GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: METROLOGY & INSTRUMENTATION
(Code: 3341905)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering, Mechatronics Engineering	**4th Semester**

1. RATIONALE

The students of Mechanical Engineering branch are basically concerned with manufacturing various machine components in shops as per given drawing. Today the industrial processing and manufacturing techniques have become complex and complicated and their control is very much difficult by human judgment only. Therefore, the exact and precise measurements are the basic need of the industries. This course of Metrology & Instrumentation, therefore, provides required knowledge and skills and creates self confidence in students so that they can work on shop floor independently for accurate and precise measurements and manufacturing.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Select and use appropriate analog and digital measuring and gauging instruments for a given manufacturing situation**

3. COURSE OUTCOMEs (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Measure the given mechanical elements and assemblies using linear and angular analog /digital measuring instruments.
ii. Check geometrical accuracy of given application.
iii. Explain surface roughness checking instruments.
iv. Measure and derive important dimensions of various thread forms and gears.
v. Select and use non destructive testing methods.
vi. Check the dimensions using the gauges.
vii. Select and measure variables using appropriate sensors and transducers.

4. TEACHING AND EXAMINATION SCHEME:

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
4	0	4	8	70	30	40	60	200

Legends: L -Lecture; **T -**Tutorial/Teacher Guided Student Activity; **P -**Practical; **C -** Credit; **ESE-**End Semester Examination; **PA -** Progressive Assessment.

5. COURSE DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I **Linear and angular measurement**	1a. Distinguish between accuracy, precision and error. 1b.Determine least count of given measuring instrument	1.1 Inspection, quality and quality control-definitions and differences. 1.2 Define accuracy, precision and error. 1.3 Principle of vernier scale and least count. 1.4 Surface plates-types, important features, standards/important sizes, applications and precautions in use.
	1c. Select suitable linear measurement instrument and measure the linear dimension of given component.	1.5 Types, constructional sketch, major parts and their functions, least count , measuring methods and measurement illustration (for e.g. 12.48mm)of: i. Vernier caliper. ii. Micrometer. iii. Telescopic gauge. iv. Height gauge. v. Depth gauge.
	1d. Describe the procedure for wring the slip gauge and set given dimension.	1.6 Slip gauge-types, applications, and wringing method.
	1e.Select suitable angular measurement instrument 1f. Describe the measurement procedure for the angular dimension of given component.	1.7 Sketch, major parts and their functions, least count , measuring methods and measurement illustration of: i. Bevel Protector. ii. Sine bar. iii. Angle gauges. iv. Angle Dekkor. v. Spirit level. vi. Clinometers. vii. Auto collimator. 1.8 Calibration – concept and need.
Unit – II	2a. Explain working of dial indicators.	2.1 Dial indicators/gauge-types, constructional sketch and applications.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Measurement of geometrical tolerances	2b.Select the measuring method and describe the measurement procedure for geometrical tolerance of given part/assembly.	2.2 Definition, symbol and measuring methods of: i. Straightness. ii. Flatness. iii. Squareness. iv. Parallism. v. Perpendicularity. vi. Roundness. vii. Concentricity. viii. Cylindricity. ix. Run out and ovality.
Unit – III **Measurement of surface roughness**	3a. Define various terminology used for surface roughness. 3b. Explain working of direct instrument methods.	3.1 Terminology used in connection with surface finish. 3.2 Comparison methods to inspect surface finish-concept and applications. 3.3 Direct instrument measurement methods-types and concepts. 3.4 Construction, working and applications of Talysurf surface roughness tester and Tomlinson tester.
	3c. Determine surface roughness of given data.	3.5 Centre line average and Root Mean Square systems of surface texture evaluation-terminology used, concept, equations and numerical examples. 3.6 Indication of various surface roughness characteristics with surface roughness symbols-interpretation.
Unit – IV **Gear and thread measurement**	4a. Define various terms used for gear nomenclature. 4b.Use gear tooth vernier to measure gear tooth thickness.	4.1 Types of gears. 4.2 Forms of gear teeth-types and concept. 4.3 Gear tooth Terminology. 4.4 Sketch, major parts and their functions, least count, measuring methods and measurement illustration of gear tooth vernier. 4.5 Derivation and numerical example to measure gear tooth thickness using: i Gear tooth vernier. ii Constant chord method. iii Base tangent method.
	4c. Explain working of profile projector.	4.6 Gear tooth profile measurement.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	4d. Define various terms used for thread nomenclature. 4e.Determine best wire size. 4f. Use two and three wire methods to determine effective diameter of thread. 4g.Describe method for measuring the pitch of given thread.	4.7 Threads-classification, elements, specifications and forms. 4.8 Measurement of major and minor diameters. 4.9 Three and two wire method of measuring effective diameter of external thread-concept, terminology used, best wire size, derivation of equation and numerical example. 4.10 Thread micrometer-sketch, method to use and determination of dimension. 4.11 Pitch measurement methods.
Unit – V **Limit gauges, Transducers and sensors**	5a. Select and check the given dimension using limit gauge.	5.1 Limit gauges-classification, sketch and applications. 5.2 Comparators-concept, types and applications.
	5b. Define static characteristics of instruments.	5.3 Instrumentation-introduction, performance characteristics. 5.4 Static characteristics of instruments.
	5c. Explain various transducers and sensors.	5.5 Transducers-concept, classifications, physical quantities which can be measured, advantages and disadvantages. 5.6 Electrical transducers-types, working principles and applications. i Linear Variable Differential Transformer (LVDT) type pressure gauge. ii Resistance type. iii Capacitance type. iv Inductance type (LVDT). v Piezo-electric. 5.7 Sensors- classification and applications.
Unit – VI **Non destructive testing**	6a. Explain various non destructive testing methods.	6.1 Non destructive testing (NDT) - concept, need and advantages. 6.2 NDT- important methods, working with sketch and applications.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – VII **Temperature, pressure and flow measurement**	7a. Select and describe the method for using appropriate temperature measuring device to measure temperature of given hot body.	7.1 Introduction. 7.2 Classification, working principle, construction, working, advantages, limitations and applications of temperature measuring devices: i. Mercury in glass thermometer. ii. Bimetallic thermometer. iii. Resistance thermometer. iv. Thermister. v. Thermocouple. vi. Radiation pyrometers. vii. Optical pyrometers.
	7b.Select and describe the method for using appropriate pressure and flow measuring device to measure pressure/flow.	7.3 Pressure measurement scales. 7.4 Types and applications of manometers (only list and applications). 7.5 Working principle, construction, working, advantages, limitations and applications of pressure measuring devices: i. Bellows type pressure gauge. ii. Diaphragm type pressure gauge. iii. Bourdon tube pressure gauge. iv. Dead weight piston gauge. 7.6 Concept of transducer based pressure measuring devices- resistance type, capacitance type and inductance type. 7.7 Classification of flow measuring devices. 7.8 Working principle, construction, working, advantages, limitations and applications of volumetric flow measuring devices: i. Bellows type. ii. Rotating impeller. iii. Rotating lobs. iv. Nutating Disc. v. Reciprocating piston. vi. Obstruction. 7.9 Working principle, construction, working, advantages, limitations and applications of velocity measuring

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		devices: i. Pitot tube. ii. Orifice meter. iii. Rota meter.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Linear and angular measurement	10	06	04	04	14
II	Measurement of geometrical tolerances	06	02	02	03	07
III	Measurement of surface roughness	06	02	02	03	07
IV	Gear and Thread measurement	12	04	04	06	14
V	Limit gauges, transducers and sensors	08	02	04	05	11
VI	Non destructive testing	06	02	02	03	07
VII	Temperature, pressure and flow measurement	08	03	03	04	10
Total		**56**	**21**	**21**	**28**	**70**

Legends: R = Remembrance; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

General Notes:

a. If midsem test is part of continuous evaluation, unit numbers I (Up to 1.6 only), II, III and VII (Up to point number 7.6 only) are to be considered.

b. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of*

*certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*
Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. required
1	I	**Preperatory Activity:** a. S.I. basic, supplementary and derived units and their conversions. Convert given length, area and volume from one unit to another. (From mm to cm and m, from mm to inch, from m to yard and foot, from mm^2 to $inch^2$ and vice-versa, mm^3 to $inch^3$ and vice-versa ,etc.). b. Convert given degree to radian and vice-versa. c. Various drafting, surface finish and geometrical symbols. d. Define axis, axes, centre, angles, plane, solid angle.	02
2	I	**Linear And Angular Measurement:** Each student will select and bring at least such five mechanical components which will have use of instruments specified below. Same are to be approved by teacher. After approval, student will: a. Sketch each component. b. Sketch and label main parts of instruments to be used. c. Calculate least count of the instrument/s to be used. d. Measure and record applicable dimensions of each component using: i. Vernier calliper. ii. Inside micrometer. iii. Outside micrometer. iv. Telescopic gauge. v. Height gauge. vi. Depth gauge. vii. Bevel protector. viii. Clinometers.	14
3	I	**Sine Bar:** Measure angle between two planes with the help of sine bar and slip gauges.	02
4	II	**Straightness:** a. Sketch the part and setup, list the instruments used, list the steps followed and record the observations for checking straightness. b. Plot straightness observations on graph paper.	02
5	II	**Flatness:** Sketch the part and setup, list the instruments used, list the steps followed and record the observations for checking flatness.	02

6	II	**Squareness, Perpendicularity And Parallity:** Sketch the part and setup, list the instruments used, list the steps followed and record the observations for checking following. a. Squareness. b. Perpendicularity and Parallity.	02
7	II	**Roundness, Cylindricity, Concentricity, Run Out And Ovality:** a. Sketch the part and setup, list the instruments used, list the steps followed and record the observations for checking roundness, cylindricity, concentricity, run out and ovality. b. Prepare polar graph for roundness observations.	02
8	III	**Surface Roughness:** a. Tabulate machining processes, and roughness values (Ra , mm),roughness grade number and roughness symbol. b. Demonstrate various surfaces having different roughness values. c. For given component, sketch the component, judge the roughness of surfaces and show surface roughness symbols on applicable surfaces. d. Measure surface roughness value of given machined surface.	04
9	IV	**Gear Measurement:** a. Sketch gear tooth nomenclature. b. Sketch gear tooth vernier and label each part. c. Calculate chordal thickness and height of given gear. d. Determine tooth height. e. Measure and compare chordal thickness of given spurs gear using gear tooth vernier.	02
10	IV	**Thread Measurement:** For given external threaded part: a. Draw nomenclature for ISO screw threads (Internal and external both). b. Explain and derive best wire size. c. Sketch the part and show the dimensions to be measured. d. Sketch the set up and instruments used to measure/derive major diameter, minor diameter and effective diameter using two wire and three wire methods. e. Measure the pitch. f. Use threaded ring gauge. g. Record observations.	04
11	V	**Limit Gauges:** a. Demonstrate use of various limit gauges. b. Select appropriate limit gauge for given dimension/part and check the dimension with gauge. c. Record your observations.	02
12	V	**Demonstration of Transducers and Sensors:** a. Demonstrate electrical (LVDT type, resistance type, capacitance type, inductance type and piezo-electric.) transducers and various sensors. b. Sketch each demonstrated transducers and sensors and tabulate specifications, range, resolution and applications of each.	04

13	VI	**Non Destructive Testing:** a. Demonstrate ultrasonic testing of NDT. b. Observe and interpret X ray test of any weld joint.	02
14	VII	**Temperature Measurement:** a. Sketch the set up and constructional sketch of thermocouple used to measure temperature. b. Measure the temperature of hot body/hot liquid with thermocouple. c. Record the observation.	02
15	VII	**Pressure Measurement:** a. Sketch the set up and constructional sketch of pressure gauge used to measure pressure. b. Measure the pressure with pressure gauge. c. Record the observation.	02
16	VII	**Flow Measurement:** a. Sketch the set up and venture meter used to measure flow. b. Measure the flow with venture meter. c. Record the observation.	02
17	ALL	**Mini Project and Presentation:** a. Select actual mechanical assembly from industry/real life/scrap shop/garage/etc. (made up of at least 4 to 5 mechanical components) and get it approved by teacher. b. Measure geometrical tolerances. Sketch setup drawing to measure geometrical tolerances. Measure geometrical tolerances and record the observations. c. Dismantle the assembly, sketch the parts and measure dimensions. Record your observations. d. Present the work including photographs and movies of actual project work.	06
		TOTAL	56

Notes:

a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.

b. Term work report must not include any photocopy/ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only. Photographs/movies of group members actually working on mini project should be allowed.

c. Term work report content of each experience should also include following.
   i. Reports.
   ii. Student activities.

d. Mini project and presentation topic/area has to be assigned to the student in the beginning of the term by batch teacher. This may be assigned individually or in the group of maximum 2 to 3 students.

e. For 40 marks ESE, students are to be assessed for competencies achieved. They should be given following tasks. (i and any one from ii, iii and iv.)
   i. Measure the linear/angular dimensions and geometrical tolerances of given part/assembly.
   ii. Measure tooth thickness using gear tooth vernier.
   iii. Measure effective diameter of given thread.
   iv. Explain working of transducers and sensors.

8. SUGGESTED LIST OF STUDENT ACTIVITIES

SR.NO.	ACTIVITY
1	Visit the workshop and identify the machines and arrangements which require geometrical tolerances.
2	Visit any industry / tool room and observe the working of inspection and testing department. Also prepare the report.

9. SPECIAL INSTRUCTIONAL STRATEGIES

Sr. No.	Unit No.	Unit Title	Strategies
1	I	Linear and angular measurement	Demonstrate actual instrument, video movies of measuring methods.
2	II	Measurement of geometrical tolerances	Show actual assemblies require geometrical tolerance, show measuring methods movies.
3	III	Measurement of surface roughness	Show various samples of surface textures, videos,
4	IV	Gear and thread measurement	Demonstrate use of gear tooth vernier, videos. Show various forms of threads, show measuring methods movies
5	V	Limit gauges, Transducers and Sensors	Demonstrate limit gauges usage. Demonstrate actual transducers and sensors, movies, industrial visits.
6	VI	Non destructive testing	Videos, PPTs, industrial visits.
7	VII	Temperature, pressure and flow measurement	Demonstrate actual instruments, movies, industrial visits.

10. SUGGESTED LEARNING RESOURCES

(A) List of Books:

Sr no.	Title of Books	Author	Publication
1	Mechanical measurements and instrumentation	R.K.Rajput	KATSON
2	Metrology and Instrumentation	Tahir	
3	Mechanical Measurement	Sirohi R.S., Radha Krishnan H.C.	New Age International
4	Practical Engineering Metrology	K.W.B.Sdarp	Pitman
5	Engineering Metrology	R.K.Jain	Khanna Publications.
6	Industrial Instrumentation	Donald A. Eckman	
7	Industrial Instrumentation & Control	S K Singh	Tata McGrawHill

8	Mechanical Measurement	Beckwith & Buck	Narosa publishing House
9	Mechanical Measurement and Control	D.S.Kumar	Metropolitan Book Pub.
10	Practical Engineering Metrology	K.W.B.Sdarp	Pitman
11	Mechatronics	W.Bolten	PEARSON
12	Gear Metrology	C.A.Scoks	

(B) List of equipments:

1. Surface plate, 500 x 500 mm.
2. Vernier calliper, 100 to 200mm, least count 0.01mm.
3. Vernier calliper, 100 to 200mm, least count 0.01mm, digital.
4. Inside micrometers, least count 0.01mm, 0-25mm, 25-50mm, 50-75mm.
5. Outside micrometer, least count 0.01mm, 0-25mm, 25-50mm, 50-75mm.
6. Outside micrometer, least count 0.001mm, 0-25mm.
7. Telescopic gauge- 10-100mm.
8. Height gauge- 300mm with least count 0.01mm.
9. Depth gauge- 100 mm with least count 0.01mm.
10. Bevel protector with least count 5'.
11. Clinometers.
12. Slip gauge box-
13. Sine bar- 150mm, 200mm.
14. Straight edge, 500mm.
15. Feeler gauge, radius gauge, thread pitch gauge.
16. Dial indicators magnetic stand.
17. Dial indicators, least count 0.01mm.
18. V blocks.
19. Samples of various surface textures and different surface roughness.
20. Microprocessor- stylus-probe based surface roughness testing machine.
21. Microscope to compare various textures and surface roughness.
22. Gear tooth vernier.
23. Profile projector.
24. Set of best wires to measure thread dimensions.
25. Thread micrometers.
26. Thread pitch measuring machine.
27. Thread
28. Set of limit gauges- sorted sizes, plug gauges, thread ring gauges and snap gauges.
29. LVDT type, resistance type, capacitance type, inductance type and piezo-electric type transducers.
30. Sensors, position, proximate, velocity, force/strain,
31. Thermocouple.
32. Bourdon pressure gauge.
33. Venturimeter.

(C) List of softwares/ learning websites:

a. http://en.wikipedia.org/wiki/Metrology (metrology).
b. https://www.youtube.com/watch?v=4hlNi0jdoeQ (vernier).
c. https://www.youtube.com/watch?v=FNdkYIVJ3Vc(vernier).
d. https://www.youtube.com/watch?v=O8vMFFYNIfo (micrometer)
e. https://www.youtube.com/watch?v=h98HPVuWjLA (depth micrometer)
f. https://www.youtube.com/watch?v=SmXfGan_NXQ (telescopic gauge)
g. http://www.authorstream.com/Presentation/007sandeepks-1858141-angular-measurment/ (angular measurement).
h. http://askguru.net/t-Angular-Measurement-ppt
i. https://www.youtube.com/watch?v=aBzh6i5fQ70 (surface roughness)
j. https://www.youtube.com/watch?v=S7SXD6sKQ-I(surface roughness)
k. https://www.youtube.com/watch?v=eVpoJzLJa0U(surface roughness)
l. https://www.youtube.com/watch?v=3Od7vnoMwGg(surface roughness)
m. https://www.youtube.com/watch?v=XnLiTPGE6pk (three wire thread measurement)
n. https://www.youtube.com/watch?v=Gdvtw0pTAOs (thread pitch).
o. https://www.youtube.com/watch?v=qMgXGedDffw (dial indicator)
p. http://www.authorstream.com/Presentation/donzvasanth-1501139-unit-2-linear-angular-measurement/
q. http://en.wikipedia.org/wiki/List_of_gear_nomenclature#Addendum (gear nomenclature).
r. https://www.google.co.in/search?q=gear+tooth+vernier+caliper&tbm=isch&tbo=u&source=univ&sa=X&ei=MIuEUsqSOsiKrQeywIFQ&ved=0CCgQsAQ&biw=1600&bih=804 (gear tooth vernier).
s. http://www.youtube.com/watch?v=lc4dsNvm2Ks (principle of mech. meas).
t. http://www.youtube.com/watch?v=nv3GuJArjNU (Transducers).
u. http://www.youtube.com/watch?v=iMIzApq1CQ0 (pressure measurement).
v. http://www.youtube.com/watch?v=JKuoQ5FV2c8 (temperature meas.).
w. http://www.youtube.com/watch?v=GNOI_7ftbQ0(temperature meas.) .
x. http://www.youtube.com/watch?v=7xUdPVpafyI (flow measurement).
y. http://www.ignou.ac.in/upload/Unit-4-62.pdf (limit gauges).
z. http://www.scribd.com/doc/55242715/8/Types-of-limit-gauges
aa. http://www.youtube.com/watch?v=v25PCV_IJCw (sensors)
bb. http://www.youtube.com/watch?v=QItuf6lNvmI(sensors)
cc. http://www.youtube.com/watch?v=pOvTyvBqzgM (displacement sensors)
dd. http://www.youtube.com/watch?v=inLkCOwVgyM (force sensors)
ee. http://www.youtube.com/watch?v=jxv0ITAr74A(force sensors)
ff. http://www.youtube.com/watch?v=0MP_9n08urA(force sensors)
gg. http://www.youtube.com/watch?v=zAddvPHfKnw(force sensors)
hh. http://www.youtube.com/watch?v=_fQSMVf3hdM (calibration).
ii. http://www.youtube.com/watch?v=HwSxBRaxn_4(calibration).
jj. http://www.youtube.com/watch?v=ZymDMUuVuyY (geometrical Tol.)
kk. http://www.gobookee.org/measurement-of-geometric-tolerances-in-manufacturing/
ll. http://www.me.metu.edu.tr/courses/me410/exp1/410exp1theory.pdf
mm. http://www.youtube.com/watch?v=5eaSkU6Ecik (flatness measurement)
nn. http://www.youtube.com/watch?v=1tBnpzyhVXU (measuring straightness)

oo. http://www.youtube.com/watch?v=1JNCe9fwRUw (measuring perpendicularity)
pp. http://www.youtube.com/watch?v=eJ8a0k8kQIE(Roundness and cylindricity)
qq. http://www.youtube.com/watch?v=V0R5GVCxBy4 (NDT)

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics:

- **Prof. A. M. Talsaniya**, Lecturer in Mechanical Engineering, Sir B.P.I., Bhavnagar.

Coordinator and Faculty Members from NITTTR Bhopal.

- **Dr. K.K. Jain**, Professor and Dean, Department of Mechanical Engineering.
- **Prof. C.K. Chugh**, Professor, Mechanical Engineering, NITTTR, Bhopal.