SAFALTA.COM
An Initiative by अमर उजाला

PHYSICS

NEET and JEE Main 2020 : 45 Days Crash Course

Problem Solving Class

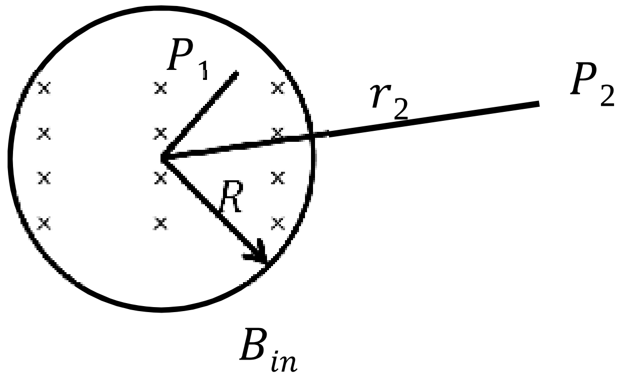
(EMI and AC)

By,
Ritesh Agarwal, B. Tech. IIT Bombay

P-Q1801

For the situation described in figure the magnetic field changes with time according to, $B = (2.00t^3 - 4.00t^2 + 0.8)T$ and $r_2 = 2R = 5.0\ cm$

The force on an electron located at $P_2 = t = 2.00s$ is



$A)$ 8×10^{-21} N

B) 8×10^{-16} N

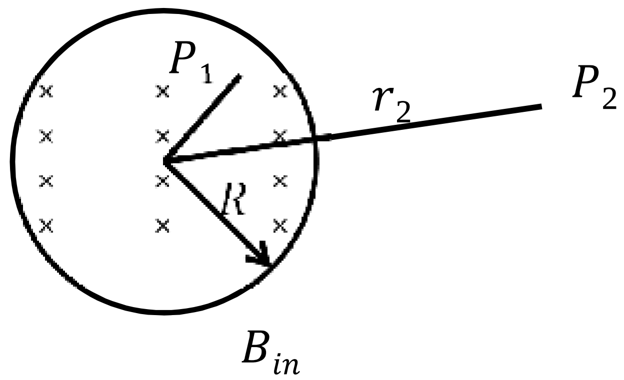
C) 3.96×10^{-21} N

D) 5.6×10^{-19} N

P-Q1801-Solution

Ans [A]

Point P2 is out side the circle



At P_2

For symmetrical situations induced electric field

$$E.l = \frac{d\phi}{dt}$$

$$E(2.\pi.r_2) = \pi.R^2.\frac{dB}{dt}$$

$$\therefore E = \frac{R^2}{2.r_2}.\left(\frac{dB}{dt}\right)$$

$$F = qE = \frac{e.R^2}{2.r_2}(6t^2 - 8.t)$$

Force on charge ***q*** due to electric field

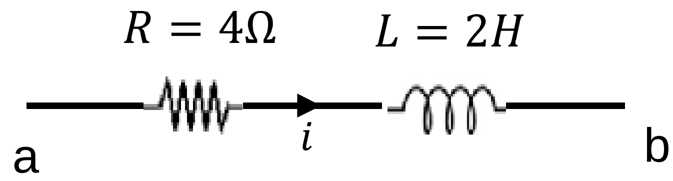
Substituting the values we have,

$$F = \frac{(1.6\times10^{-19})(2.5\times10^{-2})}{2\times5\times10^{-2}}[6.(2)^2 - 8(2)]$$

$$= 8.0\times10^{-21}$$

P-Q1802

In the figure shown $i = 10.e^{-4t}A.\ Find\ V_{ab}$



$A)\ -26 \times e^{-4t}$

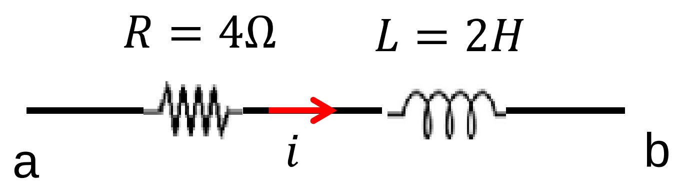
B) 60$\times\ e^{2t}$

C) $-40 \times e^{-4t}$

D) $-20 \times e^{-2t}$

P-Q1802-Solution

Ans [C]



$$V_L = +L\frac{di}{dt}$$ ← Potential across inductor

$$= (2)\frac{d}{dt}(10 \times e^{-4t})$$

$$= -80 \times e^{-4t}$$

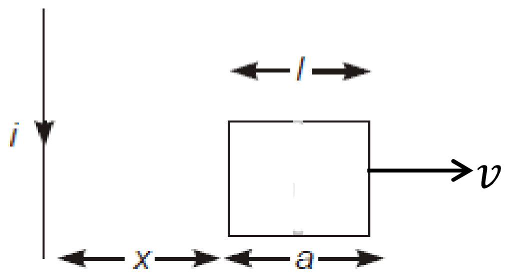
Potential difference between points a and b

Further , $V_a - i.R - l\frac{di}{dt} = V_b$ ← Applying potential difference btw two points

$$or\ \ V_{ab} = (10 \times e^{-4t})(4) - 80 \times e^{-4t} = -40 \times e^{-4t}$$

P-Q1808

A square frame with side a and a long straight wire is carrying a current i are located in the same plane as shown in figure. The frame translates to the right with a constant velocity v. Find the emf induced in the frame as a function of distance x



A) $\frac{\mu_0 a^2 i.x}{2\pi(x+v)}$

B) $\frac{\mu_0 a^2 i.v}{2\pi x(x+a)}$

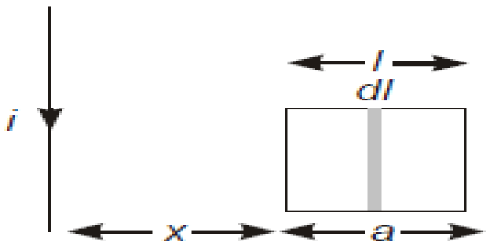
C) $\frac{\mu_0 a^2 i.v}{4\pi(x+a)}$

D) $\frac{\mu_0 a^2 i.v\, x}{2\pi(x+a)}$

P-Q1808-Solution

Ans [B]

Consider an elementary section of length *dl* of the frame as shown in figure. Magnetic flux linked with this section,



$$d\phi_m = BdB = \frac{\mu_0}{4\pi}\frac{2i}{x+l}a\,dl$$

Flux due to dl element (as wire)

Total magnetic flux linked with the frame,

$$\phi_m = \int d\phi_m = \frac{\mu_0 a i}{2\pi}\int_0^a \frac{dl}{x+l}$$

$$= \frac{\mu_0 a i}{2\pi}[\ln(x+a) - \ln x]$$

Total flux through the frame

Induced emf

$$e = \frac{-d\phi_m}{dt} = -\frac{\mu_0 a i}{2\pi}\cdot\left[\frac{1}{x+a} - \frac{1}{x}\right]\frac{dx}{dt}$$

$$= \frac{\mu_0 a^2 i}{2\pi x(x+a)}v = \frac{\mu_0 a^2 i v}{2\pi x(x+a)}$$

Induced emf due to change in flux

P-Q1822

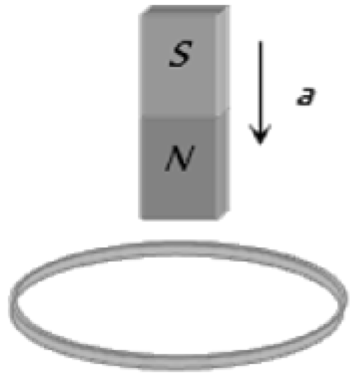
A metallic ring is attached with the wall of a room. When the north pole of a magnet is brought near to it, the induced current in the ring will be (as seen from the magnet) :

(A) First clockwise then anticlockwise

(B) In clockwise direction

(C) In anticlockwise direction

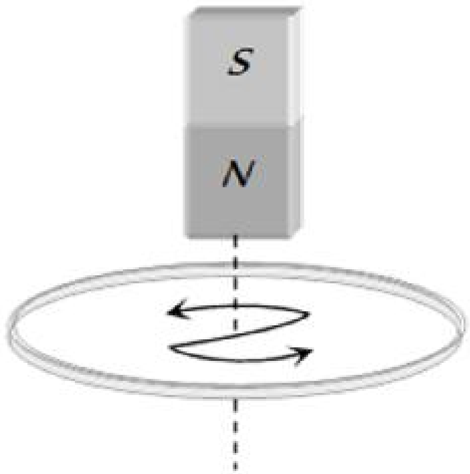
(D) First anticlockwise then clockwise



P-Q1822-Solution

Ans [C]

As it is seen from the magnet side induced current will be anticlockwise.



From Lenz's law if there is an increment of flux in downward direction then current in the coil flows such that it opposes the increment so coil produces current in Anticlockwise direction.

P-Q1823

In a coil of area **10 cm^2** and **10 turns** with a magnetic field directed perpendicular to the plane and is changing at the rate of $\mathbf{10^8}$ ***gauss/second***. The resistance of the coil is **20 *ohm***. The current in the coil will be :

(A) 5 *amp* (B) 0.5 *amp*

(C) 0.05 *amp* (D) None

P-Q1823-Solution

Ans [A]

$$I = \frac{e}{R}$$

$$= \frac{-N(d\phi/dt)}{R}$$

$$= \frac{10 \times 10^8 \times 10^{-4} \times 10^{-4} \times 10}{20}$$

$$= 5\text{ A}$$

From faraday's law $e = -N\frac{d\emptyset}{dt}$

$\emptyset = B.A$

P-Q1824

A **50 turns** circular coil has a radius of $3 \times 10^{-2}\,m$, it is kept in a magnetic field acting normal to the area of the coil. The magnetic field increased from **0.10 *tesla*** to **0.35 *tesla*** in **2 *milliseconds***. The average induced e.m.f. in the coil is :

(A) $1.77\ volts$

(B) $17.7\ volts$

(C) $177\ volts$

(D) $0.177\ volts$

P-Q1824-Solution

Ans [B]

From faraday's law $e = -N\frac{d\emptyset}{dt}$

$$e = -\frac{N(B_2 - B_1)A\cos\theta}{\Delta t}$$

Using $\emptyset = B.A = \mathrm{BAcos\theta}$

$$= -\frac{50(0.35 - 0.10)\times \pi(3\times 10^{-2})^2 \times \cos 0^\circ}{2\times 10^{-3}}$$

$$= 17.7\ V.$$

P-Q1825

The current flowing in two coaxial coils in the **same direction**. On increasing the distance between the two, the electric current will :

(A) Increase

(B) Decrease

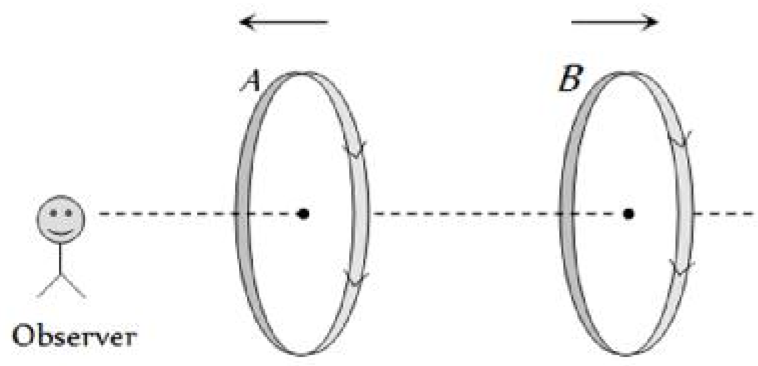
(C) Remain unchanged

(D) The information is incomplete

P-Q1825-Solution

Ans [A]

Induced current in both the coils assist the main current so current through each coil increases.



As they move away flux passes through them decreases and they want to maintain that amount of flux (Lenz's Law) so the current increases.

P-Q1826

Magnetic flux ***f*** (in *weber*) linked with a closed circuit of resistance **10 *ohm*** varies with time ***t*** (in seconds) as

$\emptyset = \mathbf{5t^2 - 4t + 1}$

The induced electromotive force in the circuit at ***t* = 0.2 *sec***. is

(A) 0.4 *volts* (B) – 0.4 *volts*

(C) – 2.0 *volts* (D) 2.0 *volts*

P-Q1826-Solution

Ans [D]

$$e = -\frac{d\phi}{dt}$$

From Faraday's Law

$$= -(10t - 4)$$

By differentiating the given function

$$(e)_{t=2} = -(10 \times 0.2 - 4)$$

$$= 2\,volt$$

P-Q1827

Magnetic flux in a circuit containing a coil of resistance 2Ω changes from **2.0 *Wb*** to **10 *Wb*** in **0.2 *s***. The charge passed through the coil in this time is :

(A) 0.8 *C*

(B) 1.0 *C*

(C) 5.0 *C*

(D) 4.0 *C*

P-Q1827-Solution

Ans [D]

$$q = \frac{N}{R}(\Delta\phi)$$

$$= \frac{1}{2} \times (10 - 2)$$

$$= 4C$$

We can derive this equation using

$$e = -\frac{d\emptyset}{dt}, e = iR \;\&\; i = \frac{dq}{dt}$$

P-Q1829

Two rails of a railway track insulated from each other and the ground are connected to a milli voltmeter. What is the reading of voltmeter, when a train travels with a speed of **180 km/hr** along the track. Given that the vertical component of earth's magnetic field is $0.2 \times 10^{-4}\ \boldsymbol{Wb/m^2}$ and the rails are separated by **1 meter** :

(A) 10^{-2}

(B) 10^{-3}

(C) 10^{-4}

(D) 1 volt

P-Q1829-Solution

Ans [B]

$$e = B_v . vl$$

Induced EMF when there is some relative motion between B and conductor.

$$= 0.2 \times 10^{-4} \times \left(\frac{180 \times 1000}{3600} \right) \times 1$$

$$= 10^{-3}\ V$$

P-Q1841

A solenoid has **2000** turns wound over a length of **0.30** *meter*. The area of its cross-section is $\mathbf{1.2 \times 10^{-3} m^2}$. Around its central section, a coil of **300** turns is wound. If an initial current of **2 A** in the solenoid is reversed in **0.25** *sec*, then the e.m.f. induced in the coil is :

(A) 60 mV

(B) 30 mV

(C) 32 mV

(D) 48 mV

P-Q1841-Solution

Ans [D]

Potential generate Due to flux change

Mutual inductance of two coils is given as $M = \frac{\mu_0 N_1 N_2 A}{l}$

$$e = M\frac{di}{dt}$$

$$= \frac{\mu_0 N_1 N_2 A}{l} \cdot \frac{di}{dt}$$

$$= \frac{4\pi \times 10^{-7} \times 2000 \times 300 \times 1.2 \times 10^{-3}}{0.30} \times \frac{|2-(-2)|}{0.25}$$

$$= 48.2 \times 10^{-3}\ V = 48\ mV$$

P-Q1842

Two coils of self inductance L_1 and L_2 are placed closer to each other so that total flux in one coil is completely linked with other. If is mutual inductance between them is **M**, then:

(A) $M = L_1 L_2$

(B) $M = L_1 / L_2$

(C) $M = \sqrt{L_1 L_2}$

(D) $M = (L_1 L_2)^2$

P-Q1842-Solution

Ans [C]

$$M = -\frac{e_2}{di_1/dt} = -\frac{e_1}{di_2/dt}$$

Also $e_1 = -L_1 \frac{di_1}{dt} . e_2 = -L_2 \frac{di_2}{dt}$

Using $e = L\frac{di}{dt}$

$$M^2 = \frac{e_1 e_2}{\left(\frac{di_1}{dt}\right)\left(\frac{di_2}{dt}\right)} = L_1 L_2$$

$$\Rightarrow M = \sqrt{L_1 L_2}$$

P-Q1844

An inductance ***L*** and a resistance ***R*** are first connected to a battery. After some time the battery is disconnected but ***L*** and ***R*** remain connected in a closed circuit. Then the current reduces to **37%** of its initial value in :

(A) $RL\ sec$

(B) $\frac{R}{L}$ sec

(C) $\frac{L}{R}\ sec$

(D) $\frac{1}{LR}\ sec$

P-Q1844-Solution

Ans [C]

When battery disconnected current through the circuit start decreasing exponentially according to

$$i = i_0 e^{-Rt/L}$$

$$\Rightarrow 0.37 i_0 = i_0 e^{-Rt/L}$$

$$\Rightarrow 0.37 = \frac{1}{e} = e^{-Rt/L}$$

$$\Rightarrow t = \frac{L}{R}$$

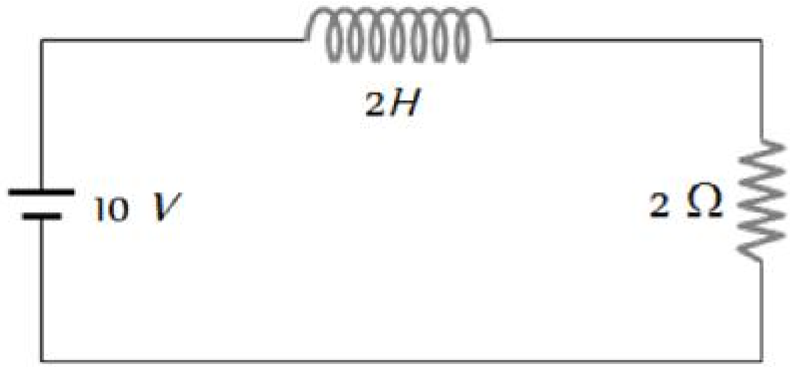
This time is called time constant of R-L circuit

Similarly for charging current increases as

$$i = i_0(1 - e^{-\frac{Rt}{L}})$$

P-Q1845

In the figure magnetic energy stored in the coil is



(A) Zero

(B) Infinite

(C) 25 *joules*

(D) None of the above

P-Q1845-Solution

Ans [C]

$$i = \frac{V}{R} = \frac{10}{2} = 5A$$

Assuming the inductor is Ideal (It has no resistance)

$$U = \frac{1}{2}Li^2$$

Energy stored in an inductor when current ‘i’ flows through it

$$= \frac{1}{2} \times 2 \times 25$$

$$= 25J$$

P-Q1848

In a step-up transformer, the turn ratio is **1 : 2**. A **Leclanche cell** (e.m.f. **1.5V**) is connected across the primary. The voltage developed in the secondary would be :

(A) 3.0 *V* (B) 0.75 *V*

(C) 1.5 *V* (D) Zero

P-Q1848-Solution

Ans [D]

Transformer doesn't work on dc

Transformer works only when current is changing with time and in DC current remains constant so no voltage will induce

P-Q1849

In a transformer **220** ac voltage is increased to **2200** *volts*. If the number of turns in the secondary are **2000**, then the number of turns in the primary will be :

(A) 200 (B) 100

(C) 50 (D) 20

P-Q1849-Solution

Ans [A]

In a transformer induced voltage across the coil is directly proportional to the No of turns ($V \propto N$)

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\Rightarrow N_p = \left(\frac{220}{2200}\right) 2000$$

$$= 200$$

P-Q1852

A transformer is employed to reduce **220 *V*** to **11 *V***. The primary draws a current of **5 *A*** and the secondary **90 *A***. The efficiency of the transformer is

(A) 20% (B) 40%

(C) 70% (D) 90%

P-Q1852-Solution

Ans [D]

Efficiency of transformer = $\frac{Output\ Power}{Input\ Power} \times 100\ \%$

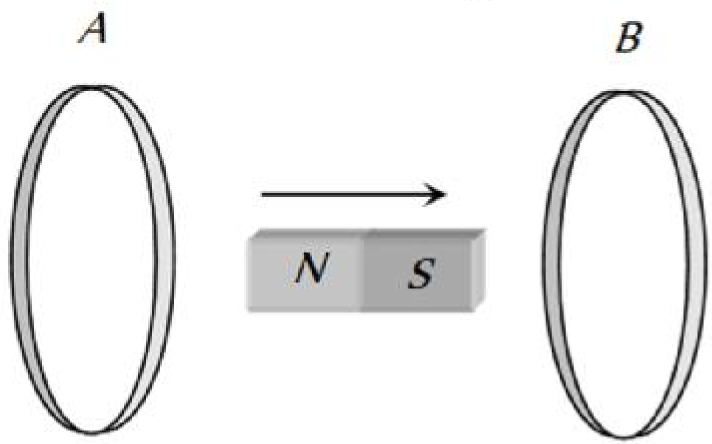
$$\eta = \frac{V_s i_s}{V_p i_p} \times 100$$

$$= \frac{11 \times 90}{220 \times 5} \times 100$$

$$= 90\ \%$$

P-Q1854

In the diagram shown if a bar magnet is moved along the common axis of **two single turn** coils *A* and *B* in the direction of arrow



(A) Current is induced only in *A* & not in *B*

(B) Induced currents in *A* & *B* are in the same direction

(C) Current is induced only in *B* and not in *A*

(D) Induced currents in *A* & *B* are in opposite directions

P-Q1854-Solution

Ans [D]

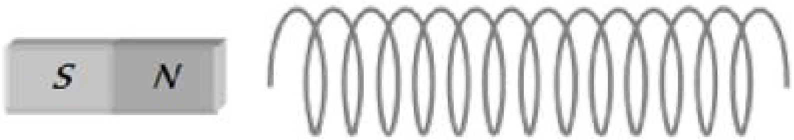
Induced currents in A & B are in opposite directions .

South pole is moving towards ring B so it will oppose this change according to lenz's law and it produces current in clockwise direction.

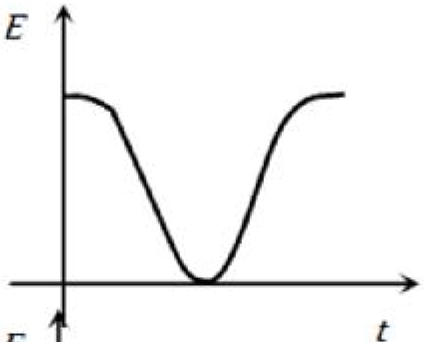
North pole is going away from the Ring B so it will induce current in clockwise direction when we watch from north pole so for an observer standing left to ring A this current will be anticlockwise.

P-Q1855

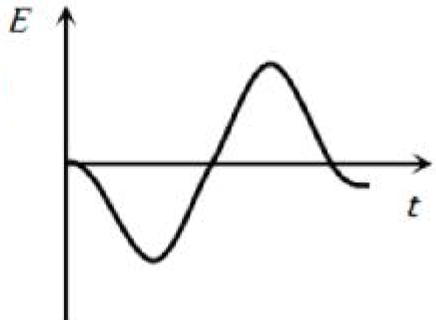
The variation of induced emf (E) with time (t) in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as :



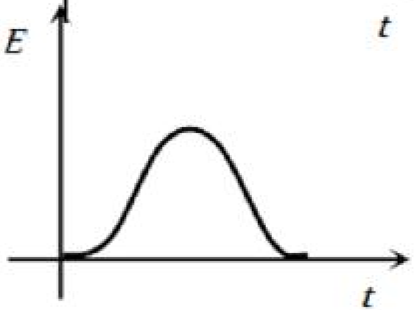
(A)



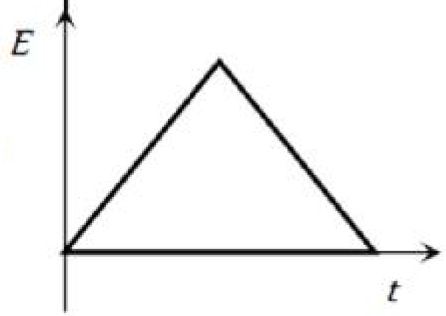
(B)



(C)



(D)



P-Q1855-Solution

Ans [B]

As the magnet moves towards the coil, the magnetic flux increases (nonlinearly). Also there is a change in polarity of induced emf when the magnet passes on to the other side of the coil .

When north is approaching, inward flux is increasing so it produces anticlockwise current to produce outward flux (From lenz's law).

When it is coming out to the coil at that time inward flux will decrease and it produces current in anticlockwise direction hence polarity changes so for second half the graph is in negative side

P-Q1856

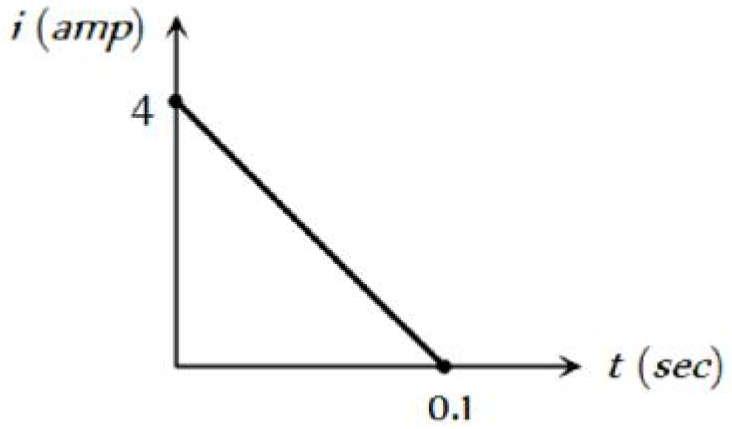
Some magnetic flux is changed from a coil of resistance **10 *ohm***. As a result an induced current is developed in it, which varies with time as shown in figure. The magnitude of change in flux through the coil in *webers* is :

(A) 2

(B) 4

(C) 6

(D) None of these



P-Q1856-Solution

Ans [A]

$$|dq| = \frac{d\phi}{R} = i\,dt = \text{Area under } i - t \text{ graph}$$

$$\therefore d\phi = (\text{Area under } i - t \text{ graph})\ R$$

From Faraday's law $e = \frac{d\emptyset}{dt}$

$$= \frac{1}{2} \times 4 \times 0.1 \times (10) = 2\ wb.$$

P-Q1863

Two pure inductors each of self inductance *L* are connected in parallel but are well separated from each other. The total inductance is :

(A) $2L$

(B) L

(C) $\frac{L}{2}$

(D) $\frac{L}{4}$

P-Q1863-Solution

Ans [C]

Inductors obey the laws of parallel and series combination of resistors.

For parallel combination $\frac{1}{L_{Eq}} = \frac{1}{L_1} + \frac{1}{L_1}$

P-Q1961

L*, *C and ***R*** represent physical quantities inductance, capacitance and resistance respectively.

The combination representing dimension of frequency is :

(a) LC

(b) $(LC)^{-1/2}$

(c) $\left(\frac{L}{C}\right)^{-1/2}$

(d) $\frac{C}{L}$

P-Q1961-Solution

Ans [B]

$$\text{Frequency} = \frac{1}{2\pi\sqrt{LC}}$$

Resonance Frequency

So the combination which represents dimension of frequency is

$$\frac{1}{\sqrt{LC}} = (LC)^{-1/2}$$

P-Q1962

A capacitor is a near **perfect insulator** for :

(A) Alternating currents

(B) Direct currents

(C) Both ac and dc

(D) None of these

P-Q1962-Solution

Ans [B]

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu\, C}$$

$$\text{For dc } \nu = 0, \quad \therefore X_C = \infty$$

Frequency of DC is zero so reactance due to capacitor is Infinity for DC so no current will flow through the capacitor

Capacitor blocks **Direct Current**

P-Q1963

If an alternating voltage is represented as $\boldsymbol{E = 141 \sin 628t}$ then the ***rms* value** of the voltage and the frequency are respectively :

(a) $141\ V, 628\ Hz$

(b) $100\ V, 50\ Hz$

(c) $100\ V, 100\ Hz$

(d) $141\ V,\ 100\ Hz$

P-Q1963-Solution

Ans [C]

$$E = 141 \sin(628\, t),$$

The root mean square value of the alternating voltage is equal to $\frac{1}{\sqrt{2}}$ times the peak value

$$E_{rms} = \frac{E_0}{\sqrt{2}} = \frac{141}{1.41} = 100\,V$$

$$2\pi f = 628$$

Using $\omega = 2\pi f$

$$\Rightarrow \; f = 100\,Hz$$

P-Q1964

A **280** ***ohm*** electric bulb is connected to **200*V*** electric line. The **peak value** of current in the bulb will be :

(A) About one ampere

(B) Zero

(C) About two ampere

(D) About four ampere

P-Q1964-Solution

Ans [A]

$$i_{rms} = \frac{200}{280} = \frac{5}{7} A.$$

Using Ohm's Law ; $V = IR$

$$i_0 = i_{rms} \times \sqrt{2}$$

The root mean square value of the alternating voltage is equal to $\frac{1}{\sqrt{2}}$ times the peak value

$$= \frac{5}{7} \times \sqrt{2} \approx 1A.$$

The bulb is connected through a **200** voltage line it means that 200 V is the rms value of voltage

P-Q1965

The voltage of domestic ac is **220 *volt***. What does this represent :

(A) Mean voltage

(B) Peak voltage

(C) Root mean voltage

(D) Root mean square voltage

P-Q1965-Solution

Ans [D]

Generally the given value are rms value until and unless it is not said that given value is peak value

RMS **à** Root Mean Square values are written on the electrical appliance.

P-Q1966

The main reason for preferring use of **AC voltage over DC voltage** :

(A) DC Batteries are of low voltage

(B) DC uses alternators whereas as uses generators

(C) There are no DC generators

(D) AC voltages can be easily and efficiently converted from one voltage to the other by means of transformers

P-Q1966-Solution

Ans [D]

AC voltages can be easily and efficiently converted from one voltage to the other by means of transformers

To minimize the power loses during transmission voltage of AC is kept down and for this purpose we use transformer this operation is not possible with DC

P-Q1967

Transformer uses the **principle** of :

(A) Conduction

(B) Induction

(C) Charge conservation

(D) Least action

P-Q1967-Solution

Ans [B]

Transformer works on the principle of induction

In transformer we induce the current in the secondary coil by flowing the current in primary coil

P-Q1968

A lamp is connected in series with a capacitor and connected to **an AC source**. As the capacitance value is **decreased**.

(A) The lamp does not glow

(B) The lamp starts turning on and off

(C) The lamp glows brighter

(D) The lamp glows dimmer and dimmer

P-Q1968-Solution

Ans [D]

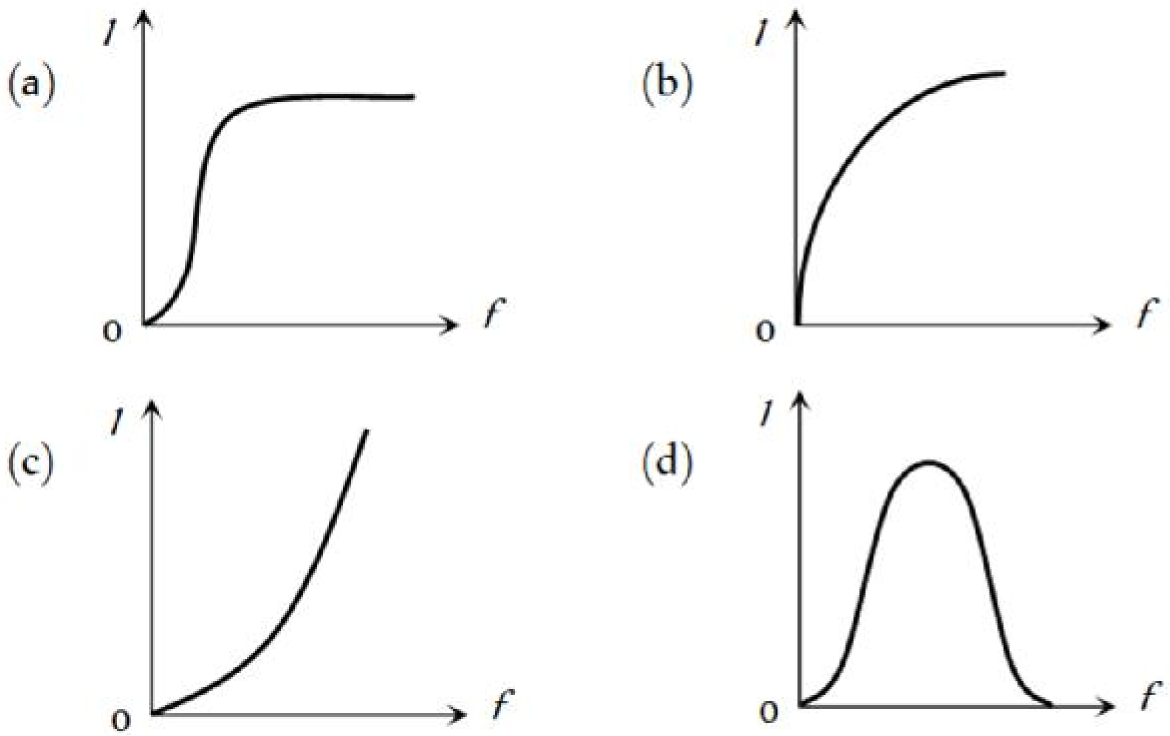
As one decreases the value of capacitance the net impedance of circuit increases and current decreases

$$X_C = \frac{1}{\omega C}$$

As we decreases C value of reactance of capacitor increases and it results in the decrement of current and hence power across the bulb decreases

P-Q1969

An ac source of variable frequency ***f*** is connected to an ***LCR* series** circuit. Which one of the graphs in figure represents the variation of current ***I*** in the circuit with frequency ***f*** :



P-Q1969-Solution

Ans [D]

For frequency $0 - f_r$, Z decreases hence $(i = V/Z)$, increases and for frequency $f_r - \infty$, Z increases hence i decreases.

Till resonance frequency (At low frequencies) inductor has lower reactance than capacitor so as we **increase frequency net impedance decreases** and current **increases** till resonance.

After **resonance frequency** capacitor has **low reactance** and **current** start decreasing as as we increase **frequency reactance** of **inductor increase**.

In **ac circuits impedance** is given by $Z = \sqrt{R^2 + ({X_L}^2 - {X_c}^2)}$

PQ17Q44

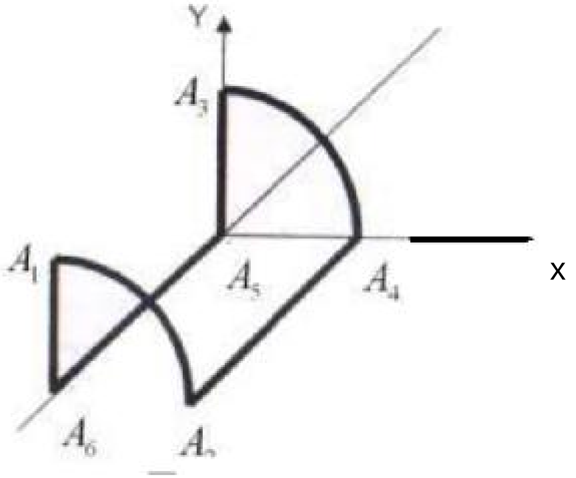
A time varying magnetic field B = $B_0 t\,\hat{k}$ is confined in a cylindrical region. cutting the XY plane on a circle of radius $x^2 + y^2 = 4$. We have placed a wire frame as shown. Segment A_1A_2 and A_3A_4 are identical quarter circles. The net emf induced in the wire frame is equal to

(A) Zero

(B) $2B_0$

(C) $4B_0$

(D) B_0



PQ17S44

Ans [A]

Due to time varying magnetic field, emf will induce only in segment A_1A_2 and A_3A_4 Only. Since induced emf in both segment is equal and opposite net emf in the loop will be zero. Hence current is zero.

Use the faraday's law

$$\varepsilon = \frac{-d\phi}{dt} = \int E.dl$$

$$\phi = \int B \cdot dA$$

The **induced emf** in a coil is equal to the negative of the rate of **change** of **magnetic** flux times the number of turns in the coil. It involves the interaction of charge with **magnetic field**.

PQ17Q51

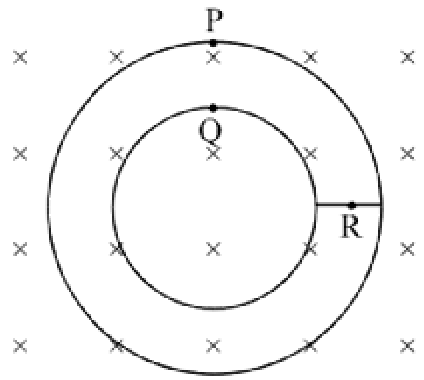
Figure shown plane figure made of a conductor located in a magnetic field along the inward normal to the plane of the figure. The magnetic field starts diminishing. Then the induced current

(A) at point P is anticlockwise

(B) at point Q is anticlockwise

(C) at point R is backward

(D) at point R is zero

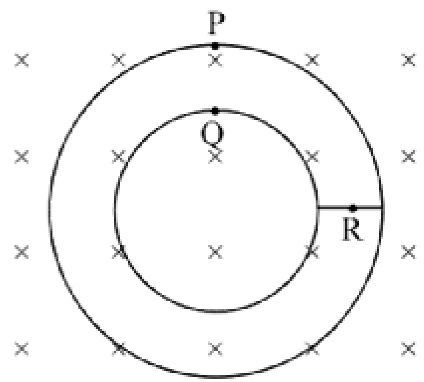


PQ17S51

Ans [D]

From KCL current at R is zero induce field will be in the form of concentric circle having orientation clockwise since at P and Q there in a close path so induce current will be clockwise. The **induced emf** in a coil is equal to the negative of the rate of **change** of **magnetic** flux times the number of turns in the coil. It involves the interaction of charge with **magnetic field**.

$$\varepsilon = iR = -\frac{\Delta \Phi_B}{\Delta t} \qquad iR = -A\frac{dB}{dt}$$



Use the faraday's law $\varepsilon = \frac{-d\phi}{dt}$

If current enter through R, then there is no place for current to leave Q, so current in R = 0

P-Q1970

“***An electric lamp connected in series with a variable capacitor and ac source, its brightness increases with increase in capacitance***”

The above statement is :

(A) True (B) False

(C) Nothing can be said (D) May be true , Depends on the situation

P-Q1970-Solution

Ans [A]

Capacitive reactance **decreases** with **increase** in capacitance of capacitor.

- **Capacitive** reactance $X_C = \frac{1}{\omega C}$.
- When **capacitance *C* increases**, the capacitive **reactance decreases**.
- Due to **decrease** in its values, the current in the circuit will increases $\left(I = \frac{E}{\sqrt{R^2+{X_C}^2}}\right)$.
- Hence **brightness** of **source** (or **electric lamp**) will **also increases**.