in performing kinematics and dynamic analysis of robot systems. (BL-3)
3. Analyze different robot manipulators. (BL-4)
4. Understand the concept of robot exoskeleton. (BL-2)
5. Examine the robot assisted percutaneous interventions. (BL-4)

UNIT-I

Introduction: Coordinate frames and homogeneous transformations-I, coordinate frames and homogeneous frames-II, differential transformations, transforming differential changes between coordinate frames.

UNIT-II

Robot kinematics: Manipulator model, direct kinematics, inverse kinematics, manipulator Jacobian.
Robot dynamics: Trajectory planning, dynamics of manipulator, manipulator dynamics multiple degree of freedom ,stability of dynamical system.

UNIT-III

Manipulator control and neural networks: Biped robot basics and flat foot biped model, biped robot flat foot and toe foot model, artificial neural network, neural network based control for robot manipulator.

UNIT-IV

Robotic exoskeletons: Introduction, force control of an index finger exoskeleton, neural control of a hand exoskeleton, neural control of a hand exoskeleton based on human subjects intention, redundancy resolution of human fingers using robotic principles, manipulability analysis of human fingers during coordinated object rotation ,kinematics of flexible link robots.

UNIT-V

Robot assisted percutaneous interventions : Experiments on robot assisted percutaneous interventions, sliding mode control, higher order sliding mode control, smart needles for percutaneous interventions-I , smart needles for percutaneous interventions-II.

Text Books:

1. Mittal & Nagrath, "Robotics and Control", Tata McGraw-Hill Education, 2003.
2. Schilling Robert J, "Fundamentals of Robotics: Analysis and Control", Prentice-Hall, 1990. (TJ211.S334)
3 Niku Saeed B, "An Introduction to Robotics Analysis, Systems, Applications", Prentice-Hall, 2001.

Suggested Reading:

1 Niku Saeed B, "An Introduction to Robotics Analysis, Systems, Applications", Prentice-Hall, 2001.
2 K S Fu,Ralph Gonzalez,C S G Lee, "Robotics: Control Sensing. Vision and Intelligence", Tata McGraw-Hill Education, 1987.

H20ME034

ACOUSTIC MATERIALS AND METAMATERIALS

Instruction	2 Hours per week
Course Duration	8 Weeks
Credits	2

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of acoustic propagation and signal analysis. (BL-2)
2. Analyze principles of acoustic barrier materials, sound absorbing materials, acoustic metamaterials. (BL-4)
3. Differentiate conventional and acoustic metamaterials. (BL-2)
4. Design of membrane type metamaterials of sonic crystals . (BL-6)
5. Recommend suitable acoustic materials. (BL-5)

UNIT-I

Acoustics fundamentals: Sound propagation in fluids, advanced concepts in acoustics: introduction, sound wave propagation in fluid, sound propagation at medium boundaries, standing waves and modes, sound signal analysis, principles of noise control.

UNIT-II

Acoustic materials: Acoustic materials, enclosures, barriers, enclosures and barriers-tutorial, sound absorbing materials, porous-fibrous sound absorbers, panel sound absorbers, Helmholtz resonators, tutorial on sound absorbers, perforated panel absorbers.

UNIT-III

Micro-perforated panel absorbers: Limitations of conventional acoustic materials, micro perforated panel absorbers, introduction to acoustic metamaterials.

UNIT-IV

Acoustic metamaterials: History of acoustic metamaterials, applications of acoustic metamaterials, membrane type acoustic metamaterials, introduction to sonic crystals, advantages and applications of membrane type AMM, tutorial on membrane type AMM.

UNIT-V

Guidelines for material selection: Introduction to sonic crystals, fundamentals of crystals principle of working of sonic crystals, tutorial on sonic crystals, more on sonic crystals and conclusions.

Text Books:

1. David A. Bies, and Colin H. Hansen, “Engineering Noise Control: Theory and practice”, Spon Press, 2009.
2. M. J. Crocker ,“Introduction to Principles of Noise and Vibration Control”, in Handbook of Noise and Vibration Control, John Wiley and Sons Inc, 2007.
3. Richard V. Craster and Sébastien Guenneau, “Acoustic Metamaterials” Springer, 2013.

Suggested Readings:

1. Perngjin Frank Pai ,“Theory and Design of Acoustic Metamaterials” SPIE-International Society for Optical Engineering, 2014.
2. Vakakis Alexander F ,“Fundamentals and Applications of Acoustic Metamaterials” World Scientific, 2014.

H20ME035

MATLAB PROGRAMMING FOR NUMERICAL COMPUTATION

Instruction	3 Hours per week
Course Duration	8 Weeks
Credits	2

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of MATLAB programming , error approximation. (BL-2)
2. Apply MATLAB functions for integration. (BL-3)
3. Make use of MATLAB functions for linear and nonlinear problems. (BL-3)
4. Identify ways of using linear and nonlinear regression and interpolation functions in MATLAB (BL-3)
5. Choose explicit ODE solving techniques in single and multiple variables. (BL-5)

UNIT-I

Introduction to MATLAB programming, approximations and errors: Basics of MATLAB programming, array operations in MATLAB, loops and execution control, working with files: scripts and functions, plotting and program output, defining errors and precision in numerical methods, truncation and round-off errors, error propagation, global and local truncation errors.

UNIT-II

Numerical differentiation and integration: Numerical differentiation in single variable, numerical differentiation: higher derivatives , differentiation in multiple variables , Newton-cotes integration formulae , multi-step application of trapezoidal rule ,MATLAB functions for integration.

UNIT-III

Linear equations.: Linear algebra in MATLAB lecture, Gauss elimination, LU decomposition and partial pivoting, iterative methods, Gauss Siedel , special matrices, tri-diagonal matrix algorithm.

Nonlinear equations: Nonlinear equations in single variable, MATLAB function fzero in single variable, fixed-point iteration in single variable, Newton-Raphson in single variable, MATLAB function fsolve in single and multiple variables , Newton-Raphson in multiple variables.

UNIT-IV

Regression and interpolation: Introduction, linear least squares regression (including lsqcurvefit function), functional and nonlinear regression (including lsqnonlin function) , interpolation in MATLAB using spline and pchip.

UNIT-V

Ordinary differential equations (ODE) and practical aspects: Introduction, implicit and explicit Euler's methods,second-order Runge-Kutta methods, MATLAB ode45 algorithm in single variable,higher order Runge-Kutta methods, error analysis of Runge-Kutta method, MATLAB ode45 algorithm in multiple variables ,stiff ODEs and MATLAB ode15s algorithm , practical example for ODE-IVP , solving transient PDE using method of lines.

Text Books:

1. Fausett L.V, “Applied NumericalAnalysis Using MATLAB”, 2/e, Pearson Education,2007.
2. Chapra S.C. and Canale R.P, “Numerical Methods for Engineers”, 5/e., McGraw Hill,2006.
3. Rudra Pratap, “Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers”, Oxford Edition , 2010.

Suggested Reading:

1. Rao V Dukkipati, “MATLAB for Mechanical Engineers”, New Age Science Limited, 2009.
2. Bober, W., “Numerical and analytical methods with MATLAB”, Boca Raton: CRC Press,2009.

H20ME036

ERGONOMICS IN AUTOMOTIVE DESIGN

Instruction	3 Hours per week
Course Duration	4 weeks
Credits	1

Outcomes: At the end of the course, the students are able to

1. Understand anthropometric and biomechanical data. (BL-2)
2. Understand occupant packaging and visibility aspects of the driver. (BL-2)
3. Analyze driving performance and driver workload measurement. (BL-4)
4. Apply virtual ergonomics evaluation technique and automotive craftsmanship. (BL-3)

UNIT-I

Introduction to automotive ergonomics: Driver information acquisition and processing, anthropometric and biomechanical data in automotive design.

UNIT-II

Occupant packaging: Basics and details, principle of control and display design, usability evaluation of in-vehicle control and displays, human fields of view and driver's fields of view, in vehicle and external visibility of the driver.

UNIT-III

Entry and exit by drivers and passengers: Basics and details, driver distraction and driving performance measurement, driver workload measurement.

UNIT-IV

Virtual ergonomics: Evaluation technique and its application in automotive design, automotive craftsmanship.

Text Books:

1. Bhise,V.D., "Ergonomics in the automotive design process" ,CRC Press, 2016.
2. Harvey, C and Stanton,N.A , "Usability analysis for in-vehicle systems", CRC Press, 2016.
3. Gkikas, N, "Auto Ergonomics Driver -Vehicle Interaction", CRC Press, 2016.

Suggested Reading:

1. Happian -Smith, J .ed. ,"An introduction to modern vehicle design" ,Elsevier, 2001.
2. Castro, C., "Human factors of visual and cognitive performance in driving" CRC Press, 2008.

H20ME037

FOUNDATIONS OF COGNITIVE ROBOTICS

Instruction	3 Hours per Week
Course Duration	4 Weeks
Credits	1

Course Outcomes: At the end of the course, the students are able to

1. Understand importance of cognitive robot and smart materials. (BL-2)
2. Explain about intelligence, thinking. (BL-2)
3. Develop knowledge of artificial intelligence related to robots . (BL-3)
4. Design intelligent systems. (BL-6)
5. Apply AI based approach to various systems. (BL-3)

UNIT-I

Introduction: Introduction to cognitive robotics and human robot interaction, smart materials I, II, III.

UNIT-II

Intelligence thinking: Thinking, cognition, and intelligence, defining intelligence - embodiment and its implications.

UNIT-III

Artificial intelligence and theory of intelligence: Role of neuroscience and bio robotics, synthetic methodology for intelligence.

UNIT-IV

Intelligent system design and cognition development: Properties of complete agents, agent design principle, developmental robot design, matching brain and body dynamics.

UNIT-V

Control of intelligent systems- ai based approach: Artificial neural networks (ANN), fuzzy logic, genetic algorithms and other nature inspired methods, optimal control using ANN.

Text Book

1. Dale Purves "Neuroscience", Sinauer Associates, 5^{th} Ed., 2011
2. Rolf Pfeifer and Josh Bongard, "How the body shapes the way we think-A New View of Intelligence", MIT Press,2007
3. Jitendra R. Raol, Ramakalyan Ayyagari, "Control Systems: Classical, Modern, and AI-Based Approaches", CRC Press,2019.

H20ME038

THEORY OF RECTANGULAR PLATES

Instruction	3 Hours per Week
Course Duration	4 Weeks
Credits	1

Outcomes: At the end of the course, the students are able to

1. Examine systematic development of plate governing equations using the variational calculus. (BL-3)
2. Discuss the basic analytical solutions techniques for bending, free vibration and buckling cases. (BL-2)
3. Apply to develop governing equation and solutions for functionally graded plate, piezoelectric plates (currentresearch topics). (BL-4)
4. Apply MATLAB functions to simulate vibration of rectangular plates. (BL-4)

UNIT-I
Basic terminology, equations and methods: Basic of solid mechanics, energy principles, classification of plate theories and some basics. Tutorial: Transformation of tensors.

UNIT-II
Derivation of classical plate equations: Kinematic assumptions for various theories, development of governing equations, boundary conditions and plate constitutive relations, governing equation for plate. Tutorial: Reduced stiffness & plate stiffness.

UNIT-III
Analytical solution : Navier and levy for bending case, Navier solution + levy solution, levy solution. Tutorial: Load matrices calculation.

UNIT-IV
Apprpoximte solution: Apprpoximte solution techniques and 3D solution, extended Kantorovich method and buckling ofplates, 3D solutions, MATLAB coding + Abaqus. Tutorial: Levy solutions.

Text Books:

1. J. N. Reddy, “Theory and Analysis of Elastic Plates and Shells”, CRC Press, 2006.
2. K. Bhaskarand T.K. Varadan, “Plates: Theories and Applications”, Wiley, 2014.
3. K. Chandrashekhara, “Theory of Plates”, University Press (India) Limited, 2001.

Suggested Reading:

1. Stephan P. Timoshenko, “Theory of Plates and Shells”, McGraw-Hill, Import, 1964.
2. L. G. Jaeger, Elementary “Theory of Elastic Plates”, 1/e, Pergamon 1964.