Course and Examination Scheme (V and VI Semester)

of NEP 2020 Curriculum

Bachelor of Technology in Mechanical Engineering

(Faculty of Science and Technology)

GONDWANA UNIVERSITY, Gadchiroli
MIDC Road Complex, Gadchiroli
PIN-442 605, (M.S.)

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SEMESTER– V																		
Course Category	**Board of Studies**	**Course Code**	**Name of the Course**	**Teaching Scheme**				**Examination Scheme**										**Credit**
				Hours per week				**Theory Marks**						**Practical Marks**				
				L	**T**	**P**	**T**	**Duration in hrs.**	**MSE (CA)**	**IE (CA)**	**ESE (UA)**	**Total**	**Min (CA+UA)**	**CA**	**UA**	**Total**	**Min (CA+UA)**	
MDM	Mechanical Engineering	STMDMMEC501	Multi-disciplinary Minor-III	3	--	--	3	3	10	10	80	100	40	--	--	--	--	3
OE	Mechanical Engineering	STOEMEC502	Open Elective- III	2	--	--	2	2	5	5	40	50	20	--	--	--	--	2
PCC	Mechanical Engineering	STPCCMEC503	Heat Transfer	3	1	--	4	3	10	10	80	100	40	--	--	--	--	4
PCC	Mechanical Engineering	STPCCMEC504	Kinematics of Machines	3	1	--	4	3	10	10	80	100	40	--	--	--	--	4
PCC	Mechanical Engineering	STPCCMEC505	Design of Machine Elements	3	1	--	4	3	10	10	80	100	40	--	--	--	--	4
PEC	Mechanical Engineering	STPECMEC506A/B/C	Program Elective - I	3	--	--	3	3	10	10	80	100	40	--	--	--	--	3
PCC	Mechanical Engineering	STPCCMEC507	Heat Transfer Lab	--	--	2	2	--	--	--	--	--	--	25	25	50	25	1
PEC	Mechanical Engineering	STPECMEC508A/B/C	Program Elective – I Lab.	--	--	2	2	--	--	--	--	--	--	25	25	50	25	1
Total				**17**	**3**	**4**	**24**	**--**	**55**	**55**	**440**	**550**	**--**	**50**	**50**	**100**	**--**	**22**
Marks Grand Total				**650**														

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SEMESTER–V						
LIST OF OPEN ELECTIVES - III COURSE			**LIST OF PROGRAM ELECTIVES - I**		**LIST OF PROGRAM ELECTIVES – I LAB**	
Sr.	**Course Code**	**Name of the course**	**Course Code**	**Name of the course**	**Course Code**	**Name of the course**
A	STOEMEC502	Operations Research Techniques	STPECMEC506A	Internal Combustion Engines and Gas Turbines	STPECMEC508A	Internal Combustion Engines and Gas Turbines Lab
B	STOEETC502	Automotive Electronics	STPECMEC506B	Production Technology	STPECMEC508B	Production Technology Lab
C	STOECSE502	Software Project Management	STPECMEC506C	Computer Aided Design	STPECMEC508C	Computer Aided Design Lab
D	STOEINS502	Power Plant Instrumentation				
E	STOECEC502	Remote Sensing and GIS				
F	STOEELE502	Introduction to Smart Grid				

Note:

1. Note: The offering of any open elective or Program elective course shall be subject to a minimum enrollment of fifteen (15) students.
2. If a student opts for Program Elective – I (Serial No. A), they will be eligible only for the corresponding Program Elective – I Lab (Serial No. A); the same applies for serial no. B

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SEMESTER– VI																	
Course Category	Board of Studies	Course Code	Name of the Course	Teaching Scheme				Examination Scheme									Credit
				Hours per week				Theory Marks						Practical Marks			
				L	T	P	T	Duration in hrs.	MSE (CA)	IE (CA)	ESE (UA)	Total	Min (CA+UA)	CA	UA	Total	Min (CA+UA)	
MDM	Mechanical Engineering	STMDMMEC601	Multi-disciplinary Minor-IV	3	--	--	3	3	10	10	80	100	40	--	--	--	--	3
PCC	Mechanical Engineering	STPCCMEC602	Thermal Engineering	3	--	--	3	3	10	10	80	100	40	--	--	--	--	3
PCC	Mechanical Engineering	STPCCMEC603	Mechanical Measurement	2	--	--	2	2	5	5	40	50	20	--	--	--	--	2
PCC	Mechanical Engineering	STPCCMEC604	Dynamics of Machines	3	--	--	3	3	10	10	80	100	40	--	--	--	--	3
PEC	Mechanical Engineering	STPECMEC605A/B/C	Program Elective - II	3	--	--	3	3	10	10	80	100	40	--	--	--	--	3
PEC	Mechanical Engineering	STPECMEC606A/B/C	Program Elective – III	3	--	--	3	3	10	10	80	100	40	--	--	--	--	3
PCC	Mechanical Engineering	STPCCMEC607	Mechanical Engineering Lab	--	--	2	2	--	--	--	--	--	--	25	25	50	25	1
PEC	Mechanical Engineering	STPECMEC608A/B/C	Program Elective – II Lab.	--	--	2	2	--	--	--	--	--	--	25	25	50	25	1
PEC	Mechanical Engineering	STPECMEC609A/B/C	Program Elective – III Lab.	--	--	2	2	--	--	--	--	--	--	25	25	50	25	1
VSEC	Mechanical Engineering	STVSECMEC610	Soft Skills	--	1	2	3	--	--	--	--	--	--	50	--	50	25	2
Total				**17**	**1**	**8**	**26**	**--**	**55**	**55**	**440**	**550**	**--**	**125**	**75**	**200**	**--**	**22**
Marks Grand Total				**750**														

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SEMESTER–VI			
LIST OF PROGRAM ELECTIVES - II		**LIST OF PROGRAM ELECTIVES – II LAB**	
Course Code	**Name of the course**	**Course Code**	**Name of the course**
STPECMEC605A	Automation in Manufacturing	**STPECMEC608A**	Automation in Manufacturing Lab
STPECMEC605B	Metrology and Quality Control	**STPECMEC608B**	Metrology and Quality Control Lab
STPECMEC605C	Rapid Prototyping and Additive Manufacturing	**STPECMEC608C**	Rapid Prototyping and Additive Manufacturing Lab

LIST OF PROGRAM ELECTIVES - III		**LIST OF PROGRAM ELECTIVES – III LAB**	
Course Code	**Name of the course**	**Course Code**	**Name of the course**
STPECMEC606A	Automobile Engineering	**STPECMEC609A**	Automobile Engineering Lab
STPECMEC606B	Product Life Cycle Management	**STPECMEC609B**	Product Life Cycle Management Lab
STPECMEC606C	Finite Element Methods	**STPECMEC609C**	Finite Element Methods Lab

Note:

1. Note: The offering of any Program elective course shall be subject to a minimum enrollment of fifteen (15) students.
2. If a student opts for Program Elective – II or III (Serial No. A), they will be eligible only for the corresponding Program Elective – II or III Lab (Serial No. A); the same applies for serial no. B

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EXIT CRITERIA FOR BACHELOR DEGREE IN VOCATION (AFTER THIRD YEAR)																		
Course Category	Board of Studies	Course Code	Name of the Course	Teaching Scheme				Examination Scheme										Credit
				Hours per week				Theory Marks						Practical Marks				
				L	T	P	T	Duration in hrs.	MSE (CA)	IE (CA)	ESE (UA)	Total	Min (CA+UA)	CA	UA	Total	Min (CA+UA)	
Exit offline courses offered by department (Student may choose and enroll in any one of these courses)																		
EX3	Mechanical Engineering	STEXMEC621	Design Process Management (PLM)	--	2	12	14	--	--	--	--	--	--	100	100	200	100	8
EX3	Mechanical Engineering	STEXMEC622	Autonomous, Connected, Electric Vehicles (ACE)	--	2	12	14	--	--	--	--	--	--	100	100	200	100	8
EX3	Mechanical Engineering	STEXMEC623	Automotive Systems	--	2	12	14	--	--	--	--	--	--	100	100	200	100	8
OR																		
EX3	Mechanical Engineering	STEXMEC631	Internship / Technical Project											100@	100	200	100	8
OR																		
EX3	Mechanical Engineering	STEXMEC641	Two online skill courses (diploma level) from NSQF / ESSC / ANY Other agency which provides certification.											200@	--	200	100	8
Total																**200**	**100**	**8**
Marks Grand Total				200														

@ Evaluation based on seminar, internship report, technical project report, skill courses certification etc as mentioned in detailed syllabus.

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STMDMMEC501

Title of Course: **PLC and Automation (Multi-Disciplinary Minor - III (MDM))**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Explain the fundamentals of PLC and industrial automation systems.

CO2 Develop basic PLC ladder logic programs using industrial sensors and actuators.

CO3 Analyze pneumatic and hydraulic automation circuits for industrial applications.

CO4 Describe SCADA, HMI and industrial communication systems used in automation.

CO5 Explain robotic systems and modern automation concepts in manufacturing industries

Unit	Content	Hours
I	Introduction to Automation and Control Systems: Basics of industrial automation, types of automation – fixed, programmable and flexible automation, introduction to PLC, architecture of PLC, input/output modules, CPU, memory organization, PLC scan cycle, industrial control systems, hardwired relay logic versus programmable logic, review of digital logic gates (AND, OR, NOT, NAND, NOR, XOR) Logic gates conversion to ladder diagrams, applications of PLC in manufacturing industries.	9
II	PLC Programming and Industrial Sensors: PLC programming fundamentals, ladder logic programming, bit-level instructions and latching circuits, timers (TON, TOF, RTO), counters (CTU, CTD), internal relays, sequencing operations, arithmetic and logical instructions, analog and digital I/O, interfacing sensors and actuators, proximity sensors, limit switches, temperature and pressure sensors, fault diagnostics and troubleshooting of PLC systems.	9
III	Distributed Control Systems (DCS): Architecture; Local Control Units (LCU), Operator Interface (HMI), and System Redundancy (Processor and Communication). Industrial Communication: Evolution of signal standards (4-20mA). Overview of HART, Fieldbus, and Modbus protocols. Safety Systems: Fail-Safe philosophy, Emergency Shutdown Systems (ESD), and the role of interlocks in process protection	9
IV	SCADA, HMI and Industrial Communication: Introduction to SCADA systems, Human Machine Interface (HMI), data acquisition systems, industrial communication protocols, Modbus, Profibus and Ethernet, PLC-SCADA integration, supervisory control systems, alarms and data logging, industrial networking, safety and reliability in automation systems	9
V	Robotics and Modern Automation Applications: Introduction to industrial robots, robot anatomy and configurations, end effectors and drives, robotic applications in manufacturing,	9

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	CNC and automation integration, flexible manufacturing systems (FMS), Industry 4.0 concepts, IoT in automation, smart factories, case studies on automated production systems.	

Text Books:

1. Industrial Automation and Robotics, S. K. Saha, McGraw-Hill India
2. Manufacturing Processes and Automation, R. S. Parmar, Khanna Publishers
3. Process Control and Its Automation, Dr. M. Meenakshi, Khanna Publishing House
4. Instrumentation and Control in Process Industries, Dr. P. N. Singh, S. R. Bhat, Khanna Publishing House

Reference books:

1. Programmable Logic Controllers, Frank D. Petruzella, McGraw-Hill Education
2. Programmable Logic Controllers: Principles and Applications, John W. Webb and Ronald A. Reis, Prentice Hall of India (PHI Learning)
3. PLC and Industrial Automation: An Introduction, Madhuchhanda Mitra and Samarjit Sen Gupta, Penram International Publishing (India) Pvt. Ltd.

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STOEMEC502

Title of Course: **Operations Research Techniques (Open Elective – III)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
2	--	--	2	2	2	5	5	40	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Explain fundamental concepts of Operations Research and solve linear programming problems using graphical and basic simplex methods

CO2 Apply transportation and assignment models for optimal resource allocation

CO3 Analyze project networks using CPM and PERT techniques

CO4 Apply decision-making criteria and solve basic sequencing problems

Unit	Content	Hours
I	**Introduction & Linear Programming** Introduction to Operations Research, Definitions, Characteristics, Limitations and applications (multi-branch relevance) Formulation of LPP Graphical Solution of LPP (Two variables) Simplex Method: Basic procedure for solving standard LPPs (introductory level)	7
II	**Transportation & Assignment** Transportation Problem Basic feasible solution by NW Corner, Least Cost Method and Vogel's Approximation Method (VAM) Assignment Problem: Hungarian Method (Simple cases)	7
III	**Project Management** Project Scheduling, Basic concepts CPM (Critical Path Method): Network construction, critical path, total float PERT: Expected time calculation (Limited to simple problems).	8
IV	**Decision Theory & Sequencing** A. Decision Theory: Decision making under uncertainty, Maximax, Maximin, Minimax Regret criteria B. Sequencing: n jobs, 2 machines problem, Johnson's Rule, Idle time calculation	8

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Text Books:

1. Operations Research by Prem Kumar Gupta and D. S. Hira, S. Chand & Company Ltd.
2. Operations Research: An Introduction by Hamdy A. Taha, Prentice Hall of India
3. Operations Research by P. K. Pannerselvam, Prentice Hall of India
4. Operations Research, A.P. Verma, S.K. Kataria & Sons publication.
5. Operations Research, Problems-solutions, J. K. Sharma, Macmillan India ltd.

Reference Books:

1. Introduction to Operations Research by Frederick S. Hillier and Gerald J. Lieberman, McGraw-Hill
2. Operations Research by Kanti Swarup, Sultan Chand & Sons.
3. Operations Research, S. Kalavathy, Vikas Publishing House pvt. Ltd.
4. Quantitative Techniques in Management, N.D. Vohra, Tata McGraw-Hill Publishing Company Ltd.

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPCCMEC503

Title of Course: **Heat Transfer**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	1	--	4	4	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Determine temperature distribution and heat transfer rate in steady heat flow through single and multilayer plane wall, cylinder and spheres.

CO2 Analyse steady state heat conduction through fins and unsteady heat conduction through plane wall, cylinder and spheres

CO3 Interpret and evaluate film coefficient and heat flow rate in free and forced convection mode

CO4 Explain the laws of thermal radiation and analyse the radiation heat exchange between the surfaces

CO5 Analyse the heat exchanger by LMTD and NTU effectiveness method

Unit	Content	Hours
I	Introduction to basic modes and laws of heat transfer, General heat conduction equation in Cartesian, cylindrical & spherical co-ordinates. Thermal conductivity and diffusivity. One dimensional steady state conduction equation for the plane wall, cylinder and sphere. Thermal resistance of composite structures, contact resistance, overall heat transfer coefficient, critical thickness of insulation.	9
II	**Extended Surfaces (Fins): -** Types of Fins. Fins of uniform cross-sectional area, Temperature distribution and heat transfer rate, fin efficiency and effectiveness. Error in temperature measurement. Un-steady state heat transfer, lumped heat capacity analysis, Biot Number, Fourier Number and their significance.	9
III	**Forced convection**: - Physical significance of non-dimensional parameters, Concept of velocity & thermal boundary layer thickness, Laminar flow over flat plate and through tube, turbulent flow over flat plate, through tubes, over cylinders and spheres. **Free or natural convection**: - Physical significance of non-dimensional parameters, Free convection over vertical plates and cylinders, horizontal plates and cylinders spheres, Enclosed spaces. **Boiling and condensation: -** Heat transfer with phase change, pool boiling curve & regimes	9

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	of pool boiling. Film & drop wise condensation, Laminar film condensation on vertical surface, Film condensation on horizontal tubes, Introduction to heat pipe.	
IV	**Thermal Radiation**:- Surface emission properties, Absorptivity, Transmissivity, Reflectivity, Black body radiation, radiation intensity, laws of radiation– Kirchhoff's, Planck's, Wien displacement, Stefan Boltzmann & Lambert's Co-sine law. Emissivity, Emissive power. **Radiation exchange between surfaces: _** shape factor algebra, Heat exchange between non-black bodies, Radiation shields.	9
V	**Heat Exchanger: -** Classification, LMTD method of heat exchange analysis for parallel and counter flow arrangement. Overall heat transfer coefficient, Fouling factor **Effectiveness NTU method: -** heat exchanger analysis by NTU method, design aspects of heat exchangers. Introduction to compact heat exchanger.	9

Text Books:

1. Heat and Mass Transfer – Domkundwar, Dhanpat Rai
2. Heat Transfer – Dr. D. S. Kumar
3. Heat Transfer – S. P. Sukhatme
4. Heat and mass transfer – R. K. Rajput

Reference Books:

1. Introduction to heat Transfer – Incropera & Dewitt J. Wiley
2. Elements of Heat Transfer – M. N. Ozisik

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPCCMEC504

Title of Course: **Kinematics of Machines**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	1	--	4	4	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Explain basic concepts of kinematics, types of mechanisms, and determine mobility of mechanisms using kinematic criteria.

CO2 Analyze displacement, velocity, and acceleration of mechanisms using graphical and analytical methods.

CO3 Understand and design cam-follower systems and determine follower motion characteristics and cam profiles.

CO4 Analyze gear systems and gear trains, and evaluate velocity ratios in simple, compound and epicyclic gear trains

CO5 Understand friction-based power transmission elements including belts, clutches, and brakes and analyze their basic operating principles.

Unit	Content	Hours
I	**Fundamentals of Mechanisms** Basic kinematic concepts and definitions; Mechanism and machines, classification of mechanisms and kinematic pairs; degree of freedom and mobility using Kutzbach criterion; Grashof's law and its applications; inversions of four-bar chain, single and double slider crank chain	9
II	**Kinematic Analysis of Mechanisms** Displacement analysis of simple mechanisms; velocity analysis using relative velocity method, instantaneous centre of rotation method and Kennedy's theorem; graphical velocity analysis of mechanisms using velocity polygons; acceleration analysis of mechanisms including tangential and normal components, Coriolis component of acceleration	10
III	**Cams and Followers** Classification of cams and followers; terminology and definitions; displacement diagrams; follower motions including uniform velocity, parabolic, simple harmonic motion and cycloidal motions; velocity and acceleration of followers, Graphical construction cam profile, Cams with	9

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	specified contours, circular and tangent cams; pressure angle and undercutting.	
IV	**Gears and Gear Trains** Involute and cycloidal gear tooth profiles; gear terminology and parameters; law of gearing and conjugate action; spur gear kinematics including contact ratio and interference; helical, bevel, worm and rack and pinion gears (basic kinematics only); simple, compound and epicyclic gear trains and their velocity ratio analysis.	9
V	**Friction and Power Transmission Elements** Basic concepts of friction; laws of dry friction; sliding and rolling friction; friction in machine elements; belt and rope drives, open and crossed belt drives, velocity ratio, slip and creep; Introduction to chain drive, classification of chains.	8

Text Books:

1. Theory of Machines, S. S. Rattan, McGraw Hill Education (India) Pvt. Ltd.
2. Theory of Machines and Mechanisms, J. J. Uicker, G. R. Pennock and J. E. Shigley, Oxford University Press
3. Theory of Machines, Thomas Bevan, CBS Publishers & Distributors Pvt. Ltd.
4. Theory of Machines, R. S. Khurmi and J. K. Gupta, S. Chand Publishing
5. Theory of Mechanisms and Machines, A. Ghosh and A. K. Mallik, East-West Press Pvt. Ltd
6. Theory of Machines, V. P. Singh, Dhanpat Rai and Co.(Pvt.) Ltd.

Reference Books:

1. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines**,** Robert L. Norton**,** McGraw Hill Education
2. Mechanism and Machine Theory**,** J. S. Rao and R. V. Dukkipati**,** New Age International (P) Ltd.
3. Mechanics of Machines**,** William L. Cleghorn**,** Oxford University Press
4. Kinematics and Dynamics of Machinery**,** Charles E. Wilson and J. Peter Sadler**,** Pearson Education
5. Theory of Machines**,** Sadhu Singh**,** Pearson Education India

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPCCMEC505

Title of Course: **Design of Machine Element**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	1	--	4	4	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Apply fundamentals of machine design, material selection, stress analysis, and theories of failure in designing the machine elements

CO2 Design solid and hollow shafts under static, fluctuating, and torsional loading conditions using stress and failure analysis principles.

CO3 Analyse and design mechanical joints such as welded, bolted, and riveted joints for safe load transmission

CO4 Design power screws and springs considering strength, stiffness, efficiency, and stress analysis under different loading conditions.

CO5 Apply stress analysis and design principles for pressure vessels and lever mechanisms.

Unit	Content	Hours
I	Definition of design, types of design, design process, and general considerations in machine design. Manufacturing considerations in design. Mechanical properties, ISIS standards of engineering materials, Selection of material. Factor of safety, Theories of failure, modes of failure, compound stresses, eccentric axial loading, variable stresses in machine parts, Stress concentration factor, methods for reducing stress concentration factor, Goodman's criteria, Soderberg criteria, Gerber`s criteria, fatigue design for finite & infinite life of the parts subjected to variable loads. Introduction, construction, and applications of **Cotter joints** in machine elements. Design of cotter, rod, socket, and spigot based on tensile, crushing, and shear stresses. Introduction, construction, and applications of **knuckle joints** for tensile load transmission, Design of rod, pin, eye, and fork based on tensile, shear, and crushing stresses.	9
II	**Design of Shaft**: Introduction to shafts, types of shafts, materials used, and functions in power transmission, Design of solid and hollow shafts based on strength and rigidity considerations, Torsion equation, power transmitted by shafts, and angle of twist calculations, Design under combined bending and torsional loads using equivalent twisting and bending moments, Shaft design considering fluctuating loads, fatigue stresses, and shock factors, Application of failure theories such as maximum shear stress and distortion energy theory, ASME code for shaft	9

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	design and numerical problems on shaft dimension calculations.	
III	**Welded Joint:** Design of single transverse, double transverse, parallel fillet, combination fillet, butt joint, and eccentrically loaded welded joints. **Bolted joint:** Design of bolted fasteners, bolts of uniform strength, bolted joints under eccentric loading **Riveted joint:** Introduction, classification, and applications of riveted joints, Failure modes of riveted joints: tearing, shearing, and crushing failures, Design of riveted joints for boiler shells.	9
IV	**Design of power screw**: Introduction, construction, and applications of power screws in lifting and motion transmission devices, Types of threads used in power screws, Torque required to raise and lower loads, efficiency, and self-locking condition of screws, Design of screw, nut, and collar based on shear, bearing, and compressive stresses. **Design of Springs**: Types of springs, Stress and deflection analysis of close-coiled helical springs under axial loading. Design of compression and tension springs based on strength and stiffness criteria. Spring index, Wahl's stress factor, and fatigue considerations in spring design. Numerical problems on spring dimensions, load carrying capacity, and deflection calculations.	9
V	**Pressure vessels**: Classification of thin & thick cylindrical pressure vessels, Stresses in thin & thick cylindrical pressure vessels when subjected to internal pressure, Expression for circumferential & longitudinal stresses, Design of pressure vessel, heads & cover plate. **Design of lever**: Hand lever, Foot lever, and Bell crank lever.	9

List of tutorials

1. Numerical on Shafts
2. Numerical on Cotter and Knuckle joints
3. Numerical on Welded, Bolted and Riveted joints
4. Numerical on Power screw
5. Numerical on Springs
6. Numerical on pressure vessels and their components
7. Numerical on types of Levers

Text Books

1. Design of Machine Element, V. B. Bhandari, McGraw-Hill Publishers, New Delhi
2. A textbook of Machine Design, R. S. Khurmi, J. S. Gupta, S. Chand Publishing N. Delhi
3. Design Data for Machine Elements, B. D. Shiwalkar
4. Machine Elements in Machine Design Robert L. Mott Pearson
5. Machine Design, P. C. Sharma and D. K. Agrawal, Katson Book
6. Design Data Handbook, K. Mahadevan, Balaveera Reddy, CBS Publishers

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Reference Books:

1. Mechanical Engineering Design, Shigley, J.E. and Mischke, C.R., Fifth Edition, McGraw-Hill International, 1989
2. Design of Machine Elements, Merhyle F. Spottes, Prentice-Hall, 1994.
3. Machine Design; Theory and Practice Aaron D. Deutschman, Walter J. Michels, Charles E. Wilson Macmillan, 1975
4. Fundamentals of Machine Component Design, Robert C. Juvinal, R.C., K.M. Marshek, John Wiley & Sons

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC506(A)

Title of Course: **Internal Combustion Engines and Gas Turbines (Program Elective – I)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Explain the construction, working principles, and classifications of I.C. engines.
CO2 Analyze fuel supply, lubrication, and cooling systems used in S.I. and C.I. engines.
CO3 Evaluate combustion processes and factors affecting engine performance.
CO4 Perform engine testing and analyze performance and emission characteristics.
CO5 Analyze the operation and performance of gas turbine plants and jet propulsion systems.

Unit	Content	Hours
I	**Introduction to Internal Combustion Engines** Energy conversion in I.C. engines, Basic engine components and nomenclature, Working principles of I.C. engines, Classification of I.C. engines, Comparison between Spark Ignition (S.I.) and Compression Ignition (C.I.) engines, Valve timing diagrams, Applications of I.C. engines, Engine performance parameters **Conventional and Alternative Fuels for I.C. Engines** Petrol and diesel fuels, Octane and cetane ratings, Alternative fuels: LPG, CNG, ethanol, biodiesel, and other biofuels, Biodiesel preparation and its applications	9
II	**Fuel Supply Systems in S.I. Engines** Carburetors, Calculation of the air-fuel ratio, Multi-Point Fuel Injection (MPFI), Port Fuel Injection (PFI), Worked out Examples **Fuel Supply Systems in C.I. Engines** Direct Injection (DI), Common Rail Direct Injection (CRDI), Distributor fuel injection system, Individual pump system, Fuel pumps and fuel injectors, Worked out Examples **Engine Friction and Lubrication Systems** Functions and requirements of lubrication, Lubrication systems used in I.C. engines **Engine Heat rejection and Cooling Systems** Necessity of cooling, Air cooling and water-cooling systems, Heat rejection and cooling mechanisms **Ignition System**	9

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	Functions and requirements of ignition system, Ignition systems used in I.C. engines, Spark advance mechanism	
III	**Combustion in S.I. Engines** Normal combustion process, Stages of combustion, Factors affecting normal combustion, Combustion chamber design criteria, Types of combustion chambers, Abnormal combustion, Pre-ignition, Flame propagation, Detonation and knocking, Factors affecting knocking, Turbulence, swirl, squish, and tumble effects **Combustion in C.I. Engines** Combustion phenomenon, Combustion in direct and indirect injection systems, Fuel spray behavior, Stages of combustion in C.I. engines, Factors affecting combustion, Ignition delay and auto-ignition, Factors affecting ignition delay, Diesel knock and abnormal combustion, Ignition lag period, Supercharging, turbocharging, and scavenging	9
IV	**Performance Testing of I.C. Engines** Importance of engine testing, Measurement of: Indicated Power (IP), Brake Power (BP), Frictional Power (FP), Speed, Fuel consumption, Air consumption. Morse test for measurement of IP, Willan's line method and motoring test for measurement of FP. Calculation of: Indicated thermal efficiency, Brake thermal efficiency, Volumetric efficiency, Mechanical efficiency. Preparation of heat balance sheet, Numerical problems on heat balance sheet, Engine performance characteristic curves. **Engine Emissions and Control** Introduction to engine emissions, S.I. engine emissions: HC, CO, and Nox, Emission control methods for S.I. engines, C.I. engine emissions: HC, CO, NOx, smoke, smog, and particulate matter, Emission control methods for C.I. engines, Comparison of S.I. and C.I. engine emissions, Emission standards: Euro norms, Bharat Stage (BS) norms. Effects of engine emissions on human health	9
V	**Gas Turbines** Ideal gas turbine cycles, Isentropic efficiency and stage efficiency, Applications of gas turbines, Pressure losses in gas turbine systems, Performance enhancement techniques: Intercooling, Reheating, Regeneration. Fuel-air ratio, Combustion efficiency, Performance calculations, Open-cycle and closed-cycle gas turbine plants, Cogeneration and combined power cycles. **Jet Propulsion** Principles and working of: Turbojet, Turboprop, Ramjet, Pulsejet. Simple turbojet cycle Thrust power, Propulsive power, Thermal efficiency, Propulsive efficiency, Overall efficiency.	9

Text Books: -

1. Internal Combustion Engines, V. Ganesan, Tata McGraw-Hill Publishing Company Ltd, Fourth Edition, 2013
2. A Course in Internal Combustion Engines, M. L. Mathur and R. P. Sharma, Dhanpat Rai Publications

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Pvt. Ltd, First Edition, Re-print 2003
3. Internal Combustion Engines, Rajput R. K., Laxmi Publications Pvt. Ltd, First Edition, Re-print 2014

Reference Books:

1. Internal Combustion Engines and Air Pollution, R. Yadav, Central Publishing House, Allahabad, Second Edition, 2004
2. Internal Combustion Engine Fundamentals, John B. Heywood, Tata McGraw-Hill. Publishing Company Ltd, First Edition, 2011
3. Automotive Engines, Srinivasan, Tata McGraw-Hill Publishing Company Ltd., First Edition, 2001
4. Internal Combustion Engines, Domkundwar and Domkundwar, DhanpatRai Publications Pvt. Ltd. First Edition,
5. Obert E. F, “Internal Combustion Engines and Air Pollution”, Harper and Row Publication Inc. NY, 1973.
6. Heisler H, “Advanced Engine Technology”, Edward Arnold, 1995.
7. Heldt P. M, “High Speed Combustion Engines”, Oxford & IBH publishing Co. India, 1985.
8. Stockel M W, Stockel T S and Johanson C, “Auto Fundamentals”, The Goodheart, Wilcox Co. Inc., Illinois, 1996.

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC506 (B)

Title of Course: **Production Technology (Program Elective – I)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Explain production systems, plant layouts, and productivity improvement techniques used in manufacturing industries.

CO2 Apply production planning, scheduling, and inventory control techniques for efficient manufacturing operations.

CO3 Analyze work study and industrial engineering techniques for improving productivity and reducing manufacturing cost.

CO4 Explain quality control and maintenance techniques used for reliable and efficient production systems.

CO5 Describe modern production practices and smart manufacturing technologies used in advanced industries

Unit	Content	Hours
I	**Production Systems and Plant Layout** Introduction to production systems, types of production, product design and process selection, plant location factors, plant layout types, material handling systems, line balancing, productivity concepts.	9
II	**Production Planning and Control (PPC)** Introduction to PPC, forecasting methods, routing, scheduling, loading, dispatching, follow-up, aggregate production planning, capacity planning, inventory control techniques, EOQ, ABC analysis, MRP and ERP concepts, Jigs & fixtures: introduction and types.	9
III	**Work Study and Industrial Engineering** Method study, motion economy principles, work measurement techniques, time study, work sampling, standard time calculation, ergonomics, workplace design, wage incentive plans, productivity improvement methods.	9
IV	**Quality Control and Maintenance Engineering** Quality concepts, inspection and testing, control charts, acceptance sampling, total quality management (TQM), ISO standards, maintenance types, preventive and predictive maintenance, TPM concepts.	9

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V	**Modern Production and Smart Manufacturing** Lean manufacturing, Just-In-Time (JIT), Kaizen, Six Sigma basics, flexible manufacturing systems (FMS), computer-integrated manufacturing (CIM), Industry 4.0 concepts, smart manufacturing, IoT in production, sustainable manufacturing.	9

Text Books Recommended:

1. Production Technology, R. K. Jain, Khanna Publishers New Delhi, 2014
2. Production Engineering, P.C. Sharma, S. Chand Company Limited, New Delhi, 2012
3. Production and Operations Management — S. N. Chary — Tata McGraw Hill Education
4. Industrial Engineering and Production Management — Martand Telsang — S. Chand Publications
5. Lean Manufacturing Systems and Cell Design — Nicholas S. — CRC Press
6. Operations Management — S. Anil Kumar & N. Suresh — New Age International Publishers
7. Statistical Quality Control — M. Mahajan — Dhanpat Rai Publications

Reference Books Recommended:

1. Quality Control and Industrial Statistics — A. M. Sarma — Khanna Publishers
2. Production Modern Production/Operations Management — Elwood S. Buffa & Rakesh K. Sarin — Wiley India
3. Manufacturing Planning and Control for Supply Chain Management — F. Robert Jacobs, William L. Berry, D. Clay Whybark & Thomas E. Vollmann — McGraw Hill
4. Operations Management for Competitive Advantage — Richard B. Chase, Nicholas J. Aquilano & F. Robert Jacobs — Tata McGraw Hill
5. Work Study and Ergonomics — M. S. Sanders & Ernest J. McCormick — McGraw Hill
6. Total Quality Management — Dale H. Besterfield — Pearson Education
7. Automation, Production Systems and Computer Integrated Manufacturing — Mikell P. Groover — Pearson Education

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC506 (C)

Title of Course: **Computer Aided Design (Program Elective – I)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Recognize basic graphics fundamentals and related hardware. Select appropriate geometric modeling algorithms for generation of graphical primitives and employ rasterization.

CO2 Employ transformations routines for 2-D and 3-D geometric and co-ordinate transformations.

CO3 Apply FEM techniques for basic thermal and structural analysis.

CO4 Formulate and solve truss and two-dimensional problems.

CO5 Formulate and solve basic engineering optimization problems.

Unit	Content	Hours
I	Definition of CAD, CAD software modules (Operating system, Graphics, Applications, Programming, Communication), Rasterization principle, Rasterization of line, Frame buffer, N-bit plane buffers, simple color frame buffer, Line generation using Bresenham's & DDA algorithms for line circle ellipse.	9
II	Two dimensional geometric and co-ordinate transformation like scaling, translation, rotation & reflection, shear. Concepts of homogeneous representation and concatenated transformation, Inverse transformation (Enumeration of entity on graph paper) Three dimensional geometric and co-ordinate transformation like scaling, translation, rotation and reflection. Reflection about on arbitrary line, Bezier curve (for control points.) Algorithms for windowing and clipping.	9
III	Fundamental concept of finite element method: Plane stress and stain, Compatibility condition, Minimum potential energy principle, Displacement function, shape function for linear and quadratic bar element, Stiffness matrix, force Matrix.	9
IV	Truss problems (Linear shape function only), Shape function for CST, Two dimensional problems using constant strain triangle.	9
V	Objective of Optimum design, adequate and optimum design, Johnson's method of optimum design, primary design equation, subsidiary design equations and limit equations, optimum design with normal specification of simple machine elements like: tension bar, transmission shaft, pressure vessel, helical spring etc. Introduction to redundant specification with suitable example.	9

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Text and Reference Books:

1. CAD/CAM: Theory & Practice – Ibrahim Zeid, McGraw-Hill publication.
2. Procedural Elements for Computer Graphics – David F. Rogers, McGraw-Hill publication.
3. Computer Control of Manufacturing Systems – Yoram Koren, McGraw-Hill Inc. publication.
4. Introduction to Finite Elements in Engineering – T. R. Chandrupatla & A. D. Belegundu, Pearson publication.
5. Mechanical Design Synthesis with Optimization Applications. Johnson R. C., Van Nostrand–Reinhold Publications.

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPCCMEC507

Title of Course: **Heat Transfer Lab**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course outcomes:

After completing the course, the students will be able to;

CO1	Determine thermal conductivity of metals, liquids and insulation
CO2	Estimate heat transfer coefficients in natural and forced convection mode
CO3	Investigate Thermal radiation phenomena and verify radiation laws
CO4	Evaluate the performance of Heat exchanger
CO5	Analyze heat transfer performance of fins and determine fin effectiveness and efficiency

Lab Activities: A minimum of eight practical should be performed from the topics listed below.

List of practical:

1. Determination of thermal conductivity of metal bar
2. Determination of thermal conductivity of insulating material in the powder form.
3. Determination of thermal conductivity of liquids by guarded plate heater method.
4. Determination of temperature distribution and heat transfer rate for a fin under (A) Free convection & (B) Forced convection condition.
5. Determination of heat transfer coefficient in forced convection of air through a pipe/tube.
6. Determination of heat transfer coefficient in natural convection of air over a vertical cylinder
7. Determination of critical heat flux in saturated pool boiling.
8. Determination of condensation heat transfer in film wise & drop wise modes.
9. Determination of LMTD, overall heat transfer coefficient and effectiveness of heat exchanger
10. Determination of emissivity of non-black surfaces.
11. Verification of Stefan-Boltzmann constant.
12. Study of heat pipes.

A Journal/Report on practical conducted shall be submitted by each student. University Practical examination shall be on viva-voce of 10 marks and practical performance or objective test of 15 marks.

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC508 (A)

Title of Course: **Internal Combustion Engines and Gas Turbines Lab (Program Elective Lab – I)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course Outcomes (COs)

Upon successful completion of the Internal Combustion Engines and Gas Turbines Laboratory, students will be able to:

CO1: Identify and explain the construction, components, and working principles of S.I. and C.I. engines, fuel supply systems, ignition system, lubrication and cooling systems, gas turbine systems, and jet propulsion systems.
CO2: Conduct performance tests on petrol and diesel engines and evaluate engine performance parameters such as brake power, thermal efficiency, specific fuel consumption, and mechanical efficiency.
CO3: Perform heat balance tests, Morse tests, and valve timing analysis to determine engine characteristics and interpret experimental results.
CO4: Conduct performance trials on air compressors and centrifugal blowers, and analyze their operating characteristics and efficiencies.
CO5: Demonstrate practical skills in the assembly and disassembly of internal combustion engines and identify the functions of various engine components.

List of Experiments

Minimum Eight out of following shall be performed.

1. Study of Internal Combustion Engine Components
   - Identification and function of major components of S.I. and C.I. engines.
2. Study of Valve Timing Diagram
   - Determination of valve timing and port timing of a four-stroke engine.
3. Study of Fuel Supply Systems
   - Study of carburettor, MPFI, and CRDI fuel injection systems and their working principles.
4. Study of Ignition Systems
   - Study of battery ignition, magneto ignition and electronic ignition systems used in S.I. engines.
5. Study of Lubrication and Cooling Systems
   - Identification and working of splash, pressure lubrication, air-cooling, and water-cooling systems.
6. Performance Test on a Single cylinder Diesel Engine
   - Determination of brake power, brake thermal efficiency, specific fuel consumption, and mechanical efficiency under varying loads.
7. Performance Test on a Single cylinder Petrol Engine
   - Determination of brake power, brake thermal efficiency, specific fuel consumption, and mechanical efficiency under varying loads.

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8. Heat Balance Test on an I.C. Engine
    - Preparation of heat balance sheet and determination of energy distribution.
9. Morse Test on a Multi-Cylinder Petrol Engine
    - Determination of indicated power and mechanical efficiency.
10. Trial on single stage air compressor.
11. Trial on two stage air compressors.
12. Trial on reciprocating air compressor.
13. Trial on Centrifugal air blower.
14. Assembly& dis-assembly of internal combustion engine.
15. Study of Gas Turbine Components
    - Identification and function of compressor, combustion chamber, turbine, and accessories.
16. Study of Jet Propulsion Systems
    - Demonstration and comparison of turbojet, turboprop, ramjet, and pulsejet engines using models, animations, or simulation software.

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC508 (B)

Title of Course: **Production Technology Lab (Program Elective Lab – I)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Analyse different plant layouts, work-study techniques, and motion economy principles for improving manufacturing productivity.

CO2 Apply production planning and control techniques such as line balancing, inventory control, EOQ, reorder level, and ABC analysis in manufacturing systems.

CO3 Use statistical quality control tools, including sampling plans, OC curves, and control charts, for quality monitoring and process improvement.

CO4 Develop preventive maintenance schedules and implement lean manufacturing practices such as Kaizen and 5'S for efficient production management.

CO5 Identify and study various jigs and fixtures and explain their role in improving accuracy, productivity, and standardization in manufacturing operations.

Lab Activities: A minimum of eight practical should be performed from the topics listed below.

List of practical:

1. Study and preparation of different plant layouts such as process, product, fixed position, and cellular layout.
2. Measurement of standard time for a machining or assembly operation using stopwatch time study.
3. Study of motion economy principles using operation process charts and flow process charts.
4. Balancing of an assembly line and calculation of line efficiency and idle time.
5. Determination of Economic Order Quantity (EOQ), reorder level, and ABC analysis.
6. Design and analysis of single sampling plans and OC curves.
7. Preparation of preventive maintenance schedules for machine tools or manufacturing equipment.
8. Identification of wastes in a manufacturing process and implementation of basic Kaizen/5S techniques.
9. Study of Different Types of Jigs & Fixtures and understand industrial applications of jigs and fixtures.
10. Construction and interpretation of $\bar{X}$-chart, R-chart, p-chart, c-chart

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V Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC508 (C)

Title of Course: **Computer Aided Design Lab (Program Elective Lab – I)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Prepare code in C language for generation of 2-D graphical entities and basic surfaces.
CO2 Apply 2-D and 3-D transformations routine to solve the problems.
CO3 Create model for simple solid geometries using CAD software's.
CO4 Analyze 1-D and 2-D problems by finite element method.
CO5 Optimize the given problem for finding best feasible solution.

Lab Activities: A minimum of eight practical should be performed from the topics listed below.

List of practical:

1. Development of application program for DDA.
2. Development of application program for Bresenham's Line Generation Algorithm.
3. Development of application program for Bresenham's Circle Generation Algorithm.
4. Development of application program for Bresenham's Ellipse Generation Algorithm.
5. Development of application program for Scaling, Translation and Rotation.
6. Development of application program for Standard Reflection.
7. Development of application program for Clipping.
8. Solution of 1D FE problems (Linear Bar) using commercial / freeware / self-developed application programs.
9. Solution of 1D FE problems (Quadratic Bar) using commercial / freeware / self-developed application programs.
10. Solution of Truss problems using commercial / freeware / self-developed application programs.
11. Solution of 2D FE problems based on CST using commercial / freeware / self-developed application programs.
12. Creation of 3D models of machine components, assemblies, and automobile parts using commercial CAD software.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STMDMMEC601

Title of Course: Industrial Robotics (Multi-Disciplinary Minor - IV (MDM-IV)

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Analyze robot kinematics, workspace, and dynamics using D-H parameters and transformations.

CO2 Apply robot motion control and evaluate industrial robot controllers.

CO3 Select appropriate sensors, actuators, and end effectors for robotic systems.

CO4 Evaluate robotic applications in material handling, processing, and assembly operations.

CO5 Design and analyze robotic work cells considering safety, control, and simulation

Unit	Content	Hours
I	Automation and Robotics, Robot anatomy, configuration of robots, joint notation schemes, work volume, introduction to manipulator kinematics, position representation, forward and reverse transformations of a 2- DOF arm, a 3- DOF arm in two dimensions, a 4 – DOF arm in three-dimension, homogeneous transformations in robot kinematics, D-H notations, solving kinematics equations, introduction to robot arm dynamics.	9
II	Basic control system models, slew motion, joint –interpolated motion and straight-line motion, controllers like on/off, proportional, integral, proportional plus integral, proportional plus derivative, proportional plus integral plus derivative.	9
III	Robot actuation and feedback components position and velocity sensors, actuators and power transmission devices, mechanical grippers, vacuum cups, magnetic grippers, pneumatic, electric , hydraulic and mechanical methods of power and control signals to end effectors.	9
IV	General considerations in robot material handling, material transfer applications, pick and place operations, palletizing and related operations, machine loading and unloading, die casting, plastic molding, forging, machining operations, stamping press operations using robots. Application of robot in spot welding continuous are welding, spray coatings, Robots in Assembly Operations.	9
V	Robot cell layouts, multiple robots and machine interface, other considerations in work cell design, work cell control, safety devices and interlocks, error detection and recovery, work cell controller, robot cycle time analysis, robotic simulation using software.	9

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TEXT BOOK:

1. Industrial Robotics, M. P. Groover, M. Weiss , R.N. Nagel, N.G. Odrey, McGraw Hill International, Koren Robotics, 1986
2. Robotic Technology, S.R.Deb, McGraw Hill International, 994 Flexible Automation,
3. Robotic Engineering, An Integrated Approach , Richard D. Klafter, Thomas A.Chmielewski, M. Negin, PHI Publication

REFERENCE S BOOKS:

1. Robotics, K .S.Fu , R. C. Gonzales , C.S.G.Lee, Tata Mc Graw Hills, International Edition, 1987
2. Introduction to Robotics - Analysis, System, Application, Saeed B. Niku, Pearson Education
3. Robotic Safety Systems: An Applied Approach by Justin Starr and Christopher Quick
4. Robot System Reliability and Safety: A Modern Approach by B.S. Dhillon
5. Industrial Robotics: Programming, Simulation and Applications, Edited by Low Kin Huat
6. Digital Manufacturing: Methods and Tools in Modern Manufacturing, K. Case, L. Gao

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPCCMEC602

Title of Course: **Thermal Engineering**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Describe steam generators, mountings, accessories, and evaluate draught performance.
CO2 Evaluate the performance of Steam generator and analyse the steam nozzle.
CO3 Analyse the performance of steam turbine.
CO4 Evaluate the performance of steam condenser.
CO5 Analyze the performance of Reciprocating compressor and Rotary compressor.

Unit	Content	Hours
I	**Steam Generators:** - Indian boiler regulation, Fire tube boilers, water tube boilers, High pressure boilers. Introduction to Boiler Mountings and Accessories. **Boiler Draught and Performance:** -Definition and classification of draught, Chimney height and diameter, condition for maximum discharge through a chimney, efficiency of chimney, draught losses.	9
II	**Performance of steam generators:** - Evaporative capacity, equivalent evaporation, factor of evaporation, boiler efficiency, Economizer efficiency, percentage heat utilized in boiler, Overall efficiency of boiler, boiler power, Energy conservation opportunities in boiler **Introduction to steam engines, Steam Nozzles:** - Types of steam nozzles, steam flow through nozzles, flow through actual nozzles, supersaturated expansion of steam.	9
III	**Steam Turbines:** - Introduction, working and classification of steam turbines, Impulse turbine, reaction turbine, Turbine efficiencies, losses in steam turbines, governing of steam turbines, special forms of turbines.	9
IV	**Steam Condensers:** - Types and functions of condensers, elements of condensing plant, Sources of air in condenser, effects of air leakage in condenser, methods of obtaining maximum vacuum in condensers, vacuum efficiency, condenser efficiency, Estimation of cooling water required, Air extraction, Cooling towers, Cooling ponds.	9
V	**Reciprocating air compressors:** - Single stage compressor work, (Without and with clearance), volumetric efficiency, actual Indicator diagram, free air delivery (FAD), Multistage compression	9

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	Rotary air compressors, Displacement Compressors: - Root blower and vane blower**.** **Steady flow compressors: -** Centrifugal compressor and axial flow compressor.	

Text Books:

1. Power Plant engineering – V. M. Domkundwar.
2. Thermal Engineering - P. L. Ballaney
3. Thermal Engineering - Mathur & Mehta.
4. Thermal Engineering —– Vasandani & Kumar
5. Thermal Engineering –R. S. Khurmi and J. K. Gupta
6. Thermal Engineering –R. K. Rajput

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPCCMEC603

Title of Course: **Mechanical Measurement**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
2	--	--	2	2	2	05	05	40	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Explain basic concepts measurement

CO2 Describe dynamic characteristics of measurements system

CO3 Identify instruments for measurements of linear & angular displacement and speed

CO4 Identify instruments for measurement of strain, Weight, force, Torque, Power, and Pressure

Unit	Content	Hours
I	Purpose, Structure and elements of measuring system. Static characteristics of measurement system elements including systematic, statistical characteristics, generalized model of system elements and calibration, measurements error	8
II	Dynamic characteristics of measurements system, First and second order instruments, Transfer function G(S), Step, Ramp, and Frequency response, dynamic Errors, Signals and Noise in measurement system (No Mathematical treatment)	7
III	Classification, Principle, Sensing Elements, constriction, Range and working of instruments for measurements of linear & angular displacement and speed.	8
IV	Classification, Principle, Sensing elements, construction, Range and working of instruments for measurement of strain, Weight, force, Torque, Power, Pressure	7

Text Books:

1. Principles of measurements system, John P. Bentely, Pearson Education Asia
2. Mechanical Measurements by D.S. Kumar
3. Mechanical Measurements and Instrumentation by R.K. Rajput

Reference Books:

1. Mechanical Measurements" by T.G. Beckwith, R.D. Marangoni, and J.H. Lienhard
2. "Measurement Systems: Application and Design" by Ernest O. Doebelin
3. "Instrumentation for Engineering Measurements" by James W. Dally and William E. Riley
4. "Mechanical and Industrial Measurements" by R.K. Jain
"Engineering Metrology and Measurements" by N.V. Raghavendra and L. Krishnamurthy.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPCCMEC604

Title of Course: **Dynamics of Machines**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Analyze static and dynamic forces in mechanisms and reciprocating engines.

CO2 Explain flywheel operation, gyroscopic effects, and governor characteristics.

CO3 Evaluate longitudinal and transverse vibration behaviour of mechanical systems.

CO4 Analyze torsional vibrations in rotor and geared shaft systems.

CO5 Apply balancing principles to rotating and reciprocating masses in engines.

Unit	Content	Hours
I	**Static Force Analysis:** Constraint and applied forces, Static Equilibrium, Equilibrium of two and three force members, Member with two forces and torque, Force conventions, free body diagrams, Superposition, Principle of virtual work, Friction in Mechanisms. **Dynamic Force Analysis:** D'Alembert's Principle, Equivalent offset inertia force, Dynamic analysis of slider crank and four link mechanism, Velocity & Acceleration of piston, Engine Force Analysis, Turning Moment on Crank shaft, Dynamically Equivalent System, Inertia of connecting Rod, Inertia Forces in Reciprocating Engines (Graphical Method)..	9
II	**Turning Moment Diagrams & Engine Flywheel:** Turning moment diagrams for Single Cylinder Four Stroke Engine, Multi Cylinder Engine, Function of Flywheel, Maximum Fluctuation of Energy, Coefficient of Fluctuation of Energy, Dimensions of Flywheel Rim. **Gyroscope:** Angular Velocity, Angular Acceleration, Gyroscopic Couple (Torque), Gyroscopic Effect on Aero planes, Naval Ships, Stability of Two-Wheel Vehicle. **Governors:** Types of Governors, Watt Governor, Porter Governor, Proell Governor, Hartnell Governor, Centrifugal & Inertia Governors, Hunting, Isochronism in Governors. (No Numerical Treatment in Governors).	9

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III	**Vibrations** **Longitudinal Vibrations:** Free Longitudinal Vibrations, Damped Vibrations, Logarithmic Decrement, Forced Vibrations, Magnification Factor, Vibration Isolation & Transmissibility. **Transverse Vibrations:** Natural Vibrations of Shaft and beams under different types of load conditions, Frequency of Natural Transverse Vibrations for Point Load, Uniformly Distributed Load, Frequency of Natural Transverse Vibrations for a shaft or beam carrying several point loads, Dunkerlay's Method, Energy Method, Critical speed or Whirling Speed of Shaft.	9
IV	**Torsional Vibrations:** Free Torsional Vibrations for Single Rotor System, Two Rotor System, Three Rotor System, Torsionally Equivalent Shaft. Free Torsional Vibrations of a Geared System.	9
V	**Balancing:** Static and Dynamic Balancing, Balancing of Rotating Masses, Balancing of several Rotating masses in different planes, Balancing of Reciprocating Masses, Hammer Blow, Variation of Tractive Force, Swaying Couple, Secondary Balancing, Balancing of Locomotives, Balancing of In line Engines, Balancing of Radial Engines.	9

Text Books:

1. Theory of machines & Mechanisms - Shigley
2. Theory of Machines & Mechanisms - Ghosh & Mallik
3. Theory of Mechanisms - S. S. Rattan
4. Mechanism and Machine Theory - Rao & Dukipatti
5. Theory of Vibrations - W. T. Thomson

Reference Books:

1. Theory of Machine - Thomas Bevan
2. Theory of Machines - Sandor & Erdman
3. Mechanical Vibrations - Grover

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC605(A)

Title of Course: **Automation in Manufacturing (Program Elective – II)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Apply concepts of automated flow lines.

CO2 Prepare manual part program and computer aided part program.

CO3 Analyze robot anatomy and recognize flexible manufacturing system

CO4 Appraise automated material handling and storage system.

CO5 Employ concept of modeling and group technology in industry

Unit	Content	Hours
I	**Introduction to Automation:** Automation: Definition, Types, reasons for automating, Functions for manufacturing. Automated Flow Lines: - Methods of work part transport, Buffer storage. General terminology and analysis of transfer lines without storage, partial automation, automated flow lines with storage buffers, Line balancing, Methods of line balancing. Manual Assembly Lines. Automated Assembly systems - Types, parts delivery system.	9
II	**Numerical Control Production Systems:** Basic concepts, NC coordinate systems. Types of NC systems - Point to point, straight cut & continuous path. Tape & tape readers. NC part programming - Punched tape & tape formats, NC words, methods of part programming, manual part programming. Introduction to APT (Programming not expected), Direct numerical control. Computer Numerical Control. Applications & Economics of NC.	9
III	**Industrial Robotics:** Introduction, Robot anatomy, Robot control systems, Robot configurations, end effectors, sensors, Introduction to robot programming, Robot Applications in Material handling. **Computer Aided Design:** Fundamentals of CAD, Design Process, Benefits of Computer Aided Design **Computer Aided Manufacturing:** Manufacturing Planning, Manufacturing Control, Computer Integrated manufacturing. **Flexible Manufacturing Systems** – Levels of flexibility components, FMS benefits.	9

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	Computer Aided Process Planning: Retrieval CAPP systems, generative CAPP systems, benefits of CAPP.	
IV	**Automated material handling & storage**: Introduction to Material Handling equipment, Unit load Concepts, Automated Guided vehicle Systems. Types:- Driverless trains, AGVS pallet trucks, AGVS unit-load carriers, Traffic control & safety, System management, Analysis of AGVS systems, AGVS applications. **Automated Storage & Retrieval System** - Types: Unit load AS / RS, mini load AS / RS, man on board AS/RS, automated item retrieval system, deep lane AS/RS - Basic components & special features of AS/RS, Carrousel storage systems.	9
V	**Modelling and Simulation**: Optimization Techniques, Low-Cost Automation: hydraulic and pneumatic system concepts and components, Mechanical and Electromechanical Systems. **Group Technology:** Part families, parts classification & coding, Opitz classification systems, production flow analysis, Machine cell design - composite part concept, types of cell design, best machine arrangement, benefits of group technology.	9

TEXT BOOKS:

1. Automation, Production Systems and Computer Integrated Manufacturing, Groover, M.P., Pearson Prentice hall publication .
2. Industrial Robotics, Technology, Programming and Applications, Groover, M.P.; Weiss, M.; Nagel, R.N. and Odrey, N.G. , McGraw Hill Intl. Edition.
3. Introduction to Robotics, Analysis, Control and Applications, Niku, Saeed B., Willey Publication.
4. Robotics-Control, Sensing, Vision and Intelligence, Fu, K.S.; Gonzalez, R.C. and Lee, C.S.G., McGraw Hill Intl. Ed.
5. CAD / CAM - Zimmers & Groover – PHI

REFERENCE BOOKS :

1. Robot Technology Fundamentals, Keramas, James G, Thomson Learning –Delmar .
2. Handbook of Robotics, Noff, Shimon Y., John Wiley and Sons.
3. Introduction to Robotics, Analysis, Systems and Applications, Niku, Saeed B. Prentice Hall of India.
4. Numerical Control & - Kundra, Rao & Tewari – TMH Computer Aided Manufacturing
5. Computer Control of Manufacturing - Yoram Koren - McGraw Hill. Systems

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC605(B)

Title of Course: **Metrology and Quality Control (Program Elective – II)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course outcomes:

After completing the course, the students will be able to;

CO1 Explain the fundamentals of metrology, measurement systems, standards, calibration procedures, and statistical concepts used in measurement.

CO2 Use linear measuring instruments and evaluate geometric features such as straightness, flatness, squareness, parallelism, roundness, and cylindricity.

CO3 Describe screw thread and gear terminology and perform basic measurements related to screw threads and gears.

CO4 Analyze quality control concepts, process capability, control charts, and statistical control techniques for manufacturing processes.

CO5 Apply acceptance sampling techniques, interpret O.C. curves

Unit	Content	Hours
I	Introduction to metrology: Definition, types, need of inspection, terminologies, methods of measurement, selection of instruments, measurement errors, units, Measurement standards, calibration, statistical concepts in metrology	9
II	Linear metrology: Steel rule, calipers, vernier caliper, vernier height gauge, vernier depth gauge, micrometers, slip gauges, Measurement of straightness, flatness, squareness, parallelism, roundness, cylindricity	9
III	Screw thread metrology: Introduction, screw thread terminology, screw thread measurement. Gear measurement: Introduction, types of gears, gear terminology	9
IV	Quality Control: Definition, function, objective characteristics. Quality, Quality of design, quality of conformance, process control charts and process capability. Statistical quality control.	9
V	Acceptance sampling techniques O.C. curves, sampling plans, inspection types and objectives.	9

Text Books:

1) Engineering Metrology and Measurements by N.V. Raghavendra and L. Krishnamurthy
2) Textbook of Metrology by M. Mahajan

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3) Engineering Metrology by R.K. Jain:

Reference Books:

1. Instrumentation for Engineering Measurements by James W. Dally and William E. Riley
2. Mechanical and Industrial Measurements by R.K. Jain
3. Engineering Metrology and Measurements by N.V. Raghavendra and L. Krishnamurthy

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC605(C)

Title of Course: **Rapid Prototyping and Additive Manufacturing (Program Elective – II)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course Outcomes:

After completing the course, the students will be able to;

CO1 Recall the concepts, evolution and classification of rapid prototyping and additive manufacturing processes.

CO2 Explain the principles of CAD data preparation and process planning for additive manufacturing.

CO3 Describe the working principles and applications of various additive manufacturing processes.

CO4 Identify suitable materials and rapid tooling methods for engineering applications.

CO5 Apply basic design guidelines and recognize emerging trends in additive manufacturing.

Unit	Content	Hours
I	**Introduction to Rapid Prototyping and Additive Manufacturing:** Introduction to product development cycle, concurrent engineering and reverse engineering. Evolution and need for rapid prototyping, comparison between conventional manufacturing and additive manufacturing, advantages, limitations and applications of additive manufacturing. Classification of additive manufacturing processes according to ASTM standards. Concepts of rapid tooling and the role of additive manufacturing in Industry 4.0 and digital manufacturing.	9
II	**CAD Modelling and Process Planning:** Geometric modelling techniques and CAD requirements for additive manufacturing. STL file format and its characteristics, STL file generation, defects and repair techniques. Slicing methods, support structures, build orientation, layer thickness selection, process planning and build time estimation. Introduction to software tools used in additive manufacturing.	9
III	**Additive Manufacturing Processes:** Principles, working mechanism, process parameters, materials and applications of various additive manufacturing processes including Stereolithography (SLA), Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS), Laminated Object Manufacturing (LOM), Selective Laser Melting (SLM), Electron Beam Melting (EBM), Binder Jetting and Direct Energy Deposition processes. Comparative analysis of different additive manufacturing	9

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	techniques.	
IV	**Materials and Applications of Additive Manufacturing:** Materials used in additive manufacturing including polymers, metals, ceramics and composites. Material properties and selection criteria. Concepts of direct and indirect rapid tooling. Applications of additive manufacturing in aerospace, automobile, biomedical, tooling industries, consumer products and customized manufacturing. Industrial case studies and recent developments in additive manufacturing.	9
V	**Design Considerations and Emerging Trends:** Design guidelines for additive manufacturing, topology optimization, lattice structures and part consolidation. Post-processing techniques, quality control and inspection of additively manufactured parts. Economic aspects and sustainability issues. Emerging trends such as hybrid manufacturing, 4D printing, bioprinting and future scope of additive manufacturing technologies	9

Text Books:

1. P. N. Rao, Manufacturing Technology: Foundry, Forming and Welding, McGraw Hill Education, New Delhi.
2. R. K. Rajput, A Textbook of Manufacturing Technology, Laxmi Publications, New Delhi.
3. V. Raghavan, Materials and Manufacturing Processes, Prentice Hall of India.
4. A. K. Purohit and K. Sridhar, Additive Manufacturing and 3D Printing, Satya Prakashan, New Delhi.

Reference Books:

1. Amit Bandyopadhyay and Susmita Bose, Additive Manufacturing, CRC Press.
2. V. K. Jain, Advanced Machining Processes, Allied Publishers, New Delhi.
3. P. C. Sharma, Production Engineering, S. Chand Publications, New Delhi.
4. P. N. Rao, CAD/CAM: Principles and Applications, McGraw Hill Education, New Delhi.
5. B. S. Nagendra Parashar and R. K. Mittal, Elements of Manufacturing Processes, Prentice Hall of India.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC606(A)

Title of Course: **Automobile Engineering (Program Elective – III)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course Outcomes (CO):

After completing the course, the students will be able to;

CO1 Explain the classification, construction, layout, safety features, and major components of conventional and electric automobiles.

CO2 Analyze the construction, working, operation, maintenance, and troubleshooting of clutch systems and manual/automatic transmission systems.

CO3 Describe the construction, working, maintenance, and troubleshooting of driveline components and automotive braking systems.

CO4 Evaluate the performance and operational characteristics of steering systems, wheel alignment, suspension systems, wheels, and tyres.

CO5 Explain the construction, operation, testing, maintenance, and troubleshooting of automotive electrical systems, including batteries, charging systems, starting systems, lighting systems, and vehicle accessories.

Unit	Content	Hours
I	History and development of automobiles, Definition of Automobile, Classification of automobiles, Vehicle specifications, The basic structure, Layout of conventional and electric vehicles, Different types of layouts like FEFWD, REFWD, FERWD, RERWD, 2WD, 4WD Major components and functions of an automobile, Chassis, Function of chassis, construction and details (frames, sub-frames, frameless vehicles, vehicle dimensions), details of chassis & body materials, Safety Considerations; Safety Features of Latest Vehicle. Engine Construction -Structural components and materials, Recent development in Automobiles.	9
II	**Clutch:** Definition, Function, Necessity, Requirements of clutch systems, Classification of clutch, Types of clutches, Principal of clutches, Dry friction clutches – Cone clutch, single plate clutch, multi-plate clutch, semi-centrifugal clutch and centrifugal clutch, Wet clutches	9

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	Clutch operation. Clutch components – Clutch plate, clutch facing and other clutch components, Preliminary inspection of clutch, Clutch adjustments, clutch overhaul, clutch refacing, clutch trouble shooting, Fluid flywheel **Gear Box:** Function and Principal of transmission, Necessity of transmission Types of transmission: Manual Transmission – sliding mesh gear box, constant mesh gear box and synchromesh gear box, gear selector mechanism, transfer gear box, lubrication & control, Gear box trouble shooting Automatic transmission – Epicyclic gear box, freewheel unit, over drive, torque Converter, continuously variable transmission.	
III	**Drive line:** Propeller shaft, Universal joint, Hooke's joint, Constant velocity joint, Propeller shaft overhaul, Propeller shaft trouble shooting, Final drive, Differential - need & types, Rear axle, Rear axle drive - hotchkiss drive, torque tube drive, Rear axle shaft supporting, rear axle casing, rear axle trouble shooting **Brakes –** Function and Principal of Brake, Requirement of braking system, Brake efficiency and stopping distance, Fading of brake, Weight transfer and wheel skidding Types of brakes: purpose, location, construction, method of actuation and extra braking effort Types - mechanical, hydraulic, pneumatic brakes, electrical brakes, servo brake, vacuum servo brake, engine exhaust brakes, air brake, hand brake, antilock brake system, Drum & disc brakes, comparison, details of components, brake adjustment. Brake trouble shooting	9
IV	**Front axle and Steering systems:** Front axle, Wheel alignment, factors of wheel alignment, Factors pertaining to wheel, Principle of steering, center point steering, Steering geometry, Camber, king pin inclination, combined angle scrub radius, castor, toe-in or toe out, correct steering angle, Steering mechanism, cornering force, self-righting torque, understeer and oversteer, Steering linkages, Steering gears, steering ratio, reversibility, Power steering, special steering systems, Steering trouble shooting **Wheels and tyres:** Types of wheels, wheel dimensions, Types of tyres, tyres specification, factors affecting tyres performance, special tyres, wheel balancing. Wheel and tyre trouble shooting. **Suspension systems:** Objects of suspension, Requirement of suspension systems, Function of suspension spring, Type of suspension spring - Leaf spring, coil spring, torsion bars and rubber spring, Shock absorber, conventional and independent suspension system, Stabilizer or anti-roll device, Air suspension, Hydro elastic suspension, Suspension system trouble shooting	9
V	**Storage Batteries:** Function, Types - Lead acid battery, Alkaline battery, Zinc – air battery	9

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	Battery capacity and battery rating, Battery charging, Battery testing, Battery maintenance, Battery trouble shooting. **Charging System:** Principal of Generator, Constructional details, Generator output control, Testing procedure, Faults and their diagnosis, maintenance, Principal and operation of regulators, regulator servicing, regulator setting, Alternator – principal, constructional details, alternator regulation, Comparison of alternator with d.c. generator. **Starting System:** Starting motor, Characteristics of D. C. motors, Starting drives, Bendix drive, overrunning clutch drive, Dyer drive, Starting motor switches and control circuit, starting system trouble shooting. **Lighting System:** Lighting system, wiring circuit, Wires, Headlights, Lighting switches, Indicating lights, Lighting system trouble shooting. **Accessories:** Horn, Indicator, Wiper, Speedometer, Tachometer, Automobile air-conditioning, Ventilating system, Heating system, Mirrors, Panel board instruments, Central locking facility, Tools and equipment for repair and overhaul, testing equipment's.	

Text and References Books:

1. Automobile Mechanics - Joseph Heitner
2. Motor Vehicle Technology - J. A. Dolan
3. Automotive Mechanics - W. H. Crouse
4. Motor Vehicle: K. Newton and W. Seeds, T. K. Gawet.
5. Automotive Mechanics – Ganeshan
6. Automotive Engineering, Kirpal Singh, Vol. I & II, Standard Publishers, New Delhi, 2002.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC606(B)

Title of Course: **Product Life cycle Management (Program Elective – III)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course Outcomes

After completing the course, the students will be able to;

CO1 Explain PLM concepts, lifecycle phases and business benefits.
CO2 Apply PDM, BOM and configuration management.
CO3 Analyze collaborative engineering and engineering change processes.
CO4 Evaluate CAD/CAM/CAE, ERP, MES, IoT and Digital Twin integration.
CO5 Implement PLM strategies for sustainable product development

Unit	Content	Hours
I	**Introduction to PLM:** Product lifecycle phases, Product development process, Concurrent engineering, Stakeholders, Product architecture, Digital enterprise, PLM benefits, Product innovation, Market requirements	9
II	**Product Data Management:** PDM concepts, BOM management, Document management, Classification, Metadata, Version, control, Revision control, Configuration management, Collaboration, Security.	9
III	**Engineering Change Management:** ECR, ECO/ECN, Workflow, Approval process, Change impact, Risk assessment, Quality integration, Traceability, Compliance, Audit	9
IV	**PLM Integration:** CAD/CAM/CAE integration, ERP integration, MES integration, SCM integration, Cloud PLM, IoT, Digital Thread, Digital Twin, Industry 4.0, MBSE	9
V	**Advanced PLM:** Sustainability, End-of-life management, Product analytics, AI in PLM, Additive manufacturing, Smart factory, Service lifecycle, Circular economy, Future trends, Industrial case studies	9

Text and Reference books

1. John Stark - Product Lifecycle Management
2. Michael Grieves - Product Lifecycle Management
3. Saaksvuori & Immonen - Product Lifecycle Management
4. CIMdata PLM Resources
5. PTC Windchill Documentation

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC606(C)

Title of Course: **Finite Element Methods (Program Elective – III)**

Teaching Scheme					Examination Scheme (Theory)				
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	MSE	IE	ESE	Total
3	--	--	3	3	3	10	10	80	100

Course Outcomes (CO):

After completing the course, the students will be able to;

CO1 Explain the fundamentals of elasticity, variational principles, and formulate one-dimensional bar finite elements for structural analysis.

CO2 Analyze discretized engineering systems and formulate finite element equations for axisymmetric problems.

CO3 Analyze two-dimensional continuum and truss structures using appropriate finite element formulations to determine stresses and displacements.

CO4 Analyze beam, isoparametric, and torsional finite element models using numerical integration and matrix solution techniques.

CO5 Apply finite element algorithms for dynamic and thermal analyses and utilize commercial FEA software for solving practical engineering problems.

Unit	Content	Hours
I	**Elasticity Fundamentals** Fundamentals of stress and strain; stress and strain components; stress–strain relationships; elastic constants; plane stress and plane strain; differential equations of equilibrium; compatibility equations; boundary conditions; Saint-Venant's principle; introduction to Airy's stress function. **Introduction to Finite Element Method** Historical background and scope of the Finite Element Method (FEM) in engineering applications. **Variational Principles** Concept of virtual work; principle of minimum potential energy; Rayleigh–Ritz method. **One-Dimensional Bar Elements** Finite element modeling and analysis using one-dimensional (1-D) bar elements; formulation of the element stiffness matrix; assembly procedure; application of boundary conditions; load vector; and temperature effects.	9
II	**Discretization Concepts** Concept of discretization of a continuum into finite elements; degrees of freedom (DOF); bandwidth; basic types of two-dimensional (2-D) and three-dimensional (3-D) finite elements;	9

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	displacement models; and convergence requirements. **Axisymmetric Analysis** Finite element formulation of axisymmetric solids subjected to axisymmetric loading using Constant Strain Triangle (CST) ring elements; formulation of the stiffness matrix; application of boundary conditions; load vector; and stress computation.	
III	**Two-Dimensional Continuum Elements** Finite element formulation and analysis of two-dimensional problems using Constant Strain Triangle (CST) and Linear Strain Triangle (LST) elements; element stiffness matrix; assembly procedure; boundary conditions; load vector; stress computation; and temperature effects. **Truss Elements** Finite element modeling and analysis of two-dimensional plane trusses; local and global coordinate systems; element stiffness matrix; assembly procedure; application of boundary conditions; load vector; determination of member forces and stresses.	9
IV	**Beam Elements** Finite element modeling and analysis using beam elements; formulation of the element stiffness matrix; assembly procedure; application of boundary conditions; and load vector. **Isoparametric Elements** Introduction to subparametric, isoparametric, and superparametric elements; higher-order finite elements. **Numerical Integration** Introduction to numerical integration techniques, including Gauss quadrature. **Torsion** Finite element analysis of torsion in prismatic bars using triangular elements. **Mathematical Prerequisites** Matrix algebra and matrix operations; eigenvalues and eigenvectors; methods for solving systems of simultaneous equations, including Gauss elimination and matrix decomposition methods; shape functions.	9
V	**Dynamic Analysis** Introduction to dynamic analysis; formulation of the mass matrix for one-dimensional bar elements; free vibration analysis of one-dimensional bar elements. **Thermal Analysis** Finite element analysis of steady-state one-dimensional and two-dimensional heat conduction problems using one-dimensional bar and triangular elements, respectively. **Programming and Software Aspects** Programming aspects of the Finite Element Method, including algorithms for: Reading finite element model data, Formulation of element stiffness matrices, Formulation of element load vectors, Assembly of element stiffness matrices into the global stiffness matrix, Assembly of element load vectors into the global load vector, Application of boundary conditions, Solution of the global system of equations, Determination of nodal displacements, strains, and stresses	9

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	Industrial Applications Pre-processing and post-processing in Finite Element Analysis (FEA); overview of commercial FEA software packages.	

Text Books:

1. Fundamentals of Finite Element Analysis – David V. Hutton – McGraw-Hill Education
2. Introduction to Finite Elements in Engineering – Tirupathi R. Chandrupatla & Ashok D. Belegundu – Pearson
3. Finite Element Method: Basic Concepts and Applications – S. S. Bhavikatti – New Age International Publishers
4. An Introduction to the Finite Element Method – J. N. Reddy – McGraw-Hill Education

Reference Books:

1. Concepts and Applications of Finite Element Analysis – Robert D. Cook, David S. Malkus, Michael E. Plesha & Robert J. Witt – Wiley
2. Theory of Elasticity – S. P. Timoshenko & J. N. Goodier – McGraw-Hill Education
3. The Finite Element Method – O. C. Zienkiewicz & R. L. Taylor – Butterworth-Heinemann (Elsevier)
4. Finite Element Procedures – Klaus-Jürgen Bathe – Prentice Hall
5. Programming the Finite Element Method – Ian M. Smith, D. V. Griffiths & Lennart Margetts – Wiley

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPCCMEC607

Title of Course: **Mechanical Engineering Lab**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Analyze the performance and dynamic behavior of mechanical systems through experimental investigations.

CO2 Evaluate the performance of thermal engineering systems and interpret experimental results.

CO3 Apply measurement techniques using sensors and transducers for engineering applications.

CO4 Apply quality improvement and lean manufacturing principles to analyze manufacturing processes.

CO5 Develop and apply computer-based graphical and engineering models to solve mechanical engineering problems.

Lab Activities: A minimum of eight practicals should be performed from the topics listed below.

List of Practicals:

1. Performance characteristics of Gyroscope.
2. Performance characteristics of Governor.
3. Determination of natural frequency of single/ double rotor system.
4. Determination of Jump-off speed of cam follower system.
5. Performance test on petrol / diesel engine.
6. Performance test on cooling tower.
7. Performance on rotary/reciprocatory/centrifugal compressor.
8. Visit to Power Plant (Compulsory).
9. To study the output characteristics of LVDT.
10. To study the transducer for speed/pressure/force measurement.
11. Identification of wastes in a manufacturing process and implementation of basic Kaizen/5s techniques.
12. Construction and interpretation of $\bar{X}$-chart, R-chart, p-chart, c-chart.

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13. Development of application program for Bresenham's line/circle/ellipse Generation Algorithm.
14. Development of application program for Scaling, Translation and Rotation.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC608(A)

Title of Course: **Automation in Manufacturing Lab. (Program Elective Lab. – II)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Prepare and execute Manual and Computer Aided Programming.
CO2 Distinguish various configurations used for robots.
CO3 Recognize concept of Flexible Manufacturing System.
CO4 Describe the Automated Storage and Retrieval System.
CO5 Recognize concept of Modeling and Group technology

Lab Activities: A minimum of eight practicals should be Performed from the topics listed below.

LIST OF PRACTICALS:

1. Performance. Simulation on CNC Lathe.
2. Performance, Simulation of CNC Milling Machine.
3. Manual Part Programming
4. Study of Robot joints and configurations.
5. Performance, Robot operations for Industrial Practices
6. Study of Flexible Manufacturing System.
7. Study of Computer Aided Process Planning System.
8. Study of Automated Guided Vehicle System
9. Study of Automated Storage and Retrieval System
10. Study of Hydraulic and Pneumatic System .
11. Study of Group Technology.

A Journal/Report on practicals conducted shall be submitted by each student. University Practical examination shall be on viva-voce of 10 marks and practical performance or objective test of 15 marks.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC608(B)

Title of Course: **Metrology and Quality Control Lab. (Program Elective Lab. – II)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course Description: After completing this course student will have basic understanding of the metrology, linear measurements, screw thread and gear measurement and the concept of quality control.

Course Outcomes:

After completing the course students will able to:

CO1 Select, calibrate, and use linear measuring instruments such as vernier calipers, micrometers, height gauges, depth gauges, and slip gauges for dimensional measurement.

CO2 Measure and evaluate geometric characteristics of engineering components such as straightness, flatness, squareness, parallelism, roundness, and cylindricity.

CO3 Perform measurement and inspection of screw threads and gears using appropriate metrological instruments and techniques.

CO4 Analyze measurement data, estimate measurement errors, and apply statistical methods for quality assessment. Understand the inspection techniques

CO5 Construct and interpret control charts, process capability indices, acceptance sampling plans, and O.C. curves for quality control applications.

Lab Activities: A minimum of eight practicals should be Performed from the topics listed below.

List of lab Practicals

1) Measurement using Vernier Caliper.
2) Measurement using Micrometer.
3) Calibration using Slip Gauges.
4) Measurement of Straightness and Flatness.
5) Measurement of Squareness and Parallelism.
6) Measurement of Roundness and Cylindricity.
7) Screw Thread Measurement.
8) Gear Tooth Measurement.

Quality control

1) Case studies on process control
2) Design of sampling plans
3) Statistical Quality Control using Control Charts.
4) Process Capability Analysis.
5) Acceptance Sampling and O.C. Curve Analysis.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC608(C)

Title of Course: **Rapid Prototyping and Additive Manufacturing Lab. (Program Elective Lab. – II)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Recall the concepts, evolution, classification and applications of rapid prototyping and additive manufacturing processes

CO2 Explain CAD data preparation, STL file generation and process planning involved in additive manufacturing

CO3 Describe process planning methods and operating principles used in additive manufacturing processes**.**

CO4 Identify suitable process parameters and materials and apply additive manufacturing techniques for fabrication and evaluation of components.

CO5 Apply basic design considerations and recognize emerging trends and industrial applications of additive manufacturing

List of Experiments

1. Study of different rapid prototyping and additive manufacturing techniques.
2. Study of ASTM classification and applications of additive manufacturing processes.
3. Creation of CAD models and conversion into STL format.
4. Study and repair of STL file defects.
5. Generation of support structures and slicing of CAD models.
6. Estimation of build time and selection of build orientation and layer thickness.
7. Fabrication of components using FDM-based 3D printer.
8. Dimensional inspection and accuracy evaluation of printed components.
9. Study of post-processing techniques for additively manufactured parts.
10. Industrial case study and prototype development using additive manufacturing.

Lab Activities: Students will be able to perform, analyse, and document any eight experiments from the prescribed list of ten experiments to gain practical exposure to Rapid Prototyping and Additive Manufacturing processes and applications.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC609(A)

Title of Course: **Automobile Engineering Lab. (Program Elective Lab. -III)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Identify and explain the construction, layout, and functions of major automobile systems and components, including conventional and electric vehicle configurations.

CO2 Demonstrate the working principles, assembly, disassembly, and maintenance procedures of clutch, gearbox, transmission, driveline, and rear axle systems.

CO3 Analyze the operation and performance characteristics of braking, steering, suspension, wheel alignment, and tyre systems used in automobiles.

CO4 Perform testing, maintenance, and troubleshooting of automotive electrical systems, including batteries, charging systems, starting systems, lighting systems, and vehicle accessories.

CO5 Apply practical knowledge to inspect, diagnose, and evaluate automobile subsystems, including air-conditioning systems, and prepare technical reports based on experimental observations.

Lab Activities: A minimum of eight practicals should be Performed from the topics listed below.

List of Experiments

1. **Study of Automobile Chassis and Vehicle Layouts**
   - Identification of major automobile components and study of conventional and electric vehicle layouts.
2. **Study of Clutch Assembly**
   - Construction, working, and dismantling/assembly of clutches.
3. **Study of Gearbox**
   - Construction and operation of sliding mesh, constant mesh, and synchromesh gearboxes.
4. **Study of Automatic Transmission System**
   - Demonstration of epicyclic gearbox, torque converter, and continuously variable transmission (CVT).
5. **Study of Propeller Shaft, Universal Joint, and Differential**
   - Identification of components and study of working principles.
6. **Study of Rear Axle Assembly**

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- Construction, types, and maintenance of rear axle systems.

7. **Study of Braking Systems**
   - Demonstration of hydraulic, pneumatic, drum, disc, and ABS braking systems.
8. **Study of Steering Geometry and Wheel Alignment**
   - Measurement and analysis of camber, caster, kingpin inclination, and toe settings.
9. **Study of Steering Gear Mechanisms**
   - Construction and operation of manual and power steering systems.
10. **Study of Suspension Systems**
    - Examination of leaf spring, coil spring, torsion bar, shock absorber, and independent suspension systems.
11. **Study of Wheels and Tyres**
    - Identification of tyre specifications, wheel balancing, and tyre maintenance procedures.
12. **Study of Automobile Batteries**
    - Battery testing, charging, maintenance, and determination of battery characteristics.
13. **Study of Charging System**
    - Testing and performance evaluation of alternator and voltage regulator.
14. **Study of Starting System**
    - Construction and operation of starter motor and starting drives.
15. **Study of Automobile Lighting and Accessories**
    - Wiring circuits, headlights, indicators, horn, wiper, speedometer, and dashboard instruments.
16. **Study of Automobile Air Conditioning System**
    - Identification of components and working of automotive air-conditioning systems.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC609(B)

Title of Course: **Product Life Cycle Management Lab. (Program Elective Lab. -III)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Understand PLM architecture, lifecycle phases, and product development process.

CO2 Create and manage product structures, BOM, documents, revisions, and configurations.

CO3 Apply ECR, ECO, and workflow management concepts in PLM systems.

CO4 Understand CAD, ERP, and MES integration with PLM platforms.

CO5 Demonstrate Digital Twin, Digital Thread, and Industry 4.0 concepts using PLM tools.

Lab Activities: A minimum of eight practicals should be Performed from the topics listed below.

List of Practicals:

1. Study of PLM architecture and lifecycle phases.
2. Study of product development process.
3. Creation of Product Structure and BOM.
4. Document management and check-in/check-out.
5. Revision and version management.
6. Configuration management.
7. Engineering Change Request (ECR).
8. Engineering Change Order (ECO).
9. Workflow creation and approval routing.
10. CAD integration with PLM.
11. ERP integration overview.
12. MES integration overview.
13. Digital Twin and Digital Thread demonstration.
14. Industry 4.0 and IoT in PLM.
15. Mini case study using Windchill/Teamcenter/ENOVIA.

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STPECMEC609(C)

Title of Course: F**inite Element Methods Lab. (Program Elective Lab. -III)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	2	2	1	--	25	25	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Understand and explain basic concepts of elasticity, discretization, and finite element formulation for engineering problems.

CO2 Formulate and analyze one-dimensional bar and axisymmetric finite element problems under mechanical and thermal loading.

CO3 Develop and analyze two-dimensional structural elements such as CST, LST, truss, beam, and torsion problems using FEM.

CO4 Apply and demonstrate FEM procedures for dynamic, thermal, and programming-based problems including solution interpretation

Lab Activities: A minimum of eight practical should be Performed from the topics listed below.

List of Practicals:

1. Introduction to the FEM environment and FEA software.
2. Analysis of a 1-D bar element under axial and thermal loading.
3. Mesh generation and discretization of engineering models.
4. Axisymmetric analysis of pressure vessels using CST ring elements.
5. 2-D continuum analysis using CST and LST elements.
6. Plane truss analysis.
7. Beam analysis using beam elements.
8. Torsional analysis of prismatic bars.
9. Free vibration analysis of bar elements.
10. Steady-state heat conduction analysis of 2-D models.

Reference and Text Books:

1. Introduction to Finite Elements in Engineering – Tirupathi R. Chandrupatla & Ashok D. Belegundu – Pearson Education
2. Fundamentals of Finite Element Analysis – David V. Hutton – McGraw-Hill Education
3. Finite Element Method: Basic Concepts and Applications – S. S. Bhavikatti – New Age International

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Publishers
4. The Finite Element Method – O. C. Zienkiewicz & R. L. Taylor – Butterworth-Heinemann (Elsevier)
5. Concepts and Applications of Finite Element Analysis – Robert D. Cook, David S. Malkus, Michael E. Plesha & Robert J. Witt – Wiley
6. Theory of Elasticity – S. P. Timoshenko & J. N. Goodier – McGraw-Hill Education
7. Programming the Finite Element Method – Ian M. Smith, D. V. Griffiths & Lennart Margetts – Wiley
8. Finite Element Analysis: Theory and Application with ANSYS – Saeed Moaveni – Pearson Education

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VI Semester B. Tech. Mechanical Engineering (NEP 2020)

Course Code: STVSECMEC610

Title of Course: **Soft Skills**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	1	2	3	2	--	50	--	50

Course outcomes:

After completing the course, the students will be able to;

CO1 Communicate effectively using verbal, non-verbal, listening, reading, and writing skills in academic and professional situations.

CO2 Demonstrate self-confidence, interpersonal effectiveness, emotional intelligence, and teamwork in diverse situations.

CO3 Prepare professional documents and perform effectively in presentations, group discussions, and interviews.

CO4 Exhibit professional ethics, leadership qualities, workplace etiquette, and lifelong learning attitudes for career growth.

Unit	Content	Hours
I	**Foundations of Communication and Confidence Building** Importance of Soft Skills for Engineers, Self-awareness and Self-introduction, Communication Process, Barriers to Communication, Verbal and Non-verbal Communication, Listening Skills, Vocabulary Building and Pronunciation, Confidence Building Techniques.	
II	**Interpersonal Skills, Emotional Intelligence and Teamwork** Personality Development, Positive Attitude and Motivation, Emotional Intelligence, Self-esteem and Self-confidence, Interpersonal Skills, Teamwork and Collaboration, Time Management, Conflict Resolution, Stress Management, Meditation & Mindfulness practices, Resilience and Work-life balance	
III	**Professional Communication and Employability Skills** Business and Professional Communication, Email Writing, Report Writing Basics, Resume Preparation, Cover Letter Writing, Presentation Skills, Group Discussion Techniques, Interview Skills, Professional Grooming and Etiquette	
IV	**Leadership, Professional Ethics and Career Readiness** Leadership Styles, Professional Ethics, Workplace Etiquette, Decision Making, Problem Solving and Critical Thinking, Creativity and Innovation, Corporate Culture, Lifelong Learning, Career Planning and Professional Networking	

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List of Tutorials

1. Importance of communication in engineering profession
2. Analysis of effective communication videos
3. Preparation of self-introduction script
4. Vocabulary enhancement exercises
5. SWOT analysis of self
6. Goal setting and career planning
7. Time management techniques
8. Teamwork and leadership discussions
9. Resume writing workshop
10. Email writing formats
11. Group discussion strategies
12. Interview question analysis
13. Presentation planning and structure
14. Leadership styles analysis
15. Corporate culture discussion
16. Career roadmap preparation
17. Innovation and creativity exercises
18. Professional networking practices

List of Practical

1. Self-introduction (2 minute)
2. Speaking about family, village, school and career goals
3. Reading newspaper articles aloud
4. Pronunciation improvement exercises
5. Extempore speaking on simple topics
6. Team-building games
7. Group task execution and reporting
8. Problem-solving in teams
9. Role play on conflict management
10. Time management exercise

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11. Group communication practice
12. Peer feedback exercise
13. Preparation of personal resume
14. Professional email writing
15. Individual presentation (3 minutes)
16. Mock group discussion
17. Personal interview practice
18. Video-recorded presentation with feedback
19. Professional Etiquette, Dressing and Self-Presentation for Employability
20. Debate on contemporary issues
21. Career goal presentation
22. LinkedIn profile creation
23. Final integrated presentation

(Note: 1. Approximately **70% of the practical sessions are designed to be speaking- oriented**.

2. **Any 15 practical** shall be performed from the above list to develop communication, presentation, and interpersonal skills among students.)

Suggested Continuous Assessment Scheme

Component	Weightage
Tutorial Assignments	20%
Communication Activities	20%
Presentations	20%
Group Discussion & Interview	20%
Portfolio (Resume, Emails, Reports, Reflection Diary)	20%

Recommended Laboratory Infrastructure

- Language Laboratory
- Computer with Internet Facility
- LCD Projector

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- Presentation Recording Facility (Student's Mobile)
- Public Address System
- Group Discussion Room

Text Books

1. Sanjay Kumar & Pushp Lata, Communication Skills, Oxford University Press India.
2. Barun K. Mitra, Personality Development and Soft Skills, Oxford University Press India.
3. Meenakshi Raman & Sangeeta Sharma, Technical Communication: Principles and Practice, Oxford University Press India.
4. S. Hariharan, N. Sundararajan and S. Shanmugapriya, Soft Skills, MJP Publishers.
5. D. S. Prakash Rao, Communication Skills for Professionals, Himalaya Publishing House.
6. R. Subramanian, Professional Ethics and Human Values, Oxford University Press India.

Reference Books

1. Dale Carnegie, How to Win Friends and Influence People, Simon & Schuster India.
2. Stephen R. Covey, The 7 Habits of Highly Effective People, Simon & Schuster India.
3. Daniel Goleman, Emotional Intelligence, Bloomsbury India.
4. Lesikar, Flatley & Rentz, Business Communication, McGraw-Hill Education India.
5. Courtland L. Bovee & John V. Thill, Business Communication Today, Pearson India.
6. Andrew J. DuBrin, Human Relations and Interpersonal Skills, Pearson India.
7. Carole Fleming, The Serious Business of Small Talk, Viva Books India.
8. Brian Tracy, Speak to Win, Amacom (Indian Edition).

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Two-year UG Diploma in Engineering/Technology

Exit Course after Third Year of B.Tech. Mechanical Engineering

Course Code: STEXMEC621

Title of Course: **Design Process Management (PLM)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	2	12	14	8	--	100	100	200

Course outcomes:

After completing the course, the students will be able to;

CO1 Understand the concepts, stages, and importance of Product Lifecycle Management.
CO2 Analyze product development processes and engineering change management.
CO3 Apply PDM and PLM tools for managing product information and collaboration.
CO4 Integrate CAD/CAE/CAM, ERP, and manufacturing systems within a PLM environment.
CO5 Develop a mini project based on PLM implementation and lifecycle optimization

Unit	Content	Hours
I	Introduction & Fundamentals: Introduction to Product Lifecycle Management, Product lifecycle stages, Evolution of PLM, Concurrent Engineering, Product Development Process, Role of PLM in Manufacturing Industries, Digital Transformation, Industry 4.0, Product Innovation, Benefits and challenges of PLM implementation.	
II	Product Data Management & Collaboration: Product Data Management (PDM), BOM Management, Document Management, Configuration Management, Revision & Version Control, Workflow Management, Product Structures, Cross-functional Collaboration, Supplier Integration and Data Governance.	
III	PLM Systems & Engineering Change Management: PLM Architecture, Engineering Change Request (ECR), Engineering Change Order (ECO), Change Management Process, Traceability, Requirements Management, Quality Integration, Product Compliance, Risk Management and Industrial Case Studies.	
IV	CAD/CAE/CAM & Enterprise Integration: Integration of CAD, CAE and CAM systems with PLM, ERP and MES Integration, Digital Manufacturing, Digital Thread, Digital Twin Concepts, Cloud-based PLM, IoT Applications, Smart Manufacturing and Industry Best Practices.	
V	Lab Work and Project: Creation of Product Structures and BOM, Document & Workflow Management, Engineering Change Process Demonstration, CAD Data Management, Lifecycle Analysis, PLM Software Demonstration (Windchill/Teamcenter/3DEXPERIENCE), Mini Project and Presentation.	

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Textbooks

1. John Stark – Product Lifecycle Management (PLM): 21st Century Paradigm for Product Realisation
2. Michael Grieves – Product Lifecycle Management
3. Saaksvuori & Immonen – Product Lifecycle Management
4. Ameri and Dutta – Product Lifecycle Management: Closing the Knowledge Loops

Reference Books

1. CIMdata – PLM Best Practices
2. PTC Windchill Documentation
3. Siemens Teamcenter Documentation
4. Dassault Systèmes 3DEXPERIENCE Platform Guides
5. Industry 4.0 and Digital Manufacturing References

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Exit Course after Third Year of B.Tech. Mechanical Engineering

Course Code: STEXMEC622

Title of Course: **Autonomous, Connected, Electric Vehicles (ACE)**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	2	12	14	8	--	100	100	200

Course outcomes:

After completing the course, the students will be able to;

CO1 Introduce the fundamentals of electric, connected, and autonomous vehicle technologies.

CO2 Develop practical skills in EV systems, sensors, communication, and vehicle automation.

CO3 Demonstrate hands-on competency in vehicle simulation, troubleshooting, and smart

Tutorial Content:

1. **Introduction to ACE Vehicles**: Evolution of automobile technology, overview of electric, connected, and autonomous vehicles, vehicle architecture, classification of EVs, hybrid vehicles, smart mobility concepts, government policies and standards.
2. **Electric Vehicle Systems**: Batteries and energy storage systems, battery management system (BMS), electric motors and drives, charging systems, regenerative braking, power electronics, EV transmission systems, thermal management.
3. **Connected Vehicle Technologies:** Internet of Vehicles (IoV), V2V and V2I communication, CAN protocol, telematics, GPS and navigation systems, cloud connectivity, cyber-security in connected vehicles, intelligent transportation systems.
4. **Autonomous Vehicle Technologies**: Sensors and actuators, LiDAR, radar, ultrasonic and camera systems, perception and localization, path planning, artificial intelligence in vehicles, ADAS, autonomous driving levels and safety systems.
5. **Simulation, Diagnostics and Future Trends:** Vehicle simulation tools, diagnostics and fault analysis, EV testing standards, autonomous vehicle simulation platforms, smart charging, vehicle-to-grid (V2G), sustainable mobility, future trends in ACE technology.

Tutorial Content (2 Hrs/Week)

Tutorial No.	Tutorial Topics
T1	Basics of electric and autonomous vehicles
T2	Battery sizing and energy calculations
T3	Motor selection and drive calculations
T4	CAN communication and network analysis
T5	ADAS case studies and autonomous vehicle levels

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T6	Vehicle sensor data interpretation
T7	Smart charging and energy management problems
T8	Simulation exercises using MATLAB/Simulink or EV software

Practical Content (12 Hrs/Week)

Practical No.	Practical Title
P1	Identification of EV powertrain components
P2	Study and testing of a lithium-ion battery pack
P3	Battery charging and discharging characteristics
P4	Performance analysis of BLDC motor drive
P5	Regenerative braking system demonstration
P6	Study of CAN communication in vehicles
P7	GPS and vehicle tracking experiment
P8	Sensor interfacing for autonomous vehicles
P9	LiDAR/camera-based obstacle detection
P10	ADAS feature demonstration and testing
P11	EV simulation using MATLAB/Simulink
P12	Vehicle diagnostics and fault identification
P13	Autonomous vehicle path planning simulation
P14	Mini project on connected or electric vehicle application

(Note: The students have to complete at least TEN practical from the list)

Text Books Recommended:

1. Electric and Hybrid Vehicles, Iqbal Husain, CRC Press.
2. Autonomous Vehicle Technology, James M. Anderson, RAND Corporation.
3. Fundamentals of Electric Vehicles, Sandeep Dhameja, Wiley.
4. Vehicle Dynamics and Control, Rajesh Rajamani, Springer.
5. Connected Vehicles, Radovan Miucic, Wiley Publications.

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Exit Course after Third Year of B.Tech. Mechanical Engineering

Course Code: STEXMEC623

Title of Course: **Automotive System Engineering**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	2	12	14	8	--	100	100	200

Course Description – This course covers the fundamentals of automotive systems, including the design and working of key subsystems such as powertrain, transmission, braking, steering, and electrical systems, along with modern technologies like EVs and automotive electronics.
It also introduces Value Analysis & Benchmarking techniques to improve performance, optimize cost, and enhance product quality through functional analysis and comparison with industry standards, supported by practical applications and case studies**.**

Course outcomes:

After completing the course, the students will be able to;

CO1 Understand the working principles of various automotive systems and subsystems.
CO2 Analyse key automotive systems such as powertrain, transmission, braking, and steering.
CO3 Apply Value Analysis and Benchmarking for cost and performance improvement.
CO4 Perform teardown and benchmarking of automotive components.
CO5 Develop a mini project based on automotive system design or value engineering

Unit	Content	Hours
I	**Introduction & Fundamentals** Introduction to Automotive Systems and Value Analysis & Benchmarking, Evolution of automotive technology and cost optimization techniques, Overview of vehicle subsystems (Powertrain, Transmission, Braking, Steering, Suspension, Electrical Systems), Function analysis and types of value (use, esteem, exchange), Conventional vs. electric and hybrid vehicles, Role of electronics and automation (ECUs, sensors, actuators), Automotive communication systems (CAN, LIN), Introduction to benchmarking types and methodology, Industry trends (EV, ADAS, smart vehicles), Importance of VAB in improving quality and reducing cost.	
II	**Automotive Systems & Cost Analysis:** Automotive powertrain systems (IC engine, MPFI, CRDI), Transmission systems (Manual, Automatic, CVT), Electric vehicle architecture (Battery, Motor, Controller), Vehicle electrical and electronic systems, Introduction to FAST (Function Analysis System Technique), Cost breakdown and cost vs. worth analysis, Materials and manufacturing processes in automotive components, Benchmarking tools and performance metrics, Applications, advantages and	

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	limitations of automotive systems from cost and performance perspective.	
III	**BIW Chassis Systems & Benchmarking Techniques:** Suspension systems (types and working), Steering systems (manual & power), Braking systems (Disc, Drum, ABS), Interior & Exterior Trimming Parts, Basics of vehicle dynamics and control, Product benchmarking techniques and reverse engineering, Teardown methodology for automotive components, Component comparison and gap analysis, Design optimization techniques, Case studies in automotive benchmarking and performance improvement.	
IV	**Advanced Systems & Value Engineering Applications:** Automotive Safety and Advanced Systems, Passive and active safety systems (Airbags, ABS, ESC), Introduction to ADAS (Adaptive Cruise Control, Lane Assist), Automotive electronics and control systems, Basics of automotive cybersecurity, Emission norms and environmental considerations, Testing and validation of automotive systems, Industrial applications and case studies. Implementation of Value Engineering, Design for Cost, Design for Manufacturing (DFM), Design for Assembly (DFA)	
V	**Lab Work and Project:** **Automotive System Study (Cut Section & Practical Understanding)** • Study & understand Tractor cut section (engine, transmission layout and working) • Study of HVAC system and its components & working • Study of MPFI (Multi-Point Fuel Injection) system • Study of Synchromesh Gearbox (construction and working) • Study of Rear Axle & Differential system • Study of Starting and Charging system • Study of Spark Ignition (SI) system • Study & understanding of Exhaust system and Silencer • Study of Electrical Wiring Board Diagram • Study of Teardown Process of Vehicle Dashboard & closer components	

Textbooks:

1. Kirpal Singh – Automobile Engineering, Vol I & II
2. Lawrence D. Miles – Techniques of Value Analysis and Engineering
3. V. Ganeshan – Internal Combustion Engines
4. R.K. Rajput – A Textbook of Automobile Engineering

Reference Books:

1. Robert Bosch – Automotive Handbook
2. Jack Erjavec – Automotive Technology: A Systems Approach
3. Del Younker – Value Engineering: Analysis and Methodology
4. Robert Camp – Benchmarking: The Search for Industry Best Practices
5. SAE International – Automotive Engineering & Benchmarking Practices

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Exit Course after Third Year of B.Tech. Mechanical Engineering

Course Code: STEXMEC631

Title of Course: **Internship / Technical Project**

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	16	16	8	--	100	100	200

Course Objectives

- To provide experiential learning through industrial training or technical project work.
- To enable students to apply engineering knowledge to real-world industrial problems.
- To develop professional skills including communication, teamwork, leadership, ethics, and technical documentation.
- To promote innovation, creativity, self-learning, and lifelong learning.

Course outcomes:

After completing the course, the students will be able to;

CO1 Apply engineering knowledge and technical skills to solve practical industrial or engineering problems.

CO2 Demonstrate professional competence through successful completion of internship or technical project activities.

CO3 Prepare professional technical reports and effectively communicate technical outcomes through presentations.

CO4 Demonstrate professional ethics, teamwork, leadership, project management, and lifelong learning abilities.

Course Guidelines

Each student shall undertake either an Internship or a Technical Project approved by the Head of the Department. Internship may be carried out in Industry, MSME, Government Organization, PSU, R&D Laboratory, Start-up, Academic Institution or any University-approved organization.

The Technical Project shall be undertaken individually in the field of Mechanical Engineering and shall demonstrate application of theoretical knowledge to practical problem-solving. The project work shall include problem identification, literature review, planning and design, technical execution, experimentation/analysis (as applicable), documentation, and preparation of a detailed technical report.

General Guidelines

1. Each student shall be assigned a Faculty Mentor by the Department.
2. The student shall maintain regular contact with the Faculty Mentor throughout the course.
3. Periodic progress reviews shall be conducted by the Faculty Mentor. Satisfactory progress is mandatory.

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4. The Faculty Mentor shall guide, monitor, verify progress, evaluate submissions and recommend eligibility for final assessment.
5. Where applicable, an Industry Mentor/Training Supervisor may guide the student during internship.
6. There shall be no theory examination.
7. Evaluation shall be based on technical work, report, seminar presentation and viva-voce.
8. Originality and professional ethics shall be maintained.
9. Reports shall be certified by the Faculty Mentor (and Industry Mentor, wherever applicable) before submission

Course Requirements

Each student shall complete and submit the following:

- Logbook/Work Diary, duly verified by the Faculty Mentor and, wherever applicable, the Industry Mentor.
- Internship Completion Certificate (for Internship, where applicable).
- Approved Project Synopsis (for Technical Project).
- Comprehensive Internship/Project Report.
- Seminar Presentation.
- Appearance in the Final Viva-Voce Examination.

Assessment & Evaluation

Component	**Internal (Faculty Mentor / Department)**	**External (University Examiner)**
Continuous progress Assessment	20	-
Technical Work / Performance	30	-
Evaluation of Report	20	30
Seminar / Presentation	15	30
Viva-voce/Professional and Technical Competency	15	40
Total	100	100

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Exit Course after Third Year of B.Tech. Mechanical Engineering

Course Code: STEXMEC641

Title of Course: Online skill courses (diploma level) from NSQF / ESSC / ANY Other agency which provides certification

Teaching Scheme					Examination Scheme (Practical)			
Lecture	Tutorial	Practical	Periods/week	Credits	Duration in Hours	CA	UA	Total
--	--	--	--	8	--	200	--	200

Course Objectives

- To enhance employability through certified skill development.
- To develop industry-relevant competencies.
- To encourage lifelong learning through recognized online platforms.
- To strengthen practical knowledge in emerging technologies.

Course Outcomes:

Course outcomes:

After completing the course, the students will be able to;

CO1 Acquire industry-relevant technical skills.
CO2 Demonstrate competency through certification.
CO3 Apply acquired skills in engineering applications.
CO4 Present and justify learning outcomes effectively.

MOOC Enrollment Guidelines

1. Students must enroll only in approved MOOCs offered through SWAYAM, NPTEL, or other recognized online learning platforms.
2. The department will provide a list of eligible and recommended MOOC courses for student enrollment.
3. Each student shall be assigned a Faculty Mentor by the Department.
4. Students are permitted to enroll in Exit MOOC courses during Semester VI, subject to prior approval from the Head of the Department (HoD). The grades/results of these courses will be considered for the exit course.
5. The final list of enrolled MOOC courses shall be approved and officially recorded by the department before the commencement of the course.
6. Each MOOC must have a minimum duration of eight (8) weeks.
7. The Faculty Mentor shall guide, monitor, verify progress, evaluate submissions and recommend eligibility for final assessment.
8. Students may choose a MOOC from any one of the following specialization areas:

- Thermal and Fluid Sciences

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- Manufacturing Engineering
- Design and Analysis
- CAD, CAM, and CIM
- Robotics and Automation
- Computational Mechanics
- Mechatronics
- Any other emerging technology in Mechanical Engineering approved by the department

Student Responsibilities:

Students enrolled in a MOOC are required to:

- Attend/view all lecture videos regularly.
- Complete and submit all assignments, quizzes, and other course requirements within the stipulated deadlines.
- Appear for and successfully pass the final proctored examination conducted by the respective MOOC platform.

Course Completion

Upon successful completion of the MOOC, students shall:

- Submit the MOOC completion certificate to the Departmental MOOC Coordinator within the prescribed timeline.

The Departmental MOOC Coordinator shall verify the authenticity of the certificate and maintain semester-wise records of all completed MOOC courses.

Assessment and Evaluation:

Assessment Scheme

Component	**Maximum Marks**
Online Skill Course – I	100
Online Skill Course – II	100
Total (College Assessment)	**200**

Assessment and Evaluation Guidelines

1. The student shall successfully complete two online skill courses from approved certification agencies as mentioned in general guidelines.
2. Each online skill course shall be assessed independently by the respective certification agency through its prescribed examination and evaluation process.
3. The student must obtain a Pass/Successful Completion status in each of the two online skill courses as per the criteria prescribed by the respective certification agency.
4. The marks obtained in each online skill course shall be normalized to an equivalent score out of 100

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marks as per the standard normalization methodology.

5. The College Assessment (200 Marks) shall comprise the normalized marks of the two online skill courses, with 100 marks assigned to each course.
6. The student shall submit the original course completion certificates and mark statements issued by the respective certification agencies for verification by the Department.

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