



SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

Approved by AICTE, New Delhi, Affiliated to Anna University, Chennai

Accredited by NAAC-UGC with 'A++' Grade (Cycle III) &

Accredited by NBA (B.E - CSE, EEE, ECE, Mech & B.Tech.IT)

COIMBATORE-641 035, TAMIL NADU



SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

Approved by AICTE, New Delhi, Affiliated to Anna University, Chennai

Accredited by NAAC-UGC with 'A++' Grade (Cycle III) &

Accredited by NBA (B.E - CSE, EEE, ECE, Mech & B.Tech.IT)

COIMBATORE-641 035, TAMIL NADU



B

Reg. No:

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

B.E/B.Tech- Internal Assessment – I
Academic Year 2024-2025 (Even)

Fourth Semester
Electrical and Electronics Engineering
23EET206/ Measurements and Instrumentation

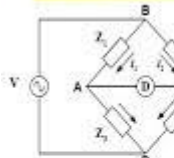
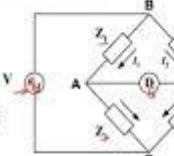
KEY ANSWER

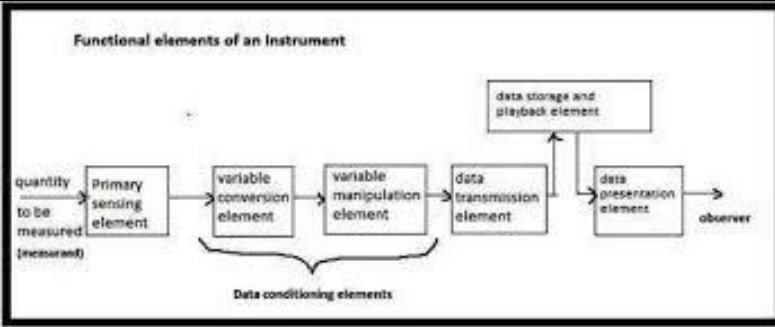
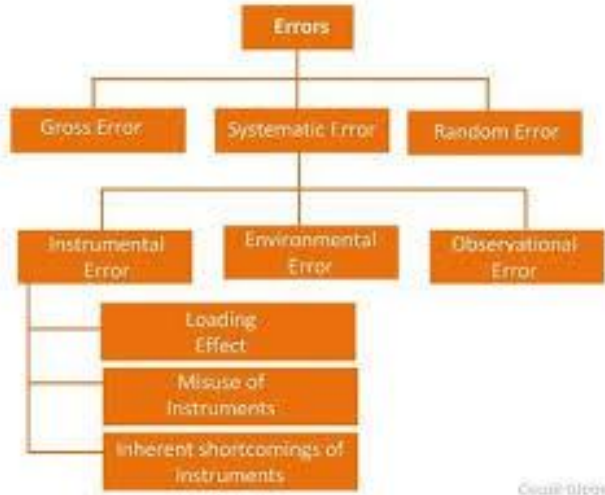
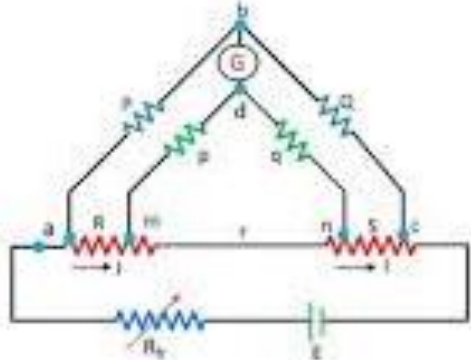
Time: 1^{1/2} Hours

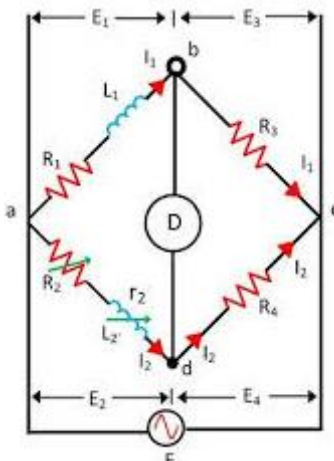
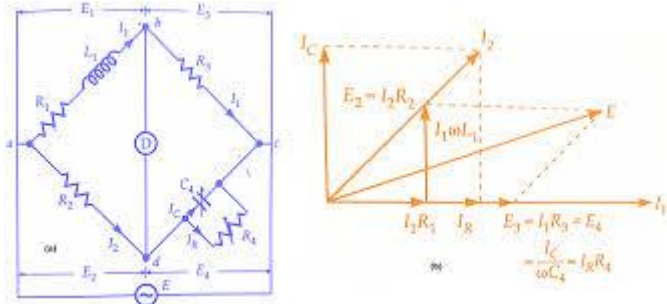
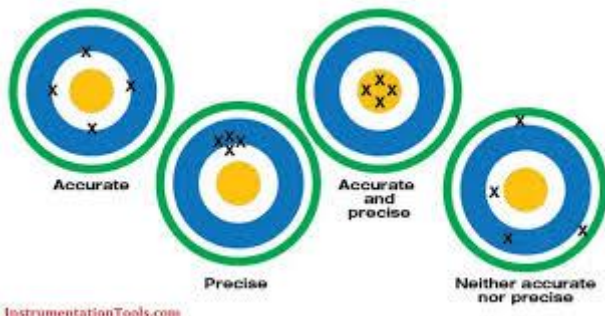
Maximum Marks: 50

Answer All Questions

1.	Classify the analog Instruments based on operating principle. <pre> graph TD Instrument --> MechanicalInstrument[Mechanical Instrument] Instrument --> ElectricalInstrument[Electrical Instrument] Instrument --> ElectronicInstrument[Electronic Instrument] ElectricalInstrument --> AbsoluteIndirect[Absolute Indirect] ElectricalInstrument --> SecondaryDirect[Secondary Direct] SecondaryDirect --> AnalogInstrument[Analog Instrument] SecondaryDirect --> DigitalInstrument[Digital Instrument] AnalogInstrument --> DeflectingInstrument[Deflecting Instrument] AnalogInstrument --> NullDeflection[Null Deflection] DeflectingInstrument --> IndicatingInstruments[Indicating Instruments] DeflectingInstrument --> IntegratingInstrument[Integrating Instrument] DeflectingInstrument --> RecordingInstrument[Recording Instrument] </pre>
2.	Illustrate the term Accuracy and Precision?

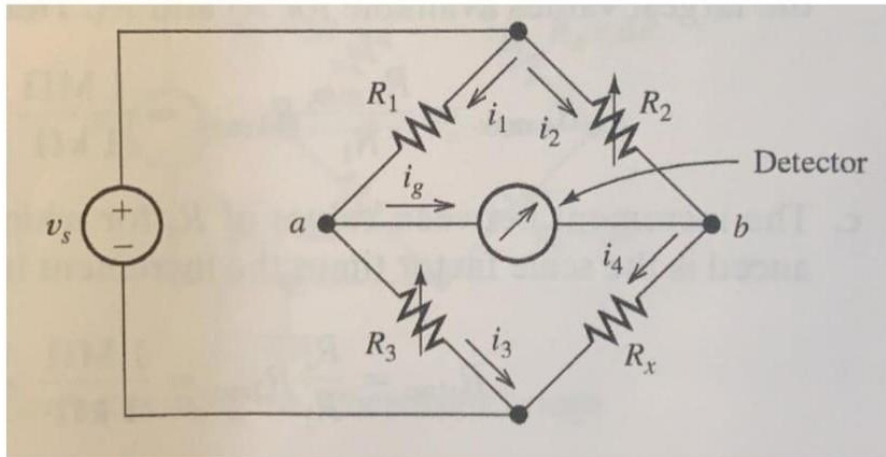
		<table><thead><tr><th>Accuracy</th><th>Precision</th></tr></thead><tbody><tr><td>Accuracy is closeness with the true value of the quantity being measured.</td><td>Precision is a measure of the reproducibility of the measurement.</td></tr><tr><td>Measurement can be accurate but not necessarily precise.</td><td>Measurement can be precise but not necessarily accurate.</td></tr><tr><td>It can be determined with a single measurement.</td><td>It needs several measurements to be determined.</td></tr><tr><td>Accuracy may be affected with systematic error.</td><td>Precision may be affected with random error.</td></tr><tr><td>Accurate values have to be precise in most cases.</td><td>Precise values may or may not be accurate.</td></tr><tr><td>Degree of conformity.</td><td>Degree of reproducibility.</td></tr></tbody></table>	Accuracy	Precision	Accuracy is closeness with the true value of the quantity being measured.	Precision is a measure of the reproducibility of the measurement.	Measurement can be accurate but not necessarily precise.	Measurement can be precise but not necessarily accurate.	It can be determined with a single measurement.	It needs several measurements to be determined.	Accuracy may be affected with systematic error.	Precision may be affected with random error.	Accurate values have to be precise in most cases.	Precise values may or may not be accurate.	Degree of conformity.	Degree of reproducibility.	
Accuracy	Precision																
Accuracy is closeness with the true value of the quantity being measured.	Precision is a measure of the reproducibility of the measurement.																
Measurement can be accurate but not necessarily precise.	Measurement can be precise but not necessarily accurate.																
It can be determined with a single measurement.	It needs several measurements to be determined.																
Accuracy may be affected with systematic error.	Precision may be affected with random error.																
Accurate values have to be precise in most cases.	Precise values may or may not be accurate.																
Degree of conformity.	Degree of reproducibility.																
3.	Write the two conditions to be satisfied for balancing AC bridges. AC Bridge: Balance Condition  - all four arms are considered as impedance (frequency dependent components) - The detector is an ac responding device: headphone, ac meter - Source: an ac voltage at desired frequency Z_1, Z_2, Z_3 and Z_4 are the impedance of bridge arms At balance point: $E_{BD} = E_{BC}$ or $I_1 Z_1 = I_2 Z_2$ $I_1 = \frac{V}{Z_1 + Z_3} \text{ and } I_2 = \frac{V}{Z_2 + Z_4}$ General Form of the ac Bridge Complex Form: $Z_1 Z_4 = Z_2 Z_3$ Polar Form: $Z_1 Z_4 (\angle \theta_1 + \angle \theta_4) = Z_2 Z_3 (\angle \theta_2 + \angle \theta_3)$ Magnitude balance: $Z_1 Z_4 = Z_2 Z_3$ Phase balance: $\angle \theta_1 + \angle \theta_4 = \angle \theta_2 + \angle \theta_3$																
4.	What type of AC bridge is used for measurement of capacitance? And write its formula. AC bridges  - all four arms are considered as impedance (frequency dependent components) - The detector is an ac responding device: headphone, ac meter - Source: an ac voltage at desired frequency Z_1, Z_2, Z_3 and Z_4 are the impedance of bridge arms At balance point: $E_{BD} = E_{BC}$ or $I_1 Z_1 = I_2 Z_2$ $I_1 = \frac{V}{Z_1 + Z_3} \text{ and } I_2 = \frac{V}{Z_2 + Z_4}$ General Form of the ac Bridge Complex Form: $Z_1 Z_4 = Z_2 Z_3$																
5.	List any two limitations of wheat stone bridge. Limitation of Wheatstone bridge: "It is not susceptible to high dc current." ... "The Wheatstone bridge measures resistance from few "ohms" to "megohms." "The upper range of the bridge can be increased with the help of the applied "emf", and the lower range is limited by connecting the lead at the binding post."																
6.	(a)	With aid of block diagram showing the basic functional elements of an general instrument and explain the functions of each block with example	13														

		 The flowchart titled 'Functional elements of an Instrument' shows the process from 'quantity to be measured (measurand)' through a 'Primary sensing element', 'variable conversion element', and 'variable manipulation element' (collectively labeled 'Data conditioning elements'). This leads to a 'data transmission element', which connects to both a 'data storage and playback element' and a 'data presentation element'. The 'data presentation element' finally leads to the 'observer'.	
		(OR)	
	(b)	Discuss in detail various types of errors associated in measurement and how these errors can be minimized?  The flowchart titled 'Errors' categorizes errors into 'Gross Error', 'Systematic Error', and 'Random Error'. 'Systematic Error' is further divided into 'Instrumental Error', 'Environmental Error', and 'Observational Error'. 'Instrumental Error' is further detailed with 'Loading Effect', 'Misuse of Instruments', and 'Inherent shortcomings of Instruments'.	13
7.	(a)	Explain the operation of Kelvin bridge with neat circuit diagram and also derive the expression for determining unknown resistance.  The circuit diagram of a Kelvin bridge shows a Wheatstone bridge with four arms. The top arm contains a variable resistor 'G'. The left arm contains a resistor 'P' in series with a resistor 'R'. The right arm contains a resistor 'Q' in series with a resistor 'S'. The bottom arm contains a resistor 'R' in series with a resistor 'S'. A galvanometer 'G' is connected between the junction of 'P' and 'Q' and the junction of 'R' and 'S'. A battery 'E' is connected across the bridge, and a current 'I' is indicated. $C + t_1 = \frac{A}{B} (D + t_2)$ Also we have $\frac{t_1}{t_2} = \frac{A}{B}$ (1) $\text{So, } \frac{t_1}{t_2 + t_2} = \frac{A}{A + B} \Rightarrow t_1 = \frac{A}{A + B} \times t$ As $t_1 + t_2 = t$ and $t_2 = \frac{B}{A + B} \times t$ We can write equation (1) as $C + \frac{A}{A + B} \times t = \frac{A}{B} \times \left(D + \frac{B}{A + B} \times t \right)$ It implies that $C = \frac{A}{B} \times D$	13
		(OR)	
	(b)	Explain how inductance is measured in terms of known capacitance using Maxwell's bridge and also derive the equation for balanced condition.	13

		 Writing the equation for balance $(R_1 + j\omega L_1) \left(\frac{R_4}{1 + j\omega C_4 R_4} \right) = R_2 R_3$ or $R_1 R_4 + j\omega L_1 R_4 = R_2 R_3 + j\omega R_2 R_3 C_4 R_4$ Separating the real and imaginary terms, we have $R_1 = \frac{R_2 R_3}{R_4} \quad \dots(16.18)$ and $L_1 = R_2 R_3 C_4 \quad \dots(16.19)$ 	
8.	(a)	Define and explain the following static characteristics of an instrument with real time example. Also explain the types of static errors possible in an instrument. a) Accuracy, b) Resolution, c) Sensitivity and d) Linearity.  InstrumentationTools.com	14
		(OR)	
	(b)	Explain how unknown resistance is measured in terms of known resistance using wheat stone bridge and also derive the equation for balanced condition with numerical calculations.	14

The Wheatstone bridge is a circuit used to measure unknown resistances. For example, it is used by mechanical and civil engineers to measure the resistances of strain gauges in experimental stress studies of machines and buildings. The circuit is shown below. The circuit consists of a DC voltage source v_s , a detector, the unknown resistance to be measured R_x , and three precision resistors R_1 , R_2 and R_3 . Usually, R_2 and R_3 are adjustable resistances, which is indicated in the figure by the arrow drawn through the resistance symbols.

The detector is capable of responding to very small currents (less than one microampere). However, it is not necessary for the detector to be calibrated. It is only necessary for the detector to indicate whether or not current is flowing through it. Often, the detector has a pointer that deflects one way or the other, depending on the direction of the current through it. In operation, the resistors R_2 and R_3 are adjusted in value until the detector indicates zero current. In this condition, we say that the bridge is balanced. Then, the current i_g and the voltage V_{ab} across the detector are zero.



- (1). Please derive the unknown R_x in terms of R_1 , R_2 and R_3 .
- (2). Model the Wheatstone Bridge circuit in MATLAB/Simulink and verify the result you found in Part (1).
- (3). Find a real-world application of Wheatstone Bridge and explain how it works. Model your application of Wheatstone Bridge in MATLAB/Simulink.