Serial No.

QUESTION BOOKLET

A

54021

ELECTRICAL ENGINEERING (05)

Time Allowed : 3 Hours
[1 Hour for Objective
2 Hours for Subjective]

Maximum Marks : 200
[100 Marks for Objective
100 Marks for Subjective]

INSTRUCTIONS FOR CANDIDATES

1. This Question Booklet consists of **two** Parts (Objective and Subjective). Candidate has to attempt both the Parts.
2. **In Objective Part, there are 50 questions carrying 2 marks each. There is no negative marking for any wrong answer. In Subjective Part, four (4) questions should be answered in which Question No. 1 is compulsory.**
3. Please do not open this Question Booklet until you are told to do so.
4. Candidate must fill up the necessary information in the space provided on the OMR Answer Sheet before commencement of the test.
5. For marking the correct answer, darken one circle by **black or blue** ball-point pen only. Please do not mark on more than one circle. Darkening on more than one circle against an answer will be treated as wrong answer.
6. Do not detach any leaf from this Question Booklet. After the examination, hand over the OMR Answer Sheet to the Room Invigilator.
7. Possession and use of Calculator, Mobile Phone and Pager is prohibited in the Examination Hall.
8. Candidates are informed that evaluation of OMR Sheets will be done by Electronic Machine. So, they should shadow the bubbles of Roll No., Booklet Series and Booklet No. properly, otherwise Machine will not be able to evaluate it. Failure to comply this instruction will be sole responsibility of the candidates.

SEAL

PART—A

(Objective)

1. Two a.c. sources feed a common variable resistive load as shown in Fig. 1. Under the maximum power transfer condition, the power absorbed by the load resistance R is

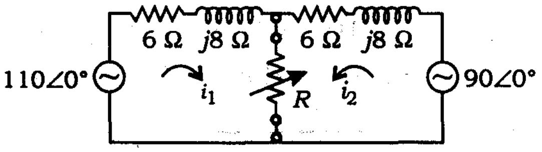

Fig. 1

(A) 2200 W (B) 1250 W

(C) 1000 W (D) 625 W

2. The two-port network P shown in Fig. 2 has Port 1 and Port 2, denoted by terminals (a, b) and (c, d) respectively. It has an impedance matrix Z with parameter denoted by Z_{ij}. A 1 Ω resistor is connected in series with the network at Port 1. The impedance matrix of the modified two-port network (shown as a dashed box) is

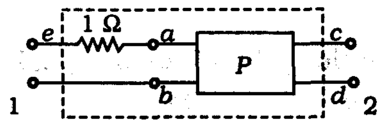

Fig. 2

(A) $\begin{bmatrix} Z_{11}+1 & Z_{12}+1 \\ Z_{21} & Z_{22}+1 \end{bmatrix}$

(B) $\begin{bmatrix} Z_{11}+1 & Z_{12} \\ Z_{21} & Z_{22}+1 \end{bmatrix}$

(C) $\begin{bmatrix} Z_{11}+1 & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}$

(D) $\begin{bmatrix} Z_{11}+1 & Z_{12} \\ Z_{21}+1 & Z_{22} \end{bmatrix}$

3. The transfer function

$$Y_{12}(s) = I_2(s) / V_1(s)$$

for the network shown in Fig. 3 is

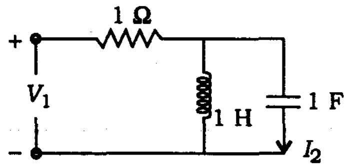

Fig. 3

(A) $\dfrac{s^2}{s^2+s+1}$

(B) $\dfrac{s}{s+1}$

(C) $\dfrac{1}{s+1}$

(D) $\dfrac{s+1}{s^2+1}$

4. The driving point impedance

$$Z(s) = \frac{s+3}{s+4}$$

behaves as

(A) a resistance of 0·75 ohm at low frequencies

(B) a resistance of 1 ohm at high frequencies

(C) a resistance of 0·75 ohm at high frequencies

(D) Both (A) and (B) above

5. A sinusoidal source of voltage V and frequency f is connected to a series circuit of variable resistance R and a fixed reactance X. The locus of tip of current-phasor, I, as R is varied from 0 to ∞ is

(A) a semicircle with a diameter of V / X

(B) a straight line with a slope of R / X

(C) an ellipse with V / R as a major axis

(D) a circle of radius R / S and origin at $(0, V/2)$

6. Which of the following statements is/are true for the circuit shown in the given Fig. 4?

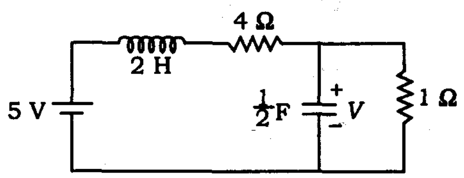

Fig. 4

1. It is a first-order circuit with steady-state values of $V = \frac{5}{3}$ V, $I = \frac{5}{4}$ A.
2. It is a second-order circuit with steady-state values of $V = 1$ V; $I = 1$ A.
3. The network function $V(s) / I(s)$ has one pole.
4. The network function $V(s) / I(s)$ has two poles.

Select the correct answer using the codes given below :

Codes :

(A) 1 and 3

(B) 2 and 4

(C) 2 alone

(D) 1 alone

7. The r.m.s. value of the current $i(t)$ in the circuit shown in Fig. 5 is

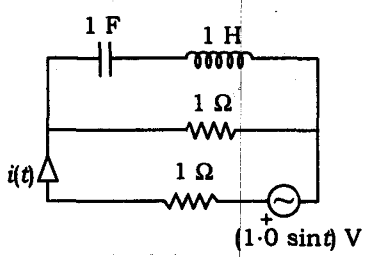

Fig. 5

(A) $\frac{1}{2}$ A

(B) $\frac{1}{\sqrt{2}}$ A

(C) 1 A

(D) $\sqrt{2}$ A

8. In the Fig. 6 shown below, all elements used are ideal. For time $t < 0$, S_1 remains closed and S_2 open. At $t = 0$, S_1 is opened and S_2 is closed. If the voltage V_{c_2} across the capacitor c_2 at $t = 0^-$ is zero, the voltage across capacitor combined at $t = 0^+$ will be

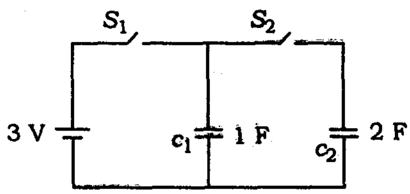

Fig. 6

(A) 1 V

(B) 2 V

(C) 1·5 V

(D) 3 V

9. The driving-point impedance of a one-port reactive network is given by

(A) $\frac{(s^2+1)(s^2+2)}{s(s^2+3)(s^2+4)}$

(B) $\frac{(s^2+1)(s^2+3)}{s(s^2+2)(s^2+4)}$

(C) $\frac{s(s^2+1)}{(s^2+2)(s^2+3)}$

(D) $\frac{1}{(s+1)}$

10. A two-port device is defined by the following pair of equations :

$$i_1 = 2V_1 + V_2 \text{ and } i_2 = V_1 + V_2$$

Its impedance parameters (Z_{11}, Z_{12}, Z_{21}, Z_{22}) are given by

(A) (2, 1, 1, 1)

(B) (1, − 1, − 1, 2)

(C) (1, 1, 1, 2)

(D) (2, − 1, − 1, 1)

11. A first-order, low-pass filter is given with $R = 50\ \Omega$ and $C = 5\mu F$. What is the frequency at which the gain of the voltage transfer function of the filter is 0·25?

(A) 4·92 kHz

(B) 0·49 kHz

(C) 2·46 kHz

(D) 24·6 kHz

12. A signal $X(t) = 6\cos 10\pi t$ is sampled at the rate of 14 Hz. To recover the original signal, the cut-off frequency f_c of the ideal low-pass filter should be

(A) 5 Hz $< f_c <$ 9 Hz

(B) 9 Hz

(C) 10 Hz

(D) 14 Hz

13. The Fourier transform of a double-sided exponential signal $x(t) = e^{-b|t|}$

(A) is $\dfrac{2b}{(b^2+(i)^2)}$

(B) is $\dfrac{e^{-j\tan^{-1}\left(\frac{(i)}{b}\right)}}{(b^2+(i)^2)}$

(C) does not exist

(D) exists only when it is single-sided

14. A sample of *p*-type semiconductor is subjected to the combined effect of mutually perpendicular field E_X and magnetic field B_Z as shown in Fig. 7. This would result in the following events :

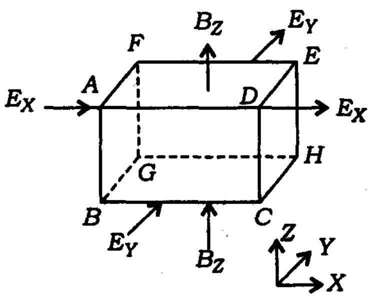

Fig. 7

1. Lorentz force drives the majority carriers to the face *ABCD*.

2. Electric field E_Y results and grows.

3. The faces *ABCD* and *EFGH* are oppositely charged.

4. Lorentz forces on holes is balanced.

The correct sequence of these events is

(A) 1, 3, 4, 2

(B) 3, 1, 2, 4

(C) 1, 3, 2, 4

(D) 3, 1, 4, 2

15. The Hall coefficient of a specimen of doped semiconductor is $3{\cdot}06 \times 10^{-4}\ m^3 C^{-1}$ and the resistivity of the specimen is $8{\cdot}93 \times 10^{-3}$ ohm meter. The majority carrier mobility (in units of $m^2V^{-1}s^{-1}$) will be

(A) 0·0078

(B) 0·035

(C) 0·151

(D) 0·350

16. Consider the following statements :

Magnetic field induced orbital dipole moment in an atom is

1. in a direction opposite to that of the applied field
2. larger for larger atoms
3. independent of effective electron mass
4. 1·3 times of zero-field orbital dipole moment

Of these statements

(A) 1 and 2 are correct

(B) 2 and 3 are correct

(C) 3 and 4 are correct

(D) 1 and 4 are correct

17. Two concentric spheres of radii a and b carry charges $+Q$ and $-Q$ respectively as shown in Fig. 8. Potential at the centre p will be

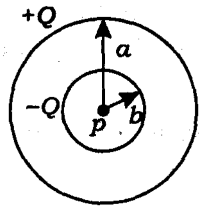

Fig. 8

(A) zero

(B) $\dfrac{Q}{4\pi\varepsilon_0 b}$

(C) $\dfrac{-Q}{4\pi\varepsilon_0 b}$

(D) $\dfrac{Q}{4\pi\varepsilon_0}\left[\dfrac{1}{a}-\dfrac{1}{b}\right]$

18. An infinite long conductor is carrying a current I in a region of permeability μ_1 and in the vicinity of another region of permeability μ_2 as shown in Fig. 9. For calculating the field in the first region, the effect of discontinuity is replaced by an image I' and with $\mu_1 < \mu_2$.

Which one of the following statements is correct in this regard?

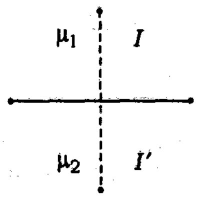

Fig. 9

(A) I and I' have the same strength and direction

(B) I and I' have opposite direction but same strength

(C) I and I' have same direction but different strengths

(D) I and I' have opposite direction and different strengths

19. A flat slab of dielectric $(\varepsilon_r = 5)$ is placed normal to a uniform field with a flux density $D = 1$ coulomb/m^2. The slab is uniformly polarized. Polarization p in the slab (in coulomb/m^2) will be

(A) 0·8

(B) 1·2

(C) 4·0

(D) 6·0

20. A parallel-plate capacitor with air as dielectric is charged and then disconnected from the supply. The force between the plates is F. If the capacitor is now immersed in a liquid dielectric of dielectric constant ε, then the force between the plates will be

(A) $\varepsilon^2 F$

(B) εF

(C) F

(D) F/ε

21. A circular loop has its radius increasing at a rate of 2 m/s. The loop is placed perpendicular to a constant magnetic field of 0·1 Wb/m^2. When the radius of the loop is m, the e.m.f. induced in the loop will be

(A) 0·8π V

(B) 0·4π V

(C) 0·2π V

(D) zero

22. Match List–I with List–II and select the correct answer using the codes given below the lists (symbols have their usual meanings) :

List–I	*List–II*
(a) Poisson's equation	1. $\nabla^2\phi = 0$
(b) Laplace's equation	2. $\nabla^2 E + K_0^2 E = 0$
(c) Joule's equation	3. $\nabla^2\phi = \dfrac{-P}{\varepsilon_0}$
(d) Helmholtz's equation	4. $\dfrac{dP}{dV} = U_j\,\overline{E}\cdot\overline{J}$

Codes :

	a	b	c	d
(A)	2	1	4	3
(B)	3	4	1	2
(C)	3	1	4	2
(D)	2	4	1	3

23. A circular ring carrying a uniformly distributed charge Q and a point charge $-Q$ on the axis of the ring is shown in Fig. 10. The magnitude of the dipole moment of the charge system is

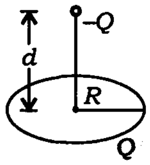

Fig. 10

(A) Qd

(B) QR^2/d

(C) $Q\sqrt{R^2 + d^2}$

(D) QR

24. Consider the following statements regarding Maxwell's equations in differential form (symbols have their usual meanings) :

1. For free space $\nabla \times H = (\sigma + j\omega\varepsilon)E$
2. For free space $\nabla \cdot D = \rho$
3. For steady current $\nabla \times H = J$
4. For static electric field $\nabla \cdot D = \rho$

Of these statements

(A) 1 and 2 are correct

(B) 2 and 3 are correct

(C) 3 and 4 are correct

(D) 1 and 4 are correct

25. A magnetic field

$$\vec{B} = (\vec{a}_x + 2\vec{a}_y \cdot 4\vec{a}_z)$$

exists at a point. If a test charge moving with a velocity

$$\vec{V} = V_0(3\vec{a}_x - \vec{a}_y + 2\vec{a}_z)$$

experiences no force at a certain point, the electric field at that point will be

(A) $\vec{E} = -V_0(3\vec{a}_x - 2\vec{a}_y - 4\vec{a}_z)$

(B) $\vec{E} = -V_0(14\vec{a}_y + 7\vec{a}_z)$

(C) $\vec{E} = -\frac{V_0}{\mu}(14\vec{a}_y + 7\vec{a}_z)$

(D) $\vec{E} = +\frac{V_0}{\mu}(14\vec{a}_y + 7\vec{a}_z)$

26. A transmission line having 50 Ω impedance is terminated in a load of $(40 + j30)$ Ω. The VSWR is

(A) $j0{\cdot}033$

(B) $0{\cdot}8 + j0{\cdot}6$

(C) 1

(D) 2

27. A positive charge of Q coulomb is located at point $A(0, 0, 3)$ and a negative charge of magnitude Q coulomb is located at point $B(0, 0, -3)$. The electric field intensity at point $C(4, 0, 0)$ is in the

(A) negative X-direction

(B) negative Z-direction

(C) positive X-direction

(D) positive Z-direction

28. The vector H in the far field of an antenna satisfies

(A) $\nabla \cdot H = 0$ and $\nabla \times H = 0$

(B) $\nabla \cdot H \neq 0$ and $\nabla \times H \neq 0$

(C) $\nabla \cdot H = 0$ and $\nabla \times H \neq 0$

(D) $\nabla \cdot H \neq 0$ and $\nabla \times H = 0$

29. In the Maxwell bridge as shown in Fig. 11, the values of resistance R_X and inductance L_X of a coil are to be calculated after balancing the bridge. The component values are shown in the same figure at balance. The values of R_X and L_X will respectively be

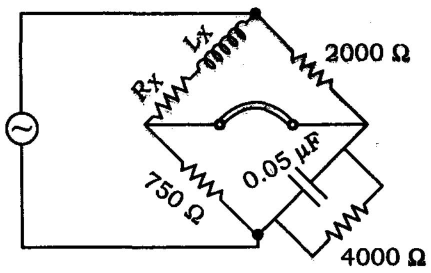

Fig. 11

(A) 375 ohm, 75 mH

(B) 75 ohm, 150 mH

(C) 37·5 ohm, 75 mH

(D) 75 ohm, 75 mH

30. A voltmeter having an accuracy of ±3 percent of full-scale 250 V range is employed to read 150 V. The actual voltage value will fall within the range

(A) 140·5 V to 150·5 V

(B) 143 V to 150 V

(C) 142·5 V to 157·5 V

(D) 147 V to 153 V

31. Two sinusoidal signals $p(\omega_1, t) = A\sin\omega_1 t$ and $q(\omega_2, t)$ are applied to X and Y inputs of a dual-channel CRO. The Lissajous figure displayed on the screen is shown in Fig. 12. The signal $q(\omega_2, t)$ will be represented as

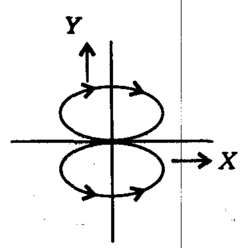

Fig. 12

(A) $q(\omega_2, t) = A\sin\omega_2 t;\ \omega_2 = 2\omega_1$

(B) $q(\omega_2, t) = A\sin\omega_2 t;\ \omega_2 = \omega_1 / 2$

(C) $q(\omega_2, t) = A\cos\omega_2 t;\ \omega_2 = 2\omega_1$

(D) $q(\omega_2, t) = A\cos\omega_2 t;\ \omega_2 = \omega_1 / 2$

32. The Maxwell's bridge shown in Fig. 13 is at balance. The parameters of the inductive coil are

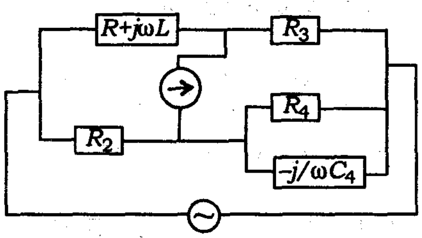

Fig. 13

(A) $R = \frac{R_2 R_3}{R_4}$, $L = C_4 R_2 R_3$

(B) $L = \frac{R_2 R_3}{R_4}$, $R = C_4 R_2 R_3$

(C) $R = \frac{R_4}{R_2 R_3}$, $L = \frac{1}{(C_4 R_2 R_3)}$

(D) $L = \frac{R_4}{R_2 R_3}$, $R = \frac{1}{(C_4 R_2 R_3)}$

33. A $4\frac{1}{2}$ digit DMM has the error specification as 0·2% of reading +10 counts. If a d.c. voltage of 100 V is read on its 200 V full-scale, the maximum error that can be expected in the reading is

(A) ±0·1%

(B) ±0·2%

(C) ±0·3%

(D) ±0·4%

34. The simplified block diagram of a 10-bit A/D converter of dual-slope integrator type is shown in Fig. 14. The 10-bit counter at the output is clocked by a 1 MHz clock. Assuming negligible time overhead for the control logic, the maximum frequency of the analog signal that can be converted using this A/D converter is approximately

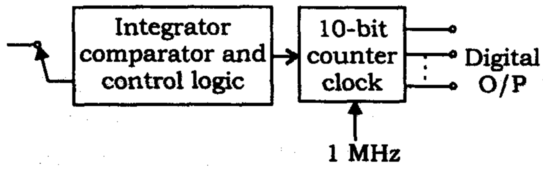

Fig. 14

(A) 2 kHz

(B) 1 kHz

(C) 500 Hz

(D) 250 Hz

35. The difference between the indicated value and true value of a quantity is

(A) gross error

(B) absolute error

(C) dynamic error

(D) relative error

36. A 1000 V d.c. supply has two 1-core cables as its positive and negative leads. Their insulation resistances to earth are 4 MΩ and 6 MΩ respectively as shown in Fig. 15. A voltmeter with resistance 50 kΩ is used to measure the insulation of the cable, when connected between the positive core and earth. Then the voltmeter reads

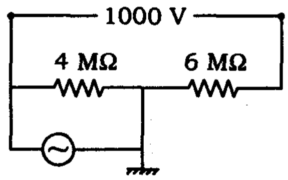

Fig. 15

(A) 8 V (B) 16 V

(C) 24 V (D) 40 V

37. The line-to-line input voltage to the 3-phase, 50 Hz, a.c. circuit shown in Fig. 16 is 100 V r.m.s. Assuming that the phase sequence is RYB the wattmeters would read

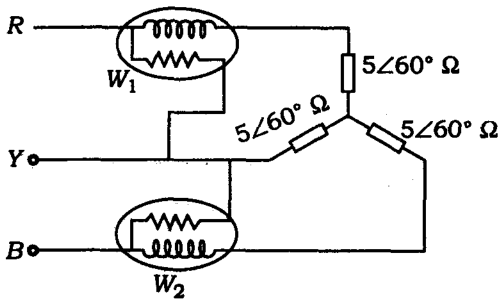

Fig. 16

(A) $W_1 = 886$ W and $W_2 = 886$ W

(B) $W_1 = 500$ W and $W_2 = 500$ W

(C) $W_1 = 0$ W and $W_2 = 1000$ W

(D) $W_1 = 250$ W and $W_2 = 750$ W

38. In the multimeter circuit shown in Fig. 17 for a.c. voltage measurement, the function of the diode D_1 is to

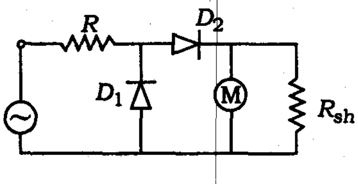

Fig. 17

(A) provide half-wave rectification

(B) make the rectifier D_2 perform full-wave rectification

(C) bypass reverse leakage current D_2 in the negative cycle of the input

(D) short-circuit over range voltages

39. Semiconductor *A* has a higher band gap than semiconductor *B*. If both *A* and *B* have the same dimension, the same number of electrons at a given temperature and same electron and hole mobilities, then

(A) *A* has the same number of holes as *B*

(B) *A* has a large number of holes than *B*

(C) *A* has less number of holes than *B*

(D) Any of the above statements (A), (B) or (C) could be true

40. The electronic configuration of an iron atom is

(A) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

(B) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$

(C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

(D) None of the above

41. A series *R-L-C* circuit will have unity power factor if operated at a frequency of

(A) $1/LC$

(B) $1/\omega\sqrt{LC}$

(C) $1/\omega^2 LC$

(D) $1/2\pi\sqrt{LC}$

42. Which of the following pairs is/are correctly matched?

	Material	*Application*
1.	Rochelle salt	Phonograph
2.	Barium titanate	Amplifier
3.	Quartz	Oscillator

Select the correct answer using the codes given below :

(A) Only 2

(B) 1 and 2

(C) 1 and 3

(D) 2 and 3

43. A sample of iron carrying a current is subjected to a magnetic field. Match List–I with List–II to indicate the influence of angle between the magnetic field and current on the resistivity of the sample and select the correct answer from the codes given below :

List–I (*Direction of current*)	*List–II* (*Electrical resistivity*)
(a) Parallel to magnetization	1. Increase
(b) Perpendicular to magnetization	2. Decrease
	3. Unchanged

Codes :

	a	b
(A)	1	2
(B)	2	1
(C)	3	2
(D)	3	1

44. A metal has a conduction charge density (η) of 20×10^{28} electrons per cubic meter. What is the average (mean) time (in seconds) between the electron-ion collision?

The resistivity is 3×10^{-8} ohm-m (use an electron mass of 9×10^{-31} kg and an electron charge of $1{\cdot}6 \times 10^{-19}$ coulomb).

(A) 2×10^{-15}

(B) 4×10^{-15}

(C) $5{\cdot}8 \times 10^{-15}$

(D) 8×10^{-15}

45. When a *p*-type semiconductor material is bonded to an *n*-type semiconductor material and terminals are added, the resulting structure has the following property :

(A) Built-in potential results

(B) A voltage appears at the terminals

(C) Resistance increases with increasing temperature

(D) A good conductor results since both *n* and *p* materials are doped

46. When a *p*-type semiconductor material is bonded to an *n*-type semiconductor material and terminals are added, the resulting structure does not have the following property :

(A) Ideally, the forward bias resistance is zero

(B) As temperature is increased above from temperature, the material resistance decreases because the doping material charges are 'freed'

(C) Both holes and electrons contribute to the current flows

(D) The resistance increases with increasing doping

47. Magnetostriction is a phenomenon whereby the magnetisation of a ferromagnetic material leads to a change in

(A) relative permeability

(B) physical dimensions

(C) spontaneous magnetisation

(D) magnetic susceptibility

48. Match List–I with List–II and select the correct answer using the codes given below the lists :

List–I *(Type of magnetic material)*	*List–II* *(Orientation of individual dipole moment)*
(a) Ferromagnetic	1. ↓↓
(b) Antiferro-magnetic	2. ↑↓↑↓
(c) Ferrimagnetic	3. ↑
	4. ↑↑↑↑

Codes :

	a	b	c
(A)	4	2	1
(B)	1	2	4
(C)	2	1	3
(D)	4	2	3

49. A current of

$$-8+6\sqrt{2}(\sin\omega t+30^\circ)\ \text{A}$$

is passed through three meters. They are centre-zero PMMC meter, a true r.m.s. meter and a moving-iron instrument. The respective readings (in A) will be

(A) 8, 6, 10

(B) 8, 6, 8

(C) –8, 10, 10

(D) –8, 2, 2

50. The R-L-C circuit has $L = 10$ mH, $C = 1\ \mu$F, $R = 3{\cdot}3\ \Omega$ and an a.c. supply as $E(t) = \cos\omega t$. At resonance, the current amplitude is

(A) 3·3 A

(B) 0·15 A

(C) 0·30 A

(D) None of the above

★★★