Department of Mechanical Engineering

P-23 Curriculum

(Sandwich Pattern)

Semester-IV

(Course Contents)

(2023-24)

GOVERNMENT POLYTECHNIC, MUMBAI

(Academically Autonomous Institute, Government of Maharashtra)

Programme: Diploma in Mechanical Engineering (Sandwich Pattern)

Learning and Assessment Scheme (P23) | **With Effect From Academic Year : 2023-24**

Duration Of Programme : 6 Semester | **Duration: 16 Weeks**

Semester: Fourth | **Scheme : P23**

Sr. No.	Course Code	Course Title	Course Type	Total IKS Hrs for Sem	Learning Scheme					Credits	Assesment Scheme														
					Actual Contact Hrs/Week			Self Learning (TW + Assignment)	Notional Lerning Hrs / Week		Paper Duration (hrs.)	Theory					Based on LL & TL Practical						Based on Self Learning		Total Marks
												FA-TH		SA-TH	Total		FA-PR		SA-PR		SA-OR		SLA		
					CL	TL	LL					T1 Max	T2 Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
1	ME23111	Materials Technology	DSC	2	3	-	2	1	6	3	2 Hrs 30Min	20	20	60	100	40	25	10	25#	10	-	-	25	10	175
2	ME23112	Power Engineering	DSC	1	3	-	2	1	6	3	2 Hrs 30Min	20	20	60	100	40	25	10	-	-	-	-	25	10	150
3	ME23113	Manufacturing Processes	DSC	2	3	-	2	1	6	3	2 Hrs 30Min	20	20	60	100	40	25	10	25#	10	-	-	25	10	175
4	ME23114	Industrial Engineering & Management	DSC	1	3	-	2	1	6	3	2 Hrs 30Min	20	20	60	100	40	25	-	-	-	-	-	25	10	175
5	ME23601	Solid Modelling	SEC			-	4	-	4	2	-	-	-	-	-	-	25	10	25#	10	-	-	-	-	50
6	ME23502	Emerging Trends in Mechanical engineering	AEC		2	-	-	2	4	2	-	-	-	-	-	-			-	-	-	-	50	20	50
7	SL23503	Entreprenuership Development (MOOC)	AEC			-	-	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Elective-I (Core Technology)																								
	ME23201	Automobile Engineering	DSE	1	4	-	2	-	6	3	2 Hrs 30Min	20	20	60	100	40	25	10	-	-	-	-	-	-	125
	ME23202	Industrial Maintenance	DSE	1	4	-	2	-	6	3	2 Hrs 30Min	20	20	60	100	40	25	10	-	-	-	-	-	-	125
		Total		**7**	**18**		**14**	**8**	**40**	**20**		**100**	**100**	**300**	**500**	**200**	**150**		**75**				**150**		**900**

Abbreviations : CL-Classroom Learning, TL-Tutorial Learning, LL- Laboratory Learning, FA-Formative Assessment, SA-Summative Assessment, IKS-Indian Knowledge System, SLA-Self Learning Assessment

Note :

1. FA-TH represents two class tests of 20 marks each conducted during semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then candidate shall be declared as fail & will have to repeat & resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.*15Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. *Self learning hours shall not be reflected in the TimeTable.

Course Category :

Discipline Specific Course (DSC): 4, Discipline Specific Elective (DSE): 2, Value Education Course(VEC): 1, Intern./Apprenti./Project./ Community(INP): 0, Ability Enhancement Course (AEC) : 2, Skill Enhancement Course (SEC) : 1, Inter Disciplinery Elective (IE) : 0

Coordinator
Curriculum Development Cell

Head of Department
Department of Mechanical Engineering

In-Charge
Curriculum Development Cell

Principal
Government Polytechnic, Mumbai

Programme : Diploma in Mechanical Engineering (Sandwich Pattern)													
Course Code: ME23111					**Course Title: Materials Technology**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
						FA-TH		**SA-TH (2Hrs 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**T1**	**T2**			**PR**	**OR**		
3	-	2	1	6	3	20	20	60	25	25#	-	25	175

Total IKS hrs. for course: 1

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @$ Internal Online Examination
Note:

1. FA-TH represents total TWO class tests of 20 marks each conducted during the term.
2. SA-TH represents End term exam of 60 marks.
3. FA-PR represents Term work of 25 marks.
4. SLA represents self-learning assessment.

I. Rationale

Engineering industry consumes variety of engineering materials, metals as well as non-metals. Mechanical Engineering Technicians require to know the understanding of various materials with respect to their structure, properties and behavior. While working in different domains of Mechanical Engineering, technicians shall possess the competence to select appropriate materials for required application from the array of conventional ferrous and non-ferrous materials as well the advanced materials, productively.

In this context, the mechanical engineering diploma student must be well versed with steels, cast irons, nonferrous materials, composites and other advanced materials. Also the student is required to have hands- on learning experience on some destructive and non-destructive testing methods.

Hence it is apt to study this course with the objective to develop the competency of selection of appropriate material for required applications and material testing

II. Industry / Employer Expected Outcome:

Apply industrial engineering concepts, and managerial skills in industry.

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

CO1	Apply basics of material crystal structures and mechanical properties of materials for required applications in material selection and perform optical metallography.
CO2	Interpret Iron and Iron Carbide Equilibrium Diagram and correlate microstructure of steels and cast irons with it
CO3	Describe characteristics of composite materials, and other advanced materials and select them for appropriate applications

CO4	Interpret characteristics, compositions and microstructures of non-ferrous materials and Identify ceramics for their proper selection for applications
CO5	Compare, select and perform various heat treatments on steels and CI
CO6	Describe and perform destructive, non-destructive tests on materials

IV.Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
1	TLO 1.1 Interpret the crystal structure of specified materials TLO 1.2 Identify microstructure of the given material with justification. TLO 1.3 Explain with sketches the procedure to prepare a given sample.	**Materials Structures, Mechanical Properties and Metallography** 1.1 Classification of engineering materials, Mechanical properties of materials and their importance in material selection, crystal structures, unit cells, crystal parameters Average number of atoms, atomic packing factors for SC, BCC, FCC and HCP crystal cells, Theoretical Density Calculation, defects in crystal structures & their significance 1.2 *Metallography: Procedure of metallographic sample preparation for optical microscopy, etchants and etching action for two phase alloys, Principle of optical metallurgical microscope, its parts, magnification, concept of grain, grain boundary. [*This subtopic shall be taught in Lab] **Course Outcome: CO1 Teaching Hours:05 Marks: 08 (R-2, U-3, A-3)**
2	TLO 2.1 Identify & Interpret the given equilibrium diagram & reactions with justification. TLO 2.2 Identify the given fields of steels on Iron carbon diagrams with justification. TLO 2.3 Select relevant steel for the given application with justification. TLO 2.4 Select the relevant cast irons as white, gray cast iron for the given job with justification. TLO 2.5 Interpret the given material designations. TLO 2.6 Identify the properties of the given composition of cast iron with justification.	**Ferrous Materials** 2.1 Basic terminology: Definitions: Equilibrium diagram, phases, variables, components of equilibrium diagram, solid solution, types of solid solutions, alloys, Lever rule, Iron- Iron Carbide Equilibrium Diagram with details of phases 2.2 Plain Carbon Steels: Classification of steels based on carbon contents, their Cooling, microstructures, Applications of plain carbon steels 2.3 Specifications of steels: IS, AISI, EN systems 2.4 Cast Irons: Comparison of steels and cast irons, Classification of Cast Irons and form of carbon into them, factors influencing microstructures of cast irons, white cast irons, malleable cast iron, grey cast iron, nodular cast iron, Compacted Graphite Cast Iron, ADI, properties and applications of these cast irons **Course Outcome: CO2 Teaching Hours: 09 Marks: 12 (R-2, U-4, A-6)**
3	TLO 3.1 Describe the properties and applications of the given alloy steels. TLO 3.2 Describe the properties	**Alloy Steels & Advanced Materials** 3.1 Need of alloy steels, Limitations of Plain Carbon Steels, effects of alloying elements 3.2 Maraging steel, HSLA steel, creep resistant steel, High temperature

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
	and applications of the given advanced material TLO 3.3 Select relevant non-ferrous material for the specified application with justification..	alloys, Low expansion steels 3.3 HSS- types & composition, Stainless steels: Types, composition and applications 3.4 Advanced Materials: Composite Materials- Definition, Need & advantages, Classification, PMC, MMC, CMC, nano composites, constituents, rue of mixture and applications, Processing of composites, Concept and behavior and applications of Shape Memory Alloys & Self-healing materials **Course Outcome: CO3 Teaching Hours:08 Marks:12 (R-2, U-4, A-6)**
4	TLO 4.1 Describe the properties and applications of the given copper alloy & aluminium alloy. TLO 4.2 Describe the properties and applications of the given bearing material TLO 4.3 Select relevant non-ferrous material for the specified application with justification.. TLO 4.4 Select relevant ceramic material for the given job with justification. TLO 4.5 Suggest relevant alternative materials for the given job with justification.	**Nonferrous Materials & Ceramics** 4.1 Need of nonferrous materials, Properties, compositions and applications of Copper and its alloys: Cartridge brass, Muntz metal, season cracking of brasses, Aluminium bronze, Tin bronze, silicon bronze, Phospher bronze 4.2 Aluminium & its alloys: Properties, compositions and applications, LM5, LM6, LM14 4.3 Lead and Tin based sliding bearing materials (Babbits) 4.4 Ceramic Materials: Types and Applications of ceramics- Glass, Glass ceramics, Refractories, Abrasives, Advanced ceramics **Course Outcome: CO4 Teaching Hours:06 Marks:08 (R-2, U-3, A-3)**
5	TLO 5.1 Describe with sketches the specified heat treatment processes. TLO 5.2 Select the relevant heat treatment processes for given material with justification. TLO 5.3 Explain with sketches the working principle of the given heat treatment furnace. TLO 5.4 Suggest the relevant heat treatment process for the given situation with justification..	**Heat Treatments** 5.1 Objectives of heat treatments, cooling media, cooling stages, Martensitic transformation, retained austenite, its effects, 5.2 Heat Treatment Processes: Annealing: Conventional annealing, isothermal annealing, Spherodise annealing, Normalizing, Hardening: Conventional hardening, Martensitic Transformation, Tempering: Objectives, types, Process of tempering, Surface Hardening: Carburising, nitriding, Induction hardening, flame hardening, Heat Treatments for Cast Irons, Hardenability, Pollution & environmental issues related with heat treatments **Course Outcome:CO5 Teaching Hours:09 Marks:12 (R-2, U-5, A-5)**
6	TLO 6.1 Choose a relevant hardness tester based on the given situation with justification. TLO 6.2 Study Various Destructive and Non-Destructive Testing.	**Testing of Materials** 6.1 Destructive Testing: Objectives & Procedures of Hardness Measurement: Brinell & Rockwell Method, Objectives & Procedures of Fatigue testing, Objectives & Procedures of wear testing, creep testing 6.2 Non-Destructive Testing: Objectives, Procedure, advantages and limitations of Dye Penetration Test, Magnetic Particle Test, Ultrasonic Crack Detection Test, Radiography Tests, Eddy current Test **Course Outcome: CO6 Teaching Hours:08 Marks:08 (R-2, U-3, A-3)**

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr No	Laboratory Learning Outcome **(LLO)** aligned to CO's.	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hrs.**	**Relevant COs**
1	LLO 1.1 Use optical metallurgical microscope to observe given sample.LLO 1.1 Use slitting machine to prepare sample of given dimension. LLO 1.2 Use grinding machine & polishing papers to prepare surface of given sample..	Preparation of Metallographic Sample	4	CO1
2	LLO 2.1 Use suitable etchant for microscopic examination of given sample. LLO 2.2 Use a metallurgical microscope to observe micro structure of given specimen. LLO 2.3 Interpret the micro structure of given specimen.	Interpretation of microstructures of various steels	2	CO2
3	LLO 3.1 Use a metallurgical microscope LLO 3.2 Interpret the microstructure of Cast Iron.	Interpretation of microstructures of various Cast Irons	2	CO2
4	LLO 4.1 Identify SMA behaviour of given sample	Interpretation of SMA behavior	2	CO3
5	LLO 5.1 Use a metallurgical microscope LLO 5.2 Interpret the microstructure of nonferrous materials.	Interpretation of microstructures of various nonferrous materials	2	CO4
6	LLO 6.1 Identify the component. LLO 6.2 Study performance of heat treatment on steel sample	Performance of heat treatment on steel sample	4	CO5
7	LLO 7.1 Use Brinell Hardness tester LLO 7.2 Use a Rockwell Hardness tester. LLO 7.3 Determine hardness of given sample.	Hardness Measurement by Brinell Hardness Method and Rockwell Hardness Method	4	CO6
8	LLO 9.1 Identify given sample LLO 9.2 Enlist various resources required. LLO 9.3 Evaluation of hardenability of steel by Jominy End Quench Test	Evaluation of hardenability of steel by Jominy End Quench Test	2	CO5
9	LLO 9.1 Identify given sample	Performance of Dye Penetration Test	4	CO6

Sr No	Laboratory Learning Outcome **(LLO)** aligned to CO's.	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hrs.**	**Relevant COs**
	LLO 9.2 Enlist various resources required. LLO 9.3 Perform ultrasonic dry detection test..			
10	LLO 9.1 Identify given sample LLO 9.2 Enlist various resources required. LLO 9.3 Perform magnetic particles test..	Performance of Magnetic Particles Test	2	CO6
11	LLO 9.1 Identify given sample LLO 9.2 Enlist various resources required. LLO 9.3 Perform creep test..	Performance of creep Test	2	CO6

VI. Suggested activities for specific learning(self learning): Students will prepare the report for the following activities/task assigned to them.

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1. Assignment on ultrasonic flaw detection Test
2. Assignment on mechanical properties and metallography.
3. Assignment on ferrous materials.
4. Assignment on non ferrous materials.
5. Assignment on heat treatment .

VII. Table:

Unit No	**Topic Title**	**Distribution of Theory Marks**		
		R Level	**U Level**	**A Level**
1	**Materials Structures, Mechanical Properties and Metallography**	2	4	2
2	**Ferrous Materials**	4	4	4
3	**Alloy Steels & Advanced Materials**	2	6	4
4	**Nonferrous Materials & Ceramics**	2	4	2
5	**Heat Treatments**	2	6	4
6	**Testing of Materials**	2	2	4
	Total	**16**	**24**	**20**

VIII. Assessment Methodologies/Tools

A) Formative assessment (Assessment for Learning)

Each experiment/ assignment to be assessed on following rubrics (10 marks)

Neatness , completeness	Understanding & timely completion	Attendance & Regularity	Total
04 Marks	04 Marks	02 Marks	10 Marks

B) Summative Assessment (Assessment of Learning)

End term Theory examination of 60 marks.

Suggested COs - POs Matrix Form

CO's	Programme Outcomes (PO's)							PSO's	
	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	2	2	3	1	3
CO2	3	2	-	2	2	2	3	2	3
CO3	3	2	-	2	2	2	3	2	3
CO4	3	2	-	-	2	3	3	2	3
CO5	3	2	-	-	2	3	3	2	3
CO6	3	2	-	-	2	3	3	2	3
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

IX. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Material Science and Metallurgy for Engineers	Dr. V. D. Kodgire, S.V. Kodgire, Everest Publishing House, 44th Ed; 2018	978-8176-3140-08
2	Materials Science and Engineering, Introduction	William D Callister Jr, David G Rethwisch, Wiley, 9th Ed, 2014	978-1118-3245-78
3	Physical Metallurgy for Engineers	Donald S. Clark, Wilbur R. Varney, CBS Publishers & Distributors, 3rd Edition, 2004	978-8123-9117-86

4	A Text Book of Materials Technology	S. B. Barve, Vipul Prakashan, 1st Ed, 2014	978-9382-7916-14
5	Self-Healing Materials: Principles and Technology	George Wypych, Chemtec Publishing, 1st Ed, 2017	978-1927-8852-39

X. Learning Websites & Portals

Sr.No	Link / Portal	Description
1	https://depts.washington.edu/matseed/mse_resources/Webpage/Metals/metalstructure.htm	Metal structure
2	https://www.kemet.co.uk/blog/metallography/what-is-metallography	Metallography
3	https://web.utk.edu/~prack/MSE%20300/FeC.pdf	Iron Carbide diagram
4	https://www.youtube.com/watch?v=AH3ekqeiyZo	Mechanical properties of materials
5	https://www.youtube.com/watch?v=AH3ekqeiyZo	Mechanical properties of materials
6	https://www.youtube.com/watch?v=fc8zrgYJCJw	Mechanical properties of materials
7	https://www.youtube.com/watch?v=UuHofNW40Yw	Mechanical properties of materials

XI. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Mr. Chetan Waje	General Manager	Auto Health care , Nashik
2	Mr. Kiran Dhande	Lecturer in Mechanical Engineering	Government Polytechnic, Chatrapati Sambaji nagar
3	Dr. V.U. Rathod	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
4	Mrs. A. N. Naik	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai

Coordinator,
Department of Mechanical Engineering

Head of Department
Department of Mechanical Engineering

I/C, Curriculum Development Cell

Principal

Programme : Diploma in Mechanical Engineering (Sandwich Pattern)													
Course Code: ME23112					**Course Title: Power Engineering.**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2Hrs. 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	**--**	**2**	**1**	**6**	**3**	**20**	**20**	**60**	**25**	**--**	**--**	**25**	**150**

Total IKS Hrs. for course: 01 Hour.

Abbreviations: CL- Classroom Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

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

Note:

1. FA-PR represents Term work of 25 Marks.

I. Rationale: Power producing and absorbing devices are essentials for mechanical engineering. It is necessary for technologists to analyze working and monitor the performance of devices like internal combustion engines, air compressors, gas turbines and steam turbines. This knowledge is also useful in selecting suitable prime mover for given application and to maintain and test the same. The diploma holders in Mechanical Engineering are responsible for supervising and maintenance of Refrigeration& Air Conditioning systems. For this purpose, the knowledge and skill covering basic principles of refrigeration and air conditioning is required to be imparted to the students, which play a vital role in maintaining controlled atmosphere in different domestic and industrial applications.

II. Industry / Employer Expected Outcome:

To study the basic concepts of Engineering Thermodynamics and subsequently understand working of all the heat exchanging devices and be able to handle them securely and confidently.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning.

CO1	Identify different components I.C. Engine.
CO2	Test the performance of I.C. engine.
CO3	Maintain reciprocating air compressors.
CO4	Identify different components of gas turbine and jet engines.
CO5	Test the performance of refrigeration and air-conditioning systems.
CO6	Make basic calculation of psychometric properties and processes.

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
1	1.1 Calculate performance of given engine based on corresponding air standard cycle 1.2 explain with sketches valve timing diagrams for the given engine. 1.3 explain with sketch the construction and working of the given IC engine auxiliary (turbocharger, in line ffuel injection pump, fuel injectors) 1.4 explain maintenance procedure of the given fuel injection pump MPFI system and CRDI unit.	**Unit-1: Internal Combustion Engines** **1.1** Internal Combustion Engines: Assumptions made in air standard cycle, Brief description of Carnot, Otto and Diesel cycles with P-V and T-S diagrams, classification of I.C. engines, neat sketch of I.C. engine indicating component parts, Function of each part and materials used for the component parts - Cylinder, crank case, crank pin, crank, crank shaft, connecting rod, wrist pin, piston, cylinder heads, exhaust valve, inlet valve, Working of four-stroke and two-stroke petrol and diesel engines, Comparison of two stroke and four stroke engines; Comparison of C.I. and S.I. engines, Valve timing diagrams for four stroke engine. **1.2** Engine Systems: Fuel supply system of Petrol engines: Principle of operation of simple carburetor. Fuel supply system of Diesel engines: Types of injectors and fuel pumps, cooling system- air cooling, water cooling system.; Ignition systems – Battery coil ignition and magneto ignition (description and working). Types of lubricating systems used in I.C. Engine.
Course Outcome : CO1	**Learning Hours : 08**	**Marks: 10**
2	2.1 Explain the procedure to calculate the performance parameters of the given I.C. engine. 2.2 Explain the process to calculate indicated power of the given engine using Morse test. 2.3 Explain procedure to measure emissions of exhaust gases in the given engine 2.4 Apply BS6 norms to the given engine. 2.5 State the procedure to undertake routine maintenance of the given I.C. engine.	**Unit-2: Testing of IC Engines.** 2.1 Performance of I.C. Engines: Brake power; Indicated power; Frictional power; Brake and Indicated mean effective pressures; Brake and Indicated thermal efficiencies; Mechanical efficiency; Relative efficiency; Performance test; Morse test; Heat balance sheet; Methods of determination of B.P., I.P. and F.P., Simple numerical problems on performance of I.C. engines. 2.2 Concept of pollutants in S.I. and C.I. engines, pollution control norms for two and four wheelers, BS4 and BS6. Engine Control Unit (ECU): working and diagnosis procedure.
Course Outcome : CO2	**Learning Hours : 08**	**Marks: 10**

3	3.1explain with sketches working of the given compressor 3.2Explain the procedure to calculate the performance parameters of the given compressor 3.3Recommend the type of compressor for the given applications with justification 3.4 State the procedure to undertake routine maintenance of the given type of air compressor.	**Unit-3: Air Compressors** 3.1Functions of air compressor – uses of compressed air, types of air compressors, Construction and working of Single stage and two stage reciprocating air compressor, necessity of multistage compression, intercooling, Safety measures for handling high pressure air, representation of processes involved on PV diagram, calculation of work done. 3.2 Testing of reciprocating air compressors: Pressure ratio, compressor capacity, FAD, volumetric efficiency, isothermal efficiency, numerical. Methods of energy saving. 3.3 Introduction to Rotary compressors.
Course Outcome : CO3	Learning Hours : 07	Marks: 10
4	4.1Explain with sketches working of the given type of gas turbine 4.2Identify different components of the given engine with justification 4.3Explain with sketches the working of given rocket propulsion system 4.4 State the procedure to undertake routine maintenance of the given gas turbine 4.5State the procedure to undertake maintenance of the given propulsion engine.	**Unit-4: Gas Turbines and Jet Propulsion** 4.1 Types of gas turbine: Classification, open cycle gas turbine and closed cycle gas turbine, PV and TS diagram and working of gas turbine. Brayton cycle, comparison of gas turbines with reciprocating IC engines, applications and limitations of gas turbine. 4.2 Jet Propulsion: Principle of operation of turbojet, turboprop, ram-jet engine, application of jet engines 4.3 Rocket propulsion: liquid and solid propellant systems, rocket fuels.
Course Outcome : CO4	Learning Hours : 06	Marks: 08
5	5.1 Sketch Carnot cycle and vapor compression cycle with the given type of P-V, T-S, P-H diagram 5.2 Calculate COP of paper compression cycle for the given and tell you values next choose the refrigerant based on properties for given application with justification 5.3 Explain with sketches construction and working of the given components of	**Unit-5: Introduction to Refrigeration** 5.1 Vapor compression cycle; Representation of the vapor compression cycle on P-H, T-S & P-V Diagram; Refrigerating effect, work done and power required; Effects of super heating and sub cooling, Simple Vapor absorptions cycle. Simple problems on vapor compression cycle. 5.2 Refrigerants: Introduction to refrigerants; Desirable Properties of refrigerants; comparison of refrigerants in domestic refrigeration systems like R12, R22, & R134a with reference to their properties. 5.3 Detection of refrigerants leakage; Charging the system with refrigerant; Lubricants used in refrigeration and their properties.

	vapor compression system 5.4 Select component of the given refrigeration systems using ASHRAE handbook with justification	5.4 Refrigerant flow controls: Capillary tube; Automatic expansion valve; Thermo- static expansion valve. 5.6 Application of refrigeration: Cold storage, Dairy refrigeration, Ice making industry, Water coolers.
Course Outcome : CO5	Learning Hours : 08	Marks: 12
6	6.1 Determine the given property of the given air using psychrometric chart 6.2 Explain with sketches construction and working of the given refrigeration and air conditioner 6.3 State the procedure to undertake routine maintenance of the given type of air compressor.	**Unit-6: Air conditioning** 6.1 Introduction to Air conditioning; Factors affecting Air conditioning; specific humidity, relative humidity, degree of saturation, DBT, WBT, DPT, sensible heat, latent heat, total enthalpy of air. Psychometric chart and its use; Psychometric process-sensible heating and cooling, Humidifying and dehumidifying; Adiabatic saturation process; Window air-conditioning, split type air-conditioning, car air-conditioning and central air-conditioning. 6.2 Latest development in refrigeration and air conditioning, Inverter technology, auto-defrosting, blast cooling, star rating.
Course Outcome : CO6	Learning Hours : 08	Marks: 10

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	**Sr. No**	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hrs.**	**Relevant COs**
Assemble/dismantle 4 stroke petrol or diesel engine.	1	Assemble/dismantle 4 stroke petrol or diesel engine.	04	CO1
Assemble/dismantle 2 stroke petrol or diesel engine.	2	Assemble/dismantle 2 stroke petrol or diesel engine.	04	CO1
Perform test on the given I.C. Engine to prepare heat balance sheet.	3	Perform test on the given I.C. Engine to prepare heat balance sheet.	04	CO2
Perform test on the two stage reciprocating air compressor to find volumetric and isothermal efficiency.	4	Perform test on the two stage reciprocating air compressor to find volumetric and isothermal efficiency.	04	CO3
Demonstration on gas turbine model.	5	Demonstration on gas turbine model.	02	CO4
Demonstration on vapor compression refrigeration cycle.	6	Demonstration on vapor compression refrigeration cycle.	04	CO5

Demonstration and working of split type and window type air-conditioner.	7	Demonstration and working of split type and window type air-conditioner.	04	CO6
Visit to an ice plant or cold storage plant or central air conditioning plant.	8	Visit to an ice plant or cold storage plant or central air conditioning plant.(If possible)	04	CO5,CO6
		Total	30	

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

Only one micro project is planned to be undertaken by a student that needs to be assigned to him or her in the beginning of the semester. it should be preferably being individually undertaken to build up the skill and confidence in every student to become problem solver so that he or she con tributes to the projects of the industry. in special situation 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 in compass two or more COs which are in fact, and integration of PrOs, UOs and ADOs. 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 total duration of the micro project should not be less than 15 student engagement hours during the course. 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, however similar micro projects could be added or given to the students by the concern faculty:

1. Display various components of MPFI system on wooden board with labels.
2. Take sample of cooling load calculation sheet list the components of cooling load along with percentage contribution of different loads in a refrigeration or air conditioning.
3. Display various parts of a hermetically sealed or open compressor on wooden board with labels
4. Collect and display different gasket required for single cylinder and multi cylinder I.C. engine
5. Prepare report on different types of lubricating oils, oil filters and coolants for petrol engines w.r.t. physical and chemical properties, cost, safety, disposal etc.
6. Make a working model of air compressor.

7. Prepare a step by step procedure for dismantling and assembly of multi cylinder I.C. engine tabulate different tools used in dismantling of I.C. engines against components for which these tools are used.
8. Comparative study of hybrid vehicles, electric vehicle and conventional vehicles.
9. Collect working and constructional details of different types of reciprocating and rotary compressors.
10. Collect specifications working and constructional details of different types of refrigeration and air conditioning units.
11. Prepare detail report on automobile emissions by visiting nearby PUC testing center. (With reference to standard referred research papers)
12. Prepare a report on Impact of Global Warming. (With reference to standard referred research papers)

VII. Suggested Specifications Table (Theory):

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Internal Combustion Engines	4	2	4	10
2	Testing of IC Engines	2	4	4	10
3	Air Compressors	2	4	4	10
4	Gas Turbines and Jet Propulsion	4	2	02	08
5	Introduction to Refrigeration	2	4	06	12
6	Air conditioning	2	4	4	10
	Total	**16**	**16**	**28**	**60**

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

Each Experiment/ assignment to be assessed on following rubrics (10 marks)

Attendance & Regularity	Technical Understanding & Interpretation of given experiment/assignment/model.	Presentation & completion	Total
02 Marks	04 Marks	04 Marks	10 Marks

Summative Assessment (Assessment of Learning)

TH - Term End examination of 60 Marks duration 2 hours 30 mins.

IX. References/ Books:

Sr. No.	Title	Author, Publisher, Edition and Year of publication	ISBN
1	Internal combustion engines	Mathur M.I., Sharma R.P. Dhanpatrai publication (P)Ltd, New Delhi 2012	1234567144047 9788189928469,
2	Thermal Engineering	Rajput R.K Laxmi publications New Delhi Edition -9,2010	8131808041, 9788131808047
3	A Textbook of Internal Combustion Engines	Rajput R.K, Laxmi publications , Third edition, New Delhi 2016	13: 978-8131800669
4	IC Engines combustion and Emissions	Pundir B.P Narosa Publishing house, New Delhi(2010)	13:978-8184870879
5	Refrigeration and Air Conditioning	Khurmi R.S; Gupta J.K. S. Chand publication , New Delhi(2016)	978-81-219-2781-9
6	Thermal Engineering	Singh Sadhu, Pati Sukumar, Pearson Education: First edition, New Delhi (2018)	13:978-935286687
7	Engineering Thermodynamics	PK Nag; Tata McGraw Hill, Delhi. Edition 4, 2008.	0-07-026062-1
8	Engineering Thermodynamics	CP Arora; Tata McGraw Hill, Delhi. Edition 1, 2001.	0-07-462014-2
9	Internal Combustion Engines	V. Ganesan; McGraw Hill Education, 4th Edition,(2017)	978-1259006197
10	A Course in Thermal Engineering	Domkundwar , Kothandaraman, Dhanpat Rai & Co. (P) Limited	-------

X.E-References:

1. https://swayam.gov.in/
2. www.youtube.com
3. https://learnengineering.org/
4. https://nptel.ac.in/

XI.CO Vs PO and CO Vs PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
CO1	3	3	2	1	1	1	1	2	1
CO2	2	2	1	1	1	1	1	2	2
CO3	3	2	2	2	1	1	1	2	3
CO4	3	3	3	2	2	1	1	2	3
CO5	3	3	3	2	2	1	1	2	3
CO6	3	3	3	2	2	1	1	2	3

XII.Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organisation
1	Prof. Dr. Celestino Ruivo	Professor	University of Algarve-Portugal.
2	Dr. Ram Deshmukh	Lecturer In Mechanical Engg.	Cusrow Wadia Institute of Technology, Pune.
3	Dr. Vishal D. Chaudhari	Lecturer In Mechanical Engg.	Cusrow Wadia Institute of Technology, Pune.
4	Mr. Sanjay Yelge	Sr. Manager	Thyssenkruup Industries, Pimpri, Pune.
5	Dr. S. G. Taji	HOD (Mechanical)	G.P.Mumbai
6	Mr. E. C. Dhembare	LME,	G.P.Mumbai

Coordinator,
Curriculum Development,
Department of

Head of Department
Department of _____

I/C, Curriculum Development Cell

Principal

Programme: Diploma in Mechanical Engineering (Sandwich Pattern)													
Course Code: ME23113						**Course Title: Manufacturing Process**							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						**Examination Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH**	**FA- PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	-	2	1	5	3	20	20	60	25	25#	-	25	175

Total IKS hrs. for course: 2

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

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

Note:

1. FA-TH represents total TWO class tests of 20 marks each conducted during the term.
2. SA-TH represents End term exam of 60 marks.
3. FA-PR represents Term work of 25 marks.
4. SLA represents self-learning assessment.

Rationale

The diploma mechanical engineer must be exposed to basic manufacturing processes. This course will help the student to get familiarized with working principle and operation like turning, drilling, milling, casting, and joining processes. Knowledge of these processes will help them to select most appropriate process for the desired results in terms of getting raw material converted in to finish product. Diploma engineers frequently encounter diverse manufacturing processes. This course aims to enhance student's comprehension of manufacturing methods, like turning, drilling, milling, grinding, casting and joining.

Industry / Employer Expected Outcome: Produce a given component using various manufacturing processes.

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

CO1	Describe basic foundry procedures.
CO2	Describe construction of lathe machine and produce a part on lathe machine as per given drawing.
CO3	Describe construction of drilling machine and produce a part on drilling machine as per given drawing.
CO4	Describe construction of milling machine and produce a part on milling machine as per given drawing.
CO5	Describe construction of grinding machine and produce a part on grinding machine as per given drawing.
CO6	Describe joining processes and produce a job as per given drawing.

Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
1	1.1 Describe significance of pattern allowances & colour coding. 1.2 Describe sand moulding process. 1.3 Describe different casting process. 1.4 Enumerate Safety practices in foundry shop.	**Foundry Practices** 1.1 Pattern making: -Pattern materials, types of patterns, pattern allowances, colour coding, 1.2 Moulding: Moulding sands, types and properties of sands, moulding tools and equipment, elements of sand moulds. 1.3 Casting: Casting in Indus valley civilization (IKS), Permanent mould casting- Gravity & Pressure Die casting, defects in castings and remedies, 1.4 Safety practices/ precautions in foundry shop. **COURSE OUTCOME: CO1 TEACHING HOURS :07 MARKS: 10 (R-4, U-4, A-2)**
2	2.1 Describe construction & specification of lathe machine. 2.2 List various operations performed on lathe machine. 2.3 Describe nomenclature of single point cutting tool. 2.4 Enumerate Safety practices in turning shop.	**Lathe Machine** 2.1. Introduction, working principle of turning. 2.2. Classification of lathe machine, parts & functions of Centre lathe, specification of Centre lathe. 2.3. Lathe operations: turning, taper turning, facing, parting off, knurling, thread cutting, drilling, boring. Lathe machining parameters-speed, feed & depth of cut. 2.4. Single point cutting tool geometry, 2.5. Safety precautions while working on lathe. 2.6. Basic maintenance practices-cleaning, greasing & oiling of machine. **COURSE OUTCOME: CO2 TEACHING HOURS :08 MARKS: 10 (R-2, U-4, A-4)**
3	3.1. Describe parts, their functions & specification of drilling machine. 3.2. List various operations performed on drilling machine. 3.3. Describe nomenclature of twist drill. 3.4. Enlist safety practices while using drilling machine.	**Drilling Machine** 3.1. Introduction, working principle of drilling 3.2. Classification of drilling machine, parts & functions of sensitive drilling machine, specification of sensitive drilling machine. 3.3. Drilling operations: drilling, reaming, boaring & counter boaring, counter sinking and spot facing. Drilling process parameters-speed, feed & depth of cut. 3.4. Twist drill nomenclature, 3.5. Safety precautions while working on drilling machine 3.6. Basic maintenance practices-cleaning, greasing & oiling of machine. **COURSE OUTCOME: CO3 TEACHING HOURS :07 MARKS: 10 (R-4, U-4, A-2)**

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
4	4.1. Describe parts, their functions & specification of milling machine 4.2. List various operations performed on milling machine. 4.3. Describe simple indexing method using dividing head 4.4. Enumerate safety practices while working on milling machines	**Milling Machine** **4.1.** Introduction, working principle of milling. **4.2.** Classification of milling machine, parts & functions of column & knee type milling machine, specification of column & knee type milling machine. **4.3.** Milling operations: up milling & down milling, plain milling, face milling, side milling, end milling, straddle milling, gang milling, Milling process parameters-speed, feed & depth of cut. **4.4.** Milling Cutters: types and applications. **4.5.** Gear cutting: Indexing, dividing head, simple indexing. **4.6.** Safety precautions while working on Milling machine **4.7.** Basic maintenance practices-cleaning, greasing & oiling of machine. **COURSE OUTCOME: CO4 TEACHING HOURS :08 MARKS: 10 (R-2, U-4, A-4)**
5	5.1 Describe construction & specification of surface grinding machine. 5.2 List various operation performed on surface grinding machine. 5.3 Describe the construction of grinding wheel. 5.4 Describe the significance of dressing & truing.	**Grinding Machine** **5.1.** Introduction, working principle of grinding. **5.2.** Classification of grinding machine, parts & functions of horizontal surface grinding machine, specification of horizontal surface grinding machine. **5.3.** Grinding operations: Surface grinding, cylindrical grinding & tool grinding. Grinding process parameters-speed, feed & depth of cut. **5.4.** Grinding wheel: abrasives, bonds, grits, grade, structure, standard marking systems. Dressing & truing of grinding wheel. **5.5.** Safety precautions while working on grinding machine **5.6.** Basic maintenance practices- cleaning, greasing & oiling of machine. **COURSE OUTCOME: CO5 TEACHING HOURS :07 MARKS: 10 (R-4, U-4, A-2)**
6	6.1 Describe the classification of welding processes. 6.2 Describe gas welding process 6.3 Differentiate various arc welding processes. 6.4 Compare soldering and brazing process. 6.5 List causes of welding defects and suggest remedies.	**Joining Processes** 6.1. Introduction, working principle of Welding 6.2. Welding and weldability, classification of welding processes. 6.3. Gas welding: gas welding equipment, oxy-acetylene welding, types of flame. 6.4. Arc welding: arc welding equipment, shielded metal arc welding, TIG and MIG welding. 6.5. Soldering and brazing process, fillers, merits, demerits and applications, comparison. 6.6. Defects in welded joints causes and remedies. 6.7. Safety practices/ precautions in welding shop. **COURSE OUTCOME: CO6 TEACHING HOURS :07 MARKS: 10 (R-4, U-4, A-2)**

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
	6.6 Enumerate safety guidelines and precautions for a welding shop	

Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr No	Laboratory Learning Outcome (LLO) aligned to CO's.	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Setup a lathe machine for given job as per operations. LLO 1.2 Select suitable cutting parameters for operations as per given job. LLO 1.3 Prepare a turning job as per given drawing.	Produce a job on a lathe machine that comprises facing, plain turning and step turning operations as per the given drawing.	02	CO2
2	LLO 2.1 Setup a lathe machine for taper turning operations. LLO 2.2 Calculate taper angle for taper turning operations as per given job. LLO 2.3 Prepare a taper turning job as per given drawing.	Produce a job on a lathe machine that comprises taper turning and grooving operations as per the given drawing.	04	CO2
3	LLO 3.1 Setup a lathe machine for chamfering and knurling operations. LLO 3.2 Select suitable cutting parameters for chamfering and knurling operations. LLO 3.3 Prepare a chamfering and knurling job as per given drawing.	Produce a job on a lathe machine that comprises knurling and chamfering operations as per the given drawing.	02	CO2
4	LLO 4.1 Setup a lathe machine for threading operation. LLO 4.2 Select suitable cutting parameters for threading operation. LLO 4.3 Prepare a threading job as per given drawing.	Produce a job on a lathe machine that comprises threading operations as per the given drawing.	04	CO2
5	LLO 5.1 Setup a drilling	Produce a job on a drilling machine comprising drilling operations as per	02	CO3

Sr No	Laboratory Learning Outcome **(LLO)** aligned to CO's.	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hrs.**	**Relevant COs**
	machine for given job as per operations. LLO 5.2 Prepare a drilling job as per given drawing.	the given drawing on flat surface/ cylindrical surfaces.		
6	LLO 6.1 Setup a milling machine and cutter for given job. LLO 6.2 Use dividing head for indexing LLO 6.3 Prepare a spur gear on milling machine as per the given drawing.	Produce a spur gear using indexing mechanism as per the given drawing.	06	CO4
7	LLO 7.1 Setup a surface grinding machine. LLO 7.2 Prepare a grinding job as per given drawing	Produce a job using surface grinder as per the given drawing.	02	CO5
8	LLO 8.3 Prepare material for fabricating a job. LLO 8.4 Select suitable equipment and tool for welding. LLO 8.5 Fabricate job as per given drawing	Fabricate a job using arc welding machine as per given drawing.	04	C06
9	LLO 9.1 Prepare joint for soldering/brazing by applying flux. LLO 9.2 Perform soldering/brazing operations on the given components	Perform soldering / brazing operations on the given components.	02	CO6
10	LLO 10.1 Identify type of pattern and its material LLO 10.2 Enumerate tools used to prepare sand mould. LLO 10.3 Identify type of casting method followed LLO 10.4 Identify the product being manufactured LLO 10.5 Enlist the safety practices followed in foundry shop	Industrial visit/video demonstration to observe foundry practices/casting processes followed by industries.	02	CO1

Suggested Micro Project / Activities for Specific Learning / Skills Development (Self Learning):

- Visit a small scale unit/fabrication shops and prepare a report.
- Visit a two wheeler /four wheeler servicing/repairing shop and prepare a report.
- Prepare model of Single point cutting tool using suitable material.
- Prepare model of Twist drill/ Milling cutter/ parts of Lathe machine/ drill machine/ milling machine/ grinding machine using suitable material
- Observe the video on manufacturing of engineering component by casting method, and prepare a report.

I. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks		
		R Level	U Level	A Level
1	**Foundry Practices**	4	4	2
2	**Lathe Machine**	2	4	4
3	**Drilling Machine**	2	4	4
4	**Milling Machine**	2	4	4
5	**Grinding Machine**	2	4	4
6	**Joining Processes**	2	4	4
	Total	**14**	**24**	**22**

Assessment Methodologies/Tools

A)Formative assessment (Assessment for Learning)

Each experiment/ assignment to be assessed on following rubrics (10 marks)

Job drawing, tool handling & safety precautions	Job quality, accuracy & timely completion of job	Attendance & Regularity	Total
04 Marks	04 Marks	02 Marks	10 Marks

B) Summative Assessment (Assessment of Learning)

End term Theory examination of 60 marks.

End term practical examination of 25 marks. (TWO hrs.)

Suggested COs - POs Matrix Form

CO's	Programme Outcomes (PO's)							PSO's	
	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	2	-	01	01	03
CO2	3	2	-	3	2	2	3	2	3
CO3	3	2	-	3	2	2	3	2	3
CO4	3	2	-	3	2	2	3	2	3
CO5	3	2	-	3	2	2	3	2	3
CO6	3	2	-	3	2	2	3	2	3
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

II. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Elements Of Workshop Technology Vol-1	S K Hajra Choudhury, A K Hajra Choudhury, Nirjhar Roy, Media Propoters & Publisher PVT. LMT.	13 5551234102415
2	Elements Of Workshop Technology Vol-2	S K Hajra Choudhury, A K Hajra Choudhury, Nirjhar Roy, Media Propoters & Publisher PVT. LMT.	978-8-185-09915-6.
3	Manufacturing Technology Vol-1	P N RAO, McGraw Hill, New Delhi.	9781259062575
4	Manufacturing Technology Vol-2	P N RAO, McGraw Hill, New Delhi.	9789353160524
5	Ancient Metal Technology and Archaeology of South Asia: a Pan-Asian perspective	D.P. Agrawal, Aditya Prakashan, New Delhi	9788173051777

Learning Websites & Portals

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=Wc2gpWcmGK4	Lathe Machine Operations
2	https://www.youtube.com/watch?v=DGsV6RhBnbM	Radial drilling machine
3	https://www.youtube.com/watch?v=zzXdddrV2so	Simple Job on milling machine
4	https://www.youtube.com/watch?v=2CIcvB72dmk	Basics of Metal Casting
5	https://www.youtube.com/watch?v=-w7E88zox6w	Closed die forging

6	https://www.youtube.com/watch?v=RyLvVMg84xs	Basics of welding process
7	www.nptel.ac.in/courses	

III. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Dr. H P Khairnar	Assistant Professor	V.J.T.I., Matunga, Mumbai-19
2	Amol S. Dhande	Lecturer in Mechanical Engineering	Government Polytechnic, Ratnagiri
3	Dr. V.U. Rathod	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
4	Mr. S. B. Bidgar	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai

Coordinator,
Department of Mechanical Engineering

Head of Department
Department of Mechanical Engineering

I/C, Curriculum Development Cell

Principal

Programme: Diploma in Mechanical Engineering /Rubber Technology (Sandwich Pattern)												
Course Code: ME23114						**Course Title:** Industrial Engineering & Management						
Compulsory / Optional: Compulsory												
Teaching Scheme and Credits						**Examination Scheme**						
						FA-TH		**SA-TH**	**FA-PR**	**SA**		
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**T1**	**T2**			**PR**	**OR**	**SLA**
3	-	2	1	6	3	20	20	60	25	-	-	25

Total IKS hrs. for course: 1

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

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

Note:

1. FA-TH represents total TWO class tests of 20 marks each conducted during the term.
2. SA-TH represents End term exam of 60 marks.
3. FA-PR represents Term work of 25 marks.
4. SLA represents self-learning assessment.

Rationale

The diploma mechanical engineer has to utilize the available resources like men, materials, machines, methods of manufacturing etc. for better productivity by eliminating wastefulness in production processes. This needs measurement of methods, and work i.e. method study and time study. Industrial engineering parts of this course help students to apply industrial engineering concepts to maximize the efficiency of a plant by best use of man, machine, materials etc. Engineers working in an industry have to manage the various resources for smooth functioning of industry. Management part of this course introduces management principles, managerial skills, safety aspects, and industrial acts to engineer.

Industry / Employer Expected Outcome:

Apply industrial engineering concepts, and managerial skills in industry.

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

CO1	Prepare job sequence over the machines by applying industrial engineering concepts.
CO2	Apply work study and time study techniques to optimize manufacturing processes.
CO3	Apply ergonomic principles for designing simple mechanical work station.
CO4	Apply Management Concept and Managerial Skills
CO5	Manage different industrial resources efficiently.
CO6	Interpret different Industrial Safety norms and Industrial Acts

Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
1	**1.1** Describe Needs and Objectives of Industrial Engineering. **1.2** Describe methods of improving productivity. **1.3** Enlist the principles of plant layout design. **1.4** Prepare detail sequence of operation for manufacturing the given component.	**Process Engineering** 1.1 Industrial Engineering: Definition, Needs and Objectives. 1.2 Production: concept, Types of Production, Batch production, Job Production and Continuous production system, and their comparison. 1.3 Productivity: Definition, Labour productivity, Material productivity and Machine productivity. Methods of improving productivity. 1.4 Plant Layout: Objectives, Types of plant layout, Principles of plant layout design, Factors affecting plant layout, Symptoms of bad plant layout. 1.5 Production Planning and Control (PPC): Definition, Functions of PPC, Operation routing, Job Sequencing (n jobs and 2 machines), Line balancing (simple numerical), Gantt chart **Course Outcome: CO1 Teaching Hours: 9 Marks: 12 (R-4, U-4, A-4)**
2	2.1 Perform method study for manufacturing of given component. 2.2 Prepare relevant charts using recording techniques. 2.3 Perform time study for manufacturing of given component. 2.4 Calculate standard time for the given activity using work measurement.	**Method Study, Time Study & Motion Study** **2.1** Method Study (Work Study): Definition and objectives of method study, Procedure of method study, Selection of work for method study. Therbligs **2.2** Charting Techniques: Outline process chart, Flow process chart, Flow diagram, Travel chart, Two handed process chart, String diagram. **2.3** Time Study (Work Measurement): Definition and objectives of time study. Procedure, Equipment required to conduct time study, **2.4** Factors affecting rate of work, Types of elements, Rating and allowances, **2.5** Calculation of standard time. **Course Outcome:CO2 Teaching Hours: 10 Marks:14 (R-4, U-6, A-4)**
3	3.1 Apply ergonomics concept to improve working conditions in the given industrial environment. 3.2 Apply ergonomic principles to the given component.	**Ergonomics** **3.1** Ergonomics: Concept, need, Man-machine relationship, anthropometric and functional anatomy of data. **3.2** Ergonomics in design of control members-push button, knobs, levers, crank , hand wheel **3.3** Ergonomic considerations applied to types and location of display. **Course Outcome:CO3 Teaching Hours:06 Marks:06 (R-2, U-2, A-2)**

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
4	4.1 Describe Principles of Management 4.2 Enumerate Managerial skills.	**Management Concept and Managerial Skills** **4.1** Management: Definition, role and importance of management, **4.2** Principles of Management, levels of management and their functions. **4.3** Organization, Management, Administration, relation between administration and management. **4.4** Managerial skills **COURSE OUTCOME: CO4 TEACHING HOURS :08 MARKS: 10 (R-2, U-4, A-4)**
5	5.1 Understand the significance of Industrial Resource Management. 5.2 Describe objectives of personnel management. 5.3 Describe objectives of materials management. 5.4 Describe objectives of financial management.	**Industrial Resource Management** **5.1 Personnel Management:** Need, objectives, functions of personal management, Training and development. **5.2 Materials Management:** Definition of Inventory, inventory control, objectives of inventory control, ABC analysis. **5.3 Financial Management:** Need, objectives, functions, Types and sources of capital, Budgets and account, Balance sheet, Elements of costing. **COURSE OUTCOME: CO5 TEACHING HOURS :06 MARKS: 10 (R-2, U-4, A-4)**
6	6.1 Describe General safety norms for industrial unit. 6.2 Interpret various industrial acts.	**Industrial Safety and Industrial Acts** **6.1** Need of safety measures **6.2** General safety norms for industrial unit **6.3** Accident: Definition, types of industrial accidents, general causes of accidents. **6.4** Industrial Acts : Indian Factories Act, Industrial Dispute Act, Workman Compensation Act, Minimum wages Act. Labour CODE. **COURSE OUTCOME: CO6 TEACHING HOURS :06 MARKS: 08 (R-2, U-4, A-2)**

Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr No	Laboratory Learning Outcome **(LLO)** aligned to CO's.	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hrs.**	**Relevant COs**
1	LLO 1.1 Prepare the drawing of a component LLO 1.2 Enlist the operations to be performed to manufacture the given job. LLO 1.3 Prepare process plan.	Prepare detailed process plan for manufacturing of hexagonal nut/Hexagonal headed bolt/stud/plain washer/given component	04	CO1
2	LLO 2.1 Prepare the drawing of a component LLO 2.2 Enlist the operations to be performed to manufacture the given job. LLO 2.3 Prepare chart of sequence of operation.	Prepare chart of sequence of operation for manufacturing of hexagonal nut/Hexagonal headed bolt/stud/plain washer/given component	02	CO1
3	LLO 3.1 Prepare the drawing of a component. LLO 3.2 Enlist the operations to be performed to manufacture the given job. LLO 3.3 Analyse the motions involved in machining operations of the given job.	Apply the method study approach to analyse the motions involved in machining operations of the given job.	02	CO2
4	LLO 4.1 Prepare the drawing of a component. LLO 4.2 Enlist the operations to be performed to manufacture the given job. LLO 4.3 Measure time components involved in machining operation of a given job.	Apply work measurement technique to analyse the time components involved in machining operation of a given job using stop watch.	04	CO2
5	LLO 5.1 Prepare the drawing of a component. LLO 5.2 calculate the time components to perform operations to manufacture the given job. LLO 5.3 Calculate standard	Calculate the standard time for all the operations involved in step turning process.	02	CO2

Sr No	Laboratory Learning Outcome **(LLO)** aligned to CO's.	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hrs.**	**Relevant COs**
	time to perform operations to manufacture the given job.			
6	LLO 6.1 Identify the activity to be performed. LLO 6.2 Enlist the therbligs required LLO 6.3 Prepare motion chart of given activity using therbligs symbols.	Prepare motion chart of given activity using standard symbols of therbligs	02	CO3
7	LLO 7.1 Identify the component. LLO 7.2 Apply ergonomic principle for given component	Use ergonomic principle for given component	02	CO3
8	LLO 8.3 Identify organization. LLO 8.4 identify type of management. LLO 8.5 Enlist the functions of key posts.	Identify any one organization, and describe how it is managed /administered. Enlist the functions of key posts.	04	C04
9	LLO 9.1 Identify organization. LLO 9.2 Enlist various resources required. LLO 9.3 Identify how various resources are managed.	Identify any one organization, and describe how various resources are managed in it.	04	CO5
10	LLO 10.1 Identify general safety norms to be followed in industrial unit LLO 10.2 Enumerate key features of Indian Factories Act. LLO 10.3 Enumerate key features of Industrial Dispute Act LLO 10.4 Enumerate key features of Workman Compensation Act LLO 10.5 Enumerate key features of Minimum wages Act.	Describe general safety norms to be followed in industrial unit, and key features of Indian Factories Act, Industrial Dispute Act, Workman Compensation Act, Minimum wages Act.	04	CO6

I. Suggested Self Learning: Students will prepare the report for the following activities/task assigned to them.

1. Prepare detailed process plan for manufacturing of given component.
2. Prepare chart of sequence of operation for manufacturing of given component
3. Apply the method study approach to analyse the motions involved in machining operations of the given job.
4. Apply work measurement technique to analyse the time components involved in machining operation of a given job using stop watch.
5. Calculate the standard time for all the operations involved to perform operations on given job.
6. Prepare motion chart of given activity using standard symbols of therbligs.
7. Collect ergonomic data for given domestic/office items or control panels of 2 wheeler/ 4 wheeler.
8. Identify any one organization, and describe how it is managed /administered. Enlist the functions of key posts.
9. Collect information about general safety norms followed in industries.
10. Collect information about Indian Factories Act, Industrial Dispute Act, Workman Compensation Act, Minimum wages Act.

II. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks		
		R Level	U Level	A Level
1	**Process Engineering**	4	4	4
2	**Method Study & Time Study**	4	6	4
3	**Ergonomics**	2	2	2
4	**Management Concept and Managerial Skills**	2	4	4
5	**Industrial Resource Management**	2	4	4
6	**Industrial Safety and Industrial Acts**	2	4	2
	Total	**16**	**24**	**20**

Assessment Methodologies/Tools

A) Formative assessment (Assessment for Learning)

Each experiment/ assignment to be assessed on following rubrics (10 marks)

Neatness , completeness	Understanding & timely completion	Attendance & Regularity	Total
04 Marks	04 Marks	02 Marks	10 Marks

B) Summative Assessment (Assessment of Learning)

End term Theory examination of 60 marks.

Suggested COs - POs Matrix Form

CO's	Programme Outcomes (PO's)							PSO's	
	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	2	2	3	1	3
CO2	3	2	-	2	2	2	3	2	3
CO3	3	2	-	2	2	2	3	2	3
CO4	3	2	-	-	2	3	3	2	3
CO5	3	2	-	-	2	3	3	2	3
CO6	3	2	-	-	2	3	3	2	3
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

III. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Industrial Engineering And Management	O.P. Khanna, Dhanpat Rai,	ISBN-10 818992835X
2	Industrial Engineering and Production Management	Martand T Telsang, S Chand	ISBN-13. 978-8121917735
3	Ergonomics at Work: Human Factors in Design and Development	D.J.Oborne. . John Wiley & Sons Ltd, 3rd Edition - 23 January 1995.	ISBN-13: 978-0471952350 ISBN-10: 9780471952350.
4	Principles of management	Omvir Chaudhary, Prakash singh. New Delhi New age international (P) Ltd. 2011.	isbn 978 81 224 3039 4
5	Industrial Organization And Management	Sahu, K. C., Basu, S.K., Rajiv b., phi	• ISBN-10 8120344219

Learning Websites & Portals

Sr.No	Link / Portal	Description

1	www.nptel.ac.in/courses	

IV. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Dr S.G. Jadhav	Assistant Professor	V.J.T.I., Matunga, Mumbai-19
2	Mr. C. R. Khaire	Lecturer in Mechanical Engineering	K.J. S. P.,Vidyavihar, Mumbai
3	Dr. V.U. Rathod	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
4	Mr. S. B. Bidgar	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai

Coordinator,
Department of Mechanical Engineering

Head of Department
Department of Mechanical Engineering

I/C, Curriculum Development Cell

Principal

Programme : Diploma in Mechanical Engineering (Sandwich Pattern)													
Course Code: ME23601					**Course Title: Solid Modeling**								
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						**Examination Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2 Hrs 30 min.)**	**FA-PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
–	--	**4**	**-**	**4**	**2**	–	–	–	**25**	**25#**	--	**–**	**50**

Total IKS Hrs. for course: Nil

Abbreviations: CL- Classroom Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH- Self Learning Hours, NLH- Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# Online Examination, @$ Internal Online Examination
Note:
1. FA-PR represents Term work of 25 Marks
2. SA-PR represents Summative assessment of 25 Marks

Rationale

The global engineering and manufacturing industries are heavily reliant on state-of-the-art design and manufacturing technologies. Companies are increasingly looking for professionals who are proficient in using high-end CAD and CAM tools. Solid modeling is an essential skill for creating precise, realistic 3D representations of parts and assemblies. Integrating CAD (for design) and CAM (for manufacturing) ensures that students can go from conceptual design directly to production with minimal errors.

The field of engineering design and manufacturing has witnessed a remarkable transformation with the advent of advanced computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies. These tools have become indispensable in various industries, including automotive, aerospace, industrial design, and consumer electronics. The subject of **Solid Modeling**, incorporating high-end CAD software and CAM integration, is crucial for providing students with a comprehensive understanding of the modern design and manufacturing process. This rationale outlines the significance of this subject in the context of contemporary engineering education and industry practices.

Industry / Employer Expected Outcome

To be proficient in using high-end CAD software tools and become aware of using CAM software tools used in various engineering sectors to become capable of quickly transitioning into professional roles without requiring extensive training on CAD software, thereby reducing on boarding time and improving productivity from the outset.

Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course:

CO1	Create and Constraint 2D sketches
CO2	Generate 3D models of machine components
CO3	Prepare assembly of 3D modelled components.
CO4	Create 3D surface models
CO5	Generate orthographic views/ drawings of models / assemblies.
CO6	Simulate tool path and create NC files

Course Content Details:

Unit No.	Laboratory Learning Outcomes (LLO's) aligned to CO's.	Topics / Sub-topics
1	1.1 Identify the applications and benefits of solid modeling in engineering design. 1.2 Navigate and utilize the user interface and navigation tools for creating 2D sketches. 1.3 Generate and modify 2D sketches with precision using advanced sketch tools. 1.4 Export and print 2D sketches in standardized formats for practical use.	**Introduction & 2D Sketching** Introduction, Need of solid modeling, Different software's for Solid Modeling, Applications, Benefits. Getting familiar with User Interface, Navigation tools, Drawing Units. Print setup, Layout preparation, Making basic sketches- rectangle, circle etc., making polygons, circular/rectangular sketch patterns, Modifying 2D sketches using trim, extend, offset etc. Geometrical constraints, Export the drawing in dxf/ dwg,/ svg,/ pdf formats , and Print /Plot the drawings
Course Outcome : CO1		
2	2.1 Construct 3D models using extrude, revolve, and sweep. 2.2 Apply Boolean operations and modification tools to refine 3D models. 2.3 Develop construction and reference planes for accurate modeling. 2.4 Design basic mechanical components with practical applications. 2.5 Export and print 3D models in various standardized formats for manufacturing.	**3D Modeling** 3D modeling using extrude, revolve, sweep, etc. 2.2 Modifying 3D models by fillet, chamfer, use of rectangular and circular patterns, move, copy etc. Boolean operation: union, subtract, intersection 2.3 Making construction /reference planes 2.4 Modeling of simple machine components, such as spur gear, 3D spanner, nut bolts, pipe Joints, couplings, brackets, tools etc. 2.5 Export model in IGES/ STEP/ STL/dxf/ dwg,/ svg,/ pdf formats, and Print /Plot the 3D models

Course Outcome : CO2		
3	3.1 Assemble multiple components into functional assemblies. 3.2 Implement joints and constraints to achieve desired assembly behavior. 3.3 Simulate and analyze assembly motion, creating exploded views for documentation. 3.4 Export and print assemblies using recognized formats for presentation and manufacturing.	**Assembly Modeling** 3.1 3D Modeling of assembly components (Assembly should have minimum three components like screw jack, tails stock, pipe vice, tool holders, couplings, pipe joints etc.) 3.2 Joints/constraints in Assembly, 3.3 Assembly motion, 3.4 Exploded view of assembly 3.5 Export assembly in IGES/ STEP/ STL/dxf/ dwg,/ svg,/ pdf formats & Print /Plot the Assembly
Course Outcome : CO3		
4	4.1 Develop freeform surface models for various engineering applications. 4.2 Design and refine surface models for real-world objects like bottles and tools. 4.3 Export and prepare surface models for printing and further use in production.	**Surface Modeling** 4.1 Introduction, Creating free form surfaces 4.2 Creating free form surface models like water bottle, flower pot, heating iron, detergent bottle, soap case etc. 4.3 Export model IGES/ STEP/ STL/dxf/ dwg,/ svg,/ pdf formats, and Print /Plot the surface model.
Course Outcome : CO4		
5	5.1 Generate accurate 2D drawings derived from 3D models and assemblies. 5.2 Produce views, including sectional and isometric projections, for comprehensive documentation. 5.3 Annotate dimensions and create bills of material for assembled designs. 5.4 Export and print technical drawings for use in manufacturing and presentations.	**Drafting** 5.1 Generate 2D drawings from 3D models 5.2 Insert base view, projected views - front view, top view, side view, sectional views, isometric views, etc. 5.3 Drafting of Assemblies 5.4 Dimensioning, 5.5 Bill of material/ part list for assemblies 5.6 Export drawing in IGES/ STEP/ STL/dxf/ dwg,/ svg,/ pdf formats, and Print /Plot the drawing of model/ assemblies
Course Outcome : CO5		
6	6.1 Configure and simulate CAM	**Introduction to CAM**

	tools for precise machining paths. 6.2 Prepare and export NC files and tool paths for manufacturing processes. 6.3 Export/print NC files for production.	6.1 Setup, Tool Manager, drilling tool path, 2D toolpath, simulate, post NC files 6.2 3D Printing, export to STL 6.3 Print /Plot the tool path and NC files

Course Outcome : CO6

Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr. No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Use navigating tools to create 2D sketches with constraints. LLO 1.2 Produce and print/plot at least four 2D sketches to demonstrate proficiency in 2D drafting.	1	Introduction to Graphics User Interface, Demonstrate the use of navigating tools, sketching of 2D sketches and constraints. **Prepare minimum four 2D sketches and printing/ plotting the drawings**	10	CO1
LLO 2.1 Develop 3D models from 2D sketches using commands like extrude, revolve, and sweep. LLO 2.2 Modify and refine 3D models, and print/plot at least four machine components.	2	Demonstrate to prepare 3D models from 2D sketches involving use of extrude, revolve, sweep, etc. commands, and modify commands. **Prepare minimum four 3D Models of machine components and printing / plotting the models.**	10	CO2
LLO 3.1 Assemble components from 3D models and integrate motion into assemblies. LLO 3.2 Print/plot the completed assembly to showcase functionality.	3	Demonstration of assembling the 3D models, establishing the motion in components of assembly. **Prepare an assembly from 3D modelled components, establish motion in assembly components, and printing/plotting an assembly.**	10	CO3
LLO 4.1 Create exploded views of assemblies to visualize component relationships. LLO 4.2 Print/plot the exploded views to demonstrate assembly understanding.	4	Demonstration of creating an exploded view of an assembly. **Prepare exploded view of an assembly from prepared assembly and printing/plotting exploded view of an assembly.**	06	CO3
LLO 5.1 Design freeform surface models such as bottles or lamps using advanced tools. LLO 5.2 Print/plot at least four freeform models to validate design capabilities.	5	Demonstration of creating free form surfaces such as water bottle, flower pot, heating iron, detergent bottle, soap case, table lamp etc. **Prepare minimum four freeform surface models and printing / plotting the surface model.**	06	CO4

LLO 6.1 Generate orthographic and isometric views of 3D models to communicate design intent. LLO 6.2 Prepare and print/plot drafting views for at least four models.	6	Demonstration of creating drafting i.e. base view, projected views, sectional views, isometric views of models. **Prepare the drafting of minimum four 3D models and printing / plotting the different views of 3D model.**	06	CO5
LLO 7.1 Produce orthographic/ isometric views and a bill of materials (BoM) for assemblies. LLO 7.2 Print/plot the drafting of at least one assembly with a complete BoM.	7	Demonstration of creating drafting i.e. base view, projected views, sectional views, isometric views of assembly, and bill of materials. **Prepare the drafting of minimum one assembly, bill of material (BoM), and printing / plotting the different views of assembly**	04	CO5
LLO 8.1 Select appropriate tools to simulate machining paths for components. LLO 8.2 Print/plot the tool paths to verify machining strategies.	8	Demonstration for Computer Aided Manufacturing for machining of the given component. **Select the tool, and simulate toolpath for machining of the modelled component, and print / plot the tool path.**	04	CO6
LLO 9.1 Develop G-codes to automate the machining process for given components. LLO 9.2 Print/plot the G-codes to ensure accuracy in execution.	9	Demonstration for Computer Aided Manufacturing for machining of the given component. **Generate the G codes for machining of the given component and print / plot the codes.**	04	CO6

Note: All Sheets and Assignments are compulsory.

Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

I. Specification Table: Not Applicable

Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

Each sheet/ assignment to be assessed on following rubrics (10 marks)

Attendance & Regularity	Technical Understanding & Interpretation of given problem	Accuracy and pace of completion	Total
02 Marks	04 Marks	04 Marks	10 Marks

Summative Assessment (Assessment of Learning)

Practical Examination: - 25 Marks external practical examination based on curriculum.

Suggested COs - POs Matrix Form

Course Outcomes (COs)	Programme Outcomes (POs)								
	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	-	2	-	-	2	1	1
CO2	3	2	3	2	1	-	2	2	2
CO3	3	3	3	3	2	2	2	3	3
CO4	3	3	3	3	2	1	2	2	2
CO5	3	3	3	3	2	3	3	3	2
CO6	3	3	3	3	2	3	2	3	2

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

II. Suggested Learning Materials / Books

Sr.No	Author	Title	Publisher
1	Fundamentals Of Cad/Cam/Cim	Dr. Vikram Sharma, International Book House (P).Ltd Delhi (1 January 2012)	**ISBN-10 :** 9789381335734 **ISBN-13 :** 978-9381335734
2	Mastering CAD/CAM	Ibrahim Zeid, McGraw-Hill Higher Education	**ISBN**:0072976810, 9780072976816

III. Learning Websites & Portals

Sr. No	Link /Portal	Description

o		
1	https://www.youtube.com/watch?v=5aHulvtaiKw	Student can go through free tutorials available related to CAD software
2	https://www.youtube.com/watch?v=M0kmFmC-kCEhhttps://www.youtube.com/watch?v=5aHulvtaiKw	Student can go through free tutorials available related to CAD software
3	https://www.youtube.com/watch?v=2XI6vPDATQ0&list=PLROUP1bV8REQNj5I6vyydhaAUO6IdgfXU	Student can go through free tutorials available related to CAD software
4	https://www.youtube.com/watch?v=XV2KBbPCJ-A	Student can go through free tutorials available related CAD software

IV. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Mr.D.G.Pendokhare	Lecturer in Mechanical Engineering	Government Polytechnic, Thane
2	Mr.A.G.Joshi	Lecturer in Mechanical Engineering	Government Polytechnic, Ahmednagar
3	Mr. G. B.Patil	Senior Lead Engineer	Stellantis India Pvt.Ltd. Pune.
4	Mr. K. V. Patil	Sel. Grade Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
5	Mr. E. C. Dhembare	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai

Coordinator,	Head of Department
Curriculum Development,	Department of Mechanical Engineering
Department of Mechanical Engineering	
I/C, Curriculum Development Cell	Principal

Programme : Diploma in Mechanical Engineering (Sandwich Pattern)													
Course Code: ME23502					**Course Title: Emerging Trends in Mechanical Engineering**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2Hrs 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
2	**--**	**--**	**2**	**4**	**2**	**--**	**--**	**--**	**--**	**--**	**--**	**50**	**50**

Total IKS Hrs. for course: 01 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, SLA- Self Learning Assessment

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

I. Rationale:

The field of mechanical engineering is undergoing a transformative phase, driven by rapid advancements in technology, increasing environmental concerns, and the need for sustainable development. The course **"Emerging Trends in Mechanical Engineering"** is designed to equip students with the knowledge and skills required to navigate and contribute to these evolving trends. The course focuses on cutting-edge technologies and their applications across various industries, ensuring that students are prepared to meet the demands of the modern engineering landscape.

This course equips students with skills in **electric vehicles**, **autonomous driving**, **Industry 4.0** (IoT, AI, smart factories), **automation**, **green energy** (renewables, waste-to-energy), and **agricultural technologies** (cold chain, post-harvest systems). It bridges traditional engineering with modern innovations, preparing students to address sustainability, efficiency, and technological advancements in mobility, manufacturing, energy, and agriculture.

II. Industry / Employer Expected Outcome:

Industry employers expect graduates of this course to possess skills in integrating emerging technologies like electric vehicles, IoT, AI, and automation into manufacturing and automotive systems. Additionally, they anticipate proficiency in utilizing smart manufacturing, green energy solutions, and data-driven decision-making to enhance efficiency, sustainability, and innovation in industrial operations.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning.

CO1	Understand and analyze the latest innovations in the automobile industry, including electric vehicles (EVs), autonomous driving technologies, and connected cars.
CO2	Comprehend the key principles of IoT, AI, and their role in Industry 4.0 for smart manufacturing and automation.
CO3	Investigate the latest advancements in manufacturing technologies such as additive manufacturing (4D printing), advanced robotics, and automation.
CO4	Understand the principles and technologies related to renewable energy sources like wind, solar, and bioenergy.
CO5	Analyze the role of advanced mechanical systems and automation in modern agriculture equipment for precision farming.

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
1	1.1Understand the growth and role of Electric Vehicles (EVs). 1.2Differentiate between BEVs, PHEVs, and HEVs. 1.3Analyze market trends and adoption rates of EVs. 1.4Evaluate challenges and opportunities in EV adoption. 1.5Explore advancements in battery technology. 1.6Understand levels of autonomy in vehicles and current technologies. 1.7Identify key players and their role in autonomous driving. 1.8Examine challenges in autonomous vehicle development.	**Unit-1: Recent trends in automobile industry** 1.1Electrification of Vehicles • Rise of Electric Vehicles (EVs) • Types of EVs: BEVs, PHEVs, HEVs. • Market adoption and growth statistics. • Challenges and Opportunities • Battery technology and charging infrastructure. • Government policies and incentives. 1.2Autonomous Driving and Connectivity • Autonomous Vehicles (AVs) • Levels of autonomy and current state of technology. • Key players and pilot programs. • Connected Cars • IoT and vehicle-to-everything (V2X) communication. • Enhanced safety and convenience features.
Course Outcome : CO1	Learning Hours : 06	
2	2.1Understand the evolution of Industry 4.0 and key technologies driving the Fourth Industrial Revolution. 2.2Explain the fundamentals of the Internet of Things (IoT) and its applications and benefits in industrial environments. 2.3Analyze data collection techniques and the role of	**Unit-2: IOT, AI & Industry 4.0** 2.1 Introduction to Industry 4.0 • Overview of Industry 4.0 • Historical context: From Industry 1.0 to 4.0 • Key drivers of the Fourth Industrial Revolution • Key Technologies in Industry 4.0 2.2Internet of Things (IoT) • IoT fundamentals

	predictive analytics in improving manufacturing efficiency. 2.4Recognize AI and machine learning applications in manufacturing processes and smart factory automation. 2.5 Understand digital supply chain management concepts and the benefits of smart, data-driven supply chains in Industry 4.0.	• Applications and benefits in industry 2.3Big Data and Analytics • Data collection and analysis techniques • Predictive analytics in manufacturing 2.4Artificial Intelligence and Machine Learning • AI applications in industry • Use cases of machine learning in manufacturing processes • Smart Factories and Automation 2.5 Supply Chains and Industry 4.0 • Digital Supply Chain Management • Concepts and tools for digital supply chain management • Benefits of smart supply chains • Supply Chain Resilience - Reduce Obsolescence & Material scarcity risk by providing effective & efficient supply chain. • Sustainability in SCM - Sustainable Supply Chain with its 17 SDGs. • Productivity - Enhance Efficiency & Ensure Cost competitiveness.
Course Outcome : CO2 Learning Hours : 08		
3	3.1Understand the components and role of automation and robotics in smart manufacturing systems. 3.2Analyze the need for automation and its principles, strategies, and benefits in manufacturing systems. 3.3 Identify and differentiate between types of automation: fixed, programmable, flexible, hard, and soft automation. 3.4Explore industrial robotics, including robot anatomy, control systems, sensors, and applications, as well as 4D printing and 3D scanning technologies.	**Unit-3: Smart Manufacturing Systems** 3.1 Smart Manufacturing Systems • Definition and components of smart factories • Role of automation and robotics 3.2 automation- need. basic elements of automated systems. automation principles and strategies benefits 3.3 types of automation. fixed, programmable, flexible, hard and soft automation 3.4 industrial robotics- robot anatomy robot control systems and effectors, sensor in robotics, industrial robot applications 3.4 4D printing Technology, printing techniques, 3D scanning Technology -function application.
Course Outcome : CO3 Learning Hours : 06		

4	4.1 Understand the importance of green energy and identify key renewable energy sources like solar, wind, geothermal, and biomass. 4.2 Explore applications of renewable energy in heating, cooking, lighting, and other areas, focusing on sustainability. 4.3 Examine energy generation, distribution, and utilization processes for renewable energy sources. 4.4 Investigate the role of green nanotechnology, combustion technology, waste-to-energy systems, and biofuels in sustainable energy production.	**Unit-4: Green Energy.** 4.1 Introduction to Green Energy Importance of green energy Green (Renewable) energy sources: Solar, wind, geothermal, hydropower, ocean, and biomass energy. • Applications: Using renewable energy for heating, cooking, lighting, and more • Sustainability: How to reflect climate change and sustainability in the curriculum • Energy generation, distribution, and utilization: How renewable energy is created, transported, and used • Green nanotechnology: How nanotechnology can be used to create green energy • Combustion technology: How combustion technology can be used to create green energy • Waste to energy: How waste can be turned into energy • Biofuels: How biofuels can be created and used to generate energy.
Course Outcome : CO4 Learning Hours : 06		
5	5.1 Understand the functions and applications of agricultural equipment, including tillers, sowing, weeding, spraying, and harvesting machines. 5.2 Examine the components and importance of cold chain systems in agriculture and post-harvest handling. 5.3 Analyze the National Cooling Action Plan (NCAP) and its role in promoting sustainable cold storage and transportation in agriculture.	**Unit-5: Agriculture equipment and post-harvest Technology** 5.1 Tillers: sowing and planting equipment, weeding machines, spraying machines, harvesting, post harvesting machines 5.2 elements of cold chain. 5.3 National cooling action plan (NCAP)
Course Outcome : CO5 Learning Hours : 04		

Note: Any one unit from the above five units, has to be preferably taught by alumni of Govt. Polytechnic Mumbai.

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.:
Not Applicable.

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

Note: Student are required to complete any five micro projects from the suggested list given below. Similar micro projects could be added or given to the students by the concern faculty.

1. **Micro project 1: Comparative Analysis of EV Types (BEVs, PHEVs, HEVs)**
    - **Objective**: Compare Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Hybrid Electric Vehicles (HEVs) in terms of performance, cost, and environmental impact.
    - **Deliverable**: A detailed comparison chart and a short report highlighting the pros and cons of each type.
    - **Tools**: Online research, case studies, and EV market reports.

2. **Micro project 2: Design a Charging Infrastructure Plan for a City**
    - **Objective**: Propose a plan for setting up EV charging stations in a city, considering factors like population density, traffic patterns, and power grid capacity.
    - **Deliverable**: A map with proposed locations and a brief report justifying the plan.
    - **Tools**: Google Maps, EV charging station data, and power grid information.

3. **Micro project 3: IoT-Based Smart Factory Simulation**
    - **Objective**: Simulate a small-scale smart factory using IoT concepts (e.g., sensors, actuators, and data flow).
    - **Deliverable**: A flowchart or block diagram showing how IoT connects machines, collects data, and enables real-time monitoring.
    - **Tools**: Simulation software (e.g., Tinkercad, MATLAB, or any IoT platform).

4. **Micro project 4: Predictive Maintenance Using Machine Learning**
    - **Objective**: Develop a simple predictive maintenance model using machine learning to predict equipment failure based on historical data.
    - **Deliverable**: A basic ML model (e.g., decision tree or regression) and a report explaining the approach.
    - **Tools**: Python (Scikit-learn), sample datasets (e.g., Kaggle).

5. **Micro project 5: Design a Flexible Automation System**
    - **Objective**: Design a flexible automation system for a small-scale manufacturing process (e.g., assembly line).
    - **Deliverable**: A schematic diagram and a brief description of the system's components and functionality.
    - **Tools**: CAD software (e.g., SolidWorks, AutoCAD) or hand-drawn sketches.

6. **Micro project 6: Industrial Robot Application Case Study**
    - **Objective**: Research and present a case study on the application of industrial robots in a specific industry (e.g., automotive, electronics).

- **Deliverable**: A presentation or report highlighting the robot's role, benefits, and challenges.
- **Tools**: Online research, industry reports, and case studies.

7. **Micro project 7: Design a Solar-Powered Device**
    - **Objective**: Design a small solar-powered device (e.g., a solar charger or light) and explain its working principle.
    - **Deliverable**: A prototype design (can be a model or diagram) and a brief report on its applications.
    - **Tools**: Solar panel kits, basic electronics components, and design software.

8. **Micro project 8: Waste-to-Energy Feasibility Study**
    - **Objective**: Conduct a feasibility study on converting waste into energy for a small community or industry.
    - **Deliverable**: A report outlining the process, benefits, and challenges of waste-to-energy conversion.
    - **Tools**: Online research, case studies, and waste management data.

9. **Micro project 9: Design a Post-Harvest Cooling System**
    - **Objective**: Design a simple cooling system for post-harvest storage of agricultural produce, considering the elements of the cold chain.
    - **Deliverable**: A schematic diagram and a brief description of the system's components and functionality.
    - **Tools**: CAD software or hand-drawn sketches.

10. **Micro project 10: Analysis of National Cooling Action Plan (NCAP)**
    - **Objective**: Analyze the National Cooling Action Plan (NCAP) and its impact on agriculture and post-harvest technology.
    - **Deliverable**: A short report summarizing the key points of NCAP and its relevance to agriculture.
    - **Tools**: Government documents, online research, and case studies.

VII. Suggested Specifications Table (Theory): Not Applicable.

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

Each Experiment/ assignment to be assessed on following rubrics (10 marks)

Attendance & Regularity	Technical Understanding & Interpretation of given experiment/assignment/model.	Presentation & completion	Total
02 Marks	04 Marks	04 Marks	10 Marks

Summative Assessment (Assessment of Learning): Not Applicable.

IX. References/ Books:

Sr. No.	Title	Author, Publisher, Edition and Year of publication	ISBN
1	Electric Vehicles and the end of ICE Age	Anupam Singh Publisher: Adhyyan Books Edition: 1, 2019	ISBN: 9789387502765, 9387502767
2	Industry 4.0: Technologies, Applications, and Challenges (Emerging Trends in Mechatronics)	Aydin Azizi and Reza Vetankhaha barenji Edition:1st ed. 2023	ISBN-13:978-9811920110
3	Internet of Things (IoT)	Dr. Kamlesh Lakhwani, Dr. Hemant kumar Gianey, Joseph Kofi Wireko, Kamal Kant Hiran Edition: First Edition	ISBN-13: 978-9389423365
4	Green Energy	River Publishers Series in Communications and Networking Editor: M. D. Tiwari & Anurika Vaish, IIIT-Allahabad, India	ISBN: 9788792329417
5	Renewable Energy Sources and Emerging Technologies	D.P. Kothari, K.C.Singal, Rakesh Ranjan Publisher : Prentice Hall India Learning Private Limited; 2nd edition (1 January 2011)	ISBN-10 : 8120344707 ISBN-13 : 978-8120344709
6	Industry 4.0: The Industrial Internet of Things	Alasdair Gilchrist (Author) Publisher: Apress	ISBN-13978-1484249703
7	Electric and Hybrid Vehicles: Technologies, Modeling, and Control	Amir Khajepour, Saber Fallah, and Avesta Goodarzi	ISBN: 978-1118970566
8	Industry 4.0: The Industrial Internet of Things.	by Alasdair Gilchrist	ISBN: 978-1484220467
9	Automation, Production Systems, and Computer-Integrated Manufacturing	Mikell P. Groover	ISBN: 978-0133499612
10	Agricultural Mechanics: Fundamentals and Applications	by Ray V. Herren	ISBN: 978-0357028638

X.E-References:

1. https://youtu.be/aaOB-ErYq6Y?si=8h_-jE1DxeUQP0Gc
2. https://youtu.be/tiwVMrTLUWg?si=5KYI9q4vfvx6FXiI

3. https://youtu.be/kpW9JcWxKq0?si=i9_7xxAOrJOQDh1w
4. https://youtu.be/6mBO2vqLv38?si=C-CSTAB4gePPXq5n
5. https://youtu.be/HcqpanDadyQ?si=YfY6M54X8-f2-1Gf
6. https://youtu.be/a0_lo_GDcFw?si=VdA5AiadgubGlU_5
7. https://youtu.be/aNDSWLGTw6M?si=shoYqxQBDOZMKoK0
8. https://youtu.be/wEtH6tT9HA4?si=wRZBlogw7qt6mOZ2
9. https://youtu.be/MyK4BzbxcdU?si=a7GdTIhxb0EeIT-Q
10. https://youtu.be/1kUE0BZtTRc?si=s09MxbP7KibeQqxD
11. https://youtu.be/D2-hWT5LcRg?si=xsPXum9bOZPODmHK
12. https://youtu.be/u8CVwxLtD14?si=0oyXshPMXlJ4MFnb

XI.CO Vs PO and CO Vs PSO Mapping:

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	1	3	2	2	2	2
CO2	2	-	1	3	3	2	3	2	2
CO3	3	2	2	3	3	3	2	3	3
CO4	3	2	2	2	3	-	1	1	1
CO5	3	3	3	3	3	2	2	3	3
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

XII.Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organisation
1	Mr. K.B.Salunkhe	Selection Grade Lecturer in Mechanical Engineering	Government Polytechnic, Thane.
2	Dr. Shirish D.Dhobe	Selection Grade Lecturer in Mechanical Engineering	Government Polytechnic, Pune.
3	Mr.Sumedh Gamare	Chief Manager , SCM	Siemens Ltd. Mumbai.
4	Dr.S.G.Taji.	Head of Department, Mechanical Engineering	Government Polytechnic, Mumbai
5	Mr. K.V.Patil	Selection Grade Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
6	Dr.V.U.Rathod	Selection Grade Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
7	Mr.S.B.Bidgar	Selection Grade Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
8	Mr.E.C.Dhembare	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
9	Mr.K.Z.Dhangare	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
10	Miss.A.N.Naik	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai

Coordinator, Head of Department

Curriculum Development, Department of Mechanical Engineering

Department of Mechanical Engineering

I/C, Curriculum Development Cell Principal

Programme : Diploma in Mechanical Engineering (Sandwich Pattern)													
Course Code: ME23201					**Course Title: Automobile Engineering**								
Compulsory / Optional: Optional													
Learning Scheme and Credits						**Assessment Scheme**							
						FA-TH		**SA-TH (2Hrs 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**T1**	**T2**			**PR**	**OR**		
4	**--**	**2**	**--**	**6**	**3**	**20**	**20**	**60**	**25**	**--**	**--**	**--**	**125**

Total IKS Hrs. for course: 01 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, SLA- Self Learning Assessment

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

Note:

1. FA-PR represents Term work of 25 Marks

I. Rationale: Automobile sector has been helping the world for the overall development and it has been creating wage and self-employment opportunities both in public and private sectors. Mechanical engineering technologists should have an overall understanding of various aspects of automobile systems. This course provides a broad knowledge about the different vehicle layout, transmission and controls, electrical and electronics systems, vehicle safety and security, features of motor vehicle acts along with automobile maintenance with automobile maintenance systems. This knowledge will be helpful to the students in co relating various automobile systems with each other and provide good practical input with theoretical knowledge for technological advancement of the industry / society.

II. Industry / Employer Expected Outcome:

To study the basic concepts of Automobile Engineering and interpret the required automobile component based on the analysis of the automobile specifications.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning.

CO1	Prepare vehicle layouts with chassis specification.
CO2	Interpret power flow diagrams of transmission systems.
CO3	Select suitable braking and steering systems for different application.
CO4	Select tyres and suspension system for different applications
CO5	Prepare simple electrical – electronics circuits for automobile systems.
CO6	Maintain automobile air conditioning system.

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
1	1.1 Identify various automobile components and their location on the given vehicle. 1.2 Describe with sketches the function of the given part. 1.3 Draw labelled vehicle layout of the given vehicle. 1.4 Select relevant type of alternative fuel for the given application with justification.	**Unit-1: Introduction to automobiles** 1.1 Automobile: definition, classification of automobiles, Major components of automobiles with their function and location. 1.2 Vehicle layout: Definition significance of Vehicle Layout. Different types of Vehicle layout (FEFWD, FERWD, RERWD, 4WD) Advantages, Disadvantages, Applications and Comparisons of different types of vehicle layout. 1.3 Function of chassis, frame, classification of chassis frame with advantages, disadvantages and applications. Basic body nomenclature. 1.4 Alternative fuels: LPG and CNG: need, fuel characteristics, advantages, limitations. Layout of electric vehicles, need, working, advantages, limitations. Hydrogen as fuel. Safety precautions while handling automobile accessories and equipment.
Course Outcome : CO1	**Learning Hours : 10**	**Marks: 10**
2	2.1 Identify the major components of the given transmission system. 2.2 Select type of transmission for the given application. 2.3 Explain with sketches the working principle of the given overdrive with labelled diagram. 2.4 Explain the working principle of differential for the given vehicle. 2.5 Interpret the power flow diagram of the given transmission system.	**Unit-2: Transmission system** 2.1 Need and Requirements of transmission system. Its components and their functions. 2.2 Clutch: Function and working principle of clutch, types and construction of clutches such as Single plate and Multiplate type and Centrifugal clutch. Faults & remedies in clutch. 2.3 Gearbox: Necessity of gear box, Constant mesh & Synchromesh gear box with their construction and operation. 2.4 Semi-automatic transmission: Function, Construction and Working of Overdrive, Automatic Transmission, fluid flywheel: Function, Construction and Working of Fluid flywheel. 2.4 Propeller shaft: Function, Necessity, Types, Construction and working 2.5 Differential: need, Construction and Working, differential action and operation 2.6 Axle: Hotchkiss and torque tube drives, rear axle-full floating axle, semi-floating and three quarter floating axle. Front axle.
Course Outcome : CO2	**Learning Hours : 12**	**Marks: 10**
3	3.1 Explain with sketches the terms related to steering system. 3.2 explain with sketches the working principle of the given type of steering gearbox for	**Unit-2: Control Systems** 3.1 Steering System: Necessity, functions & types of steering system. Construction and working of Recirculating ball type and Rack and Pinion type. Steering Geometry- Caster, Camber, King pin inclination, Toe In and Toe Out, Steering axis inclination. Principle of Power steering, Construction and

	the given vehicle. 3.3 Sketch the labelled layout of the given type of Braking system. 3.4 Explain with sketches the working of the given ABS.	working of Power steering 3.2 Braking System: Function, Need, Principle of braking system, Types of automotive braking systems, Mechanical, Hydraulic and Air operated. Hydraulic braking systems: Layout & components of hydraulic braking Systems. Construction and working of Master cylinder and wheel cylinder, Tandem cylinder. Drum braking system, Disc Braking Systems, Air braking system: layout and working. 3.4 Anti-lock braking system: Layout of ABS, Types of ABS
Course Outcome : CO3	**Learning Hours : 12**	**Marks: 10**
4	4.1 Explain the terms related to the given suspension system. 4.2 Explain with sketches the working principle of the given type of suspension system. 4.2 Select relevant suspension system for the given applications. 4.3 Explain procedure, tool and equipment for wheel alignment and balancing.	**Unit-4: Suspension System, wheel and tyres.** 4.1 Suspension System: Function, Necessity and classification of suspension system, front and rear suspension system, Advantages of front wheel independent suspension system. construction and working of Wishbone type, Mac Pherson type, Trailing link type, coiled springs, Constructional features of leaf spring and Construction and working of shock absorbers, air suspension system. 4.2 Wheels and Tyres: Function, Necessity and requirement of wheel rims and tyres. Types of wheels-spoked, disc, light alloy cast. Types of rims. Tyres-Desirable properties, types-redial ply, cross ply, tubeless. Factors affecting tyre life. Purpose and procedure of wheel alignment and wheel balancing.
Course Outcome : CO4	**Learning Hours : 10**	**Marks: 08**
5	5.1 Explain the given terms related to automobile electrical system. 5.2 Explain with sketches principle of the given electrical component of the vehicle. 5.3 Select relevant battery for the given application.	**Unit-5: Electrical Systems.** 5.1 Ignition system: Introduction to ignition system; Battery Ignition systems and magneto Ignition system; Electronic Ignition system; Construction and working of lead acid battery; Elements of starting system; Types of lights used in the automobile: 5.2 Battery: Automotive battery construction and operation, battery capacity, Battery ratings, Battery tests. Charging System: Need of charging system, Construction and operation of charging system, Dynamo, Alternator principle, construction and working 5.3 Starting System: Need of starting system layout, Bendix and solenoid drive
Course Outcome : CO5	**Learning Hours : 08**	**Marks: 12**
6	6.1 Explain the working of various components of automobile air conditioning system. 6.2 Sketch labelled layout of automobile air conditioning system	**Unit-6: Automobile Air Conditioning System.** 6.1 Locate various components of air conditioning systems in a vehicle. 6.2 Introduction, layout of car air conditioning system, components of a system, working of a system, parameter control (Humidity, temperature, purity of air) required. 6.3 Important precautions while using AC system.

Course Outcome : CO6	**Learning Hours : 08**	**Marks: 10**

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr. No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
1.1 Draw 2 wheeler and 4 wheeler vehicle layout.	1	To draw vehicle layout. (2 wheeler and 4 wheeler)	04	CO1
2.1 Understand working and layout of transmission system	2	Demonstration of auto transmission in automobiles.	02	CO1
3.1 Dismantle / Assemble single plate clutch	3	Dismantle and assemble single plate clutch	02	CO2
4.1 Dismantle / Assemble multi plate clutch	4	Dismantle and assemble multi plate clutch	02	CO2
5.1 Dismantle / Assemble the propeller shaft assembly.	5	Dismantle and assemble the propeller shaft assembly.	02	CO2
6.1 Dismantle / Assemble synchromesh gear box or constant mesh gear box.	6	Dismantle and assemble synchromesh gear box or constant mesh gear box.	02	CO2
7.1 Dismantle / Assemble Differential gear box of automobile.	7	Dismantle and assemble Differential gear box of automobile.	02	CO2
8.1 Dismantle / Assemble the power steering system.	8	Dismantle and assemble the power steering system.	02	CO3
9.1 Dismantle brake system (drum /disk)	9	Dismantle brake system (drum /disk) and observe various components of it. Write function of important components.	04	CO3
10.1 Dismantle / Assemble suspension system	10	Dismantle and assemble leaf spring, torsion bar, dependent & independent suspension.	02	CO4
11.1 Dismantle / Assemble the wheel and tyre assembly.	11	Dismantle and assemble the wheel and tyre assembly.	02	CO4
12.1 Inspect battery components	12	Testing of battery like Ah rating, type of battery, no. of cells, vents, charge status by using hydrometer and voltmeter.	02	CO5
1.31 Understand car AC system	13	Demonstration of car air-conditioning system.	02	CO6
		Total	**30**	

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

NIL

VII. Suggested Specifications Table (Theory):

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Introduction to Automobiles	4	2	4	10
2	Transmission system	4	4	4	12
3	Control Systems	4	4	4	12
4	Suspension System, wheel and tyres	4	2	4	10
5	Electrical Systems	2	2	4	08
6	Automobile Air conditioning System	2	2	4	08
	Total	**20**	**16**	**24**	**60**

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

Each Experiment/ assignment to be assessed on following rubrics (10 marks)

Attendance & Regularity	Technical Understanding & Interpretation of given experiment/assignment/ model.	Presentation & completion	Total
02 Marks	04 Marks	04 Marks	10 Marks

Summative Assessment (Assessment of Learning)

TH - Term End examination of 60 Marks duration 2 hours 30 mins.

IX. References/ Books:

Sr. No.	Title	Author, Publisher, Edition and Year of publication	ISBN
1	A Text book of Automobile Engineering	Rajput R.K. Laxmi Publications Pvt. Ltd, New Delhi, 2008.	97881170089919

2	Automotive Mechanics	Crouse W.H., Anglin D.W. Tata-McGraw Hill publications**,** Delhi(1965)	978007070148215
3	Automobile Engineering (vol. I & II)	Dr. Kirpal Singh, Standard Publishers, New Delhi.(2004)	9788180141034
4	Automobile Engineering	H. M. Sethi Tata-McGraw Hill edition -1, (2006)	9780074603901
5	Automotive Mechanics	S Shrinivasan Tata-McGraw Hill, 2nd edition (2017)	0070494916 978-0070494916
6	Automobile Engineering	T. R. Banga, Nathu Singh. Khanna publishers (2005)	8174092218 978-8174092212

X.E-References:

1. www.tatamotors.com
2. www.marutisuzuki.com
3. www.auto.howstuffworks.com
4. You tube videos for automobile systems

XI.CO Vs PO and CO Vs PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
CO1	3	3	2	2	1	1	2	1	1
CO2	2	3	2	1	1	1	2	1	1
CO3	2	2	2	2	1	2	1	1	1
CO4	2	2	3	3	3	1	1	1	1
CO5	2	2	2	2	1	2	1	1	1
CO6	2	3	2	1	1	1	2	1	1

XII.Industry Consultation Committee:

Sr. No	**Name**	**Designation**	**Institute/Organisation**
1	Mr. K.Z. Dhangare	LME	G.P.Mumbai
2	Mr. E.C.Dhembare	LME	G.P.Mumbai
3	Mr. Prashant Chavan	LME	G.P.Murtizapur
4	Mr. Kiran B Salunke	LME	G.P.Thane
5	Mr. Gautam. Patil	Manager	Mahindra and Mahindra Ltd Nashik
6	Mr. Sachin Khalkar	Manager	Mahindra and Mahindra Ltd Nashik

Coordinator,
Curriculum Development,
Department of _____

Head of Department
Department of _____

I/C, Curriculum Development Cell

Principal

Programme : Diploma in Mechanical Engineering (Sandwich Pattern)													
Course Code: ME23202					**Course Title: Industrial Maintenance**								
Compulsory / Optional: Optional (Elective-1)													
Learning Scheme and Credits						**Assessment Scheme**							
						FA-TH		**SA-TH (2Hrs 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**T1**	**T2**			**PR**	**OR**		
4	--	**2**	--	**6**	**3**	**20**	**20**	**60**	**25**	--	--	--	**125**

Total IKS Hrs. for course: 01 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, SLA- Self Learning Assessment

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

Note:

1. FA-PR represents Term work of 25 Marks

I. Rationale:

Maintenance is one of the important functions in any type of industry. Also every mechanical engineer should be aware of basic principles of maintenance and maintenance management. With the advancements in manufacturing processes, machine tools and other service sectors, the employment opportunities in the field of maintenance are increasing.

This course in industrial maintenance provides the opportunity to students to get familiar with the maintenance procedures of simple mechanical systems/ components, basics of maintenance management and new approaches like TPM, 5S.

II. Industry / Employer Expected Outcome:

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning.

CO1	Describe basic terminology in maintenance practices
CO2	Describe & select appropriate maintenance strategy for given equipment
CO3	Describe basics of TPM & 5S
CO4	Describe the procedure for the maintenance of given mechanical systems or components
CO5	Describe the spares management norms for maintenance and describe lubrication activities
CO6	Describe the documentation used in maintenance activities in industries.

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
1	1.1 Understand the concepts of maintenance. 1.2 Study the costs of maintenance. 1.3 Understand the organizational structure.	**Unit-1: Basics of Maintenance Engineering** 1.1 Definition, Need & Importance of maintenance, basic terminology related to maintenance- Mean time between failure (MTBF), mean time to repair (MTTR), Terotechnology, Reliability 1.2 Objectives and functions of maintenance department, consequences of equipment failures 1.3 Costs of maintenance 1.4 Organizational structure for maintenance, skills required for maintenance activities
Course Outcome : CO1	**Learning Hours : 09**	**Marks: 06**
2	2.1 Learn the factors to be considered in maintenance systems. 2.2 Understand maintenance strategies. 2.3 Understand equipment life cycle and maintenance schedule.	**Unit-2: Maintenance Systems/ Maintenance Strategies** 2.1 Factors considered in deciding criticality of equipment, Maintenance Plan Preparation, 2.2 Maintenance strategies, their characteristics and applications: Break down/ corrective maintenance, Preventive maintenance, Condition based maintenance (CBM), Reliability based maintenance, equipments used for CBM 2.3 Equipment Life cycle- Bath Tub Curve and maintenance strategies, Factors considered in maintenance system design 2.4 Preparation of maintenance schedule for preventive maintenance, maintenance cycle, Preparing Check list for PM
Course Outcome : CO2	**Learning Hours : 10**	**Marks: 12**
3	3.1 Understand the philosophy of TPM and objectives of TPM. 3.2 Understand the concept of 5S.	**Unit-3: Total Productive Maintenance (TPM)** 3.1 Philosophy of TPM, Six losses due to inferior maintenance, Concept of Autonomous Maintenance 3.2 Objectives and Benefits of TPM, Overall Equipment Efficiency (OEE) 3.3 Stages of implementation of TPM, Pillars of TPM 3.4 5S & its implementation

Course Outcome : CO3	Learning Hours : 10	Marks: 08
4	4.1 Learn and perform maintenance of various mechanical systems and components. 4.2 Study the safety in maintenance .	**Unit-4:Maintenance of Mechanical Systems & Components** 4.1 Maintenance of bearings, clutches, couplings, flexible drives, gears & gear drives, shafts 4.2 Maintenance of Pumps, Air Compressors, Condensers 4.3 Maintenance of Pneumatic systems: Common problems in pneumatic systems, Maintenance schedule of pneumatic systems 4.4 Maintenance of hydraulic Systems: Common problems in hydraulic systems, Maintenance schedule of hydraulic systems 4.5 Maintenance of Conveyors, Overhead Hoists, cranes 4.6 Safety in maintenance activities, Energy saving through planned Maintenance
Course Outcome : CO4	Learning Hours : 15	Marks: 16
5	5.1 Understand the classification of spares. 5.2 Learn the various lubrication methods and types of lubricant.	**Unit-5: Spares Management & Lubrication** 5.1 Classification of spares, norms for stock, stock of electrical spares, 5.2 Lubrication, different methods of lubrication 5.3 Lubricants, function of Lubricant, Properties of Lubricant, Types of Lubricant
Course Outcome : CO5	Learning Hours : 08	Marks: 10
6	6.1 Understand the maintenance requisition procedure. 6.2 Learn to prepare maintenance manual.	**Unit-6: Documentation for maintenance Activities** 6.1 Maintenance requisition Procedure, Work order, work permit system 6.2 Maintenance Manual, History Cards, Defect analysis, Down time analysis
Course Outcome : CO6	Learning Hours : 08	Marks: 08

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr. No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
1.1 Learn the basics of maintenance engineering.	1	Assignment on basics of maintenance engineering	2	CO1
2.1 Learn to prepare how to do preventive maintenance.	2	Preparation of check list for preventive maintenance for assigned equipment/ machine in workshop or laboratory	4	CO2
3.1 Understand the concept of 5S / TPM.	3	Assignment on TPM/ Assignment on 5S	4	CO3

4.1 Perform maintenance activity.	4	Performance of maintenance activity for assigned equipment/ machine (Group activity) & preparation of activity report	4	CO4
5.1 Learn how to prepare lubricaton schedule.	5	Preparation of lubrication schedule for assigned equipment/ machine and its implementation during term	4	CO5
6.1 Learn various maintenance activities.	6	Assignment on documentation for maintenance activities	2	CO6
7.1 Prepare project on maintenance related activities.	7	Mini Project on assigned maintenance related activity in the group of four students [students to work throughout term and present work]	4	CO1-CO6
8.1 Learn the concepts of maintenance.	8	Expert lecture by maintenance professional or visit to maintenance department in industry	2	CO1-CO6
9.1 Learn Condition based maintenance- using the equipments.	9	Condition based maintenance- using the equipments for measurement of signatures	4	CO2
10.1 Learn how maintenance of pneumatic system is done.	10	Performance of maintenance activities on pneumatic systems	4	CO4
11.1 Learn how maintenance of pneumatic system is done	11	Performance of maintenance activities on hydraulic systems	4	CO4
		Total	30	

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): Nil

VII. Suggested Specifications Table (Theory):

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Basics of Maintenance Engineering	2	4	-	6
2	Maintenance systems/ Maintenance strategies	4	4	4	12
3	Total Productive Maintenance	2	4	2	8
4	Maintenance of mechanical systems and components	4	8	4	16
5	Spare management and lubrication	4	4	2	10
6	Documentation for maintenance activities	-	4	4	8
	Total	**16**	**28**	**16**	**60**

VIII. Assessment Methodologies/Tools:

Formative assessment (Assessment for Learning)

Each Experiment/ assignment to be assessed on following rubrics (10 marks)

Attendance & Regularity	Technical Understanding & Interpretation of given experiment/assignment/ model.	Presentation & completion	Total
02 Marks	04 Marks	04 Marks	10 Marks

Summative Assessment (Assessment of Learning)

TH - Term End examination of 60 Marks duration 2 hours 30 mins.

IX. References/ Books:

Sr. No.	Title	Author, Publisher, Edition and Year of publication	ISBN
1	Maintenance and spare parts management	P. Gopalkrishnan, A. K. Banerji, Prentice Hall of India, 2nd Ed; 2004	978-8120-3066-91
2	Principles and practice of Total Productive Maintenance	Bikash Bhadury, Allied Publishers Ltd, 1st Ed; 1998	978-8170-2380-58
3	Pneumatic Systems Principles and Maintenance	S.R. Mujumdar, Tata McGraw Hill Publishing Company Ltd, 1st Ed; 1995	978-0074-6023-17
4	Maintenance Fundamentals	R. Keith Mobley, Elsevier Butterworth–Heinemann, 2nd Ed., 2004	978-0750-6779-81
5	Industrial Maintenance	H P Garg, S Chand & company,3rd Ed., 1987	978-8121-9016-80
6	Plant maintenance engineering	R K Jain, Khanna publications, 2nd Ed; 2018	978-8174-0929-46
7	Maintenance engineering and management	R.C. Mishra and K Pathak, Prentice Hall of India Pvt. Ltd, New Delhi, 12th Ed; 2004	978-8120-3457-37
8	Total productive maintenance	K. S. Madhavan, Shingo institute of Japanese management, 1st Ed; 2014	978-8190-6715-52

9	Engineering maintenance- A modern approach	B. S. Dhillon, CRC Press, 1st Ed; 2002	978-1587-1614-21

X.E-References:

1. https://www.licensedelectrician.com/Store/Maintenance.htm
2. https://www.youtube.com/watch?v=f58SW0Hwcf0
3. https://www.youtube.com/watch?v=6Zh8_x17qhI
4. https://www.youtube.com/watch?v=foq43sPPmMo
5. https://easyengineering.net/me6012-maintenance-engineering/
6. www.sasurieengg.com/e-course-material/MECH/IV-Year%20Sem%208/ME2037%20ME.pdf
7. https://www.coursehero.com/file/46869813/ME6012-ME-Complete-Notespdf/

XI.CO Vs PO and CO Vs PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
CO1	2	1	2	1	2	1	3	2	1
CO2	2	2	3	2	2	2	3	2	2
CO3	3	2	3	3	2	2	3	3	2
CO4	3	2	3	3	2	2	3	3	2
CO5	3	3	3	2	3	2	3	3	2
CO6	3	3	3	2	3	2	3	3	2

XII.Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organisation
1	Mr. Jawale S. M.	Ex. General Manager	Godrej & Boyce Mfg. Co. Pvt. Ltd. Mumbai
2	Mr. Sachin Khalkar	Deputy Manager	Mahindra & Mahindra Ltd; Nashik
3	Mr. Yogesh Gaidhani	Head of Department, Mechanical Engineering	K K Wagh Polytechnic, Nashik
4	Mr. Gajanan Gore	Lecturer in Mechanical Engineering	Government Polytechnic, Jalna
5	Mr. K. Z. Dhangare	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai

6	Miss. A. R. Hagawane	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai

Coordinator,
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Principal