GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**Power Engineering**
COURSE CODE	**ME41203**
PREREQUISITE COURSE CODE & TITLE	**Engineering Thermodynamics (ME 31202)**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL				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	
ME41203	Power Engineering	DSC	04	-	02	-	06	03	03	30	70	100	40	25	10	25#	10			150

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, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

The knowledge of power engineering is useful in selecting a suitable prime mover for a given application along with maintaining and testing of these devices. Therefore, the knowledge and skills covering the basic principles of power engineering devices are necessary for mechanical diploma engineers. In view of the requirements, this course is designed to establish basic fundamental and practical knowledge in the fields of I.C. engines and its auxiliaries, air compressors, gas turbines, jet propulsion system, refrigeration & air conditioning systems.

III. COURSE-LEVEL LEARNING OUTCOMES (CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Conduct the test for the performance of refrigerator.
CO2: Conduct the test for the performance of air conditioner.
CO3: Identify the different components of IC engine auxiliaries.
CO4: Conduct the test for the performance of the IC engine
CO5: Maintain different components of air compressor.
CO6: Identify the different components of gas turbine and jet propulsion system.

IV. THEORY LEARNING OUT COMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		SECTION I		
UNIT –I	**Refrigeration**			**(CL Hrs- 12 , Marks-12)**
1	TLO 1.1 Sketch vapor compression refrigeration (VCRS) and Vapor absorption refrigeration (VARS) cycle on P-H and T-S diagram. TLO 1.2 Select the refrigerant for given application TLO 1.3 Explain GWP and ODP	1.1 Definition of refrigeration, refrigeration effect, unit of refrigeration 1.2 Principle of Vapor Compression Refrigeration System (VCRS) components, working of VCRS, representation of the vapor compression cycle on P-H & T-S diagram, sub cooling and superheating. expression for refrigerating effect, work done and power required, coefficient of performance COP. (Simple numerical on VCRS) 1.3 Principle of vapor absorption refrigeration system (VARS), basic components, construction and working. comparison of VCRS and VARS. (No numerical on VARS) 1.4 Refrigerants-Definition, properties of refrigerant, primary and secondary refrigerant, selection of refrigerant, concept of Global Warming Potential (GWP), Ozone Depletion Potential (ODP).	1. Lecture using Chalk and Board 2. Charts and Models 3. Video presentation	CO1
UNIT –II	**Air Conditioning**			**(CL Hrs- 04 , Marks-11)**
2	TLO 2.1 Determine property of the air for the given condition. TLO 2.2 Explain window and split air conditioner	2.1 Air conditioning definition, classification, comfort air conditioning, industrial air conditioning. 2.2 Psychrometry, properties of air, psychrometric processes: sensible heating, cooling, humidification, dehumidification, cooling and humidification, cooling and dehumidification, representation on psychrometric chart. (Simple numerical using psychrometric charts and tables) 2.3 Construction and working of window and split air conditioner, refrigerator, water cooler, ice plant, and cold storage.	1. Lecture using Chalk and Board 2. Charts and Models 3. Video presentation	CO2

UNIT-III IC Engine and Auxiliaries (CL Hrs-10, Marks-12)				
3.	TLO 3.1 Explain with sketch the construction and working of IC engine auxiliaries (turbo chargers, inline fuel injection pump, piezoelectric injectors, EGR, MPFI systems. TLO3.2 Explain CRDI system	3.1 VVTI Engines – concept and arrangement, supercharging, Turbocharging, objectives and advantages, Variable geometry turbo chargers, MPFI layout, various sensors in IC engines. Rotary and inline fuel injection pump, piezoelectric injectors, Exhaust Gas Recirculation (EGR) layout. 3.2 Common rail direct injection diesel engines (CRDI) control by electronic control unit (ECU)	1. Lecture using, charts, models Chalk and Board	CO3
SECTION II				
UNIT-IV Testing of IC Engine and Pollution Control				**(CL Hrs-14, Marks-12)**
4	TLO 4.1 Calculate the performance parameters of the given I.C. engine. TLO 4.2 Explain the procedure to calculate the indicated power of the given engine using the Morse test. TLO4.3 Explain with neat sketch working of catalytic converter to control the emissions from the I.C engine. TLO 4.4 Illustrate the diagnostic procedure of the Engine Control Unit with flow diagram.	4.1 Purpose of I.C. engine testing, I.C. engine testing norms. Definition & measurement of performance parameters brake power, indicated power, frictional power, brake and indicated mean effective pressures, brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, and relative efficiency. Morse test, heat Balance sheet, (Simple numerical on the performance of I.C. engines, Morse test & heat balance sheet) 4.2 Polluting emissions in S.I. & C.I engines and their effects on the environment. Pollution Controlling methods: Catalytic converters. Standard pollution norms like EURO IV & VI, BS-VI. Engine Control Unit (ECU: Working and Diagnostic procedure	Lecture using Chalk and Board	CO4
UNIT-V Introduction to Air Compressors				**(CL Hrs-10, Marks-11)**
5	TLO 5.1 Classify air compressors. TLO 5.2 Explain the construction and working of single-stage& two-stage reciprocating air compressors. TLO 5.3 Calculate the performance parameters of the given compressor. TLO 5.4 Select relevant air compressor for the given application with justification.	5.1 Function of air compressor, uses of compressed air, classification of air compressors. Construction and working of single-stage and two-stage reciprocating air compressors, screw compressor, centrifugal compressor, axial flow compressor. Comparison of rotary compressor with reciprocating air compressor. 5.2 Necessity of multi-staging, advantages of multi-staging, inter cooling,	1. Lecture using Chalk and Board 2. Charts and Models 3. Video presentation	CO5

	.	representation of processes involved on P-V diagram, calculation of work done. 5.3 Specifications of air compressors, pressure ratio, compressor capacity, free air delivered, volumetric efficiency, isothermal efficiency. (Simple numerical on reciprocating air compressor)		
UNIT- VI Gas Turbines & Jet Propulsion				**(CL Hrs-10, Marks-12)**
6	TLO 6.1Name different components of gas turbines. TLO 6.2 Compare open cycle and closed cycle gas turbine. TLO 6.3 Name applications of gas turbine. TLO 6.4 Explain the working principle of Ramjet Turbojet, Turboprop and Rocket engine.	6.1 Introduction to a gas turbine, working cycle, Elements of a gas turbine. (Descriptive treatment only) 6.2 Open cycle and closed cycle gas turbine. Their comparison (Descriptive treatment only) 6.3 Applications of a gas turbine (Descriptive treatment only). 6.4 Working principle of Turbojet, Rocket, Rocket fuels. (Descriptive treatment only)	1. Lecture using Chalk and Board 2. Charts and Models 3. Video presentation	CO6

V.

LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Perform the test using vapor compression refrigeration test rig to measure the various parameters like temperature, pressure and calculate the COP of the system.	* Perform test on vapor compression refrigeration cycle test rig to find the COP	2	CO1
2	LLO 2.1 Measure air properties of conditioned air such as dry bulb temperature, wet bulb temperature using a sling psychrometer.	* Demonstrate the use of sling psychrometer	2	CO1
3	LLO 3.1 Prepare a schematic diagram showing the various components of a domestic refrigerator and prepare a sketch of flow-path of refrigerant.	* Trace the flow of refrigerant through various components of the domestic refrigerator, water cooler. .	2	CO1
4	LLO 4.1 Perform a test using a window air conditioner to measure temperature, pressure, mass flow rate etc. and perform a test using a window air conditioner to determine its COP.	Test on window air conditioner	2	CO2
5	LLO 5.1 Measure the input current, voltage, working pressure and temperature by using appropriate measuring instruments. And diagnose the faults in the given air-conditioning system	* Demonstration of split air conditioner.	2	CO2

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
6	LLO 6.1 Perform the test using air conditioning test rig to measure the various parameters like temperature, pressure, mass flow rate of air etc. and calculate the COP and cooling capacity of the given air conditioning system.	*Test on air conditioning test rig.	4	CO2
7	LLO 7.1 Inspect the air conditioning system and prepare the checklist for energy efficiency	Demonstrate Energy saving in air conditioning system.	2	CO2
8	LLO 8.1 Identify the different components of water cooler, ice plant, and cold storage.	Demonstrate the different components of Refrigerator, water cooler, ice plant, and cold storage.	4	CO1
9	LLO 9.1 Prepare a schematic diagram showing the various components of VVTI Engines, supercharging and turbocharging, LLO 9.2 Prepare a sketch of MPFI, EGR, CRDI layout.	* Demonstration of IC engines Auxiliaries: VVTI engine, supercharger, turbocharger, inline fuel injection pump, piezoelectric injectors, EGR, MPFI, CRDI systems.	2	CO3
10	LLO 10.1 Select proper instrument to conduct a test on IC engine. Measure the various parameters like temperature, pressure, fuel consumption, water flowrate, using I.C. engine test rig	* Demonstration of I.C. engine test rig Part I	2	CO4
11	LLO 11.1Calculate the various parameters like Indicated power, Brake power, Frictional power, and Mechanical efficiency, fuel consumption, water flow rate, speed and load by using tachometer & dynamometer to prepare a heat balance sheet	*Demonstrate Morse Test on I.C. engine test rig Part – II	2	CO4
12	LLO 12.1 Measure various pollutants in the S.I or C.I engine. Analyze pollutants in the given S.I or C.I engine.	*Use of exhaust gas analyzer for S.I or C.I engine	2	CO4
13	LLO 13.1 Diagnose the faults in given I.C. engine and suggest the remedies over the faults detected.	Diagnosis test on I.C. engine using engine control unit (ECU).	2	CO4
14	LLO14.1 Identify different components of Single stage and two stage reciprocating compressor and draw constructional details of given air compressor.	* Demonstration on two stage reciprocating compressor part I.	2	CO5
15	LLO 15.1 Perform the test using two stage reciprocating air compressor test rig to measure the various parameters like temperature, pressure, air flow rate, actual volume of free air delivered and Calculate	*Demonstration on two stage reciprocating compressor part II	2	CO5

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
	pressure ratio, volumetric efficiency and thermal efficiency. LLO 15.2 Draw the performance characteristics.			
16	LLO16.1 Identify the different components of gas turbine model or chart.	Demonstration of gas turbine models. .	2	CO6
17	LLO 17.1 Draw constructional details of Jet propulsion engine Ramjet Turbojet, Turboprop and Rocket engine using model or chart,	* Demonstration of various jet propulsion system using charts. .	2	CO6

Note: Out of above suggestive LLOs -

'*' Marked Practical (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

VI. SUGGESTED SELF LEARNING ACTIVITIES/ ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SLA)

NA

VII. LABORATORY EQUIPMENT/ INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Exhaust gas analyzer 3/5 gas analyzer - For CO (%)-Range 0-10, For HC (ppm)- Range 0-10000, PM-Range 0-9000.	04
2	Test rig of two-stage reciprocating air compressor with minimum ½ HP motor with necessary pressure and temperature gauges at a suitable location	06
3	Charts and videos on construction and working of different components of gas turbine and jet propulsion system.	
4	Test rig of single cylinder/multi cylinder I.C. Engine with 3/5/7 HP Petrol/Diesel Engine with necessary arrangement	08, 09
5	Air conditioning test rig with hermitically sealed compressor ½ to ¼ HP motor, air-cooled condenser, expansion devices like TEV or capillary tube, pressure and temperature gauges at suitable locations, blower unit with 1HP,3 phase motor, steam generator to generate steam with suitable piping for introducing steam in the duct- 8-liter capacity with 2 kw heater	04
6	Standard sling psychrometer to measure DBT and WBT.	11
7	Vapor compression refrigeration test rig with hermitically sealed compressor ½ to ¼ HP motor, air-cooled condenser, expansion devices like TEV or capillary tube, pressure and temperature gauges at suitable locations.	10
8	Actual working or scrap unit of water cooler of minimum 200 liter capacity having all necessary parts	12
9	Old cut section of window air conditioner, tool Box containing flaring tool, spanner, piercing pliers, hammer, side cutter, cordless screw driver, rounding tool etc.	13, 14. 16
10	Actual working or scrap unit of a domestic refrigerator of a minimum 165 liters having all	17

	necessary parts	
11	Engine Control Unit (ECU), OBD II car diagnostic tool Grade II	04,10
12	Gas turbine and jet engine models	11
13	Refrigeration tools required for repair and maintenance process od refrigeration and air conditioning system	12
14	Charts, videos, models for VVTI Engine, supercharger, turbocharger, inline fuel injection pump, piezoelectric injectors, EGR, MPFI, CRDI systems.	1

VIII. SUGGESTED FOR 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
SECTION-I								
1	I	Refrigeration	CO1	12	2	2	4	12
2	II	Air Conditioning	CO2	04	2	2	2	11
3	III	IC Engine and Auxiliaries	CO3	10	4	4	6	12
SECTION-II								
4	IV	Testing of IC Engine and Pollution Control	CO4	14	2	4	8	12
5	V	Introduction to Air Compressors	CO5	10	4	4	6	11
6	VI	Gas Turbines & Jet Propulsion	CO6	10	2	4	8	12
Grand Total				**60**	**16**	**20**	**34**	**70**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment to Learning)
Two-unit tests of 30 marks and average of two-unit tests. For laboratory learning 25 Marks	End semester assessment of 25 marks for laboratory learning. End semester assessment of 70 marks.

X. 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
CO1	**3**	**-**	**-**	**3**	**-**	**2**	**3**	-	2
CO2	**3**	**2**	**-**	**3**	**-**	**2**	**3**	-	2
CO3	**3**	**2**	**-**	**-**	**-**	**3**	**3**	-	3
CO4	**3**	**2**	**-**	**-**	**-**	**3**	**3**	-	3
CO5	**3**	**-**	**-**	**-**	**-**	**-**	**-**	-	-
CO6	**3**	**-**	**-**	**3**	**-**	**2**	**2**	-	-

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

XI.SUGGESTED LEARNING MATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Mathur M.L , SharmaR. P	Internal Combustion Engines	Dhanpat Rai Publication (P) Ltd , New Delhi 2018,ISBN : 9789383182428
2	V. Ganeshan	Internal Combustion Engines	Tata McGraw Hills, New Delhi, ISBN:9781259006197
3	C.P Arora	Refrigeration and Air-Conditioning	Tata McGraw Hill Education, New Delhi 2021, ISBN: 9789390385843
4	S.Domkunwar and A.Domkunwar	A course of Thermal Engineering	Dhanpat Rai and sons. ASIN-B01MZAPV8F
5	R.S.Khurmi &J.K.Gupta	A text book of Thermal Engineering	S.Chand Publication. ISBN- 9788121925730

XII. LEARNINGWEBSITES& PORTALS

Sr.No	Link/Portal	Description
1.	https://youtu.be/JocJWQzwmpM?si=mnvKY3HdeuAq_nDb	https://youtu.be/qOywzwr8gZg?si=6f5ygzMNZ9DKU4dO
2.	https://youtu.be/NB8QiZ4sVco?si=LkfF0P-CB8Tnvmlb	https://youtu.be/yLWzBuk5lRs?si=g6nCvkTcRqIW-tV0
3.	https://www.youtube.com/watch?v=Kj_NEUu2xvw	https://youtu.be/FABa5iwdfiU?si=Oy7B51ZQAgbtWN5w
4.	https://www.youtube.com/watch?v=qO9BrKLKiLE	https://youtu.be/PjcdqAkP0UA?si=6lvVh5t1-d13X-gj
5.	https://www.youtube.com/watch?v=H_RgFXjg-5s	https://youtu.be/tyD5Ps0nnd0?si=c8EFtflwWGNe2hMu

Name & Signature:

Dr. Ashish D. Vikhar
(Lecturer in Mechanical Engineering)

Dr. S. S. More
(Lecturer in Mechanical Engineering)

(Course Experts)

Name & Signature:

Dr. N.G Kulkarni
(Programme Head)

Name & Signature:

Shri.S.B.Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**DESIGN OF MACHINE ELELMENTS**
COURSE CODE	**ME41205**
PREREQUISITE COURSE CODE & TITLE	**Strength of Material (AM31201)**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL Practical				Based on SL		Total Marks
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ME41205	Design of Machine Elelments	DSC	04	-	02	-	06	03	04	30	70	100	40	25	10	25#	10	-	-	150

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2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. Self-learning hours shall not be reflected in the Timetable.
6. Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

The subject "Design of Machine Elements" is the creation of new and better machines and improving the existing ones. A new or better machine is one which is more economical in the overall cost of production and operation. 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. . To enable a student to work there, he should know how to design simple machine elements, apply the knowledge of material strength, manufacturing processes, computer-aided drawing, etc. This course aims at developing analytical and selection of material abilities , calculate the dimension of mechanical componenets in the student to give solutions to simple engineering design problems using standard procedures.

III. INDUSTRY EXPETED 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.**

IV. COURSE-LEVEL LEARNING OUTCOMES (CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning.

CO1. Select suitable materials for designing machine elements.
CO2. Design joint, levers and linkages for various applications.
CO3. Design power transmission elements like shafts, keys and couplings.
CO4. Design fasteners, power screws and springs for various applications.
CO5. Select standard components from the design data book/manufacturer's catalogue.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes(TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant CO's
SECTION-I				
UNIT-I FUNDAMENTALS OF DESIGN (CL HRS-08, MARKS-11)				
1.	**TLO** 1.1. State general design procedure for the given component under static loading. **TLO** 1.2 Identify the specified loads and calculate stresses for the given component **TLO** 1.3 Identify the materials from the given designation. **TLO** 1.4 Select the relevant standards and codes for design of the given component. **TLO** 1.5 Explain various aesthetic design considerations in the given situation.	1.1 Machine design philosophy, general design procedure & considerations. 1.2 Types of loads, concept of stresses, bearing pressure, bending and shear stress, principal stresses. 1 .3 Factor of Safety (FOS), factors for selection of FOS 1.4 Stress concentration meaning, causes and remedies. 1.5 Designation of materials as per IS code, advantages of standardization, use of design data book. 1.6 Concept of Fatigue, S-N curve and Endurance limit. 1.7 Maximum principal stress theory and Maximum shear stress theory. 1.8 Modern aesthetic considerations in design.	Lecture using Chalk and Board	CO1

UNIT-II DESIGN OF JOINTS, LEVERS AND LINKAGES (CL HRS-10 MARKS-12)				
2	**TLO** 2.1. State design procedure Knuckle Joint, Turnbuckle. **TLO** 2.2. State design procedure of Hand/Foot Lever and Bell Crank Lever. **TLO** 2.3. Sketch the given joint(s), lever(s), link(s) and their resisting sections. **TLO** 2.4. Calculate the dimensions and stresses for the given joints, levers for given data. **TLO** 2.5. Calculate the dimensions and stresses for the C-clamp Hacksaw, Drill machine column, offset Link for given data.	2.1 Design of Knuckle Joint, Turnbuckle. 2.2. Types of Levers: First Type, Second Type & Third Type of Levers & its applications. 2.3 Design of Levers: -Hand/Foot Lever and Bell Crank Lever. 2.4 Design of C-clamp, Hacksaw, Drill machine column, offset Link.	1. Lecture Using Chalk-Board/ smart board, 2. Presentations Video Demonstrations	CO1, CO2
UNIT-III DESIGN OF SHAFT, KEYS AND COUPLING (CL HRS-12, MARKS-12)				
3	**TLO** 3.1. Write design procedure for the given shaft. **TLO** 3.2. Write design procedure of design keys and couplings. **TLO** 3.3 Sketch the given shaft, key(s) and coupling(s). **TLO** 3.4. Design the given shaft, key and coupling for given application. **TLO** 3.5. Select the given shaft, keys and coupling for given application from design data book.	3.1 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. Design for line shafts between bearings with pulleys in between. 3.2 Types of keys, effect of Keyway on strength of shaft. Rectangular and square sunk key. 3.3 Coupling: Requirement of Good Coupling, Types of shafts couplings, Design of muff coupling, flanged coupling.	1. Lecture using Chalk and Board 2. Charts and Models 3. Video presentation	CO3

SECTION-II				
UNIT- IV DESIGN OF POWER SCREWS (CL HRS-10, MARKS-13)				
4	**TLO 4.1.** Write strength equations for the given screw and nut combination. **TLO 4.2.** Design the given power screw TLO 4.3. Sketch the Screw Jack with design dimension using manual drawing /AutoCAD	4.1.Basic concepts of power screw Thread Profiles of Square, Acme, Buttress used for power Screws, relative merits and demerits of each. Self-locking and overhauling properties, Torque required to overcome thread friction, efficiency of power screws. 4.2. Design of Screw Jack, (only screw and nut).	Lecture Using Chalk-Board/ smart board, Presentations, Video Demonstrations.	CO4
UNIT –V DESIGN OF SPRINGS (CL HRS- 10, MARKS-12)				
5	**TLO 5.1** Identify & categorize the type of spring used on given application. **TLO 5.2** Choose suitable material for spring with justification & write specifications. **TLO 5.3** Sketch the given type of spring. **TLO 5.4** Write design procedure of the given type of helical compression spring. **TLO 5.5** Find dimensions of spring for the given application.	5.1 Classification and Applications of Springs, Spring terminology, materials specifications. 5.2 Stresses in helical compression springs, Wahl's stress factor, Deflection of springs. 5.2 Energy stored in springs. Springs in series and parallel. 5.4 Design of Helical compression springs subjected to concentric applied loads like I.C. engine valves, weighing balance, railway buffers.	1.Lecture using Chalk and Board 2.Charts and Models 3.Video presentation	CO4
UNIT –VI DESIGN OF BOLTED , WELDED JOINTS AND BEARING (CL HRS- -06, MARKS-10)				
	TLO 6.1.Design bolted joint for eccentrically loaded situation for given data. **TLO 6.2.** Calculate the length of weld for the given application. **TLO 6.3** Identify & categorize the given types of bearing. **TLO 6.4** List the Life of	6.1.Design of Bolted Joints subjected to eccentric loading. 6.2 Bolts of Uniform Strength, 6.3.Design of parallel and transverse fillet welds, axially loaded symmetrical section. 6.4 Bearings: Concept, classification, terminology, Linear motion bearings	1.Lecture using Chalk and Board 2.Charts and Models 3.Video presentation	CO5

	bearings for various types of machines. **TLO 6.5** Select suitable bearing for given application from manufacturer's catalogue.	applications. Life of bearings for various types of machines. 6.5 Selection of bearing from manufacturer's catalogue. (No numericals)		

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

Sr. No	Practical/Tutorial/LaboratoryLearningOutcome(LLO)	Laboratory Experiment / Practical Titles /TutorialTitles	Number ofhrs.	Relevant COs
1	LLO 1.1 Identify the material used in any four machine components. LLO 1.2 Collect the specification of the materials.	* Identify the material used in any four machine components (like Lathe, Shaper, Milling & drilling machines) and collect the specification of the materials and justify the selection.	02	CO1
2	LLO 2.1 Identify & draw various modes of failure for the machine components used in laboratories/workshops. LLO 2.2 Draw various modes of failure for the machine components used in laboratories/workshops.	*Identify & draw various modes of failure for the machine components used in various laboratories/workshops, under different loading conditions.	02	CO1
3	LLO 3.1Collect IS codes for design of following machine elements from design data book. (ISO metricthreads, Cast iron Flexible coupling, Keys, Screws, Bolts, Nuts.) LLO 3.2 List IS codes for design of following machine elements.. (ISO metric threads, Cast iron Flexible coupling, Keys, Screws, Bolts, Nuts).	*Identify & List IS codes for design of following machine elements. (ISO metric threads, Cast iron Flexible coupling, Keys, Screws, Bolts, Nuts, (similar components).	02	CO1
4	LLO 4.1 Select suitable material for elements of knuckle joint. LLO 4.2 Identify modes of failures in knuckle joint. LLO 4.3 Determine the dimensions of elements used in knuckle joints. LLO 4.4 Draw the knuckle joint using available software or manual drawing.	*Design of Knuckle Joint.	02	CO2
5	LLO 5.1 Select the materials for turnbuckle. LLO 5.2 Identify the modes of failure in the elements of turnbuckle LLO 5.3 Determine the dimensions of elements used in turnbuckle LLO 5.4 Select the turnbuckle from design data book (IS 3121:2023) LLO 5.5 Draw the turn buckle using available software or manual drawing.	*Determination of dimensions of elements of turnbuckle for given load condition.	02	CO1 CO2

Sr. No	Practical/Tutorial/LaboratoryLearningOutcome(LLO)	Laboratory Experiment / Practical Titles /TutorialTitles	Number ofhrs.	Relevant COs
6	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, Hand/Foot lever.	*Determination of dimensions of elements of Hand/Foot lever for given load condition	02	CO1 CO2
7	LLO 7.1. Select the materials for lever used for given application. LLO 7.2 Identify various modes of failure for lever used for given application. LLO 7.3 Determine the dimensions of lever used for given at least two application. LLO 7.2.verify the dimensions of lever used for given at least two application.	Design and draw the lever used in two/three-wheeler brake lever, four-wheeler accelerator pedal, lever of hand operated sugar cane juice machine, railway signal levers, safety valve levers, operating levers in different mechanisms/machines and verify the dimensions	02	CO1 CO2
8	LLO 8.1 Select the materials for C clamp used for given application LLO 8.2 Identify various modes of failure for the machine components used in c clamp LLO 8.3 Determine the dimensions of C-Clamp	*Design C clamp for any one application	02	CO1 CO2
9	LLO 9.1 Select suitable material for elements of given application using design data book. LLO 9.2 Identify modes of failures in shafts, keys and coupling LLO 9.3 Determine the dimensions of elements used in given application LLO 9.4 Select suitable dimensions of standard shafts (IS 3688:1990), sunk keys (IS 2048:1983) and coupling used. LLO 9.5 Select bearing used for given application from manufacturers catalogue LLO 9.6 Draw coupling (Assembly & Details) of given power transmission system using available software or manual drawing.	*Design of power transmission system in various machines like Lathe machine drilling machine or similar machines etc.	06	CO1 CO3 CO5
10	LLO 10.1 Select suitable material for elements of given application using design data book. LLO 10.2 Identify modes of failures in shafts, keys and coupling LLO 10.3 Determine the dimensions of elements used in given application LLO 10.4 Select suitable dimensions of standard shafts (IS 3688:1990), sunk keys (IS 2048:1983) and coupling used. LLO 10.5 Select bearing used for given application from manufacturers	Design of power transmission system in various machines like flour mill, Milling machine or similar machines etc.	06	CO1 CO3 CO5

Sr. No	Practical/Tutorial/LaboratoryLearningOutcome(LLO)	Laboratory Experiment / Practical Titles /TutorialTitles	Number ofhrs.	Relevant COs
	catalogue LLO 10.6 Draw coupling (Assembly & Details) of given power transmission system using available software or manual drawing.			
11	LLO 11.1 Select material for screw and nut for screw jack LLO 11.2 Identify modes failure in screw and nut of screw jack LLO 11.3 Determine dimensions of screw and nut of screw Jack LLO 11.4 Select the suitable dimension of screw and nut using IS 7008:1999 (for trapezoidal threads) or square threads (IS 2585:2006) LLO 11.5 Draw Screw and nut of Screw Jack using available software or manual drawing.	*Design Screw and nut of Screw Jack and Draw using available software or manual drawing...	04	CO1 CO4
12	LLO 12.1 Select the suitable material for spring. LLO 12.2 Identify the modes of failures in spring. LLO 12.3 Determine dimensions of spring used in selected application.	* Design of helical compression spring. (Any two design cases)	02	CO1 CO4
13	LLO 13.1 Identify type loading condition in given application of welded joint LLO 13.2 Calculate length of weld for given welded joint.	*Design a transverse and parallel fillet weld subjected to static and dynamic loading	02	CO5
14	LLO 14.1 Identify modes of failure in given application LLO 14.2 Select suitable factor of safety LLO 14.3 Determine dimension of screw used in given application	*Design of screwed joint subjected to concentric or eccentric load (Any two design cases)	02	CO5
			24	

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 MICROPROJECT/ ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SELF-LEARNING)

ASSIGNMENT

01. Find load, stresses on single point cutting tool and also prepare chart/model for the same.
02. Make models of various joints and levers highlight resisting sections of different elements. (use wood or M.S material)
03. Prepare list of different types of bearings used in a bike and write their specifications and basis for selection.
04. 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
05. 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.
06. Collect different types of springs and write applications of the same.

MICRO PROJECT

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

FIELD VISIT

01. Field visit to nearby industries

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	i) 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 gears Working models/ Acrylic/Aluminum/Cast/Scrap/Used component	8

7	Models of lead screw of lathe, feed screw of machine tools, clamping screws, toggle jackscrew, screw jackWorking models/ Acrylic/Aluminum/Cast/Scrap/Used component.	9

IX. SUGGESTED FOR 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
SECTION I									
1	I	Fundamentals of design	CO1	08		2	3	6	11
2	II	Design of joints, levers and linkages.	CO2	10		2	4	6	12
3	III	Design of shaft, keys and coupling.	CO3	12		2	4	6	12
SECTION II									
4	IV	Design of power screws	CO4	10		4	4	6	13
5	V	Design of springs	CO4	10		4	4	6	12
6	VI	Design of bolted , welded joints and bearing	CO5	06		1	2	4	10
Grand Total				**56**		**15**	**21**	**34**	**70**

X. ASSESSMENT METHODOLOGIE /TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
Two-unit tests of 30 marks and average of two-unit tests. For laboratory learning 25 Marks.	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 Out comes* (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
CO1	3	3	3	-	--	--	2	-	-
CO2	3	3	3	2	--	1	2	1	-
CO3	3	3	3	2	--	1	2	1	-
CO4	3	3	3	2	--	1	2	1	-
CO5	3	3	3	2	--	1	2	-	-

Legends: -High:03, **Medium:**02,**Low:**01,**No Mapping:**-
*PSOsaretobeformulatedattheinstitutelevel

XII. SUGGESTED LEARNINGMATERIALS/ 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

XII. 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

Name &Signature:

Dr.Shirish Dinkarrao Dhobe
(Lecturer in Mechanical Engineering)

Mr. Rangnath R. Godbole
(Lecturer in Mechanical Engineering)

(Course Experts)

Name & Signature:	Name & Signature:
Dr. Nitin G. Kulkarni (Programme Head)	**Shri.S.B.Kulkarni** (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**Industrial Robotics**
COURSE CODE	**ME51205**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**NO**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme												
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				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	
ME51205	Industrial Robotics	DSE	03	-	02	01	06	03	02	15	35*#	50	20	25	10			25	10	100

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, ***** - Online Examination, **$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 15 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

An Industrial Robotics course for diploma engineering provides diploma holders with specialized skills and knowledge in the operation and maintenance of robotic systems, aligning with the growing demand for automation and robotics in various industries. Robots can work in hazardous conditions, such as poor lighting, toxic chemicals, or tight spaces. They can lift heavy loads without injury or tiring. In addition to this, automated robotics makes production efficient, responsive, flexible and innovative which are key elements of staying competitive. This course will teach the students about an automation system with Robots, selection of the equipment's for a Robotics System and more. It is an enormous need that students to learn Industrial Robotics to become industry ready.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following CO**s** on completion of course-based learning.

CO1: Select an Industrial robot for given applications.
CO2: Identify basic components of industrial robots.
CO3: Select actuator and sensor for given robotic application.
CO4: Program robot for the given application.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
UNIT-I	**Introduction to Industrial Robotics & Safety**			**(CL Hrs.- 06, Marks- 04)**
1.	TLO1.1 Explain the need for industrial robot TLO1.2 Select the industrial robot for the given application. TLO1.3 Perform safety practices while using robots.	1.1 Introduction, brief history of Industrial Robots, Application of Robots in Industries, Types of Robots. 1.2 Defining Parameters of Robots, Major Robot Manufacturers, Selection and Classification of Industrial Robots. 1.3 Safe Practices while Handling the Robot, General Safety Information, Safety Symbols on the Robotic Arm, Robot Controller, and Teach Pendant, Personal Safety Equipment, Moving the Robot without Power, Residual Risks.	Lecture using Chalk and Board Video Demonstrations	CO1
UNIT-II	**Components & Anatomy of Industrial Robot**			**(CL Hrs.- 10, Marks-07)**
2	TLO 2.1 Explain fundamental terminology TLO 2.2 Identify the type of configuration of given industrial. TLO 2.3 Explain basic elements of robotic system. TLO 2.4 Classify robot end effector. TLO 2.5 Select an end effector for the given application.	2.1 Robot configurations- (Spherical), Cylindrical, Cartesian, Polar Coordinate, Jointed arm (Articulated), SCARA (Selective Compliance Assembly Robot Arm). 2.2 Basic elements of Robot system (Robot Anatomy): Base, Manipulator arm, End Effectors, Sensors and transducers, Actuators and Drives, Control systems 2.3 Robot specification: Degree of Freedom, Work envelope, Load carrying capacity, Speed of movement, Accuracy, Repeatability, Control Resolution, Spatial resolution, 2.4 Basic Robot motions: - Vertical motions, Radial motions, Rotational motions, Pitch motions, Roll motions, Yaw motions. 2.5 Types mechanical joints used in Robotics system: - Linear Joint, Orthogonal joint, Rotational Joint, Twisting Joint, Revolving Joint	Lecture using Chalk and Board	CO1, CO2

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		(Symbol, Notations) 2.6 Robots End Effectors: Types of End Effectors Gripper and Tools, Grippers- Mechanical, Pneumatic, Magnetic, Vacuum, adhesive, Considerations in gripper selection		
UNIT-III Industrial Robot: Actuators, Drives & Sensors (CL Hrs-12, Marks-08)				
3	TLO 3.1 Compare actuators for robot systems. TLO 3.2 Explain the different drive systems of industrial robots. TLO 3.3 Select robot sensors for the given application.	3.1 Actuators and types: Pneumatic, Hydraulic and Electric. Drive and drive system 3.2 Robotic Sensors: Introduction to Sensors in Robotics, classification of Sensors Tactile Sensors, Touch sensors, Force sensors, Force sensing wrist, Joint sensing, Tactile array sensors, Proximity and Range Sensors, Miscellaneous Sensors and Sensor based Systems, Desirable features of sensors in Robotics. Uses of Sensors in Robotics. 3.3 Encoders: Incremental and Absolute Encoders.	1. Lecture using Chalk and Board 2. Charts and Models 3. Video presentation	CO3
UNIT- IV Industrial Robot Programming & Maintenance (CL Hrs-17, Marks-16)				
4	TLO 4.1 Perform installation of industrial robot. TLO 4.2 Use teach pendant industrial robot teaching. TLO 4.3 Operate the industrial robot for given condition. TLO 4.4 Perform maintenance of industrial robots. TLO 4.5 Identify type of robot used for the given applications.	4.1 Industrial Robot Installation, Connecting Power Cables, Encoder for Cables, and Teach Pendant. 4.2 Robot Operation, Switching Modes, Jogging, Homing the Robot. 4.3 Managing Robot Errors and Faults, logging in and Configuring I/O 4.4 Robot Programming: Brief Introduction to Teach Pendant, Robot Programming Instructions, Jogging of Robot, Overview of Teach Pendant, Robot Arm, and Robot Controller, Central Processing Unit (CPU). I/O Channels, CAN I/O Module, Removable Storage, Basic Robot Program Instructions: MOVE, POINT, WAIT, SET, IF, ELSE, LOOP, HALT, JUMP. 4.5 Robots in material handling- industrial Pick and Place, Palletization. 4.6 Robots in processing operations - Spot welding, Continuous arc welding,	1. Lecture using Chalk and Board 2. Charts and Models 3. Video presentation	CO4

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		Spray of coating, Maintenance of Industrial Robot: Inspection of Belts and Pulleys, Changing Belts, Parameters Measurement (Voltage/Current), Recommended Spares, Troubleshooting, Fault List.		

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

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Identify different basic robotic components and their working for given system.	*Introduction to Industrial robotics lab and safety	02	CO1
2	LLO 2.1 Prepare control panel wiring	Robot installation and control panel wiring	02	CO2
3	LLO 3.1 Make use of teach Pendant.	*Demonstration of teach pendant	02	CO2
4	LLO 4.1 Jogging robot with different motion commands for given application	* Operate robot for basic motions using teach pendant	02	CO3
5	LLO 5.1 Identify types of motor and drive used in Robotics.	* Demonstration of Motor and drive	02	CO2
6	LLO 6.1 Make use of pneumatic system for industrial Robotic system.	* Demonstration of pneumatic system	02	CO2
7	LLO 7.1 Make use of end effector' for given application.	* Interfacing of end effectors	02	CO2
8	LLO 8.1 Select sensor for given application.	* Interfacing of sensors.	02	CO2
9	LLO 9.1 Make use of basic commands in robotics.	*Robot programming basic- Basic Robot Program Instructions: MOVE, POINT, WAIT, SET, IF, ELSE LOOP, HALT, JUMP	02	CO4
10	LLO 10.1 Program the robot for machine movement (pick and drop.	*Robot programming for pick and drop	02	CO4
11	LLO 11.1Make use of merged movements command for Robotic application.	Industrial robot program for Merged Movements Circular and Arc Movements	02	CO4
12	LLO 12.1 Program robot for machine tending application.	Setup and Programming for Machine Tending with Industrial Robotic Arm	02	CO4
13	LLO 13.1Program robot for MIG Welding.	Setup and Programming for Robotic MIG Welding	02	CO4
14	LLO 14.1Apply robot vision system for given application	Setup and Programming for Vision System	02	CO4
15	LLO 15.1Program robot to follow 2D path.	Setup and Programming for 2D Path Following	02	CO4

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
16	LLO 16.1Apply voice command for given robotic application.	Setup and Programming for Voice Command	02	CO4
17	LLO 17.1 Apply Colour sensor for given robotic application.	*Setup and Programming for Colour Sensing	02	CO4
18	LLO 18.1 Program robot to identify material.	Setup and Programming for Material Sensing	02	CO4
19	LLO 19.1 Program robot for palletizing application.	Setup and Programming for Palletizing	02	CO4
20	LLO 20.1Program robot for gasketing/sealing application.	* Setup and programming for Gasketing /Sealing.	02	CO4
21	LLO 21.1 Program robot for pick and place operation using Magnetic gripper	Setup and Programming for Magnetic Pick and Place	02	CO4
22	LLO 22.1 Program robot for pick and place operation using Suction gripper	Setup and Programming for Suction based Pick and Place	02	CO4
23	LLO 24.1 Program Robot for Logistic sorting system.	*Setup and Programming for Logistic Sorting System	02	CO4
24	LLO 25.1 Program robot for spray painting.	Setup and Programming for Robotic Spray Painting	02	CO4
25	LLO 26.1 Program motion with CAD file.	Importing CAD to motion	02	CO4
26	LLO 27.1 Prepare end effector using 3D printing.	Demonstration of End Effector manufacturing using 3D printing.	02	CO4
27	LLO 28.1 Perform maintenance of robotic system	Maintenance and troubleshooting of industrial robot	02	CO1

Note: Out of the above suggestive LLOs -

'*' Marked Practical's (LLOs) Are mandatory.

Minimum 80% of the above list of lab experiments are to be performed.

Judicial mix of LLOs is to be performed to achieve desired outcomes

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

Assignments

- Prepare a report on the latest technology of industrial robots.
- Prepare a report on robot manufacturing industries.
- Prepare a report on gripper manufacturing industries.
- Prepare a report on types of industrial robots.
- Prepare a report on industries using robots.

Microprojects

- Visiting industries have robots and prepare detail reports on operational and maintenance practices.
- Simulate various robot programs on free robot simulation software.
- Develop robot programs for performing various industrial operations

- Develop a simple model for any one DoF.
- Develop a model for any one type of industrial robot.
- Case study on robotics systems used in automobile/ manufacturing industry.
- Case study on future robot technologies.
- Case study on various future applications of robotic systems.

VII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr. No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Machine Tending compatible with Industrial Robot - Dummy Parts, Application Panel, Safety Fence, Operating Panel & HMI - Cell Peripheral Items (Wire, Cables, Flux, Cable Tie, etc.) - Robot with Control Panel, Teach Pendant, Power Cable, Adaptor Plate & Pedestal, - Belt Conveyor - Dummy CNC machine - Pneumatic Panel	1,2,14,
2	Electro Pneumatic Training Cell - Solenoid Valve, Pneumatic Cylinder, FRL Unit - Limit Switch, I/O Box - Pneumatic Peripherals - Display Table	6
3	Motor Training Cell - Connections for PLC with Cable and Software - Servo Motor with Drive, Stepper Motor with Drive, Induction Motor, - BLDC Motor -I/O Box - Display Table	5
4	EOAT (End of Arm Tooling) Lab - Suction Cups, Vacuum Generator (Venturi), Vacuum Cups Fittings - Pneumatic Gripper Training Kit, 2-Jaw Pneumatic cylinder, Pneumatic Cylinder - Connectors - 24VDC Electromagnetic Gripper - Solenoid Valve, Mounting Bracket, Manifold, FRL Unit - I/O Box, Peripherals, Display Table, Pneumatic Tubing	1,7
5	MIG Welding Setup - MIG Power Source, Wire Feeder, Gas Regulator, Welding Torch, Welding Fixture - Power Cable, Earthing Cable - Robot with Control Panel, Teach Pendant, Power Cable, Adaptor Plate & Pedestal - Trigger Cable, Wire Spool (additional spools to be purchased by the college) - Parts for Welding - Additional parts must be purchased by the college	13
6	Vision System - Microcontroller Board, Image Camera for Microcontroller Board, External Lighting, Ethernet Switch - Suction Cups, Vacuum Generator (Venturi), Vacuum Cups Fittings, Solenoid Valve, Pneumatic Tubing	16, 25
7	2D Path Following - Microcontroller Board, 24VDC Power Supply, Wire Loop, Contact Sensor - CAD-2-Motion Software Package	14

8	Voice Command - Microcontroller Board, Android App (Downloadable, without phone) - Integration Cables	15
9	Colour Sensing - Microcontroller Board, Image Sensor, External Lighting - Suction Cups, Vacuum Generator (Venturi), Vacuum Cups Fittings, Solenoid Valve, Pneumatic Tubing	17
10	Material Sensing - Microcontroller Board, Inductive Sensor - Suction Cups, Vacuum Generator (Venturi), Pneumatic Tubing, Solenoid Valve	18
11	Static Palletizing - Conveyor, Gravity Feed, Empty Pallet/Box Dispenser -Suction Cups, Vacuum Generator (Venturi), Vacuum Cups Fittings, Solenoid Valve, Pneumatic Tubing	19
12	Magnetic Pick and Place - 24VDC Electromagnetic Gripper, Mounting Bracket - Metal & Non-Metal Parts, Parts Holding Fixture	21
13	Gluing Application - Robot with Control Panel, Teach Pendant, Power Cable, Adaptor Plate & Pedestal - Pneumatic Glue Dispenser, Glue Cartridge, Dispensing Part, Part Holding Fixture Solenoid Valve, Pneumatic Tubing	22, 28
14	Logistic sorting System - Microcontroller Board, Suction Cups, Vacuum Generator (Venturi), Vacuum Cups Fittings, Solenoid Valve Conveyor Belt, Pneumatic Tubing	24
15	Additive Manufacturing System - Additive MFG (FDM 3D Printer) FDM Spool	27
16	Spray Painting Lab - Spray Painting Booth, Spray Painting Gun (Robotic Automatic) - Spray Painting Gun Mounting Bracket, Painting Stand - Solenoid Valve, TR10 Robot with Control Panel, Teach Pendant, Power Cable, Adaptor Plate & Pedestal Pneumatic Tubing, Pneumatic Flow Control Valve	25
17	Robots Part Library - Timing Pulley, Timing Belt, Bevel Gears, Drive Shaft - Bearings (Ultra-Thin, Angular, Thrust, Double Row, etc.) SMC Covers, Ultra Flexible Cable, Military Grade Poka yoke Connectors	1,2,3
18	Other Parts - Encoder, Current Noise Filter, SMPS, Compact Relays.	Al

VIII. 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 Industrial Robotics & Safety	CO1	06	02	02	-	04
2	II	Components & Anatomy of Industrial Robot	CO2	10	03	02	02	07
3	III	Industrial Robot: Actuators, Drives & Sensors	CO3	12	02	02	04	08
4	IV	Industrial Robot Programming & Maintenance	CO4	17	04	04	08	16
Grand Total				**45**	**11**	**10**	**14**	**35**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
1. Term work	1. End semester practical examination

X. 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
CO1	3	3	-	2	2	2	2	2	2
CO2	3	3	2	2	2	2	2	2	2
CO3	3	3	2	3	2	2	3	3	3
CO4	3	3	2	3	2	2	3	3	3

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

XI.SUGGESTED LEARNING MATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Mikell P. Groover, Michell Weiss Roger, N. Nagel, Nicholas G. Odrey & Ashish Dutta	Industrial Robotics	McGraw Hill Education (India) Pvt. Ltd., Chennai 2012, ISBN (l 3): 978-1-25-900621-0
2	Ramchandran Nagarajan	Introduction to Industria Robotics	Pearson Education India, New Delhi, 2006, ISBN: 978-93-325-4480-2
3	R. K. Rajput	Robotics and Industria Automation	S. Chand limited, 2008 ISBN- 9788121929974
4	R. K. Mittal & I. I Nagrath	Robotics and Control	TATA McGraw Hill education India Pvt. Ltd. New Delhi, 2010 ISBN:0-07-048293-4
5	Ganesh S. Hegde	A Textbook on Industria Robotics	University Science Press, New Delhi, 2009, ISBN: C-16689/08/12
6	D. J. Todd	Fundamentals of Robot Technology	British library Cataloguing in Publication Data ISBN (l 3): 978-94-011-6770-3
7	Ghosal, Ashitava	Robotics-Fundamental, Concepts and Analysis	Oxford University Press 2006, ISBN (10) 978-0-07-026509-7

XII. LEARNING WEBSITES & PORTALS

Sr.No	Link Portal	Description
1.	https://ifr.org/	International Federation of Robotics.
2.	https://www.exeter.ac.uk/	In collaboration with COROT Project.
3.	https://www.gre.ac.uk/	In collaboration with COROT Project.
4.	https://npte1.ac.in/courses/ll2l05319	NPTEL Course - Industrial Robotics: Theories for Implementation.
5.	https://nptel.ac.in/courses/112105249	NPTEL Course - Robotics
6	http://www.mechanalyzer.com/downloads-roboanalyzer.html	Simulation Software- Robo analyser.
7	http://www.roboanalyzer.com/tutorials.html	Simulation Software - tutorials
8	https://www.youtube.com/watch?v=l1gRr NI4BU	Introduction to Industrial Robot
9	https://www.youtube.com/watch?v=X7iBT51599c	Industrial Robot Manipulator
10	https://www.youtube.com/watch?v=_canCYWZPsc&t=227s	Animation of Work Envelope
11	http://vlabs.iitkgp.ernet.in/mr/exp0/index.html#	Virtual Lab — IIT Kharagpur

Name &Signature:

Dr. Sunil Ruprao Adhau
(Lecturer in Mechanical Engineering)

Dr. S. S. Panpatil
(Lecturer in Mechanical Engineering)

(Course Experts)

Name & Signature:

Dr. Nitin Ganesh Kulkarni
(Programme Head)

Name & Signature:

Shri. S.B. Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**INDUSTRIAL AUTOMATION**
COURSE CODE	**ME41204**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				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	
ME41204	INDUSTRIAL AUTOMATION	DSC	3	--	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Term: 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, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing the minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course.
2. If a candidate does not secure the minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit the SLA work.
1. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
3. **1 credit** is equivalent to **30 Notional hours**.
4. * Self-learning hours shall not be reflected in the Timetable.

6.* Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

The swift advancement of technology and the rising demand for superior productivity, consistent quality, and operational efficiency have positioned industrial automation as a pivotal element in modern manufacturing. In an increasingly competitive and innovation-driven industrial landscape, sectors such as automotive, pharmaceuticals, food processing, and electronics are rapidly integrating automation systems to streamline operations, lower costs, and maintain high standards of output.

The **Industrial Automation** course is designed to prepare students to meet these industry demands by providing a strong foundation in both theoretical concepts and hands-on application of automation technologies. The curriculum encompasses critical domains including fluid power systems (hydraulics and pneumatics), electro-mechanical components, programmable logic controllers (PLCs), and microcontroller-based control systems.

Students will engage in experiential learning by designing, assembling, and troubleshooting automation circuits. Realistic industrial scenarios are simulated using industry-standard tools such as FluidSIM, PLC programming software, and microcontroller development platforms (e.g., Arduino, Raspberry Pi). The course

further emphasizes the importance of integrating mechanical, electrical, and electronic components seamlessly.

This comprehensive approach ensures students are well-equipped to contribute effectively to the evolving field of industrial automation and the broader goals of smart manufacturing and Industry 4.0.

III. INDUSTRY-EXPECTED OUTCOME

Ability to design, implement, and maintain automated industrial systems using PLCS, SCADA, sensors, and control technologies.

IV. COURSE-LEVEL LEARNING OUTCOMES (CO'S)

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

CO1: Explain the fundamental principles and industrial applications of hydraulic and pneumatic systems.
CO2: Interpret and analyse hydraulic and pneumatic circuit diagrams using standard symbols and control elements.
CO3: Design and simulate automation circuits involving hydraulic, pneumatic, and electro-pneumatic components using software tools.
CO4: Develop ladder logic programs for industrial applications and integrate PLCs with electro-Hydraulic/Pneumatic systems.
CO5: Demonstrate the use of microcontrollers in industrial automation setups for control and monitoring tasks.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLOs) aligned to COs.	Learning content mapped with TLOs.	Suggested Learning Pedagogies	Relevant COs
SECTION-I				
UNIT-I INTRODUCTION TO INDUSTRIAL AUTOMATION & FLUID POWER (CL Hrs-06, Marks- 08)				
1.	TLO1.1 Explain the need for and benefits of automation in various industries. TLO1.2 Classify different types of automation used in industries. TLO1.3 Describe how energy is converted and transmitted in hydraulic and pneumatic systems. TLO1.4 Differentiate between hydraulic and pneumatic systems based on working principles and applications. TLO1.5 Apply basic physical laws relevant to fluid power systems. TLO1.6 Identify common industrial applications of fluid power systems.	1.1 Introduction to Automation: Need, Benefits, and Types 1.2 **Classification:** Fixed, Programmable, and Flexible Automation with examples 1.3 Introduction to Fluid Power Systems, Overview of energy conversion and transmission in fluid systems 1.4 **Comparison:** Hydraulics vs Pneumatics, Advantages, limitations, and industrial use-cases 1.5 Pascal's Law, Boyle's Law, Charles' Law, Bernoulli's Principle, Continuity Equation 1.6 Practical implications and examples.	Chalkboard Demonstration Presentations, Hands-on	**CO1**

UNIT-II INDUSTRIAL HYDRAULICS(CL Hrs-10, Marks-15)				
2.	TLO 2.1 Identify and explain the function of components in a hydraulic power system. TLO 2.2 Describe the construction and working of each pump TLO 2.3 Explain their function and importance in system health. TLO 2.4 Identify types and properties of hydraulic fluids. TLO 2.5 Interpret hydraulic symbols based on IS/ISO standards. TLO 2.6 Explain the working and application of directional, pressure, and flow control valves. TLO 2.7 Classify and describe different types of hydraulic cylinders and motors. TLO 2.8 Interpret and analyse standard hydraulic circuits used in industrial applications.	**2.1 Key components** of a hydraulic power system. **2.2 Hydraulic Components** • **Pumps:** Construction and working of Gear pump, Vane pump, and Axial and radial piston pump. • **Hydraulic Filters:** Types, functions, and applications. • **Hydraulic Fluids:** Role and importance in hydraulic systems, Basic functions-power transmission, lubrication, cooling, sealing, Types of Hydraulic Fluids-Mineral-based (petroleum) fluids, Synthetic fluids, Water-based fluids, Biodegradable fluids. Properties of Hydraulic Fluids-Viscosity and Viscosity Index (VI), Lubricity, Thermal and oxidation stability, Anti-wear and corrosion resistance, Demulsibility. **2.3 Hydraulic Symbols and Representation** • Standardised symbols for hydraulic components such as valves, pumps, and actuators. • Techniques for interpreting and drawing hydraulic circuit symbols. • Symbol representation as per IS/ISO standards. **2.4 Control Valves:** • **Directional Control Valves (DCV)**: Construction and working principles of 2/2, 3/2, 4/2, and 5/3 DCV; various methods of actuation (manual, mechanical, electrical, pilot), simple and pilot-operated check valves (pilot to open, pilot to close). • **Pressure control valves (PCV):** Construction and working of Pressure relief valve, pressure reducing valve, sequence valve, and Unloading valve. • **Flow Control Valves (FCV):** Classification, Construction, working, and applications of Non-Compensated, Pressure Compensated, Pressure & Temperature Compensated Flow Control Valves. **2.5 Hydraulic Actuators** • **Linear actuators:** Construction and working of single-acting (spring and gravity return), double-acting (single and double piston rod end), and cylinders and their uses. • **Rotary Actuators:** Construction and Working of Gear, Gerotor, Vane, Piston Motors, and their Uses. **2.5 Standard Hydraulic Circuits**	Chalkboard Demonstration Presentations, Hands-on	CO1, CO2

		• Two-Pump Unloading Valve Circuit • Counterbalance Circuit • Sequencing Circuit • Synchronizing Circuit • Speed Control Circuits- Meter-in and meter-out.		
UNIT- III INDUSTRIAL PNEUMATICS(CL Hrs- 06 , Marks-12)				
3	TLO 3.1 Identify key components in a pneumatic system and explain their functions. TLO 3.2 Explain the operation and selection of pneumatic control valves. TLO 3.3 Compare single-and double-acting pneumatic cylinders and describe their industrial applications. TLO 3.4 Use pneumatic logic elements to implement control operations. TLO 3.5 Design pneumatic circuits for typical industrial tasks.	**3.1 Key components** of a Pneumatic power system. **3.2 Compressors:** Types, construction, working principle of Reciprocating & Rotary compressors, FRL (Filter-Regulator-Lubricator) Unit, Air Dryers, and Reservoirs **3.3** Construction and working of Rotary spool D.C. valve, Dual pressure valve, Shuttle valve, and Quick exhaust valve. **3.4** Practical circuits involving Quick exhaust valve, logic OR, AND, NOT functions. **3.5** Direct and Indirect Control of Single and Double-Acting Cylinder Pneumatic Circuits	Chalkboard Demonstration Presentations, Hands-on	CO1, CO2, CO3
SECTION -II				
UNIT-IV ELECTRO-HYDRAULICS & ELECTRO-PNEUMATICS (CL Hrs- 08, Marks-12)				
4	TLO 4.1 Describe the operation of electrical actuators such as solenoid valves, relays, and limit switches. TLO 4.2 Explain the operation of various input, control, and Output devices TLO 4.3 Design and implement simple circuits for controlling pneumatic actuators. TLO 4.4 Implement latching and timer-based control in electro-pneumatic circuits. TLO 4.4 Analyse and compare the use of AND and OR logic functions in controlling pneumatic actuators.	**4.1 Introduction to Electro-Pneumatics/Hydraulics:** Overview of electro-pneumatic and electro-hydraulic systems, emphasising integrating electrical control with pneumatic/hydraulic actuation. **4.2 Commonly Used Devices in Electro-Pneumatic Systems:** • **Input Devices:** Push Buttons (NO/NC), Limit Switches, Proximity Sensors (Inductive, Capacitive), Pressure Switches, and Reed Switches. • **Control Devices**: Relays, Timers, Counters. • **Output Devices:** Solenoids (for controlling pneumatic valves), Indicator lamps, Buzzers. **4.3 Electro-Pneumatic Circuits:** • Circuits for **direct and indirect control** of pneumatic actuators. • Circuits implementing control of actuators using an **AND logic function.** • Circuits implementing control of actuators using **OR logic function.**	Chalkboard Demonstration Presentations, Hands-on	CO2, CO3, CO4

UNIT –V PROGRAMMABLE LOGIC CONTROLLERS (PLC) (CL Hrs- 09, Marks-14)				
5	TLO 5.1 Explain the architecture, scan cycle, and operational principles of a PLC. TLO 5.2 Identify types of I/O modules, memory structures, and addressing techniques in PLC. TLO 5.3 Develop basic ladder logic programs for industrial automation tasks. TLO 5.4 Implement timer, counter, and sequence operations using ladder logic. TLO 5.5 Integrate PLC with hydraulic and pneumatic systems for control applications.	**5.1 PLC Structure and Working:** • Basic components and internal structure of a Programmable Logic Controller (PLC). • Types of PLCS • Working principle of a PLC through its scan cycle **5.2 Input/Output Modules and Memory Types:** • Digital and analogue I/O modules • Various types of PLC memory include program memory and data memory. • Addressing modes are used to identify inputs, outputs, and memory locations within the PLC. **5.3 Ladder Logic Basics:** • Basic elements of a ladder diagram. • Logic operations used in ladder diagrams, such as AND, OR, and NOT • Rules for Ladder Diagram Programming. • Basic control elements are used in PLC programs- contacts, coils, Timers, counters, Internal Relays (Flags) • Apply PLC to control position control, motor speed control, sequential control circuits, and pressure and force control.	Chalkboard Demonstration Presentations, Hands-on	CO4
UNIT –VI: INTRODUCTION TO MICROCONTROLLERS AND ARDUINO APPLICATIONS IN INDUSTRIAL AUTOMATION(CL Hrs-06, Marks-09)				
		6.1Microcontrollers in Mechanical Systems: • Microcontroller and its role in modern mechanical systems. • Benefits of using Arduino: Low-cost, open-source, flexible, and easy to use. • Comparing Arduino, PLCS, and Embedded Systems in terms of use, cost, and flexibility. **6.2Introduction to Arduino:** • Arduino Hardware Architecture • Arduino Software (IDE) and Programming. • Applications of Arduino in Automation • Advantages of Arduino for Small-Scale Projects. **6.3Types of Sensors:** • **Sensors:** • **Temperature & Humidity Sensor:** Measures environmental temperature and humidity. • **PIR Sensor:** Detects human movement or motion. • **Ultrasonic Sensor:** Measures distance	Chalkboard Demonstration Presentations, Hands-on	CO5

		using ultrasonic waves. • **Colour Sensor:** Detects and identifies colours in objects. • **Interfacing:** Connecting and integrating these sensors with Arduino for real-time data acquisition and control applications. **6.4 Output devices:** • **Output Devices:** LEDs (Light Emitting Diodes), LCD Displays (e.g., 16x2 LCD), and Motors (DC, Stepper, Servo). • **Interfacing:** Connecting and controlling output devices using Arduino. **6.5Applications of PLC in Mechanical Systems** PLCs are used to control: • Position of mechanical components. • Motor speed (start/stop, speed variation). • Sequential tasks (step-by-step operations in machines). • Pressure and force in hydraulic/pneumatic systems.		

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

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment/ Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Draw ISO symbols for all components and their types used in fluid systems.	***Draw ISO symbols of all components and their types used in fluid systems.**	2	CO1
2	LLO 2.1 Develop and implement a Sequential Circuit for Two Hydraulic Actuators	***Design and Demonstration of a Sequential Circuit for Two Hydraulic Actuators in A+B+B-A- Sequence Operation using a Sequence valve.**	2	CO1
3	LLO 3.1 Develop and implement speed control circuits for hydraulic actuators using Meter-In and Meter-Out configurations.	***Design and Demonstration of Speed Control Circuits for Hydraulic Actuators (Meter-In and Meter-Out Circuits).**	2	CO2
4	LLO 4.1 Develop and implement a Pneumatic Circuit for the Direct Control of a Single-Acting Cylinder	***Pneumatic Circuit for Direct Control of a Single-Acting Cylinder.**	2	CO2
5	LLO 5.1 Develop and implement a Pneumatic Circuit for indirect Control of a Double-Acting Cylinder	***Pneumatic Circuit for Indirect Control of a Double-Acting Cylinder.**	2	CO2
6	LLO 6.1 Develop and implement an electro-hydraulic circuit for the direct operation of a Double-acting cylinder.	***Electro-Hydraulic Circuit for Direct Control of a Double-Acting Cylinder.**	2	CO2
7	LLO 7.1 Develop and implement an electro-hydraulic circuit for the indirect operation of a Double-acting cylinder.	***Electro-Hydraulic Circuit for Indirect Control of a Double-Acting Cylinder.**	2	CO3

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment/ Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
8	LLO 8.1 Develop and implement the AND logic function using two normally open push buttons in an Electro-Hydraulic Circuit.	***Implementation of AND Logic Function Using Two Normally Open Push Buttons in an Electro-Hydraulic Circuit.**	2	CO3
9	LLO 9.1 Develop and implement the OR logic function using two normally open push buttons in an Electro-Hydraulic Circuit.	***Implementation of OR Logic Function Using Two Normally Open Push Buttons in an Electro-Hydraulic Circuit.**	2	CO3
10	LLO 10.1 Develop and implement a PLC program to control two double-acting cylinders in a defined A+ B+ A− B− sequence.	***PLC Program for Controlling Two Double-Acting Cylinders in A+ B+ A− B− Sequential Operation.**	2	CO3
11	LLO 11.1 Develop and implement a PLC program to perform position control of a linear actuator using limit switch feedback.	PLC-Based Position Control of a Linear Actuator Using Limit Switch Feedback.	2	CO4
12	LLO12.1 Develop and implement a PLC program to control the speed of an induction motor using a Variable Speed Drive (VFD)	***PLC-Controlled Variable Speed Drive for Induction Motor.**	2	CO4
13	LLO 13.1 Develop and implement a PLC program to control a stepper motor using a stepper motor driver	PLC-Based Control of Stepper Motor Using Stepper Motor Driver.	2	CO4
14	LLO 14.1: Apply knowledge of sensors to implement a distance-based object detection system using an ultrasonic sensor and buzzer.	Develop an Arduino program to interface an ultrasonic sensor and activate a buzzer when an object is detected within a predefined distance.	2	CO5
15	LLO 15.1: Analyse sensor data and display measured distance on an LCD using Arduino programming.	Develop an Arduino program to interface an ultrasonic sensor and display the measured distance of an object on an LCD screen.	2	CO5
16	LLO 16.1: Apply motion detection techniques using a PIR sensor to activate audio-visual indicators via Arduino.	Develop an Arduino program to interface a PIR sensor that detects motion and triggers a buzzer and RGB LED upon detection.	2	CO5
17	LLO 17.1: Create a temperature monitoring and alert system using Arduino by interfacing a temperature sensor, LCD, and buzzer.	Develop an Arduino program to read temperature sensor data, display it on an LCD, and activate a buzzer if the temperature exceeds a threshold.	2	CO5
18	LLO 18.1: Apply control logic to rotate a servo motor to desired angles using Arduino.	***Develop an Arduino program to rotate a servo motor to a specified angle in both clockwise and anticlockwise directions**.	2	CO5

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment/ Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
19	LLO 19.1: Create a motor control system for stepper motor rotation using Arduino programming techniques.	Develop an Arduino program to rotate a stepper motor to a specified angle in both clockwise and anticlockwise directions.	2	CO5

***Note:** A total of thirteen laboratory experiments are to be performed, of which twelve marked with an asterisk (*) are mandatory. The remaining one experiment should be selected from the rest of the experiments.

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

SELF-LEARNING - MICRO PROJECT/ASSIGNMENT/ACTIVITIES (ANYONE)

ASSIGNMENTS:

Each Micro project, assignment, or activity is to be assigned to groups consisting of no more than four students.

a) Create a PowerPoint presentation on Hydraulic and Pneumatic Braking Systems. The presentation should be prepared and delivered by a group of 2–3 students.
b) Conduct an industrial survey focused on hydraulic oils used in hydraulic systems. The aim is to gather detailed information on the various types of oils, their properties, leading manufacturers, specifications, trade names, criteria for oil selection, pricing, and available packaging sizes.
c) Create a PowerPoint presentation on Accessories Used in Hydraulic and Pneumatic Systems. This should also be presented by a group of 2–3 students.
d) Conduct a Market Survey and prepare a report on Suppliers of Fluid Power-Based earth-moving equipment, such as JCB and Mahindra Earth Master. This task should be completed by a group of 4 students.
e) Prepare a **Chart on a Full Imperial Drawing Sheet** displaying **ISO Standard Symbols** used in hydraulic and pneumatic circuits. This should be done by a group of 2 students.
f) Prepare a **Classification Chart of Pumps and Actuators** on a full imperial drawing sheet. This should be completed by a group of 2 students.
g) Prepare and present a **Seminar or Presentation on Types of Oil Filters** used in fluid power systems. A group of 2–3 students should present this.
h) Prepare **Display Charts Featuring Types of Seals and Gaskets** used in hydraulic systems. Include actual samples if available.
i) Visit an **Automobile Service Station** and write a **Report on the Use of Pneumatic Hand Tools** observed during the visit.
j) Visit a **Construction Site** and prepare a **Report on Hydraulic and Pneumatic Equipment in Use**, such as JCB or other automated machinery.

MICROPROJECTS:

i) 3D printed ISO symbols as detachable tags.

ii) 3D printed mock valves/ cylinders/ directional control elements/pumps / Motors

iii) Prepare a working model of a hydraulic crane, a hydraulic Lifter using discarded medical syringes as actuators

iv) Create a display board showcasing samples of pipes and pipe fittings, along with their specifications from various manufacturers.

VIII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Hydraulic Trainer, Pneumatic Trainer, PLC, Arduino Uno Board, Various Sensors, and Output Devices.	ALL

IX. SUGGESTED FOR 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
SECTION -I								
1	I	**INTRODUCTION TO INDUSTRIAL AUTOMATION & FLUID POWER**	**CO1**	**06**	**04**	**03**	**01**	**08**
2	II	**INDUSTRIAL HYDRAULICS**	**CO1, CO2**	**10**	**06**	**05**	**04**	**15**
3	III	**INDUSTRIAL PNEUMATICS**	**CO2, CO3**	**06**	**05**	**04**	**03**	**12**
SECTION -II								
4	IV	**ELECTRO-HYDRAULICS & ELECTRO-NEUMATICS**	**CO3, CO4**	**08**	**02**	**05**	**05**	**12**
5	V	**PROGRAMMABLE LOGIC CONTROLLERS (PLC)**	**CO4, CO5**	**09**	**03**	**06**	**05**	**14**
6	VI	**INTRODUCTION TO MICROCONTROLLERS AND ARDUINO APPLICATIONS IN INDUSTRIAL AUTOMATION**	**CO5**	**06**	**02**	**04**	**03**	**09**
Grand Total				**45**	**22**	**37**	**21**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
1. Tests 2. Seminar/Presentation 3. Term Work	1. ESE Practical Examination 2. End-of-Semester Theory Examination

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 Lifelong Learning	PSO-1	PSO-2
CO1	**2**	**2**	**2**	**--**	**2**	**--**	**2**	**--**	**--**
CO2	**2**	**3**	**2**	**2**	**--**	**--**	**2**	**--**	**--**
CO3	**2**	**3**	**3**	**3**	**--**	**2**	**2**	**3**	**2**
CO4	**2**	**2**	**3**	**3**	**--**	**3**	**2**	**3**	**2**
CO5	**2**	**2**	**2**	**2**	**--**	**2**	**3**	**2**	**2**
Legends:- High:3, **Medium:**2, **Low:**1, **No Mapping:** -									
*PSOs are to be formulated at the Program level									

XII. SUGGESTED LEARNING MATERIALS/BOOKS

Sr. No.	Author(s)	Title	Publisher & Edition with ISBN Number
1	S. R. Mujumdar	Oil Hydraulic Systems: Principles and Maintenance	Tata McGraw-Hill, 1st Edition, ISBN: 978-0074637487
2	S. R. Mujumdar	Pneumatic Systems: Principles and Maintenance	Tata McGraw-Hill, 1st Edition, ISBN: 978-0074602317
3	Anthony Esposito	Fluid Power with Applications	Pearson Education, 7th Edition (2000), ISBN: 81-7758-580-0
4	Harry Stewart	Hydraulics and Pneumatics	Taraporewala Publications, 1st Edition, ISBN: 978 0672234125
5	B. Joji	Pneumatic Controls	Wiley India, 2014 Edition, ISBN: 978 8126515424
6	Andrew Parr	Hydraulics and Pneumatics: A Technician's and Engineer's Guide	Butterworth-Heinemann, 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., New York, 1st Edition, ISBN: 978-0831111144
9	Vickers Systems International	Industrial Hydraulics Manual	---
10	Parambath, Joji.	Electro-pneumatics and Automation	Self-published, 2020, ISBN: 979 8654701573

Sr. No.	Author(s)	Title	Publisher & Edition with ISBN Number
11	Md. Abdus Salam	Fundamentals of Pneumatics and Hydraulics	Springer Nature, 2022, ISBN: 978-981-19-0855-2
12	Festo Didactic	Basic Principles of Pneumatics and Electro-Pneumatics	Festo Didactic, ISBN: 978-3-000-00000-0
13	Frank D. Petruzella	Programmable Logic Controllers	McGraw-Hill Education, 4th Edition, ISBN: 9780073510880
14	William Bolton	Programmable Logic Controllers	Newnes (Elsevier), 6th Edition, ISBN: 9780080969121
15	Jon Stenerson	Fundamentals of Programmable Logic Controllers, Sensors, and Communications	Pearson Education, ISBN: 9780130618900
16	Max Rabiee	Programmable Logic Controllers: Hardware and Programming	Goodheart-Willcox, 1st Edition, ISBN: 9781590706419
17	Gary D. Anderson	PLC Programming Using RSLogix 500	CreateSpace, ISBN: 9780578541035
18	Luis Bryan, E.A. Bryan	Programmable Controllers: Theory and Implementation	Industrial Text Co., 2nd Edition, ISBN: 9780826913081
19	Michael McRoberts	Beginning Arduino	Apress, ISBN: 9781430232407
20	Massimo Banzi, Michael Shiloh	Getting Started with Arduino	Maker Media, ISBN: 9781680457020
21	Simon Monk	Programming Arduino: Getting Started with Sketches	McGraw-Hill Education, ISBN: 9781260143247
22	John Boxall	Arduino Workshop: A Hands-On Introduction with 65 Projects	No Starch Press, ISBN: 9781593274481
23	Simon Monk	Practical Electronics for Inventors	McGraw-Hill Education, ISBN: 9781259587542
24	Jonathan W. Valvano	Embedded Systems: Introduction to the MSP432 Microcontroller	CreateSpace Independent, ISBN: 9781512185676
25	Dogan Ibrahim	Arduino-Based Embedded Systems	Newnes (Elsevier), ISBN: 9780128198161

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 the 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 a Hydraulic cylinder
12	https://www.youtube.com/watch?v=icaqvfAtccY	Telescopic cylinder animation
13	https://youtu.be/SR47RaA1Zdk	Pneumatics, Pneumatic Control, and Electro-pneumatic explained - Pneumatics for beginners.

Name & Signature:

Mr. R.S. Solanke
Lecturer in Mechanical Engineering

Mr.S.B. Kulkarni
Lecturer in Mechanical Engineering

(Course Experts)

Name & Signature:

Dr.N.G. Kulkarni
(Programme Head)

Name & Signature:

Shri. S.B. Kulkarni
(CDC In-charge)

GOVERNMENTPOLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**CAPSTONE PROJECT**
COURSE CODE	**ME41207**
PREREQUISITE COURSE CODE & TITLE	**Acquired 60 credits**, including all First Year course credits.
CLASS DECLARATION COURSE	YES

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				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	
ME41207	**CAPSTONE PROJECT**	**INP**	--	--	**4**	--	**4**	**2**	--	--	--	--	--	**50**	**20**	**50#**	**20**	--	--	**100**

Total IKS Hrs for Term: 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, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing the minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that Course.
2. If a candidate does not secure the minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit the SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Project work at the institute level serves as a vital bridge between theoretical learning and practical application. It offers students a valuable platform to apply the concepts, knowledge, and technical skills acquired in classrooms and laboratories to address real-world problems—ranging from well-defined tasks to complex, open-ended challenges. This experiential learning approach fosters a deeper understanding of engineering and technological principles by encouraging students to design, develop, and implement solutions in realistic contexts.

The course is strategically designed to integrate interdisciplinary knowledge gained throughout the diploma program, thereby enhancing students' ability to approach problems holistically. Furthermore, it plays a crucial role in nurturing essential professional competencies such as critical thinking, problem-solving, creativity, teamwork, project planning, and innovation.

In alignment with industry and societal expectations, students are encouraged to undertake projects that go beyond conventional solutions and aim to provide impactful, sustainable outcomes. By engaging in such projects, students not only reinforce their technical capabilities but also improve their

employability by developing a mindset geared towards innovation, collaboration, and continuous improvement.

III. INDUSTRY EXPECTED OUTCOME

This course is designed to enable students to develop the industry-relevant competency of:

Effectively executing innovative solutions to real-world problems through collaborative teamwork, adhering to defined timelines, and delivering a well-documented project report.

IV. COURSE-LEVEL LEARNING OUTCOMES (CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Identify real-world field problems relevant to the project work conducted at the institute.
CO2: Analyse the feasibility and viability of the project by conducting data collection and experiments, as well as evaluating required resources, costs, and support.
CO3: Apply technical knowledge and engineering skills to develop effective solutions for real-life or industrial problems.
CO4: Evaluate the proposed project work's ethical considerations and societal impacts.
CO5: Create a comprehensive project report and present the methodology and results within the institute.
CO6: Demonstrate the project outcomes, findings, and achievements effectively through presentations and exhibits.

V. GENERAL GUIDELINES FOR PROJECT WORK

i) Project Selection and Scope

- The project must align with the field of engineering or technology. Interdisciplinary projects are permitted if expected to deliver outcomes aligned with industry relevance or societal needs.

Indicative Project Focus Areas:

i) Automation and Mechatronics
ii) Manufacturing and Production Engineering
iii) Thermal and Energy Systems
iv) Automobile and Mobility Solutions
v) Design and CAD/CAE Applications
vi) Maintenance and Condition Monitoring
vii) Renewable Energy Technologies
viii) Refrigeration and Air Conditioning (RAC)
ix) Environmental and Sustainable Engineering
x) Interdisciplinary and Smart Systems
xi) Agricultural and Rural Engineering Solutions

- Students should select projects that match their skills, knowledge and interests. Faculty should support students in identifying suitable topics.
- Study-based (theoretical-only) projects are **not encouraged**. Projects should involve practical implementation.

ii) Team Structure and Mentorship

- Each project must be executed by a group of 3–4 students under the guidance of an assigned faculty mentor.
- Faculty may organize teams based on:

  - Students' individual strengths and interests
  - Industry-relevant functional roles
  - Project requirements and scope
  - Balanced skill distribution among team members
  - Academic performance and specialization

iii) Nature and Type of Projects

Projects may involve:

- Hardware development
- Software development
- Combination of both

All projects must demonstrate logic building, problem-solving, and application of technologies learned during the diploma program.

Acceptable project formats include:

- Prototype design (design, build, test, and evaluate)
- Application/software development

iv) Project Execution and Documentation

- Students must develop a working model/prototype/software and simultaneously prepare a comprehensive project report.
- Submissions must include:
- One hard copy and one soft copy of the project report
- A soft copy of the source code or a demonstration video/file of the working model
- The project report should include (as applicable):
- Problem Definition
- Platform/Hardware Specifications
- Feasibility Study (Cost & Time Estimates)
- Design Diagrams (UML, Use Case, Activity, DFD, CFD, ERD, etc.)
- Key Code Snippets
- Testing Methodology and Results
- Limitations and Future Scope
- References (Books, Journals, Websites)

v) Project Diary and Supervision

A project diary must be maintained by each group to log:

- Weekly progress and milestones
- Design decisions and challenges
- Faculty feedback and updates
- Faculty mentors should review the diary weekly and provide constructive feedback. The diary should be concise (5–10 pages) and follow the format outlined in Annexure IV.

vi) Learning Outcomes Expected (As Applicable)

- Faculty should ensure students gain the following competencies through project execution:
- Identify and define real-world problems within their domain
- Investigate root causes and possible solutions
- Evaluate solution feasibility, including financial implications
- Gather and analyze data from reliable sources (e.g., books, web, experts, market)
- Develop required designs and execution plans
- Prepare and deliver effective seminar presentations.

vii) Industry-Sponsored Projects

- For industry-guided projects, implementation steps may vary per industry standards.
- However, students must still meet institutional submission criteria:
- Project report format
- Project diary
- Final demonstration
- Assessment based on institutional RUBRICs

viii) National Relevance

Projects should ideally address national thrust areas such as:

- Environmental Sustainability
- Digitization
- Automation
- Renewable Energy
- Other relevant socio-technical development domains.

VI. COURSE IMPLEMENTATION STAGES

1. Orientation Session

A Project Orientation Session shall be conducted during the last week of the fourth term by the Portfolio In-charge faculty. This session will brief students on:

- Project objectives.
- Scope and expected deliverables
- Guidelines for execution and assessment
- Faculty and institutional support

2. Mapping of Students and Faculty Mentors

Students will be organized into teams and assigned faculty mentors based on the following criteria:

- Alignment of student interests
- Faculty expertise
- Team size and project scope

3. Problem Identification and Finalisation

Students are required to:

- Conduct a field survey or exploratory study under faculty supervision
- Identify a real-world, relevant, and feasible problem
- present the idea to a group of faculty members for approval
- This activity may begin in the 4th semester (concurrent with the seminar) and must be completed by the **first week of the 5th semester**

4. Requirement Gathering

A dedicated week is allotted for collecting detailed project requirements, including:

- Estimation of human resources
- Identification of technical (hardware/software) needs
- Feasibility study and cost analysis

Outcome: Students must present their findings to the faculty mentor for approval.

5. Project Planning

Students must prepare a comprehensive project plan covering:

- Task allocation and resource planning
- Timeframe and cost estimation
- Team member responsibilities
- Selection of an appropriate development model (e.g., Waterfall, Agile, Spiral)

Deliverables: A clear roadmap including timelines, milestones, and expected outcomes.

6. Project Proposal Submission

The finalized project proposal must be submitted in **soft copy format** and should include:

- Project title and objectives
- Detailed requirement analysis
- Project plan and execution strategy
- Expected deliverables and outcomes
- Development model and tools to be used

7. Project Development, Testing & Report Preparation

Under the continuous guidance of faculty mentors, students shall:

- Develop the project according to the approved plan
- Maintain project documentation throughout the development lifecycle
- Prepare a detailed final report that includes:
  - System design and architecture
  - Implementation details
  - Testing procedures and results
  - Challenges encountered and solutions adopted
  - Final outcomes and evaluation metrics

8. Project Demonstration

Students must present their project in two stages:

- **Preliminary Demonstration:** A progress review shown to the faculty guide during the development phase.
- **Final Demonstration:** A complete presentation of the working model or application during the End Semester Examination (ESE).

VII. DETAILED WEEKWISE TIMELINE FOR THE COURSE IMPLEMENTATION STAGES:

Week	Activity	Responsibilities
Week 1	**Orientation Session** (Last week of 4th Term)	Portfolio In-charge Faculty: Brief students on project objectives, scope, deliverables, guidelines, execution, and assessment.
Week 2	**Mapping of Students and Faculty Mentors**	Portfolio In-charge Faculty: Organize students into teams based on interests, faculty expertise, team size, and project scope.
Week 3-4	**Problem Identification and Finalisation**	Students: Carry out a field survey or exploratory study under faculty supervision, identify a relevant real-world problem, finalise the issue, and submit a synopsis for faculty approval.
Week 5	**Requirement Gathering**	Students: Collect detailed project requirements (human resources, technical needs, feasibility study, and cost analysis).
Week 6	**Requirements Gathering Presentation**	Students: Present findings to the faculty mentor for approval.
Week 7	**Project Planning**	Students: Prepare a project plan including task allocation, resource planning, timeline, budget, development model, and deliverables. Faculty Mentor: Review plan.
Week 8	**Project Proposal Submission**	Students: Submit final project proposal (title, objectives, requirements, plan, tools, outcomes). Faculty Mentor: Review and approve.
Week 9-12	**Project Development, Testing & Report Preparation**	Students: Begin project development according to the plan. Maintain documentation. Test and iterate. Prepare final report (design, implementation, testing results).
Week 13	**Preliminary Demonstration**	Students: Present a progress review to the faculty mentor.
Week 14	**Project Finalisation & Report Completion**	Students: Finalise development. Prepare a detailed project report with system design, testing results, challenges, and outcomes.
According to the Examination Schedule	**Final Demonstration (End Semester Examination)**	Students: Conduct final demonstration of the working model/application during the ESE. Faculty: Evaluate the project based on the demonstration and report.

VIII. CRITERIA FOR ASSESSMENT/EVALUATION OF PROJECT WORK

A. Formative Assessment (FA) Criteria

The evaluation of students during the fifth semester for Progressive Assessment (PA), totalling **50 marks**, will be carried out based on the following criteria:

i) Rubrics for Assessment of the Team

Course Name :		**Course Code :**	
Student Names :		**Team Enrollment Numbers :**	
Project Batch Number:		**Division :**	
Faculty Guide Name:		**Term :**	

Sr. No.	Week	Assessment Criteria	Max Marks	Rubric Scale – Performance Description (1 to 5)	Marks
1	Week 3-4	Project Selection and Problem Definition	5	1 – The problem is not clearly defined or irrelevant	
				2 – Lacks clarity and relevance	
				3 – Defined and generally relevant	
				4 – Clearly defined and suitable	
				5 – Well-defined, innovative, and impactful	
2	Week 5	Literature Review and Data Collection	5	1 – Insufficient or irrelevant sources	
				2 – Limited data with unclear relevance	
				3 – Adequate review with relevant data	
				4 – Structured, relevant data	
				5 – Comprehensive and critically evaluated sources	

Sr. No.	Week	Assessment Criteria	Max Marks	Rubric Scale – Performance Description (1 to 5)	Marks
3	Week 6	Project Design / Concept and Execution	10	1–2 Design is poorly structured; minimal or no execution	
				3–4 Weak concept, unclear goals, and limited execution	
				5–6 Basic concept with moderate execution; design may lack innovation or clarity	
				7–8 Solid, functional design with good planning and consistent execution	
				9–10 Creative, technically sound design with excellent planning and thorough execution	
4	Week 7	Progress According to Action Plan / Milestones	5	1 – No measurable progress	
				2 – Progress is significantly behind schedule	
				3 – Moderate progress; some tasks completed	
				4 – Mostly on schedule with minor delays	
				5 – Fully on schedule and meeting milestones	
5	Week 08	Quality and Presentation of the Project Report	5	1 – Poorly organized and unclear	
				2 – Disorganized with formatting issues	
				3 – Fair structure and readability	
				4 – Well-organized and readable	
				5 – Professionally formatted and well-written report	

Note: The above rubric will be used as the assessment framework for evaluating performance for the whole team.

ii) Rubrics for Assessment of the Individual:

Course Name :		**Course Code :**	
Student Name :		**Enrollment Number :**	
Project Batch Number:		**Division :**	
Faculty Guide Name:		**Term :**	

Sr. No.	Week	Assessment Criteria	Max Marks	Rubric Scale – Performance Description (1 to 5)	Marks
1	Week 2–13 (Ongoing)	Individual Contribution to the Team	10	1 -2 Rarely involved or shows minimal effort	
				3 -4 Occasionally contributes with limited involvement	
				4 –5 Participates adequately	
				6 – 7 Active and dependable team member	
				8 –10 Consistently proactive, often leads initiatives	
2	Week 2–13 (Ongoing)	Subject Knowledge and Understanding	10	1–2 Very limited understanding of subject concepts; unable to answer questions	
				3–4 Basic awareness but with significant gaps in understanding	
				5–6 Fair knowledge of concepts; can answer general questions correctly	
				7–8 Good understanding of a subject; explains concepts clearly and applies them logically	
				9–10 Excellent grasp; demonstrates deep insight, applies concepts to real-world/project scenarios	

Note: The above rubric will be used as the assessment framework for evaluating individual student performance.

iii) Total Formative Assessment (FA) Marks

Sr. No.	Assessment Criteria	Marks
1	Team Assessment	30
2	Individual Assessment	20
	Total	**50**

Note: The Total **Formative Assessment (FA) Marks** for the individual student.

B. Summative Assessment Criteria

*The summative assessment for students in the Fifth Semester End-Semester Examination (ESE) will carry a total of **50 marks** and shall be conducted by the faculty. Appropriate rubrics may be developed by the faculty for evaluation.*

Course Name :		**Course Code :**	
Student Name :		**Enrollment Number :**	
Project Batch Number:		**Division :**	
Faculty Guide Name:		**Term :**	

Sr. No.	Week	Assessment Criteria	Max Marks	Performance Description (Score Range)	Marks
1	According to the Examination Schedule	**Knowledge and Skill Set Developed**	10	**1–2**: Minimal knowledge gained	
				3–4: Basic understanding with limited skills	
				5–6: Moderate knowledge and practical exposure	
				7–8: Sound knowledge and good skill application	
				9–10: Excellent grasp and skill mastery with advanced application	
2	According to the Examination Schedule	**Quality and Potential of the Project**	10	**1–2**: Poor quality, unclear purpose	
				3–4: Basic functionality with low impact	
				5–6: Adequate quality with moderate potential	
				7–8: High-quality, practical utility	
				9–10: Exceptional quality and strong potential for real-world implementation	
3	According to the Examination Schedule	**Creativity, Innovation, and Teamwork**	10	**1–2**: Lacks originality, poor collaboration	
				3–4: Limited creativity and uneven teamwork	
				5–6: Shows creativity and fair teamwork	
				7–8: Innovative and well-coordinated efforts	
				9–10: Highly original ideas with exemplary team synergy	

4	According to the Examination Schedule	**Project Design, Development, Execution**	10	**1–2**: Poor design and implementation	
				3–4: Basic structure with several gaps	
				5–6: Functional design and moderate execution	
				7–8: Well-planned and executed efficiently	
				9–10: Robust, optimized design with flawless execution	
5	According to the Examination Schedule	**Project Presentation**	10	**1–2**: Disorganized and unclear	
				3–4: Lacks confidence and structure	
				5–6: Acceptable delivery with room for improvement	
				7–8: Clear, engaging, and well-structured	
				9–10: Highly professional, confident, and impactful presentation	

Note: The above rubric will be used as the assessment framework for evaluating individual student performance.

IX. SUGGESTED COS- POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes (PSOs)	
	PO1 -Basic and Discipline-Specific Knowledge	PO2- Problem analysis	PO3- Design/ Development of Solutions	PO-4 Engineering Tools, Experimentation and Testing	PO-5 Engineering Practices for Society, Sustainability, and Environment	PO-6 Project Management	PO-7 Lifelong Learning	PSO-1	PSO-2
CO1	2	2	--	--	2	2	2	--	--
CO2	2	3	2	2	--	3	2	2	2
CO3	3	3	3	3	2	2	2	3	3
CO4	--	--	--	--	3	2	2	--	--
CO5	2	2	2	2	--	3	2	--	--
CO6	2	2	2	2	2	3	3	--	--

X. TYPOGRAPHICAL GUIDELINES FOR PROJECT REPORT WRITING

After the completion of the project work, each student is required to submit a project report. The report should adhere to the following structure and formatting guidelines:

A. STRUCTURE OF THE REPORT

The project report must include the following sections in the given order:

1. **Cover Page** – As per *Annexure I*.
2. **Title Page** – As per *Annexure I*.
3. **Certificate** – As per *Annexure II*.
4. **Acknowledgment** – A brief section in which the student may express gratitude to individuals and organizations who supported the project. As per *Annexure III*.
5. **Abstract** – A one-page summary outlining the objective of the project and the methodology adopted. As per *Annexure IV*.
6. **Table of Contents** – Prepared as per general guidelines. As per *Annexure V*.
7. **List of Figures**-The **purpose of the List of Figures** in a project report is to provide a clear and organized index of all visual representations used throughout the document. As per *Annexure VI*
8. **List of Tables -**The **purpose of the List of Tables** in a project report is to provide a structured overview of all tabular data included in the document. As per *Annexure VI*
9. **Project Description** –
   - Divided into chapters or sections.
   - Each chapter should comprehensively describe a specific phase or component of the project.
   - Include properly labelled diagrams, tables, and flowcharts wherever applicable.
10. **Conclusion** – Summarizes findings and outcomes of the project work.
11. **References** –
    - Begin two spaces below the heading "**REFERENCES**", aligned to the left.
    - Use **single spacing** within entries and list in **alphabetical order**.
    - References must be cited in the text using **square brackets [ ]**, numbered according to their first appearance.
    - Include author name(s), publication year, and other relevant details.

B. REPORT SPECIFICATIONS

1. **Binding**: Hard-bound only
2. **Cover Color**: Black with gold-embossed text (as per *Annexure 1*)
3. **Number of Copies**: Five – One per student and one departmental copy

Paper Size: A4 (portrait orientation)

4. **Margins**:
   - Top: 1 inch
   - Bottom: 1 inch
   - Right: 1 inch
   - Left: 1.5 inches
5. **Font Style**: Times New Roman
6. **Font Sizes**:
   - **Chapter Titles:** 16-point**, Bold, Uppercase**
   - **Headings:** 14-point, **Bold**
   - **Body Text:** 12-point, **Regular**
7. **Line Spacing**: 1.5 throughout the report
8. **Page Numbering**: Bottom center in the format "Page X of N"

Annexure-I

GOVERNMENT POLYTECHNIC, PUNE

(An Autonomous Institute of the Government of Maharashtra)

DEPARTMENT OF MECHANICAL ENGINEERING

PROJECT REPORT

ON

"[TITLE OF THE PROJECT IN CAPITAL LETTERS]"

Submitted By

Student name 1 (enrollment no.)
Student name 2 (enrollment no.)
Student name 3 (enrollment no.)
Student name 4 (enrollment no.)

UNDER THE GUIDANCE OF

[Guide's Full Name]
(Designation, e.g., Lecturer, Department of Mechanical Engineering)

Submitted in Partial Fulfilment

of

The Requirements for the Award of the Diploma in

MECHANICAL ENGINEERING

ACADEMIC YEAR: 20__–20__

GOVERNMENT POLYTECHNIC, PUNE, Ganeshkhind Road, Shivajinagar, Pune – 411016

Annexure-II

GOVERNMENT POLYTECHNIC, PUNE

(An Autonomous Institute of the Government of Maharashtra)

DEPARTMENT OF MECHANICAL ENGINEERING

CERTIFICATE

This is to certify that

1)Name of Student	Enrollment Number
2)Name of Student	Enrollment Number
3)Name of Student	Enrollment Number
4)Name of Student	Enrollment Number

has completed the necessary project work and prepared the bonafide report on

"PROJECT TITLE"

in a satisfactory manner as a partial fulfillment of the requirements for the

DIPLOMA IN

MECHANICAL ENGINEERING

FOR THE ACADEMIC YEAR

20__- 20__

(H.O.D) **(Principal)**

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

Annexure-III

Acknowledgment

(Sample Format)

We would like to express our sincere gratitude to all those who supported and guided us throughout the successful completion of this project.

We are especially thankful to **[Guide's Name]**, our project guide, for their constant encouragement, valuable suggestions, and constructive feedback during the entire duration of this project work.

We would also like to thank **[Head of Department's Name]**, Head of the Department of **[Branch Name]**, Government Polytechnic, Pune, for providing us with the necessary infrastructure and support.

We are deeply grateful to **[Principal's Name]**, Principal, Government Polytechnic, Pune, for providing us with this valuable opportunity and for fostering an academic environment conducive to learning and innovation.

Our heartfelt thanks go to all the faculty members and technical staff of the **[Department Name]** for their help in various ways during this project.

We also wish to acknowledge the support of our classmates, friends, and family members who encouraged and motivated us throughout the journey.

Lastly, we are thankful to the **Government Polytechnic, Pune**, for allowing us to work on this project as a part of our academic curriculum.

Student name 1 (enrollment no.)
Student name 2 (enrollment no.)
Student name 3 (enrollment no.)
Student name 4 (enrollment no.)

Annexure-IV

Abstract

The abstract serves as a one-page comprehensive summary that encapsulates the core aspects of the project. It begins by clearly stating the primary objective or goal of the work, providing the reader with an understanding of the problem being addressed or the purpose behind the study. Following this, the abstract outlines the methodology employed, detailing the approach, techniques, tools, and processes used to achieve the project's objectives. This section may also briefly touch on the scope of the work, key findings, and any conclusions or implications derived from the results. The abstract offers a concise yet informative overview, enabling readers to quickly grasp the essence and significance of the project without delving into the full report.

Annexure-V

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PROJECT DAIRY

Course code :		**Course Name :**	
Student Name :		**Enrollment Number :**	
Project Batch Number:		**Division :**	
Faculty Guide Name:		**Term :**	

Date	Enrollment Numbers of Present Students	Work Assigned/Corrections Suggested	Faculty Remarks	Faculty Signature

Signature of Faculty **Signature of HOD**

Name & Signature: **Shri. S.B. Kulkarni** Lecturer in Mechanical Engineering (Course Expert)	**Dr. N. G. Kulkarni** Head Mechanical Engineering
Name & Signature: **Dr. N. G. Kulkarni** Head Mechanical Engineering	Name & Signature: **Shri. S.B. Kulkarni** (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**Heating, Ventilation, Air Conditioning and Refrigeration**
COURSE CODE	**ME51202**
PREREQUISITE COURSE CODE & TITLE	**Engineering Thermodynamics (ME 31202)**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Category /s	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Basedon SL		Total Marks
														Practical						
										FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
			CL	TL	LL					Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ME51202	HEATING VENTILATION, AIR CONDITIONING AND REFRIGERATION	DSE	3	-	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs. for Term: 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, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that Course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Diploma engineers often encounter issues related to HVAC system performance. Basic knowledge allows them to diagnose problems, perform initial troubleshooting, and communicate effectively with specialized HVAC technicians for repairs and maintenance. HVAC systems play a vital role in maintaining acceptable indoor air quality by controlling ventilation, filtration, and humidity levels. HVAC systems are crucial for ensuring comfort, safety, sustainability and efficiency in both residential and commercial applications. Therefore, this course is designed to provide knowledge & skills related to HVAC.

III. COURSE-LEVEL LEARNING OUTCOMES (CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1- Apply Psychrometric principles for HVAC applications.
CO2 - Select appropriate components for given HVAC applications.
CO3 - Select appropriate air conditioning systems for given situation.
CO4 - Calculate cooling load for the particular situation.
CO5- Develop proper air distribution systems according to site requirement for the given situation

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT.

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		SECTION –I		
	UNIT-I	**Applied Psychrometry (CL Hrs- 06 , Marks- 11)**		
1.	TLO 1.1 Draw various psychrometric processes on psychrometric chart for given Air properties. TLO 1.2 Calculate air properties by using Psychrometry for given data. TLO 1.3 Explain the factors affecting the thermal comfort of human body. TLO 1.4 Explain the strategies for improving indoor air quality.	1.1 Introduction to Air cooling, Concept of Heat Pump. 1.2 Psychrometric Chart: Psychrometric properties of air, Psychrometric processes using By-Pass factor(BPF), Apparatus Dew Point (ADP), Sensible Heat Factor (SHF) and adiabatic mixing of two air streams (Simple numericals on Psychrometry). 1.3 Thermal Comfort: Basic parameters, Thermodynamics of human body, Thermal comfort and Comfort charts, Factors affecting thermal comforts. 1.4 Indoor air Quality (IAQ): Indoor air contaminants, Basic strategies to improve indoor air quality.	Lecture Using Chalk- Board Presentations Videos Collaborative learning	CO1

UNIT-II		**Cooling System Components (CL Hrs-08 , Marks- 12)**		
2	TLO 2.1 Classify compressor used in HVAC system. TLO 2.2 Explain the working of any two components of HVAC system. TLO 2.3 Explain the working of any two auxiliary devices used in HVAC system.	2.1 Refrigeration Compressors: Classifications, Construction and working of Hermetically sealed air compressor, Open type compressor, Rotary compressor, Centrifugal compressor, Screw and Scroll compressor and their applications. 2.2 Condensers: Classifications,Working of air and Water- cooled condensers, Evaporative condensers, comparisons and applications. 2.3 Evaporators: Classification, Working & Applications of finned type, Bared tube, Plate type, Flooded, Shell and Tube type evaporators. 2.4 Expansion devices: Classification, Capillary tube, Automatic expansion valve, thermostatic expansion valve, their selection, working and application.	Lecture Using Chalk-Board Presentations Videos Collaborative learning	CO2
UNIT-III		**Air Conditioning Systems (CL Hrs- 08 , Marks- 12)**		
3	TLO 3.1 Classify Air conditioning system. TLO 3.2 Explain working of any one Air conditioning system. TLO 3.3 Explain the working of Cassette air conditioning system. TLO 3.4 Explain the constructional features of Central air conditioning. TLO 3.5 Select relevant components for given air conditioning system. TLO 3.6 Select the insulating materials for given Air conditioning system. TLO3.7 Describe the air conditioning maintenance procedure.	3.1 Classification of air conditioning System- Summer and Winter, Year around air conditioning, Unitary air conditioning construction, application & comparison. 3.2 Construction and working of Cassette air conditioning system. 3.3 Central air conditioning- types, Direct and Indirect central air conditioning construction, application. 3.4 Insulations- Purpose, types of insulation, materials and their properties. 3.5 Heating Coils-Types.	Lecture Using Chalk-Board, Presentations, Videos, Collaborative learning, Hands on experience on different test rigs/ prototype.	CO3

SECTION –II				
UNIT- IV Cooling Load Calculations (CL Hrs-07, Marks-12)				
4	TLO 4.1 List the factors to be considered for cooling load calculations. TLO 4.2 Identify the sources of heat gain in air Conditioning system for the given situation with justification. TLO 4.3 Calculate cooling load for the given situation.	4.1 Introduction & necessity of Cooling Load Calculations- Energy Efficiency, System Sizing, Occupant Comfort. 4.2 Factors to be considered for cooling load calculations. 4.3 Calculation of Sensible and Latent heat gain sources. Cooling load calculation for- Auditorium/ Computer laboratory/ Class room	Lecture Using Chalk-Board, presentations, Videos, Collaborative learning, Hands on experience	CO4
Unit – V Ventilation and Infiltration (CL Hrs- 08 , Marks-12)				
5	TLO 5.1 Explain the principles of Ventilation including Natural and Mechanical ventilation systems. TLO 5.2 List the design criteria for duct system.	5.1 Ventilation and Infiltration: Natural ventilation, Mechanical ventilation, Concept of Basement Ventilation, Heat Sensors. 5.2 Concept of Air handling unit, Air distribution system- Closed perimeter system, Extended perimeter system, Radial duct system, construction and application of Supply, Return and Make up ducts. 5.3 Duct Design: Definition of duct and types of ducts, Economic factors influencing duct layout, Materials for ducts and its specification, Flow through duct, Pressure in ducts, losses in ducts, Equivalent diameter of a circular duct for rectangular sections, Factors considered for duct design. (Simple numericals on duct design).	Lecture Using Chalk-Board, presentations, Videos, Collaborative learning, Hands on experience	CO4,CO5
Unit – VI Air Distribution Systems(CL Hrs- 08 , Marks-11)				
6	TLO 6.1 Describe different types of air distribution systems. TLO 6.2 Select appropriate	6.1 Air Distribution System: : Factors to be considered for Air distribution system, Types of air distribution devices. Types of Fans used in air conditioning applications,	Lecture Using Chalk-Board, presentations, Videos, Collaborative	CO4,CO5

	components for an air distribution system. TLO 6.3 Describe design criteria for air distribution system in given situation.	Types of Supply air outlets, Selection and location of Outlets, Filters, Diffusers, Grills, Blowers and Dampers. air jet nozzles, Concept of Variable air Volume (VAV) systems and working. 6.2 Introduction to Automobile air conditioning system. Basic requirements for Installation, testing of HVAC Systems, selection of appropriate air conditioning systems for given situation with justification.	learning, Hands on experience	

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

Sr No	Practical / Tutorial / Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Select the proper tools for dismantling and assembling. LLO 1.2 Inspect condition of components.	*Dismantle and assemble hermitically Sealed compressor	2	CO2
2	LLO 2.1 Identify the components of a Household refrigerator LLO2.2 Make use of manufacturer catalogue for specifications and ratings for each component.	*Identify different components of household refrigerator with their specification available in the laboratory.	2	CO2
3	LLO 3.1 Identify the components of a Vapor compression cycle LLO 3.2 DemonstratetheVapor compression cycle	* Identify different components of Vapor compression cycle with their specification available in the laboratory.	2	CO2
4	LLO 4.1 Conduct performance test on Vapor compression system to calculate COP LLO 4.2 Measure the power supplied to compressor.	*Determine COP of given Vapor compression system	2	CO2
5	LLO 5.1 Measure air properties using appropriate Psychrometer efficiently. LLO 5.2 Calculate various air properties using	* Measurement of air properties.	2	CO1

	Psychrometeric Chart.			
6	LLO 6.1 Identify the components of a Unitary air conditioner. LLO 6.2 Make use of manufacturer catalogue for specifications and ratings for each component.	*Identification of various components of Unitary air conditioning system with specifications.	2	CO2
7	LLO 7.1 Select the proper tools for dismantling and assembling. LLO 7.2 Inspect condition of components.	*Dismantling & assembling of the Cassette air conditioning system.	2	CO2 CO3
8	LLO 8.1 Identify the components of a Central air Conditioning system. LLO 8.2 Demonstrate the Central air Conditioning system.	*Demonstration on CentralAir conditioner system.	2	CO2 CO3
9	LLO 9.1 Select the proper tools for dismantling and assembling. LLO 9.2 Inspect condition of components.	*Dismantling & assembling of Automobile air conditioner.	2	CO2 CO3
10	LLO 10.1 Conduct performance test on air Conditioning Test rig to evaluate the cooling effect. LLO 10.2 Measure and record parameters such as supply air temperature, return air temperature, outdoor air temperature and humidity levels.	*Conduct performance test to measure various parameters on air conditioning system.	2	CO4
11	LLO 11.1 Analyze the specific thermal loads and environmental conditions of a specific space. LLO 11.2 Calculate heat gain and losses.	* Conduct performance test on load calculations for cooling and heating.	2	CO4
12	LLO 12.1 Prepare air distribution system layout. LLO 12.2 Create schematic layouts by using Auto-CAD that illustrate the proposed duct routes,	*Prepare layout of air distribution system of given space.	2	CO4 CO5

	sizes, and connections.			
13	LLO 13.1 Identify the components of a railway HVAC system. LLO 13.2 Demonstrate the railway HVAC system.	Demonstration of railway HVAC system.	2	CO3 CO5
14	LLO 14.1 Identify the components of air conditioning system used in ancient India. LLO 14.2 Prepare a report on air conditioning system used in ancient India.	Air conditioning system used in ancient India. (IKS)	2	CO1 CO2 CO3 CO4 CO5

VI. SUGGESTED MICROPROJECT/ ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT(SELF-LEARNING)

a) Prepare a proposal report of cold storage set up.
b) Measure Refrigeration capacity of split air conditioner.
c) Collect different air outlet devices used in Central air conditioning system
d) Download Manufacturer's catalogue of Refrigeration compressors.
e) Prepare display charts of types of refrigerant used in commercial and Industrialapplications.
f) Visit to nearby Central air conditioning plant/Malls/Showrooms and collectinformation regarding air conditioning and prepare report on it.
g) Conduct market survey of household refrigerators, make, capacity, arrangement,features, commercial terms etc.
h) Conduct market survey of window air conditioner make, capacity, arrangement,features, commercial terms etc.
i) Collect information about automobile air conditioning of different vehicles.
j) Comparative study of various types of compressors with detailed specification &market survey.
k) Comparative study of various types of condensers with detailed specification &market survey.
l) Comparative study of various types of evaporators with detailed specification &market survey.
m) Comparative study of various types of expansion devices with detailedspecification& market survey.
n) Study of different types of refrigerants with properties, designation, selection &applications.
o) Comparative study of different types of central air-conditioning system withdetailed specification and visit analysis report. (viz. AHU,FCU,VAV)
p) To prepare bills of materials for the maintenance of the given Refrigeration and airconditioning equipment.

VII. LABORATORY EQUIPMENT/ INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr.No	EquipmentNamewithBroadSpecifications	RelevantLLO Number
1	Hermetically sealed compressor cut section model	1
2	Vapour compression Test rig consisting of Hermetically sealed compressor 1TR capacity, Air-cooled condenser, Expansion devices like TEV and capillary tube, Evaporator coils, with arrangements for measurement of COP of VCC and Heat Pump	3,4
3	Measurement of air properties. Psychrometeric Chart with Digital Psychrometer/ Sling Psychrometer/Wall mounted Psychrometer/: Temperature measurement: range/accuracy/resolution:-4° to 122°F(-20°to50°C)/±1.8°F(±1°C)/0.1° Humidity measurement range/resolution:0to100%RH/0.1% Humidity measurement accuracy: ±3% of reading from 10 to 90% RH; ±4% Dew point measurement range/accuracy: -47° to 122°F/±1.2°F (±0.6°C) Response time: 60 seconds (typical) Readout sizes: 3/8 in. high digits on upper readout; 3/16 in. high digits on lower readout Auto power off: 20 minutes of inactivity Weight: 2.65 oz.(75g) Powersource:Two"AAA"batteries (included)	5
4	Identification of various components of UnitaryAir conditioner with specifications. Cooling Capacity: Min 1 TR or more.	6
5	Dismantling & assembling of the Cassette air conditioning system. Cooling Capacity: Min 1 TR or more.	7
6	Demonstration on CentralAir conditioner system. Cooling Capacity: Min 10 TR or more.	8
7	Dismantling & assembling of Automobile air conditioner. AutomobileAC Compressor, Capacity: 10 - 1000 CFM or more.	9
8	Experimental set up ofAir conditioning system. Cooling Capacity: Min 1.5 TR or more.	10
9	Cooling and heating load calculations. Lux meter: MAX / MIN, Backlight, Auto Power Off. Range: 0 ~ 100,000 lux / 0 ~20,000 Accuracy: ± 5% rdg + 10 dgt (< 10.000 lux / fc) ± 10% rdg + 10 dgt (>10.000 lux/fc) Resolution: 0.1 lux or 0.1 fc. Anemometer: Temperature Range:-20.0~60.0ºC Humidity Range (Rh %): 0.0% ~ 99.9 % RH Range: 0.70~30.00 m/s	11
10	Prepare layout of air distribution system of given space. Educational version license of Auto-CAD or as per availability.	12
11	Demonstration on railway HVAC system. By using available Interactive Classroom Techniques.	13

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE

(SpecificationTable)

Sr.No	Unit	Unit Title	Aligned Cos	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION –I								
1	I	Applied Psychrometry	CO1	06	2	4	5	11
2	II	Cooling SystemComponents	CO2	08	2	4	6	12
3	III	Air Conditioning Systems	CO3	08	2	4	6	12
SECTION –II								
4	IV	Cooling Load Calculations	CO4	07	2	4	6	12
5	V	Ventilation and Infiltration	CO5	08	2	4	6	12
6	VI	Air Distribution Systems	CO5	08	2	4	5	11
GrandTotal				**45**	**12**	**24**	**34**	**70**

IX. ASSESSMENT METHODOLOGIES / TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
1. Term work of 25 marks 2. Two-unit tests of 30 marks and average of two-unit tests.	1. End semester practical examination 25 marks 2. End semester ssessment of 70 marks.

X. SUGGESTED COS-POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes * (PSOs)	
	PO-1Basic 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-6Project Management	PO-7 LifeLong Learning	PSO- 1	PSO- 2
CO1	3	2	-	3	2	3	2	-	-
CO2	3	2	-	2	-	3	2	-	-
CO3	3	2	-	2	-	3	2	-	-
CO4	3	3	-	2	3	3	2	-	-
CO5	3	2	3	3	3	3	3	2	2

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

3. SUGGESTED LEARNING MATERIALS /BOOKS

Sr.No	Author	Title	PublisherwithISBNNumber
1	Khurmi R.S. & J.K.Gupta	Refrigeration andAir Conditioning	S. Chand publication, New Delhi,(2008), ISBN-10:8121927811
2	Arora C.P.	Refrigeration and Air Conditioning	Tata McGraw-Hill Publication, New Delhi, (2009), ISBN-13-978-07-008390-5
3	Ananthnarayan P.M	Basic Refrigeration and Air Conditioning	Tata McGraw-Hill Publication, New Delhi, (2013), ISBN- 9781259062704
4	Sapali S.N.	Refrigeration and Air Conditioning	PHI publication, New Delhi, (2013) ISBN - 9788120348721
5	Prasad Manohar	Refrigeration andAir Conditioning	NewAge International, New Delhi, (2011), ISBN- 9788122414295
6	R.K.Rajput	Refrigeration andAir Conditioning	S.K.Kataria& Sons, New Delhi, (2018) ISBN-13- 9788188458400
7	Dossat R.J.	Principles of Refrigeration	John Wiley and Sons Ltd, UK, (2009) ISBN 978- 0130272706

4. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1	https://youtu.be/YoN5251ta18?si=7t18E4M3uUVgJ_r4	Basic Concepts of Psychrometry andAir-Conditioning
2	https://youtu.be/WM09L5aUuyE ? si=rX8vNmF3nxCDOTM-	FundamentalsofThermalComfort
3	https://youtu.be/NpaR7x-caAo?si=1Sg1Uz0kRwpua_9r	IndoorAirQuality
4	https://youtu.be/yqpR7udHBEA? si=CXsKDKAWaHemwGOA	OutdoorDesignConditions
5	https://youtu.be/YUgN5D-bmpg?si=x6nxT3cwdxwze2mc	Air-ConditioningSystems
6	https://youtu.be/tNj8ocNO4iw?si=_cvQGVSwOOo1jXH6	workingofCassetteairconditioningsystem
7	https://youtu.be/xMkgzVR1Luo?si=uyDAtROjjxnMg7MT	IntroductiontoHVAC
8	https://youtu.be/rTBoP8LbTJA?si=2DCzHNZ3E3rJbEhU	CoolingLoadCalculation
9	https://youtu.be/gRcgUfeAHl4?si=5l0EdmQDsYXGy2Q_	AirDistributionSystem-1
10	https://youtu.be/7Kd3p-xDT2U?si=Ek-Z2yyg9g24I7NE	AirDistributionSystem-2
11	https://youtu.be/BNl638zbWRQ?si=4Mes8896maK3_n3Z	VariableAirVolume(VAV)systemsand working.

Note:

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

Name & Signature: (Mrs. SonaliS.Nagawade) Lecturer in Mechanical Engineering	(Mr. R.S. Solanke) Lecturer in Mechanical Engineering (Course Experts)
Name & Signature: Dr. N.G. Kulkarni (Programme Head)	Name & Signature: Shri.S.B.Kulkarni (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**Diploma in ME**
PROGRAMME CODE	**04**
COURSE TITLE	**Energy Management**
COURSE CODE	**ME51206**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL				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	
ME51206	**Energy Management**	**DSE**	**3**	**0**	**2**	**1**	**6**	**3**	**3**	**30**	**70**	**100**	**40**	**25**	**10**	**25#**	**10**	**25**	**10**	**175**

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2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. *Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

The Energy Management course is designed to address the growing need for professionals who can effectively plan, monitor, and control energy consumption across various sectors. As global energy demands rise and environmental concerns intensify, organizations require skilled individuals to implement strategies that optimize energy use, reduce costs, and minimize environmental impact.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Understand the Principles of Energy Management.
CO2: Prepare energy audit report.
CO3: Use different methods of energy conservation.
CO4: Implement energy conservation measures for thermal systems.
CO5: Assess energy projects from economic, policy, and environmental perspectives.
CO6: Identify and compare various energy storage technologies.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		Section-I		
UNIT-I Introduction to Energy Management			**(CL Hrs- 10 , Marks- 14)**	
1.	TLO 1.1 Definition and Scope of Energy Management TLO 1.2 Energy Conservation and Efficiency Concepts TLO 1.3 Global and Indian Energy Scenario TLO 1.4 Role and Responsibilities of an Energy Manager	1.1 Definition of energy management and its significance in industry 1.2.Scope of energy management: industrial, commercial, and residential sectors 1.3 Objectives of Energy management : cost reduction, resource conservation, and Sustainability 1.4 Difference between energy conservation and energy efficiency 1.5 Importance of energy efficiency in mechanical systems 1.6 Overview of world energy resources and consumption patterns 1.7 India's energy mix : sources, demand, and challenges 1.8 Trends in energy consumption and future projections 1.9 Functions and duties of an energy manager in industry, skills and qualifications required	Lecture using Chalk and Board	CO1
UNIT-II Energy Audit			**(CL Hrs-6 , Marks- 12)**	
	TLO 2.1 Types of Energy Audits TLO 2.2 Objectives of Energy Audits TLO 2.3 Benefits of regular energy audits TLO 2.4 Energy Audit Methodologies TLO 2.5 Key Instruments and Measurement Techniques TLO 2.6 Preparation of audit reports and presentation of findings	2.1.Preliminary (walk-through) vs. detailed energy audits 2.2.Identifying energy-saving opportunities, benchmarking 2.3 Energy Audit Methodologies for Preliminary and Detailed audits 2.4. Types of instruments: power analyzers, flow meters, temperature sensors, Calibration 2.5 Maintenance of audit instruments. 2.6.Safety precautions during measurement 2.7 Preparation of audit reports and presentation of finding	Lecture using Chalk and Board, Video presentation	CO2
UNIT-III Energy Conservation Techniques			**(CL Hrs-06 , Marks- 09)**	
3	TLO 3.1 Conservation in Electrical Systems (Motors, Lighting, HVAC)	3.1 Use of high-efficiency motors and variable frequency drives, 3.2 Lighting upgrades : LED, Occupancy sensors, day lighting, 3.3 HVAC optimization proper sizing, maintenance, and controls 3.4 Boiler operation optimization and	Lecture using Chalk and Board, Video presentation	CO3

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	TLO 3.2 Conservation in Thermal Systems (Boilers, Furnaces, Insulation) TLO 3.3 Waste Heat Recovery and Cogeneration	regular maintenance, 3.5 Furnace efficiency Improvements : preheating, insulation, selection and application of insulation materials 3.6 Types of waste heat recovery systems (heat exchangers, economizers) 3.7 Principles and benefits of cogeneration (combined heat and power), Industrial applications.		
Section-II				
UNIT-IV Energy Management in Industrial Utilities			**(CL Hrs- 10 , Marks-13)**	
4	TLO 4.1 Overview of Major Industrial Utilities (Compressed Air, Steam, Water, HVAC) TLO 4.2 Energy Efficiency in Compressed Air Systems TLO 4.3 Steam Generation, Distribution, and Utilization TLO 4.4 Water Management and Conservation Techniques	4.1 Role of utilities in industrial operations 4.2 Common inefficiencies and energy losses 4.3 Impact on overall plant energy consumption 4.4 Leak detection and repair. Proper sizing and maintenance of compressors. Use of variable speed drives and air receivers 4.5 Boiler efficiency and steam quality improvement. Insulation and steam trap management 4.6 Water usage mapping and monitoring Recycling and reuse of process water 4.7 Implementation of water-saving devices	Lecture using Chalk and Board, Video presentation	CO4
UNIT –V Energy Policy, Economics, and Environmental Impact			**(CL Hrs- 4, Marks-10)**	
5	TLO 5.1 National and International Energy Policies TLO 5.2 Energy Economics : Cost-Benefit Analysis, Life Cycle Costing TLO 5.3 Environmental Impacts: Emissions, Climate Change, Mitigation Strategies	5.1 Overview of key National and Global energy policies and regulations 5.2 Indian Energy Conservation Act and its implications 5.3 Government incentives and schemes for energy efficiency 5.4 Energy Economics: Cost-Benefit Analysis, Life Cycle Costing 5.5 Sources and types of emissions from industrial activities 5.6 Impact of energy use on climate change 5.7 Strategies for emission, reduction and sustainable practices	Lecture using Chalk and Board, Video presentation	CO5

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
UNIT –VI Energy Storage and Grid Integration			**(CL Hrs- 09 , Marks-12)**	
6	TLO 6.1 Energy storage technologies (batteries, pumped hydro, etc.) TLO 6.2 Grid integration of renewable energy sources TLO 6.3 Smart grids and micro grids	6.1 Energy storage technologies: Battery energy storage systems (BESS), pumped hydro storage (PHS), compressed air energy storage (CAES), and other energy storage technologies. 6.2 Grid integration: Integrating renewable energy sources into the grid, including grid stability, power quality, and grid resilience. 6.3 Smart grids: Advanced grid management systems, including smart grid infrastructure, advanced metering infrastructure (AMI), and grid automation. 6.4 Microgrids: Design and operation of microgrids, including grid-connected and islanded modes.	Lecture using Chalk and Board, Video presentation	CO6

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

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO1.1 Measurement of electrical energy consumption in a lab setup	Measurement of electrical energy consumption in a lab setup	2	CO1
2	LLO2.1 To collect information about global and Indian energy market.	*To collect information about global and Indian energy market.	2	CO1
3	LLO3.1 Audit of lighting systems for energy efficiency	*Audit of lighting systems for energy efficiency	2	CO2,CO3
4	LLO4.1 Measurement and analysis of heat loss in insulated pipes	*Measurement and analysis of heat loss in insulated pipes	2	CO3,CO4
5	LLO5.1 Boiler efficiency assessment using direct and indirect methods	Boiler efficiency assessment using direct and indirect methods	2	CO3,CO4
6	LLO6.1 Study of waste heat recovery using heat exchangers	*Study of waste heat recovery using heat exchangers	2	CO3
7	LLO7.1 Energy audit of a compressed air system	Energy audit of a compressed air system.	2	CO2, CO3
8	LLO8.1 Perform energy audit for workshop/Office/Home.	*Perform energy audit for workshop/Office/Home.	2	CO2
9	LLO9.1 Prepare report on Energy conservation and Environmental issues	Prepare report on Energy conservation and Environmental issues.	2	CO4

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
10	LLO10. 1 Compare performance of solar panels in grid-tied vs. off-grid setups	*Compare performance of solar panels in grid-tied vs. off-grid setups	2	CO6
11	LLO11.1Study the grid's frequency response with/without energy storage.	*Study the grid's frequency response with/without energy storage	2	CO6
12	LLO12.1 Prepare presentation on National and International Energy Policies	*Prepare presentation on National and International Energy Policies	2	CO5
13	LLO13.1 Identify Energy audit Instruments	*Identify Energy audit Instruments and study the uses of it	2	CO2
14	LLO14.1 Study the charge/discharge profile of a battery (e.g., Li-ion or lead-acid).	*Study the charge/discharge profile of a battery (e.g., Li-ion or lead-acid).	2	CO6
15	LL015.1 To prepare a report on visit to cogeneration system.	*Prepare report on visit to cogeneration system.	2	CO3
16	LLO16.1 Measure the performance and efficiency of battery energy storage systems.	Measure the performance and efficiency of battery energy storage systems.	2	CO6
17	LLO17.1 Develop a case study on the effectiveness of energy policies in promoting energy efficiency	*Develop a case study on the effectiveness of energy policies in promoting energy efficiency	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

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

Micro project:

Assignment/Case studies:

1. Study energy management projects and initiatives
2. Collect information about Future trends and opportunities in energy management.
3. Make a report on Industrial Energy Savings by Real-world examples from manufacturing and process Industries.
4. Get a case study report on energy saved, cost reduction and payback period.
5. Prepare a market survey on energy efficient motors and transformers.
6. Read and write important features of "Energy conservation act 2003"

VII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Lux meter	LLO3
2	Ammeter MI 0-5-10 A .	LLO3
3	Voltmeter MI 0-150-300 V.	LLO1,LLO3
4	Wattmeter 0-3000 W.	LLO1,LLO3
5	Digital Multi-meter.	LLO1,LLO3
6	Energy efficient transformer.	LLO 3
7	Energy efficient motors.	LLO4,5
8	Energy efficient luminaries.	LLO4,5
9	Energy efficient Equipments /Devices.	LLO3,7,8
10	Power Guard Meter.	LLO10
11	Battery Analyzer	LLO16
12	Thermocouple	LLO4

VIII. SUGGESTED FOR 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
Section-I								
1	I	**Introduction to Energy Management**	CO1	10	10	4	-	14
2	II	**Energy Audit**	CO2	06	4	4	4	12
3	III	**Energy Conservation Techniques**	CO3	06	6	3	-	09
Section-II								
4	IV	**Energy Management in Industrial Utilities**	CO4	10	08	5	-	13
5	V	**Energy Policy, Economics, and Environmental Impact**	CO5	04	04	6	-	10
6	VI	**Introduction to Renewable Energy**	CO6	09	02	4	6	12
Grand Total				**45**	**34**	**26**	**10**	**70**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
Two-unit tests of 30 marks and average of two-unit tests is considered. For laboratory learning 25 Marks. Self-Learning Assessment of 25 Marks	End semester practical examination of 25 marks for laboratory learning. End semester (SA-TH) assessment of 70 marks.

X. 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
CO1	**3**	**-**	**-**	**-**	**3**	**2**	**3**	**-**	**-**
CO2	**3**	**2**	**-**	**2**	**3**	**2**	**2**	**-**	**-**
CO3	**3**	**2**	**-**	**2**	**3**	**2**	**3**	**-**	2
CO4	**3**	**2**	**-**	**3**	**3**	**2**	**3**	**-**	2
CO5	**3**	**-**	**-**	**3**	**3**	**3**	**3**	**-**	3
CO6	**3**			**2**	**3**	**2**	**3**	**-**	2

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

XI. SUGGESTED LEARNING MATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	D.S.Chauhan, S.K.Srivastava,	Non-Conventional Energy Resources	New Age International (P) Ltd. Publishers, Second 2011.
2	Bansal, Kleemann, Meliss	Renewable Energy Sources & Conversion Technology	Tata McGraw Hill **Publishing** Co., New Delhi, 1990.
3	D. Yogi Goswami, Frank Kreith,	Energy Management and Conservation Handbook,	CRC Press; 2nd edition (6 September 2016); TAYLOR & FRANCIS
4	R K Rajput	Non-Conventional Energy Resources	S Chand & Company (3 November 2014)
5	Nidamarathi Vinay Saketh	Energy Audit	BEE PUBLICATION

XII. LEARNING WEBSITES & PORTALS

Sr. No	Link/Portal	Description
1.	http://digimat.in/nptel/courses/video/121106014/L01.html	Non-Conventional Energy Resources
2.	https://youtu.be/XqjC0PS32SE	Energy audit
3.	https://youtu.be/6vOg-u7c1IE	Energy Management & Conservation Techniques
4.	https://youtu.be/pFK-xvc4_0s	Energy Conservation & Management'

Name & Signature:

Mr. S. P. Paranjape
(Lecturer in Mechanical Engineering)

Mrs. P. S. Sarode
(Lecturer in Mechanical Engineering)

(Course Experts)

Name & Signature:	Name & Signature:
Dr. N. G. Kulkarni (Programme Head)	Shri. S. B. Kulkarni (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**Power Plant Engineering**
COURSE CODE	**ME51207**
PRE-REQUISITE COURSE CODE & TITLE	**Engineering Thermodynamics (ME 31202)**
CLASS DECLARATION COURSE	**YES**

I. LEARNING &ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme										
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL				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	
ME51207	Power Plant Engineering	DSE	03	-	02	01	06	03	03	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs. for Term: 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, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Power Plants are the growth engines of any nation today. Electrical power is one of the main resource for any type of industry. Economic growth of the nation essentially results into growth in power sector. Various conventional and non-conventional power plants such as Hydro, Steam, Gas, Diesel, Nuclear power plants, Solar, Wind are employed for power generation. Most of the power plants use mechanical engineering equipment and components. Hence, this course attempts to provide the basic knowledge of the components, operation and maintenance of power plants to the students and would also acquaint them with the latest technological advances taking place in this sector.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Identify various components of Hydroelectric and Diesel power plants.
CO2: Select high pressure Boiler for power generation capacity of plants.
CO3: Identify various components of Steam and Gas turbine power plants.
CO4: Identify various components of Solar, Wind power plants.
CO5: Identify various components of nuclear power plants.
CO6: Estimate economic parameters of power plants.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT:-

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		Section - I		
		UNIT-I Introduction to Power Plants (CL Hrs-06, Marks-09)		
1.	TLO 1.1 Explain energy conversion in the given power plant. TLO 1.2 Identify elements of the given Hydro, Gas, Diesel power plant(s). TLO 1.3 Explain preventive maintenance procedure of the given power plants. TLO 1.4 Explain predictive maintenance procedure of the given power plants.	1.1 World and national scenario of demand and supply of energy. 1.2 Introduction to power plants: their importance and types. 1.3 Hydroelectric power plant: Classification, General arrangement, operating principle, advantages and limitations, Maintenance. 1.4 Diesel power plant: Introduction, components, advantages and limitations, Diesel generating set, Maintenance.	Lecture using Chalk, Black Board and Smart Board	CO1
		UNIT-II High Pressure Boilers (CL Hrs-08, Marks-12)		
2	TLO 2.1 Explain with sketches of the working of the given type of boiler TLO 2.2 Compare the salient features of the given types of high pressure boilers. TLO 2.3 Explain Preventive maintenance of the given high pressure boilers. TLO 2.4 Explain Predictive maintenance of the given high pressure boilers.	2.1 High Pressure Boilers — Classification. 2.2 Construction and principle of working of Lamont boiler, Benson boiler, Loeffler boiler, Velox boiler, Schmidt Hardman boiler, Ramsin boiler. 2.3 Fluidized bed combustion boilers (FBC): principle, need, types, various arrangement, control system and advantages over other boiler systems. 2.4 Comparison or various types of boilers. 2.5 Indian Boiler Regulation Act.	Lecture using Chalk, Black Board and Smart Board	CO2

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		2.6 Maintenance procedure of major components of high pressure and FBC boilers.		
UNIT-III Steam and Gas Power Plants (CL Hrs-08, Marks-14)				
3	TLO 3.1 Explain with sketches the given Fuel handling system. TLO 3.2 Identify various elements of the given Steam power plant and its control system. TLO 3.3 Explain with sketches the given control(s) system of Steam power plant. TLO 3.4 Identify the given Component(s) of Gas Power Plant. TLO 3.5 Explain preventive maintenance of the given major component **o**f given turbine power plants. TLO 3.6 Explain predictive maintenance of the given major component of given turbine power plants.	3.1 **Steam power plants**: Introduction, components, advantages and limitations. 3.2 Fuel handling systems in power plants: types, components. 3.3 Electro-Static Precipitators. 3.4 Control systems of power plants: Elements, Types, desirable characteristics. 3.5 Steam temperature control and feed water control systems. 3.6 Maintenance procedure of major components of Steam power plant. 3.7 **Gas Turbine power plants:** Open and close cycle with constant pressure gas turbine power plant. 3.8 Components of gas turbine power plant. 3.9 Methods to improve the thermal efficiency of a simple open cycle constant pressure gas turbine power plant. 3.10 Advantages of gas turbine power plant over others. 3.11 Maintenance procedure of major components of Gas turbine power plants.	Lecture using Chalk, Black Board and Smart Board	CO3
Section - II				
UNIT- IV Solar and Wind power plants (CL Hrs-08, Marks-11)				
4	TLO 4.1 Understand Solar Thermal Systems. TLO 4.2 Explain working of Solar Photovoltaic Systems. TLO 4.3 Understand Wind energy systems. TLO 4.4 Explain Basic Components of a Wind Energy Conversion	4.1 Solar Collectors used in power generation. 4.2 Elements used in Solar PV system, Solar Cell Technologies, Solar Cell, Module, and Array Construction. 4.3 Basic Principles of Wind Energy Conversion. The Power in the Wind, Forces on the Blades, Wind Energy	Lecture using Chalk, Black Board and Smart Board	CO4

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	(WEC) System. TLO 4.5 Calculate wind energy/power	Conversion, Wind Data and Energy Estimation. 4.4 WEC systems, Types of Wind Machines (Wind Energy Collectors), Generating Systems, Energy Storage, Applications of Wind Energy. 4.5 Wind energy/power, wind speed, swept area of wind mill blades.		
UNIT –V Nuclear Power Plants (CL Hrs-08, Marks-12)				
5	TLO 5.1 Sketch labeled arrangement of the given nuclear power plant. TLO5.2Explain with sketches working of the given reactors. TLO 5.3 Compare the calorific values of the given types of fuels. TLO 5.4 Interpret the regulations for nuclear power plants.	5.1 Nuclear power plant: Classification, General arrangement, operating principles. 5.2 Nuclear Fuels and Reactors. 5.3 Advantages and limitations. 5.4 Introduction to regulating agencies and regulations: Atomic Energy Regulatory Board (AERB), International Atomic Energy Agency (IAEA).	Lecture using Chalk, Black Board and Smart Board	CO5
UNIT –VI Economic Analysis of Power Plants (CL Hrs- 08 , Marks-12)				
6	TLO 6.1 Estimate Cost of Electricity in the given situation using simple numerical problems. TLO 6.2 Calculate performance parameters for the given power plant using simple numerical problems. TLO 6.3 Understand Electricity generation in ancient India	6.1 Estimation of production cost ofe1ectrical energy in various types of power plants. 6.2 Estimation of various Performance parameters. 6.3 Factors affecting choice of a power plant. 6.4 (*IKS) Systems and components used in Electricity generation in ancient India	Lecture using Chalk, Black Board and Smart Board	CO6

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

Sr. No	Practical/Tutorial/Laboratory Learning Outcome(LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO1.1 Identify various components used in Hydroelectric power plant.	*Use of models, charts, simulation and real videos	2	CO1
2	LLO2.1 Maintain various components used in Hydroelectric power plant.	Use of models, charts, simulation and real videos.	2	CO1

Sr. No	Practical/Tutorial/Laboratory Learning Outcome(LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
3	LLO3.1 Identify various components used in Diesel engine power plant. LLO3.2 Identify various components of Portable Generator Set	* Demonstration on diesel engine. Dismantling and Assembly Portable Generator Set	2	CO1
4	LLO4.1 Understand working of the High pressure boilers.	* Demonstration on Models of boilers.	2	CO2
5	LLO5.1 Understand preventive maintenance of the High pressure boilers.	* Demonstration on Models of boilers	2	CO2
6	LLO6.1 Interpret standards for the materials, design, construction, inspection, and testing of boilers and their components in India	*Interpretation with the help of provisions in Indian Boiler Regulations Act (IBR).	2	CO2
7	LLO7.1 Identify various components used in Thermal power plant.	* Use of models, charts, simulation and real videos for understanding thermal power plant.	2	CO3
8	LLO8.1 Identify various components used in Gas turbine power plant.	Use of models, charts, simulation and real videos, for understanding gas turbine power plant.	2	CO3
9	LLO9.1 Identify various components used in Solar Thermal power plant.	* Use of models, charts, simulation and real videos, for understanding solar thermal power plant.	2	CO4
10	LLO10.1 Identify various components used in solar PV cell/panel operated power plant.	* Use of models, charts, simulation and real videos for understanding solar power plant.	2	CO4
11	LLO11.1 Prepare working/non-working model of solar PV cell/panel operated power plant.	*Preparation of solar power plant model using PV cell and other electrical appliances available in the institute lab/market.	2	CO4
12	LLO12.1 Identify various components used in Wind mill power plant.	* Use of models, charts, simulation and real videos for understanding Wind mill Power plants.	2	CO4
13	LLO13.1 Prepare working/non-working model of wind mill power plant.	Prepare and assemble wind mill using different mechanical components.	2	CO4
14	LLO14.1 Identify various components of Nuclear Power Plants	* Use of models, charts, simulation and real videos for understanding Nuclear Power plants.	2	CO5
15	LLO15.1 Prepare report for production cost electrical energy for any one power plant LLO15.2 Prepare case study report on performance parameters of any one power plant.	Preparing report based on actual data related to establishment of particular power plant.	2	CO6
16	LLO16.1 Compare the process of electricity generation in modern India with that of ancient India.	* (IKS) Use of various literature and Internet resources describing information about electricity generation in ancient India	2	CO6

Sr. No	Practical/Tutorial/Laboratory Learning Outcome(LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
			32	

Note: Out of above suggestive LLOs -
'*' Marked Practical (LLOs) Are mandatory.
Minimum 80% of above list of lab experiment are to be performed.
Judicial mix of LLOs is to be performed to achieve desired outcomes

V. SUGGESTED SELF LEARNING ACTIVITIES ASSIGNMENT ACTIVITIES FOR SPECIFIC LEARNING SKILLS DEVELOPMENT (SLA)

The SLA could be industry application based, internet-based, workshop- based, laboratory-based or field-based. Each SLA should encompass two or more COs which are in fact, an integration of LLOs and TLOs. Each student will have to maintain dated term work consisting of individual contribution in the SLA work and produce it for submission. The student ought to submit SLA term work by the end of the semester to develop the industry oriented COs.

A suggestive list of SLA is given here. Similar SLA could be added by the concerned faculty:

a) Collection of information about nearby cogeneration plant.
b) Comparative study of various parameters of performance evaluation of a power plant.
c) Maintenance of a diesel generator set (DG set).
d) Develop maintenance procedure for preventive and predictive maintenance of a typical Hydro Power Plant and its components.
e) Develop maintenance procedure for preventive and predictive maintenance of a typical Diesel power plant and its components.
f) Develop maintenance procedure for preventive and predictive maintenance of typical FBC boilers and its components.
g) Develop maintenance procedure for preventive and predictive maintenance of a typical High-pressure boiler and its components
h) Develop maintenance procedure for preventive and predictive maintenance of a typical Steam Power Plant and its components.
i) Develop maintenance procedure for preventive and predictive maintenance of a typical Gas Power Plant and its components.
j) Preparation of Working / Non-working model of allotted power plant by faculty.
k) Prepare a report on given topic to be studied by watching videos from internet.
l) Prepare a report by visiting available nearby power plant.
m) Prepare a report by conducting survey on conventional power plants available in India.
n) Prepare a report by conducting survey on non-conventional power plants available in India.

VI. LABORATORY EQUIPMENT INSTRUMENTS TOOLS SOFTWAR REQUIRED:-

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Working Model of Hydropower plant-Small Turbine (capacity-0.25KW),lighting system as a load(min.10bulbs of various capacity)	LLO1.1 LLO2.1
2	5KVA Diesel Generator set.	LLO3.1 LLO3.2
3	Working model of Steam Power plant-oil fired Boiler (min Capacity-0.5KW), Reaction steam Turbine, Surface Condenser, generator, power distribution system to power bank.	LLO7.1
4	Fuel nozzles, Liners, Spark plugs, Flex hoses, Check valves etc. component of Gas turbine power plant.	LLO7.1 LLO8.1 LLO3.1
5	Model of gas power plant including all major components	LLO8.1
6	Condenser, economizer etc, components of Steam Power, Plant.	LLO7.1
7	Working model of Loffler Boiler.	LLO4.1
8	Working model of Benson Boiler.	LLO5.1
9	Working model of Electrostatic Precipitator.	LLO7.1 LLO8.1
10	Model of FBC Boiler.	LLO4.1 LLO5.1 LLO7.1
11	Working model of Feed water control system.	LLO4.1 LLO5.1 LLO7.1
12	Temperature sensor and Temperature sensing system.	All LLOs
13	Working model of Solar thermal power plant.	LLO9.1 LLO10.1 LLO11.1
14	Working model of Solar PV cell/panel operated power plant.	LLO9.1 LLO10.1 LLO11.1
15	Working model of Wind mill power plant.	LLO12.1 LLO13.1
16	Model of Nuclear Power plant.	LLO14.1
17	AxCYCLE Software Thermodynamic Simulation Software for heat balance calculations of heat production and energy conversion cycles.	All LLOs

VII. SUGGESTED FOR 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
SECTION - I								
1	I	**Introduction to Power Plants**	CO1	6	3	0	6	09
2	II	**High Pressure Boilers**	CO2	8	2	4	6	12
3	III	**Steam and Gas Power Plants**	CO2, CO3	8	4	4	6	14
SECTION - II								
4	IV	**Solar and Wind power plants**	CO4	08	2	3	6	11
5	V	**Nuclear Power Plants**	CO5	08	2	4	6	12
6	VI	**Economic Analysis of Power Plants**	CO6	08	2	4	6	12
Grand Total				**46**	**15**	**19**	**36**	**70**

VIII. ASSESSMENT METHODOLOGIES/ TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment for Learning)
1. Term work	1. End semester practical examination

IX.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-6ProjectManagement**	**PO-7 Life Long Learning**	**PSO-1**	**PSO-2**	**PSO-3**
CO1	**3**	**-**	**-**	**2**	**-**	**2**	**2**	**-**	**-**	**-**
CO2	**3**	**2**	**-**	**2**	**-**	**2**	**2**	**-**	**-**	**-**
CO3	**3**	**2**	**-**	**2**	**2**	**2**	**2**	**-**		**-**
CO4	**3**	**2**	**-**	**2**	**-**	**2**	**2**	**-**		**-**
CO5	**3**	**2**	**-**	**2**	**-**	**2**	**2**	**-**		**-**
CO6	**3**	**3**		**3**		**3**	**2**	3		

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

X. SUGGESTEDLEARNINGMATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Nag P.K.	Power Plant Engineering	Tata McGraw Hill ISBN: 9789339204tJ4
2	El-Wakil M.M.	Power Plant Technology	Prentice Hall India ISBN:9780070702448
3	Raja A. K.	Power Plant Engineering	Prentice Hall India ISBN:9788122418316
4	Sharma,P.C. and Nagpal	A Text Book of Power Plant Engineering	McGraw Hill Education,(India) ISBN: 9789350143841
5	Yadav R.	Steam and Gas Turbine and	Central Publication house ISBN: 9788185444352

XII. LEARNINGWEBSITES& PORTALS

Sr. No.	Link/ Portal	Description
1.	https://www.eia.gov/energyexplained/hydropower https://www.energy.gov/eere/water/types-hydropower-plants https://en.wikipedia.org/wiki/Hydroelectricity https://www.britannica.com/science/hydroelectric-power	Information, construction, working of Hydroelectric Power Plants
2.	https://en.wikipedia.org/wiki/Thermal_power_station https://www.tepco.co.jp/en/hd/about/facilities/thermal-e.html https://www.youtube.com/watch?v=IdPTuwKEfmA https://byjus.com/free-ias-prep/thermal-power-plants-in-india-for-prelims-exam/ https://en.wikipedia.org/wiki/Gas-fired_power_plant https://energyeducation.ca/encyclopedia/Natural_gas_power_plant	Information, construction, working of Thermal Power Plants and Gas Power Plants
3.	https://simple.wikipedia.org/wiki/Solar_power_plant https://www.energy.gov/eere/wind/how-do-wind-turbines-work https://en.wikipedia.org/wiki/Nuclear_power_plant	Information, construction, working of Solar, Wind and Nuclear and Gas Power Plants
4.	https://www.lkouniv.ac.in/site/ https://www.slideshare.net/slideshow/diesel-power-plant	Information, construction, working of Diesel Engine Power Plants
5.	https://www.cmu.edu/ceic/assets https://www.sciencedirect.com/science/article https://www.researchgate.net/publication	Economic Analysis of Power Plants

Name &Signature:	
Mr. Balu Baban Dome Lecturer in Mechanical Engineering	Dr. Sachidanand Swamirao More Lecturer in Mechanical Engineering
(Course Experts)	
Name & Signature: Dr. N.G. Kulkarni (Programme Head)	Name & Signature: Shri.S.B.Kulkarni (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**Automobile Engineering**
COURSE CODE	**ME51203**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				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	
ME51203	**Automobile Engineering**	DSE	03	-	02	1	06	03	03	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Term: 02 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, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Diploma holders in Mechanical Engineering are expected to identify the components in automobile systems, select the different layouts as per the applications and demonstrate the working of various automobile systems. This course will be helpful to student in correlating various automobile systems with each other and provides the opportunity to work in various automobile manufacturing units, sales and service of automobiles products.

III. INDUSTRY EXPECTED OUTCOME

Use various engineering principles to different automobile engineering systems and equipment.

IV. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Draw general layout of Automobile systems.
CO2: Identify faults in Transmission system of an automobile.
CO3: Identify different components of steering and braking systems.
CO4: Identify different components of Suspension systems.
CO5: Inspect different elements of starting and Charging circuit of an automobile and
CO6: Use Emission analyzer tools for effective implementation of legislative emission norms.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		SECTION-I		
	Unit - I Introduction to Automobile		**(CL Hrs.- 07 , Marks- 12)**	
1.	TLO 1.1 Identify various components of vehicle. TLO 1.2 Classify automobiles on the basis of various criteria. TLO 1.3 Draw layout of various vehicles. TLO 1.4 State the advantages and disadvantages of layout of various vehicle. TLO 1.5 State the function of chassis, frame and body. TLO 1.6 Compare conventional frame and Unitized frame. TLO 1.7 Explain with sketch the functions of various components of Electric & Hybrid vehicles.	1.1 Automobile: Definition, Major Components of Automobiles with their functions. 1.2 Classification of Automobiles on the basis of Purpose, Load capacity, Fuels used, based on drive, no. of wheels and axles, transmission, Suspension. 1.3 Vehicle Layout: Significance of vehicle Layout, Different types of vehicle layout, Front Engine Front Wheel Drive, Front Engine Rear Wheel Drive, Rare Engine Rear Wheel Drive, Four Wheel Drive. (FEFWD, FERWD, RERWD, 4WD), Advantages and Disadvantages. 1.4 Function of Chassis, Frame and Body: Chassis components, Functions of frame, Loads acting on the frame, Advantages, disadvantages and types of frames (Conventional frame, sub-frames, unitized frame or frameless construction), Requirements of Body, different types of body styles. 1.5 Electric & Hybrid Vehicle: Needs, components and their Functions. 1.6 Development of Automobiles from Ancient time. (IKS) (No Theory question)	Model Demonstration Video Demonstrations Presentations Lecture Using Chalk-Board	CO1
	UNIT-II	**Automobile Transmission system I (CL Hrs-08 , Marks- 12)**		
2	TLO 2.1 Draw layout of transmission system TLO 2.2 State the necessity of clutch. TLO 2.3 Compare Single plate clutch & Multi plate clutch. TLO 2.4 Explain Single Plate clutch and Multi plate clutch with neat sketch. TLO 2.5 Explain working of	2.1 Transmission System Layout, components and its application: Layout of two wheel drive transmission system (2WD) and four wheel drive transmission system (4WD) and application. 2.2 Clutch: Function and Necessity, Requirement, classification, working principle, construction and working of Single plate (Coil Spring and Diaphragm) clutch, Multi plate Clutch.	Model Demonstration Video Demonstrations Presentations Lecture Using Chalk-Board	CO2

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	various types of Gear box with sketch.	2.3 Gear Box: Manual Transmission, Classification, Construction and working of Constant Mesh Gear Box and Synchromesh Gear Box. Automatic transmission, Torque converter , Epicyclic Gearbox (Gear Train).		
	UNIT-III Automobile Transmission system II, ,wheels and tyres (CL Hrs-07 , Marks- 11)			
3	TLO 3.1 State the function of propeller shaft, Universal joint and slip joint. TLO 3.2 Explain the working principle of Differential with sketch. TLO 3.3 Identify various types of axle and its components TLO 3.4 Explain with sketch Torque converter. TLO 3.5 State the types of wheel rims and it's Nomenclature. TLO 3.6 Compare Radial Ply, Cross Ply tyres. TLO 3.7 Select suitable tyres on the basis of designation. TLO 3.8 State the necessity of wheel alignment and balancing TLO 3.9 State the procedure of wheel alignment and balancing	3.1 Propeller Shaft: Functions and Necessity, Construction of propeller shaft, Functions of universal joint and slip joint 3.2 Differential: Function and Necessity, construction and working principle. 3.3 Axle: Front axle Construction and requirements, Types of (Front) Stub axle, construction and functions of Semi floating, Fully floating type of rear axle. 3.4 Wheels, Rims and Tyres: Function and requirement of wheels. Types of wheels 3.5 Tyre cross section: Cross Ply, Radial ply and belted bias, Tyre designation, Factors affecting tyre life. 3.6 Wheel Alignment and Wheel balancing: Purpose of wheel alignment, Procedure of wheel alignment .Purpose of wheel balancing and procedure of wheel balancing	Model Demonstration Video Demonstrations Presentations Lecture Using Chalk-Board	CO2
	SECTION- II			
	UNIT-IV Automobile Control Systems (CL Hrs- 08 , Marks- 12)			
4	TLO 4.1 State the function of braking system. TLO 4.2 Explain various types of brake system with neat sketch. TLO 4.3 Explain with sketch major components of hydraulic brake systems. TLO 4.4 Compare Disc and Drum Brakes. TLO 4.5 Explain the concept of ABS.	4.1 Braking System: Function and Braking Requirements, Classification of brakes. Construction and working of Drum and Disc Brakes. Working of Mechanical, Hydraulic and Air brake system. 4.2 Major Components of Hydraulic braking System: Master Cylinder, Wheel cylinder. 4.3 Introduction of Antilock brake system (ABS) 4.4 Steering System: Function and Requirements, Construction of steering	Model Demonstration Video Demonstrations Presentations Lecture Using Chalk-Board	CO3

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	TLO 4.6 Explain Working of Steering linkages. TLO 4.7 Explain with sketch various types of steering gear boxes. TLO 4.8 Describe the terms related to steering geometry with neat sketch	linkages for rigid axle and Independent suspension systems. 4.5 Steering Geometry: Castor, camber, Toe-in, Toe-out, King pin inclination, understeer and over steer. 4.6 Steering Gear box: Types, Construction and working of Rack and pinion, Recirculating ball type steering gear box, Necessity and principle of power steering.		
	UNIT- V	**Automobile Suspension (CL Hrs-07, Marks-11)**		
5	TLO 5.1 Explain with neat sketch working of various type of suspension system. TLO 5.2 Compare Rigid axle and Independent Suspension. TLO 5.3 Describe working of hydraulic Shock absorber and Air Suspension system.	5.1 Suspension Systems: Function, Requirements, and types. 5.2 Rigid axle suspension, independent suspension system: Introduction, Construction and working of Mac-pherson strut type, wishbone type of suspension system. 5.3 Shock Absorber and Air Suspension: construction and working of Telescopic shock absorber and Air suspension system.	Model Demonstration Video Demonstrations Presentations Lecture Using Chalk-Board	CO4
	UNIT –VI	**Introduction to Auto Electrical Systems and Emission (CL Hrs- 08 , Marks-12)**		
6	TLO 6.1 Explain battery components and working. TLO 6.2 State Battery rating and its capacity. TLO 6.3 State the function of starter and alternator. TLO 6.4 Explain the working of different types of ignition system with sketch. TLO 6.5 Explain the Complete and Incomplete Combustion and Constituents of Exhaust Gases. TLO 6.8 Explain Three way catalytic convertor - Construction and working. TLO 6.9 State Emission norms	6.1 Introduction to Battery and its components: Function and Requirements of battery, Types of battery, Battery Rating and Battery Capacity. 6.2 Starting System and charging system: Functions and Requirement of starting and charging system, starting system components and their functions, Alternator components and their functions. Working Principle of alternator. 6.3 Ignition System: Introduction to various types of Ignition Systems. (Battery Ignition, Magneto Ignition and Electronic Ignition System) 6.4 Complete and Incomplete Combustion, Constituents of Exhaust Gases. 6.5 Three way catalytic convertor - Construction and working. 6.6 Emission norms of BS-VI	Model Demonstration Video Demonstrations Presentations Lecture Using Chalk-Board	CO5, CO6

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

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Identify automobile systems like (Transmission ,Control ,Suspension , Electrical and Electronics) LLO 1.2 Draw layout of various types of vehicles. Front Engine Front Wheel Drive, Front Engine Rear Wheel Drive, Rare Engine Rear Wheel Drive, Four Wheel Drive.(FEFWD, FERWD, RERWD, and 4WD) LLO 1.3 Compare various layouts.	Prepare a Layout of Vehicle available in laboratory	2	CO1
2	LLO 2.1 Select various tools available in laboratory. LLO 2.2 Categorize tools available in laboratory.	Observe and Maintain given automobile component using various service tools .	2	CO1
3	LLO 3.1 Dismantle given clutch. LLO 3.2 Identify components of clutch. LLO 3.3 Draw any components of the clutch. LLO 3.4 Identify fault in clutch. LLO 3.5 Assemble clutch.	*Dismantle, inspect and reassemble given clutch assembly.	4	CO2
4	LLO 4.1 Dismantle gear box LLO 4.2 Identify various components of Constant Mesh/Synchro Mesh Gear Box. LLO 4.3 Inspect components of gear box. LLO 4.4 Identify fault in gear box LLO 4.5 Assemble gear box.	* Dismantle, inspect and reassemble given Gear Box	4	CO2
5	LLO 5.1 Dismantle differential. LLO 5.2 Identify the components of Differential. LLO 5.3 Check components of differential. LLO 5.4 Identify Fault in differential. LLO 5.5 Assemble differential.	* Dismantle, inspect and reassemble given Differential unit.	4	CO2
6	LLO 6.1 Repair Drum and Disc Brake. LLO 6.2 Compare Drum and Disc Brake LLO 6.3 Carry out brake bleeding procedure.	* Observe and inspect different types of braking system in various automobiles.	4	CO3
7	LLO 7.1 Identify components of steering Systems. LLO 7.2 Draw steering linkages LLO 7.3 Identify possible causes of failure in steering system LLO 7.4 Suggest remedial action	Identify different components of Steering system available in laboratory	2	CO3

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
8	LLO 8.1 Identify components of Suspension systems LLO 8.2 Compare rigid axle and Independent suspension systems. LLO 8.3 Identify possible faults. LLO 8.4 Suggest remedial action.	* Identify different components of Suspension system in laboratory	2	CO4
9	LLO 9.1 Perform battery test. LLO 9.2 Analyze the result of Open Voltage and Specific Gravity test for battery.	Test a lead acid battery for open voltage and specific gravity.	2	CO5
10	LLO 10.1 Identify necessity of wheel balancing and wheel alignment. LLO 10.2 List stepwise procedure for wheel balancing and wheel alignment.	Observe the process of Wheel balancing and wheel alignment at automobile service center.	2	CO5
11	LLO 11.1 Perform Emossion test. LLO 11.2 Analyze the result of Emission test.	* Observe and analyze the Emission test at Automobile service center.	2	CO5
			30	

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:

Only one micro-project is planned to be undertaken by a student that needs to be assigned to them. In special situations where groups have to be formed for micro projects, the number of students in the group should not exceed three. The micro-project could be industry application-based, internet-based, workshop based, laboratory-based or field-based. Each micro-project should encompass two or more COs that integrate PrOs, UOs and ADOs (Affective Domain Outcomes). Each student will have to maintain a dated work diary of individual contributions to the project work and give a seminar presentation before submission. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs. A representative list of micro-projects is given here. The concerned faculty could add similar micro-projects:

a. Prepare a chart of symbolic representation of different electrical-electronic components used in automobiles. (e.g. earthing, fuse, circuit breaker, capacitor, resistor, coil, switch, diode, motor, semiconductor etc.) Course Code: ME5103 MECH, GPP Page 367 of 452 180 OB

b. Collect information on chassis specifications of different vehicles.

c. Visit a modem service station and prepare a layout indicating various sections, specialized equipment, machines and basic amenities.

d. Prepare a case study on the following topics related to transport management through group discussion:

i. Current public transport scenario in India ii. RTO policies for enhancing road safety

iii. Importance of metro rail in the rapid transition system

iv. Review of worldwide effective rapid transition systems (E.g. BRT System in Bogota, Singapore, Japan, Malaysia)

v. Traffic crisis in metro cities: causes and cures
vi. Role of motor vehicle department in transport management

e. Information search and market survey through magazines like Overdrive, Autocar, Auto India, internet surfing and site visits on following topics:
i. Automobile manufacturers in India.
ii. Aerodynamic optimization in automobiles.
iii. Current (Indian/Worldwide) automobile market of 2/4 wheeler industry.
iv. Upcoming vehicles on alternative fuels in the Indian auto industry. v. Adaptive suspension system

f. Prepare a chart of road traffic signs in mandatory, cautionary, and informatory categories. Display it in your department/institute.

g. Prepare a simple automobile lighting circuit display with wiring color codes.

h. Information search and market review on "Different types of automobile service tools and specialized equipment and machines" used in Modem Service Stations

i. Prepare a report on electric and hybrid vehicles.

Assignment:

Other than the classroom and laboratory learning, the following are the suggested student-related co-curricular activities that can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct the following activities in group and prepare reports of about five pages for each activity, also collect/record physical evidence for their (student's) portfolio which will be helpful for their placement interviews:

a. Prepare a comparative chart overall specifications of automobiles of same class
b. Survey of brake oil and engine oil used in automobiles.
c. Search information about ratings and specifications of batteries, alternators, starters,
d. Prepare posters to illustrate the organization chart in the automobile workshop

VIII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Model of any TWO/FOUR wheel drive (2W/4W Drive) Vehicle.	01,08,09
2	Automobile Service tool kit with Axle Stand/Scissor/Hydraulic Screw Jack	01
3	Single plate Clutch components (Coil Spring and Diaphragm)	02
4	Working model of transmission system	04
5	Bike with Multiplate clutch and brakes	04
6	Constant Mesh / Synchro Mesh Gear Box used in four wheeler.	05
7	Working Models of Differential Assembly	06
8	Working Model of Disc Brake and Drum Brake	07
9	Working model of steering gear box Rack and Pinion, Recirculating Ball type and Power steering.	08
10	Model of Semi Elliptical Leaf Spring	09
11	Model of Mac-Pherson suspension.	09,10
12	12 Volt Lead Acid Battery in working condition, 7-50 AH.	11
13	Multi meter with voltage measuring range 0-100 V.DC ,	12
14	Hydrometer for specific gravity test (Sp.gr. Range of 1.100-1.300)	13
15	PUC apparatus used to measure and analyze vehicle emission result	14

IX. SUGGESTED FOR 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 Automobile	CO1	7	3	3	6	12
2	II	Automobile Transmission system I	CO2	8	3	5	8	12
3	III	Automobile Transmission system II	CO2	7	3	5	7	11
4	IV	Automobile Control Systems	CO3	8	2	3	5	12
5	V	Automobile Suspension ,wheels and tyres	CO4	7	2	3	5	11
6	VI	Introduction to Auto Electrical Systems and Emission	CO5	8	2	2	3	12
Grand Total				**45**	**15**	**21**	**34**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
1. Term work	1. End semester practical examination

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
CO1	3	2	2	2	2	2	2	2	2
CO2	3	2	2	3	2	2	2	2	2
CO3	3	2	2	3	2	2	2	2	2
CO4	3	2	2	2	2	2	2	2	2
CO5	3	2	2	3	2	3	2	2	3
CO6	3	2	2	3	3	3	2	2	3

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

XII. SUGGESTED LEARNING MATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Dr. Kirpal Singh	Automobile Engineering Vol. I and II	Standard Publications,7 December 2020 ISBN-13: 978-818 0142420.
2	C.P. Nakra	Basic Automobile Engineering	Dhanpat Rai Publishing Co. 1 January 2023 ISBN-13.978-9352168828
3	K.K.Jain, R.B.Asthana	Automobile Engineering	McGraw Hill 1JAN 2012 ISBN-13: 978-0070445291
4	Shrinivasan	Automotive Mechanics	McGraw Hill, 23 May-2018, ISBN-13 978-1760421502
5	Crouse W.H. and Anglin D.W.	Automotive Mechanics	McGraw-Hill (31 January 1993,ISBN-13 978-0028009438
6	Rajput R.K	A Text Book of Automobile Engineering	Laxmi Publications Pvt.ltd.,New Delhi, (2007) ISBN:97881170089919.
7	TOM Denton	Automobile Electrical and Electronics Systems	Routledge; 5th edition (12 September 2017) SBN-13 978-1138310490
8	Kamaraju Ramakrishna	Automobile Engineering	PHI Learning Pvt. Ltd., New Delhi, (20 ISBN: 9788120346109.
9	Prof. Dr. Ravi Prakash Arya	Engineering and Technology in Ancient India	INDIAN FOUNDATION FOR VEDIC SCIENCE ,ISBN: 9788194759300 (2020)

XII. LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	http://nptel.ac.in/courses. (NPTEL)	Automobile Courses
2	https://www.araiindia.com/Draft AIS Standards.asp.	Certification and Testing Agency (ARAI, Pune)
3	https://www.saeindia.org/.	For Membership of students in (SAE India)
4	https://www.youtube.com/watch?v=wCu9W9xNwtI.	Working of Manual transmission
5	https://www.youtube.com/watch?v=vOo3TLgL0kM.	Working of Synchromesh Gear Box
6	https://www.youtube.com/watch?v=aNGA5Ejq8A4.	Differential working Principle
7	https://www.youtube.com/watch?v=VFu-6tckyc8.	Axle Repair and Maintenance
8	https://www.youtube.com/watch?v=LCMs-7K8nLk.	Alloy wheels manufacturing
9	https://www.youtube.com/watch?v=W1vOzcBbgfg	Working of constant mesh gear box
10	https://www.youtube.com/watch?v=uTeMz6d7hwA	Operation of Synchromesh gear box
11	https://www.youtube.com/watch?v=M5H7UY55rrw	Battery open voltage test
12	https://www.youtube.com/watch?v=devo3kdSPQY&t=3s	Transmission system components.
13	https://www.youtube.com/watch?v=X6JejXjGQiQ	Mac-Pherson strut suspension
14	https://www.youtube.com/watch?v=rbYRif0Iy0w	Vehicle layout

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

Name &Signature:

Mr. Madhukar Raghunath Mundhe
(Lecturer in Mechanical Engineering)

Mr. Vaibhav J. Deshpande
(Lecturer in Mechanical Engineering)

(Course Experts)

Name & Signature:	Name & Signature:
Dr. N.G.Kulkarni (Programme Head)	Shri. S.B.Kulkarni (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**Cold Chain Management**
COURSE CODE	**ME51208**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL				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	
ME51208	Cold Chain Management	DSC	03	00	02	1	06	03	02	15	35	50	20	25	10	25#	10	25	10	125

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, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 15 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. *Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Cold chain management is a system for preserving temperature-sensitive goods throughout their journey from production to use. It involves maintaining specific temperature ranges (typically 2-8°C or 35-45°F) to prevent spoilage and ensure product quality. Cold chain management is used to prevent the loss of product effectiveness and ensure public health. Proper cold chain management is used to minimizes waste, spoilage, and the need for product recalls, leading to lower costs and increased efficiency. The course is prepared with the view of making the diploma students capable of carrying out fundamental operations in cold storage and its management.

III. COURSE-LEVELLEARNING OUTCOMES (CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Understand the basics of cold chain management.
CO2: Determine energy efficiency in cold storage system.
CO3: Maintain different components of cold storage system
CO4: Understand temperature monitoring and tracking system in cold chain.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
UNIT-I Introduction to Cold Chain Management and systems				**(CL Hrs-12, Marks-05)**
1.	TLO 1.1 Classify and explain cold chain management system TLO 1.2 Identify difference between a general warehouse and cold chain warehouse TLO 1.3 Apply cold chain system to different application. TLO 1.4 Explain benefits of cold chain	1.1 Definition and importance of cold chain management, Difference between a general warehouse and cold chain warehouse. 1.2 Types of products requiring cold chain management (food, fruits, liquids, pharmaceuticals, biological materials) Types of refrigerated transportation systems (trucks, containers, shipping), Types of cold storage systems (walk-in coolers, freezers, refrigerated warehouses). 1.3 Benefits and challenges of cold chain management.	Lecture using Chalk and Board	CO1
UNIT-II Design of Cold Storage and Transportation Systems				**(CL Hrs-10, Marks-10)**
2	TLO 2.1 Classify cold storage systems. TLO 2.2 Define cold storage system for given condition. TLO2.3 Determine energy efficiency in cold storage system. TLO 2.4 Select the types of cold chain with respect to the requirement for different types of products.	2.1 Design and operation of cold storage systems, hygienic design considerations for chillers and chilled storages. Chilled air circulations, temperature control, monitoring during transportation. Cleanliness, defrosting practices. 2.2 Insulation and energy efficiency in cold storage, evaporative cooling, cold load estimation, refrigerated container trucks: freezer storages, freezer room temperatures, insulation of freezer rooms: pre-cooling and pre freezing. 2.3 Construction of small and large commercial cold storages. Design and operation of solar powered refrigerated vans. 2.4 Cold transportation operation and maintenance. Preventive maintenance, safety measures.	Lecture using Chalk and Board	CO1, CO2

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
UNIT- III Temperature Control and Monitoring				**(CL Hrs-10, Marks-10)**
3	TLO3.1 Name different temperature control techniques (refrigeration, insulation, packaging) TLO3.2 Explain temperature monitoring and tracking system in cold chain. TLO3.3 Explain data logging for temperature control in cold chain.	3.1 Temperature control techniques (refrigeration, insulation, packaging), cold room refrigeration system working principal. 3.2 Cold room temperatures, insulation, properties of insulating materials, air diffusion equipment, doors and other openings. Optimum temperatures of storage for different food materials- meat and poultry products, marine products, fruits and vegetables, spices and food grains. 3.3 Temperature monitoring and tracking systems. Data logging and analysis for temperature control.	1. Lecture using Chalk and Board 2. Charts and Models 3. Video presentation	CO4
UNIT –IV Application of cold chain management and case studies				**(CL Hrs- 10, Marks-10)**
4	TLO4.1 Explain cold chain management in food industry. TLO4.2 Explain cold chain management in pharmaceutical industry. TLO4.3 Explain role of national logistics policy (NLP) in chain management. TLO4.4 Explain case studies of successful cold chain implementations and GATI-SHAKTI scheme.	4.1 Cold chain management in the food industry, freezing of food equipments, freezer types, blast freezers, contact plate freezers, conveyor quick freezers, individual quick freezing. cryogenic freezing. 4.2 Chilling of foods: chilling equipment for liquid foods. Chilled foods transport and display cabinets, packaging of chilled foods. 4.3 Introduction to vaccine cold chain management, cold storage management practice (stacking and handling of material). Introduction to cold chain market and Role of national logistics policy (NLP). 4.4 Case studies of successful cold chain implementation, Introduction to GATI-SHAKTI scheme.	1. Lecture using Chalk and Board 2. Charts and Models 3. Video presentation	CO1, CO4

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/TUTORIALEXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Prepare a schematic diagram showing the various components of Cold Room Refrigeration System	*****Explain construction details of Cold Room Refrigeration System	2	CO1
2	LLO 2.1 Prepare a schematic diagram showing the various components of cold storage.	*****Demonstration of cold storage.	2	CO1
3	LLO 3.1 Prepare a sketch types of cold storage systems walk-in coolers, freezers, refrigerated warehouses.	*****Demonstrate cold storage systems walk-in coolers, freezers, refrigerated warehouses.	2	CO2
4	LLO 4.1 Draw constructional details of cold chiller and the refrigerator	*****Demonstrate the difference between cold chiller and refrigerator.	2	CO1
5	LLO 5.1 Measure temperature of food materials in the cold storage.	*****Measurement of optimum temperatures of storage for different food materials.	2	CO3
6	LLO 6.1 Monitor the temperature of cold storage.	*****Measurement optimum temperatures of storage for meat and poultry, fruits and vegetables.	2	CO2
7	LLO 7.1 Identify different components of Freezing of food equipments,	*****Demonstration of Freezing of food equipments.	2	CO3
8	LLO 8.1 Identify different components of Blast freezers.	*****Demonstrate construction and working of Blast Freezers	2	CO3
9	LLO 9.1 Identify different components of contact Plate Freezers.	*****Demonstrate construction and working of contact plate freezers.	2	CO3
10	LLO 10.1 Identify different components of conveyorized quick freezers.	Demonstrate construction and working of conveyorized quick freezers.	2	CO3
11	LLO 11.1 Explain components of food processing chiller equipmets.	*****Demonstrate construction and working of food processing chiller equipmets for Cheese, Meat, Sauce, Yogurt, Ice cream, Chocolate, Bakeries	2	CO3
12	LLO 12.1 Explain constructional details of Cryogenic freezing	*****Demonstrate the constructional details of Cryogenic freezing with sketch.	2	CO3
13	LLO 13.1 Maintain the cold storage system LLO 13.2 Explain preventive maintenance and safety measures in the operation of cold storage.	Demonstrate the maintainance procedure of cold storage system	2	CO3
14	LLO 14.1 Explain constructional details of Vaccine cold Carriers and Cold Boxes.	Demonstrate vaccine cold carriers and cold Boxes	2	CO4
15	LLO 15.1 Prepare a layout of nearby cold storage system.	*****Industrial visit to cold storage system nearby area and write industrial visit report.	6	CO1, CO2, CO3,CO4

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
16	LLO 16.1 Explain Demonstrate national logistic policy of GATI-SHAKTI for cold chain management	Demonstrate national logistic policy of GATI-SHAKTI for cold chain management	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

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

Suggested assignment on SLA

1) Analyze Real-World Cold Chain Data: Research and analyze data related to specific cold chain operations (e.g., vaccine distribution, food supply chain). Identify trends, bottlenecks, and areas for improvement
2) Design a Cold Chain Solution: Develop a cold chain solution for a specific product or scenario (e.g., designing packaging for a perishable item, optimizing transportation routes). Consider factors like temperature requirements, transit time, and cost.
3) Design a Cold Chain Solution: Develop a cold chain solution for a specific product or scenario (e.g., designing packaging for a perishable item, optimizing transportation routes). Consider factors like temperature requirements, transit time, and cost.
4) Design a Cold Chain Solution: Develop a cold chain solution for a specific product or scenario (e.g., designing packaging for a perishable item, optimizing transportation routes). Consider factors like temperature requirements, transit time, and cost.
5) Design a Cold Chain Solution: Develop a cold chain solution for a specific product or scenario (e.g., designing packaging for a perishable item, optimizing transportation routes). Consider factors like temperature requirements, transit time, and cost.
6) Design a Cold Chain Solution: Develop a cold chain solution for a specific product or scenario (e.g., designing packaging for a perishable item, optimizing transportation routes). Consider factors like temperature requirements, transit time, and cost.

Micro project: NA
Assignment: NA

VII. LABORATORY EQUIPMENT/ INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	2 Ton cold room chiller: a walk-in storage facility in a controlled condition to keep a consistent cold temperature	1,2,3,4,5
2	Cold room refrigeration system: cooling capacity: 1.5 kW to 100 kW	1
3	250 L, 50KG, single door, stainless steel blast freezer	4
4	Contact plate freezer, voltage: 220V/380V for sea food and meat.	4
5	Vaccine carriers and cold boxes	4
6	Portable temperature data logger	3, 4
7	Food processing chillers includes both air-cooled and water-cooled systems 2-34 HP	3

VIII. SUGGESTED FORWEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE

(Specification Table)

Sr.No	Unit	Unit Title	Aligned CO's	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Cold Chain Management and systems	CO1	12	4	4	6	05
2	II	Design of Cold Storage and Transportation Systems	CO1, CO 2	12	2	4	8	10
3	III	Temperature Control and Monitoring	CO3	12	4	4	6	10
4	IV	Application of Cold Chain Management and case studies	CO4	12	2	4	8	10
Grand Total				**48**	**16**	**20**	**34**	**35**

IX. ASSESSMENT METHODOLOGIES/ TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
Two-unit tests of 15 marks and average of two-unit tests. For laboratory learning 25 Marks.	End semester assessment of 25 marks for laboratory learning. End semester assessment of 35 marks.

X. SUGGESTED COs- POs MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							ProgrammeSpecificOutcomes*(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
CO1	**3**	-	-	-	-	-	-	-	-
CO2	**3**	**2**	-	-	-	**2**	**2**	-	-
CO3	**3**	**2**	-	-	-	**2**	**3**	-	2
CO4	**3**	**2**	-	**3**	-	**2**	**3**	-	2

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

XI. SUGGESTED LEARNING MATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Raymond R.Gunther	Refrigeration, Air conditioning and Cold Storage	Chilten Company, Philadelphia, USA 1957
2	Clive D.J.Dellino	Cold and Chilled Storage Technology	Kluwer Academic Publishers (1997)
3	S. Domkundwar and SubhashArora	A Course in refrigeration and Air Conditioning	DhanpatRai and sons, Publishers, New Delhi (1994)
4	E.R.Hollowell	Cold Storage and Freezer Storage Manual	AVI Publishing Co. (1980)

XII. LEARNINGWEBSITES& PORTALS

Sr.No	Link/ Portal	Description
1.	https://youtu.be/HQA3Tk09mWs?si=bi5VjDKkydb51Z8O	https://youtu.be/f4G52Sv8TBQ?si=gvcczz-OviTuIgm2
2.	https://youtu.be/izKDjm7NMmk?si=D7hWIi3PotPkZp5v	https://youtu.be/LobjigsNckM?si=lSUu_IoTfArfmeOM
3.	https://youtu.be/0qzJfSokmVc?si=HV8u8S2bjUW51wTY	https://youtu.be/hBdkKpawMR0?si=pkoFcNVgpXPYCLhm
4.	https://youtu.be/0qzJfSokmVc?si=equS5FPuMcthd5ri	https://youtu.be/KnRuc4LKO98?si=SDFsF0JjRx9C4Vj8
5.	https://youtu.be/PS3XonWgt9c?si=gj6zsd0-LZ0iLvXg	https://youtu.be/5cTHpIj0zO0?si=aOGtkhaXZP8OmAiF

Name & Signature: Mr. Pushpak U. Garge (Lecturer in Mechanical Engineering) (Course Experts) Dr.AshishD.Vikhar (Lecturer in Mechanical Engineering)	
Name & Signature: Dr. N.G.Kulkarni (Programme Head)	Name & Signature: Shri.S.B.Kulkarni (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**Computerized Integrated Manufacturing**
COURSE CODE	**ME51204**
PREREQUISITE COURSE CODE & TITLE	**Advanced Manufacturing Technology (WS 51201)**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL				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	
ME51204	Computerized Integrated Manufacturing	DSE	3	0	2	1	6	3	2	15	35	50	20	25	10	25#	10	25	10	125

Total IKS Hrs for Term: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,***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 15 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

The Computer Integrated Manufacturing (CIM) course for Diploma in Mechanical Engineering is designed to equip students with the essential knowledge and practical skills required to integrate computer technology with modern manufacturing processes. As the manufacturing industry rapidly evolves towards automation and smart production systems, this course provides a strong foundation in CAD/CAM, robotics, and automation tools that are crucial for efficient, precise, and flexible production. It prepares students to understand and apply digital technologies to optimize manufacturing operations and improve productivity. By bridging mechanical engineering principles with computer-based systems, the course enhances students employability and readiness for advanced roles in the industry, aligning with the goals of Industry 4.0.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

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.

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1 - Interpret the components of CIM architecture & apply logical steps of CAPP for a given application.
CO2 - Apply CAM techniques to optimize machining processes.
CO3 - Use of CIM networking and apply cellular manufacturing, FMS techniques in different applications
CO4 – Identify different components and use robotic system and AGVs.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes(TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
UNIT-I Introduction to Computer Integrated Manufacturing (CIM) & Computer Aided Process Planning (CAPP) (CL Hrs-12, Marks- 09)				
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. TLO 1.4 State the importance of CAPP. TLO 1.5 Explain the importance of control systems. TLO 1.6 Distinguish between the MRP and ERP. TLO 1.7 Explain the concept of CAPP, ERP, MRP and their applications in 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) 1.4 Logical steps in CAPP, Aggregate production planning and master production schedule 1.5 Material Requirement Planning, capacity planning, Control Systems: Shop floor control, inventory control 1.6 Manufacturing resource planning (MRP), Enterprise resource planning (ERP)	Lecture Using Chalk-Board Video Demonstrations Presentations Case Study	CO-1
UNIT-II Computer-Aided Manufacturing (CAM) (CL Hrs-12, Marks-08)				
2	TLO 2.1 State the importance of CAM in CIM. TLO 2.2 Explain the importance of HMI and SCADA in the Industrial Automation. TLO 2.3 Plan and prepare the sequence of processing steps for an NC machine in CAMC. TLO 2.4 Describe the emerging trends in CAM.	2.1 Introduction to CAM: CAM software and systems, CAM data exchange and compatibility 2.2 Human Machine Interface (HMI) and Supervisory Control and Data Acquisition (SCADA): Introduction, need, benefits and typical applications 2.3 Computer-Aided Manufacturing Control (CAMC): Interfacing Part Program to CNC, Computerized Control Monitoring and Control, Computer Aided Quality Control (CAQC) 2.4 Overview of Emerging Areas: Supply	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Case Study	CO2

Sr. No	Theory Learning Outcomes(TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		Chain Management (SCM), Digital Manufacturing, Industry Revolution 4.0.		
UNIT- III CIM Networking, Cellular Manufacturing & Flexible Manufacturing Systems (FMS) (CL Hrs-12, Marks-09)				
3	TLO 3.1 Distinguish the different network topologies in CIM with sketch. TLO 3.2 Explain the given application of software, network software, and network hardware with its purpose. TLO 3.3.Explain the cellular manufacturing TLO 3.4 Define different types of flexibility and its benefits. TLO 3.5 Make use of FMS planning and control in different applications. TLO 3.6 Explain the applications of FMS.	3.1 CIM Networking: Types of networks and its characteristics, applications, Types of network topologies-star, bus and ring topology 3.2 Component of Networking : Application software for CIM, Network software, and network hardware 3.3 Group Technology, Quantitative analysis in cellular manufacturing, Rank order clustering method. 3.4 Types of Flexibility, FMS components, FMS application and benefits 3.5 FMS planning and control	Lecture Using Chalk-Board Presentations video Demonstrations Site/Industry Visit Case Study	CO3
UNIT –IV Automated Guided Vehicle (AGV) & Introduction to Robotics (CL Hrs-12, Marks- 09)				
4	TLO 4.1 Explain the applications of AGV TLO 4.2 Define robotics and its importance in CIM. TLO 4.3 Make use of robotic elements for given application. TLO 4.4 Distinguish between the different types of robots. TLO 4.5 Explain the applications of robotics in CIM. TLO 4.6 Construct a PLC Programming to control a simple automation system.	4.1 AGV application, vehicle guidance technology, vehicle management and safety 4.2 Robotics: Definition, need, basic concepts and benefits. 4.3 Elements and Components of Robotics-End effectors-grippers andtools, Drive systems, Control systems 4.4 Types of Robotics -Concept and constructional details of Cartesian, Cylindrical, Polar Configuration Robot, Gantry robot, Selective Compliance Articulated Robot Arm (SCARA). 4.5 Advantages, limitations and applications of robotics in CIM 4.6 Basics of PLC programming	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Case Study	CO4

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

Sr No	Practical / Tutorial / Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs	Relevant COs
1	LLO 1.1 Comparative study of traditional manufacturing verses CIM implementation manufacturing.	*Case study of implementation of CIM in any one manufacturing industry.	2	CO1
2	LLO 2.1 Prepare a process plan for suitable manufacturing operations (e.g. casting, forming, welding) LLO 2.2 Develop an optimized sequence of operations for manufacturing a selected part using any suitable CAPP software.	Computer Aided Process Plan for the selected part using various CAPP Software.	2	CO1
3	LLO 3.1 Understand the concept of MRP and ERP system	*Study of MRP and ERP system for manufacturing planning and scheduling.	2	CO1
4	LLO 4.1 Understand the key application of supply chain management.	*Case study of supply chain management.	2	CO2
5	LLO 5.1 : Construct Layout to facilitate continuous flow of materials and components with minimal transport and delay.	Prepare cellular flow flexible layout based on similar product families.	2	CO3
6	LLO 6.1 Inspect the dimensional accuracy of component using available CAQC software.	Inspection of the part using available CAQC software.	2	CO3
7	LLO 7.1 Prepare a detailed report on the elements of an FMS and its computer-controlled automation. LLO 7.2 Arrange a presentation in a group on FMS technology in modern smart factories.	*Elements of FMS and its nature of controlling by computer through Video film/actual demonstration.	2	CO3
8	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.	• To prepare Layout of network topology and network hardware/ network software for given situation.	2	CO4

9	LLO 9.1 Understand working principle of Automated Material Handling Systems LLO 9.2 Identify different components of Automated Material Handling Systems	Working principle, navigation system, safety mechanism of Automated Material Handling Systems	2	CO4
10	LLO 10.1 Write a simple Ladder Logic program for simple applications. LLO 10.2 Program for simple automation applications.	*To develop PLC Programming to control a simple automation system.	2	CO4
11	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.	*Programming of a robot to perform simple task.	4	CO4
12	LLO 12.1 Prepare a robot program toper form simple tasks by using available Teach Pendant/ Offline Programming/ Simulation Software.	*Use Teach Pendent/Offline Programming/Simulation Software to program robotic arm to perform pick and place and stacking of objects.	2	CO4
13	LLO 13.1 Prepare a detailed report on robotic elements, type, configuration, and control mechanisms. LLO 13.2 Arrange a presentation in a group on findings of robotics trends in Industry 4.0 and Smart Manufacturing.	To study various elements of Robotic Systems, types of robots, their configuration, and the nature of controlling by computer through video/actual demonstration (plant visit).	2	CO4
14	LLO 14.1 Select suitable networking peripherals/components to establish network. LLO 14.2 Set up networking of CNC machines, computers and other devices using the relevant method efficiently.	*Establish networking between CNC Machines, computers and supported peripherals of your Institute to exchange the manufacturing data and produce simple component.	2	CO1, CO2, CO3

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.**

VI. SUGGESTED MICROPROJECT/ ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING /SKILLS DEVELOPMENT(SELF-LEARNING)

Assignment: -

1. Programming of a robot to perform simple task : Visit a robotics lab and program the robot to perform simple task like pick and place, identify sort objects by their color and material, welding of a component, painting etc.
2. Develop a PLC circuit having different sensors and actuators for simple task like traffic signals, door operation etc.
3. Prepare and present a case study of any industry which uses Industry 4.0 and smart manufacturing.

SLA Assignment 1: Evolution of Computer Integrated Manufacturing
Objective: Understand the history and development of CIM systems.
Task:

- Research and present the evolution of CIM from traditional manufacturing to Industry 4.0.
- Include key milestones, technologies, and the impact on production efficiency.
- Prepare a timeline with major developments and explain their significance.

SLA Assignment 2: Components of a CIM System
Objective: Explore the key components and technologies that make up a CIM system.
Task:

- Identify and describe the main elements of a CIM system (CAD, CAM, CNC, FMS, etc.).
- Use diagrams to show how these components interact in an integrated environment.
- Provide real-world examples where these systems are used.

SLA Assignment 3: CNC Programming and Automation
Objective: Develop basic skills in CNC programming.
Task:

- Write a basic CNC program (G-code) for a simple turning or milling operation.
- Explain the code line-by-line and simulate it using any open-source CNC simulator (like NC Viewer).
- Discuss how CNC machines are integrated in CIM environments.
-

SLA Assignment 4: Role of Robotics in CIM
Objective: Analyze the application of industrial robots in manufacturing systems.
Task:

- Research different types of industrial robots used in CIM (e.g., pick and place, welding, assembly).
- Explain their role in automation, productivity, and flexibility.
- Present a case study of a factory using robotics in an integrated manufacturing setup.

SLA Assignment 5: CIM and Smart Manufacturing
Objective: Understand how CIM connects with modern smart manufacturing practices.
Task:

- Explore how technologies like IoT, AI, cloud computing, and big data enhance CIM systems.
- Compare traditional CIM with smart CIM systems.
- Predict future trends and challenges in implementing fully smart CIM systems.

VII. LABORATORYEQUIPMENT/INSTRUMENTS/TOOLS/SOFTWAREREQUIRED

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 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+10user)	7,10,12,13,9

SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE

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) & Computer Aided Process Planning (CAPP)	CO1	12	2	5	2	09
3	II	Computer-Aided Manufacturing (CAM)	CO2	12	2	4	2	08
4	III	CIM Networking, Cellular	CO3	12	3	4	2	09

		Manufacturing & Flexible Manufacturing Systems (FMS)						
5	IV	Automated Guided Vehicle (AGV)& Introduction to Robotics	CO4	12	2	4	3	09
Grand Total				**48**	09	17	09	**35**

(Specification Table)

VIII. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
1. Two-unit tests of 15 marks and average of two-unit tests, 2. For laboratory learning 25 Marks 3. Self-Learning Assessment of 25 marks	1. End semester assessment of 25 marks for laboratory learning, 2. End semester assessment of 35 marks.

IX. SUGGESTED COs- POsMATRIXFORM

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

Legends:-High:03,**Medium:**02,**Low:**01,**NoMapping:**-
*PSOs are to be formulated at the institute level

X. SUGGESTEDLEARNINGMATERIALS/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	
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, NewJersy, ISBN: 0133217388	
13	Pabla B.S., Adithan M.	CNC Machines	New Age International, New Delhi,ISBN: 8122434266	

XII. 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)	

Name & Signature: **Shri. M.S. Pol** Lecturer in Mechanical Engineering	 **Shri. A.M. Joshi** Lecturer in Mechanical Engineering
(Course Experts)	
Name & Signature: **Dr. N.G. Kulkarni** (Programme Head)	Name & Signature: **Shri. S. B. Kulkarni** (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ME**
PROGRAMME CODE	**04**
COURSE TITLE	**Manufacturing Systems Engineering**
COURSE CODE	**ME41206**
PREREQUISITE COURSE CODE & TITLE	**Advanced Manufacturing Technology (WS 51201)**
CLASS DECLARATION COURSE	**Yes**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				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	
ME41206	Manufacturing Systems Engineering	DSC	02	-	02	02	06	03	02	15	35	50	20	25	10	25#	10	25	10	125

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, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 15 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

The course on Manufacturing Systems Engineering equips students with the knowledge and skills related to Group Technology, Flexible Manufacturing Systems, Computer Integrated Manufacturing, and Lean Manufacturing for optimizing and modernizing manufacturing operations. The opportunities will be provided to students to explore evolution of manufacturing, implementing efficient layouts and material handling, leveraging automation and data-driven approaches, and focusing on waste reduction and sustainability

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1 - Suggest changes in given manufacturing industries/workshop considering technological advancement, product life cycle and technology life cycle.

CO2 - Apply principles of VSM, Select suitable Material Handling equipment, and understand components of Cost.

CO3 - Apply the different tools of lean manufacturing for productivity improvement.

CO4 - Use of Maintenance and Reliability in manufacturing industry.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
UNIT-I	**Introduction to Manufacturing System**		**(CL Hrs- 7 , Marks- 9)**	
1.	TLO 1.1 Compare the features of Industry 1.0, 2.0, 3.0 and 4.0 TLO 1.2 Explain the role of computers in manufacturing industries. TLO 1.3 Identify the stage of given product on product life cycle. TLO 1.4 Identify the stage of specified technology on technology life cycle.	1.1 Evolution of transformation in manufacturing systems up to Industry 4.0. 1.2 System approach in manufacturing industries. 1.3 Role of computers and information technology in manufacturing and manufacturing systems. 1.4 Product life cycle & its importance. 1.5 Technology life cycle for new product development.	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit	CO1
UNIT-II	**Integrated Manufacturing Efficiency Tools**		**(CL Hrs-8 , Marks- 9)**	
2.	TLO 2.1 Understand and implement VSM TLO 2.2 Select / use material handling equipment TLO 2.3 Understand cost analysis	2.1 Value Stream Mapping (VSM) : Definition, Objectives, VA/NVA Analysis, Elements of VSM, Steps to Create a VSM, Benefits 2.2 Material Handling : Introduction, Objectives, Principles of Material Handling, Types of Material Handling Equipment, Selection Criteria 2.3 Costing in Manufacturing Introduction, Types of Costs, Cost Estimation Techniques, Cost Control Techniques, Budgeting, Importance of Costing.	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit	CO2
UNIT-III	**Lean Manufacturing System**		**(CL Hrs- 8 , Marks- 9)**	
3	TLO 3.1 Explain the need of lean manufacturing. TLO 3.2 Identify the material flow management system. TLO 3.3 Apply the concept of green production system.	3.1 Introduction of Lean Manufacturing, Elements of Lean Manufacturing, Workplace organization. Plant Layout and types of plant layout. (process, product, fixed-position, and combination layouts) 3.2 Material flow management system, Kanban card system, 7 types of waste. 3.3 Concept of Manufacturing excellence, approaches to manufacturing excellence, Green supply chain management.	Lecture Using Chalk-Board Video Demonstrations Presentations Case Study	CO3
UNIT- IV	**Maintenance and Reliability in Manufacturing Systems**		**(CL Hrs-7, Marks-8)**	
4	TLO 4.1 State the need and importance of maintenance. TLO 4.2 List different types of maintenance. TLO 4.3 Describe maintenance record. TLO 4.4 Explain Total Productive Maintenance.	4.1 Importance of maintenance strategies in manufacturing systems for ensuring uptime and reliability. 4.2 Types of Maintenance: Preventive, Predictive, and Breakdown maintenance strategies and their applications. 4.3 Maintenance manual and maintenance	Lecture Using Chalk-Board Video Demonstrations Presentations Case Study	CO4

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	TLO 4.5 Apply Reliability Engineering in industry.	record 4.4 Total Productive Maintenance (TPM) and its pillars. 4.5 Reliability Engineering in Manufacturing: Principles of reliability and how it affects manufacturing system performance.		

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

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Collect the given job from your institute workshop. LLO 1.2 Sketch the product life cycle. LLO 1.3 Suggest the changes in existing production cycle.	* Case study of Product Life Cycle of a Manufactured Component.	4	CO1
2	LLO 2.1 Collect the given job from your institute workshop or any lab. LLO 2.2 Sketch technology life cycle of the product. LLO 2.3 Suggest the changes in existing technology life cycle.	Case study of Technology Life Cycle of a Manufactured Component	4	CO1
3	LLO 3.1 Understand how to collect and represent process data LLO 3.2 Identify value-added vs. non-value-added activities	Analyzing the current state and designing a future state for the series of events that take a product from start to finish.	2	CO2
4	LLO 4.1 Identify various types of material handling systems LLO 4.2 Analyze suitability of equipment for different materials and layout	Comparative Study of Different Material Handling Equipment	2	CO2
5	LLO 5.1 Calculate material, labor, overhead, and total cost LLO 5.2 Understand the components of production costing	Estimate the Production Cost of a Simple Product	2	CO2
6	LLO 6.1 Identify the place of machines and raw material in the workshop. LLO 6.2 Choose a machine where to organize workplace area.	* Plan the Workplace area of workshop by considering lean manufacturing concept.	2	CO3
7	LLO 7.1 Identify any machine from workshop. LLO 7.2 Prepare a checklist of maintenance parameters of machine.	*Checklist of preventive maintenance of any machine in the workshop.	2	CO3
8	LLO 8.1 Identify the different raw materials used in the workshop. LLO 8.2 Draw a material flow chart for the component.	*Material flow chart for material management in the workshop.	2	CO3

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
9	LLO 9.1 Draw the steps in supply chain of manufacturing a component in the workshop.	Supply chain chart for any manufacturing activity in the workshop.	4	CO3
10	LLO 10.1 Identify different type of failure mode in machine. LLO 10.2 find out the causes of failure of machine	Prepare maintenance chart of any one machine available in workshop.	2	CO4
11	LLO 11.1 find out the causes of failure of bearing. LLO 11.2 Care to be taken to increase reliability of bearing.	Prepare chart of basic maintenance practice for bearing.	2	CO4
12	LLO 12.1 Find out the causes of failure of shaft and pulley. LLO 12.2 Care to be taken to increase reliability of shaft and pulley.	Prepare chart of basic maintenance practice for shaft and pulley.	2	CO4
13	LLO 13.1 Find out the causes of failure of coupling. LLO 13.2 Care to be taken to increase reliability of coupling.	Prepare chart of basic maintenance practice for coupling.	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

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

Micro project:

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her. In special situations where groups have to be formed for micro projects, the number of students in the group should not exceed three. The micro-project could be industry application based, internet-based, workshop based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of Pro's , UOs and ADOs (Affective Domain Outcomes). Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs. A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a list of industrial components which are produced through machining processes and describe the manufacturing procedure of the same in brief.

b. Visit a work shop which contains latest industrial Turret lathe, Capstan lathe, Single spindle, automats, Automatic machines. Write a detail report on working of such machine or machines, parts produced, and other relevant information. Identify the jobs produced on such machines and draw the sketches of jobs.

c. Explain the Concepts of Industry 4.0 such as Internet of Things (IoT), Cyber-Physical Systems, and Big Data Analytics.

d. Study the concept of Smart Manufacturing and Smart Factories in the digital era.

e. Describe the role of simulation and optimization in digital manufacturing using digital twins.

f. Write the applications of Artificial Intelligence (AI) and Machine Learning (ML) in predictive maintenance, process optimization, and decision-making support systems.
g. Collect information of advanced techniques related with quality control from nearby industry
h. Collect the different ERP, MRP PLM, SCM, DBMS and CRM software names, company name, product name, and features.
i. Perform web search and prepare a report on the latest advancements and industrial practices in India and abroad in CAD/CAM/CAPP/CAE/CIM/FMS/ ERP, MRP/PLM/SCM/DBMS and CRM.
j. Prepare a report for the material flow in any manufacturing industry.
k. Prepare a report on supply chain management in any manufacturing industry.
l. Collect the information on different type of waste in manufacturing industry.
m. Write down the basic maintenance practice for chain, machine belt, gears etc.

Assignment: -

Other than the classroom and laboratory learning, the following are the suggested student-related co-curricular activities that can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct the following activities in group and prepare reports of about five pages for each activity, also collect/record physical evidence for their portfolio which will be helpful for their placement interviews:

a. Write the Challenges in Manufacturing Systems like Issues of Integration, Scalability, and Complexity in modern manufacturing environments.
b. Case studies showcasing the application of different manufacturing systems in industries.
c. Overview and criteria for selecting systems like Conveyors, Automated Guided Vehicles (AGVs), and Robotics.
d. Write the lean principles and techniques for optimizing production flow and balancing workloads in any industry
e. Write the information about Vendor selection, supplier evaluation, and the role of e-procurement systems.
f. Collect the technical details about all production facilities available at nearby industry/industries.
g. Visit or participate in technical events, exhibitions, conferences, seminars etc.
h. Collect/download at least four different machine tool catalogues.
i. Write the strategies to minimize waste and optimize scrap utilization in the manufacturing process.

VII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	CNC Milling Machine: Spindle speed- Up to 6000 rpm, X-axis: 500 mm to 1,500 mm, Y-axis: 300 mm to 1,000 mm, Z-axis: 300 mm to 1,000 mm, Spindle power- Up to 11 KW	1,2,5,6,7
2	Lathe Machine: Chuck size- 200 to 250 mm, Spindle speed- Up to 4000 rpm, Max turning length-195 mm, Feed rate-Up to 4-6 m/min	1,2,5,6,7
3	Milling Machine: Longitudinal travel (X)- 800 mm, Cross travel (Y)- 300 mm, Vertical travel (Z)- 250 mm, Spindle speed- Up to 5000 rpm, Power- 3 HP	1,2,5,6,7
4	CNC Turning Machine: Chuck size- 200 to 250 mm, Spindle speed- Up to 6000 rpm, Max turning length- 500 mm, Spindle power- Up to 11 KW	1,2,5,6,7

VIII. SUGGESTED FOR 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 Manufacturing System	CO1	7	2	2	3	9
2	II	Integrated Manufacturing Efficiency Tools	CO2	8	2	3	3	9
3	III	Lean Manufacturing System	CO3	8	2	2	4	9
4	IV	Maintenance and Reliability in Manufacturing Systems	CO4	7	2	2	3	8
Grand Total				**30**	**8**	**10**	**17**	**35**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
For laboratory learning 25 Marks. Two-unit tests of 15 marks and average of two-unit tests.	End semester assessment of 25 marks for laboratory learning. Online End semester assessment of 35 marks.

X. 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**
CO1	**3**	**-**	**-**	**1**	**1**	**1**	**1**	**-**	**-**
CO2	**2**	**3**	**3**	**2**	**2**	**2**	**2**	2	**-**
CO3	**3**	**-**	**-**	**1**	**1**	**2**	**1**	**-**	**-**
CO4	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**-**	**-**

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

XI. SUGGESTED LEARNING MATERIALS/BOOKS

Sr. No	Author	Title	Publisher with ISBN Number
1	Stanley B. Gershwin	Manufacturing Systems Engineering	First Edition, PTR Printice Hall, New Jersey (ISBN No. 978-0135606087)
2	Mikell P. Groover	Fundamentals of Modern Manufacturing	Fourth Edition, Wiley, USA (ISBN No. 978- 0470467008)
3	Vajpayee S. K.	Principles of Computer- Integrated Manufacturing	First Edition, Prentice Hall India Learning Private Limited (ISBN No. 978-8120314764)
4	H. K. Shivanand	Flexible Manufacturing Cells and System	First Edition, New Age International Publishers (ISBN No. 978-8122472677)

XII. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1.	https://www.youtube.com/watch?v=HDUzowyGIvQ	Manufacturing system
2.	https://www.youtube.com/watch?v=Vek8lUbjqVU	Computer Integrated Manufacturing (CIM) System
3.	https://www.youtube.com/watch?v=9OL7BMBa4ys	Lean Manufacturing System
4.	https://www.youtube.com/watch?v=V_r4YyxZI7w&list=PLvnqvcxateTCdEQhoQnh-BKwdtVFZRCiA	Maintenance and Reliability in Manufacturing Systems
5.	https://www.youtube.com/watch?v=WzKV4h2pl0w	Total productive maintenance

Name &Signature:

(Mrs. D.S. Waghmare)
Lecturer in Mechanical Engineering

(Mrs. Vaishali G. Talkit)
Lecturer in Mechanical Engineering

(Course Experts)

Name & Signature:	Name & Signature:
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