QB365

Important Questions - Electromagnetic Induction and Alternating Currents

12th Standard CBSE

Physics

Reg.No. : | | | | | |

Time : 01:00:00 Hrs

Total Marks : 50

Section-A

1) In the relation $\phi =$ BA cos θ, θ is angle........ **1**

(a) which normal to surface area makes with the direction of magnetic field

(b) which magnetic field makes with the surface (c) which is never constant (d) none of the above

2) SI unit of magnetic flux is **1**

(a) henry (b) weber (c) coulomb (d) volt

3) The cause of induced e.m.f. is **1**

(a) magnetic flux (b) magnetic field (c) area (d) change in magnetic flux

4) When number of turns of a soleniod is doubled, its self inductance becomes k times, where k= **1**

(a) 2 (b) 1 (c) 8 (d) 4

5) The magnetic flux linked with a coil is $\phi =$ (3t-2t+1) milliweber. The e.m.f. induced in the coil at t = 1sec is **1**

(a) 4V (b) 4$\times$10^{-3}V (c) 6V (d) 4$\times$10^{3}V

6) Which of the following does not have the dimension of time? **1**

(a) RC (b) $\frac{L}{R}$ (c) $\frac{R}{L}$ (d) $\sqrt{LC}$

Section-B

7) An artificial satellite with a metal surface is orbiting the earth around the poles. Will there be any induced current due to earth's magnetic field ? **2**

8) Show that the rate of change of magnetic flux has the same units as induced e.m.f. **2**

9) A circular brass loop of radius a and resistance R is placed with its plane perpendicular to a magnetic field, which varies with time as $B = B_0 \sin \omega t$. Obtain the expression for the induced current in the loop. **2**

10) How days the mutual inductance of a pair of coils hange when (i) distance between the coils is increased (ii) an iron sheet is placed between the two coils ? **2**

11) A coil is wound on an iron core and looped back on itself so that the core has two sets of closely wound wires in series carrying current in opposite senses. How is its self inductances affected? **2**

12) Explain why resistance coils are usually double wound. **2**

Section-C

13) A circular coil of radius 8.0 cm and 20 turns is rotated about its vertical diameter with an angular speed of 50 rad s^{-1} in a uniform horizontal magnetic feild of magnitude 3.0×10^{-2} T. Obtain the maximum and average emf induced in the coil. If the coil forms a closed loop of resistance 10 Ω, calculate the maximum value of current in the coil. Calculate the average power loss due to Joule heating . Where does this power come from? **3**

14) A wheel with 10 metallic spokes each 0.5 m long is rotated with a speed of 120 rev/min in a plane normal to the horizontal component of earth's magnetic field B_H at a place. If B_H=0.4 G at the place, what is the induced emf between the axle and the rim of the wheel? Note that 1G=10^{-4} T. **3**

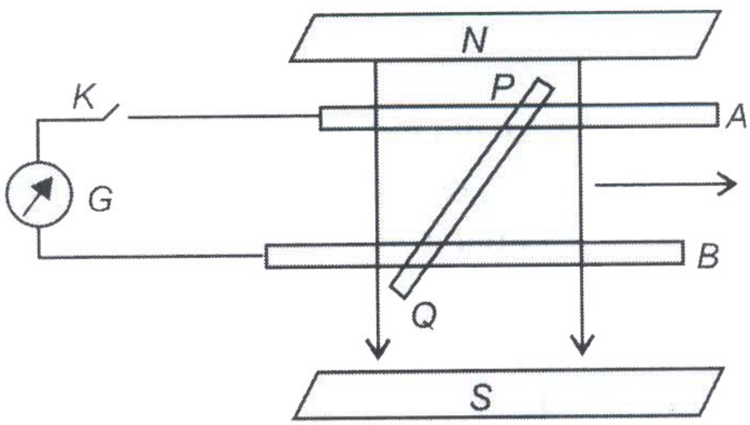
Section-D

15) A square loop of side 12cm with its sides parallel to X and Y-axis is moved with a velocity of 8 cm s^{-1} in the positive X-directon in an environment containing a magnetic field in the positive Z-direction. The field is neither uniform in space nor constant in time. It has a gradient of 10^{-3} T cm^{-1} along the negative x-direction, and it is decreasing in time at he rate of 10^{-3} T s^{-1}. Determine the direction and magnitude of the induced current in the loop if its resistance is 4.5m Ω **3**

16) An air cored solenoid with length 30cm, area of cross-section 25cm^2 and number of turns 500 carries a current of 2.5A. The current is suddenly switched off in a brief time of 10^{-3}s. How much is the average back e.m.f. induced across the ends of the open switched in the circuit? Ignore the variation in magnetic field near the ends of the solenoid. **3**

Section-E

17) Figure given below shows a metal PQ resting on the smooth rail AB and positioned between the poles of a permanent magnet. The rails, the rod, and the magnetic field are in three mutual perpendicular directions. A galvano-meter G connects the rails through a switch K. Length of the rod =15 cm, B=0.50 T, resistance of the closed loop containing the rod=9.0 mΩ Assume the field to be uniform. **5**



(a) Suppose K is open the rod is moved with a speed of 12 cm s^{-1} in the direction shown in the figure. Give the polarity and magnitude of the induced emf.

(b) Is there an excess charge built up at the ends of the rods when K is open? What if K is closed?

(c) With K open and the rod is moving uniformly, there is no net force on the electrons in the rod PQ even though they do experience magnetic force due to the motion of the rod. Explain.

(d) What is the retarding force on the rod when K is closed?

(e) How much power is required (by an external agent) to keep the rod moving at the same speed (=12 cm s^{-1}) when K is closed? How much power is required when K is open?

(f) How much power is dissipated as heat in the closed circuit? What is the source of this power?

(g) What is the induced emf in the moving rod if the magnetic field is parallel to the rails instead of being perpendicular?

18) An LC circuit a 20 mH inductor and a 50 μF capacitor with an initial charge of 10 mC. The resistance of the circuit is negligible. Let the instant the circuit is closed be t=0. (a) What is the total energy stored initially? IS it conserved during LC oscillations? (b)What is the natural frequency of the circuit? (c) At what time is the energy stored (i) completely electrical (i.e., stored in the capacitor)? (ii) completely magnetic (i.e., stored in the inductor)/ (d) At what times is the total energy shared equally between the inductor and the capacitor? (e) If a resistor is inserted in the circuit, how much energy is eventually dissipated as heat? **5**

19) A circuit containing a 80 mF inductor and a 60 μF capacitor in series is connected to a 230 V, 50 Hz supply. The resistance of the circuit is negligible. (a) Obtain the current amplitude and rms values. (b) Obtain the rms values of potential drops across each element. (c) What is the average power transferred to the inductor? (d) What is the average power transferred to the capacitor? (e) What is the total average power absorbed by the circuit? (Average implies 'average over one cycle'.) **5**

20) A series LCR circuit with L=0.12 H, C=480 nF, R=23 Ω is connected to a 230 V variable frequency supply. (a) What is the source frequency for which current amplitude is maximum? Obtain this maximum value. (b) What is the source frequency for which average power absorbed by the circuit is maximum? Obtain the value of this maximum power. (c) For which frequencies of the source is the power transferred to the circuit half the power at resonant frequency? What is the current amplitude at these frequencies? (d) What is the Q-factor of the given circuit? **5**

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Section-A

1) (a) which normal to surface area makes with the direction of magnetic field **1**

2) (b) weber **1**

3) (d) change in magnetic flux **1**

4) (d) 4 **1**

5) (b) 4×10^{-3}V **1**

6) (c) $\frac{R}{L}$ **1**

Section-B

7) **2**

Yes, induced current will be there. This is because, at poles, earth's magnetic field is totally vertical. The orbiting satellite will intercept this field and emf will be induced.

8) Induced e.m.f., $e = V = \frac{work}{charge} = \frac{ML^2T^{-2}}{AT}$ **2**

$= [M^1L^2T^{-3}A^{-1}]$

Rate of change of magnetic flux$= \frac{d\Phi}{dt} = \frac{BA}{t}$

$= \frac{FA}{qvt} = \frac{(MLT^{-2})(L^2)}{(AT)(LT^{-1})(T)} \quad (\because F = Bqv)$

$= [M^1L^2T^{-3}A^{-1}]$

Both have the same units/dimensions.

9) Induced current, $I = \frac{induced \quad e.m.f/}{resistance} = \frac{e}{R}$ **2**

$$= \frac{d\Phi/dt}{R} = \frac{-1}{R}\frac{d}{dt}(BA \quad cos0^\circ)$$
$$I = -\frac{A}{R}\frac{d}{dt}(B_0 sin\omega t) = -\frac{AB_0}{R}cos\omega t(\omega)$$
$$= -\frac{A\omega B_0}{R}cos\omega t$$

10) **2**

(i) On increasing distance between the two coils, magnetic flux passing from one coil to the other decreases. Therefore, mutual inductance decreases. (ii) When an iron sheet is placed between the two coils, mutual inductance increases because $M \propto \mu$ (the permeability).

11) **2**

As two sets of closely wound wires carry currents in opposite senses, therefore, their induced effects cancel. The self inductance reduces. In a special case, we may have

$L_{equiv} = L_1 + L_2 - 2M = L + L - 2L = 0$

12) **2**

The resistance coils are double wound to avoid induction effects. Magnetic field due to current in one half of the coil is cancelled by magnetic field due to current in the other half of the coil (which is in opposite direction).

Section-C

13) $\varepsilon_{max} = 0.603V; \quad I_{max} = 0.0603 \quad A$ P=0.018W **3**

14) 6.28×10^{-5} V **3**

Section-D

15) **3**

Here, area of loop, A = $(1210^{-2})^2 = 144\times10^{-4}$ m^2;

velocity, v = 8 cm s^{-1} = 8×10^{-2} ms^{-1}

$\frac{dB}{dx}$ = 10^{-3} T cm^{-1} $\frac{dB}{dt}$ = 10^{-3} T s^{-1}, R = 4.5×10^{-3} ohm

Induced e.m.f., e = ?

Rate of change of magnetic flux due to explicit time variation in

B = $A\left(\frac{dB}{dt}\right)$ = $(144\times10^{-4})\times10^{-3}$ Wb s^{-1} = 1.44×10^{-5} Wb s^{-1}.

Rate of change of magnetic flux due to motion of the loop in a non-uniform magnetic field = = $(144\times10^{-4})\times10^{-3}\times8 = 11.52\times10^{-5}$ Wb/s.

As both the effects cause a decrease in magnetic flux along the positive Z-direction, therefore, they add up.

$\therefore$ Total induced e.m.f., e = 1.44×10^{-5} +11.52 10^{-5} = 12.96×10^{-5} V

Induced current, = $\frac{e}{R} = \frac{12.96\times10^{-5}}{4.5\times10^{-3}} = 2.88\times10^{-2}A$

The direction of induced current is such as to increase the flux through the loop along positive Z-dirction. For example, for the observer, if the loop moves to the right, the current will be seen to be anticlockwise.

16) **3**

Here, l = 30cm = 30×10^{-2} m, A = 25cm^2 = 25×10^{-4} m^2

$$As, \quad e=\frac{d\phi}{dt}=\frac{(dB)A.(N)}{dt} \qquad \left(As \quad B=\mu_0\frac{NI}{l}\right)$$

$$\therefore \quad e=\frac{(\mu_0 NdI)A(N)}{l.dt} \qquad (dI=I_1-I_2=2.5A)$$

$$e=\ 4\pi\times10^{-7}\times\frac{(500)^2}{30\times10^{-2}}\times\frac{2.5\times25\times10^{-4}}{10^{-3}}=6.5volt$$

Section-E

17) 9.0V, P is +ve end, Q is -ve end **5**

75×10^{-3} N

9.0×10^{-3} W; No power

Zero

18) (a) 1.0 J, yes (b) ω =10^3 rad s^{-1}, v=159 Hz (e) 1.0 J **5**

19) (a) I_o=11.6 A; I_{rms}=8.24 A (b) V_{Lrms}=207 V, V_{crms}=437 V **5**

20) (a) V_o=663 Hz; I_o=14.14 A (b) V_o=663 Hz; P_{max}=2300 W (c) 648 Hz; 678 Hz; 10 A (d) 21.7 **5**