VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

For
Second Year
of
Four Year Undergraduate Programme
Leading to
Bachelor of Technology (B Tech) Degree in Mechanical Engineering

Implemented from the batch admitted in Academic Year 2023-24

B. Tech. Mechanical Engineering

Program Educational Objectives (PEOs)

1. To attain Analytical, Experimental and Computational expertise in Mathematics, Applied Sciences and Core Engineering subject domain.
2. To discharge responsibilities towards society by achieving high standards of professionalism, leadership and ethical behavior.
3. To comprehend the need for higher studies and lifelong learning so as to remain in competitive and sustainable environment.

Program Outcomes (POs)

PO1: Apply knowledge of mathematics, science and engineering to design, analyze and evaluate mechanical components & complex systems.

PO2: Analyze problems of mechanical engineering including design thermal and manufacturing industrial systems.

PO3: Design, implement, and evaluate mechanical systems and processes considering public health, safety, cultural, societal and environmental issues.

PO4: Design and conduct experiments using domain knowledge and analyze data to arrive at valid conclusions.

PO5: Apply recent techniques, skills, knowledge and computer based methods & tools to solve mechanical problems.

PO6: Analyze the local and global impact of modern technologies on individual organizations, society and culture.

PO7: Apply knowledge of contemporary issues to investigate and solve problems with a concern for sustainability and eco-friendly environment.

PO8: Exhibit responsibility in professional, ethical, legal and social issues.

PO9: Function effectively in teams, in diverse and multidisciplinary areas to accomplish common goal.

PO10: Effective written and verbal communication on complex engineering activities and exhibit leadership qualities.

PO11: Apply management principles to manage projects in multidisciplinary environment.

PO12: Pursue life-long and independent learning as a means to enhance knowledge and skills.

Program Specific Outcomes (PSOs)

Our Graduate should be able to apply principles of Mechanical Engineering to:

1. Specify, manufacture, test, operate and document basic mechanical systems and processes.
2. Analyse, design, develop and implement advanced mechanical systems and processes.
3. Select solutions to the mechanical engineering problems based on ethics, sustainability and long term benefits to society.

	V J T I Veermata Jijabai Technological Institute (Central Technological Institute, Maharashtra State, INDIA) H. R. Mahajani Marg, Matunga, Mumbai 400019 Tel.No. +91 22 24198101-02 Fax +91 22 24102874 www.vjti.ac.in

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Credit Framework for UG Programme in Mechanical Engineering (Level 5.0- UG Diploma) - Semester - III

Sr.	Course Type	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
									TA	MST	ESE
1	PCC	R5MA2002T	Mathematics for Mechanical Engineers	3	0	0	3	3	20	30	50
2	PCC	R5ME2001T	Manufacturing Technology	3	0	0	3	3	20	30	50
3	PCC	R5SE2004T	Mechanics of Deformable Solids	3	0	0	3	3	20	30	50
4	PCC	R5ME2002T	Applied Thermodynamics	2	0	0	2	2	20	30	50
5	PCC	R5ME2003T	Machine Drawing	2	0	0	2	2	20	30	50
6	PCC	R5ME2004T	Measurement and Metrology	3	0	0	3	3	20	30	50
7	MDM		Multi-disciplinary Minor-I	2	0	0	2	2	20	30	50
8	VSEC	R5ME2001L	Manufacturing Technology Laboratory	0	0	2	2	1	ISCE :60		40
9	VSEC	R5ME2003L	Machine Drawing Laboratory	0	0	2	2	1	ISCE :60		40
10	PCC	R5ME2004L	Measurement and Metrology	0	0	2	2	1	ISCE :60		40
11	VEC	R5CH2401T	Environmental Science	2	0	0	2	2	ISCE :60		40
			Total	20	0	6	26	23			

Abbreviations: **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **ISCE** In-semester Continuous Evaluation, **PCC** Program Core, **MDM** Multi-Disciplinary Minor **VSEC** Vocational and Skill Enhancement Course, **OE** Open Elective, **VEC** Value Education Course

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Credit Framework for UG Programme in Mechanical Engineering (Level 5.0- UG Diploma) - Semester - IV

Sr.	Course Type	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
									TA	MST	ESE
1	PCC	R5ME2005T	Kinematics of Machines	3	0	0	3	3	20	30	50
2	PCC	R5ME2006T	Fluid Mechanics	3	0	0	3	3	20	30	50
3	PCC	R5ME2007T	Mechatronics, Robotics & Control	3	0	0	3	3	20	30	50
4	PCC	R5ME2008T	Digital Manufacturing	3	0	0	3	3	20	30	50
5	MDM		Multi-disciplinary Minor-II	2	0	0	2	2	20	30	50
6	VEC	R5HS2402T	Universal Human Values	2	0	0	2	2	ISCE :60		40
7	PCC	R5ME2006L	Fluid Mechanics Laboratory	0	0	2	2	1	ISCE :60		40
8	VSEC	R5ME2007L	Mechatronics, Robotics & Control Laboratory	0	0	2	2	1	ISCE :60		40
9	VSEC	R5ME2008L	Digital Manufacturing	0	0	2	2	1	ISCE :60		40
10	AEC		Modern Indian Language	2	0	0	2	2	ISCE :60		40
11	CEP/FP	R5ME2601P	Comm. Engg. Project / Field Project	0	0	4	4	2	ISCE :60		40
			Total	18	0	10	28	23			

Abbreviations: **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **ISCE** In-semester Continuous Evaluation, **PCC** Program Core, **MDM** Multi-Disciplinary Minor **VSEC** Vocational and Skill Enhancement Course, **OE** Open Elective, **VEC** Value Education Course, **AEC** Ability Enhancement Course, **CEP** Community Engineering Project, **FP** Field Project

List of Exit Courses after completion of Semester III and IV

1. Exit option is available for students those who have earned the total 88 credits at the End of Second Semester.
2. Student who wants to avail the exit option after first year have to earn additional 6-8 credits from the list of courses shown below.
3. These courses student have to complete within summer vacation after 2nd Year.
4. After fulfilment as mentioned in 1 to 3 above, Students can earn U.G Diploma and same will be issued by the Institute.

List of Exit Courses after completion of Semester III and IV: Mechanical Engineering

Sr.	Course Type	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
									TA	MST	ESE
1	EC	R5ME2901I	Internship (6-8 weeks)					6	ISCE :60		40
2	EC	R5ME2902L	Computer Aided Drawing	0	0	4	4	2	ISCE :60		40
3	EC	R5ME2903L	Machining	0	0	4	4	2	ISCE :60		40
4	EC	R5ME2904L	Solid Modelling & 3 D Printing laboratory	0	0	4	4	2	ISCE :60		40

Abbreviations: **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **ISCE** In-semester Continuous Evaluation, **PCC** Program Core, **OJT** On Nob Training

SEMESTER-III

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – III
Course Code	**R5MA2002T**	
Course Title	**Mathematics for Mechanical Engineers**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Apply the discrete and continuous probability distributions to find probabilities and expected value of a random variable.
2. Apply Laplace transforms and Inverse Laplace transforms to solve ordinary differential equations.
3. Find the Fourier series representation of a periodic function.
4. Solve linear system of equations and non -linear equations using numerical methods.
5. Apply different techniques like interpolation, numerical integration to solve different engineering problem.
6. Solve initial and boundary value problems in differential equations using numerical methods.

Course Contents

Probability distributions

Review of probability (Sample space, random experiment and events), Conditional probability, dependent and independent events, Bayes theorem, Random variables - discrete and continuous, probability density function, cumulative distribution function, Moment generating function, Expectation, variance, Joint probability, marginal and conditional p.m.f.s, Conditional expectation, Special discrete distributions- Binomial, Poisson, Geometric and Negative Binomial distribution.
Special continuous distributions - Normal distribution, Exponential distribution, additive properties of variables, Central limit theorem.

Laplace Transforms

Definition of the Laplace transform, Laplace transforms of standard functions like polynomials, trigonometric. Exponential, hyperbolic functions.
Properties of Laplace transform: Linearity, First shifting theorem, change of scale, Multiplication and division by t, second shifting theorem. Transforms of derivatives and integrals
Heaviside unit step function, Dirac's delta function, Laplace transform of Periodic function,
Inverse Laplace transforms using linear property, partial fractions and convolution theorem,
Solution of Ordinary Differential Equations using Laplace and Inverse Laplace transforms.

Fourier Series

Orthogonal and Orthonormal sets, Expressions of a Function in Series of Orthogonal Functions. Dirchlet's conditions. Fourier series of periodic function with period 2l, 2π. Fourier series of even and odd functions. Half range series expansion, Parseval's Identity.

Numerical methods

Numerical solutions of non-linear equations, Solutions of Linear systems of equations by numerical methods, Interpolation by Lagrange polynomials, Integration by trapezoidal and Simpson's rule, Single and Multi-step methods for solving first order differential equations.

Text Books

1. Fundamentals of Mathematical Statistics by V. K. Kapoor and S. C. Gupta, Sultan Chand and Sons, 2020.
2. Probability and Statistics for Engineers and Statistics by Rorald Walpole, 9^{th} edition, Pearson India.
3. M.K.Jain, S.R.K. Iyengar, R.K.Jain, Numerical methods for scientific and engineering computation, Fourth Edition.
4. Erwin Kreyszig, Advanced Engineering Mathematics, 10^{th} Edition, John Wiley & sons, 2006.
5. Ramana B. V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11^{th} Reprint, 2010.
6. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36^{th} Edition, 2010.

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – III***
Course Code	**R5ME2001T**	
Course Title	**Manufacturing Technology**	
Prerequisites	**Manufacturing Processes**	

COURSE OUTCOMES

The student should be able to –

1. Illustrate the use of various tools used in industries to manufacture the component.
2. Identify effect of various parameters on tool life.
3. Select appropriate machining process depending upon desired output characteristics
4. Optimize cost of component manufacturing.

Course Contents

Tool Geometry

Tool signature of single point cutting tools – ASA, ORS, MRS and NRS systems. Tool geometry of drills, reamers, milling cutters, broaches, gear hobs.

Tool Wear, Tool Life and Machinability

Tool wear – types, mechanisms and measurement. Tool life equations. Effect of machining parameters on tool life.Machinability criteria and its measurement. Coolants – functions, types, selection, effect on cutting forces, tool life and surface finish.

Metal Cutting Theory

Features of commonly used machining processes and machining parameters. High Speed Machining. Cutting Tools types, materials, properties and tool geometry. Mechanism of chip formation, Orthogonal and Oblique cutting, Chip flow direction in turning, shaping, drilling and milling with force analysis. Temperature in cutting and Cutting Fluids.

Economics of Machining

Costs associated with machining operations. Calculation of optimum cutting for minimum cost and maximum production rate. Product design considerations in machining. Process planning, make/buy decisions, automated process planning, concurrent engineering.

Sheet Metal Working

Press – Types, classifications, operations, specifications and selection. Press tool components, Types of Dies – Piercing, Blanking, Progressive, Compound and Combination, Cutting Action in shearing of metals in Press Tool operations, Effect of clearance, Cutting force calculations, Methods of reducing cutting forces, Blanking and Piercing Die Design, Design principles of Bending Dies.

Jigs and Fixtures

Parts, Construction, Types and operations on Jigs and Fixtures. Principles of Jigs and Fixture design location, clamping, clearance, stability and handling. Design of Jigs and Fixture of simple components.

Non-Conventional Machining-I (Mechanical and Chemical Processes)

Introduction, Classification, Principle, Working and Applications of Chemical Machining, Electrochemical Machining, Abrasive Jet Machining, Ultrasonic Machining.

Non-Conventional Machining-II (Electrical and Thermal Processes)

Principle, Working and Applications of Electric Discharge Machining, Electron Beam Machining, Ion Beam Machining, Plasma Arch Machining, Laser Machining- Cutting and Welding

Superfinishing Processes: Lapping, Honing, and polishing. Advanced super finishing processes.

Micromachining Processes: Micromanufacturing- Overview, Diamond Micromanufacturing, High Resolution Lithography, LIGA Process, Self-Assembly, etc.

Gear Manufacturing

Gear materials and methods of gear manufacture. Form and generation methods of gear cutting – milling, shaping, planning, Cutting of spur, helical and straight bevel gears. Gear finishing operations – shaving, grinding, lapping and honing.

Text Books

1. M.P. Groover, Fundamental of Modern Manufacturing: Materials, Processes and Systems. John Wiley and Sons, Fifth Edition, 2012
2. Chapman, Workshop technology vol. I,II & III, Edward Arnold Publication Ltd., London
3. Manufacturing Engineering & Technology, S. Kalpakjian and S. R. Schmid, Fourth Edition; Prentice Hall, 2001.
4. S.K. Hajra Choudhari, Workshop Technology, Vol. I & II, Media Promoters & Publishers, Mumbai.
5. Hoffman, Introduction to Jigs and Fixtures, Galgotia Publishers, Fifth Edition, 2008

Recommended Reading

1. HMT Hand book, Production Technology, Tata McGraw Hill Education Private Limited, 2001
2. P. C. Sharma, Production Engineering, Khanna Publications, Eighth Revised Edition, 1999
3. S. E. Rusinoff, Manufacturing Processes, Times India Press, Reprint Edition, 1962
4. Doyle, Manufacturing Processes and Materials for engineers, Prentice Hall of India Press
5. S. K. Basu, Fundamentals of Tool Design, Oxford & IBH Publishing Co. Pvt. Ltd.
6. Frank W. Liou, Rapid Prototyping & Engineering Applications, CRC Press, Taylor & Francis Group, 2011

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester –III***
Course Code	**R5SE2004T**	
Course Title	**Mechanics of Deformable bodies**	
Prerequisites	**Engineering Mechanics, Mathematics - I & II**	

Course Content

Simple Stresses and Strains

Mechanical properties of materials, analysis of internal forces, simple stress and strain, stress-strain curve, Hooke's law, modulus of elasticity, shearing, thermal stress, Hoop stress, Poisson's ratio, volumetric stress, bulk modulus, shear modulus, relationship between elastic constants. Stresses in thin cylindrical and spherical shells.

Strain energy and resilience

Load deflection diagram, strain energy, proof resilience, stresses due to gradual, sudden and impact loadings, shear resilience, strain energy in terms of principal stresses.

Shear and Moment in Beams

Concept of shear force and bending moment in beams due to point load UDL, UVL and couple, interpretation of vertical shear and bending moment, relations among load, shear force and bending moment. Shear force and bending moment diagrams for beams subjected to combination of different types of loads.

Stresses in Beams

Moment of inertia of different sections, bending and shearing stresses in a beam, theory of simple bending, derivation of flexural formula, economic sections, horizontal and vertical shear stress, distribution shear stress for different geometrical sections- rectangular, solid circular, I-section, other sections design for flexure and shear.

Combined Stresses

Combined axial and flexural loads, middle third rule, kernel of a section, load applied off the axes of symmetry.

Principle stresses and strains

Uni-axial stress, simple shear, general state of stress for 2D element, ellipse of stress, principle stresses and principal planes, principal strains, shear strains, strain rosettes, Mohr's circle for stresses and strains.

Beam Deflections

Differential equation of deflected beam, slope and deflection at a point, calculations of deflection for determinate beams by double integration and Macaulay's method, Method of superstition

Torsion

Introduction and assumptions, derivation of torsion formula, torsion of circular shafts, stresses and deformation in determinate solid/ homogeneous/composite shafts, torsional strain energy.

Columns and Struts

Concept of short and long Columns, Euler and Rankine's formulae, limitation of Euler's formula, equivalent length, eccentrically loaded short compression members.

Text Books

1. S.S. Ratan, Mechanics of Materials, Tata McGraw Hill Pvt. Ltd
2. S.M.A. Kazimi, Solid Mechanics, McGraw Hill, First Revised Edition, 2017
3. F.L. Singer and Pytel, Strength of Materials, Harper Collins Publishers, 2002.
4. S. Timoshenko, Strength of Materials: Part-I (Elementary Theory and Problems), CBS Publishers, New Delhi

Recommended Reading

1. E.P. Popov, Introduction to Mechanics of Solid, prentice- Hall, Second Edition 2005.
2. S.H. Crandall, N.C. Dahl and T.J.Lardner, An introduction to the Mechanics of Solids, Tata McGraw Hill, Third Edition, 2017.
3. G H Ryder, Strength of Materials Palgrave Macmillan; International student edition.
4. James M. Gere and Barry J. Goodno, Mechanics of Materials , Cengage Learning, 6^{th} Ed, 2009
5. Gere and Timoshenko , Mechanics of Materials, CBS 2nd Edition
6. Timoshenko and Youngs , Elements of Strength of Materials , Affiliated East -West Press
7. Beer, Johnston, D E wolf and Mazurek, Mechanics of Materials, TMH Pvt Ltd., New Delhi
8. I H Shames, Introduction to Solid Mechanics, Prentice Hall India.
9. W. Nash, Strength of Materials , Schaum's Outline Series, McGraw Hill Publication, Special Indian Edition
10. R. Subramanian, Strength of Materials by, Oxford University Press, Third Edition 2016

Links for online NPTEL/SWAYAM courses:

1. http://www.nptelvideos.in/2012/11/strength-of-materials-prof.html
2. https://swayam.gov.in/nd1_noc20_ce34

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – III***
Course Code	**R5ME2002T**	
Course Title	**Applied Thermodynamics**	
Prerequisites	**Physics, Engineering Mathematics, Engineering Thermodynamics**	

COURSE OUTCOMES

The student should be able to –

1. Examine the performance of Steam Generators
2. Analyse the performance of Steam Nozzles and Turbines.
3. Investigate the parameters affecting the performance of a Compressor.
4. Evaluate the performance of Steam & Gas Turbine Power Plants.
5. Analyse the performance of Refrigeration & Psychrometric Processes.

Course Contents

Steam Generators

Classification of Boilers, Ideal requirements of a Boiler, Fire tube and Water tube boiler, Low pressure and high pressure boilers, important features of HP boilers.
Mountings and Accessories,
Equivalent evaporation of boilers, Boiler performance test, Boiler efficiency.

Steam Turbines

Steam Nozzles : Isentropic flow of Steam through Convergent and Convergent-Divergent Nozzles, Nozzle efficiency, Velocity Coefficient.
Steam Turbine : Basics of Steam Turbine, Classification, Pressure and Velocity variation along the flow direction, Compounding of turbine.
Impulse Turbine – Velocity Diagram, condition for max efficiency,
Reaction Turbine – Velocity Diagram, Degree of Reaction, Parson’s Turbine, Condition for maximum efficiency.

Compressors

Classification of compressors.

Reciprocating Compressors : Single – stage with and without clearance, work & power calculations, FAD and volumetric Efficiency. Multistaging with intercooling.

Introduction to Rotary compressors, Axial Compressors and Centrifugal Compressors.

Gas & Steam Turbine Power Plants

Gas Turbine Power Plant : Ideal Brayton Cycle, Actual Barryton Cycle.
Methods to increase efficiency – Intercooler, Reheat, Regeneration.

Steam Turbine Power Plant – Ideal Rankine Cycle, Actual Rankine Cycle.

Reverse Power (Refrigeration) Cycles

Reverse Carnot Cycle.

Reverse Brayton Cycle, Reverse Stirling Cycle and Vapour Compression Cycle as the variants of Reverse Carnot Cycle.

Calculation of Coefficient of Performance (COP) for Reverse Power Cycles.

Text Books

1. R. Yadav, Applied Thermodynamics & Heat Engines –Vol II, Fifth Edition, Central Publishing House, Allahabad, 2012.
2. Domkundwar, Kothandaraman & Domkundwar, A course in Thermal Engineering, Dhanpat Rai & Co., Third Edition, 2016.
3. P. K. Nag, Basic & Applied Thermodynamics, McGraw-Hill Education, Second Edition, 2009.

Recommended Reading

1. Moran & Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley & Sons Inc., Ninth Edition, 2018.
2. Yunus A. Cengel and Michael A. Boles, Thermodynamics: An Engineering Approach, McGraw-Hill Higher Edition, Eighth Edition, 2017.
3. Sonntag, Borgnakke & Van Wylen, Fundamentals of Thermodynamics, John Wiley & Sons Inc., Ninth Edition, 2017.
4. Y. V. C. Rao, Theory and Problems in Thermodynamics, Second Edition, 2012.

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – III
Course Code	**R5ME2003T**	
Course Title	**Machine Drawing**	
Prerequisites	**Engineering Graphics**	

COURSE OUTCOMES

The student should be able to –

1. Prepare geometrical model of various machine elements.
2. Draw assembly drawing of various machine elements.
3. Draw various machine parts drawing using CAD software.

Course Contents

Introduction to Machine Drawing

Machine Drawing, Production Drawing, Part Drawing, Assembly Drawing, etc.
Review of dimensioning, notes, Type of section & their use.

Development of Lateral Surfaces of Sectioned Solids:

Lateral surface development of Prism, Pyramid, Tetrahedron, Hexahedron, Cylinder, and Cone with Section Plane inclined to HP or VP only (Excluding Reverse Development).

Solid Geometry

Intersection of surfaces and solids: - Intersection of prisms, cylinders, cone with prism & cylinder. Both solids in simple position. Primary Auxiliary views, projections of simple machine parts.

Free Hand Sketches

Preparation of 2-D drawings of standard machine elements (Nuts, Bolts, Keys, Cotter, Screws, Springs, Oil Seals, etc.)

Conventional representation of threaded parts, Types of threads; thread designation, Conventional representation of machine components and materials, Designation of standard components

Types of bearings: Simple, Solid, bushed, I. S. conventional representation of ball and roller bearings.

Pipe Joints: Different types of pipe fittings like sockets, nipples, plugs, bends, Tees, elbows, crosses, etc.

Power transmission elements: Flat belt, V belt, gears, chains, ropes, sprockets

Detailed and Assembly Drawings

Types of Couplings: Muff, Flanged, Protected Flanged, Oldham, Universal.

Types of bearings -: Plummer Block, Foot Step Bearings.

IC Engine parts: Piston, connecting rod, crankshaft etc.

Lathe Tool Post, Machine Vice, Pipe Vice, Screw Jack, Tail stock, Cylinder relief valve, control, etc.

Jigs and Fixtures: Introduction to Jigs and fixtures, Jigs and Fixtures (any two from each)

Bill of materials.

Introduction to Computer Aided Drafting & Design

Overview of 2D Drafting: Drawing, Editing, Dimensioning, Layering, Hatching, Array, detailing, detail drawing**,** etc.

3D Geometric Modeling & Assembly: Sketcher – Datumplane – Protrusion – holes – part modeling – extrusion – revolve– sweep –loft – blend – fillet – pattern – chamfer – round – mirror – section – assembly – Drafting - Preparation of Bill of material

Introduction to AutoLISP Programme

Overview of Visual basic for application integrated development environment (VBA IDE) interface, Use of VBA IDE for customization of AutoCAD, Design of user interface for 2D drawing of standard machine parts

Introduction to Augmented Reality (AR) and Virtual Reality (VR)

Text Books

1. N. D. Bhatt, Machine Drawing, Charotar Publications, 49th edition, 2014
2. K.I.Narayana, P. Kannaiah, K. Venkata Reddy, Machine Drawing, New Edge publications, 3rd edition, 2006
3. Junnarkar N. D., Machine Drawing, Pearson Education, 2004
4. Sham Tickoo, Customizing AutoCAD 2013, CAD CIM Technologies Publisher, 2013

Recommended Reading

1. Sidheshwar and Kanheya, Machine Drawing, Tata McGraw-Hill Publications, 37th Reprint, 2009
2. R.B.Gupta, A Textbook of Machine Drawing, Satya Prakashan Tech. Publication, 6th edition, 2012
3. N. D. Bhatt, Engineering Drawing, Charotar Publications, 53rd edition, 2014
4. BIS Standards: IS919, IS2102 and IS8000, Bureau of Indian Standards.

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester –IV
Course Code	**R5ME2004T**	
Course Title	**Measurement and Metrology**	
Prerequisites	**Mathematics for Engineers- I & II, Machine Drawing**	

COURSE OUTCOMES

The student should be able to –

1. Understand the role of different measurements techniques
2. To analyze and measure different physical parameters using modern measurement methods
3. Various instruments used for measurement of mechanical and electrical parameters
4. Design of limits, fits and tolerances for given applications

Course Contents

Introduction

Concept and Need of Measurements, Generalized measuring systems and instruments, Classification of methods of measurement, Standards, Units, Precision and Accuracy, Repeatability and Reproducibility, Sensitivity, and Readability, Sources of error in measurement, Statistical analysis of Error, Correction, Calibration and Interchangeability

Linear and Angular Measurement

Standards of Linear Measurement, Abbe's principle, Line and End Standards, Linear Measuring Instruments: Vernier Caliper and Micrometers, Vernier Height Gauge and Depth Gauge, Interval Measurement: Slip Gauges, Optical Flats

Systems of Limits and Fits

Concept of Tolerances, Limits and Fits, Allowances, Tolerance Analysis, Limits Gauges and Gauges Design.

Comparators

Mechanical, Electrical, Optical, and Pneumatics, Angle Measuring Instruments: Sine Bar, Bevel Protractor, Clinometer, Autocollimator, Functions of Coordinate Measuring Machine

Measurements of Geometric Forms and Finish

Form Measurement: Measurements of Straightness, Squareness, Flatness, Circularity and Cylindricity, Optical Projectors, Tool Maker's Microscope, Optical Measuring Microscope, Finish Measurement: Quantitative Evaluation of Surface Roughness, Methods of Measuring Surface Finish by Contact and Non-Contact Methods

Measurement of Threads and Gears: Threads Measurement

Standard Threads Profiles and Measurement of Minor Diameter, Major Diameter, Effective Diameter, Pitch, Angle and Form for Internal and External Threats, Threads Gauges, Gear

Measurement: Standard Gear Profiles and Measurement of Tooth Thickness and Pitch, Checking Profile of Spur Gear, Parkinson Gear Tester, Problems on Gear Measurement

Interferometry

Principle of Interference, Optical Flat, Fringe Patterns, NPL Interferometer

Laser metrology

Applications of lasers in precision measurements- Laser interferometer, speckle measurements, laser scanners.

Measurement of Displacement, Speed, Force, and Torque

Tachometers and Stroboscope, Accelerometer, Proving Ring, Load Cells: Hydraulic and Pneumatic, Torque Measurement on Rotating Shafts Dynamometers: Absorption, Transmission and Driving

Measurement of Pressure, Flow, Temperature and Strain

Bourdon Tube, Diaphragm and Bellows, Vacuum Measurement: Mcleod guage, Thermal Conductivity Gauge and Ionization Gauge, Dead Weight Gauge Tester, Electromagnetic Flux Meters, Ultra-Sonic Flow Meters and Hot Wire Anemometer, Flow Visualization Techniques, Temperature Measurement by Thermometers, Bimetallic, Thermocouples, Thermistors and Pyrometers, Measurement of Flow, Strain Measurement

Introduction to Geometric Dimensioning & Tolerancing (GD&T)

Introduction, Dimensioning with tolerances indicating various types of fits.

Coordinate Measuring Machine (CMM)

Fundamental features of CMM – development of CMMs – role of CMMs – types of CMMs – modes of operation – types of probes – probe calibration – non-contact type probes – direct computer control – software packages – operational modes – metrological features – coordinate systems – portable arm CMMs. Reverse Engineering.

Text Books

1. Engineering Metrology and Measurements by N.V. Raghavendra and L.Krishnamurthy, Oxford University Press.
2. I.C. Gupta, Engineering Metrology, Dhanpat Rai Publications, Seventh Edition, 2018
3. Shotbolt, C.S. and Galyer. J. Metrology for Engineers, Cassell Publ., Fifth Edition, 1990.
4. R. K. Jain, Engineering Metrology, Khanna Publishers, Twentieth Edition, 2009

Recommended Reading

1. A. K. Sawhney, Mechanical Engineering Measurements, Dhanpat Rai & Sons
2. W. Bolton, Instrumentation and Control System, Elsevier, First Edition, 2004
3. S.P. Venkateshan, Mechanical Measurements, Ane books, India, Second Edition, 2015
4. Norman Nise, Control System Engineering, John Wiley and Sons, Sixth Edition, 2010
5. Richard S. Figliola, Donald E. Beasley, Theory and Design for Mechanical Measurements, Wiley, Fifth Edition, 2012
6. C. Dotson, R. Harlow and R. Thompson, Fundamentals of Dimensional Metrology, Thomson Delmer Learning, Singapore, Sixth Edition, 2015
7. John A Bosch, Giddings and Lewis Dayton, Coordinate Measuring Machines and Systems, Marcel Dekker, Inc., 1999

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – III***
Course Code	**R5ME2001L**	
Course Title	**Manufacturing Technology Lab**	
Prerequisites	**Manufacturing Processes**	

COURSE OUTCOMES

The student should be able to –

1. Develop skills in precision turning, shaping, milling and grinding work.
2. Detect the difficulties encountered during manufacturing and assembly.
3. Evaluate overall dimensions of part and precisely manufacture products for desired function
4. Relate manufacturing theory to practice through laboratory experiments

Job: Students will design a small product which has a specific functionality. It is expected that at least 04 manufacturing processes should be required to completely manufacture the part. Student will prepare operation sheet, process picture as well calculate theoretical time required for completion of part.

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – III
Course Code	**R5ME2003L**	
Course Title	**Machine Drawing Laboratory**	
Prerequisites	**Engineering Graphics**	

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to -

1. Understand the concept of machine elements and their drawings.
2. Learn the standard conventions and notations for machine drawings.
3. Visualize different machine elements and draw their different views.
4. Learn basic concept of assembly and detailed drawing.

Drawing sheet based Exercise:

1. Sheet based on Development of Lateral Surfaces of Sectioned Solids
Conversion of orthographic projections in to pictorial view for the complex machine parts
2. Drawing of complex parts with sectional views
3. Screw threads and screwed fasteners
4. Simple assemblies I: couplings and keys / shaft joints / pipe joints
5. Simple assemblies II: engine components / bearings
6. Complex Assembly and detailed drawings: machine vice / lever safety valve / lathe tailstock / water pump / crane hook etc.

CAD Exercises:

1. Modeling of 3D parts from orthographic views
2. Assembly of parts and motion simulation of mechanical systems
3. Preparation of drawings from CAD models
4. Complicated assemblies and creation of assembly drawings
5. Development of production drawings using CAD software
6. Design of user interface for 2D drawing of standard machine parts using a AutoLISP programme.

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – III
Course Code	**R5ME2004L**	
Course Title	**Measurement and Metrology Laboratory**	
Prerequisites	**Mathematics for Engineers- I & II, Machine Drawing**	

COURSE OUTCOMES

The student should be able to –

1. Calibrate various measuring Instruments
2. Use common measuring instruments
3. Explain the principle and working of specialized measuring instruments.

List of Experiments

1. Measurement of screw threads using Universal Measuring Microscope, Three wire method, Thread pitch micrometer, etc.
2. Measurement of straightness error using autocollimator, spirit level, etc.
3. Calibration of pressure gauge using dead weight tester.
4. Calibration of dial gauge using dial gauge calibrator.
5. Calibration of LVDT based height measuring device using Gauge Blocks.
6. Measurement of strain using strain gauges and strain indicator using various bridge arrangements.
7. Determination of defects in materials using Ultrasonic Flaw Detector.
8. Measurement of gear profile error and other parameters using profile projector, disc micrometer, gear tooth vernier, etc.
9. Measurement of cutting tool angles using Tool Maker's microscope.
10. Calibration of thermocouples using constant temperature bath, study of platinum resistance strain gauge, etc.
11. Determination of time constant of a thermometer.
12. Study of surface texture measurement using stylus type profilometer.
13. Conduct gauge R & R study.
14. Measurement of area using planimeter, identifying and experiencing the feel of different limits and fits
15. Study of CNC CMM, Articulated Arm CMM with laser scanner, roundness testing machine, 3D optical profilometer, laser scan micrometer, coating thickness measurement, sound level measurement, spring tester, etc.

Minimum 10 experiments should be conducted

References

[1] Raghavendra, N.V., and Krishnamurthy, L., 2013, Engineering Metrology and Measurements, Oxford University Press.
[2] Figliola, R.S., and Beasley, D.E., 2021, Theory and Design for Mechanical Measurements, John Wiley & Sons.
Kirkup, L., and Frenkel, R.B., 2006, An Introduction to Uncertainty in Measurement using the GUM, Cambridge University Press.
[4] ISO/ASME/IS standard

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – III***
Course Code	**R5CH2401T**	
Course Title	**Environmental Science**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:

1. Imply the basic knowledge of environmental protection, sustainable development and improvement.
2. Categorize and scrutinize impact of human development on natural resources and its conservation.
3. Interpret the impact of environmental problems on socio economic growth.
4. Apply different Science and Technology (S&T) based sustainability solutions and technological improvement, and methods for the remediation of degraded environment.
5. Familiarize with the legislation, management and protocols existing for environmental protection.

Course Contents

Significance of Environment Science

Definition, basic principles and scope of environment science. Need for awareness Industrialization & Urbanization; Basic Ecological Concepts Ecosystems, nature of environmental threats, Current environmental problems,

Importance of clean air.

Natural Resources Management and Sustainability

Concept of Ecosystem, Conservation of ecosystem: Natural Resources, Renewable and Non-renewable Resources, Natural resources and challenges with the conservation.

Forest resources, Water resources, Energy resources

Role of an individual in conservation of natural resources.

Impact of energy use on Environment.

Energy conservation and sustainability

Environment & Society

Urbanization and environment, social movements, Community participation, JFM, participation by NGOs

Impact of energy use on Environment, energy production on environment change, nuclear

explosion, impact of dam construction,
Energy conservation and sustainability

Green Technologies

Role of advancements in science and technology in developing environment friendly technologies 3 R's for Green Technology, Green technology towards sustainable future, Reduction of ecological footprint,

Concept of Sustainability and Green Chemistry as a tool for sustainable development

Environmental Legislation, Management & Policies

Aims And Objectives of Environmental Impact Assessment (EIA), Environmental Management Plan (EMP) , Indian forest act, The water act(prevention and control of water pollution), The Air act (prevention & control of air pollution)

International efforts for environmental protection and contribution of India for same, National Action Planon Climate Change

Role of Ministry of Environment, forest and climate

Mitigation measures for climate change, international protocols, Montreal protocol, Kyoto protocol,
Carbon credits and carbon trading

Reference Books

1. De, Environmental Chemistry, 6th Edition, New Age International.
2. Erach Bharucha, Text Book of Environmental Studies for Undergraduate Courses,Universities Press, Second Edition (UGC Recommended)
3. P.K.Goel, Water Pollution, Causes, Effects and Control, New Age International
4. Dr. Jagdish Krishnaswamy and Dr. R. J. Ranjit Daniels, Environmental Studies, Wiley India Private Limited, New Delhi, First Edition, 2009.

Recommended Readings

1. Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad,
2. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T., Environmental Encyclopedia, Jaico Publ. House, Mumbai, 2000
3. Jadhav, H &Bhosale, V.M., Environmental Protection and Laws. Himalaya Pub. House, Delhi, 1995
4. Wanger K.D., Environmental Management. W.B. Saunders Co. Philadelphia, USA, 1998
5. Trivedi R.K., Handbook of Environmental Laws, Rules Guidelines, Compliances and Stadards, Vol I and II, Enviro Media (R)

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – III***
Course Code	**R5ME2201T**	
Course Title	**Introduction to Robotics**	
Prerequisites		

COURSE OUTCOMES

After completion of course, students would be able:

1. To understand the terminologies related to Robotics.
2. To select robotic sub-systems and systems.
3. To understand basic principles of robot system integration.
4. To understand Socio-Economic aspect of robotic technology.

COURSE CONTENTS

Introduction to robotics

Brief History, Basic Concepts of Robotics such as Definition , Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device etc., Introduction to Principles & Strategies of Automation, Types & Levels of Automations, Need of automation, Industrial applications of robot.

Grippers and Sensors for Robotics

Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basicgripper system.

Sensors for Robots - Types of Sensors used in Robotics, Classification and applicationsof sensors, Characteristics of sensing devices, Selections of sensors. Need for sensorsand vision system in the working and control of a robot.

Drives and Control for Robotics

Drive - Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems: Types of Controllers, Introduction to closed loop control

Programming and Languages for Robotics

Robot Programming: Methodsof robot programming, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS etc., Development of languages since WAVE till ROS.

Related Topics in Robotics

Socio-Economic aspect of robotization. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, New trends & recent updates in robotics.

References

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
4. R. D. Klafter, Thomas A. Chmielewski, and Mechael Negin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc. (2009)

Additional Reading

1. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd,New Delhi (2003)
2. S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, JohnWiley & Sons Ltd., (2020)
3. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods andAlgorithms, Springer (1997)
4. Mikell Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta,Industrial Robotics 2nd edition, SIE, McGraw Hill Education (India) Pvt Ltd (2012)
5. https://nptel.ac.in/courses/107106090
   Introduction to robotics, Dr. Krishna Vasudevan, Dr. Balaraman Ravindran, Dr. T Asokan, IIT Madras

6. https://nptel.ac.in/courses/108108147
   Sensors and Actuators Prof. Hardik Jeetendra Pandya, IISc Bangalore

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – III
Course Code	**R5ME2202T**	
Course Title	**Warfare Platforms and Systems**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:
1. Understand the basics of defence technology and modern military operations.
2. Analyse the different combat systems in different warfare scenarios.
3. Evaluate the performance of various weapon systems used in military operations.
4. Understand various advancements in defence technologies and their impact on modern conflict.
5. Integrate knowledge from various branches of engineering for developing warfare systems.

Course Contents

Introduction to Defense Technology

Overview of defense technology, Importance, and impact, Historical evolution of defense systems Types of warfare platforms: land, sea, air; Significance of defense technology in modern military operations

Fundamentals of Warfare Systems

Fundamentals of Land, Naval and Air Warfare Systems, Basic principles of operation and design

Weapon Systems

Guided and precision munitions. Emerging technologies in weapon systems

Electronic Warfare

Concepts of electronic warfare: jamming, spoofing, and countermeasures. Technologies and techniques used in electronic warfare

Communication Systems, Cyber Defense and Security

Introduction to cyber warfare and its impact on defense. Basic principles of network security and cyber threat analysis. Military communication systems and protocols. Secure communication techniques and technologies

Text Books

1. Minah Sindane Bloem & Llewellyn Hartnick, Defence Technology Made easy, BK Publishing (Pty) Ltd. South Africa, 2015.
2. David Miller Modern Naval Combat, Crescent Publication.
3. S.A. Vakin, L.N. Shustov & R.H. Dunwell, Fundamentals of Electronic Warfare 2001
4. Neri Filippo, Introduction to Electronic Defense Systems, Artech House Publishers.
5. G. Maral, M. Bousquet, Z. Sun., Satellite Communications Systems: systems, techniques and technology, John Willy and Sons.
6. Yacov Bar-Shlomo, An Introduction to Weapons Systems, Create Space, Independent Publishing Platform.
7. M.I. Skolnik, Introduction to Radar Systems, Tata McGraw Hill edition, 2001.

Recommended Readings

1. Nunney, Light and Heavy Vehicle Technology, Elsevier.
2. Alastair D. McAulay, Military Laser Technology for Defense: Technology for Revolutionizing 21st Century Warfare, 1st edition Wiley-Interscience Publication.
3. Tupper, E. C Fourth.,Introduction to Naval Architecture. Butterworth-Heinemann Publication.
4. Thor I. Fossen, Marine Control Systems Guidance, Navigation, and Control of Ships, Rigs, and Underwater Vehicles, Marine Cybernetics, Trondheim, Norway.
5. B.P. Lathi and Zhi Ding, Modern digital and analog communication systems, Oxford University Press.

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – III***
Course Code	**R5ME2203T**	
Course Title	**An Introduction to Aerospace Engineering**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:
1. Interpret simple aerodynamic systems like airfoils, aircrafts and its control surfaces
2. Analyze Rocket engines, Nozzles, Air-breathing engines
3. Evaluate Performance of aircrafts, Navigation of missiles, and working of Radar systems
4. Identify Futuristic aerospace technologies

Course Contents

Atmosphere

Properties and characteristics of the atmosphere

Basic Components of Fixed-Wings Airborne Systems

The fixed wings, control surfaces – ailerons and rudders, their functionality and basic working principles

Introductory Fluid Mechanics & Aerodynamics

Concept of Pressure; A primer on Conservation Laws – Mass, Momentum and Energy. Bernoulli's Principle; A primer on viscous flows and concept of skin-friction; Basic Principle of Lift generation, airfoils – symmetric and cambered; Irrotational flows: Sink, source, doublet & irrotational vortex

Introduction to Propulsion Systems

Primer on the thermodynamic cycles of aircraft engines – ideal and real cycles; Axial Compressors and Turbines; Turbofan, turboprop, turbojet engines; An historical perspective of engines; Rocket engines – the principle of thrust generation with converging-diverging nozzles

Aircraft Performance

Mechanics of flight; Flight stability - considerations of stability in commercial and fighter aircrafts; Glide, climb, ceiling, turn and pull-up; V-n diagram; Range and Endurance

Navigation, Guidance & Control

Brief introduction to radar; Guided missiles, simplified missile guidance laws

Futuristic Aerospace Technologies

Electric propulsion; Hydrogen combustion engines; Supersonic & hypersonic Ramjet/Scramjet engines; AI assisted designs; Smart Materials etc.

Reference Books

1. Robert W. Fox, Alan T. McDonald, Philip. P. Pritchard, Introduction to Fluid Mechanics, 6th Edition, Wiley, 2003.
2. Frank M. White, Fluid Mechanics, Tata McGraw-Hill, 7th Edition, 2012
3. J.D. Anderson Jr., Introduction to Flight, McGraw-Hill, 8th Edition, 2012.
4. Saeed Farokhi, Aircraft Propulsion, John Wiley & Sons, 2nd Edition, 2014.
5. Merill I. Skolnik, Introduction to Radar Systems, Tata McGraw-Hill, 3rd Edition, 2001.
6. P. Zarchan, Tactical and Strategic Missile Guidance, AIAA, 7th Edition, 2019.

Recommended Reading

1. P.K. Kundu and I.M. Cohen, Fluid Mechanics, Elsevier Academic Press, 3rd Edition, 2004
2. M. van Dyke, An Album of Fluid Motions, The Parabolic Press, Only Edition, 1982
3. Prof. D. Ghose, Navigation, Guidance and Control, Lecture notes NPTEL, 2013
4. On Rocket Engines/Motors: https://eaglepubs.erau.edu/introductiontoaerospaceflightvehicles/chapter/rocket-engines/
5. Album of Fluid Motions
6. R. M. O'Donnel, Introduction to Radar Systems, MIT OpenCourseWare https://www.ll.mit.edu/outreach/radar-introduction-radar-systems-online-course
7. S. Corda, Introduction to Aerospace Engineering with a Flight Test Perspective, Wiley, 1st Edition, 2017.

SEMESTER-IV

Programme Name	**Bachelor of Technology in Mechanical Engineering**	**Semester IV**
Course Code	**R5ME2005T**	
Course Title	**Kinematics of Machinery**	
Prerequisites	**Engineering Mechanics, Mathematics - I & II**	

Course Content

Basic Kinematics

Structure, Machine, Link and its types, Kinematics pairs, Kinematic chain and mechanism, Grubbler's criteria, Inversions of kinematic chains, inversions of - four bar chain, single slider crank chain and double slider crank chain.

Inversion of Chain

Study of various mechanisms derived from inversions of following chains with regard to motion of links of mechanism, motion modification, quality of motion transmission (uniform, nonuniform, SHM, non – SHM), limiting positions, dead positions, quick return property, applications. Four bar chain (Grashoffian, non-Grashoffian), Single slider crank chain, Double slide crank chain.

Mechanisms with Lower Pairs

Straight line generating mechanisms, Exact straight line generating mechanisms. Mechanism – Peueillier, Hart Approximate straight line generating mechanisms – Watts, Roberts, etc. Offset slider crank mechanism, Pantograph, Hook joint single and double, Steering gear mechanisms – Ackerman, Devis.

Velocity Analysis of Mechanisms

Velocity analysis by instantaneous centre of rotation method (Graphical approach), Velocity analysis by relative velocity method (Graphical Approach). Analysis is extended to find rubbing velocities at joints, mechanical advantage (graphical approach) (mechanisms upto 6 links)

Acceleration Analysis of Mechanism

Velocity Acceleration analysis by relative method (mechanism upto 6 links) including pairs involving Corioli's acceleration (Graphical approach) Velocity acceleration analysis of mechanisms (upto 4 links) by complex variable method (Analytical approach)

Gear Mechanism

Types of gears, Law of gearing, Involute and cycloid gear tooth profile. Path of contact arc of contact, contact ratio for involute and cycloid tooth profile. Interference in involute gears. Critical Numbers of teeth for interference free motion. Methods to control interference in involute gears.

Cam Mechanism

Cams and its Classification, Followers and its Classification, Motion analysis and plotting of displacement – time, velocity time, and acceleration time, jerk-time graphs for uniform velocity, UARM, SHM and Cycloid motions (combined motions during one stroke excluded), Cam profile for radial and offset followers. Motion analysis of simple cams – R-R cam, D-R-R and D-R-D-R cam operating radial translating follower, Pressure angle and methods to control pressure angle

Text Books

1. J. J. Uicker, G. R. Pennock and J. E. Shigley, Theory of Machines, Oxford University Press, (4th Edition), 2015.
2. S. S. Ratan, Theory of Machines, McGraw-Hill Education (India) Private Limited, Fourth Revised Edition, 2017
3. P.L. Ballaney, Theory of Machines and Mechanisms, Khanna s, Delhi, Twenty-fifth Edition, 2003
4. Ghosh and A. Malik, Theory of Mechanism and Machines, Affiliated East –West Press Pvt. Ltd. New Delhi, 2008

Reference Book

1. John J. Uicker Jr , Gordon R. Pennock , Joseph E. Shigley, Theory of Machines and Mechanisms, Oxford press, Fifth Edition, 2016
2. V. M. Fairs, Kinematics, McGraw Hill, 1988
3. Erdman and G. N. Sander, Mechanism Design: Analysis and Synthesis, Vol. I, Prentice Hall, Fourth Edition, 2001
4. J. Hannah and R.C. Stephens, Mechanics of Machines-Elementary Theory and Examples, Butterworth-Heinemann, Fourth Edition, 1984

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – IV
Course Code	**R5ME2006T**	
Course Title	**Fluid Mechanics**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Outline the significance of fluid properties
2. Analyse static fluid systems
3. Apply the governing equations of mass, momentum and energy to fluid flows
4. Analyse internal and external fluid flows
5. Develop dimensionless parameters to aid experimentation

Course Contents

Fundamental Concepts

History and Scope of Fluid Mechanics, Definition of a Fluid, Fluid as a Continuum, Methods of Description: Molecular, Lagrangian, and Eulerian; Fluid Properties, Basic Flow Analysis Techniques, Classification of Fluid Motions

Fluid Statics

Force, Stress, and Pressure at a Point, Basic Equation of Fluid Statics, Pressure Variation in a Static Fluid, Pressure Measurement – Manometers, Hydrostatic Forces on Plane and Curved Surfaces, Buoyancy and Stability

Integral Relations for a Control Volume

Basic Physical Laws of Fluid Mechanics, The Reynolds Transport Theorem, Conservation of Mass, The Linear Momentum Equation, Frictionless Flow: The Bernoulli's equation, The Angular Momentum Theorem, The Energy Equation

Differential Relations for Fluid Flow

Motion of a Fluid Particle (Kinematics) –Fluid Translation: Acceleration of a Fluid Particle in a velocity Field, Fluid Rotation, Fluid Deformation, Flow visualization, The Differential Equation of Mass conservation, The Stream Function and the velocity potential function, Vorticity and Irrotationality, Frictionless Irrotational Flows, The Differential Equation of Linear Momentum (Navier – Stokes Equations), Euler's equation, Bernoulli's equation and application

Flow Measurement –The Orifice plate, The Flow Nozzle, The Venturimeter, Rotameter, Turbine Meter, Rectangular and Triangular Notches, Pitot tube, Electromagnetic Flow Meters, Hot Wire Anemometer, Laser- Doppler Anemometer (LDA), Flow visualization – PIV

Dimensional Analysis and Similarity

The Principal of Dimensional Homogeneity, The Pi Theorem, Significant Dimensionless Groups in Fluid Mechanics, Flow Similarity and Model Studies

Internal Incompressible Viscous Flow

Fully Developed Laminar Flow Between Infinite Parallel Plates (Both Plates Stationary and Upper Plate Moving with Constant Speed), Fully Developed Laminar Flow in a Pipe;

Flow in Pipes and Ducts – Shear Stress Distribution in a Fully Developed Pipe Flow, Turbulent Velocity Profiles in a Fully Developed Pipe Flow, Energy Considerations in a Pipe Flow, Calculation of Head Loss – Major and Minor Losses, Flow through siphon, Branching pipes and equivalent pipe

External Incompressible Viscous Flow

Boundary Layers: The Boundary Layer Concept, The Boundary Layer thickness, Laminar Flat-Plate Boundary Layer, Momentum Integral Equation, Use of Momentum Integral Equation for Flow with Zero Pressure Gradient – Laminar Flow & Turbulent Flow, Pressure Gradients in Boundary Layer Flows

Fluid Flow about Immersed Bodies: Drag – Flow over Flat Plate Parallel and Normal to the Flow, Friction and Pressure Drag, Flow over Sphere and Cylinder, Streamlining, Lift

Compressible Flow

Introduction: Review of Thermodynamics, The Speed of Sound, Adiabatic and Isentropic Steady Flow, Isentropic Flow with Area changes, The Normal Shock Wave, Operation of Converging and Diverging Nozzles

Text Books

1. S.K. Som, G. Biswas, Suman Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw-Hill Education, Third Revised Edition, 2017
2. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, Fluid Mechanics, Wiley, Eighth Edition, 2018
3. Yunus A. Cengel & John M. Cimbala, Fluid Mechanics – Fundamentals & Applications, Tata McGraw-Hill, Third Edition, 2013

Recommended Reading

1. Frank M. White, Fluid Mechanics, Tata McGraw-Hill, Eighth Edition, 2015.
2. Victor L. Streeter, E. Benjamin Wylie, Keith W. Bedford, Fluid Mechanics, McGraw-Hill Education (India), Ninth Revised Edition, 2017.
3. Edward J. Shaughnessy, Jr. Ira M. Katz, James P. Schaffer, Introduction to Fluid Mechanics, Oxford University Press, 2005
4. Shames, Mechanics of Fluids, , McGraw Hill Book Co., New Delhi, 1992

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – IV***
Course Code	**R5ME2008T**	
Course Title	**Digital Manufacturing**	
Prerequisites		

Course Outcomes

The student should be able to –

1. Develop a CNC program for machining a part.
2. Understand the working principles and applications of additive manufacturing processes.
3. Understand and apply the principles of design for additive manufacturing
4. Understand the drivers and enablers of Industry 4.0.

Course Contents

Introduction to Computer Numerical Control

Introduction to Computer Numerical Control (CNC), Coordinate system, working principal of CNC, Constructional features of CNC machine tools, Designation of axis in CNC systems, CNC coordinate system, positional control, system devices; drives, ball screws, transducers, feedback devices, Turning Centers, Machining Centers

CNC Part Programming

Steps in developing CNC part program, Machining Center programming, turning center programming, Tool length and radius compensations, subroutine and Do loop using canned cycle, APT language programming, CNC program generation from CAD models

Introduction to Additive Manufacturing

Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM, Additive Manufacturing Process Chain

Additive Manufacturing Processes

Vat Photopolymerization, Powder Bed Fusion, Material Jetting, Binder Jetting, Extrusion based processes, sheet lamination techniques, direct energy deposition, direct wire technologies

Applications of Additive Manufacturing

Prototyping, Rapid Tooling, Applications of Am for Medical, Automotive and aerospace, Sports goods, energy devices, consumer goods, construction industry

Design for Additive Manufacturing (DfAM)

General Guidelines for DfAM, Design to Minimize Print Time, Design to Minimize Postprocessing, Design Guidelines for Part Consolidation, Design for Minimal Material Usage, Computational Tools for Design Analysis, Design for Polymer AM, Design for Metal AM

Introduction to Industry 4.0

Globalization and Emerging Issues, The Fourth Revolution, Lean Production Systems, Mass Customization, Smart and Connected Business Perspective, Smart Factories, Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis

Text books

1. Computer Control of Manufacturing Systems, Yoram Koren, McGraw Hill International, Singapore, 2006
2. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker., Springer, 2010
3. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
4. Introduction to Industrial Internet of Things and Industry 4.0, Sudip Misra, Chandana Roy, Anandarup Mukherjee, CRC Press, 2020

Recommended Reading

1. Computer Aided Manufacturing, Tien - Chien Chang, Richard A Wysk and Hsu-Pin Wang, PHI, New Dellhi,2006
2. Rapid Prototyping: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2003.
3. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, Pethuru Raj and Anupama C. Raman, CRC Press, 2012
4. The 3D Printing Handbook: Technologies, Design and Applications, Redwood, Ben, Filemon Schoffer, and Brian Garret, 3D Hubs, 2017.

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – IV
Course Code	**R5ME2007T**	
Course Title	**Mechatronics, Robotics & Control**	
Prerequisites	**Basics of Electrical & Electronics Engineering, Measurement & Metrology**	

COURSE OUTCOMES

The student should be able to –

1. Build low-cost automation circuits and study of sensors
2. Prepare the assembly programs in 8085µp for various applications.
3. Use of programmable logical controllers and understanding robotics and control
4. Apply the assembly programming in 8051µc for arithmetic operations various applications.

Course Contents

Introduction to Sensors, Transducers and Actuators

Introduction to Sensors, Transducers and Actuators Principle, working and applications of-Limit switches, proximity switches like inductive, capacitive and optical, Thumb wheel switches magnetic reed switches, Optical encoders-displacement measurement, rotary, incremental

Low-Cost Automation (LCA)

Introduction to LCA circuits, Construction of LCA circuits, Actuator – solenoids – on-off applications, triggering. Types of relays – solid state

8085 Microprocessor

8085 Microprocessor Architecture, Pin configuration, working of microprocessor and applications. Introduction to ICs used for interfacing such as – Programmable peripheral devices, memory, keyboard, display – LCD, LED, I/O device, ADC, DAC etc. Assembly programming, stack and subroutine (CALL, RET, PUSH, POP).

Programmable Logic Controller (PLC)

Introduction, PLC definition, PLC block diagram, Difference between relay panel and PLC, power supply, input/output modules (analog, digital) concepts of sink/source, set/reset, advantages and disadvantages, installation, troubleshooting and maintenance. Ladder diagrams and sequence listing, large process ladder diagram construction, flowcharting as a programming method, Basic PLC functions Register basics, timer functions, counter functions

8051 Microcontroller

8051Microcontroller Architecture, Pin configuration, working of microprocessor, and applications. Assembly language programming - Jump, Loop, Call instructions. Addressing modes - Arithmetic, Logic Instructions & programs. I/O port programming - LCD, ADC, DAC, STEPPER MOTOR, DC MOTOR interfacing.

Robotics

Robot configurations: serial and parallel; Denavit–Hartenberg parameters;
Manipulators kinematics; Rotation matrix, Homogenous transformation matrix; Direct and inverse

Control Theory and Systems

Basic control concepts; Feedback; Open and closed loop control; Concept of block diagrams; P, PI and PID controllers, Kinematics for robot position and orientation

Text Books

1. Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with the 8085, Sixth Edition, 2013
2. Muhammad Ali Mazidi, The 8051 microcontroller & embedded systems, Pearson Education, Second Edition, 2005

Recommended Reading

1. NIIT Programmable Logic Control – Principles and Applications. Prentice Hall of India, 2004
2. Kolk R.A. and Shetty D., Mechatronics systems design, Vikas Publishing, New Delhi, Second Edition, 2010
3. Mahalik N.P., Mechatronics principles, concepts and applications, Tata McGraw Hill Publishing, First Edition, 2003
4. J.R. Fawcett, Pneumatic circuits, Trade & Technical Press, Fourth Edition, 1980

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – IV
Course Code	**R5ME2007T**	
Course Title	**Universal Human Values**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Analyze the significance of value inputs provided in formal education along with skills and develop a broader perspective about life and education
2. Formulate their aspirations and concerns at different levels of living, and the way to fulfill them in a sustainable manner.
3. Evaluate their current state of understanding and living, and model a healthy lifestyle
4. Examine the issues of home sickness, interactions with seniors on the campus, peer pressure with better understanding and feel grateful towards parents, teachers and others
5. Develop more confidence and commitment for value-based living in family, society and nature

Course Contents

Aspirations and concerns

Understanding basic human aspirations, fixing one's goals, and the need for a holistic perspective in form of Universal Human values

Self management

Self confidence, handling peer pressure, time management, anger, stress, personality development and self improvement which leads to harmony in the human being.

Understanding Health

Health issues, healthy diet, healthy lifestyle which shall lead to Harmony of the self and body in forms of mental and physical health.

Relationships

Learning to handle home sickness, gratitude towards parents, teachers and others, understanding impact of ragging and interaction, competition and cooperation to achieve harmony in relationships.

Participation in society, participation in nature leading to harmony in the society and nature/existence, Role of education in developing holistic perspective

Text Books

1. E.P.G.Gohl, L.D.Vilensky, Textile Science, an Explanation of Fibre Properties, Second Edition, 1987, CBS s & Distributors Pvt. Ltd.
2. Manufactured Fibre Technology, V.B. Gupta and V.K. Kothari, Springer Science + Business Media, 2003, ISBN 978-94-010-6473-6

Recommended Reading

1. Tatsuya Hongu, Glyn O. Phillips, Machiko Takigam, New Millennium Fibers, Woodhead Publishing Ltd., CRC Press LLC, 2005, ISBN 0-8493-2598-6.
2. H.V.S. Murthy, Introduction to Textile Fibres (Revised edition- 2015), Wood Head Publication, ISBN 9789385059094.

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – IV
Course Code	**R5ME2006L**	
Course Title	**Fluid Mechanics Laboratory**	
Prerequisites		

COURSE OUTCOMES

The student should be able to –

1. Calibrate instruments used for measurement of pressure, flow rate etc.
2. Verify principles in fluid statics and dynamics.
3. Measure pressure distribution, lift and drag around cylinders and Aerofoils.

List of Experiments [Any Ten]:

1. Calibration of Pressure and Vacuum Gauge
2. Hydrostatic Forces on Plane Surfaces
3. Stability of a Floating Body
4. Verification of Bernoulli's Theorem
5. Calibration of Venturimeter
6. Calibration of Orifice Meter
7. Friction Losses in a Pipe
8. Friction Losses in Pipe fittings
9. Drag measurement on flat plate parallel and normal to the flow
10. Pressure Distribution around the Cylinder
11. Pressure Distribution around the NACA2412 Aerofoil
12. Drag & Lift Measurement of NACA2412 Aerofoil with variable Flap
13. Flow visualization in a water tunnel

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – IV
Course Code	**R5ME2007L**	
Course Title	**Mechatronics, Robotics and Control Laboratory**	
Prerequisites		

Course Outcomes

The student should be able to –
1. Design basic pneumatic circuits.
2. Formulate and execute the assembly programs in 8085µp.
3. Interface 8051µc for different applications.

List of Experiments:

1. Experiments on Pneumatic Kit
a. Actuation of Single acting cylinder.
b. Actuation of Double acting cylinder.
c. Actuation of cascading pneumatic circuit.
2. Experiment on the Logic gates trainer
3. Assembly programming on 8085 µp kit
a. Introduction to8085 µp.
b. Assembly programming for arithmatic operations on 8085 µp.
c. Assembly programming for logical operations on 8085 µp.
4. Interfacing with 8051 µc.
a. Interfacing of 8051 µc with LCD.
b. Interfacing of 8051 µc with DAC.
c. Interfacing of 8051 µc with ADC.
d. Interfacing of 8051 µc with stepper motor.
e. Interfacing of 8051 µc with DC motor.

Text Books:

1. Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with the 8085, Sixth Edition, 2013
2. Muhammad Ali Mazidi, The 8051 microcontroller & embedded systems, Pearson Education, Second Edition, 2005

Recommended Reading

1. NIIT Programmable Logic Control – Principles and Applications. Prentice Hall of India, 2004
2. Kolk R.A. and Shetty D., Mechatronics systems design, Vikas Publishing, New Delhi, Second Edition, 2010
3. Mahalik N.P., Mechatronics principles, concepts and applications, Tata McGraw Hill Publishing, First Edition, 2003 VJTI B.Tech. – Mechanical Engineering– 2018-19|P a g e 4 4 4. J.R. Fawcett, Pneumatic circuits, Trade & Technical Press, Fourth Edition, 1980

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – IV
Course Code	**R5ME2008L**	
Course Title	**Digital Manufacturing Laboratory**	
Prerequisites		

Course Outcomes

The student should be able to –

1. Develop and execute the CNC program for CNC Milling and Turning Machine
2. Print the part using 3D printer
3. Generate the CNC program using CAM software
4. Simulate the additive manufacturing process using software
5. Optimize the design of 3D printed part

List of Experiments:

1. CNC Milling Manual Part Programming
2. CNC Turning Manual Part Programming
3. Toolpath Generation using CAM software for CNC milling machine
4. Toolpath Generation using CAM software for CNC turning machine
5. 3D printing using FDM printing techniques
6. 3D Printing using SLA printing techniques
7. Additive manufacturing simulation using commercial softwares
8. Design optimization for additive manufacturing using commercial software

Mini-Project: A group project based on concepts of digital manufacturing learned during the course.

References

1. CNC Programming Operator Manual-Sinumerik /Fanuc, 2023, Siemens
2. Machining Simulation using Solidworks CAM, Kuang-Hua Chang, SDC Publications, 2021
3. ANSYS Additive User Guide (Print and Science), 2020, Ansys Corporation

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – IV***
Course Code	**R5ME2204T**	
Course Title	**Mechanics of Robots**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:

1. To understand terminologies related to Kinematics and Dynamics of Robots.
2. To apply mathematics for manipulator positioning and motion planning.
3. To analyse basics of motion programming as per kinematics.
4. To estimate the force/torque required to drive a robot.

COURSE CONTENTS:

Mathematical Preliminaries of Robotics

Spatial Descriptions: positions, orientations, and frame, mappings: changing description from frame to frame, Operators: translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters.

Robot Kinematics

Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach.

Velocities & Statics

Cross Product Operator for kinematics, Jacobians - Direct Differentiation, Basic Jacobian, , Jacobian Jv / Jw, Jacobian in a Frame, Jacobian in Frame {0}, Kinematic Singularity, Kinematics redundancy, Force balance equation, Forces, Velocity/Force Duality, Virtual Work, Force ellipsoid, Jacobian, Kinematic Singularity, Kinematics redundancy, Mechanical Design of robot linkages,

Path Planning

Definition-Joint space technique, Use of P-degree polynomial-Cubic,polynomial- Cartesian space technique, parametric descriptions, straight line and circular paths, position and orientation planning

Robot Dynamics

Introduction to Dynamics, Velocity Kinematics, Acceleration of rigid body, mass distribution

Newton’s equation, Euler’s equation.

Text Books

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
2. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
3. J. J. Craig, “Introduction to Robotics: Mechanics and Control”, 3rd edition, Addison-Wesley (2003).

Additional Reading

1. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford UniversityPress (2006)
2. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).
3. https://nptel.ac.in/courses/112105249
   Robotics, Prof. Dilip Kumar Pratihar, IIT Kharagpur

4. https://nptel.ac.in/courses/112101098
   Robotics, Prof. P. Seshu, Prof. P.S. Gandhi, Prof. K. Kurien Issac, Prof. B. Seth, Prof. C. Amarnath, IIT Bombay

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – IV
Course Code	**R5ME2205T**	
Course Title	**Airforce Systems and Configurations**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:

1. Evaluate the airforce systems for various mission profiles.
2. Apply basic principles of engineering and aeronautics for enhancing the performance of aircraft systems.
3. Analyze the design considerations and configurations of various airforce platforms.
4. Evaluate the aerodynamic principles, propulsion mechanisms, and flight performance of the missile.

Course Contents

Basics of thermodynamics, fluid Dynamics & Solid Mechanics

Mechanics of flight

Fixed and rotary wing, straight and level flight of aircraft, aircraft control, and movement, aircraft control surfaces, aerodynamics, power requirements, range; speed, ceiling, survivability, and payload.

Classification & mode of operation of various propulsion systems

Introduction to Gas Turbine Jet Engine design & performance.

Introduction to Aircraft and Missile Structural Components

Spars; Ribs; Stringer; Longerons, Analysis of stress; Analysis of strain, Failure Theories; Fatigue theory

Rockets & Missiles Fundamentals

Basics of Missile Physics, Introduction to Guided Missiles, Classification of Missiles, Missile Aerodynamic Configurations, Two, Three and Six DOF Equations of Motion, Ballistic Missile Trajectory, Basic Characteristics of Guided Missile

Reference Books

1. John D. Anderson, Jr, Introduction to Flight, McGraw Hill Education, Eighth Edition,
2. John D. Anderson Jr., Computational Fluid Dynamics: Basics with Applications, McGraw Hill Education
3. James Njuguna, Lightweight Composite Structures in Transport: Design, Manufacturing, Analysis and Performance, Woodhead Publishing, 2016
4. Jack D. Mattingly, Keith Boyer, Elements of Propulsion: Gas Turbines and Rockets, American Institute of Aeronautics & Astronautics.
5. George Paul Sutton and Oscar Biblarz, Rocket Propulsion Elements, John Wiley & Sons
6. Jeffrey A. Isaac-son, David R. Vaughan, Estimation and Prediction of Ballistic Missile Trajectories, RAND (29 May 1996)

Recommended Readings

1. Chuan Tau Edward Lan, Airplane Aerodynamics and Performance,
2. Manoj Kumar Buragohain, Composite Structures: Design, Mechanics, Analysis, Manufacturing and Testing, CRC Press.
3. S. R. Mohan, Fundamentals of Guided Missiles, Defence Research and Development Organisation
4. H.I.H. Saravanamuttoo, Prof G.F.C. Rogers, H. Co-hen, Gas Turbine Theory, Prentice Hall.
5. D. Raymer, Aircraft design: a conceptual approach.

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – IV
Course Code	**R5ME2206T**	
Course Title	**Flight and Space Mechanics**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:

1. Evaluate performance of aircrafts
2. Analyze Stability of aircrafts
3. Analyze manoeuvrability and control of aircrafts, missiles, drones etc.
4. Apply orbital mechanics fundamentals to space/interplanetary flights

Course Contents

Atmosphere

Properties and characteristics of the atmosphere

Lift and drag on 3D Geometries

3D Wings; Starting, Bound & Wingtip vortices; Induced Drag; Different kinds of Drag, Center of pressure, Center of Moments.

Performance of Aircrafts

Performance: Level flight, cruise and climb, optimal cruise trajectories, Vn-diagrams; Performance comparison of jet and propeller driven engines.

Stability of Aircrafts

Static longitudinal, directional and lateral stability and control, Stick-fixed and Stick-free stability, Hinge moments, Trim-tabs, Aerodynamic balancing

Manoeuvrability and Control

Longitudinal, lateral Control, Control Surface configurations for control, Stall Recovery, Airplane Spin

Space Mechanics

Conic Sections and Central force motion; Orbital Mechanics & Kepler's Laws; Lambert's

Problem; Non-Keplerian motion; Orbit Manoeuvres – Hohmann transfer, inclination change bi-elliptic manoeuvres; Lunar/Interplanetary trajectories- sphere of influence.

Reference Books

1. J.D. Anderson Jr., Introduction to Flight, McGraw-Hill, 8th Edition, 2012
2. E. L. Houghton, P.W. Carpenter, Aerodynamics for Engineering Students, Butterworth-Heinemann, 5th Edition, 2003.
3. J Katz, A Plotkin, Low-Speed Aerodynamics, Cambridge University Press, 2nd Edition, 2001.
4. P. Zarchan, Tactical and Strategic Missile Guidance, AIAA, 7th Edition, 2019.

Recommended Reading

1. W. F. Phillips, Mechanics of Flight, John Wiley & Sons, 2nd Edition, 2009
2. B.W. McCormick, Aerodynamics, Aeronautics and Flight Mechanics, John Wiley & Sons, 1st Edition, 1979
3. R. Battin, Lectures and Lectures Notes – Astrodynamics, MIT OpenCourseWare, 2008
4. Prof. D. Ghose, Navigation, Guidance and Control, Lecture notes NPTEL, 2013
5. B. Etkin, Dynamics of Atmospheric Flight, John Wiley & Sons, 1st Edition, 1971