Third Semester							
				L	T	P	Credit
1	PCC	CRA101	Elements of Mechanical Engineering	3	1	2	5
2	BSC	BSRA101	Mathematics -III	3	1	0	4
3	PCC	CRA102	Introduction to Artificial Intelligence	3	0	2	4
4	PCC	CRA103	Kinematics of Robotics-I	3	1	2	5
5	PCC	CRA104	Engineering Materials	3	0	2	4
6	MNC	MCRA101	Environmental Sciences and Sustainability	2	0	0	0
7	PW&S	SMRA101	Seminar and Technical Report Writing for Engineers	0	0	2	1
8	MPD	MPD102	MPD	0	0	1	0
9	PW&S	TRRA101	Training 1 (after 1st Year)				1
Total (31 hrs)							24

Fourth Semester							
				L	T	P	Credit
1	PCC	CAR105	Machine Drawing and CAD	0	0	6	3
2	PCC	CRA106	Strength of Materials	3	1	2	5
3	PCC	CRA107	Kinematics of Robotics -II	3	1	2	5
4	PCC	CRA108	Industrial Engineering	3	0	2	4
5	PEC	ERA10X	Elective- I	4	0	0	4
6	HSS	HSMC103	Business Essentials for Engineers	2	0	0	2
7	HSS	HSMC104	Universal Human Values: Understanding Harmony	2	0	0	2
8	MNC	MC101	Indian Constitution	2	0	0	0
9	MPD	MPD102	MPD	0	0	1	1
Total (33 hrs)							&

Fifth Semester							
				L	T	P	Credit
1	PCC	CRA109	Robotics Actuators and Sensors	3	0	2	4
2	PCC	CRA110	Machine Learning	3	1	2	5
3	PCC	CRA111	Hydraulic and Pneumatic Systems	3	0	2	4
4	PCC	CRA112	Analogue and Digital Electronics	3	0	2	4
5	PEC	ERA10X	Elective- II	4	0	0	4
6	ESC	ESRA102	Design Thinking	0	0	2	1
7	MNC	MC102	Essence of Indian Knowledge	2	0	0	0
8	MPD	MPD103	MPD	0	0	1	0
9	PW&S	TRME102	Training -II (after 2nd year)				1
Total (30 hrs)							23

Sixth Semester							
				L	T	P	Credit
1	PCC	CRA113	Microprocessors and Micro Controllers	3	0	2	4
2	PCC	CRA114	Mechatronics	3	0	2	4
3	PCC	CRA115	Computer Integrated Manufacturing	3	1	2	4
4	PEC	ERA10X	Elective- III	4	0	0	4
5	ESC	ESRA101	Prog. Specific Course (Artificial Intelligence in Robotics)	3	0	2	4
6	ESC	ESC106	Entrepreneurship and Startups	3	0	0	3
7	MNC	MOC101	Organizational Behavior	2	0	0	0
8	PW&S	PRRA101	Minor Project	0	0	2	1
9	PW&S	FSRA101	Professional Skills for Engineers	2	0	0	2
10	MPD	MPD103	MPD	0	0	1	1
Total (34 hrs)							28

Seventh Semester							
				L	T	P	Credit
1	PEC	MOOCS	Elective –IV	4	0	0	3
2	OEC	MOOCS	OE –I	3	0	0	3
3	OEC	MOOCS	OE –II	3	0	0	3
4	OEC	MOOCS	OE –III	3	0	0	3
5	PW&S	PRRA102	Major Project	0	0	6	3
6	MPD	MPD104	MPD	0	0	1	0
Total							15

Eighth Semester							
				L	T	P	Credit
1	PW&S	TRRA103	Industrial Training (Trg-III)				12
2	MPD	MPD104	MPD	0	0	1	1
Total							13

Course Code: CRA101
Course Title: Elements of Mechanical Engineering

Programme: B.Tech.(RAI)	L: 3 T:1P:2	Credits:5
Semester:3rd	Theory/Practical: Theory	Teaching Hours: L(45) + T(15) + P(30) = 90
Total Max.Marks:150	Continuous Assessment (CA) Marks: 90	End Semester Examination(ESE) Marks: 60
Minimum Percentage of Numerical/Design/Programming Problems in ESE:50%		
Duration of End Semester Examination (ESE):3hours		
Course Type: Core Course		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Scientific Calculator, Steam Table/Charts

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1	Understand the basic concepts of thermodynamics and Zeroth Law of Thermodynamics.
2	Apply the knowledge of First law of thermodynamics for various engineering applications.
3	Analyze the concept of Second law of Thermodynamics and related properties for the feasibility of engineering systems and solve engineering problems.
4	Evaluate and analyze the performance of Air Standard cycles for the particular applications in IC Engine.
5	Understand various types of conventional manufacturing processes and their applications.
6	Understand various types of computer controlled Manufacturing process and application of Robotics in manufacturing.

Content

Part-A

Unit-1. Basic concepts of Thermodynamics 06 Hrs.

Thermodynamic System, Boundary and Surroundings, Control (fixed) mass and Control Volume concept, Thermodynamic State, Thermodynamic Property, Thermodynamic equilibrium, Thermodynamic path and process, Concept of reversible process, Quasi-static process, Irreversible process, Cyclic process, Energy and its forms; Physical insight to internal energy, Energy transfer across system boundary i.e. transient energies, Heat and work transfer-their comparison and sign conventions, Displacement work and other modes of work, Zeroth law of Thermodynamics.

Unit-2. First law of Thermodynamics 09Hrs.

First law of Thermodynamics and its applications to closed and open system, Analysis of non- flow processes for a control mass undergoing constant volume, constant pressure, constant temperature, adiabatic and poly-tropic processes. Steady and unsteady flow processes and its applications in various engineering devices.

Unit-3. Second law of Thermodynamics 08 Hrs.

Limitations of first law of Thermodynamics, Heat reservoir, source and sink, Heat engine, Refrigerator, Heat pump, Kelvin-Plank and Clausius Statements of second law and their corollaries, Carnot and reversed Carnot cycle, Concept of entropy, T-S diagram, Principle of increase in entropy, Applications of

second law, Available and non-available energy, Enthalpy and entropy as a function of independent variables, Third law of Thermodynamics.

Part-B

Unit-4.Gas power cycles and IC Engines 08 Hrs.

Air standard cycle and air standard efficiency. Otto cycle (constant volume heat addition cycle), Diesel cycle (constant pressure heat addition cycle), Dual cycle (mixed, composite and limited pressure heat addition cycle) and Brayton cycle; Comparison of Otto, Diesel and Dual cycle under some defined similar parametric conditions. Introduction to heat engines, Classification and constructional features of I.C. engines.

Unit-5. Manufacturing Concepts 06 Hrs.

Introduction to Manufacturing Processes: Casting, Machining, Forming, Powder Metallurgy, Welding; Selection of a Manufacturing Process, Types of Production: Job Shop Production, Batch Production, Mass Production; Non-Conventional Machining: Mechanical Energy Based Machining, Chemical Energy Based Machining, Electrochemical energy based Machining, Thermo electrical Energy Based Machining.

Unit-6.Computer Controlled Manufacturing Processes 08 Hrs.

Introduction, Numerical Control: Advantages and Disadvantages of NC systems, Comparison between conventional and NC machines; Classification of Numerical Control Machines: Types of Motion, Programming Method, Control System; Robotics: Structure of a Robot, Applications of Robots in Manufacturing, Robotic Scenario in India; Advantages of automation and computer controlled machines.

Text Books

1. P.K. Nag, "Engineering Thermodynamics", McGraw Hill Education (India), 6th Ed. 2017.
2. V. Ganeshan, "Thermal Engineering", McGraw Hill Education (India),
3. Y.A.Cengel, M.A.Boles, "Thermodynamics–An Engineering Approach", McGraw Hill Education, 8th Ed. 2017.
4. B.S. N. Parashar, R.K.Mittal, "Elements of Manufacturing Processes", PHI Learning, 10th Edition, 2011
5. H.S. Shan, " Manufacturing Processes", Cambridge University Press, 2nd Edition, 2017

Reference Books

1. J.B. Jones, & R.E. Dugan, "Engineering Thermodynamics", Prentice Hall, 1st Edition 1995.
2. D.B. Spalding, E.H. Cole, "Engineering Thermodynamics", Edward Arnold, London, 1982.
3. V.G. Erokhim, M.G. Makhan, "Fundamentals of Thermodynamics and Heat Engines", Mir Publishers, Moscow, 1986.
4. I. Shvets, V. Tolubinsky, "Heat Engineering", Med Tech Science and Technology Series, 2nd Edition 1975.

Supplementary SWAYAM Course:

S. No.	Course Name	Instructor	Host Institute	URL
1	Concepts of Thermodynamics	Prof. Suman Chakaraborty	IIT, Kharagpur	https://archive.nptel.ac.in/courses/112/105/112105266/
2	Basic Thermodynamics	Prof. S.K. Som	IIT, Kharagpur	https://archive.nptel.ac.in/courses/112/105/112105123/

3	Engineering Thermodynamics	Prof.V. Babu	IIT, Madras	https://archive.nptel.ac.in/courses/112/106/112106310/

Laboratory Work

Exp. No.	Experiment Title
1	Study of construction and operation of 2 stroke and 4 stroke Petrol and Diesel engines using actual engines or models.
2	Determine the brake power, indicated power, friction power and mechanical efficiency of a multi cylinder petrol engine running at constant speed (Morse Test).
3	Performance testing of a diesel engine from no load to full load (at constant speed) for a single cylinder/ multi-cylinder engine in terms of brake power, indicated power, mechanical efficiency and specific fuel consumption and to measure the smoke density. Draw/obtain power consumption and exhaust emission curves.
4	Performance testing of a petrol engine from no load to full load (at constant speed) for a single cylinder/ multi-cylinder engine in terms of brake power, indicated power, mechanical efficiency and specific fuel consumption and to measure the exhaust emissions. Also, draw/obtain power consumption and exhaust emission curves
5	To study the principle of Eclectic Discharge Machining and observe the machining process on a conductive workpiece
6	To study the basic concepts , working principle and operation of an Industrial Robotic Arm

Course Code: CRA102
Course Title: Introduction to Artificial Intelligence

Programme: B.Tech.	L: 3 T: 0 P: 2	Credits: 4
Semester: 1	Theory/Practical: Theory	**Teaching Hours:** 45(L)+30(P) = 75 hrs
Total Max. Marks: 150	Continuous Assessment (CA) Marks: 90	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical / Design / Programming Problems in ESE: 20%		
Duration of End Semester Examination (ESE): 3 hours		
Course Type: Core Course		

Prerequisites (if any): foundation in mathematics, basic physics, and Python programming
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1	Understand fundamentals of robotics, AI, and intelligent agents in robotic systems.
2	Analyze sensors, actuators, perception, and sensor fusion techniques in robotics.
3	Apply robot kinematics, motion planning, and control techniques using simulations.
4	Implement AI search algorithms and planning methods for robotic navigation and tasks.
5	Use knowledge representation, reasoning, and decision-making in autonomous robotic applications.

Content

Part-A

Unit-1 Introduction to Artificial Intelligence **08 Hrs**

Definition and history of AI, AI vs Machine Learning vs Robotics, Components of intelligent systems, Applications of AI in mechanical engineering, Overview of AI tools

Unit-2 Intelligent Agents and Problem-Solving **07 Hrs**

Concept of intelligent agents, Types of agents, Problem solving in AI, State space representation, Search techniques: Breadth First Search, Depth First Search, Heuristic search, Applications in robotics navigation

Unit-3 Knowledge Representation **08 Hrs**

Knowledge representation in AI, Logic in AI, Rule based systems, Expert systems, Inference mechanisms, Case study: AI in fault diagnosis of machines

Part-B

Unit-4 Basics of Machine Learning **08 Hrs**

Introduction to Machine Learning, Types of learning: Supervised learning, Unsupervised learning, Simple algorithms: Linear regression, Decision trees, Clustering Applications in mechanical systems: Predictive maintenance, Quality control

Unit-5 Artificial Neural Networks and Deep Learning **06 Hrs**

Biological inspiration of neural networks, Artificial Neural Network basics, Introduction to deep learning, Applications: Image recognition in manufacturing, Defect detection

Unit-6 AI Applications in Robotics and Industry **07 Hrs**

AI in industrial robots, Computer vision basics, Autonomous vehicles, Smart factories (Industry 4.0), Human-robot interaction, Ethical issues in AI

Text Books

1. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson, 4th Edition, 2020.
2. Saroj Kaushik, "Artificial Intelligence", Cengage Learning India, Second Edition, 2022.

Reference Books

1. Elaine Rich & Kevin Knight, *Artificial Intelligence*, McGraw Hill, 3rd Edition, 2008.
2. S. K. Saha, *Introduction to Robotics*, McGraw Hill, 2nd Edition, 2014.
3. Mikell P. Groover et al., Industrial Robotics: Technology, Programming, and Applications, McGraw Hill, 2nd Edition, 2010.
4. Trivedi, M.C., "A Classical Approach to Artificial Intelligence", Khanna Publishing House, Delhi.
5. A.Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd edition, Sebastopol, CA: O'Reilly Media, 2022.

Laboratory Work

Exp. No.	Experiment Title
1	To understand basic Python programming constructs used in robotics. (Python, Jupyter Notebook)
2	Case Study: AI Applications in Mechanical Engineering. (Tools: Python (Pandas, Matplotlib))
3	Implement a rule-based agent (IF–ELSE logic)
4	Represent robot navigation problem as state space
5	Implement Breadth First search (Robot path planning using BFS)
6	Implement Depth First search (Robot navigation using DFS)
7	Implement A* algorithm for robot navigation.
8	Implement Rule-Based Expert System (Simple fault diagnosis system for machines)
9	Build a small neural network from scratch without using any deep learning libraries.
10	Simulate robot navigation using BFS, DFS, and A* algorithms combined.

Supplementary SWAYAM Course

Sr. No.	Course Name	Instructor	Host Institute	URL
1	Artificial Intelligence: Search Methods for Problem Solving	Prof. Deepak Khemani	IIT Madras	https://onlinecourses.nptel.ac.in/noc 25_cs88/preview
2	Artificial Intelligence: Concepts and Techniques	Prof. V. Susheela Devi	IISc Bangalore	https://onlinecourses.nptel.ac.in/noc 25_cs159/preview
3	Robotics	Prof D K Pratihar	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc25_me166/preview
4	Introduction to Robotics	Prof. Asokan T Prof. Balaraman Ravindran Prof. Krishna Vasudevan	IIT Madras	https://nptel.ac.in/courses/107106090

Course Code: CRA103
Course Title: Kinematics of Robotics-I

Programme: B.Tech.	L: 3 T: 1 P: 2	Credits: 5
Semester: 3RD	Theory/Practical: Theory	Teaching Hours: 45(L) + 15 (T) + 30(P) = 90
Total Max. Marks: 150	Continuous Assessment (CA) Marks: 90	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical/Design/Programming Problems in ESE: 60%		
Duration of End Semester Examination (ESE):3hours		
Course Type: Core Course		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1	Analyze kinematic chains and mechanisms.
2	Perform position, velocity and acceleration analysis of mechanisms.
3	Design mechanisms for motion generation and robotic applications.
4	Apply balancing and gyroscopic concepts in mechanical and robotic systems.
5	Use computational tools for mechanism analysis and simulation.

Content

Part A

Unit I Fundamentals of Mechanisms **05 Hrs**

Introduction to mechanisms and machines, links, kinematic pairs and kinematic chains, classification of kinematic pairs, constrained motion, degrees of freedom and mobility analysis using Gruebler's criterion, basic applications of mechanisms in robotic systems.

Unit II Mechanism Analysis **08 Hrs**

Position, velocity and acceleration analysis of planar mechanisms, relative velocity method, instantaneous centre method, vector loop method for mechanism analysis, introduction to matrix methods for kinematic analysis.

Unit III Linkage Mechanisms and Motion Generation **09 Hrs**

Analysis of four-bar mechanisms, slider–crank mechanisms and quick-return mechanisms, coupler curves and path generation, path, motion and function generation, graphical and analytical methods for mechanism synthesis, applications of linkage mechanisms in robotic manipulators and automation systems.

Part B

Unit IV Cam and Screw Mechanisms **09 Hrs**

Introduction to cam and screw mechanisms, classification of cams and followers, follower motion laws (uniform velocity, simple harmonic motion, cycloidal motion), displacement, velocity and acceleration diagrams, pressure angle and basic cam profile design. Screw drives, lead, pitch and efficiency of power

screws, self-locking condition, lead screws and ball screws used in robotic actuators and positioning systems.

Unit V Gear and Gear Trains **08 Hrs**

Introduction to gears and gear terminology, involute and cycloidal tooth profiles, law of gearing, spur gears, helical gears, bevel gears and worm gears, simple, compound and planetary gear trains, velocity ratio and torque transmission, applications of gear systems in robotic joints and industrial automation systems.

Unit VI Balancing and Gyroscopic Effects **06 Hrs**

Static and dynamic balancing of rotating masses, balancing of several masses in the same plane and in different planes, balancing of reciprocating masses, introduction to gyroscopic principles, gyroscopic couple and its effects on machines and vehicles, applications of gyroscopic effects in robotic platforms, drones and mobile robots.

Text Books

1. **S. S. Rattan,** *Theory of Machines,* 4th Edition, McGraw Hill Education Pvt. Ltd., New Delhi.
2. **A. K. Ghosh and A. K. Mallik**, *Theory of Mechanisms and Machines*, 3rd Edition, East-West Press Pvt. Ltd., New Delhi.
3. **Thomas Bevan**, *Theory of Machines*, 3rd Edition, CBS Publishers and Distributors, New Delhi.
4. **J. J. Uicker, G. R. Pennock, and J. E. Shigley**, *Theory of Machines and Mechanisms*, 4th Edition, Oxford University Press, New York.

Reference Books

1. **Robert L. Norton**, *Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines*, 6th Edition, McGraw Hill Education, New York.
2. **Mark W. Spong, Seth Hutchinson, and M. Vidyasagar,** *Robot Modeling and Control*, 1st Edition, John Wiley & Sons, New York.
3. **Bruno Siciliano and Oussama Khatib (Editors)**, *Springer Handbook of Robotics*, 2nd Edition, Springer, Cham, Switzerland.

Supplementary SWAYAM Course

Sr. No.	**Course Name**	**Instructor**	**Host Institute**	**URL**
1	Dynamics & Control of Mechanical Systems	Prof. Ashitava Ghosal	IISc. Bangalore	https://onlinecourses.nptel.ac.in/noc22_me96
2	Kinematics of Mechanisms and Machines	Prof. Anivan DasGupta	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc25_me46
3	Engineering Mechanics - Statics and Dynamics	Prof. Anubhab Roy	IIT Madras	https://onlinecourses.nptel.ac.in/noc25_me20

Laboratory Work

Exp. No	Experiment Title
1	To study various types of kinematics links, pairs, chains & Mechanisms
2	To study Whitworth Quick Return Motion Mechanisms, Reciprocating Engine

	Mechanism, and Oscillating Engine Mechanism
3	To study of inversions of four bar linkage
4	To study of inversions of single/double slider crank mechanisms
5	To study gyroscopic effects through models
6	To determine gyroscopic couple on Motorized Gyroscope
7	To perform experiment on dead weight type governor to prepare performance characteristic Curves, and to find stability & sensitivity
8	To perform experiment on spring controlled governor to prepare performance characteristic Curves, and to find stability & sensitivity
9	To perform the experiment for static / dynamic balancing

Course Code: CRA104
Course Title: Engineering Materials

Programme: B.Tech.	L: 3 T: 0 P: 2	Credits: 4
Semester: 3RD	Theory/Practical: Theory	Teaching Hours: 45(L) + 30(P) = 75
Total Max. Marks: 150	Continuous Assessment (CA) Marks: 90	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical/Design/Programming Problems in ESE:10%		
Duration of End Semester Examination (ESE):3hours		
Course Type: Core Course		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1	Apply crystallographic rules to calculate coordination number, APF, and c/a ratios for various crystal structures
2	Describe and explain the fundamental theories of imperfections in solids, diffusion mechanisms, plastic deformation, and re-crystallization processes
3	Explain, apply, and analyze heat treatment processes, surface hardening, and steel hardenability with evaluation.
4	Describe the principle and working of XRD, Spectroscopy, TEM and electron crystal interactions.
5	Summarize the types of design, methodology for selection of materials
6	To analyse failure mechanisms and material testing methods

Content

Part-A

Unit-1 Introduction to Engineering Materials and Crystallography 06 Hrs.

Introduction: Classification of Engineering Materials, Advanced Materials and Future Materials like ceramics, polymers, composites etc. Atomic Structure, Bonding and Crystal Structure of Solids, Crystal Structures, Crystalline, Quasi Crystalline and Non Crystalline Materials, Miller Indices, Miller-Bravais Indices for Planes and Directions of Cubic and Non-Cubic Structures.

Unit-2 Imperfections and Strengthening of Engineering Materials 08 Hrs.

Diffusion: Diffusion Mechanisms, Steady & Non-steady State Diffusion, Fick's Laws. Phase Diagrams : Phase Rule, Equilibrium Phase Diagrams, Phase Systems - Isomorphous, Eutectic with No and Limited Solid Solubility and Peritectic. Iron-Carbon Phase Diagram, TTT Diagram. Imperfections in Solids: Point Defects, Line Defects and Interfacial Defects and Bulk or Volume Defects, Recovery, Recrystallization and Grain Growth, Work Hardening, Grain Boundary Strengthening, Strengthening by Second Phase Particles - Precipitation and Dispersion of materials specific properties.

Unit-3 Heat Treatment Techniques and Surface Hardening 09 Hrs.

Principles and applications. Processes viz. annealing, normalizing, hardening, tempering. Surface hardening of steels: Principles of induction and oxyacetylene flame hardening. Procedure for carburizing, nitriding and cyaniding. Harden-ability: determination of harden-ability. Jominy end-quench test. Defects due to heat treatment and their remedies. Hardenability: Significance, Critical and ideal critical diameter,

Jominy End Quench method, Factors affecting hardenability. Characteristics of quenchants, Different quenching media. Development of residual stresses, Quench cracking.

Part B

Unit-4 Advanced Microscopy and Spectroscopy Techniques 05 Hrs.

Electron-crystal interaction, X-ray diffraction- Theory, Intensity calculation, Transmission Electron Microscope – Equipment features, Sample preparation, Electron dispersive spectroscopy.

Unit-5 Design-Oriented Materials Selection 08 Hrs.

Relationship between processing, structure properties of various engineering materials, Materials selection criteria-shape, micro structural factors, performance criteria in service and other strategic requirements of engineering components to be designed. Economic considerations.Types of design, materials data and design tools, Methodology for selection of materials for the components, selection of processes to meet the design requirements, Systematic selection process-pertinent case studies, Multiple constraints; its handling Strategies.

Unit-6 Material Failures in Robotic and Engineering Systems 05 Hrs.

Corrosion, Wear & Failure Analysis: Types of corrosion and prevention techniques, Wear mechanisms: adhesive, abrasive, erosive, Failure theories, Case studies of material failure in robotic systems.

Text Books:

1. V. Raghavan, Materials Science, , PHI Learning Private Ltd., 2010.
2. W.D.Callister,Jr ,R.Balasubramaniam, Callister's Materials Science and Engineering, Wiley, 2010
3. G.K. Narula, K.S. Narula, V.K. Gupta, Materials Science, , Tata McGraw Hill, 2010.
4. A.K. Bhargava, Engineering Materials: Polymers, Ceramics and Composites, , PHI Learning (P) Ltd.

Reference Books

1. V. Raghavan, Materials Science and Engineering – A First Course, Prentice Hall of India Private Limited, 2015, 6th Edition.
2. Avner S.H., Introduction to Physical Metallurgy 1997 McGraw Hill Education (India) Ltd

Supplementary SWAYAM Course

Sr. No.	**Course Name**	**Instructor**	**Host Institute**	**URL**
1	Materials Informatics	Prof. Sai Gautam Gopala Krishnan	IISc. Bangalore	https://nptel.ac.in/courses/113108922
2	Introduction to Material Science and Engineering	Prof. Rajesh Parsad	IIT Delhi	https://nptel.ac.in/courses/113102080
3	Properties of Material (Nature and Properties of Material III)	Prof. Ashish Garg	IIT Kanpur	https://onlinecourses.nptel.ac.in/noc25_mm34

Laboratory Work

Exp. No	Experiment Title
1	Specimen preparation for Microstructural examination- cutting, grinding, polishing etc itching of Stainless Steels & High-Speed Steel Specimens.

2	To study the mechanism of chemical corrosion and its protection.
3	To study heat treatment processes (hardening and tempering) of steel specimen.
4	To study the properties of various types of plastics.
5	Study of Ultrasonic testing method.
6	Study of Jominy end-quench hardenability test.
7	To determine crystal planes using Miller Indices.
8	To study wear characteristics using Pin-on-Disc Wear Test.

Course Code: BSRA101:
Course Title: Mathematics-III

Programme: B.Tech.	L: 3 T: 1 P: 0	Credits: 4
Semester: 3RD	Theory/Practical: Theory	Teaching Hours: 45(L) + (15) = 75
Total Max. Marks: 100	Continuous Assessment (CA) Marks: 40	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical/Design/Programming Problems in ESE: 90%		
Duration of End Semester Examination (ESE): 3hours		
Course Type: Core Course		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Use of (non-programmable) scientific calculator is allowed

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1	Explain the concepts, properties, and applications of Laplace Transforms and evaluate definite integrals.
2	Apply Fourier Series and Fourier Transforms to represent periodic functions and analyze engineering problems involving frequency-domain techniques.
3	Solve boundary value problems involving wave, heat, and Laplace equations using the method of separation of variables, Fourier transforms, and Laplace transforms.
4	Analyze scalar and vector fields using the concepts of gradient, divergence, curl, directional derivatives, and scalar potential functions in engineering applications.
5	Apply vector integration and the theorems of Green, Stokes, and Gauss to evaluate line, surface, and volume integrals in physical and engineering problems.
6	Analyze vector spaces and linear transformations, and solve systems of linear equations using the concepts of basis, dimension, kernel, range, and matrix representation.

Content

Part-A

Unit-1 Laplace Transforms **07 Hrs.**

Definition and existence of Laplace Transforms, Laplace transforms of various standard functions, properties of Laplace transforms, inverse Laplace transforms, Laplace transform of derivatives and integrals, Transform of multiplication and division by t, convolution theorem, Evaluation of integrals by Laplace Transform, Laplace transform of unit step function, Impulse function, Dirac delta function.

Unit-2 Fourier Analysis **10 Hrs**

Introduction, even and odd functions, periodic functions, Dirichlet's conditions for Fourier series, Euler's formulae for Fourierseries expansion, change of interval, half-rangeseriesexpansions. Fourier Integral and Fourier Transform, relation between Laplace and Fourier Transform, properties of Fourier transform, Convolution theorem.

Unit-3 Solution of Boundary Value Problems **05 Hrs**

Introduction to boundary value problems involving partial derivatives, Wave equation in onedimension, Heat conduction equation in one dimension and Laplace equation in two dimensions. Solution of boundary value problems by the method of separation of variables and by Fourier and Laplace transforms.

Part-B

Unit 4: Vector Calculus (Differentiation) **06 Hrs**

Scalar point function, Vector point function, vector differentiation, gradient, divergence andcurl, directional derivatives with their physical interpretations, solenoidal and irrotational motions, Scalar potential function.

Unit 5: Vector Calculus (Integration) 07 Hrs

Vector integration: Line integrals, work done, conservative fields, surface integrals and volume integrals, Statements and illustrations of theorems of Green, Stokes and Gauss and their applications.

Unit-6 Linear Algebra 10 Hrs

Definition of vector spaces and subspaces, Linear combination and span of vectors, Linear dependence and linear independence, Basis and dimension of a vector space, Definition and properties of linear transformations, Kernel and range of a linear transformation, Matrix representation of linear transformations, Change of basis, Rowspace, column space, and null space, Applications to systems of linear equations.

Text Books:

1. B.S. Grewal. Higher Engineering Mathematics 44thedition Khanna Publishers
2. Erwin Kreyzig. Advanced Engineering Mathematics 9thedition Wiley India Pvt Ltd
3. Bali N. P, "Textbook of Engg. Mathematics", Laxmi Publishers, 5th Edition, 2010.
4. Sreenadh, S.2014.Fourier Series and Integral Transforms. New Delhi, India: S Chand.

References:

1. Iyengar, T.K.V., B.Krishna Gandhi and S. Ranganatham & M.V.S.S.N. Prasad.n.d. LaplaceTransforms, Numerical Methods & Complex Variables. S. Chand Publishing, 2018.
2. Dennis G. Zill, Michael R. Cullen, Advanced Engineering Mathematics, CBS Publishers
3. R.K. Jain and S.R.K. Iyenger, "Advanced Engineering Mathematics", Narosa Publications, New Delhi, 2008.
4. B.V. Ramana, "Higher Engineering Mathematics", 11th Reprint, Tata McGraw-Hill, New Delhi, 2010.
5. Sharma J. N. and Gupta R.K., "Differential Equations", Krishna Prakashan Media, 47th Edition, 2009.

Course Code: CRA105
Course Title: Machine Drawing and CAD

Programme: B. Tech.	L: 0 T: 0 P: 6	Credits: 3
Semester: 4th	Theory/Practical: Practical	Teaching Hours: 90 Hrs..
Total Max. Marks: 50	Continuous Assessment (CA) Marks: 50	End Semester Examination (ESE) Marks: 00
Minimum Percentage of Numerical / Design / Programming Problems in ESE: 00%		
Duration of End Semester Examination (ESE): NA		
Course Type: Core Course		

Prerequisites (if any): NIL
Additional Material Allowed in ESE:

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1	Acquire the knowledge of Traditional Machine Drawing and Computer Aided Drafting **(**CAD) through software and its features
2	Impart knowledge of threads, fasteners, joints and couplings.
3	Use standards used in machine drawing of machine components and assemblies.
4	Create and read production drawings for robotic components and systems and deduce their functions
5	Use manual drafting or CAD tools for making drawings of robotic components and assemblies.
6	Assemble of components and make sectioned views of the mechanical and robotic system assembly and interpret its working

Laboratory Work

The following exercises are to be done in 3D modeling using SolidWorks or other software's

Exp. No.	Experiment Title
1	Modeling and assembly of nut and bolt (Popular forms of threads including square threads)
2	Flange Coupling
3	Knuckle joint
4	Limits and fits with the help of 3D Modeling
5	Pneumatic cylinder modeling and assembly
6	Modeling and assembly of Pneumatic Pick and Place Mechanism
7	Modeling and assembly of Robotic Grippers
8	Modeling and assembly of Linear motion Guide rail assembly
9	Modeling and assembly of Pivot or foot step bearing
10	Modeling and assembly of Robotic Arm (Manipulator mechanism)

Text Books

1. Ajeet Singh, "Machine Drawing (including Auto CAD)", McGraw Hill, 2nd edition, 2012
2. N.D. Bhatt, "Machine Drawing", Charotar publications,50th Edition, 2014
3. P.S. Gill, "Machine Drawing", S K Kataria and Sons, 18th edition, 2017 Reprint
4. Pohit, G., Machine Drawing with AutoCAD, Pearson Education Asia (2007).
5. Dhawan, R.K., Machine Drawing, S.Chand & Company Limited (2003).

Reference Books

1. Gene R. Cogorno,"Geometric Dimensioning and Tolerancing for Mechanical Design", McGraw-Hill Professional, 2 nd Edition,2011.

2. Paul Drake, Jr., “Dimensioning & Tolerancing Handbook”, McGraw-Hill Professional, 1 st Ed, 1999
3. French, T. E. and Vierck, C. J., Graphic Science and Design, McGraw Hill (2000)

Course Code: CRA106
Course Title: Strength of Materials

Programme: B.Tech.	L: 3 T: 1 P: 2	Credits: 5
Semester: 4TH	Theory/Practical: Theory	Teaching Hours: L(45) + T(15) + P(30) = 90
Total Max. Marks: 150	Continuous Assessment (CA) Marks: 90	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical / Design / Programming Problems in ESE: 70%		
Duration of End Semester Examination (ESE): 3 hours		
Course Type: Core Course		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1	Formulate mechanics problems using calculus and differential equations.
2	Solve, analyze and design beams under bending stresses.
3	Understand the design considerations of structures Courseed to different/wide range of loading conditions including thermal loads.
4	Relate the design problems with practical applications.
5	Solve problem involving simple and combined modes, including torsion.
6	Evaluate slope and deflection in different type of beams under different loading conditions

Content

Part-A

Unit-1 Simple Stresses and Strains **08 Hrs.**

Concept of stress and strain; St. Venant's principle, stress and strain diagram, Hooke's law, Young's modulus, Poisson ratio, stress at a point, stress and strains in bars Courseed to axial loading. Modulus of elasticity, stress produced in compound bars Course to axial loading. Temperature stress and strain calculations due to applications of axial loads and variation of temperature in single and compound bars. Compound stress and strains, the two-dimensional system; stress at a point on a plane, principal stresses and principal planes; Mohr's circle of stress; ellipse of stress and their applications. Generalized Hook's Law, principal stresses related to principal strains.

Unit-2 Bending Moment (B.M) and Shear Force (S.F) Diagrams **08 Hrs.**

S.F and B.M definitions. BM and SF diagrams for cantilevers, simply supported beams with or without overhangs and calculation of maximum BM and SF and the point of contra flexure under the following loads: Concentrated loads, Uniformity distributed loads over the whole span or part of span, Combination of concentrated loads (two or three) and uniformly distributed loads, Uniformity varying loads & Application of moments Relation between rate of loading, shear force and bending moment.

Unit-3 Thin cylinders and spheres **06 Hrs.**

Calculation of Hoop stress, longitudinal stress in a cylinder, the efficiency of joints, changes in dimensions due to internal pressure. Principal stresses in a spherical shell, change in diameter and internal volume.

Part-B

Unit-4 Bending Stresses and Deflection in Beams **09 Hrs.**

Bending theory; assumptions, derivation of bending equation and its application to beams of rectangular, circular and channel, I and T- sections. Combined, direct and bending stresses in afore-mentioned sections, composite / flitched beams. Relationship between moment, slope and deflection, Double integration method, Macaulay's method, moment area method and use of these methods to calculate slope and deflection for the following: a. Cantilevers b. simply supported beams with or without overhang under concentrated loads, uniformly distributed loads or combination of concentrated & uniformly distributed loads.

Unit-5 Torsion **07 Hrs.**

Derivation of torsion equation, its assumptions and application on the hollow and solid circular shafts. Torsional rigidity, combined torsion and bending of circular shafts, principal stresses and maximum shear stresses under combined loading of bending and torsion.

Unit-6 Columns and Struts **07 Hrs.**

Columns and failure of columns: Euler's formulas; Rankine-Gordon's formula, Johnson's empirical formula for axially loaded columns and their applications

Text Books

1. S.S. Rattan, "Strength of Materials", Tata McGraw Hill, 11th Edition, 2014 (E-Book).
2. R.S. Lehri, "Strength of Materials", Katson, 11th Edition, 2012.
3. Egor P. Popov, "Engineering Mechanics of Solids", Prentice Hall of India, 2nd Edition, 2001.
4. R. Subramanian, "Strength of Materials", Oxford University Press, 3rd Edition, 2 2007.
5. Timoshenko, "Mechanics of Materials", CBS Publication, 2nd Edition, 2006.

Reference Books

1. Kirpal Singh, "Mechanics of Materials", Standard Publishers, 7th Edition, 2013.
2. Ferdinand P. Been, Russel Johnson Jr and John J. Dewole, "Mechanics of Materials", Tata Mc-GrawHill Publishing Co. Ltd., 2005.
3. Sadhu Singh, "Strength of Materials", Khanna Publication, 11th Edition, 1978.
4. Russell C. Hibbeler, "Mechanics of Materials", Pearson Publications, 10th Edition, 2016.

Supplementary SWAYAM Course

Sr. No.	**Course Name**	**Instructor**	**Host Institute**	**URL**
1	Strength of Materials	Prof. Sriman Kumar Bhattacharyya	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc19_ce18/preview
2	Strength of Materials	Prof. K Ramesh	IIT Madras	https://onlinecourses.nptel.ac.in/noc25_me73/preview
3	Structural Analysis-I	Prof. Amit Shaw	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc25_ce54/preview

Laboratory Work

Experiment No.	Experiment Title
1	To perform tensile test in ductile and brittle materials and to draw stress-strain curve and to determine various mechanical properties.
2	To perform compression test and impact tests on the given specimen
3	To perform hardness test. (Aluminium, Mild steel and Hardened steel)

4	To perform torsion test and to determine various mechanical properties of the given material
5	To perform bending test on beam and to determine the Young's modulus and modulus of rupture
6	To determine buckling load of long columns with different end conditions.
7	To draw load/ defection curve for helical spring
8	To perform Fatigue test on circular test piece.

Course Code: CRA107
Course Title: Kinematics of Robotics-II

Programme: B.Tech.	L: 3 T: 1 P: 2	Credits: 5
Semester: 4TH	Theory/Practical: Theory	Teaching Hours: 45(L)+15(T) + 30(P) = 90
Total Max. Marks: 150	Continuous Assessment (CA) Marks: 90	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical/Design/Programming Problems in ESE: 70%		
Duration of End Semester Examination (ESE):3hours		
Course Type: Core Course		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1	Select appropriate sensors and actuators for robotic applications.
2	Analyze forward and inverse kinematics of robot manipulators.
3	Model robot manipulators using coordinate transformations and DH parameters.
4	Derive equations of motion and perform dynamic analysis of robot manipulators.
5	Analyze forces, velocities and singular configurations in robotic manipulators.
6	Implement basic control and programming of robotic systems using embedded controllers.

Content

Part-A

Unit I: Introduction to Robots, Sensors and Actuators 05 Hrs.

Robot classification, serial and parallel manipulators, robot selection and applications, classification of various sensors and actuators used in robotics.

Unit II Spatial Descriptions and Transformations 09 Hrs.

Description of a position, an orientation, different frames. Mappings involving general frames, rotated and translated frames. Translational, Rotational, Transformation operator. Transform equations. Representation of Orientation. Fixed angles and Eulers angles. Transformation of free vectors.

Unit III Manipulator Kinematics 08 Hrs.

Link description, link and connection description, Denavit–Hartenberg (DH) notations. Convention for affixing frames to link. Link transformations, actuator space, cartesian space; task oriented space, operational space. Standard names of frames. Inverse manipulator kinematics; closed form solutions and numerical solutions.

Part B

Unit IV Velocities and Static Forces 08 Hrs.

Time dependent Position and orientation, Linear and Rotational velocities, motion of a links, velocity propagation from link to link. Jacobians, singularities. Static forces in a manipulator. Force domain, transformations of velocities and static forces.

Unit V Manipulator Dynamics **08 Hrs.**

Acceleration of a rigid body (linear/angular), moment of inertia, Newton's equation, Euler's equation, computations of a forces and torques. Manipulators dynamics equations. Lagrangian dynamic formulation. Manipulator dynamics in a Cartesian space, dynamic simulations. Trajectory generation. Manipulator - mechanism design.

Unit VI Linear Control of Manipulators **07 Hrs.**

Feedback and closed loop control, second order linear systems, control of second order systems, Control – Law partitioning, trajectory following control, continuous vs discrete time control.

Texts Books:

1. Craig, J. J., Introduction to Robotics: Mechanics and Control, Pearson, 3rd Edition.
2. Saha, Subir Kumar, Introduction to Robotics, Tata McGraw Hill.
3. Ghosal, Ashitava, Robotics: Fundamental Concepts and Analysis, Oxford University Press.

References Books:

1. Siciliano, Bruno and Oussama Khatib, Springer Handbook of Robotics, Springer.
2. Spong, Mark W., Seth Hutchinson, and M. Vidyasagar, Robot Modeling and Control, Wiley.
3. Alciatore, David G. and Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw Hill.

Supplementary SWAYAM Course

Sr. No.	**Course Name**	**Instructor**	**Host Institute**	**URL**
1	Dynamics & Control of Mechanical Systems	Prof. Ashitava Ghosal	IISc. Bangalore	https://onlinecourses.nptel.ac.in/noc22_me96
2	Kinematics of Mechanisms and Machines	Prof. Anivan DasGupta	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc25_me46
3	Engineering Mechanics - Statics and Dynamics	Prof. Anubhab Roy	IIT Madras	https://onlinecourses.nptel.ac.in/noc25_me20

Lab Experiments

Experiment No	Experiment Title
1	To understand different coordinate frames used in robotic manipulators
2	To perform translation and rotation using homogeneous transformation matrices.
3	To assign Denavit–Hartenberg (D-H) parameters to a robotic manipulator.
4	To determine the end-effector position using forward kinematics.
5	To determine the position and orientation of a three-link manipulator.
6	To determine joint angles for a desired end-effector position.

Course Code: CRA108
Course Name: Industrial Engineering

Programme: B.Tech.(ME)	L: 3T:0 P:2	Credits:4
Semester:6th	Theory/Practical: Theory	Teaching Hours: 45(L)+ 30(P) = 75 Hrs.
Total Max.Marks:150	Continuous Assessment (CA) Marks: 90	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical/Design/Programming Problems in ESE:20%		
Duration of End Semester Examination (ESE): 3hours		
Course Type: Core Course		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Scientific Calculator.

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1	Analysis and select a better site for a new, expended or modified industrial unit
2	Measure and analysis the work and methods used to carry out the work
3	Measure and design various ergonomical aspects
4	Understand the concepts of management
5	Understand the legislations and latest Amendments in Industrial Sector
6	Understand the latest and newer industrial engineering techniques

Content

Part A

Unit I Plant Location & Layout **09 Hrs.**

Nature of Location Decision, Importance of Plant Location, Dynamic Nature of Plant Location, Choice of site for selection, Comparison of location, Principles of Plant layout and Types, factors affecting layout, methods, factors governing flow pattern, travel chart, analytical tools of plant layout, layout of manufacturing shop floor, repair shop, services sectors and process plant. Quantitative methods of Plant layout: CRAFT and CORELAP, Relationship diagrams.

Unit II Productivity and Work Study **11 Hrs.**

Definition o productivity, application and advantages of productivity improvement tools, reasons for increase and decreases in productivity. Areas of application of work study in industry. Work study. Method Study: Objectives and procedure for methods analysis, Recording techniques, Charts and Diagram, Micro motion and macro-motion study: Principles of motion economy, Normal work areas and work place design. Work Measurement: Objectives, techniques – time study, work sampling, pre-determined motion time standards (PMTS) Determination of time standards. Observed time, basic time, normal time, rating factors, allowances, and standard time. Job Evaluation and Wage Plan: Objective, Methods of job evaluation, job evaluation procedure, merit rating (Performance appraisal), method of merit rating, wage and wage incentive plans

Unit III Ergonomics **05Hrs.**

Need and relevance of ergonomics in industry, introduction to anthropometry, considerations in designing man machine systems, effect of environmental considerations like heat light, ventilation, humidity etc. on human performance, Occupational health and Safety Standard (OHSAS).

Part - B

Unit IV Concepts of Management and Production Planning and Control 08 Hrs

Planning, Organizing, Staffing, Directing and Controlling, Centralization versus decentralization of authority and responsibility, Concept of benchmarking. Types of Production systems and their Characteristics, functions and objectives of Production Planning and Control, Sales forecasting: Techniques and Applications, Steps of Production Planning and Control: Process planning, Leading, Scheduling, Dispatching and Expediting with illustrative examples, Introduction to line of balance, assembly line balancing, and progress control.

Unit V Industrial Legislation 07 Hrs.

Need for Industrial legislation, Factories act 1948, Industrial dispute act 1947, The Indian trade unions act 1926, Industrial employment act 1946, Payment of wage act 1936, Workmen compensation act 1923, Payment of bonus act 1965, Employees provident fund scheme 1952. Latest amendments and Legislations Concept ISO 9000, ISO 14000 and QS 9000

Unit VI Current Trends 05Hrs.

Definitions, Scope And Applications of Agile Manufacturing, Six Sigma, Value Engineering, Just-In-Time, Total Quality Management, Enterprise Resource Planning, Kaizen, Total Productive Maintenance. Failure Mode Effect Analysis, Statistical Quality Control: Quality circles, , Quality assurance, Acceptance sampling, Quality Contro Charts

Text Books

1. A.P. Verma, "Industrial Engineering & Management", S. K. Kataria & Sons, 2014.
2. H.S. Shan, "Work Study and Ergonomics" Dhanpat Rai & Co. , 2004.
3. A. Shtub & Y. Cohen, "Introduction to Industrial Engineering", CRC Press, Taylor & Francis Group.
4. O.P. Khanna, " Industrial Engineering and Management" , Dhanpat Rai & Co.
5. Philip E Hick, "Industrial Engineering & Management", Tata McGraw Hill, 1994
6. R. Panneerselvam "Production and Operations Management", PHI Private Ltd.,

Reference Books:

1. Telsang Martand, "Industrial Engineering & Production Management", S Chand & Co, 2006.
2. Lee J. Krajewski, "Operations Management: Processes and Supply Chains", Pearson Education, 2016
3. J.L. Riggs "Production System, Planning, Analysis and Control", Wiley
4. Martand Telsang "Industrial Engineering and Production Management", S Chand & company.
5. B. Kumar "Industrial Engineering and Management" Khanna Publishers
6. ILO, "Introduction to Work Study", Oxford and IBH Publishing, 3rd Edition, 2008

Supplementary SWAYAM Course:

Sr. No	Course Name	Instructor	Host Institute	URL
1	Industrial engineering & operation Research	Prof. Uday Shanker Dixit	| IIT Guwahati	https://onlinecourses.nptel.ac.in/noc25_me181
2	Principles of Industrial Engineering	Prof. D. K. Dwivedi	IIT Roorkee	https://onlinecourses.nptel.ac.in/noc26_me78
3	Operation Management	Prof. Inderdeep Singh	IIT Roorkee	https://onlinecourses.nptel.ac.in/noc20_me30

Topics for Self Learning (TSL)

1	Kanban

2	Poke Yoka
3	Design of Experiments

Lab Work

Exp. No	Experiment Title
1	Case study demonstration on location decision and site selection
2	Case study on plant layout problem
3	Case Study on forecasting problem using different forecasting techniques
4	To draw the Operation and flow process chart for Academic and Industrial Organization
5	Measure the standard time for a given task
6	Measure the impact of noise on human body
7	Measure the impact of lighting and ventilation on human body

Course Code: ERA101
Course Title: Introduction to Unmanned Aerial Vehicles

Programme: B.Tech.	L: 4 T: 0 P: 0	Credits: 4
Semester: 3rd	Theory/Practical: Theory	Teaching Hours: L(60) = 60
Total Max. Marks: 100	Continuous Assessment (CA) Marks: 40	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical / Design / Programming Problems in ESE: NA		
Duration of End Semester Examination (ESE): 3 hours		
Course Type: Elective Course		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1	Understand drone fundamentals: Grasp the basic components, design principles, and diverse applications of drones.
2	Master flight mechanics: Learn the principles of aerodynamics, stability, and control in drone operations.
3	Explore advanced navigation systems: Study GPS, GNSS, and autonomous technologies for precise drone navigation..
4	Analyze industry applications: Investigate drone usage across industries
5	Understand regulatory frameworks at national & international level
6	Develop the approach in troubleshooting of UAVs

Content

Part-A

Unit-1 Introduction to Drone Technology and Design 08 Hrs.

Overview of Drone Technology - History and Evolution of Drones - Types and Classifications of Drones - Overview of Applications in Various Industries. Drone Components and Basic Design - Key Components: Motors, Propellers, ESCs, Frames - Flight Control Systems and Sensors - Basic Drone Design Principles.

Unit-2 Aerodynamics, Flight Mechanics, and Navigation 11 Hrs.

Aerodynamics and Flight Mechanics -Principles of Lift, Drag, and Thrust - Stability and Control Mechanisms - Impact of Aerodynamics on Drone Design. Navigation Systems and Communication - GPS, GNSS, and IMU Integration - Communication Protocols: RF, Wi-Fi, and LTE - Advanced Navigation Techniques.

Unit-3 Sensors, Payloads, and Autonomous Systems 11 Hrs.

Advanced Sensors and Payload Integration - Camera Systems, LiDAR, and Infrared Sensors - Payload Design and Integration - Balancing Payload Weight and Drone Performance. Autonomous Systems and AI in Drones - Autonomous Flight Technologies - AI and Machine Learning Applications in Drones - Path Planning and Obstacle Avoidance

Part-B

Unit-4 Industry Applications 11 Hrs.

Industry Applications of Drones - Agriculture, Construction, Logistics, and Environmental Monitoring - Case Studies of Successful Drone Implementations - Challenges and Opportunities in Various Sectors

Unit-5 Future Trends, Case Studies **09 Hrs.**

Emerging Technologies and Innovations - The Role of Drones in Smart Cities and IoT -Predictions for the Next Decade, Entrepreneurship Opportunities for Drone Pilots and Drone Engineers, Industry visit

Unit-6 Regulations, Saftey and Ethics **11 Hrs.**

Regulations, Safety, and Ethical Considerations - Global and Regional Drone Regulations - Safety Standards and Compliance - Privacy, Security, and Ethical Issues, DGCA regulations

Text Books

1. John Baichtal, Drone Technology: A Complete Guide for Beginners and Experts
2. Douglas M. Marshall, Richard K.Barnhart, and Eric Shappee, Introduction to Unmanned Aircraft Systems
3. John Baichtal and Terry Kilby, Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs

Reference Books

1. Randal W. Beard and Timothy W.McLain, Small Unmanned Aircraft: Theory and Practice b
2. Mark LaFay and Kraig Becker Drones for Dummies

Supplementary SWAYAM Course

Sr. No.	**Course Name**	**Instructor**	**Host Institute**	**URL**
1	Aeromechanics of Unmanned Aerial Vehicles / Drones	Prof. Abhishek	IIT Kanpur	https://onlinecourses.nptel.ac.in/noc26_ae03/preview
2	Drone Surveying	Prof. Pradeep Kumar Garg, Prof. Prakhar Misra	IIT Roorkee	https://onlinecourses.nptel.ac.in/noc26_ce12/preview

Course Code: ERA102
Course Name: Advanced Materials for Robotics

Programme: B. Tech.	L: 4 T: 0 P: 0	Credits: 4
Semester: 4th	Theory/Practical: Theory	Teaching Hours: L(60) = 60
Total Max. Marks: 100	Continuous Assessment (CA) Marks: 40	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical / Design / Programming Problems in ESE: 00%		
Duration of End Semester Examination (ESE): NA		
Course Type: Elective		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#	Course Outcomes(CO)
1	Explain the properties of advanced structural materials used in robotics, analyze strength, fatigue, and wear requirements of robotic components
2	Classify different composite materials used in robotic systems, evaluate mechanical behavior and manufacturing methods of composites
3	Working principles of smart and functional materials, analyze actuation and sensing behavior of SMAs, piezoelectric and EAP materials
4	Explain the role of nanomaterials in enhancing robotic performance, Compare surface engineering techniques for wear and corrosion resistance.
5	Identify materials used in robotic sensors and actuators, analyze material requirements for MEMS and electromagnetic devices.
6	Analyze material behavior in layered manufacturing techniques and Design robotic components using 3D printing and DfAM principles.

Content

Part A

Unit–I: Advanced Structural Materials for Robotics 08Hrs.

Limitations of conventional materials in robotics, High-strength alloys: Titanium alloys, Aluminum-Lithium alloys, Magnesium alloys, Advanced steels (HSLA, maraging steel), Material properties relevant to robotics: Strength-to-weight ratio, Fatigue and wear resistance, Thermal stability, Applications in robotic arms, frames, joints etc.

Unit–II: Composite Materials in Robotics 10 Hrs.

Introduction to composites and classifications, Fiber-reinforced composites: Carbon fiber composites (CFRP), Glass fiber composites (GFRP), Kevlar composites, Matrix materials: polymer, metal, ceramic, Manufacturing techniques: Hand lay-up, Filament winding, Resin transfer molding, Applications in drones, humanoid robots, exoskeletons**.**

Unit–III: Smart and Functional Materials 10 Hrs.

Introduction to smart materials, Shape Memory Alloys (SMA): Nitinol, Working principle and phase transformation, Piezoelectric materials: Working mechanism, Use in sensors and actuators, Magnetostrictive materials, Electro-active polymers (EAPs), Applications in soft robotics and micro-actuators.

Part B

Unit–IV: Nano-Materials and Surface Engineering 10 Hrs.

Introduction to nanotechnology, Carbon-based nanomaterials: Carbon nanotubes, Graphene, Nano-coatings for wear, corrosion, and friction control, Surface modification techniques: PVD, CVD, Thermal spraying, Role of nanomaterials in sensors and energy storage.

Unit–V: Materials for Sensors, Actuators & Future Robotics 11 Hrs.

Materials for robotic sensors: Semiconductor materials, Optical and MEMS materials, Materials for actuators: Electro-magnetic materials, Dielectric elastomers, Bio-materials and bio-inspired materials, Sustainable and recyclable materials, Future trends: Self-healing materials, 4D printing materials, AI-assisted material selection.

Unit–VI: Additive Manufacturing & Advanced Processing of Materials 11Hrs.

Introduction to additive manufacturing (AM), 3D printing materials: Polymers, metals, ceramics, AM techniques: FDM, SLS, SLA, DMLS, Material behavior in layered manufacturing, Design for AM (DfAM), Applications of AM in rapid prototyping of robots.

Text Books:

1. William D. Callister, Jr., David G. Rethwisch "Materials Science and Engineering: An Introduction" Comprehensive coverage of fundamental and advanced materials concepts, Wiley 10th Edition (2020).
2. Krishan K. Chawla, Composite Materials: Science and Engineering" Springer Nature (Springer) Edition: 4th Edition (2019).
3. M. V. Gandhi and B. S. Thompson Smart Materials and Structures" Chapman & Hall, Springer, Publication Year: 1992.

Reference Books

1. S. K. Kulkarni, ",Nanotechnology: Principles and Practices", Springer 3rd Edition (2014)
2. Ian Gibson, David Rosen, and Brent Stucker "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer 2nd Edition (2015).
3. Michael F. Ashby "Materials Selection in Mechanical Design", Butterworth- Heinemann, 6th Ed

Supplementary SWAYAM Course

Sr. No.	**Course Name**	**Instructor**	**Host Institute**	**URL**
1	Experimental Nanobiotechnology	Prof. P. Gopinath	IIT Roorkee	https://onlinecourses.nptel.ac.in/noc25_bt44
2	Advances in Additive Manufacturing of Materials: Current status and emerging opportunities	Prof. Bikramjit Basu	IISc Bangalore	https://onlinecourses.nptel.ac.in/noc25_mm02

Course Code: ERA103
Course Name: Machine Vision

Programme: B. Tech.	L: 4 T: 0 P: 0	Credits: 4
Semester: 4th	Theory/Practical: Theory	Teaching Hours: L(60) = 60
Total Max. Marks: 100	Continuous Assessment (CA) Marks: 40	End Semester Examination (ESE) Marks: 60
Minimum Percentage of Numerical / Design / Programming Problems in ESE: 00%		
Duration of End Semester Examination (ESE): NA		
Course Type: Elective		

Prerequisites (if any): NIL
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#	Course Outcomes(CO)
1	Explain basic terminologies and models for digital image formation.
2	Apply edge detection, blobs detection and corner detection techniques to represent visual features.
3	Make use of feature descriptors and matching techniques to identify objects.
4	Analyze the characteristics by segmenting the image into different regions.
5	Determine objects by identifying regularities in pattern analysis.
6	Design a computer vision system for a real-world problem.

Content

Part-A

Unit I Introduction to Machine Vision 08Hrs.

Overview of Machine Vision and its role in robotics, Components of a Machine Vision System, Cameras, Lighting. Image sensors (CCD, CMOS), Lenses and optics, Image formation and camera models, Industrial applications of machine vision

Unit II Introduction to Digital images and Image Representation 10 Hrs.

Introduction to Computer Vision, Introduction to digital images and image representation, Image Formation: Photometric Image Formation, Reflectance Capture and Representation, Image Sensing, Image Compression, Image Processing Operations (Linear Filtering, Correlation, Convolution)

Unit III Image Acquisition and Preprocessing 10 Hrs.

Image sampling and quantization, Color spaces (RGB, HSV, Grayscale), Image enhancement techniques (Histogram equalization, Contrast stretching), Image filtering (Smoothing filters, Median filtering, Gaussian filtering), Noise reduction methods

Part-B

Unit IV Image Segmentation and Feature Extraction 14 Hrs.

Human Visual System, Feature Matching. Hough transform; From points Matching, Region Splitting and Merging, Edge Based approaches to segmentation, Thresholding techniques, Edge detection methods (Sobel, Canny, Prewitt), Region-based segmentation, Morphological operations (Dilation, Erosion, Opening and closing), Feature extraction (Corners, Edges, Shape descriptors) .

Unit V Object Detection and Recognition 10 Hrs.

Template matching, Pattern recognition basics, Object detection techniques, Feature matching methods, Introduction to machine learning for vision, Classification methods (SVM, k-NN basics)

Unit VI Applications of Machine Vision **08 Hrs.**

Motion Estimation and Object Tracking, Gesture Recognition, Face and Facial Expression Recognition, Image Fusion

Text Books

1. Richard Szeliski,, "Computer Vision: Algorithms and Applications", 1st Edition, Springer.
2. Gonzaleze and Woods, "Digital Image Processing", 4th Edition, Pearson.
3. Richard Hartley, "Multiple View Geometry in Computer Vision", 2nd Edition, Cambridge University Press.

Reference Books:

1. KeinosukeFukunaga,,"Introduction to Statistical Pattern Recognition", Academic Press Professional, Inc. San Diego, CA, USA.
2. Anil K. Jain, "Fundamental of Digital Image Processing", Prentice-Hall of India Pvt. Ltd

Supplementary SWAYAM Course

Sr. No.	**Course Name**	**URL**
1	Computer Vision‖,	https://nptel.ac.in/courses/106/105/106105216/
2	Computer Vision‖,	https://swayam.gov.in/nd1_noc19_cs58/preview