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

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 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
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.

METROLOGY AND MEASUREMENT **Course Code : 313316**

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
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

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

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.
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

METROLOGY AND MEASUREMENT **Course Code : 313316**

Sr.No	Link / Portal	Description
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