SHIV NADAR

INSTITUTION OF EMINENCE DEEMED TO BE UNIVERSITY

DELHI NCR

Department of

Mechanical Engineering

School of Engineering

UNDERGRADUATE PROSPECTUS

(B. Tech - Mechanical with specialization)

Effective from 21-25 batch

I. Overview of the Department of Mechanical Engineering

Mechanical Engineering plays a major role in structuring and building the systems used in the real world. The mechanical engineers play a crucial role by designing, and manufacturing these systems. The career path of a mechanical engineer is largely determined by individual's choice – a unique advantage in an ever-changing competitive world. The mechanical engineering curriculum focuses on material science, solid and fluid mechanics, thermodynamics and heat transfer, automation and control, design and manufacturing**.** To summarize, the versatility, wide-ranging scope and universal relevance of mechanical engineering open up career avenues in all possible branches of the engineering profession. The department currently offers the following programs: Bachelor of Technology (B. Tech) in Mechanical Engineering, with the option of minor in any other streams of interest, and Ph.D. in Mechanical Engineering.

Our core objective is to develop leaders of tomorrow and conduct translational research to address the major technological bottlenecks. Department has developed state-of-the-art laboratories that not only cater to the undergraduate curriculum but also foster research in various specialized and interdisciplinary areas. There is an array of specialized mechanical engineering subjects such as energy storage and conversion, functional materials, materials processing, microfluidic devices, additive manufacturing, robotics, tribology and vibrations**.** This creates potential career opportunities in diverse areas within an industry, government and R&D, such as automotive industries, power generation, medical and manufacturing industries**.** To achieve this goal, the department is absorbing the best talent globally by hiring faculty members who have wide-ranging experience of academics and research as well as industry. In addition, we are focusing on collaborations with various industries to design relevant curricula and to provide students with an exposure to the real world.

Undergraduate Program

Bachelor of Technology in Mechanical Engineering with the option of doing minor in any other stream of interest.

Program Educational Objectives (PEO)

The Mechanical Engineering Program at SNU is designed to create and disseminate multidisciplinary strategic knowledge of the discipline and develop efficient, eco-friendly systems to cater the need of the industries and academic community.

The department is envisioned to nurture Mechanical Engineers in some emerging areas, namely Green Energy Technology Systems, High-Performance Computing, Advanced Materials and Manufacturing domains by addressing the relevant needs and challenges of the country. The department is offering a plethora of subjects along with three programs (B. Tech, M. Tech and Ph.D.) and some state of the art laboratory facilities towards imparting complete knowledge through experiential learning and skill development so that students can face any technological challenges and can come up with efficient and sustainable solutions.

Our students and researchers are expected to:

- Understand fundamental theory and apply their engineering knowledge and critical thinking to solve real world challenging Mechanical Engineering problems. The skills we impart on the students will be extremely valuable for their professional growth or contribution in non-engineering fields or business.
- Work in a technical environment with an understanding and necessity for the personal integrity, ethical behavior, and continuous improvement for the benefit of the community.
- Disseminate technical information through scholarly publication, conferences and continuing education.

II. Credit Break-up of UG Curriculum in Mechanical Engineering

Our balanced curriculum has a number of sub categories from which the students need to secure minimum credits. Every student has to secure the minimum credits as given in the table in the next page. Being a university, we have the freedom to constantly update the content of our courses to allow the best of knowledge to be imparted.

Department of Mechanical Engineering

Revised Credit Distribution		Total number of Credits: 160
S. No.	**Category**	**New Credits**
1	Core Common Curriculum (CCC)	18
2	University Wide Elective (UWE)	18
3	CCC/UWE	6
4	Basic Sciences (BS)	20
5	Engineering Sciences (ES)	9
6	Major Core	68
7	Major Elective	9
8	Project I + Project II	12
Total Credits		160

All undergraduate students at SNIOE must take a core group of common subjects designated as Core Common Curriculum (or CCC) courses. The CCC is designed to provide students a broad-based understanding of the world, its physical, biological and social systems, the development of human civilization and culture, and the historical development, etc.

A UWE course for a student is any non-CCC course outside the student's major from any department of SNIOE. The UWE credits for a student cannot come from courses that is either core course or elective course of the student's major. For example, a student may use UWE to pursue a variety of interests in dance, media, communication, history and sociology. Alternatively, a student may concentrate the UWE credits in one direction and use them to earn a minor degree in other department.

Core Common Curriculum	
S. No.	**Category**
1	Indian History and Society (IHS)
2	World History and Society (WHS)
3	Culture and Communication (CAS)
4	Physical and Living Systems (PLS)
5	Cognition and Intelligence (CAI)
6	Technology and Society (TAS)
7	Environment and Ecology (EAE)
8	Reasoning and Analysis (RAA)
Total Credits: 18 – 24	

Basic Sciences			**Total number of Credits: 20 Credits**	
S. No.	**Course Code**	**Course**	**L:T:P**	**Credits**
1	PHY101	Physics-1	3:1:0	4
2	PHY102	Physics-2	3:1:1	5
3	MAT103	Maths-1	3:1:0	4
4	MAT104	Maths-2	3:1:0	4
5	MAT205	Maths-3	3:0:0	3
Total Credits				20
Engineering Sciences			**Total Number of Credits: 9 Credits**	
S. No.	**Course Code**	**Course**	**New L:T:P**	**Credits**
1	CSD101	Introduction to Computing and Programming	3:0:1	4
2	EED101	Introduction to Electrical Engineering	3:1:1	5
Total Credits				9
Major Core			**Total number of Credits: 68 Credits**	
S. No.	**Course Code**	**Course**	**L:T:P**	**Credits**
1	MED101	Manufacturing Processes	1:0:1	2
2	MED104	Descriptive Engineering Drawing	2:0:1	3
3	MED105	Engineering Mechanics: Statics and Dynamics	3:1:0	4
4	MED201	Materials Science and Engineering	3:0:1	4
5	MED203	Mechanics of Solids	3:0:1	4
6	MED204	Kinematics and Dynamics of Machines	3:0:1	4
7	MED205	Engineering Thermodynamics	2:1:0	3
8	MED208	Manufacturing Sciences	3:0:1	4
9	MED209	Mechanical Engineering Design & Graphics	2:0:1	3
10	MED210	Principles of Industrial Engineering	3:0:0	3
11	MED211	Mechanics of Fluids	3:0:1	4
12	MED301	Applied Thermodynamics	2:1:0	3
13	MED303	Heat and Mass Transfer	3:0:1	4
14	MED305	Refrigeration & Air Conditioning	2:0:1	3
15	MED306	Fluid Machinery	2:0:1	3
16	MED309	Operations Research	2:1:0	3
17	MED314	Computer Aided Design & Manufacturing	2:0:1	3
18	MED315	I. C. Engines & Automobiles	3:0:1	4
19	MED320	Machine Design	3:0:0	3
20	MED412	Mechatronics & Control System	3:0:1	4
Total Credits				**68**

Major Electives -9 credits

S. No.	Course Code	Course	L:T:P	Credits
1	MED307	Finite Element Method	3:0:0	3
2	MED404	Adv. Comp. Programming & Numerical Techniques	3:0:0	3
3	MED409	Mechanics of Composite Structures	3:0:0	3
4	MED410	Computational Fluid Dynamics	3:0:0	3
5	MED415	Mechanical Vibrations	3:0:0	3
6	MED313	Computer Integrated Manufacturing	3:0:0	3
7	MED316	Advanced Manufacturing Processes	2:0:1	3
8	MED318	Supply Chain Management	3:0:0	3
9	MED308	Power Plant Engineering	3:0:0	3
10	MED403	Solar Energy	2:0:1	3
11	MED410	Computational Fluid Dynamics	3:0:0	3
12	MED413	Energy Conversion Tech and Energy Management	3:0:0	3
13	MED316	Advanced Manufacturing Processes	2:0:1	3
14	MED322	Advanced Materials and Applied Tribology	2:0:1	3
15	MED414	Surface Engineering	2:0:1	3
16	MED324	Fundamentals of Hydrogen Fuel Cells	3:0:0	3
17	MED326	Industrial Automation	2:0:1	3
18	MED416	Robotics	2:0:1	3
19	MED417	Soft Robotics	2:0:1	3

Semester-wise course offering

First Semester

S. No.	Course Code	Course Title	L:T:P	Credits
1		CCC 1		3
2	MAT103	Maths-1	3:1:0	4
3	PHY101	Physics-1	3:1:0	4
4	MED101	Manufacturing Process	1:0:1	2
5	MED104	Descriptive Engineering Drawing	2:0:1	3
6	MED105	Engineering Mechanics: Statics and Dynamics	3:1:0	4
Semester Credits				20

Second Semester

S. No.	Course Code	Course Title	L:T: P	Credits
1		CCC 2		3
2		CCC 3		3
3	MAT104	Maths-2	3:1:0	4
4	PHY102	Physics-2	3:1:1	5
5	CSD101	Introduction to Computing and Programming	3:0:1	4
6	EED101	Introduction to Electrical Engineering	3:1:1	5
Semester Credits				24

Third Semester

S. No.	Course Code	Course Title	L:T: P	Credits
1		CCC 4		3
2	MAT205	Maths-3	3:0:0	3
3	MED201	Materials Science and Engineering	3:0:1	4
4	MED203	Mechanics of Solids	3:0:1	4
5	MED208	Manufacturing Sciences	3:0:1	4
6	MED211	Mechanics of Fluids	3:0:1	4
7		UWE- I		3
Semester Credits				25

Fourth Semester

S. No.	Course Code	Course Title	L:T: P	Credits
1		CCC 5		3
3	MED204	Kinematics and Dynamics of Machines	3:0:1	4
2	MED205	Engineering Thermodynamics	2:1:0	3
4	MED209	Mechanical Engineering Design & Graphics	2:0:1	3
5	MED210	Principles of Industrial Engineering	3:0:0	3

6	MED314	Computer Aided Design and Manufacturing	2:0:1	3
7		UWE II		3
Semester Credits				22

Fifth Semester

S. No.	Course Code	Course Title	L:T: P	Credits
1		CCC 6		3
2		CCC 7/UWE		3
3	MED301	Applied Thermodynamics	2:1:0	3
4	MED303	Heat and Mass Transfer	3:0:1	4
5	MED309	Operations Research	2:1:0	3
6	MED320	Machine Design	3:0:0	3
7	MED412	Mechatronics & Control System	2:1:1	4
8		UWE- III		3
Semester Credits				26

Sixth Semester

S. No.	Course Code	Course Title	L:T: P	Credits
1		CCC 8/UWE		3
2	MED305	Refrigeration & Air Conditioning	2:0:1	3
3	MED306	Fluid Machinery	2:0:1	3
4	MED315	I. C. Engines & Automobiles	3:0:1	4
5		UWE-IV	3:0:0	3
6		UWE–V	3:0:0	3
7		Major Elective –I	3:0:0	3
Semester Credits				22

Seventh Semester

S. No.	Course Code	Course Title	L:T: P	Credits
1		Major Elective – II	3:0:1	3
2		Major Elective – III	3:0:0	3
3		UWE–VI	3:0:0	3
4	MED497	Project-1	0:0:6	6
Semester Credits				15

Eighth Semester

S. No.	Course Code	Course Title	L:T: P	Credits

1	MED498	Project-2	0:0:6	6
Semester Credits				6

Specialization Tracks

The students enrolled in B. Tech. Mechanical Engineering (4 year) would have an option to specialize in one the following emerging areas

- Computational Techniques in Mechanical Engineering
- Energy Technology
- Robotics and Industrial Automation

The student must complete a minimum of 9 credits in the chosen area of specialization.

List of elective courses in specialization tracks

Major Elective 09 Credits				
Track 1 : Computational Techniques in Mechanical Engineering				
S. No.	**Course Code**	**Course**	**L:T:P**	**Credits**
1	MED307	Finite Element Method	3:0:0	3
2	MED404	Adv. Comp. Programming & Numerical Techniques	3:0:0	3
3	MED409	Mechanics of Composite Structures	3:0:0	3
4	MED410	Computational Fluid Dynamics	3:0:0	3
5	MED415	Mechanical Vibrations	3:0:0	3
Track 2 : Energy Technology				
S. No.	**Course Code**	**Course**	**L:T:P**	**Credits**
1	MED308	Power Plant Engineering	3:0:0	3
2	MED403	Solar Energy	2:0:1	3
3	MED410	Computational Fluid Dynamics	3:0:0	3
4	MED413	Energy Conversion Tech and Energy Management	3:0:0	3
5	MED324	Fundamentals of Hydrogen Fuel Cells	3:0:0	3
Track 3 : Robotics and Industrial Automation				
S. No.	**Course Code**	**Course**	**L:T:P**	**Credits**
1	MED326	Industrial Automation	2:0:1	3
2	MED416	Robotics	2:0:1	3
3	MED417	Soft Robotics	2:0:1	3

Mechanical Minor course requirement list

Students from other departments in the university have the option to take a minor degree from the Mechanical stream. The list of course requirements to obtain a Mechanical minor degree is as follows. Total credit for minor requirement is minimum twenty-one.

Mandatory Courses-12 credits*				
S.No.	**Course Code**	**Course Name**	**credit**	**Prerequisite**
1	MED101	Manufacturing Processes	2	None
2	MED104	Descriptive Engineering Drawing	3	None
3	MED105	Engineering Mechanics: Statics and Dynamics	4	None
4	MED205	Engineering Thermodynamics	3	None
*If a student has completed 'n' number of equivalent credits among the above three courses, as a part of major curriculum then 'n' number of credits should be taken extra from the optional courses				
Optional courses- Minimum 9 credits among the following**				
1	MED203	Mechanics of Solids	4	MED105 or equivalent other dept course
2	MED204	Kinematics and Dynamics of Machines	4	MED105 or equivalent other dept course
3	MED211	Fluid Mechanics	4	None
4	MED303	Heat and Mass Transfer	4	MED205 & MED211 or equivalent other dept courses
5	MED209	Mechanical Engineering Design & Graphics	3	MED104 & MED203 or equivalent other dept courses
6	MED309	Operations Research	3	None
7	MED306	Fluid Machinery	3	MED211 or equivalent other dept course
8	MED210	Principles of Industrial Engineering	3	None
9	MED208	Manufacturing Sciences	4	MED101
10	MED320	Machine Design	3	MED209
**Equivalent courses in the student's major discipline will not be counted towards minor requirement. Apart from these equivalent courses, the student has to complete optional course requirement				

Description of courses offered in Mechanical Engineering Department

MED101: Manufacturing Processes (L: T: P-1:0:1)

Unit-I: Carpentry Shop – Basic concepts, Types of woods and their properties, Seasoning of wood, Carpentry tools, Carpentry Processes, Carpentry joints.
Fitting Bench Working Shop – Introduction, Vices, Fitting tools, Fitting Processes

Unit-II: Welding Shop - Introduction to welding, Weldability, Types of welding, Metallurgy of Weld, Arc Welding, Resistance Welding, Spot Welding
Machine Shop - Introduction to machine tools and machining processes; Types of cutting tools, Selection of cutting speeds and feed, Simple machining operations on Lathe.

Unit-III: Metal Forming: Basic metal forming operations & uses of such as: Forging, Rolling, Wire & Tube-drawing/making and Extrusion, and its products/applications. Press-work, & die & punch assembly, cutting and forming, its applications. Hot-working versus cold-working.
Misc. Processes: Powder-metallurgy process & its applications, Plastic-products manufacturing, Galvanizing and Electroplating.

Unit-IV: Sheet Metal Shop -Introduction to sheet metal shop, Metals used in sheet metal works, Hand tools and accessories e.g., different types of hammers, hard and soft mallet, Sheet Metal operation, Sheet Metal Joints Hems and Seams, Sheet metal allowance, Sheet Metal working machines.
Foundry Shop – Introduction, Pattern Materials, Method of constructing a pattern, Moulding Processes.

Lab experiments:

1	To perform the given two work pieces as a lap joint by arc welding.
2	To join the given two work pieces as a single 'V' butt by arc welding.
3	To perform the given M.S. piece into a square shape of 48 mm. side.
4	To perform a Mild steel square flat with multiple Operations.
5	To perform a job for facing, turning, Knurling, taper turning, grooving and
6	To perform a Rectangular Tray by sheet metal work as per dimension given in drawing
7	To perform a square tray by sheet metal work as per dimension given in drawing
8	To perform a job for Knurling, taper turning, grooving and threading as per drawing.
9	To perform Cross Lap Joint from the given wooden pieces for the desired dimensions.
10	To perform corner wood joint from the given wooden pieces for the desired Dimensions.
11	To perform a mound cavity making from a given pattern for green sand casting.

Reference Books:

1. Kalpakjian and Schmid, Manufacturing Engineering and Technology, 7 ed., Pearson.
2. Kumar & Gupta, Manufacturing Processes, Prentice Hall India.
3. Workshop technology, by W. A. J. Chapman, Taylor & Francis.
4. Rao, Manufacturing Processes, McGraw Hill Education.

MED104: Descriptive Engineering Drawing (L: T: P-2:0:1)

Unit 1 Introduction to engineering drawing: principles of engineering graphics and their significance – drawing instruments and their use, conventions in drawing, lettering, dimensioning rules, geometrical construction, Curves used in engineering practice and their constructions.

Unit 2 Orthographic projection in first angle projection only: principles of orthographic projections, conventions – first and third angle projections. Projections of points and lines inclined to both the planes.

Unit 3 Projections of planes and solids: projections of regular planes, inclined to both planes. Projections of regular solids inclined to both planes.

Unit 4 Development of surfaces: development of surfaces of right, regular solids – development of prisms, cylinders, pyramids, cones.

Unit 5 Isometric projections: principles of isometric projections-isometric scale- isometric views conventions-plane figures.

Reference Books:

1. N. D. Bhat (2006), Engineering Drawing, Charotar Publications, New Delhi.
2. Venugopal (2010), Engineering Drawing and Graphics, 2nd edition, New Age Publications, New Delhi.
3. Johle (2009), Engineering Drawing, Tata Mc Graw Hill, New Delhi, India.

MED105: Engineering Mechanics-Statics and Dynamics (L: T: P-3:1:0)

1. Fundamental principles & concepts
Newton's laws, gravitation, force (external and internal, transmissibility), couple, moment (about point and about axis), couple and couple moment, resultant of concurrent and non-concurrent coplanar forces, static equilibrium, free body diagram, reactions. problem formulation concept; 2-d statics, two and three force members

2. Analysis of structures
Assumptions, rigid and non-rigid trusses; simple truss (plane and space), analysis by method of joints. analysis of simple truss by method of sections; compound truss (statically determinate, rigid, and completely constrained). beams: types of loading and supports; shear force, bending moment.

3. Virtual work and energy method
Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom and the solution of problems.

4. Center of mass & area moments of inertia
First moment of area and centroid, mass and center of mass, centroids of lines, areas, volumes, composite bodies. area moments- and products- of inertia, radius of gyration, transfer of axes, composite areas. rotation of axes.

5. Mass moment of inertia
Second moment of mass, mass moments- and products- of inertia, radius of gyration, transfer of axes, flat plates (relation between area- and mass- moments- and products- of inertia), composite bodies. rotation of axes.

6. Friction
Coulomb dry friction laws, simple surface contact problems, friction angles, types of problems, wedges. belt friction. square-threaded screw (self-locking, screw jack).

7. Kinematics of particle
Rectilinear motion; plane curvilinear motion (rectangular, path, and polar coordinates). 3-d curvilinear motion; relative and constrained motion.

8. Kinetics of particle
Newton's 2nd law (rectangular path, and polar coordinates). work-kinetic energy, power, potential energy. impulse-momentum (linear, angular).

Reference Books:

1. Shames, I.H. and Rao, G.K.M., 1967. Engineering mechanics: statics and dynamics. Englewood Cliffs: Prentice-Hall.
2. Hibbeler, R.C., 2011. Engineering mechanics statics and dynamics, 11th edition, New Delhi Pearson.
3. Chandramouli, P.N., 2013. Engineering mechanics, PHI.
4. Manish Bhaskar, 2010, Problems in engineering mechanics, CBS Publishers & Distributors.

MED201: Materials Science and Engineering (L: T: P-3:0:1)

Chapter-1: Introduction

Material science and engineering, Classification of engineering materials, Structure-property relationship, bonding forces and energies, Equilibrium and kinetics, Stability and Meta-stability, Basic thermodynamic functions, Entropy, Kinetics of thermally activated processes

Chapter-2: Crystal Geometry and Structure Determination

Geometry of crystal, Space lattice, Crystal structure, Crystal directions and planes, Structure determination by X-ray diffraction, atomic structure and chemical bonding

Chapter-3: Crystal Imperfections

Defects in materials, Point defects, Dislocations, Properties of dislocations, Dislocation theory Surface imperfections

Chapter-4: Phase Diagrams

The phase rule, Single-component systems, Binary-phase diagrams, Iron-Carbon Phase diagram, Microstructural changes during cooling, The lever rule.

Chapter-5: Phase Transformations

Time-scale for phase change, Nucleation and grain growth, Nucleation kinetics, Overall transformation kinetics, Applications, Recovery, recrystallization and grain growth, Diffusion

Chapter-6: Plastic Deformation in Crystalline Materials

Plastic deformation by slip, Shear strength of perfect and real crystals, Critical resolved shear stress for slip, Stress to move a dislocation, Effect of temperature on dislocation movement, Dislocation multiplication, Work hardening and dynamic recovery

Chapter-7: Strengthening Mechanisms in Materials

Introduction, Strengthening from grain boundaries, Solid solution strengthening, Strengthening by fine particles, Strain hardening, Bauschinger effect

Chapter-8: Corrosion and Degradation of Materials

Introduction, Electrochemical considerations, Corrosion rates, Prediction of corrosion rates, Passivity, Environmental effects, Forms of corrosion, Corrosion prevention

Reference Books:

1. William D. Callister, “Material Science and Engineering”, Wiley
2. V. Raghavan, “Material Science and Engineering: A First Course”, PHI
3. G.E. Dieter, “Mechanical Metallurgy”, McGraw Hill

MED203: Mechanics of Solids (L: T: P-3:0:1)

1. Introduction: Definition of Solids and deformations. Review of basics of engineering mechanics. Introduction of the concept of stress and strains. Definition of Solids and deformations. Review of basics of engineering mechanics. Introduction of the concept of stress and strains.

2. Stress and strain transforms: Plane dependence of stress and strains. 1D, 2D and 3D stress transformation problems. Introducing principal stresses and principal planes. Overview of failure theories and structural safety.

3. Theory of Bending and shearing: Introducing shearing, pure bending and pure shear problems. Shear force and bending moment diagrams. Estimating bending, shearing and torsional stresses.

4. Buckling instability: Developing buckling theory. Estimating Euler critical loads. Buckling characterization of columns.

Reference Books:

1. Goodno, Barry J., and James M. Gere. Mechanics of materials. Cengage Learning, 2020.
2. Beer, F.P., Johnston, E.R., DeWolf, J.T. and Mazurek, D.F., 2015. Mechanics of Materials. 7th_Edition. New York. MeGraw-Hill Education Ltd.
3. Timoshenko and Gere, Mechanics of Materials. PWS Publishing Company, 1997PWS Publishing Company, 1997
4. Ferdinand P. Beer, John T. DeWolf, E. Russell Johnston, Jr., David Mazurek · 2011. Mechanics of Materialls. Tata McGraw-Hill.

MED204: Kinematics and Dynamics of Machines (L: T: P-3:0:1)

1. Kinematics: Review of Kinematics of Machines (KoM), Linkage Mechanism, Velocity and Acceleration in Mechanisms: Graphical & Analytical methods.

2. Static Force Analysis: Constraints and Applied forces, Equilibrium of two and three force members, free body diagrams, Static equilibrium, Analytical and Graphical methods

3. Dynamic Force Analysis: D'alembert's principle, Engine force analysis, Flywheel and Turning moment diagrams: single and multi-cylinder steam engines.

4. Balancing: Static and Dynamic balancing of machines, balancing of masses in different planes

5. Brakes and Dynamometers: Type of brakes, Band brake, Band and block brakes, internal expanding shoe brake

6. Governors: Various types of governors, Sensitivity, Stability, Effort and Power of Governors.

7. Gyroscope: Effect of gyroscopic couple on the stability of aero planes & automobiles

8. Vibration: Mechanical vibration, free and forced vibrations of single degree-of-freedom systems, torsional vibration, Critical speeds of shaft.

Reference Books:

1. S.S Rattan, Theory of Machines, 3rd Edition, Tata McGraw-Hill Education, 2010.
2. RS Khurmi, Theory of Machines, S Chand Publication, 2005.
3. William T. Thomson, Theory of Vibration with Applications, 2nd Edition, George Allen & Unwin, 1983.
4. Norton, Kinematics & Dynamics of Machinery, Tata McGraw-Hill Education, 1961.
5. J. S. Rao, Kinematics of Machinery Through HyperWorks, Springer, 2011.
6. State of art in the field of mechanisms and machines: Journal articles (review articles), proceedings and other publications.

MED205: Engineering Thermodynamics (L: T: P-2:1:0)

Unit-1 Introduction and Basic Concepts: Introduction and Definition of Thermodynamics, Dimensions and Units, Microscopic and Macroscopic Approaches, Systems, Surroundings and Universe, Concept of Continuum, Control System Boundary, Control Volume and Control Surface, Properties and State, Thermodynamic Properties, Path, Process and Cycle, Thermodynamic Equilibrium, Quasi Static Process, Energy and its Forms, Work and Heat Transfer (Numerical)
Zeroth Law of Thermodynamics: Zeroth Law of Thermodynamics, Temperature and its' Measurement, Temperature Scales.

Unit-2 First Law of Thermodynamics: Joules Experiment, First Law of Thermodynamics, Internal Energy and Enthalpy, Applications of First Law of Thermodynamics to Cycles, Flow and Non-Flow Processes and, Steady Flow Energy Equation and its applications to Different Devices (Numerical), PMM-I.

Unit-3 Second Law of Thermodynamics: Limitations of First Law, Thermal Reservoir, Heat Engines, Heat Pump and Refrigerator, Kelvin Planck and Clausius Statement of Second Law, Equivalence of Kelvin Plank and Clausius Statements, Reversible and Irreversible Processes, Carnot Cycle and Carnot Engine, Carnot Theorem and it's Corollaries, Thermodynamic Temperature Scale, PMM-II (Numerical).

Unit-4 Entropy: Clausius Inequality, Concept of Entropy, Entropy Change in Different Thermodynamic Processes, Tds Equation, Principle of Entropy Increase, TS Diagram, Third Law of Thermodynamics (Numerical).
Availability and Irreversibility: Available and Unavailable Energy, Availability and Irreversibility, Second Law Efficiency, Helmholtz & Gibb's Function (Numerical).

Unit-5 Properties of Steam: Pure Substance and Phase Change, Properties and Processes of Steam P-v Diagrams, T-s and Mollier Diagrams, Dryness Fraction, (Numerical using Steam Table and Mollier Diagrams).

Reference Books:

1. Thermodynamics: an engineering approach, Y A Cengel and M A Boles, McGrawHill Education
2. Engineering Thermodynamics, P K Nag, McGraw Hill Education
3. Basic and Applied Thermodynamics, P K Nag, McGraw Hill Education
4. Fundamentals of Engineering Thermodynamics, M J Moran and H N Shapiro, Wiley

MED208: Manufacturing Sciences (L: T: P-3:0:1)

Unit I: Metal Casting: Introduction to metal casting, Solidification of Metals, Characteristics of sand casting, Patterns, Pattern allowances, Pattern materials, Types of patterns, Moulding materials, Moulding sand properties, Types of sand moulds, Cores, Gating system, Casting Defects, Special casting processes, Cast structures

Unit II: Metal Removal Processes: Mechanism of metal cutting, Types of tools, Tool Geometry, Tool Signature, Orthogonal and Oblique cutting, Mechanics of chip formation, Chip morphology, Tool wear and failure, Machinability, Cutting-tool materials, Cutting fluids, Brief description of metal removal processes: Turning, drilling, boring and Milling, Material removal rate and machining time

Unit III: Metal Joining Processes: Classification of joining processes, Welding technique, Different welding processes: Gas Welding, Electric Arc Welding, Tungsten Inert-gas Welding (TIG), Gas Metal-Arc Welding (GMAW), Submerged Arc Welding (SAW), Resistance Welding, Friction Stir Welding (FSW), Defects in Weldments

Unit IV: Bulk Deformation Processes: Introduction to bulk deformation processes, Hot and cold working, Forging, Types of forging, Forging defects, Rolling, Defects in rolled products, Extrusion, Metal flow in extrusion, Rod drawing, Wire and Tube drawing, Swaging, Severe plastic deformation processes: Friction stir processing, Equal channel angular extrusion and high pressure torsion

Unit V: Powder Metallurgy: Production of metal powders, Particle size and shape, Blending of metal powders, Compaction of metal powders, Shaping processes, Sintering, Finishing operations, Design considerations for powder metallurgy

Unit VI: Non-Conventional Machining Processes: Need of non-conventional machining, Classification of non-conventional machining processes, Different non-conventional machining processes: Water jet machining, Abrasive jet machining, Chemical machining, Electrochemical machining, Electrical discharge machining, Laser-beam machining

Unit VII: Non-Conventional Machining Processes: Heat treatment of metals, Annealing, Martensite formation in steel, Precipitation hardening, Surface hardening, Heat treatment methods and facilities, Surface processing operations, Industrial cleaning processes, Diffusion and ion implantation, Plating and related processes, Conversion coating, Vapour deposition processes, Thermal and mechanical coating processes

Reference Books:

1. Serope Kalpakjian and Steven.R. Schmid, "Manufacturing Processes for Engineering Materials" Pearson
2. P.N. Rao, Manufacturing Technology, McGraw Hill
3. B.S. Nagendra Parashar and R.K. Mittal, Elements of Manufacturing Processes, PHI

MED209: Mechanical Engineering Design & Graphics (L: T: P-2:0:1)

Unit-I Fundamentals of Design: Introduction & Definitions, general procedure of Machine Design, System Design Cycle, Strength and Stiffness Design, Standards in Design, Selection of Preferred sizes, selection of material, designation of Cast iron, steel and alloy steel

Unit-II Design against static and Dynamic load: Modes of failure, Factor of safety, Principal stresses, Stresses due to bending and torsion, Theory of failure, Cyclic stresses, Fatigue and endurance limit, Stress concentration factor, Stress concentration factor for various machine parts, Notch sensitivity, Design for finite and infinite life, Soderberg, Goodman criteria.

Unit-III Mechanical Spring: Terminology in spring, Material for helical springs, End connections for compression and tension helical springs, Stresses and deflection of helical springs of circular wire, Design of helical springs subjected to static and fatigue loading.

Unit-IV Riveted Joints: Riveting methods, materials, Types of rivet heads, Types of riveted joints, Caulking and Fullering, Failure of riveted joint, Efficiency of riveted joint, Eccentric loaded riveted joint.

Unit-V Design of Shaft: Shaft: Cause of failure in shafts, Materials for shaft, Stresses in shafts, Design of shafts Subjected to twisting moment, bending moment and combined twisting and bending moments, ASME code for Shaft Design.

Unit-VI Design of Keys: Keys: Types of keys, splines, Selection of square & flat keys, Strength of sunk key.

Reference books:

1) Design of Machine Elements by V. B. Bhandari , Tata McGraw-Hill Education, 2010
2) Machine Design by P. C .Sharma and DK Agrawal.
3) Machine Design, Fundamental and Applications by P.C. Gope, PHI learning pvt. Ltd., 2012
4) Design Data Hand Book for Mechanical Engineers : In SI and Metric Units (English) 3rd Edition by K. Mahadevan.

MED210: Principles of Industrial Engineering (L: T: P-3:0:0)

1. Introduction to Industrial Engineering: History, Definition, product/process strategy, the trend in IE, Scope of IE, Productivity, type of productivity, Efficiency, and Effectiveness.

2. Production Planning and Control:

i. **Forecasting analysis:** Qualitative model (Questionnaire survey, Delphi Method), Time series models (Simple average method, weighted average method, kth period method, and exponential smoothing method), Linear Regression Model, Seasonal forecasting Model, Causal Model, Performance measure analysis (MAD, MSE, MPAE, etc.)

ii. **Production Sequencing and Scheduling of** single machine, Parallel machine, flow shop and Job shop, operations planning (SPT, EDD, Johnson's rule, etc.); Gantt chart, work order, Assembly Line balancing problem

3. Aggregate Production Planning: Introduction, Formulation of APP, LPP approach, Transportation approach to APP, Uniform strategy, Chase strategy, Pure strategy,

4. Material Requirement Planning: Introduction, Definition, Independent demand Vs dependent demand concept, MRP Inputs, Bill of material, Master production schedule, MRP Logic, Benefits of MRP.

5. Inventory Control: Scope, purchasing and storing, Type of Inventory, ABC, VED Analysis, Quantitative Inventory Models (EOQ with and without Backordering, POQ with and without backordering, Inventory Discount Policy)

6. Introduction to Work Study

Reference Books:

1. E.S. Buffa, and R.K. Sarin, , John Wiley & Sons, "Modern Production / Operations Management"
2. Ravi Shankar, "Industrial Engineering and Management"
3. O.P. Khanna, "Industrial Engineering and Management"
4. Philip E Hicks, "Specifications of Industrial Engineering and Management: A New Perspective"
5. G. Srinivasan, "Quantitative Models in Operations and SCM"

MED211: Mechanics of Fluids (L: T: P-3:0:1)

1. Introduction: Definition of Fluid and continuum, Physical properties, Newtonian and non-Newtonian fluids, and concept of capillarity

2. Fluid Statics: Fundamental equation of fluid statics, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies, metacentre & metacentric height.

3. Kinematics of Fluid flow: Lagrangian and Eulerian methods for flow field description, one, two and three dimensional flows, steady and unsteady flows, uniform and non-uniform flows, material derivative and acceleration, streamlines, path lines and steak lines, translation, rotation and rate of deformation of fluid element, vorticity and circulation, concept of steam function and velocity potential.

4. Dynamics of Fluid Flow: System, concept of conservation of mass-continuity equation, differential and integral forms of continuity equation, Reynold's transport theorem, conservation of momentum, analysis of control volume systems- inertial and non-inertial control volumes, Euler's equation of motion, Bernoulli's equation and its applications to vortex flow and measurement of flow through pipes, Pitot tube, orifice meter, venturi meter, flow through orifices and mouthpieces.

5. Dimensional Analysis and Hydraulic Similitude: Dimensional analysis, Buckingham's Pi theorem, important dimensionless numbers and their significance, geometric, kinematics and dynamic similarity, model studies.

6. Viscous flows: Viscosity laws, Navier-stokes equation, exact solution of Navier-stokes equation-parallel flow in a straight channel, Couette's flow, Hagen Poiseuille flow, flow through concentric cylinders, low Reynolds number flow, viscous flow through pipes, Darcy's friction factor, losses in pipes due to sudden enlargement and contraction, exit and entry losses, losses due to bends and fittings, flow through pipes arranged in parallel and series.

Reference Books:

1. Som, S. K. & Biswas G.: Introduction of fluid mechanics & Fluid Machines, TMH.
2. Yunus A. Cengel and John M. Cimbala: Fluid Mechanics Fundamentals and Applications, McGraw Hill Education
3. White F. M: Fluid Mechanics, McGraw hill Education
4. Pijush K. Kundu: Fluid Mechanics, Elsevier India
5. I. H. Shames, Mechanics of Fluids, McGraw Hill Education.
6. http://web.mit.edu/hml/ncfmf.html

MED301: Applied Thermodynamics (L: T: P-2:1:0)

Unit-I Thermodynamic relations: Mathematical conditions for exact differentials. Maxwell Relations, Clapeyron Equation, Joule-Thompson coefficient and Inversion curve. Coefficient of volume expansion, Adiabatic & Isothermal compressibility.

Unit-II Boilers: Steam generators-classifications. Working of fire-tube and water-tube boilers, boiler mountings & accessories, Draught & its calculations, air pre heater, feed water heater, superheater. Boiler efficiency, Equivalent evaporation. Boiler trial and heat balance. **Condenser:** Classification of condenser, Air leakage, Condenser performance parameters

Unit-III Steam Engines: Rankine and modified Rankine cycles. **Steam & Gas Nozzles:** Flow through nozzle, Variation of velocity, Area and specific volume, Choked flow, Throat area, Nozzle efficiency, off design operation of nozzle, Effect of friction on nozzle, super saturated flow.

Unit-IV Steam Turbines: Classification of steam turbine, Impulse and reaction turbines, Staging, Stage and overall efficiency, Reheat factor, Bleeding, Velocity diagram of simple & compound multistage impulse & reaction turbines & related calculations work done efficiencies of reaction, Impulse reaction Turbines, state point locus, Comparison with steam engines, Losses in steam turbines, Governing of turbines. **Gas Turbine:** Gas turbine classification, Brayton cycle, Principles of gas turbine, Gas turbine cycles with intercooling, reheat and regeneration and their combinations, Stage efficiency, Polytropic efficiency. Deviation of actual cycles from ideal cycles.

Unit-V Jet Propulsion: Introduction to the principles of jet propulsion, Turbojet and turboprop engines & their processes, Principle of rocket propulsion, Introduction to Rocket Engine. **Introduction to working of I. C. Engines:** Compression Ignition engines, Spark Ignition engines, 2 stroke and 4 stroke engines, Performance parameters of I. C. engine, Heat balance sheet. **Fuels and Combustion:** Combustion analysis, Heating Values, Air requirement, Air/Fuel ratio, Standard heat of Reaction and effect of temperature on standard heat of reaction, heat of formation, adiabatic flame temperature.

Reference Books:

1. Power Plant Engineering – P K Nag, McGraw Hill Education
2. Thermal Engineering – Mahesh M Rathore, McGraw Hill Education
3. Basic and Applied Thermodynamics– P K Nag, McGraw Hill Education
4. Thermodynamics: an engineering approach, Y A Cengel and M A Boles, McGrawHill Education
5. Applied Thermodynamics for Engineering Technologists – T D Eastop and A McConkey, Pearson Education
6. Thermodynamics Basic and Applied- V Ganesan, McGraw Hill Publications

MED303: Heat and Mass Transfer (L: T: P-3:0:1)

UNIT-I

Introduction and basic concepts: Thermodynamics and heat transfer, Heat transfer mechanisms: Conduction, Convection and Radiation, Thermal conductivity, Simultaneous heat transfer. **Heat conduction equation:** Introduction, One dimensional heat conduction equation, General heat conduction equation, Boundary and initial conditions. **Steady heat conduction:** Steady heat conduction in plane walls, Thermal contact resistance, generalized thermal networks, Heat conduction in cylinders and spheres, Critical radius of insulation, Heat transfer from finned surfaces. **Transient heat conduction:** Lumped system analysis, Transient heat conduction in large plane walls, long cylinders and spheres with spatial effects

UNIT-II

Fundamentals of convection: Physical mechanism of convection, Classification of fluid flows, Velocity boundary layer, Thermal boundary layer, Laminar and turbulent flows, Heat and momentum transfer in turbulent flow, Derivation of differential convection equations, Solutions of convection equations for a flat plate, Analogies between momentum and heat transfer. **External forced convection:** Drag and heat transfer in external flow, Parallel flow over flat plates, Flow across cylinders and spheres, Flow across tube banks. **Internal forced convection:** Introduction average velocity and temperature, the entrance region, General thermal analysis, Laminar flow in tubes, Turbulent flow in tube. **Natural convection:** Physical mechanism of natural convection, Equation of motion and the grashof number, Natural convection over surfaces, Natural convection from finned surfaces, Natural convection inside enclosures, Combined natural and forced convection

UNIT-III

Heat exchangers: Types of heat exchangers, the overall heat transfer coefficient, Analysis of heat exchangers, The log mean temperature difference method, The effectiveness- NTU method, Selection of heat exchangers. **Fundamentals of thermal radiation:** Introduction, Thermal radiation, Blackbody radiation, Radiation intensity, Radiative properties, Atmospheric and solar radiation. **Radiation heat transfer:** The view factor, View factor relations, Radiation heat transfer: black surfaces, Radiation heat transfer: diffuse, gray surfaces, Radiation shields and the radiation effect, Radiation exchange with emitting and absorbing gases. **Mass transfer:** Introduction, Analogy between heat and mass transfer, Mass diffusion, Boundary conditions, Steady mass diffusion through a wall, Water vapor migration in buildings, Transient mass diffusion, Diffusion in a moving medium, Mass convection, Simultaneous heat and mass transfer

Reference Books:

1. Heat and Mass Transfer by Yunus A. Cengel, Afshin J. Ghajar
2. Heat and Mass Transfer by P K Nag
3. Fundamentals of Heat and Mass Transfer by Lavine, Incropera and Dewitt
4. Heat and Mass Transfer by R.K. Rajput
5. Fundamentals of Engineering Heat and Mass Transfer by R. C. Sachdeva

MED305: Refrigeration & Air Conditioning (L: T: P-2:0:1)

UNIT-I

Methods of cooling: Sensible cooling, Endothermic mixing, Phase change processes, Expansion of liquids, Expansion of gases, Thermoelectric cooling, Adiabatic demagnetization **Vapour compression refrigeration systems:** Carnot refrigeration cycle, Standard Vapor Compression Refrigeration System, Performance of VCRS cycle, Modifications of VCRS cycle, Actual VCRS System. **Refrigerants:** Refrigerant Selection Criteria, Classification of Refrigerant **Expansion devices:** Automatic Expansion Valve, Thermostatic Expansion Valve and Capillary tube

UNIT-II

Condensers: Types of condensers, Heat transfer in condensers. **Evaporators:** Types of evaporators, Heat transfer in evaporators. **Refrigerant Compressors:** Types of compressors, Reciprocating compressor, Volumetric Efficiency

UNIT-III

Vapour absorption refrigeration systems: Simple Vapour Absorption System, Ammonia-Water Refrigeration System. **Psychrometry:** Important Psychrometric Properties, Wet Bulb Temperature, Psychrometric Chart, Psychometric Processes, Summer air conditioning system, Evaporative air conditioning system.

Reference Books:

1. C.P. ARORA
2. J.K. GUPTA and R.S. KHURMI
3. R.K. RAJPUT
4. WILBERT STOECKER
5. A.R. TROTT and T. WELCH

MED306: Fluid Machinery (L: T: P-2:0:1)

UNIT-I

Introduction: Classification of Fluid Machines & Devices, Application of Impulse-Momentum equation on flow through hydraulic machinery. **Impact of jet:** Introduction to hydrodynamic thrust of jet on a fixed and moving surface **Hydraulic Turbines:** Classification of turbines, Impulse turbines, Pelton Turbine, Constructional details, Velocity triangles, Power and efficiency calculations

UNIT-II

Reaction Turbines: Francis and Kaplan turbines, Constructional details, Velocity triangles, Power and efficiency calculations, Draft tube, Unit and specific speed, Performance characteristics, Selection of water turbines. Euler's fundamental equation.

UNIT-III

Centrifugal Pumps: Classifications of centrifugal pumps, Vector diagram, Work done by impeller, Efficiencies of centrifugal pumps, Specific speed, Performance characteristics.

Introduction to Positive Displacement Pumps

UNIT-IV

Other Machines: Hydraulic accumulator, Special duty pumps, Intensifier, Hydraulic press, Lift and cranes, Theory of hydraulic coupling and torque converters **Water Lifting Devices:** Hydraulic ram, Jet pumps, Air lift pumps.

List of Experiments

1. Impact of Jet
2. Pelton Turbine
3. Francis Turbine
4. Kaplan Turbine
5. Centrifugal Pump
6. Reciprocating Pump
7. Gear Pump
8. Hydraulic Ram

Reference Books:

1. Fluid Mechanics and Fluid Machines. S. K. Som, G. Biswas and S. Chakraborty. McGrawHill Education
2. Fluid Mechanics and Machinery. C. S. P. Ojha, R. Berndtsson and P. N. Chandramouli. Oxford University Press.
3. Hydraulics and Fluid Mechanics Including Hydraulic Machines. P. N. Modi, S. M. Seth. Standard Book House.
4. Fluid Mechanics and Thermodynamics of Turbomachinery. S. L. Dixon and C. Hall. Butterworth-Heinemann

MED309: Operations Research (L: T: P-2:1:0)

UNIT-I

(a) Origins and Impacts of Operations Research
(b) Formulations
i. Mathematical Models
ii. Model Components
iii.Formulation Examples.

UNIT-II

Simplex Solution Technique
i. Graphical Method
ii. Algebraic Approach
iii.Summary: Tableau Method HW2 due for Week 4.

UNIT-III
Special Cases of Simplex Method
i. Nonrestricted, nonpositive variables and minimization proble
ii. Infeasible and Unbounded Linear Programs
iii. Software for Larger Linear Programs

UNIT- IV
Network Problems and Applications
i. Transportation Problem Formulations
ii. Assignment Problem Formulations

UNIT- V
Queuing Theory

UNIT- VI
CPM/PERT

Reference Books:
1. Introduction to Operations Research, by F.S. Hillier and G.J. Lieberman
2. Operations Research, by Gupta Prem Kumar and Hira D.S.

MED314: Computer Aided Design & Manufacturing (L: T: P-2:0:1)

1. Introduction to CAD:
- Overview of CAD and its applications in various industries
- Historical development and evolution of CAD
- Benefits and advantages of using CAD in design processes

2. CAD Software training:
- Introduction to CAD software packages (3D experience platform)
- Familiarization with the CAD software interface, tools, and features

3. Geometric Modeling:
- Understanding 1D, 2D and 3D geometric entities
- Creating and modifying geometric shapes and objects
- Applying geometric constraints and relationships between entities

4. Parametric Modeling:
- Introduction to parametric modeling concepts and principles
- Creating parametric models and establishing relationships between objects
- Modifying designs by adjusting parameters and constraints

5. Part Design, Assembly Design and Drafting:

- Assembling components and creating complex assemblies
- Applying constraints and relationships to ensure proper fit and functionality
- Creating accurate technical drawings and views

6. Project Work:

- Hands-on projects to apply CAD principles and techniques to real-world design challenges
- Developing problem-solving skills and critical thinking through project-based learning

Reference Books:

1. Ibrahim Zeid, Mastering CAD/CAM, Tata McGraw-Hill Education.
2. P. N. Rao, CAD/CAM: Principles and Applications, Tata McGraw-Hill Education.
3. M. Groover, E. Zimmers, CAD/CAM : Computer-Aided Design and Manufacturing, Pearson Education Singapore Pte Ltd
4. S. P. Regalla, Computer Aided Analysis and Design, I.K. International Publishing House Pvt. Ltd.

MED315: I.C. Engines & Automobiles (L: T: P-3:0:1)

1. Introduction

Historical and Modern Development, Nomenclature, Classification and Comparison of SI and CI engines, 4 stroke & 2 stroke engines, First Law analysis, Energy Balance.

2. Engine Testing and Performance

Performance parameters, Efficiencies such as thermal, mechanical, volumetric etc., Measurement of operating parameters such as speed, fuel and air consumption, Powers- IHP, BHP, FHP, Numerical problems, India and International standards of Testing.

3. Combustion

Combustion in CI and SI engines: Ignition Limits, Stages of combustion, Combustion parameters, Delay period and Ignition Lag, Turbulence and Swirl, Effects of engine variables on combustion parameters, Abnormal combustion in CI and SI engines, Detonation and knocking, Control of abnormal combustion, Types of combustion chamber.

Pollutant Formation and Control: Unburned hydrocarbon emissions, CO and NO_x emissions and emission control methods.

4. Introduction to Automobiles

Frame and Body: Layout of chassis, types of chassis frames and bodies, their constructional features and materials. Auto-electric system.

5. Power Transmission

Requirements of transmission system; General Arrangement of Power Transmission system; Clutch: single plate, multi plate, cone clutch, semi centrifugal, vacuum and hydraulic clutches, Fluid coupling; Gear Boxes: Sliding mesh, constant mesh, synchromesh and epicyclic gear boxes, automatic transmission system, overdrive, propeller shaft, universal joints, front wheel drive, differential, rear axle drives, rear axle types, two wheel and four-wheel drive.

6. Automotive Brakes, Tyres & Wheels
Classification of Brakes; Principle and constructional details of Drum Brakes, Disc Brakes; Brake actuating systems; Mechanical, Hydraulic, Pneumatic Brakes; Factors affecting Brake performance, Power & Power Assisted Brakes; Types of Wheels; Types of Tyre & their constructional details, Wheel Balancing.

LAB WORK:

- Performance test of single cylinder four-stroke SI engine
- Performance test of single cylinder four-stroke CI engine
- Performance test of multi cylinder four-stroke SI engine
- Performance test of multi cylinder four-stroke CI engine
- Performance test of CI engine with variable compression ratio
- Study of Maruti engine
- Study of fuel pump and injector of a four-stroke CI engine
- Study of spark ignition system of SI engine
- Study of gearbox and turbocharger
- Valve timing diagram of single cylinder four-stroke CI engine

Reference books:

1. Ganesan, V. "Internal Combustion Engines", Third Edition, Tata McGraw-Hill.
2. Rajput, R. K. "A Textbook of Internal Combustion Engines", Third Edition, Laxmi Publicatons.
3. Singh, K. "Automobile Engineering Volume 1", Twelth Edition, Standard Publishers.
4. Rajput, R. K. "A Textbook of Automobile Engineering", Second Edition, Laxmi Publications.
5. Heywood, J. B. "Internal Combustion Engine Fundamentals", Tata McGraw-Hill
6. Pulkrabek, W. "Engineering Fundamentals of Internal Combustion Engine", Prentice Hall India.
7. Crouse, W. H and Anglin, D. L. "Automotive Mechanics", Tata McGraw-Hill.

MED320: Machine Design (L: T: P-3:0:0)

1. Introduction of fundamental of design: Basic Procedure of Machine Design, Basic Requirements of Machine Elements, Selection of Manufacturing Method, Design Considerations of Castings, Design Considerations of Forgings, Design Considerations of Machined Parts, Design Considerations of Welded Assemblies, Design for Manufacture and Assembly (DFMA) etc.

2. Introduction to Machine Vibration: Free Vibration, Critical damping, Forced vibration, steady state amplitude, single degree of freedom system, energy method, resonance, system with more than one degree of freedom.

3. Designing for Brakes and Clutches: Clutches: Torque Transmitting Capacity, Multi-disk Clutches, Friction Materials, Cone Clutches, Energy Equation, Brakes: Energy Equations, Block Brake with Short Shoe, Block Brake with Long Shoe, Pivoted Block Brake with Long Shoe, Internal Expanding Brake, Band Brakes.

4. Design and analysis Bearings: Rolling Contact Bearings: Types of Rolling-contact Bearings, Principle of Self-aligning Bearing, Selection of Bearing-type, Static Load Carrying Capacity, Dynamic Load Carrying Capacity, Equivalent Bearing Load, Load-Life Relationship, Selection of Bearing Life, Load Factor Design for Cyclic Loads and Speeds, Sliding Contact Bearings: Basic Modes of Lubrication, Viscosity, Measurement of Viscosity Viscosity Index, Petroff's Equation, Viscous Flow through Rectangular Slot, Hydrostatic Step Bearing, Energy Losses in Hydrostatic Bearing, Reynold's Equation

5. Design and analysis of I C Engine parts: Internal Combustion Engine, Cylinder and Cylinder Liner, Bore and Length of Cylinder, Thickness of Cylinder Wall, Stresses in Cylinder Wall, Cylinder Head, Design of Studs for Cylinder Head, Piston, Piston Materials, Thickness of Piston Head, Piston Ribs and Cup, Piston Rings, Piston Barrel, Piston Skirt, Piston Pin, Connecting Rod, Buckling of Connecting Rod, Cross-section for Connecting Rod.

Reference Books:

1. Design of Machine Elements by V. B. Bhandari , Tata McGraw-Hill Education, 2010
2. Machine Design by P. C .Sharma and DK Agrawal.
3. Machine Design, Fundamental and Applications by P.C. Gope, PHI learning pvt. Ltd., 2012
4. Design Data Hand Book for Mechanical Engineers : In SI and Metric Units (English) 3rd Edition by K. Mahadevan.
5. Mechanical Engineering Design by J. E. Shigley, McGraw Hill, 1989
6. Advanced Machine Design by J. Harland Billings.
7. Machine Design: An Integrated Approach, 2/E by NORTON, Pearson Education India, 2000.
8. Engineering Design by Faupel, J.H., and Fisher, F.E.,Wiley- Interscience-1981.
9. Mechanical Analysis and Design by A.H. Burr, Elsevier. 1982

MED412: Mechatronics & Control System (L: T: P-2:1:1)

UNIT-I

Introduction to Mechatronic Systems: Key elements – Mechatronics Design process –Design Parameters – Traditional and Mechatronics designs – Advanced approaches in Mechatronics - Industrial design and ergonomics, safety.

UNIT-II

Mechatronic System Components: Common sensors/actuators: Stepper motor, servo motor, Pneumatic cylinder, Direction control valve, Proportional pressure regulator, encoders, limit switches, LVDT etc.

UNIT-III

Pneumatic Automation and Data Acquisition: Introduction to pneumatic circuit design: intuitive method, cascading method, Karnaugh-Veitch maps. Sizing of parts. Analog and digital signals. Means of acquisition.

UNIT-IV

Case Studies: Projects are assigned to students in batches of four. Each team shall receive a project kit and an objective. Creative freedom is given with respect to execution-bonus points going to out of the box thinking. The project will be divided into 4 sections that would be evaluated in 4 rounds of presentations held during class hour-5 minutes per presentation. Round 1-concept and overall picture, round 2-Kinematics and electronics, round 3-coding. The culminating presentation will be demonstration of the working model. Each round is given equal weightage. Marks awarded in each round is final, no marks shall be awarded to earlier rounds based on current progress.

Practicals: Lab sessions are designed to familiarize students with Industrial automation tools such as **PLC**, FLUIDSIM, Pneumatic automation (FESTO), Block diagram based programming upon National Instruments products. Emphasis will be given to virtual instrumentation. Elements of image processing will also be included.

Reference Books:

1. David Galciatore and Michael B Histand, "Introduction to mechatronics and measurement systems"

MED307: Finite Element Method (L: T: P-3:0:0)

1. Linear Finite Element (FE) procedures in Solid Mechanics: Governing equations (kinematics, constitutive law, equilibrium equations), Work concepts - Principle of minimum potential energy and principle of virtual work. Finite element formulation for linear elastic statics – 3D and 2D (plane stress, plane strain and axisymmetric) problems

2. Computation of element matrices and vectors: Shape function or interpolation function for rectangular and triangular element in 2D and Hexahedral and tetrahedral elements in 3D, convergence concepts, mapping of elements, numerical integration – Gauss Quadrature.

3. Generalization of FE concepts: Variational formulation, Euler-Lagrange differential equations; Constrained equations – Lagrange multipliers and Penalty method; Weighted residual methods

4. Application of FEM to Poisson's equation: Variational representation; FE formulation; Ex. steady state heat transfer, Ideal fluid flow, Torsion of shaft etc.

5. Solution of algebraic equations: Review of linear algebra; Gauss elimination and matrix factorization; III-conditioning problems

Reference Books:

1. Cook, R. D., Malkus, D. S., and Plesha, M.E., Concepts and Applications of Finite Element Analysis, 3rd Edition, John Wiley, 1989.
2. Bathe, K. J., Finite Element Procedures, Prentice Hall of India, 1982.
3. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vol. 1 (The Basis), Butterworth-Heinemann, 2000.
4. Krishnamoorthy, C. S., Finite Element Analysis (theory and programming), 2nd Edition, Tata

McGraw-Hill Education, 1995.
5. Young W. Known., The finite element method using matlab, 2nd Edition, CRC Press, 2000.
6. State of art in the field of FEA: Journal articles (review articles), proceedings and other publications.

MED324: Fundamentals of Hydrogen Fuel Cell Technology (L: T: P-3:0:0)

Chapter 1- Hydrogen as a Green Fuel
Hydrogen Economy, Hydrogen production, Electrochemistry of Water Splitting, Oxygen Evolution Reaction (OER), Hydrogen Evolution Reaction (HER), Concept of Overpotential, Water-splitting Technologies for Hydrogen Generation, Role of Electrocatalysts.

Chapter 2- Fuel Cell Principles
Introduction, Fuel Cell Types, Basic Fuel Cell Operation, Fuel Cell Performance, Characterization, Environment Aspects, Fuel Cell thermodynamics, Fuel Cell Efficiency, Thermodynamics of Reversible Fuel Cells

Chapter 3- Fuel Cell Reaction Kinetics
Electrode Kinetics, Concept of Activation Energy, Exchange Current Density, Galvani Potential, Butler-Volmer Equation, Catalyst-Electrode Design, Catalysis in Fuel Cells, Sabatier Principle

Chapter 4- Fuel Cell Charge and Mass Transport
Characteristics of Fuel Cell Transport Resistance, Review of Fuel Cell Electrolyte Classes, Diffusivity and Conductivity, Transport in Electrode versus Flow Structure, Diffusive Transport, Convective Transport

Chapter 5- Fuel Cell Characterization
What Do We Want to Characterize, Overview of Characterization Techniques, In Situ Electrochemical Characterization Techniques, Ex Situ Characterization Techniques

Chapter 6- Fuel Cell Technology
Overview of Fuel Cell Types, Phosphoric Acid Fuel Cell, Polymer Electrolyte Membrane Fuel Cell, Alkaline Fuel Cell, Molten Carbonate Fuel Cell, Solid-Oxide Fuel Cell, Other Fuel Cells Summary Comparison

Reference Books:
1. L. Zhang, H. Zhao, D.P. Wilkinson, X. Sun, J. Zhang, Electrochemical Water Electrolysis-Fundamentals and Technologies, CRC Press
2. R.O' Hayre, S.W. CHA, W.G. Colella, F.B. Prinz, Fuel Cell Fundamentals, Wiley

MED404: Adv. Comp. Programming & Numerical Techniques (L: T: P-3:0:0)

1. Practice Session on MATLAB/C. Curve fitting and Data handling in MATLAB/C.
2. Approximations and errors in computing.
3. Linear Equations and Non-linear Equations; finding roots of polynomial
4. Solving Linear Systems: Gauss Elimination, Gauss-Jordan; LU and QR Decomposition; Implementation in MATLAB/C.
5. Solving Linear System with iterative methods: Jacobi method, Gauss-Seidel Method; Implementation in MATLAB/C.
6. Numerical Integration: Trapezoid Rule, Simpson's Rule, Gaussian Quadrature; Implementation in MATLAB/C.
7. Ordinary Differential Equations: Runge-Kutta Method, Predictor-Corrector Method; Implementation in MATLAB/C.

Reference Books:

1. E. Balagurusamy, "Numerical Methods", McGraw Hill.
2. Steven C. Chapra and Raymond P.Canale, "Numerical Methods for Engineers", McGraw Hill Education.
3. V. Rajaraman, "Computer oriented numerical methods", PHI learning pvt ltd.
4. Laurene V. Fausett "Applied Numerical Analysis using MATLAB", Pearson.
5. Rudra Pratap "Getting Started with MATLAB: A Quick Introduction for Scientist and Engineers", Oxford University Press.

MED409: Mechanics of Composite Structures (L:T:P-3:0:0)

1. Introduction to Composites: Selection of materials for structural design, physical properties, design criteria (strength, stiffness and stability), derivation of performance indices for three design criteria, types of materials, definition of composite materials, special features of composites, application of composite materials, basic ingredients of composites (fiber and matrix), classification of composites, characteristics or properties of fiber and matrix and their classification.

2. Micromechanics of Composites: Individual constituent material properties, lamina properties: Rule of mixture, RVE or unit cell homogenization techniques

3. Macromechanics of Composites: Lamina: Assumptions in macromechanical modelling of composites, Uniaxial experiments to express 3-D compliance matrix coefficients in terms of engineering constants, 2-D plane stress stiffness matrix, stiffness matrix in principle material coordinate system and global coordinate systems, Invariant form of the lamina stiffness matrix, strength of lamina, failure envelope of lamina: Maximum stress criterion, and Tsai-Wu-Haun failure criterion,

4. Macromechanics of Composites: Laminate: Definition of laminate, properties of nth ply (lamina), laminate orientation code, laminate constitutive law in terms of lamina constitutive law. Invariant form of laminate constitutive law.

5. Classical Laminate Plate Theory (CLPT): Plate theories, Assumptions in the CLPT, solution of test cases using CLPT and validation for different loading and boundary conditions.

6. Computer program for composite laminate: Flow chart and algorithm for 2-D constitutive law of laminate, program to get the laminate constitutive law for a given input: ply material properties and orientation code

Reference Books:

1. Jones, R. M., Mechanics of Composite Materials, Technomic Publication.
2. Herakovich, C.T., Mechanics of Fibrous Composites, John Wiley & Sons, Inc. New York, 1998.
3. Gibson, R. F., Principles of Composite Material Mechanics, CRC Press, 2nd Edition, 2007.
4. Reddy, J. N., Mechanics of Laminated Composite Plates and Shells – Theory and Analysis, CRC Press, 2nd Edition, 2004.
5. Twardowski, T.E., Introduction to Nanocomposite Materials: Properties, Processing, Characterization, Destech Publications, 2007.
6. Stephen W. Tsai, Composites Design, Think composites, 4th Edition, 1988.
7. State of art in the field of composites: Journal articles (review articles), proceedings and other publications.

MED410: Computational Fluid Dynamics (L: T: P-3:0:0)

Unit-I Basics of fluid dynamics: Review of Fluid Flow Governing Equations-Differential and Integral forms. conservation of mass momentum energy. Introduction to CFD

Unit-II Finite Difference Method: Taylor Series, Higher order expressions, Truncation error, Discretization of 1D and 2D diffusion equation-steady and unsteady, Explicit and implicit formulation, Iterative linear system solvers- Gauss Jacobi and Gauss Siedel and Stability analysis-Von-Neumann analysis. Mathematical nature of PDEs and flow equations.

Unit-III Finite Volume Method: Introduction to Finite Volume method, 1-D steady diffusion equation, Handling boundary conditions, Convection Diffusion Equation, Properties of a discretization scheme, Convective schemes.
Staggered and collocated grid, SIMPLE algo for the solution of Navier Stokes Equation, Treatment of boundary conditions.

Reference Books:

1. Computational Fluid Mechanics and Heat Transfer, R H Pletcher, J C Tannehill and D A Anderson. CRC Press.
2. Computational Fluid Dynamics, T J Chung- Cambridge University Press.
3. An introduction to Computational fluid dynamics: The finite volume method, H Versteeg and W Malalasekera. Pearson.
4. Numerical Heat Transfer and Fluid Flow, S V Patankar. CRC Press.

MED415: Mechanical Vibrations (L: T: P-3:0:0)

UNIT–1: Introduction to ordinary differential equations (ODEs), linear algebra concepts and computational methods to solve ODEs such as Runge Kutta method and Euler technique. Concept of dynamic equilibrium explained through D'Alembert's principle. Explaining oscillatory problems using Kelvin-Voight model (spring-mass-dashpot arrangement).

UNIT–2: Introduction to single degree of freedom free and forced vibration problems. Deriving equations of motion using Rayleigh, Newtonian and Hamiltonian principles. Solutions to free un-damped, free damped oscillations, forced un-damped and forced damped oscillations. Concepts of resonance and real resonance. Introduction to transmissibility and base excitation.

UNIT–3: Interchangeability between time and frequency domains using Fourier analysis. Introduction to displacement, velocity and acceleration sensors. Applications of vibration based sensors in structural health monitoring. Brief idea of modal techniques and inverse problems.

UNIT–4: Overview of two-degree of freedom vibrating systems. Concepts of proportional damping and coupled equations of motion. Applications in vehicle vibration problems, aircraft flutter problems and harnessing useful energy from vibrating systems.

Reference Books:

1. Michael Groover, Mechanical Vibrations.
2. William Thomson et al. Theory of vibrations with applications.
3. Mario Paz, Structural Dynamics - Theory and Computation.
4. S.S. Rao. Mechanical Vibrations 5th Edition.
5. S. Adhikari. Damping Models for Structural Vibration.

MED313: Computer Integrated Manufacturing (L: T: P-3:0:0)

1. Introduction To FMS, RMS, CIM: Introduction to FMS, FMS equipment, tool management system, system layouts, reconfigurable machines and systems, CIM technology issues, CIM Models.

2. Material Handling, Storage & Data Collection: Functions, types, analysis of material handling equipment's. Design of conveyor and AGV systems, storage system performance, AS/RS, carousel storage system, WIP storage system, interfacing handling storage with manufacturing. Automatic data collection, bar code technology, Radio Frequency Identification.

3. Process Planning: Approaches to process planning, CAPP- variant approach and generative approach, study of a typical process planning, system.

4. ERP Modules: Materials, human resource, production, sales, marketing and finance, dynamic enterprise modeling.

5. NETWORKS: Computer networks, a perspective, goals, applications, switching techniques, circuit switching, message switching, packet switching, network components, existing network, ARPANET, concepts of network protocol, OSI reference model.

6. LAN & Access Techniques: Topologies - star, ring, bus. Ethernet, transmission media, protocols, polling, contention, ALOHA, CSMA, CSMA/CD, token ring protocols, performance comparisons.

7. Internetworking Devices: Principles, repeaters, bridges, routing with bridges, routers, gateways, hubs and switches, TCP/IP protocol structure, internet protocol, transmission protocol, applications.

8. Fundamentals of Networking: Networking concepts, LOSI, MAP, TOP, LAN and WAN, internet and related technologies, collaborative engineering.

9. CIM Case Studies: CIM implementation, integration, benefits of CIM.
Mini-project: Product/machine part is to be taken up and by teams comprising no more than 4 members, and they are to use the skills they learn in class to design, analyze and make them.

Reference Books:

1. Basandra S K and Jaiswal, "Local Area Networks", Galgotia Publications Pvt. Ltd, New Delhi, 2006.
2. Taylor E D, "Networking Handbook", Tata McGraw Hill Co. Ltd, New Delhi, 2004.
3. Rao P N, "CAD/CAM, Principles and Applications", Tata McGraw Hill Co. Ltd, New Delhi, 2004.
4. Tien-chien Chang and Richard A Wysk, "An Introduction to Automated Process Planning Systems", Prentice Hall Inc., Englewood Cliffs, New Jersey, 1985.
5. Radhakrishnan P and Subramanyan S, "CAD/CAM/CIM", New Age International Ltd, 2003.

MED318: Supply Chain Management (L: T: P-3:0:0)

1. Introduction to supply chain: Definition, complexity, key issues, centralized vs. decentralized systems, Electronic commerce, Types of Supply chain, supply chain strategies.

2. Facility layout and location: Qualitative aspects and models for layout decisions, Quantitative models for layout decisions (a) p-median location model, (b) location-allocation problem with and without dedicated facilities, (c) location and allocation problem in Multi stages supply chain.
Facility layout (a) Qualitative Model: ALDEP (b) Quantitative model: Quadratic Assignment problem, CRAFT, (C) Cellular layout: rank order clustering.

3. Probabilistic inventory management: Safety stock models (a) ROL computation based on costs and service level for discrete distribution (b) Safety stock model for normal distribution, (c) Continuous review-integrated model, (d) periodic review-integrated model, (e) Newsvendor problem.

4. Transportation and distribution network: Mathematical formulation for Transportation problems, Multistage Transportation Problem, Cross-docking, Transshipment problem, Fixed charge transportation problem, Truck allocation problem, Direct shipment/intermediate storage policies, Point to point transportation problem, Travelling salesman problem, Vehicle scheduling problem

5. Outsourcing: Make or buy decisions

6. Value of information and supply chain integration: Role of IT in supply chain, Bullwhip effect, Push-based, pull based systems, RFID.

7. Scheduling models and applications

Reference Books:
1. Supply Chain Management by Chopra and Meindl.
2. Quantitative Models in Operations and Supply Chain Management by G. Srinivasan.
3. Supply Chain Management by Janat Shah.
4. Operations Management by Evans and Collier.

MED308: Power Plant Engineering (L: T: P-3:0:0)

Unit-I Steam/Vapor Power Plants: Typical layout of steam power plant; steam power cycles; efficiencies in a steam power plant; fuels and combustion; steam generators; steam turbines; condenser, feed-water, and circulating water systems; disadvantages of steam; combined cycle power generation.

Unit-II Hydro-electric and Nuclear Power Plants: Advantages and disadvantages of hydel power; essential elements of a hydel power plant; classification of hydel power plants; types of turbines and their performance; scientific basis of nuclear power generation; types of reactors; safety issues of nuclear power plants.

Unit-III Diesel Engine and Gas Turbine Power Plants: Advantages and disadvantages of diesel engine power plant; types of diesel engine power plants; general layout of diesel engine power plants; performance characteristics of diesel engine power plants; components of a gas turbine power plant; fuels and materials of gas turbine.

Unit-IV Environmental and Economic Aspects of Power Plants: Environmental pollution due to power plants; greenhouse effect; acid rain; smog; nuclear radiation; load-duration curve; power plant economics; Indian energy scenario.

Reference Books:
1. P. K. Nag, Power Plant Engineering, McGraw Hill Education, 2015 (4th Reprint). ISBN (13): 978-93-3920-404-4
2. R. K. Rajput, Power Plant Engineering, Laxmi Publications, 2016 (5th Edition). ISBN (13): 978-81-3180-255-7.

MED403: Solar Energy (L: T: P-2:0:1)

Unit-1 Sun and Earth relationship
The Sun, Solar Radiation, Radiation Measurement, Sun-Earth Relationships, Empirical Equations for Predicting the Availability of Solar Radiation.

Unit-2 Solar collectors
Solar collector and working principle, Description of a Liquid flat plate collector, Absorber plates, Materials for flat plate collector, Energy balance, Performance Analysis of Liquid Flat Plate Collectors, Transmissivity, Collector efficiency factor.

Unit-3 Solar thermal energy storage
Introduction, Types of energy storage methods, Classification of PCMs, Organic phase change materials, Inorganic phase change materials, Solar water heating system, Solar air heating system, Solar cooker.

Unit-4 Applications of Solar thermal energy

Solar Water Heating System, Solar Cooker, Solar Refrigeration, Solar Power Plants, Solar Ponds.

Recommended Books:

1. Solar energy by H.P. Garg and J. Prakash
2. Solar energy by S.P. Sukhatme
3. Solar thermal engineering by P.J. Lunde
4. Solar energy by J.S. Hsieh
5. Solar thermal engineering systems by G.N. Tiwari and S. Suneja

MED413: Energy Conversion Tech and Energy Management (L: T: P-3:0:0)

Unit I: Energy sources and Environmental effects Various conventional and non-conventional energy resources – Introduction, availability, classification, relative merits and demerits; Electrical fundamentals.

Unit II: Solar energy and Wind energy conversion systems Solar photovoltaic; Solar thermal; Wind power fundamentals; Wind power systems; Wind turbine control.

Unit III: Biomass and Geothermal energy Availability of biomass and its conversion technologies; Resources of geothermal energy; Thermodynamics of geothermal energy conversion – electrical conversion, non-electrical conversion; Environmental considerations.

Unit IV: Magneto-Hydrodynamic (MHD), Thermoelectric and Thermionic generators Principle of working of MHD power plant; Performance and limitations of MHD generators; Principle of working of thermoelectric and thermionic generators; Performance and limitations of thermoelectric and thermionic generators.

Unit V: Wave energy harvesting, Ocean Thermal Energy Conversion (OTEC) Principle of working of wave energy harvesting; Performance and limitations of wave energy harvesting; Wave and tidal power harvesting; OTEC.

Unit VI: Fuel Cells Principle of working of various types of fuel cells and their performance and limitations.

Unit VII: Special Topics in Energy Harvesting Vibration energy harvesting (piezoelectric); Rain energy harvesting; Hydropower; Generator losses.

Unit VIII: Introduction to Energy Management and Energy Conservation Need for energy management; Complete cycle analysis of fossil fuels; Energy efficiency as the sixth fuel; Energy conservation in cogeneration and waste heat recovery, boiler systems, insulations, heating and cooling of buildings, lighting systems, electric motors, compressed air systems, home appliances and automobiles; Assessment of energy conservation measures – energy index, cost index; Energy quality – high grade energy versus low grade energy.

Unit IX: Energy Storage Mechanical – pumped hydro, compressed air, flywheel, gravitational; Thermal – sensible heat, latent heat, cryogenic; Chemical – power to gas/liquid, hydrogen, methane, biofuels/synthetic fuels; Electrical – capacitor, superconducting electro-magnet; Electrochemical – battery (rechargeable), flow battery, super-capacitor.

Unit X: Energy Economics Hydrogen-based economy, Energy in transportation; Economics of energy efficiency – Lifecycle Cost Analysis (LCA), time value of money, Benefit-Cost Ratio (BCR), payback period analysis; Energy matrix.

Reference Books:

1. David Buchla, Thomas Kissell and Thomas Floyd, “Renewable Energy Systems”, Pearson, 2015, ISBN: 978-0-13-262251-6.
2. Felix A Farret and M. Godoy Simoes, “Integration of Renewable Sources of Energy”, 2nd Edition Wiley, 2018, ISBN: 978-1-11-913737-5.
3. John Twideu and Tony Weir, “Renewal Energy Resources”, BSP Publications, 2006.
4. M. V. R. Koteswara Rao, “Energy Resources: Conventional & Non-Conventional “BSP Publications, 2006.
5. D. S. Chauhan, “Non-conventional Energy Resources”, New Age International.
6. C.S. Solanki, “Renewal Energy Technologies: A Practical Guide for Beginners” PHI Learning.
7. Peter Auer, “Advances in Energy System and Technology". Vol. 1 & II Edited by Academic Press.
8. AC 2011-488: AN UNDERGRADUATE COURSE ON RENEWABLE ENERGY CONVERSION SYSTEMS FOR ENGINEERING TECHNOLOGY STUDENTS, Radian G Belu, Drexel University (Tech.).
9. M. Kanoglu and Y. A. Cengel, Energy Efficiency and Management for Engineers, McGraw Hill Education (India) Reprint 2020. ISBN (13): 978-93-90385-50-8.

MED414: Surface Engineering (L:T:P-2:0:1)

1. Introduction: Definition, need and motivation, evolution of surface engineering, terminology, overview of different types of techniques used for surface engineering, advantages and limitations of surface engineering, few examples

2. Thick coatings development: Introduction, and working principal and process parameters of different thermal spraying techniques (flame spray, arc, plasma and detonation gun), coating building phenomenon, pre- and post-coating treatments. Introduction and working principal of cold spraying technique. Other thick coating deposition techniques- laser and microwave. Advantages and limitations. Characterization of coatings, evaluation of coating microstructure and physical properties, defect identification and its effect on derived properties, techniques used for determination of different mechanical properties, efficacy of different coating techniques in controlling degradation.

3. Thin film deposition techniques: Physical vapor deposition (PVD) processes: - Thermal and E-beam Evaporation, Ion-Treatment, Ion-Plating, Magnetron sputtering, Chemical vapor deposition (CVD), Plasma enhanced CVD, Atomic layer deposition, Pulsed laser deposition.

4. Structure of thin films and Applications: Different phases of thin film development: - Evaporation, Deposition- Adsorption, Diffusion and Nucleation, Structure development, Characterization of thin films- Microstructure, composition and properties. Performance of thin films in Tribology, Corrosion, Tribo-corrosion applications

5. Surface modification using severe plastic deformation: Overview of SPD processes, Application of SPD processes in surface engineering, and Structure-property relation in SPD modified surfaces.

6. **Micro-nano fabrication for surface engineering:** Micro-nano machining, photolithography, dry and wet etching techniques, deep reactive ion etching, non-conventional lithography techniques, capillary force lithography, optical soft lithography, micro/nano imprinting.

List of Experiments

1. To investigate the effect of severe surface deformation on the microstructural evolution and mechanical properties
2. To evaluate the influence of surface modification on degradation behavior of structural materials.
3. To demonstrate energy storage in surface activated materials
4. To demonstrate the effect of micro/nano texturing on the corrosion behavior of materials
5. To demonstrate the effect of micro/nano texturing on electrochemical energy storage
6. Development of polymer thin films using chemical vapour deposition system for controlling corrosion and hydrophobicity
7. To evaluate the microstructure and mechanical properties of the thermal spray coating
8. Microwave assisted processing for modulating the surface properties for wear and corrosion protection

Reference Books:

1. Lech Pawlowski: The Science and Engineering of Thermal Spray Coatings, John Wiley & Sons (2008)
2. Anatolii Papyrin: Cold spray technology, McGraw hill Education
3. A. W. Batchelor, Loh Nee Lam, Margam Chandrasekaran: Materials Degradation and its Control by Surface Engineering, Imperial College Press, (2011)
4. Ramnarayan Chattopadhyay, Advanced thermally assisted surface engineering processes, Kluwer Academic Publishers (2004)
5. J.R. Davis, Surface engineering for corrosion and wear resistance, ASM International (2001)

MED326: Industrial automation (L:T:P-2:0:1)

UNIT I INTRODUCTION TO Flexible Manufacturing System

Introduction to Flexible Manufacturing System (FMS), FMS Part selection problem, FMS Loading problem: Multiple batches and changeover time, FMS Scheduling Problem.

UNIT II Instrumentation and robotics

Reconfigurable Manufacturing Systems (RMS), Basics of instrumentation, Analog and digital signals, PLC programming-ladder logic and structured text, Sensors and actuators, Motor control theory, Applications of robotics, Robot/Cobot-ISO standards and safety regulations, ROS. Automated testing and inspection.

UNIT III Modular production stations and robot centred cell

Modular Production Stations(MPS), Programming Individual MPS, Integration of MPS stations into FMS/RMS, Introduction to robot Pick and place, building robot centered cell.

UNIT IV Introduction to ML

Supervised/ Unsupervised Learning, Introduction to the concepts of Classification, Regression and Clustering, Perceptron for Classification and Multi Layered Perceptron.

Practicals: Lab sessions are designed to familiarize students with Industrial automation tools such as **PLC**, MPS, FMS and COBOT programming.

Reference Books:

Modern robotics: mechanics, planning, and control by Kevin M. Lynch and Frank Chongwoo Park

MED416: Robotics (L: T: P-2:0:1)

UNIT I Kinematics and control
Forward kinematics: Theory, Simulation and practice, Inverse kinematics: Theory, Simulation and practice, Dynamics, Control engineering practice, Trajectory planning: Collision detection/avoidance of a variety of robots, Path planning of mobile robots, SLAM, and sensor fusion. Machine learning applied to robotics.

UNIT II Computer vision
Convolutional Neural Net (CNN), RNN and Generative Models, Introduction to Computer Vision (CV), CV using CNNs.

UNIT III Motion and locomotion of bioinspired robots
Locomotion of bio-inspired robots: quadruped and biped. Reinforcement learning and evolutionary algorithms applied to biomimetic robot locomotion. Visual servoing using cobot.

UNIT IV Build a robot
Build a robot using given kit. ROS is used to control it. The kit will have a SoC computer, camera, and a collection of sensors and actuators chosen as per the prevailing theme. The theme though varying with every semester, will always involve Computer vision and ML to plot trajectory autonomously for the robot to accomplish a task.

Practicals: Lab sessions are designed to familiarize individual sensors and actuators that come with the project kit as well as to give students the skills needed to write control algorithm.

Reference Books:
Modern robotics: mechanics, planning, and control by Kevin M. Lynch and Frank Chongwoo Park

MED417: Soft Robotics (L: T: P-2:0:1)

UNIT I Introduction
Introduction: soft vs rigid robots, need and applications of soft robots, advantages and limitations, role of biomimetic and bioinspiration, examples of different plant and animal inspired soft robots

UNIT II Materials and actuation
Elastomers, shape memory alloys, hydrogels, fluid based materials, auxetic materials, Fabrics for soft robots, wearable robots, Air powered robots and pneumatic artificial muscles, fibre-wrapped actuators, particle jamming and stiffness change, grippers.

UNIT III Fabrication
Fabrication of soft robots: 3D printing routes such as Stereolithography, fused deposition Modelling, Inkjet printing, Direct ink writing, Continuous liquid interface production, molding processes based on gravity, centrifugal and vacuum, spin and dip casting, vacuum infusion, soft lithography techniques

UNIT IV Introduction to robot instrumentation and control

Introduction to robot instrumentation and control, Integration of Robotic System and Control, Soft sensors for strain, force, contact; embedding sensors in soft systems, Soft robot's dynamics form the control point of view, Mathematical Modelling, Stabilization of unstable equilibria, Optimal Control of Articulated Soft Robots, Controlling Soft Robots: Control in task space, Estimation of the Robot's stiffness, Application of MATLAB in Automatic Control

Reference Books:

1. Stanford University, Mechanical Engineering https://web.stanford.edu/class/me23n/
2. Northwestern University, Mechanical Engineering, https://www.mccormick.northwestern.edu/mechanical/academics/courses/descriptions/495-topics-in-soft-robotics.html
3. Hideko Koshima, Mechanically Responsive Materials for Soft Robotics, Wiley, ISBN: 9783527346202
4. Alexander Verl, Alin Albu-Schäffer, Annika Raatz, Oliver Brock, Soft Robotics: Transferring Theory to Application, Springer Berlin Heidelberg, ISBN: 9783662445068
5. Gareth J. Monkman, Soft Robotics, Bentham Science, ISBN: 9789815051735
6. Jaeyoun Kim, Microscale Soft Robotics, Springer International Publishing, ISBN: 9783319502861