SYLLABUS OF
UNDERGRADUATE DEGREE COURSE

Aeronautical Engineering

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

B.Tech. : Aeronautical Engineering

2nd Year - III Semester

f THEORY										
SN	Category	Course Code	Course Title	Hours			Marks			Credit
				L	T	P	IA	ETE	Total	
1	DC	3AR4-01	Aero Engineering Thermodynamics	3	1	0	30	70	**100**	**4**
2		3AR4-02	Aerospace Materials	2	0	0	30	70	**100**	**2**
3		3AR4-03	Elements of Aeronautics	3	0	0	30	70	**100**	**3**
4		3AR4-04	Fluid Mechanics and Turbo Machines	3	1	0	30	70	**100**	**4**
5		3AR4-05	Manufacturing Processes	3	0	0	30	70	**100**	**3**
6	UC	3AR2-01	Engineering Mechanics	3	0	0	30	70	**100**	**3**
			Sub Total	**17**	**2**	**0**	**180**	**420**	**600**	**19**
PRACTICAL & SESSIONAL										
7	DC	3AR4-20	Machine Drawing Practice	0	0	2	60	40	**100**	**1**
8		3AR4-21	Production Practice Lab	0	0	2	60	40	**100**	**1**
9		3AR4-22	Fluid Mechanics and Turbo Machines Lab	0	0	2	60	40	**100**	**1**
10		3AR4-23	Thermodynamics Laboratory	0	0	2	60	40	**100**	**1**
11	UI	3AR7-30	Professional Training	0	0	2*	60	40	**100**	**1**
12	CCA	3AR8-00	SODECA/NCC/NSS/ ANANDAM/IPR	-	-	-	-	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. : Aeronautical Engineering
2nd Year - IV Semester

THEORY										
SN	Category	Course Code	Course Title	Hours			Marks			Credit
				L	T	P	IA	ETE	Total	
1	DC	4AR4-01	Heat Transfer	3	1	0	30	70	**100**	**4**
2		4AR4-02	Mechanics of Solids	3	1	0	30	70	**100**	**4**
3		4AR4-03	Aircraft Propulsion	3	0	0	30	70	**100**	**3**
4		4AR4-04	Aerodynamics-I	3	0	0	30	70	**100**	**3**
5		4AR4-05	Fuels and Combustion	3	0	0	30	70	**100**	**3**
6	UC	4AR2-01	Advanced Engineering Mathematics	3	0	0	30	70	**100**	**3**
			Sub Total	**18**	**2**	**0**	**180**	**420**	**600**	**20**
PRACTICAL & SESSIONAL										
7	DC	4AR4-20	Aircraft Propulsion Lab	0	0	2	60	40	**100**	**1**
8		4AR4-21	Materials Testing Lab	0	0	2	60	40	**100**	**1**
9		4AR4-22	Heat Transfer Lab	0	0	2	60	40	**100**	**1**
10		4AR4-23	MATLAB Programming	0	0	2	60	40	**100**	**1**
11	CCA	4AR8-00	SODECA/NCC/NSS/ ANANDAM/IPR	-	-	-	-	100	**100**	**1**
			Sub- Total	**0**	**0**	**8**	**240**	**260**	**500**	**5**
			TOTAL OF IV SEMESTER	**18**	**2**	**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**

3AR4-01: AERO-ENGINEERING THERMODYNAMICS

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**: Concept of continuum, Macroscopic approach, Thermodynamic systems: Closed, Open and Isolated systems, Property, State, Path and Process, Quasi-static process, Work, Modes of work. **Zeroth and First Law of Thermodynamics**: Zeroth law of thermodynamics, Concept of temperature and heat, Internal energy, Enthalpy, Concept of ideal and real gases, First law of thermodynamics, Applications to closed and open systems, Steady and unsteady flow energy equations. Numerical Problems	9
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, Clausius Inequality **Entropy**: Entropy, Calculation of Entropy change, Principle of entropy increase, Temperature-Entropy diagram, Second law analysis of a control volume, Numerical Problems	9
3	**Availability**: Basics: Energy in non-flow processes: Expressions for the energy of a closed system, Equivalence between mechanical energy forms and exergy, Flow of energy associated with heat flow, Exergy consumption and Entropy generation, Loss in available energy, Availability Function, Irreversibility, Numerical Problems	9
4	**Properties of Pure Substances and Gas Mixtures:** Pure substance, Concept of Phase, Graphical representation of thermodynamic properties of pure substances in solid, liquid and vapour phases, Phase rule, P-V, P-T, T-S, H-S diagrams, Properties of steam, Steam tables, Mollier chart. **Gas Mixtures:** Ideal gas, Real gas, Internal energy, enthalpy and specific heats of an ideal gas,	9

	Equations of state, Dalton's law of partial pressures, Gibbs Dalton law, Thermodynamic properties of gas mixtures, Numerical Problems	
5	**Vapour and Gas Power cycles:** **Vapour Power Cycles:** 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. **Gas Power Cycles:** Air standard efficiency, Otto cycle, Diesel cycle, Dual Cycle, Mean-effective pressure, Brayton cycle: Reheat and Regenerative cycle, Numerical Problems	9

TEXT BOOKS

1. Nag.P.K., "Engineering Thermodynamics", 6th Edition, Tata McGraw Hill (2017), New Delhi
2. Cengel Y.A., Boles M.A, Thermodynamics-An Engineering Approach, McGraw Hill, 2011
3. Richard E. Sonntag, Claus Borgnakke & Gordon J. Van Wylen, Fundamentals of Thermodynamics, 6th Edition, John Wiley and Sons Inc. New York, NY 2003.

REFERENCE BOOKS

1. Rao Y.V.C., An Introduction to Thermodynamics, Revised Edition, Universities Press.
2. Rogers G. and Mayhew Y., Engineering Thermodynamics: Work and Heat Transfer, 4th Edition, Pearson Education.
3. Jones J. B. and Dugan R.E, Engineering Thermodynamics, Prentice Hall of India.
4. Moran M. J and Shapiro H. N., Fundamentals of Engineering Thermodynamics, John Wiley and Sons.
5. Holman. J. P., "Thermodynamics", 3rd Edition, McGraw-Hill, 2007.

3AR4-02: Aerospace Materials

Credit: 2Max **Marks: 100(IA: 30, ETE: 70)**

2L+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. 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.
3. Acquire knowledge on aircraft materials- metallic and non-metallic
4. Understand the properties of super alloys, ablative materials and high energy material.
5. Study material corrosion and prevention

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: Identify appropriate aircraft materials for a given application.
4. CO4: Explain the properties of super alloys, ablative materials and high energy material.
5. CO5: Understand material corrosion process and apply prevention technique.

S. No.	Contents	Hours
1	**Introduction to Aircraft Materials:** General properties of materials, Definition of terms, Requirements of aircraft materials, Testing of aircraft materials, Inspection methods, Application and trends in usage in aircraft structures and engines, Selection of materials for use in aircraft. **Aircraft Metal Alloys:** Aluminum alloys, Magnesium alloys, Titanium alloys, Plain carbon and Low carbon Steels, Corrosion and Heat resistant steels, Maraging steels, Copper alloys, Producibility and Surface treatments aspects for each of the above.	6
2	**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. **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.	6
3	**Super Alloys:** General introduction to super alloys, Nickel based super alloys, Cobalt based super alloys, and Iron based super alloys, manufacturing processes associated with super alloys, Heat treatment and surface treatment of super alloys. **Composite Materials:** Definition and comparison of composites with conventional monolithic materials, Reinforcing fibers and Matrix materials, Fabrication of composites and quality control aspects, Carbon-Carbon Composites production, properties and applications, inter metallic matrix composites, ablative composites based on polymers, ceramic matrix, metal matrix composites based on aluminum, magnesium, titanium and nickel based composites for engines.	6

4	**Polymers, Polymeric Materials & Plastics and Ceramics & Glass:** Knowledge and identification of physical characteristics of commonly used polymeric material: plastics and its categories, properties and applications; commonly used ceramic, glass and transparent plastics, properties and applications, adhesives and sealants and their applications in aircraft.	5
5	**Corrosion and its Prevention:** Knowledge of the various methods used for removal of corrosion from common aircraft metals and methods employed to prevent corrosion. Purpose of painting, Types of aircraft paints, Aircraft painting process. **High Energy Materials:** Materials for rockets and missiles. Types of propellants and its general and desirable properties, insulating materials for cryogenic engines. Types of solid propellants: Mechanical characterization of solid propellants using uni-axial, strip-biaxial and tubular tests.	5

TEXT BOOKS

1. William D. Callister Jr Materials Science and Engineering, John Wiley & Sons., 2001.
2. G. F. Titterton, Aircraft Material and Processes, English Book Store, New Delhi, 1998.
3. H. Buhl, “Advanced Aerospace Material”, Spring Berlin 1992.

REFERENCE BOOKS

1. C G Krishnadas Nair, Handbook of Aircraft materials, Interline publishers, Bangalore, 1993,
2. B. S. Gupta, Aerospace material, Vol. 1-2-3 ARDB, Chand & Co 1996.
3. E. R. Parker, Materials for Missiles and Space, John Wiley, McGraw-Hill, 1963.
4. E. T. Hill, Materials of Aircraft Construction, Pitman London.

3AR4-03: Elements of Aeronautics

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

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

Course Objectives

1. To know the history and basic principle of aviation.
2. To understand the foundation of flight, aircraft structures, material aircraft propulsion.
3. To develop an understanding stability of an aircraft along with its different systems.

Course Outcomes

Student will be able to

1. Appreciate and apply the basic principle of aviation
2. Apply the concepts of fundaments of flight, basics of aircraft structures, aircraft propulsion and aircraft materials during the development of an aircraft
3. Comprehend the complexities involved during development of flight vehicles.

S. No	Contents	Hours
1	**Introduction to Aircrafts:** History of aviation; Atmosphere and its properties; Classification of aircrafts; Basic components of an aircraft; aircraft axis system; aircraft motions; control surfaces and high lift devices; conventional design configurations; principle of operation of each major part; Helicopters, their parts and functions. **Aircraft Structures and Materials:** Introduction; structural members; general types of construction; monocoque, semi-monocoque and geodesic structures; typical wing and fuselage structure; metallic and non-metallic materials for aircraft application..	8
2	**Basic principles of flight:** Significance of speed of sound; airspeed and groundspeed; standard atmosphere; Bernoulli's theorem and its application for generation of lift and measurement of airspeed; forces over wing section, aerofoil nomenclature, pressure distribution over a wing section. Lift and drag components – generation of lift and drag; lift curve, drag curve, types of drag, factors affecting lift and drag; centre of pressure and its significance; aerodynamic centre, aspect ratio, Mach number and supersonic flight effects; simple problems on lift and drag.	9
3	**Aircraft Propulsion:** Aircraft power plants, classification based on power plant and location and principle of operation. Turboprop, turbojet and turbofan engines; ramjets and scramjets; performance characteristics. Aircraft power plants – basic principles of piston, turboprop and jet engines; Brayton cycle and its application to gas turbine engines; use of propellers and jets for production of thrust; comparative merits and limitations of different types of propulsion engines; principle of thrust augmentation.	9
4	**Aircraft Stability:** Forces on an aircraft in flight; static and dynamic stability; longitudinal, lateral and roll stability; necessary conditions for longitudinal stability; basics of aircraft control systems. Effect of flaps and slats on lift, control tabs, stalling, gliding, landing, turning, aircraft manoeuvres; stalling, gliding, turning. Simple problems on these. Performance of aircraft – power curves, maximum and minimum speeds for horizontal flight at a given altitude; effect of changes in engine power and	9

	altitude on performance; correct and incorrect angles of bank; aerobatics, inverted manoeuvre, manoeuvrability. Simple problems.	
5	**Introduction to Aircraft Systems:** Aircraft systems (Mechanical) – hydraulic and pneumatic systems and their applications; environment control system; fuel system, oxygen system. Aircraft systems (Electrical) – flight control system, cockpit instrumentation and displays; communication systems; navigation systems; power generation systems – engine driven alternators, auxiliary power Module, ram air turbine; power conversion, distribution and management.	9

TEXT BOOKS

1. Anderson, J.D., “Introduction to Flight”, McGraw-Hill, 1995.
2. Stephen.A. Brandt,"Introduction to Aeronautics: A design perspective" American Institute of Aeronautics & Astronautics,1997
3. Fundamentals of Flight Vol-I to Vol-IV, Lalit Gupta and O P Sharma, Himalayan Books, 2006

REFERENCE BOOKS

1. Kermode, A.C., “Mechanics of Flight”, Himalayan Book, 1997
2. Flight without formulae, A.C. Kermode, Pearson Education India, 1989
3. Flight stability and automatic control, Nelson R.C, McGraw-Hill International Editions ,1998
4. Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration Ian Moir, Allan Seabridge, John Wiley & Sons, 2011

3ME4-04: Fluid Mechanics and Turbo machines

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

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

Course Objectives

1. To give fundamental knowledge of fluid, its properties and behaviour
2. To imbibe basic laws and equations used for analysis of static and dynamic fluid flows and to enable determining the losses in a flow system
3. To introduce fluid boundary layer development concept
4. To enable determining performance parameters of hydraulic pumps and turbines

Course Outcomes

Student will be able to

1. CO1: Define and distinguish and perform calculations to determine fluid properties
2. CO2: Apply fluid kinematic and dynamic relations to measure losses and discharge through pipes of different arrangements
3. CO3: Outline boundary layer properties and develop non-dimensional numbers to model fluid dynamic situations
4. CO4: Classify, compare and analyse the performance parameters of hydraulic pumps and turbines

S. No	Contents	Hours
1	**PROPERTIES OF FLUIDS:** **Introduction:** What is Fluid? -Application area of Fluid Mechanics, The No-Slip Condition, A brief history of fluid mechanics. **Classification of Fluid Flows**: System and Control Volume - Continuum-Properties of Fluids and their influence on fluid motion. **Pressure:** -Pressure at a point, Variation of pressure with depth, The barometer and atmospheric pressure, Gauge and vacuum pressures-Static, dynamic and Stagnation Pressures, Measurement of pressure, Piezometer, U-tube and differential manometers, Pitot tube, Buoyancy and Floatation	8
2	**FLUID KINEMATICS AND DYNAMICS** **Fluid dynamics:** Surface and body forces, Euler's and Bernoulli's equations for flow along a stream line, Total energy line, Hydraulic gradient line, General energy equation. **Closed conduit flow:** Reynold's experiment, Reynolds number, The entrance region, Entry length, Laminar flow in pipes, Darcy Weisbach equation, Turbulent flow in pipes, Minor losses in pipes, Pipes in series and Pipes in parallel, Measurement of flow: Venturi meter and orifice meter, Recent developments in friction and discharge measurements.	8
3	**BOUNDARY LAYER CONCEPTS AND DIMENSIONAL ANALYSIS** **Boundary Layer Concepts:** Definition, Boundary layer thickness, Displacement thickness, Momentum thickness and Energy thickness, Development of laminar and turbulent boundary layers, Boundary layer in transition, Separation of boundary layer, Submerged objects, Drag and lift, Drag force on a flat plate due to boundary layer. **Dimensional Analysis and Modeling:** Need for dimensional analysis-Dimensional Homogeneity, Dimensional analysis and similarity, The Method of Repeating Variables and the Buckingham Pi	9

	Theorem, Similitude, Types of similitude, Dimensionless parameters, Application of dimensionless parameters, Model analysis	
4	**TURBOMACHINES:** **Basics of Turbomachinery:** Hydrodynamic force of jets on stationary and moving flat, Inclined, and curved vanes, Eulers's equation, Jet striking centrally and at tip, Velocity diagrams, Work done and Efficiency, Flow over radial vanes. **Hydraulic Pumps:** Theory of roto-dynamic machines, various efficiencies, velocity components at entry and exit of the rotor, velocity triangles, Centrifugal pumps, working principle, Work done by the impeller, Performance curves, Reciprocating pump, Working principle, Rotary pumps, Classification.	9
5	**HYDRAULIC TURBINES:** Classification of turbines, Heads and efficiencies, Impulse and Reaction turbines, Pelton wheel, Francis turbine, working principle, Work done, Efficiencies, Hydraulic design, Draft tube theory, Functions and efficiency. **Performance of Hydraulic Turbines:** Turbine scaling laws, Specific speed, Characteristic curves, Governing of turbines, Selection of type of turbine, Cavitation, Surge tank, Water hammer.	9

TEXT BOOKS

1. Yunus A. Cengel and John M. Cimbala. "Fluid Mechanics Fundamentals and Applications", McGraw Hill Edition 2006, Sixth Reprint 2009.
2. Frank M. White, "Fluid Mechanics", McGraw Hill, 8th Edition, 2015
3. Dr. R. K. Bansal "A Textbook of Fluid Mechanics and Hydraulic Machines", Laxmi Publications, New Delhi, Revised Ninth Edition.
4. Dr. P. N. Modi and S. M. Seth, "Hydraulics and Fluid Mechanics Including Hydraulics Machines", ISBN-13: 9788189401269, Standard Book House.

REFERENCE BOOKS

1. Streeter, V. L. and Wylie E. B., "Fluid Mechanics", McGraw Hill Publishing Co. 2010
2. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, "Fluid Mechanics and Machinery", 2011

3ME4-05: 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.	6

	Heat input, effect of welding parameters preheating, and post heating temperature. Selection of electrodes, flux etc. Soldering, brazing and braze welding and their application.	
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.

3AR2-01: Engineering Mechanics

(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 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. 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.	8

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

3AR4-20: 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 Part B

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	36

3AR4-21: 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.	

3AR4-22: Fluid Mechanics and Turbo machines Lab

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

0L+0T+2P

Course Objectives

The objective of the course is to enable the students to gain a hands-on experience with fluidic devices, understand the fundamental concepts of measurement techniques and impart practical exposure on the performance evaluation methods of various flow measuring equipment and hydraulic turbines

Course Outcomes

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

1. CO1: Ability to analyze a variety of practical fluid-flow devices and utilize fluid mechanics principles in design
2. CO2: Ability to estimate the friction and measure the frictional losses in fluid flow
3. CO3: Ability to Evaluate and estimate the characteristic study of hydraulic turbines under different working conditions

S. No	Contents	Hours
1	Determination of meta-centric height of a given body	
2	Determination of Cd, Cv & Cc for given orifice	
3	Determination of velocity of water by Pitot tube	
4	Calibration and flow rate determination using Venturimeter and Orifice meter	
5	Verification of Bernoulli's theorem and draw the HGL, TEL	
6	Determine the Darcy's Friction factor in various diameters of pipes	
7	To study the boundary layer velocity profile over a flat plate and to determine the boundary layer thickness	
8	Determine the Minor Losses (Different Valve connections, Sudden Expansion, Sudden Contraction, Bends, Joints) in various pipe fittings	
9	Determination of the Reynolds number for laminar, turbulent and transitional flow in pipe	
10	Determine the coefficient of impact of Jet on given Vanes	
11	Determine the overall efficiency of Pelton wheel Turbine at Constant Speed and Constant Head and drawing the characteristic curves	
12	Determine the overall efficiency of Francis wheel Turbine at Constant Speed and Constant Head and drawing the characteristic curves	

Suggested readings

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

3AR4-23: Thermodynamics Lab

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

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

Course Objectives

To enhance the basic knowledge in applied thermodynamics

Course Outcomes

Student will be able to

1. Ability to perform test on diesel/petrol engine
2. Ability to explain the characteristics of the diesel/Petrol engine
3. Ability to determine the properties of the fuels.

S. No	Contents	Hours
1	Performance test on a 4-stroke engine	
2	Valve timing of a 4–stroke engine and port timing of a 2 stroke engine	
3	Determination of effectiveness of a parallel flow heat exchanger	
4	Determination of effectiveness of a counter flow heat exchanger	
5	Determination of heating value of a fuel	
6	Determination of specific heat of solid	
7	Determination of thermal conductivity of solid.	
8	Determination of thermal resistance of a composite wall.	
9	COP test on a vapour compression refrigeration test rig	
10	COP test on a vapour compression air-conditioning test rig	

4AR4-01: Heat Transfer

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

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

Course Objectives

1. To impart a comprehensive knowledge of various modes of heat transfer.
2. To empower the students for solving heat transfer problems in the industry.
3. To equip the student in the design of heat exchangers.

Course Outcomes

Student will be able to -

1. Apply the basic laws of heat transfer.
2. Solve problems of steady and unsteady state heat conduction for simple geometries.
3. Analyse natural and forced convective heat transfer process.
4. Solve radiation heat transfer problems.
5. Design of heat exchangers by LMTD and NTU methods.
6. Conduct experiments, interpret the data and analyse the heat transfer problems.

S. No	Contents	Hours
1	**Fundamental Concept**: Basic principles of heat conduction, convection and thermal radiation; Fundamental laws; Identification of significant modes of heat transfer in practical applications.	3
2	**Conduction I**: General equation of heat conduction in Cartesian, cylindrical and spherical coordinates; One dimensional steady state conduction in simple geometries - plane wall, cylindrical and spherical shells; Electrical analogy; Conduction in composite walls and shells; Critical thickness of insulation; Thermal contact resistance; Overall heat transfer coefficient; One dimensional steady conduction heat transfer with internal heat generation in plane walls, cylinders and spheres.	6
3	**Conduction II:** Steady state heat conduction in 2D systems - graphical and numerical methods of solution; Conduction shape factor; Unsteady state heat transfer – Systems with negligible internal resistance - lumped heat capacity analysis; Infinite bodies – flat plate, cylinder and sphere; Semi-infinite bodies – chart solutions.	6
4	**Convection I**: Review of fluid mechanics concepts; Equations of conservation of mass, momentum and energy. Forced convection: External flow over flat plate, cylinder, sphere and bank of tubes; Internal flow through circular pipes; Boundary layers for flow over a flat plate, curved objects and flow through 90 circular pipes.	5
5	**Convection II:** Natural convection: Steady one dimensional flow over vertical, horizontal and inclined plates; Steady one dimensional flow over cylinders and spheres; Combined free and forced convection; Introductory concepts of boiling and condensation.	6
6	**Radiation:** Introduction, Physical Mechanism, Radiation Properties/laws, Radiation Shape Factor, Relations between shape factors, Heat exchange between non-black bodies, Infinite Parallel Planes, cylinders, spheres, Radiation Shields. Solar Radiation, Effect of Radiation on Temperature Measurement	7
7	**Heat Exchangers:** Introduction, Analysis of Heat Exchangers: LMTD for parallel flow HX, LMTD for counter Flow HX, Effectiveness for parallel Flow /Counter Flow HX, Design of HX, Compact Heat Exchangers, Cross flow Heat Exchangers	8

	Boiling And Condensation: boiling types, mechanism, Pool Boiling: Nucleate Boiling, CHF Flow Boiling: Plug/Slug flow, types, Mechanism Film-wise / Drop wise Condensation	

TEXT BOOKS

1. Yunus A Cengel and Afshin J Ghajar, Heat and Mass Transfer: Fundamentals and Applications, 5th edition, McGraw-Hill, 2015.
2. R C Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, 5th edition, New Age International, 2017.

REFERENCE BOOKS

1. Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, Fundamentals of Heat and Mass Transfer, 7th edition, Wiley, 2011.
2. J P Holman and Souvik Bhattacharyya, Heat Transfer, 10th edition, McGraw-Hill, 2016.

4AR4-02: 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.

4AR4-03: Aircraft Propulsion

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

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

Course Objectives

1. Know the design and performance of subsonic and supersonic inlets, types of combustion chambers and factors affecting the combustors.
2. Discuss the types of nozzles, flow conditions in nozzles, interaction of nozzle flow with adjacent surfaces and thrust reversal
3. Explain different types of compressors and turbines, work done, velocity diagrams and stage efficiency calculations.

Course Outcomes

Student will be able to -

1. CO1: Students will be able to review the basic thermodynamic principles and fundamentals of gas turbine engines
2. CO2: Students will be able to outline the concepts of subsonic and supersonic inlets for jet engines
3. CO3: Students will be able to evaluate the operating characteristics of compressors and turbines in terms of blade shapes, angles, and direction of rotation
4. CO4: Students will be able to describe the fundamentals of combustion chamber, nozzle, ramjet and rocket propulsion

S. No	Contents	Hours
1	**Air-Breathing Engines Classes:** Classification, operational envelopes; description and function of gas generator, turbojet, turbofan, turboprop, turbo shaft, ramjet, scramjet, turbojet/ramjet combined cycle engine; Engine thrust, takeoff thrust, installed thrust, thrust equation; engine performance parameters, specific thrust, specific fuel consumption and specific impulse, thermal efficiency, propulsive efficiency, engine overall efficiency and its impact on aircraft range and endurance; engine cycle analysis and performance analysis for turbojet, turbojet with afterburner, turbofan engine, turboprop engine.	8
2	**Inlets and Combustion Chambers:** Internal flow and stall in subsonic inlets, relation between minimum area ratio and eternal deceleration ratio, diffuser performance, supersonic inlets, starting problem on supersonic inlets, shock swallowing by area variation; Classification of combustion chambers, combustion chamber performance, effect of operating variables on performance, flame stabilization.	8
3	**Nozzles:** Theory of flow in isentropic nozzles, nozzles and choking, nozzle throat conditions, nozzle efficiency, losses in nozzles. Over expanded and under expanded nozzles, ejector and variable area nozzles, interaction of nozzle flow with adjacent surfaces, thrust reversal.	8
4	**Compressors:** Principle of operation of centrifugal compressor and axial flow compressor, work done and pressure rise, velocity triangles, degree of reaction, free vortex and constant reaction designs of axial flow compressor, performance characteristics of centrifugal and axial flow compressors, stage efficiency calculations, cascade testing.	8
5	**Turbines:** Principle of operation of axial flow turbines, limitations of radial flow turbines, work	8

	done and pressure rise, velocity triangles, degree of reaction, free vortex and constant angle designs, performance characteristics, sample ramjet design calculations, flame stability problems in ramjet combustors, integral ram rockets.	

TEXT BOOKS

1. Hill, P.G. & Peterson, C.R. ―Mechanics & Thermodynamics of Propulsion, Addison Wesley Longman INC, 1999.
2. Mattingly J.D., ―Elements of Propulsion: Gas Turbines and Rocket, AIAA, 1991.

REFERENCE BOOKS

1. Cohen, H. Rogers, G. F.C. and Saravanamuttoo, H.I.H. ―Gas Turbine Theory, Longman, 1989.
2. Oates, G.C. - Aero thermodynamics of Aircraft Engine Components, AIAA Education Series, New York, 1985.

4AR4-04: Aerodynamics I

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

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

Course Objectives

1. To introduce fundamental aerodynamic theories and aerodynamic characteristics of airfoils and wings
2. To familiarize students with viscous flows

Course Outcomes

Student will be able to -

1. CO1: Student will be able to classify airfoils and label their nomenclature; apply governing equations to formulate necessary subsidiary equation in order to determine the aerodynamic forces
2. CO2: Students will be able to explain potential flow theories and solve their combinations.
3. CO3: Students will be able to estimate the aerodynamic characteristics of airfoils
4. CO4: Students will be able to estimate the aerodynamic characteristics of wings
5. CO5: Students will be able to formulate and solve boundary layer problems

S. No	Contents	Hours
1	**Aerodynamic Forces and Moments:** Euler equation, incompressible Bernoulli's equation. Streamlined and bluff-bodies. Airfoil nomenclature and classification, Centre of pressure, aerodynamic centre and aerodynamic moment, generation of lift, drag and moment, incompressible flows over airfoils, calculation of lift and drag from measured pressure distribution. Low speed wind tunnels.	8
2	**Potential Flows:** Circulation and vorticity, Stoke's theorem, streamline, stream function. Irrotational flow, potential function, equipotential lines, governing equation for irrotational and incompressible fluid flow, elementary flows and their combinations. Ideal Flow over a circular cylinder, D'Alembert's paradox, Magnus effect, Kutta Joukowski's theorem, real flow over smooth and rough cylinder.	8
3	**Airfoils:** Low speed aerodynamic characteristics of symmetric and cambered airfoils. Concept of point vortex, line vortex and vortex sheet, Kutta condition, Kelvins circulation theorem and starting vortex, Classical thin airfoil theory – symmetric & cambered airfoils.	8
4	**Wings:** Finite wing nomenclature. Incompressible flow over wing, vortex filament, bound vortex, horse shoe vortex, downwash, induce angle of attack and drag. Type of drag, Biot- savart law and Helmholtz's vortex theorem. Prandtl's lifting line theory and limitations. Elliptic lift distributions, expression for induced angle of attack and induce drag. Two dimensional and three-dimensional wings lift curve slope and effect of aspect ratio. High lift devices.	8
5	**Viscous Flows:** Boundary layer equations for a steady, two-dimensional incompressible flow, boundary layer growth over a flat plate, critical Reynolds number, Blasius solution - self-similar solutions and other important results. Basics of turbulent flow – one and two equation models.	8

TEXT BOOKS

1. Anderson, Jr., J.D., Fundamentals of Aerodynamics, McGraw-Hill Education; 6th edition, 2016

REFERENCE BOOKS

1. Bertin, J.J., Aerodynamics for Engineers, Fourth edition, Pearson Education, 2011
2. Arnold M. Kuethe and Chuen–Yen Chow, "Foundations of Aerodynamics: Bases of Aerodynamic Design", John Wiley & Sons; 5th edition, 1997
3. McCormick, B.W., Aerodynamics, Aeronautics, & Flight Mechanics, second edition, John Wiley, 2009
4. Jan Roskam and Chuan-Tau Lan, Airplane Aerodynamics and Performance, DAR corporation, third edition, 1997

4AR4-05: Fuels and Combustion

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

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

Course Objectives

1. Comprehend the basic properties of fuel.
2. Acquire the knowledge of fuel treatment.
3. Understand the combustion fundamentals and performance

Course Outcomes

Student will be able to –

1. Explain the fuel properties and fuel treatment process.
2. Select the alternative fuels for aerospace applications.
3. Compute the combustion performance.

S. No	Contents	Hours
1	**Fuel Properties:** Fuel Properties, Relative Density, API Gravity, Molecular Mass, Distillation Range, Vapor Pressure, Flash Point, Volatility Point, Viscosity, Surface Tension, Freezing Point, Specific Heat, Latent Heat, Thermal Conductivity, Combustion Properties of Fuels, Calorific Value, Enthalpy, Spontaneous-Ignition temperature, Limits of Flammability, Smoke Point, Luminometer Number, Smoke Volatility Index, Pressure and Temperature Effects, Sub atmospheric Pressure, Low Temperature, High Temperature	8
2	**Fuel Treatment:** Introduction, Types of Hydrocarbons, Paraffins, Olefins, Naphthenes, Aromatics, Production of Liquid Fuels, Removal of Sulfur Compounds, Contaminants, Asphaltenes, Gum, Sediment, Ash, Water, Sodium, Vanadium, Additives, Gum Prevention, Corrosion Inhibition/Lubricity Improvers, Anti-Icing, Antistatic–Static Dissipators, Metal Deactivators, Antismoke.	9
3	**Alternative Fuels aerospace applications:** Hydrogen, Methane, Propane, Ammonia, Alcohols, Slurry fuels, Synthetic fuels, Fuels Produced by Fischer–Tropsch Synthesis of Coal/Biomass, Biofuels, Alternative fuel Properties, Combustion and Emissions Performance, Fischer–Tropsch Fuels, Biodiesel Fuels, Highly Aromatic (Broad Specification). **Basic Considerations:** Introduction to Gas turbine Combustor, Basic Design Features, Combustor Requirements, Combustor Types and parts, Fuel Preparation, Atomizers, liner wall-cooling Techniques, combustor stability limits, combustor exit temperature traverse quality (pattern factors), Combustors for Low Emissions.	9
4	**Combustion Fundamentals:** Deflagration, Detonation, Classification of Flames, Physics of combustion Chemistry, Flammability Limits, Global Reaction-Rate Theory, Weak Mixtures, Rich Mixtures, Laminar Premixed Flames, laminar and turbulent flame burning velocity, measurement techniques for flame velocity, Factors Influencing Laminar Flame Speed, Equivalence Ratio, Initial Temperature, Pressure, Laminar Diffusion Flames, Turbulent Premixed Flames, Flame Propagation in Heterogeneous Mixtures of Fuel Drops, Fuel Vapor and Air. Combustion flame characterization: Droplet and Spray Evaporation, Heat-Up Period, Evaporation Constant, Convective Effects, Effective Evaporation Constant, Spray Evaporation,	9

	Ignition Theory, Gaseous Mixtures, Heterogeneous Mixtures, Spontaneous Ignition, Flashback, Stoichiometry, Adiabatic Flame Temperature, Factors Influencing the Adiabatic Flame Temperature, Fuel/Air Ratio, Initial Air Temperature, Pressure.	
5	**Combustion Performance:** Combustion Efficiency, The Combustion Process, Reaction-Controlled Systems, Burning Velocity Model, Stirred Reactor Model, Mixing-Controlled Systems, Evaporation-Controlled Systems, Reaction- and Evaporation Controlled Systems. Flame Stabilization & Fuel Classification: Definition of Stability Performance, Measurement of Stability Performance, Bluff-Body Flame holders, Stabilization, Mechanisms of Flame Stabilization, Flame Stabilization in Combustion Chambers, Classification of Liquid Fuels, Aircraft Gas Turbine Fuels, Engine Fuel System, Aircraft Fuel Specifications, Classification of Gaseous Fuels.	9

TEXT BOOKS

1. Arthur H. Lefebvre & Dilip R. Ballal, Gas Turbine Combustion, CRC Press, 3rd Edition, 2010
2. Minkoff, G.J., and C.F.H. Tipper, Chemistry of Combustion Reaction, London Butterworths, 1962.
3. Samir Sarkar, Fuels & Combustion, Orient Long man 1996.

REFERENCE BOOKS

1. Wilson, P.J. and J.H. Wells, Coal, Coke and Coal Chemicals, McGraw-Hill, 1960.
2. Williams, D.A. and G. James, Liquid Fuels, London Pergamon, 1963.
3. Gas Engineers Handbook, New York, Industrial Press, 1966.

4AR2-01: Advanced Engineering Mathematics

(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 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
	Total	40

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.

4AR4-20: Aircraft Propulsion Lab

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

0L+0T+2P

Course Objectives

To familiarize the students to the working of jet engines and its different working conditions

Course Outcomes

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

1. CO1: Students will be able to understand the heat transfer analysis over the surface of the aircraft structure,
2. CO2: Students will be able to understand the working of different jet engines

S. No	Contents	Hours
1	Study of jet engines parts	
2	Study of free convective heat transfer over a flat plate	
3	Study of forced convective heat transfer over a flat plate	
4	Ignition studies of solid and liquid propellants	
5	Operation of a ramjet engine	
6	Velocity Profile Study of Free Jet	
7	Velocity Profile Study of Wall Jet	
8	Study of Thrust of hybrid propulsion system with oxidiser-fuel mixing ratio	
9	Preparation of fuel grain for hybrid rocket	
10	Burning rate measurement of solid propellants in a strand burner	

4AR4-21: Materials 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.	

4AR4-22: Heat Transfer Lab

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

0L+0T+2P

Course Objectives

1. Understand the various forms of heat transfer and their applications in real life problems.
2. Analyze different methods to calculate the heat transfer coefficient in various heat transfer problems.
3. Analyze the theoretical knowledge and apply it in conducting experiments in the forms of heat transfer.

Course Outcomes

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

1. Perform steady state conduction experiments to estimate thermal conductivity of different materials for plane, cylindrical and spherical geometries
2. Perform the transient heat conduction experiment and obtain variation of temperature along the length of the pin fin.
3. Estimate heat transfer coefficients in forced convection, free convection and determine effectiveness of heat exchangers
4. Perform radiation experiments: determine surface emissivity of a test plane and Stefan-Boltzmann's constant and compare with theoretical values
5. Estimate heat transfer coefficients in condensation, boiling and effectiveness of heat pipe

S. No	Contents	Hours
1	Introduction to laboratory, experiments, evaluation plan etc.	
2	Determination of the thermal conductivity of a given metal sample and comparison with tabulated values.	
3	Determination of the thermal conductivity of a given liquid and comparison with tabulated values.	
4	Heat conduction in spherical coordinate system.	
5	Study of heat conduction by electrical analogy: experiment on a composite wall.	
6	Determination of rate of heat transfer in natural convection from a cylinder and comparison with theoretical calculations.	
7	Determination of rate of heat transfer in forced convection from a heated pipe and comparison with theoretical calculations.	
8	Prediction of temperature distribution and efficiency of a pin fin under forced and free convection and comparison with theoretical calculations.	
9	Study of the regimes of pool boiling and determination of critical heat flux	
10	Determination of emissivity of a given surface.	
11	Determination of Stefan-Boltzmann constant and comparison with reference value	
12	Demonstration of condenser, heat pipe and mass transfer apparatus.	

4AR4-23: MATLAB Programming

(Common for AR, ME and MX)

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

0L+0T+2P

Course Objectives

1. To Impart the Knowledge to the students with MATLAB software.
2. To provide a working introduction to the MATLAB technical computing environment.
3. To introduce students the use of a high-level programming language, MATLAB.

Course Outcomes

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

1. Understand the basics of MATLAB
2. Understand solving linear and polynomial equations using MATLAB

S. No	Contents	Hours
1	Study of Introduction to MATLAB	
2	Study of basic matrix operations	
3	Script Files and Function Files	
4	To solve linear equation, Gaussian Elimination	
5	Determination of Eigen values and Eigen vectors of a Square matrix.	
6	Polynomial Curve Fitting, Least Square Curve Fitting	
7	Numerical Integration (Quadrature), Double Integration	
8	A first-order linear ODE, A second-order linear ODE	
9	Synthesis of Any Mechanism	
10	Determination of roots of a polynomial.	
11	Basics of 2-D and 3-D plots	