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S. No.	Subject Code	Subject Name	Maximum Marks Allotted					Total Marks	Contact Hours per week			Total Credits
			Theory			Practical						
			End Sem.	Mid Sem. Exam.	Quiz/ Assignment	End Sem	Term work / Lab Work & Sessional		L	T	P	
1.	PSCC-MT101	Introduction to Robotics	70	20	10	-	-	100	3	1	0	4
2.	PSCC-MT102	Industrial Automation	70	20	10	-	-	100	3	1	0	4
3.	PSEC-MT101	Program Specific Elective-I	70	20	10	-	-	100	3	0	0	3
4.	PSMC-MT101	Computational Methods	70	20	10	-	-	100	3	0	0	3
5.	LC-MT101	CAD/CAM Lab	-	-	-	60	40	100	0	0	4	2
6.	LC-MT102	Robotics Lab	-	-	-	60	40	100	0	0	4	2
7.	MLC - 1	Basics of Manufacturing & Electronics System	70	20	10	-	-	100	2	0	0	2
8.	AUD-1	Audit Course -I	-	-	-	-	-	-	2	0	0	0
Total			**350**	**100**	**50**	**120**	**80**	**700**	**16**	**2**	**8**	**20**

*MST: Minimum of two mid semester tests to be conducted. L: Lecture T: Tutorial P: Practical

S. No.	Program Specific Elective-I
1	PSEC-MT101(A) Computer Aided Modeling & Design
2	PSEC-MT101 (B) Mechatronics System & Application
3	PSEC-MT101 (C) Vibration & Noise Control

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PSCC-MT101	Introduction To Robotics	3L: 1T: 0P (04 hrs)	Credits: 04

Pre-requisite's: Theory of Machines, Mechatronics

Course Objective:

- To develop the student's knowledge in various robot structures and their workspace.
- To develop student's skills in perform kinematics analysis of robot systems.
- To provide the student with some knowledge and skills associated with robot control.

Course Content:

Module 1 **(08 hrs)**

Introduction of Robots: Classification of robots, Present status and future trends. Basic components of robotic system. Basic Terminology-Accuracy, Repeatability, Resolution, Degree of freedom. Mechanisms and transmission, End effectors, Grippers-different methods of gripping, Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, Cam type gripper, Magnetic grippers, Vacuum grippers, Air operated grippers; Specifications of robot.

Module 2 **(10 hrs)**

Drive systems and Sensors: Drive system- hydraulic, pneumatic and electric systems, Sensors in robot – Touch sensors, tactile sensor, Proximity and range sensors, Robotic vision sensor, Force sensor, Light sensors, Pressure sensors.

Module 3 **(10 Hrs)**

Kinematics and Dynamics of Robots: 2D, 3D Transformation, Scaling, Rotation, Translation, Homogeneous coordinates, multiple transformations, Simple problems. Matrix representation, Forward and reverse kinematics of three degree of freedom, Homogeneous transformations, Inverse kinematics of robot, robot Arm dynamics, D-H representation of robots, basics of trajectory planning.

Module 4 **(10 hrs)**

Robot Control: Programming and Applications Robot controls-Point to point control, Continuous path control, intelligent robot, control system for robot joint, control actions, feedback devices, encoder, resolver, LVDT, motion interpolations, adaptive control.

Module 5 **(10 hrs)**

Introduction to Robotic Programming: On-line and off-line programming, programming examples. Robot applications-material handling, machine loading and unloading, assembly, Inspection, welding, spray painting.

Course Outcomes:

After completion of this course, the students are able to:

1. Demonstrate the robot anatomy with joint notations and applications.
2. Familiarize with the most common robot sensors and understand fundamental sensor processing algorithms and their engineering trade-offs and identify and use of different types of drives and end effectors required for specific applications.
3. Explore the computational challenges inherent in fundamental mobile robotic tasks (e.g. localization, mapping, motion planning) and dealing with forward kinematics, inverse kinematics.

4. Develop simple robot control systems integrating perception, planning, and action.
5. To develop programming principles and languages for a robot control system. Create various applications and implementation with economical analysis of industrial robot systems.

List of Text Book:

1. Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, “Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.
2. Craig. J. J. “Introduction to Robotics- mechanics and control”, Addison- Wesley, 1999.
3. S.R. Deb, “Robotics Technology and flexible automation”, Tata McGraw-Hill Education., 2009.
4. Richard D. Klafter, Thomas .A, ChriElewski, Michael Negin, "Robotics Engineering an Integrated Approach", PHI Learning, 2009.

List of Reference Book:

1. Francis N. Nagy, Andras Siegler, "Engineering foundation of Robotics", Prentice Hall Inc., 1987.
2. P.A. Janaki Raman, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing Company Ltd., 1995.
3. Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University press, 2008.
4. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., “Robotics control, sensing, vision and intelligence”, McGraw Hill Book co, 1987
5. Ray Asfahl. C., “Robots and Manufacturing Automation”, John Wiley & Sons Inc.,1985 MERA-605 Introduction

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PSCC-MT102	Industrial Automation	3L :1T :0P (04 hrs)	Credits:4

Pre-requisite's: Theory of Machines, Mechatronics

Course Objective:
This course provides theoretical and practical aspects of implementing automation in industry. This course offers learning of pneumatics/ hydraulics systems, electrical controls and Programmable logic controllers.

Course Content:

Module 1 **(10 hrs)**

Introduction: Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Production Economics: Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process.

Module 2 **(12 hrs)**

Detroit-Type Automation: Automated Flow lines, Methods of Workpart Transport, Transfer Mechanism, Buffer Storage, Control Functions, and Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines Without Storage, Partial Automation, Automated Flow Lines with Storage Buffers, Computer Simulation of Automated Flow Lines.

Module 3 **(10 hrs)**

Material handling and Identification Technologies: The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems.

Automated Storage Systems: Storage System Performance, Automated storage/retrieval systems, Work-in-process Storage, interfacing handling and storage with manufacturing. Product identification system: Barcode, RFID etc.

Module 4 **(12 hrs)**

Control Technologies in Automation: Industrial control systems, process industries verses discrete manufacturing industries, continuous verses discrete control, computer process Control and its Forms. Computer Based Industrial Control: Introduction & automatic process control, building blocks of automation system: LAN, analog & digital I/O modules, SCADA system & RTU. automated inspection and testing: Inspection and testing, statistical quality control.

Module 5 **(10 hrs)**

Automated Inspection: Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, other contact inspection methods, machine vision, other optical inspection methods.

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Course Outcome:

After completion of this course, the students are able to:

1. Describe working of various blocks of basic industrial automation system.
2. Analysis of Automated Flow Lines.
3. Identity, design and Analysis of Material Handling and material storage systems.
4. Summarize distributed control system and control technologies in automation.
5. Use of various Industrial Automation Inspection methods.

List of Text/Reference Book:

1. "Automation, Production Systems and Computer Integrated Manufacturing"- M. P. Grover, Pearson Education.
2. "Computer Based Industrial Control" – Krishna Kant, EEE-PHI
3. Principles and Applications of PLC – Webb John, Mc millan 1992
4. "An Introduction to Automated Process Planning Systems" – Tiess Chiu Chang & Richard A. Wysk
5. "Anatomy of Automation" – Amber G.H & P.S. Amber, PrenticeHall.

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PSEC-MT101(A)	Computer Aided Modeling & Design	3L:0T:0P (03hrs)	Credits:03

Pre-requisite's: AutoCAD

Course Objective:
To acquaint and equip with the computer aided design and manufacturing of farm machinery with the help of CAD.

Course Content:

Module1: (08 hrs)
Introduction: Criteria for selection of CAD workstations, Single Design Process, Design criteria, Geometric modeling, entities, 2D & 3D Primitives. 2D & 3D Geometric Transformations: Translation, Scaling, Rotation, Reflection and Shearing, concatenation. Graphics standards: GKS IGES, PDES. Wire frame modeling: Curves, Curve representation, Analytic curves, Synthetic curves-Bezier, B-Spline, NURBS.

Module2: (10 hrs)
Surface Modeling: Surface representations, surface generation methods, Analytic Surface – Plane Surface, Ruled Surface, Surface of Revolution, Synthetic Surface-Cubic, Bezier, B-spline, Blending of surfaces, surface rendering.

Module 3 (10 hrs)
Solid Modeling Techniques: Graph Based Model, Boolean Models, Instances, Cell Decomposition & Spatial – Occupancy Enumeration, Boundary Representation (B-rep) & Constructive Solid Geometry (CSG).

Module 4 (12 hrs)
Advanced Modeling Concepts: Feature Based Modeling, Assembling Modeling, Behavioral Modeling, Conceptual Design & Top Down Design. Capabilities of Modeling& Analysis Packages such as solid works, Unigraphics, Ansys, Hyper mesh. Computer Aided Design of mechanical parts and Interference Detection by Motion analysis.

Module 5 (08 hrs)
Application Of CAD: In 3d Printing And Manufacturing, Simulation, Solving practical Problems, Calculate Area Volume And Other Mass Properties.

Course Outcomes:
After completion of this course, the students are able to:
1. Ability to create fully constrained solid models that can be quickly modified using standard software tools.
2. Ability to use, identify and explain standard features in solid modeling including protrusions, revolutions, cutouts, and patterns
3. Ability to use standard software tools to create engineering drawings, or other documents, to fully describe the geometries and dimensions of parts, as well as to document assemblies according to standard practice
4. Ability to use standard software tools to create part assemblies and check for clearances.

5. Ability to create the drawings of farm implements and their analysis.

List of Text Book:

1. Ibrahim Zeid, "CAD/CAM, Theory and Practice", McGraw Hill, 1998.
2. Foley, Van Dam, Feiner and Hughes, "Computer Graphics Principles and Practice", Addison – Wesley, 2000.

List of Reference Book:

1. Martenson, E. Micheal, "Geometric Modeling", John Wiley & Sons, 1995.
2. Hill Jr, F.S., "Computer Graphics using open GL", Pearson Education, 2003.
3. Hearn & Baker, "Computer Graphics", PHI.

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PSEC-MT101(B)	**Mechatronics System & Application**	**3L :0T :0P (03 hrs)**	**Credits:03**

Pre-requisite's: Fundamentals of Mechanical Engineering and Electronics Engineering

Course Objective:
The course trains students to practice Mechatronics Engineering in various areas of industrial and non-industrial automation.

Course Content:

Module 1 **(08 hrs)**

Introduction: Introduction to Mechatronics System, mechatronics in manufacturing, product and design, Measurement Systems, Control System, comparison between traditional and mechatronics approach. Sensors and Transducers: Introduction, Performance terminology, Displacement, Position and Proximity, Velocity and motion, Fluid pressure, Temperature sensors, Light sensors, Selection of sensors.

Module 2 **(10 hrs)**

Mechanical Actuation System: Cams, Gear trains, Ratchet and Pawl, Belt and chain drives, Bearings. Hydraulic and Pneumatic Actuation System: Introduction to Hydraulic and Pneumatic Systems, Directional Control valves, Flow control valves. Electrical Actuation System: Electrical systems, Solid State Switches, Solenoids, D.C. motors, A.C. motors, Stepper motors.

Module 3 **(10 hrs)**

Processors/Controllers Microprocessors: Microprocessor systems, Microcontrollers, applications. Programmable Logic Controllers: Basic PLC structure, Input/output processing, ladder programming, latching and internal relays, Sequencing, Timers and counters, Shift registers, Master and jump controls, Code conversion, Data handling, selection of PLC.

Module 4 **(12 hrs)**

System Models: Mathematical models, Mechanical, Electrical, hydraulic and Thermal Systems, Modeling of dynamic systems. Design of Mechatronics systems: Stages in designing Mechatronics system, Traditional and Mechatronic design.

Module 5 **(06 hrs)**

Case studies of Mechatronics system: Pick and place robots, automated guided vehicle, Automatic car park barrier, Engine management system.

Course Outcomes:
After completion of this course, the students are able to:

1. An ability to identify, select, and integrate mechatronics components to meet product requirements.
2. An ability to develop kinematic, dynamic and control models for robots.
3. An ability to use commercial software tools for modeling and simulation of mechatronics systems.
4. An ability to design, analyze, and optimize mechatronics products.
5. An ability to write technical reports and present engineering design solutions efficiently.

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List of Text Book:

1. W. Bolton, “Mechatronics” , Pearson education, second edition, fifth Indian Reprint, 2003.
2. Smaili and F. Mrad, "Mechatronics- integrated technologies for intelligent machines", Oxford university press, 2008.

List of Reference Book:

1. R.K Rajput, A textbook of mechatronics, S. Chand & Co, 2007.
2. Michael B. Histand and David G. Alciatore, “Introduction to Mechatronics and Measurement Systems”, McGraw-Hill International Editions, 2000.
3. D. A. Bradley, Dawson D., Buru N.C. and. Loader A.J, “Mechatronics”, Chapman and Hall, 1993.
4. Dan Necsulesu, “Mechatronics”, Pearson Education Asia, 2002 (Indian Reprint).
5. Lawrence J. Kamm, “Understanding Electro – Mechanical Engineering”, An Introduction to Mechatronics, Prentice – Hall of India Pvt., Ltd., 2000.
6. Nitaigour Premchand Mahadik, “Mechatronics”, Tata McGraw-Hill publishing Company Ltd,

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PSEC-MT101(C)	Vibration & Noise Control	3L:0T :0P (03 hrs)	Credits:03

Pre-requisite's: Nil

Course Objective:

- To present a problem oriented in depth knowledge of vibration noise and harness control.
- To address the underlying concepts and methods behind vibration noise and harness control.

Course Content:

Module 1 **(12 hrs)**

(A) Multi Degree Freedom System: Free Vibration equation of motion. Influence Coefficient i) Stiffness Coefficient ii) Flexibility Coefficient Generalized coordinates, and Coordinate couplings. Langranges Equations Matrix Method Eigen Values Eigen Vector problems. Model Analysis. Forced Vibrations of undamped system and model analysis.

(B) Multi Degree System Numerical Methods: (i) Rayleigh`s Method, (ii) Rayleigh Ritz Method (iii) Holzer`s Method (iv) Methods of Matrix iterations (v) Transfer Matrix Method, Impulse response and frequency response functions.

Module 2 **(10 hrs)**

Continuous System: Vibrations of String, Bars, Shafts and beams, free and forced vibration of continuous systems. Vibration Measurement:- FFT analyzer, vibration exciters, signal analysis. Time domain & Frequency domain analysis of signals. Experimental modal analysis, Machine Conditioning and Monitoring, fault diagnosis.

Module 3 **(10 hrs)**

Transient vibrations: Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response functions.

Vibration Control: Balancing of rotating machine, In-situ balancing of rotors, control of natural frequency introduction of damping, vibration isolation & vibration absorbers.

Module 4 **(10 hrs)**

Random Vibrations: Expected values auto and cross correlation function, Spectral density, response of linear systems and analysis of narrow band systems.

Non Linear Vibrations: Systems with non-linear elastic properties, free vibrations of system with non-linear elasticity and damping, phase-plane technique, Duffing's equation, jump phenomenon, Limit cycle, perturbation method.

Module 5 **(08 hrs)**

Noise and Its Measurement: Sound waves, governing equation its propagation, Fundamentals of Noise , Decibel, Sound Pressure level, Sound Intensity, Sound fields, reflection, absorption and transmission .Noise measurement , Sound meter , Allowed exposure levels and time limit by B.I.S., Octave Band analysis of sound, Fundamentals of Noise control, source control, path control ,enclosures, noise absorbers, noise control at receiver.

Course Outcomes:

After completion of this course, the students are able to:

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1. The student can identify different areas of vibration noise and harshness control.
2. Vibration measurement and analysis of continuous system.
3. Analysis of transient vibrations and balancing of rotating machine.
4. Analysis of random and non-linear vibrations in a system.
5. Analyze and control noise pollution.

List of Text Book:

1. Theory of Vibrations with Applications: W T Thomson CBS Publishers, Delhi.
2. Mechanical Vibrations : S S Rao Addison-Wesley Publishing Co.
3. Fundamentals of Vibration: Leonard Meirovitch, McGraw Hill International Edison.
4. Principles of Vibration Control: Ashok Kumar Mallik, Affiliated East- West Press.

List of Reference Book:

1. Mechanical Vibrations A H Church ,John Wiley & Sons Inc
2. Mechanical Vibrations J P Den Hartog, McGraw Hill.
3. Mechanical Vibration Analysis : Srinivasan ,McGraw Hill.
4. Mechanical Vibrations : G K Groover. Vibration and Noise for Engineers: Kewal Pujara , Dhanpat Rai & co.

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PSMC-MT101	Computational Methods	3L:0T :0P (03 hrs)	Credits:03

Course Objective:

- behavior of functions studying different approach of derivatives for the function of single variable
- approximate a function using various interpolation techniques and solve numerically linear system of equations
- functions of two or more variables, their differentiation, properties and applications as most of entities in the real world are dependent of several independent entities
- find the derivative at a point numerically and numerical solution of initial value problems
- Visualize connection between mathematical expressions and physical meaning of the problem.

Module1: **(08 hrs)**

Introduction to Computational Mathematics-mathematical modeling, review of Taylor series, numerical error (floating-point representation, computer arithmetic, round-off errors, and loss of significance in numerical computations),

Locating Roots of Equations- bisection method, Newton's method, secant method, introduction to the solution of systems of nonlinear equations - Newton's method for systems

Module2: **(08 hrs)**

Solving Systems of Linear Equations-direct methods (LU factorization), basic iterative methods (Jacobi, Gauss-Seidel and SOR)

Interpolation -polynomial interpolation, piecewise polynomial and spline interpolation

Module 3: **(06 hrs)**

Numerical differentiation and solution of ordinary differential equations- finite differences, Runge-Kutta methods ,multistep methods and stiff equations

Module 4: **(08 hrs)**

Various approaches in FEM, direct stiffness method, energy approach and Galerkin's approach, detailed method for structural analysis problems, various elements, development of element stiffness matrices.

Module 5: **(08 hrs)**

FEM: Applications to bar, beam, truss, spring, shaft problems, Two dimensional elements. Plane stress and plane strain problems. Three dimensional elements and their applications. Iso-parametric elements, plate bending and shell elements, Axi-symmetric problem, vibration problem.

Course Outcome:

1. Solve linear system of equtions
2. evaluate derivative at a value using an appropriate numerical method in various research problems, solve differential equation numerically
3. demonstrate the strength of mathematics in modelling and simulating real world problems of science and engineering

List of Text Books:

1. M.K. Jain, S.R.K. Iyenger and R.K. Jain: Computational Methods for Partial Differential equations, Wiley Eastern, 1994..

2. G.D. Smith: Numerical Solutions to Partial Differential Equations, Oxford University Press, 1986.
3. L. Lapidus and G.F. Pinder: Numerical Solution of Partial Differential Equations in Science and Engineering, John Wiley, 1982.
4. List of Reference Books: C.
5. 1 Johnson: Numerical Solution of Partial Differential Equations by the Finite Element Method, Dover Publications, 2009.
3. H.P. Langtangen: Computational Partial Differential Equations, Springer Verlag, 1999.

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LC-MT101	CAD CAM lab	0L:0T:4P (04 hrs)	Credits:02

Pre-requisite's: Any CAD Software

Course Objective:

To impart fundamental knowledge to students in the latest technological topics on Computer Aided Design, Computer Aided Manufacturing and Computer Aided Engineering Analysis and to prepare them for taking up further research in the areas.

List of Experiment:

Modeling (Creation of 3D assembly model of following machine elements using 3D modeling software)

1. Piston
2. Connecting Rod
3. Flange Coupling
4. Screw Jack
5. Knuckle Joint

CAM

6. Step turning using turning cycle with taper.
7. Step turning using canned cycle (roughing and finishing cycle).
8. Step turning using canned cycle with taper.
9. Taper turning and grooving using canned cycle.
10. External thread cutting.
11. CNC milling machine to perform i) Slot milling ii) End milling iii) Simulation Using CAM Software:
12. Automated CNC tool path & G code generation using CAD/CAM software.

Course Outcomes:

After completion of this course, the students are able to:

1. Apply/develop solutions or to do research in the areas of Design and simulation in Mechanical Engineering.
2. Have abilities and capabilities in developing and applying computer software and hardware to mechanical design and manufacturing fields.
3. Review and document the knowledge developed by scholarly predecessors and critically assess the relevant technological issues.
4. Formulate relevant research problems; conduct experimental and/or analytical study and analyzing results with modern mathematical / scientific methods and use of software tools.
5. Design and validate technological solutions to defined problems and communicate clearly and effectively for the practical application of their work.

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LC-MT102	Robotics Lab	0L:0T:4P (04 hrs)	Credits:02

Pre-requisite's: Robotics

Course Objective:
Undertake kinematics analysis of robot manipulators. Understand and be able to apply a variety of techniques to solve problems in areas such as robot control and navigation. Describe different mechanical configurations of robot manipulators.

List of Experiment:

1. Forward and Inverse kinematics of two axis planar articulated robot using analytical and DH algorithm using Lego NXT.
2. Forward and Inverse kinematics to control hand movements in NAO.
3. Study and selection of Gripper.
4. Implementation of trajectory planning algorithm for straight line motion using Matlab and executing PID based control of two axis planar articulated robot in Lego NXT.
5. Analysis and Simulation using Fanuc Robo guide software and real time Programming
6. Forward Kinematics of PUMA 560
7. Inverse Kinematics of PUMA 560
8. Oldham Coupling Mechanism
9. A quick return mechanism
10. CAM follower mechanism

Course Outcomes:
After completion of this course, the students are able to:

1. Undertake kinematics analysis of robot manipulators.
2. Understand the importance of robot dynamics.
3. Have an understanding of the functionality and limitations of robot actuators and sensors.
4. Understand and be able to apply a variety of techniques to solve problems in areas such as robot control and navigation.
5. Describe different mechanical configurations of robot manipulators.

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MLC-1	Basics of Manufacturing and Electronics System	2L:0T:0P (02 hrs)	Credits:02

Pre-requisite's: Nil

Course Objective:
To impart knowledge about basics of manufacturing process and electronics engineering to cultivate the ability to develop and implement this knowledge into robotics and automation.

Course Content:

Module 1 **(10 hrs)**

Welding: Definition of welding, Gas Welding, Electric Arc Welding- Principle of arc, arc welding equipment, manual metal arc welding. Resistance welding- Principle, Resistance spot welding, Resistance seam welding. Electron beam welding, Laser beam welding, Brazing, Soldering. Metal Removal Processes- Introduction of metal removal processes, Concept of chip formation, Orthogonal and oblique cutting, Classification of machine tools, Generation and forming, methods of generating surfaces, Basic elements of machine tools. Introduction to centre lathe, Shaper, Planer and Slotter.

Module 2 **(10 hrs)**

Milling- Introduction, Types of milling machines. Hole Making Operations- Introduction to Drilling, Boring, Reaming, Tapping. Grinding- Introduction, Grinding wheel-abrasive type, grain size; Types of grinding machines - cylindrical grinding, surface grinding, centre less grinding, Honing, Lapping. Introduction to Gear cutting operations.

Module 3 **(10 hrs)**

Numeric Control of Machine Tools: Numeric control, NC machine tools, Introduction to CNC and DNC. Unconventional Machining Processes- Working principles, Applications, advantages and limitations of EDM, ECM, USM,WJM, LBM.

Module 4 **(10 hrs)**

DC and AC circuits: Introduction of DC Circuit parameters and energy sources (Dependent and Independent), Mesh and Nodal Analysis, Superposition, Thevenin's, Norton's, Reciprocity. Introduction to DC and Induction motors (both three phase and single phase), Stepper Motor and Permanent Magnet Brushless DC Motor. Speed and Torque Equation of D.C. motors, Characteristics of D.C. series, shunt and compound motors and their applications, Starting and speed control of D.C. motors, Braking of D.C. motors, Efficiency and testing of D.C. Machines, Introduction of D.C. servo motor and permanent magnet / brushless D.C. motors.

Module 5 **(10 hrs)**

P-N Junction Diode: Introduction to BJT and MOSFETS, hybrid model for transistor at low frequencies. Digital and analog signals, number systems, Boolean algebra, Switching Functions- Canonical Forms- logic gates with simple applications, logic gates, Codes- BCD, Gray Code, Excess-3 Code, ASCII, EBCDIC, Conversion between various Codes. Combinational Logic Circuits:- Review of basic gates- Universal gates, Adder, Subtractor, Serial Adder, Parallel Adder- Carry Propagate Adder, Carry Look-ahead Adder, Carry Save Adder, Comparators, Parity Generators, Decoder and Encoder, Multiplexer and De-multiplexer, ALU, PLA and PAL.

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Course outcomes:

After completion of this course, the students are able to:

1. Analyze the welding process behavior for common and newer welding techniques.
2. Select the best process out of the available various advanced manufacturing processes for the given job assignment.
3. Understand requirements to achieve maximum material removal rate and best quality of machined surface while machining various industrial engineering materials.
4. Understand the basic properties of electrical elements, and solve DC circuit analysis problems. DC network theorems.
5. Explain the basic properties diodes and their application.

List of Text Book:

1. P. N. Rao, "Manufacturing Technology-Metal Cutting and Machine Tools", TMH.
2. M. P. Groover, "Fundamentals of Modern Manufacturing", Wiley India Pvt., Ltd.
3. M. P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", PHI
4. S.N Singh, “Basic Electrical Engineering” PHI India Ed 2012.
5. Chakrabarti, Chanda, Nath “Basic Electrical Engineering” TMH India”, Ed 2012.
6. R.P. Jain, “Modern Digital Electronics”, TMH, 2nd Ed.
7. Morris Mano, Digital Logic and Computer Design”, Pearson.

List of Reference Book:

1. Serope Kalpakjian and Steven R. Schimid, "Manufacturing Processes", Pearson.
2. Gerling Heinrich, “All about Machine Tools”, New Age Publication, 2003.
3. ZyiKohavi, “Switching & Finite Automata Theory”, TMH, 2nd Edition.
4. S.Salivahanan, A. Vallavaraj, C. Gnanapriya, “Digital Signal Processing”, Tata McGraw Hill International/TMH, 2007.