Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Fourth**

Course Title : **Mechanical Measurement**

Course Code : **22040**

1. RATIONALE

The art of measurement plays an important role in the development of engineering field. With advances in technology, measurement techniques have also taken rapid strides with precision, innovations, and refinements in instruments. The course aims at making an Automobile Engineering student familiar with the principles of measurements and working of instruments for automobile engineering applications.

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 analog and digital measuring devices to assure quality in automobile 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. Use relevant linear measuring instruments in automobile engineering situations.
b. Measure various parameters like displacement, pressure, temperature, force and sound related to automobile components.
c. Perform angular measurements on automobile components.
d. Perform measurement of various thread and gear parameters.
e. Measure various geometrical tolerances on automobile components.
f. Apply modern quality improving techniques in industrial situations.

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
1	-	2	3	--	--	--	--	--	--	--	25@	10	25~	10	50	20

*(#): No theory Exam; (~[1]): For the **practical only** courses, the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e. 15 marks) and micro-project assessment (seen in section 12) has a weightage of 40% (i.e. 10 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.*

***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.

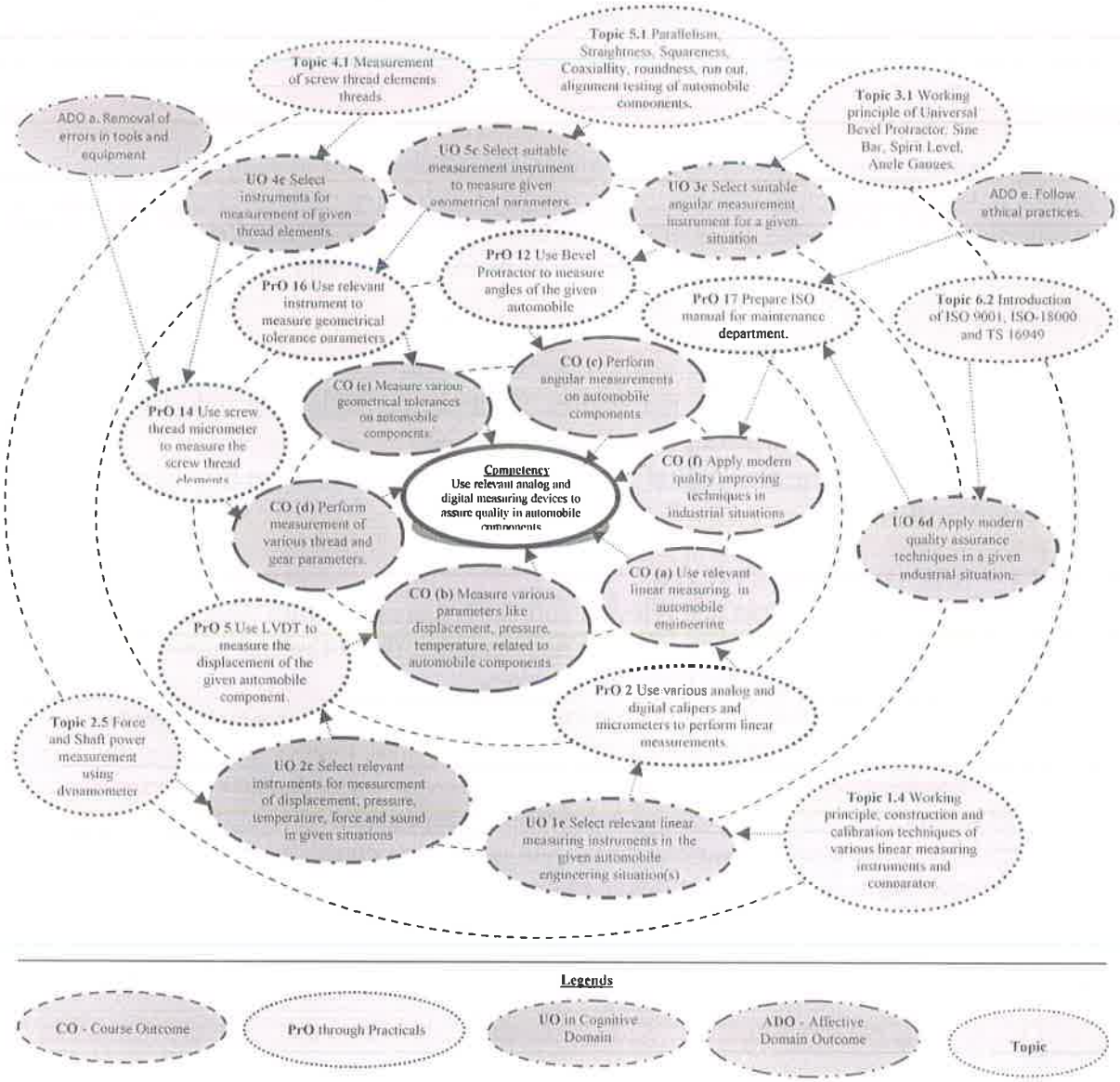

Figure 1 - Course Map

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, screw pitch gauge, feeler gauge, straight edge, plug gauge, thread gauge, thread ring gauge, adjustable snap gauge to measure relevant parameters in given automobile components.	1	02*
2	Use various analog and digital calipers and micrometers to perform	1	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	linear measurements on the given automobile components.		
3	Use dial indicator to measure the given size attribute and compare it with slip gauge as a standard to inspect the given components.	I	02
4	Use pneumatic comparator for inspection of the given size attribute of the given automobile component.	I	02
5	Use LVDT to measure the displacement of the given automobile component.	II	02
6	Use compression gauge to measure the compression and vacuum of the given cylinder.	II	02*
7	Use temperature gauge to measure the temperature of engine.	II	02
8	Use decibel meter to measure noise level in the given engine.	II	02
9	Use contact type and non contact type tachometer to measure the speed of the given engine shaft.	II	02*
10	Use dynamometer to measure the power of the given output shaft.	II	02
11	Use surface roughness measuring instruments to measure the surface roughness of the given engine components.	II	02
12	Use Bevel Protractor to measure angles of the given automobile components and verify it with Sine bar.	III	02*
13	Use Angle dekkor / autocollimator to measure the angles of the given automobile components	III	02
14	Use screw thread micrometer to measure the screw thread elements and compare the same using tool maker's microscope or optical profile projector.	IV	02*
15	Use gear tooth vernier caliper to measure the given gear tooth elements and verify it by optical profile projector/ micrometer using over pin method.	IV	02
16	Use relevant instrument to measure geometrical tolerance parameters for the given automobile components.	V	02*
17	Perform quality audit and prepare quality manual using ISO procedure for maintenance department of your institute.	VI	02*
	Total		**34**

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 %
1	Proper handling of measuring instruments.	10
2	Operating and measurement using appropriate instrument.	40
3	Comparison between various measuring devices.	20
4	Answer oral questions.	20

S. No.	Performance Indicators	Weightage in %
5	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. Removal of errors in tools and equipment.
b. Calibration of instruments.
c. Plan, construct, compile for measurement of complex components.
d. Demonstrate working as a leader / a team member.
e. 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 and
- '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 authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Set of Radius gauge, At least 26 leaves, Range 0.5-13mm by 0.5mm	1
2	Set of screw pitch gauge (Inch/Metric), At least 28 Leaves, Range- 4 to 56 TPI, 0.5mm to 6mm	1
3	Set of filler gauge-At least 20 leaves, Range 0.05-1mm by 0.05mm	1
4	Straight edge- Grade 0,Grade 00, Grade 1, Grade 2 (IS-2220)	1
5	Plug gauge- At least one from Range-1 mm to 40 mm, (IS-6137 – I983)	1
6	Thread plug gauge- At least one from Range 1 to 25 mm	1
7	Thread ring gauge- At least one from Range 1 to 25 mm	1
8	Go-No Go single ended- At least one from Range 1 to 25 mm	1
9	Double ended snap gauge- At least one from Range 1 to 25 mm	1
10	Adjustable snap gauge- At least one from Range 1 to 25 mm	1
11	vernier caliper-Range 0-300 mm,	02
12	Dial type vernier caliper-Range 0-300 mm	02
13	Digital vernier caliper-Range 0-300 mm.	02
14	vernier height gauge-0 to 300 mm.	02
15	vernier depth gauge-0 to 300mm ,	02
16	Inside- micrometer-Range 0-25,25-50,50-100 mm.	02
17	Outside micrometer-Range 0-25,25-50,50-100 mm.	02
18	Digital outside micrometer-Range 0-25,25-50,50-100 mm.	02
19	Dial indicator with magnetic stand-Range 0-10 mm, Range 0-100 mm	03

S. No.	Equipment Name with Broad Specifications	PrO. No.
20	Standard Slip gauge set- At least one from M 45,M87,M112	03
21	Pneumatic comparator unit-0 to 10 bar	04
22	LVDT-Measuring range 270 mV/V (bridge output per 1 V supply voltage)	05
23	Compression gauge unit for Petrol 0-300psi (kg/cm^2) and Diesel 0-1000 psi(kg/cm^2)	06
24	Vacuum gauge unit for Petrol 0-30 in. Hg and Diesel 0-30 in. Hg.	06
25	Pressure gauge diaphragm type Range 0- 20 Bar	06
26	Pressure gauge bellows,40,50,63mm dial, diaphragm seal, static pressure upto 60kg/cm2g	06
27	Bourdon tube C type with LVDT Display 3.5 digit display for pressure/ displacement	06
28	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	07
29	Temperature gauge bimetallic strip gauge. Ÿ Scale °F, K, Dual Scale °C/°F. Ÿ Over range protection 130% FSD. BMT	07
30	Temperature gauge thermocouple Type J, Iron (+) Constantan (-), 0 to 760°C, Suitable for vacuum, reducing, or inert atmospheres.	07
31	Standard Disable meter for sound measurement	08
32	Eddy Current Dynamometer Power rating: 0.18 KW to 55 KW Max Speed: 4,000 RPM; Torque Indicator: Spring Balance OR Digital Indicator with Zero, Span, Calibration presets; Max Torque: 100 KgM (1000 Nm); Speed Sensor: 60-Tooth wheel with Magnetic Speed Pick up Sensor Torque Sensor: Spring Balance with Pulley and rope, Load cell or Rotary Torque Sensor; Cooling: Self Cooled or FAN Cooled, to avoid Water Cooling hassles.	10
33	Multi digital stratoscope cum tachometer for speed measurement- upto 5000 rpm contact	09
34	Multi digital stratoscope cum tachometer for speed measurement- upto 5000 rpm Non contact	09
35	Surface measuring instrument-Talysurf	11
36	Universal bevel protractor: Graduation: 5min.(0°- 90°- 0°) Blade 150, 300 mm.	12
37	Sine bar, Sine Centre (0-200mm)	12
38	Angle dekkor/Auto collimator(0 to 30')	13
39	Set of Angle gauges box, Grade 1.	13
40	Screw thread micrometer.	14
41	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; Work piece 5Kg; Light source :24V, 2W (special bulb); Continuously adjustable light intensity; Green filter.	14
42	Profile projector with gear profile/Thread profile Templates: Opaque fine grained ground glass 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	14

S. No.	Equipment Name with Broad Specifications	PrO. No.
	±0.05% Surface ±0.05%; Illumination Counter 24V/150W halogen lamp with illumination control; Resolution 0.005/0.001/0.0005 mm.	
43	Gear tooth vernier caliper. (0-25mm)	15

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. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Basics of measurement.	1a. Explain the given standard(s) of measurement. 1b. Calculate least count of the given linear measuring instrument. 1c. Identify the sources of errors in instruments in the given component with justification. 1d. Describe with sketches the procedure for linear measurements using the given measuring instruments. 1e. Select relevant linear measuring instruments in the given automobile engineering situation(s) with justification.	1.1 Definition of metrology, objectives of metrology, types of metrology, Need of inspection, Precautions while using instruments. 1.2 Errors in measurements- environmental errors signal transmission errors, observation errors (parallex), operational errors. 1.3 Standards for measurement- line standard end standard, Wavelength standard. 1.4 Working principle, construction and calibration techniques of various linear measuring instruments and comparator.
Unit– II Miscellaneous Measurement.	2a. Identify different available instruments for measurement of given quantities. 2b. Describe with sketches the procedure to measure displacement, pressure, temperature, sound, force and sound using the given measuring instruments. 2c. Select relevant instruments for measurement of displacement, pressure, temperature, sound, force and sound in the given automobile engineering situations with justification. 2d. Describe with sketches the procedure to measure surface finish of the given component.	2.1 Displacement Measurement: working principal of Capacitive transducer, Potentiometer, LVDT 2.2 Pressure Measurement: Working principal of Pressure gauge-Diaphragm, Bellows, Bourdon tube, Electrical resistance type pressure measurement devices. 2.3 Temperature Measurement: Working principal of Bimetallic strip gauge, thermometer, RTD, Thermistor, thermocouple, Pyrometers-radiation and optical type. 2.4 Sound Measurement: Measurement of sound using Electro dynamic microphone and Carbon microphone. 2.5 Force and Shaft power measurement: Tool Dynamometer (Mechanical

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Type), Eddy Current Dynamometer, Strain Gauge Transmission Dynamometer. 2.6 Speed measurement - Working principal of tachometer, Mechanical , Electrical tachometer- Inductive Pick Up. Capacitive Pick Up. Stroboscope
Unit– III Angular Measurement	3a. Identify the parameters of angular measurement in the given case. 3b. Describe procedure to measure angles using the given angular measuring instrument. 3c. Select suitable angular measurement instrument for the given situation with justification.	3.1 Working principle of Universal Bevel Protractor, Sine Bar, Spirit Level, Angle Gauges, Angle dekkor or autocollimator
Unit-IV Thread and Gear Measurements.	4a. Identify errors in threads and their effects in the given assembly. 4b. Describe procedure to measure thread related elements using the given thread measuring instrument. 4c. Select instrument for measurement of the given thread elements with justification. 4d. Identify types of errors in gear tooth and effects in assembly. 4e. State the relevant instrument for measurement of the given Gear tooth parameters with justification.	4.1 Measurement of screw thread elements such as major diameter, minor diameter, effective diameter, pitch, thread angle for internal and external threads. 4.2 Working principle of screw thread micrometer, optical profile projector, tool maker's microscope. 4.3 Measurement of tooth thickness by constant chord method, base tangent method, gear tooth vernier, 4.4 Errors in gears such as backlash, run out, composite, concentricity. 4.5 Dimension over pin measurement
Unit-V Alignment and Geometrical testing	5a. Describe the given Geometrical relationships for the given components. 5b. Describe the alignment checking procedure for the given automobile components assembly. 5c. Select suitable measurement instrument to measure the given geometrical parameters with justification. 5d. Describe relevant tests for the given automobile component	5.1 Parallelism, Straightness, Squareness, Coaxiallity, roundness, run out, alignment testing of automobile components.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-VI Quality control	6a. Explain principles of modern quality improving techniques. 6b. Describe the features of the given type of ISO for the given industry. 6c. List quality assurance activities in the given industry. 6d. Explain relevant quality assurance techniques in the given industrial situation.	6.1 Quality Control- Quality assurance, cost of quality, value of quality, 6.2 Introduction of ISO 9001, ISO-18000 and TS 16949. 6.3 Concept of quality circle,7QC Tools, TQM, Six-sigma, Pokayoke, Kaizen-5s, Kanban.

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 (INTERNAL)

Unit No.	Unit Title	Practical Hours	Distribution of practical Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of measurement.	04	01	01	02	04
II	Miscellaneous Measurement	14	02	01	05	08
III	Angular Measurement	04	-	01	03	04
IV	Thread and Gear Measurements	04	-	02	02	04
V	Alignment and Geometrical testing	04	-	01	01	02
VI	Quality control	04	-	01	02	03
Total		**34**	**03**	**07**	**15**	**25**

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 practicals performed in laboratory.
b. Give seminar on relevant topic.
c. Prepare power point presentation or animation showing measurement applications.
d. Collect and analyze precision and accuracy of various measuring instruments.

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. No. of practical's selection to be performed should cover all units.

12. SUGGESTED 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 is 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 is given here. Similar micro-projects could be added by the concerned faculty:

a. Collect the data and information from internet/ automobile industry regarding modern measuring techniques and instruments.
b. Collect quality policy of at least two industries.
c. Identify various ISO certifying agencies with rules for certification.
d. Form a group of quality circle and solve any one quality related industrial problem.
e. Observe the Quality audit activity and prepare report.
f. Develop control charts used in automobile industry.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Mechanical Measurements and Control	Kumar, D.S.	Metropolitan Publications, New Delhi, 2009 ISBN: 978-8120004238
2	Mechanical and Industrial Measurements	Jain, R.K.	Khanna Publications, New Delhi, 2008, ISBN NO. -978-81-7409-191-2
3	Engineering Metrology	Jain, R.K.	Khanna Publications, New Delhi, 2015, ISBN NO. 978-81-7409-153-X
4	Mechanical Measurements and Instrumentation	Sawhney, A.K.	Dhanpat Rai and Sons, New Delhi. 2005, ISBN NO. 456714564X, 1234567145642
5	Measurement Systems	Doebelin, E.O.	McGraw Hill Publications, New Delhi, 2016, ISBN No., 9780070616721
6	Instrumentation Devices and Systems	Narang C.S.	McGraw Hill Publications, New Delhi, 2011, ISBN NO. 0074633503.

S. No.	Title of Book	Author	Publication
			9780074633502
7	Instrumentation, Measurement and Analysis	Nakra, B. C. , Chaudhary K.K.	McGraw Hill Publication, New Delhi, 2004, ISBN NO. 0070482969, 9780070482968
8	Mechanical Measurement	Beckwith, Thomas	Pearson Education, New Delhi, 2007, ISBN NO. 8131717186,
9	Total Quality Management	Dale, H. Besterfield and others	Pearson Education, Delhi, 2014, ISBN NO. 9788131717189
10	Instrumentation for Engg. Measurement	Dally, James W	Wiley India, Bangalore, 1993, ISBN NO. 13: 9780471551928

14. SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=lc4dsNvm2Ks
b. www.slideshare.net/anandpatange05/mechanical-measurement-control
c. https://www.howacarworks.com/engine/how-to-measure-the-engine-temperature
d. https://www.howstuffworks.com/engine/how-to-measure-the-engine-temperature
e. http://www.sabcable.net/fileadmin/user_upload/pdf/catalog_gb/Thermotechnik_gb/Temperature_Measurement_in_Test_Vehicles.pdf
f. https://web.mst.edu/~cottrell/ME240/Resources/Temperature/Temperature.pdf
g. https://law.resource.org/pub/in/bis/ais/arai.in.ais.020.2008.pdf
h. http://www.ntc.gov.au/Media/Reports/(9745A524-E60D-9B7C-835B-CDAF7DC19D8B).pdf
i. https://en.wikipedia.org/wiki/Pressure_measurement
j. https://en.wikipedia.org/wiki/MAP_sensor
k. https://www.youtube.com/watch?v=242tbZPKEXc
l. https://www.youtube.com/watch?v=37oJtcUTpL8
m. https://www.youtube.com/watch?v=jeBQJI-YwVc
n. https://www.youtube.com/watch?v=0JXCw5pOecg
o. https://www.youtube.com/watch?v=F7uCEeipdCw
p. https://www.youtube.com/watch?v=vu5-A_ythtM
q. textofvideo.nptel.iitm.ac.in/103105064/lec43.pdf