Maharashtra State Board Of Technical Education, Mumbai

Learning and Assessment Scheme for Post S.S.C Diploma Courses

Programme Name : Diploma In Mechanical Engineering
Programme Code : ME
With Effect From Academic Year : 2023-24
Duration Of Programme : 6 Semester
Duration : 16 WEEKS
Semester : Sixth
NCrF Entry Level : 4.0
Scheme : K

Sr No	Course Title	Abbrevation	Course Type	Course Code	Total IKS Hrs for Sem.	Learning Scheme					Credits	Assessment Scheme											
						Actual Contact Hrs./Week			Self Learning (Activity/ Assignment /Micro Project)	Notional Learning Hrs /Week		Paper Duration (hrs.)	Theory				Based on LL & TL				Based on Self Learning		Total Marks
																	Practical						
						CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
													Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
(All Compulsory)																							
1	MANAGEMENT	MAN	AEC	315301	1	3	-	-	1	4	2	1.5	30	70*#	100	40	-	-	-	-	25	10	125
2	DESIGN OF MACHINE ELEMENTS	DME	DSC	316357	-	4	-	2	2	8	4	4	30	70	100	40	25	10	25#	10	25	10	175
3	INDUSTRIAL ENGINEERING AND QUALITY CONTROL	IEQ	DSC	316362	-	4	-	2	2	8	4	3	30	70	100	40	25	10	-	-	25	10	150
4	INDUSTRIAL HYDRAULICS AND PNEUMATICS	IHP	DSC	316363	-	4	-	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150
5	3D MODELLING AND ADDITIVE MANUFACTURING	3DM	SEC	316013	-	-	-	4	-	4	2	-	-	-	-	-	25	10	25#	10	-	-	50
6	CAPSTONE PROJECT	CPE	INP	316004	-	-	-	2	2	4	2	-	-	-	-	-	50	20	50#	20	50	20	150
Elective - II (Any - One)																							
7	COMPUTER INTEGRATED MANUFACTURING SYSTEMS	CIM	DSE	316359	-	4	-	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150
	ALTERNATIVE ENERGY SOURCES AND ENERGY MANAGEMENT	AEM	DSE	316364	-	4	-	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150
	COLD CHAIN MANAGEMENT	CCM	DSE	316365	2	4	-	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150
Total					**3**	**19**		**14**	**7**		**20**		**150**	**350**	**500**		**175**		**150**		**125**		**950**

Abbreviations : CL- Classroom Learning , TL- Tutorial Learning, LL-Laboratory Learning, FA - Formative Assessment,SA -Summative Assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends : @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :
1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

Course Category : Discipline Specific Course Core (DSC) , Discipline Specific Elective (DSE) , Value Education Course (VEC) , Intern./Apprenti./Project./Community (INP) , AbilityEnhancement Course (AEC) , Skill Enhancement Course (SEC) , GenericElective (GE)

Programme Name/s : **Mechanical Engineering**
Programme Code : **ME**
Semester : **Sixth**
Course Title : **INDUSTRIAL HYDRAULICS AND PNEUMATICS**
Course Code : **316363**

I. RATIONALE

Hydraulic and pneumatic control systems are widely used in various industries due to their versatility and adaptability to automation. It plays vital role in modernization, semi automation and automation of various industrial equipment. This course will impart the basic skills and knowledge to diploma technician to use and maintain different types of hydraulic and pneumatic systems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcome through various teaching learning experiences: Use different types of hydraulic and pneumatic systems for various engineering applications.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Identify various components of hydraulic and pneumatic systems from their symbols
- CO2 - Select pump, compressor and actuator for given fluid operated system.
- CO3 - Select appropriate control valves for given fluid operated system.
- CO4 - Select appropriate special components for advanced fluid operated system.
- CO5 - Develop hydraulic and pneumatic circuits for given applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316363	INDUSTRIAL HYDRAULICS AND PNEUMATICS	IHP	DSC	4	-	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Prepare the general layout of hydraulic and pneumatic systems in given situation. TLO 1.2 Interpret the symbols of given hydraulic and pneumatic components. TLO 1.3 Choose suitable hydraulic fluid as per given requirement based on its properties. TLO 1.4 Explain construction and working of filter with sketch.	**Unit - I Introduction to Hydraulic and Pneumatic Systems** 1.1 Oil hydraulic & pneumatic system: Basic components and general layout, advantages and disadvantages, comparison between electric, hydraulic and pneumatic systems 1.2 ISO Symbols (ISO 1219-1:2012 for symbols and ISO 1219-2:2012 for circuit diagram) used in hydraulic and pneumatic system 1.3 Hydraulic Fluid: Functions, types, properties like viscosity, viscosity index and demulsibility, selection of fluids, the effect of temperature and pressure on hydraulic fluid system 1.4 Oil filters: Degree of filtration, filtration material, types, construction and working of depth, surface, full flow and proportional filter. 1.5 Construction and working of Filter, Regulator and Lubricator (FRL) unit used in pneumatics	Lecture Using Chalk-Board Presentations Video Demonstrations Model Demonstration Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain pumps and its classification. TLO 2.2 Compare various types of pumps on the basis of given factors. TLO 2.3 Select pump for the given application. TLO 2.4 Explain compressor and its classification. TLO 2.5 Write constructional details of pneumatic compressors, actuators and control valves with neat sketch. TLO 2.6 Classify various types of actuators with justification. TLO 2.7 Write constructional details of hydraulic actuators with neat sketch. TLO 2.8 Select actuator for the given application with justification	**Unit - II Pumps and Compressors and Actuators** 2.1 Hydraulic pumps: Classification, construction and working of gear pump (external and Internal), gerotor pumps, vane pump (imbalanced and balanced), screw pump, piston pump (axial and radial),Comparison of pumps 2.2 Compressors: Types, construction, working principle of reciprocating and rotary compressors – vane, screw 2.3 Selection of pump and compressor for given application. 2.4 Hydraulic and pneumatic actuators: Classification, function and applications 2.5 Construction and working of linear Actuators: Single acting (spring and gravity return), double acting (Single and double piston rod end) cylinders. 2.6 Construction and working of rotary actuators: Gear, gerotor, vane, piston motors, applications	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Presentations Flipped Classroom
3	TLO 3.1 Classify direction control/pressure control/flow control valves TLO 3.2 Write constructional details of given direction Control/pressure Control/flow control valves with neat sketch. TLO 3.3 Select suitable actuation methods of direction control valves as per working condition. TLO 3.4 Compare direction Control/pressure Control/flow control valves on various grounds TLO 3.5 Select appropriate control valve for given application	**Unit - III Control Valves** 3.1 Direction control valves (DC Valve):Classification, construction, working and applications of poppet valve, sliding and rotary spool valve, 2/2, 3/2, 4/2, 4/3, 5/2, 5/3, DC valves simple and pilot operated check valves (pilot to open, pilot to close) methods of actuation of DC valves, Comparison of DC valves, Selection of standard center position in 3 positions DC valves. 3.2 Pressure Control Valve (PC Valve): Classification, construction, working and applications of relief valve (direct and pilot operated), pressure reducing valve (direct and pilot operated), sequence, unloading and counter balance valves. Comparison on various grounds. 3.3 Flow control valves (FC Valve): Classification, construction, working and applications of non-compensated, pressure compensated, pressure and temperature compensated flow control valve.	Lecture Using Chalk-Board Presentations Video Demonstrations Model Demonstration Role Play

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Describe with sketch construction and working of given type special actuators TLO 4.2 Select appropriate type of special valves for given application TLO 4.3 Select appropriate accessories in hydraulic and pneumatic system TLO 4.4 Illustrate the use of various components of Electro Pneumatic system TLO 4.5 Develop ladder diagram for simple hydraulic and pneumatic circuits	**Unit - IV Advanced Components and Accessories** 4.1 Construction and working of special designs: Telescopic, tandem and rodless cylinder. 4.2 Dual pressure valve (AND logic valve), Shuttle valve (OR Logic valve), time delay valve and quick exhaust valve 4.3 Accessories: Types, construction and functions of pipes, hoses, fittings, seals and gaskets, accumulators, muffler 4.4 Introduction to electro pneumatics, important steps, function of commonly used devices (manually actuated push button switches, limit switches, pressure switches, solenoids, relays, timers, temperature switches, proximity sensors, electric counters), advantages. PLC programming methods. 4.5 Development of ladder diagrams of simple hydraulic and pneumatic circuits OR, AND, time delay, sequencing (Basics of PLC are already covered elsewhere)	Lecture Using Chalk-Board Presentations Video Demonstrations Model Demonstration
5	TLO 5.1 Draw hydraulic and pneumatic circuits using direction control valve for given application. TLO 5.2 Draw hydraulic and pneumatic circuits using pressure control valve for given application TLO 5.3 Draw hydraulic and pneumatic circuits using flow control valve for given application TLO 5.4 Develop hydraulic circuit for specified applications TLO 5.5 Develop pneumatic circuit for specified applications TLO 5.6 Describe maintenance procedure of the given hydraulic and pneumatic system.	**Unit - V Hydraulic and Pneumatic Circuits** 5.1 Direct and indirect (with pilot valve) triggering of linear and rotary hydraulic and pneumatic actuators 5.2 Single and double sequence circuit, two pump unloading circuit, counterbalance circuit, circuit for reduced pressure in part of the system. 5.3 Meter in, meter out and bleed off circuits for hydraulic and pneumatic actuators. 5.4 Logic OR circuit, logic AND- two hand safety circuit, quick exhaust Circuit 5.5 Hydraulic circuits using accumulator as an auxiliary power source, leakage compensator, emergency power source 5.6 Position dependent automatic reversal of piston and pressure dependent automatic reversal of piston, time dependent automatic reversal of piston (Time Delay Circuit) 5.7 Continuous to and fro motion of double acting cylinder with roller operated valves and solenoid operated valves and limit switches. 5.8 Regenerative circuit, rapid feed return circuit, cylinder synchronizing circuits (Series and parallel) 5.9 Hydraulic circuits for milling machine, shaper machine and surface grinding machine 5.10 Maintenance of hydraulic and pneumatic system – fault finding and remedies	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

INDUSTRIAL HYDRAULICS AND PNEUMATICS **Course Code : 316363**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify the components of hydraulic and pneumatic trainers	1	*Identification of hydraulic and pneumatic system components	2	CO1
LLO 2.1 Draw ISO symbols of the components of hydraulic and pneumatic trainers	2	* ISO Symbols of hydraulic and pneumatic components	2	CO1
LLO 3.1 Use pumps mounted on hydraulic trainer.	3	Hydraulic Pumps used in hydraulic system	2	CO2
LLO 4.1 Use compressor and FRL unit mounted on Pneumatic trainer	4	Compressor and FRL unit used in pneumatics	2	CO2
LLO 5.1 Use linear actuators mounted on hydraulic and Pneumatic trainer LLO 5.2 Measure velocity of linear actuators in both the strokes using suitable speed measurement device.	5	*Hydraulic and pneumatic linear actuators	2	CO2
LLO 6.1 Use rotary actuators mounted on hydraulic and Pneumatic trainer LLO 6.2 Measure RPM of rotary actuators using suitable speed measurement device.	6	Hydraulic and pneumatic rotary actuators	2	CO2
LLO 7.1 Prepare hydraulic and pneumatic circuits for actuation of linear and rotary actuators by direct triggering using suitable DC valves. LLO 7.2 Demonstrate hydraulic and pneumatic circuits for actuation of linear and rotary actuators by direct triggering using suitable DC valves following the given procedure.	7	Linear and rotary actuators movement by direct method using suitable DC valves	2	CO3 CO5
LLO 8.1 Prepare hydraulic and pneumatic circuits for actuation of linear and rotary actuators by indirect triggering using suitable DC valves. LLO 8.2 Demonstrate hydraulic and pneumatic circuits for actuation of linear and rotary actuators by indirect triggering using suitable DC valves following the given procedure.	8	*Linear and rotary actuators movement by indirect method using suitable DC valves	2	CO5
LLO 9.1 Prepare circuits using pressure relief and sequence valve LLO 9.2 Demonstrate circuits using pressure relief and sequence valve following the given procedure.	9	*Pressure relief and sequence valve circuits	2	CO3 CO5
LLO 10.1 Prepare speed control circuits for hydraulic actuators (meter in and meter out circuits) LLO 10.2 Demonstrate speed control circuits for hydraulic actuators (meter in and meter out circuits) following the given procedure.	10	* Speed control circuit for hydraulic (meter in and meter out circuits)	2	CO5
LLO 11.1 Prepare speed control circuits for pneumatic actuators. LLO 11.2 Demonstrate speed control circuits for pneumatic actuators following the given procedure.	11	Speed control circuit for pneumatic actuators	2	CO2 CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 12.1 Prepare pneumatic circuits using quick exhaust valve, logic OR, AND, NOT functions. LLO 12.2 Demonstrate pneumatic circuits using quick exhaust valve, logic OR, AND, NOT functions following the given procedure.	12	* Pneumatic circuits involving use of Quick exhaust valve, logic OR, AND functions	2	CO4 CO5
LLO 13.1 Prepare pneumatic circuits using double rod end cylinder /telescopic cylinder. LLO 13.2 Demonstrate pneumatic circuits using double rod end cylinder/ telescopic cylinder following the given procedure.	13	Special purpose actuators pneumatic circuits	2	CO4 CO5
LLO 14.1 Develop ladder diagram for simple circuits	14	Ladder diagram for simple circuits	2	CO4 CO5
LLO 15.1 Diagnose the common faults in hydraulics/pneumatics systems. LLO 15.2 List the corrective measures for identified faults in hydraulics/pneumatics systems.	15	* Simple maintenance of hydraulics/pneumatics	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- This course has no SLA allocated but course teacher can optionally allot microprojects to the students to enhance learning. A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty: a. Market survey of oil used in hydraulic system(Manufacturers, specifications, trade names, cost, packing size) b. Prepare working model of hydraulic crane using waste injections used by Doctors. c. Prepare report of agriculture equipment working on hydraulic and pneumatics. (field based) d. Prepare visit report to observe use of Pneumatic system used by Dentist. e. Prepare visit report on automobile vehicle cleaning service station to observe the hydraulic actuator and system used. f. Prepare display board by collecting sample of pipes and pipe fittings with specifications of different manufactures.(New/Worn out)

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Hydraulic trainer with transparent /actual working components. Hydraulic power pack with sump tank, capacity: 25 Liters, with Oil level Indicator, hydraulic gear pump:,2.5 LPM at working pressure 35 bar ,1440 RPM, 1 HP, 230V AC,SAC,DAC, pressure control, 3/2,4/2,4/3 lever operated, solenoid operated DC Valves, FC Valves,Manifolds	1,2,3,5,6,7,8,9,10,15
2	Pneumatic trainer with transparent/ actual working components, SAC(40 Ø x 22 x 50 mm Stroke, spring return: 01 No.) ,DAC(40 Ø x 22 x 100 mm Stroke: 01 No.), FRL Unit, 2/2,3/2,4/2 Hand lever DC Valves,4/2 Way Double Solenoid valve(1/4”, 24V DC valve), FC Valves , AND,OR Logic gate valves, Manifolds, Hoses	1,2,4,5,6,7,8,11,12,13,15
3	Single /Multistage Reciprocating Compressor (pressure 0-15 bar, Air receiver capacity: 160 liters)	4,5,6,7,8,11,12,13,15
4	Tachometer (mechanical/non contact) for speed measurement (Range 0 to 5000 rpm)	5,6
5	Pneumatic hand tools like nut runner, hand grinder, impact wrench, screw driver, drill	5,6,7,11
6	Actual electropneumatic devices like Limit switches, Pressure switches, Solenoids, Relays, Timers, Temperature switches, Proximity sensors, Electric counters	8,13
7	Cut sections of various pumps of 1 HP showing main parts,3/2,4/2,5/3 lever /push button operated valves, cylinders of stroke length of 150,200 mm, Unidirectional and Bidirectional Air/ hydraulic motors, accumulators Vertical type, 10- 50 micron filters.	All
8	Working / actual models of pumps, cylinders, valves, other components	All
9	Standard tool kit	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks

INDUSTRIAL HYDRAULICS AND PNEUMATICS **Course Code : 316363**

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Hydraulic and Pneumatic Systems	CO1	8	2	4	4	10
2	II	Pumps and Compressors and Actuators	CO2	14	4	6	8	18
3	III	Control Valves	CO3	14	4	6	8	18
4	IV	Advanced Components and Accessories	CO4	11	2	4	6	12
5	V	Hydraulic and Pneumatic Circuits	CO5	13	2	4	6	12
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests of 30 marks and average of two-unit tests.
- For laboratory learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	1	1	1	-	1	1			
CO2	3	2	2	2	1	1	1			
CO3	3	2	2	2	1	1	1			
CO4	3	2	2	2	1	1	1			
CO5	3	2	2	2	1	1	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number

Sr.No	Author	Title	Publisher with ISBN Number
1	Majumdar S.R	Oil Hydraulic system Principles and maintenance	Tata McGraw Hill,1st Edition, ISBN: 9780074637487
2	Majumdar S.R	Pneumatics Systems Principles and Maintenance	Tata McGraw Hill,1st Edition, ISBN-978-0-07-460231-7
3	Anthony Esposito	Fluid Power with applications	Pearson Education, Inc 2000,7th Edition, ISBN 81- 7758-580-0
4	Harry Stewart	Hydraulics and Pneumatics	Taraporewala Publication,1st Edition, ISBN:978-0672234125
5	Joji B.	Pneumatic Controls	Wiley India Pub., Edition 2014, ISBN:978-8126515424
6	Andrew Parr	Hydraulics & Pneumatics A Technicians & Engineers Guide	Butterworth-Heinemann Publisher,3rd Edition, ISBN: 978-0080966755
7	S.Ilango, V.Soundararajan	Introduction to Hydraulics and Pneumatics	PHI Learning Pvt.Ltd. Delhi, 2nd Edition , ISBN:978-81-203-4406-8
8	D. Stewart	Hydraulic And Pneumatic Power For Production Industrial Hydraulics	Industrial Press INC. 200, Madison Avenue, 1st Edition, New-York 10016.ISBN:978-0831111144
9	Vickers Systems International	Industrial Hydraulics Manual	Vickers Systems International (Company Manual)
10	FESTO	Product Catalogue of FESTO	Company catalogue
11	Open source software	Animation software for hydraulics and pneumatics	Any version freely available

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://en.wikipedia.org/wiki/Hydraulic_pump	Hydraulic Pumps
2	https://www.youtube.com/watch?v=Qy1iV6EzNHg	Animation of Hydraulic pumps
3	https://www.youtube.com/watch?v=pWuxYnqYDnk	Animation of Hydraulic pumps
4	https://www.youtube.com/watch?v=sEVTIRYHoGg	Eaton Pump assembly
5	http://nptel.ac.in/courses/112105047/	Video lectures of IIT Faculty
6	http://nptel.ac.in/courses/112106175/	Lecture series and notes by IIT faculty
7	https://www.youtube.com/watch?v=XAItnsUcES0	Pneumatic control valves animation
8	https://www.youtube.com/watch?v=yIot4shcOkE	Control valve symbol generation
9	https://www.youtube.com/watch?v=jsMJbJQkGTs	Animation of D.C. Valve
10	https://www.youtube.com/watch?v=CQPwvWXbV3w	Animation of 4/2,4/3 D.C Valves
11	https://www.youtube.com/watch?v=bovfDsAYSbc	Animation of Hydraulic cylinder
12	https://www.youtube.com/watch?v=icaqvfAtccY	Telescopic cylinder animation
13	https://youtu.be/SR47RaA1Zdk	Pneumatics, Pneumatic Control and Electropneumatic explained - Pneumatics for beginners
14	https://youtu.be/Alr7EZFYMS4	Hydraulics History and documentary (Modern Marvel)

INDUSTRIAL HYDRAULICS AND PNEUMATICS **Course Code : 316363**

Sr.No	Link / Portal	Description

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

ALTERNATIVE ENERGY SOURCES AND ENERGY MANAGEMENT **Course Code : 316364**

Programme Name/s : **Mechanical Engineering**
Programme Code : **ME**
Semester : **Sixth**
Course Title : **ALTERNATIVE ENERGY SOURCES AND ENERGY MANAGEMENT**
Course Code : **316364**

I. RATIONALE

The conventional energy resource is limited in nature and will be exhausted in future. With increasing environmental concerns and depleting fossil fuels, its necessary to understand and work with renewable energy sources like solar, wind, and biomass. Recently significant advances are made in utilization of solar energy in heating and electrical energy conversion applications. Biomass and bio fuels are also getting importance. This course is designed for diploma students to acquire skills in operating and maintaining the renewable energy technologies for its proper utilization through energy management practices.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcome through various teaching learning experience: Maintain various types of renewable energy systems efficiently and economically following standard procedures.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Select proper instruments for performing energy audit.
- CO2 - Identify energy conservation opportunities in mechanical and electrical systems.
- CO3 - Design cost effective solar thermal and photovoltaic system as per requirement.
- CO4 - Utilize wind and biomass as a renewable energy technology for energy generation.
- CO5 - Select suitable source(s) of energy generation using principles of renewable energy.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316364	ALTERNATIVE ENERGY SOURCES AND ENERGY MANAGEMENT	AEM	DSE	4	-	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
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2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Classify renewable and non-renewable energy sources TLO 1.2 Explain the role of energy sources in a growing economy. TLO 1.3 Select relevant instruments to perform energy audit TLO 1.4 Describe energy audit and its importance in the context of energy management. TLO 1.5 Differentiate between a preliminary energy audit and a detailed energy audit. TLO 1.6 State the requirements and scope of ISO 50001 and ISO 50002.	**Unit - I Energy Scenario and Audit** 1.1 Types of energy sources- Commercial energy and noncommercial energy, renewable and non-renewable energy. 1.2 Sector wise renewable energy consumption in India, energy needs of growing economy, energy pricing, energy security, National Action Plan on Climate Change (NAPCC), integrated energy policy and its need. 1.3 Definition, Energy audit- need, types of energy audit and methodology – preliminary energy audit and detailed energy audit, energy units and conversion. 1.4 Electrical Energy, electrical load management and maximum demand control, power factor improvements, energy efficient equipment’s and appliances, star rating 1.5 Instruments and metering for Energy audit – Auto digital clamp meter, lux meters, pyranometer, sunshine recorder, pyrheliometer, combustion gas analyzer, psychrometer, fyrite. Selection of above instruments. 1.6 Introduction to ISO 50001: Energy management and energy savings, ISO 50002: Energy audit requirement.	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain the need and importance of the energy conservation act-2001. TLO 2.2 Prepare energy flow within a system using sankey diagram. TLO 2.3 Develop an energy monitoring and targeting plan TLO 2.4 Recommend energy conservation opportunities in mechanical and electrical systems.	**Unit - II Energy Management and Conservation** 2.1 Definition and objectives of energy management, energy conservation act-2001 and its features, need for energy management program, need and importance of energy conservation and management, sankey diagram, specific energy consumption. 2.2 Energy Monitoring and Targeting - Definition, elements of monitoring and targeting, benefits of monitoring and targeting. 2.3 Energy conservation opportunities in mechanical systems – Water Pumps, steam distribution system and its losses, steam leakage, air leakage, fans and blowers, cooling towers, Heating Ventilation & Air Conditioning (HVAC) systems. 2.4 Energy conservation opportunities in electrical systems – Lightning system, diesel gas energy power generation system, electrical motors, industrial drive, variable speed drive.	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study
3	TLO 3.1 Classify solar thermal system on the basis of given parameters. TLO 3.2 Select concentrated solar collector for given application with justification. TLO 3.3 Design a stand-alone solar photovoltaic system and pumping system for residential application. TLO 3.4 Select a suitable solar dryer for drying of food products on large scale with suitable justification.	**Unit - III Direct use of Solar Energy** 3.1 Solar Thermal Systems – Classification of solar thermal system ,Types of solar collectors- Flat Plate Collectors (FPC), Evacuated Tube Collector (ETC), natural and forced circulation water heating system , design and costing of solar water heating system (Simple numerical) 3.2 Solar concentrating collectors – Parabolic collectors, parabolic dish collector and solar tower. Solar dryers - Classification, construction, working and applications in commercial, agricultural, domestic sector. Applications of solar energy. 3.3 Solar Photovoltaic (PV) Systems - Solar photovoltaic technologies - advantages and limitations. Solar PV system - types and their Components - Solar Cell modules , panels and array. Solar cell connecting arrangements, solar PV module ratings and cost, battery ratings and cost, inverter ratings and cost, Maximum Power Point Tracking (MPPT). 3.4 Stand-alone photovoltaic System: Home lighting and other usage - Solar PV system designing, cost estimation of a PV System, solar PV water pumping system, design of solar PV pumping System (Simple numerical), Net Metering, Open Access and Power Purchase Agreements (PPA)	Lecture Using Chalk-Board Presentations Model Demonstration Site/Industry Visit Case Study

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 State the criteria for site selection of wind energy conversion system. TLO 4.2 Describe wind energy conversion system using block diagram. TLO 4.3 Identify the types and components of wind energy conversion systems. TLO 4.4 State the reasons to consider compressed bio gas as biofuel. TLO 4.5 Explain the role of India's national policy on biofuels in promoting sustainable energy.	**Unit - IV Indirect use of Solar Energy** 4.1 Wind Flow - Motion of wind, variability in wind speed and its effect. Basic terminologies: Cut-in, cut-out and survival wind speeds, site selection consideration. 4.2 Wind Energy Conversion System (WECS): Types of wind turbines, components of wind turbine and its functions, Horizontal Axial Wind Turbine (HAWT), construction, working and specifications of HAWT, concept of wind form and project cycle. 4.3 Basic principles of biomass conversion, application of biomass in real world – Solid- Briquettes and pallets, manufacturing process, calorific value, advantages and limitations. Liquid – Ethanol from corn and sugarcane, production process, calorific value, advantages and limitations. Gas – Compressed Bio Gas (CBG), production process, calorific value, advantages and limitations. Case study of Laltipara Gaushala (Gwalior). India's national policy on biofuels- key objectives and features.	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit
5	TLO 5.1 State the economic, environmental, and social benefits of adopting renewable energy sources. TLO 5.2 Classify different types fuel cells and state their applications. TLO 5.3 State the various applications of OTEC. TLO 5.4 Describe the operation of geothermal power plant. TLO 5.5 Identify the components of tidal power plant. TLO 5.6 State objectives and features of key renewable energy schemes like PM-KUSUM and Mukhyamantri Saur Krushi Pump Yojana.	**Unit - V Other Renewable Energy Sources** 5.1 Need for use of new and renewable energy sources. 5.2 Hydrogen energy and fuel cell: Principle of operation, classification, advantages, limitation and application of fuel cell. 5.3 Ocean Energy - Ocean Thermal Energy Conversion (OTEC), general arrangement and working principle. 5.4 Geothermal Energy - Sources, working principle, construction and working of geothermal energy power plant, advantages, limitation & applications. 5.5 Tidal Energy - Tidal power, basic principle, construction and working of tidal power Plant. 5.6 Ministry of New and Renewable Energy (MNRE) schemes for agriculture sector in Maharashtra – Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM-KUSUM) Scheme, Mukhyamantri Saur Krushi Pump Yojana – objectives and its salient features.	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Use energy audit instruments to measure energy consumption in the workshop. LLO 1.2 Identify energy consumption patterns.	1	*Preliminary energy audit in a workshop facility (Machine Shop)	2	CO1
LLO 2.1 Prepare a list of computer peripherals including monitors, printers, scanners, etc., and other devices that consume electrical energy for the purpose of audit. LLO 2.2 Measure humidity and temperature of HVAC system and also measure lightning by lux meter. LLO 2.3 Identify energy conservation opportunities	2	Detailed energy audit for a computer laboratory.	2	CO1
LLO 3.1 Measure intensity of lighting by lux meter. LLO 3.2 Identify energy conservation opportunities	3	* Determination of the value of lux for classroom, library, workshop, cafeteria/canteen, laboratory, corridor, etc. and suggest energy conservation for the same.	2	CO2
LLO 4.1 Select the specific energy meters in different parts of the institute. LLO 4.2 Calculate the average energy consumption based on the collected baseline data. LLO 4.3 Plot CUSUM chart using data obtained in LLO 4.2.	4	Cumulative sum (CUSUM) technique to monitor the electrical energy consumptions of different energy meters used in institute.	2	CO2
LLO 5.1 Measure current, voltage and power output of the solar cells/panel. LLO 5.2 Measure power output of the solar panel at different inclination angles. LLO 5.3 Prepare the record sheet for data obtained in LLO 5.2	5	*Measurement of different parameters like voltage, ampere, and temperature of the solar module of 100 Watts at different inclination angle.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 6.1 Review the last 12 months data obtained from electricity bills for average monthly energy consumption in kilowatt-hours (kWh). LLO 6.2 Determine the Size of the Solar System. LLO 6.3 Calculate the Number of Panels LLO 6.4 Select an inverter that matches the capacity of the solar panels and is suitable for residential use. LLO 6.5 Design the mounting structure for the panels on the roof by using CAD LLO 6.6 Calculate the size and length of DC and AC cable	6	Design rooftop solar system of 1 to 5 kW for a residential house and list the components and structure required for the same	2	CO3
LLO 7.1 Select different materials for drying. LLO 7.2 Prepare a record sheet for external and internal temperature, relative humidity after every 15 min. LLO 7.3 Analyze the data collected during the drying process.	7	*Measure different parameters like temperature, relative humidity and time required in drying different materials (like grapes, raw mango, fruits, vegetables, herbs, grains, or spices) using solar dryer.	2	CO3
LLO 8.1 Select different food materials or liquids to cook, such as water, rice, vegetables, or a simple food item. LLO 8.2 Use a thermometer to measure the ambient temperature and the initial temperature of the cooking material. LLO 8.3 Use a thermometer to measure the temperature of the cooking material at regular intervals LLO 8.4 Calculate the efficiency of solar cooker.	8	* Factors affecting on the efficiency solar cooker and measure their performance under various conditions.	2	CO3
LLO 9.1 Select a location for the measurement of wind speed at various heights. LLO 9.2 Measure wind speed using given meters at different heights and locations. LLO 9.3 Plot the graph of wind speed vs. height for different locations.	9	* Measurement of wind speed at different heights and locations by using digital anemometer	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 10.1 Collect sawdust/wooden dust/cow dung. LLO 10.2 Prepare briquettes and pallets by manually. LLO 10.3 Lay the briquettes or pellets on a drying rack or tray.	10	*Preparation of briquettes/pallets using waste saw dust/wooden dust/cow dung/ cattle dung.	2	CO4
LLO 11.1 Select a biofuels and conventional fuels for study purpose. LLO 11.2 Prepare a comparison chart.	11	Comparative analysis of biofuels with conventional fuels in terms of energy content, viscosity, flash point, combustion efficiency, calorific value, fuel density, temperature and pH value.	2	CO4
LLO 12.1 Identify different components of fuel cell.	12	*Demonstration of hydrogen fuel cell using video/animation	2	CO5
LLO 13.1 Identify different components of geothermal power plant. LLO 13.2 Prepare a report on geothermal power plant.	13	Demonstration of geothermal power plant using video/animation.	2	CO5
LLO 14.1 Identify different components of ocean thermal power plant. LLO 14.2 Prepare a report on ocean thermal power plant.	14	Demonstration of ocean thermal power plant using video/animation.	2	CO5
LLO 15.1 Identify different components of wind power plant. LLO 15.2 Prepare a report on wind power plant.	15	Demonstration of wind power plant using video/animation/visit.	2	CO4

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- NOT APPLICABLE

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Hand tools such as Screwdriver, Wrenches, Sockets, Pliers, Hammers, Torque Wrench, Spanners ,Pliers ,Wire Strippers, Cable Cutters & hand gloves etc.	1,2,3,4,5,6,7,8,9,10
2	Digital Clamp Meter - DC Voltage: 0- 600V, AC Voltage: 0 – 600V, Clamp Jaw Size: up to 50mm, Temperature: -50°C to 1000°C, AC Current: 0 – 1000A. Digital multimeter - DC Voltage up to 600V, AC Voltage up to 600V, DC Current up to 20A Digital Infrared Thermometer- Temperature Range -50 °C to 550 °C Lux Meter (Illuminance Meter) – Range 0 to 2,00,000 LUX Digital Humidity meter - Temperature Rage: -50 °C to 70°C, Humidity Range: 20% to 90%	1,2,3,4,5,7,8
3	Solar module up to 150 Watt, 12V, Polycrystalline	5
4	Solar dryer: - Capacity 5 to 10 kg Per Day Drying, Drying Tray 2 numbers Food, Grade Aluminum Perforated, Temperature Range - 55 to 85 deg Celsius	7
5	Solar Box Type Cooker, Temperature ranges up to 100 degrees Celsius	8
6	Digital anemometer – Air velocity 0 to 45 m/s, Temperature Range up to 50 degrees Celsius	9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Energy Scenario and Audit	CO1	10	2	4	6	12
2	II	Energy Management and Conservation	CO2	10	2	4	6	12
3	III	Direct use of Solar Energy	CO3	16	2	6	12	20
4	IV	Indirect use of Solar Energy	CO4	10	2	4	6	12
5	V	Other Renewable Energy Sources	CO5	14	2	8	4	14
Grand Total				**60**	**10**	**26**	**34**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests of 30 marks and average of two-unit tests.
- For laboratory learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.
- End semester assessment of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	2	3	3	2	3			
CO2	3	2	2	3	3	2	3			
CO3	3	2	3	3	3	2	3			
CO4	3	2	2	-	3	2	3			
CO5	3	-	-	-	3	-	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Chetan Singh Solanki	Renewable Energy Technologies- A Practical guide for beginners	PHI Learning Pvt. Ltd (2017) ISBN:9788120334342
2	Joshua Earnest, Tore Wizelius	Wind Power Plants and Project Development	PHI Learning Pvt. Ltd. (2017) ISBN: 978-81 203-5127-1
3	D.P.Kothari, K.C.Singal, Rakesh Ranjan	Renewable Energy Sources and Emerging Technologies	PHI Learning Pvt. Ltd (2017) ISBN: 978-81 203-4470-9
4	G.D.Rai	Non-Conventional Energy Sources	Khanna Publishers (2017) ISBN:978 8174090737
5	Bureau of Energy Efficiency	General aspects of energy management and energy audit	Bureau of Energy Efficiency, Fourth Edition 2015
6	Bureau of Energy Efficiency	Energy Efficiency in Electrical Utilities	Bureau of Energy Efficiency, Fourth Edition 2015
7	Bureau of Energy Efficiency	Energy Efficiency in Mechanical Utilities	Bureau of Energy Efficiency, Fourth Edition 2015
8	Garg H and Prakash J	Solar Energy: Fundamentals and Applications	McGraw Hill Education, New Delhi (2017) , ISBN- 978-0074636312

Sr.No	Author	Title	Publisher with ISBN Number
9	S.P. Sukhatme, Nayak J. K	Solar Energy: Principles of Thermal Collection and Storage	McGraw-Hill Education (India) (2017) ISBN:978-93-5260-711-2
10	Dr.Dharmsena, Dr.Jaylaxmi	Applications of Green Power and Green Energy in Modern Life	Notion Press (2024) ISBN:979-8895440933

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=__co3m8nVUg&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=6	Non-concentrating solar collectors
2	https://dst.gov.in/climate-change-programme	National action plan on climate change (NAPCC)
3	https://pib.gov.in/newsite/PrintRelease.aspx?relid=154719	Need For an Integrated Energy Policy in India
4	https://beeindia.gov.in/sites/default/files/1Ch3.pdf	Energy management and audit
5	https://www.youtube.com/watch?v=mh51mAUexK4&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk	Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems
6	https://www.youtube.com/watch?v=pH03Y5KwpjU	Solar PV System & PV System Design
7	https://www.youtube.com/watch?v=L3AEXdvtIkk&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=19	Characteristics and properties of biomass
8	https://www.youtube.com/watch?v=7_1ELq9qGPo	Bio-CNG plant
9	https://mopng.gov.in/en/page/11	India's National Policy on Biofuels
10	https://mnre.gov.in/en/policies-and-regulations/schemes-and-guidelines/schemes/	Ministry of New and Renewable Energy (MNRE) schemes for agriculture sector in Maharashtra

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

COLD CHAIN MANAGEMENT **Course Code : 316365**

Programme Name/s : **Mechanical Engineering**
Programme Code : **ME**
Semester : **Sixth**
Course Title : **COLD CHAIN MANAGEMENT**
Course Code : **316365**

I. RATIONALE

The design, optimization, and upkeep of machinery used to maintain necessary temperatures along with the supply chain from manufacturing to the customer are the core topics of Mechanical Engineering. Cold Chain management refers to the proper handling and transportation of temperature-sensitive items. The concepts, tools, and procedures required for effective cold chain management in a variety of sectors, including chemicals, food, and pharmaceuticals, are covered in this course. For businesses that need to store, ship, and distribute temperature-sensitive goods under controlled circumstances, cold chain management is crucial. The purpose of this course is to give students the information and abilities they need to efficiently manage Cold Chain logistics while maintaining product quality, safety, and legal compliance.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences: Perform activities related to Cold-Chain Management according to requirement such as products, quality, packaging and storage efficiently.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Interpret the significance and components of the Cold Chain Management in various industries.
- CO2 - Choose appropriate Cold Chain Packaging Techniques and Storage Systems for different applications.
- CO3 - Create cost effective sustainable Cold Chain system as per client requirement.
- CO4 - Apply appropriate Operations, Monitoring and Risk Management Strategies in Cold Chain.
- CO5 - Use the regulatory frameworks, policies and best practices that ensure efficient and environmentally sustainable Cold Chain Management

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316365	COLD CHAIN MANAGEMENT	CCM	DSE	4	-	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 2 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain the significance of the Cold Chain. TLO 1.2 Identify the key components of the Cold Chain. TLO 1.3 List the applications of Cold Chain Management in different sectors/industries. TLO 1.4 Identify key technological advancements in modern Cold Chain Management. TLO 1.5 Explain the global and national challenges affecting Cold Chain logistics.	**Unit - I Introduction to Cold Chain Management** 1.1 Definition and Importance, Key Components of Cold Chain, Applications in Food, Pharmaceuticals, and Chemicals, Global, National and Local Cold Chain Challenges 1.2 The Development of Cold Chain: Historical and Modern Development, Food Cold Chain, Medicinal Cold Chain, Vaccine Cold Chain 1.3 Fundamentals of Cold Chain & Logistic: Principles of Cold Chain Logistics Features & Structure of Cold Chain Logistics, Supply Chain Versus Cold Chain Management, Global Cold Chain Management, Role of Indian railways in cold chain. 1.4 Socio-economic and Environmental Impacts of Cold Chain: Social Impacts, Economic Impacts, Environmental Impacts.	Lecture Using Chalk-Board Collaborative learning Video Demonstrations Presentations

COLD CHAIN MANAGEMENT **Course Code : 316365**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain the role of refrigeration and freezing in Cold Chain logistics. TLO 2.2 List different packaging materials used in Cold Chain logistics. TLO 2.3 Explain the importance of temperature and humidity control in the Cold Chain. TLO 2.4 List different types of refrigerated vehicles and their functions in the Cold Chain. TLO 2.5 Explain the role of Cold Storage and Refrigerated warehouses in preserving perishable goods. TLO 2.6 Select the appropriate refrigerated containers for various applications.	**Unit - II Cold Chain Packaging Techniques & Storage Systems** 2.1 Basic Elements for Cold Chain: Refrigeration and Freezing, Insight into Refrigeration and Freezing of Perishable Food products. 2.2 Cold Chain Packaging Techniques: Packaging Materials for Cold Chain Logistics, Insulated Packaging Systems, Sustainable Packaging Solutions. 2.3 Product Characteristics: Temperature/Humidity, Time, Chilling and Freezing Injury, Respiratory Metabolism. 2.4 Facilities and Equipment in Cold Chain: Refrigerated Vehicles, Cold Storage /Refrigerated Warehouse, Work in Refrigerated Warehouse in Cold Chain, Automation in Cold Chain Environment, Refrigerated Containers-Temperature-controlled vehicle with solar power, Multi-temperature trailer, Intelligent container Cold Chain Equipment, Maintenance of Refrigeration Equipment.	Lecture Using Chalk-Board Video Demonstrations Site/Industry Visit Collaborative learning

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Differentiate between fixed costs (e.g., infrastructure, equipment, depreciation) and variable costs in Cold Chain. TLO 3.2 List common financial and operational challenges in maintaining an efficient Cold Chain. TLO 3.3 Explain the importance of energy optimization in Cold Chain operations and its impact on cost and sustainability. TLO 3.4 Classify energy-efficient transportation methods and technologies used in Cold Chain logistics. TLO 3.5 List essential KPIs for monitoring financial performance Cold Chain. TLO 3.6 Explain financial modelling techniques to assess the ROI for Cold Storage Infrastructure. TLO 3.7 List future trends & innovations in Cold Chain compliance.	**Unit - III Optimization Techniques in Cold Chain Management** 3.1 Introduction to Cold Chain and Cost Dynamics: Cost Components in Cold Chain (Fixed and Variable Costs), Challenges in Cold Chain Cost Management. 3.2 Optimizing Energy Use in Cold Chain Operations: Energy, Maintenance, Transportation Techniques for Cost Reduction in Cold Chain Operations, Life Cycle Cost Analysis of Cold Chain Equipment, Energy Efficiency and Cost Reduction in Refrigeration Technologies and Energy Consumption, Renewable Energy in Cold Chain Logistics, Reducing Carbon Footprint and Operational Costs. 3.3 Financial Modelling and Cost-Benefit Analysis: Building a Cost Model for Cold Chain Operations, Cost drivers and Key Performance Indicators (KPIs), Return on Investment (ROI) analysis of cold storage investments, Break-even Analysis for Cold Chain Operations, Evaluating profitability thresholds, Scenario analysis and sensitivity testing. 3.4 Future Trends and Innovations in Cold Chain Compliance - Use of Internet of Things (IoT), Block Chain and Artificial Intelligence (AI).	Lecture Using Chalk-Board Presentations Case Study Collaborative learning

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Explain the 4 "Rs" of Cold Chain management and their significance. TLO 4.2 Classify various Cold Chain monitoring tools and their role in ensuring product safety. TLO 4.3 List the common risks in Cold Chain logistics. TLO 4.4 Explain the different quality assessment methodologies and apply them to maintain product integrity. TLO 4.5 Explain risk management strategies in Cold Chain.	**Unit - IV Cold Chain Operations, Monitoring & Control Systems** 4.1 4 "Rs" in Cold Chain Management. 4.2 Cold Chain Monitoring Tools: Chart Recorder, Time–Temperature Indicator, Data Loggers, Radio Frequency Identification(RFID), and Sensors, Wireless Sensor Networks and Internet of Things in Cold Chain, Integration of Tools and Technologies for Cold Chain. 4.3 Risk Management in Cold Chain: Risks in Cold Chain Logistics, Handling Disruptions in the Cold Chain, Contingency Planning and Emergency Response, Quality Control and Safety Standards.	Video Demonstrations Presentations Site/Industry Visit Collaborative learning
5	TLO 5.1 Explain the role of government bodies and international organizations in setting and enforcing Cold Chain standards. TLO 5.2 List Indian Cold Chain Regulation governed by different bodies. TLO 5.3 State the functions of FSSAI, BIS, and APEDA in regulating food and export Cold Chains. TLO 5.4 State the role of different organizations in refrigeration standards. TLO 5.5 Identify key drivers of sustainability in the Cold Chain industry. TLO 5.6 Explain the Challenges in Retrofitting Older Cold Chain Infrastructure with Sustainable Technologies.	**Unit - V Standards, Regulations & Sustainable Innovations in Cold Chain Management** 5.1 Introduction to Cold Chain Regulations and Standards - Importance of regulations, Role of Indian Government in cold chain. Indian Cold Chain Regulations – Governed by Food Safety and Standards Authority of India (FSSAI), Bureau of Indian Standards (BIS), Agricultural and Processed Food Products Export Development Authority (APEDA).for food safety and exports. 5.2 Cold Storage and Refrigeration Standards - Best practices for refrigerated transport and storage as per International Institute of Refrigeration (IIR), Standards for refrigeration system efficiency as per American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). 5.3 Indian Government Schemes and Initiatives Boosting Cold Chain Infrastructure for Agricultural Growth in India: Pradhan Mantri Kisan SAMPADA Yojana (PMKSY), Small Farmer Agri-Business Consortium (SFAC) Assistance. 5.4 Sustainable Innovation in Cold Chain: Importance, Social-Economic-Environmental Benefits, Challenges of Retrofitting Older Cold Chain Infrastructure with Sustainable Technologies.	Presentations Case Study Video Demonstrations Collaborative learning

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

COLD CHAIN MANAGEMENT **Course Code : 316365**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify Real-World Cold Chain Applications. LLO 1.2 Analyze Cold Chain Data as per Applications.	1	*ICT enabled tools to prepare technical feasibility report based on Local factors.	2	CO1
LLO 2.1 Identify Cold Chain Logistics Challenges. LLO 2.2 Interpret the data based on key National & global factors affecting Cold Chain logistics.	2	ICT enabled tools to prepare technical feasibility report base don National & Global challenges affecting cold chain logistics.	2	CO1
LLO 3.1 Identify the various insulation materials. LLO 3.2 Select suitable insulation materials for Cold Room Design.	3	Insulation materials for Cold Room design.	2	CO2
LLO 4.1 Use thermometers, data loggers, and hygrometers. LLO 4.2 Measure temperature and relative humidity inside cold storage.	4	Measurement of different product characteristics of Cold Storage.	2	CO2
LLO 5.1 Use thermometers, data loggers, and hygrometers. LLO 5.2 Measure temperature distribution and fluctuations within the storage environment.	5	*Measurement of different product characteristics in Iceplant/ Water cooler/ Chiller/ Refrigerator.	2	CO2
LLO 6.1 Label different component's used in Refrigerated vehicle. LLO 6.2 Draw layout of refrigerant path flow diagram using CAD.	6	Different components used in Refrigerated vehicle.	2	CO2
LLO 7.1 Interpret simulation results and propose improvements in block chain-based cold chain systems. LLO 7.2 Prepare a brief report using data obtained under proposed block chain-based improvements.	7	*Preparation of report on Data Logger & Simulation used in Block chain, Cold Chain.	2	CO3
LLO 8.1 Select relevant strategy for cost effectiveness of cold chain system using online data. LLO 8.2 Use suitable strategy for cost effectiveness.	8	Strategies to optimize based on cost effectiveness using identified Cold Chain system.	2	CO3
LLO 9.1 Prepare check list for inspection of cold chain vehicle. LLO 9.2 Use check list for inspection of cold chain vehicle.	9	Inspection of a cold chain vehicle.	2	CO4

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 10.1 Inspect the changes in texture, color and odor over time due to storage conditions. LLO 10.2 Compare the spoilage process of perishable food in different storage conditions.	10	Comparison of rotting of perishible food with and without refrigerator.	2	CO4
LLO 11.1 Identify Cold Chain Monitoring Tools. LLO 11.2 Use Cold Chain Monitoring Tools.	11	*Make use of Cold Chain Monitoring Tools.	2	CO4
LLO 12.1 Prepare report on relevant data from government reports, official websites, and research papers. LLO 12.2 Analyze statistical data related to PMKSY funding, beneficiaries, and impact assessment.	12	*Pradhan Mantri Kisan SAMPADA Yojana (PMKSY).	2	CO5
LLO 13.1 Use data loggers and sensors to monitor energy consumption and temperature stability before and after retrofitting in given situation. LLO 13.2 Apply Sustainable Retrofitting Techniques in given situation.	13	Retrofitting Older Cold Chain Infrastructure with Sustainable Technologies.	2	CO1 CO2 CO3 CO4 CO5
LLO 14.1 Prepare brief report about the risks of maintaining an intact cold chain in emergency situations. LLO 14.2 List the measures to minimize the risk in cold chain system during emergency situations.	14	*Cold Chain Technology in Medical Emergency-(Case Study of Covid 19 for Vaccine)	2	CO1 CO2 CO3 CO4 CO5
LLO 15.1 Design prototype to preserve Agriculture Products in given situation. LLO 15.2 Test the prototype with operational parameters like temperature & humidity.	15	*Model of “Subjee Cooler” –Case Study by IIT Bombay.	2	CO1 CO2 CO3 CO4 CO5
LLO 16.1 Identify the techniques of preservation of Agricultural Products used in ancient India. LLO 16.2 Prepare a report on components of preservation of Agricultural Products used in ancient India.	16	*Preservation of Agricultural Products in Ancient India- (IKS)	2	CO1 CO2 CO3 CO4 CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING /

COLD CHAIN MANAGEMENT **Course Code : 316365**

SKILLS DEVELOPMENT (SELF LEARNING) : NOT APPLICABLE

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Applications of Cold Chain logistics. Focus on its importance in preserving perishable goods, including food, pharmaceuticals, and vaccines, and explore case studies, challenges, and future trends in this vital supply chain area etc.	1
2	Contingency Planning and Emergency Response in Cold chain Include Risk Assessment & Identification, Preventive measures & backup plans, Emergency response plan, Disaster recovery plan, Post-incident analysis & continuous improvement etc.	10
3	Report on Cold chain monitoring tools used in Refrigerated vehicle. Include key parameters monitored in Refrigerated vehicles such as GPS location tracking, Door open/close status, Power supply status etc. Include Data Loggers, Smart Refrigeration Systems, Real-time GPS & IoT Sensors, Real-life examples of cold chain monitoring in logistics etc.	11
4	Pradhan Mantri Kisan SAMPADA Yojana (PMKSY) Include objectives of PMKSY, Components of PMKSY, Benefits & Impact implementation mechanism, Case studies & success stories etc.	12
5	Retrofitting older Cold chain infrastructure with sustainable technologies. Include key technologies and expected benefits, Compliance & Certifications, Financial & Policy support for Retrofitting, importance of sustainability in retrofitting, Case studies & Real-world implementations etc.	13
6	Cold chain technology in medical emergency Include importance of Cold Chain in Vaccine distribution , Cold chain challenges during COVID-19, Vaccine Cold Chain implementation etc.	14
7	Preparation of model of “Subjee Cooler” Structural components-wood, metal, or plastic to provide support Cooling mechanism-Sand, clay bricks, or charcoal Insulation Materials-Natural fiber insulation Assembly & Construction Tools-Saw, Hammer, Nails, Screws, Measuring Tape, Glue etc. Monitoring tools-Thermometer, Hygrometer etc.	15
8	Overview of ancient Indian agricultural preservation techniques Include traditional methods used for grains, fruits, vegetables, dairy, and meat preservation Role of Ayurveda, Herbal & Natural preservation techniques, Sustainability & relevance in modern times.	16
9	Report on global and local challenges affecting cold chain logistics Include infrastructure and energy constraints, Regulatory compliance and standardization, Technological and operational challenges etc.	2
10	Collection of information on different Packaging materials used in Cold Chain Logistics. Types of Packaging Materials Used, Phase Change Materials (PCMs), Rigid & Flexible Packaging, Key Considerations for Packaging Selection etc.	3

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
11	Equipment required for measuring product characteristics in Cold storage Temperature measurement: Infrared (IR) Thermometer Specification:Non-contact measurement, Temperature range: -40°C to 600°C Response Time: <1 second, Accuracy: ±1°C etc. Humidity measurement: Digital Hygrometer, Humidity range: 0% to 100% RH, Accuracy: ±2% RH Anemometer (Air flow meter): Measures airflow velocity (m/s) and air volume (CFM), Temperature Range: -10°C to 50°C Light intensity measurement: Lux meter, measures brightness inside storage areas. Range: 0–200,000 Lux etc.	4
12	Equipment required for measuring product characteristics during Visit to Dairy/ Frozen food processing plants Temperature measurement: Infrared (IR) Thermometer Specification: Non-contact measurement, Temperature range: -40°C to 600°C Response Time: <1 second, Accuracy: ±1°C etc. Humidity measurement: Digital Hygrometer, Humidity range: 0% to 100% RH, Accuracy: ±2% RH etc.	5
13	Different components are used in Refrigerated vehicle such as: Include Large Refrigerated Trucks, Refrigeration Unit (Cooling System), Insulated Cargo box, Evaporator unit (inside cargo area, Airflow & ventilation system, Temperature Monitoring & control System, Sealing mechanism (Doors & Insulation seals) etc.	6
14	Report on Data logger & Simulation used in Block chain, Cold chain. Include types of data loggers Used in Cold chain, Role and benefits of Block chain, importance of simulation, Types of simulations, Challenges and future developments etc.	7
15	Cost Components in Cold Chain Cost Management. Include Infrastructure cost, Energy and Utility costs, Transportation costs, Packaging and Handling costs, Monitoring and Compliance costs, Labor and Workforce costs etc.	8
16	Building of Cost Model for Cold Chain Operations. Include fixed costs, Variable costs, Build a cost model framework, ROI & Profitability analysis	9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Cold Chain Management	CO1	10	2	4	6	12
2	II	Cold Chain Packaging Techniques & Storage Systems	CO2	12	2	4	8	14
3	III	Optimization Techniques in Cold Chain Management	CO3	14	2	6	8	16
4	IV	Cold Chain Operations, Monitoring & Control Systems	CO4	10	2	4	6	12
5	V	Standards, Regulations & Sustainable Innovations in Cold Chain Management	CO5	14	2	8	6	16

COLD CHAIN MANAGEMENT **Course Code : 316365**

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
Grand Total				60	10	26	34	70

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests of 30 marks and average of two-unit tests.
- For laboratory learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	-	-	2	3	2			
CO2	3	3	-	2	-	3	3			
CO3	3	2	-	2	3	3	3			
CO4	3	3	-	2	3	3	3			
CO5	3	2	-	-	3	3	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Aung Myo Min, Yoon Seok Chang	Cold Chain Management	Springer International Publishing AG Genre: Business & Economics, 1st Edition. 2023 ISBN: 9783031103766,
2	Ajay Kumar Gupta	The Complete Book on Cold Storage, Cold Chain & Warehouse (with Controlled Atmosphere Storage & Rural Godowns)	Niir Project Consultancy Services, 5th Edition, 2022 ISBN: 9788195577521.

Sr.No	Author	Title	Publisher with ISBN Number
3	Vijay Yadav Tokala, Majeed Mohammed	Cold Chain Management for the Fresh Produce Industry in the Developing World	CRC Press; 1st edition (30 November 2021), ISBN-13:978-0367498191
4	World Health Organization	Manual on the management, maintenance and use of blood cold chain equipment	World Health Organization (10 March 2006), ISBN-13: 978-9241546737

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://youtu.be/EeNuQ5N2rNM?si=HWlU6gGY6BEmVr23	Cold Chain Management Introduction
2	https://youtu.be/HQA3Tk09mWs?si=7YdC23HQXkmpypd1	What Is a Cold Chain?
3	https://youtu.be/CyIwn7qEoy0?si=78nVOr_0D-G0yLQ2	What is the Cold Chain Process?
4	https://youtu.be/QxfnfGDbDyk?si=jjJ4zBaQjiNIumtH	Cold chain Vaccine storage and transportation
5	https://youtu.be/W44EKTz41aU?si=tBdP1_2NKasNgizx	Advanced Insulated Packaging Material for Cold-Chain Shipping
6	https://youtu.be/bqvR0zJMgqw?si=zrM_y2xOedGJWCdR	Large-scale cold-chain logistics automation
7	https://youtu.be/6N3qjr2MIYk?si=715ao7ZlB7Q5bF55	Best Practices: Managing the cold chain
8	https://youtu.be/jus-4svrUSY?si=pli83DOp3L5o0pUL	What is Cold Chain Equipment
9	https://youtu.be/16lw7AKtHHo?si=oIac0luK5NvHHUU8	Refrigerated trucks
10	https://youtu.be/Q17R6GyxUzs?si=js4veflAzLqf2qRX	Refrigerated Container Features

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

Programme Name/s	**: Architecture Assistantship/ Architecture and Interior Design/ Automobile Engineering./ Artificial Intelligence/ Agricultural Engineering/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Architecture/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Software Technology/ Computer Science & Engineering/ Fashion & Clothing Technology/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Food Technology/ Computer Hardware & Maintenance/ Instrumentation & Control/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Instrumentation/ Interior Design & Decoration/ Interior Design/ Civil & Environmental Engineering/ Mechanical Engineering/ Mechatronics/ Medical Laboratory Technology/ Manufacturing Technology/ Medical Electronics/ Metallurgical Engineering/ Production Engineering/ Printing Technology/ Polymer Technology/ Surface Coating Technology/ Computer Science/ Textile Technology/ Electronics & Computer Engg.**
Programme Code	**: AA/ AD/ AE/ AI/ AL/ AN/ AO/ AT/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CST/ CW/ DC/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ FC/ HA/ IC/ IE/ IF/ IH/ IS/ IX/ IZ/ LE/ ME/ MK/ ML/ MRT/ MU/ MY/ PG/ PN/ PO/ SC/ SE/ TC/ TE**
Semester	**: Fifth / Sixth**
Course Title	**: MANAGEMENT**
Course Code	**: 315301**

I. RATIONALE

Effective management is the cornerstone of success for both organizations and individuals. It empowers diploma engineers/ professionals to accomplish their tasks with finesse and efficiency through strategic planning and thoughtful execution, projects can optimize finances, enhance safety measures, facilitate sound decision-making, foster team collaboration and cultivate a harmonious work environment. The diploma engineers require leadership and management skills with technical knowledge of the core field to carry out various tasks smoothly. This course aims to instill fundamental management techniques, empowering diploma engineers/ professionals to enhance their effectiveness in the workplace.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcome through various teaching learning experiences: Apply the relevant managerial skills for achieving optimal results at workplace.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Use relevant management skills to handle work situation
- CO2 - Apply appropriate techniques of product, operations and project management
- CO3 - Use comprehensive tools of recent management practices
- CO4 - Plan suitable marketing strategy for a product / service
- CO5 - Utilize supply chain and human resource management techniques for effective management

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

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MANAGEMENT **Course Code : 315301**

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315301	MANAGEMENT	MAN	AEC	3	-	-	1	4	2	1.5	30	70*#	100	40	-	-	-	-	25	10	125

Total IKS Hrs for Sem. : 1 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Justify the importance of management thoughts in Indian knowledge system. TLO 1.2 Describe the importance of management in day to day life. TLO 1.3 Explain Henry Fayol’s principles of management. TLO 1.4 Describe the role of each level of management in its management hierarchy. TLO 1.5 Practice the self management skills for a given situation TLO 1.6 Apply the required managerial skills for a given situation	**Unit - I Introduction to Management** 1.1 Evolution of management thoughts from ancient/medieval to modern times in India (IKS) 1.2 Management: meaning, importance, characteristics, functions & challenges. 1.3 Introduction to scientific management- Taylor's & Fayol's principles of management 1.4 Levels & functions of management at supervisory level. 1.5 Self management skills: Self awareness, self discipline, self motivation, goal setting, time management, decision making, stress management, work life balance and multitasking 1.6 Overview of Managerial Skills: negotiation skills, team management, conflict resolution, feedback, leadership	Presentations Case Study Interactive session Quiz competition Mixed Picture Puzzle

MANAGEMENT **Course Code : 315301**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Identify the appropriate creativity technique for new product development TLO 2.2 Describe the new product development process for a product / service TLO 2.3 Comprehend the importance of various strategic steps Product Management TLO 2.4 Elaborate Agile product management TLO 2.5 Explain the significance of the Project Management TLO 2.6 Describe the various tools of project management	**Unit - II Product, Operations and Project Management** 2.1 Creativity and innovation management: creativity techniques - brainstorming, checklist, reverse brainstorming, morphological analysis, six thinking hats. 2.2 New product development, change management 2.3 Product Management -meaning, strategic steps for sustainable design of a product 2.4 Agile product management- concept, benefits, principles and manifesto 2.5 Project Management: importance, areas within project management,4Ps and phases 2.6 Tools of Project Management: PERT and CPM, GANTT & Chart Overview of Estimate and Budget	Presentations Case Study Video Demonstrations Presentations Role Play
3	TLO 3.1 Understand the importance of quality management tools TLO 3.2 Explain the importance of various techniques for optimization and waste minimization TLO 3.3 State the importance of ISO quality standards TLO 3.4 Describe ERP TLO 3.5 State the importance of ISO TLO 3.6 Recognize the importance of customer satisfaction as a competitive advantage	**Unit - III Management Practices** 3.1 Quality circle, kaizen, Six Sigma, TQM 3.2 5S, Kanban card system, TPM, Lean Manufacturing: Meaning, Steps and Importance 3.3 Quality Standards and ISO: Meaning, ISO 9001:2016, ISO 14000, OSHA 2020 3.4 The overview of ERP along with example 3.5 Service quality and customer/client satisfaction, servicescape	Presentation Case study Interactive session Quiz Video Demonstration Lecture Using Chalk-Board
4	TLO 4.1 Explain the importance of marketing techniques TLO 4.2 Explain the importance of needs, wants and desires in marketing TLO 4.3 Interpret the traditional and digital marketing techniques TLO 4.4 Plan different aspects of an event management	**Unit - IV Marketing Management** 4.1 Marketing management: meaning, significance, Seven P's of Marketing 4.2 Needs, wants and demands in marketing. Customer relationship management 4.3 Types of marketing: traditional and digital marketing 4.4 Event management: types, different aspects of event management, crisis management	Case Study Interactive session based video Role Play Flipped Classroom Presentations

MANAGEMENT **Course Code : 315301**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 State the importance of supply chain and logistics management TLO 5.2 Explain the components of supply chain and logistics Management TLO 5.3 Describe the role of information technology in supply chain & logistics management TLO 5.4 State the significance of Human Resource Management TLO 5.5 Analyze the various methods of recruitment, selection and training for an organization TLO 5.6 List the qualities of a successful supervisor	**Unit - V Supply Chain & Human Resource Management** 5.1 The overview of Supply Chain and logistics Management 5.2 Components of Supply Chain and logistics Management 5.3 Role of information technology in supply chain & logistics management 5.4 Overview of Human Resource Management-Meaning,significance,scope and principles 5.5 Recruitment, selection and training of human resources. Chalk Circle 5.6 Qualities of a successful supervisor /team leader and types of leadership	Presentations Video Demonstrations Case Study Collaborative learning Video Demonstrations Chalk-Board

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES : NOT APPLICABLE.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment / Article

- Make a one page note based on a book of management you read.
- Write a short article on inventory management exploring online learning resources.
- Prepare a report on ISO standards applicable to your field. a. IATF 16949-2016 / SLA-TS 16949-2016, - Automotive Industry b. ISO 22000 — Food safety management c. ISO 50001 — Energy management d. ISO/IEC 27001 - Cyber Security e. ISO/DIS 4931-1 - Buildings and civil engineering works
- Prepare a 4 quadrant matrix of time management for managing the tasks.
- Prepare a report on any one software used for Supply Chain and Logistics Management.
- Prepare a GANTT Chart for project management related to your field.

Note Taking

- Watch a Tedx Talk Video on managerial skills and take notes in the form of keywords.

Case Study

- Prepare a case study and discuss the same on following topics a.Self Management Skills b.Six Thinking Hats c.Kaizen d.Quality Circle e.Safety Measures in different organizations related to your field
- Study the recruitment and selection process of any organization related to your field.
- Prepare a case study on management lessons based on life of Chhatrapati Shivaji Maharaj
- Conduct outbound training on managerial skills. Make a video and upload on social media.

Quizes

- Participate in online quizzes related to areas of management .

Assignment

- Workshops to be conducted for students on following topics a. creativity techniques b. time management c. stress management d. negotiation and conflict e. goal setting f. meditation new product development

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED : NOT APPLICABLE

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Management	CO1	13	8	6	4	18
2	II	Product, Operations and Project Management	CO2	8	2	4	6	12
3	III	Management Practices	CO3	8	4	4	6	14
4	IV	Marketing Management	CO4	8	2	4	6	12
5	V	Supply Chain & Human Resource Management	CO5	8	4	4	6	14
Grand Total				**45**	**20**	**22**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- MCQ Based Class Test, Self Learning Activities / Assignment

Summative Assessment (Assessment of Learning)

- Summative Assessment (Assessment of Learning) MCQ based

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3

MANAGEMENT **Course Code : 315301**

CO1	1	1	1	-	-	2	3			
CO2	1	3	3	-	1	3	3			
CO3	1	3	1	-	1	1	3			
CO4	1	2	2	-	1	2	3			
CO5	1	1	2	-	1	2	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	A. K. Gupta	Engineering Management	S. Chand, ISBN: 81-219-2812-5, 2007, 2nd Edition
2	O. P. Khanna	Industrial Engineering &management	Dhanpat Rai Publication, ISBN: 978-8189928353, 2018
3	Harold Koontz and Heinz Weinrich	Essentials of Management	Tata McGraw Hill Education ISBN: 9789353168148, 2020, 12th edition
4	E. H. McGrath	Basic Managerial Skills for All	PHI ISBN: 978-8120343146, 2011, 9th Edition
5	Andrew DuBrin	Management Concepts and Cases	Cengage Learning, ISBN: 978-8131510537, 2009, 9th edition
6	K. Dennis Chambers	How Toyota Changed the World	Jaico Books ISBN: 978-81-8495-052-6, 2009
7	Jason D. O'Grandy	How Apple changed the Wolrd	Jaico Publishing House ISBN: 978-81-8495-052-0, 2009
8	Subhash Sharma	Indian Management	New Age International Private Limited ; ISBN-978-9389802412, 2020, 1st edition
9	Chitale, Dubey	Organizational Behaviour Text and Cases	PHI LEARNING PVT. LTD., ISBN: 978-9389347067, 2019, 2nd Edition

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.debonogroup.com/services/core-programs/six-thinking-hats/	Six Thinking Hats
2	https://hbr.org/1981/09/managing-human-resources	HR Management
3	https://theproductmanager.com/topics/agile-product-management/	Agile Product Management
4	https://www.cdlogistics.ca/freight-news/the-5-components-of-supply-chain-management	Supply Chain Management
5	https://www.infosectrain.com/blog/understanding-the-concepts-of-gantt-chart-and-critical-path-methodology-cpm	PERT, CPM, GANTT Chart
6	https://www.simplilearn.com/best-management-tools-article	Management Tools
7	https://www.psychometrica.in/free-online-psychometric-tests.html	Psychometric Tests
8	https://www.investopedia.com/terms/e/erp.asp	ERP
9	https://asq.org/quality-resources/quality-management-system	QMS
10	https://testlify.com/test-library/creative-thinking/	Psychometric Tests
11	https://www.mindtools.com/	Management Skills
12	https://www.investopedia.com/terms/d/digital-marketing.asp	Digital Marketing

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

MANAGEMENT **Course Code : 315301**

MSBTE Approval Dt. 24/02/2025 **Semester - 5 / 6, K Scheme**

Programme Name/s	**: Automobile Engineering./ Artificial Intelligence/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Software Technology/ Computer Science & Engineering/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Computer Hardware & Maintenance/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Civil & Environmental Engineering/ Mechanical Engineering/ Mechatronics/ Manufacturing Technology/ Metallurgical Engineering/ Production Engineering/ Computer Science/ Electronics & Computer Engg.**
Programme Code	**: AE/ AI/ AN/ AO/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CST/ CW/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ HA/ IE/ IF/ IH/ LE/ ME/ MK/ MRT/ MY/ PG/ SE/ TE**
Semester	**: Sixth**
Course Title	**: CAPSTONE PROJECT**
Course Code	**: 316004**

I. RATIONALE

Capstone projects in engineering study are considered important as it allow students to integrate and apply the knowledge and skills acquired throughout their academic program and effectively demonstrating their learning of programme by tackling a real-world problem, ultimately keeping them well prepared for the job market. The capstone project is usually the final assignment and plays a vital role in preparing students for the world of work to its practical applications and ability to help hone students' professional knowledge and skills. Normally, capstone projects are developed in collaboration with industries or businesses, providing students with valuable insights. Capstone projects has been considered as an integral part of diploma curriculum. It helps learners to perform and demonstrate skills gained due to early courses of Diploma study independent. Therefore, this is considered as a course of final year/semester study.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Apply professional skills for solving , executing and demonstrating solutions to real-world problems

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Elaborate the identified field problem from the perspective of project work at institute.
- CO2 - Conduct feasibility & viability analysis (using data collection, experiments, Simulation , Coding) to validate required resources, cost, support of the project work.

- CO3 - Apply the acquired knowledge and skills in providing solutions to the real field/industrial problems.
- CO4 - Present Project and its output/ findings / achievements alongwith its exhibits.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316004	CAPSTONE PROJECT	CPE	INP	-	-	2	2	4	2	-	-	-	-	-	50	20	50#	20	50	20	150

V. General guidelines for PROJECT WORK

- The Project- problems must be related to the programme or may be interdisciplinary, based on the industry expected outcomes.
- The individual students have different aptitudes and strengths. Project work, therefore, should match the strengths of students. For this purpose, students should be asked to identify the type of project work they would like to execute.
- Project titles are to be finalized in co-ordination/consultation with the Faculty mentor. However, faculty may form a team of students as per specific roles- Literature survey/data collection, data Analysts, model/prototype developers, testers, Project managers using IoTs ITES and software /application development. Study type project is NOT advisable.
- Project must be assigned to a group of 3-4 students under the guidance of identified faculty mentor.
- Students are required to prepare a prototype/working model/software of the Project and simultaneously prepare a report.
- Students shall Submit One Hard copy and one Soft copy each of Project Report and soft-copy of the project code or the working model.
- Students must maintain a project execution diary having the progress steps and details. The concerned faculty should check the diary on a weekly basis and accordingly interact with students based on the progress shown and keep proper record with feedback if any.
- Project shall address National Thrust area such as Environment, Digitization, Automation, sustainability and similar domains.
- Student shall try to use the national and international standards wherever possible (processes / materials / equipments etc ..)

VI. Project facilitation guidelines:

Once the Project statement has been finalized and allotted to the students, the Faculty Mentor role is very important as guide, motivator, catalyser to promote learning and sustain the interest of the students. At the same time the Faculty Mentor is not expected to guide the students on each step, otherwise it will curb the creativity

of the students-group. The Faculty Mentor has to work as a mentor. Following should be kept in mind while facilitating the project at the institute:

1.Project orientation cum -briefing: the project should be relevant to the curriculum of the programme. The project shall be cost effective taking safety aspects, ethical issues, environmental issues and confidentiality as per expectation of industry(if any) into consideration, The work may be industry Sponsored.

2.Information search and data collection: the information and data should be realistic and relevant to the problem /project. Hypothetical data is not to be taken into consideration.

3.Implementation and Monitoring: The project must have important steps /milestones to achieve as per the time frame/action plan prepared by students and faculty. The monitoring mechanism such as daily/weekly dairy (**Format given below)** must be clearly explained and delineated for the students.

VII.Criteria of Assessment /Evaluation of Project work

A. Formative Assessment (FA) criteria

The **Formative Assessment** (FA) of the students for 50 marks is to be done based on following criteria.

Appropriate RUBRICS may be used for assessment

Rubrics for Assessment of the team

Sr.No.	Criteria	Marks
1	Project Selection & Problem definition	05
2	Literature survey and data collection/ Gathering	05
3	Design / concept of project/ Working - Execution of Project	10
4	Stage wise progress as per Action plan/milestone	05
5	Quality Report Writing	05

Rubrics for Individual Assessment

Sr.No.	Criteria	Marks
1	Contribution as a team member	05
2	Depth of Knowledge	10
3	Presentation	05

B. Summative Assessment Criteria

- The summative assessment for 50 marks is to be done and based on following criteria. This assessment shall be done by the faculty mentor and External examiner.

Sr.No.	Criteria	Marks
1	Capstone Project Completion as per plan	10
2	Project related Requirement Analysis & Designing	10
3	Developing a Solution with proper justifications, Teamwork	10

4	Project Report Writing	10
5	Project Presentation	10

(**NOTE :** Team based and Individual performance based summative assessment may include Innovativeness , Technology used , user friendliness , cost effectiveness , society benefits etc..)

SUGGESTED RUBRIC FOR SUMMATIVE ASSESSMENT OF CAPSTONE PROJECT

PROJECT ASSESSMENT				
Project Title:				
Project Assessment Rubric				
Performance	**Excellent**	**Good**	**Fair**	**Poor**
Criteria	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
Capstone Project Completion	Excellent	Good	Fair	Poor
	The project is completed as per tasks described in synopsis.	**The project is completed but require minor modifications.**	**The project is completed but require several modifications.**	**The project is not completed as per tasks described in synopsis.**
Project related Requirement Analysis & Designing	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Effectively contributed in requirement analysis and designing.	**Partially Contributed in requirement analysis and designing.**	**Attempted to contribute in requirement analysis and designing**	**No contribution in requirement analysis and designing.**
Developing a Solution with proper justifications , Teamwork	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Developed the critical solution modules with Innovation, optimized design and worked very well with the team.	**Developed some solutions with higher complexity and worked well with the team.**	**Attempted to develop few solutions and worked with the team.**	**No contribution in developing a solution and in the team.**
Project Report Writing	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Worked very well to submit an excellent project report .	**Worked well to submit the project report with covering all the aspects of a standard report.**	**Tried to submit the project report but standard of report was not satisfactory.**	**No contribution in project report writing.**
Project Presentation	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Presented the project work flawlessly.	**Presented the project work very nice.**	**Presented the project work not so well.**	**Presentation skill is not up to the mark.**
Project Group Members				

ROLL NUMBER/Enrollment Number				
NAME				
Comments (if any)				

NOTE : " These are suggestive rubrics Faculty mentor and external examiner may frame different rubrics as per Programme need and assigned Project work "

C. Self Learning Assessment

Self Learning Assessment **Max Marks -50**

Sr.No.	Criteria	Max Marks	Marks Obtained
1	Project Selection & Problem definition	10	
2	Literature survey and data collection/ Gathering	05	
3	Design / concept of project/ Working - Execution of Project	15	
4	Stage wise progress as per Action plan/milestone/ psychomotor motor skills acquired	10	
5	Quality Report Writing	10	

VIII. CO-PO Mapping

CO-PO mapping will vary project wise and shall be prepared by concerned faculty for the given project

IX. Typographical instructions/guidelines for Project report writing

Following is the suggestive format for preparing the Project report. Actual report may differ slightly depending upon the nature of industry. The training report may contain the following.

a. The PROJECT report shall be computer typed (English- British) and printed on A4 size paper.
b. Text Font -Times New Roman (TNR), Size-12 point
c. Subsection heading TNR- 12 point bold normal
d. Section heading TNR- 12 capital bold
e. Chapter Name/ Topic Name – TNR- 14 Capital
f. All text should be justified. (Settings in the Paragraph)
g. The report must be typed on one side only with double space with a margin 3.5 cm on the left, 2.5 cm on the top, and 1.25 cm on the right and at bottom.
h. The training report must be hardbound/ Spiralbound with cover page in black colour. The name of the candidate, diploma (department), year of submission, name of the institute shall be printed on the cover [Refer sample sheet (outer cover)]

i. The training report, the title page [Refer sample sheet (inner cover)] should be given first then the Certificate followed by the acknowledgment and then contents with page numbers.

X. Project Report

On completion of the project work, every student will submit a project report which should contain the following:

1. Cover Page (as per annexure 1)
2. Title page (as per annexure 2)
3. Certificate by the Guide (as per annexure 3)
4. Acknowledgment (The candidate may thank all those who helped in the execution of the project.)
5. Abstract (It should be in one page and include the purpose of the study; the methodology used.)
6. Table of Contents (as per general guidelines): Detailed description of the project (This should be split in various chapters/sections with each chapter/section describing a project activity in totality).

    Chapter–1 Introduction (background of the Industry or User based Problem/Task)
    Chapter–2 Literature Survey (to finalize and define the Problem Statement)
    Chapter–3 Scope of the project
    Chapter–4 Methodology/Approach, if any
    Chapter-5 Details of designs, working and processes
    Chapter-6 Results and Applications

7. Conclusion
8. References (The listing of references should be typed 2 spaces below the heading “REFERENCES” in alphabetical order in single spacing left – justified. It should be numbered consecutively (in square [ ] brackets, throughout the text and should be collected together in the reference list at the end of the report. The references should be numbered in the order they are used in the text. The name of the author/authors should be immediately followed by the year and other details). Typical examples of the references are given below:

NOTE:

1. Project report must contain only a relevant and short mention – technology or platform or tools used. It must be more focussed on project work and its implementation
2. Students can add/remove/edit chapter names as per the discussion with their guide

Formats

Project Report

“Project Title----------”

as a partial fulfilment of requirement of the

THIRD YEAR DIPLOMA IN

Submitted by

1)Name Of Student **Enrollment Number**

2)Name Of Student **Enrollment Number**

3)Name Of Student **Enrollment Number**

4)Name Of Student **Enrollment Number**

Are the bonafide on

FOR THE ACADEMIC YEAR

20-----20---

(H.O.D)

(Principal)

(Internal Guide) **(External Examiner)**

Department Name

(If NBA Accredited mention that)
Institute Name

(An Affiliated Institute of Maharashtra State Board of Technical Education)

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Note:

***Students can add/remove/edit chapter names as per the discussion with their guide**

Annexure

PROJECT DIARY (Weekly/Daily)

Name of the Student : _____

Name of Guide (Faculty) : _____

Enrollment Number : _____ Semester: _____Project batch Number : _____

WEEK : _____

Date	Activity carried out (Details)	Achievement of mile stone/step as per plan	Remark of Faculty
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			

Dated Signature of Faculty **Dated Signature of HOD**

MSBTE LOGO INST LOGO

Certificate

This is to certify that

Mr./Ms. *bearing examination seat No.* *has*

*Satisfactorily completed his/her **PROJECT** entitled*

Along with his/her batchmates in partial fulfillm ent for the

Diploma Course in

< PROGRAMME NAME>

*Of the **Maharashtra State Board of Technical Education** at our Polytechnic during the Academic Year20 -20 .*

The Project is completed by a group consisting of Persons under the guidance of the Faculty Guide

_____

Faculty Name and Signature (Internal)	**Faculty Name and Signature (External if applicable)**	**HOD Name and Signature with Department Stamp**
Date and Time		

MSBTE Approval Dt. 04/09/2025 **Semester - 6, K Scheme**

3D MODELLING AND ADDITIVE MANUFACTURING **Course Code : 316013**

Programme Name/s : **Mechanical Engineering/ Metallurgical Engineering**
Programme Code : **ME/ MY**
Semester : **Sixth**
Course Title : **3D MODELLING AND ADDITIVE MANUFACTURING**
Course Code : **316013**

I. RATIONALE

Industry needs to build models-based applications which are being developed using solid modeling software. The 3D Modeling and Additive Manufacturing course equips diploma students with essential skills in designing and producing mechanical parts using 3D modeling and additive technologies.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry outcome through various teaching learning experience: Apply skills to create, prototype and manufacturing of mechanical components using solid modeling and 3D printing techniques.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Prepare 2D drawing using sketch toolbar of given 3D modeling software.
- CO2 - Prepare 3D solid models from 2D sketch using given 3D modeling software.
- CO3 - Prepare assembly of part models using given 3D modeling software.
- CO4 - Plot a drawing for given part model/ assembly.
- CO5 - Prepare components of assembly using 3D printer/ rapid prototyping machine.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316013	3D MODELLING AND ADDITIVE MANUFACTURING	3DM	SEC	-	-	4	-	4	2	-	-	-	-	-	25	10	25#	10	-	-	50

Total IKS Hrs for Sem. : 0 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Draw 2D sketch using sketch tool. TLO 1.2 Draw template for 2D sketch.	**Unit - I Working in 2D environment** 1.1 Drawing tool: Line, Construction line, Rectangle, Polygon, Circle, Arc, Ellipse, Spline, etc. 1.2 Editing tool: Trim, Delete, Extend, Erase, Mirror, etc. 1.3 Modify tool: Chamfer, Fillet, Copy, Move, Pattern etc. 1.4 Linear, Angular dimensions, Dimensional constraint and Geometrical constraint. 1.5 Drawing template: Prepare drawing template consisting of name plate, boundary lines and projection symbol.	Lecture Using Chalk-Board Presentations Video Demonstrations
2	TLO 2.1 Draw 3D models of given components. TLO 2.2 Modify 3D models of given components. TLO 2.3 Draw Auxiliary planes.	**Unit - II Development of solid models** 2.1 Working in 3D environment: Planes, creating 3D Solid Models of simple machine parts. 2.2 Part tool: Extrude, Hole, Revolve, Rib, Sweep, swept blend, Pattern, etc. 2.3 Part Modify tool: Chamfer, Round, Copy, Move, Draft, etc. 2.4 Creating parts using auxiliary plane.	Demonstration Video Demonstrations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Assemble given 3D components. TLO 3.2 Produce exploded view of given assembly drawing.	**Unit - III Computer aided assembly** 3.1 Assembly drawing: Preparation of assembly drawing by using assembly tool. 3.2 Relative degrees of freedom and constraints of assembly. 3.3 Rotational and translational motions of assembly, constraining motions. 3.4 Exploded view: Explode the assembly.	Video Demonstrations Lecture Using Chalk-Board Presentations
4	TLO 4.1 Generate production drawing from given assembly. TLO 4.2 Prepare part list. TLO 4.3 Setup printing parameters. TLO 4.4 Plot production drawing.	**Unit - IV Plotting and drafting 3D assembly** 4.1 Generate orthographic projection of assembly: Various views- Sectional, Auxiliary, Isometric Views, etc. 4.2 Bill of Materials : Prepare part lists, Name plate on sheet. 4.3 Printer selection, paper size, orientation. 4.4 Page set up and plotting drawing.	Video Demonstrations Presentations Lecture Using Chalk-Board
5	TLO 5.1 Select suitable material for part printing using 3D Printer in given situation. TLO 5.2 Create slices in Slicer software. TLO 5.3 Print given component using 3D printer.	**Unit - V Additive manufacturing** 5.1 3D printing file formats. 5.2 Selection of material. 5.3 Printing parameter setting: Temperature, wall thickness, infill percentage, orientation, etc. 5.4 Need of supports, types of support. 5.5 Slicing layers using software. 5.6 Exporting and printing.	Video Demonstrations Lecture Using Chalk-Board Presentations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Use of sketch toolbar for drawing 2D entities.	1	*Preparing drawing template consisting of name plate, boundary lines and projection symbols.	2	CO1
LLO 2.1 Draw the simple 2D components from given part drawing. LLO 2.2 Plot the given components drawing.	2	Drawing and plotting two simple 2D geometries using sketcher commands.	2	CO1 CO4
LLO 3.1 Draw the simple 3D components from given part drawing. LLO 3.2 Plot the given components.	3	*Drawing and plotting the given two simple 3-D drawings using 3D modeling commands.	4	CO1 CO2 CO4

3D MODELLING AND ADDITIVE MANUFACTURING **Course Code : 316013**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Draw the complex 3D components from given part drawing. LLO 4.2 Plot the given components.	4	Drawing and plotting the given two complex 3D drawings using 3D modeling commands.	4	CO1 CO2 CO4
LLO 5.1 Develop 3D model of components from given part drawing. LLO 5.2 Plot the given components.	5	*Drawing and plotting the production drawing of the 3D part models of individual components of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts.(Problem-I)	4	CO1 CO2 CO4
LLO 6.1 Develop 3D model of components from given part drawing. LLO 6.2 Plot the given components.	6	*Drawing and plotting the production drawing of the 3D part models of individual components of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts. (Problem-I continued)	4	CO1 CO2 CO4
LLO 7.1 Develop 3D model of components from given part drawing. LLO 7.2 Plot the given components.	7	*Drawing and plotting the production drawing of the 3D part models of individual components of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts. (Problem-I continued)	4	CO1 CO2 CO4
LLO 8.1 Develop 3D model of components from given part drawing. LLO 8.2 Plot the given components.	8	*Drawing and plotting the production drawing of the 3D part models of individual components of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts. (Problem-I continued)	4	CO1 CO2 CO4
LLO 9.1 Assemble the given 3D components from given part drawing. LLO 9.2 Plot the given components.	9	*Assembly and plotting the orthographic views of the assembly, bill of materials of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts. (Problem-I)	4	CO1 CO2 CO3 CO4
LLO 10.1 Develop 3D model of components from given part drawing. LLO 10.2 Plot the given components.	10	Drawing and plotting the production drawing of the 3D part models of individual components of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts. (Problem-II)	4	CO1 CO2 CO4
LLO 11.1 Develop 3D model of components from given part drawing. LLO 11.2 Plot the given components	11	Drawing and plotting the production drawing of the 3D part models of individual components of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts. (Problem-II continued)	4	CO1 CO2 CO4
LLO 12.1 Develop 3D model of components from given part drawing. LLO 12.2 Plot the given components.	12	Drawing and plotting the production drawing of the 3D part models of individual components of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts. (Problem-II continued)	4	CO1 CO2 CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 13.1 Develop 3D model of components from given part drawing. LLO 13.2 Plot the given components.	13	Drawing and plotting the production drawing of the 3D part models of individual components of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts. (Problem-II continued)	4	CO1 CO2 CO4
LLO 14.1 Assemble the given 3D components from given part drawing. LLO 14.2 Plot the given components.	14	Assembly and plotting the orthographic views of the assembly, bill of materials of Bench vice/ Drill Jig/ Screw Jack/ Tool Post/ any assembly consisting of at least five parts. (Problem-II)	4	CO1 CO2 CO3 CO4
LLO 15.1 3D print the given component.	15	*Printing any one component from above assembly using 3D printer/ Rapid prototyping machine.	8	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING) : NOT APPLICABLE

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Workstation with latest configurations for each student, Microsoft Windows 10 or above, with minimum i5 Processor (2.5 GHz), 8 GB RAM, 512 SDD.	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15
2	LCD projector (at least 4500 lumens and aspect ratio 16:10)/ Screen/ Interactive board.	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15
3	Plotter: Multifunction Wide format plotter, Scanning Size A0-A4, Resolution 1200 X 1200/ Printer with latest versions (A3/A4 size) Laserjet.	1,2,3,4,6,7,8,9,10,11,12,13,14,15
4	Free version/ Latest Educational version of 3-D modelling software such as CATIA, Solid Works, Creo, NX4, etc.	5
5	3D printer (FDM): size- 200 x 200 x 250 mm, layer resolution 0.08 mm to 0.4 mm, print speed 40-120 mm/sec, Nozzle size 0.4mm,Filament-ABS/PLA/Composite.	5
6	Software: 3D printing software (slicing software).	5
7	Filament PLA, PETG, Nylon, ABS.	5

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table) : NOT APPLICABLE

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- For laboratory learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 25 marks for laboratory learning

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	1	2	3	1	2	1			
CO2	3	1	2	3	1	2	1			
CO3	3	1	2	3	1	2	1			
CO4	3	1	2	3	1	2	1			
CO5	3	1	2	3	2	2	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Sham Tickoo	CATIA V5R20 for Designers	Softcover, Cadcim Technologies
2	Sham Tickoo	Pro/ENGINEER Wildfire for Designers	Softcover, Cadcim Technologies
3	Sham Tickoo	Solid Works For Designers Release 2006	Softcover, Cadcim Technologies
4	Sham Tickoo	Autodesk Inventor for Designers: Release 10	Softcover, Cadcim Technologies
5	Sham Tickoo, Deepak Maini	NX 4 for Designers	Softcover, Cadcim Technologies
6	Sham Tickoo, Deepak Maini	Solid Edge V19 for Designers	Softcover, Cadcim Technologies

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://archive.nptel.ac.in/courses/112/102/112102304/	NPTEL: Engineering graphics and design

3D MODELLING AND ADDITIVE MANUFACTURING **Course Code : 316013**

Sr.No	Link / Portal	Description
2	https://www.3ds.com/store/cad/solid-modeling	Dassault systems: What is solid modeling and why is it so essential to design?
3	https://en.wikipedia.org/wiki/Solid_modeling	Solid modeling
4	https://www.youtube.com/watch?v=vjX4PDJcFOI	Solid modeling
5	https://www.youtube.com/watch?v=JjKs-lePlPY	How to Read & Create 3d Models from 2d Drawings

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

DESIGN OF MACHINE ELEMENTS **Course Code : 316357**

Programme Name/s : **Mechanical Engineering/ Production Engineering**
Programme Code : **ME/ PG**
Semester : **Sixth**
Course Title : **DESIGN OF MACHINE ELEMENTS**
Course Code : **316357**

I. RATIONALE

Machine Design is the strategy of developing new or improved machines to accomplish direct/indirect human based need. Design department of industry is one of the major job areas for Diploma Technicians. A Diploma holder is required to assist in the Design and Development of Prototype and other components. For this, it is essential that he is made conversant with usual fundamental design procedures, IS codes,standards and guidelines for selection of appropriate material. Diploma student should also be aware of the principles related to design of machine components and its applications.This course aims at developing analytical and selection abilities in the student to give solutions to simple engineering design problems using standard procedures.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences: Apply various design principles & procedures for designing simple machine components.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Use fundamental concepts of design of machine elements for given application
- CO2 - Determine the dimensions of joints and levers.
- CO3 - Select the dimensions of shafts, keys, couplings and bearings used in Power transmission.
- CO4 - Select the suitable thread (Screw and Nut) screws for power transmission and fasteners.
- CO5 - Design springs for the given load conditions.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316357	DESIGN OF MACHINE ELEMENTS	DME	DSC	4	-	2	2	8	4	4	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain machine design, its procedure and general considerations. TLO 1.2 Enlist the loads acting on a machine element. TLO 1.3 Describe bearing pressure, crushing stress and principal stresses acting on a machine element. TLO 1.4 Explain factor of safety for ductile and brittle materials. TLO 1.5 Describe stress concentration with the causes and remedies to reduce stress concentration. TLO 1.6 Identify the materials from given standard designations. TLO 1.7 Explain the concept of fatigue and endurance limit. TLO 1.8 State the theories of elastic failures. TLO 1.9 Explain the aesthetic considerations in design of machine elements.	**Unit - I Fundamentals of Design** 1.1 Machine design: Definition, philosophy, general design procedure, general considerations in design of machine elements. 1.2 Loads acting on machine elements (static). 1.3 Stresses:Bearing pressure, crushing stress, principal stresses. 1.4 Factor of Safety (FOS), conditions for selection of FOS 1.5 Stress concentration: Concept, causes and remedies to reduce stress concentarion. 1.6 Designation of materials as per IS code, advantages of standardization 1.7 Concept of Fatigue, S-N curve and Endurance limit. 1.8 Theories of Elastic Failures: Maximum Principal Stress theory and Maximum Shear Stress theory. 1.9 Aesthetic considerations in design: Elements of aesthetic design, Morgan's colour code,	Lecture Using Chalk-Board Video Demonstrations Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Identify the sections resisting failure with the type of failure of the machine components of joints and levers. TLO 2.2 Describe the design procedure of knuckle joint and turnbuckle. TLO 2.3 Calculate the dimensions of elements of knuckle joint and turnbuckle from the given load. TLO 2.4 Describe the design procedure of hand/foot lever and bell crank lever TLO 2.5 Calculate the dimensions of elements of hand/foot lever and bell crank lever. TLO 2.6 Explain the procedure for design of parallel and transverse fillet weld subjected to static and dynamic loading. TLO 2.7 Determine the length of weld for given application	**Unit - II Design of Joints and Levers.** 2.1 Design of Knuckle Joint, Turnbuckle. 2.2 Types of Levers: First Type, Second Type & Third Type of Levers & its application 2.3 Design of Levers :Hand/Foot Lever and Bell Crank Lever. 2.4 Design C-clamp and offset links 2.5 Design parallel and transverse fillet weld subjected to static and dynamic loading.	Model Demonstration Lecture Using Chalk-Board

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Explain the concept of torsion. TLO 3.2 Use torsional and bending equations for determining the stresses acting on shafts, keys and couplings. TLO 3.3 Explain the types of shafts, keys and couplings with their applications. TLO 3.4 Explain the procedure for design of shaft, keys and coupling for the given condition. TLO 3.5 Determine the dimensions of shaft, keys and coupling for given application. TLO 3.6 Classify the bearings used in power transmission system according to their application. TLO 3.7 Explain the procedure for selection of bearing from manufacturer's catalogue.	**Unit - III Design of Power Transmission through Shaft.** 3.1 Torsion: Concept, assumptions in theory of pure torsion, torsional equation, angle of twist. 3.2 Design of Shafts: Types of shafts, Shaft materials, Standard sizes, Design of solid and hollow shafts based on strength and rigidity criteria. Design of hollow and solid shaft for combined bending and twisting moments and considering the effect of shock and fatigue. 3.3 Design of keys: Types of keys, applications, design of square and rectangular sunk keys, effect of Keyway on strength of shaft. 3.4 Coupling: Types of shafts couplings, Design of muff coupling. 3.5 Bearings: Concept, classification, terminology, applications. 3.6 Selection of bearing (radial ball bearing only) from manufacturer's catalogue.(No numerical)	Lecture Using Chalk-Board Presentations Video Demonstrations. Model Demonstration
4	TLO 4.1 Explain the types of threads used in power transmission and fastening. TLO 4.2 Select appropriate thread profile to be used for given application. TLO 4.3 Determine the torque and efficiency induced in power screw. TLO 4.4 Determine the stresses induced in screw and nut TLO 4.5 Explain the procedure for design of screw and nut of screw jack for given load. TLO 4.6 Determine the dimensions of screw and nut used for power transmission and fastening TLO 4.7 Explain bolt of uniform strength	**Unit - IV Design of Power Screws and Screwed Joints** 4.1 Types of thread profiles used in power transmission and fastening, terminology, relative merits and demerits of each thread profile. 4.2 Torque required to overcome thread and collar friction (no derivation), Efficiency of power screws, Self-locking and overhauling of power screw. 4.3 Stresses induced in screws and nuts (power screw and screwed joint). 4.4 Design of Screw Jack(only screw and nut). 4.5 Design of Bolted joints subjected to direct and eccentric loading, Eccentric load acting parallel to axis of bolt and perpendicular to axis of bolt. (Except angular loads) 4.6 Bolts of Uniform Strength	Lecture Using Chalk-Board Presentations Video Demonstrations. Model Demonstration

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Explain various spring used with their applications TLO 5.2 Determine the stresses induced in helical spring. TLO 5.3 Determine the deflection and equivalent spring stiffness for springs in series and parallel. TLO 5.4 Explain the procedure for design of helical compression spring for the given application. TLO 5.5 Determine the dimensions of spring for given load condition	**Unit - V Design of Springs** 5.1 Springs: Classification and Applications of Springs, Spring - terminology, materials specifications. 5.2 Stresses in helical springs, Wahl's stress factor, Deflection of springs. 5.3 Energy stored in springs, Springs in series and parallel 5.4 Design of Helical springs used in I.C. engine valves, weighing balance, railway buffers.	Lecture Using Chalk-Board Smart board Presentations, Model Demonstration Video Demonstrations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify the material used in any four machine components. LLO 1.2 Collect the specification of the materials.	1	*Material used as per IS standards in simple machines.	2	CO1
LLO 2.1 Identify various modes of failure for the given machine components. LLO 2.2 Draw various modes of failure for the given machine components.	2	Modes of failure in simple machine componenets.	2	CO1
LLO 3.1 Select suitable material for elements of knuckle joint. LLO 3.2 Select suitable factor of safety (FOS). LLO 3.3 Identify modes of failures in knuckle joint. LLO 3.4 Determine the dimensions of elements used in knuckle joints. LLO 3.5 Draw the knuckle joint using available software or manually.	3	*Design of Knuckle Jionts.	2	CO1 CO2

DESIGN OF MACHINE ELEMENTS **Course Code : 316357**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Select the materials for turnbuckle. LLO 4.2 Identify the modes of failure in the elements of turnbuckle LLO 4.3 Determine the dimensions of elements used in turnbuckle LLO 4.4 Select the turnbuckle from design data book (IS 3121:2023) LLO 4.5 Draw the turn buckle using available software or manually.	4	Determination of dimensions of elements of turnbuckle for given load condition	2	CO1 CO2
LLO 5.1 Identify type of loading condition in given application of welded joint LLO 5.2 Calculate length of weld for given welded joint	5	Design a transverse and parallel fillet weld subjected to static and dynamic loading	2	CO2
LLO 6.1 Select suitable material for Hand/Foot lever LLO 6.2 Identify modes of failure in the elements used in Hand/Foot lever LLO 6.3 Determine the dimensions of elements used in Hand/Foot lever LLO 6.4 Draw Bell Crank Lever and Hand/Foot lever.	6	*Determination of dimensions of elements of Hand/Foot lever for given load condition	2	CO1 CO2
LLO 7.1 Select the materials for C clamp used for given application LLO 7.2 Identify various modes of failure for the machine components used in c clamp LLO 7.3 Determine the dimensions of C-Clamp	7	Design C clamp for any one application	2	CO2
LLO 8.1 Select suitable material for elements of given application using design data book. LLO 8.2 Select suitable factor of safety (FOS) LLO 8.3 Identify modes of failures in shafts, keys and coupling LLO 8.4 Determine the dimensions of elements used in given application LLO 8.5 Select suitable dimensions of standard shafts (IS 3688:1990), sunk keys (IS 2048:1983) and muff coupling LLO 8.6 Select bearing used for given application from manufacturers catalogue LLO 8.7 Draw Muff coupling (Assembly & Details) of given power transmission system using available software or manually.	8	*Design of power transmission system in various machines like Lathe machine ,flour mill, drilling machine etc.	6	CO1 CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 9.1 Select material for screw and nut for screw jack LLO 9.2 Select factor of safety (FOS) LLO 9.3 Identify modes of failure in screw and nut of screw jack LLO 9.4 Determine dimensions of screw and nut of screw Jack LLO 9.5 Select the suitable dimension of screw and nut using IS 7008:1999 (for trapezoidal threads) or square threads (IS 2585:2006) LLO 9.6 Draw Screw and nut of Screw Jack using available software or manually.	9	Draw the knuckle joint using available software or manually.	4	CO1 CO4
LLO 10.1 Identify modes of failure in given application LLO 10.2 Select suitable factor of safety LLO 10.3 Determine dimension of screw used in given application	10	*Design of screwed joint subjected to concentric or eccentric load (Any two design cases)	2	CO4
LLO 11.1 Select the suitable material for spring. LLO 11.2 Identify the modes of failures in spring LLO 11.3 Select suitable Factor of Safety (FOS) for the material of spring. LLO 11.4 Determine dimensions of spring used in selected application LLO 11.5 Draw the spring using available software or manually.	11	* Design of helical compression spring. (Any two design cases)	2	CO5
LLO 12.1 Design Screw Jack used for cars or for similar applications and verify the dimensions. LLO 12.2 Prepare CAD drawings (working drawing) of Screw Jack with help of above designed dimensions. LLO 12.3 Select the suitable material for spring. LLO 12.4 Identify the modes of failures in spring LLO 12.5 Select suitable factor of safety (FOS) for the material of spring. LLO 12.6 Determine dimensions of spring used in selected application LLO 12.7 Draw the spring	12	Design of helical tension spring. (Any two design cases)	2	CO1 CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- find load, stresses on single point cutting tool and also prepare chart/model for the same.
- Make models of various joints and levers highlight resisting sections of different elements. (use wood or M.S material)
- Prepare list of different types of bearings used in a bike and write their specifications and basis for selection.
- Prepare list of different types of levers and springs used in a bike, bicycle, Auto Rickshaw, Moped and write their specifications and basis for selection
- Make chart indicating different thread profile and sizes required for different loads in case of screw jack, toggle jack, C-clamps and lead screw of machines.
- Collect different types of springs and write applications of the same.

Micro project

- Make models of various joints and levers highlight resisting sections of different elements
- Make models of various shafts, keys and pulleys highlight resisting sections
- Make models of various couplings highlight resisting sections of different elements
- Prepare model of eccentrically loaded bolted and welded joint and highlight the maximum loaded section.
- Make chart indicating different thread profile and sizes

Field visit

- Field visit to nearby industries

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Different Springs, Nut-Bolt, Standard sectionsWorking models/ Acrylic/Aluminum/Cast/Scrap/Used component	11,12
2	Working models/ Acrylic/Aluminum/Cast/Scrap/Used component of i) Knuckle joint ii) Turn-Buckle	3,4
3	Wall charts for- Types of levers, Types of joints,Tolerance, surface finish, limits and fits, Helicalsprings, Bolted joints, Welded joints, Bearingdesignation, Various types of bearingsAll charts should be plasticor acrylic coated -size 3 ft ×3 ft	3,4,6,8,10
4	i) Foot, Hand, Bell-crank lever ii) Offset linkWorking models/ Acrylic/Aluminum/Cast/Scrap/Used component	6,7
5	Pulley, Shaft, Keys and couplings (all types) ii)Belt, Chain, Gear drive, Metallic ropeWorking models/ Acrylic/Aluminum/Cast/Scrap/Used component	8
6	Ball bearing-single, double row, angular contactand thrust, rolling contact bearings-cylindrical,taper roller, thrust, pedestal, journal, pivot bearing,Spur gear, Helical gearsWorking models/ Acrylic/Aluminum/Cast/Scrap/Used component	8
7	Models of lead screw of lathe, feed screw ofmachine tools, clamping screws, toggle jackscrew, screw jackWorking models/ Acrylic/Aluminum/Cast/Scrap/Used component	9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals of Design	CO1	10	4	4	4	12
2	II	Design of Joints and Levers.	CO2	12	2	4	6	12
3	III	Design of Power Transmission through Shaft.	CO3	15	4	6	8	18
4	IV	Design of Power Screws and Screwed Joints	CO4	13	2	6	8	16
5	V	Design of Springs	CO5	10	2	4	6	12
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests of 30 marks and average of two-unit tests. For laboratory learning 25 Marks,For Self learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 25 marks for laboratory learning. End semester assessment of 70 marks.

XI. SUGGESTED COS - POS MATRIX FORM

DESIGN OF MACHINE ELEMENTS **Course Code : 316357**

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	3	3	-	--	--	1			
CO2	3	3	3	2	--	1	1			
CO3	3	3	3	2	--	1	1			
CO4	3	3	3	2	--	1	1			
CO5	3	3	3	2	--	1	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	S G Kulkarni	Machine Design	McGraw Hill Education (India) Private Limited, 2013, ISBN : 9780070647886
2	Bhandari V. B.	Design of Machine Elements	McGraw-hill education India Pvt. limited, New Delhi, 2017, ISBN-13:978-9339221126
3	Khurmi R.S. and Gupta J.K.	Machine Design	S. Chand New Delhi, 2005, ISBN 10:8121925371 ISBN13:9788121925372
4	Jindal U.C.	Machine Design	Pearson Education India New Delhi, 2010, ISBN13:9788131716595
5	Pandya and Shah	Machine Design	Charotar Publishing house Pvt.ltd. Anand, Gujarat, 2015, ISBN-13:9789385039102
6	Shigley	Mechanical Engineering Design	McGraw-hill education India Pvt. limited, New Delhi, 2017, ISBN-13:978-9339221638
7	PSG	Design Data Book	PSG College of Technology Coimbatore, 2012, ISBN-10:8192735508
8	ISO	IS Codes: IS 4218: 1967 ISO Metric Threads, IS 2693: 1964 Cast Iron Flexible Couplings.	BIS New Delhi
9	ISO	IS 2292: 1963 Taper keys and Keyways, IS 2293: 1963 Gib Head Keys and Keyways	BIS New Delhi
10	ISO	IS 2389: 1963Bolts, Screws, Nuts and Lock Nuts, IS 4694: 1968 Square threads	BIS New Delhi
11	ISO	IS 808: 1967 Structural Steel	BIS New Delhi
12	SKF/NBC	SKF/NBC Catalogue for Bearings	Catalogue for Bearings

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=5EgSrTZ39I8	Animation of knuckle joint
2	https://www.youtube.com/watch?v=i-Z4hz_KX0M	Working of screw jack
3	https://www.youtube.com/watch?v=xjFYKBuatU8	Bearing Selection
4	https://archive.org/details/gov.in.is.3121.2023/page/n5/mode/2up	IS 3121:2023 for turnbuckle
5	https://law.resource.org/pub/in/bis/S01/is.4218.2.2001.pdf	IS 4218:2001 for general purpose metric threads
6	https://ia800205.us.archive.org/35/items/gov.in.is.4552.1.1993/is.4552.1.1993.pdf	IS 4552:1993 for screw jack
7	https://law.resource.org/pub/in/bis/S01/is.2585.2006.pdf	Is 2585:2006 for square threads
8	https://law.resource.org/pub/in/bis/S01/is.2048.1983.pdf	IS 2048:1983 for sunk keys
9	https://law.resource.org/pub/in/bis/S13/is.7906.1.1997.pdf	Is 7906:1997 for helical springs
10	https://law.resource.org/pub/in/bis/S10/is.1024.1999.pdf	IS 1024:1999 for parallel fillet weld

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

COMPUTER INTEGRATED MANUFACTURING SYSTEMS **Course Code : 316359**

Programme Name/s : **Mechanical Engineering/ Manufacturing Technology/ Production Engineering**

Programme Code : **ME/ MRT/ PG**

Semester : **Sixth**

Course Title : **COMPUTER INTEGRATED MANUFACTURING SYSTEMS**

Course Code : **316359**

I. RATIONALE

The manufacturing industry has undergone significant transformations in recent years, driven by advances in computer technology, automation, and robotics. As a result, there is a growing need for skilled professionals who can design, implement, and manage computer-integrated manufacturing systems. This course intends to help the students of Mechanical Engineering with a comprehensive understanding of the concepts, techniques, and applications of Computer Integrated Manufacturing.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcome through various teaching learning experiences to: Apply skills related to Computer-Integrated Manufacturing Systems in real-world manufacturing environment.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Interpret the components of CIM architecture for a given application.
- CO2 - Apply CAD techniques to design simple mechanical parts.
- CO3 - Apply CAM techniques to optimize machining processes.
- CO4 - Use different software and hardware in CIM efficiently.
- CO5 - Develop program to manage robotic / automation system using relevant software.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316359	COMPUTER INTEGRATED MANUFACTURING SYSTEMS	CIM	DSE	4	-	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 State the importance of CIM in modern manufacturing. TLO 1.2 Explain the terms production rate, quality, accuracy, repeatability and flexibility related to quality metrics. TLO 1.3 Organize the various components in CIM framework architecture.	**Unit - I Introduction to Computer Integrated Manufacturing (CIM)** 1.1 Historical development, Definition, concept, and importance of CIM in modern manufacturing 1.2 Current Production Needs- Production rate, Quality, Accuracy, Repeatability, Flexibility 1.3 CIM Architecture and Components- Computer-Aided Design (CAD), Computer Aided Process Planning (CAPP), Computer Aided Manufacturing Control (CAMC), Computer Aided Business Function (CABF)	Lecture Using Chalk-Board Video Demonstrations Presentations Case Study
2	TLO 2.1 State the importance of finite element analysis and optimization techniques. TLO 2.2 Distinguish between concurrent and sequential engineering with different parameters. TLO 2.3 Prepare the simple engineering component by using CAD/CAE software. TLO 2.4 Explain the concept of CAPP, CABF, ERP, MRP and their applications in CIM.	**Unit - II Computer-Aided Design (CAD)** 2.1 Introduction to CAD-Geometric Modelling, Finite Element Analysis and optimization, Overview of CAD-CAE Integration 2.2 Concurrent Engineering (CE) and Sequential Engineering (SE) -Concept, Elements, Advantages, Disadvantages. 2.3 CAD software and systems: Introduction of Software for CAE, Simulation, Automated Drafting, and generation of report 2.4 Logical steps in CAPP, CABF, Enterprise Resource Planning (ERP), Role of ERP in Business, Advantages and applications of ERP Software, Material Resource Planning (MRP), Role of MRP in Business, Advantages and benefits of MRP Software's.	Presentations Lecture Using Chalk-Board Video Demonstrations Site/Industry Visit

COMPUTER INTEGRATED MANUFACTURING SYSTEMS **Course Code : 316359**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 State the importance of CAM in CIM. TLO 3.2 Explain the importance of HMI and SCADA in the Industrial Automation. TLO 3.3 Plan and prepare the sequence of processing steps for an NC machine in CAMC. TLO 3.4 Describe the emerging trends in CAM.	**Unit - III Computer-Aided Manufacturing (CAM)** 3.1 Introduction to CAM: CAM software and systems, CAM data exchange and compatibility 3.2 Human Machine Interface (HMI) and Supervisory Control and Data Acquisition (SCADA): Introduction, need, benefits and typical applications 3.3 Computer-Aided Manufacturing Control (CAMC): Interfacing Part Program to CNC, Computerized Control Monitoring and Control, Computer Aided Quality Control (CAQC) 3.4 Overview of Emerging Areas: Supply Chain Management (SCM), Digital Manufacturing, Industry Revolution 4.0.	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Case Study
4	TLO 4.1 Distinguish different network topologies in CIM with sketch. TLO 4.2 Explain the given application of software, network software, and network hardware with its purpose. TLO 4.3 Describe the types of DBMS with their functions.	**Unit - IV CIM Networking and Data Base Management System** 4.1 CIM Networking: Types of networks and its characteristics, applications, Types of network topologies-star, bus and ring topology 4.2 Component of Networking: Application software for CIM, Network software, and network hardware 4.3 Database Management System (DBMS): Database types (Hierarchical, Network, Relational, Object Oriented), Function of DBMS, Selection of DBMS, Advantages of DBMS.	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Case Study
5	TLO 5.1 Define automation and robotics and their importance in CIM. TLO 5.2 Make use of automation and robotic elements for given application. TLO 5.3 Distinguish between different types of automation and robots. TLO 5.4 Explain the applications of automation and robotics in CIM.	**Unit - V Automation and Robotics** 5.1 Automation: Definition, need, principles and benefits , Robotics: Definition, need, basic concepts and benefits 5.2 Elements of Automation, Levels of automation, Components of Robotics-End effectors-grippers and tools, Drive systems, Control systems 5.3 Types of Automation and Robotics -Concept, Definition, need, and elements of Fixed, Programmable, Flexible Automation -Concept and constructional details of Cartesian, Cylindrical, Polar Configuration Robot, Gantry robot, Selective Compliance Articulated Robot Arm (SCARA). 5.4 Advantages, limitations and applications of automation and robotics in CIM	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Case Study

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

COMPUTER INTEGRATED MANUFACTURING SYSTEMS **Course Code : 316359**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Convert 3D modeled components into detailed 2D engineering drawings with proper views and projections. LLO 1.2 Use dimensioning and tolerances as per ISO, ASME, or BIS standards.	1	*Drawing of simple mechanical parts modeled using the drafting workbench of CAD Software.	2	CO1 CO2
LLO 2.1 Develop orthographic projections (front, top, and side views) and isometric projections for component visualization. LLO 2.2 Apply GD&T principles in technical drawings for accurate part specifications.	2	*Development of the simple mechanical part by using the geometric modeling workbench (Any 3 D modelling software).	2	CO2
LLO 3.1 Generate a Bill of Materials (BOM) and properly format the title block. LLO 3.2 Generate automated BOMs from CAD assemblies using built-in tools in software (like SolidWorks, CATIA, AutoCAD, Creo or any suitable software.)	3	Generation of Bill of Material (BOM) and other data using CAD Software.	2	CO2
LLO 4.1 Prepare a process plan for a suitable manufacturing operations (e.g. casting, forming, welding) LLO 4.2 Develop an optimized sequence of operations for manufacturing a selected part using any suitable CAPP software.	4	Computer Aided Process Plan for the selected part using various CAPP Software.	2	CO1 CO2
LLO 5.1 Choose appropriate G and M codes for preparing part on CNC (Turning or Milling) LLO 5.2 Develop a part with simple machining operations (like facing, turning, drilling, etc.) as per given drawing.	5	*CNC code for a simple machining operation using a CNC Machine/Trainner/Simulator.	2	CO1 CO2 CO3
LLO 6.1 Inspect the dimensional accuracy of component using available CAQC software.	6	Inspection of the part using available CAQC software.	2	CO3
LLO 7.1 Select a suitable MRP software for CIM and assembly. LLO 7.2 Prepare report on the real-time data obtained by MRP Software in automated manufacturing.	7	MRP (Material Resource Planning) software for CIM and assembly.	2	CO1 CO3 CO4
LLO 8.1 Prepare a layout using suitable network topology in given situation. LLO 8.2 Connect given computer systems/hardware as per network layout.	8	*Layout of network topology and network hardware/network software for given situation.	2	CO4

COMPUTER INTEGRATED MANUFACTURING SYSTEMS **Course Code : 316359**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 9.1 Simulate the given system component (s) such as conveyors, machining centers, assembly lines using available software.	9	*Design simple manufacturing cells (e.g., machining cell, assembly cell) using available CAD software.	2	CO1 CO2 CO3 CO5
LLO 10.1 Write a simple Ladder Logic program for simple applications. LLO 10.2 Program for simple automation applications.	10	*PLC Programming to control a simple automation system.	2	CO5
LLO 11.1 Select the required hardware components (motors, sensors, Prime controllers) and their functions. LLO 11.2 Program for the simple robot with wrist or arm movements (to move forward, backward, turn, and stop) using motor control commands.	11	Programming of a robot to perform simple task.	2	CO5
LLO 12.1 Prepare a robot program to perform simple tasks by using available Teach Pendant/Offline Programming/Simulation Software.	12	*Use Teach Pendent/Offline Programming/Simulation Software to program a robotic arm to perform pick and place and stacking of objects.	2	CO1 CO5
LLO 13.1 Prepare a detailed report on the elements of an FMS and its computer-controlled automation. LLO 13.2 Arrange a presentation in a group on FMS technology in modern smart factories.	13	Elements of FMS and its nature of controlling by computer through Video film/actual demonstration (plant visit).	2	CO3 CO5
LLO 14.1 Prepare a detailed report on robotic elements, type, configuration, and control mechanisms. LLO 14.2 Arrange a presentation in a group on findings of robotics trends in Industry 4.0 and Smart Manufacturing.	14	Various elments of Robotic Systems, types of robots, their configuration, and the nature of controlling by computer through video/actual demonstration (plant visit).	2	CO4 CO5
LLO 15.1 Select suitable networking peripherals/components to establish network. LLO 15.2 Set up networking of CNC machines, computers and other devices using the relevant method efficiently.	15	*Establish networking between CNC Machines, computers and supported peripherals of your Institute to exchange the manufacturing data and produce simple component.	2	CO4

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING) : NOT APPLICABLE

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Free / Educational versions of CAD Software (1+20 users)	1,2,3,4
2	Free / Educational versions of 3D Modelling software (1+10 users)	1,2,3,4
3	Computers minimum 4GB RAM and above	1,2,3,4,5
4	Microcontrollers (e.g., Arduino, Raspberry Pi), sensors (e.g., temperature, humidity).	10,11,12,13
5	Free / Educational versions software of networking, Robot programming, simulation.	10,11,12,13,9
6	Educational programmable robotics arm to manipulate objects.	10,11,14,15
7	Free / Educational versions software of networking FMS Simulation Software	13
8	CNC Milling 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type-X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, with ATC along with essential accessories.	15
9	Free / Educational versions software of CAM Software (1+20 user)	4,6,8
10	CNC Turning 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type minimum diameter 25 mm, Length 120 mm with ATC along with essential accessories.	5,15
11	CNC Simulation software and control pads (CAMLAB CNC Software, MasterCAM/NXCAM/, DONC CNC machine simulator, PRO, SWANSOFT, CAPSMILL and CAPSTURN IN cam software, DONCMILL AND DONCTURN software), CutViewer Turn& Mill, Sinewave Turn& Mill or equivalent simulation software.	5,15
12	Free / Educational versions software of CAQC software or CMM/other system	6
13	Free / Educational versions software of MRP/ERP/CRM/SCM and PLM Software (1+10 user)	7,10,12,13,9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Computer Integrated Manufacturing (CIM)	CO1	8	4	8	0	12
2	II	Computer-Aided Design (CAD)	CO2	12	4	10	0	14
3	III	Computer-Aided Manufacturing (CAM)	CO3	14	2	6	6	14
4	IV	CIM Networking and Data Base Management System	CO4	14	4	4	6	14
5	V	Automation and Robotics	CO5	12	4	6	6	16
Grand Total				**60**	**18**	**34**	**18**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests of 30 marks and average of two-unit tests, For laboratory learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 25 marks for laboratory learning, End semester assessment of 70 marks.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	3	2	-	1	1			
CO2	3	2	3	3	1	2	1			
CO3	3	2	3	3	1	2	1			
CO4	3	2	3	2	-	2	1			
CO5	3	2	3	3	1	2	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Rao P N	Computer Aided Manufacturing	McGraw-Hill Education, New Delhi (2010), ISBN-9780074631034
2	Groover, Mikell P	Automation Production System and Computer Integrated Manufacturing	Pearson Education Ltd. Canada ISBN: 9780130546524
3	Dr. Sushil Kumar Chaudhary, Dr. R S Jodoun	Computer Integrated Manufacturing & Computer Aided Manufacturing	Walnut Publication, ISBN: 9391145272
4	R K Rajput	Robotics and Industrial Automation	S Chand Publishing, ISBN: 9788121929974
5	Kant S	Principles of Computer-Integrated Manufacturing	Prentice Hall India Learning Private Limited ISBN-13. 978-8120314764
6	R. Panneerselvam, P. Senthilkumar, P. Sivasankaran	Computer-Integrated Manufacturing: Automation in Manufacturing	Cengage India Private Limited ISBN: 9353503205
7	Radhakrishnan P.	CAD/CAM/CIM	New Edge International Publisher, New Delhi ISBN: 8122439802
8	Chang, T.C. and Wysk, R. A	Computer-aided manufacturing	Prentice Hall PTR, ISBN-10. 0131429191.
9	Alavudden A, Venkateshwran N	Computer Integrated Manufacturing	PHI Learning Pvt. Ltd., 2008, ISBN-9788120333451
10	Waldner J B	CIM: Principles of Computer Integrated Manufacturing	John Wiley & Sons Inc. UK (1992) ISBN: 9780471934509

Sr.No	Author	Title	Publisher with ISBN Number
11	Scheer A W	CIM Computer Integrated Manufacturing Towards the Factory of The Future	Springer-Verlag Berlin and Heidelberg GmbH & Co. I SBN: 9783642789908
12	William W.	Flexible Manufacturing Cells and System	Luggen Hall, England Cliffs, New Jersy, ISBN: 0133217388
13	Pabla B.S., Adithan M.	CNC Machines	New Age International, New Delhi, ISBN: 8122434266

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=2HbHmdVf6nI	Automation & Control Computer Integrated Manufacturing Trainer
2	http://www.digimat.in/nptel/courses/video/112104289/L02.html	NPTEL Video Course on CIM
3	https://www.youtube.com/watch?v=_zr4__3Rz0c	How Computer-Integrated Manufacturing is Revolutionizing the Industry?
4	https://www.youtube.com/watch?v=XJjc923jiKk	Introduction of CIM
5	https://www.youtube.com/watch?v=N-QyvP3FqKI	Robotics and Automation
6	https://www.youtube.com/watch?v=66WYARKYz5c	Industry 4.0: Robotics & Automation
7	https://www.youtube.com/@PSDettmerMATC	Robotics & Automation
8	https://www.youtube.com/watch?v=xBLdHyVdYew	Robotic Process Automation (RPA)
9	https://www.youtube.com/watch?v=C-Xljmtfk38	Robotics and Automation: Revolutionizing Maintenance
10	https://www.youtube.com/watch?v=U2AGLeJBFNg	World’s most advanced robotic warehouse
11	https://www.youtube.com/watch?v=3rkqzmAG7G4	WH FLEX - Flexible Automation System
12	https://www.youtube.com/watch?v=Hx6DXuildSc	Computer Aided Manufacturing (CAM)
13	https://www.youtube.com/watch?v=FdipJNG_vV8	Computer Aided Manufacturing (CAM)

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

INDUSTRIAL ENGINEERING AND QUALITY CONTROL **Course Code : 316362**

Programme Name/s : **Mechanical Engineering**
Programme Code : **ME**
Semester : **Sixth**
Course Title : **INDUSTRIAL ENGINEERING AND QUALITY CONTROL**
Course Code : **316362**

I. RATIONALE

In today's highly competitive industrial environment, efficiency and quality are critical for organizational success. Industrial Engineering focuses on process optimization, resource utilization, and system efficiency, while quality control ensures that products and services meet predefined standards. The integration of these two aspects enables industries to minimize waste, reduce costs, enhance product reliability, and improve customer satisfaction. This course plays a crucial role in developing Mechanical Diploma Engineering students with the knowledge and skills required to optimize industrial processes, enhance productivity, and ensure quality in manufacturing and service sectors by using conventional as well as modern computerized methods.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcome through various teaching learning experiences: Apply knowledge & skills related to Industrial Engineering for enhancement of quality & productivity..

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Prepare the process sheet in given situation.
- CO2 - Apply work study techniques for optimizing manufacturing processes.
- CO3 - Apply quality control tools for monitoring product quality in industrial processes.
- CO4 - Determine process Capability using Statistical Quality Control techniques.
- CO5 - Choose relevant computer aided quality control / inspection method for manufacturing.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316362	INDUSTRIAL ENGINEERING AND QUALITY CONTROL	IEQ	DSC	4	-	2	2	8	4	3	30	70	100	40	25	10	-	-	25	10	150

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 List site selection factors. TLO 1.2 Draw types of plant layout. TLO 1.3 Compare types of production systems. TLO 1.4 Explain methods for improving productivity. TLO 1.5 Prepare operation sheet for given component TLO 1.6 Explain need and importance of line balancing	**Unit - I Plant and Process Engineering** 1.1 Plant location and layout: Importance of site selection, factors affecting site selection, types of plant layouts, design principles of plant layout, merits and demerits of different plant layouts. 1.2 Production systems: Types of production system job order production, batch production, mass production, continuous production. 1.3 Productivity: -Definition, measurement of productivity, methods of improving productivity. 1.4 Process Engineering: Definition and importance of process engineering, procedure of process planning, factors affecting process planning, operation sheet/route sheet. 1.5 Line balancing: Definition, importance of line balancing.	Lecture Using Chalk-Board Video Demonstrations Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain importance of industrial engineering. TLO 2.2 Define work study, method study, time study. TLO 2.3 State the objectives of work study, method study, time study. TLO 2.4 State meaning of therblig symbols. TLO 2.5 Prepare a relevant type of chart for given process using recording techniques. TLO 2.6 Calculate standard time for a given activity.	**Unit - II Work Study** 2.1 Industrial Engineering: Definition, need, objectives and scope. 2.2 Work study: Components of work study, method study (Motion study) and time study (Work measurement) 2.3 Method study: Definition, objectives, procedure, factors considered for selection of work for method study 2.4 Recording techniques of method study: Process charts — outline process chart, flow process chart, two handed process chart/SIMO chart, multiple activity chart, flow diagram, string diagram, therbligs, travel chart. 2.5 Work Measurement : Objectives, procedure, time study, time study equipment, time study allowances. 2.6 Calculation of standard time. (simple numerical on work study)	Lecture Using Chalk-Board Video Demonstrations Presentations Role Play
3	TLO 3.1 Explain different quality concepts. TLO 3.2 Define cost of quality and value of quality. TLO 3.3 Solve quality problems using quality control tools for a given problem. TLO 3.4 Differentiate between quality control and inspection. TLO 3.5 Differentiate between types of inspection.	**Unit - III Quality Control** 3.1 Meaning of quality of product and services, importance of quality control, quality characteristics, quality of design, quality of conformance, quality of performance, meaning and importance of quality assurance. 3.2 Quality economics: Cost of quality, value of quality, economics of quality confirmation, cost of quality appraisal, prevention, external and internal failure cost. 3.3 Quality control tools: Basic concept and areas of application. various Q-C tools, cause-and-effect diagram (fishbone or Ishikawa diagram), check sheet, histogram, pareto chart and scatter diagram 3.4 Inspection definition and meaning, difference between Inspection and quality control, classification of inspection —(i) Inprocess inspection (ii) Final inspection (iii) Raw material inspection. 3.5 Role of quality control inspector /supervisor.	Lecture Using Chalk-Board Presentations Video Demonstrations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Explain SQC and its importance. TLO 4.2 Differentiate variables and attribute data. TLO 4.3 Draw control charts for variables and attributes. TLO 4.4 Determine process capability of a given manufacturing process. TLO 4.5 Explain different types of sampling plan.	**Unit - IV Statistical Quality Control** 4.1 Definition, objectives and benefits of Statistical Quality Control (SQC). 4.2 Variable and attribute measurement. inherent and assignable sources of variation. 4.3 Control charts for variables — X bar and R charts, control charts for attributes p, np, c charts. 4.4 Process capability of machine (+/-3 sigma or +/- 6 sigma), Cp and Cpk calculations. 4.5 Acceptance sampling concept, comparison with 100% inspection operating characteristics curve. 4.6 Different types of sampling methods.	Lecture Using Chalk-Board Presentations Video Demonstrations
5	TLO 5.1 List different types of computer-aided process planning. TLO 5.2 Describe computer-aided quality control TLO 5.3 List quality control software. TLO 5.4 Describe computer-aided inspection TLO 5.5 Compare traditional quality control and computer aided quality control TLO 5.6 Explain CAQC, its objectives and relevant manufacturing example.	**Unit - V Computer-aided Process Planning and Quality Control** 5.1 Computer-Aided Process Planning (CAPP):- Introduction, objectives, types, applications, comparison between traditional process planning and CAPP 5.2 Computer-Aided Quality Control (CAQC) Introduction, objectives, types ,applications comparison between traditional quality control and CAQC 5.3 Computer-Aided Inspection (CAI):- Introduction, objectives, applications, comparison between traditional inspection and CAI.	Lecture Using Chalk-Board Presentations Flipped Classroom

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify nearby small scale industry. LLO 1.2 List product, process and volume. LLO 1.3 Prepare suitable plant layout.	1	Preparation of Plant Layout for Small Scale Industry.	2	CO1
LLO 2.1 Identify key dimensions, tolerances and surface finish requirement. LLO 2.2 Evaluate manufacturing feasibility based on part print analysis LLO 2.3 Enlist manufacturing operation LLO 2.4 Arrange the optimized sequence of operation	2	Part print analysis for manufacturing feasibility.	2	CO1

INDUSTRIAL ENGINEERING AND QUALITY CONTROL **Course Code : 316362**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 3.1 Analyze the given job and interpret its design and manufacturing requirements. LLO 3.2 Identify suitable manufacturing processes and sequences them appropriately LLO 3.3 Select appropriate machines, tools, cutting parameters, and inspection methods LLO 3.4 Prepare a comprehensive process plan including operation sheets and process routing.	3	*Preparation of a detail process plan for a given manufacturing job.	4	CO1 CO5
LLO 4.1 Select the activity for motion study from given examples. LLO 4.2 Select the equipment's for motion study LLO 4.3 Record motion involved in operation.	4	Record motions of given manufacturing operation using motion study.	2	CO2
LLO 5.1 Select the activity for time study from given examples LLO 5.2 Select the proper equipment's for time study LLO 5.3 Measure time component involved in operation LLO 5.4 Compile measured time for each activity	5	Measure time of given manufacturing operation using time study method.	2	CO2
LLO 6.1 Identify the essential and excess motions in given situation. LLO 6.2 Assess the excess motion and time in given situation LLO 6.3 Prepare new motion chart by eliminating excess motion time.	6	* Productivity improvement using motions and time study.	2	CO2
LLO 7.1 Select activity from given examples LLO 7.2 Choose appropriate THERBLIGS for motion study LLO 7.3 Draw two handed motion chart.	7	* Construction of two handed motion chart	2	CO2
LLO 8.1 Prepare multiple activity chart for given situation.	8	Prepration of multiple activity chart	2	CO2
LLO 9.1 Select work to be measured from given examples LLO 9.2 Record the time activity wise by observing each activity LLO 9.3 Calculate standard time by adding normal time and applicable allowances	9	*Determination of standard time for given manufacturing operation	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 10.1 Select problem for pareto chart analysis from given examples LLO 10.2 Choose any computer aided quality control software LLO 10.3 Generate a pareto chart	10	*Pareto chart using computer aided quality control software.	2	CO3 CO5
LLO 11.1 Identify a real-world mechanical issue (e.g., machine failure, defective parts, poor surface finish). LLO 11.2 Choose any computer aided quality control software LLO 11.3 Construct a fishbone diagram	11	Develop a fishbone diagram for a given mechanical problem.	2	CO3 CO5
LLO 12.1 Collect and arrange data LLO 12.2 Calculate X bar and R LLO 12.3 Calculate UCL and LCL LLO 12.4 Draw and interpret variable chart LLO 12.5 Validate using CAQC software.	12	*Preparation of variable control charts (X bar and R) for given data and validate using CAQC software.	2	CO4 CO5
LLO 13.1 Collect and arrange data LLO 13.2 Calculate P bar and C bar LLO 13.3 Calculate UCL and LCL LLO 13.4 Draw and interpret attribute chart LLO 13.5 Validate using CAQC software.	13	Preparation attribute control charts (P-chart and C-chart) for given data and validate using CAQC software.	2	CO4 CO5
LLO 14.1 Collect and arrange data LLO 14.2 Determine process capability LLO 14.3 Validate using CAQC software.	14	*Determination of process capability and validate using CAQC software.	2	CO4 CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Industrial Visit to an Automobile manufacturing plant
- Collect an information and make a report about Quality Circle forum of India. (QCFI)
- Collect an information and make a repot about different software's used in CAPP, CAQC and CAI
- Choose a task (Typing a document, packing items, assembling a small product etc.), record time for each step using a stopwatch, and analyze it. Suggest improvements if any.
- Analyze the ergonomic setup of a workstation (e.g., Computer desk, Assembly line, Kitchen work area of a Canteen,

Machine shop arrangement, Inspection table). Identify posture issues, repetitive strain risks, and suggest ergonomic improvements.
• Visit to Small-Scale Industry, create a layout to reduce material handling time and improve workflow efficiency.
• Prepare Wall Chart of 3 Sigma and Six Sigma Curves.
• Prepare a wall chart using standard Therbligs, Giving meaning of Each Symbol.
• Compare Manual Process planning with a computer aided approach.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Standard samples like steel balls, bearings, turning operation jobs, Milling operation Jobs, Gears for sample measurement	2,4,14,12,13
2	Open source freeware / educational version CAQC,CAPP,CAI software	3,10,11,14,12,13
3	Stop watch timing capacity: 23 Hrs, 59 mins and 59.99 secs, Accuracy: +/- 3 seconds/day	5,6,7,8,9,10
4	Digital video camera for micro motion analysis with following specification (i) ISO 100-12800 (ii) Focal length f= 3.5-5.6 (iii) 24.2 MP(iv) lenses 18-55 mm	5,6,7,8,9,10

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Plant and Process Engineering	CO1	12	4	4	6	14
2	II	Work Study	CO2	12	4	4	6	14
3	III	Quality Control	CO3	12	2	8	4	14
4	IV	Statistical Quality Control	CO4	14	2	4	12	18
5	V	Computer-aided Process Planning and Quality Control	CO5	10	2	4	4	10
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two Unit Tests of 30 Marks and average of two unit tests.
- For Laboratory learning Term Work -25 Marks ;
- For Self Learning-25 Marks

Summative Assessment (Assessment of Learning)

- End Semester Assessment of 70 Marks

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	2	-	-	2	1			
CO2	3	2	1	-	1	-	1			
CO3	3	3	2	1	1	-	1			
CO4	3	3	2	1	-	-	1			
CO5	3	3	2	3	-	-	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Khanna, O.P.	Industrial Engineering and management	Dhanapat Rai Publications(P) Ltd., New Delhi, (1980), ISBN-10: 818992835X
2	Mahajan M.	Statistical Quality Control	Dhanpat Rai and Sons, New Delhi, (2006) ISBN-10: 817700039X
3	Jain R.K	Engineering Metrology	Khanna Publishers; Special Edition (1 January 2022); Khanna Publishers ISBN-10 9788174091536 ISBN-13 978-8174091536
4	M. Groover	Computer-Aided Design and Manufacturing	Pearson Education; 1st edition (1 January 2003); Pearson Education ISBN-10, 8177584162. ISBN-13, 978-8174906700
5	P. N. Rao	Computer Aided Manufacturing	McGraw Hill Education (1 July 2017) ISBN-10 007463103 ,ISBN-13 ,978-0074631034
6	L C Jhamb	Production Planning and Control	Everest Publishing House; 12th Edition (1 January 2010) ISBN-10 8186314725 ,ISBN-13 978-8186314722
7	T R Banga , S C Sharma	Industrial Organization and Engineering Economics.	Khanna Publication 1 January 2006 ISBN - 10 8174090789 ISBN - 13 978-9174090782

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://youtu.be/6ZevuJlCFBM?si=X5vCK0GAHSlU21m7	Process capability Cp, Cpk, Pp, Ppk, analysis in MINITAB
2	https://www.youtube.com/watch?v=gJDYV2SmFeY	Introduction and concept of productivity
3	https://www.youtube.com/watch?v=KNFZXNWYVno	Work Study: Basic concept
4	https://www.youtube.com/watch?v=y6NKspIn2XE	Method Study: Recording techniques
5	http://digimat.in/nptel/courses/video/112107259/L01.html	Introduction: Fundamental concepts of quality, inspection and their role in manufacturing
6	https://www.youtube.com/watch?v=yYIVumq6sVM	Production planning and control
7	https://www.youtube.com/watch?v=qb3mvJ1gb9g	Statistical quality control (SQC)
8	https://hcmindonesia.wordpress.com/wp-content/uploads/2012/12/introduction-to-work-study.pdf	Introduction to work study: Edited by George Kanawaty Fourth (revised) edition
9	https://www.youtube.com/watch?v=oMEXLiANqMU	Computer aided quality control

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students