ELECTRICAL MEASUREMENT AND INSTRUMENTS
(AEIE 2203)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) In single-phase induction-type energy meters, maximum torque is produced when the shunt magnet flux lags the supply voltage by
(a) 90 degree (b) 0 degree (c) 45 degree (d) 60 degree.

(ii) Moving iron type instruments can be used as
(a) standard instruments for calibration of other instruments
(b) indicator type instruments as on panels
(c) transfer type instruments
(d) all of these.

(iii) The desirable static characteristic(s) of a measurement is/are
(a) precision (b) accuracy (c) sensitivity (d) all of these.

(iv) The reliability of an instrument refers to
(a) measurement of changes due to temperature variation
(b) degree to which repeatability continues to remain within specified limits
(c) the life of the instrument
(d) the extent to which the characteristics remain linear.

(v) High ac voltages are usually measured with
(a) magnetic voltmeter
(b) potential transformers with voltmeters
(c) inductive voltmeter
(d) current transformers and voltmeters.

(vi) Ammeter-voltmeter method is used for the measurement of
(a) high resistance (b) low resistance
(c) medium resistance (d) insulation resistance.

(vii) The potentiometer is standardized for making it
(a) precise (b) precise and accurate
(c) accurate (d) accurate and direct reading.

(viii) Which bridge is used for measuring frequency?
(a) Andersen Bridge (b) Schering Bridge
(c) De Sauty Bridge (d) Wien's Bridge.

(ix) The relative error is the
(a) difference of measured value and true value
(b) ratio of absolute error to the measured value of the measurand
(c) ratio of absolute error to the true value of the measurand
(d) ratio of probable error to the true value of the measurand.

(x) The instrumental error of an instrument is classified as
(a) gross error (b) systematic error
(c) random error (d) indefinite error.

Group – B

2. (a) What are the differences between moving coil and moving iron type instruments? What are the main sources of errors in moving coil instruments?

(b) A moving coil instrument gives a full scale deflection of 20 mA when the potential difference across its terminals is 250 mV.
(i) Calculate the shunt resistance for a full scale deflection corresponding to 10 A.
(ii) Calculate the series resistance for full scale reading with 500 V.

(c) Define the term span and resolution of an analog instrument. A measuring instrument has a calibrated range of 10- 50 mA, which has 100 divisions and can be read ½ a division correctly. Find out the span and resolution of that instrument.

(2 + 2) + (2 + 2) + (2 + 2) = 12

3. (a) What are the advantages and disadvantages of moving-iron instruments?

(b) A PMMC voltmeter with a resistance of 20 Ω gives a full-scale deflection of 120° when a potential difference of 100 mV is applied across it. The moving coil has dimensions of 30 mm × 25 mm and is wound with 100 turns. The control spring constant is 0.375×10^{-6} N-m/degree. Find the flux density in the air gap. Find also the dimension of copper wire of coil winding if 30% of the instrument resistance is due to coil winding. The specific resistance of copper is 1.7×10^{-8} Ωm.

(c) An electrostatic voltmeter reading up to 2000 volts is controlled by a spring having torsion constant of 8×10^{-6} Nm/rad and has full scale deflection of 90^0. When reading is zero, the capacitance is 10 pF. What is the capacitance when the instrument reads 1500 volts?

4 + 4 + 4 = 12

Group – C

4. (a) List the errors associated with single phase induction type energy meter and the possible remedies to overcome these errors.

A correctly adjusted single phase 240V watt-hour meter has a meter constant of 600 revolutions per kWh. Determine the speed of the disc for a current of 8 A at a lagging power factor of 0.6.

(b) A current transformer with turn-ratio of 1:201 is rated as 1000/5 A 25 VA. The core loss and magnetizing components of primary current are 3 A & 7 A under rated conditions. Determine the ratio error and phase angle error for full burden at 0.8 power factor lagging.

(6 + 2) + 4 = 12

5. (a) Explain the working principle of a Crompton dc potentiometer with suitable diagram.

(b) A single-range laboratory type dc potentiometer has a 18 step dial switch where each step represents 0.1 V. The dial resistors are 10 Ω each. The slide wire of the potentiometer is circular and has 11 turns and a resistance of 1 Ω per turn. The slide wire has 100 divisions and it is possible to read up to ¼ of a division. The working battery has a voltage of 6 V. Calculate (i) measurement range of the potentiometer and (ii) the resolution.

8 + 4 = 12

Group – D

6. (a) The four arms of a Maxwell's inductance–capacitance bridge at balance are Arm AB: A choke coil L_1 with an equivalent series resistance R_1, Arm BC: A non-inductive resistance of 800 Ω, Arm CD: A mica capacitor of 0.3 μF in parallel with a non-inductive resistance of 800 Ω and Arm DA: A non-inductive resistance 800 Ω. Supply is given between terminals A and C and the detector is connected between nodes B and D. Derive the equations for balance of the bridge and hence determine values of L_1 and R_1. Draw the phasor diagram of the bridge under balanced condition.

(b) An ac bridge is configured as follows:
Arm AB: A resistance of 600 Ω in parallel with a capacitance of 0.3 μF
Arm BC: An unknown non-inductive resistance
Arm CD: A noninductive resistance of 1000 Ω
Arm DA: A resistance of 400 Ω in series with a capacitance of 0.1 μF
If a supply is given between terminals A and C and the detector is connected between nodes B and D, find the resistance required in the arm BC and also the supply frequency for the bridge to be balanced.

(4 + 2 + 2) + (2 + 2) = 12

7. (a) Draw a neat schematic diagram and phasor diagram of the Carey-Foster bridge. Derive the expression for the unknown capacitance in terms of known components.

(b) In the Carey-Foster bridge, the arm AB contains a mutual inductance of 18.35 mH and a total non-inductive resistance of 200 Ω; BC is of zero resistance; CD has a non-inductive resistance of 100 Ω; and DA comprises a non-inductive resistance of 119.5 Ω in series with an unknown capacitor. The self-inductance of the coil in the arm AB is 40.6 mH. Determine the capacitance of the unknown capacitor and the equivalent series resistance.

(4 + 4) + 4 = 12

Group – E

8. (a) Describe with suitable schematic diagrams, the Murray loop test for localization of earth fault and short circuit fault in low voltage cables.

(b) In a test for earth fault by Murray loop test, the faulty cable is looped with a sound (healthy) cable .The sound and faulty cables are identical and have a resistance of 4Ω/km. The faulty cable is of the same length and cross section. Resistances of the ratio arm of the measuring bridge circuit are 50 Ω and 34 Ω at balance. Determine the length of each cable and the distance of fault from the test end.

(c) What is the advantage of Varley loop test over Murray loop test?

(2 + 2 + 3) + 4 + 1 = 12

9. (a) Three resistors have the following ratings:
$R_1 = 47\ \Omega \pm 4\%$, $R_2 = 65\ \Omega \pm 4\%$, $R_3 = 55\ \Omega \pm 4\%$
Determine the magnitude and limiting errors in ohms and in percentage of the resistance of these resistors connected in series.

(b) A pressure gauge was tested to obtain its calibration curve and the following set of data were obtained:

Input (kg/cm^2)	0	1	2	3	4	5	6	7	8	9	10
Output (kg/cm^2)	0	0.9	2.05	2.9	4.1	5.05	5.95	7.02	7.89	9.08	9.96

Plot the calibration curve using (i) method of sequential differences & (ii) method of extended differences.

2 + (5 + 5) = 12