Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Third**

Course Title : **Engineering Metrology**

Course Code : **22342**

1. RATIONALE

Measurement activities are given prime importance in industry. The diploma technicians often come across measuring different parameters of machined components and the appropriate fitment of interchangeable components in the assemblies. The student has to identify the variables to be measured, decide the accuracy required, select the instrument, investigate reasons for defects and give suggestions, decide whether to accept or reject the jobs, suggest methods of salvaging the defective material manufactured. The different methods and instruments which can be used for linear and angular measurements, geometrical parameters (like surface finish, Squareness, Parallelism, Roundness etc) and the use of gauges and system of limits, fits, tolerances etc. are often required to be dealt in detail by a diploma engineer on the shop floor. Therefore, this course attempts to impart the necessary knowledge and develop the required abilities so that he can perform his job efficiently and effectively in modern industry.

2. COMPETENCY

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

- **Use relevant instruments to measure various parameters of machine components.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Select the relevant instrument for measurement.
b. Use different types of comparators.
c. Select gauges, fits and tolerances for machine components.
d. Use relevant instruments to measure different parameters of screw thread and gear.
e. Use linear and angular measuring instruments.
f. Select relevant surface testing methods.

4 TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken

during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.
Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

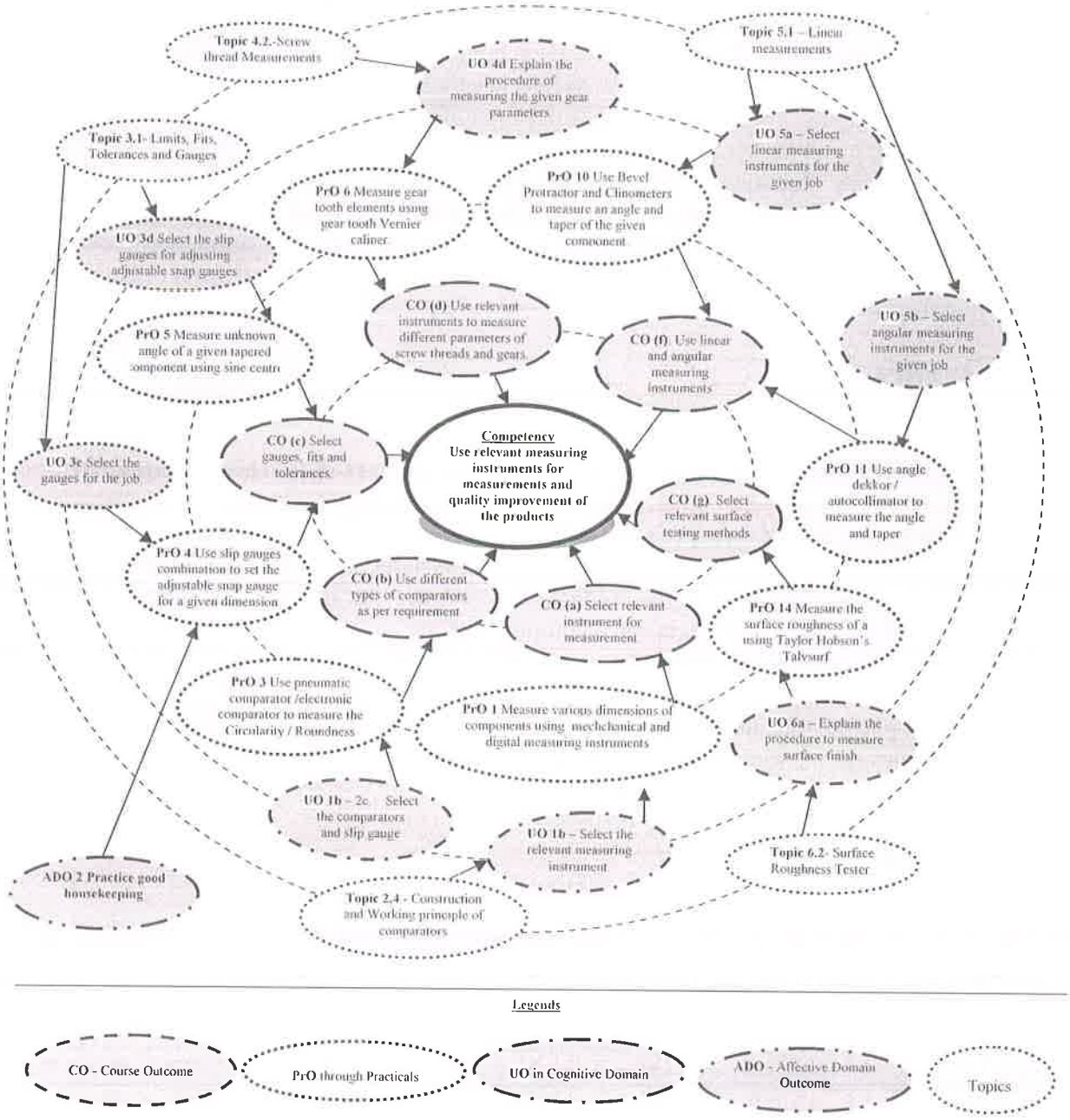

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Measure various dimensions of a given components using radius gauge, Vernier caliper, Vernier height gauge, micrometer (use both mechanical and digital).	I	02
2	Measure bores of a give sample using internal micrometers and dial bore indicators.	II	02*
3	Use pneumatic comparator /electronic comparator to Measure the Circularity / Roundness of the given specimen and compare it with the given standard	II	02
4	Use slip gauges combination to set the adjustable snap gauge Go end and No-Go end for a given dimension.	III	02*
5	Measure gear tooth elements using gear tooth Vernier caliper.	IV	02
6	Measure the effective diameter of the screw thread using profile projector / Tool maker Microscope.	IV	02*
7	Use floating carriage micrometer to measure minor, major and effective diameter of screw thread.	IV	02*
8	Measure unknown angle of a given tapered component using sine centre in combination with slip gauges.	V	02
9	Use Bevel Protractor and Clinometers to measure an angle and taper of the given component.	V	02*
10	Use angle dekkor / autocollimator to measure the angle and taper of given component.	V	02*
11	Measure flatness of the given component by interpreting fringes using monochromatic light source and optical flat.	VI	02
12	Measure flatness of a given surface plate using spirit level.	VI	02*
13	Measure the surface roughness of a given sample using Taylor Hobson's Talysurf / surface roughness tester.	VI	02*
14	Use dial indicator to check the Lathe machine parameters like parallelism, squareness, trueness, alignment.	VI	02
15	Measure run out of cylindrical component using dial indicator.	VI	02
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1.	Prepare experimental set up	10

S. No.	Performance Indicators	Weightage in %
2.	Handling of measuring instruments precisely during performing practical.	30
3.	Follow Safety measures	10
4.	Accuracy in Measurement	20
5.	Answers to questions related with performed practices.	10
6.	Submit journal report on time	10
7.	Follow Housekeeping	5
8.	Attendance and punctuality	5
TOTAL		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member
e. Maintain tools and equipment
f. Follow ethical practices

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment Name with Broad Specifications	PrO S.No.
1	Vernier Calliper-0-200mm (Mannual)	1
2	Digital Vernier Caliper- 0-200mm	1
3	Radius gauge (0.01mm to 14mm)	1
4	Screw pitch gauge – mm and TPI	1
5	Filler gauge (0.01 to 1.9mm)	1
6	Micrometer-0-25mm, 25-50mm.	1
7	Dial Micrometer (0- 25mm),(25-50mm)	1
8	Surface Plate-Granite. (200 x200x 50)	1
9	Vernier Height and Depth Gauge (mechanical and digital) 0-300mm	1
10	Micrometer Depth Gauge. (0-150mm)	1
11	Sine Bar, Sine Centre (0-200mm)	7
12	Slip Gauge set- Grade 1, 87 Pieces	2,7
13	Angle gauges box, Grade 1	7

S. No.	Equipment Name with Broad Specifications	PrO S.No.
14	Universal bevel protractor:Graduation: 5min.(0°- 90°- 0°) Blade 150, 300 mm.	8
15	Angle dekkor and Autocollimator (0 to 30')	9
16	Profile projector with gear profile/Thread profile Templates: Opaque fine grained ground glasss screen with 90°, 60°, 30° cross line Location; fitted with graduated ring (0-360°) L.C. 1min; Optics Std10X, 20X, Measuring Range Std 100mm x 100mm; Opt X axis upto 400mm, Y axis upto 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
17	Screw pitch gauge. (0-25mm)	4
18	Floating Carriage Micrometer: Least count: 0.001 mm; Standard micrometer or electronic type; Non rotary 8mm micrometer spindle; Indicator with 0.001mm std dial; Admit between center 200 mm; Max Diameter capacity 100mm; Standard Accuracy + or – 0.005mm;	6
19	Monochromatic light source unit – 1 unit Light Source: 35W Sodium Wavelength: 0.575 micron; Power 220V/50HZ (110V available on request)	10
20	Optical flat set Range (0.2μm) Diameter/thickness 45/12mm and 60/15mm.	10
21	Gauges-plug (3piece) Grade A/X	2,3,6
22	Snap gauge- adjustable/ double ended (3piece) Grade A/X	3
23	Steel Ring gauges: Grade A/X, 1.5-2.00, 2.0-4.0, 4.0-12.0, 12.0-20.0 mm	2,3
24	Dial Indicator(0-25mm) with magnetic stand	12
25	Clinometer: Base length: 200 mm / 1000 mm • Measuring range: ± 17.5 mm/m (± 1°) • Sensitivity per Digit: ± 0.001 mm/m • Accuracy: < ± 0.2% (full scale) • Linearity: < ± 0.2% (full scale) • Operating temperature: – 10° to + 40°C	8
26	Gear tooth vernier caliper (0-25mm)	4
27	Spirit Level: Base length : 200 mm + 1 mm; Base width : 20 mm + 0 – 1; Height : 25 + 1 mm; Bubble opening : 50 mm x 8 mm (length x width); Sensitivity : 2 Min. 30 Sec per 2 mm arc division of the vial; Least count of graduation : 2 mm; Effective length of bubble : 20 + 1 mm	12
28	Tool maker's microscope: Dimensions 152 x 152mm; Stage glass size 96 x 96mm; Feeding range 50 x 50 mm; Maximum height 115mm x 107mm; Workpiece 5Kg; Light source :24V, 2W (special bulb); Continuously adjustable light intensity; Green filter.	5
29	Parkinson's Tester/ Gear Rolling Tester with master gears: Accuracy 0.25mm, Gear diameter of 40-80mm, Base size 320 x 100mm, Prject magnification 5x, Involute profile testing.	4
30	Roundness measuring machine (0-1000mm)	13
31	Pneumatic comparator – Air gauge unit with compressor; Generated pressure range: (-0.95~60)bar; media: Air; Adjust resolution:0.1mbar(10Pa); Buna-N for seals; Output interface connection:M20×1.5Female.	2
32	Electronic Comparator: Work Base : high chrome high carbon, hardened, ground & lapped; A precision electronic probe is provided with the unit with a measuring range of + /- 2.0 m.m; Counter : A single line display counter unit resolution 0.0001 m.m, 0.001 m.m.	2
33	Surface roughness Taylor Hobson's Tester (max. sample length 0.8mm)	11

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to Metrology	1a. Explain the testing parameters used for the given instrument. 1b. Select the relevant measuring instrument for the given job with justification. 1c. Select the various measuring standards as per situation with justification. 1d. Calculate the least count of all basic measuring instruments.	**Metrology Basics** 1.1 Definition of metrology, objectives of metrology. 1.2 Categories of metrology, Scientific metrology, Industrial metrology, Legal metrology. 1.3 Need of inspection, Precision, Accuracy ,Sensitivity, Readability, Calibration, Traceability, Reproducibility. 1.4 Sources of errors, Factors affecting accuracy. 1.5 Selection of instrument, Precautions while using an instruments for getting higher precision and accuracy. 1.6 Concept of least count of measuring Instrument.
Unit– II Standards and Comparators	2a. Select the various measuring standards for given situation with justification. 2b. Explain the construction and working principle of the given comparator. 2c. Select the comparators and slip gauge for the given job.	2.1 Definition and introduction to line Standard, end standard, Wavelength standard and their comparison. 2.2 Slip gauge and its accessories. 2.3 Definition and Requirement of good comparator, Classification, use of comparators. 2.4 Construction and Working principle of comparators- Dial indicator, Sigma Comparator, Pneumatic comparator- high pressure differential type. 2.5 Relative advantages and disadvantages.
Unit– III Limits, Fits, Tolerances and Gauges	3a. Apply limits, fits and tolerances on the given job. 3b. Select grades, fits and tolerances from tolerance chart for the given sample. 3c. Select the gauges for the given job with justification. 3d. Select the slip gauges for adjusting adjustable snap gauges with	3.1 Concept of Limits and Fits, deviation and Tolerances. 3.2 Basic Terminology, Selective Assembly, Interchangeability. 3.3 Indian standard (IS 919-1993) Fits, types of fits,Hole and Shaft Basis System, guide for selection of fit. 3.4 ISO system of limit and fit,(Numerical on finding the limit and tolerances of hole andshaft assembly). 3.5 Gauges: Limit gauges. Taylors principle of gauge design Plug, Ring Gauges, snap gauge, adjustable snap gauge.

	justification.	
Unit– IV Screw thread Measurements and Gear Measurement	4a. Calculate screw thread Parameters using the given method. 4b. Identify different elements of the given screw thread. 4c. Explain different types of errors in thread and pitch of the given screw thread. 4d. Explain the procedure of measuring the given gear parameters.	4.1 Screw thread terminology, Errors in threads and Pitch 4.2 Measurement of different elements such as major diameter, minor diameter, effective diameter, pitch diameter , Best size of wire Two wire method, Thread gauge micrometer. 4.3 working principle of floating carriage micrometer. 4.4 Introduction to Tool Maker's Microscope, applications and working principle. **Gear Measurement** 4.5 Analytical and functional inspection of Gear, Measurement of tooth thickness by constant chord method and base tangent Method by Gear Rolling tester / Parkinson's Gear Tester. 4.6 Measurement of tooth thickness by Gear tooth Vernier and Profile projector Errors in gears such as backlash, run out.
Unit– V Linear and Angular Measurement	5a. Select linear measuring instruments for the given job with justification. 5b. Select angular measuring instruments for the given job with justification. 5c. Explain the concept of angular measurement with the help of given sample. 5d. Explain the procedure of measuring angles using different instruments for the given job.	5.1 Concept of linear measurement and its instruments: surface plate, V-block, calipers, combination set, depth gauge, vernier instruments, micrometer instruments, slip gauges. 5.2 Concept of angular measurement. 5.3 Instruments for angular Measurements. 5.4 Use and working of universal bevel protractor, sine bar, spirit level. 5.5 Principle of Working of Clinometers, Angle Gauges (With Numerical on Setting of Angle Gauges), Angle dekkor as an angular comparator.
Unit–VI Other Measurements	6a. Explain the procedure to measure surface finish of the given components. 6b. Select machine tool test and alignment test for the given job with justification.	61 Primary and secondary texture, terminology of surface texture as per IS 3073-1967, CLA, Ra, RMS, Rz values and their interpretation, Symbol for designating surface finish on drawing. 62 Various techniques of qualitative analysis, working principle of stylus probe type instruments, Surface

	6c. Measure the surface finish of the given components. 6d. Explain the procedure for measuring complex dimensions of the given job using CMM.	Roughness Tester, Interferometry. 63 Parallelism, Straightness, Squareness, roundness, run out, alignment tests of Lathe and Drilling, machine tools as per IS standard. 64 Flatness testing using Monochromatic light source with optical flat, Introduction to CMM.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Metrology	06	02	04	04	10
II	Standards and Comparators	10	02	04	04	10
III	Limits, Fits ,Tolerances and Gauges	08	02	04	06	12
IV	Screw thread Measurements and Gear Measurement	08	02	04	06	12
V	Linear and Angular Measurement	08	04	04	04	12
VI	Other Measurements	08	04	04	06	14
Total		**48**	16	24	30	70

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews

a. Prepare journal based on practical performed in Metrology laboratory .Journal consist of drawing, observations , required measuring tools, equipments, date of performance with teacher signature.
b. Prepare/Download a specifications of followings:
   i. Measuring Tools and equipment in Metrology laboratory.
   ii. Machineries in Metrology laboratory
c. Undertake a market survey of local dealers for Measuring equipments and prepare a report.
d. Visit to any Tool room and prepare a report consisting
   i. Different advanced Measuring Instruments
   ii. Different Measuring standards and Calibration process
   iii. Care and maintenance of measuring instruments observed.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
b. 'L' in item No. 4 does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About 15-20% of the topics/sub-topics which is relatively simpler or descriptive in nature is to be given to the students for self-directed learning and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for co-curricular activities.
e. Guide student(s) in undertaking micro-projects.
f. Arrange visit to nearby industries for understanding various Measuring processes.
g. Show video/animation films to explain functioning of various measuring Instruments.
h. Give Micro projects.
i. Use different instructional strategies in classroom teaching.
j. In respect of item no.10 above the teachers need to ensure to create opportunities and pursue for such co-curricular activities.

12. SUGGESTED TITLES OF MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Comparative study of various linear measuring Instruments Like Steel Rule, Inside – outside Calliper, Inside-outside Vernier caliper, Inside-outside Micrometer, Digital Vernier caliper, Digital Micrometer (any one) with proper justifications.
b. Comparative Study of surface finish of Various Samples manufactured by various manufacturing processes (min.5) using surface roughness instruments with proper justification
c. Collect information of Coordinate Measuring Machine and prepare a report.
d. Comparative study of different parameters of Spur gear (Min. 5) having same module using appropriate instruments.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Engineering Metrology	R K Jain	Khanna Publication, New Delhi, 2014, ISBN-10: 817409153X
2.	Metrology and Measurement	A K Bewoor and V A Kulkarni	McGraw Hill Education (India) Pvt. Ltd. , New Delhi, 2017, ISBN13-9780070140004
3.	Engineering Metrology and Measurement	S B Raghvendra and Krishnamurthy	Oxford Publication, New Delhi, 2013, ISBN-13: 978-0198085492
4.	Measurement and Metrology	R K Rajput	S.K. Kataria and Sons, New Delhi, 2013, ISBN-13: 978-9350142301
5	Engineering Metrology for Engineers	J. F. W. Galyer and C.R. Shotbolt	Prentice Hall Publication, New Delhi, 2007, ISBN-10: 8179928486

14. SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/112106138
b. https://cosmolearning.org/video-lectures/pyrometry-cont
c. Tangram Software for CMM
d. Dong-Do software for Electronic comparator
e. https://www.youtube.com/watch?v=VpmZjIsV4C4
f. www.youtube.com/watch?v=qNlIZYAk9pI
g. https://www.youtube.com/watch?v=xcvNl1HHY9o
h. https://www.youtube.com/watch?v=DxdFiIDrFBc
i. https://www.youtube.com/watch?v=-_ZeUgVjajc
j. https://www.youtube.com/watch?v=iTjBPHtADA4
k. https://www.youtube.com/watch?v=I4h644S_64w
l. https://www.youtube.com/watch?v=XQT6RSNN9sA
m. https://www.youtube.com/watch?v=FgNAlKTTNtE
n. https://www.youtube.com/watch?v=sLZeR7RMGFA
o. https://www.youtube.com/watch?v=QGBRwXwxnuU
p. https://www.youtube.com/watch?v=jTbRMMgbnNU
q. https://www.youtube.com/watch?v=KeZ5CfPOlBc
r. https://www.youtube.com/watch?v=3hOVfbGSQ0c
s. https://www.youtube.com/watch?v=80sNyYPTXPA
t. https://www.youtube.com/watch?v=EWqThb9Z1jk
u. https://www.youtube.com/watch?v=j-u3IEgcTiQ
v. https://www.youtube.com/watch?v=CLEP5LQ-y0I