DAY TWENTY SIX

Unit Test 5

(Magnetostatic, EMI & AC, EM Wave)

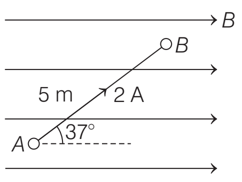
1 A solenoid of some length and radius 2 cm has a layer of winding. A 2 cm long wire of mass 5 g lies inside the solenoid along the axis of solenoid. The wire is connected to some external circuit, so that a current of 5 A flows through the wire. The value of current to be in the winding, so that magnetic force supports the wire weight is (take, $g = 10\,ms^{-2}$)

(a) zero
(b) $\simeq$ 400A
(c) $\simeq$ 32000A
(d) Not possible

2 A circular coil of 20 turns and radius 10 cm is placed in a uniform magnetic field of 0.1 T normal to the plane of the coil. The coil carries a current of 5 A. The coil is made up of copper wire of cross-sectional area $10^{-5}\,m^2$ and the number of free electrons per unit volume of copper is 10^{29}. The average force experienced by an electron in the coil due to magnetic field is

(a) 5×10^{-25}N
(b) zero
(c) 8×10^{-24}N
(d) None of these

3 A wire *AB* of length 5 m carrying a current of 2A is placed in a region of uniform magnetic field $B = 0.5$ T as shown in figure. The magnetic force experienced by wire is



(a) 5 N
(b) 4 N
(c) 3 N
(d) 8 N

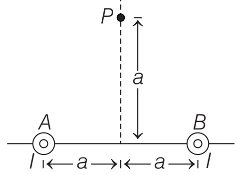
4 A coil of metal wire is kept stationary in a non-uniform magnetic field, then

(a) an emf and current both induced in the coil
(b) a current but no emf is induced in the coil
(c) an emf but no current is induced in the coil
(d) Neither emf nor current is induced in the coil

5 A thin circular ring of area *A* is held perpendicular to a uniform magnetic field of induction *B*. A small cut is made in the ring and a galvanometer is connected across the ends such that the total resistance of the circuit is *R*. When the ring is suddenly squeezed to zero area, the charge flowing through the galvanometer is

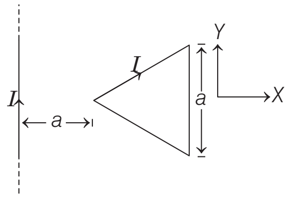
(a) $\frac{BR}{A}$
(b) $\frac{AB}{R}$
(c) ABR
(d) $\frac{B^2A}{R^2}$

6 Two infinite long current carrying wires *A* and *B* are placed as shown in figure. Each wire carries same current *I*. The resultant magnetic field intensity at point *P* is



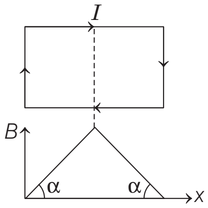
(a) $\frac{\mu_0 I}{2\pi a}$
(b) $\frac{\sqrt{2}\mu_0 I}{2\pi a}$
(c) $\frac{\mu_0 I}{2\sqrt{2}\pi a}$
(d) $\frac{\mu_0 I}{4\sqrt{2}\pi a}$

7 An equilateral triangular loop is kept near to a current carrying long wire as shown in figure. Under the action of magnetic force alone, the loop



(a) must move away from wire along *X*-axis
(b) must move towards wire along *X*-axis
(c) must move along *Z*-axis
(d) must move along *Y*-axis

8 A current carrying loop is placed in the non-uniform magnetic field whose variation in space is shown in figure. Direction of magnetic field is into the plane of paper. The magnetic force experienced by loop is

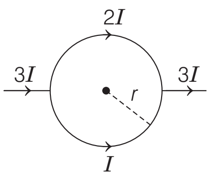


(a) non-zero (b) zero
(c) can't say anything (d) None of these

9 An electron is launched with velocity **v** in a uniform magnetic field **B**. The angle θ between **v** and **B** lies between 0 and $\frac{\pi}{2}$. Its velocity vector **v** returns to its initial value in a time interval of

(a) $\frac{2\pi m}{eB}$
(b) $\frac{2\times 2\pi m}{eB}$
(c) $\frac{\pi m}{eB}$
(d) depends upon angle between **v** and **B**

10 A straight conductor carrying a direct current of $3I$ is split into $2I$ and I as shown in the figure.



Magnetic induction at centre of loop of radius r is

(a) 0 (b) $\frac{\mu_0 I}{2\pi r}$
(c) $\frac{\pi_0 I}{2r}$ (d) $\frac{\mu_0 I}{4r}$

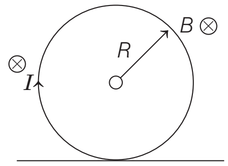
11 A wire in the form of a circular loop of radius r lies with its plane normal to a magnetic field B. If the wire is pulled to take a square shape in the same plane in time t, the emf induced in the loop is given by

(a) $\frac{\pi B r^2}{t}\left(1-\frac{\pi}{10}\right)$ (b) $\frac{\pi B r^2}{t}\left(1-\frac{\pi}{8}\right)$
(c) $\frac{\pi B r^2}{t}\left(1-\frac{\pi}{6}\right)$ (d) $\frac{\pi B r^2}{t}\left(1-\frac{\pi}{4}\right)$

12 The mutual inductance between two planar concentric rings of radii r_1 and r_2 (with $r_1 > r_2$) placed in air is given by

(a) $\frac{\mu_0 \pi r_2^2}{2r_1}$ (b) $\frac{\mu_0 \pi r_1^2}{2r_2}$
(c) $\frac{\mu_0 \pi (r_1 + r_2)^2}{2r_1}$ (d) $\frac{\mu_0 \pi (r_1 + r_2)^2}{2r_2}$

13 A conducting loop is placed in a magnetic field (uniform) as shown in the figure. For this situation mark the correct statement.



(a) The force of compression experienced by loop is IRB
(b) The force of compression experienced by loop is $2\pi IRB$
(c) The force of expansion experienced by loop is IRB
(d) The force of expansion experienced by loop is $2\pi IRB$

14 Mark the correct statement.

(a) Ideal inductor does not dissipate power in an AC circuit
(b) Ideal inductor dissipates maximum power in an AC circuit
(c) In an inductor, current lags behind the voltage by π
(d) In inductor, current leads voltage by π

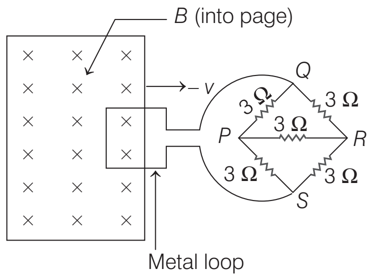
15 Two very long straight parallel wires carry steady currents I and $-I$, respectively. The distance between the wires is d. At a certain instant of time, a point charge q is at a point equidistant from the wires in the plane of the wires. Its instantaneous velocity v is perpendicular to this plane. The magnitude of the force due to the magnetic field acting on the charge at this instant is

(a) $\frac{\mu_0 Iqv}{2\pi d}$ (b) $\frac{\mu_0 Iqv}{\pi d}$ (c) $\frac{2\mu_0 Iqv}{\pi d}$ (d) zero

16 An aeroplane is moving North horizontally, with a speed of 200 ms^{-1}, at a place where the vertical component of the earth's magnetic field is 0.5×10^{-4} T. What is the induced emf set up between the tips of the wings if they are 10 m apart?

(a) 0.01 V (b) 0.1 V (c) 1 V (d) 10 V

17 A square metal wire loop of side 10 cm and resistance 1 Ω is moved with a constant velocity v in a uniform magnetic field $B = 2$ T as shown in the figure. The magnetic field is perpendicular to the plane of the loop and directed into the paper. The loop is connected to a network of resistors, each equal to 3 Ω. What should be the speed of the loop, so as to have a steady current of 1 mA in the loop?



(a) 1 cm s^{-1} (b) 2 cm s^{-1} (c) 3 cm s^{-1} (d) 4 cm s^{-1}

18 At a certain place, the horizontal component of earth's magnetic field is $\sqrt{3}$ times the vertical component. The angle of dip at that place is

(a) 30° (b) 45° (c) 60° (d) 90°

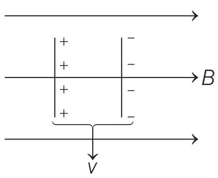
19 A magnetic dipole is acted upon by two magnetic fields which are inclined to each other at an angle of 75°. One of the fields has a magnitude of $\sqrt{2} \times 10^{-2}$T. The dipole attains stable equilibrium at an angle of 30° with this field. What is the magnitude of the other fields?

(a) 0.01 T (b) 0.02 T (c) 0.03 T (d) 0.04 T

20 A charge of 4μC is placed on a small conducting sphere that is located at the end of thin insulating rod of length 0.5 m. The rod rotates in horizontal plane with a constant angular velocity of 100 rads^{-1} about a vertical axis that passes through its other end. The magnetic moment of the rotating charge is

(a) zero
(b) 0.5×10^{-4} Am^2
(c) 1.25×10^{-4} Am^2
(d) magnetic moment is not defined for this case

21 A parallel plate capacitor is moving with a velocity of 25 ms^{-1} through a uniform magnetic field of 1.5 T as shown in figure. If the electric field within the capacitor plates is 175 NC^{-1} and plate area is 25×10^{-7} m^2, then the magnetic force experienced by positive charge plate is



(a) 1.45×10^{-13} N (b) zero
(c) 8.67×10^{-15} N (d) 3.87×10^{-15} N

22 In an AC circuit, the potential difference V and current I are given respectively by $V = 100 \sin(100t)$ V and $I = 100 \sin\left(100t + \frac{\pi}{3}\right)$ mA. The power dissipated in the circuit will be

(a) 10^4 W (b) 10 W (c) 2.5 W (d) 5 W

23 An inductor L, a capacitor of 20 μF and a resistor of 10 Ω are connected in series with an AC source of frequency 50 Hz. If the current is in phase with the voltage, then the inductance of the inductor is

(a) 2.00 H (b) 0.51 H (c) 1.5 H (d) 0.99 H

24 An AC circuit having an inductor and a resistor in series draws a power of 560 W from an AC source marked 210 V-60 Hz. The power factor of the circuit is 0.8, the impedance of the circuit and the inductance of the inductor is

(a) 65 Ω, 0.2 H (b) 64 Ω, 1.0 H
(c) 63 Ω, 0.1 H (d) 50 Ω, 1.5 H

25 The resonant frequency and Q-factor of a series L-C-R circuit with $L = 3.0$ H, $C = 27\,\mu$F and $R = 7.4\,\Omega$. How will you improve the sharpness of resonance of the circuit by reducing its full width at half maximum by a factor of 2?

(a) Resistance of circuit should be increased
(b) Resistance of the circuit remain same
(c) Resistance of circuit should be increased by 3.7 Ω
(d) Resistance of the circuit should be reduced to 3.7 Ω

26 About 5% of the power of a 100 W light bulb is converted to visible radiation. What is the average intensity of visible radiation

(i) at a distance of 1 m from the bulb?
(ii) at a distance of 10 m?

Assume that the radiation is emitted isotropically and neglect reflection.

(a) 0.2 Wm^{-2}, 0.002 Wm^{-2} (b) 0.6 Wm^{-2}, 0.006 Wm^{-2}
(c) 0.3 Wm^{-2}, 0.003 Wm^{-2} (d) 0.4 Wm^{-2}, 0.004 Wm^{-2}

27 A charged particle oscillates about its mean equilibrium position with a frequency of 10^9Hz. Frequency of the electromagnetic waves produced by the oscillator is

(a) 10 Hz (b) 10^5 Hz (c) 10^9 Hz (d) 10^{10} Hz

28 The amplitude of the magnetic field part of a electromagnetic wave in vacuum is $B_0 = 510$ nT. What is the amplitude of the electric field part of the wave?

(a) 140 NC^{-1} (b) 153 NC^{-1}
(c) 163 NC^{-1} (d) 133 NC^{-1}

29 Match the following column I with column II.

	Column I		Column I
A.	Capacitor	1.	increases AC
B.	Inductor	2.	reduces AC
C.	Energy dissipation is due to	3.	is conductor for DC
D.	A transformer	4.	resistance only

Code

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

30 Match the following of column I with column II.

	Column I		Column II
A.	Lorentz force	1.	$\oint \mathbf{E}.d\mathbf{A} = \frac{q}{\varepsilon_0}$
B.	Gauss's law	2.	$d\mathbf{B} = \frac{\mu_0}{4\pi} \frac{Id\mathbf{l} \times \mathbf{r}}{r^3}$
C.	Biot-Savart law	3.	$\mathbf{F} = q\,[\mathbf{E} + (\mathbf{v} \times \mathbf{B})]$
D.	Coulomb's law	4.	$F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$

Code

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

31 Match the following of column I with column II.

Column I		Column II	
A.	Ultraviolet	1.	Radar system
B.	Infrared	2.	Roengten
C.	X-rays	3.	Heat radiation
D.	Microwaves	4.	Water purification

Code

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

32 **Assertion** (A) Two identical heaters are connected to two different sources one DC and other AC having same potential difference across their terminals. The heat produced in heater supplied with DC source is greater.

Reason (R) The net impedance of an AC source is greater than resistance.

(a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion
(b) Both Assertion and Reason are false
(c) Assertion is true but Reason is false
(d) Both Assertion and Reason are true but Reason is not true explanation of Assertion

33 **Assertion** (A) Induction coils are made of copper.

Reason (B) Induced current is more in wire having less resistance

(a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion
(b) Both Assertion and Reason are false
(c) Assertion is true but Reason is false
(d) Both Assertion and Reason are true but Reason is not true explanation of Assertion

Direction (Q. Nos. 34-40) *Each of these questions contains two statements : Statement* I *and Statement* II. *Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c), (d) given below*

(a) Statement I is true, Statement II is true; Statement II is the correct explanation for Statement I
(b) Statement I is true, Statement II is true; Statement II is not the correct explanation for Statement I
(c) Statement I is true; Statement II is false
(d) Statement I is false; Statement II is true

34 **Statement I** A flexible wire loop of irregular shape carrying current when placed in a uniform external magnetic field acquires circular shape.

Statement II Any current carrying loop when placed in external magnetic field tries to acquires minimum energy and hence maximum magnetic flux and for a given perimeter circular shape is having greatest area.

35 **Statement I** A hanging spring is attached to a battery and switch. On closing the switch a current suddenly flows in the spring, as a result spring compresses.

Statement II When two current carrying coils are placed close to each other in same plane, then they attract each other if sense of current is same in both.

36 **Statement I** No current is induced in a metal loop if it is rotated in an electric field.

Statement II The electric flux through the loop does not change with time.

37 **Statement I** The power factor of an inductor is zero.

Statement II In the inductor, the emf and current differ in phase by $\frac{\pi}{2}$.

38 **Statement I** In a series *R-L-C* circuit the voltage across-resistor, inductor and capacitor are 8 V, 16 V and 10 V respectively. The resultant emf in the circuit is 10 V.

Statement II Resultant emf of the circuit is given by the relation $E = \sqrt{V_R^2 + (V_L - V_C)^2}$.

39 **Statement I** X-rays travel faster than light waves in vacuum.

Statement II The energy of X-rays photon is greater than the light photon.

40 **Statement I** An electron moving in the positive *x*-direction enters a region where uniform electric and magnetic fields exist perpendicular to each other. The electric field is in the negative *y*-direction. If the electron travels undeflected in this region, the direction of the magnetic field is along the negative *z*-axis.

Statement II If a charged particle moves in a direction perpendicular to a magnetic field, the direction of the force acting on it is given by Fleming's left hand rule.

ANSWERS

1. (d)	**2.** (a)	**3.** (c)	**4.** (d)	**5.** (b)	**6.** (a)	**7.** (a)	**8.** (b)	**9.** (a)	**10.** (d)
11. (d)	**12.** (a)	**13.** (d)	**14.** (a)	**15.** (d)	**16.** (b)	**17.** (b)	**18.** (a)	**19.** (a)	**20.** (b)
21. (a)	**22.** (c)	**23.** (b)	**24.** (c)	**25.** (d)	**26.** (d)	**27.** (c)	**28.** (b)	**29.** (a)	**30.** (a)
31. (a)	**32.** (d)	**33.** (a)	**34.** (a)	**35.** (a)	**36.** (c)	**37.** (a)	**38.** (a)	**39.** (d)	**40.** (b)

Hints and Explanations

1 Whatever be the current through solenoid winding, the direction of magnetic field is along the axis of solenoid and hence the magnetic force experienced by wire is zero and hence its weight cannot be supported by magnetic force.

2 Drift speed of electron,

$$v_d = \frac{I}{neA} = \frac{5}{10^{29} \times 1.6 \times 10^{-19} \times 10^{-5}}$$

$$= 3.125 \times 10^{-5} \text{ ms}^{-1}$$

Average magnetic force experienced by each electron is,

$F = qvB$

$$= 1.6 \times 10^{-19} \times 3.125 \times 10^{-5} \times 0.1$$

$$= 0.5 \times 10^{-24} \text{ N} = 5 \times 10^{-25} \text{ N}$$

3 Length of wire AB, $l = 5$ m

Current, $i = 2$ A, $\theta = 37°$ and $B = 0.5$ T

Magnetic force on wire, $F = iBl \sin\theta$

$$= 2 \times 0.5 \times 5 \times \sin 37° = 3 \text{ N}$$

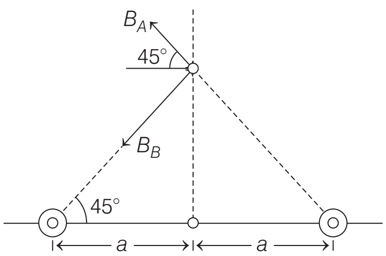
5 $\therefore$ Induced charge, $q = \dfrac{\text{Change of flux}}{\text{Resistance}}$

$$= \frac{\phi_f - \phi_i}{R}$$

But final area = 0, therefore, $\phi_f = 0$.

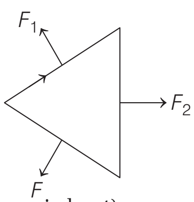
Numerically, $\phi_i = BA$. Therefore, $q = BA/R$.

6 $B_A = B_B = \dfrac{\mu_0 I}{2\pi \times \sqrt{2}\, a}$



So, $B = \sqrt{B_A^2 + B_B^2} = \dfrac{\mu_0 I}{2\,\pi a}$

7 The net force acting on loop would be along X-axis (to determine whether it is along positive or negative, X-axis calculation has to be carried out) as shown in figure.



8 Each and every pair of loop elements located symmetrically w.r.t. central line experiences zero net force. So, total magnetic force experienced by loop is zero.

9 Time interval in which its velocity v returns to its initial value is same as time period of the particle, to execute the circle.

Since, it does not depend upon θ. So, time required $= \dfrac{2\,\pi m}{eB}$.

10 $\therefore B_{\text{net}} = \dfrac{\mu_0 2I}{4r} - \dfrac{\mu_0 I}{4r} = \dfrac{\mu_0 I}{4r}$

11 Induced emf

$$(e) = \frac{\text{Magnetic field} \times \text{change in area}}{\text{Time}}$$

$$= \frac{B\Delta A}{t}$$

Since, the circumference of the circular loop $= 2\pi r$,

The side of the square loop $= \dfrac{2\pi r}{4} = \dfrac{\pi r}{2}$

Therefore,

$$\Delta A = \pi r^2 - \left(\frac{\pi r}{2}\right)^2 = \pi r^2 \left(1 - \frac{\pi}{4}\right)$$

$$\therefore \quad e = \frac{B(\pi r^2)}{t}\left(1 - \frac{\pi}{4}\right)$$

12 Magnetic field due to the larger coil at its centre is

$$B = \frac{\mu_0 I}{2r_1}$$

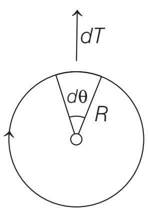
where, I is the current in the larger coil. Flux through the inner coil is

$$\phi = B \times \pi r_2^2 = \frac{\mu_0 I}{2r_1} \times \pi r_2^2$$

But $\quad \phi = MI$

Therefore, $\quad M = \dfrac{\mu_0 \pi r_2^2}{2r_1}$

13 By right hand thumb rule force of expansion would act on it whose magnitude is given by



$dT = I(d\mathbf{l} \times \mathbf{B})$

$\Rightarrow T = IB\int dl$

$= 2\,\pi\, IRB$

14 The instantaneous voltage and current in an AC circuit containing an ideal inductance only are

$$E = E_0 \sin \omega t\,,\ I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$P_{\text{ins}} = EI = E_0 I_0 \sin \omega t \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$= -E_0 I_0 \sin \omega t \cos \omega t = -\frac{1}{2} E_0 I_0 \sin 2\omega t$$

Average power for one complete cycle is

$$P = \frac{1}{T}\left(-\frac{1}{2} E_0 i_0\right)\int_0^T \sin 2\omega t\, dt = 0$$

15 Since, **B** and v are anti-parallel to each other, angle between the two is zero or 180°.

$$\mathbf{F} = q\,v \times \mathbf{B} = qv\ B \sin\theta$$

For $\quad \theta = 0, \sin 0 = 0 \ \Rightarrow\ F = 0$

16 $\therefore$

$e = Blv = 0.5 \times 10^{-4} \times 10 \times 200 = 0.1$ V

17 The network $PQRS$ is a balanced Wheatstone's bridge. Hence, the resistance of 3 Ω between P and R is ineffective. The net resistance of the network, therefore, is 3 Ω. Total resistance $R = 3\ \Omega + 1\ \Omega = 4\ \Omega$.

Now, induced emf is

$e = Blv = 2 \times 0.1 \times v = 0.2v$.

$\therefore$ Induced current $I = \dfrac{e}{R} = \dfrac{0.2\,v}{4}$

Given, $\quad I = 1 \times 10^{-3}$ A

Hence, $\quad 1 \times 10^{-3} = \dfrac{0.2\,v}{4}$

Which gives, $v = 2 \times 10^{-2}\ \text{ms}^{-1} = 2\ \text{cms}^{-1}$

18 $\therefore B_H = B\cos\theta$ and $B_V = B\sin\theta$

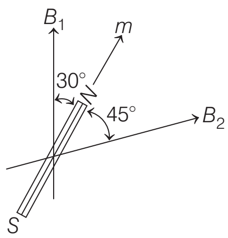
Hence, $\quad \dfrac{B_V}{B_H} = \tan\theta$

Given, $\quad \dfrac{B_V}{B_H} = \dfrac{1}{\sqrt{3}}$

Therefore, $\quad \tan\theta = \dfrac{1}{\sqrt{3}}$, i.e. $\theta = 30°$

19 Refer to figure. Let θ_1 (= 30°) be the angle between the magnetic moment vector **m** and the field vector $\mathbf{B}_1$ (= 1.5×10^{-2} T).

Then, as shown in figure, the angle between m and the other field $\mathbf{B}_2$ will be $\theta_2 = 75° - 30° = 45°$.



The field $\mathbf{B}_1$ exerts a torque $\tau_1 = \mathbf{m} \times \mathbf{B}_1$ on the dipole and the field $\mathbf{B}_2$ exerts a torque $\tau_2 = \mathbf{m} \times \mathbf{B}_2$, where **m** is the magnetic moment of the dipole.

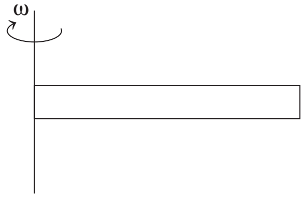
Since, the dipole is in stable equilibrium, the net torque $\tau\ (= \tau_1 + \tau_2)$ must be zero, i.e. the two torques must be equal and opposite. In terms of magnitudes, we have

$$mB_1 \sin\theta_1 = mB_2 \sin\theta_2$$

or $$B_2 = \frac{B_1 \sin\theta_1}{\sin\theta_2}$$

$$= \frac{\sqrt{2} \times 10^{-2} \times \sin 30^\circ}{\sin 45^\circ} = 0.01\ \text{T}$$

20 A moving charge along a circle is equivalent to a current carrying ring, whose current is given by



$$I = \frac{q}{T} = \frac{q}{2\pi/\omega}$$

$$\Rightarrow I = \frac{4 \times 10^{-6}}{2\pi} \times 100 = 0.64 \times 10^{-4}\ \text{A}$$

Magnetic moment of rotating charge is $M = IA$

$$\Rightarrow M = 0.64 \times 10^{-4} \times \pi \times (0.5)^2$$

$$= 0.5 \times 10^{-4}\ \text{Am}^2$$

21 Electric field in between the capacitor plates is given by

$$E = \frac{q}{\varepsilon_0 A}$$

where, q is the charge on capacitor.

$$q = \varepsilon_0 A \times E$$

$$= 8.85 \times 10^{-12} \times 25 \times 10^{-7} \times 175$$

$$= 3.87 \times 10^{-15}\ \text{C}$$

Magnetic force experienced by positive plate is,

$F_m = qvB = 1.45 \times 10^{-13}$ N in a direction out of plane of paper.

22 Voltage amplitude $V_0 = 100$ V,

current amplitude $I_0 = 100$ mA

$$= 100 \times 10^{-3}\ \text{A}$$

and phase difference between I and V is $\phi = \frac{\pi}{3} = 60^\circ$.

Now, power dissipated is given by

$$P = \frac{V_0 I_0}{2} \cos\phi$$

$$= \frac{100 \times 100 \times 10^{-3}}{2} \times \cos 60^\circ = 2.5\ \text{W}$$

23 In an L-C-R circuit, the current and the voltage are in phase ($\phi = 0$), when

$$\tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R} = 0$$

or $$\omega L = \frac{1}{\omega C} \quad \text{or} \quad L = \frac{1}{\omega^2 C}$$

Here, $\omega = 2\pi f = 2 \times 3.14 \times 50\ \text{s}^{-1}$

$= 314\ \text{s}^{-1}$ and $C = 20$

$\mu\text{F} = 20 \times 10^{-6}$ F

$$\therefore L = \frac{1}{(314\ \text{s}^{-1})^2 \times (20 \times 10^{-6}\ \text{F})} = 0.51\ \text{H}$$

24 The average power over a complete cycle is

$$P = E_{\text{rms}} \times I_{\text{rms}} \times \cos\phi$$

where, $\cos\phi$ is the power factor

$$\therefore \quad I_{\text{rms}} = \frac{P}{E_{\text{rms}} \times \cos\phi} = \frac{560}{210 \times 0.8}$$

$$= \frac{10}{3}\ \text{A}$$

The impedance of the circuit is

$$Z = \frac{E_{\text{rms}}}{I_{\text{rms}}} = \frac{210\ \text{V}}{(10/3)\ \text{A}} = 63\ \Omega$$

The power is consumed in R only. Therefore,

$$P = (I_{\text{rms}})^2 R \quad \text{or} \quad R = \frac{560}{\left(\frac{10}{3}\right)^2} = 50.4\ \Omega$$

Now, the impedance of an L-R circuit is

$$Z = \sqrt{R^2 + (\omega L)^2}$$

$$\therefore (\omega L)^2 = Z^2 - R^2 = (63)^2 - (50.4)^2$$

$$= 1428.84\ \Omega^2$$

or $$\omega L = \sqrt{1428.84} = 37.8\ \Omega$$

$$\therefore \quad L = \frac{37.8}{2\pi f} = \frac{37.8}{2 \times 3.14 \times 60} = 0.1\ \text{H}$$

25 Given, $L = 3.0$ H,

$$C = 27\ \mu\text{F} = 27 \times 10^{-6}\ \text{F}$$

and $R = 7.4\ \Omega$

The resonant frequency is given by

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{3.0 \times (27 \times 10^{-6})}}$$

$$= 111\ \text{rads}^{-1}$$

The Q-factor of the circuit is given by

$$Q = \frac{\omega_0 L}{R} = \frac{111 \times 3.0}{7.4} = 45$$

The "bandwidth" (the difference of half-power frequencies is given by

$$\omega_2 - \omega_1 = R/L$$

Smaller the value of $(\omega_2 - \omega_1)$, sharper is the resonance. To reduce $(\omega_2 - \omega_1)$ by a factor of 2, the resistance R should be halved that is, the resistance of the circuit should be reduced to $3.7\ \Omega$.

26 Power converted into visible radiation

$$P = \frac{5}{100} \times 100 = 5\ \text{W}$$

$$\text{Intensity} = \frac{\text{Energy}}{\text{Area} \times \text{Time}}$$

$$= \frac{\text{Power}}{\text{Area}} = \frac{P}{4\pi r^2}$$

(i) Intensity $= \frac{5}{4 \times 3.14 \times 1 \times 1}$

$$= 0.4\ \text{Wm}^{-2}$$

(ii) Intensity $= \frac{5}{4 \times 3.14 \times 10 \times 10}$

$$= 0.004\ \text{Wm}^{-2}$$

27 Frequency of electromagnetic wave = Frequency of oscillation of charge.

28 $\frac{E_0}{B_0} = c$ or $E_0 = cB_0$

32 Heat (AC) $= V_{\text{rms}} I_{\text{rms}} = \frac{V_{\max} I_{\max}}{2}$

Heat (DC) $= V_{\max} I_{\max}$

33 Since, copper consists of a very small ohmic resistance so, inductance coils are made of copper. A large induced current is produced in such.

34 Each section of irregular wire loop experiences an outward force.

35 Opposite polarities are produced in the forces of spring loops.

36 A current is induced in a loop only if magnetic flux linked with the coil changes.

37 $\therefore \cos\phi = \cos\frac{\pi}{2} = 0$

38 The resultant emf in the L-C-R circuit is given by

$$E = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$E = \sqrt{(8)^2 + (16 - 10)^2} = \sqrt{64 + 36}$$

$$E = 10\ \text{V}$$

39 Since, X-rays are electromagnetic waves, we know that electromagnetic wave travels with same velocity of light in vacuum.

Now, from the formula

$$E = \frac{hc}{\lambda}$$

The wavelength of X-rays are small than light waves and energy is inversely proportional to the wavelength. Hence, the energy of X-rays photon will be greater than light waves.

40 Because electron has a negative charge, an electric field in the negative y-direction will deflect it in the positive y-direction. It will travel undeflected if the magnetic field imparts an equal deflection in the negative y-direction. Since, the magnetic force is perpendicular to the magnetic field and the charge of electron is negative, the direction of the magnetic field (according to Fleming's left hand rule) should be along the negative z-direction.