Program Name : **Diploma in Production Engineering / Production Technology**

Program Code : **PG / PT**

Semester : **Fourth**

Course Title : **Metrology and Quality Assurance**

Course Code : **22450**

1. RATIONALE

This subject is related with the science of measurements and quality assurance. After studying this subject the diploma technicians working in manufacturing organization shall be able to handle various measuring instruments and do quality inspection. This course will facilitate students to select the appropriate measuring instruments for different types of measurements and able to take various decisions regarding acceptance or rejection of produced components by investigating reasons for defects formed and giving suggestions for improvements in it.

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 measuring instruments and quality improvement tools.**

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 comparators as per requirement.
b. Select grades, fits and tolerances.
c. Use relevant instruments to measure different parameters of screw thread and gear.
d. Use linear and angular measuring instruments.
e. Use relevant surface testing methods.
f. Maintain quality of products and service.

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
4	-	2	6	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

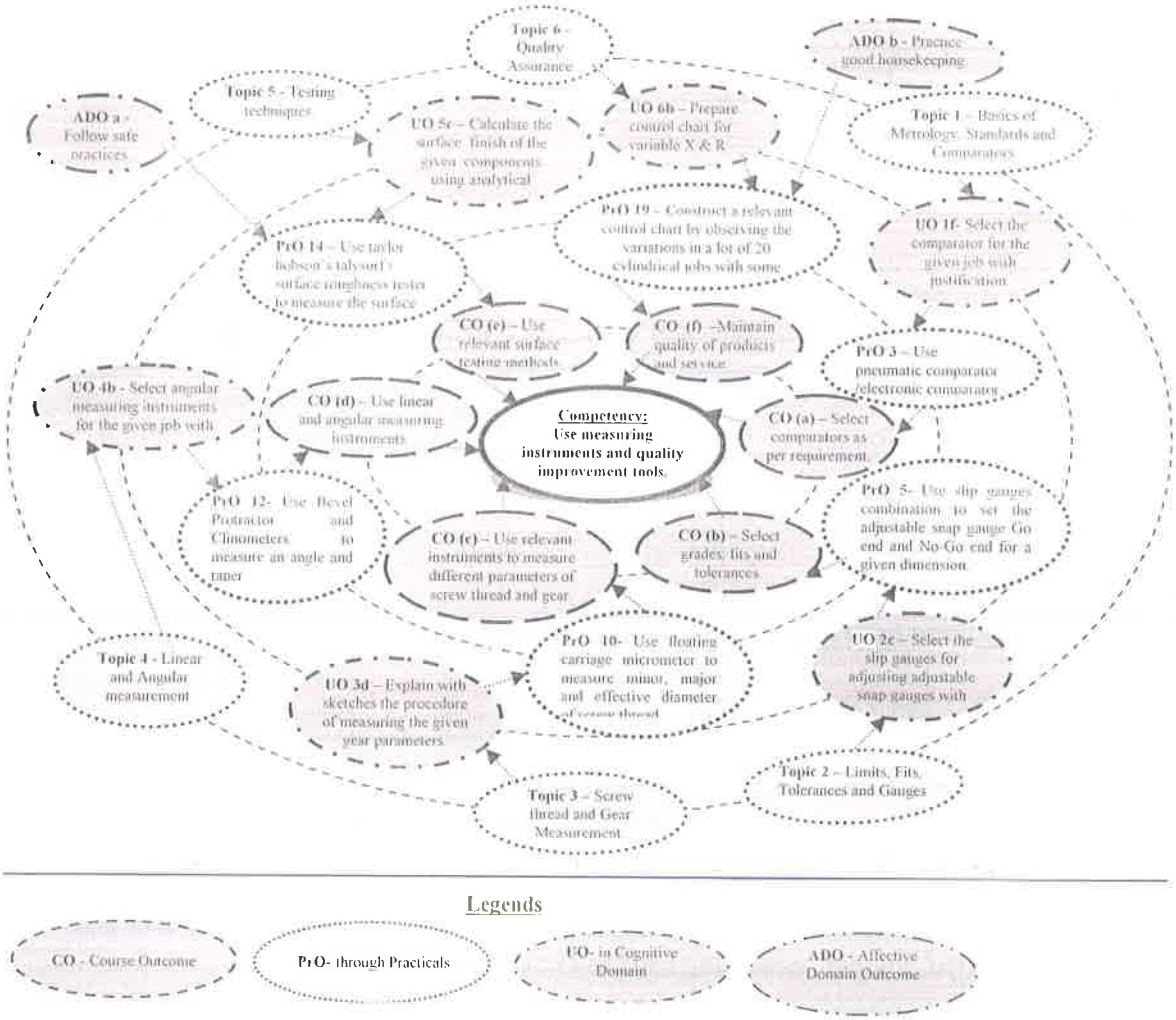

Figure 1 - Course Map

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	Use radius gauge, Vernier caliper, Vernier height gauge, micrometer (use both mechanical and digital) to measure dimensions of a given components.	IV	2*
2	Use internal micrometers and dial bore indicators to measure bores of a give sample.	IV	2
3	Use pneumatic comparator /electronic comparator to measure the Circularity / Roundness of the given specimen and compare it with the given standard.	I	2
4	Use monochromatic light source and optical flat to measure flatness of the given component by interpreting fringes.	V	2
5	Use slip gauges combination to set the adjustable snap gauge Go	II	2

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	end and No-Go end for a given dimension.		
6	Use sine centre in combination with slip gauges to measure unknown angle of a given tapered component.	IV	2*
7	Calibrate Dial gauge using dial gauge Tester.	I	2*
8	Use gear tooth Vernier caliper Constant Chord /Span Micrometer to measure gear tooth elements.	III	2
9	Use profile projector / Tool maker Microscope to measure the effective diameter of the screw thread.	III	2*
10	Use floating carriage micrometer to measure minor, major and effective diameter of screw thread.	III	2
11	Calculate the least count of the given measuring Instruments and compare the results.	I	2*
12	Use Bevel Protractor and Clinometers to measure an angle and taper of the given component.	IV	2
13	Use angle dekkor / autocollimator to measure the angle and taper of given component.	IV	2*
14	Use Taylor Hobson's Talysurf / surface roughness tester to measure the surface roughness of a given sample.	V	2*
15	Use roughness tester to identify the surface finish of the given components.	V	2
16	Use dial indicator to check the Lathe machine parameters like parallelism, squareness, trueness, alignment.	V	2
17	Use dial indicator to measure run out of cylindrical component.	V	2
18	Use CMM for Measuring different dimensions of the given engineering product.	V	2
19	Construct a relevant control chart by observing the variations in a lot of 20 cylindrical jobs with some nominal outside diameter.	VI	2*
19	Test the given product for ensuring the quality characteristics, quality of design, quality of conformance and quality of performance.	VI	2
20	Perform the quality audit for the given problem and prepare the report.	VI	2
	Total		**40**

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 12 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 %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10

S. No.	Performance Indicators	Weightage in %
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	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 safety 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. No.
1	Vernier Caliper – 0–200 mm (Manual)	1
2	Digital Vernier Caliper – 0-200 mm	1
3	Radius gauge (0.01 mm to 14 mm)	1
4	Screw pitch gauge – mm and TPI	1
5	Filler gauge (0.01 to 1.9 mm)	1
6	Micrometer – 0–25 mm, 25-50 mm	1
7	Dial Micrometer (0–25 mm), (25–50 mm)	1
8	Surface Plate - Granite (200 x 200 x 50)	1
9	Vernier Height Gauge and Depth Gauge (mechanical and digital) 0-300 mm	1, 6, 7
10	Micrometer Depth Gauge (0- 150 mm)	1
11	Sine Bar, Sine Centre (0-200 mm)	1
12	Slip Gauge set - grade 1	6
13	Angle gauges box-Grade 1	5, 6
14	Universal bevel protractor: Graduation - 5 min. (0°- 90°- 0°) Blade 150, 300 mm.	7
15	Angle Dekkor and Autocollimator (0 to 30')	12
16	Profile projector with gear profile/Thread profile Templates: Opaque fine grained ground glasses screen with 90°, 60°, 30° cross line	13
		9

S. No.	Equipment Name with Broad Specifications	PrO. No.
	Location; fitted with graduated ring (0-360°) L.C. 1 min; Optics Std. 10X, 20X, Measuring Range Std. 100 mm x 100 mm; Opt X axis upto 400 mm, Y axis upto 200 mm; Focusing Travel 100 mm; 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.	
17	Screw pitch gauge (0-25 mm)	9, 10
18	Floating Carriage Micrometer: Least count - 0.001 mm; Standard micrometer or electronic type; Non-rotary 8 mm micrometer spindle; Indicator with 0.001mm std. dial: Admit between center 200 mm; Max Diameter capacity 100 mm; Standard Accuracy + or – 0.005 mm.	10
19	Monochromatic light source unit – 1 unit Light Source: 35W Sodium Wavelength: 0.575 micron: Power 220 V/50 HZ (110V available on request)	4
20	Optical flat set Range (0.2μm) Diameter/thickness 45/12 mm and 60/15 mm.	4
21	Gauges - plug (3piece) Grade A/X	5
22	Snap gauge - adjustable/ double ended (3piece) Grade A/X	5
23	Steel Ring gauges: Grade A/X, 1.5-2.00, 2.0-4.0, 4.0-12.0, 12.0-20.0 mm	5
24	Dial Indicator (0-25 mm) with magnetic stand	16
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.	12
26	Gear tooth Vernier caliper (0-25 mm)	8
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.	4
28	Tool Maker's microscope: Dimensions 152 x 152mm, Stage glass size 96 x 96mm, Feeding range 50 x 50 mm, Maximum height 115 mm x 107 mm, Workpiece 5Kg, Light source: 24V, 2W (special bulb), Continuously adjustable light intensity, Green filter.	9
29	Parkinson's Tester/ Gear Rolling Tester with master gears: Accuracy 0.25mm, Gear diameter of 40-80 mm, Base size 320 x 100 mm, Project magnification 5x, Involute profile testing.	8
30	Roundness measuring machine (0-1000 mm)	16, 17
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.	3
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 mm; Counter : A single line display counter unit resolution 0.0001 mm, 0.001 mm.	3
33	Surface roughness Taylor Hobson's Tester (max. sample length 0.8 mm)	11

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Basics of Metrology, Standards and Comparators	1a. Explain the testing parameters used for the given instrument. 1b. Explain the sources and types of errors for the given instrument. 1c. Select the relevant measuring instrument for the given job with justification. 1d. Convert given types of standards as per the given situation. 1e. Select measuring standards as per situation with justification. 1f. Select the comparator for the given job with justification. g. Explain with sketch construction and working principle of the given type of comparator.	**Basics of Metrology:** 1.1 Metrology and its objectives. Need of inspection. 1.2 Precision, Accuracy, Sensitivity, Readability, Calibration, Repeatability, Reproducibility. 1.3 Sources and types of errors. 1.4 Selection of instrument, Factors affecting accuracy, Precautions while using instruments for getting higher precision and accuracy. 1.5 Concept of least count of measuring Instrument. **Standards of measurements:** 1.6 Definition and introduction to line Standard, end standard, Wavelength standard and their comparison. 1.7 Calibration of end bars. **Comparators:** 1.8 Definition, classification, requirement of good comparator and uses of comparator. 1.9 Construction, working principle and relative merits and demerits of Dial indicator, Sigma comparator and high pressure differential type Pneumatic comparator.
Unit– II Limits, Fits, Tolerances and Gauges	2a. Apply limits, fits and tolerances on the given drawing. 2b. Select grades, fits and tolerances from tolerance chart for the given job with justification. 2c. Select the slip gauges for adjusting adjustable snap gauges with justification. 2d. Select the gauges for the given job with justification.	2.1 Concept of Limits and Fits, allowance, deviation and Tolerance. 2.2 Basic Terminology, Selective Assembly, Interchangeability. 2.3 Indian standard (IS 919-1993) Fits, types of fits, Hole and Shaft Basis System, guide for selection of fits. 2.4 ISO system of limit and fit. (Numerical on finding the limit and tolerances of hole and shaft assembly) 2.5 Gauges: Limit gauges, Taylor's principle of gauge design, Plug, snap gauge and adjustable snap gauge.
Unit– III Screw thread and	3a. Calculate screw thread Parameters by using given method for the	**Screw Thread Measurements** 3.1 Screw thread terminology, Errors in threads and Pitch.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Gear Measurement	given data. 3b. Identify the different elements in the figure of the given screw thread. 3c. Explain with different types of errors in thread and pitch of the given screw thread. 3d. Explain with sketches the procedure of measuring the given gear parameters.	3.2 Measurement of different elements such as major diameter, minor diameter, effective diameter, pitch, Best size of wire, two wire method, Thread gauge micrometer. 3.3 Working principle of floating carriage micrometer. 3.4 Introduction to Tool Maker's Microscope, applications and working principle. **Gear Measurements** 3.5 Analytical and functional inspection of gear. Errors in gears such as backlash, run out etc; 3.6 Measurement of tooth thickness by constant chord method and base tangent method by Gear rolling tester/ Parkinson's gear tester. 3.7 Measurement of tooth thickness by gear tooth Vernier and profile projector.
Unit– IV Linear and Angular Measurement	4a. Select linear measuring instruments for the given job with justification. 4b. Select angular measuring instruments for the given job with justification. 4c. Explain the concept of angular measurement with the help of given sample. 4d. Explain with sketch the procedure of measuring angles using given instruments for the given job.	4.1 Concept of linear measurement and its instruments: surface plate, V-block, calipers, combination set, depth gauge, Vernier instruments, micrometer instruments, slip gauges. 4.2 Concept of angular measurements, Instruments for angular measurements. 4.3 Working of universal bevel protractor, sine bar, and spirit level, principle of working of Clinometers, Angle gauges (with numerical on setting of Angle gauges), Angle Dekker as an angular comparator.
Unit–V Testing techniques	5a. Select the alignment test for the given machine tool with justification. 5b. Explain the procedure of flatness testing for the given job. 5c. Calculate the surface finish of the given components using analytical method. 5d. Explain the procedure for measuring complex	5.1 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 5.2 Working principle of stylus probe type instruments, Surface roughness testers, interferometry. 5.3 Machine tool metrology parallelism, straightness, squareness, roundness, run out, alignment tests of Lathe and Drilling machine tools as per IS standard. 5.4 Flatness testing using Monochromatic light

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	dimensions of the given job using CMM.	source with optical flat. 5.5 Coordinate measuring machines (CMM): Introduction, operation and major applications.
Unit – VI Quality Assurance	6a. Interpret the given problem on the basis of given cost. 6b. Prepare control chart for variable X and R chart for the given data. 6c. Prepare control chart for attributes p, np and c chart for the given problem of defective samples. 6d. Test the given product for ensuring the quality characteristics. 6e. Perform the quality audit for the given problem. 6f. Explain the procedure of evaluating process capability of the given manufacturing process 6g. Prepare acceptance sampling for the given situation to draw the OC curve.	6.1 Concept and Meaning of Quality, Control and quality control. Objectives of quality control. Quality characteristics. 6.2 Quality of design, Quality of conformance and Quality of Performance, Concept of reliability and maintainability, Economics of quality, Cost of rework and repair. 6.3 Quality Audit: Quality assurance functions, Scope of quality audit practices, Quality and Inspection, Inspection stages, Difference between inspection & quality control. 6.4 Six sigma: Statistical meaning, six sigma approach, Introduction to ISO 9001-2008, ISO14000 and TS 16949 and its implementation. Concept of Zero defects. 6.5 Causes of variation, variable & attribute data, Tools for quality control, Control chart for variable X and R chart, control chart for attributes p, np and C-chart. 6.6 Process capability: Definition, Process capability of machine, Cp and Cpk calculations, Interpretation about process. 6.7 Concept of acceptance sampling, advantages and disadvantages of sampling inspection, operating characteristics (OC) Curve, different types of sampling plans with merits and demerits.

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	Basics of Metrology, Standards and Comparators	12	04	04	04	12
II	Limits, Fits, Tolerances and Gauges	08	02	04	02	08
III	Screw thread and Gear Measurement	10	04	04	04	12
IV	Linear and Angular Measurement	10	02	04	04	10
V	Testing Techniques	10	04	04	04	12
VI	Quality Assurance	14	06	06	04	16
	Total	**64**	**22**	**26**	**22**	**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 consists 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 different manufacturing processes (min. 5) using surface roughness instruments with proper justification.
c. Collect information of Coordinate Measuring Machine (CMM) and prepare a report.
d. Comparative study of different parameters of Spur gear (Min. 5) having same module using appropriate instruments.
e. List out the manufacturing organizations which are certified as Six Sigma, ISO 9001-2008, ISO-14000 or implementing any of the method of quality improvement with justification.
f. Draw frequency Histogram, frequency polygon and Ogive for given (min. 50 readings) samples. Find Mean, Mode, Median, Standard Deviation, Variance, Range and draw normal distribution curve. Do Pareto analysis.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Engineering Metrology	Jain R. K.	Khanna Publication, New Delhi. ISBN-10: 817409153X,
2	Engineering Metrology and Measurements	Raghvendra N. V., Krishnamurthy L.	Oxford University Press, New Delhi, 2013, ISBN-0-19-808549-4
3	Measurement and Metrology	Rajput R. K.	S. K. Kataria and Sons, New Delhi. ISBN-10: 9350142309
4	Total Quality Management	Mandal S. K.	Vikas Publishing House, Noida, 2015. ISBN-81-259-1663-6
5	Total Quality Management	B Senthi, Arasu Praveen Paul J	Scitech Publications (India) Pvt Ltd, Chennai, 2015,ISBN-9788183715782
6	Quality Control	Kulkarni V. A.., Bewoor A. K.	Wiley India Pvt. Ltd, New Delhi, 2012. ISBN: 978-81-265-1907-1

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.nptel.ac.in/courses/112106138
b. www.cosmolearning.org/video-lectures/pyrometry-cont
c. Tangram Software for CMM
d. Dong-Do software for Electronic comparator
e. www.youtube.com/watch?v=VpmZjIsV4C4
f. www.youtube.com/watch?v=qNlIZYAk9pI
g. www.youtube.com/watch?v=xcvNl1HHY9o

h. www.youtube.com/watch?v=DxdFiIDrFBc
i. www.youtube.com/watch?v=-_ZeUgVjajc
j. www.youtube.com/watch?v=iTjBPHtADA4
k. www.youtube.com/watch?v=I4h644S_64w
l. www.youtube.com/watch?v=XQT6RSNN9sA
m. www.youtube.com/watch?v=FgNAlKTTNtE
n. www.youtube.com/watch?v=sLZeR7RMGFA
o. www.youtube.com/watch?v=QGBRwXwxnuU
p. www.youtube.com/watch?v=jTbRMMgbnNU
q. www.youtube.com/watch?v=KeZ5CfPOlBc
r. www.youtube.com/watch?v=3hOVfbGSQ0c