(4th – SEMESTER)

Operations Management

Subject Code -MEC401

1. Rationale: The success of any organisation not only depends on quality of its products and services but also depends on the people within it. Thus, an operational manager has to play a prominent role in an organisation with human capital and machines. Therefore, managerial skills are essential for enhancing their employability and carrier growth. This course is therefore designed to provide basic concepts in operations management, forecasting techniques, capacity planning, aggregate planning, master production schedule, quality, and inventory and supply chain management for effective utilisation of resources and competitive advantage through operational excellence

2. Course Outcomes: On Completion of course, the student will be able to:

CO-01	Prepare a production capacity utilization plan based on demand forecast and available production capacity for a given product.
CO-02	Prepare a master production plan based on a production capacity utilization plan and a material management plan for a given product.
CO-03	Prepare a process plan using time study, motion study and other appropriate methods to ensure process efficiency.
CO-04	Prepare a quality assurance plan based on a given quality model which is suitable for either a product or a service organisation.

3. Course Content

Week	CO	PO*	Lecture (Knowledge)	Tutorial (Activity)	Practice (Skill)
1	01	01	**Introduction to Operation Management** 1. Introduction to Operation Management - Operation Functions 2. Evolutions and Historical Events in Operational Management 3. Productivity and Competitiveness, Strategy and operation	Ref Table 1	• Virtual Tour Organization (You tube) • Problems on Productivity
2	01	01	**DEMAND FORECASTING** 1.Demand Forecasting- Demand Behavior-Trend Cycle - Seasonal Background - Steps in Forecasting Process 2. Short range and Long Range Forecast 3. Qualitative Forecast methods	Ref Table 1	Problems on • Qualitative Forecast - Delphi method, Market Research method • Quantitative Forecast - Time series Method a) Moving average (Naive forecast , Simple moving Average, Weighted moving Average)
3	01	01	1. Quantitative Forecast methods 2. Seasonal Adjustments 3. Forecast Accuracy	Ref Table 1	Problems on b) Exponential smoothing
4	01	01	**CAPACITY AND AGGREGATE PLANNING** 1. Need for Capacity Planning – Capacity expansion Strategies – Capacity planning Models. 2. Aggregate planning- Methods 3. Master production Schedule	Ref Table 1	Problems on • Capacity Planning, • Aggregate planning • Master production Schedule

5	01	01	**PROCESS PLANNING** 1. Make or Buy Decision Outsourcing- Factors for Outsourcing decision- Process Selection – Batch , Mass ,Continuous Components of e-manufacturing	Ref Table 1	• Virtual Tour on Batch, Mass and continuous Process • Develop an Operation Sheet indicating Process Plan and Process flow chart for a given component.
6	03	01	1.Motion Study 2. Man- Machine chart 3. Concepts on Time Study	Ref Table 1	• Develop Job Process chart with Process Symbols for a given Process. • Develop Man- Machine chart for a given Process. • Case study on Time Study Principles for a given process.
7	02	01	**INVENTORY MANAGEMENT** 1. Elements of Inventory Management- Inventory Costs- Carrying, Ordering and Shortage Costs 2.Inventory Control Systems- Continuous Inventory System (Fixed-Order-Quantity System) Periodic Inventory System (Fixed-Time-Period System) 3. Concept on ABC Classification, Economic Order Quantity Models, Production Quantity Model	Ref Table 1	Problems on • ABC Classification System • Economic Order Quantity Models • The Production Quantity Model
8	02	01,02	1. Order Quantity for A Periodic Inventory System Order Quantity with Variable Demand 2. JIT -Pull System 3 Kanban's System	Ref Table 1	Case study on JIT (Eg:Toyoto Production System)
9	02	01	**Supply Chain Management** 1.Supply Chains Supply Chains for Service Providers 2.Value Chains The Management of Supply Chains 3.Vendor Selection- Vendor	Ref Table 1	Study on • The Bullwhip Effect • Risk Pooling • Green Supply Chains

			evaluation and Vendor Development, Negotiations		
10	02	01	1.Supply Chain Uncertainty and Inventory 2.E-Business, Electronic Data Interchange 3.Supply Chain Integration-Collaborative Planning, Forecasting, And Replenishment	Ref Table 1	Study on • Information Technology: Supply Chain Enabler • Bar Codes • Radio Frequency Identification • Build-To-Order (BTO)
11	02	01,07	1.Material Requirements Planning (MRP) Enterprise Resource Planning (ERP), 2. Warehouse Management Systems Collaborative Logistics, Distribution Outsourcing 3.Finance/Accounting-Sales/Marketing-Production/Materials Management-Human Resources	Study the latest technological changes in this course and present the impact of these changes on industry	Case study on Procurement-Outsourcing. • E-Procurement • E-Market places • ERP MODULES
12	04	01,04,07	QUALITY MANAGEMENT 1. Quality from The Customer's Perspective Dimensions of Quality for Manufactured Products Dimensions of Quality for Services 2. Quality from The Producer's Perspective A Final Perspective On Quality The Cost of Quality The Cost of Achieving Good Quality 3. The Cost of Poor Quality The Quality–Productivity Ratio Quality Management System		Practice on Quality Tools • Process Flowcharts • 5 Whys, Cause-And-Effect Diagrams • Check sheets And Histograms • Pareto Analysis • Scatter Diagrams
13	04	04,05,07	1. TQM and QMS The Focus of Quality Management—Customers 2. Quality Management in The Supply Chain The Role of Employees in Quality Improvement Kaizen and Continuous Improvement Quality Circles 3. Process Improvement Teams Six Sigma The Breakthrough Strategy: DMAIC		Practice on The Deming Wheel (PDCA Cycle) • Process Control Charts • Statistical Quality Control • ISO 9000 • ISO14000
Total in hours			**39**	**13**	**52**

Reference:

Sl. No.	Description
1	Production and Operations Management – Creating Value along the Supply Chain By Russel and Taylor , Wiley Publications , 7 Edition
2	Modern Production and Operation Management By Buffa and Sarin, Wiley Publications, 8 edition
3	Production and Operations Management By Chary, Tata Mc Graw Hill Publications
4	Production and Operations Management- Concepts, Models and Behaviour By Adam and Ebert, Prentice Hall Publications

LIST OF SOFTWARES/ LEARNING WEBSITES:

1. www.youtube.com/watch?v=SF53ZZsP4ik
2. www.youtube.com/watch?v=iPZlQ3Zx5zc

Tools/ Equipment/ Software's Required

1. ERP Software

CNC Programming and Machining

Subject Code -MEC402

1. Rationale: In recent years the manufacturing environment has undergone dramatic change. For achieving market goals, it is essential to produce quality parts in less time. Evolution of information technology, variety manufacturing concepts with zero lead time demand and quality consciousness have supported fast adaption of computerized numerical control (CNC) machines. As in human beings' mental ability is becoming more important than physical ability to do the manual work, similarly CNC programming in the same way has more importance along with selection and use of CNC tooling. In this course therefore an attempt has been made to develop skills required for programming, tooling etc for CNC machine. CNC machines normally are not limited to machine tools only but realm of CNC has widened in almost all areas of manufacturing, processes and support activities. It is therefore very important for Diploma mechanical engineers to master CNC technology.

2. Course Outcomes/Skill Sets: At the end of this course, student will be able to:

CO-01	Identify various components of a CNC machine and list the use of those components for any given CNC operation.
CO-02	Study a given production drawing and list the right tools needed to produce a product as per the drawing.
CO-03	Write a CNC turning and milling program for a given production drawing, simulate the program and execute the program in production mode.
CO-04	Develop and/or import a 3-D model of a given component drawing, generate the CNC programming codes using CAM software and execute the program in production mode.

3. Course Content

Week	CO	PO*	Lecture (Knowledge)	Tutorial (Activity)	Practice (Skill)
1	01	01	1. Introduction to CNC Machines- Advantages of CNC machines over Conventional machines 2. Explain the Construction features of CNC machine- Machine Structure, bed, spindle motor and drive, axes motor and ball screws using Multimedia 3. Explain Guide ways, LM guides, console, control switches, coolant system, hydraulic system using Multimedia	Ref Table 1	1. Demonstrate Personal, Conduct, Shop etiquettes and general safety practices in CNC machine Comply safe handling of CNC machines, tools and Equipment. 2. Demonstration of CNC machine and its parts - bed, spindle motor and drive, axes motor and ball screws, guide ways, LM
					guides, console, control switches, coolant system, hydraulic system, 3. Identification of safety switches, machine over travel limits and emergency stop. Machine starting & operating in Reference Point, JOG and Incremental Modes

2	01,02	01	1. Explain Axis convention of CNC machine 2. Explain Cutting tool materials, cutting tool geometry – insert types, holder types, insert cutting edge geometry. 3. ISO nomenclature for turning tool holders, boring tool holders, indexable inserts. - Tool holders and inserts for radial grooving, face grooving, threading, drilling	Ref Table 1	1. Conduct a preliminary check of the readiness of the CNC machine viz., cleanliness of machine, referencing – zero return, 2. Functioning of lubrication, coolant level, correct working of sub-system
3	01,02	01,04	1. Explain Automatic tool exchanger using Multimedia 2. Explain the importance of Tool length compensation, Tool nose Radius compensation and Tool Wear compensation. 3. Explain Machine Zero and Work Zero	Ref Table 1	1. Perform Work and tool setting: - Job zero/work coordinate system and tool setup and live tool setup 2. CNC machining centre operation in various modes: JOG, EDIT, MDI, SINGLE BLOCK, AUTO 3. Setting the tool offsets, entry of tool nose radius and orientation in CNC console
4	03	01,04	1. Explain Programming sequence and format - Absolute and Incremental System 2. Explain G codes and M codes 3. Explain Linear interpolation and Circular Interpolation	Ref Table 1	1. Geometry Wear Correction. Geometry and wear offset correction in CNC Console 2. Program checking in dry run, single block modes
5.	03	01	1. Explain cutting Parameters – Feed, Speed and depth of cut w.r.t CNC machine as per Catalogue 2. Explain Canned Cycle, Mirroring and Subroutines	Ref Table 1	1. Learn various numerical keys, Address Keys, functional Keys of operational console
6.	03	01,04	Write the Part Program for Facing, Turning, Step turning and Taper turning (Write Program for 3 models and execute any one on the machine)	Ref Table 1	1. Input the Program into the Simulator and operate the Simulator 2. Transfer the simulated Program to machine
					3. Set the machine with necessary tools and Job 4. Execute the Program in Auto mode to produce the Job.

7.	03	01,04	Write the Part Program for Turning, Profile turning and Thread cutting (Write Program for 3 models and execute any one on the machine)	Ref Table 1	1. Input the Program into the Simulator and operate the Simulator 2. Transfer the simulated Program to machine 3. Set the machine with necessary tools and Job 4. Execute the Program in Auto mode to produce the Job
8.	03	01,04	Write a CNC milling program for Pocket machining (Write Program for 3 models and execute any one on the machine)	Ref Table 1	1. Input the Program into the Simulator and operate the Simulator 2. Transfer the simulated Program to machine 3. Set the machine with necessary tools and Job 4. Execute the Program in Auto mode to produce the Job
9	03	01,04	Write a part program for drilling 4 holes in a plate Six holes along PCD on a circular plate	Ref Table 1	1. Input the Program into the Simulator and operate the Simulator 2. Transfer the simulated Program to machine 3. Set the machine with necessary tools and Job 4. Execute the Program in Auto mode to produce the Job
10.	03	01,04,07	Write a Program using Mirroring Write a Program using Subroutines	Ref Table 1	1. Input the Program into the Simulator and operate the Simulator 2. Transfer the simulated Program to machine 3. Set the machine with necessary tools and Job 4. Execute the Program in Auto mode to produce the Job
11	04	01,04,07	Generate the Part Program for Component requiring Turning, Step turning Profile turning and Thread cutting by using CAM software (Program for 3 models and execute any one on the machine)		1. Transfer the simulated Program to machine 2. Set the machine with necessary tools and Job 3. Execute the Program in Auto mode to produce the Job

12	04	01,04,07	Generate a CNC program for component having Pocket machining using CAM software (Program for 3 models and execute any one on the machine)	Study the latest technological changes in this course and present the impact of these changes on industry	1. Transfer the simulated Program to machine 2. Set the machine with necessary tools and Job 3. Execute the Program in Auto mode to produce the Job
13			Demonstrate the manufacturing of following components on CNC machines using YouTube Videos 1. CNC Turning 2. Rollers 3. Spacers 4. Brackets Discuss and Prepare a Report on the videos Presented for each manufactured component		Demonstrate the manufacturing of following components on CNC machines using YouTube Videos 1. Spindles 2. Frames 3. Engine Block 4. Ball Bearings Discuss and Prepare a Report on the videos Presented for each manufactured component
Total in hours			**39**	**13**	**52**

Reference:

Sl. No.	Description
1	Automation, Production Systems, and Computer- Aided Manufacturing by Mikell P. Groover Prentice-Hall International publication
2	CAD/CAM Principles and Applications P N Rao McGraw Hill Education
3	CNC Machines. Pabla B.S., Adithan M. New Age International, New Delhi,2014(reprint)
4	Computer Numerical Control-Turning and Machining centers. Quesada Robert Prentice Hall 2014

LIST OF SOFTWARES/ LEARNING WEBSITES:

1. http://www.nptel.ac.in
2. http://www.youtube.com/watch?v=M3eX2PKM1RI
3. http://www.youtube.com/watch?v=EHQ4QIDqENI&list=PLBkqkLQO2nAt5MNLo
4. http://www.youtube.com/watch?v=hJFLcvtiNQ I
5. http://www.youtube.com/watch?v=BIM1AyxfYkw .
6. http://www.mtabindia.com
7. http://www.swansoftcncsimulator.com

Equipment/software list with Specification for a batch of 20 students

Sl. No.	Particulars	Specification	Quantity
01	CNC Turning Centre (Tutor or Productive)	Minimum diameter 25 mm, Length 120 mm with ATC. (Approximate)	

02	CNC Milling Centre (Tutor or Productive) X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, With ATC.(Approximate)	X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, With ATC.(Approximate)	
03	Simulation software likes: CNC Simulator Pro, Swansoft CNC, etc.		
04	Latest version of CAD/CAM integration software like MASTER CAM, NX CAM OR EDGE CAM		
05	Desk top computer	Latest configuration	

Product Design and Development

Subject Code -MEC403

1. Rationale: Design department of industry is one of the major job areas for Diploma engineers. The fundamental knowledge of Strength of Materials, Engineering Materials, and Computer Aided Design and Drafting is essential to meet job requirement in this sector. To enable a student to work here, they should know how to design a simple machine element, usual procedures in development of product, fundamental knowledge in design of simple machine elements such as shafts, springs, couplings etc, codes, norms, standards and guidelines for selection of appropriate material. In addition to this, Diploma engineers are required to read and interpret the drawings. Therefore, it is essential that they have competency in preparing drawings of machine parts. This course aims at developing analytical abilities in the student to give solutions to simple engineering design problems using standard procedures. Hence this course has been introduced with the expectations that efforts will be made to provide appropriate learning experiences in the use of basic principles to the design solution for applied problems to develop the required skill and competencies.

2. Course Outcomes/Skill Sets: At the end of the Course, the student will be able to:

CO-01	Explain the key principles of product design considering Strength, Aesthetic and Ergonomic
CO-02	Design simple machine elements like shafts, springs, couplings and knuckle joints using standard data.
CO-03	Prepare CAD Part and Assembly drawings for couplings and knuckle joints based on designed parameter.
CO-04	Produce Component based on designed Parameters using 3- D Printing Techniques

3. Course Content

Week	CO	PO*	Lecture (Knowledge)	Tutorial (Activity)	Practice (Skill)
1	01	01	**Product Development and Design**: 1. Explain Product Development- Stages of Product Development- Need and Feasibility study 2. Explain Development of design- Selection of Materials and Process 3. Explain Protype –launching of product –Product life cycle	Ref Table 1	Discuss case studies of Product development by using Video
2	01	01	**General consideration in design:** Based on • Functional requirement • Effect on environment • Life, Reliability, Safety	Ref Table 1	Case study

			• Principles of Standardization • Assembly Feasibility • Maintenance-Cost-Quantity • Legal issues and Patents • Aesthetic and Ergonomic factors • Choice of Materials • Feasibility of Manufacturing Processes		
3	01	01	**Aesthetic and Ergonomic consideration in Design:** • Explain Aesthetic considerations- Basic types of product forms, Designing for appearance, shape, Design features, Materials, Finishes, proportions, Symmetry Contrast etc. • Morgan's color code. • Ergonomic considerations- Relation between man, machine and environmental factors. Design of displays and controls.	Ref Table 1	Case Study on Ergonomics and Aesthetic design principles.
4	02	03,04	**Torsion of Shaft:** 1. Assumptions in Shear stress in a shaft subjected to torsion – Strength and Rigidity (Solid and Hollow shaft) 2. Power Transmitted by Solid and Hollow shaft - ASME and BIS Code for power Transmission 3. Problems on Shafts subjected to only Shear based on Rigidity and Strength	Ref Table 1	1. Validate the Problems on Shafts for Strength and Rigidity using Ansys (One each on Strength and Rigidity)
5	02	03,04	1. Problems on Shafts subjected to only Shear based on Rigidity and Strength 2. Problems on Shaft subjected to only Bending 3. Problems on Shaft subjected to only Bending	Ref Table 1	1. Recap of CAD commands 2. Practice on Section of Solids- a) Prisms b) Pyramid
6	02	03,04	1 Problems on Shaft subjected to combined Shear and Bending. 2. Problems on Shaft subjected to combined Shear and Bending 3. Problems on Shaft subjected to combined Shear and Bending	Ref Table 1	1. Practice on Section of Solids- a) Cylinder b) Cone
7	02,03	03,04	**Springs:** 1. Classification of springs- Application of springs- Leaf springs –Application	Ref Table 1	Sections on Simple Machine Elements (CAD) a) Sectional front view, Front view with

			2. Terminology of Helical spring- Materials and Specification of springs 3. Design of helical spring		Right half in Section, Front view with Left half in Section b) Sectional Top View c) Sectional Side View
8	02,03	03,04	Design of helical spring	Ref Table 1	Sections on Simple Machine Elements (CAD) a) Sectional front view, Front view with Right half in Section, Front view with Left half in Section b) Sectional Top View c) Sectional Side View
9	02,03	03,04	**Coupling:** Design of Muff coupling	Ref Table 1	Using CAD, prepare Part Models for Muff coupling based on designed parameter and assemble the same. Extract the Sectional views for the above machine element indicating Surface Texture and Bill of Materials
10	02,03	03,04	Design of Protected type Flange Coupling	Ref Table 1	Using CAD, prepare Part Models for Protected type Flange Coupling based on designed parameter and assemble the same. Extract Sectional views for the above machine element indicating Surface Texture and Bill of Materials
11	02,03,	03,04,07	Design of Knuckle Joint		Using CAD, prepare Part Models for Knuckle Joint based on designed parameter and assemble the same. Extract Sectional views for the above machine element indicating Surface Texture and Bill of Materials
12	04	03,04,07	**3D Printing** 1. Introduction, Process, Classifications, Advantages of		

			additive over conventional Manufacturing, Applications, Modelling for Additive Manufacturing 2. Additive Manufacturing Techniques, 3D Printing Materials and its forms, Post Processing Requirement and Techniques. 3. Product Quality, Inspection and Testing, Defects and their causes, Additive Manufacturing Application Domains	Study the latest technological changes in this course and present the impact of these changes on industry	Preparation of 3D Printer for printing – Modelling, Saving CAD file into STL file, Slicing, Material loading and printing parameter selection
13	04	03,04,07	1. Working of Fused Deposition Modelling (FDM) Machine- Single and Multi Nozzle printers, Machine Configuration- Cartesian, Delta, Polar and robotic arm configuration 3D printers 2. Common FDM materials- PLA, ABS, PA, TPU,PETG, PEEK and PEI, Printer Parameters - Temperature of the nozzle and the platform, the build speed, the layer height, Warping, Layer Adhesion, Support Structure, In-fill & Shell Thickness 3. Benefits & Limitations of FDM, Software Tools- 3D modelling, Slicers & 3D Printer Hosts		Printing of Designed and Modelled component (flange coupling and knuckle joint) on any available 3D printing machine and carryout post processing of additively manufactured product (Inspection and defect analysis).
Total in hours			**39**	**13**	**52**

Reference:

Sl. No.	Description
1	A Text book of Machine Design R.S. Khurmi & J.K.Gupta S. Chand publication
2	Machine design S G Kulkarni McGraw Hill Education Publications
3	Introduction to Machine design V B Bhandari McGraw Hill Education Publications
4	Design Of Machine Elements Vol I, Vol II J.B.K. Das , P.L.Srinivas Murthy Sapna Publication
5	Machine Component Design William Orthwein Jaico publication
6	Design Data Hand Book for Mechanical Engineers K Mahadevan & K Balaveera Reddy CBS publications
7	Khanna Editorial, "3D Printing and Design", Khanna Publishing House, Delhi.
8	J.D. Majumdar and I. Manna, "Laser-Assisted Fabrication of Materials", Springer Series in Material Science, 2013
9	D.T. Pham and S.S. Dimov, "Rapid manufacturing: The technologies and applications of rapid prototyping and rapid tooling", London-New York, Springer, 2001

10	Lan Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
11	Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
12	CK Chua, Kah Fai Leong, "3D Printing and Rapid Prototyping- Principles and Applications", World Scientific, 2017
13	L. Lu, J. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Kulwer Academic Press, 2001
14	Zhiqiang Fan And Frank Liou, "Numerical Modelling of the Additive Manufacturing (AM) Processes of Titanium Alloy", InTech, 2012

LIST SOFTWARES/WEBSITES

1. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_home.html 2 http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod4. html

Equipment/software list with Specification for a batch of 20 students

Sl. No.	Particulars	Specification	Quantity
01	Latest version of CAD software	----------	
02	Desk top computer	Latest configuration	
03	Laser printer	----------	
04	3-D Printing Machine		

Elements of Industrial Automation

Subject Code -MEC404

1. Rationale: In present scenario, Manufacturing industries are moving towards complete automation. Small and medium industries are in a phase of switching to PLC and SCADA technology for data acquisition and control. Industrial automation systems are used to control and monitor a process, machine or device in a computerized manner that usually fulfils repetitive functions or tasks. They are intended to operate automatically in order to reduce and improve human work in the industry. Advantages of this technology is commonly attributed to higher production rates and increased productivity, more efficient use of materials, better product quality, improved safety, shorter workweeks for labour, and reduced factory lead times. The Automation Engineer will design, program, simulate and commission automated machines and plant- wide processes to perform many job functions. Depending on the size of the organization, the engineer will perform some or all of these responsibilities. Therefore, it is necessary for diploma engineers to have knowledge of both PLC and SCADA technology. This course attempts to provide basic theoretical and practical aspects of automation technologies to develop operational competency. Hence this course is the foundation for diploma engineers who want to further specialise in the field of industrial automation

2. Course Outcomes: At the end of this course, student will be able to

CO-01	Select the right sensor and/or actuator for automating a given application and demonstrate process variables using sensors and/or transducers.
CO-02	Perform specified control functions using a Programmable Logic Controller (PLC) and list various applications of embedded systems.
CO-03	Design and test an automation system for a required operational specification and troubleshoot to resolve any given issue(s).
CO-04	Explain the concepts of SCADA, HMI and DCS and list their various applications

3. Course Content

Week	CO	PO*	Lecture (Knowledge)	Tutorial (Activity)	Practice (Skill)
1	01	01	Introduction:	Ref Table 1	Study the following appliances/ automation

			1. Need and benefits of Industrial Automation, Automation Hierarchy, Basic components of automation system, description of each component 2. Automation technology as a part of engineering sciences, Key development milestones in the history of automation technology, Effects of automation on people. 3. Types of automation system:- Relay logic and PLC		systems and identify various elements used and their function 1. Air conditioning System 2. Automatic water level control 3. Elevator(for Three Floor) 4. Washing Machine Write the Block Diagram For each and explain with a Multimedia Presentation
2	01	01	Programmable logic controller: 1. Introduction, Compare Relay Logic Control and PLC Logic Control, Internal Architecture of PLC 2. I/O Modules (Interfaces), Memory organization. Input devices: • Mechanical Switches • Proximity Switches 3. Input devices: • Photo electric Sensors and Switches • Encoders • Temperature Sensors • Position/Displacement Sensors	Ref Table 1	Demonstrate the working of below shown Switches/Sensor. a. Various industrial Switches (Push Button, ON/OFF, Toggle, Emergency, Rotary Switches etc.) b. Proximity- Inductive, Capacitive and Optical Sensor c. Temperature Sensor d Float Sensors **Note: Connect each sensor directly to the LED/Lamp with appropriate power supply**
3	01	01	1. Input devices: • Strain Gauges • Pressure Sensors • Liquid level detectors 2. Input devices: • Fluid flow measurement • Smart Sensors 3. Output Devices: • Relay • Directional control Valve	Ref Table 1	You tube presentation on Input and Output devices

4	01	01	1. ADC and DAC 2.Motors- DC motor, Synchronous motor, Servo motor, 3.Induction motor, Stepper motor	Ref Table1	Demonstrate the Forward and Reversal of Stepper, Servo and DC Motors with the help of Drivers. **Note: Demonstrate the above without using any controllers**
5	02	02	PLC Programming: 1. Programming standards, List Different PLC Programming, Ladder diagram, 2. Standard IEC 1131-3 Symbols used for I/O Devices 3. Ladder diagram for logic gates. AND,OR,NOT,NAND,NOR,XOR, XNOR	Ref Table1	• Execute energized motor or bulb using Switches in series or Parallel • Write ladder diagram to test digital logic gates and Execute/Simulate the same.
6	02	01	1. Writing Equivalent ladder diagram for Electric Switch, Belt drive , motor circuit Latching, Sequential O/P 2. Introduction to Timer functions. Applications of timing functions in process control -- On Delay Timer Function, Off-delay Timer Function	Ref Table 1	• There are 3 mixing devices on a processing line A,B ,C. After the process begin mixer-A is to start after 7 seconds elapse, next mixer-B is to start 3.6 second after A. Mixer-C is to start 5 seconds after B. All of then remain ON until a master enable switch is turned off. Develop PLC ladder diagram, timing diagram and simulate the same • Write a Ladder Program to count the number of Items moving

			3. PLC counter functions, Applications of PLC counter function in process control		on a conveyor Belt and Execute/Simulate the same
7	03	02	1) Relay, Jumps and Subroutines 2) Develop Ladder Program for relay based motor control automation such that the motor reverses its direction when the limit switches are activated 3) Develop a PLC ladder diagram to construct an alarm system which operates as follows. - If one input is ON nothing happens. - If any two inputs are ON, a red light goes ON. - If any three inputs are ON, an alarm sirens sound. - If all are ON, the fire department is notified.	Ref Table 1	• Execute the Ladder Program for relay based motor control automation such that the motor reverses its direction when the limit switches are activated and also Demonstrate by interfacing with PLC • Simulate the PLC ladder diagram developed for an alarm system and also Demonstrate by interfacing with PLC
8	03	02	1 & 2) Develop PLC program for the following application a) Traffic Light 3)Develop PLC program for the following application b) Water Level Indicator	Ref Table 1	Execute a PLC program for the following applications i) Traffic light controlling ii) Water level controlling
9	03	02	1 & 2) Develop automatic door system using optical sensor and linear actuator 3) Develop Automatic Elevator control	Ref Table 1	• Execute automatic door system using optical sensor and linear actuator • Design ladder diagram for an Automatic Elevator control Also, Test and simulate the ladder diagram designed to operate and control the Automatic Elevator control

10	03	02	1 & 2) Design ladder diagram for car parking. (Hint: car is to be detected and enter the parking space to a particular location if space is available. If there is no space, a lamp should indicate that parking is full) 3) Design ladder diagram for operating and controlling the Lift.	Ref Table 1	• Simulate a ladder diagram for car parking. • Test and simulate a ladder diagram designed to operate and control the Lift
11	02	02,07	1) Embedded System- Block Diagram of Embedded System 2) Applications of Embedded System • Robotics Drones • Braking System • Air conditioning, Refrigerator • Engine control System, 3)Applications of Embedded System • Automatic Washing machine • Microwave Oven • Keyless entry in Automobiles.	**Study the latest technologica l changes in this course and present the impact of these changes on industry**	You tube Presentation on Applications of Embedded System
12	04	01,07	1) Concepts on Distributed control System, 2) Concepts on HMI 3)Introductions to SCADA		• Multi media Exposure to DCS system • Demonstrate the HMI interface to control Light in AND/OR Logic
13	04	01,07	1) Typical SCADA block diagram, 2) Benefits of SCADA, 3) Applications of SCADA		• Multi media Exposure to SCADA system OR • Make case study visiting any nearby industry (Packaging/Milk Dairy/Processing) using HMI, SCADA/DCS systems.

Total in hours	**39**	**13**	**52**

5. Reference :

Sl. No.	Description
1	Programmable logic Controllers By W. BOLTON
2	Digital electronics By FLYOD
3	Exploring PLC with applications By PRADEEP KUMAR SRIVATSAVA
4	Automation , Production systems and Computer integrated Manufacturing By MIKELL GROOVER
5	Sensors Hand book-SABRIE SOLOMAN-MC-GRAW HILL publications
6	Hand book of Modern Sensors" Physics ,Designs and Applications- JACOB FRADEN-Springer Publications
7	Electric Motors and Drives BY AUSTIN HUGHES and BILL DRURY

6. LIST OF SOFTWARE/LEARNING WEBSITES

1. http://www.vlab.com
2. http://www.mtabindia.com
3. http://www.nptel.ac.in

7. Equipment/software list with Specification for a batch of 20 students

Sl. No.	Particulars	Specification	Quantity
01	PLC Trainer Kit with the following Modules		
	• Door Controller • Car Parking Application • Water Level Controller • Conveyor Controller Application • Lift control Application With different Length Patch Cords		
02	Switches • Mechanical Switches • Proximity Switches • Photo electric Sensors and Switches		
03	Sensors • Temperature Sensors • Position/Displacement Sensors • Strain Gauges • Pressure Sensors • Liquid level detectors • Fluid flow measurement • Smart Sensors • Proximity Sensors		
04	Induction Motor with DOL Starter	3 Phase Ac 50 Hz	
05	Synchronise Motor with DOL Starter	3 Phase Ac 50 Hz	
06	Stepper Motor	Standard size	
07	Relays	Standard size	
08	Counter and Timers	Standard size	