INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**INSTRUMENTATION AND CONTROL SYSTEMS**				
Course Code	AME019				
Program	B.Tech				
Semester	SEVEN				
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	2	1
Course Coordinator	Dr. GVR Seshagiri Rao, Associate Professor				

I. COURSE OVERVIEW:

The Present course concentrates on developing basic understanding about various instruments that are involved in measuring. This course enables the student to understand the working of various measuring instruments. The course focuses on all principles, working, advantages, disadvantages and applications of various measuring instruments. In this course; students also will gain a broad understanding of the control systems. Student can learn in detail about how to measure displacement, temperature, pressure, level, flow, acceleration, vibration, strain, humidity, force, torque and power and their appropriate application.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME010	V	Machine Tools and Metrology

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Instrumentation and Control Systems	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	PPT	✗	Chalk & Talk	✔	Assignments	✗	MOOCs
✔	Open Ended Experiments	✔	Seminars	✗	Mini Project	✔	Videos
✗	Others						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. **There could be a maximum of two sub divisions in a question.**

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Table 1: The expected percentage of cognitive level of questions in SEE.

Percentage of Cognitive Level	Blooms Taxonomy Level
10 %	Remember
50 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

Table 2: Assessment pattern for CIA

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams

Quiz –Online Examination:

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT):

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours / classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table 3.

Table 3: Assessment pattern for AAT

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended experiment
20%	30%	30%	10%	10%

VI. COURSE OBJECTIVES:

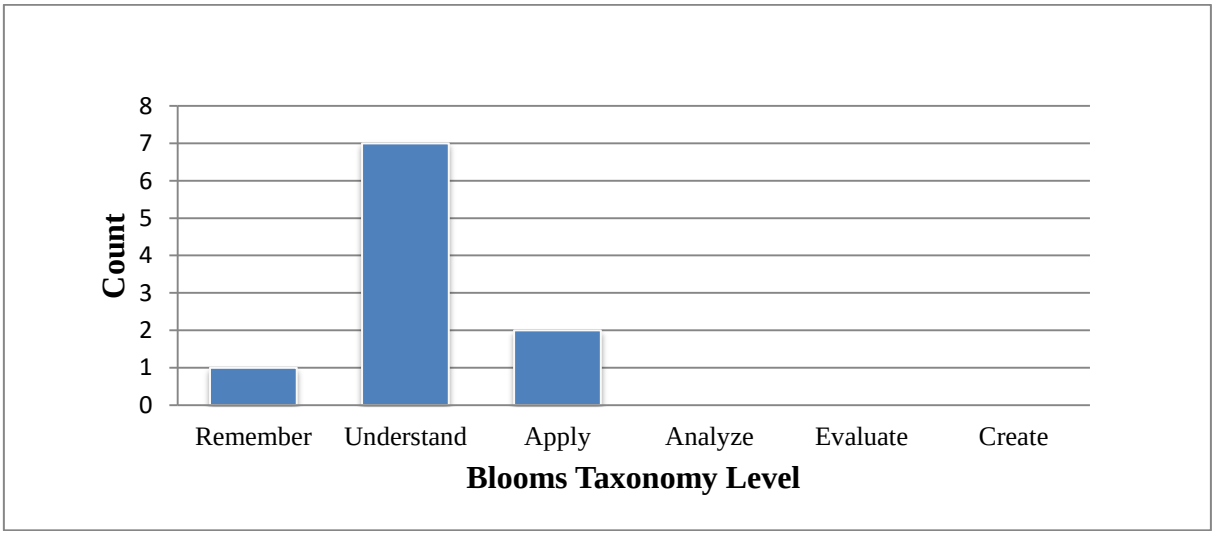
The students will try to learn:	
I	The fundamental knowledge of measuring principles, configuration and functional description of instruments with static, dynamic inputs and error control.
II	The concepts and working of instrumentation devices for displacement, flow, dynamic and other mechanical measurement applications.
III	Instrumentation practices and automatic control system for monitoring industrial real time processes within limits of parameter specifications.

VII. COURSE OUTCOMES:

After successful completion of the course, students will be able to:		
	Course Outcomes	**Knowledge Level (Bloom's Taxonomy)**
CO 1	**Recognize** the importance of basic principles, configuration and functional description of measuring instruments.	Remember
CO 2	**Describe** performance characteristics of an instrument when the device is exposed to measure dynamic inputs and error control.	Understand
CO 3	**Categorize** the measuring instruments based on the principle of working with the physical parameters such as displacement, temperature and pressure.	Understand

CO 4	**Explain** calibration of instruments for measurement of all types of mechanical parameters.	Understand
CO 5	**Demonstrate** working principle of level measuring devices for ascertaining liquid level and choose appropriate device for controlling fluid level in industrial applications.	Understand
CO 6	**Discuss** the theory, phenomena and working principle of flow measuring instruments and calibration.	Understand
CO 7	**Make use of** appropriate instrument for measuring Speed, Acceleration and Vibration by considering different aspects.	Apply
CO 8	**Demonstrate** the concepts for measurement of Stress, Strain, Humidity and their application for finding stress, strain, and humidity.	Understand
CO 9	**Describe** the principles of measurement of force, torque and power and their application in industries for finding force, torque and power.	Understand
CO 10	**Apply** relevant control systems for speed, position and control processes in practical applications.	Apply

COURSE KNOWLEDGE COMPETENCY LEVELS



VIII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	CIE/Quiz/AAT
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health	2	Seminar/ conferences / Research papers

Program Outcomes		Strength	Proficiency Assessed by
	and safety, and the cultural, societal, and Environmental considerations.		
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Professional engineering practice.	2	Assignments / Discussion
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	2	Class group / Multi-disciplinary group
PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Discussion on Innovations / Presentation
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	Research paper analysis / Short term courses

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency assessed by
PSO1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	2	Research papers / Industry exposure
PSO2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high-speed machining.	2	Research papers / Group discussion / Short term courses
PSO3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of instrumentation and control.	3	Research papers / Industry exposure

3 = High; 2 = Medium; 1 = Low

X. MAPPING OF EACH CO WITH PO(s), PSO(s):

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CO 4	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	√	√	-	-	-	-	-	-	-	-	-	-	-	-	√
CO 6	√	√	-	-	-	-	-	-	-	-	-	-	-	-	√
CO 7	√	√	-	-	-	-	-	-	-	-	-	-	-	-	√
CO 8	√	√	-	-	-	-	-	-	-	-	-	-	-	-	√
CO 9	√	√	-	-	-	-	-	-	-	-	-	-	-	-	√
CO 10	√	√	-	-	-	-	-	-	-	-	-	-	-	-	√

XI. JUSTIFICATIONS FOR CO – PO/PSO MAPPING – DIRECT

Course Outcomes	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO 1	**PO 1**	Recognize (knowledge) the importance of basic principles, configuration, appreciate (understanding) their importance and applicability (apply) *in solving (complex) engineering problems of measurement* by applying the **scientific principles** of *mathematics* **and science.**	2
CO 2	**PO 1**	Demonstrate (understand) performance characteristics of an instrument when the device is exposed to measure dynamic inputs and error control systems by applying the principles of **mathematics** and **engineering fundamentals**	2
CO 3	**PO 1**	Categorize (understand) the measuring instruments based on the principles of working with the physical parameters such as displacement, temperature and pressure etc., in *solving (complex) fluid flow engineering problems* by applying the principles of **mathematics, science** and **engineering fundamentals**.	3
CO 4	**PO 1**	Explain (understand) calibration of instrument for measurement of all types of mechanical parameters by applying the principles of **mathematics, science** and **engineering fundamentals**.	3
	PO 2	Understand the given **problem statement** and **formulate** (complex) engineering problems and choosing appropriate measuring device for calibration considering mechanical parameter and substantiate with **interpretation** of variation in the **results.**	4
CO 5	**PO 1**	Demonstrate (understand) working principle of level measuring device for ascertaining parameter such as liquid level , in solving (complex) liquid level engineering problems by applying the applying the principles of **mathematics, science** and **engineering fundamentals** for controlling fluid level in industrial applications.	3
	PO 2	Understand the given **problem statement** and **formulate** (*complex) fluid level engineering phenomena* for deriving related equations from the provided information and substantiate with **interpretation of** variations in the **results**.	4

	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of instrumentation.	2
CO 6	**PO 1**	Explain (understand) the theory, phenomena and working of flow measuring instruments to solution of flow engineering problem by applying the principles of **mathematics, science** and **engineering fundamentals** to perform calibration for flow measuring devices.	3
	PO 2	Understand the given **problem statement** and **formulate** *(complex) fluid flow engineering phenomena* for deriving related equations from the provided information and substantiate with **interpretation** of variations in the **results**.	4
	PSO 3	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 7	**PO 1**	Make use of (knowledge, understand and apply) appropriate instrument for measuring Speed, Acceleration and Vibration (*complex) engineering problems by applying the principles of* **mathematics, science** and engineering **fundamentals** of instrumentation related.	3
	PO 2	Understand the given **problem statement** and **formulate** *(complex) speed, acceleration and vibration related engineering phenomena* for deriving related equations from the provided information and data in reaching substantiated conclusions by the **interpretation of** variation in the **results**.	4
	PSO 3	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 8	**PO 1**	Demonstrate (understand) measurement of stress, strain, humidity and their application *in solving (complex)* Stress, Strain and Humidity by applying the principles of **mathematics, science** and **engineering fundamentals** of instrumentation and control systems.	3
	PO 2	Understand the given **problem statement** and **formulate** *(complex) stress, strain, humidity related engineering phenomena* for deriving related equations from the provided information and data in reaching substantiated conclusions by the **interpretation** of variation in the **results**.	4
	PSO 3	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of instrumentation and control.	2
CO 9	**PO 1**	Explain (understand) the theories, phenomena and working principles (knowledge) for measurement of forces, torques, power and its applicability (apply) in industry in solving (complex) problems such as forces, torque and power by applying the principles of **mathematics, science** and **engineering fundamentals .**	3
	PO 2	Understand the given **problem statement** and **formulate** *(complex) force, torque and power related engineering phenomena* for deriving related equations from the provided	4

		information and data in reaching substantiated conclusions by the **interpretation** of **results**.	
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of instrumentation and control.	2
CO 10	**PO 1**	Apply (knowledge, understand, apply) relevant control, system for speed, position and control processes in practical application understanding the knowledge in solving (*complex) engineering problems* related to control of various systems by applying the principles of **mathematics, science** and **engineering fundamentals.**	3
	PO 2	Understand the given **problem statement** and **formulate** the design *(complex) engineering problems* of control systems by applying the principles of **mathematics, science** and **engineering fundamentals.**	4
	PSO 3	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of instrumentation and control.	2

XII. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING

Course Outcomes	Program Outcomes / No. of Key Competencies Matched												PSO / No. of key competencies		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	12	1	2	2
CO 1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	4	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	4	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 7	3	4	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 8	3	4	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 9	3	4	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 10	3	7	-	-	-	-	-	-	-	-	-	-	-	-	2

XIII. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

Course Outcomes	Program Outcomes / No. of key competencies												PSOs/ No. of key competencies		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	12	1	3	2
CO 1	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 2	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 4	100.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 5	100.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
CO 6	100.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
CO 7	100.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 8	100.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
CO 9	100.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
CO 10	100.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

XIV. COURSE ARTICULATION MATRIX (PO – PSO MAPPING)

COs and POs and COs and PSOs on the scale of 0 to 3, **0** being **no correlation**, **1** being the **Low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 – **0**≤ C ≤ 5%–No correlation
1 – 5 <C≤ 40%– Low/ Slight
2 – 40 % <C< 60% –Moderate
3 – 60% ≤ C< 100% – Substantial /High

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3

CO 6	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 7	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 8	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 9	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 10	3	3	-	-	-	-	-	-	-	-	-	-	-	-	3
TOTAL	30	9													15
AVERAGE	**3.0**	**1.3**													**3.0**

XV. ASSESSMENT METHODOLOGY - DIRECT

CIE Exams	PO 1,PO 2	SEE Exams	PO 1, PO 2 PO 4	Assignments	PO 1,PO 2 PO 5	Seminars	PO 9, PO 10, PO 12
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO 4	5 Minutes Video	PO 5	Tech talk	PO 10	Open Ended Experiments	PO 12

XVI. ASSESSMENT METHODOLOGY - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✗	Assessment of Mini Projects by Experts		

XVII. SYLLABUS

UNIT-1	**PRINCIPLES OF MEASUREMENT**
Definition – Basic principles of measurement – Measurement systems, generalized configuration and functional descriptions of measuring instruments – examples. Dynamic performance characteristics – sources of error, Classification and elimination of error.	
UNIT-II	**MEASUREMENT OF DISPLACEMENT, TEMPERATURE, PRESSURE**
Measurement of Displacement: Theory and construction of various transducers to measure displacement – Piezo electric, Inductive, capacitance, resistance, ionization and Photo electric transducers, Calibration procedures. Measurement of Temperature: Classification – Ranges – Various Principles of measurement Expansion, Electrical Resistance – Thermistor – Thermocouple – Pyrometers – Temperature Indicators. Measurement of Pressure: Units – classification – different principles used. Manometers, Piston, Bourdon pressure gauges, Bellows – Diaphragm gauges. Low pressure measurement – Thermal conductivity gauges – ionization pressure gauges, McLeod pressure gauge.	
UNIT-III	**MEASUREMENT OF LEVEL, FLOW, SPEED, ACCELERATION AND VIBRATION**
Measurement of Level: Direct method – Indirect methods capacitive, ultrasonic, magnetic, cryogenic fuel level indicators – Bubbler level indicators. Flow Measurement: Rotameter, magnetic, Ultrasonic, Turbine flow meter, Hot – wire anemometer, Laser Doppler Anemometer (LDA).	

Measurement of Speed: Mechanical Tachometers – Electrical tachometers – Stroboscope, Noncontact type of tachometer. Measurement of Acceleration and Vibration: Different simple instruments – Principles of Seismic instruments – Vibrometer and accelerometer using this principle.	
UNIT-IV	**MEASUREMENT OF STRESS–STRAIN, HUMIDITY, FORCE, TORQUE AND POWER**
Stress Strain Measurements: Various types of stress and strain measurements – electrical strain gauge gauge factor – method of usage of resistance strain gauge for bending compressive and tensile strains usage for measuring torque, Strain gauge Rosettes. Measurement of Humidity: Moisture content of gases, sling psychrometer, Absorption psychrometer, Dew point meter. Measurement of Force, Torque and Power: Elastic force meters, load cells, Torsion meters, Dynamometers.	
UNIT-V	**ELEMENTS OF CONTROL SYSTEMS**
Elements of Control Systems: Introduction, Importance – Classification – Open and closed systems Servomechanisms–Examples with block diagrams–Temperature, speed & position control systems.	
Textbooks:	
1. K Padma Raju, Y J Reddy, "Instrumentation and Control Systems", McGraw Hill Education1st Edition, 2016. 2. S W. Bolton, "Instrumentation and Control Systems", Newness Publisher, 1st Edition, 2004. 3. K Singh, "Industrial Instrumentation and Control", McGraw Hill Education, 3rd Edition, 2015.	
Reference Books:	
1. Schmidt, L.V., "Introduction to Aircraft Flight Dynamics", AIAA Education Series, 1st Edition, 1998, ISBN A-56347-226-0.G. 2. McCormick, B.W., "Aerodynamics, Aeronautics, and Flight Mechanics", Wiley India, 2 nd Edition, 1995, ISBN 97.	

XVIII. COURSE PLAN

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Outcomes	Text (T) book / Reference (R) book
1	Introduction, definition, fundamental measuring process.	CO 1	T1: 1.1-1.16
2	Basic principles of measurement, classification, measurement systems.	CO 1	T1: 1.1-1.16
3-4	generalized configuration and functional descriptions of measuring instruments – examples	CO 1	T2:26.7 R2:21.51
5	Static performance characteristics.	CO 2	T1: 1.16
6-7	Dynamic performance characteristics	CO 2	T1: 1.16
8	Sources of error, Classification of errors.	CO 2	T1: 1.16
9	Classification of errors, elimination of error and calibration.	CO 2	T1: 1.16
10	Zero order, 1st order 2nd order systems.	CO 2	T1: 1.121.16
11-12	Classification of transducers, Theory and construction of LVDT, Resistance, Inductive transducer for measurement of displacement.	CO 3	T1: 14.114.2

Lecture No	Topics to be covered	Course Outcomes	Text (T) book / Reference (R) book
13	Theory and construction of capacitance transducer for measurement of displacement.	CO 3	T1: 14.1 14.2
14	Theory and construction of Piezo electric and photo electric transducer transducers for measurement of displacement.	CO 3	T1: 14.1-14.2
15	Theory and construction of Ionization and Photo electric transducer for measurement of displacement.	CO 3	T1: 14.1-14.2
16	Hall effect Transducer, LDR	CO 3	T1: 14.1-14.2
17	Measurement of Temperature: Classification – Ranges	CO 3	T1: 20.1-20.3
18	Various principles of measurement – Expansion, Electrical Resistance	CO 3	T1: 20.1-20.3
19	Resistance Temperature Detector (RTD)	CO 3	T1: 20.1-20.3
20	Thermistor for temperature measurement.	CO 3	T1: 20.1-20.3
21	Thermocouple for temperature measurement	CO 3	T1: 20.1-20.3
22	Pyrometers – Temperature Indicators	CO 3	T1: 20.120.3
23	Measurement of Pressure: Units – classification – different principles used	CO 4	T1: 18.1-18.3
24	Piston gauge, Manometers,	CO 4	T1: 18.118.3
25-26	Bourdon pressure gauges, Bellows – Diaphragm gauges. Low pressure measurement	CO 4	T1: 18.1-18.3
27	Thermal conductivity gauges	CO 4	T1: 18.118.3
28	Ionization pressure gauges, Mcleod pressure gauge	CO 4	T1: 18.118.3
29	Measurement of Level: Direct method – Indirect methods	CO 5	T1: 24.124.2
30	Capacitive, ultrasonic level measurement	CO 5	T1: 24.1-24.2
31	Magnetic, cryogenic fuel level indicators	CO 5	T1: 24.1-24.2
32	Bubbler level indicators	CO 5	T1: 24.1-24.2
33	Flow Measurement: Rotameter, magnetic flow meter	CO 6	T1: 21.121.2
34	Ultrasonic, Turbine flow meter	CO 6	T1: 21.1-21.2
35	Hot – wire anemometer, Laser Doppler Anemometer (LDA)	CO 6	T1: 21.1-21.2
36	Measurement of Speed: Mechanical Tachometers	CO 7	T1: 15.1 15.3
37	Electrical tachometers	CO 7	T1: 15..3
38	Noncontact type of tachometer , Stroboscope	CO 7	T1: 15.1 15.3
39	Measurement of Acceleration and Vibration: Different simple instruments	CO 7	T1: 16.1-16.2

Lecture No	Topics to be covered	Course Outcomes	Text (T) book / Reference (R) book
40	Principles of Seismic instruments	CO 7	T1: 16.1-16.2
41-42	Vibrometer and accelerometer using this principle	CO 7	T1: 16.116.2
43-44	Stress Strain Measurements: Various types of stress and strain measurements	CO 9	T1: 9.1- 9.5
45	Electrical strain gauge	CO 8	T1: 9.1- 9.5
46	Gauge factor – method of usage of resistance strain gauge for bending compressive and tensile strains	CO 8	T1: 9.1- 9.5
47	Usage for measuring torque, Strain gauge Rosettes	CO 8	T1: 9.1- 9.5
48	Measurement of Humidity: Moisture content of gases, sling psychrometer	CO 8	T1: 10.1-10.6
49	Absorption psychrometer, Dew point meter	CO 8	T1: 10.1-10.6
50	Measurement of Force , and Elastic force meters	CO 9	T1: 10.1-10.6
51	Measurement of Torque	CO 9	T1: 11.1-11.5
52	load cells, Torsion meters	CO 9	T1: 11.1-11.5
53-54	Measurement of Power, Dynamometers	CO 9	T1: 11.1-11.5
55	Elements of Control Systems: Introduction, Importance, Classification	CO 10	T1: 11.1-11.5
56	Open and Closed systems	CO 10	T1: 28.1-16
57-58	Servomechanisms–Examples with block diagrams	CO 10	T1: 28.1-28.16
59	Temperature control systems, Speed control system	CO 10	T1: 28.1-28.16
60	Position control systems	CO 10	T1: 28.1-28.16

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