Semester IV

Theory of Machines

1.1 Course Number:ME211
1.2 Contact Hours: 3-1-0 Credits: 11
1.3 Semester-offered: 2nd Year - Even
1.4 Prerequisite: Diploma level Mathematics
1.5 Syllabus Committee Members: Dr. Abhimanyu Kar, Dr. Sanat Kumar Singha, Dr. Naveen Mani Tripathi, and Dr. Karthik Babu NB

2. Objective:

i) To study analytical and graphical methods for understanding kinematics of mechanisms.
ii) To understand dynamics of various machine elements.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Terminology, Mechanisms and Inversions**	1.1 Introduction: Mechanisms and machines, applications, study of mechanisms, kinematics and kinetics, kinematic link or element, types of links, kinematic pairs, degrees of freedom, types of constrained motions, classification of kinematic pairs, chains, kinematic chain, unconstrained chain, locked chain, linkage, mechanism, structure. Mobility of planar mechanisms with lower and higher pairs, Kutzbach criterion, types of joints, Gruebler's criterion, determination of mobility using methods of joints and loops. 1.2 Kinematic Chains and Inversions: Inversions of four-link chain, single slider-crank chain and double slider-crank chain, Grashof's law. 1.3 Mechanisms with Lower Pairs: Quick return motion mechanisms, straight line motion, intermittent Motion mechanisms, toggle mechanism, pantograph, Ackerman steering gear mechanism.	8
2	**Velocity and Acceleration Analyses of Mechanisms**	2.1 Graphical Methods: Velocity analyses of four-link mechanisms by relative velocity method. Instantaneous centre, Aronhold Kennedy theorem, determination of linear and angular velocity using instantaneous center method. 2.2 Analytical Methods: Analysis of slider-crank chain using analytical expressions.	12

3	**Cams, Gears and Gear Trains**	3.1 Cams: Introduction, types of cams, types of followers, terminology, advantages and disadvantages. 3.2 Gears: Introduction and classification of gears, gear terminology, law of gearing, characteristics of involute action, interference in involute gears, methods of avoiding interference, back lash, comparison of involute and cycloidal teeth. 3.3 Gear Trains: Simple gear trains. Compound gear trains for large speed reduction. Planetary or epicyclic gear trains, algebraic and tabular methods of finding velocity ratio of epicyclic gear trains.	6
4	**Static & Dynamic Force Analyses and Balancing**	4.1 Static Force Analysis: Constraint and a0pplied forces, static equilibrium, force convention, free-body diagrams, two- and three-force members, members with two forces and a torque, four-force members. 4.2 Dynamic Force Analysis: D'Alembert's principle, equivalent offset inertia force, dynamic analyses of four-link mechanisms and slider-crank mechanisms. 4.3 Balancing: Static and dynamic balancing, balancing of reciprocating masses.	10
5	**Flywheels, Governors and Gyroscopes**	5.1 Flywheels: Turning-moment diagrams, fluctuations of energy, dimensions of flywheel rims. 5.2 Governors: Difference between a flywheel and a governor, types of governors, sensitiveness, hunting, isochronism, stability, controlling force of a governor. 5.3 Gyroscopes: Angular velocity and acceleration, gyroscopic torque or couple.	6
Total			**42**

4. Readings

i) S. S. Rattan, Theory of Machines, 4th Ed, Tata McGraw Hill, 2014.
ii) R. S. Khurmi and J. K. Gupta, Theory of Machines, 14th Ed, S. Chand, 2020.
iii) J. J. Uicker (Jr.), G. R. Pennock and J. E. Shigley, Theory of Machines and Mechanisms, 3rd Ed, Oxford International Student Edition, 2010.

5. Outcome of the Course:

1) Understand kinematic links, pairs, chains, mechanisms, structures and super-structures.
2) Calculate mobility of a kinematic chain.
3) Study graphical and analytical methods for kinematics of four-link and slider-crank mechanisms.
4) Understand kinematics of cams, gears and gear trains.

5) Study static and dynamic force analyses of four-link and slider-crank mechanisms.
6) Knowledge of balancing of reciprocating masses.
7) Understand dynamics of flywheels, governors and gyroscopes.

Heat and Mass Transfer

1.1 Course Number- ME212
1.2 Contact Hours- 3-1-0 Credits: 11
1.3 Semester Offered- 2nd Year Even
1.4 Prerequisite: Diploma level Mathematics
1.5 Syllabus Committee members- Dr. Abhimanyu Kar, Dr. Sanat Kumar Singha, Dr Naveen Mani Tripathi, Dr. Karthik Babu NB

2. Objective:

i) To understand modes of heat transfer, *i.e.* conduction, convection and radiation.
ii) To study diffusion mass transfer.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Introduction**	Modes of heat transfer, Relationship to thermodynamics, Analyses of heat transfer problems	4
2	**Thermal Conduction**	The thermal conductivity of solids, Liquids and gases, Factors influencing conductivity measurement. The general differential equation of conduction, One dimensional steady state conduction, Linear heat flow through a plane and composite wall.	10
3	**Forced and Natural Convection**	Physical Mechanism of Forced Convection, Dimensional analysis for forced convection, velocity and Thermal Boundary layer, Flow over plates, Flow in tubes, Reynolds's analogy, Physical Mechanism of Natural Convection Empirical relationship for natural convection.	10
4	**Thermal Radiation**	Introduction, absorption and reflection of radiant energy, Emission, Radiosity and irradiation, Black and non-black bodies, Kirchhoff's law, intensity of radiation, Radiation exchange between black surface, Geometric Configuration factors. Grey body relation exchange between surface of unit configuration factors, Electrical analogy to simple problems.	10
5	**Heat Exchangers**	Types of Heat Exchangers and their construction details, Parallel flow heat exchangers, Counter flow heat exchangers	4

6	**Diffusion Mass Transfer**	Basic concepts, Diffusion mass transfer, Fick's law of diffusion, Steady state molecular diffusion.	4
Total			**42**

4. Readings

4.1 Reference Books:

1. Bergman, Theodore L., Theodore L. Bergman, Frank P. Incropera, David P. Dewitt, and Adrienne S. Lavine. Fundamentals of heat and mass transfer. John Wiley & Sons, 2011.
2. J.P. Holman, Heat Transfer, 10th Ed., Tata McGraw Hill, 2011.
3. Yunus A. Cengel, Heat Transfer – A Practical Approach, 2nd Ed., McGrawHill, 2002.

5. Outcome of the Course:

1) Define heat flux and heat flow rate.
2) Understand Fourier's law, Newton's law and Stefan-Boltzmann law in the context of heat transfer.
3) Derive heat diffusion equation.
4) Study one dimensional heat conduction problems and lumped parameter analysis.
5) Understand heat transfer from extended surfaces.
6) Define Nusselt number, Prandtl number, Reynolds number and Grashof number.
7) Evaluate convective heat transfer based empirical correlations.
8) Understand Fick's law of diffusion mass transfer.

Applied Thermodynamics

1.1 Course Number- ME213
1.2 Contact Hours- 3-1-0 Credits: 11
1.3 Semester Offered- 2nd Year Even
1.4 Prerequisite: NA
1.5 Syllabus Committee members- Dr. Abhimanyu Kar, Dr. Sanat Kumar Singha, Dr Naveen Mani Tripathi, Dr. Karthik Babu NB

2. Objective:

i) Understand power producing cycles and refrigeration cycles with vapor and air as fluids.
ii) Understand different processes in IC Engines, calculate BP, IP, FP and prepare Heat Balance Sheet.
iii) Understand different laws governing gases and their mixtures.
iv) Understand steam boilers and their performance.
v) Understand steam turbines and their performance, Understand compressors and condensers and their performance.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Properties of Pure Substances**	P-V, P-T, T-S, H-S diagram for steam, different types of steam, Introduction to steam tables with tables with respect to specific volume, pressure, temperature, enthalpy and entropy.	8
2	**Steam Power Cycles**	Properties and processes of ideal vapour, Qualities of steam, Simple steam power cycle, Rankine Cycle, Actual Vapour Cycle, Actual Vapour Cycle Processes, Reheat cycle, ideal and Practical Regenerative Cycles, Characteristics of an ideal Working Fluid in Vapour Power Cycles, Binary Vapour Cycles.	8
3	**I.C. Engines**	Air Standard Assumptions, Otto Cycle, Diesel Cycle, Dual Cycle, Practical Gas Power Cycles	8
4	**Gas Turbines**	Brayton cycle, components of a gas turbine power plant, Co-generation cycle.	8
5	**Refrigeration and Airconditioning**	Types Refrigeration cycles, Reverse Carnot cycle, Vapour Compression Refrigeration cycle, Vapour Absorption Refrigeration cycle, Relative Humidity, Specific Humidity, Wet and dry bulb temperature.	8
Total			**40**

4. Readings

4.1 Textbooks:

1. P.K. Nag, Engineering Thermodynamics, TMH Publishers
2. J. Selwin Rajadurai, Thermodynamics & Thermal Engineering, New Age International Publishers

4.2 Reference Books:

1. C.P. Arora, Thermodynamics, TMH Pub.
2. D.S. Kumar, Thermal Science & Engineering, S.K. Kataria & Sons
3. S.C. Gupta, Thermodynamics, Pearson Education
4. Cengal & Boles, Thermodynamics- An Engineering Approach, Mc Graw Hill
5. K. Ramakrishna, Engineering Thermodynamics, Anuradha Agencies

5. Outcome of the Course:

1) Understanding thermodynamics and its applications.
2) Understand the applications of thermodynamics is systems.
3) Understanding of Turbine, IC engines and latest automobile technologies.
4) Understand the Applied Mechanics, Refrigeration and Air conditioning.

Design of Machine Elements

1.1 Course Number- ME215
1.2 Contact Hours- 3-1-0 Credits: 11
1.3 Semester Offered- 2nd Year Even
1.4 Prerequisite: NA
1.5 Syllabus Committee members- Dr. Abhimanyu Kar, Dr. Sanat Kumar Singha, Dr Naveen Mani Tripathi, Dr. Karthik Babu NB

2. Objective:

1. Enable students to attain the basic knowledge required to understand, analyze, design and select machine elements required in transmission systems.
2. Impart design skills on static load and variable load problems.
3. Understand the working and function of each machine element and their uses in machinery.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Design against static & variable loads**	Selection of Materials, Design Stress, Factor of Safety, Stress concentration factor in tension, bending and torsion, Theories of failures. Notch sensitivity, Design for variable and repeated loadings, Fatigue stress concentration factor, Endurance diagrams, Introduction to fracture mechanics.	9
2	**Basic Elements Design**	Types of keys and Splines, Design of Socket-Spigot, Cotter joint, Sleeve and Cotter joint, Gib and Cotter joint, Design of Knuckle joint, Design of Splines. **Couplings:** Types of couplings, Design of flange and flexible couplings, Compression coupling, Muff coupling. **Shaft and Axles:** Transmission shaft, Design against static load, Design for strength, Rigidity and stiffness, Design under continuous loading for fatigue.	9
3	**Threaded fasteners**	Geometry of thread forms, Terminology of screw threads and thread standards, Specifications of steel bolts, Initial tension, Relation between bolt tension and torque, **Power Screws:** Power screws, Collar friction, Stresses in screw, Coefficient of friction, Efficiency of thread.	9
4	**Riveted & Welded Joints**	Types of rivet heads, Types of riveted joints, Failure of riveted joint, Strength of rivet joint, Efficiency of riveted joint, Design of riveted joint, eccentrically loaded riveted joint. Types of welded joints, Stresses in butt and fillet welds, Strength of welded joints, Location and dimension of weld design, eccentrically loaded joint, welded joint subjected to bending moment, Design procedure, Fillet welds under	9

		varying loads, Stress relieving techniques.	
5	**Pulley & Flywheel**	Flywheel Inertia, Stresses in Flywheel and pulleys, failure criterion. **Chain Drives:** Chain drives, Roller chains, Geometric relationships, Dimensions of chain components, Polygonal effect, Power rating of roller chains, Selection of Chain drives. **Belt & Rope Drive:** Design of Flat and Round belt drives, V-Belt, Timing belt, Wire Rope.	9
Total			**45**

4. Readings

4.1 Textbooks:

1. V.B. Bhandari,Design of Machine Elements, McGraw HILL Publications. 3rd edition,
2. K. Mahadevan / K.Balveera Reddy, Design Data Handbook for mechanical engineers, CBS publication, 4th Ed.,2013
3. Design of Machine Elements by V.B. Bhandari, McGraw HILL Publications. 3rdedition

4.2 Reference Books:

1. M.F Spotts, T.E Shoup, L.E. Hornberger, S.R Jayram and C V Venkatesh, Design of Machine Elements, 8th Ed., Person Education.
2. V. B. Bhandari, Design of Machine Elements, 2nd Ed., Tata Mcgraw Hill.
3. R. C. Juvinall and K. M Marshek, Fundamentals of Machine Component Design, 3rd Ed., Wiley Student Edition

5. Outcome of the Course:

1) Apply the knowledge of Indian Standard codes and engineering fundamentals of material selection and manufacturing considerations in design.
2) Design various members such as beams, levers, laminated springs for bending and stiffness.
3) Design various machine components under torsion such as shafts, shaft couplings, and keys.
4) Design various threaded fasteners, power screws and curved machine components.

Manufacturing Technology-II

1.1 Course Number- ME214
1.2 Contact Hours- 3-1-0 Credits: 11
1.3 Semester Offered- 2nd Year Even
1.4 Prerequisite: NA
1.5 Syllabus Committee members- Dr. Abhimanyu Kar, Dr. Sanat Kumar Singha, Dr Naveen Mani Tripathi, Dr. Karthik Babu NB

2. Objective:

i) Understand the importance, types, and important parameters in machining processes.
Study various types of cutting machines and mechanisms used to achieve cutting motion.
Learn about versatile machining processes, nomenclatures, tools motion and their applications (including milling, abrasive process, broaching)
ii) Learn basic CNC programming and usefulness in automation.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Theory of Metal Cutting**	Mechanics of chip formation, single point cutting tool, forces in machining, Types of chip, cutting tools– nomenclature, orthogonal metal cutting, thermal aspects, cutting tool materials, tool wear, tool life, surface finish, cutting fluids and Machinability.	8
2	**Turning Machines**	Centre lathe, constructional features, specification, operations – taper turning methods, thread cutting methods, special attachments, machining time and power estimation. Capstan and turret lathes- tool layout – automatic lathes: semi automatic – single spindle : Swiss type, automatic screw type – multi spindle:	8
3	**Shaper, Milling and Gear Cutting Machines**	Shaper – Types of operations. Drilling, reaming, boring, Tapping. Milling operations-types of milling cutter. Gear cutting – forming and generation principle and construction of gear milling, hobbing and gear shaping processes –finishing of gears.	7
4	**Abrasive Process and Broaching**	Abrasive processes: grinding wheel – specifications and selection, types of grinding process–cylindrical grinding, surface grinding, centreless grinding and internal grinding- Typical applications– concepts of surface integrity, broaching machines: broach construction – push, pull, surface and continuous broaching machines.	8
5	**CNC Machining**	Numerical Control (NC) machine tools – CNC types, constructional details, special features, machining centre, part programming fundamentals CNC –manual	7

		part programming –micromachining – wafer machining.	
Total			**38**

4. Readings

4.1 Textbooks:

1. Hajra Choudhury, "Elements of Workshop Technology", Vol.II., Media Promoters 2014
2. Rao. P.N “Manufacturing Technology - Metal Cutting and Machine Tools", 3rd Edition, Tata McGraw-Hill, New Delhi, 2013.

4.2 Reference Books:

1. Richerd R Kibbe, John E. Neely, Roland O. Merges and Warren J.White “Machine Tool Practices”, Prentice Hall of India, 1998
2. Geofrey Boothroyd, "Fundamentals of Metal Machining and Machine Tools", Mc Graw Hill, 1984
3. HMT, "Production Technology", Tata McGraw Hill, 1998.
4. Roy. A.Lindberg, “Process and Materials of Manufacture,” Fourth Edition, PHI/Pearson Education 2006.

5. Outcome of the Course:

1) Describe the geometry of single-point tools, the idea of oblique and orthogonal cutting, and the heat effects of metal cutting.
2) Adapt Taylor's tool life concepts and the Merchant narrow shear plane model of metal cutting to the particular issue at hand.
3) Calculate the machining time for turning, shaping, and milling operations and describe the constructional details, operating principles, and operations carried out on ordinary and special purpose machine tools.
4) Describe the various grinding techniques as well as the honing, lapping, and superfinishing procedures.
5) Explain the principles at work in the various high-velocity forming techniques.

Mechatronics and Industrial Automation

1.1 Course Number- ME216
1.2 Contact Hours- 3-0-0 Credits: 9
1.3 Semester Offered- 2nd Year Even
1.4 Prerequisite: NA
1.5 Syllabus Committee members- Dr. Abhimanyu Kar, Dr. Sanat Kumar Singha, Dr Naveen Mani Tripathi, Dr. Karthik Babu NB

2. Objective:

i) Recognize essential Mechatronics system components and depict them in the block diagram
ii) Comprehend the idea of the transmission elements, sensors, and actuators.
iii) Have knowledge of mechanical applications for electronic gadgets.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Introduction**	Definition of Mechatronics, Multi-disciplinary scenario, origins. Evaluation of Mechatronics, an overview of mechatronics. Design of mechatronics system. Measurement system and function of main elements of measurement systems. Need for mechatronics in industries. Objectives, advantages and disadvantages of mechatronics. Microprocessor based controllers. Principle of working of automatic camera, engine management system, automatic washing machine. **Review Of Transducers and Sensors:** Definition and classification of transducers. Definition and classification of sensors. Principle of working and applications of light sensors, proximity sensors and Hall effect sensors.	8
2	**Elements of CNC Machines**	Structure, guide ways – Friction, Autifriction and Frictionless guide ways, Merits and demerits. Drives – Recirculating ball screw and nut. Advantages and disadvantages over conventional screw and nut. Concept of stick-slip phenomenon, Concept of preloading of ball nuts.Roller screw- planetary roller screw recirculation roller screw. Spindle and spindle bearings in machine tool. Various types of loads encountered by spindle and spindle bearing. Types of bearings – friction, antifriction and frictionless bearing. Merits and demerits of each. Selection of spindle and spindle bearing, preloading of bearings, different method of preloading in detail.	8
3	**Electrical Actuators**	Actuator and actuator system. Classifications of actuator system with examples. Mechanical switches, Concept of bouncing Methods of Preventing bouncing of mechanical	7

		switches. Solenoids, Relays. Solid state switches – Diodes, Thyristors, Triacs, Transistors, Darlington pair. Electrical actuator. Principle, construction and working of AC, DC motors, stepper motors, permanent magnet motors, servomotors, Servo systems and control.	
4	**Hydraulic Actuators**	Valves, Classification, Pressure Control valves-Pressure relief valves, Pressure regulating/reducing valves, Pressure sequence valve. Flow control valves – principle, needle valve, globe valve. Direction control valve-sliding spool valve, solenoid operated. Symbols of hydraulic elements. Hydraulic cylinders – constructional features, classification and applications. Hydraulic motors – Types, vane motors and piston	7
5	**Signal Conditioning**	Concept, necessity, op-amps, protection, filtering, wheat stone bridge digital signals- Multiplexer. Data acquisition-Introduction to digital signal processing-Concepts and different methods.	6
Total			**36**

4.Readings

4.1 Textbooks:

1.W. Bolton, Longman, Mechatronics, 2Ed, Pearson Publications.
2. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi

4.3 Reference Books:

1. G.W. Kurtz, J.K. Schueller, P.W. Claar. II, Machine design for mobile and industrial applications, SAE.
2. T.O. Boucher, Computer automation in manufacturing - an Introduction, Chappman and Hall.
3. Mechatronics, Intl. J. published by Pergamon Press

5. Outcome of the Course:

1) Students able to implement automation in simple mechanical processes.
2) Students able to clarify the function of transducers, actuators, and electrical motors.
3) Students able to construct fluid power circuits for various processes.

Workshop Technology Laboratory

1.1 Course Number- ME218L
1.2 Contact Hours- 0-0-3 Credits: 3
1.3 Semester Offered- 2nd Year Even
1.4 Prerequisite: NA
1.5 Syllabus Committee members- Dr. Abhimanyu Kar, Dr. Sanat Kumar Singha, Dr Naveen Mani Tripathi, Dr. Karthik Babu NB

2. Objective:

i) To get acquainted with various carpentry and machine tools
ii) To learn hands-on manufacturing of wood turning items
iii) To learn to use milling, shaping, drilling, grinding machines and motorized hacksaw

3. Course Content:

Unit-wise distribution of content and number of Lab Sessions

Unit	Topics	Experiments	Lab Sessions
1	**Carpentry Shop**	Introduction and practice of Wood Turning Lathe operation along with a job preparation.	2
		Introduction and practice of wood Surface Planner operation along with a job preparation.	1
		Introduction and practice of wood sawing operations (circular & jig saw) along with a job preparation.	1
		Introduction and practice of wood grinding operation along with a job preparation.	1
		Introduction and practice of wood Disc Sander operation along with a job preparation.	1
		Study of different carpentry tools	1
2	**Machine Shop**	Introduction and practice of Shaper machining operation along with a job preparation.	1
		Introduction and practice of milling machining operation along with a job preparation	1
		Introduction and practice of drilling machining operation along with a job preparation	1
		Introduction and practice of grinding machining operation along with a job	1

		preparation	
		Introduction and practice of motorized hacksaw machining operation	1
Total			**12**

4. Readings

4.1 Textbooks:

1. P.N. Rao, Manufacturing Technology (Vol. - I & II), Tata McGraw Hill Pub. Company, New Delhi
2. P.C. Sharma, A Text Book of Production Technology (Manufacturing Processes & Technology), S. Chand and Company Ltd., New Delhi.

4.2 Reference Books:

1. Serope Kalpakjian & Schmid, Manufacturing Engineering and Technology, Pearson Education, Delhi.
2. Kibbe Richard R – PHI, Machine Tool Practices, New Delhi.

5. Outcome of the Course:

1) To be able to identify the common carpenter's tools
2) To be able to fabricate a workpiece using any of the following machines: milling machine, twist drill, grinding wheel and motorized hacksaw