SYLLABUS OF
UNDERGRADUATE DEGREE COURSE

Mechatronics

Effective for the students admitted in year 2021-22 and onwards.

B.Tech.: Mechatronics
2nd Year - III Semester

f THEORY										
SN	Category	Course Code	Course Title	Hours			Marks			Credit
				L	T	P	IA	ETE	Total	
1	DC	3MX4-01	Engineering Thermodynamics	3	1	0	30	70	**100**	**4**
2		3MX4-02	Digital System Design	3	0	0	30	70	**100**	**3**
3		3MX4-03	Manufacturing Processes	3	0	0	30	70	**100**	**3**
4		3MX4-04	Materials Engineering and Technology	3	0	0	30	70	**100**	**3**
5		3MX4-05	Elements of Electronics	3	0	0	30	70	**100**	**3**
6	UC	3MX2-01	Engineering Mechanics	2	1	0	30	70	**100**	**3**
			Sub Total	**17**	**2**	**0**	**180**	**420**	**600**	**19**
PRACTICAL & SESSIONAL										
7	DC	3MX4-20	Machine Drawing Practice	0	0	2	60	40	**100**	**1**
8		3MX4-21	Production Practice Lab	0	0	2	60	40	**100**	**1**
9		3MX4-22	Electronic Devices and Circuits Lab	0	0	2	60	40	**100**	**1**
10		3MX4-23	Digital System Design Lab	0	0	2	60	40	**100**	**1**
11	UI	3MX7-30	Professional Training	0	0	2*	60	40	**100**	**1**
12	CCA	3MX8-00	SODECA/NCC/NSS/ ANANDAM/IPR	0	0	-	-	100	**100**	**1**
			Sub- Total	**0**	**0**	**10**	**300**	**300**	**600**	**6**
			TOTAL OF III SEMESTER	**17**	**2**	**10**	**480**	**720**	**1200**	**25**

L = Lecture, **T** = Tutorial, **P** = Practical, **IA**=Internal Assessment, **ETE**=End Term Exam, **Cr**=Credits

***for calculation of contact hours**

B.Tech. : Mechatronics
2nd Year - IV Semester

THEORY										
SN	Category	Course Code	Course Title	Hours			Marks			Credit
				L	T	P	IA	ETE	Total	
1	DC	4MX4-01	Mechanics of Solids	3	1	0	30	70	**100**	**4**
2		4MX4-02	Fluid Mechanics	3	1	0	30	70	**100**	**4**
3		4MX4-03	Analog Electronics	3	0	0	30	70	**100**	**3**
4		4MX4-04	Sensors and Instrumentation	3	0	0	30	70	**100**	**3**
5		4MX4-05	Internal Combustion Engines and Hybrid Controls	3	0	0	30	70	**100**	**3**
6	UC	4MX2-01	Advanced Engineering Mathematics	2	1	0	30	70	**100**	**3**
			Sub Total	**17**	**3**	**0**	**180**	**420**	**600**	**20**
PRACTICAL & SESSIONAL										
7	DC	4MX4-20	Materials Testing Lab	0	0	2	60	40	**100**	**1**
8		4MX4-21	Fluid Mechanics Lab	0	0	2	60	40	**100**	**1**
9		4MX4-22	Sensors and Instrumentation Lab	0	0	2	60	40	**100**	**1**
10		4MX4-23	Analog Electronics Lab	0	0	2	60	40	**100**	**1**
11	CCA	4MX8-00	SODECA/NCC/NSS/ ANANDAM/IPR	-	-	-	-	100	**100**	**1**
			Sub- Total	**0**	**0**	**8**	**240**	**260**	**500**	**5**
			TOTAL OF IV SEMESTER	**17**	**3**	**8**	**420**	**680**	**1100**	**25**

L = Lecture, **T** = Tutorial, **P** = Practical, **IA**=Internal Assessment, **ETE**=End Term Exam, **Cr**=Credits

*****for calculation of contact hours

3MX4-01: Engineering Thermodynamics

(Common for ME and MX)

Credit: 4Max **Marks: 100(IA: 30, ETE: 70)**

3L+1T+0P **End Term Exam: 3 Hours**

Course Objectives

To disseminate the basic concepts of thermodynamics and the working devices operating on the principles of thermodynamics.

Course Outcomes

Student will be able to

1. CO1: Students will be able to understand the basic concepts/laws of thermodynamic substances, processes and systems as a whole.
2. CO-2: Students will be able to establish the relation between thermodynamic properties and to identify the models to estimate the thermodynamic properties of working substances in closed system and open system.
3. CO-3: Students will be able to evaluate thermodynamic performances of different power cycles and other thermal systems.

S. No	Contents	Hours
1	**Basic Concepts and definitions of Thermodynamics**: System, Surroundings, Property, Energy, Thermodynamic Equilibrium, Process, work and modes of work. **Zeroth and First Law of Thermodynamics**: Zeroth of Thermodynamics, Temperature scale, First law of thermodynamics, First law analysis of some elementary processes. Steady and unsteady flow energy equations.	3
2	**Second Law of Thermodynamics**: Heat engine, Heat pump and refrigerator, Second law of thermodynamics, Equivalence of the Kelvin Plank and Clausius statements. Reversible and Irreversible Processes, Carnot engine, Efficiency of a Carnot engine, Carnot principle, thermodynamic temperature scale, Clausis Inequality. **Entropy**: Entropy, Calculation of Entropy change, Principle of entropy increase. Temperature-Entropy diagram, Second law analysis of a control volume. **Availability:** Available energy, Loss in available energy, Availability Function, Irreversibility.	9
3	**Thermodynamic Properties of Fluids:** Pure substance, Concept of Phase, Graphical representation of p-v-T data, Properties of steam. Steam tables, Mollier chart. **Ideal Gas and Real Gas**: Ideal gas, Real gas, Internal energy, enthalpy and specific heats of an ideal gas, equations of state, Dalton's law of partial pressures, Gibbs Dalton law, Thermodynamic properties of gas mixtures.	12
4	**Thermodynamic Relations**: Thermodynamic variables, Independent and dependent variables, Maxwell's thermodynamic relations, Thermodynamic relations involving entropy, Thermodynamic relations involving enthalpy and internal energy, Joule-Thomson coefficient, Clapeyron equation. **Power Cycles:** Otto cycle, Diesel cycle, Dual cycle, Brayton cycle and Ericsson cycle.	9

5	**Vapour power cycle:** Rankine cycle, effect of operating conditions on its efficiency, properties of ideal working fluid in vapour power cycle Reheat cycle, regenerative cycle, bleeding extraction cycle, feed water heating co-generation cycle.	8

TEXT BOOKS

1. Nag.P.K., "Engineering Thermodynamics", 6th Edition, Tata McGraw Hill (2017), New Delhi
2. Van G.J. Wylen and Sonntag R.E., Fundamental of Thermodynamics, John Wiley & Sons, 2003

REFERENCE BOOKS

1. Cengel Y.A., Boles M.A, Thermodynamics-An Engineering Approach, McGraw Hill, 2011
2. Rao Y.V.C., An Introduction to Thermodynamics, Wiley Eastern Ltd., 1993.
3. Rogers, Gorden., Engineering Thermodynamics, Pearson Education
4. Jones J.B.&.Dugan R.E, Engineering Thermodynamics, Prentice Hall of India.
5. Moran M.J and H.N. Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley and Sons

3MX4-02: Digital System Design

Credit: 3Max **Marks: 100(IA: 30, ETE: 70)**

3L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. Understand and escalate the importance of basic concepts and principles of digital electronics
2. Enable the students with various concepts of minimization of logical expressions to be familiar with logical algebra.
3. Develop the ability to understand and design combinational circuits.
4. Ability to analyse and design sequential circuits.
5. Ability to applications of digital electronics..

Course Outcomes

Upon successful completion of the course the students will be able to;

1. Students will be able to analyze and explain fundamental concepts of the digital number system and codes.
2. Students will be able to reduce digital logic function with various minimization technique like k-map, Mc-clusky methods.
3. Students will be able to analyse and design of combinational logical circuit.
4. Students will be able to design the sequential circuits using SR, JK, D, T flip-flops.
5. Students will be able to design applications of digital electronics..

S. No.	Contents	Hours
1	**Basics of Digital Electronics:** Introduction to digital electronics, Number systems, Arithmetic operations of Binary, Octal, Hexadecimal numbers, Interconversion of various number system, Types of codes, hamming codes, Logical operations, Basic and Universal gates, Implementation of circuit using universal gates	6
2	**Minimization Techniques:** Review of Boolean Algebra. Definition of combinational, Canonical forms, Generation of switching equations from truth tables, Karnaugh maps-3, 4 and 5 variables. Incompletely specified functions (Don't care terms). Simplifying max – term equations. Quine - McClusky minimization technique, Quine – McClusky using don't care terms, Reduced Prime Implicant tables	8
3	**Analysis and design of combinational logic:** Adders, subtractors, Decoders, Encoders, Digital multiplexers, Demultiplexers, Design of logic circuits by multiplexers, Parallel and serial adders, BCD adders, Binary comparators, Binary multiplier, Programmable Logic Devices, Concept of Programmable logic devices like FPGA. Logic implementation using programmable devices.	8
4	**Flip-Flops and its Applications:** Latches, Flip-flops, R-S, D, J-K, T, Master Slave flip flops. Conversions of flip-flops, Counters: Synchronous & Asynchronous ripple and decade counters, Modulus counter, Skipping state counter, Counter design, Ring counter, Counter applications, Registers: Buffer register, Shift register	9
5	**Applications of Digital Circuits:** Construction of state diagrams, Mealy and Moore Machines, Finite state machines, Design of Synchronous FSM, Algorithmic State Machines charts. Designing synchronous circuits like Pulse train generator, Pseudo Random Binary Sequence generator, Clock generation.	9

TEXT BOOKS

1. D. P. Kothari and J. S Dhillon, ―Digital Circuits and Design, Pearson, 2016,
2. Morris Mano, ―Digital Design, Prentice Hall of India, Third Edition.
3. K. A. Navas, ―Electronics Lab Manual, Volume I, PHI, 5
4. S Salivahanan , S Arivazhagan "Digital System and Design", Vikas Publication.

REFERENCE BOOKS

1. John M Yarbrough-Digital Logic Applications and Design, Thomson Learning,2001.
2. Donald D. Givone, ―Digital Principles and Design, McGraw Hill, 2002.
3. Charles H Roth Jr., Larry L. Kinney ―Fundamentals of Logic Design, Cengage Learning, 7th Edition.

3MX4-03: Manufacturing Processes

(Common for AR, ME and MX)

Credit: 3Max **Marks: 100(IA: 30, ETE: 70)**

3L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To teach the manufacturing processes which convert raw materials into useful products adapted to human needs.
2. To expose the students to a variety of manufacturing processes including their typical use and capabilities.
3. To teach the important effects that manufacturing processes may have on the material properties of the processed part with a focus on the most common processes.
4. To provide a technical understanding of common processes to aid in appropriate process selection for the material and required tolerances.
5. The students will enable to seek employment in engineering upon graduation and provide a firm foundation for manufacturing technologies.

Course Outcomes

Upon successful completion of the course the students will be able to;

1. **CO1:** Upon graduation, students would have acquired and developed the necessary background and skills for successful careers .
2. **CO2:** After completing the program, the student should be well prepared for management positions in industry or continued education toward a graduate degree.
3. **CO3:** The student will be having the capability of selecting suitable manufacturing processes to manufacture the products optimally.
4. **CO4:** The student will be able to identify/control the appropriate process parameters, and possible defects of manufacturing processes so as to remove them.
5. **CO5:** Acquire abilities and capabilities in the areas of advanced manufacturing methods, quality assurance and shop floor management.

S. No.	Contents	Hours
1	General classification and introduction to manufacturing processes **Introduction to Foundry:** Steps involved in casting, advantages, limitations and applications of casting process, pattern types, allowances for pattern, pattern materials, color coding and storing of patterns moulding. **Moulding**: methods and processes-materials, equipment, moulding sand ingredients, essential requirements, sand preparation and control, properties, testing; grain fineness; moisture content, clay content and permeability test. cores and core making, Design considerations in casting, gating and riser - directional solidification in castings, metallurgical aspects of casting	8
2	**Casting Processes**: Sand castings, pressure die casting, permanent mould casting, centrifugal casting, precision investment casting, shell moulding, CO_2 moulding, continuous casting-squeeze casting, defects in castings, causes, effects and remedy.	6

3	**Metal Joining Processes**: Types of welding: gas welding, arc welding, shielded metal arc welding, GTAW, GMAW, SAW, ESW, Resistance welding (spot, seam, projection, percussion, flash types), thermit welding, flame cutting - use of Oxyacetylene, modern cutting processes, arc cutting. Heat input, effect of welding parameters preheating, and post heating temperature. Selection of electrodes, flux etc. Soldering, brazing and braze welding and their application.	6
4	**Special Welding Processes:** Principles and process details of Forge welding; Friction welding; laser beam welding, electron beam welding, diffusion welding; ultrasonic welding. explosive welding, welding defects; types, causes, effects and remedy.	6
5	**Metal Forming Processes**: Classification; hot working and cold working, principle, advantages, disadvantages and applications. Forging: classification, drop forging and press forging methods and use; Forging dies; types, materials. Rolling: characteristics and applications of hot rolling and cold rolling; Extrusion: work materials and products; Press tool works; Basic principles, system, operations and applications. Drawing: wire drawing, tube drawing and deep drawing. Shearing; parting, notching, trimming, nibbling, blanking and piercing.	8
6	**Powder Metallurgy**: properties of powder processed materials, powder manufacturing, mechanical pulverization, sintering, electrolytic process, chemical reduction, atomization, properties of metal powders, compacting of powders sintering, advantages and applications of powder metallurgy.	6

TEXT BOOKS

1. P.N. Rao, Manufacturing Technology, Vol. I, Tata McGraw Hill, NewDelhi, 2014
2. Amitabha Ghosh and Mallik, “Manufacturing Science”, East West Press Pvt. Ltd.
3. R. K Jain, A Text Book of Production Technology, Khanna Publishers, NewDelhi. 1999.
4. R. K. Rajput, A Text Book of Manufacturing Technology, Laxmi Publications, India, 2007.

REFERENCE BOOKS

1. S. Kalpakjian, Manufacturing Engineering and Technology, Pearson Education, Singapore
2. S. K. Hajra Choudhry, Elements of Workshop Technology, Vol I, Media Promoters & Publishers Pvt.,Ltd.
3. De Garmo, Materials and Processes in Manufacturing, Prentice Hall of India, New Delhi.

3MX4-04: Materials Engineering and Technology

(Common for ME and MX)

Credit: 3Max **Marks: 100(IA: 30, ETE: 70)**

3L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. Core competence in materials, i.e. fundamental understanding of material behavior, or conceived, designed, and realized useful products and technology platforms within realistic engineering constraints.
2. Choose their careers as practicing materials engineer in all fields of materials industries
3. Understanding of the subject to present a wealth of real world engineering examples to give students a feel of how material science is useful in engineering practices.
4. To apply knowledge of materials solutions to enhance or radically improve existing and future technology.

Course Outcomes

Upon successful completion of the course the students will be able to;

1. **CO1:** Distinguish the various casting methods for product making with their merits and demerits.
2. **CO2:** Distinguish the various materials joining process and associated defects with possible cause and cure.
3. **CO3:** Discuss various metals forming process with its application.
4. **CO4:** Understanding of powder metallurgy.
5. **CO5:** Apply the manufacturing process suitable for making products.

S. No.	Contents	Hours
1	**Introduction:** Introduce Material Science & Engineering and provide basis for different materials categories and classification. **Crystallography:** Bonding in solids: Ionic, amorphous and crystalline, single crystal and polycrystalline material, polymorphism, lattice, unit cell, Bravais lattice, types of crystals, Linear and Planer densities, crystal defects and their effect on properties (Point, Line ,Surface and Volume defects), strengthening mechanism, Elastic & plastic modes of deformation, Bauschinger's effect, slip & twinning, strain hardening, cold/hot working, recovery, re-crystallization and grain growth.	7
2	**Solidification:** Mechanism of solidification, Homogenous and Heterogeneous nucleation, crystal growth, cast metal structures. Phase Diagram I: Solid solutions, Hume Rothary rule, substitutional and interstitial solid solutions, intermediate phases, Gibbs phase rule. **Phase Diagram:** Construction of equilibrium diagrams involving complete and partial solubility, lever rule. Iron carbon equilibrium diagram description of phases, solidification of steels and cast irons, invariant reactions.	5
3	**Heat treatment:** TTT curves, continuous cooling curves, annealing and its types. Normalizing, hardening, tempering, martempering, austempering, hardenability, Jominey end quench test, surface hardening methods like carburizing, cyaniding, nitriding, flame hardening and induction hardening. Application of above processes to machine components and mechanical equipment's such as gears, shaft bearings, turbine blades, crank shafts, pistons etc.	7

4	**Mechanical properties and testing of materials:** Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress-strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Hardness: Rockwell, Brinell and Vickers and their relation to strength. Impact Test (Charpy and Izod specimens, Fatigue Test (Fatigue testing apparatus, S-N Curve for ferrous and non-ferrous, Fatigue fracture (transgranular fracture), endurance and fatigue limits, Methods of improving fatigue life.	5
5	**Non-metallic materials:** Polymers-types of polymer, commodity and engineering polymers, properties and applications of PE, PP, PS, PVC, 4 PMMA, PET, PC, PA, ABS, PI, PAI, PPO,PPS, PEEK, PTFE Polymers. Urea and Phenol formaldehydes. **Ferrous and non-ferrous metals**: Effect of alloying additions on steel (Mn, Si, Cr, Mo, V, Ti & W), stainless and tool steels, HSLA steel.	5
6	**Classification** of steels and cast iron constitution and properties. BIS standards. **Engineering Ceramics**: Properties and applications of Al_2O_3, SiC, Si_3N_4, PSZ etc. Mechanical/Electrical behaviour and processing of Ceramics. **Fiber and particulate reinforced composites:** types, production techniques, structure, Processing and applications. **Introduction to nano materials:** Nano structured materials, nano clusters & nano crystals, smart materials.	5

TEXT BOOKS

1. William D. Callister Jr Materials Science and Engineering, John Wiley & Sons., 2001.
2. V. Raghavan, Materials Science and Engineering, Prentice Hall, India, 2007.
3. B. K. Agrawal, Introduction to Engineering Materials, Tata McGraw-Hill, 1988.

REFERENCE BOOKS

1. Narula, Narula and Gupta, Material Science, New Age Publishers, India, 1988.
2. H. VanVlack, Elements of Materials Science and Engineering, , Addison- Wesley Edn., 1998
3. K. Bhargava, C.P. Sharma. Mechanical Behavior & Testing of Materials, P H I Learning Private Ltd., 2011
4. S.H.,Avner, Introduction to Physical Metallurgy, 2nd Edition, Tata McGraw-Hill, 1997
5. G. E. Dieter, Mechanical Metallurgy, McGraw Hill Book Company, London, 1988.

3MX4-05: Elements of Electronics

Credit: 3Max **Marks: 100(IA: 30, ETE: 70)**

3L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. Understand and escalate the importance of basic concepts and principles Semiconductor Physics
2. Enable the students with concepts P-N junction
3. Develop the ability to understand all components and characteristics of BJT.
4. Ability to analyse the properties of FET.
5. Understanding the working and characteristics of various photoelectronic devices..

Course Outcomes

Student will be able to

1. Students will be able to analyse and explain fundamental concepts of the semiconductor physics.
2. Students will be able analyse behaviour of P-N junction.
3. Students will be able to analyse current characteristics and biasing of BJT.
4. Students will be able to explain construction, working and characteristics of FET.
5. Students will be able to analyse photo electronic devices.

S. No	Contents	Hours
1	**Semiconductor Physics:** Semiconductor Materials, Band gap structures of semiconductors, Classifications of semiconductors, Degenerate and non-degenerate semiconductors, Direct and indirect band gap semiconductors, Hall Effect, Electronic properties of Silicon, Germanium, Compound Semiconductor, Gallium Arsenide, Gallium phosphide & Silicon carbide, Variation of semiconductor conductivity, resistance and bandgap with temperature and doping, Drift and Diffusion current, Thermistors, Sensitors	8
2	**PN Junction:** Formation of PN junction, Depletion region, Junction capacitance, Diode equation (no derivation) Effect of temperature on reverse saturation current, V - I characteristics and simple applications of i) Junction diode, ii) Zener diode, iii) Tunnel diode and iv) Varactor diode.	8
3	**Bipolar Junction Transistor (BJT) :** Transistor terminals , Transistor Action, current components in BJT, BJT static characteristics (Input and Output) , Early effect , CB , CC , CE configurations of transistor and bias conditions (cut off, active, and saturation regions), CE configuration as two port network, Load line analysis (AC and DC), Transistor Biasing – Fixed and self-bias.	9
4	**Field Effect Transistor (FET):** Construction and working of JFET, output and transfer characteristics of FET, Determination of FET parameters. Application of FET as Voltage variable resistor. Advantages of FET over BJT. MOSFET, Construction and working of enhancement and depletion modes, output and transfer characteristics Application of MOSFET as a switch.	9
5	**Photo electronic Devices:** Construction and Characteristics of Light Dependent Resistor (LDR), Photo voltaic Cell, Photo diode, Photo transistor and Light Emitting Diode (LED)	6

TEXT BOOKS

1. Robert L Boylestad -Elements of Electronics Engineering, Pearson Education
2. J. Millman's & C. Halkias–Integrated Electronics: Analog & Digital Circuits Systems,2/e TMH
3. D P Kothari, I J Nagrath, 'Basic Electronics', 2nd edition, McGraw Hill Education (India), Private Limited, 2018.
4. M.S.Sukhija and T.K.Nagsarkar, Basic Electrical and Electronics Engineering, Oxford University Press, 2012

REFERENCE BOOKS

1. David A. Bell, "Electronic Devices and Circuits", Oxford University Press, 5th Edition, 2008.
2. Allen Mottershed – Electronic Devices and Circuits, PHI.
3. J.B. Gupta—Electronic Devices and Circuits, KATARIA
4. Salivahanan: Electronic Devices and Circuits, TMH

3MX2-01: Engineering Mechanics

(Common for AR, ME and MX)

Credit: 3Max **Marks: 100(IA: 30, ETE: 70)**

2L+1T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To enable students to apply fundamental laws and basic concepts of rigid body mechanics to solve problems of bodies under rest or in motion.
2. To enable the students to apply conditions of static equilibrium to analyse physical systems.
3. To compute the properties of areas and bodies.

Course Outcomes

Student will be able to

1. Compute the resultant of system of forces in plane and space acting on bodies.
2. Predict the support-reactions and the internal forces of the members of various trusses and frames.
3. Analyse equilibrium problems with friction.
4. Apply transfer theorems to determine properties of various sections.
5. Analyse equilibrium of connected bodies virtual work method.
6. Predict motion parameters of bodies under rectilinear, curvilinear and general plane motion.

S. No	Contents	Hours
1	**Introduction to Engineering Mechanics 8 Introduction to Engineering Mechanics:** Composition and resolution of forces, parallelogram law, principle of transmissibility, types of force systems - concurrent and concurrent coplanar forces, resultant of coplanar force systems couple, moment of a force Varignon's theorem, concept of free body diagrams, concept of equilibrium of coplanar force and non-coplanar systems.	5
2	**Analysis of Structures and Friction:** Introduction to plane trusses, analysis of plane trusses by method of joints and method of sections. Friction: Laws of friction, types of friction, equilibrium of force systems involving frictional forces, wedge friction. Free body diagrams involving frictional forces.	8
3	**Properties of Surfaces and Moment of Inertia:** Properties of Surfaces and Volumes: Centroid and center of gravity, derivation of centroids from first moment of area, centroids of composite sections, center of gravity of common volumes - cylinder, cone, sphere, theorem of Pappus-guldinus. Moment of Inertia: Area moment of inertia of plane and composite shapes, parallel axis theorem, perpendicular axis theorem, polar moment of inertia, mass moment of inertia of common volumes - thin plates, thin rod, cylinder, cone, sphere, rectangular prism, radius of gyration, Principle of virtual work.	8
4	**Kinematics:** Equations of motion for rigid bodies, constant and variable acceleration, rectilinear and curvilinear motion, motion under gravity -projectile motion, use of rectangular coordinates, tangential and normal coordinates, radius of curvature, rotation of a rigid body about a fixed axis, introduction to plane motion.	8
5	**Kinetics and Ideal Systems:** Kinetics: Principles of dynamics - Newton's Laws of motion, D'Alembert's principle in rectilinear translation, principle of work and energy.	8

	Ideal Systems: Principle of conservation of energy, concept of power, conservation of linear and angular momentum, principle of momentum and impulse, impact - types of impact. Basic principles: Equivalent force system, Equations of equilibrium, Free body diagram; Reaction, Static indeterminacy.	

TEXT BOOKS

1. Beer F.P and Johnson E.R., "Vector Mechanics for Engineers- Statics and Dynamics",9th Edition, Tata McGraw-Hill Publishing Company
2. Meriam J.L., Kraige L.G, et al., "Engineering Mechanics Statics and Dynamics", 9th Edition, (An Indian Adaptation), Wiley India

REFERENCE BOOKS

1. Hibbeler R. C and Gupta A., Engineering Mechanics,", 12th Edition, 2012, Pearson Education
2. Shames I.H and Rao G.K.M., "Engineering Mechanics Statics and Dynamics", 4th Edition, Pearson

3MX4-20: Machine Drawing Practice

(Common for AR, ME and MX)

Credit: 1Max **Marks: 100(IA: 60, ETE: 40)**

0L+0T+2P

Course Objectives

1. To acquire the knowledge of CAD software and its features.
2. To familiarize the students with Indian Standards on drawing practices.
3. To impart knowledge of thread forms, fasteners, keys, joints and couplings.
4. To make the students understand and interpret drawings of machine components leading to preparation of assembly drawings manually and using CAD packages.
5. To acquire the knowledge of limits, tolerance and fits and indicate them on machine drawings

Course Outcomes

1. Identify the national and international standards pertaining to machine drawing.
2. Understand the importance of the linking functional and visualization aspects in the preparation of the part drawings.
3. Apply limits and tolerances to assemblies and choose appropriate fits for given assemblies.
4. Interpret the Machining and surface finish symbols on the component drawings.
5. Preparation of the part or assembly drawings as per the conventions.

S. No	Contents	Hours
1	**Part – A (Theory and Sketch-book)** Review of graphic interface of the software. Review of basic sketching commands and navigational commands. Starting a new drawing sheet. Sheet sizes. Naming a drawing, Drawing units, grid and snap. Conversion of pictorial views into orthographic projections of simple machine parts (with section planes indicated on the part). Thread Forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal & External) square and Acme. Sellers thread, American Standard thread. Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw. Keys: Parallel key, Taper key, Feather key, Gib-head key and Woodruff key. Joints: Cotter joint (socket and spigot), knuckle joint (pin joint) for two rods. Couplings: Split Muff coupling, Protected type flanged coupling, pin (bush) type flexible coupling, and universal coupling (Hooks' Joint). Limits, Fits and Tolerances: Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, machining symbols, types of fits with symbols and applications, geometrical tolerances on drawings. Standards followed in industry.	Simultaneous to section 2

2	**Part – B (Use any CAD software)** A. Plummer block (Pedestal Bearing) B. Lever Safety Valve C. I.C. Engine connecting rod D. Screw jack (Bottle type) E. Tailstock of lathe F. Machine vice G. Tool head of shaper	

3MX4-21: Production Practice Lab

(Common for AR, ME and MX)

Credit: 1Max **Marks: 100(IA: 60, ETE: 40)**

0L+0T+2P

Course Objectives

1. The course provides students with fundamental knowledge and principles in material removal processes.
2. In this course, the students apply the fundamentals and principles of metal cutting to practical applications through multiple labs using lathes, milling machines, grinding machines and other machining processed.
3. To demonstrate the fundamentals of machining processes and machine tools.
4. Demonstration of Casting and welding techniques in detail.

Course Outcomes

Upon successful completion of the course the students will be able to;

1. **CO1:** Study of various parts of lathe machine and its construction. Understanding of various lathe operations i.e. turning, taper turning, chamfering and knurling, thread cutting.
2. **CO2:** Study shaper machine, its mechanism and calculate quick return ratio, and milling machine.
3. **CO3:** Understanding of various Foundry shop operations. i.e. prepare mould, perform moisture test and clay content test, Strength Test, hardness test and to perform permeability test.
4. **CO4:** Understanding of Welding shop and practice on spot welding.

S. No	Contents	Hours
1	**Turning Shop** 1. To study lathe machine construction, attachments, lathe tools cutting speed, feed and depth of cut. 2. To cut multi-start Square/Metric threads on lathe machine. 3. To perform taper turning using compound rest. 4. Boring using a boring bar in a centre lathe and cut BSW/Metric internal threads on lathe machine.	
2	**Machine shop** 1. To study the milling machine, milling cutters, indexing heads and indexing methods and to prepare a gear on milling machine. 2. To machine a hexagonal /octagonal nut using indexing head on milling machine. 3. To study of single point cutting tool geometry and to grind the tool as per given tool geometry. 4. To study shaper machine, its mechanism and calculate quick return ratio and to prepare a job on shaper from given mild steel rod.	
3	**Demonstration and study** 1. Demonstration for job by eccentric turning on lathe machine. 2. Study of capstan lathe and its tooling and prepare a tool layout & job as per given drawing.	

	3. Grinding of milling cutters and drills. 4. Study of grinding wheel and their materials.	
4	**Foundry Shop** 1. To prepare mould of a given pattern requiring core and to cast it in aluminium. 2. To perform moisture test and clay content test. 3. To perform permeability test 4. A.F.S. Sieve analysis test. 5. Strength Test (compressive, Tensile, Shear Transverse etc. in green and dry conditions) and Hardness Test (Mould and Core).	
5	**Welding Shop** 1. Hands-on practice on spot welding.	

3MX4-22: Electronic Devices and Circuits Lab

Credit: 1Max **Marks: 100(IA: 60, ETE: 40)**

0L+0T+2P

Course Objectives

1. To be familiar with electronic components ICs, bread board, power supplies, CRO.
2. To be able to implement and analyse circuits on digital storage CRO.
3. To analyse P-N junction diode.
4. To analyse BJT and its biasing circuits
5. Able to plot characteristics of FET, photo diode and LDR..

Course Outcomes

Upon successful completion of the course the students will be able to;

1. Students will be able work on bread board with electronic components and DSCRO.
2. Students will be able to analyse and explain fundamental concepts of basic electronics.
3. Students will be able to analyse P-N junction.
4. Students will be able to verify the working and characteristics of BJT.
5. Students will be able to analyse and verify the working of FET and photo electronic devices ..

S. No	Contents	Hours
1	Study the following devices: (i) Analog & digital multimeter (ii) Function/ Signal generators Regulated d. c. power supplies (constant voltage and constant current operations)	
2	Study of digital storage CRO and store a transient on it.	
3	Study of analog CRO, CRO probes, measurement of time period, amplitude, frequency & phase angle using Lissajous figures.	
4	Plot V-I characteristic of P-N junction diode & calculate cut-in voltage, reverse Saturation current and static & dynamic resistances.	
5	Plot V-I characteristic of zener diode and study zener diode as voltage regulator. Observe the effect of load changes and determine load limits of the voltage regulator.	
6	Plot frequency response curve for audio amplifier and to determine gain bandwidth product.	
7	Plot drain current - drain voltage and drain current – gate bias characteristics of field effect transistor and measure of Idss & Vp	
8	Plot input and output characteristics of LDR and Photo Diode.	
9	Plot gain- frequency characteristic of emitter follower & find out its input and output resistances.	
10	Plot input and output characteristics of BJT in CB, CC and CE configurations.	

TEXT BOOKS

1. J. Millman's & C. Halkias–Integrated Electronics: Analog & Digital Circuits Systems,2/e TMH
2. Robert L. Boylested & Louis Nashelshky– Electronic Devices and Circuit theory, PHI.
3. K. A. Navas, ―Electronics Lab Manual, Volume I, PHI, 5S Salivahanan , S Arivazhagan "Digital System and Design", Vikas Publication.

REFERENCE BOOKS

1. Electronic Devices-Conventional Current Version By Floyd (9th Edition)
2. Schaum's Outlines Electronic Devices and Circuits

3MX4-23: Digital System Design Lab

Credit: 1Max **Marks: 100(IA: 60, ETE: 40)**

0L+0T+2P

Course Objectives

1. To be familiar with logic gates ICs, bread board, power supplies.
2. To be able to implement and analyse circuits on bread board.
3. To design and analyse combinational logic circuits.
4. To design and analyse sequential logic circuits
5. Able to implement applications of combinational & sequential logic circuits..

Course Outcomes

Upon successful completion of the course the students will be able to;

1. Students will be able work on bread board with ICs.
2. Students will be able to analyse and explain fundamental concepts of the digital logic gates.
3. Students will be able to analyse and design of combinational logical circuit.
4. Students will be able to verify the working of flip-flops.
5. Students will be able to design and verify applications of digital electronics.

S. No	Contents	Hours
1	To study AND,OR,NOT,NAND,NOR and XOR gates.	
2	To study the realization of basic gates using universal gates.	
3	To design, implement and verify the truth table of half adder and half subtractor using logic gates.	
4	To design, implement and verify the truth table of full adder and full subtractor using logic gates.	
5	To study and design 2:1 and 1:2 demultiplexer.	
6	To study and design 2:4 decoder.	
7	Design and build BCD-to-7 segment decoder.	
8	To verify truth table of various flip flops.	
9	To design and implement 2-bit up counter using D flip flops.	
10	Design and construct unidirectional shift register.	

TEXT BOOKS

1. D. P. Kothari and J. S Dhillon, —Digital Circuits and Design, Pearson, 2016,
2. Morris Mano, —Digital Design, Prentice Hall of India, Third Edition.
3. K. A. Navas, —Electronics Lab Manual, Volume I, PHI, 5

REFERENCE BOOKS

1. John M Yarbrough-Digital Logic Applications and Design, Thomson Learning,2001.
2. Donald D. Givone, —Digital Principles and Design, McGraw Hill, 2002.
3. Charles H Roth Jr., Larry L. Kinney —Fundamentals of Logic Design, Cengage Learning, 7th Edition.

4MX4-01: Mechanics of Solids

(Common for AR, ME and MX)

Credit: 4Max **Marks: 100(IA: 30, ETE: 70)**

3L+1T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To understand the basic concepts of the stresses and strains for different materials and strength of structural elements.
2. To know the development of internal forces and resistance mechanism for one dimensional and two dimensional structural elements.
3. To analyse and understand different internal forces and stresses induced due to representative loads on structural elements.
4. To analyse and understand principal stresses due to the combination of two dimensional stresses on an element and failure mechanisms in materials.
5. To evaluate the behavior of torsional members, columns and struts.

Course Outcomes

Student will be able to

1. To evaluate the strength of various structural elements internal forces such as compression, tension, shear, bending and torsion.
2. To suggest suitable material from among the available in the field of manufacturing.
3. To evaluate the behavior and strength of structural elements under the action of compound stresses and thus understand failure concepts.
4. To understand the basic concept of analysis and design of members subjected to torsion.
5. To understand the basic concept of analysis and design of structural elements such as columns and struts.

S. No	Contents	Hours
1	**Introduction** Concept of stress, Mechanical properties of materials, stress-strain diagrams (tension- structural steel, aluminum and compression-copper, cast iron) internal forces (stress resultants), Normal stress and strain, Linear elasticity, Hooke's law, and Poisson's ratio with limitations, Shear stress and strain, Hooke's law in shear, stress circle	3
2	**Uniaxial loaded members-** Changes in lengths of axially loaded members- prismatic bars, cables; Changes in lengths under non-uniform conditions-bars with intermediate axial loads, bars consisting of prismatic segments, bars with continuously varying loads or dimensions; Stresses in Statically Indeterminate Structures, Thermal effects; pre-strains of bolts and turnbuckles; Axial stresses on inclined sections, maximum normal and shear stresses, Strain energy - elastic and inelastic strain energy, strain-energy density, impact loading, suddenly applied load, repeated loading and fatigue, Saint-venant's principle, nonlinear stress-strain curves	7
3	**Analysis of Stress and Strain**	5

	Plane stress- stresses on inclined sections, transformation equations for plane stress; Principal stresses and maximum shear stresses; Mohr's circle for plane stress; Hooke's law for plane stress and volume change; Relation between various elastic constants, Tri-axial stress - maximum shear stresses, Hooke's law for tri-axial stress, unit volume change and volumetric strain Members subjected to combined loadings, concept of theory of failure.	
4	Stresses and strains in the walls of thin spherical pressure vessels and cylindrical pressure vessels;	2
5	**Shear Forces and Bending Moments** Types of beams, loads, and reactions, types of loads, shear forces and bending moments, relationships between loads, shear forces, and bending moments – for distributed, concentrated and couple loading; Shear-force and bending moment diagrams for - concentrated load, uniform load, several concentrated loads, combination of loads, couple loading	6
6	**Stresses in Beams** Pure bending and non-uniform bending, Theory of flexure for initially straight beams, distribution of bending stresses across the beam cross-section, curvature of a beam, longitudinal strains in beams, normal stresses in beams, moment-curvature relationship, flexure formula and limitations; Strain Energy due to bending Shear stresses in beams of rectangular cross section, circular cross section, beams with flanges - shear formula; distribution of shear stresses, maximum and minimum shear stresses and limitations; built-up beams	4
7	**Deflections of Beams** Differential equations of the deflection curve; Deflections by integration of the bending-moment equation; deflections by integration of the shear-force and load equations; method of superposition; moment-area method; Castigliano's theorem	6
8	**Torsion** Torsional deformations of a circular bar- shear stress and strains outside and within the bar and in circular tubes; angle of twist; limitations of the torsion formula; Non-uniform torsion for constant torque, stepped and composting shafts; transmission of power by circular shafts; Stresses and strains in pure shear- stresses on inclined planes, strains in pure shear; Transmission of power by circular shafts; statically indeterminate torsional members; strain energy in torsion and pure shear; Thin-walled tubes- shear stresses and shear flow, torsion formula for thin-walled tubes;	5
9	**Columns** Buckling and Stability- Critical Load, Equilibrium, Effective Lengths of Columns; Euler buckling theory - Columns with pinned ends, column fixed at the base and free at the top, column with both ends fixed against rotation, column fixed at the base and pinned at the top	3

	Columns with eccentric axial loads, the Secant formula for columns Introduction to Inelastic Buckling - Tangent-Modulus Theory, Reduced-Modulus Theory, Shanley Theory	

TEXT BOOKS

1. Gere, J.M. and Goodno, B.J., "Strength of Materials", Indian Edition (4th reprint), Cengage Learning India Private Ltd.
2. S.S. Rattan " Strength of Materials" McGraw Hill Education (India) Pvt. Ltd., 2nd Edition (Sixth reprint 2013)
3. Mechanics of Materials Paperback by B.C. Punmia , Ashok Kumar Jain , Arun Kumar Jain, Laxmi PublicatioN

REFERENCE BOOKS

1. Beer, F.P., Johuston, Jr., E.R., Dewolf, J.T. and Mazureu, D.E., "Mechanics of Materials", Fifth Edition, McGraw Hill
2. Hibbeler, R.C., "Mechanics of Materials", Sixth Edition, Pearson
3. Crandall, S.H., Dahl, N.C. and Lardner, T.J., "An Introduction to the Mechanics of Solids", 2nd Edition, McGraw Hill.

4MX4-02: Fluid Mechanics

(Common for AR, ME and MX)

Credit: 4Max **Marks: 100(IA: 30, ETE: 70)**

3L+1T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To apply hydrostatic law, principle of mass and momentum in fluid flows, concepts in Euler's and Bernoulli equations.
2. To provide fundamental knowledge of fluids, its properties and behaviour under various conditions of internal and external flows.
3. To determine the losses in a flow system, flow through pipes, boundary layer concepts.

Course Outcomes

Student will be able to -

1. Analyse various hydraulic systems by applying the fundamental laws of fluid statics.
2. Solve the fluid flow governing equations by taking suitable constraints and assumptions
3. Evaluate major and minor losses in pipes
4. Analyse the practical significance of open channel flows
5. Perform dimensional analysis on any real life problems
6. Interpret the boundary layer aspects of laminar and turbulent flows
7. Experimentally determine the fluid properties and flow parameters using various experimental setups

S. No	Contents	Hours
1	**Unit-1:** Basic Definitions and Fluid Properties: Definition of Fluid. Incompressible and compressible fluids. Fluid as a continuum, Mass, density, specific weight, relative density, specific volume. Bulk modulus, velocity of sound Ideal fluid, viscosity. Newtonian and Non-Newtonian fluid, Kinematic viscosity, Effect of temperature and pressure on viscosity, surface tension capillarity, vapour pressure and cavitation. Fluid Statics: General differential equation, Hydrostatics Manometry, Fluid forces on submerged surfaces. Curved surfaces, Isothermal atmosphere, polytropic atmosphere. Buoyancy and floatation.	6
2	**Unit-2:** Kinematics and Conservation of Mass: Flow classifications. Fluid velocity and acceleration, streamlines and the stream function. Pathlines and streak lines. Deformation of a fluid element, vorticity and circulation. Irrotational and Rotational flow. Flownet, Laplace equation Conservation of mass and the continuity equation for three dimensions. Fluid Momentum: The momentum theorem. Applications of the momentum theorem. Equation of motion, Euler's equation of motion. Integration of Euler's equation of motion--Bernoulli's equation. Applications of Bernoulli's equation. Equation of motion for viscous fluid, Navier Stoke's equation	7
3	**Unit-3:** Flow Through Pipes: Reynold's experiment. Darcy's Weisback equation. Loss of head due to sudden enlargements, contraction, entrance, exit obstruction, bend, pipe fittings. Total and Hydraulic gradient lines, Flow through pipe line, Pipes in series, parallel, Transmission of power through pipes. Orifice discharging, free Jet, vena contracta, co-efficient of contraction, velocity and discharge,	8

	Orifices and mouthpieces, Nozzles and weirs.	
4	**Unit-4:** Laminar Flow Simple Solution of Navier Stokes equations. Hagen-Poiseuille flow, Plane Poiseuille flow and coutte flow. Turbulent Flow: Variation of friction factor with Reynold's number, The Prandtl Mixing length hypothesis applied to pipe flow, velocity distribution in smooth pipes, rough pipes. The Universal pipe friction laws. The Boundary Layer: Description of the boundary layer, Boundary layer thickness, boundary layer separation and control. The Prandtl boundary layer equation. Solution for laminar boundary layer. The momentum equation for the boundary layer. The flat plate in uniform free stream with no pressures gradients: Approximate momentum analysis - Laminar boundary layer. Turbulent boundary layer, Viscous sublayer, combined laminar and turbulent boundary layers.	9
5	**Unit-5:** Dimensional Analysis: Buckingham's theorem, Model Similitude. Force ratio, Reynolds, Froude's, Mach, Weber and Euler numbers and their applications. Undistorted model, distorted model. Film Lubrications: Tower's experiment. Reynold's theory and interpretation. High speed journal loaded and unloaded. Sommerfeld diagram. Hydrostatic Lubrication. Flow around a Body: Drag, Skin friction drag, Pressure drag. Combined skin friction and pressure drag (Profile drag), Wave drag. lift induced drag, Flow past sphere and cylinder.	9

TEXT BOOKS

1. Yunus A. Çengel, John M. Cimbala, Fluid Mechanics: Fundamentals And Applications, McGraw-Hill, 3rd Edition, 2013.

REFERENCE BOOKS

1. Robert W. Fox, Alan T. McDonald, Philip J. Pirtchard John W. Mitchell, Introduction to Fluid Mechanics, 9th Edition, Wiley Publications, 2015.
2. Donald F. Elger, Barbara C. Williams, Clayton T. Crowe, John A. Roberson, Engineering Fluid Mechanics, John Wiley & Sons, 10th Edition, 2013.
3. V.L. Streeter, Fluid Mechanics, McGraw Hill Book Co., 2010.

4MX4-03: Analog Electronics

Credit: 3Max **Marks: 100(IA: 30, ETE: 70)**

3L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To expose the students semiconductor device, performance characteristics and their application.
2. To expose different signal processing technique and characteristics.

Course Outcomes

Student will be able to -

1. Understand the characteristics of BJTs and FETs.
2. Design and analyze BJT and FET amplifier circuits.
3. Design sinusoidal and non-sinusoidal oscillators.
4. Understand the functioning of linear ICs.
5. Design of Linear IC based circuits.

S. No	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Transistor biasing and stabilization:-** Operating point, Analysis and design of fixed bias circuit, Self-bias circuit, Emitter stabilized bias circuit, Voltage divider bias circuit, Stability factor of different biasing circuits and its problems.	6
3	**Transistor analysis:-** The Classical Discrete circuit bias (Voltage divider bias), Biasing using a collector to base feedback resistor. BJT Transistor Modeling, The re transistor model, Common emitter fixed bias, Voltage divider bias, Emitter follower configuration. Darlington connection- DC bias; The Hybrid equivalent model, Approximate Hybrid Equivalent Circuit- Fixed bias, Voltage divider, Emitter follower configuration; Complete Hybrid equivalent model, Hybrid π Model.	9
4	**Feedback Amplifier:-** General feedback structure, Properties of negative feedback, The Four Basic Feedback Topologies, The series-shunt, series-series, shunt-shunt and shunt-series amplifiers (Qualitative Analysis).	7
5	**Power Amplifiers and Oscillators:-** Introduction, Classification of output stages,, Class A output stage, Class B output stage: Transfer Characteristics, Power Dissipation, Power Conversion efficiency, Class AB output stage, Class C tuned Amplifier. FET based Phase shift oscillator, LC and Crystal Oscillators (no derivation).	9
6	**Op-Amp and general applications:-** DAC - Weighted resistor and R-2R ladder, ADC- Successive approximation type, Small Signal half wave rectifier, Active Filters, First and second order low-pass and high-pass Butterworth filters, Band-pass filters, Band reject filters. Inverting and Non inverting Amplifiers – Closed Loop voltage gain, Input impedance, Output impedance, Bandwidth with feedback. DC and AC Amplifiers, Summing, Scaling and Averaging Amplifiers, Instrumentation amplifier, Comparators, Zero Crossing Detector, Schmitt trigger, 555 Timer.	9

TEXT BOOKS

1. Microelectronic Circuits, Theory and Applications, Adel S Sedra, Kenneth C Smith, 6th Edition, Oxford,

2. Op-Amps and Linear Integrated Circuits, Ramakant A Gayakwad, 4th Edition. Pearson Education.

REFERENCE BOOKS

1. Electronic Devices and Circuit Theory, Robert L Boylestad and Louis Nashelsky.
2. Fundamentals of Microelectronics, BehzadRazavi, 2nd Edition, John Weily.
3. J. Millman & C.C. Halkias- Integrated Electronics, 2nd edition, 2010, TMH.

4MX4-04: Sensors and Instrumentation

Credit: 3Max **Marks: 100(IA: 30, ETE: 70)**

3L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To make students familiar with the constructions and working principle of different types of sensors and tr ansducers.
2. To make students aware about the measuring instruments and the methods of measurement and the use of different transducers.

Course Outcomes

Student will be able to -

1. Apply the use of sensors for measurement of displacement, force and pressure.
2. Employ commonly used sensors in industry for measurement of temperature, position, accelerometer, vibration sensor, flow and level.
3. Demonstrate the use of virtual instrumentation in automation industries.

S. No	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Measurement:** Generalized systems of measurement system response, importance of damping. Dynamics of generalized system. Impedance matching and experimental planning. Accuracy, sensibility, uncertainty, precision repeatability, error, error classification. Treatment of stage sample and multi-sample data, uncertainty analysis. Statistical - data analysis.	8
3	**Transducers:** Various types, their desired characteristics. Pressure: Measurement devices for low and high pressure, Bridgman gauge, thermal conductivity gauge, Ionization gauge, strain gauge, pressure cells. Measurement of dynamic pressure. Temperature: Bi-materials, Pressure, thermo-electric, thermo-metering, pyrometry, thermocouples-error compensation, high speed temperature measurement.	9
4	**Flow:** Positive displacement and objection meters, measurement by drag effects. Hot wire and magnetic flow meters, flow visualization methods, Schlieren technique, pressure probes. Displacement Velocity Acceleration : Transducers, LVDT, angular velocity measurement, Photocell method, Stroboscope accelerometer, etc.	8
5	**Force, Torque, Strain Measurement:** Strain gauge factor in bounded strain gauges, temperature compensation, hydraulic and pneumatic system, use of strain gauges on rotating shafts, Strain gauge rosettes.	8
6	**Control System:** Concept of open and closed loop system, Feedback, servomechanism and servo-systems, Representation of control system block diagrams. Hydraulic system. Electric system and pneumatic system. Concept of stability..	7

TEXT BOOKS

1. DVS Murthy, Transducers and Instrumentation, PHI 2nd Edition 2013
2. D Patranabis, Sensors and Transducers, PHI 2nd Edition 2013
3. S. Gupta, J.P. Gupta/PC interfacing for Data Acquisition & Process Control, 2nd ED/Instrument Society of America, 1994.

REFERENCE BOOKS

4. Gary Johnson/Lab VIEW Graphical Programing II Edition/McGraw Hill 1997.
5. Arun K. Ghosh, Introduction to measurements and Instrumentation, PHI, 4th Edition 2012.
6. A.D. Helfrick and W.D. cooper,Modern Electronic Instrumentation & Measurement Techniques, PHI-2001
7. Hermann K.P. Neubert, Instrument Transducers 2nd Edition 2012, Oxford University Press.

4MX4-05: Internal Combustion Engines and Hybrid Controls

Credit: 3Max **Marks: 100(IA: 30, ETE: 70)**

3L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To introduce students to the working of spark ignition and compression ignition engines and their systems.
2. To introduce students to the cooling and lubrication system of spark ignition and compression ignition engines.
3. To introduce students about the gas turbines.
4. To enhance the understanding of students in engine emissions, pollution and their control.
5. To introduce students to the recent trends in IC Engines like stratification, multi-point injection, plasma ignition etc.

Course Outcomes

Student will be able to -

1. Apply the laws of thermodynamics to the working of I.C engines.
2. Compare the merits and demerits of different types of fuel injection systems used in IC engines
3. Determine performance and combustion characteristics of SI and CI engines
4. Propose design modifications for the existing turbochargers and superchargers
5. Demonstrate the developments to enhance the efficiency and performance of IC engines and gas turbine.
6. Get introduced to electric vehicles, understand how are EVs different from ICE vehicles and identify various parts of an electric vehicles

S. No	Contents	Hours
1	**Introduction:** Basic components and terminology of IC engines, working of four stroke/two stroke - SI and CI engines with PV and Valve Timing Diagrams, classification and application of IC engines, engine performance and emission parameters IC engines performance: Performance test - Measurement of Brake power, Indicated power, Fuel consumption, Air consumption; Heat balance test, Morse test and Retardation test on IC engine.	4
2	**Mixture preparation :** Mixture preparation in Spark Ignition Engines: Spark ignition Engine mixture requirements - Feedback Control Carburetors –Properties of Fuel - Injection systems –Mono-point and Multipoint injection – Gasoline Direct Injection – Air motion. Mixture preparation in Compression Ignition Engines: Direct and indirect injection systems – Combustion chambers - Properties of Fuel -Fuel spray behavior - spray structure - spray penetration and evaporation – Air motion- Injectors and nozzles.	6
3	**Combustion in CI and SI Engines:** Stages of combustion in SI and CI engines – Combustion phasing - heat release rate based on cylinder pressure measurement-Knock in CI and SI engines- Measurement and control of Knock.	5

4	History of Hybrid and Electric Vehicles technology, Economics and Environmental aspects of vehicle technologies. Vehicle dynamics-vehicle resistance, dynamic equation, tire ground adhesion, maximum tractive effort, vehicle speed, transmission characteristics, vehicle performance. Hybrid and electric drive trains-configurations of electric vehicles, traction motor characteristics, basic concept of hybrid traction, hybrid drive train architecture – series, parallel torque and speed coupling.	4
5	**Electric propulsion unit:** different motors, configuration and control of dc and induction motor drives, introduction to power modulators, control, advanced motor drives for EV: PMSM, BLDC, SRM and SyncRel Motor drives. Energy storage, regenerative breaking, classification of different energy management strategies, fundamentals of regenerative braking. Sizing the drive system-propulsion motor, sizing the power electronics, selecting the energy storage technology, communications.	6
6	**Overview of Automotive Control Systems:** Automotive Control-System Design Process, Identifying the Control Requirements, Review of Engine Modeling, Engine Operations, Engine Control Loops, Control-Oriented Engine Modeling, Control of Hybrid and Electric vehicles: ECU, CAN-bus, and Vehicle Dynamics Control.	5
7	**Controls of Engines:** Control of Automotive Transmission Systems, Powertrain Control Systems, Air–Fuel Ratio Control, Control of Spark Timing, Idle-Speed Control, and Transmission Control.	3
8	**Control of Hybrid Systems:** Control of Hybrid Vehicles, Series, Parallel, and Split Hybrid Configurations, Hybrid Vehicle-Control Hierarchy, Control Concepts for Series Hybrids, Control Concepts for Parallel Hybrids, Control Concept for Split Hybrids, Feedback-Based Supervisory Controller for PHEVs, Parametric Design Considerations, Cruise and Headway Control, Antilock Brake and Traction-Control Systems, Vehicle Stability Control, Four-Wheel Steering, Active Suspensions, Overview of Intelligent Transportation Systems, Preventing Collisions, Longitudinal Motion Control and Platoons, Automated Steering and Lateral Control.	9

TEXT BOOKS

1. V Ganesan, Internal Combustion Engine, 4th edition, Tata Mc-Graw Hill, 2012.
2. Mathur.M.L & Sharma R.P, Internal Combustion Engine, Dhanpat Rai Publications, 2010.

REFERENCE BOOKS

1. Richard Stone, Introduction to Internal Combustion Engines, 4thedition, Palgrave Macmillan, 2012.
2. John B.Heywood, Internal Combustion Engine Fundamentals, 2nd Edition, Tata McGraw Hill, 2011.
3. Gupta H.N., Fundamentals of Internal Combustion Engines, Prentice Hall of India
4. F. EdwardObert, Internal Combustion Engines, Harper and Raw Publisher
5. John B. Heyword, Internal Combustion Engines Fundamentals, McGraw Hill
6. Zong Xuan, Automotive propulsion systems, CRC press, 2015.
7. A. Galip Ulsoy, Ann Arbor, Automotive Control Systems, Cambridge university press, 2012.
8. M. Thoma, F. Allgöwer, M. Morari, Identification for automotive systems, Springer, 2012.
9. B.T. Fijalkowski, Automotive Mechatronics: Operational and Practical Issues, Springer, 2011
10. Emadi, A. (Ed.), Miller, J., Ehsani, M., “Vehicular Electric Power Systems” Boca Raton, CRC Press, 2003
11. Husain, I. “Electric and Hybrid Vehicles” Boca Raton, CRC Press, 2010.

4MX2-01: Advanced Engineering Mathematics

(Common for AR, ME and MX)

Credit: 3Max **Marks: 100(IA: 30, ETE: 70)**

2L+1T+0P **End Term Exam: 3 Hours**

Course Objectives

1. To make students able to understand Laplace transform and its properties and apply the Laplace transform to solve ordinary and partial differential equations.
2. To make students able to understand the Fourier series, Fourier transforms and Z-transforms with applications in engineering science.
3. To make students able to understand a system of linear equations, interpolations, numerical differentiation and integration

Course Outcomes

After completing this course, students will be able to understand and solve

1. **CO-1:** the Laplace transform and its properties and apply the Laplace transform to solve ordinary and partial differential equations.
2. **CO-2:** the Fourier series, Fourier transforms and Z-transforms with applications in engineering science.
3. **CO-3**: a system of linear equations, interpolations, numerical differentiation and integration

S. No	Contents	Hours
1.	**Laplace transforms:** Definition, Laplace transforms of elementary functions, Properties of Laplace transforms, First shifting theorem, Change of scale property, Laplace transforms of derivatives and integrals, Laplace transform of periodic functions, Heaviside unit step function and Dirac delta function. Inverse Laplace transforms and their properties, Convolution theorem, Applications of Laplace transform for solving differential equation of first and second order with constant coefficients and partial differential equations.	10
2.	**Fourier series:** Fourier series, Fourier series of even and odd functions, Change of intervals, half-range Fourier sine and cosine series, Parseval`s identity **Z-Transform:** Definition, elementary properties and formulae, Convolution theorem, inverse Z-transform.	6
3.	**Fourier Transforms:** Fourier integrals, Fourier sine and cosine integrals. Fourier transform, Fourier sine and cosine transforms and their elementary properties, Convolution theorem, Application of Fourier transforms to BVP.	8
4.	**Numerical Analysis-I:** Forward difference operator, Backward difference operator, Shift operator, Average operator, Central difference operator and their relationship, Roots of non-linear equations: Bisection method, Regula-Falsi method, Newton-Raphson method	6
5.	**Numerical Analysis-II:** Newton‘s forward interpolation formula, Newton’s backward interpolation formula, Stirling‘s Formula; Lagrange‘s interpolation formula, Divided differences, Newton‘s divided difference formula, Gauss‘ Forward central Difference Formula, Gauss‘ Backward central Difference Formula, Numerical differentiation, Numerical Integration, Trapezoidal rule, Simpson‘s one-third rule, Simpson‘s three-eight rule.	10

TEXT BOOKS

1. R. K. Jain and S.R.K. Iyengar, “Advanced Engineering Mathematics”, Narosa Publications.

REFERENCE BOOKS

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons
2. M. K. Jain, S.R.K. Iyengar and R. K. Jain, "Numerical Methods for Scientific and Engineering Computation", New Age Pvt. Pub, New Delhi..
3. R. K. Jain and S.R.K. Iyengar, “Advanced Engineering Mathematics”, Narosa Publications.

4MX4-20: Material Testing Lab

(Common for AR, ME and MX)

Credit: 1Max **Marks: 100(IA: 60, ETE: 40)**

0L+0T+2P

Course Objectives

1. Students may apply knowledge of mathematics and engineering in calculating the mechanical properties of structural materials.
2. Ability to work on multi-disciplinary teams in the area of materials testing.
3. Ability to use the techniques, skills and modern engineering tools necessary for engineering and used in engineering design.
4. Understanding of professional and ethical responsibility in the areas of material testing.
5. Ability to communicate effectively the mechanical properties of materials.

Course Outcomes

Upon successful completion of the course the students will be able to;

1. **CO1:** The students will understand the different types of crystal structures.
2. **CO2:** The students will be able to identify and select the suitable materials for different application.
3. **CO3:** The students will be able to find out the mechanical properties of various materials.
4. **CO4:** The students will be able to prepare and evaluate the microstructures of different material specimens.
5. **CO5:** The students will be able to understand heat treatment techniques, and their effect on behavior of material.

S. No	Contents	Hours
	Material Science Lab Experiments:	
1	Study of various crystals structures through models BCC, FCC, HCP, tetrahedral and octahedral voids.	
2	Specimen preparation for micro structural examination cutting, grinding, polishing, etching.	
3	Comparative study of microstructures of different given specimens (mild steel, gray C.I., brass, cooper etc.)	
4	Heat treatment experiments such as annealing, normalizing, quenching, case hardening and comparison of hardness before and after.	
5	Study of Microstructure and hardness of steel at different rates of cooling.	
	Material Testing Lab Experiments: (At least 5 of the following)	
1	To perform Tensile/Compressive/Shear/torsion test on a given material and to determine its various mechanical properties under tensile/compression/Shear/torsional loading	
2	To determine Rockwell/ Vickers/Brinell hardness of a given material	
3	Impact testing on impact testing machine like Charpy, Izod or both.	
4	Torsion testing of a rod on torsion testing machine.	

5	Spring index testing on spring testing machine.	
6	Deflection of beam experiment, comparison of actual measurement of deflection with dial gauge to the calculated one, and or evaluation of young's modulus of beam.	
7	Study of non-destructive testing methods like magnetic flaw detector, ultrasonic flaw detector, and eddy current testing machine, dye penetrate tests.	
8	Fatigue testing on fatigue testing machine	
9	Creep testing on creep testing machine.	

4MX4-21: Fluid Mechanics Lab

(Common for AR, ME and MX)

Credit: 1Max **Marks: 100(IA: 60, ETE: 40)**

0L+0T+2P

Course Objectives

1. To get familiar students about the usage and working principle of different instruments used in fluid mechanics
2. Application of instruments to calculate various parameter such as fluid pressure, discharge, losses in pipes etc.
3. Calibration of instruments

Course Outcomes

Upon successful completion of the course the students will be able to;

1. CO1: Methods of discharge measurements on open channel flow and closed conduit flow
2. CO2 Calibration flow measuring devices used in pipes, channels and tanks assessment
3. CO3 To calculate losses in flow
4. CO4 Verification and characterization of flow through experiments

S. No	Contents	Hours
1	Introduction to various Instruments.	
2	Determination of metacentric height.	
3	Calibration of a venturi meter.	
4	Determination of frictional losses in pipes of different diameters.	
5	Determination of minor losses in pipes.	
6	Calibration of v- notch and rectangular notch.	
7	Reynolds dye experiment for flow characterization.	
8	Determination of Cc, Cv and Cd of an orifice.	
9	Verification of Bernoulli‘s theorem.	
10	Calibration of orifice meter.	
11	Verify the impulse momentum equation (impact of jet).	

Suggested readings

1. Gupta V. P (2009) “Laboratory manual of fluid mechanics and machines” CBS, 9788123900094.

4MX4-22: Sensors and Instrumentation Lab

Credit: 1Max **Marks: 100(IA: 60, ETE: 40)**

0L+0T+2P

Course Objectives

1. To make students familiar with the constructions and working principle of different types of sensors and trans ducers.
2. To make students aware about the measuring instruments and the methods of measurement and the use of diffe rent transducers.

Course Outcomes

Student will be able to –

1. Apply the use of sensors for measurement of displacement, force and pressure.
2. Employ commonly used sensors in industry for measurement of temperature, position, accelerometer, vibration sensor, flow and level.
3. Demonstrate the use of virtual instrumentation in automation industries.

S. No	Contents	Hours
1	Water level measurement kit: a) To draw I/P vs O/P characteristics. b) Study of water level indication. c) To plot the curve between error and different measured water level.	
2	To draw the characteristics of following temperature transducers: - a) PT 100 b) Thermistor c) K Type Thermocouple.	
3	LVDT Kit: a) To study excitation and balancing network. b) To study phase difference. c) To plot curve between displacement and output voltage.	
4	To study various pressure sensors like Bourdon tube, Diaphragms, Pressure Switches, Bellows etc.	
5	Design of Opto-coupler using photoelectric transducers.	
6	Torque measurement Kit: a) To study about unbalanced strain. b) To plot the curve between torque vs strain	
7	To draw characteristics of LDR.	
8	To draw Characteristics of Hall effect sensor.	

4MX4-23: Analog Electronics Lab

Credit: 1Max **Marks: 100(IA: 60, ETE: 40)**

0L+0T+2P

Course Objectives

1. To expose the students semiconductor device, performance characteristics and their application.
2. To expose different signal processing technique and characteristics.

Course Outcomes

Student will be able to -

1. Understand the characteristics of BJTs and FETs.
2. Design and analyze BJT and FET amplifier circuits.
3. Design sinusoidal and non-sinusoidal oscillators.
4. Understand the functioning of linear ICs.
5. Design of Linear IC based circuits.

S. No	Contents	Hours
1	**Plot gain:** Frequency characteristics of Transistor amplifier with and without feedback in the emitter circuit and determine bandwidths, gain bandwidth products and gains at 1kHz with and without negative feedback.	
2	Plot and study the characteristics of small signal amplifier using FET.	
3	Study of push pull amplifier. Measure variation of output power & distortion with load.	
4	Study Wein bridge oscillator and observe the effect of variation in R oscillator frequency	
5	Study transistor phase shift oscillator and observe the effect of variation in R & C on oscillator frequency and compare with theoretical value.	
6	Study the following oscillators and observe the effect of variation of C on oscillator frequency: (a) Hartley (b) Colpitts	
7	Design and Testing of Low pass and High pass Filters using Op-amplifiers.	
8	Study of a Digital Storage CRO and store a transient on it.	
9	Study of Class A, Class B and Transfer Characteristics of Power amplifiers.	
10	To plot the characteristics of MOSFET and CMOS.	
11	Study of Zero Crossing Detector, Schmitt trigger, 555 Timer.	