METROLOGY AND MEASUREMENT **Course Code : 313316**

Programme Name/s : **Mechanical Engineering/ Production Engineering**
Programme Code : **ME/ PG**
Semester : **Third / Fourth**
Course Title : **METROLOGY AND MEASUREMENT**
Course Code : **313316**

I. RATIONALE

The Diploma Mechanical Engineer should understand, use and select various measuring instruments as they often come across measuring different parameters of machined components and the appropriate fitment of interchangeable components in the assemblies. Students should also be familiar with the principles of instrumentation, transducers and measurement of non-electrical parameters like, force and sound.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The diploma technician will be able to Use relevant measuring instruments for various conditions of measurement efficiently.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Select relevant linear measuring instrument for measurement.
- CO2 - Select different gauges and comparators for measurement of given components.
- CO3 - Use relevant instrument for measurement of different parameters of engineering components.
- CO4 - Select relevant instrument for measuring the physical parameters of given system.
- CO5 - Use relevant instrument for measurement of operating parameters of system.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313316	METROLOGY AND MEASUREMENT	MAM	DSC	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 1 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Define various parameters of Metrology and Measurement. TLO 1.2 Explain characteristics of measuring instruments. TLO 1.3 Explain different types of standards. TLO 1.4 Describe working principle of Linear measuring instruments. TLO 1.5 Identify errors in given instrument. TLO 1.6 Select relevant measuring instrument for the given job with justification.	**Unit - I Overview of Metrology and Linear Measurement** 1.1 Definition of Metrology, objective and types of Metrology, Need of inspection, Methods of measurements. 1.2 Characteristics of instruments – Static characteristics: Least count (resolution), Range and Span, Accuracy and Precision, Reliability, Calibration, Hysteresis, Dead Zone, Drift, Sensitivity, Threshold, Repeatability, Reproducibility, Linearity, Amplification, Magnification. Dynamic characteristics: Speed of response, Fidelity, Overshoot. 1.3 Standards: Definition and characteristics of Line standard, End standard and Wavelength standard. 1.4 Linear measuring Instruments: Working principle of Vernier caliper, micrometer, height gauge and depth gauge. 1.5 Types of Errors and its sources in Measurements, Factors affecting on accuracy. 1.6 Selection of instrument, Precautions while using an instrument for getting higher precision and accuracy.	Lecture Using Chalk-Board Presentations Video Demonstrations Demonstration
2	TLO 2.1 Explain construction and working of given comparators. TLO 2.2 Use gauges for given job with justification. TLO 2.3 Select slip gauges for building specific dimensions.	**Unit - II Gauges and Comparators** 2.1 Comparators: Definition, Requirement of a good comparator, Classification, Use of comparators, Working principle (Merits and Demerits) of Dial indicator and Pneumatic Comparator (Air Gauge), Selective Assembly, Interchangeability. 2.2 Gauges: Limit gauges. Taylor's principle of Gauge design, Plug, Ring Gauges, Snap gauges. 2.3 Slip gauges: Wringing of Slip Gauges (Numerical). Precautions	Lecture Using Chalk-Board Presentations Video Demonstrations Demonstration
3	TLO 3.1 Select Angular measuring instrument for given component and calculate unknown angle. TLO 3.2 Calculate screw thread parameters using given method. TLO 3.3 Explain procedure of measuring the given parameters of gear. TLO 3.4 Describe procedure for examining surface finish of the given component. TLO 3.5 Explain procedure for Measurement by CMM.	**Unit - III Angular, Screw Thread, Gear and Surface Finish Measurements** 3.1 Angle measurement: Instruments used in Angular Measurements: Angle Gauges (No Numerical), Bevel Protractor, sine bar. Principle of Working of Angle Dekkor. 3.2 Screw thread Measurements: Screw thread terminology, measurement of different elements such as major diameter, minor diameter, effective diameter, pitch, thread angle. Best wire size, Two wire method, Working principle of floating carriage micrometer. 3.3 Gear Measurement: Parkinson Gear tester, Gear tooth Vernier, Profile projector. 3.4 Surface Roughness Measurement: Meanings of surface texture and definitions, methods of surface measurement - Ra, Rz and RMS values (No Numerical), Principle of Interferometry, Taylors Hobsons Talysurf. 3.5 CMM: Introduction to Coordinate Measurement Machine (CMM) and its merits.	Lecture Using Chalk-Board Presentations Video Demonstrations Demonstration

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Classify transducers for the given application. TLO 4.2 Identify the given transducer with justification. TLO 4.3 Explain displacement measuring instrument. TLO 4.4 Explain temperature measuring instruments. TLO 4.5 Interpret principles of flow measuring instruments for given system.	**Unit - IV Displacement, Temperature and Flow Measurement** 4.1 Generalized measuring system and its components. 4.2 Transducers: Classification of transducers- active and passive, contact, non-contact, Mechanical, Electrical, analog, digital. Applications of transducers. 4.3 Displacement Measurement: Specification, selection and application of displacement transducer, LVDT, RVDT, Potentiometer. 4.4 Temperature Measurement: Non-electrical methods- Bimetal and Liquid in glass thermometer. Electrical methods- RTD, Thermistor, Thermocouple. 4.5 Flow measurement: Types of flow meters. Selection criteria for flow meters. Variable area meter- Rota meter. Vane type Anemometer.	Lecture Using Chalk-Board Presentations Video Demonstrations Demonstration
5	TLO 5.1 Explain principles and constructional features of sound measuring device. TLO 5.2 Explain principles and constructional features of force measuring device. TLO 5.3 Choose speed measuring instrument for a given system with justification.	**Unit - V Miscellaneous Measurements** 5.1 Acoustics Measurement: Sound characteristics - intensity, frequency, pressure, power, sound level meter. 5.2 Force Measurement: Load cell- Hydraulic, Pneumatic and Strain Gauge 5.3 Speed Measurement: Tachometers: Eddy current Drag Cup Tachometer, Contact less Electrical tachometer - Inductive Pick Up, Capacitive Pick Up and Stroboscope.	Lecture Using Chalk-Board Presentations Video Demonstrations Demonstration

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Use ancient measurement system for measurement of length and weight.	1	*Measurement of Length and weight by using ancient measurement system (IKS)	2	CO1 CO5
LLO 2.1 Measure dimensional parameters by using linear measuring instruments. LLO 2.2 Operate different linear measuring instruments.	2	*Measurement of dimensions of component using vernier caliper, vernier height gauge, vernier depth gauge, micrometer and inside micrometer.	2	CO1
LLO 3.1 Check the geometrical parameters of a component with the help of mechanical comparators. LLO 3.2 Operate dial gauge for different applications.	3	Roundness checking of the given component using dial indicator / dial gauge.	2	CO2
LLO 4.1 Use Bevel Protractor and Sine bar for measurement of unknown angle. LLO 4.2 Operate Bevel Protractor and Sine bar for angle measurement.	4	*Measurement of unknown angle of a component using Bevel Protractor and verification by Sine bar.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 5.1 Use floating carriage micrometer for measurement of major, minor and effective diameter of screw threads. LLO 5.2 Operate optical profile projector for checking thread profile.	5	*Measurement of the screw thread elements by using floating carriage micrometer and verification by optical profile projector	2	CO3
LLO 6.1 Measure face width and tooth thickness of a gear by using gear tooth vernier caliper. LLO 6.2 Operate optical profile projector for measuring gear profile.	6	*Measurement of the gear tooth elements using gear tooth vernier caliper and verification by optical profile projector.	2	CO3
LLO 7.1 Examine the machined surface using surface roughness tester.	7	*Measurement of the surface roughness of machined surface by using surface roughness tester.	2	CO3
LLO 8.1 Use different optical flats for measurement of surface flatness. LLO 8.2 Identify the types of observed fringe patterns of optical flats.	8	Measurement of flatness of given component by using optical flats.	2	CO3
LLO 9.1 Use Autocollimator / Angle Dekkor for measurement of angle or taper of given component.	9	Measurement of the unknown angle of a given component by Autocollimator / Angle Dekkor.	2	CO3
LLO 10.1 Measure displacement of micrometer by using LVDT. LLO 10.2 Use LVDT for measurement of linear displacement.	10	*Measurement of displacement by using Linear Variable Displacement Transducer (LVDT).	2	CO4
LLO 11.1 Measure temperature of a system by using thermometer. LLO 11.2 Use Thermocouple for measurement of temperature of given system.	11	Measurement of temperature by thermocouple and Verification by thermometer.	2	CO4
LLO 12.1 Measure the flow rate of liquid by rotameter.	12	Measurement of flow rate of liquid by rotameter.	2	CO4
LLO 13.1 Measure given weights by using Load Cell.	13	*Measurement of weight by using a load cell.	2	CO5
LLO 14.1 Measure sound level using sound meter	14	Sound intensity measurement using sound meter	2	CO5
LLO 15.1 Measure the speed of rotating shaft by stroboscope or inductive pick up. LLO 15.2 Use stroboscope or inductive pick up for measurement of speed of rotating shaft.	15	Measurement of speed of rotating shaft by stroboscope or inductive pick up.	2	CO5

Note : Out of above suggestive LLOs -

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

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

Micro project

- 1)Comparative study of various linear measuring instruments like steel rule, Inside-outside micrometer, Vernier caliper and Digital caliper with proper justification.

2)Comparative study of surface finish of various samples machined by various machining / finishing processes using surface roughness tester.
3)Prepare a report on calibration procedure of Vernier Caliper and Micrometer followed by NABL Lab.
4)Prepare a visit report on measurement systems used in near by industries / SME / Workshops / Fabrication shops.
5)Perform comparative study of different contact and non contact type transducers / sensors.
6)Visit to Automobile service station, observe the different sensors used in cars and prepare a report of the same. (Name, Use, Location, Working, Applications)

Assignment

- 1)Prepare a report to interpret effect of errors on the accuracy of instrument and measurement.

2)Visit to any nearby shop or industry and list out different gauges used for inspection along with its purpose.
3)Prepare a comparative study of different screw threads measuring instruments on the basis of their least count, accuracy, cost, ease of operation
4)Prepare a short report on different types of Rotameter.
5)Prepare a set of procedure for sound measurement with suitable instrument.

Note :

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

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Inductive transducer – measurement range 0 to 100mm – sensor – inducive (nonlinear) solenoid type onboard with micrometer, micrometer screw gauge assembly for displacement, bridge balance type circuit Display 3.5-digit display	10
2	Sensor – type K (Cr-AI) thermocouple, sensor assembly and water bath with heating arrangement Display 3.5-digit display.	11
3	Rotameter -Trainer -sensor – standard glass rotameter, process tank with motor pump display – flat position on graduated scale.	12
4	Load cell – Force measurement range 5-50N – sensor 4 arm bridge with strain gauge capacity – 2Kg 3.5-digit display	13
5	Sound level meter: Measuring range 30-130 dB, portable and easy to use	14
6	Multi digital Stroboscope cum Tachometer for speed measurement – up to 5000 rpm.	15
7	Vernier Calipers (0-200 mm)	2
8	Vernier Height Gauge and Depth Gauge. (0-300 mm)	2
9	Outside Micrometer (0-25mm, 25-50mm)	2
10	Inside Micrometer 0-25mm	2
11	Surface Plate-Granite (24 x 36 inch)	2,4,7
12	Dial indicator (0-25mm) with magnetic stand.	3,4
13	Universal bevel protractor Graduation: 5 min (0 deg-90 deg -0 deg)	4

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
14	Sine bar, Sine Center (0-200mm)	4
15	Floating Carriage Micrometer: Least Count 0.001mm; Standard micrometer or electronic type; Non rotary 8mm micrometer spindle; Indicator with 0.001 standard dial; admit between center 200mm; Max diameter capacity 100mm; Standard accuracy ± 0.005mm.	5
16	Profile projector with gear profile / Thread profile templates. Opaque fine grained ground glass screen with 90o, 60o, 30o cross line Location; fitted with graduated ring (0 to 360 o) L.C. 1 min; Optics Std 10X, 20X, Measuring Range Std 100mm X 100mm; opt X axis up to 400mm, Y axis up to 200mm; Focusing Travel 100mm; Magnification Accuracy Contour ± 0.05% Surface ± 0.05%; Illumination Countor 24V / 150W halogen lamp with illumination control; Resolution 0.005/0.001/0.0005 mm.	5,6
17	Surface roughness Tester (Max Sampling length 0.8 mm) having profile printing facility.	7
18	Optical flats set range (0.2 µm) Diameter / Thickness 45/12mm and 60/15mm.	8
19	Angle Dekkor and Autocollimator (0 to 30')	9

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Overview of Metrology and Linear Measurement	CO1	12	4	4	6	14
2	II	Gauges and Comparators	CO2	10	2	6	4	12
3	III	Angular, Screw Thread, Gear and Surface Finish Measurements	CO3	18	4	6	10	20
4	IV	Displacement, Temperature and Flow Measurement	CO4	12	2	4	8	14
5	V	Miscellaneous Measurements	CO5	8	2	4	4	10
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Term work (Lab Manual), Self-Learning (Assignment) Question and Answers in class room, quiz and group discussion. Note: Each practical will be assessed considering-60% weightage to process related and 40 % weightage to product related.

Summative Assessment (Assessment of Learning)

- Practical Examination, Pen and Paper Test

XI. SUGGESTED COS - POS MATRIX FORM

METROLOGY AND MEASUREMENT **Course Code : 313316**

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	N.V. RAGHAVENDRA and L. KRISHNAMURTHY	ENGINEERING METROLOGY AND MEASUREMENTS	Oxford University Press, New Delhi, India ISBN-13: 978-0-19-808549-2. (2013)
2	Anand K Bewoor and Vinay A Kulkarni	METROLOGY AND MEASUREMENTS	Tata McGraw-Hill Education Private Limited, New Delhi , India ISBN (13): 978-0-07-014000-4 (2017)
3	R K Jain	Engineering Metrology	Khanna Publication, New Delhi, ISBN-10:817409153X (2022)
4	R. K. Rajput	Engineering Metrology & Instrumentation	S.K. Kataria and Sons ISBN:9788185749822 (2009)
5	R K Jain	Mechanical and Industrial Measurements	Khanna Publication, New Delhi ISBN: 8174091912 (1995)
6	Thomas G. Beckwith, Roy D. Marangoni, John H. Lienhard ·	Mechanical Measurements	Pearson Prentice Hall ISBN:9780136093763 (2013)

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://onlinecourses.nptel.ac.in/noc20_me94/preview	NPTEL MOOCS course on Engineering Metrology
2	https://onlinecourses.nptel.ac.in/noc23_me09/preview	NPTEL MOOCS course on Mechanical measurement systems.
3	https://www.youtube.com/watch?v=Hi7NUJdznc0	Video Lecture on Engineering Metrology by IIT Madras.

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Sr.No	Link / Portal	Description
4	http://www.digimat.in/nptel/courses/video/112106179/L33.html	Video Lecture on Electrical and electronic comparators, Optical comparators NPTEL Video Course : Metrology
5	https://www.bing.com/videos/riverview/relatedvideo?&q=videos+on+CMM+measurement+IIT&&mid=6C0843737C0E8F2019006C0843737C0E8F201900&&FORM=VRDGAR	Video on Part inspection by using CMM
6	https://www.bing.com/videos/riverview/relatedvideo?q=videos+on+screw+thread+measurement+IIT&&view=riverview&mmscn=mtsc&mid=9850B2C61C0872810AC19850B2C61C0872810AC1&&aps=196&FORM=VMSOVR	Measurement of screw thread elements.
7	https://www.bing.com/videos/riverview/relatedvideo?&q=videos+on+displacement+measurement&&mid=53BAFCB5E8DA5553247253BAFCB5E8DA55532472&&FORM=VRDGAR	Potentiometer Working Principle
8	https://www.bing.com/videos/riverview/relatedvideo?&q=bimetallic+temperature+measurement+devices&&mid=3ADB81DF5F95342EE5B53ADB81DF5F95342EE5B5&&FORM=VRDGAR	How Bimetallic Temperature Gauges Works
9	https://www.bing.com/videos/riverview/relatedvideo?&q=flow+measurement+devices+rotameter&&mid=145B5C41696FC6AFF30B145B5C41696FC6AFF30B&&FORM=VRDGAR	Flow Measurement Devices
10	https://www.bing.com/videos/riverview/relatedvideo?&q=carbon+microphone&&mid=B08AB66B421E46892B46B08AB66B421E46892B46&&FORM=VRDGAR	Build a carbon microphone with a soda can and a paper clip
11	https://www.bing.com/videos/riverview/relatedvideo?&q=hair+hygrometer+working+principle&&mid=20C836F03B5418F173D620C836F03B5418F173D6&&FORM=VRDGAR	Actual working of Hair Hygrometer

Note :

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

PRODUCTION PROCESSES **Course Code : 314340**

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

Programme Code : **ME/ PG**

Semester : **Fourth**

Course Title : **PRODUCTION PROCESSES**

Course Code : **314340**

I. RATIONALE

This course is designed to elevate students knowledge of production processes by engaging them in analyzing and evaluating various production processes. Students will progress from understanding of basic concepts to selecting appropriate production methods for specific engineering applications. The aim of this course is to increase the ability to make effective decisions in production planning and control.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Select relevant production processes in different industrial/field applications.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Use appropriate CNC machine as per given application.
- CO2 - Prepare the component using grinding and various finishing operation.
- CO3 - Produce gears using various gear manufacturing methods.
- CO4 - Select the press and its components for various applications.
- CO5 - Select suitable Non-Traditional machining process for given component.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA			
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min		
314340	PRODUCTION PROCESSES	PPR	DSC	4	-	2	-	6	3	3	30	70	100	40	25	10	-	-	-	-	125	

Total IKS Hrs for Sem. : 2 Hrs

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

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

Note :

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

PRODUCTION PROCESSES **Course Code : 314340**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Classify CNC machines. TLO 1.2 List functions of different elements of CNC machine. TLO 1.3 Draw a basic schematic diagram of a CNC machine, labeling key components. TLO 1.4 Explain the different constructional details of CNC machine. TLO 1.5 Explain the various inserts used in CNC machine.	**Unit - I Fundamentals of CNC machine** 1.1 Introduction: Definition, advantages and applications of CNC 1.2 Classification of CNC: Point-to-point, continuous path, straight path, absolute and incremental co-ordinate system, open loop and closed loop control system. 1.3 Constructional elements of CNC: Machine structure-Bed, slide ways, column and tables.Spindle drives-Stepper motor, servo motor & hydraulic motor. Movement's actuators- re-circulating ball screw, linear motion bearings. Feedback elements- Positional and velocity feed backs. Automatic tool changer- Tool magazine, turret head. Pallet changer- Linear and rotary pallet changer. 1.4 Tooling: Indexable inserts, ISO code and nomenclature	Lecture Using Chalk-Board Presentations Video Demonstrations
2	TLO 2.1 Define the surface finish. TLO 2.2 Designate the grinding wheels. TLO 2.3 Explain process of grinding wheel dressing and truing. TLO 2.4 Explain construction and working of different grinding machines. TLO 2.5 Explain the different superfinishing process	**Unit - II Grinding and Superfinishing** 2.1 Introduction: Definition of surface finish. Significance of grinding in manufacturing. 2.2 Grinding wheels: Abrasives, Grit size, Grade structure and bond type. 2.3 Grinding wheel dressing and truing-Purpose and methods 2.4 Types of Grinding machines: Construction and working of Surface, cylindrical and Internal grinders. 2.5 Super finishing Processes: Lapping, Honing, Buffing, Polishing etc.	Lecture Using Chalk-Board Presentations Video Demonstrations
3	TLO 3.1 List different gear cutting methods. TLO 3.2 Explain the working principle of gear cutting methods. TLO 3.3 Differentiate amongst different gear cutting methods. TLO 3.4 Identify typical applications of gear shaping for different gear types. TLO 3.5 Explain the working principle of various gear manufacturing methods. TLO 3.6 List different gear finishing methods. TLO 3.7 State the importance of gear finishing.	**Unit - III Gear Manufacturing Methods** 3.1 Importance of gear cutting, Gear manufacturing methods. 3.2 Gear Milling: Types of milling operations for gear manufacturing, cutter selection, advantages, limitations, and applications. 3.3 Gear Shaping Process: Basics of gear shaping, tooling requirement, machining considerations, advantages, limitations, and applications. 3.4 Gear Broaching Process: Working Principle, broaches for gear teeth, applications and limitations of gear broaching. 3.5 Gear Hobbing: Working principle, equipment setup, cutting parameters, advantages, disadvantages, and applications. 3.6 Gear Finishing methods: Importance and need of gear finishing, Introduction to Gear Finishing processes like Gear grinding, Gear Honing, Gear Burnishing, Gear Lapping	Lecture Using Chalk-Board Presentations Video Demonstrations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Name different sheet metals used in press industry. TLO 4.2 Classify press. TLO 4.3 Name different components of press. TLO 4.4 Explain working of press with neat sketch. TLO 4.5 Compare between Jigs and Fixtures. TLO 4.6 Explain locations methods of jigs and fixtures. TLO 4.7 Explain the principle of Jig and fixtures.	**Unit - IV Press and Accessories** 4.1 Introduction: Common sheet metals used in industry. 4.2 Presses and their classification: Mechanical, Hydraulic and Pneumatic, Selection criteria for presses (Force, Speed, Production volume and type of operation) 4.3 Press tools and dies: Components of press tool. 4.4 Jigs and Fixtures: Introduction, Types, Principles of Jigs and fixtures, Methods of location.	Lecture Using Chalk-Board Presentations Video Demonstrations
5	TLO 5.1 Classify Non traditional machining processes. TLO 5.2 List the factors to be considered for non-traditional process selection . TLO 5.3 Explain working principle of USM/EDM/ECM/LBM process. TLO 5.4 Compare various Non traditional processes on given parameters. TLO 5.5 State the factors considered for process selection of Non traditional machining. TLO 5.6 Describe the RP cycle. TLO 5.7 Draw block diagram of CIM.	**Unit - V Non-Traditional Machining Processes** 5.1 Need for Non-Traditional Machining processes, Limitations of conventional processes, Classification of Non-Traditional Processes, Factors considered for process selection. 5.2 Electrical Discharge Machine(EDM) : Working Principle, Process parameters, applications, advantages, and disadvantages. 5.3 Ultrasonic Machining(USM): Working Principle, Process parameters, applications, advantages, and disadvantages. 5.4 Electrochemical Machining (ECM): Working Principle, Process parameters, applications, advantages, and disadvantages. 5.5 Laser Beam Machining (LBM): Working Principle, Process parameters, applications, advantages, and disadvantages. 5.6 Rapid Prototyping (RP):Introduction,Definition Cycle and applications 5.7 Computer Integrated Manufacturing (CIM): Introduction, Components of CIM, Benefits of CIM.	Lecture Using Chalk-Board Presentations Video Demonstrations

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify different components of CNC LLO 1.2 Set the machine for given operation by using suitable parameters	1	*CNC machine.	2	CO1
LLO 2.1 Perform the surface grinding machine to finish the given job surface. LLO 2.2 Compare the pre finish and post finish condition using surface tester.	2	*Preparation of given job using Surface Grinding operation.	4	CO2
LLO 3.1 Use of grinding and lapping machine for finishing the given job surface with different surface finish operations. LLO 3.2 Compare the surface finish with justification.	3	Comparison of surface finish using i. Grinding machine ii. Lapping operation	4	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Calculate the number of teeth of gears using dividing head. LLO 4.2 Measure the dimensions of gear teeth thickness.	4	*Required data for gear manufacturing.	4	CO3
LLO 5.1 Prepare given sheet metal component as per given drawing. LLO 5.2 Fabricate any sheet metal utility job as per drawing. (any one)	5	*Manufacturing of a sheet metal component	2	CO4
LLO 6.1 Prepare a Jig as per requirement using relevant principles. LLO 6.2 Prepare a Fixture as per requirement using relevant principles.	6	Jig/Fixture Manufacturing for different machines available in workshop.	6	CO4
LLO 7.1 Prepare a colored chart showing working principle of non-traditional machining process.	7	*Non Traditional machining processes (any two).	2	CO5
LLO 8.1 Prepare a colored chart showing constructional features of non-traditional machining process.	8	Non Traditional machining processes (any two).	4	CO5
LLO 9.1 Collect information regarding tool sharpening methods in ancient India.	9	*Information collection for tool sharpening in ancient India.(IKS)	2	CO1 CO2 CO3 CO4 CO5

Note : Out of above suggestive LLOs -

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

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

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	CNC Turning 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type minimum diameter 25 mm, Length 120 mm with ATC, (Suggested)	1
2	CNC Milling 250 with standard accessories and multi-controller changing facility with simulated control panel and related software. Training or Productive type-X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, with ATC. (Suggested)	1
3	Surface Grinder (200*13*31.75) Spindle speed 2800 rpm; Surface Table-225*450 mm Vertical Feed Graduation 0.01 mm 0.01 mm, Cross Feed Graduation 0.05 mm 0.05 mm	2
4	Semi automatic Lapping machine,Dimension:30 X 28 X 47, 1 KW,230 V,50 Hz,	2,3
5	Milling machine, face milling cutter, side and face milling cutter, end mill cutter. Minimum 500 mm longitudinal traverse, with required indexing head, set of work holding devices, cutting tools, accessories, and tool holders.	4,6
6	Hydraulic Press Machine 10 Ton,Non CNC,H ype, 230 V,50Hz,Semi-automatic (10-50 Ton),	5
7	Centre lathe machine. (Length between centers 1000 mm, swing 500 mm,) 3 Jaw self centred chuck,Chucking Diameter Range 25-200 mm,	6

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
8	Drilling Machine (drill diameter up to 40 mm),1.5 HP, Base size 500 x 500,Spindle Speed 110-1500 rpm, Drilling Capacity 40 mm,	6

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals of CNC machine	CO1	10	2	4	6	12
2	II	Grinding and Superfinishing	CO2	10	2	4	6	12
3	III	Gear Manufacturing Methods	CO3	15	4	6	8	18
4	IV	Press and Accessories	CO4	15	4	6	8	18
5	V	Non-Traditional Machining Processes	CO5	10	2	4	4	10
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

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

Summative Assessment (Assessment of Learning)

- End Semester Assessment of 70 Marks

XI. SUGGESTED COS - POS MATRIX FORM

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Rao P.N.	Manufacturing Technology Vol-2	McGraw Hill, New Delhi, ISBN: 9789353160524,July 2018, Fourth Edition

PRODUCTION PROCESSES **Course Code : 314340**

Sr.No	Author	Title	Publisher with ISBN Number
2	S K Hajra Choudhury, A K Hajra Choudhury, Nirjhar Roy	Elements Of Workshop Technology Vol-2	Media Propoters & Publisher PVT. LMT., ISBN: 978-8-185-09915-6,Jan 2010,Fifteenth Edition.
3	O. P. Khanna & Lal	Production Technology Volume- II	Dhanpat Rai Publications ISBN: 978-81-7409-099-7,1976,Nineteenth Edition.
4	Dr.P.C.Sharma	Production Technology	S.Chand Publications.ISBN: 978-93-550-1069-8,Dec 2006,Seventh Edition.
5	P.K.Mishra	Non-conventional Machining	Narosa Publishing House ISBN: 978-8173191381,Jan 1997,Reprint 2018.
6	S.F.Krar,A.R.Gill,P.Smid	Technology of Machine Tools	Tata-McGraw Hill ISBN: 9781260087932,April 2019, Eighth Edition.
7	Mikell P.Groover	Fundamentals of Modern Manufacturing	John Wiley & Sons, Inc.ISBN: 978-1-119-47521-7,Jan 2010,Fourth Edition.
8	Kenneth G. Cooper	Rapid Prototyping Technology	Marcel Dekker Inc.ISBN :9780824702618,Jan 2001,First Edition.

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://youtu.be/Oy875yOH1bc	CNC Machine Animation
2	https://youtu.be/jh8852sfhpw	Ultrasonic machining animation
3	https://youtu.be/06QxjEAMrKc?list=PLwFw6Nkm8oWqFJUxiUuu5c0uHK076lz2K	Non-conventional machining

Note :

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

BASICS OF MECHATRONICS **Course Code : 314017**

Programme Name/s : **Mechanical Engineering**
Programme Code : **ME**
Semester : **Fourth**
Course Title : **BASICS OF MECHATRONICS**
Course Code : **314017**

I. RATIONALE

Mechanical diploma engineer has to work on various multidisciplinary systems under the umbrella of Mechatronics. The goal of the course is to develop an understanding of basic elements underlying mechatronics systems viz. sensors, actuators, PLC, and control software etc.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Use appropriate sensors, actuators and controller for given mechatronics system(s).

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Identify basic elements of mechatronics system such as sensors, actuators, controllers etc.
- CO2 - Use sensors for different mechatronics systems
- CO3 - Use actuators for different mechatronics systems
- CO4 - Develop PLC program for various mechatronics systems
- CO5 - Use microcontroller for different mechatronics systems

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
314017	BASICS OF MECHATRONICS	BOM	AEC	-	-	2	-	2	1	-	-	-	-	-	25	10	25@	10	-	-	50

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

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

BASICS OF MECHATRONICS **Course Code : 314017**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Compare traditional system and mechatronics systems with the help of block diagram TLO 1.2 Identify sensor, actuators in the given diagram of the mechatronic system with justification	**Unit - I Fundamental of Mechatronics** 1.1 Introduction : Definition of Mechatronics, Mechatronics in Manufacturing products 1.2 Comparison between Traditional and Mechatronics approach 1.3 Block diagram representation of General Mechatronics system showing various components with suitable example	Chalk board Display charts
2	TLO 2.1 Explain the working of the given sensor TLO 2.2 Select the relevant sensor for the given application TLO 2.3 Differentiate between sensor and transducer TLO 2.4 Explain with sketches working principle of given type of thermal, optical, electric sensors	**Unit - II Sensors and Transducers** 2.1 Sensors and transducers: Definition, difference, classification 2.2 Thermal, optical, electric sensors 2.3 Transducers: Need of transducers, types of transducers: primary, secondary, active, passive, analog and Digital 2.4 Selection criteria of sensor and transducer	Demonstration of actual devices Chalk board NPTEL Video
3	TLO 3.1 Explain with sketches the working of the given Pneumatic actuator with sketch and block diagram TLO 3.2 Explain with sketches the working of the given Hydraulic actuator with sketch and block diagram TLO 3.3 Select the relevant actuator for the given application	**Unit - III Actuators** 3.1 Introduction and Classification of Actuators Need and Scope 3.2 Pneumatic Actuation system: Single and Double acting actuators 3.3 Hydraulic Actuation system: Single and Double acting actuators 3.4 Electric Actuation system: Solenoid, relay, stepper motors	Pneumatic trainer kit Hydraulic trainer kit Video Demonstrations Chalk board
4	TLO 4.1 Explain with the block diagram working of PLC TLO 4.2 Select the PLC for the given application TLO 4.3 Write a simple program using ladder diagram for the given application	**Unit - IV Programmable Logic Controller (PLC)** 4.1 Introduction, definition, PLC block diagram, Manufacturers of PLC 4.2 Power supply, Input/output modules 4.3 Ladder logic symbols 4.4 Basic PLC Ladder logic programming, timers, counters	Chalk board Hands-on activity on PLC trainer kit
5	TLO 5.1 Explain the working of the given microcontroller with block diagrams TLO 5.2 Explain with the circuit diagram interfacing of stepper motor TLO 5.3 Explain with the circuit diagram interfacing of Relay	**Unit - V Microcontroller** 5.1 Comparison of Microprocessor and Microcontroller 5.2 Introduction, architecture, I/O ports 5.3 Interfacing of steeper motor, relay	Chalk board Video Demonstrations

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify sensor, transducer and actuator	1	*Identification of Sensors, actuators available in the laboratory	2	CO1
LLO 2.1 Identify PLC and microcontroller	2	*Identification of PLC and microcontroller available in the laboratory	2	CO1

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 3.1 Develop ladder diagram for simple application using sensor and actuator LLO 3.2 Execute PLC program for simple application	3	*Development of Ladder diagram and program PLC for simple application using sensor and actuator	2	CO1 CO2 CO3 CO4
LLO 4.1 Develop ladder diagram for logic gates LLO 4.2 Execute PLC program for the logic gates	4	*Verification of Logic gate functions for the given Ladder diagram by using PLC	2	CO4
LLO 5.1 Develop ladder diagram for staircase lighting LLO 5.2 Execute PLC program for staircase lighting	5	Development of Ladder diagram and program PLC for two-way switch logic for staircase lighting	2	CO1 CO2 CO3
LLO 6.1 Develop ladder diagram for Timers and counters LLO 6.2 Execute PLC program for Timers and counters	6	*Development of Ladder diagram and program PLC for Timers and Counters	2	CO4
LLO 7.1 Develop ladder diagram for water level control LLO 7.2 Execute PLC program for water level control	7	Development of Ladder diagram and program PLC for water level control	2	CO1 CO2 CO3 CO4
LLO 8.1 Develop ladder diagram for pedestrian light on off control LLO 8.2 Execute PLC program for pedestrian light on off control	8	Development of Ladder diagram and program PLC for pedestrian light (green/red) toggle control	2	CO1 CO2 CO3 CO4
LLO 9.1 Develop ladder diagram for temperature control LLO 9.2 Execute PLC program for temperature control	9	*Development of Ladder diagram and program PLC for on/off temperature control	2	CO1 CO2 CO3 CO4
LLO 10.1 Develop ladder diagram for lift/elevator control LLO 10.2 Execute PLC program for lift/elevator control	10	Development of Ladder diagram and program PLC for lift/ elevator control	2	CO1 CO2 CO3 CO4
LLO 11.1 Develop ladder diagram for single acting/double acting pneumatic system LLO 11.2 Execute PLC program for single acting/double acting pneumatic system	11	Development of Ladder diagram and program PLC for single acting/double acting pneumatic system	2	CO1 CO2 CO3 CO4
LLO 12.1 Develop ladder diagram for single acting/double acting Hydraulic system LLO 12.2 Execute PLC program for single acting/double acting hydraulic system	12	Development of Ladder diagram and program PLC for single acting/double acting hydraulic system	2	CO1 CO2 CO3 CO4
LLO 13.1 Develop ladder diagram for door open and close system LLO 13.2 Execute PLC program for door open and close system	13	Development of Ladder diagram and program PLC for door open and close application	2	CO1 CO2 CO3 CO4
LLO 14.1 Develop ladder diagram for material rejection system LLO 14.2 Execute PLC program for material rejection system	14	*Development of Ladder diagram and program PLC for material rejection system	2	CO1 CO2 CO3 CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 15.1 Develop 8051 microcontroller program for stepper motor control LLO 15.2 Execute 8051 microcontroller program for stepper motor	15	Development of 8051 microcontroller program for stepper motor control	2	CO1 CO2 CO5
LLO 16.1 Develop 8051 microcontroller program for relay interfacing LLO 16.2 Execute 8051 microcontroller program for relay interfacing	16	*Development of 8051 microcontroller program for relay interfacing	2	CO1 CO2 CO5

Note : Out of above suggestive LLOs -

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

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

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Basic Electro-Pneumatic trainer kit 1) Single acting and double acting pneumatic cylinder 2) Bore size: minimum 8 mm bore 3) Stroke: minimum 15 mm 4) Operating pressure: compressed air up to 4 bar pressure 5) Solenoid: 24V DC connected with trainer kit	11
2	Basic Electro-Hydraulic trainer kit 1) Single acting and double acting hydraulic cylinder 2) Bore size: minimum 12 mm bore 3) Stroke: minimum 40 mm 4) Operating pressure: up to 20 bar pressure5) Solenoid: 24V DC connected with trainer kit	12
3	Door open and close module Electro-pneumatic operated door open and close facility of sensing arrival and departure of person/object within particular distance from door (Pneumatic actuator type: Single/double acting pneumatic cylinder, Bore: 8 mm, Stroke: 15 mm, Medium: Compressed air up to 4 bar pressure, Solenoid valve: +24V DC)	13
4	Raw Material rejection module 1) Raw material rejection module with facility to detect, sort and reject the object 2) The module with IR sensor and Electro-pneumatic actuator controlled by PLC (Pneumatic actuator type: Single/double acting pneumatic cylinder, Bore: 8 mm, Stroke: 15 mm, Medium: Compressed air up to 4 bar pressure, Solenoid valve: +24V DC)	14
5	8051 microcontroller development board (Functional description and interfacing) 1) 16 x 2 characters LCD 2) Seven segment display 3) LED 4) Keypad 5) Steeper motor 6) Relay 7) facility for I/O port expansion	15,16
6	PLC trainer kit 1) Digital input and output: 12 Nos. with toggle switches for applying 24 V DC inputs and outputs 2) Analog input and output: 02 Nos. 3) External power supply: 24V DC	3,4,5,6,7,8,9,10,11,12,13,14
7	Desktop PC/Laptop with PLC software and I/O communication facility: Minimum System Requirements Intel Core i3,4GB RAM, 500 GB Hard Disk.	3,4,5,6,7,8,9,10,11,12,13,14,15,16

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
8	Tank Level Controller module: Water tank with ability to sense, indicate and control high and low level (Measuring water tank 1 no., Control panel enclosure: Metal frame with accessible front panel Push buttons red and green: 1 no. (each) Indicators red and green: 1 no. (each) Buzzer: 1 no, Manual drain valve: ½", Fluid solenoid valve: 1 no. Supply: 24V DC	7

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

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Term work (Lab Manual)

Summative Assessment (Assessment of Learning)

- End semester practical examination

XI. SUGGESTED COS - POS MATRIX FORM

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Bolton, W	Mechatronics	Pearson Education, New Delhi, 2017, ISBN: 978-81-317-3253-3
2	Petruzella, F. D.	Programmable Logic Controllers	Tata McGraw Hill, New Delhi, 2024, ISBN: 978-0-07-337384-3
3	Ghosh, A. K.	Introduction to Instrumentation and Control	Prentice Hall of India, New Delhi, 2004, ISBN: 81-203-1626-6
4	Majumdar, S.R.	Pneumatics systems Principles and maintenance	Tata McGraw Hill, New Delhi,2013, ISBN: 978-0-07-463748-7
5	Majumdar, S.R.	Oil Hydraulic system- Principle and maintenance	Tata McGraw Hill, New Delhi,2013, ISBN: 978-0-07-463748-7

Sr.No	Author	Title	Publisher with ISBN Number
6	Rajput, R. K.	A Textbook of Mechatronics	S. Chand and Company New Delhi, 2022, ISBN: 978-81-219-2859-5

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=J_KoRp8SnoE&t=14s	Types of Sensors
2	https://www.youtube.com/watch?v=UrST-2yu8zQ	Lecture 1 : Introduction to Mechatronics (NPTEL course Mechatronics)
3	https://www.youtube.com/watch?v=YlmRa-9zDF8	Introduction to hydraulic system
4	https://www.youtube.com/watch?v=1lbdwPfFegY	Relay System
5	https://www.youtube.com/watch?v=5q7YasmwXCs&t=377s	Pneumatic Control : Festo Didactics
6	https://www.youtube.com/watch?v=-MLGr1_Fw0c&t=121s	Working of Solenoid Valves - Basics actuator control valve working principle
7	https://www.youtube.com/watch?v=eyqwLiowZiU	Working of Stepper Motor work.
8	https://www.youtube.com/watch?v=qQoHQ0b-d1U	Tank Level Control with PLC ladder Logic animated PLC Programming tutorials for beginners

Note :

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

MECHANICAL ENGINEERING MATERIALS **Course Code : 313317**

Programme Name/s : **Mechanical Engineering/ Mechatronics/ Production Engineering**

Programme Code : **ME/ MK/ PG**

Semester : **Third / Fourth**

Course Title : **MECHANICAL ENGINEERING MATERIALS**

Course Code : **313317**

I. RATIONALE

Mechanical diploma technician works in the metal working industry. To meet current and future metal demands it is essential to get material knowledge. Materials like ferrous and non-ferrous metals, polymer, ceramics and composites are widely used in a variety of engineering applications. This course deals with these materials along with advanced materials, their metallurgical considerations, heat treatment processes, structure property relationship and applications. This course will enable diploma engineering students to identify a variety of material and their selection for various applications which is used in connection with smelting, welding, machining, bending, extruding, tapping, soldering, casting, pumping, structural work, crushing, and other industrial processes.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Use relevant mechanical engineering materials & processes based on different applications.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Select suitable material(s) based on desired properties according to application.
- CO2 - Choose relevant alloy steel & Cast iron for mechanical components.
- CO3 - Select relevant non ferrous & powder material components for the engineering application.
- CO4 - Select relevant non metallic & Advanced material for the engineering application.
- CO5 - Use relevant heat treatment processes in given situations.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313317	MECHANICAL ENGINEERING MATERIALS	MEM	DSC	3	-	2	1	6	3	1.5	30	70*#	100	40	25	10	-	-	25	10	150

Total IKS Hrs for Sem. : 4 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 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. TLO 1.4 Identify & Interpret the given equilibrium diagram & reactions with justification. TLO 1.5 Identify the given fields of steels on Iron carbon diagrams with justification. TLO 1.6 Choose a relevant hardness tester based on the given situation with justification.	**Unit - I Basics of Engineering Materials** 1.1 Classification of engineering materials 1.2 Crystal structure, Unit cell and space lattice 1.3 Microstructure, types of microscopes 1.4 Sample preparation, etching process, types of etchants. 1.5 Properties of metals Physical Properties, Mechanical Properties. 1.6 Concept of phase, pure metal, alloy and solid solutions. 1.7 Iron Carbon Equilibrium diagram various phases. Critical temperatures and significance. Reactions on Iron carbon equilibrium diagram 1.8 Hardness testing procedure on Brinell and Rockwell tester.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Select relevant steel for the given application with justification. TLO 2.2 Select the relevant cast irons as white, gray cast iron for the given job with justification. TLO 2.3 Interpret the given material designations. TLO 2.4 Identify the properties of the given composition of cast iron with justification.	**Unit - II Steel & Cast Iron** 2.1 Broad Classification of steels. i. Plain carbon steels: Definition, Types and Properties, Compositions and applications of low, medium and high carbon steels. ii. Alloy Steels: Definition and Effects of alloying elements on properties of alloy steels. iii. . Tool steels: Cold work tool steels. Hot work tool steels, High speed steels (HSS) iv. Stainless Steels: Types and Applications v. Spring Steels: Composition and Applications. vi. Specifications of steels and their equivalents. 2.2 Steels for following components: Shafts, axles, Nuts, bolts, Levers, crank shafts, camshafts, Shear blades, agricultural equipment, household utensils, machine tool beds, car bodies, Antifriction bearings and Gears. 2.3 Types of cast irons as white. Gray, nodular, malleable 2.4 Specifications of cast iron. 2.5 Selection of appropriate cast iron for engineering applications. 2.6 Designation and coding (as per BIS, ASME, EN, DIN, TIS) of cast iron, plain and alloy steel. 2.7 Use of iron and steel in ancient India; Munda, Tikshna and Kanta types of iron and steels (IKS)	Lecture Using Chalk-Board Model Demonstration Presentations
3	TLO 3.1 Describe the properties and applications of the given copper alloy & aluminium alloy. TLO 3.2 Describe the properties and applications of the given bearing material TLO 3.3 Select relevant non-ferrous material for the specified application with justification. TLO 3.4 Explain various powder manufacturing processes.	**Unit - III Non Ferrous Materials & Powder Metallurgy** 3.1 Copper and its alloys - brasses, bronzes Chemical compositions, properties and Applications. 3.2 Use of copper in ancient India and its mention in Rigveda (IKS) 3.3 Aluminum alloys -Y-alloy, Hindalium, duralium with their composition and Applications. 3.4 Bearing materials like white metals (Sn based), aluminum, bronzes. Porous, Self -lubricating bearings. 3.5 Powder Metallurgy: Introduction, Advantages, limitations and applications. Preparation of Metal Powders, Basic Steps for Powder Metallurgy.	Model Demonstration Lecture Using Chalk-Board Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Distinguish between metallic and non-metallic materials on the basis of given composition, properties and applications. TLO 4.2 Choose relevant non-metallic material for the given job with justification. TLO 4.3 Select relevant composite material for the given job with justification. TLO 4.4 Suggest relevant alternative materials for the given job with justification.	**Unit - IV Non Metallic Materials & Advanced Materials** 4.1 Polymeric Materials i. Polymers:- types, characteristics, ii. Properties and uses of Thermoplastics, Thermosetting Plastics and Rubbers. iii.Thermoplastic and Thermosetting Plastic materials 4.2 Characteristics and uses of ABS, Acrylics. Nylons and Vinyls, Epoxides, Melamines and Bakelites 4.3 Rubbers: Neoprene, Butadiene, Buna and Silicons - Properties and applications. 4.4 Ceramics -types of ceramics, properties and applications of glasses and refractories 4.5 Composite Materials - properties and applications of Laminated and Fiber reinforced materials 4.6 Advanced Engineering Materials: Properties and applications of Nanomaterials and smart materials & Biomedical materials.	Lecture Using Chalk-Board Presentations Demonstration
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.	**Unit - V Heat Treatment processes** 5.1 Overview of heat treatment. 5.2 Annealing: Purposes of annealing, Annealing temperature range, Types and applications. 5.3 Normalizing: Purposes of Normalizing, temperature range. Broad applications of Normalizing. 5.4 Hardening: Purposes of hardening, Hardening temperature range, applications 5.5 Tempering: Purpose of tempering Types of tempering and its applications 5.6 Case hardening methods like Carburizing, Nitriding, and Cyaniding. 5.7 Heat treatment Furnaces - Muffle, Box type.	Lecture Using Chalk-Board Video Demonstrations Site/Industry Visit Presentations

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Use slitting machine to prepare sample of given dimension. LLO 1.2 Use grinding machine & polishing papers to prepare surface of given sample.	1	*Specimen preparation of a given material for microscopic examination.	2	CO1
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.	2	*Interpretation of microstructure of steels and alloy steels using metallurgical microscope on standard specimens.	2	CO1

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 3.1 Use Brinell Hardness tester LLO 3.2 Determine hardness of given sample.	3	*Hardness testing on Brinell Hardness tester of given sample material.	2	CO1
LLO 4.1 Use a Rockwell Hardness tester. LLO 4.2 Determine hardness of given sample.	4	Hardness testing on Rockwell Hardness tester of given sample material.	2	CO1
LLO 5.1 Choose appropriate hardness tester for mild steel. LLO 5.2 Use an appropriate hardness tester for mild steel.	5	Hardness testing on relevant hardness testers of given untreated and heat treated Mild Steels.	2	CO1
LLO 6.1 Choose appropriate hardness tester for alloy steel. LLO 6.2 Use an appropriate hardness tester for alloy steel.	6	Hardness testing on relevant hardness testers of given untreated and heat treated Alloy Steels.	2	CO1
LLO 7.1 Use a metallurgical microscope LLO 7.2 Interpret the microstructure of Cast Iron.	7	*Microstructure of cast iron using metallurgical microscope on standard specimens.	2	CO1 CO2
LLO 8.1 Choose appropriate hardness testers for copper & Brass. LLO 8.2 Use appropriate hardness testers for copper & Brass.	8	Hardness testing on relevant hardness testers of given Copper and Brass specimens.	2	CO1 CO3
LLO 9.1 Choose the appropriate hardness tester for Aluminium. LLO 9.2 Use an appropriate hardness tester for aluminum.	9	Hardness testing on relevant hardness testers of given Aluminuim specimens.	2	CO1 CO3
LLO 10.1 Use an appropriate peel tester LLO 10.2 Determine the adhesive strength of cellophane tape and duct tape.	10	*Adhesive strength determination of cellophane tape and duct tape using a relevant peel tester.	2	CO3
LLO 11.1 Use an appropriate peel tester LLO 11.2 Determine the adhesive strength of scotch tape, electrical tape.	11	Adhesive strength determination of scotch tape, electrical tape and masking tape using relevant peel testers.	2	CO3
LLO 12.1 Perform flame tests. LLO 12.2 Identify different types of plastics. Identification of different types of plastics using flame tests.	12	*Identification of different types of plastics using flame tests.	2	CO3
LLO 13.1 Use a High-temperature oven or electrical current LLO 13.2 Identify behavior of the shape-memory alloy .	13	*Identification of behavior of the shape-memory alloy as a function with regards to temperature using High-temperature oven or electrical current.	2	CO4
LLO 14.1 Use a muffle /box type furnace LLO 14.2 Use various quenching mediums for mild steel. LLO 14.3 Compare the hardness of mild steel.	14	*Comparison of hardness of mild steel using quenching mediums like oil ,water & brine in a muffle /box type furnace .	2	CO1 CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 15.1 Use a muffle /box type furnace LLO 15.2 Use various quenching mediums for alloy steel. LLO 15.3 Compare the hardness of alloy steel.	15	Comparison of hardness of alloy steel using quenching mediums like oil ,water & brine in a muffle /box type furnace .	2	CO1 CO5
LLO 16.1 List various ancient Indian material development processes. LLO 16.2 Compare Ancient Indian material development processes with recent processes.	16	Comparison of Ancient Indian material development processes with recent processes.	2	CO1 CO2 CO3 CO4 CO5

Note : Out of above suggestive LLOs -

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

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

Micro project

- Collect information related to Types, Properties and applications of smart materials from websites. Present the information in the form of a Chart.
- Collect samples of various types of plastics, ceramics, composites used in day-to-day applications and prepare charts containing properties, applications of the samples.
- Comparative study of various materials used in previous and current generation components of mechanical engineering equipment like IC Engine, Compressor, turbine, pumps, refrigerator, water cooler, Lathe Machine, Milling Machine, Drilling Machine grinding machine (any one) with proper justifications.
- Preparation of a chart of comparison of hardness of various materials.
- Prepare models showing various crystal structures.
- Prepare a puzzle game on Iron-carbon Equilibrium diagram.
- Determine the microstructure of different metallic components (minimum 5) using metallurgical Microscope and compare their microstructure in the given group.

Note :

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

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Slitting machine Specifications: • Capacity: 18 gauge / 1.2mm • Throat Depth: 24 inch (600mm) • Motor: 1 Hp, 230V, 50 Hz. • Minimum Slitting Width: 1 inch (25.4mm)	1

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
2	Double Disk polishing machine. Two independent polishing units mounted on a common MS frame, Disc dia 200mm, made of Aluminum. Speed continuously variable upto 950 RPM. Rating - 0.25 HP single phase 220 Volt A.C. provided with sink and swing type laboratory water tap. Waterproof Formica table top.	1
3	Digital Brinell hardness Tester 1) Test loads - 500 to 3000 Kgf. in steps of 250 Kg. 2) Magnification of objective - 14 X 3) Maximum test height - 380 mm. 4) Least count - 0.001 mm. 5) Throat depth - 200 mm.	1,3,5,6,8,9,14,15
4	Digital Rockwell hardness Tester 1) Test loads - 60, 100 & 150 kgf 2) Minor load - 10 kg 3) Max test height - 230 mm 4) Throat depth - 133 mm along with essential accessories.	1,4,5,6,8,9,14,15
5	Digital Peel Strength Tester: Make: XEEPL • Load capacity: 0 - 5 kg; Resolution: 1 gram. • Load Indicator: Microprocessor based digital load indicator with memory facility of peak load. • Clear Distance between two plates: Maximum up to 250 mm. • Speed of testing: 300 mm/minute. • Motor: Synchronous Motor. • Grips: A pair of hard chrome plated grips for thin poly film samples would be supplied. • Paint: Powder coated. • Power requirement: Single phase 230 Volts, 50Hz.	10,11
6	Spring coil of Shape memory sample (NiTi alloy) Burner/ Lighter , Sample Holder	12,13
7	Laboratory box furnace Light weight with ceramic fiber wool insulation. Exterior made of G.I. sheets powder coated. Temperature Controlled by Microprocessor based Auto tune PID digital temperature controller with CR/AL Thermocouple. Temperature Range: 1100°C., Muffle Size (inside): Temperature Range: 1100°C., Muffle Size (inside): 6”x6”x12’’, Power: 3.5 KW	14,15
8	Standard Samples of Metallurgical Microstructure Plain carbon steels, alloy steels and cast iron (before and after heat treatment) : 03 Each • Aluminum, Copper and Brass/Bronze (before and after heat-treatment): 03 Each Total 36 Specimens	2
9	Trinocular Upright Metallurgical Microscope: Coaxial Body • Body: Trinocular Head inclined at 45-degrees. • Focusing: Both side co-axial focusing knobs. • Nosepiece: Quadruple revolving nosepiece with accurate centering & amp; positive click stops. Trinocular Inverted Metallurgical Microscope (Magnification 100X, 200X, 400X & 800X) Eyepieces - WF 10X, 20X (Paired) Objectives - M 5x, M 10x, M 20x and M 40x (SL) Stage - Built-in graduated mechanical stage of size 165mm.x180mm. is controlled by convenient low coaxial positioned knobs for easy and smooth scanning of specimen.	2,7

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basics of Engineering Materials	CO1	10	4	4	6	14
2	II	Steel & Cast Iron	CO2	12	4	6	6	16
3	III	Non Ferrous Materials & Powder Metallurgy	CO3	10	4	4	6	14
4	IV	Non Metallic Materials & Advanced Materials	CO4	8	4	4	6	14
5	V	Heat Treatment processes	CO5	5	2	4	6	12
Grand Total				**45**	**18**	**22**	**30**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

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

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	1	-	1	-	1	1			
CO2	3	1	-	1	-	1	1			
CO3	3	1	-	1	-	1	1			
CO4	3	1	-	1	-	1	1			
CO5	3	1	-	1	-	1	1			
Legends :- High:03, Medium:02,Low:01, No Mapping: - *PSOs are to be formulated at institute level										

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Dieter, G.D	Mechanical Metallurgy	McGraw Hill Edu. New Delhi, 2017, ISBN. 978-1259064791
2	Avner,S.H	Introduction to Physical Metallurgy	McGraw Hill Edu. New Delhi, 2017, ISBN. 978-0074630068
3	Rajput, R.K S.	Engineering Materials And Metallurgy	Chand and Company New Delhi,2006, ISBN 978-8121927093
4	Balasubramaniam R	Callister's Materials Science and Engineering	Wiley, New Delhi, 2014, ISBN 978-8131518052
5	Parashivamurthy,K. I.	Material Science and Metallurgy	Pearson Education India, 2012, ISBN. 978-8131761625
6	Fulay, P.P., Askeland D.R	Essentials of Materials Science and Engineering	Cengage India Private Limited, 2012 , ISBN 978-8131520703
7	Kodgire, V.D., Kodgire. S.V	Material Science and Metallurgy for Engineers	Everest Publishing House, 2017, ISBN. 978-8176314008

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=jn9cP6JJ7xA	Iron - Carbon diagram
2	https://www.youtube.com/watch?v=skQRLfU3plM	Heat Treatment Processes
3	https://www.youtube.com/watch?v=E6oCdckcwYQ&list=PLyqSpQzTE6M_ON8uXt-PP8uX6hMWJeYSJ&index=3	Crystal structure
4	https://www.youtube.com/watch?v=c1ZbiBIY6Sc&list=PLxQzQgOy_JvYd32Y6XOwFOnVc4_Dkv7v6&index=38	Ceramics
5	https://www.youtube.com/watch?v=04K0bLwCDdM	Composite materials
6	https://vedicheritage.gov.in/vedic-heritage-in-present-context/metallurgy/	IKS

MECHANICAL ENGINEERING MATERIALS **Course Code : 313317**

Sr.No	Link / Portal	Description
7	https://www.youtube.com/watch?v=_eM49JlmFp0	Powder Metallurgy

Note :

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

MSBTE Approval Dt. 02/07/2024 **Semester - 3 / 4, K Scheme**

CNC PROGRAMMING **Course Code : 314018**

Programme Name/s : Mechanical Engineering
Programme Code : ME
Semester : Fourth
Course Title : CNC PROGRAMMING
Course Code : 314018

I. RATIONALE

Today's manufacturing needs like productivity, accuracy, consistency, flexibility, quality and finally performance of the product is prime importance. The course will impart knowledge & skills necessary for working in modern manufacturing demands. This course will help the student to operate CNC machines for manufacturing various jobs as per need of industry requirements.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Develop CNC program to manufacture different industrial components using CNC machines.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Develop manual part program for CNC lathe and milling machine.
- CO2 - Simulate the part program using simulation software.
- CO3 - Produce job on CNC lathe and milling machine.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
314018	CNC PROGRAMMING	CNC	SEC	-	-	4	-	4	2	-	-	-	-	-	25	10	25#	10	-	-	50

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

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

CNC PROGRAMMING **Course Code : 314018**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Identify different axes and their nomenclature. TLO 1.2 Apply tool offsetting and presetting before program execution on CNC machines. TLO 1.3 Use of word address format for programming. TLO 1.4 Explain stepwise procedure for programming.	**Unit - I Fundamentals of CNC programming** 1.1 Definition- program, programmer and programming . 1.2 Axes identification and nomenclature for CNC lathe and CNC milling machines. 1.3 Concept of tool offsetting and presetting. 1.4 Terminology used for program in Word Address Format (WAF). 1.5 Stepwise procedure for programming- study the given part drawing, set of instructions to the machine, problem definition, sequence of machining operation and process sheet, decide- material & stock size, work zero, unit, coordinate system (Absolute & Incremental), tool, cutting parameters and coordinate points.	Demonstration Lecture Using Chalk-Board
2	TLO 2.1 Explain linear and circular path operations. TLO 2.2 Calculate of cutting parameters according to job nature. TLO 2.3 Select appropriate G & M codes. TLO 2.4 Develop program as per given job drawing. TLO 2.5 Simulate on software and test dry run-on machine.	**Unit - II Linear & circular path programming** 2.1 Concept- Linear, circular path operations in lathe and milling machine. 2.2 Calculation of Cutting parameters, address parameters I, J, K, co-ordinates. 2.3 Respective G and M codes. 2.4 CNC part program as per given job drawing. 2.5 Concept of simulation and DRY-Run test.	Demonstration Lecture Using Chalk-Board
3	TLO 3.1 Distinguish between canned cycle and Sub routine call. TLO 3.2 Develop part program for canned cycle. TLO 3.3 Develop part program for Subroutine call. TLO 3.4 Identify respective G&M code for canned cycle and subroutine call.	**Unit - III Canned & Sub-routine call programming** 3.1 Concept- canned cycle, subroutine call. 3.2 Facing, step and taper turning canned cycle, respective G & M codes, procedure to write canned cycle program, its importance. 3.3 Concept of sub-routine call, respective G & M code, procedure of sub-routine call to write program, its importance.	Demonstration Lecture Using Chalk-Board

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Choose appropriate G & M codes for linear interpolation function on CNC lathe. LLO 1.2 Develop manual part program for linear interpolation function for given job.	1	* Facing operation on CNC lathe by Linear interpolation function.	2	CO1

CNC PROGRAMMING **Course Code : 314018**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 2.1 Simulate prepared part program of linear interpolation function and take corrective action (if required). LLO 2.2 Use of an appropriate simulation software for part programing.	2	* Verify part program of linear interpolation function prepared in Practical No.1 by using suitable simulation software.	2	CO2
LLO 3.1 Perform DRY run-on CNC lathe machine. LLO 3.2 Verify tool path in DRY run activity.	3	Conduct DRY run of Practical No.1 on CNC lathe machine.	2	CO3
LLO 4.1 Perform linear interpolation function on CNC lathe. LLO 4.2 Check the finished job using suitable measuring instrument.	4	* Execution of part program prepared in Practical No.1 on CNC lathe machine.	4	CO3
LLO 5.1 Choose appropriate G & M codes for linear interpolation function on CNC milling. LLO 5.2 Develop manual part program for linear interpolation function.	5	* Slotting operation on CNC milling by Linear interpolation function.	2	CO1
LLO 6.1 Simulate prepared part program of linear interpolation function and take corrective action (if required). LLO 6.2 Use of an appropriate simulation software for part programing.	6	* Verify part program of linear interpolation function prepared in Practical No.5 by using suitable simulation software.	2	CO2
LLO 7.1 Perform DRY run-on CNC milling machine. LLO 7.2 Verify tool path in DRY run activity.	7	Conduct DRY run of Practical No.5 on CNC milling machine.	2	CO3
LLO 8.1 Perform linear interpolation function on CNC milling. LLO 8.2 Check the finished job using suitable measuring instrument.	8	* Execution of part program prepared in Practical No.5 on CNC milling machine.	4	CO3
LLO 9.1 Choose appropriate G & M codes for circular interpolation function on CNC lathe. LLO 9.2 Develop manual part program for circular interpolation function.	9	* Circular path operation on CNC lathe by circular interpolation function.	2	CO1
LLO 10.1 Simulate prepared part program of circular interpolation function and take corrective action(if required). LLO 10.2 Use of an appropriate simulation software for part programing.	10	* Verify part program of circular interpolation function prepared in Practical No.9 by using suitable simulation software.	2	CO2
LLO 11.1 Perform DRY run-on CNC lathe machine. LLO 11.2 Verify tool path in DRY run activity	11	Conduct DRY run of Practical No.9 on CNC lathe machine.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 12.1 Perform circular interpolation function on CNC lathe. LLO 12.2 Check the finished job using suitable measuring instrument.	12	* Execution of part program prepared in Practical No.9 on CNC lathe machine.	4	CO3
LLO 13.1 Choose appropriate G & M codes for circular interpolation function on CNC milling. LLO 13.2 Develop manual part program for circular interpolation function.	13	* Circular path operation on CNC milling by circular interpolation function.	2	CO1
LLO 14.1 Simulate prepared part program of circular interpolation function and take corrective action (if required). LLO 14.2 Use of an appropriate simulation software for part programing.	14	* Verify part program of circular interpolation function prepared in Practical No.13 by using suitable simulation software.	2	CO2
LLO 15.1 Perform DRY run-on CNC milling machine. LLO 15.2 Verify tool path in DRY run activity.	15	Conduct DRY run of Practical No.13 on CNC milling machine.	2	CO3
LLO 16.1 Perform circular interpolation function on CNC milling. LLO 16.2 Check the finished job using suitable measuring instrument.	16	* Execution of part program prepared in Practical No.13 on CNC milling machine.	4	CO3
LLO 17.1 Choose appropriate G & M codes for canned cycle on CNC lathe. LLO 17.2 Develop manual part program for canned cycle given job.	17	Facing, step and taper turning operation by canned cycle.	2	CO1
LLO 18.1 Simulate prepared part program of canned cycle and take corrective action (if required). LLO 18.2 Use of an appropriate simulation software for part programing.	18	Verify part program of canned cycle prepared in Practical No.17 by using suitable simulation software.	2	CO2
LLO 19.1 Perform DRY run-on CNC lathe machine. LLO 19.2 Verify tool path in DRY run activity.	19	Conduct DRY run of Practical No.17 on CNC lathe machine.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 20.1 Perform Facing, step and taper turning operation by canned cycle on CNC lathe. LLO 20.2 Check the finished job using suitable measuring instrument.	20	Execution of part program prepared in Practical No.17 on CNC lathe machine.	4	CO3
LLO 21.1 Choose appropriate G & M codes for subroutine call on CNC milling. LLO 21.2 Develop manual part program for subroutine call.	21	Slotting operation on CNC milling by subroutine call.	2	CO1
LLO 22.1 Simulate prepared part program of subroutine call and take corrective action (if required). LLO 22.2 Use of an appropriate simulation software for part programing.	22	Verify part program of subroutine call prepared in Practical No.21 by using suitable simulation software.	2	CO2
LLO 23.1 Perform DRY run for subroutine call on CNC milling machine. LLO 23.2 Verify tool path in DRY run activity.	23	Conduct DRY run of Practical No.21 on CNC milling machine.	2	CO3
LLO 24.1 Perform subroutine call on CNC milling. LLO 24.2 Check the finished job using suitable measuring instrument.	24	Execution of part program prepared in Practical No.21 on CNC milling machine.	4	CO3

Note : Out of above suggestive LLOs -

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

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

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	CNC Turning 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type minimum diameter 25 mm, Length 120 mm with ATC along with essential accessories.	1,3,4,9,11,12,17,19,20
2	CNC Simulation software and control pads (CAMLAB CNC Software, MasterCAM/NXCAM/, DONC CNC machine simulator, PRO, SWANSOFT, CAPSMILL and CAPSTURN IN cam software, DONCMILL AND DONCTURN software), CutViewer Turn& Mill, Sinewave Turn& Mill or equivalent simulation software.	2,6,10,14,18,22

CNC PROGRAMMING **Course Code : 314018**

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
3	Windows 10 Home Intel Core i5 HDD Capacity 500 GB RAM 8 GB DDR3 18.5 inch Display, Dedicated Graphic Memory 512 MB, USB 1x3.0 Front 6 Back.	2,6,10,14,18,22
4	CNC Milling 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type-X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, with ATC along with essential accessories.	5,7,8,13,15,16,21,23,24

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

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Term Work

Summative Assessment (Assessment of Learning)

- Practical

XI. SUGGESTED COS - POS MATRIX FORM

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	P. M. Agrawal And V. J. Patel	CNC Fundamentals and Programming	Charotar Publishing House Pvt. Limited.ISBN:9788185594989 ,Edition-2009
2	Pawan Negi, Mangey Ram, Om Prakash Yadav	Basics of CNC Programming	River Publishers.ISBN:9781000792911,Edition-2022
3	Kaushik Kumar, Chikesh Ranjan, J. Paulo Davim	CNC Programming for Machining	Springer International Publishing.ISBN:9783030412791,Edition-2020.
4	Binit Kumar Jha	CNC Programming Made Easy	Vikas Publishing House.ISBN: 9788125911807,Edition-2003
5	Ibrahim Zeid	CAD/CAM Theory and Practice	McGraw Hill Education.ISBN:0070151342,Edition-2009

Sr.No	Author	Title	Publisher with ISBN Number
6	Pabla B. S. & M. Adithan	CNC Machines	New Age International Private Limited.ISBN:978-9388818445,Edition-2023.

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=ih4Q8TJOI5I	How to create your first turning program in CNC Simulator
2	https://www.youtube.com/watch?v=m_FVE4Q59gU	CNC Milling Simulator
3	https://www.youtube.com/watch?v=_5r2XR1h1aQ	CNC programming
4	https://www.youtube.com/watch?v=PN_tGm5Gip4	CNC machines and Interpolation
5	https://www.youtube.com/watch?v=B7MM5M7DzpM	Introduction to CNC machines
6	https://www.youtube.com/watch?v=Gi42gKGiCl0	Introduction to CNC machines.
7	https://www.youtube.com/watch?v=YpQMUpWOgbE&t=2s	Programming a CNC Lathe to make a bush - part 1 G71 roughing cycle
8	https://www.youtube.com/watch?v=wYebU4JSkGQ	Step Turning With Simulation

Note :

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

ENTREPRENEURSHIP DEVELOPMENT AND STARTUPS **Course Code : 314014**

Programme Name/s	**: Architecture Assistantship/ Automobile Engineering./ Agricultural Engineering/ Architecture/ Fashion & Clothing Technology/ Dress Designing & Garment Manufacturing/ Food Technology/ Instrumentation & Control/ Instrumentation/ Interior Design & Decoration/ Interior Design/ Mechanical Engineering/ Mechatronics/ Medical Laboratory Technology/ Medical Electronics/ Production Engineering/ Printing Technology/ Surface Coating Technology/ Textile Technology/ Travel and Tourism/ Textile Manufactures**
Programme Code	**: AA/ AE/ AL/ AT/ DC/ DD/ FC/ IC/ IS/ IX/ IZ/ ME/ MK/ ML/ MU/ PG/ PN/ SC/ TC/ TR/ TX**
Semester	**: Fourth / Fifth / Sixth**
Course Title	**: ENTREPRENEURSHIP DEVELOPMENT AND STARTUPS**
Course Code	**: 314014**

I. RATIONALE

Entrepreneurship and Startup is introduced in this curriculum to develop the entrepreneurship traits among the students before they enter into the professional life. By exposing and interacting with entrepreneurship and startup eco-system, student will develop the entrepreneurial mind set. The innovative thinking with risk taking ability along with other traits are to be inculcated in the students through micro projects and training. This exposure will be instrumental in orienting the students in transforming them to be job generators after completion of Diploma in Engineering.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

• Develop project proposals for launching small scale enterprises and starts up.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Identify one's entrepreneurial traits.
- CO2 - Use information collected from stakeholder for establishing/setting up/founding starts up
- CO3 - Use support systems available for Starts up
- CO4 - Prepare project plans to manage the enterprise effectively

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
314014	ENTREPRENEURSHIP DEVELOPMENT AND STARTUPS	EDS	AEC	1	-	2	1	4	2	-	-	-	-	-	50	20	25@	10	25	10	100

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

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Compare advantages and disadvantages of Entrepreneurship TLO 1.2 Identify entrepreneurial traits through self-analysis TLO 1.3 Compare risk associated with different type of enterprise	**Unit - I Introduction to Entrepreneurship Development** 1.1 Entrepreneurship as a career – charms, advantages, disadvantages , scope- local and global 1.2 Traits of successful entrepreneur: consistency, creativity, initiative, independent decision making, assertiveness, persuasion, persistence, information seeking, handling business communication, commitment to work contract, calculated risk taking, learning from failure 1.3 Types of enterprises and their features : manufacturing, service and trading	Presentations Lecture Using Chalk-Board
2	TLO 2.1 Explain Important factors essential for selection of product/service and selection of process TLO 2.2 Suggest suitable place for setting up the specified enterprise on the basis of given data/circumstances with justification. TLO 2.3 Suggest steps for the selection process of an enterprise for the specified product or service with justification. TLO 2.4 Plan a market study /survey for the specified enterprise	**Unit - II Startup Selection Process** 2.1 Product/Service selection: Process, core competence, product/service life cycle, new product/ service development process, mortality curve, creativity and innovation in product/ service modification / development 2.2 Process selection: Technology life cycle, forms and cost of transformation, factors affecting process selection, location for an industry, material handling. 2.3 Market study procedures: questionnaire design, sampling, market survey, data analysis 2.4 Getting information from concerned stakeholders such as Maharashtra Centre for Entrepreneurship Development[MCED], National Institute for Micro, Small and Medium Enterprises [NI-MSME], Prime Minister Employment Generation Program [PMEGP], Directorate of Industries[DI], Khadi Village Instries Commission[KVIC]	Presentations Lecture Using Chalk-Board

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Explain categorization of MSME on the basis of turnover and investment TLO 3.2 Describe support system provided by central and state government agencies TLO 3.3 State various schemes of government agencies for promotion of entrepreneurship TLO 3.4 Describe help provided by the non-governmental agencies for the specified product/service TLO 3.5 Compute breakeven point, ROI and ROS for the specified business enterprise, stating the assumptions made	**Unit - III Support System for Startup** 3.1 Categorization of MSME, ancillary industries 3.2 Support systems- government agencies: MCED, NI-MSME, PMEGP,DI, KVIC 3.3 Support agencies for entrepreneurship guidance, training, registration, technical consultation, technology transfer and quality control, marketing and finance. 3.4 Breakeven point, return on investment (ROI) and return on sales (ROS).	Presentations Lecture Using Chalk-Board
4	TLO 4.1 Explain key elements for the given business plan with respect to their purpose/size TLO 4.2 Justify USP of the given product/ service from marketing point of view. TLO 4.3 Formulate business policy for the given product/service. TLO 4.4 Choose relevant negotiation techniques for the given product/ service with justification TLO 4.5 Identify risks that you may encounter for the given type of business/enterprise with justification. TLO 4.6 Describe role of the incubation centre and accelerators for the given product/service.	**Unit - IV Managing Enterprise** 4.1 Techno commercial Feasibility study, feasibility report preparation and evaluation criteria 4.2 Ownership, Capital, Budgeting, Matching entrepreneur with the project 4.3 Unique Selling Proposition [U.S.P.]: Identification, developing a marketing plan. 4.4 Preparing strategies of handling business: policy making, negotiation and bargaining techniques 4.5 Risk Management: Planning for calculated risk taking, initiation with low cost projects, integrated futuristic planning, definition of startup cycle, ecosystem , angel investors, venture capitalist 4.6 Incubation centers and accelerators : Role and procedure	Presentations Lecture Using Chalk-Board

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Collect information of successful entrepreneurial traits	1	*Preparation of report on entrepreneurship as a career	2	CO1
LLO 2.1 Identify different traits as an entrepreneur from various field LLO 2.2 Suggest different traits from identified problem	2	Case study on ‘Traits of Entrepreneur’	2	CO1
LLO 3.1 Explore probable risks for identified enterprise.	3	*Case study on ‘Risks associated with enterprise	2	CO1
LLO 4.1 Identify new product for development LLO 4.2 Prepare a newly developed product	4	*Preparation of report on ‘Development of new Product’	2	CO1 CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 5.1 Identify Process for development of product for new startup	5	Preparation of Report on ' Process selection ' for new startup	2	CO1 CO2 CO3
LLO 6.1 Develop questioner for market survey	6	*Market survey for setting up new Start up	2	CO2 CO3
LLO 7.1 Interpret the use of Technology Life Cycle	7	A Case study on ' Technology life cycle' of any successful entrepreneur.	2	CO3
LLO 8.1 Use information related to support of startups from Government and non-government agencies' LLO 8.2 Prepare report for setting up startup	8	*Preparation of report on 'Information for setting up new startup' from MCED/MSME/KVIC etc	2	CO3 CO4
LLO 9.1 Compute ROI of successful enterprise.	9	Case study on 'Return on Investment (ROI)'of any successful startup	2	CO3
LLO 10.1 Calculate of ROS of any successful enterprise	10	Case study on 'Return on sales (ROS)'of any successful startup	2	CO3
LLO 11.1 Calculate Brake even point of any enterprise	11	Preparation of report on 'Brake even point calculation' of any enterprise.	2	CO3 CO4
LLO 12.1 Prepare feasibility report of given business	12	*Preparation of report on 'feasibility of any Techno-commercial business"	2	CO4
LLO 13.1 Plan a USP of any enterprise.	13	*A case study based on 'Unique selling Proposition (USP) of any successful enterprise	2	CO4
LLO 14.1 Prepare a project report using facilities of Atal Incubation center.	14	*Prepare project report for starting new startup using 'Atal incubation center (AIC)	2	CO1 CO2 CO3 CO4

Note : Out of above suggestive LLOs -

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

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

Micro project

- Prepare a ' Women entrepreneurship business plan ' Choose relevant government scheme for the product/service
- Prepare a 'Pitch- desk' for your start up
- Prepare a business plan for a. Market research b. Advertisement agency c. Placement Agency d. Repair and Maintenance agency e. Tour and Travel agency
- Prepare a 'Social entrepreneurship business plan, plan for CSR funding.
- Prepare a business plan for identified projects by using entrepreneurial eco system for the same (Schemes, incentives, incubators etc.)

Note :

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

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Computers with internet and printer facility	All

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Entrepreneurship Development	CO1	5	0	0	0	0
2	II	Startup Selection Process	CO2	4	0	0	0	0
3	III	Support System for Startup	CO3	3	0	0	0	0
4	IV	Managing Enterprise	CO4	3	0	0	0	0
Grand Total				**15**	**0**	**0**	**0**	**0**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

Summative Assessment (Assessment of Learning)

- End of Term Examination - Viva-voce

XI. SUGGESTED COS - POS MATRIX FORM

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Dr. Nishith Dubey, Aditya Vyas , Annu Soman , Anupam Singh	Un- boxing Entrepreneurship your self help guide to setup a successful business	Indira Publishing House ISBN-2023,978-93-93577-70-2
2	Gujral, Raman	Reading Material of Entrepreneurship Awareness Camp	Entrepreneurship Development Institute of India (EDI), GOI, 2016 Ahmedabad
3	Chitale, A K	Product Design and Manufacturing	PHI Learning, New Delhi, 2014; ISBN: 9788120348738
4	Charantimath, Poornima	Entrepreneurship Development Small Business Entrepreneurship	Pearson Education India, New Delhi; ISBN: 9788131762264
5	Khanka, S.S.	Entrepreneurship and Small Business Management	S.Chand and Sons, New Delhi, ISBN: 978-93-5161-094-6

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	http://www.mced.nic.in/allproduct.aspx	MCED Product and Plan Details
2	http://niesbud.nic.in/Publication.html	The National Institute for Entrepreneurship and Small Business Development Publications
3	http://niesbud.nic.in/docs/1standardized.pdf	Courses : The National Institute for Entrepreneurship and Small Business Development
4	https://www.nabard.org/content1.aspx?id=23andcatid=23andmid=530	Government Schemes
5	https://www.nabard.org/Tenders.aspx?cid=501andid=24	NABARD - Information Centre
6	http://www.startupindia.gov.in/pdffile.php?title=Startup%20India%20Action%20Planandtype=Actionandq=Action%20Plan.pdfandcontent_type=Actionandsubmenupoint=action	Start Up India
7	http://www.ediindia.org/institute.html	About - Entrepreneurship Development Institute of India (EDII)
8	http://www.nstedb.com/training/training.htm	NSTEDB - Training

Note :

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

THEORY OF MACHINES **Course Code : 313313**

Programme Name/s	**: Automobile Engineering./ Mechanical Engineering/ Mechatronics/ Production Engineering/**
Programme Code	**: AE/ ME/ MK/ PG**
Semester	**: Third / Fourth**
Course Title	**: THEORY OF MACHINES**
Course Code	**: 313313**

I. RATIONALE

Diploma Engineer should be able to identify and interpret various elements of machines in day-to-day life when they come across various machines in practice. In maintaining various machines, a Diploma Engineer should have sound knowledge of fundamentals of machine and mechanism. TOM subject imparts the kinematics involved in different machine elements and mechanisms like I.C. engine, cam-follower, belt-pulley, gear, flywheel etc. This course serves as a prerequisite for other courses such as Machine Design of higher semester etc.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

This course will enable the students to: Apply the knowledge & skills related to machine, mechanism & motions according to field applications.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Apply knowledge and skill related to different mechanisms and its motion in given situation.
- CO2 - Determine velocity and acceleration for given mechanism.
- CO3 - Develop a Cam profile for given type of Follower and its motions in given situation.
- CO4 - Select the suitable power transmission devices for the given field/industrial application.
- CO5 - Use knowledge and skills related to balancing of masses and vibration for various applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313313	THEORY OF MACHINES	TOM	DSC	4	-	2	-	6	3	3	30	70	100	40	25	10	-	-	-	-	125

Total IKS Hrs for Sem. : 0 Hrs

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

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

Note :

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Identify various links and pairs in the given mechanism. TLO 1.2 Identify various type motion in the given pair. TLO 1.3 Identify various kinematic chain in the given configuration. TLO 1.4 Estimate degree of freedom for given configuration. TLO 1.5 Explain different inversion of mechanism. TLO 1.6 Select suitable inversion of mechanism for different application.	**Unit - I Fundamentals and Types of Mechanism** 1.1 Kinematics of Machines: - Definition of statics, Dynamics, Kinematics, Kinetics, Kinematic link and its types, Kinematic pair and its types, constrained motion and its types 1.2 Kinematic chain (locked chain, constrained chain and unconstrained chain with equation), Degree of freedom (Kutzbach equation) 1.3 Mechanism and Inversion: Mechanism and Inversion of Mechanism, Difference between machine and structure. 1.4 Inversion of Kinematic Chain a) Inversion of four bar chain: Beam engine, Coupling rod of Locomotive, Watt's indicator mechanism. b) Inversion of single slider Crank chain: Reciprocating I.C. engine, Whitworth quick return mechanism, Rotary Engine, Oscillating cylinder engine, Crank and slotted lever quick return Mechanism, Hand Pump mechanism c) Inversion of Double Slider Crank Chain: Elliptical trammel, Scotch Yoke Mechanism, Oldham's Coupling	Classroom Lecture Model Demonstration Video Demonstrations Hands-on Presentations
2	TLO 2.1 Describe velocity and acceleration in mechanism. TLO 2.2 Draw velocity and acceleration diagram/polygon by relative velocity/ Klein's construction method following standard procedure . TLO 2.3 Determine linear and angular velocity of links in the given mechanism. TLO 2.4 Determine linear and angular acceleration of links in the given mechanism.	**Unit - II Velocity and Acceleration in Mechanism** 2.1 Concept of relative velocity and acceleration of a point on a link, Inter-relation between linear and angular velocity and acceleration. 2.2 Drawing of velocity and acceleration diagram of a given configuration, diagrams of simple Mechanisms: four bar chain and single slider crank chain (Limited up to 4 Links). 2.3 Determination of velocity and acceleration of point on link by relative velocity method (Excluding Coriolis component of acceleration) . 2.4 Klein's construction to identify velocity and acceleration of different links in single slider crank mechanism (When crank rotates with uniform velocity only).	Lecture Using Chalk-Board Video Demonstrations
3	TLO 3.1 Explain Cam and its terminology with field application. TLO 3.2 Identify the type of motion of Follower. TLO 3.3 Classify Cams and Followers. TLO 3.4 Draw Cam profile as per the given condition of Follower.	**Unit - III Cam and Follower** 3.1 Introduction to Cams and Followers, definition and applications of Cams and Followers, Cam terminology. 3.2 Classification of Cams and Followers. 3.3 Different follower motions and their displacement diagrams - Uniform velocity, simple harmonic motion, uniform acceleration and retardation. 3.4 Drawing of profile of radial Cam with knife-edge and roller Follower with and without offset (reciprocating motion only).	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Identify the different drives for power transmission. TLO 4.2 Select suitable drive for a particular application. TLO 4.3 Calculate various quantities like velocity ratio, belt tensions, angle of contact, power transmitted in belt drives. TLO 4.4 Enlist advantages and disadvantages of chain drive. TLO 4.5 Identify the different types of gear trains. TLO 4.6 Compare belt drive, chain drive and gear drive for given parameters.	**Unit - IV Power transmission (Belt, Chain and Gear)** 4.1 Belt Drive: a) Type of belts, flat belt, V-belt & its applications, material for flat and V-belt, Selection of belts b) Angle of lap, length of belt (No derivation), Slip and creep, Determination of velocity ratio of tight side and slack side tension, Power transmitted by belt. (numerical on power transmission by belt) 4.2 Chain Drives: Types of chains and sprockets, Advantages & Disadvantages of chain drive over other drives (No numerical on Chain drive). 4.3 Gear Drives: a) Classification of gears, Law of gearing, Concept of Conjugate profile (Involute only) Spur gear terminology. b) Types of gear trains, Train value & velocity ratio for simple, compound, reverted and epicyclic gear trains. (No numerical on Gear drive). Comparison between Belt drive, Chain drive and Gear drive	Lecture Using Chalk-Board Presentations Video Demonstrations Model Demonstration
5	TLO 5.1 Explain the concept of balancing. TLO 5.2 Find balancing mass and position of plane analytically and graphically in single plane. TLO 5.3 Explain the basic vibrating system with causes and remedies.	**Unit - V Balancing of Masses and Vibration** 5.1 Balancing of Rotating Masses: Concept of balancing: Need and types of balancing, Balancing of single rotating mass. 5.2 Analytical and Graphical methods for balancing of several masses revolving in same plane and different plane (Numerical on single plane only). 5.3 Vibration: Fundamentals of Vibration: Definition and concept of Free, Forced, Undamped, Damped vibrations. (no numerical) 5.4 Advantages and Disadvantages of Vibration, Causes and remedies of Vibration, Vibration isolators. Forced vibrations of longitudinal and torsional systems (Concepts only, No numerical and No derivation on vibration).	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify different mechanisms available in laboratories/institute premises LLO 1.2 Sketch the identified mechanism.	1	Identification of Mechanisms in the different laboratory and institute premises.	2	CO1 CO3 CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 2.1 Identify number of links and pairs of given mechanism LLO 2.2 Identify input link and its motion. LLO 2.3 Identify output link and its motion	2	*Estimation of kinematic data for mechanism available in the laboratory (any one from Group A and any one from Group B) Group A: i) Beam Engine ii) Coupling rod of Locomotive, iii) Watt's indicator mechanism. Group B: i) Reciprocating engine ii) Whitworth quick return mechanism. iii) Rotary Engine iv) Crank and slotted lever quick return Mechanism v) Hand Pump mechanism	2	CO1
LLO 3.1 Identify number of links and pairs of given mechanism. LLO 3.2 Identify input link and its motion. LLO 3.3 Identify Output link and its motion.	3	Estimation of kinematic data for mechanism available in the laboratory (any one from Group A and any one from Group B) Group A: i) Elliptical trammel, ii) Scotch Yoke Mechanism, iii) Oldham's Coupling Group B: i) Bicycle free wheel sprocket mechanism ii) Geneva mechanism iii) Ackerman's steering gear mechanism iv) Foot operated air pump mechanism	2	CO1
LLO 4.1 Determine degree of freedom of given mechanism	4	*Degree of Freedom of given mechanism by using Kutzbach equation. (Any five mechanisms available in the Laboratory)	2	CO1

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 5.1 Measure the ratio of time of cutting stroke to the return stroke in shaping operation.	5	*Quick return mechanism used in a shaper machine	2	CO1
LLO 6.1 Draw velocity and acceleration polygon of four bar chain. LLO 6.2 Calculate angular velocity and linear velocity of a link using given data.	6	Velocity and Acceleration of four bar chain by relative velocity method. (Two Problem on A2 size Sheet.)	2	CO2
LLO 7.1 Draw velocity and acceleration polygon of single slider crank chain. LLO 7.2 Calculate angular velocity and linear velocity of a link using given data.	7	*Velocity and Acceleration of single slider crank chain by relative velocity method. (Two Problem on A2 size Sheet.)	2	CO2
LLO 8.1 Draw a space diagram of a single slider crank mechanism LLO 8.2 Measure the velocity and acceleration of links using Klien's construction method.	8	Velocity and Acceleration of Slider crank chain by Klien's Construction Method.	2	CO2
LLO 9.1 Generate cam profile for given follower to obtain desired follower motion	9	Cam profile for knife edge Follower. (Two problem on A2 size sheet, at least one problem on offset follower)	2	CO3
LLO 10.1 Generate cam profile for given follower to obtain desired follower motion	10	Cam Profile for roller follower. (Two Problem on A2 size sheet, at least one problem on offset follower)	2	CO3
LLO 11.1 Identify displacement of follower with cam rotation	11	*Measurement of follower displacement with Cam rotation for knife edge follower and roller follower	2	CO3
LLO 12.1 Measure the angular speed using tachometer. LLO 12.2 Compute the length of belt and slip	12	*Estimation of slip, length of belt, angle of contact in an open and cross belt drive.	2	CO4
LLO 13.1 Identify the type of gears and gear train.	13	Identification of gears and gear train in Lab and Machine shop.	2	CO4
LLO 14.1 Identify the type of gears and gear train. LLO 14.2 Construct gear train for desirable velocity ratio	14	*Preparation of different Gear trains from the given gears.	2	CO4
LLO 15.1 Construct balanced system for rotating masses.	15	*Balancing of rotating unbalanced system	2	CO5

Note : Out of above suggestive LLOs -

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

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

NA

- NA

Note :

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

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Working Model of Beam Engine, Coupling rod of Locomotive, Watt's indicator mechanism, Reciprocating engine, Whitworth quick return mechanism, Rotary Engine, Crank and slotted lever quick return Mechanism, Hand Pump mechanism	1,2,4
2	Shaper machine available in institute workshop	1,2,4,5
3	Working Models of Elliptical trammel, Scotch Yoke Mechanism, Oldham's Coupling, Bicycle free wheel sprocket Mechanism, Geneva mechanism, Ackerman's steering gear Mechanism, Foot operated air pump mechanism	1,3,4
4	Working models of Flat belt and V belt arrangement for demonstration	1,4,12
5	Experimental cam follower set up: Machine consist of a cam shaft driven by a D.C. motor/Manual operated. The shaft runs in a double ball bearing. At the free end of the cam shaft a cam can be easily mounted. The follower is properly guided in bushes and the type of the follower can be changed to suit the cam under test. A graduated circular protractor is fitted coaxial with the shaft and a dial gauge can be fitted to note the follower displacement for the angle of cam rotation. A spring is used to provide controlling force to the follower system.	11
6	Tachometer: optical type of tachometer (digital Tachometer) Range speed minimum 0 to 2000RPM or more	12
7	Belt drive test benchA test bench comprising of following pulleys, belts, electrical motor, arrangement for adjusting belt tensions and regulating speed of the driving motor and a suitable mounting frame	12
8	Working Model of Gear Trains: i) Simple Gear Train ii) Compound Gear train iii) Reverted Gear Train iv) epicyclic Gear Train	13
9	Different types of Gears with different modules : al least 5 quantity of each gear Spur gearHelical gear (Single /double)Spiral gearBevel gear	13
10	Experimental set up to arrange gears and shaft such that desired gear train can be obtained for given velocity ratio.	14
11	Static & Dynamic Balancing MachineSingle phase motor connected to a shaft, containing 4 rotating masses. Each rotating masshas a facility to insert. Pulley is provided to add weights to balance the unbalance shaft	15
12	Working models of various Cam follower arrangements for demonstration (Radial cam with knife edge and Roller follower models are mandatory)	4,9,10,11

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals and Types of Mechanism	CO1	16	6	8	4	18

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
2	II	Velocity and Acceleration in Mechanism	CO2	10	2	4	6	12
3	III	Cam and Follower	CO3	10	4	4	6	14
4	IV	Power transmission (Belt, Chain and Gear)	CO4	16	4	8	4	16
5	V	Balancing of Masses and Vibration	CO5	8	4	4	2	10
Grand Total				**60**	**20**	**28**	**22**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Laboratory Performance and Term work, Class Test I & II
- Term work (Lab Manual and drawing sheet), Question and Answers in class room as well as at the time of Practical. Note: Each practical will be assessed considering 60% and 40 % weightage.

Summative Assessment (Assessment of Learning)

- End Semester Board exam- Theory

XI. SUGGESTED COS - POS MATRIX FORM

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	A. Ghosh, A. K. Malik	Theory Of Mechanisms and Machines	Affiliated East west press ISBN: 978-8185938936
2	S. S. Rattan	Theory Of Machines	Tata McGraw Hill Edu. New Delhi, 2010, ISBN: 978-9353166281
3	R.S. Khurmi, J. K. Gupta	Theory of Machines	S. Chand and Company New Delhi, ISBN: 978-8121925242
4	J. E. Shigely, J. J. Uicker	Theory Of Machines and Mechanisms	Tata McGraw Hill Edu. New Delhi, 2010, ISBN: 978-0198062325

Sr.No	Author	Title	Publisher with ISBN Number
5	R. K. Bansal, Brar J. S.	A text book of Theory of Machine	Khanna Book Publishing CO(P) LTD, New Delhi, ISBN: 9788170084181
6	P. L. Ballaney	Theory Of Machines	Khanna Book Publishing CO(P) LTD, New Delhi, ISBN: 978-8174091222
7	Sadhu Singh	Theory of Machines	Pearson Education ISBN: 978-8131760697
8	S.S. Rao	Mechanical Vibrations	Pearson Education 2018 ISBN: 978-9353062569
9	G.K. Grover	Mechanical Vibration	978-8185240565

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	http://www.mechanalyzer.com/downloads.html	Mech Analyzer is a free software developed to simulate and analyze the mechanisms
2	https://www.youtube.com/watch?v=oTcC_xXfdrA	Coupling Rod Locomotive
3	https://www.youtube.com/watch?v=8shK6kbu7Xk	Piston cylinder animation showing application of cam and gear train
4	https://www.youtube.com/watch?v=yHHeicPbEzg	Simple Beam Engine
5	https://www.youtube.com/watch?v=yHHeicPbEzg	Knife edge follower and Radial Cam
6	https://www.youtube.com/watch?v=Rib-_ZK8KfE	Roller follower with Radial Cam
7	https://www.youtube.com/watch?v=AODiJYtxuSw	Grear train animation
8	https://www.youtube.com/watch?v=klVYeSlxucU	Types of Belt drives
9	https://www.udemy.com/course/theory-of-machines-determine-degrees-of-freedom-in-a-system/	Degree of freedom
10	https://archive.nptel.ac.in/courses/112/106/112106270/	Online NPTL lectures of Theory of machine
11	https://play.google.com/store/apps/details?id=com.pinjara_imran5290.Belt_Length_Calculator&hl=en&gl=US&pli=1	Belt length calculator Application (play store app)
12	https://psmotion.com/mechdesigner/feature/cam-design-analysis	Design of Cam software
13	https://www.vlab.co.in/broad-area-mechanical-engineering	Virtual Lab
14	https://opac.library.iitb.ac.in/	Digital Central Library

Note :

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

Programme Name/s	**: Architecture Assistantship/ Automobile Engineering./ Artificial Intelligence/ Agricultural Engineering/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Architecture/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Science & Engineering/ Fashion & Clothing Technology/ Dress Designing & Garment Manufacturing/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Food Technology/ Computer Hardware & Maintenance/ Instrumentation & Control/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Instrumentation/ Interior Design & Decoration/ Interior Design/ Civil & Environmental Engineering/ Mechanical Engineering/ Mechatronics/ Medical Laboratory Technology/ Medical Electronics/ Production Engineering/ Printing Technology/ Polymer Technology/ Surface Coating Technology/ Computer Science/ Textile Technology/ Electronics & Computer Engg./ Travel and Tourism/ Textile Manufactures/**
Programme Code	**: AA/ AE/ AI/ AL/ AN/ AO/ AT/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CW/ DC/ DD/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ FC/ HA/ IC/ IE/ IF/ IH/ IS/ IX/ IZ/ LE/ ME/ MK/ ML/ MU/ PG/ PN/ PO/ SC/ SE/ TC/ TE/ TR/ TX**
Semester	**: Fourth**
Course Title	**: ENVIRONMENTAL EDUCATION AND SUSTAINABILITY**
Course Code	**: 314301**

I. RATIONALE

The survival of human beings is solely depending upon the nature. Thus, threats to the environment directly impact on existence and health of humans as well as other species. Depletion of natural resources and degradation of ecosystems is accelerated due to the growth in industrial development, population growth, and overall growth in production demand. To address these environmental issues, awareness and participation of individuals as well as society is necessary. Environmental education and sustainability provide an integrated, and interdisciplinary approach to study the environmental systems and sustainability approach to the diploma engineers.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Resolve the relevant environmental issue through sustainable solutions

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Identify the relevant Environmental issues in specified locality.
- CO2 - Provide the green solution to the relevant environmental problems.
- CO3 - Conduct SWOT analysis of biodiversity hotspot
- CO4 - Apply the relevant measures to mitigate the environmental pollution.
- CO5 - Implement the environmental policies under the relevant legal framework.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

ENVIRONMENTAL EDUCATION AND SUSTAINABILITY **Course Code : 314301**

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
314301	ENVIRONMENTAL EDUCATION AND SUSTAINABILITY	EES	VEC	3	-	-	1	4	2	1.5	30	70*#	100	40	-	-	-	-	25	10	125

Total IKS Hrs for Sem. : 2 Hrs

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

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

Note :

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain the need of studying environment and its components. TLO 1.2 Investigate the impact of population growth and industrialization on the relevant environmental issues and suggest remedial solutions TLO 1.3 Explain the Concept of 5 R w.r.t. the given situation TLO 1.4 Elaborate the relevance of Sustainable Development Goals in managing the climate change TLO 1.5 Explain the concept of zero carbon-footprint with carbon credit	**Unit - I Environment and climate change** 1.1 Environment and its components, Types of Environments, Need of environmental studies 1.2 Environmental Issues- Climate change, Global warming, Acid rain, Ozone layer depletion, nuclear accidents. Effect of population growth and industrialization 1.3 Concept of 5R, Individuals' participation in i) 5R policy, ii) segregation of waste, and iii) creating manure from domestic waste 1.4 Impact of Climate change, Factors contributing to climate change, Concept of Sustainable development, Sustainable development Goals (SDGs), Action Plan on Climate Change in Indian perspectives 1.5 Zero Carbon footprint for sustainable development, (IKS-Enviornment conservation in vedic and pre-vedic India)	Lecture Using Chalk-Board Presentations

ENVIRONMENTAL EDUCATION AND SUSTAINABILITY **Course Code : 314301**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Justify the importance of natural resources in sustainable development TLO 2.2 Explain the need of optimum use of natural resources to maintain the sustainability TLO 2.3 Differentiate between renewable and non-renewable sources of energy TLO 2.4 Suggest the relevant type of energy source as a green solution to environmental issues	**Unit - II Sustainability and Renewable Resources** 2.1 Natural Resources: Types, importance, Causes and effects of depletion. (Forest Resources, Water Resources, Energy Resources, Land resources, Mineral resources), (IKS- Concepts of Panchmahabhuta) 2.2 Impact of overexploitation of natural resources on the environment, optimum use of natural resources 2.3 Energy forms (Renewable and non-renewable) such as Thermal energy, nuclear energy, Solar energy, Wind energy, Geothermal energy, Biomass energy, Hydropower energy, biofuel 2.4 Green Solutions in the form of New Energy Sources such as Hydrogen energy, Ocean energy & Tidal energy	Lecture Using Chalk-Board Presentations
3	TLO 3.1 Explain the characteristics and functions of ecosystem TLO 3.2 Relate the importance of biodiversity and its loss in the environmental sustainability TLO 3.3 Describe biodiversity assessment initiatives in India TLO 3.4 Conduct the SWOT analysis of the biodiversity hot spot in India TLO 3.5 Explain the need of conservation of biodiversity in the given situation	**Unit - III Ecosystem and Biodiversity** 3.1 Ecosystem - Definition, Aspects of ecosystem, Division of ecosystem, General characteristics of ecosystem, Functions of ecosystem 3.2 Biodiversity - Definitions, Levels, Value, and loss of biodiversity 3.3 Biodiversity Assessment Initiatives in India 3.4 SWOT analysis of biodiversity hot spot in India 3.5 Conservations of biodiversity - objects, and laws for conservation of biodiversity	Lecture Using Chalk-Board Presentations Video Demonstrations
4	TLO 4.1 Classify the pollution based on the given criteria TLO 4.2 Justify the need of preserving soil as a resource along with the preservation techniques TLO 4.3 Maintain the quality of water in the given location using relevant preventive measures TLO 4.4 State the significance of controlling the air pollution to maintain its ambient quality norms TLO 4.5 Compare the noise level from different zones of city with justification TLO 4.6 Describe the roles and responsibilities of central and state pollution control board	**Unit - IV Environmental Pollution** 4.1 Definition of pollution, types- Natural & Artificial (Man- made) 4.2 Soil / Land Pollution – Need of preservation of soil resource, Causes and effects on environment and lives, preventive measures, Soil conservation 4.3 Water Pollution - sources of water pollution, effects on environment and lives, preventive measures, BIS water quality standards for domestic potable water, water conservation 4.4 Air pollution - Causes, effects, prevention, CPCB norms of ambient air quality in residential area 4.5 Noise pollution - Sources, effects, prevention, noise levels at various zones of the city 4.6 Pollution Control Boards at Central and State Government level: Norms, Roles and Responsibilities	Lecture Using Chalk-Board Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Explain Constitutional provisions related to environmental protection TLO 5.2 Explain importance of public participation (PPP) in enacting the relevant laws TLO 5.3 Use the relevant green technologies to provide sustainable solutions of an environmental problem TLO 5.4 Explain the role of information technology in environment protection	**Unit - V Enviornmental legislation and sustainable practices** 5.1 Article (48-A) and (51-A (g)) of Indian Constitution regarding environment, Environmental protection and prevention acts 5.2 Public awareness about environment. Need of public awareness and individuals' participation. Role of NGOs 5.3 Green technologies like solar desalination, green architecture, vertical farming and hydroponics, electric vehicles, plant-based packaging 5.4 Role of information technology in environment protection and human health	Lecture Using Chalk-Board Presentations Video Demonstrations

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

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

Assignment

•

Suggest the steps to implement (or improve the implementation) of the 5R policy in your home/institute stating your contribution
Draft an article on India's Strategies to progress across the Sustainable Development Goals
Make a chart of Renewable and non-renewable energy sources mentioning the advantages and disadvantages of each source
Conduct the SWOT analysis of biodiversity hotspot in India
Prepare a mind-mapping for the zero carbon footprint process of your field
Prepare a chart showing sources of pollution (air/water/ soil), its effect on human beings, and remedial actions
Any other assignment on relevant topic related to the course suggested by the facilitator

UNICEF Certification(s)

- Students may complete the self-paced course launched by Youth Leadership for climate Exchange under UNICEF program on portal www.mahayouthnet.in . The course encompasses five Modules in the form of Units as given below: -

Unit 1: Living with climate change
Unit 2 : Water Management and Climate Action
Unit 3: Energy Management and Climate Action
Unit 4 : Waste Management and Climate Action
Unit 5 : Bio-cultural Diversity and Climate Action
If students complete all the five Units they are not required to undertake any other assignment /Microproject/activities specified in the course. These units will suffice to their evaluations under SLA component

Micro project

•

Technical analysis of nearby commercial RO plant.
Comparative study of different filters used in Household water filtration unit
Evaluate any nearby biogas plant / vermicomposting plant or any such composting unit on the basis of sustainabilityand cost-benefit
IKS-Study and prepare a note on Vedic and Pre-Vedic techniques of environmental conversion

Visit a local polluted water source and make a report mentioning causes of pollution
Any other activity / relevant topic related to the course suggested by the facilitator

Activities

•

Prepare a report on the working and functions of the PUC Center machines and its relavance in pollution control.
Prepare and analyse a case study on any polluted city of India
Prepare a note based on the field visit to the solid waste management department of the municipal corporation / local authority
Record the biodiversity of your institute/garden in your city mentioning types of vegetation and their numbers
Visit any functional hall/cultural hall /community hall to study the disposal techniques of kitchen waste and prepare a report suggesting sustainable waste management tool
Watch a video related to air pollution in India and present the summary
Any other assignment on relevant topic related to the course suggested by the facilitator

Note :

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

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Nil	All

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Environment and climate change	CO1	8	4	4	4	12
2	II	Sustainability and Renewable Resources	CO2	10	4	4	8	16
3	III	Ecosystem and Biodiversity	CO3	8	4	4	4	12
4	IV	Environmental Pollution	CO4	12	4	8	6	18
5	V	Enviornmental legislation and sustainable practices	CO5	7	4	4	4	12
Grand Total				**45**	**20**	**24**	**26**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests (MCQs) of 30 marks will be conducted and average of two-unit tests considered. Formative assessment of self learning of 25 marks should be assessed based on self learning activity such as UNICEF Certification(s)/Microproject/assignment/activities. (60 % weightage to process and 40 % to product)

Summative Assessment (Assessment of Learning)

- Online MCQ type Exam

XI. SUGGESTED COS - POS MATRIX FORM

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Y. K. Singh	Environmental Science	New Age International Publishers, 2006, ISBN: 81-224-2330-2
2	Erach Bharucha	Environmental Studies	University Grants Commission, New Delhi
3	Rajagopalan R.	Environmental Studies: From Crisis to Cure.	Oxford University Press, USA, ISBN: 9780199459759, 0199459754
4	Shashi Chawla	A text book of Environmental Science	Tata Mc Graw-Hill New Delhi
5	Arvind Kumar	A Text Book of Enviornmental science	APH Publishing New Delhi (ISBN 978-8176485906)

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://sdgs.un.org/goals	United Nation’s website mentioning Sustainability goals
2	http://www.greenbeltmovement.org/news-and-events/blog	Green Belt Movement Blogs on various climatic changes and other issues
3	http://www.greenbeltmovement.org/what-we-do/tree-planting-fo r-watersheds	Green Belt Movement's work on tree plantation, soil conservation and watershed management techniques
4	https://www.youtube.com/@ierekcompany/videos	International Experts For Research Enrichment and Knowledge Exchange – IEREK's platform to exchange the knowledge in fields such as architecture, urban planning, sustainability
5	www.mahayouthnet.in	UNICEF Intiative for youth leadership for climate action

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Sr.No	Link / Portal	Description
6	https://eepmoefcc.nic.in/index1.aspx?lsid=297&lev=2&lid=1180&langid=1	GOI Website for public awareness on enviornmetal issues
7	https://egyankosh.ac.in/handle/123456789/61136	IGNOU's Intiative for online study material on Enviornmental studies
8	https://egyankosh.ac.in/handle/123456789/50898	IGNOU's Intiative for online study material on sustainability
9	https://sustainabledevelopment.un.org/content/documents/11803Official-List-of-Proposed-SDG-Indicators.pdf	Final list of proposed Sustainable Development Goal indicators
10	https://sustainabledevelopment.un.org/memberstates/india	India’s Strategies to progress across the SDGs.
11	https://www.un.org/en/development/desa/financial-crisis/sustainable-development.html	Challenges to Sustainable Development
12	https://nptel.ac.in/courses/109105190	NPTEL course on sustainable development
13	https://onlinecourses.swayam2.ac.in/cec19_bt03/preview	Swayam Course on Enviornmetal studies (Natural Resources, Biodiversity and other topics)
14	https://onlinecourses.nptel.ac.in/noc23_hs155/preview	NPTEL course on enviornmental studies which encomopasses SDGs, Pollution, Cliamate issues, Energy, Policies and legal framework
15	https://www.cbd.int/development/meetings/egmbped/SWOT-analysis-en.pdf	SWOT analysis of Biodiversity
16	https://www.sanskrit.nic.in/SVimarsha/V2/c17.pdf	Central sanskrkit university publication on Vedic and pre vedic enviornmetal conservation

Note :

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