ELECTRICAL AND ELECTRONIC MEASUREMENTS TEST 3

Number of Questions: 25 **Section Marks: 90**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

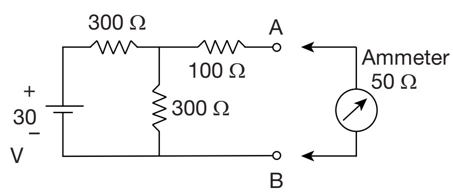
1. A null type of instrument as compared to a deflection type instrument has
   (A) faster response. (B) lower sensitivity.
   (C) higher accuracy. (D) lower precision.

2. A thermometer is calibrated 100°C to 125°C. The accuracy is specified with ±0.5 percent of instrument span. What is the maximum static error?
   (A) 0.125°C (B) 0.25°C
   (C) 0.375°C (D) 0.5°C

3. A moving coil voltmeter has a uniform scale with 200 divisions, the full scale reading is 400V and $\frac{1}{5^{th}}$ of scale can be estimated with a fair degree of certainty. Determine the resolution of the instrument in volt.
   (A) 0.1V (B) 0.2V
   (C) 0.4V (D) 0.8V

4. What is the correct sequence of the following type of ammeter and voltmeter with decreasing accuracy
   1. Induction
   2. Moving iron
   3. Moving coil permanent magnet

   (A) 3, 2, 1 (B) 2, 1, 3
   (C) 3, 1, 2 (D) 1, 3, 2

5. 

   It is desired to measure the value of current in the 100 Ω resistor as shown in figure, by connecting a 50 Ω ammeter, the percentage error in measurement will be
   (A) 16.67% (B) –16.67%
   (C) 9.38% (D) –9.38%

6. A first order instrument is characterized by
   (A) Static sensitivity
   (B) Time constant
   (C) Static sensitivity and time constant
   (D) Static sensitivity, damping coefficient and natural frequency of oscillations.

7. A moving coil ammeter has a fixed shunt of 0.01 Ω with a coil circuit resistance of 100 Ω and needs potential difference of 5V across it for full scale deflection. Calculate the current corresponding to full scale deflection
   (A) 700.05A (B) 250.025A
   (C) 1000.05A (D) 500.05A

8. A weight of 25g is used as the controlling weight in a gravity controlled instrument. Find its distance from spindle if the deflecting torque corresponding to a deflection of 45° is 1.29×10^{-3} Nm.
   (A) 26.6 mm (B) 7.44 mm
   (C) 16.19 mm (D) 4.53 mm

9. The inductive reactance of pressure coil circuit of a dynamometer wattmeter is 0.5% of its resistance value at 50 Hz frequency and the capacitance is negligible. What will be the correction factor due to the reactance for load at 0.8 lag.
   (A) 0.8175 (B) 0.8734
   (C) 0.9001 (D) 0.9914

10. Which one of the following is basically a current sensitive instrument?
    (A) Electro static instrument
    (B) Cathode ray oscilloscope
    (C) Digital voltmeter
    (D) Permanent magnet moving coil instrument

11. A moving iron instrument has full scale current of 200 mA. It is converted into a 200V voltmeter by using a series resistance made of material having negligible resistance temperature coefficient. The meter has are sistance of 240 Ω at 20°C. After carrying a steady current of 200 mA for a long time, the resistance of the coil increased to 280 Ω due to self heating. The error in voltmeter due to self heating will be
    (A) –3.85% (B) –4%
    (C) 4% (D) 3.85%

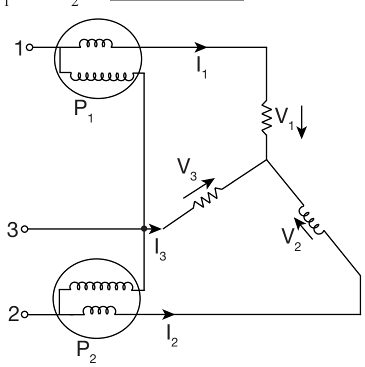
12. The inductance of a 10A electro dynamic ammeter changes uniformly at the rate of 0.1 μH/degree. The spring constant is 10^{-4} Nm/degree. The angular deflection at full scale will be
    (A) 5.73° (B) 13.78°
    (C) 28.9° (D) 125.47°

13. In a electrodynamo meter instrument the resistance of the voltage coil is 10000 Ω and the mutual inductance changes uniformly from –150 μH at zero deflection to +150 μH at full scale, the full scale angle is 1.66 rad. If a potential difference 100V is applied across the voltage circuit and a current of 5A at a power factor of 0.8 is passed through the current coil. What will be the deflection, if the spring control constant is 0.1×10^{-6} N-m/degree?
    (A) 18.15° (B) 58.42°
    (C) 72.3° (D) 94°

14. What will be the reading of an electro dynamo ammeter when a current of $i(t) = 40 - 30\sqrt{2}\,\mathrm{Co}(\omega t + 20^{o})$A is passed through it.
    (A) 10A (B) 2.42A
    (C) 26.48A (D) 50A

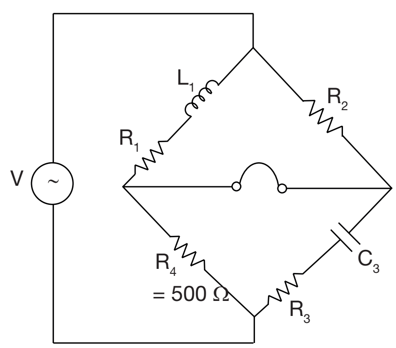
15. If an energy meter disc makes 10 revolutions in 100 seconds when a load of 720 W is connected to it, determine the meter constant in revolutions/ kWh.
(A) 250 (B) 500
(C) 750 (D) 1000

16. A 3 – ϕ unbalanced load circuit is shown in figure. Its power is measured by two wattmeters P_1 and P_2 are 720W and 580W respectively. The phase difference between V_1 and I_2 is ___________



(A) 130.58° (B) 158.43°
(C) 49.42↑° (D) 21.57°

17. In a Hay's bridge, the four arms are: R_1 = 100 Ω, R_2 = 1 k Ω, R_3 = 1 k Ω, C_3 = 25 μF and frequency, 10 rad/sec. Under the phase null condition, inductance L_1 of the coil is given by _____



(A) 0.2H (B) 0.4H
(C) 25mH (D) 300mH

18. The reading of a dynamometer type wattmeter with pressure coil phase angle of 3° is 800W when it was used to measure power of a single phase inductive load supplied by 230V, 1 – Φ, ac source. If the wattmeter is replaced by the another meter then phase angle of 1° for the pressure coil circuit a reading of 750W is obtained. What will be the load power factor?
(A) 0.313 lag (B) 0.452 lag
(C) 0.654 lag (D) 0.799 lag

19. An oscilloscope having an input resistance of 1 M Ω shunted by 50 pF capacitance is connected across a circuit having an effective output resistance of 10 k Ω. If the open circuit voltage 1.0 V peak for a 100 kHz sine wave. what will be the voltage indicated on the oscilloscope when the frequency is 1 MHz?
(A) 0.101V (B) 0.152V
(C) 0.304V (D) 0.202V

20. A 160 PF capacitor, an inductor of 160 μH and a resistor 1000 Ω are connected in series. If all the three components are +10%,what will be the percentage error of the resonant frequency.
(A) –5% (B) –10%
(C) –20% (D) –40%

21. For a 1 – Φ, 20 kV, 50 Hz supply to the schering bridge, having a standard capacitor of 100 pF, balance was obtained with a capacitance of 0.5 μF in parallel with a non-inductive resistance of 400 Ω, the non-inductive resistance in the remaining arm of the bridge is 100 Ω, what will be the power factor of the series Resistance – Capacitance section
(A) 0.414 (B) 0.629
(C) 0.754 (D) 0.873

22. A balanced bridge has the following arm parameters
Arm AB: R_1 = 1 k Ω parallel with C_1 = 1 μF
Arm BC: R_2 = 1 k Ω series with C_2 = 1 μF
Arm CD: unknown impedance (Z_x)
Arm DA: C_3 = 1 μF
If an ac voltage of frequency 1 × 10^4 rad/sec is applied across the junction *BD*, the impedance of the *arm CD* will be?
(A) (243.5 + *j*195) Ω
(B) (441.5 – *j*225) Ω
(C) (990 – *j*200) Ω
(D) (1132 + *j*406) Ω

23. A voltmeter having a sensitivity of 2000 Ω/V reads 200V on its 400V scale when connected across an unknown resistor in series with a milli-ammeter. When milli-ammeter reads 10mA, what will be the error due to the loading effect of voltmeter.?
(A) –2.5% (B) –5%
(C) –4.2% (D) –8.4%

24. The inductance of a moving iron ammeter with full scale deflection of 60° at 2A, is given by the expression $L = (5 + 80\,\theta - 2\,\theta^2 - \theta^3)$ μH, θ is the deflection in radian from the zero position. What will be the angular deflection of pointer for the current of 1A.
(A) 4.37° (B) 16.26°
(C) 27.19° (D) 54.88°

25. The range of 0 – 10A moving iron ammeter is extended to 0 – 100A. The instrument constants are R = 0.09 Ω and L = 80 μH. If the shunt is made non-inductive and the combination is correct on d.c. then the full scale error at 50 Hz will be
(A) –0.05% (B) –1.8%
(C) –2.1% (D) –3%

Answer Keys

1. C	**2.** A	**3.** C	**4.** A	**5.** B	**6.** C	**7.** D	**8.** B	**9.** D	**10.** D
11. A	**12.** A	**13.** C	**14.** D	**15.** B	**16.** A	**17.** B	**18.** B	**19.** C	**20.** B
21. B	**22.** C	**23.** B	**24.** B	**25.** D					

Hints and Explanations

1. The accuracy of null type of instrument is higher than that of deflection type. This is because of opposing effect is calibrated with the help of standards which have high degree of accuracy. Choice (C)

2. Span of thermometer = 125 – 100 = 25°C

$\therefore$ Maximum static error = $\frac{\pm 0.5\times 25}{100}$

= ±0.125°C Choice (A)

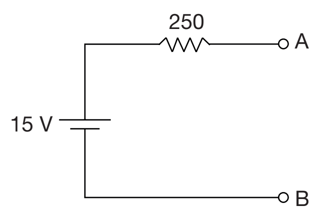
3. One scale division = $\frac{400}{200}$ = 2V

Resolution = $\frac{1}{5^{th}}$ scale division = $\frac{1}{5}$ × 2 = 0.4V

Choice (C)

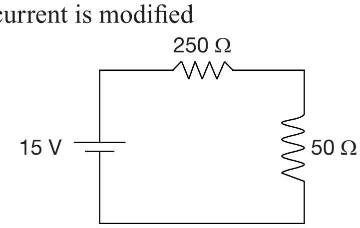
4. Induction principle generally used in wattmeters and due to its inaccuracy and high cost, won't be used in ammeters and voltmeters. Choice (A)

5. The thevenin equivalent circuit is



Actual value of current, $I_o = \frac{15}{250}$ = 60mA

When the ammeter is introduced into the circuit the value of current is modified



Measured value of current = $\frac{15}{300}$ = 50mA

%Error = $\frac{50\times 10^{-3}-60\times 10^{-3}}{60\times 10^{-3}}\times 100$ = –16.67%

Choice (B)

6. Choice (C)

7. Current through shunt $I_{sh} = \frac{5}{0.01}$ = 500A

Current through meter to given full scale deflection

$I_m = \frac{5}{100}$ = 0.05A

Total current $I = I_{sh} + I_m$ = 500 + 0.05

I = 500.05 A Choice (D)

8. Deflecting torque due to weight, $T_d = mg \sin\theta \times d$

$$d = \frac{T_d}{mg\sin\theta} = \frac{1.29\times 10^{-3}}{25\times 10^{-3}\times 9.81\times \sin 45^o}$$

d = 7.44m Choice (B)

9. Pressure coil impedance angle,

$\beta = \tan^{-1}\left(\frac{0.5}{100}\right)$ = 0.2864

Power factor of load = cos 60° = 0.8

ϕ = 60°

Connection factor = $\frac{\cos\varphi}{\cos\beta\cos(\varphi-\beta)}$

= $\frac{\cos 60}{\cos(0.2864)\cos(60-0.2864)}$ = 0.9914

Choice (D)

10. Choice (D)

11. Total resistance of the circuit when the meter is converted to a 200V voltmeter $R = \frac{200}{200\times 10^{-3}} = 1000\Omega$

Series resistance R_s = 1000 – 240 = 760 Ω

Due to temperature rise the total resistance becomes = 760 + 280 = 1040 Ω

$\therefore$ voltmeter reading = $\frac{1000}{1040}\times 200$ = 192.3V

%error = $\frac{192.3-200}{200}\times 100 = -3.85\%$ Choice (A)

12. Developed torque $T_d = I^2.\frac{dM}{d\theta}$

and spring torque $T_C = k\,\theta$

So, $T_d = T_c$

$k\,\theta = I^2.\frac{dM}{d\theta}$]

$\theta = \frac{I^2}{k}.\frac{dM}{d\theta} = \frac{(10)^2}{10^{-4}}\times 0.1\times 10^{-6}$

θ = 0.1 rad (or) 5.73° Choice (A)

13. Current through the current coil = 5A

Current through the voltage coil = $\frac{100}{10000}$ = 0.01A

Rate of change of mutual inductance, $\dfrac{dM}{d\theta} = \dfrac{150-(-150)}{1.66} = 180.73\dfrac{\mu H}{rad}$

Deflection, $\theta = \dfrac{I_1 I_2}{k} \cdot \cos\phi . \dfrac{dM}{d\theta}$

$$\theta = \frac{5\times 0.01}{\left(0.1\times 10^{-6}\right)} \times 0.8\times 180.73\times 10^{-6}$$

$\theta = 72.3^{\circ}$ Choice (C)

14. An electro dynamo ammeter reads rms value of current $I_o = 40A$, $I_m = -30\sqrt{2}$

$$I_{rms} = \sqrt{I_o^2 + \left(\frac{I_m}{\sqrt{2}}\right)^2}$$

$$= \sqrt{40^2 + \left(\frac{30\sqrt{2}}{\sqrt{2}}\right)^2} = 50A$$

Choice (D)

15. Load of kW = $\dfrac{\text{Energy consumed in kWh}}{\text{Time in hours}}$

$$0.72 = \frac{\text{Energy Consumed in kWh}}{\dfrac{100}{3600}}$$

Energy consumed in kWh = $0.72 \times \dfrac{1}{36} = 0.02$

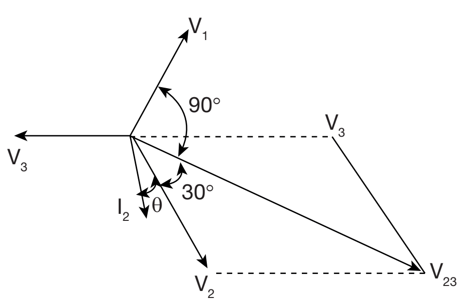
Meter constant = $\dfrac{\text{Number of revolutions}}{\text{Energy consumed in kWh}} = \dfrac{10}{0.02}$

= 500 revolutions/kWh. Choice (B)

16. Power factor angle, $\theta = \tan^{-1}\left\{\dfrac{\sqrt{3}\left(P_1 - P_2\right)}{P_1 + P_2}\right\}$

$$\theta = \tan^{-1}\left\{\frac{\sqrt{3}\left(720-580\right)}{720+580}\right\}$$

$\theta = 10.57^{\circ}$



Phase difference between V_1 and I_2 is

$= 90 + 30 + \theta = 90 + 30 + 10.57$

$= 130.58^{\circ}$ Choice (A)

17. At balance, the phase angles should be equal.

$$\tan\theta_L = \frac{X_{L_1}}{R_1} = \frac{\omega L_1}{R_1}$$

$$\tan\theta_c = \frac{X_{c_3}}{R_3} = \frac{1}{\omega R_3 C_3}$$

$\tan\theta_L = \tan\theta_c$

$$\frac{\omega L_1}{R_1} = \frac{1}{\omega R_3 C_3}$$

$$L_1 = \frac{R_1}{\omega^2 R_3 C_3} = \frac{100}{(100)^2 \times (1000) \times \left(25\times 10^{-6}\right)}$$

$$L_1 = \frac{R_1}{\omega^2 R_3 C_3} = \frac{100}{(100)^2 \times (1000) \times \left(25\times 10^{-6}\right)}$$

= 0.4H Choice (B)

18. Actual wattmeter reading = True power [1 + tan ϕ tan β]

$$\frac{800}{750} = \frac{\text{True power}\left(1+\tan\varphi . \tan 3^{o}\right)}{\text{True power}\left(1+\tan\varphi . \tan 1^{o}\right)}$$

$1.066 + 0.0186 \tan\phi = 1 + 0.0524 \tan\phi$

$\tan\phi = 1.9699$

load power factor, $\cos\Phi = 0.452$ lag Choice (B)

19. The values of capacitive reactance $X_c = \dfrac{1}{2\pi f c}$

$$X_c = \frac{1}{2\pi \times 10^{6} \times 50 \times 10^{-12}}$$

$X_c = 3200\ \Omega$

The input impedance, $Z_L = \dfrac{R\left(-jX_c\right)}{R - jX_c}$

$$= \frac{10^{6}\left(-j3.2\times 10^{3}\right)}{10^{6} - j3.2\times 10^{3}} = 3.2 \times 10^{3} \angle -90^{\circ}\ \Omega$$

The voltage across load, $E_L = \dfrac{E_o}{1 + \dfrac{Z_o}{Z_L}}$

$$E_L = 1.0 \times \frac{1}{1 + \dfrac{10\times 10^{3}\angle 0^{o}}{3.2\times 10^{3}\angle -90^{o}}}$$

$E_L = 0.304\angle -72.3^{\circ}$ V (Peak) Choice (C)

20. Resonant frequency $f_r = \dfrac{1}{2\pi\sqrt{LC}}$

$$= \frac{1}{2\pi\sqrt{160\times 10^{-12} \times 160\times 10^{-6}}} = 1\text{MHz}$$

When component are +10%

$C = 160 + 0.1 \times 160 = 176\ \mu F$ and

$L = 160 + 0.1 \times 160 = 176\ \mu H$

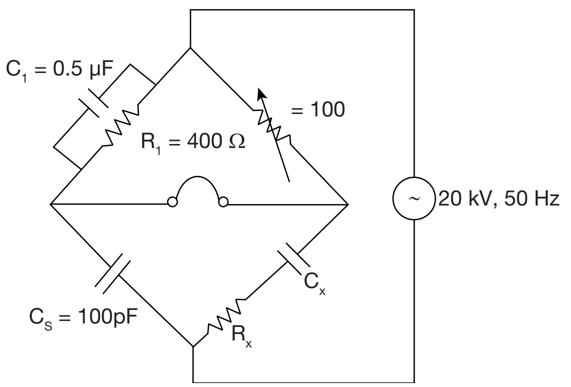
$$f_r^{1} = \frac{1}{2\pi\sqrt{L^{1} C^{1}}} = \frac{1}{2\pi\sqrt{176\times 10^{-12} \times 176\times 10^{-6}}}$$

$f_r^1 = 0.9\text{MHz}$

$$\%\text{error} = \frac{f_r^1 - f_r}{f_r} \times 100 = \frac{0.9-1}{1} \times 100 = -10\%$$

Choice (B)

21. Schering bridge, circuit

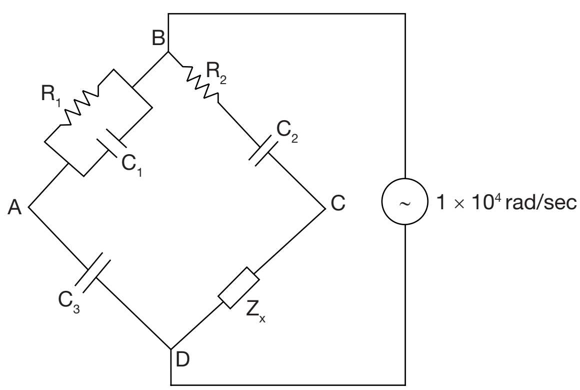


$$\text{Power factor} = \frac{R_x}{Z_x} = \omega R_x C_V = \omega R_1 C_1$$

$= 2\pi \times 50 \times 400 \times 0.5 \times 10^{-6} = 0.629$ Choice (B)

22. At balanced $Z_1 Z_x = Z_2 Z_3$

$$Z_x = \frac{Z_2 Z_3}{Z_1}$$



$$Z_x = \left\{\frac{\omega^2 C_1 C_2 R_1 R_2 - 1}{\omega^2 R_1 C_2 C_3}\right\} - j\left\{\frac{R_2 C_2 + R_1 C_1}{\omega R_1 C_2 C_3}\right\}$$

$$Z_x = \left\{\frac{(10^4)^2 \times (1\times10^{-6})(1\times10^{-6}) \times 10^3 \times 10^3 - 1}{(10^4)^2 \times 10^3 \times 10^{-6} \times 10^{-6}}\right\} - j$$

$$\left\{\frac{10^3 \times 10^{-6} + 10^3 \times 10^{-6}}{10^4 \times 10^3 \times 10^{-6} \times 10^{-6}}\right\}$$

$Z_x = 990 - j200\ \Omega$ Choice (C)

23. Circuit resistance $R_C = \dfrac{200}{10\times10^{-3}} = 20\ \text{k}\Omega$

Voltmeter resistance $R_V = 2000 \times 200 = 400\ \text{k}\Omega$

By neglecting milli-ammeter resistance unknown resistor $R_x = 20\ \text{k}\Omega$

As the voltmeter connected in parallel with the unknown resistance, $R_c = \dfrac{R_x R_V}{R_x + R_V}$

$$R_x = \frac{R_c R_V}{R_V - R_c} \Rightarrow R_x = \frac{20 \times 400}{400-20} = 21.05\ \text{k}\Omega$$

$$\text{Percentage error} = \frac{\text{meausred value - true value}}{\text{true value}} \times 100$$

$$= \frac{20-21.05}{21.05} = -5\%$$

Choice (B)

24. Rate of change of inductance, with deflection,

$$\frac{dL}{d\theta} = 80 - 4\,\theta - 3\,\theta^2$$

Since $\theta = \dfrac{\pi}{2}\text{rad}, \dfrac{dL}{d\theta} = 80 - 4\left(\dfrac{\pi}{3}\right) - 3\left(\dfrac{\pi}{3}\right)^2$

$\dfrac{dL}{d\theta} = 72.53\mu\text{H/rad}$ and $\theta = \dfrac{1}{2}\dfrac{I^2}{k}.\dfrac{dL}{d\theta}$

$$\frac{\pi}{3} = \frac{1}{2}.\frac{2^2}{k} \times 72.53 \times 10^{-6}$$

$K = 138.6 \times 10^{-6}$ Nm/rad

For the pointer current of 1A

$$\theta = \frac{1}{2} \times \frac{(1)^2 (80 - 4\theta - 3\theta^2) \times 10^{-6}}{138.6 \times 10^{-6}}$$

$277.2\theta = 80 - 4\,\theta - 3\,\theta^2$

$3\,\theta^2 + 281.2\,\theta - 80 = 0$

$\theta = 0.2836$ rad

(or) $\theta = 16.26^\circ$

Choice (B)

25. Shunt multiplier $= \dfrac{100}{10} = 10$

Shunt resistance, $R_{sh} = \dfrac{R}{m-1} = \dfrac{0.09}{10-1} = 0.01\ \Omega$

for d.c current through the meter, $I_m = \dfrac{R_{sh}}{R_{sh} + R} \times I$

$$= \frac{0.01}{0.01 + 0.09} \times 100 = 10\ \text{A}$$

With 50 Hz, the current through the meter,

$$I_m = \frac{R_{sh}}{\sqrt{(R + R_{sh})^2 + \omega^2 L^2}} \times I$$

$$I_m = \frac{0.01 \times 100}{\sqrt{(0.09 + 0.01)^2 + (2\pi \times 50 \times 80 \times 10^{-6})^2}}$$

$I_m = 9.698$A

Since the meter reading is proportional to the current,

$$= \frac{(9.698 - 10)}{10} \times 100 = -3\%$$

Choice (D)