NIRMA UNIVERSITY
INSTITUTE OF TECHNOLOGY
Teaching & Examination Scheme
Bachelor of Technology (Mechanical Engineering)

Semester-V

w. e. f. Academic Year 2024-25

Course Code	Course Title	Teaching Scheme (hours/week)				Examination Scheme			
		L	T	P	C	Duration Hours	Component Weightage		
						SEE	CE	LPW	SEE
3ME101CC24	Manufacturing Process-II	3	0	2	4	3	0.3	0.3	0.4
3ME601CC24	Design and Dynamics of Machines	3	0	2	4	3	0.3	0.3	0.4
3ME301CC24	Heat and Mass Transfer	3	0	2	4	3	0.3	0.3	0.4
	Department Elective-I	3	0	2	4	3	0.3	0.3	0.4
		3	1	0			0.6	-	0.4
	Core Course-I under Minor	3	1	0	4	3	0.6	-	0.4
		3	0	2			0.3	0.3	0.4
		2	0	4			0.3	0.3	0.4
		2	1	2			0.3	0.3	0.4
	Core Course-II under Minor	3	1	0	4	3	0.6	-	0.4
		3	0	2			0.3	0.3	0.4
		2	0	4			0.3	0.3	0.4
		2	1	2			0.3	0.3	0.4
	Total	**-**	**-**	**-**	**24**	**-**	**-**	**-**	**-**

L: Lectures, P/T: Practicals / Tutorial, C: Credits
LPW/PW: Laboratory / Project Work
SEE: Semester End Examination
CE: Continuous Evaluation

Department Elective–I

Sr. No.	Course Code	Course Name	L	T	P	C
1.	3ME302ME24	Basics of Flight and Aerodynamics	3	1	0	4
2.	3ME303ME24	Fluid Power Engineering	3	0	2	4
3.	3ME701ME24	Robotics Engineering	3	0	2	4
4.	3ME602ME24	Stress Analysis	3	0	2	4
5.	3ME201ME24	Quality and Reliability Engineering	3	1	0	4
6.	3ME702ME24	Mechatronics	3	0	2	4
7.	3ME603ME24	Mechanics of Composite Materials	3	0	2	4

w.e.f. for first year students admitted in 2022-23 and D to D students admitted in 2023-24 onwards

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	B.Tech. in Mechanical Engineering
Course Code:	
Course Title:	Manufacturing Processes-II
Course Type:	Core
Year of introduction:	2024-25

L	**T**	**Practical component**				**C**
		LPW	**PW**	**W**	**S**	
3	**0**	**2**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, student will be able to –

1	select appropriate conventional and advanced machining process for a given application,	(BL5)
2	interpret the effect of process parameters on different machining operations,	(BL5)
3	design jigs and fixtures for a given component,	(BL6)
4	develop part programs for CNC turning and machining centres.	(BL6)

Unit	**Contents**	**Teaching hours (Total 45)**
Unit I	**Conventional machining processes** Introduction of machine tools, Classification, Working and auxiliary motions; Lathe, Shaper, Planning, Drilling and Milling: Types, Specifications, Process parameters, Construction, Attachments and Operations, Turrets and Automats, gear manufacturing processes, selection and applications.	12
Unit II	**Advanced machining processes** Introduction, Classification, Advanced machining processes namely Water Jet Machining, Abrasive Jet Machining, Ultrasonic Machining, Electric Discharge Machining, Electro Chemical Machining, Plasma Arc Machining,	12

Laser Beam Machining and Electron Beam Machining: Principles, Variants, Elements, Process parameters, selection and applications.

Unit III	**Surface processing operations** Cleaning operations: Chemical and Mechanical, Coating operations: Plating, physical vapor deposition, chemical vapor deposition; Finishing operations: grinding, Lapping, Honing, Super-finishing, Polishing and Buffing, Gear finishing processes, selection and applications.	07
Unit IV	**Jigs and fixtures** Definition, usefulness in mass production; principles, methods, Types of locators, diamond pin locator, principles and types of clamps, jig bushes: purpose and types, Jigs and Fixtures for turning, milling, welding, and grinding applications.	07
Unit V	**CNC machining and additive manufacturing** CNC machine introduction, Classification, Hardware, Tooling, Programming for turning and machining centres. Additive manufacturing – basics, processes and applications.	07

Self – Study: The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Suggested Readings/References:

- HMT, *Production technology*, Tata McGraw-Hill Education.
- Groover M. P., *Fundamentals of modern manufacturing: materials processes, and systems,* John Wiley & Sons
- Smid P., *CNC programming handbook: a comprehensive guide to practical CNC programming,* Industrial Press Inc.
- Joshi P. H., *Jigs & Fixtures,* Tata McGraw Hill
- Rao P. N., *Manufacturing technology: metal cutting and machine tools (Vol. 2)*, Tata McGraw-Hill Education.
- Ghosh A. and Mallik A. K., *Manufacturing Science,* Pearson India.

Laboratory Work: Laboratory work will be based on above syllabus with minimum 10 experiments to be incorporated.

Suggested List of Experiments: (not restricted to the following)

(Only for Information)

Sr. No.	Name of Experiment/Exercise	Hours
1	To prepare a practice job demonstrating various lathe operations. (Plain, Step and Taper Turning, Knurling and RH thread cutting on Lathe).	04
2	To prepare a practice job demonstrating various operations on shaper machine. (Machining a plane surface and V-groove on Shaper machine).	04
3	To manufacture a Spur Gear (Machining a Spur Gear on Milling machine).	04
4	To demonstrate surface finish operation using cylindrical grinding machine.	02
5	To identify tooling requirement through demonstration of Automate lathe machine and capstan lathe.	02
6	To demonstrate MRR and surface quality of the job on EDM machine.	02
7	To design a Jig and Fixture for a given product.	04
8	To prepare part programs for CNC turning and machining centres.	02
9	To prepare a component using additive manufacturing process.	02

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	B.Tech. in Mechanical Engineering
Course Code:	
Course Title:	Design and Dynamics of Machines
Course Type:	Core
Year of introduction:	2024-25

L	**T**	**Practical component**				**C**
		LPW	**PW**	**W**	**S**	
3	**0**	**2**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, the student will be able to –

1	explain the concepts of design philosophy,	(BL2)
2	design welded joints, riveted joints, transmission shafts and its components, levers, power screws and springs,	(BL6)
3	evaluate the fatigue life of mechanical components.	(BL5)
4	estimate vibration of the mechanical system and the unbalance in different rotating systems.	(BL5)

Unit	**Contents**	**Teaching hours (Total 45)**
Unit I	**Design Philosophy:** Fail-safe and safe life design concepts, factor of safety, design for assembly, design for manufacturing, design for ergonomics, standardization, theories of failures, thermal stress, creep, concurrent engineering.	06
Unit II	**Levers, Shaft keys and coupling and Power Screws** Classes of levers, force analysis of lever, design of lever arms, design of fulcrum pin.Types of transmission shafts, shaft design based on strength, shaft design based on torsional rigidity, shaft design as per ASME code,	12

	design of hollow shaft based on strength and rigidity, Types of keys, design of square and flat keys, design of splines, design of muff, clamp and rigid flange coupling, design of flexible coupling. Torque requirement of lifting and lowering the load, self-locking screw, efficiency of a square threaded and self-locking screw, collar friction torque, overall efficiency, design of screw and nut.	
Unit III	**Design against fluctuating load** Stress concentration and stress concentration factors, Methods of reduction of stress concentration, mechanism of fatigue failure, estimation of endurance limit, Design for finite and infinite life for completely reversed load, Design based on Gerber, Goodman and Soderberg criteria, fatigue design under combined stresses, cumulative fatigue damage, application of fatigue loading for design of shafts, axles, various mechanical components etc.	13
Unit IV	**Welded and Riveted connections** Design of butt weld joints, Design of parallel and transverse fillet joints, Design of welded joints subjected to eccentric loading, Design of riveted joints for various configurations, efficiency estimation of riveted connections.	10
Unit V	**Springs** Types of springs, terminology of helical spring, stress and deflection equation of springs, design of helical springs, design of springs using trial and error methods.	04

Self – Study:	The self-study contents will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study content.
Laboratory Work:	Laboratory work will be based on the topics of dynamics of machines with a minimum 10 experiments to be incorporated
Suggested Readings/References:	1. Shigley, Budnyas, Nisbett, Mechanical Engineering Design, Tata McGraw Hill. 2. R. L. Norton, Machine Design, Pearson Education.

3. R. C. Juvinall, K. M. Marshek, Fundamentals of Machine Component Design, John Wiley & Sons.
4. S S Rao, Mechanical Vibrations, Person Education.
5. V. B. Bhandari, Design of Machine Element, Tata McGraw Hill.
6. Shigley, Uicker, Theory of Machines and Mechanism, Tata McGraw Hill.

Suggested list of experiments: (not restricted to the following)

Sr. No.	Title	Hours
1.	To derive the equations of motion for arbitrary linear single D.O.F. free, damped and forced vibratory systems.	06
2.	To compare the experimental and theoretical vibration response of longitudinal vibrations for spring mass system.	02
3.	To measure the natural frequency of undamped free torsional vibrations of a single rotor shaft system.	02
4.	To determine the natural frequency of damped torsional vibrations of a single rotor shaft system.	02
5.	To locate the node point for two-rotor system experimentally and theoretically.	02
6.	To observe the whirling of shaft phenomenon.	02
7.	To analyse the effect of damping on the forced vibrations of the beam.	02
8.	To determine the natural frequency of vibrations of a double pendulum.	02
9.	To perform the experimental stress analysis of a beam using strain-gauge methods.	02
10.	To identify the location of balancing masses to eliminate the static and dynamic unbalance in a rotating mass system.	06

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	BTech. in Mechanical Engineering
Course Code:	
Course Title:	Heat and Mass Transfer
Course Type:	Core
Year of Introduction:	2024-25

L	**T**	**Practical component**				**C**
		LPW	**PW**	**W**	**S**	
3	**0**	**2**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, the student will be able to:

1	assess the principles of steady and unsteady state heat conduction,	(BL5)
2	interpret the principles of heat transfer by convection, boiling and condensation,	(BL2)
3	apply the concepts of radiation heat transfer for engineering applications,	(BL3)
4	explain the basic principles of heat exchanger design and mass transfer.	(BL2)

Unit	**Contents**	**Teaching Hours (Total 45)**
Unit I	**Conduction** Derivation of generalized equation in Cartesian, Cylindrical and Spherical coordinates, generalized transport equation, one-dimensional steady state heat transfer equations, heat transfer calculations in slabs, cylinders and spheres, use of electrical analogy and estimation of resistance and heat transfer, factors affecting thermal conductivities of various substances, properties of insulation and their importance, critical thickness of insulation. Transient heat conduction in solids – lumped analysis and one-dimensional analysis using Heisler charts. Use of finite difference techniques for solving heat conduction problems.	13

	Heat transfer through extended surfaces: Types, arrangement and application, determination of fin temperature and heat transfer, fin effectiveness and fin efficiency.	
Unit II	**Convection** Dimensionless numbers, concept of hydrodynamics and thermal boundary layers, continuity momentum equation & energy equation, derivation of generalized equation in dimensionless groups for free & forced convection by dimensional analysis and principle of similarity, use of empirical co-relations to determine heat transfer co-efficient in natural and forced convection for parallel, counter and cross flow arrangements.	08
Unit III	**Boiling and Condensation** Boiling curve and modes of pool boiling, flow boiling, film and dropwise condensation, heat pipe.	04
Unit IV	**Radiation** Concept of black and grey surfaces, laws of radiation, Kirchoff's, Stephan–Boltzmann's, Planck's and Wien's laws, emissivity, electrical analogy, heat exchange between black and grey surfaces and enclosed body and enclosure, radiation shield and their effects, use of electrical analogy methods.	09
Unit V	**Heat Exchangers** Types and classification, fouling factors, overall heat transfer coefficient, LMTD calculation for parallel flow, counter flow and cross flow heat exchangers, effectiveness – NTU method, effectiveness and efficiency of heat exchangers, designation of shell and tube heat exchangers as per TEMA standards.	08
Unit VI	**Mass Transfer** Fick's law, equimolal diffusion, diffusion of vapors through stagnant medium, applications.	03

Self – Study: The self-study content will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study content.

Laboratory Work: Laboratory work will be based on above syllabus with a minimum 10 experiments to be incorporated.

Suggested Readings/References:

1. Cengel Y., Ghajar A., Heat and Mass Transfer, McGraw Hill.
2. Incropera F., DeWitt D., Fundamentals of Heat and Mass Transfer, John Wiley.
3. Sukhatme S. P., Heat Transfer, Universities Press.
4. Holman J. P., Heat and Mass Transfer, McGraw Hill.
5. Nellis G. Klein S., Heat Transfer, Cambridge University Press.

Suggested list of experiments: (not restricted to the following)

Sr. No.	Title	Hours
1.	To find thermal conductivity of a material Guarded Hot Plate method.	02
2.	To find the emissivity of a test plate.	02
3.	To find the Stefan-Boltzmann constant.	02
4.	To find the convective heat transfer coefficient in natural convection.	02
5.	To find the convective heat transfer coefficient in forced convection.	02
6.	To find overall heat transfer coefficient in a double pipe heat exchanger.	02
7.	To find overall heat transfer coefficient in a shell and tube heat exchanger.	02
8.	To find mass diffusion coefficient.	02
9.	To demonstrate the construction and performance of heat pipe.	02
10.	To find critical heat flux in pool boiling heat transfer	02
11.	To study the performance of solar flat plate collector.	02

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	B.Tech. in Mechanical Engineering
Course Code:	
Course Title:	Basics of Flight and Aerodynamics
Course Type:	Department Elective
Year of Introduction:	2024-25

L	**T**	**Practical component**				**C**
		LPW	**PW**	**W**	**S**	
3	**1**	**0**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, the student will be able to –

1 explain the evolution of aircraft and aircraft industry, (BL2)
2 infer the basics of flight and aircraft systems, (BL2)
3 apply the basic principles of aerodynamics to aircraft systems, (BL3)
4 analyse the mechanics of flight and its performance. (BL4)

Unit	**Contents**	**Teaching hours (Total 45)**
Unit I	**Overview of Aircraft Industry** The historical evolution of flight; aircraft industry, manufacturing and materials, industry supply chain; global and Indian scenario.	04
Unit II	**Basics of Flight and Aircraft Systems** Earth's atmosphere and International Standard Atmosphere. Basic principles of flight, basic components of an aircraft, structural members, aircraft axis system, aircraft motion, control surfaces and high lift devices, tail unit arrangements, landing gear arrangements, cockpit and instruments, structural concepts, stability and control. Aircraft propulsion systems- IC Engine, propeller and jet engines. Fuel systems. Hydraulic and Pneumatic systems, air-conditioning and environment control system (ECS).	14
Unit III	**Principles of Aerodynamics** Viscous flows; generation of lift, drag, pitching moments, types of drag, lift curve, drag curve, lift/drag ratio curve, factors affecting lift and drag, Center of Pressure and its effects. Pressure distribution and flow separation, airfoils and airfoil	12

nomenclature, finite wings, pressure distribution over a wing section, compressibility, Mach waves, Mach angles, Critical Mach number.

Unit IV **Flight Mechanics and Performance** 15

Introduction to flight mechanics, horizontal flight performance, power curves, maximum and minimum speeds of horizontal flight, range, endurance, effects of changes of engine power, effects of altitude on power curves. Climbing and descending flight. The flight envelope. Sonic and supersonic flight.

Self – Study: The self-study content will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study content.

Suggested Readings/References:

1. Kermode A. C., Barnard R H, Philpott D R, Mechanics of Flight, Pearson.
2. Anderson J., Introduction to Flight, McGraw Hill.
3. Kermode A. C., Flight without Formulae, Pearson.
4. Moir I., Seabridge A., Aircraft Systems, Wiley.

Suggested List of Tutorials:

1. Prediction of earth's atmosphere and air properties as per ISA.
2. Calculation of strength and stress analysis of aircraft components.
3. Calculations for a sub-sonic wind tunnel.
4. Calculations for a supersonic wind tunnel.
5. Evaluation of various characteristics of an airfoil.
6. Performance calculations for a propeller type aircraft.
7. Performance calculations for a jet propulsion aircraft.
8. CFD software applications in aerodynamics – Case studies.

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Institute:	Institute of Technology
Name of Programme:	B.Tech. in Mechanical Engineering
Course Code:	
Course Title:	Fluid Power Engineering
Course Type:	Department Elective
Year of Introduction:	2024-25

L	**T**	**Practical component**				**C**
		LPW	**PW**	**W**	**S**	
3	**0**	**2**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, the student will be able to –

1	apply the fundamentals of impact of jet to fluid flow machines,	(BL3)
2	evaluate performance characteristics of hydro turbines,	(BL5)
3	examine the working principles of hydraulic pumps,	(BL4)
4	analyse the performance of different compressors,	(BL4)
5	explain the construction and working of hydraulic systems.	(BL2)

Unit	**Contents**	**Teaching hours (Total 45)**
Unit I	**Impact of Jet** Fluid flow machines – basic principle, types, impulse-momentum principle, impact of jet on fixed and moving flat and curved vanes, series of flat and curved vanes	05
Unit II	**Hydraulic Turbines** Hydropower plants – classification, layout, major equipment, small hydropower, classification of hydro turbines, working of Pelton wheel, Francis and Kaplan turbines, velocity triangles, design criteria, governing, specific speed, characteristic curves, cavitation.	10
Unit III	**Pumps** Centrifugal pump – constructional features, basic theory, velocity triangles, design concepts, pressure rise through impeller, characteristics curves, priming, similarity relations, and specific speed.	09

Positive displacement pumps – construction, working principle, characteristic curves.

Use of commercial CFD software for analysis of fluid flow machines.

Unit IV	**Positive Displacement Compressors**	06

Reciprocating compressor – Terminology, single stage compression without and with clearance, power requirement and condition for minimum work, free air delivery, need for multi staging, and condition of minimum work for multi-staging, inter-stage cooling.

Rotary compressors – Types, salient features, applications.

Unit V	**Dynamic Compressors**	10

Centrifugal compressor – working principle, ideal energy transfer, velocity diagram, design criteria, isentropic efficiency, static and total temperatures, power input factor, slip and slip factor, pre-whirl, Mach number, surging and choking.

Axial flow compressor – **c**onstruction and operation, velocity diagram and work done factor, pressure ratio, blade loading and flow coefficient, static pressure rise, degree of reaction, airfoil blading.

Unit VI	**Hydraulic Systems**	05

Construction details, operation and application of hydraulic accumulator, intensifier, ram, fluid coupling and torque converter.

Self – Study: The self-study content will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study content.

Laboratory Work: Laboratory work will be based on above syllabus with minimum 10 experiments to be incorporated

Suggested Readings/References:

1. Cengel Y., John Cimbala J., Fluid Mechanics, Tata McGraw Hill Publishing Co. Ltd.
2. Gerhart P. M. and Wright T., Fluid Machinery- Application, Selection and Design, CRC Press.
3. Dixon S. L and Hall C. A., Fluid mechanics and Thermodynamics of Turbomachinery, Elsevier.
4. Som S. K, Biswas G., Chakraborty S., Introduction to Fluid Mechanics and Fluid Machines, McGraw Hill Publications.
5. Ojha C. S. P., Chandramouli P. N., Berndtsson R., Fluid Mechanics and Machinery, Oxford University Press.

Suggested list of experiments (not restricted to the following)

Sr. No.	Title	Hours
1.	To study the various components of hydropower plants.	02
2.	To find force coefficient for semi-circular vane.	02
3.	To study the governing of hydro turbines.	02
4.	To conduct the performance analysis of Impulse turbine.	02
5.	To conduct the performance analysis of Reaction turbine.	02
6.	To conduct the performance analysis of positive displacement pump.	02
7.	To draw performance characteristic curves for centrifugal pump	02
8.	To study the positive displacement pumps.	02
9.	To study the positive displacement compressors.	02
10.	To find the volumetric efficiency of a two-stage reciprocating compressor.	02
11.	To conduct the performance analysis of centrifugal compressor.	02
12.	To study the hydraulic systems.	02
13.	To demonstrate the commercial Computational Fluid Dynamics (CFD) software for design of fluid flow machines.	02

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	B.Tech. in Mechanical Engineering
Course Code:	
Course Title:	Robotic Engineering
Course Type:	Elective
Year of introduction:	2024-25

L	**T**	**Practical component**				**C**
		LPW	**PW**	**W**	**S**	
3	**0**	**2**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, student will be able to –

1 select the applicable robotic arm configuration, (BL3)
2 formulate the kinematic model of the robotic manipulator, (BL6)
3 develop the dynamic equation of motion and trajectory plan for robotic arm joint, (BL6)
4 recommend suitable sensors, actuators and end effectors for robotic manipulator. (BL5)

Unit	**Contents**	**Teaching hours (Total 45)**
Unit I	**Introduction to Robotics** Fundamentals of Robots, fundamentals of robot technology, classification of robotic arm, robot arm configurations, applications, Systems overview of a robot, basic components, robot specification, robot selection.	10
Unit II	**Robot Kinematics** Concept of transformation matrices, homogeneous transformation matrix and its applications to robotics, Co-ordinate transformation, transform arithmetic, inverse to transformation matrix, Denavit-Hartenber (DH) parameters, derivation of joint transformation matrix for robot manipulator, Forward kinematics, solutions for joint variables, need of inverse kinematics solutions for robot arm and its methodology, inverse kinematics for industrial robots, Linear and angular velocities of robot links and joint, mathematical concepts	13

	for calculations of velocities, Jacobian matrix for link and joint velocities, singularities for industrial robots	
Unit III	**Robot dynamics and trajectory generation** Trajectory generation for joint considering cubic polynomial, trapezoidal velocity profile and blended trajectory, joint space and cartesian space trajectory generation. Lagrange-Euler formulation, calculation of kinetic and potential energy, dynamic equation of motion 1DOF and 2DOF robotic manipulator, Newton-Euler method, introduction to recursive dynamics.	12
Unit IV	**Sensors, Actuators and End effector** Inertia calculation for robotic application, motor and load torque, selection of electric motor, other type of actuators, Internal state and External state sensors for robotic application, End effectors, Classification, Force analysis and Gripper design, software related to Robotics, Robot programming methods and languages.	10

Self – Study: The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Laboratory Work: Laboratory work will be based on above syllabus with minimum 10 experiments to be incorporated

Suggested Readings/References:

1. Klafter R. D., Thomas A Chmielewski and Michael Negin, Robotics Engineering An integrated approach, Prentice Hall
2. Mittal R. K., Nagrath I. J., Robotics and Control , Tata McGraw-Hill Publishing Company Ltd.
3. Craig John, Introduction to Robotics, mechanics and control, Pearson Education
4. Groover M.P., Mitchell Weiss, Roger N. Nagel and Nicholas Godfrey, Industrial Robotics. Tata McGraw Hill Education Pvt. Ltd
5. Ghoshal Ashitava, Robotics Fundamental Concepts and Analysis, Oxford University Press.

Suggested list of experiments: (not restricted to the following)

Sr. No.	Title	Hours
1.	To programme the robotic manipulator for setting up of different tools.	02
2.	To programme the robotic manipulator for pick and place operation.	02
3.	To programme the robotic manipulator with interfacing of external devices.	02
4.	To programme the robotic manipulator using advance features.	02
5.	To write a computer programme for coordinate transformation.	02
6.	To carry out the forward and inverse kinematics of robotic manipulator using computer programming.	02
7.	To simulate the robotic manipulator using CAD software.	04
8.	To carry out the dynamic analysis and simulation of robotic manipulator.	02
9.	To carry out the force analysis of mechanical gripper.	02
10.	To interface the position and velocity sensors with robot controller.	02
11.	To interface the motion and object detecting sensors with robot controller.	02

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	B.Tech. in Mechanical Engineering
Course Code:	
Course Title:	Stress Analysis
Course Type:	Department Elective
Year of introduction:	2024-25

L	**T**	**Practical component**				**C**
		LPW	**PW**	**W**	**S**	
3	**0**	**2**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, student will be able to –

1 apply principles of elasticity theory to estimate stresses and strains in isotropic and non-isotropic materials using a tensorial approach, (BL4)

2 formulate the boundary value problems in solid continua using stress and displacement-based solution strategies, (BL6)

3 evaluate the planar problems using Airy stress function in rectangular and polar co-ordinates, (BL5)

4 estimate the stress and strain for a mechanical component using analytical, simulations and experimental methods. (BL5)

Unit	**Contents**	**Teaching Hours (Total 45)**
Unit I	**Analysis of stress** Body force, surface force, stress/traction vector, state of stress at a point, rectangular, normal and shear components of a stress, stress components on an arbitrary plane, equality of cross shear, Numerical problems. stress invariants, principal stresses, octahedral stress, planes of maximum shear, spherical and deviatoric stresses, equilibrium relations, plane state of stress, Mohr's circle in 2D and 3D, stress transformation, equations of equilibrium in differential form, Numerical problems.Stress – strain relationship, isotropic material, modulus of rigidity, bulk modulus, Young's modulus, their relations, displacement equations of equilibrium.	13

Unit III	**Analysis of Strain** Displacement field, strains in term of displacement field, change in length and linear components, rectangular strain components, change in direction and angle, engineering shear strains, strain invariants, principal strains, strain deviator, plane state of strain, compatibility equations, Numerical Problems.	08
Unit IV	**Two dimensional problems in rectangular coordinates** Stress function formulation, plane stress, plane strain, generalized plane stress, Airy stress function, solution by polynomials -Saint-Venants principle - determination of displacements -bending of simple beams by stress function, , Numerical Problems. Airy stress function in polar coordinates, Stress Distributions Symmetrical about an Axis, general solution of two-dimensional problem in polar coordinates, application to Plates with Circular Holes, Numerical Problems.	12
Unit V	**Experimental stress analysis** Strain gauges, Requirements and materials for strain gauges, Electrical resistance strain gauges, gauge sensitivity and Gauge factor, temperature compensation, parameters affecting selection and behaviour of strain gauges, Rossette analysis and electrical circuits. Numerical Problems. Photo-elasticity, stress optics law, properties of light, plain and circular polariscope, properties of fringes and fringe interpretation, compensation and separation techniques. Numerical Problems.	12

Self – Study: The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Laboratory Work: Laboratory work will be based on above syllabus with minimum 10 experiments to be incorporated

Suggested Readings/References:

1. Srinath, L. S, Advanced Mechanics of Solids, McGraw Hill
2. Timoshenko, S. P. and . Goodier J. N., Theory of Elasticity, McGraw Hill.
3. Budyans, Advanced Strength and Applied Stress Analysis, McGraw Hill.
4. Saad, M. H., Elasticity: Theory, Applications and Numerics, Academic Press.
5. Dally, J.W., and Riley, W.F., Experimental Stress Analysis, McGraw Hill.

Suggested list of experiments: (not restricted to the following)

Sr. No.	Title	Hours
1.	To determine the stress field for the 1-D problems of mechanical engineering.	02
2.	To determine stress field for the 2-D problems of mechanical engineering.	04
3.	To determine stress field for the 3-D problems of mechanical engineering.	02
4.	To develop a computer program to solve the problem of stress analysis	04
5.	To develop a computer program to solve the problem of strain analysis	02
6.	To develop a computer program for the two-dimensional problems of theory of elasticity	04
7.	To develop a computer program for the two-dimensional problems in polar coordinates	04
8.	To evaluate strain using strain-gauge methods for the pressure vessel component.	04
9.	To determine strains in a beam using strain-gauge methods	02
10.	To use the polariscope methods for the stress analysis of components.	02

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	B.Tech. in Mechanical Engineering
Course Code:	
Course Title:	Quality and Reliability Engineering
Course Type:	Department Elective
Year of introduction:	2024-25

L	**T**	**Practical component**				**C**
		LPW	**PW**	**W**	**S**	
3	**1**	**0**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, student will be able to –

1	apply statistical process control tools for improvement of quality,	(BL3)
2	adapt design of experiment for optimizing quality characteristics,	(BL6)
3	interpret experimental data using statistical analysis,	(BL5)
4	appraise the importance of reliability engineering.	(BL5)

Unit	**Contents**	**Teaching Hours (Total 45)**
Unit I	**Quality Engineering** Introduction and importance of quality engineering, quality concepts, statistical process control tools and its limitation, measures of central tendency, measures of dispersion, binomial and normal distribution.	10
Unit II	**Experimental Design Fundamentals** Need and concept of design of experiment (DOE); experimental design techniques, application of experimental design, features of experimentation, introduction to factorial design, full and fractional factorial design of experiments, role of contrasts, confounding, fractional replication, and other aspects in factorial design.	13
Unit III	**Analysis of Variance and Taguchi Philosophy** Need for analysis of variance (ANOVA), introduction of analysis of variance, one-way and two-way ANOVA, critique of F-test. Concept of orthogonal arrays,	12

selection and utilization steps in designing, conducting, and analysing an experiment. Taguchi philosophy and it's applications, concept of Taguchi loss function and its applications.

Unit IV **Reliability Engineering** 10

Reliability engineering fundamentals; failure data analysis; failure rate; mortality curve; concept of burn in period; useful life and wear out phase of a system; mean time to failure (MTTF); mean time between failure, (MTBF) and mean time to repair (MTTR); reliability in terms of hazard rate and failure density, conditional probability and multiplication rules, concepts of system reliability, reliability, availability, maintainability, and safety (RAMS).

Self – Study: The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Suggested Readings/References:

1. Montgomery, D.C., Design and Analysis of Experiments, John Wiley and Sons.
2. Besterfield D.H., Quality Control, Prentice Hall.
3. Taguchi, G., Introduction to Quality Engineering Designing Quality into Products and Process, Asian Productivity Organization, UNIPUP.
4. Ross, P. J., Taguchi Techniques for Quality Engineering, Tata McGraw Hill.
5. Elsayed E. A., Reliability Engineering, Wiley

Suggested List of Tutorials:

1. Application of statistical process control tools for quality improvement
2. Use of control charts for variable data
3. Use of control charts for attribute data
4. Application of design of experiments using factorial design
5. Application of design of experiments using fractional factorial design
6. Perform one-way analysis of variance (ANOVA) for given data
7. Perform two-way analysis of variance (ANOVA) for given data
8. Prepare design of experiments using orthogonal arrays
9. Failure data analysis for reliability problems
10. Determination of mean time to failure (MTTF); mean time between failure, (MTBF) and mean time to repair (MTTR)
11. Evaluation of reliability for series, parallel and combined system
12. Determination of availability and maintainability for a given system

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	B.Tech. in Mechanical Engineering
Course Code:	
Course Title:	Mechatronics
Course Type:	Department Elective
Year of Introduction:	2024-25

L	**T**	**Practical Component**				**C**
		LPW	**PW**	**W**	**S**	
3	**0**	**2**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, student will be able to-

1	appraise use of various mechatronics system in automation,	(BL5)
2	discuss functionality of various components used in mechatronics system,	(BL6)
3	select the sensors, actuators and controllers for given applications,	(BL5)
4	build mechatronics system for automations problems.	(BL3)

Unit	**Contents**	**Teaching Hours (Total 45)**
Unit I	**Introduction** Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products, and design. Comparison between Traditional and Mechatronics approach, Microprocessor Based Controllers Examples, Comparison between Traditional and Mechatronics approach. Review of fundamental of Electronics	05
Unit II	**Sensors, Actuators and Signal Conditioning** Performance Terminology, displacement, position and proximity, velocity and motion, fluid pressure, temperature sensors, light sensors, selection of sensors, Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, Multiplexer, Pulse width Modulation Counters, decoders. Data acquisition – Quantizing theory, Analog to digital conversion, digital to analog conversion	11

Unit III	**Actuation Systems** Pneumatic and hydraulic systems: actuators, definition, example, types, and selection. Pneumatic actuator. Electro-pneumatic actuator. Hydraulic actuator, control valves, valve sizing valve selection. Electrical actuating systems: solid-state switches, solenoids, relay coil; electric motors; DC motors, AC motors, single phase motor; 3-phase motor; induction motor; synchronous motor; stepper motors. Mechanical Actuation Systems: Types of motion, Freedom and constraints, Loading, Gear Trains, Pawl & Ratchet, Belt & Chain drive, Bearing, Selection of Ball & Roller bearings, Mechanical aspects of motor selection, linkages	10
Unit IV	**Basic System Models and Analysis** Modelling of one and two degrees of freedom Mechanical, Electrical, Fluid and thermal systems, Block diagram representations for these systems	06
Unit V	**Programmable Logic Controller** Definition, Basic block diagram and structure of PLC, Input/Output processing, PLC Programming: Ladder diagram, logic functions, latching and sequencing, PLC mnemonics, Timers, internal relays and counters, Shift registers, Master and jump controls Data handling, Communication channels, Profi-bus and Field-bus, Analog input/output, Selection of PLC	10
Unit VI	**Mechatronics system design** Stages in designing mechatronic systems, traditional and mechatronic design, possible design solutions, various case studies	03

Self – Study: The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Laboratory Work: Laboratory Work will be based on topics covered under the above syllabus with minimum 10 experiments/exercises to be incorporated.

Suggested Readings/References:

1. W. Bolton, Mechatronics, Pearson Education India.
2. M. B. Histand and D. G. Alciatore, Introduction to Mechatronics and Measurement Systems, Tata McGraw-Hill Education.
3. D. Shetty & R. Kolk “Mechatronics System Design”, 3rd edition. PWS Publishing.

4. Patrick O.J. Kaltjob, “Control of Mechatronic Systems: Model-Driven Design and Implementation Guidelines”, Wiley Publishing.
5. HMT, “Mechatronics”, Tata McGraw-Hill Education.

Suggested list of experiments: (not restricted to the following)

Sr. No.	Title	Hours
1.	To study of various sensors and transducers using Tinkercad software.	04
2.	To study signal conditioning devices using Tinkercad.	02
3.	To study speed control of stepper motor using MATLAB Simulink.	02
4.	To study DC speed control of servo motor using MATLAB Similink.	02
5.	To model and analyse hydraulic, pneumatic circuits using automation studio.	02
6.	To model and analyse electro-hydraulic, electro-pneumatic circuits using automation studio.	02
7.	To study PLC and its applications using Twin CAT.	02
8.	To develop hydraulic and pneumatic circuits for automation.	02
9.	To demonstrate functionality of PLC for automation.	02
10.	To model and analyse Mechanical, Fluid, Electrical and Thermal systems using MATLAB Simulink software.	04

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	B.Tech. in Mechanical Engineering
Course Code:	
Course Title:	Mechanics of Composite Materials
Course Type:	Department Elective
Year of introduction:	2024-25

L	**T**	**Practical component**				**C**
		LPW	**PW**	**W**	**S**	
3	**0**	**2**	**-**	**-**	**-**	**4**

Course Learning Outcomes (CLOs):

After successful completion of the course, student will be able to

1 explain the various types of composite materials, (BL2)
2 select the appropriate manufacturing method for composite materials, (BL5)
3 compare mechanical properties of composite materials, (BL4)
4 assess the failure mechanisms for composite materials. (BL5)

Unit	**Contents**	**Teaching Hours (Total 45)**
Unit I	**Introduction** Definitions, Classifications of Engineering Materials, Composites, Reinforcements and matrices, Types of reinforcements, Types of matrices, Types of composites, Carbon Fibre composites, Properties of composites in comparison with standard materials, Applications of metal, ceramic and polymer matrix composites.	06
Unit II	**Manufacturing methods** Processing of Composite Materials, Hand and spray lay - up, injection moulding, resin injection, filament winding, Autoclave curing, pultrusion, centrifugal casting and prepregs. Fibre/Matrix Interface, mechanical. Measurement of interface strength. Characterization of systems; carbon fibre/epoxy, glass fibre/polyester, etc. Manufacturing Techniques: Tooling and Specialty materials, Release agents, Peel plies, release films and fabrics, Bleeder and breather plies, bagging films.	14

Unit III	**Mechanical Properties -Stiffness and Strength** Geometrical aspects – volume and weight fraction. Unidirectional continuous fibre, discontinuous fibers, Short fiber systems, woven reinforcements – Mechanical Testing: Determination of stiffness and strengths of unidirectional composites; tension, compression, flexure and shear, Fracture testing etc.	10
Unit IV	**Laminates** Plate Stiffness and Compliance, Assumptions, Strains, Stress Resultants, Plate Stiffness and Compliance, Computation of Stresses, Types of Laminates -, Symmetric Laminates, Antisymmetric Laminate, Balanced Laminate, Quasi-isotropic Laminates, Cross-ply Laminate, Angle ply Laminate. Orthotropic Laminate, Laminate Moduli, Hygrothermal Stresses.	10
Unit V	**Joining Methods and Failure Theories** Joining –Advantages and disadvantages of adhesive and mechanically fastened joints. Typical bond strengths and test procedures.	05

Self – Study: The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Laboratory Work: Laboratory work will be based on above syllabus with minimum 10 experiments to be incorporated

Suggested Readings/References:

1. Mathews F. L. and Rawlings R. D., Composite Materials: Engineering and Science, Chapman and Hall, London, Englan.
2. Chawla K. K., Composite materials, Second Edition, Springer.
3. Daniel, I. M. and Ishaai., O., Engineering Mechanics of Composite Materials, Oxford University Press
4. Kaw A. K., Mechanics of Composite Materials, CRC Press.

Suggested list of experiments: (not restricted to the following)

Sr. No.	Title	Hours
1.	To compare the properties of fibers and matrices.	04
2.	To prepare composite laminate using hand lay-up process.	02
3.	To prepare composite laminate using vacuum assisted resin transfer molding process.	04
4.	To demonstrate for preparation of composite product using pultrusion, and autoclave process.	02
5.	To develop a program for determination of stress for composite lamina.	04
6.	To develop a program for determination of strain for composite lamina.	04
7.	To develop a program for determination of volume and weight fraction for composite lamina.	02
8.	To manufacture the CFRP component-using pre-peg based method.	02
9.	To determine the stress, strain and deformation of an isotropic laminate using FEA.	02