Chapter
23

Electromagnetic Induction

Magnetic Flux

(1) The total number of magnetic lines of force passing normally through an area placed in a magnetic field is equal to the magnetic flux linked with that area.

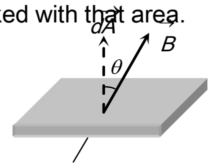


Fig. 23.1

(2) Net flux through the surface $\phi = \oint \vec{B} \cdot d\vec{A} = BA\cos\theta$

(θ is the angle between area vector and magnetic field vector)

If θ = 0° then ϕ = BA, If θ = 90° then ϕ = 0

(3) **Unit and Dimension :** Magnetic flux is a scalar quantity. It's S.I. unit is *weber* (*wb*), CGS unit is *Maxwell* or *Gauss* × *cm*²; ($1\,wb = 10^8\ Maxwell$).

(4) Other units : *Tesla* × *m*² $= \frac{N \times m}{Amp} = \frac{Joule}{Amp} = \frac{Volt \times \text{Coulomb}}{Amp}$

$= Volt \times sec$ = *Ohm* × *Coulomb* = *Henry* × *Amp*. It's dimensional formula [ϕ] = [$ML^2T^{-2}A^{-1}$]

Faraday's Laws of Electromagnetic Induction

(1) **First law :** Whenever the number of magnetic lines of force (magnetic flux) passing through a circuit changes an emf is produced in the circuit called induced emf. The induced emf persists only as long as there is change or cutting of flux.

(2) **Second law :** The induced emf is given by rate of change of magnetic flux linked with the circuit *i.e.* $e = -\frac{d\phi}{dt}$. For *N* turns $e = -\frac{N\,d\phi}{dt}$; Negative sign indicates that induced emf (*e*) opposes the change of flux.

(3) **Other formulae :** ϕ = *BA* cosθ ; Hence ϕ will change if either, *B*, *A* or θ will change

So $e = -N\frac{d\phi}{dt} = -\frac{N(\phi_2 - \phi_1)}{\Delta t} = -\frac{NA(B_2 - B_1)\cos\theta}{\Delta t}$

$= -\frac{NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

Table 23.1 : Induced *i*, *q* and *P*

Induced current (*i*)	Induced charge (*q*)	Induced power (*P*)
$i = \frac{e}{R} = -\frac{N}{R} \cdot \frac{d\phi}{dt}$	$dq = i\,dt = -\frac{N}{R} \cdot d\phi$ Induced charge is time independent.	$P = \frac{e^2}{R} = \frac{N^2}{R}\left(\frac{d\phi}{dt}\right)^2$ It depends on time and resistance

Lenz's Law

This law gives the direction of induced emf/induced current. According to this law, the direction of induced emf or current in a circuit is such as to oppose the cause that produces it. This law is based upon law of conservation of energy.

(1) When *N*-pole of a bar magnet moves towards the coil, the flux associated with loop increases and an emf is induced in it. Since the circuit of loop is closed, induced current also flows in it.

(2) Cause of this induced current, is approach of north pole and therefore to oppose the cause, *i.e.*, to repel the approaching north pole, the induced current in loop is in such a direction so that the front face of loop behaves as north pole. Therefore induced current as seen by observer *O* is in anticlockwise direction. (figure)

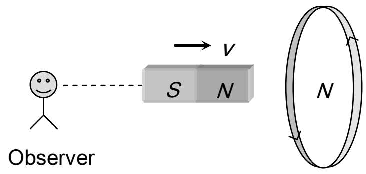
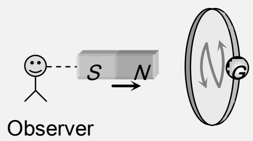
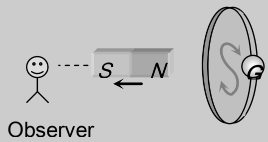
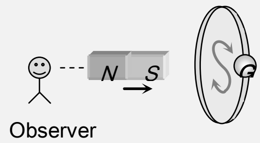
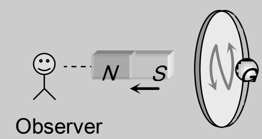


Fig. 23.2

Table 23.2 : The various positions of relative motion between the magnet and the coil

Position of magnet				
Direction of induced current	Anticlockwise direction	Clockwise direction	Clockwise direction	Anticlockwise direction
Behaviour of face of the coil	As a north pole	As a south pole	As a south pole	As a north pole
Type of magnetic force opposed	Repulsive force	Attractive force	Repulsive force	Attractive force
Magnetic field linked with the coil and it's progress as viewed from left	Cross (×), Increases	Cross (×), Decreases	Dots (·) Increases	Dots (·) Decreases

(3) If the loop is free to move the cause of induced emf in the coil can also be termed as relative motion. Therefore to oppose the cause, the relative motion between the approaching magnet and the loop should be opposed. For this, the loop will itself start moving in the direction of motion of the magnet.

(4) It is important to remember that whenever cause of induced emf is relative motion, the new motion is always in the direction of motion of the cause.

Induced Electric Field

It is non-conservative and non-electrostatic in nature. Its field lines are concentric circular closed curves.

A time varying magnetic field $\frac{dB}{dt}$ always produced induced electric field in all space surrounding it.

Induced electric field (E_{in}) is directly proportional to induced emf so $e = \oint \vec{E}_{in} \cdot d\vec{l}$ .....(i)

From Faraday's second laws $e = -\frac{d\phi}{dt}$ .....(ii)

From (i) and (ii) $e = \oint \vec{E}_{in} . d\vec{l} = -\frac{d\phi}{dt}$ This is known as integral form of Faraday's laws of EMI.

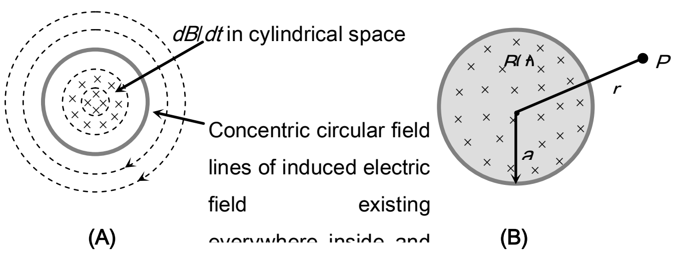


Fig. 23.3

A uniform but time varying magnetic field $B(t)$ exists in a circular region of radius 'a' and is directed into the plane of the paper as shown, the magnitude of the induced electric field (E_{in}) at point P lies at a distance r from the centre of the circular region is calculated as follows.

So $\oint \vec{E}_{in} d\vec{l} = e = \frac{d\phi}{dt} = A\frac{dB}{dt}$ *i.e.* $E(2\pi r) = \pi a^2 \frac{dB}{dt}$

where $r \geq a$ or $E = \frac{a^2}{2r}\frac{dB}{dt}$; $\boldsymbol{E_{in} \propto \frac{1}{r}}$

Dynamic (Motional) EMI Due to Translatory Motion

(1) Consider a conducting rod of length l moving with a uniform velocity $\vec{v}$ perpendicular to a uniform magnetic field $\vec{B}$, directed into the plane of the paper. Let the rod be moving to the right as shown in figure. The conducting electrons also move to the right as they are trapped within the rod.

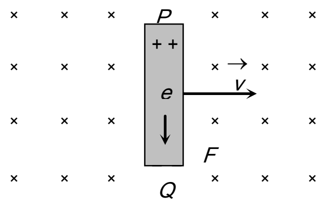
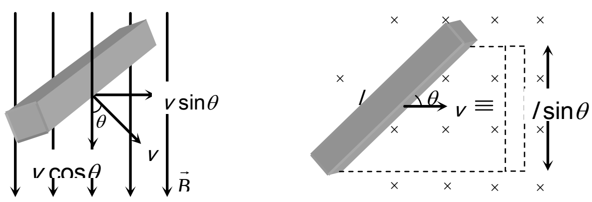


Fig. 23.4

Conducting electrons experiences a magnetic force $F_m = evB$. So they move from P to Q within the rod. The end P of the rod becomes positively charged while end Q becomes negatively charged, hence an electric field is set up within the rod which opposes the further downward movement of electrons *i.e.* an equilibrium is reached and in equilibrium $F_e = F_m$ *i.e.* $eE = evB$ or $E = vB \Rightarrow$ Induced emf $\boldsymbol{e = El = Bvl}$ $[E = \frac{V}{l}]$

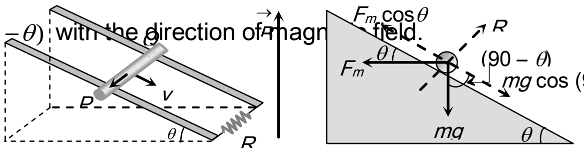
(2) If rod is moving by making an angle θ with the direction of magnetic field or length. Induced emf $e = Bvl\sin\theta$



(A) (B)

Fig. 23.5

(3) **Motion of conducting rod on an inclined plane :** When conductor start sliding from the top of an inclined plane as shown, it moves perpendicular to it's length but at an angle $(90-\theta)$ with the direction of magnetic field.



(A) (B)

Fig. 23.6

Hence induced emf across the ends of conductor $e = Bv\sin(90-\theta)l = Bvl\cos\theta$

So induced current $i = \frac{Bvl\cos\theta}{R}$ (Directed from Q to P).

The forces acting on the bar are shown in following figure. The rod will move down with constant velocity only if

$$F_m \cos\theta = mg\cos(90-\theta) = mg\sin\theta \Rightarrow Bil\cos\theta = mg\sin\theta$$

$$B\left(\frac{Bv_T l\cos\theta}{R}\right)l\cos\theta = mg\sin\theta \Rightarrow v_T = \frac{mgR\sin\theta}{B^2l^2\cos^2\theta}$$

Motional Emi in Loop by Generated Area

If conducting rod moves on two parallel conducting rails as shown in following figure then phenomenon of induced emf can also be understand by the concept of generated area (The area swept of conductor in magnetic field, during it's motion)

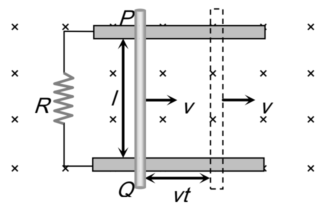


Fig. 23.7

As shown in figure in time t distance travelled by conductor = vt

Area generated $A = lvt$. Flux linked with this area $\phi = BA = Blvt$. Hence induced emf $|e| = \frac{d\phi}{dt} = Bvl$

(1) **Induced current :** $i = \dfrac{e}{R} = \dfrac{Bvl}{R}$

(2) **Magnetic force :** Conductor *PQ* experiences a magnetic force in opposite direction of it's motion and $F_m = Bil = B\left(\dfrac{Bvl}{R}\right)l = \dfrac{B^2vl^2}{R}$

(3) **Power dissipated in moving the conductor :** For uniform motion of rod *PQ*, the rate of doing mechanical work by external agent or mech. Power delivered by external source is given as

$$P_{mech} = P_{ext} = \frac{dW}{dt} = F_{ext}.v = \frac{B^2vl^2}{R} \times v = \frac{B^2v^2l^2}{R}$$

(4) **Electrical power :** Also electrical power dissipated in resistance or rate of heat dissipation across resistance is given as

$$P_{thermal} = \frac{H}{t} = i^2R = \left(\frac{Bvl}{R}\right)^2.R \; ; \quad P_{thermal} = \frac{B^2v^2l^2}{R}$$

(It is clear that $P_{mech.} = P_{thermal}$ which is consistent with the principle of conservation of energy.)

(5) **Motion of conductor rod in a vertical plane :** If conducting rod released from rest (at *t* = 0) as shown in figure then with rise in it's speed (*v*), induces emf (*e*), induced current (*i*), magnetic force (F_m) increases but it's weight remains constant.

Rod will achieve a constant maximum (terminal) velocity v_T if $F_m = mg$

So $\dfrac{B^2v_T^2l^2}{R} = mg$

$\Rightarrow \quad v_T = \dfrac{mgR}{B^2l^2}$

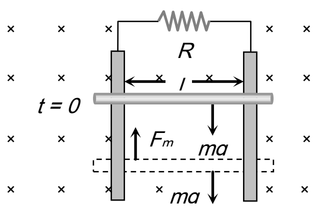


Fig. 23.8

Special cases

Motion of train and aeroplane in earth's magnetic field

(A) Fig. 23.9 (B)

Induced emf across the axle of the wheels of the train and it is across the tips of the wing of the aeroplane is given by *e* = B_vlv where *l* = length of the axle or distance between the tips of the wings of plane, B_v = vertical component of earth's magnetic field and *v* = speed of train or plane.

Motional EMI Due to Rotational Motion

(1) **Conducting rod :** A conducting rod of length *l* whose one end is fixed, is rotated about the axis passing through it's fixed end and perpendicular to it's length with constant angular velocity ω. Magnetic field (*B*) is perpendicular to the plane of the paper.

emf induces across the ends of the rod

where ν = frequency (revolution per sec) and *T* = Time period.

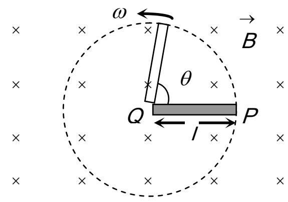


Fig. 23.10

(2) **Cycle wheel** : A conducting wheel each spoke of length *l* is rotating with angular velocity ω in a given magnetic field as shown below in fig.

Due to flux cutting each metal spoke becomes identical cell of emf *e* (say), all such identical cells connected in parallel fashion $e_{net} = e$ (emf of single cell). Let *N* be the number of spokes hence

$e_{net} = \dfrac{1}{2}Bwl^2; \omega = 2\pi\nu$

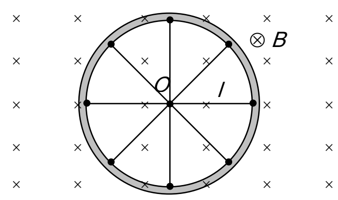


Fig. 23.11

Here $e_{net} \propto N^o$ *i.e.* total emf does not depends on number of spokes '*N*'.

(3) **Faraday copper disc generator :** A metal disc can be assumed to made of uncountable radial conductors when metal disc rotates in transverse magnetic field these radial conductors cuts away magnetic field lines and because of this flux cutting all becomes identical cells each of emf 'e' where $e = \dfrac{1}{2}B\omega r^2$,

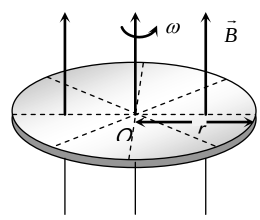


Fig. 23.12

(4) **Semicircular conducting loop** : If a semi-circular conducting loop (ACD) of radius 'r' with centre at O, the plane of loop being in the plane of paper. The loop is now made to rotate with a constant angular velocity ω, about an axis passing through O and perpendicular to the plane of paper. The effective resistance of the loop is R.

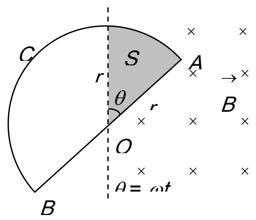


Fig. 23.13

In time t the area swept by the loop in the field *i.e.* region II

$$A = \frac{1}{2} r(r\theta) = \frac{1}{2} r^2 \omega t\,; \quad \frac{dA}{dt} = \frac{r^2\omega}{2}$$

Flux link with the rotating loop at time t $\phi = BA$

Hence induced emf in the loop in magnitude $|e| = \frac{d\phi}{dt} = B\frac{dA}{dt} = \frac{B\omega r^2}{2}$ and induced current $i = \frac{|e|}{R} = \frac{B\omega r^2}{2R}$

Periodic EMI

Suppose a rectangular coil having N turns placed initially in a magnetic field such that magnetic field is perpendicular to it's plane as shown.

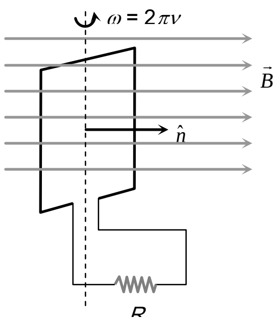


Fig. 23.14

ω – Angular speed

ν – Frequency of rotation of coil

R – Resistance of coil

For uniform rotational motion with ω, the flux linked with coil at any time t

$$\phi = NBA\cos\theta = NBA\cos\omega t$$

$\phi = \phi_0 \cos\omega t$ where $\phi_0 = NBA$ = maximum flux

(1) **Induced emf in coil** : Induced emf also changes in periodic manner that's why this phenomenon called periodic EMI

$e = -\frac{d\phi}{dt} = NBA\omega\sin\omega t \Rightarrow e = e_0 \sin\omega t$ where e_0 = emf amplitude or max. emf $= NBA\omega = \phi_0\omega$

(2) **Induced current** : At any time t, $i = \frac{e}{R} = \frac{e_0}{R}\sin\omega t = i_0 \sin\omega t$ where i_0 = current amplitude or max. current $i_0 = \frac{e_0}{R} = \frac{NBA\omega}{R} = \frac{\phi_0\omega}{R}$

Inductance

(1) Inductance is that property of electrical circuits which opposes any change in the current in the circuit.

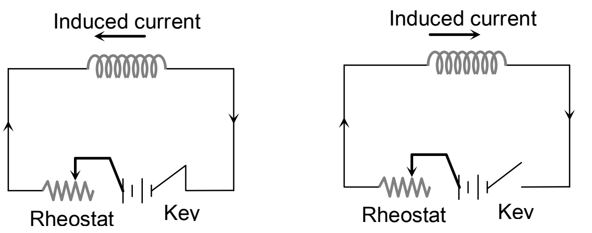
(2) Inductance is inherent property of electrical circuits. It will always be found in an electrical circuit whether we want it or not.

(3) A straight wire carrying current with no iron part in the circuit will have lesser value of inductance.

(4) Inductance is analogous to inertia in mechanics, because inductance of an electrical circuit opposes any change of current in the circuit.

Self Induction

Whenever the electric current passing through a coil or circuit changes, the magnetic flux linked with it will also change. As a result of this, in accordance with Faraday's laws of electromagnetic induction, an emf is induced in the coil or the circuit which opposes the change that causes it. This phenomenon is called 'self induction' and the emf induced is called back emf, current so produced in the coil is called induced current.



(A) Main current (B) Main current decreasing

Fig. 23.15

(1) **Coefficient of self-induction** : Number of flux linkages with the coil is proportional to the current i. *i.e.* $N\phi \propto i$ or $N\phi = Li$ (N is the number of turns in coil and $N\phi$ – total flux linkage). Hence $\boldsymbol{L = \frac{N\phi}{i}}$ = coefficient of self-induction.

(2) If i = 1*amp*, N = 1 then, $L = \phi$ *i.e.* the coefficient of self induction of a coil is equal to the flux linked with the coil when the current in it is 1 *amp*.

(3) By Faraday's second law induced emf $e = -N\dfrac{d\phi}{dt}$. Which gives $e = -L\dfrac{di}{dt}$; If $\dfrac{di}{dt} = 1\,amp/sec$ then $|e| = L$.

Hence coefficient of self induction is equal to the emf induced in the coil when the rate of change of current in the coil is unity.

(4) **Units and dimensional formula of '*L*' :** It's S.I. unit

$$\frac{weber}{Amp} = \frac{Tesla \times m^2}{Amp} = \frac{N \times m}{Amp^2} = \frac{Joule}{Amp^2} = \frac{Coulomb \times volt}{Amp^2}$$

$= \dfrac{volt \times \sec}{amp} = ohm \times \sec$. But practical unit is henry (H). It's dimensional formula $[L] = [ML^2T^{-2}A^{-2}]$

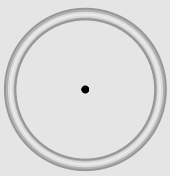
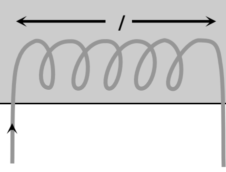
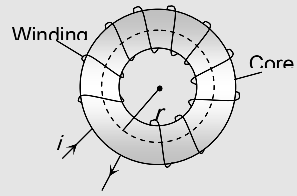
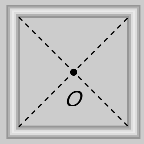
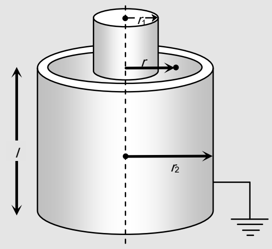
(5) **Dependence of self inductance (*L*) :** '*L*' does not depend upon current flowing or change in current flowing but it depends upon number of turns (N), Area of cross section (A) and permeability of medium (μ).

'*L*' does not play any role till there is a constant current flowing in the circuit. '*L*' comes in to the picture only when there is a change in current.

(6) **Magnetic potential energy of inductor :** In building a steady current in the circuit, the source emf has to do work against of self inductance of coil and whatever energy consumed for this work stored in magnetic field of coil this energy called as magnetic potential energy (U) of coil

$$U = \int_0^i Li\,di = \frac{1}{2}Li^2\text{ ; Also } U = \frac{1}{2}(Li)i = \frac{N\phi i}{2}$$

(7) **The various formulae for *L***

Condition	Figure
Circular coil $L = \dfrac{\mu_0 \pi N^2 r}{2}$	
Solenoid $L = \dfrac{\mu_0 \mu_r N^2 A}{l} = \dfrac{\mu N^2 A}{l} (\mu = \mu_0 \mu_r)$	
Toroid $L = \dfrac{\mu_0 N^2 r}{2}$	
Square coil $L = \dfrac{2\sqrt{2}\mu_0 N^2 a}{\pi}$	
Coaxial cylinders $L = \dfrac{\mu_0}{2\pi r}\log_e \dfrac{r_2}{r_1}$ $\dfrac{2.303}{2\pi r}\mu_0 \log_{10}\dfrac{r_2}{r_1}$	

Mutual Induction

Whenever the current passing through a coil or circuit changes, the magnetic flux linked with a neighbouring coil or circuit will also change. Hence an emf will be induced in the neighbouring coil or circuit. This phenomenon is called 'mutual induction'.

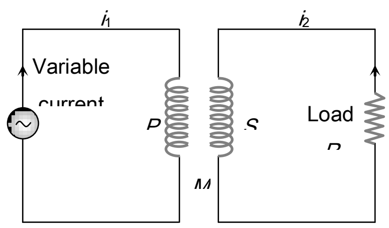


Fig. 23.16

(1) **Coefficient of mutual induction :** Total flux linked with the secondary due to current in the primary is $N_2\phi_2$ and $N_2\phi_2 \propto i_1 \Rightarrow N_2\phi_2 = Mi_1$ where N_1 - Number of turns in primary; N_2 - Number of turns in secondary; ϕ_2 - Flux linked with each turn of secondary; i_1 - Current flowing through primary; M-Coefficient of mutual induction or mutual inductance.

(2) According to Faraday's second law emf induces in secondary $e_2 = -N_2\dfrac{d\phi_2}{dt}$; $e_2 = -M\dfrac{di_1}{dt}$

(3) If $\dfrac{di_1}{dt} = \dfrac{1 Amp}{sec}$ then $|e_2|$ = M. Hence coefficient of mutual induction is equal to the emf induced in the secondary coil when rate of change of current in primary coil is unity.

(4) **Units and dimensional formula of M :** Similar to self-inductance (L)

(5) **Dependence of mutual inductance**

(i) Number of turns (N_1, N_2) of both coils

(ii) Coefficient of self inductances (L_1, L_2) of both the coils

(iii) Area of cross-section of coils

(iv) Magnetic permeability of medium between the coils (μ_r) or nature of material on which two coils are wound

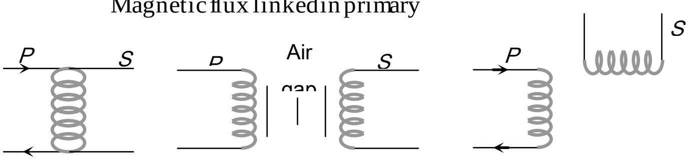
(v) Distance between two coils (As d increases so M decreases)

(vi) Orientation between primary and secondary coil (for 90° orientation no flux relation M = 0)

(vii) Coupling factor 'K' between primary and secondary coil

(6) **Relation between M, L_1 and L_2 :** For two magnetically coupled coils $M = k\sqrt{L_1L_2}$; where k – coefficient of coupling or coupling factor which is defined as

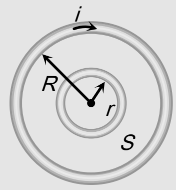
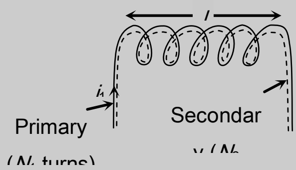
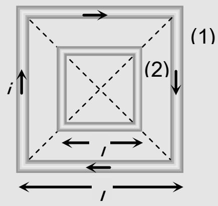
$$k = \frac{\text{Magnetic flux linked in secondary}}{\text{Magnetic flux linked in primary}}; \quad 0 \le k \le 1$$



(A) k = 1 (B) 0 < k < 1 (C) k = 0

Fig. 23.17

(7) **The various formulae for M :**

Condition	Figure
Two concentric coplaner circular coils $M = \dfrac{\pi\mu_0 N_1 N_2 r^2}{2R}$	
Two Solenoids $M = \dfrac{\mu_0 N_1 N_2 A}{l}$	
Two concentric coplaner square coils $M = \dfrac{\mu_0 2\sqrt{2}\, N_1 N_2 l^2}{\pi L}$	

Combination of Inductance

(1) **Series :** If two coils of self-inductances L_1 and L_2 having mutual inductance are in series and are far from each other, so that the mutual induction between them is negligible, then net self inductance $L_S = L_1 + L_2$

When they are situated close to each other, then net inductance $L_S = L_1 + L_2 \pm 2M$

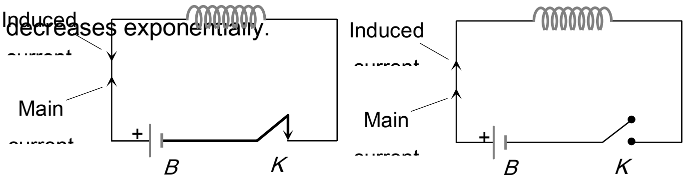
(2) **Parallel :** If two coils of self-inductances L_1 and L_2 having mutual inductance are connected in parallel and are far from each other, then net inductance L is $\dfrac{1}{L_P} = \dfrac{1}{L_1} + \dfrac{1}{L_2}$ $\Rightarrow$ $L_P = \dfrac{L_1L_2}{L_1 + L_2}$

When they are situated close to each other, then

$$L_P = \frac{L_1L_2 - M^2}{L_1 + L_2 \pm 2M}$$

Growth and Decay of Current In *LR*- Circuit

If a circuit containing a pure inductor *L* and a resistor *R* in series with a battery and a key then on closing the circuit current through the circuit rises exponentially and reaches up to a certain maximum value (steady state). If circuit is opened from it's steady state condition then current through the circuit decreases exponentially.



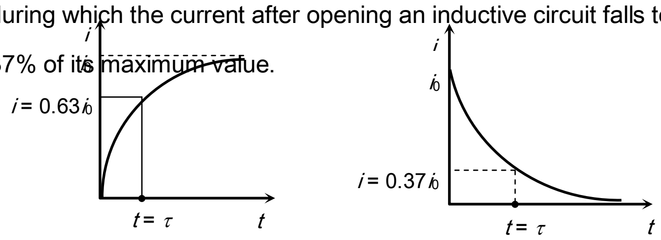
(A) Growth of current **(B)** Decay of current

Fig. 23.18

(1) The value of current at any instant of time *t* after closing the circuit (*i.e.* during the rising of current) is given by $\boldsymbol{i = i_0\left[1 - e^{-\frac{R}{L}t}\right]}$; where $i_0 = i_{\max} = \frac{E}{R}$ = steady state current.

(2) The value of current at any instant of time *t* after opening from the steady state condition (*i.e.* during the decaying of current) is given by $\boldsymbol{i = i_0 e^{-\frac{R}{L}t}}$

(3) **Time constant** (τ) **:** It is given as $\tau = \frac{L}{R}$; It's unit is *second*. In other words the time interval, during which the current in an inductive circuit rises to 63% of its maximum value at make, is defined as time constant or it is the time interval, during which the current after opening an inductive circuit falls to 37% of its maximum value.



(A) (B)

Fig. 23.19

LC- Oscillation

When a charged capacitor *C* having an initial charge q_0 is discharged through an inductance *L*, the charge and current in the circuit start oscillating simple harmonically. If the resistance of the circuit is zero, no energy is dissipated as heat. We also assume an idealized situation in which energy is not radiated away from the circuit. The total energy associated with the circuit is constant.

Frequency of oscillation is given by

$$\omega = \frac{1}{\sqrt{LC}}\,\frac{rad}{sec}$$

or $\nu = \frac{1}{2\pi\sqrt{LC}}\,Hz$

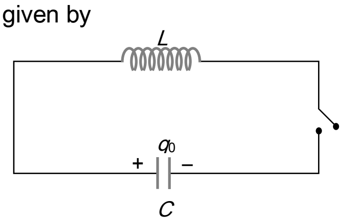


Fig. 23.20

Eddy Current

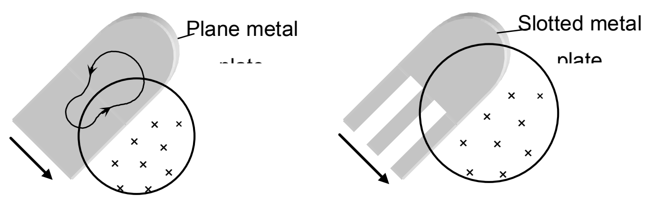
When a changing magnetic flux is applied to a bulk piece of conducting material then circulating currents called eddy currents are induced in the material. Because the resistance of the bulk conductor is usually low, eddy currents often have large magnitudes and heat up the conductor.

(1) These are circulating currents like eddies in water.

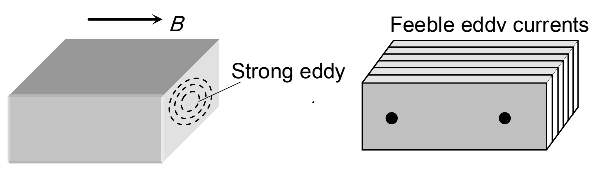
(2) Experimental concept given by Focault hence also named as "Focault current".

(3) The production of eddy currents in a metallic block leads to the loss of electric energy in the form of heat.

(4) By Lamination, slotting processes the resistance path for circulation of eddy current increases, resulting in to weakening them and also reducing losses causes by them



(A) Strong eddies produced **(B)** Feeble eddies Gradual damping



(C) Solid metallic core **(D)** Laminated core

(5) **Application of eddy currents :** Though most of the times eddy currents are undesirable but they find some useful applications as enumerated below

(i) **Dead-beat galvanometer :** A dead beat galvanometer means one whose pointer comes to rest in the final equilibrium position immediately without any oscillation about the equilibrium position when a current is passed in its coil.

This is achieved by winding the coil on a metallic frame the large eddy currents induced in the frame provide electromagnetic damping.

(ii) **Electric-brakes :** When the train is running its wheel is moving in air and when the train is to be stopped by electric breaks the wheel is made to move in a field created by electromagnet. Eddy currents induced in the wheels due to the changing flux oppose the cause and stop the train.

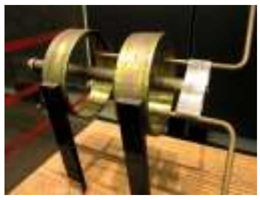
(iii) **Induction furnace :** Joule's heat causes the melting of a metal piece placed in a rapidly changing magnetic field.

(iv) **Speedometer :** In the speedometer of an automobile, a magnet is geared to the main shaft of the vehicle and it rotates according to the speed of the vehicle. The magnet is mounted in an aluminium cylinder with the help of hair springs. When the magnet rotates, it produces eddy currents in the drum and drags it through an angle, which indicates the speed of the vehicle on a calibrated scale.

(v) **Energy meter :** In energy meters, the armature coil carries a metallic aluminium disc which rotates between the poles of a pair of permanent horse shoe magnets. As the armature rotates, the current induced in the disc tends to oppose the motion of the armature coil. Due to this braking effect, deflection is proportional to the energy consumed.

dc Motor

It is an electrical machine which converts electrical energy into mechanical energy.



(1) **Principle :** It is based on the fact that a current carrying coil placed in the magnetic field experiences a torque. This torque rotates the coil.

(2) **Construction :** It consists of the following components figure.

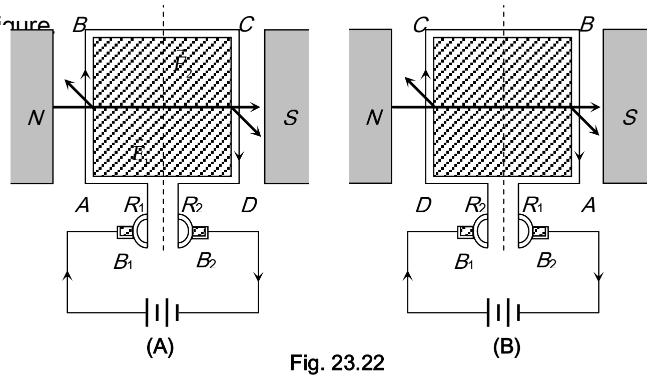


Fig. 23.22

ABCD = Armature coil, S_1, S_2 = split ring comutators

B_1, B_2 = Carbon brushes, *N*, *S* = Strong magnetic poles

(3) **Working :** Force on any arm of the coil is given by $\vec{F} = i(\vec{l} \times \vec{B})$ in fig., force on *AB* will be perpendicular to plane of the paper and pointing inwards. Force on *CD* will be equal and opposite. So coil rotates in clockwise sense when viewed from top in fig. The current in *AB* reverses due to commutation keeping the force on *AB* and *CD* in such a direction that the coil continues to rotate in the same direction.

(4) **Back emf in motor :** Due to the rotation of armature coil in magnetic field a back emf is induced in the circuit. Which is given by $e = E - iR$.

Back emf directly depends upon the angular velocity ω of armature and magnetic field B. But for constant magnetic field B, value of back emf e is given by $e \propto \omega$ or $e = k\omega$ ($e = NBA\omega \sin\omega t$)

(5) **Current in the motor :** $i = \frac{E-e}{R} = \frac{E-k\omega}{R}$; When motor is just switched on *i.e.* $\omega = 0$ so $e = 0$ hence $i = \frac{E}{R} = \text{maximum}$ and at full speed, ω is maximum so back emf e is maximum and i is minimum. Thus, maximum current is drawn when the motor is just switched on which decreases when motor attains the speed.

(6) **Motor starter :** At the time of start a large current flows through the motor which may burn out it. Hence a starter is used for starting a dc motor safely. Its function is to introduce a suitable resistance in the circuit at the time of starting of the motor. This resistance decreases gradually and reduces to zero when the motor runs at full sped.

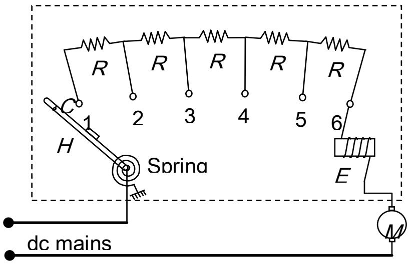


Fig. 23.23

The value of starting resistance is maximum at time $t = 0$ and its value is controlled by spring and electromagnetic system and is made to zero when the motor attains its safe speed.

(7) **Mechanical power and Efficiency of dc motor :**

Efficiency $\eta = \frac{P_{mechanical}}{P_{\sup plied}} = \frac{P_{out}}{P_{in}} = \frac{e}{E} = \frac{\text{Back e.m.f.}}{\text{Supply voltage}}$

(8) **Uses of dc motors :** They are used in electric locomotives, electric ears, rolling mills, electric cranes, electric lifts, dc drills, fans and blowers, centrifugal pumps and air compressors, *etc*.

ac Generator/Alternator/Dynamo

An electrical machine used to convert mechanical energy into electrical energy is known as ac generator/alternator.

(1) **Principle :** It works on the principle of electromagnetic induction *i.e.*, when a coil is rotated in uniform magnetic field, an induced emf is produced in it.

(2) **Construction :** The main components of ac generator are

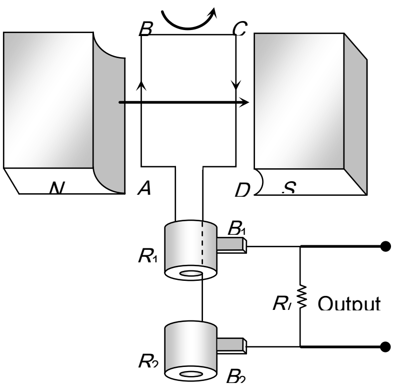


Fig. 23.24

(i) **Armature :** Armature coil (*ABCD*) consists of large number of turns of insulated copper wire wound over a soft iron core.

(ii) **Strong field magnet :** A strong permanent magnet or an electromagnet whose poles (*N* and *S*) are cylindrical in shape in a field magnet. The armature coil rotates between the pole pieces of the field magnet. The uniform magnetic field provided by the field magnet is perpendicular to the axis of rotation of the coil.

(iii) **Slip rings :** The two ends of the armature coil are connected to two brass slip rings R_1 and R_2. These rings rotate along with the armature coil.

(iv) **Brushes :** Two carbon brushes (B_1 and B_2), are pressed against the slip rings. The brushes are fixed while slip rings rotate along with the armature. These brushes are connected to the load through which the output is obtained.

(3) **Working :** When the armature coil *ABCD* rotates in the magnetic field provided by the strong field magnet, it cuts the magnetic lines of force. Thus the magnetic flux linked with the coil changes and hence induced emf is set up in the coil. The direction of the induced emf or the current in the coil is determined by the Fleming's right hand rule.

The current flows out through the brush B_1 in one direction of half of the revolution and through the brush B_2 in the next half revolution in the reverse direction. This process is repeated. Therefore, emf produced is of alternating nature.

$$e = -\frac{Nd\phi}{dt} = NBA\omega\sin\omega t = e_0\sin\omega t \quad \text{where } e_0 = NBA\omega$$

$$i = \frac{e}{R} = \frac{e_0}{R}\sin\omega t = i_0\sin\omega t \quad R \rightarrow \text{Resistance of the circuit}$$

dc Generator

If the current produced by the generator is direct current, then the generator is called dc generator.

dc generator consists of (i) Armature (coil) (ii) Magnet (iii) Commutator (iv) Brushes

In dc generator commutator is used in place of slip rings. The commutator rotates along with the coil so that in every cycle when direction of '*e*' reverses, the commutator also reverses or makes contact with the other brush so that in the external load the current remains in the some direction giving dc

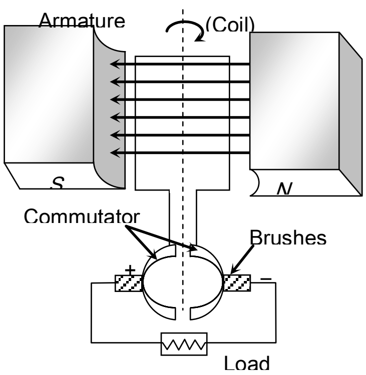


Fig. 23.25

Transformer

It is a device which raises or lowers the voltage in ac circuits through mutual induction.

It consists of two coils wound on the same core. The alternating current passing through the primary creates a continuously changing flux through the core. This changing flux induces an alternating emf in the secondary.

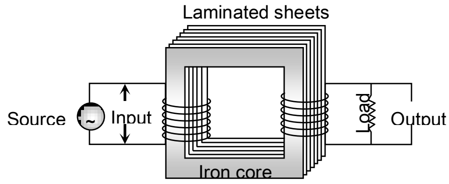


Fig. 23.26

(1) Transformer works on ac only and never on dc.

(2) It can increase or decrease either voltage or current but not both simultaneously.

(3) Transformer does not change the frequency of input ac.

(4) There is no electrical connection between the winding but they are linked magnetically.

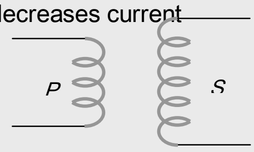
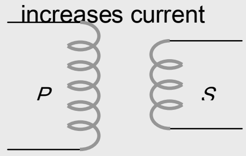
(5) Effective resistance between primary and secondary winding is infinite.

(6) The flux per turn of each coil must be same *i.e.* $\phi_S = \phi_P$; $-\frac{d\phi_S}{dt} = -\frac{d\phi_P}{dt}$.

(7) If N_P = number of turns in primary, N_S = number of turns in secondary, V_P = applied (input) voltage to primary, V_S = Voltage across secondary (load voltage or output), e_P = induced emf in primary ; e_S = induced emf in secondary, ϕ = flux linked with primary as well as secondary, i_P = current in primary; i_S = current in secondary (or load current)

As in an ideal transformer there is no loss of power *i.e.* $P_{out} = P_{in}$ so $V_S i_S = V_P i_P$ and $V_P \approx e_P$, $V_S \approx e_S$. Hence $\frac{e_S}{e_P} = \frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{i_P}{i_S} = k$; k = Transformation ratio (or turn ratio)

Table 23.3 : Types of transformer

Step up transformer	Step down transformer
It increases voltage and decreases current 	It decreases voltage and increases current 

$V_S > V_P$	$V_S < V_P$
$N_S > N_P$	$N_S < N_P$
$E_S > E_P$	$E_S < E_P$
$i_S < i_P$	$i_S > i_P$
$R_S > R_P$	$R_S < R_P$
$t_S > t_P$	$t_S > t_P$
$k > 1$	$k < 1$

(8) **Efficiency of transformer (η) :** Efficiency is defined as the ratio of output power and input power

i.e. $\eta\% = \frac{P_{out}}{P_{in}} \times 100 = \frac{V_S i_S}{V_P i_P} \times 100$

For an ideal transformer $P_{out} = P_{in}$ so $\eta = 100\%$ (But efficiency of practical transformer lies between 70% – 90%)

For practical transformer $P_{in} = P_{out} + P_{losses}$

so $\eta = \frac{P_{out}}{P_{in}} \times 100 = \frac{P_{out}}{(P_{out} + P_L)} \times 100 = \frac{(P_{in} - P_L)}{P_{in}} \times 100$

(9) **Losses in transformer :** In transformers some power is always lost due to, heating effect, flux leakage eddy currents, hysteresis and humming.

(i) ***Cu* loss (i^2R) :** When current flows through the transformer windings some power is wasted in the form of heat $(H = i^2Rt)$. To minimize this loss windings are made of thick *Cu* wires (To reduce resistance)

(ii) **Eddy current loss :** Some electrical power is wasted in the form of heat due to eddy currents, induced in core, to minimize this loss transformers core are laminated and silicon is added to the core material as it increases the resistivity. The material of the core is then called silicon-iron (steel).

(iii) **Hystersis loss :** The alternating current flowing through the coils magnetises and demagnetises the iron core again and again. Therefore, during each cycle of magnetisation, some energy is lost due to hysteresis. However, the loss of energy can be minimised by selecting the material of core, which has a narrow hysterisis loop. Therefore core of transformer is made of soft iron. Now a days it is made of "Permalloy" (*Fe*-22%, *Ni*-78%).

(iv) **Magnetic flux leakage :** Magnetic flux produced in the primary winding is not completely linked with secondary because few magnetic lines of force complete their path in air only. To minimize this loss secondary winding is kept inside the primary winding.

(v) **Humming losses :** Due to the passage of alternating current, the core of the transformer starts vibrating and produces humming sound. Thus, some part (may be very small) of the electrical energy is wasted in the form of humming sounds produced by the vibrating core of the transformer.

(10) **Uses of transformer :** A transformer is used in almost all ac operations *e.g.*

(i) In voltage regulators for TV, refrigerator, computer, air conditioner etc.

(ii) In the induction furnaces.

(iii) Step down transformer is used for welding purposes.

(iv) In the transmission of ac over long distance.

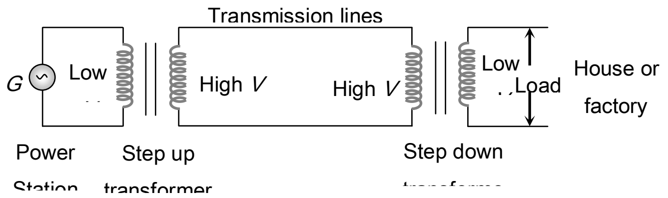


Fig. 23.27

(v) Step down and step up transformers are used in electrical power distribution.

(vi) Audio frequency transformers are used in radiography, television, radio, telephone *etc.*

(vii) Radio frequency transformers are used in radio communication.

(viii) Transformers are also used in impedance matching.

Tips & Tricks

✍ If a bar magnet moves towards a fixed conducting coil, then due to the flux changes an emf, current and charge induces in the coil. If speed of magnet increases then induced emf and induced current increases but induced charge remains same.

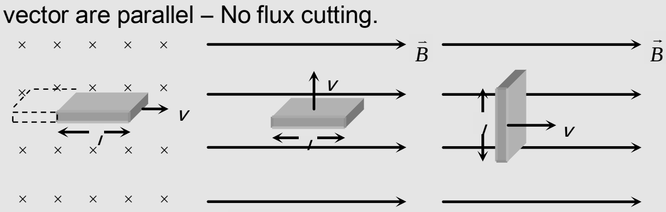
Induced parameter: e_1, i_1, q_1 $e_2\ (> e_1),\ i_2\ (> i_1),\ q_2\ (= q_1)$

✍ Can ever electric lines of force be closed curve ? Yes, when produced by a changing magnetic field.

✍ No flux cutting ⟶ No EMI

✍ Vector form of motional emf : $e = (\vec{v} \times \vec{B}).\vec{l}$

✍ In motional emf $\vec{B}, \vec{v}$ and $\vec{l}$ are three vectors. If any two vector are parallel – No flux cutting.



$\vec{v} \parallel \vec{l}$ so $e = 0$ $\vec{B} \parallel \vec{l}$ so $e = 0$ $\vec{v} \parallel \vec{B}$ so $e = 0$

✍ A piece of metal and a piece of non-metal are dropped from the same height near the surface of the earth. The non-metallic piece will reach the ground first because there will be no induced current in it.

✍ If an aeroplane is landing down or taking off and its wings are in the east-west direction, then the potential difference or emf will be induced across the wings. If an aeroplane is landing down or taking off and its wings are in the north-south direction, then no potential difference or emf will be induced.

✍ When a conducting rod moving horizontally on equator of earth no emf induces because there is no vertical component of earth's magnetic field. But at poles B_V is maximum so maximum flux cutting hence emf induces.

✍ When a conducting rod falling freely in earth's magnetic field such that it's length lies along East - West direction then induced emf continuously increases w.r.t. time and induced current flows from West - East.

✍ 1 *henry* = 10^9 *emu* of inductance or 10^9 *ab-henry*.

✍ Inductance at the ends of a solenoid is half of it's the inductance at the centre. $\left(L_{end} = \frac{1}{2} L_{centre}\right)$.

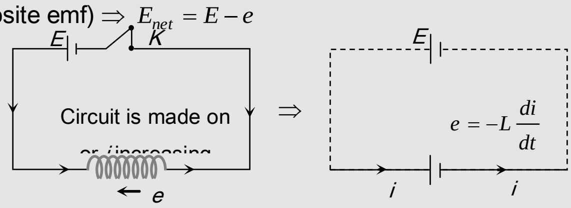
✍ A thin long wire made up of material of high resistivity behaves predominantly as a resistance. But it has some amount of inductance as well as capacitance in it. It is thus difficult to obtain pure resistor. Similarly it is difficult to obtain pure capacitor as well as pure inductor.

✍ Due to inherent presence of self inductance in all electrical circuits, a resistive circuit with no capacitive or inductive element in it, also has some inductance associated with it.

The effect of self-inductance can be eliminated as in the coils of a resistance box by doubling back the coil on itself.

✍ It is not possible to have mutual inductance without self inductance but it may or may not be possible self inductance without mutual inductance.

✍ If main current through a coil increases (i↑) so $\frac{di}{dt}$ will be positive (+*ve*), hence induced emf *e* will be negative (*i.e.* opposite emf) ⇒ $E_{net} = E - e$

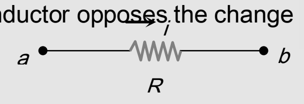


✍ Sometimes at sudden opening of key, because of high inductance of circuit a high momentarily induced emf produced and a sparking occurs at key position. To avoid sparking a capacitor is connected across the key.

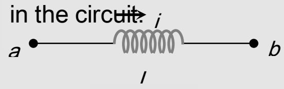
✍ Sometimes at sudden opening of key, because of high inductance of circuit a high momentarily induced emf produced and a sparking occurs at key position. To avoid sparking a capacitor is connected across the key.

✍ One can have resistance with or without inductance but one can't have inductance without having resistance.

✍ The circuit behaviour of an inductor is quite different from that of a resistor. while a resistor opposes the current *i*, an inductor opposes the change $\frac{di}{dt}$ in the circuit.



$V_{ab} = iR$



$V_{ab} = L\frac{di}{dt}$

✍ In *RL*-circuit with dc source the time taken by the current to reach half of the maximum value is called half life time and it is given by $T = 0.693\ \frac{L}{R}$.

✍ dc motor is a highly versatile energy conversion device. It can meet the demand of loads requiring high starting torque, high accelerating and decelerating torque.

✍ When a source of emf is connected across the two ends of the primary winding alone or across the two ends of secondary winding alone, ohm's law can be applied. But in the transformer as a whole, ohm's law should not be applied because primary winding and secondary winding are not connected electrically.

✍ Even when secondary circuit of the transformer is open it also draws some current called no load primary current for supplying no load *Cu* and iron loses.

✍ Transformer has highest possible efficiency out of all the electrical machines.

Ordinary Thinking

Objective Questions

Faraday's and Lenz's Law

1. In electromagnetic induction, the induced e.m.f. in a coil is independent of [CPMT 1984]
(a) Change in the flux (b) Time
(c) Resistance of the circuit (d) None of the above

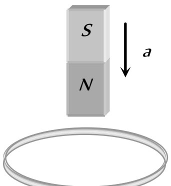
2. Lenz's law is consequence of the law of conservation of [JIPMER 1997; CPMT 1990; RPMT 1997; MP PET 1999; MP PMT 2000, 03; RPET 2003; AFMC 2004]
(a) Charge (b) Momentum
(c) Mass (d) Energy

3. In electromagnetic induction, the induced charge in a coil is independent of
(a) Change in the flux (b) Time
(c) Resistance in the circuit (d) None of the above

4. The magnetic flux through a circuit of resistance R changes by an amount $\Delta\phi$ in time Δt, Then the total quantity of electric charge Q, which passing during this time through any point of the circuit is given by [Haryana CEE 1996; CBSE PMT 2004]
(a) $Q=\frac{\Delta\phi}{\Delta t}$ (b) $Q=\frac{\Delta\phi}{\Delta t}\times R$
(c) $Q=-\frac{\Delta\phi}{\Delta t}+R$ (d) $Q=\frac{\Delta\phi}{R}$

5. A cylindrical bar magnet is kept along the axis of a circular coil. If the magnet is rotated about its axis, then [CPMT 1983; BCECE 2004]
(a) A current will be induced in a coil
(b) No current will be induced in a coil
(c) Only an e.m.f. will be induced in the coil
(d) An e.m.f. and a current both will be induced in the coil

6. 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 [AFMC 1993; MP PMT/PET 1998; Pb PET 2003]



(a) First clockwise then anticlockwise
(b) In clockwise direction
(c) In anticlockwise direction
(d) First anticlockwise then clockwise

7. A coil having an area A_0 is placed in a magnetic field which changes from B_0 to $4B_0$ in a time interval *t*. The e.m.f. induced in the coil will be [MP PET 1990]
(a) $\frac{3A_0B_0}{t}$ (b) $\frac{4A_0B_0}{t}$
(c) $\frac{3B_0}{A_0t}$ (d) $\frac{4B_0}{A_0t}$

8. The magnetic flux linked with a coil is given by an equation ϕ (in *webers*) = $8t^2+3t+5$. The induced e.m.f. in the coil at the fourth second will be [MP PET 1990]
(a) 16 *units* (b) 39 *units*
(c) 67 *units* (d) 145 *units*

9. 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

10. A copper ring is held horizontally and a bar magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet while it is passing through the ring is [CBSE PMT 1996; MP PET 1990, 99; CPMT 1991, 99; JIPMER 1997; CPMT 2003; MP PET/PMT 2001; KCET 2001; Kerala (Engg.) 2001]
(a) Equal to that due to gravity
(b) Less than that due to gravity
(c) More than that due to gravity
(d) Depends on the diameter of the ring and the length of the magnet

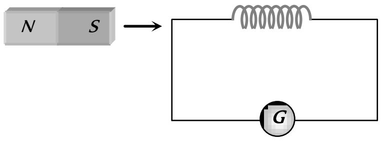
11. A square coil $10^{-2}m^2$ area is placed perpendicular to a uniform magnetic field of intensity $10^3 Wb/m^2$. The magnetic flux through the coil is [MP PMT 1990, 2001]
(a) 10 *weber* (b) 10^{-5} *weber*
(c) 10^5 *weber* (d) 100 *weber*

12. A magnet is brought towards a coil (i) speedly (ii) slowly then the induced e.m.f./induced charge will be respectively [RPMT 1997; MP PMT 2003]
(a) More in first case / More in first case
(b) More in first case/Equal in both case
(c) Less in first case/More in second case
(d) Less in first case/Equal in both case

13. The direction of induced e.m.f. during electromagnetic induction is given by [MP PET 1994, 96]
(a) Faraday's law (b) Lenz's law
(c) Maxwell's law (d) Ampere's law

14. 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 10^8 *gauss/second*. The resistance of the coil is 20 *ohm*. The current in the coil will be [CPMT 1976]
(a) 5 *amp* (b) 0.5 *amp*
(c) 0.05 *amp* (d) 5×10^8 *amp*

15. As shown in the figure, a magnet is moved with a fast speed towards a coil at rest. Due to this induced electromotive force, induced current and induced charge in the coil is E, I and Q respectively. If the speed of the magnet is doubled, the incorrect statement is [MP PET 1995]



(a) E increases (b) I increases

(c) Q remains same (d) Q increases

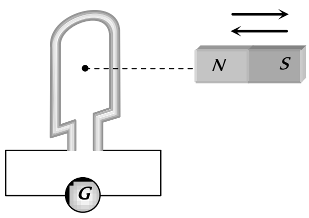
16. A coil having 500 square loops each of side 10 *cm* is placed normal to a magnetic flux which increases at the rate of 1.0 *tesla/second*. The induced e.m.f. in volts is

[CPMT 1989, 90; DCE 2002]

(a) 0.1 (b) 0.5

(c) 1 (d) 5

17. When a magnet is pushed in and out of a circular coil C connected to a very sensitive galvanometer G as shown in the adjoining diagram with a frequency ν, then



(a) Constant deflection is observed in the galvanometer

(b) Visible small oscillations will be observed in the galvanometer if ν is about 50 *Hz*

(c) Oscillations in the deflection will be observed clearly if $\nu = 1$ or 2 *Hz*

(d) No variation in the deflection will be seen if $\nu = 1$ or 2 *Hz*

18. A coil of area $100 cm^2$ has 500 turns. Magnetic field of $0.1\ weber/metre^2$ is perpendicular to the coil. The field is reduced to zero in 0.1 *second*. The induced e.m.f. in the coil is [MP PMT 1991; MH CET (Med.) 1999]

(a) 1 V (b) 5 V

(c) 50 V (d) Zero

19. A 50 turns circular coil has a radius of $3\ cm$, it is kept in a magnetic field acting normal to the area of the coil. The magnetic field B increased from 0.10 *tesla* to 0.35 *tesla* in 2 *milliseconds*. The average induced e.m.f. in the coil is

[MP PET 1994]

(a) $1.77\ volts$ (b) $17.7\ volts$

(c) $177\ volts$ (d) $0.177\ volts$

20. A coil having an area $2m^2$ is placed in a magnetic field which changes from $1Wb/m^2$ to $4Wb/m^2$ in a interval of 2 *second*. The e.m.f. induced in the coil will be

[DPMT 1999; MP PET 2002]

(a) 4 V (b) 3 V

(c) 1.5 V (d) 2 V

21. A coil has 2000 turns and area of $70 cm^2$. The magnetic field perpendicular to the plane of the coil is $0.3 Wb/m^2$ and takes 0.1*sec* to rotate through 180^o. The value of the induced e.m.f. will be

[MP PET 1993; Similar to AIIMS 1997]

(a) $8.4V$ (b) $84V$

(c) $42V$ (d) $4.2V$

22. Two different loops are concentric and lie in the same plane. The current in the outer loop is clockwise and increasing with time. The induced current in the inner loop then, is

[MP PET 1993]

(a) Clockwise

(b) Zero

(c) Counter clockwise

(d) In a direction that depends on the ratio of the loop radii

23. According to Faraday's law of electromagnetic induction

[MP PET 1994]

(a) The direction of induced current is such that it opposes the cause producing it

(b) The magnitude of induced e.m.f. produced in a coil is directly proportional to the rate of change of magnetic flux

(c) The direction of induced e.m.f. is such that it opposes the cause producing it

(d) None of the above

24. The unit of magnetic flux is

[MP PMT 1994; MP PET 1995; AFMC 1998]

(a) $Weber/m^2$ (b) *Weber*

(c) *Henry* (d) *Ampere/m*

25. The north pole of a long horizontal bar magnet is being brought closer to a vertical conducting plane along the perpendicular direction. The direction of the induced current in the conducting plane will be [MP PMT 1994]

(a) Horizontal (b) Vertical

(c) Clockwise (d) Anticlockwise

26. The magnetic field in a coil of 100 turns and 40 *square cm* area is increased from 1 *Tesla* to 6 *Tesla* in 2 *second*. The magnetic field is perpendicular to the coil. The e.m.f. generated in it is

(a) $10^4\ V$ (b) 1.2 V

(c) 1.0 V (d) $10^{-2}\ V$

27. The dimensions of magnetic flux are

[MP PMT 1994; CBSE PMT 1999]

(a) $MLT^{-2}A^{-2}$ (b) $ML^2T^{-2}A^{-2}$

(c) $ML^2T^{-1}A^{-2}$ (d) $ML^2T^{-2}A^{-1}$

28. Lenz's law gives [MP PMT 1994]

(a) The magnitude of the induced e.m.f.

(b) The direction of the induced current

(c) Both the magnitude and direction of the induced current

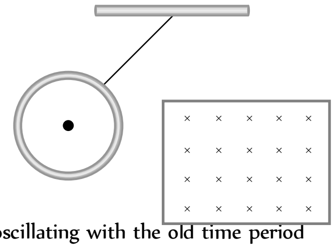
(d) The magnitude of the induced current

29. The north pole of a bar magnet is moved swiftly downward towards a closed coil and then second time it is raised upwards slowly. The

magnitude and direction of the induced currents in the two cases will be of [MP PET 1996]

	First case	*Second case*
(a)	Low value clockwise	Higher value anticlockwise
(b)	Low value clockwise	Equal value anticlockwise
(c)	Higher value clockwise	Low value clockwise
(d)	Higher value anticlockwise	Low value clockwise

30. A metallic ring connected to a rod oscillates freely like a pendulum. If now a magnetic field is applied in horizontal direction so that the pendulum now swings through the field, the pendulum will



(a) Keep oscillating with the old time period

(b) Keep oscillating with a smaller time period

(c) Keep oscillating with a larger time period

(d) Come to rest very soon

31. A circular coil of 500 turns of wire has an enclosed area of $0.1 m^2$ per turn. It is kept perpendicular to a magnetic field of induction 0.2 *T* and rotated by 180° about a diameter perpendicular to the field in 0.1 *sec*. How much charge will pass when the coil is connected to a galvanometer with a combined resistance of 50 *ohms*

(a) 0.2 *C* (b) 0.4 *C*

(c) 2 *C* (d) 4 *C*

32. A coil of 100 *turns* and area 5 *square centimetre* is placed in a magnetic field B = 0.2 *T*. The normal to the plane of the coil makes an angle of 60° with the direction of the magnetic field. The magnetic flux linked with the coil is [MP PMT 1997]

(a) $5 \times 10^{-3} Wb$ (b) $5 \times 10^{-5} Wb$

(c) $10^{-2} Wb$ (d) $10^{-4} Wb$

33. In a circuit with a coil of resistance 2 *ohms*, the magnetic flux changes from 2.0 *Wb* to 10.0 *Wb* in 0.2 second. The charge that flows in the coil during this time is [MP PMT 1997]

(a) 5.0 *coulomb* (b) 4.0 *coulomb*

(c) 1.0 *coulomb* (d) 0.8 *coulomb*

34. The direction of induced current is such that it opposes the very cause that has produced it. This is the law of [MP PMT/PET 1998]

(a) Lenz (b) Faraday

(c) Kirchhoff (d) Fleming

35. To induce an e.m.f. in a coil, the linking magnetic flux [KCET 1994]

(a) Must decrease

(b) Can either increase or decrease

(c) Must remain constant

(d) Must increase

36. A solenoid is 1.5 *m* long and its inner diameter is 4.0 *cm*. It has three layers of windings of 1000 turns each and carries a current of 2.0 *amperes*. The magnetic flux for a cross-section of the solenoid is nearly [AMU 1995]

(a) 2.5×10^{-7} *weber* (b) 6.31×10^{-6} *weber*

(c) 5.2×10^{-5} *weber* (d) 4.1×10^{-5} *weber*

37. A coil of 40 Ω resistance has 100 turns and radius 6 *mm* is connected to ammeter of resistance of 160 *ohms*. Coil is placed perpendicular to the magnetic field. When coil is taken out of the field, 32 μC charge flows through it. The intensity of magnetic field will be [RPET 1997]

(a) 6.55 *T* (b) 5.66 *T*

(c) 0.655 *T* (d) 0.566 *T*

38. Faraday's laws are consequence of conservation of [CBSE PMT 1993; BHU 2002]

(a) Energy

(b) Energy and magnetic field

(c) Charge

(d) Magnetic field

39. A magnetic field of 2×10^{-2} *T* acts at right angles to a coil of area 100 *cm* with 50 turns. The average emf induced in the coil is 0.1 *V*, when it is removed from the field in time *t*. The value of *t* is[CBSE PMT 1992; CI

(a) 0.1 *sec* (b) 0.01 *sec*

(c) 1 *sec* (d) 20 *sec*

40. The total charge induced in a conducting loop when it is moved in magnetic field depends on [MP PET 1997]

[CBSE PMT 1992; ISM Dhanbad 1994]

(a) The rate of change of magnetic flux

(b) Initial magnetic flux only

(c) The total change in magnetic flux

(d) Final magnetic flux only

41. A rectangular coil of 20 turns and area of cross- section 25 *sq* cm has a resistance of 100 *ohm*. If a magnetic field which is perpendicular to the plane of the coil changes at the rate of 1000 *Tesla* per second, the current in the coil is

[CBSE PMT 1992;
Very Similar to MHCET 2002; DPMT 2004]

(a) 1.0 *ampere* (b) 50 *ampere*

(c) 0.5 *ampere* (d) 5.0 *ampere*

42. The north pole of a magnet is brought near a metallic ring. The direction of the induced current in the ring will be [AIIMS 1999]

(a) Clockwise (b) Anticlockwise

(c) Towards north (d) Towards south

43. Lenz's law applies to [DCE 1999]

(a) Electrostatics

(b) Lenses

(c) Electro-magnetic induction

(d) Cinema slides

44. If a coil of metal wire is kept stationary in a non-uniform magnetic field, then [BHU 2000]

(a) An e.m.f. is induced in the coil

(b) A current is induced in the coil

(c) Neither e.m.f. nor current is induced

(d) Both e.m.f. and current is induced

45. The magnetic flux linked with a coil, in *webers*, is given by the equations $\phi = 3t^2 + 4t + 9$. Then the magnitude of induced e.m.f. at t = 2 *second* will be [KCET 2000; CPMT 2003; MP PET 2005]

(a) 2 *volt* (b) 4 *volt*

(c) 8 *volt* (d) 16 *volt*

46. A coil has an area of 0.05 m and it has 800 turns. It is placed perpendicularly in a magnetic field of strength $4 \times 10^{-5}\, Wb/m^2$, it is rotated through 90^o in 0.1 *sec*. The average e.m.f. induced in the coil is [CPMT 2001]

(a) 0.056 V (b) 0.046 V

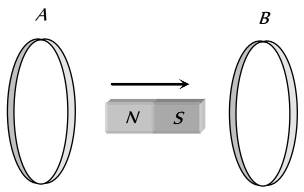
(c) 0.026 V (d) 0.016 V

47. A moving conductor coil in a magnetic field produces an induced e.m.f. This is in accordance with [AFMC 1993; MH CET 2001, 03]

(a) Amperes law (b) Coulomb law

(c) Lenz's law (d) Faraday's law

48. 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

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

$$\phi = 5t^2 - 4t + 1$$

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*

50. The formula for induced e.m.f. in a coil due to change in magnetic flux through the coil is (here A = area of the coil, B = magnetic field) [MP PET 2002]

(a) $e = -A.\dfrac{dB}{dt}$ (b) $e = -B.\dfrac{dA}{dt}$

(c) $e = -\dfrac{d}{dt}(A.B)$ (d) $e = -\dfrac{d}{dt}(A \times B)$

51. Lenz's law is expressed by the following formula (here e = induced e.m.f., ϕ = magnetic flux in one turn and N = number of turns)

(a) $e = -\phi \dfrac{dN}{dt}$ (b) $e = -N\dfrac{d\phi}{dt}$

(c) $e = -\dfrac{d}{dt}\left(\dfrac{\phi}{N}\right)$ (d) $e = N\dfrac{d\phi}{dt}$

52. A magnet is dropped down an infinitely long vertical copper tube

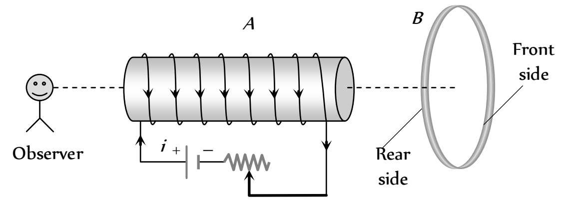
(a) The magnet moves with continuously increasing velocity and ultimately acquires a constant terminal velocity

(b) The magnet moves with continuously decreasing velocity and ultimately comes to rest

(c) The magnet moves with continuously increasing velocity but constant acceleration

(d) The magnet moves with continuously increasing velocity and acceleration

53. An aluminium ring B faces an electromagnet A. The current I through A can be altered [Kerala PET 2002]



(a) Whether I increases or decreases, B will not experience any force

(b) If I decreases, A will repel B [Kerala (Engg.) 2001]

(c) If I increases, A will attract B

(d) If I increases, A will repel B

54. The magnetic flux linked with a coil at any instant 't' is given by ϕ = 5t – 100t + 300, the e.m.f. induced in the coil at t = 2 *second* is

(a) – 40 V (b) 40 V

(c) 140 V (d) 300 V

55. A coil has 1,000 turns and 500 cm as its area. The plane of the coil is placed at right angles to a magnetic induction field of $2 \times 10^{-5}\, Wb/m^2$. The coil is rotated through 180^o in 0.2 *seconds*. The average e.m.f. induced in the coil, in *milli-volts*, is

(a) 5 (b) 10

(c) 15 (d) 20

56. When a bar magnet falls through a long hollow metal cylinder fixed with its axis vertical, the final acceleration of the magnet is [MP PMT 2001]

(a) Equal to zero

(b) Less than g

(c) Equal to g

(d) Equal to g in to beginning and then more than g

57. The magnetic flux linked with a vector area $\vec{A}$ in a uniform magnetic field $\vec{B}$ is [MP PET 2003]

(a) $\vec{B} \times \vec{A}$ (b) AB

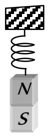
(c) $\vec{B}.\vec{A}$ [MP PET 2002] (d) $\dfrac{B}{A}$

58. The magnetic flux linked with a circuit of resistance 100 *ohm* increases from 10 to 60 *webers*. The amount of induced charge that flows in the circuit is (in *coulomb*) [MP PET 2003]

(a) 0.5 (b) 5

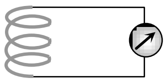
(c) 50 (d) 100

59. A magnet *NS* is suspended from a spring and while it oscillates, the magnet moves in and out of the coil *C*. The coil is connected to a galvanometer *G*. Then as the magnet oscillates,



(a) *G* shows deflection to the left and right with constant amplitude
(b) *G* shows deflection on one side
(c) *G* shows no deflection.
(d) *G* shows deflection to the left and right but the amplitude steadily decreases.

60. A coil having *n* turns and resistance $R\,\Omega$ is connected with a galvanometer of resistance $4R\Omega$. This combination is moved in time *t seconds* from a magnetic field W_1 *weber* to W_2 *weber*. The induced current in the circuit is



(a) $-\dfrac{W_2 - W_1}{5\ Rnt}$ (b) $-\dfrac{n(W_2 - W_1)}{5\ Rt}$

(c) $-\dfrac{(W_2 - W_1)}{Rnt}$ (d) $-\dfrac{n(W_2 - W_1)}{Rt}$

61. If a copper ring is moved quickly towards south pole of a powerful stationary bar magnet, then [Pb. PMT 2004]

(a) Current flows through the copper ring
(b) Voltage in the magnet increase
(c) Current flows in the magnet
(d) Copper ring will get magnetised

62. The magnetic flux linked with coil, in weber is given by the equation, $\phi = 5t^2 + 3t + 16$. The induced emf in the coil in the fourth second is [Pb. PMT 2004]

(a) 10 *V* (b) 30 *V*
(c) 45 *V* (d) 90 *V*

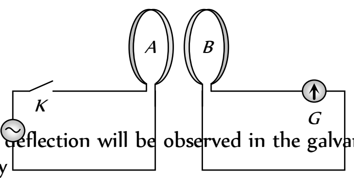
63. The coil of area 0.1 m has 500 turns. After placing the coil in a magnetic field of strength $4\times10^{-4}Wb/m^2$, if rotated through 90° in 0.1 s, the average emf induced in the coil is [Pb. PET 2002]

(a) 0.012 *V* (b) 0.05 *V*
(c) 0.1 *V* (d) 0.2 *V*

64. Magnetic flux in a circuit containing a coil of resistance 2Ω changes from 2.0 *Wb* to 10 *Wb* in 0.2 *sec*. The charge passed through the coil in this time is [DPMT 2003]

(a) 0.8 *C* (b) 1.0 *C*
(c) 5.0 *C* (d) 4.0 *C*

65. The diagram below shows two coils *A* and *B* placed parallel to each other at a very small distance. Coil *A* is connected to an ac supply. *G* is a very sensitive galvanometer. When the key is closed



(a) Constant deflection will be observed in the galvanometer for 50 *Hz* supply
(b) Visible small variations will be observed in the galvanometer for 50 *Hz* input
(c) Oscillations in the galvanometer may be observed when the input ac voltage has a frequency of 1 to 2 *Hz*
(d) No variation will be observed in the galvanometer even when the input ac voltage is 1 or 2 *Hz*

66. An infinitely long cylinder is kept parallel to an uniform magnetic field B directed along positive *z* axis. The direction of induced current as seen from the *z* axis will be [IIT-JEE (Screening) 2005]

(a) Clockwise of the +*ve z* axis
(b) Anticlockwise of the +*ve z* axis
(c) Zero
(d) Along the magnetic field

67. In a magnetic field of 0.05 *T*, area of a coil changes from $101\,cm^2$ to $100\,cm^2$ without changing the resistance which is 2Ω. The amount of charge that flow during this period is [KCET 2004]

[Orissa PMT 2005]

(a) 2.5×10^{-6} *coulomb* (b) 2×10^{-6} *coulomb*

(c) 10^{-6} *coulomb* (d) 8×10^{-6} *coulomb*

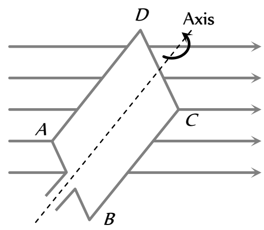
68. If a coil of 40 turns and area 4.0 cm is suddenly removed from a magnetic field, it is observed that a charge of $2.0\times10^{-4}\,C$ flows into the coil. If the resistance of the coil is 80Ω, the magnetic flux density in Wb/m^2 is [AIEEE 2004] [MP PET 2005]

(a) 0.5 (b) 1.0
(c) 1.5 (d) 2.0

Motional EMI

1. A rectangular coil ABCD is rotated anticlockwise with a uniform angular velocity about the axis shown in diagram below. The axis of rotation of the coil as well as the magnetic field *B* are horizontal. The induced e.m.f. in the coil would be maximum when

[Haryana CEE 1996; MP PMT 1992, 94, 99]



(a) The plane of the coil is horizontal
(b) The plane of the coil makes an angle of 45° with the magnetic field
(c) The plane of the coil is at right angles to the magnetic field
(d) The plane of the coil makes an angle of 30° with the magnetic field

[CPMT 1986]

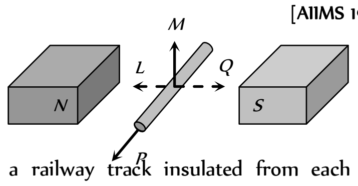
2. A 10 *metre* wire kept in east-west falling with velocity 5 *m/sec* perpendicular to the field $0.3\times10^{-4}Wb/m^2$. The induced e.m.f. across the terminal will be [MP PET 2000]

(a) 0.15 *V* (b) 1.5 *mV*
(c) 1.5 *V* (d) 15.0 *V*

3. An electric potential difference will be induced between the ends of the conductor shown in the diagram, when the conductor moves in the direction

[AIIMS 1982; DPMT 2001]

(a) *P*
(b) *Q*
(c) *L*
(d) *M*



4. 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 $0.2\times10^{-4}\,weber/m^2$ and the rails are separated by 1 *metre* [IIT 1981; KCET 2001]

(a) $10^{-2}\,volt$ (b) $10^{-4}\,volt$

(c) $10^{-3}\,volt$ (d) 1 *volt*

5. A conductor of 3 m in length is moving perpendicularly to magnetic field of 10^{-3} *tesla* with the speed of $10^2\,m/s$, then the e.m.f. produced across the ends of conductor will be

(a) 0.03 *volt* (b) 0.3 *volt*

(c) $3\times10^{-3}\,volt$ (d) 3 *volt*

6. When a wire loop is rotated in a magnetic field, the direction of induced e.m.f. changes once in each [MP PMT 1991, 04]

(a) $\frac{1}{4}$ revolution (b) $\frac{1}{2}$ revolution

(c) 1 revolution (d) 2 revolution

7. An aeroplane in which the distance between the tips of wings is 50 m is flying horizontally with a speed of 360 *km/hr* over a place where the vertical components of earth magnetic field is $2.0\times10^{-4}\,weber/m^2$. The potential difference between the tips of wings would be [CPMT 1990; MP PET 1991]

(a) 0.1 V (b) 1.0 V

(c) 0.2 V (d) 0.01 V

8. A copper disc of radius 0.1 m is rotated about its centre with 10 revolutions per second in a uniform magnetic field of 0.1 *Tesla* with its plane perpendicular to the field. The e.m.f. induced across the radius of disc is [MH CET (Med) 2001]

(a) $\frac{\pi}{10}V$ (b) $\frac{2\pi}{10}V$

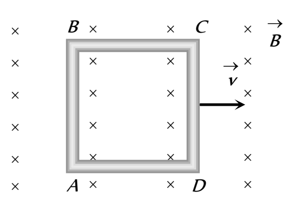
(c) $\pi\times10^{-2}V$ (d) $2\pi\times10^{-2}V$

9. A metal conductor of length 1m rotates vertically about one of its ends at angular velocity 5 *radians per second.* If the horizontal component of earth's magnetic field is $0.2\times10^{-4}\,T$, then the e.m.f. developed between the two ends of the conductor is [MP PMT 1992; AIEEE 2004]

(a) $5\,mV$ (b) $5\times10^{-4}\,V$

(c) $50\,mV$ (d) $50\,\mu V$

10. A conducting square loop of side L and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A magnetic induction B constant in time and space, pointing perpendicular and into the plane of the loop exists everywhere. The current induced in the loop is [IIT 1989; MP PET 1997; MP PMT 1996, 99; MP PMT 2002]



(a) $\frac{Blv}{R}$ clockwise

(b) $\frac{Blv}{R}$ anticlockwise

(c) $\frac{2Blv}{R}$ anticlockwise

(d) Zero

11. A player with 3 m long iron rod runs towards east with a speed of 30 *km/hr*. Horizontal component of earth's magnetic field is $4\times10^{-5}\,Wb/m^2$. If he is running with rod in horizontal and vertical positions, then the potential difference induced between the two ends of the rod in two cases will be [MP PET 1990]

(a) Zero in vertical position and $1\times10^{-3}\,V$ in horizontal position

(b) $1\times10^{-3}\,V$ in vertical position and zero is horizontal position

(c) Zero in both cases

(d) $1\times10^{-3}\,V$ in both cases

12. A coil of area 80 *square cm* and 50 turns is rotating with 2000 *revolutions per minute* about an axis perpendicular to a magnetic field of 0.05 *Tesla*. The maximum value of the e.m.f. developed in it is [MP PMT 1994]

(a) $200\pi\,volt$ (b) $\frac{10\pi}{3}volt$

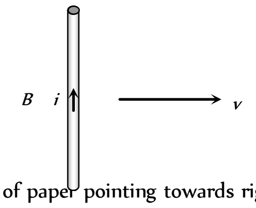
(c) $\frac{4\pi}{3}volt$ (d) $\frac{2}{3}$ *volt*

13. A conducting rod of length l is falling with a velocity v perpendicular to a uniform horizontal magnetic field B. The potential difference between its two ends will be [MP PMT 1994]

(a) $2Blv$ (b) Blv

(c) $\frac{1}{2}Blv$ (d) $B^2l^2v^2$

14. A conducting wire is moving towards right in a magnetic field B. The direction of induced current in the wire is shown in the figure. The direction of magnetic field will be [MP PET 1995]



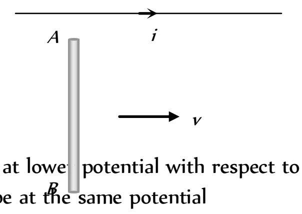
(a) In the plane of paper pointing towards right

(b) In the plane of paper pointing towards left

(c) Perpendicular to the plane of paper and down-wards

(d) Perpendicular to the plane of paper and upwards

15. The current carrying wire and the rod AB are in the same plane. The rod moves parallel to the wire with a velocity v. Which one of the following statements is true about induced emf in the rod



(a) End A will be at lower potential with respect to B

(b) A and B will be at the same potential

(c) There will be no induced e.m.f. in the rod

(d) Potential at A will be higher than that at B

16. A long horizontal metallic rod with length along the east-west direction is falling under gravity. The potential difference between its two ends will [MP PMT 1997]

(a) Be zero (b) Be constant

(c) Increase with time (d) Decrease with time

17. A two metre wire is moving with a velocity of 1 m/*sec* perpendicular to a magnetic field of 0.5 *weber/m*. The e.m.f. induced in it will be [MP PMT/PET 1998; Pb PET 2003]

(a) 0.5 *volt* (b) 0.1 *volt*

(c) 1 *volt* (d) 2 *volt*

18. A metal rod moves at a constant velocity in a direction perpendicular to its length. A constant uniform magnetic field exists in space in a direction perpendicular to the rod as well as its velocity. Select the correct statement(s) from the following

(a) The entire rod is at the same electric potential
(b) There is an electric field in the rod
(c) The electric potential is highest at the centre of the rod and decreases towards its ends
(d) The electric potential is lowest at the centre of the rod and increases towards its ends

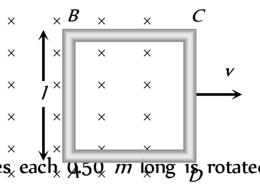
19. A conducting wire is dropped along east-west direction, then [RPMT 1997]
(a) No emf is induced
(b) No induced current flows
(c) Induced current flows from west to east
(d) Induced current flows from east to west

20. The magnetic induction in the region between the pole faces of an electromagnet is 0.7 *weber/m*. The induced e.m.f. in a straight conductor 10 *cm* long, perpendicular to *B* and moving perpendicular both to magnetic induction and its own length with a velocity 2 *m/sec* is [AMU (Med.) 1999]
(a) 0.08 *V* (b) 0.14 *V*
(c) 0.35 *V* (d) 0.07 *V*

21. A straight conductor of length 0.4 *m* is moved with a speed of 7 *m/s* perpendicular to the magnetic field of intensity of 0.9 *Wb/m*. The induced e.m.f. across the conductor will be [MH CET (Med.) 1999]
(a) 7.25 *V* (b) 3.75 *V*
(c) 1.25 *V* (d) 2.52 *V*

22. A coil of *N* turns and mean cross-sectional area *A* is rotating with uniform angular velocity ω about an axis at right angle to uniform magnetic field *B*. The induced e.m.f. *E* in the coil will be
(a) $NBA \sin\omega t$ (b) $NB\,\omega \sin\omega t$
(c) $NB/A \sin\omega t$ (d) $NBA\,\omega \sin\omega t$

23. A conducting square loop of side *l* and resistance *R* moves in its plane with a uniform velocity *v* perpendicular to one of its sides. A magnetic induction *B* constant in time and space, pointing perpendicular and into the plane at the loop exists everywhere with half the loop outside the field, as shown in figure. The induced e.m.f. is [AIEEE 2002]
(a) Zero
(b) *RvB*
(c) *VBl/R*
(d) *VBl*



24. A wheel with ten metallic spokes each 0.50 *m* long is rotated with a speed of 120 *rev/min* in a plane normal to the earth's magnetic field at the place. If the magnitude of the field is 0.4 Gauss, the induced e.m.f. between the axle and the rim of the wheel is equal to
(a) $1.256\times10^{-3}\,V$ (b) $6.28\times10^{-4}\,V$
(c) $1.256\times10^{-4}\,V$ (d) $6.28\times10^{-5}\,V$

25. A metal rod of length 2 *m* is rotating with an angular velocity of 100 *rad/sec* in a plane perpendicular to a uniform magnetic field of 0.3 *T*. The potential difference between the ends of the rod is
(a) 30 *V* (b) 40 *V*
(c) 60 *V* (d) 600 *V*

26. The wing span of an aeroplane is 20 *metre*. It is flying in a field, where the vertical component of magnetic field of earth is 5 × 10 *tesla*, with velocity 360 *km/h*. The potential difference produced between the blades will be [CPMT 2003]
(a) 0.10 *V* (b) 0.15 *V*
(c) 0.20 *V* (d) 0.30 *V*

27. A horizontal straight conductor kept in north-south direction falls under gravity, then [MP PMT 2003]
(a) A current will be induced from South to North
(b) A current will be induced from North to South
(c) No induce e.m.f. along the length of conductor
(d) An induced e.m.f. is generated along the length of conductor

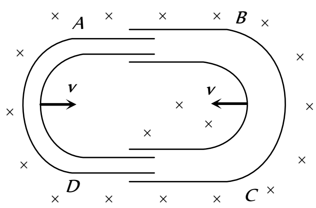
28. A rectangular coil of 300 turns has an average area of average area of $25\,cm\times10\,cm$. The coil rotates with a speed of 50 *cps* in a uniform magnetic field of strength $4\times10^{-2}\,T$ about an axis perpendicular of the field. The peak value of the induced e.m.f. is (in volt) [KCET 2004]
(a) 3000π (b) 300π
(c) 30π (d) 3π

29. A rod of length 20 *cm* is rotating with angular speed of 100 rps in a magnetic field of strength 0.5 *T* about it's one end. What is the potential difference between two ends of the rod [Orissa PMT 2004]
(a) 2.28 *V* (b) 4.28 *V*
(c) 6.28 *V* (d) 2.5 *V*

30. A circular metal plate of radius *R* is rotating with a uniform angular velocity ω with its plane perpendicular to a uniform magnetic field *B*. Then the emf developed between the centre and the rim of the plate is [UPSEAT 2004]
(a) $\pi\omega BR^2$ (b) ωBR^2
(c) $\pi\omega BR^2/2$ (d) $\omega BR^2/2$
[MP PMT 2002]

31. A circular coil of mean radius of 7 *cm* and having 4000 turns is rotated at the rate of 1800 revolutions per minute in the earth's magnetic field (*B* = 0.5 gauss), the maximum e.m.f. induced in coil will be [Pb. PMT 2003]
(a) 1.158 *V* (b) 0.58 *V*
(c) 0.29 *V* (d) 5.8 *V*

32. One conducting *U* tube can slide inside another as shown in figure, maintaining electrical contacts between the tubes. The magnetic field *B* is perpendicular to the plane of the figure. If each tube moves towards the other at a constant sped *v* then the emf induced in the circuit in terms of *B*, *l* and *v* where *l* is the width of each tube, will be [AIEEE 2005]
(a) Zero
(b) 2 *Blv*
(c) *Blv*
(d) −*Blv*
[AMU (Med.) 2002]



33. The magnitude of the earth's magnetic field at a place is B_0 and the angle of dip is δ. A horizontal conductor of length *l* lying along the magnetic north-south moves eastwards with a velocity *v*. The emf induced across the conductor is [Kerala PET 2005]
[MP PET 2003]
(a) Zero (b) $B_0 l v \sin\delta$
(c) $B_0 l v$ (d) $B_0 l v \cos\delta$

Static EMI

1. The back e.m.f. induced in a coil, when current changes from 1 ampere to zero in one *milli-second*, is 4 *volts*, the self inductance of the coil is [MP PET/PMT 1988]
(a) 1 *H* (b) 4 *H*
(c) 10^{-3} *H* (d) 4×10^{-3} *H*

2. An e.m.f. of 5 *volt* is produced by a self inductance, when the current changes at a steady rate from 3 *A* to 2 *A* in 1 millisecond. The value of self inductance is
[CPMT 1982; MP PMT 1991; CBSE PMT 1993; AFMC 2002]
(a) Zero (b) 5 *H*
(c) 5000 *H* (d) 5 *mH*

3. A 50 *mH* coil carries a current of 2 *ampere.* The energy stored in joules is [MP PET/PMT 1988; MP PET 2005]
(a) 1 (b) 0.1
(c) 0.05 (d) 0.5

4. The current passing through a choke coil of 5 henry is decreasing at the rate of 2 *ampere/sec*. The e.m.f. developing across the coil is
[CPMT 1982; MP PMT 1990; AIIMS 1997; MP PET 1999]
(a) 10 *V* (b) – 10 *V*
(c) 2.5 *V* (d) – 2.5 *V*

5. Average energy stored in a pure inductance *L* when a current *i* flows through it, is [MP PET/PMT 1988]
(a) Li^2 (b) $2Li^2$
(c) $\frac{Li^2}{4}$ (d) $\frac{Li^2}{2}$

6. A solenoid has 2000 turns wound over a length of 0.30 *metre*. The area of its cross-section is $1.2\times10^{-3}m^2$. 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
[NCERT 1982; MP PMT 2003]
(a) $6\times10^{-4}V$ (b) $4.8\times10^{-3}V$
(c) $6\times10^{-2}V$ (d) 48 *mV*

7. A coil is wound as a transformer of rectangular cross-section. If all the linear dimensions of the transformer are increased by a factor 2 and the number of turns per unit length of the coil remain the same, the self inductance increased by a factor of
(a) 16 (b) 12
(c) 8 (d) 4

8. 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 M is mutual inductance between them, then
[DCE 2002]
(a) $M = L_1L_2$ (b) $M = L_1/L_2$
(c) $M=\sqrt{L_1L_2}$ (d) $M=(L_1L_2)^2$

9. The equivalent quantity of mass in electricity is
(a) Charge (b) Potential
(c) Inductance (d) Current

10. The momentum in mechanics is expressed as $m\times v$. The analogous expression in electricity is [MP PMT 2003]
(a) $I\times Q$ (b) $I\times V$
(c) $L\times I$ (d) $L\times Q$

11. In what form is the energy stored in an inductor or
A coil of inductance *L* is carrying a steady current *i*. What is the nature of its stored energy [CBSE PMT 1990, 92;
MP PMT 1996, 2000, 02; Kerala PMT 2002]
(a) Magnetic
(b) Electrical
(c) Both magnetic and electrical
(d) Heat

12. The coefficient of self inductance of a solenoid is 0.18 *mH*. If a crode of soft iron of relative permeability 900 is inserted, then the coefficient of self inductance will become nearly
(a) 5.4 *mH* (b) 162 *mH*
(c) 0.006 *mH* (d) 0.0002 *mH*

13. In a transformer, the coefficient of mutual inductance between the primary and the secondary coil is 0.2 *henry*. When the current changes by 5 *ampere/second* in the primary, the induced e.m.f. in the secondary will be
[MP PMT 1989]
(a) 5 *V* (b) 1 *V*
(c) 25 *V* (d) 10 *V*

14. When the current in a coil changes from 8 *ampere* to 2 *ampere* in 3×10^{-2} *second*, the e.m.f. induced in the coil is 2 *volt*. The self inductance of the coil (in *millihenry*) is
[MNR 1991; UP SEAT 2000; Pb PET 2004]
(a) 1 (b) 5
(c) 20 (d) 10

15. The mutual inductance between two coils is 1.25 *henry*. If the current in the primary changes at the rate of 80 *ampere/second*, then the induced e.m.f. in the secondary is
[MP PET 1990]
(a) 12.5 *V* (b) 64.0 *V*
(c) 0.016 *V* (d) 100.0 *V*

16. A coil of wire of a certain radius has 600 turns and a self inductance of 108 *mH*. The self inductance of a 2ⁿᵈ similar coil of 500 turns will be [MP PMT 1990]
(a) 74 *mH* (b) 75 *mH*
(c) 76 *mH* [AIIMS 1980] (d) 77 *mH*

17. When the number of turns in a coil is doubled without any change in the length of the coil, its self inductance becomes
[MP PMT 1986; CBSE PMT 1992; Pb PET 2000]
(a) Four times (b) Doubled
(c) Halved (d) Unchanged

18. The average e.m.f. induced in a coil in which the current changes from 2 *ampere* to 4 *ampere* in 0.05 *second* is 8 *volt*. What is the self inductance of the coil ?
[NCERT 1984; CPMT 1997; MP PMT 1999, 2003; UPSEAT 2000; RPMT 2000; Pb. PMT 2002; RPET 2003; DPMT 2005]
(a) 0.1 *H* (b) 0.2 *H*
(c) 0.4 *H* (d) 0.8 *H*

19. If a current of 3.0 *amperes* flowing in the primary coil is reduced to zero in 0.001 *second*, then the induced e.m.f. in the secondary coil is 15000 *volts*. The mutual inductance between the two coils is
(a) 0.5 *henry* (b) 5 *henry*
(c) 1.5 *henry* (d) 10 *henry*

20. An e.m.f. of 12 *volts* is induced in a given coil when the current in it changes at the rate of 48 *amperes per minute*. The self inductance of the coil is [MP PMT 2000]

(a) 0.25 *henry* (b) 15 *henry*

(c) 1.5 *henry* (d) 9.6 *henry*

21. A closely wound coil of 100 turns and area of cross-section $1\ cm^2$ has a coefficient of self-induction 1 *mH*. The magnetic induction in the centre of the core of the coil when a current of 2*A* flows in it, will be [MP PET 1992]

(a) $0.022\ Wbm^{-2}$ (b) $0.4\ Wb\,m^{-2}$

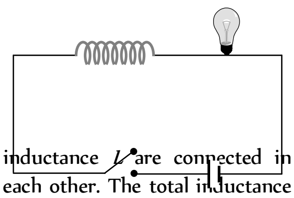
(c) $0.8\ Wb\,m^{-2}$ (d) $1\ Wb\,m^{-2}$

22. Two circuits have coefficient of mutual induction of 0.09 *henry*. Average e.m.f. induced in the secondary by a change of current from 0 to 20 *ampere* in 0.006 *second* in the primary will be

(a) 120 *V* (b) 80 *V*

(c) 200 *V* (d) 300 *V*

23. In the following circuit, the bulb will become suddenly bright if



(a) Contact is made or broken

(b) Contact is made

(c) Contact is broken

(d) Won't become bright at all

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

[MP PET 1991; Pb. PMT 1999; BHU 1998, 05]

(a) $2L$ (b) L

(c) $\frac{L}{2}$ (d) $\frac{L}{4}$

25. A coil and a bulb are connected in series with a dc source, a soft iron core is then inserted in the coil. Then

[MP PMT 1990; RPET 2001]

(a) Intensity of the bulb remains the same

(b) Intensity of the bulb decreases

(c) Intensity of the bulb increases

(d) The bulb ceases to glow

26. Self induction of a solenoid is [MP PMT 1993]

(a) Directly proportional to current flowing through the coil

(b) Directly proportional to its length

(c) Directly proportional to area of cross-section

(d) Inversely proportional to area of cross-section

27. Mutual inductance of two coils can be increased by

[MP PET 1994]

(a) Decreasing the number of turns in the coils

(b) Increasing the number of turns in the coils

(c) Winding the coils on wooden core

(d) None of the above

28. The self inductance of a coil is 5 *henry*, a current of 1 *amp* change to 2 *amp* within 5 *second* through the coil. The value of induced e.m.f. will be [MP PET 1994;

Similar MP PET/PMT 1998; CBSE PMT 1990]

(a) 10 *volt* (b) 0.10 *volt*

(c) 1.0 *volt* (d) 100 *volt*

29. The unit of inductance is [MP PMT 1994, 95;

MP PET 1997; MP PMT/PET 1998; RPET 2001]

(a) *Volt/ampere* (b) *Joule/ampere*

(c) *Volt-sec/ampere* (d) *Volt-ampere/sec*

30. The current flowing in a coil of self inductance 0.4 *mH* is increased by 250 *mA* in 0.1 *sec*. The e.m.f. induced will be

[MP PMT 1994]

(a) $+1\ V$ (b) $-1\ V$

(c) $+1\ mV$ (d) $-1\ mV$

31. 5 *cm* long solenoid having 10 *ohm* resistance and 5 *mH* inductance is joined to a 10 *volt* battery. At steady state the current through the solenoid in *ampere* will be

[MP PET 1995]

(a) 5 (b) 1

(c) 2 (d) Zero

32. When current in a coil changes to 2 *ampere* from 8 *ampere* in 3×10^{-3} *second*, the e.m.f. induced in the coil is 2 *volt*. The self inductance of the coil in *millihenry* is [MP PET 1992]

[MP PET 1995]

[CBSE PMT 1989]

(a) 1 (b) 5

(c) 20 (d) 10

33. An ideal coil of 10 *henry* is joined in series with a resistance of 5 *ohm* and a battery of 5 *volt*. 2 second after joining, the current flowing in *ampere* in the circuit will be

[MP PET 1995]

(a) e^{-1} (b) $(1-e^{-1})$

(c) $(1-e)$ (d) e

34. The number of turns of primary and secondary coils of a transformer are 5 and 10 respectively and the mutual inductance of the transformer is 25 *henry*. Now the number of turns in the primary and secondary of the transformer are made 10 and 5 respectively. The mutual inductance of the transformer in *henry* will be [MP PET 1995]

(a) 6.25 (b) 12.5

(c) 25 (d) 50

35. The inductance of a coil is $60\ \mu H$. A current in this coil increases from 1.0 *A* to 1.5 *A* in 0.1 *second*. The magnitude of the induced e.m.f. is [MP PMT 1995]

(a) $60\times10^{-6}\ V$ (b) $300\times10^{-4}\ V$

(c) $30\times10^{-4}\ V$ (d) $3\times10^{-4}\ V$

36. A circular coil of radius 5 *cm* has 500 turns of a wire. The approximate value of the coefficient of self induction of the coil will be [MP PET 1996; Pb PET 2000]

(a) 25 *millihenry* (b) 25×10^{-3} *millihenry*

(c) 50×10^{-3} *millihenry* (d) 50×10^{-3} *henry*

37. An e.m.f. of 100 *millivolts* is induced in a coil when the current in another nearby coil becomes 10 *ampere* from zero in 0.1 *second*. The coefficient of mutual induction between the two coils will be

[MP PET 1996; Kerala PMT 2004]

(a) 1 *millihenry* (b) 10 *millihenry*

(c) 100 *millihenry* (d) 1000 *millihenry*

38. In a coil of self inductance 0.5 *henry*, the current varies at a constant rate from zero to 10 *amperes* in 2 *seconds*. The e.m.f. generated in the coil is [MP PMT 1996]

(a) 10 *volts* (b) 5 *volts*

(c) 2.5 *volts* (d) 1.25 *volts*

39. A coil of self inductance 50 *henry* is joined to the terminals of a battery of e.m.f. 2 *volts* through a resistance of 10 *ohm* and a steady current is flowing through the circuit. If the battery is now disconnected, the time in which the current will decay to 1/*e* of its steady value is [MP PMT 1996]

(a) 500 *seconds* (b) 50 *seconds*

(c) 5 *seconds* (d) 0.5 *seconds*

40. The self inductance of a solenoid of length *L*, area of cross-section *A* and having *N* turns is [MP PET 1997; MP PET 2003]

(a) $\frac{\mu_0 N^2 A}{L}$ (b) $\frac{\mu_0 NA}{L}$

(c) $\mu_0 N^2 LA$ (d) $\mu_0 NAL$

41. The self inductance of a coil is *L*. Keeping the length and area same, the number of turns in the coil is increased to four times. The self inductance of the coil will now be [MP PMT 1997]

(a) $\frac{1}{4}L$ (b) *L*

(c) 4 *L* (d) 16 *L*

42. The mutual inductance between a primary and secondary circuits is 0.5 *H*. The resistances of the primary and the secondary circuits are 20 *ohms* and 5 *ohms* respectively. To generate a current of 0.4 *A* in the secondary, current in the primary must be changed at the rate of [MP PMT 1997]

(a) 4.0 *A/s* (b) 16.0 *A/s*

(c) 1.6 *A/s* (d) 8.0 *A/s*

43. The energy stored in a 50 *mH* inductor carrying a current of 4 *A* will be [MP PET 1999]

(a) 0.4 *J* (b) 4.0 *J*

(c) 0.8 *J* (d) 0.04 *J*

44. The average e.m.f. induced in a coil in which a current changes from 0 to 2 *A* in 0.05 *s* is 8 *V*. The self inductance of the coil is

(a) 0.1 *H* (b) 0.2 *H*

(c) 0.4 *H* (d) 0.8 *H*

45. If the current is halved in a coil, then the energy stored is how much times the previous value [CPMT 1999]

(a) $\frac{1}{2}$ (b) $\frac{1}{4}$

(c) 2 (d) 4

46. The SI unit of inductance, the henry, can be written as [IIT JEE 1998]

(a) *Weber/ampere* (b) *Volt-second/ampere*

(c) *Joule/(ampere)* (d) *Ohm-second*

47. A varying current in a coil changes from 10 *amp* to zero in 0.5 *sec*. If average EMF is induced in the coil is 220 *volts*, the self inductance of coil is [EAMCET 1994; MH CET (Med.) 1999]

(a) 5 *H* (b) 10 *H*

(c) 11 *H* (d) 12 *H*

48. Which of the following is wrong statement [AMU 1995]

(a) An emf can be induced between the ends of a straight conductor by moving it through a uniform magnetic field

(b) The self induced emf produced by changing current in a coil always tends to decrease the current

(c) Inserting an iron core in a coil increases its coefficient of self induction

(d) According to Lenz's law, the direction of the induced current is such that it opposes the flux change that causes it

49. A coil has an inductance of 2.5 *H* and a resistance of 0.5 *r*. If the coil is suddenly connected across a 6.0 *volt* battery, then the time required for the current to rise 0.63 of its final value is

(a) 3.5 *sec* (b) 4.0 *sec*

(c) 4.5 *sec* (d) 5.0 *sec*

50. When the number of turns and the length of the solenoid are doubled keeping the area of cross-section same, the inductance [CBSE PMT 1993

(a) Remains the same (b) Is halved

(c) Is doubled (d) Becomes four times

51. A 100 *mH* coil carries a current of 1 *ampere*. Energy stored in its magnetic field is [CBSE PMT 1992; KCET 1998]

(a) 0.5 *J* (b) 1 *J*

(c) 0.05 *J* (d) 0.1 *J*

52. The mutual inductance of an induction coil is $5H$. In the primary coil, the current reduces from $5A$ to zero in $10^{-3}s$. What is the induced emf in the secondary coil [RPET 1996]

(a) $2500V$ (b) 25000 *V*

(c) 2510 *V* (d) Zero

53. The self inductance of a straight conductor is [KCET 1998]

(a) Zero (b) Very large

(c) Infinity (d) Very small

54. What is the coefficient of mutual inductance when the magnetic flux changes by $2\times10^{-2}Wb$ and change in current is 0.01*A* [BHU 1998; AIIMS 2002]

(a) 2 *henry* (b) 3 *henry*

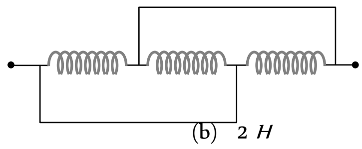
(c) $\frac{1}{2}$ *henry* (d) Zero

55. The current in a coil changes from 4 *ampere* to zero in 0.1 *s*. If the average e.m.f. induced is 100 *volt*, what is the self inductance of the coil [CPMT 1999] [MNR 1998]

(a) 2.5 *H* (b) 25 *H*

(c) 400 *H* (d) 40 *H*

56. Pure inductance of 3.0 *H* is connected as shown below. The equivalent inductance of the circuit is [MNR 1998; AIEEE 2002]



(a) 1 *H* (b) 2 *H*

(c) 3 *H* (d) 9 *H*

57. A varying current at the rate of 3 *A/s* in a coil generates an e.m.f. of 8 *mV* in a nearby coil. The mutual inductance of the two coils is

(a) 2.66 *mH* (b) 2.66×10^{-3} *mH*

(c) 2.66 *H* (d) 0.266 *H*

58. If a current of 10 *A* flows in one second through a coil, and the induced e.m.f. is 10 *V*, then the self-inductance of the coil is [CPMT 2000; Pb. PM

(a) $\frac{2}{5}H$ (b) $\frac{4}{5}H$

(c) $\frac{5}{4}H$ (d) 1 *H*

59. The inductance of a closed-packed coil of 400 turns is 8 *mH*. A current of 5 *mA* is passed through it. The magnetic flux through each turn of the coil is [Roorkee 2000]

(a) $\frac{1}{4\pi}\mu_0 Wb$ (b) $\frac{1}{2\pi}\mu Wb$

(c) $\frac{1}{3\pi}\mu_0 Wb$ [AMU 1995] (d) $0.4\,\mu_0 Wb$

60. When the current through a solenoid increases at a constant rate, the induced current [UPSEAT 2000]
(a) Is constant and is in the direction of the inducing current
(b) Is a constant and is opposite to the direction of the inducing current
(c) Increases with time and is in the direction of the inducing current
(d) Increases with time and opposite to the direction of the inducing current

61. If in a coil rate of change of area is 5 *m/milli second* and current become 1 *amp* from 2 *amp* in 2×10^{-3} *sec*. If magnitude of field is 1 *tesla* then self inductance of the coil is [RPET 2000]
(a) 2 *H* (b) 5 *H*
(c) 20 *H* (d) 10 *H*

62. The inductance of a solenoid 0.5 *m* long of cross-sectional area 20 *cm* and with 500 turns is [AMU (Med.) 2000]
(a) 12.5 *mH* (b) 1.25 *mH*
(c) 15.0 *mH* (d) 0.12 *mH*

63. The equivalent inductance of two inductances is 2.4 *henry* when connected in parallel and 10 *henry* when connected in series. The difference between the two inductances is [MP PMT 2000]
(a) 2 *henry* (b) 3 *henry*
(c) 4 *henry* (d) 5 *henry*

64. An e.m.f. of 12 *volt* is produced in a coil when the current in it changes at the rate of 45 *amp/minute*. The inductance of the coil is
(a) 0.25 *henry* (b) 1.5 *henry*
(c) 9.6 *henry* (d) 16.0 *henry*

65. An average induced e.m.f. of 1*V* appears in a coil when the current in it is changed from 10*A* in one direction to 10 *A* in opposite direction in 0.5 *sec*. Self-inductance of the coil is [CPMT 2001]
(a) 25 *mH* (b) 50 *mH*
(c) 75 *mH* (d) 100 *mH*

66. A coil of resistance 10 Ω and an inductance 5*H* is connected to a 100 *volt* battery. Then energy stored in the coil is [Pb. PMT 2001; CPMT 2002]
(a) 125 *erg* (b) 125 *J*
(c) 250 *erg* (d) 250 *J*

67. If a change in current of 0.01 *A* in one coil produces a change in magnetic flux of $1.2\times10^{-2}\,Wb$ in the other coil, then the mutual inductance of the two coils in henries is [EAMCET 2001]
(a) 0 (b) 0.5
(c) 1.2 (d) 3

68. Energy stored in a coil of self inductance 40*mH* carrying a steady current of 2 *A* is [Kerala (Engg.) 2001]
(a) 0.8 *J* (b) 8 *J*
(c) 0.08 *J* (d) 80 *J*

69. A solenoid of length *l metre* has self-inductance *L* henry. If number of turns are doubled, its self inductance [MP PMT 2001]
(a) Remains same (b) Becomes 2*L* henry
(c) Becomes 4*L henry* (d) Becomes $\frac{L}{\sqrt{2}}$ *henry*

70. Two coils *A* and *B* having turns 300 and 600 respectively are placed near each other, on passing a current of 3.0 *ampere* in *A*, the flux linked with *A* is 1.2×10^{-4} *weber* and with *B* it is 9.0×10^{-5} *weber*. The mutual inductance of the system is
(a) 2×10^{-5} *henry* (b) 3×10^{-5} *henry*
(c) 4×10^{-5} *henry* (d) 6×10^{-5} *henry*

71. In a circular conducting coil, when current increases from 2 *A* to 18 *A* in 0.05 *sec*., the induced e.m.f. is 20 *V*. The self inductance of the coil is [MP PET 2001]
(a) 62.5 *mH* (b) 6.25 *mH*
(c) 50 *mH* (d) None of these

72. Find out the e.m.f. produced when the current changes from 0 to 1 *A* in 10 *second*, given *L* = 10 *μH* [DCE 2001]
(a) 1 *V* (b) 1 *μV*
(c) 1 *mV* (d) 0.1 *V*

73. Which of the following is not the unit of self inductance [AMU (Med.) 2001]
(a) *Weber/Ampere* (b) *Ohm-Second*
(c) *Joule-Ampere* (d) *Joule Ampere*$^{-2}$

74. A coil of 100 turns carries a current of 5 *mA* and creates a magnetic flux of 10^{-5} *weber*. the inductance is [Orissa JEE 2002]
(a) 0.2 *mH* (b) 2.0 *mH*
(c) 0.02 *mH* [MP PET 2000] (d) None of these

75. In circular coil, when no. of turns is doubled and resistance becomes $\frac{1}{4}th$ of initial, then inductance becomes [AIEEE 2002]
(a) 4 *times* (b) 2 *times*
(c) 8 *times* (d) No change

76. The current in a coil of inductance 5 *H* decreases at the rate of 2 *A/s*. The induced e.m.f. is [MH CET 2002]
(a) 2 *V* (b) 5 *V*
(c) 10 *V* (d) – 10 *V*

77. The self-induced e.m.f. in a 0.1 *H* coil when the current in it is changing at the rate of 200 *ampere/second* is [DPMT 2002]
(a) $8\times10^{-4}\,V$ (b) $8\times10^{-5}\,V$
(c) $20\,V$ (d) $125\,V$

78. Two circuits have mutual inductance of 0.1 *H*. What average e.m.f. is induced in one circuit when the current in the other circuit changes from 0 to 20 *A* in 0.02 *s* [Kerala PET 2002]
(a) 240 *V* (b) 230 *V*
(c) 100 *V* (d) 300 *V*

79. An air core solenoid has 1000 turns and is one *metre* long. Its cross-sectional area is 10 *cm*. Its self inductance is [JIPMER 2002]
(a) 0.1256 *mH* (b) 12.56 *mH*
(c) 1.256 *mH* (d) 125.6 *mH*

80. The coefficient of mutual inductance of two coils is 6 *mH*. If the current flowing in one is 2 *ampere*, then the induced e.m.f. in the second coil will be [BVP 2003]
(a) 3 *mV* (b) 2 *mV*
(c) 3 *V* (d) Zero

81. An L-R circuit has a cell of e.m.f. E, which is switched on at time t = 0. The current in the circuit after a long time will be [MP PET 2003]

(a) Zero (b) $\frac{E}{R}$

(c) $\frac{E}{L}$ (d) $\frac{E}{\sqrt{L^2+R^2}}$

82. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon [AIEEE 2003]

(a) The currents in the two coils

(b) The rates at which currents are changing in the two coils

(c) Relative position and orientation of the two coils

(d) The materials of the wires of the coils

83. When the current change from + 2A to – 2A in 0.05 *second*, an e.m.f. of 8 V is induced in a coil. The coefficient of self-induction of the coil is [AIEEE 2003]

(a) 0.1 H (b) 0.2 H

(c) 0.4 H (d) 0.8 H

84. A coil resistance 20Ω and inductance 5H is connected with a 100 V battery. Energy stored in the coil will be [MP PMT 2003]

(a) 41.5 J (b) 62.50 J

(c) 125 J (d) 250 J

85. Why the current does not rise immediately in a circuit containing inductance [EAMCET 1994]

(a) Because of induced emf

(b) Because of high voltage drop

(c) Because of low power consumption

(d) Because of Joule heating

86. Two circular coils have their centres at the same point. The mutual inductance between them will be maximum when their axes

(a) Are parallel to each other

(b) Are at 60° to each other

(c) Are at 45° to each other

(d) Are perpendicular to each other

87. The current in a coil decreases from 1 A to 0.2 A. In 10*sec.* Calculate the coefficient of self inductance. If induced emf is 0.4 *volt.*

(a) 5 H (b) 3 H

(c) 4 H (d) 2 H

88. The current through choke coil increases form zero to 6A in 0.3 *seconds* and an induced e.m.f. of 30 V is produced. The inductance of the coil of choke is [MP PMT 2004]

(a) 5 H (b) 2.5 H

(c) 1.5 H (d) 2 H

89. The resistance and inductance of series circuit are 5Ω and 20H respectively. At the instant of closing the switch, the current is increasing at the rate 4A-*s*. The supply voltage is [MP PMT 2004]

(a) 20 V (b) 80 V

(c) 120 V (d) 100 V

90. A coil of N = 100 turns carries a current I = 5 A and creates a magnetic flux $\phi = 10^{-5}\,Tm^{-2}$ per turn. The value of its inductance L will be [UPSEAT 2004]

(a) 0.05 *mH* (b) 0.10 *mH*

(c) 0.15 *mH* (d) 0.20 *mH*

91. Two identical induction coils each of inductance L joined in series are placed very close to each other such that the winding direction of one is exactly opposite to that of the other, what is the net inductance [DCE 2003]

(a) L (b) 2L

(c) L/2 (d) Zero

92. If the current 30 A flowing in the primary coil is made zero in 0.1 *sec*. The emf induced in the secondary coil is 1.5 *volt*. The mutual inductance between the coil is [Pb PMT 2003]

(a) 0.05 H (b) 1.05 H

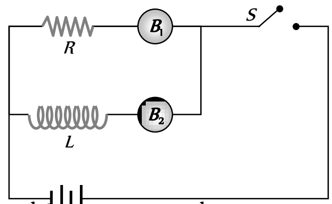
(c) 0.1 H (d) 0.2 H

93. Eddy currents are used in [AFMC 2004]

(a) Induction furnace (b) Electromagnetic brakes

(c) Speedometers (d) All of these

94. The adjoining figure shows two bulbs B_1 and B_2 resistor R and an inductor L. When the switch S is turned off [CPMT 1989]



(a) Both B_1 and B_2 die out promptly

(b) Both B_1 and B_2 die out with some delay

(c) B_1 dies out promptly but B_2 with some delay

(d) B_2 dies out promptly but B_1 with some delay

95. In L-R circuit, for the case of increasing current, the magnitude of current can be calculated by using the formula [MP PET 1994]

(a) $I = I_0 e^{-Rt/L}$ (b) $I = I_0(1-e^{-Rt/L})$

(c) $I = I_0(1-e^{Rt/L})$ (d) $I = I_0 e^{Rt/L}$

[MP PMT 2004]

96. 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 [MP PMT 1994]

(a) *RL sec* (b) $\frac{R}{L}$ *sec*

(c) $\frac{L}{R}$ *sec* (d) $\frac{1}{LR}$ *sec*

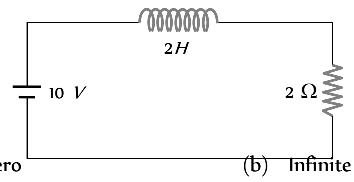
[BCECE 2004]

97. In an LR-circuit, time constant is that time in which current grows from zero to the value (where I_0 is the steady state current) [MP PMT/PET 199

(a) $0.63\, I_0$ (b) $0.50\, I_0$

(c) $0.37\, I_0$ (d) I_0

98. In the figure magnetic energy stored in the coil is [RPET 2000]



(a) Zero (b) Infinite

(c) 25 *joules* (d) None of the above

99. A capacitor is fully charged with a battery. Then the battery is removed and coil is connected with the capacitor in parallel, current varies as [RPET 2000; DCE 2000]

(a) Increases monotonically (b) Decreases monotonically

(c) Zero (d) Oscillates indefinitely

100. A coil of inductance 40 *henry* is connected in 0series with a resistance of 8 *ohm* and the combination is joined to the terminals of a 2 *volt* battery. The time constant of the circuit is

(a) 40 *seconds* (b) 20 *seconds*

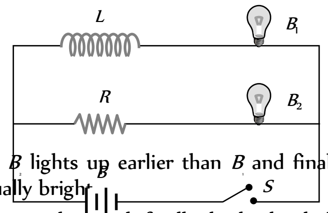
(c) 8 *seconds* (d) 5 *seconds*

101. A solenoid has an inductance of 60 *henrys* and a resistance of 30 *ohms*. If it is connected to a 100 volt battery, how long will it take for the current to reach $\frac{e-1}{e} \approx 63.2\%$ of its final value

(a) 1 *second* (b) 2 *seconds*

(c) *e seconds* (d) 2*e seconds*

102. An inductor, L a resistance R and two identical bulbs, B_1 and B_2 are connected to a battery through a switch S as shown in the figure. The resistance R is the same as that of the coil that makes L. Which of the following statements gives the correct description of the happenings when the switch S is closed



(a) The bulb B_2 lights up earlier than B_1 and finally both the bulbs shine equally bright

(b) B_1 light up earlier and finally both the bulbs acquire equal brightness

(c) B_2 lights up earlier and finally B_1 shines brighter than B_2

(d) B_1 and B_2 light up together with equal brightness all the time

103. The time constant of an *LR* circuit represents the time in which the current in the circuit [MP PMT 2002]

(a) Reaches a value equal to about 37% of its final value

(b) Reaches a value equal to about 63% of its final value

(c) Attains a constant value

(d) Attains 50% of the constant value

104. A *LC* circuit is in the state of resonance. If $C = 0.1\mu F$ and $L = 0.25$ *henry*. Neglecting ohmic resistance of circuit what is the frequency of oscillations [BHU 2003; MP PMT 2005]

(a) 1007 *Hz* (b) 100 *Hz*

(c) 109 *Hz* (d) 500 *Hz*

105. An oscillator circuit consists of an inductance of 0.5 *mH* and a capacitor of 20 μF. The resonant frequency of the circuit is nearly

(a) 15.92 *Hz* (b) 159.2 *Hz*

(c) 1592 *Hz* (d) 15910 *Hz*

106. A coil of inductance 300 *mH* and resistance 2Ω is connected to a source of voltage $2V$. The current reaches half of its steady state value in [AIEEE 2005]

(a) 0.15 *s* (b) 0.3 *s*

(c) 0.05 *s* (d) 0.1 *s*

107. A coil having an inductance of 0.5 *H* carries a current which is uniformly varying from zero to 10 ampere in 2 second. The e.m.f. (in volts) generated in the coil is [Kerala PET 2005]

(a) 10 (b) 5

(c) 2.5 (d) 1.25

108. The square root of the product of inductance and capacitance has the dimension of [KCET 2005]

(a) Length (b) Mass

(c) Time (d) No dimension

[MP PET 2000]

Application of EMI (Motor, Dynamo, Transformer...)

1. Which of the following does not depend upon the magnetic effect of some sort

(a) Moving coil galvanometer

(b) Hot wire ammeter [MP PET 2000]

(c) Dynamo

(d) Electric motor

2. Use of eddy currents is done in the following except

(a) Moving coil galvanometer

(b) Electric brakes

(c) Induction motor [AMU (Med.) 2002]

(d) Dynamo

3. Plane of eddy currents makes an angle with the plane of magnetic lines of force equal to

(a) 40^o (b) 0^o

(c) 90^o (d) 180^o

4. Which of the following is constructed on the principle of electromagnetic induction [MP PMT 2002]

(a) Galvanometer (b) Electric motor

(c) Generator (d) Voltmeter

5. A transformer is based on the principle of [AIIMS 1998; AFMC 2005]

(a) Mutual inductance (b) Self inductance

(c) Ampere's law (d) Lenz's law

6. Which of the following is not an application of eddy currents [CBSE PMT 1989]

(a) Induction furnace

(b) Galvanometer damping

(c) Speedometer of automobiles

(d) *X*-ray crystallography

7. The core of a transformer is laminated to reduce energy losses due to [Kerala PET 2002] [CBSE PMT 1990; Karnataka CET (Med.) 2001]

(a) Eddy currents (b) Hysteresis

(c) Resistance in winding (d) None of these

8. The pointer of a dead-beat galvanometer gives a steady deflection because [MP PMT 1994]

(a) Eddy currents are produced in the conducting frame over which the coil is wound

(b) Its magnet is very strong

(c) Its pointer is very light

(d) Its frame is made of abonite

9. The device that does not work on the principle of mutual induction is [KCET 1994]

(a) Induction coil (b) Motor

(c) Tesla coil (d) Transformer

10. Eddy currents are produced when [CBSE PMT 1993; AFMC 2002]

(a) A metal is kept in varying magnetic field

(b) A metal is kept in the steady magnetic field

(c) A circular coil is placed in a magnetic field

(d) Through a circular coil, current is passed

11. If rotational velocity of a dynamo armature is doubled, then induced e.m.f. will become [MP PMT 1991; AIIMS 2000]

(a) Half (b) Two times

(c) Four times (d) Unchanged

12. Dynamo is a device for converting

(a) Electrical energy into mechanical energy

(b) Mechanical energy into electrical energy

(c) Chemical energy into mechanical energy

(d) Mechanical energy into chemical energy

13. The working of dynamo is based on principle of [CPMT 1984]

(a) Electromagnetic induction

(b) Conversion of energy into electricity

(c) Magnetic effects of current

(d) Heating effects of current

14. Choke coil works on the principle of [MP PET/PMT 1988]

(a) Transient current (b) Self induction

(c) Mutual induction (d) Wattless current

15. When the speed of a dc motor increases the armature current [CPMT 1984, 85; MP PMT 2004]

(a) Increases

(b) Decreases

(c) Does not change

(d) Increases and decreases continuously

16. The output of a dynamo using a splitting commutator is

(a) dc

(b) ac

(c) Fluctuating dc

(d) Half-wave rectified voltage

17. Which of the following statement is incorrect

(a) Both ac and dc dynamo have a field magnet

(b) Both ac and dc dynamo have an armature

(c) Both ac and dc dynamo convert mechanical energy into electrical energy

(d) Both ac and dc dynamo have slip rings

18. The coil of dynamo is rotating in a magnetic field. The developed induced e.m.f. changes and the number of magnetic lines of force also changes. Which of the following condition is correct

(a) Lines of force minimum but induced e.m.f. is zero

(b) Lines of force maximum but induced e.m.f. is zero

(c) Lines of force maximum but induced e.m.f. is not zero

(d) Lines of force maximum but induced e.m.f. is also maximum

19. Dynamo core is laminated because [MP PET 1995]

(a) Magnetic field increases

(b) Magnetic saturation level in core increases

(c) Residual magnetism in core decreases

(d) Loss of energy in core due to eddy currents decreases

20. Armature current in dc motor will be maximum when [CPMT 1986, 88; MP PET 1995]

(a) Motor has acquired maximum speed

(b) Motor has acquired intermediate speed

(c) Motor has just started moving

(d) Motor is switched off

21. The armature of dc motor has $20\,\Omega$ resistance. It draws current of 1.5 ampere when run by 220 *volts* dc supply. The value of back e.m.f. induced in it will be [MP PMT 1999]

(a) 150 V (b) 170 V

(c) 180 V (d) 190 V

22. In an induction coil, the secondary e.m.f. is [KCET 1994]

(a) Zero during break of the circuit

(b) Very high during make of the circuit

(c) Zero during make of the circuit

(d) Very high during break of the circuit

23. The number of turns in the coil of an ac generator is 5000 and the area of the coil is $0.25\,m^2$. The coil is rotated at the rate of 100 *cycles/sec* in a magnetic field of $0.2\,W/m^2$. The peak value of the emf generated is nearly [AMU 1995]

(a) 786 kV (b) 440 kV

(c) 220 kV (d) 157.1 kV

24. In a dc motor, induced e.m.f. will be maximum [RPMT 1997]

(a) When motor takes maximum speed

(b) When motor starts rotating

(c) When speed of motor increases

(d) When motor is switched off

25. Work of electric motor is [RPMT 1997]

(a) To convert ac into dc

(b) To convert dc into ac

(c) Both (a) and (b)

(d) To convert ac into mechanical work

26. In an induction coil with resistance, the induced emf will be maximum when [RPMT 1996]

(a) The switch is put on due to high resistance

(b) The switch is put off due to high resistance

(c) The switch is put on due to low resistance

(d) The switch is put off due to low resistance

27. An electric motor operating on a 60 V dc supply draws a current of 10 A. If the efficiency of the motor is 50%, the resistance of its winding is [MP PET 1993] [AMU (Engg.) 2001]

(a) 3Ω (b) 6Ω

(c) 15Ω (d) 30Ω

28. A device which converts electrical energy into mechanical energy is

(a) Dynamo (b) generator

(c) Electric motor (d) Induction coil

29. An electric motor operates on a 50 *volt* supply and a current of 12A. If the efficiency of the motor is 30%, what is the resistance of the winding of the motor [Kerala PET 2002]

(a) 6Ω (b) 4Ω

(c) $2.9\,\Omega$ (d) 3.1Ω

30. A motor having an armature of resistance 2Ω is designed to operate at 220 V mains. At full speed, it develops a back e.m.f. of 210 V. When the motor is running at full speed, the current in the armature is [UPSEAT 2002]

(a) 5A (b) 105A

(c) 110A (d) 215A

31. Fan is based on [AFMC 2003]

(a) Electric Motor (b) Electric dynamo

(c) Both (d) None of these

32. A transformer is employed to [MP PET 1985; MP PMT 1993; RPET 1999]

(a) Obtain a suitable dc voltage

(b) Convert dc into ac

(c) Obtain a suitable ac voltage

(d) Convert ac into dc

33. What is increased in step-down transformer [MP PMT/PET 1998; CPMT 1999]

(a) Voltage (b) Current

(c) Power (d) Current density

34. The core of a transformer is laminated so that [CPMT 1985; MP PMT 1994, 2000, 02, 03; BHU 1999]

(a) Ratio of voltage in the primary and secondary may be increased

(b) Rusting of the core may be stopped

(c) Energy losses due to eddy currents may be reduced

(d) Change in flux is increased

35. In transformer, core is made of soft iron to reduce [AIIMS 1998; UPSEAT 2001; AFMC 2005]

(a) Hysteresis losses

(b) Eddy current losses

(c) Force opposing electric current

(d) None of the above

36. The transformation ratio in the step-up transformer is

(a) 1

(b) Greater than one

(c) Less than one

(d) The ratio greater or less than one depends on the other factors

37. 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 [MP PET/PMT 1988]

(a) 200 (b) 100

(c) 50 (d) 20

38. The ratio of secondary to the primary turns in a transformer is 3 : 2. If the power output be P, then the input power neglecting all loses must be equal to [MP PMT 1984; KCET 2003]

(a) 5 P (b) 1.5 P

(c) P (d) $\frac{2}{5}P$

39. The primary winding of a transformer has 100 turns and its secondary winding has 200 turns. The primary is connected to an ac supply of 120 V and the current flowing in it is 10 A. The voltage and the current in the secondary are [MP PMT 1991; DPMT 2004]

(a) 240 V, 5 A (b) 240 V, 10 A

(c) 60 V, 20 A (d) 120 V, 20 A

40. A step-down transformer is connected to 2400 *volts* line and 80 amperes of current is found to flow in output load. The ratio of the turns in primary and secondary coil is 20 : 1. If transformer efficiency is 100%, then the current flowing in primary coil will be

(a) 1600 A (b) 20 A

(c) 4 A (d) 1.5 A

41. A loss free transformer has 500 turns on its primary winding and 2500 in secondary. The meters of the secondary indicate 200 *volts* at 8 *amperes* under these conditions. The voltage and current in the primary is [MP PMT 1996]

(a) 100 V, 16 A (b) 40 V, 40 A

(c) 160 V, 10 A (d) 80 V, 20 A

42. An ideal transformer has 100 turns in the primary and 250 turns in the secondary. The peak value of the ac is 28 V. The *r.m.s.* secondary voltage is nearest to [MP PMT 1992]

(a) 50 V (b) 70 V

(c) 100 V (d) 40 V

43. 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 [MP PMT 1992, 2001, 04]

(a) 20% (b) 40%

(c) 70% (d) 90%

44. 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 [MP PET 1992, 99; AIIMS 2000; MP PMT 2000; RPET 2001]

(a) 3.0 V (b) 0.75 V

(c) 1.5 V (d) Zero

45. The alternating voltage induced in the secondary coil of a transformer is mainly due to [MP PET 1992; MP PMT 1996]

(a) A varying electric field

(b) A varying magnetic field

(c) The vibrations of the primary coil

(d) The iron core of the transformer

46. We can reduce eddy currents in the core of transformer [MP PET 1993]

(a) By increasing the number of turns in secondary coil

(b) By taking laminated core

(c) By making step-down transformer

(d) By using a weak ac at high potential

47. A 100% efficient transformer has 100 turns in the primary and 25 turns in its secondary coil. If the current in the secondary coil is 4 amp, then the current in the primary coil is

(a) 1 *amp* (b) 4 *amp*

(c) 8 *amp* (d) 16 *amp*

48. The efficiency of transformer is very high because [MP PET 1994]

(a) There is no moving part in a transformer

(b) It produces very high voltage

(c) It produces very low voltage

(d) None of the above

49. In a lossless transformer an alternating current of 2 *amp* is flowing in the primary coil. The number of turns in the primary and secondary coils are 100 and 20 respectively. The value of the current in the secondary coil is [MP PMT 1994]

(a) 0.08 *A* (b) 0.4 *A*

(c) 5 *A* (d) 10 *A*

50. A transformer connected to 220 *volt* line shows an output of 2 *A* at 11000 *volt*. The efficiency is 100%. The current drawn from the line is

(a) 100 *A* (b) 200 *A*

(c) 22 *A* (d) 11 *A*

51. The coils of a step down transformer have 500 and 5000 turns. In the primary coil an ac of 4 *ampere* at 2200 *volts* is sent. The value of the current and potential difference in the secondary coil will be

(a) 20 *A*, 220 *V* (b) 0.4 *A*, 22000 *V*

(c) 40 *A*, 220 *V* (d) 40 *A*, 22000 *V*

52. A power transformer is used to step up an alternating e.m.f. of 220 *V* to 11 *kV* to transmit 4.4 *kW* of power. If the primary coil has 1000 turns, what is the current rating of the secondary ? Assume 100% efficiency for the transformer [MP PET 1997]

(a) 4 *A* (b) 0.4 *A*

(c) 0.04 *A* (d) 0.2 *A*

53. A step up transformer connected to a 220 *V AC* line is to supply 22 *kV* for a neon sign in secondary circuit. In primary circuit a fuse wire is connected which is to blow when the current in the secondary circuit exceeds 10 *mA*. The turn ratio of the transformer is [MP PET 1997]

(a) 50 (b) 100

(c) 150 (d) 200

54. In a transformer the primary has 500 *turns* and secondary has 50 *turns*. 100 *volts* are applied to the primary coil, the voltage developed in the secondary will be[MP PMT 1997]

(a) 1 *V* (b) 10 *V*

(c) 1000 *V* (d) 10000 *V*

55. A transformer is used to [MP PET 1999]

(a) Change the alternating potential

(b) Change the alternating current

(c) To prevent the power loss in alternating current flow

(d) To increase the power of current source

56. A step-up transformer operates on a 230 *V* line and supplies a load of 2 *ampere*. The ratio of the primary and secondary windings is 1 : 25. The current in the primary is [CBSE PMT 1998]

(a) 15 *A* (b) 50 *A*

(c) 25 *A* (d) 12.5 *A*

57. The number of turns in the primary coil of a transformer is 200 and the number of turns in the secondary coil is 10. If 240 *volt AC* is applied to the primary, the output from the secondary will be [BHU 1997; JIPMER

(a) 48 *V* (b) 24 *V*

(c) 12 *V* (d) 6 *V*

58. The primary winding of transformer has 500 turns whereas its secondary has 5000 turns. The primary is connected to an ac supply of 20 *V*, 50 *Hz*. The secondary will have an output of [CBSE PMT 1997; AIIMS 19

(a) 200 *V*, 50 *Hz* (b) 2 *V*, 50 *Hz*

(c) 200 *V*, 500 *Hz* (d) 2 *V*, 5 *Hz*

59. A step-up transformer has transformation ratio of 3 : 2. What is the voltage in secondary if voltage in primary is 30 *V*

(a) 45 *V* (b) 15 *V*

(c) 90 *V* (d) 300 *V*

[MP PMT 1995]

60. In a transformer, the number of turns in primary coil and secondary coil are 5 and 4 respectively. If 240 *V* is applied on the primary coil, then the ratio of current in primary and secondary coil is [AFMC 1998; CPMT 20

(a) 4 : 5 (b) 5 : 4

(c) 5 : 9 (d) 9 : 5

[MP PET 1996]

61. A step-down transformer is connected to main supply 200 *V* to operate a 6 *V*, 30 *W* bulb. The current in primary is [AMU (Engg.) 1999]

(a) 3 *A* (b) 1.5 *A*

(c) 0.3 *A* (d) 0.15 *A*

62. The number of turns in primary and secondary coils of a transformer are 100 and 20 respectively. If an alternating potential of 200 *volt* is applied to the primary, the induced potential in secondary will be [RPET 1999]

(a) 10 *V* (b) 40 *V*

(c) 1000 *V* (d) 20,000 *V*

63. The ratio of secondary to primary turns is $9:4$. If power input is *P*, what will be the ratio of power output (neglect all losses) to power input [DCE 1999]

(a) 4 : 9 (b) 9 : 4

(c) 5 : 4 (d) 1 : 1

64. Voltage in the secondary coil of a transformer does not depend upon. [BHU 2000]

(a) Voltage in the primary coil

(b) Ratio of number of turns in the two coils

(c) Frequency of the source

(d) Both (a) and (b)

65. A transformer has turn ratio 100/1. If secondary coil has 4 *amp* current then current in primary coil is [RPET 2000]

(a) 4 *A* (b) 0.04 *A*

(c) 0.4 *A* (d) 400 *A*

66. In a step-up transformer the turn ratio is 1:10. A resistance of 200 *ohm* connected across the secondary is drawing a current of 0.5 *A*. What is the primary voltage and current [MP PET 2000]

(a) 50 *V*, 1 *amp* (b) 10 *V*, 5 *amp*

(c) 25 *V*, 4 *amp* (d) 20 *V*, 2 *amp*

67. Large transformers, when used for some time, become hot and are cooled by circulating oil. The heating of transformer is due to

(a) Heating effect of current alone

(b) Hysteresis loss alone

(c) Both the hysteresis loss and heating effect of current

(d) None of the above

68. In a step-up transformer the voltage in the primary is 220 *V* and the current is 5*A*. The secondary voltage is found to be 22000 *V*. The current in the secondary (neglect losses) is

[Kerala PMT 2002]

(a) 5 *A* (b) 50 *A*

(c) 500 *A* (d) 0.05 *A*

69. In a transformer, number of turns in the primary are 140 and that in the secondary are 280. If current in primary is 4*A* then that in the secondary is [AIEEE 2002]

(a) 4 *A* (b) 2 *A*

(c) 6 *A* (d) 10 *A*

70. A transformer has 100 turns in the primary coil and carries 8 *A* current. If input power is one kilowatt, the number of turns required in the secondary coil to have 500 *V* output will be

[MP PET 2002]

(a) 100 (b) 200

(c) 400 (d) 300

71. An ideal transformer has 500 and 5000 turn in primary and secondary windings respectively. If the primary voltage is connected to a 6V battery then the secondary voltage is

[Orissa JEE 2003]

(a) 0 (b) 60 *V*

(c) 0.6 *V* (d) 6.0 *V*

72. In a primary coil 5A current is flowing on 220 volts. In the secondary coil 2200 *V* voltage produces. Then ratio of number of turns in secondary coil and primary coil will be

[RPET 2003]

(a) 1 : 10 (b) 10 : 1

(c) 1 : 1 (d) 11 : 1

73. A step up transformer has transformation ration 5 : 3. What is voltage in secondary if voltage in primary is 60 *V*

[Pb. PET 2000]

(a) 20 *V* (b) 60 *V*

(c) 100 *V* (d) 180 *V*

74. In a step up transformer, 220 *V* is converted into 200 *V*. The number of turns in primary coil is 600. What is the number of turns in the secondary coil [DCE 2004]

(a) 60 (b) 600

(c) 6000 (d) 100

75. The output voltage of a transformer connected to 220 *volt* line is 1100 *volt* at 1 *amp* current. Its efficiency is 100%. The current coming from the line is [Pb. PET 2003]

(a) 20 *A* (b) 10 *A*

(c) 11 *A* (d) 22 *A*

76. Quantity that remains unchanged in a transformer is

[MP PMT/PET 1998; AIIMS 1999; J & K CET 2005]

(a) Voltage (b) Current

(c) Frequency (d) None of the above

77. In a region of uniform magnetic induction $B = 10^{-2}$ *tesla*, a circular coil of radius 30 *cm* and resistance π *ohm* is rotated about an axis which is perpendicular to the direction of *B* and which forms a diameter of the coil. If the coil rotates at 200 *rpm* the amplitude of the alternating current induced in the coil is [MP PET 2001]

(a) 4π *mA* (b) 30 *mA*

(c) 6 *mA* (d) 200 *mA*

78. In a transformer, the number of turns in primary and secondary are 500 and 2000 respectively. If current in primary is 48 *A*, the current in the secondary is

[Orissa PMT 2004]

(a) 12 *A* (b) 24 *A*

(c) 48 *A* (d) 144 *A*

79. In an inductor of inductance *L* = 100 *mH*, a current of $I = 10A$ is flowing. The energy stored in the inductor is

[Orissa PMT 2004]

(a) 5 *J* (b) 10 *J*

(c) 100 *J* (d) 1000 *J*

80. The turn ratio of a transformers is given as 2 : 3. If the current through the primary coil is 3 A, thus calculate the current through load resistance [BHU 2005]

(a) 1 A (b) 4.5 A

(c) 2 A (d) 1. 5 A

81. Core of transformer is made up of [AFMC 2005]

(a) Soft iron (b) Steel

(c) Iron (d) Alnico

82. The induction coil works on the principle of [KCET 2005]

(a) Self-induction (b) Mutual induction

(c) Ampere's rule (d) Fleming's right hand rule

83. A transformer with efficiency 80% works at 4 *kW* and 100 *V*. If the secondary voltage is 200 *V*, then the primary and secondary currents are respectively [Kerala PMT 2005]

(a) 40 *A*, 16 *A* (b) 16 *A*, 40 *A*

(c) 20 *A*, 40 *A* (d) 40 *A*, 20 *A*

84. In a step up transformer, if ratio of turns of primary to secondary is 1 : 10 and primary voltage is 230 *V*. If the load current is 2*A*, then the current in primary is

[Orissa PMT 2005]

(a) 20 *A* (b) 10 *A*

(c) 2 *A* (d) 1 *A*

85. If a coil made of conducting wires is rotated between poles pieces of the permanent magnet. The motion will generate a current and this device is called [CPMT 2005]

(a) An electric motor (b) An electric generator

(c) An electromagnet (d) All of above

86. A step-down transformer is used on a 1000 *V* line to deliver 20 *A* at 120 *V* at the secondary coil. If the efficiency of the transformer is 80% the current drawn from the line is .

[Kerala PET 2005]

(a) 3 *A* (b) 30 *A*

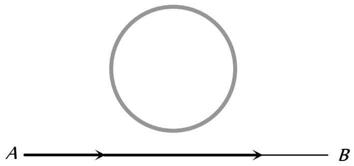
(c) 0.3 *A* (d) 2.4 *A*

Critical Thinking

Objective Questions

1. An electron moves along the line *AB*, which lies in the same plane as a circular loop of conducting wires as shown in the diagram. What will be the direction of current induced if any, in the loop

[MP PET 1989; AIIMS 1982, 2001; KCET 2003; UPSEAT 2005]



(a) No current will be induced

(b) The current will be clockwise

(c) The current will be anticlockwise

(d) The current will change direction as the electron passes by

2. A copper rod of length *l* is rotated about one end perpendicular to the magnetic field *B* with constant angular velocity ω. The induced e.m.f. between the two ends is

[MP PMT 1992; Orissa JEE 2003]

(a) $\frac{1}{2}B\omega l^2$ (b) $\frac{3}{4}B\omega l^2$

(c) $B\omega l^2$ (d) $2B\omega l^2$

3. Two different coils have self-inductance $L_1 = 8\ mH$, $L_2 = 2mH$. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same rate. At a certain instant of time, the power given to the two coils is the same. At that time the current, the induced voltage and the energy stored in the first coil are i_1, V_1 and W_1 respectively. Corresponding values for the second coil at the same instant are i_2, V_2 and W_2 respectively. Then [IIT JEE 1994]

(a) $\frac{i_1}{i_2} = \frac{1}{4}$ (b) $\frac{i_1}{i_2} = 4\ 8$

(c) $\frac{W_2}{W_1} = 4$ (d) $\frac{V_2}{V_1} = \frac{1}{4}$

4. An e.m.f. of 15 *volt* is applied in a circuit containing 5 *henry* inductance and 10 *ohm* resistance. The ratio of the currents at time $t = \infty$ and at $t = 1$ *second* is [MP PMT 1994]

(a) $\frac{e^{1/2}}{e^{1/2} - 1}$ (b) $\frac{e^2}{e^2 - 1}$

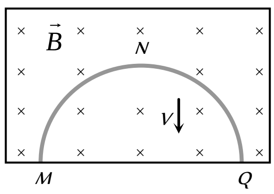
(c) $1 - e^{-1}$ (d) e^{-1}

5. Two conducting circular loops of radii R_1 and R_2 are placed in the same plane with their centres coinciding. If $R_1 >> R_2$, the mutual inductance *M* between them will be directly proportional to [MP PMT 1994; MP PET 2001]

(a) R_1 / R_2 (b) R_2 / R_1

(c) R_1^2 / R_2 (d) R_2^2 / R_1

6. A thin semicircular conducting ring of radius *R* is falling with its plane vertical in a horizontal magnetic induction *B*. At the position *MNQ*, the speed of the ring is *V* and the potential difference developed across the ring is [IIT JEE 1996]



(a) Zero

(b) $Bv\pi R^2 / 2$ and *M* is at higher potential

(c) πRBV and *Q* is at higher potential

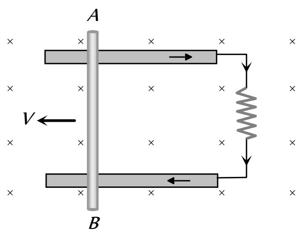
(d) $2RBV$ and *Q* is at higher potential

7. At a place the value of horizontal component of the earth's magnetic field *H* is $3\times10^{-5}\ Weber/m^2$. A metallic rod *AB* of length 2 *m* placed in east-west direction, having the end *A* towards east, falls vertically downward with a constant velocity of 50 *m/s*. Which end of the rod becomes positively charged and what is the value of induced potential difference between the two ends

(a) End *A*, $3\times10^{-3}\ mV$ (b) End *A*, 3 *mV*

(c) End *B*, $3\times10^{-3}\ mV$ (d) End *B*, 3 *mV*

8. Consider the situation shown in the figure. The wire *AB* is sliding on the fixed rails with a constant velocity. If the wire *AB* is replaced by semicircular wire, the magnitude of the induced current will



(a) Increase

(b) Remain the same

(c) Decrease

(d) Increase or decrease depending on whether the semicircle bulges towards the resistance or away from it

9. A circular loop of radius *R* carrying current *I* lies in *x-y* plane with its centre at origin. The total magnetic flux through *x-y* plane is [IIT-JEE 1999]

(a) Directly proportional to *I*

(b) Directly proportional to *R*

(c) Directly proportional to R^2

(d) Zero

10. Two identical circular loops of metal wire are lying on a table without touching each other. Loop-*A* carries a current which increases with time. In response, the loop-*B*

[IIT JEE 1999; UPSEAT 2003]

(a) Remains stationary

(b) Is attracted by the loop-*A*

(c) Is repelled by the loop-*A*

(d) Rotates about its CM, with CM fixed

(CM is the centre of mass)

11. Two coils have a mutual inductance 0.005 *H*. The current changes in the first coil according to equation $I = I_0 \sin\omega t$, where $I_0 = 10A$ and $\omega = 100\ \pi$ *radian/sec*. The maximum value of e.m.f. in the second coil is

[CBSE PMT 1998; Pb. PMT 2000]

(a) 2π (b) 5π

(c) π (d) 4π

12. A small square loop of wire of side *l* is placed inside a large square loop of wire of side *L* (*L* > *l*). The loop are coplanar and their centre coincide. The mutual inductance of the system is proportional to

(a) l / L (b) l^2 / L

(c) L / l (d) L^2 / l

13. A wire of length 1 *m* is moving at a speed of 2*ms* perpendicular to its length and a homogeneous magnetic field of 0.5 *T*. The ends of the wire are joined to a circuit of resistance 6 Ω. The rate at which work is being done to keep the wire moving at constant speed is [Roorkee 1999]

(a) $\frac{1}{12}W$ (b) $\frac{1}{6}W$

(c) $\frac{1}{3}W$ (d) 1*W*

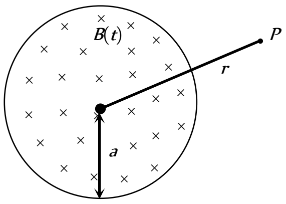
14. A uniform but time-varying magnetic field *B*(*t*) exists in a circular region of radius *a* and is directed into the plane of the paper, as shown. The magnitude of the induced electric field at point *P* at a distance *r* from the centre of the circular region

(a) Is zero

(b) Decreases as $\frac{1}{r}$

(c) Increases as *r*

(d) Decreases as $\frac{1}{r^2}$

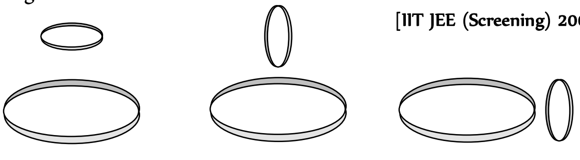


15. A coil of wire having finite inductance and resistance has a conducting ring placed coaxially within it. The coil is connected to a battery at time $t = 0$, so that a time-dependent current $I_1(t)$ starts flowing through the coil. If $I_2(t)$ is the current induced in the ring. and $B(t)$ is the magnetic field at the axis of the coil due to $I_1(t)$, then as a function of time ($t > 0$), the product $I_2(t)\,B(t)$ [IIT-JEE (Screening) 2000]

(a) Increases with time (b) Decreases with time

(c) Does not vary with time (d) Passes through a maximum

16. Two circular coils can be arranged in any of the three situations shown in the figure. Their mutual inductance will be [IIT JEE (Screening) 2001]



(a) Maximum in situation (A) (b) Maximum in situation (B)

(c) Maximum in situation (C) (d) The same in all situations

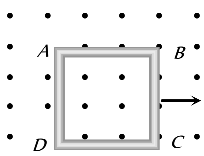
17. A metallic square loop *ABCD* is moving in its own plane with velocity *v* in a uniform magnetic field perpendicular to its plane as shown in the figure. An electric field is induced

(a) In *AD*, but not in *BC*

(b) In *BC*, but not in *AD*

(c) Neither in *AD* nor in *BC*

(d) In both *AD* and *BC*



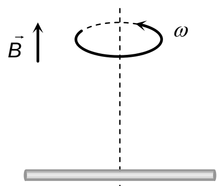
18. A conducting rod of length 2*l* is rotating with constant angular speed *ω* about its perpendicular bisector. A uniform magnetic field $\vec{B}$ exists parallel to the axis of rotation. The e.m.f. induced between two ends of the rod is [MP PET 2001]

(a) $B\omega l$

(b) $\frac{1}{2}B\omega l^2$

(c) $\frac{1}{8}B\omega l^2$

(d) Zero



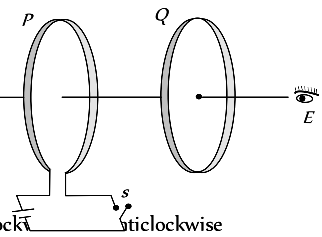
19. An inductor of 2 *henry* and a resistance of 10 *ohms* are connected in series with a battery of 5 *volts*. The initial rate of change of current is [MP PMT 2001]

(a) 0.5 *amp/sec* (b) 2.0 *amp/sec*

(c) 2.5 *amp/sec* (d) 0.25 *amp/sec*

20. As shown in the figure, *P* and *Q* are two coaxial conducting loops separated by some distance. When the switch *S* is closed, a clockwise current I_P flows in *P* (as seen by *E*) and an induced current I_{Q_1} flows in *Q*. The switch remains closed for a long time. When *S* is opened, a current I_{Q_2} flows in *Q*. Then the directions of I_{Q_1} and I_{Q_2} (as seen by *E*) are [IIT JEE (Screening) 2002]

[IIT-JEE (Screening) 2000]



(a) Respectively clockwise and anticlockwise

(b) Both clockwise

(c) Both anticlockwise

(d) Respectively anticlockwise and clockwise

21. A short-circuited coil is placed in a time-varying magnetic field. Electrical power is dissipated due to the current induced in the coil. If the number of turns were to be quadrupled and the wire radius halved, the electrical power dissipated would be

(a) Halved (b) The same

(c) Doubled (d) Quadrupled

22. A physicist works in a laboratory where the magnetic field is 2 *T*. She wears a necklace enclosing area 0.01 *m* in such a way that the plane of the necklace is normal to the field and is having a resistance $R = 0.01\ \Omega$. Because of power failure, the field decays to 1 *T* in time 10^{-3} *seconds*. Then what is the total heat produced in her necklace ? (T = *Tesla*) [Orissa JEE 2002]

(a) 10 *J* (b) 20 *J*

(c) 30 *J* (d) 40 *J*

23. A coil of inductance 8.4 *mH* and resistance 6 Ω is connected to a 12 *V* battery. The current in the coil is 1.0 *A* at approximately the time [IIT-JEE (Screening) 1999; UPSEAT 2003]

[IIT JEE (Screening) 2001]

(a) 500 *sec* (b) 20 *sec*

(c) 35 *milli sec* (d) 1 *milli sec*

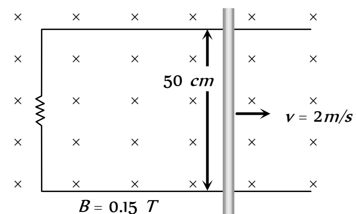
24. As shown in the figure a metal rod makes contact and complete the circuit. The circuit is perpendicular to the magnetic field with $B = 0.15\,tesla$ If the resistance is $3\,\Omega$, force needed to move the rod as indicated with a constant speed of $2m/sec$ is

(a) $3.75\times10^{-3}\,N$

(b) $3.75\times10^{-2}\,N$

(c) $3.75\times10^{2}\,N$

(d) $3.75\times10^{-4}\,N$



25. Two identical coaxial circular loops carry current *i* each circulating in the clockwise direction. If the loops are approaching each other, then [MP PMT 1995, 96]

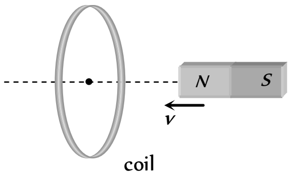
(a) Current in each loop increases

(b) Current in each loop remains the same

(c) Current in each loop decreases

(d) Current in one-loop increases and in the other it decreases

26. In the following figure, the magnet is moved towards the coil with a speed v and induced *emf* is e. If magnet and coil recede away from one another each moving with speed v, the induced *emf* in the coil will be



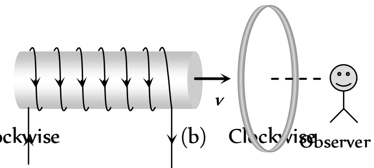
(a) e

(b) $2e$

(c) $e/2$

(d) $4e$

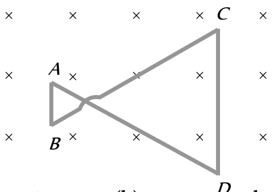
27. A current carrying solenoid is approaching a conducting loop as shown in the figure. The direction of induced current as observed by an observer on the other side of the loop will be



(a) Anticlockwise (b) Clockwise

(c) East (d) West

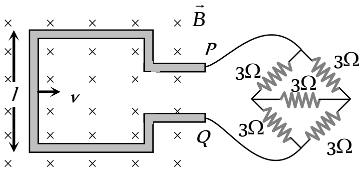
28. A conducting wire frame is placed in a magnetic field which is directed into the paper. The magnetic field is increasing at a constant rate. The directions of induced current in wires AB and CD are



(a) B to A and D to C (b) A to B and C to D

(c) A to B and D to C (d) B to A and C to D

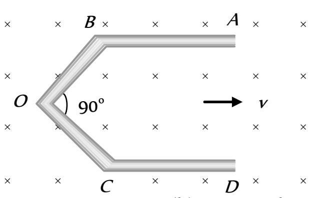
29. A square metallic wire loop of side 0.1 m and resistance of 1Ω is moved with a constant velocity in a magnetic field of 2 wb/m as shown in figure. The magnetic field is perpendicular to the plane of the loop, loop is connected to a network of resistances. What should be the velocity of loop so as to have a steady current of 1mA in loop



(a) 1 *cm/sec* (b) 2 *cm/sec*

(c) 3 *cm/sec* (d) 4 *cm/sec*

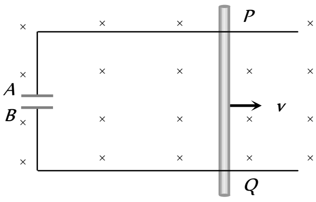
30. A conductor *ABOCD* moves along its bisector with a velocity of 1 *m/s* through a perpendicular magnetic field of 1 *wb/m*, as shown in fig. If all the four sides are of 1m length each, then the induced emf between points A and D is



(a) 0 (b) 1.41 *volt*

(c) 0.71 *volt* (d) None of the above

31. A conducting rod PQ of length L = 1.0 m is moving with a uniform speed v = 2 *m/s* in a uniform magnetic field $B = 4.0\,T$ directed into the paper. A capacitor of capacity C = 10 μF is connected as shown in figure. Then



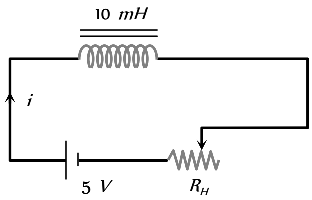
(a) q_A = + 80 μC and q_B = – 80 μC

(b) q_A = – 80 μC and q_B = + 80 μC

(c) q_A = 0 = q_B

(d) Charge stored in the capacitor increases exponentially with time

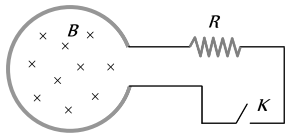
32. The resistance in the following circuit is increased at a particular instant. At this instant the value of resistance is 10Ω. The current in the circuit will be now



(a) i = 0.5 A (b) i > 0.5 A

(c) i < 0.5 A (d) i = 0

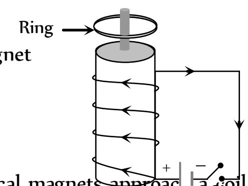
33. Shown in the figure is a circular loop of radius r and resistance R. A variable magnetic field of induction $B = B_0 e^{-t}$ is established inside the coil. If the key (K) is closed, the electrical power developed right after closing the switch is equal to



(a) $\frac{B_0^2 \pi r^2}{R}$ (b) $\frac{B_0 10 r^3}{R}$

(c) $\frac{B_0^2 \pi^2 r^4 R}{5}$ (d) $\frac{B_0^2 \pi^2 r^4}{R}$

34. A conducting ring is placed around the core of an electromagnet as shown in fig. When key K is pressed, the ring



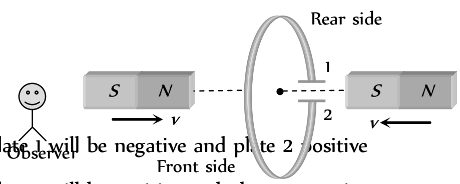
(a) Remain stationary

(b) Is attracted towards the electromagnet

(c) Jumps out of the core

(d) None of the above

35. The north and south poles of two identical magnets approach a coil, containing a condenser, with equal speeds from opposite sides. Then



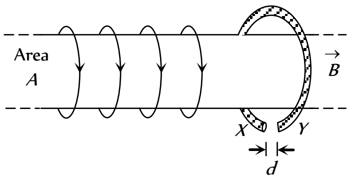
(a) Plate 1 will be negative and plate 2 positive

(b) Plate 1 will be positive and plate 2 negative

(c) Both the plates will be positive

(d) Both the plates will be negative

36. A highly conducting ring of radius R is perpendicular to and concentric with the axis of a long solenoid as shown in fig. The ring has a narrow gap of width d in its circumference. The solenoid has cross sectional area A and a uniform internal field of magnitude B_0. Now beginning at $t = 0$, the solenoid current is steadily increased to so that the field magnitude at any time t is given by $B(t) = B_0 + \alpha t$ where $\alpha > 0$. Assuming that no charge can flow across the gap, the end of ring which has excess of positive charge and the magnitude of induced e.m.f. in the ring are respectively



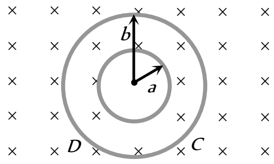
(a) $X, A\alpha$

(b) $X\ \pi R\alpha$

(c) $Y, \pi A\alpha$

(d) $Y, \pi R\alpha$

37. Plane figures made of thin wires of resistance R = 50 *milli ohm/metre* are located in a uniform magnetic field perpendicular into the plane of the figures and which decrease at the rate dB/dt = 0.1 $m\ T/s$. Then currents in the inner and outer boundary are. (The inner radius a = 10 cm and outer radius b = 20 cm)



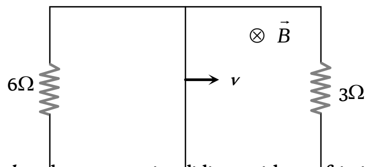
(a) 10^{-4} A (Clockwise), 2 × 10^{-4} A (Clockwise)

(b) 10^{-4} A (Anticlockwise), 2 × 10^{-4} A (Clockwise)

(c) 2 × 10^{-4} A (clockwise), 10^{-4} A (Anticlockwise)

(d) 2 × 10^{-4} A (Anticlockwise), 10^{-4} A (Anticlockwise)

38. A rectangular loop with a sliding connector of length l = 1.0 m is situated in a uniform magnetic field B = 2 T perpendicular to the plane of loop. Resistance of connector is $r = 2\Omega$. Two resistance of 6Ω and 3Ω are connected as shown in figure. The external force required to keep the connector moving with a constant velocity v = 2 m/s is



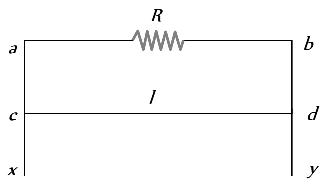
(a) 6 N

(b) 4 N

(c) 2 N

(d) 1 N

39. A wire cd of length l and mass m is sliding without friction on conducting rails ax and by as shown. The vertical rails are connected to each other with a resistance R between a and b. A uniform magnetic field B is applied perpendicular to the plane $abcd$ such that cd moves with a constant velocity of



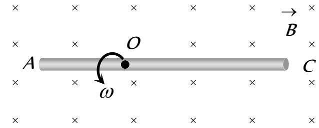
(a) $\frac{mgR}{Bl}$

(b) $\frac{mgR}{B^2l^2}$

(c) $\frac{mgR}{B^3l^3}$

(d) $\frac{mgR}{B^2l}$

40. A conducting rod AC of length $4l$ is rotated about a point O in a uniform magnetic field $\vec{B}$ directed into the paper. $AO = l$ and $OC = 3l$. Then



(a) $V_A - V_O = \frac{B\omega l^2}{2}$

(b) $V_O - V_C = \frac{7}{2}B\omega l^2$

(c) $V_A - V_C = 4B\omega l^2$

(d) $V_C - V_O = \frac{9}{2}B\omega l^2$

41. How much length of a very thin wire is required to obtain a solenoid of length l_0 and inductance L

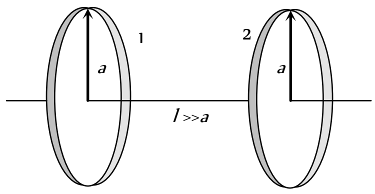
(a) $\sqrt{\frac{2\pi L l_0}{\mu_0}}$

(b) $\sqrt{\frac{4\pi L l_0}{\mu_0^2}}$

(c) $\sqrt{\frac{4\pi L l_0}{\mu_0}}$

(d) $\sqrt{\frac{8\pi L l_0}{\mu_0}}$

42. What is the mutual inductance of a two-loop system as shown with centre separation l



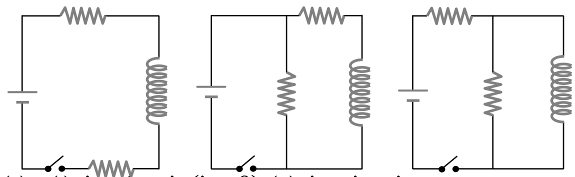
(a) $\frac{\mu_0 \pi a^4}{8l^3}$

(b) $\frac{\mu_0 \pi a^4}{4l^3}$

(c) $\frac{\mu_0 \pi a^4}{6l^3}$

(d) $\frac{\mu_0 \pi a^4}{2l^3}$

43. The figure shows three circuits with identical batteries, inductors, and resistors. Rank the circuits according to the current through the battery (i) just after the switch is closed and (ii) a long time later, greatest first



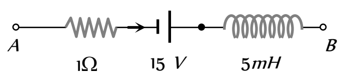
(a) (i) $i_2 > i_3 > i_1$ $(i_1 = 0)$ (ii) $i_2 > i_3 > i_1$

(b) (i) $i_2 < i_3 < i_1$ $(i_1 \neq 0)$ (ii) $i_2 > i_3 > i_1$

(c) (i) $i_2 = i_3 = i_1$ $(i_1 = 0)$ (ii) $i_2 < i_3 < i_1$

(d) (i) $i_2 = i_3 > i_1$ $(i_1 \neq 0)$ (ii) $i_2 > i_3 > i_1$

44. The network shown in the figure is a part of a complete circuit. If at a certain instant the current i is 5 A and is decreasing at the rate of $10^3 A/s$ then $V_A - V_B$ is



(a) 5 V

(b) 10 V

(c) 15 V

(d) 20 V

45. A 50 *volt* potential difference is suddenly applied to a coil with $L = 5 \times 10^{-3}$ *henry* and $R = 180\ ohm$. The rate of increase of current after 0.001 *second* is **[MP PET 1994]**

(a) 27.3 *amp/sec*

(b) 27.8 *amp/sec*

(c) 2.73 *amp/sec*

(d) None of the above

46. The current in a LR circuit builds up to $\frac{3}{4}$ *th* of its steady state value in $4s$. The time constant of this circuit is

[Roorkee 2000]

(a) $\frac{1}{\ln 2}s$ (b) $\frac{2}{\ln 2}s$

(c) $\frac{3}{\ln 2}s$ (d) $\frac{4}{\ln 2}s$

47. A conducting ring of radius 1 *meter* is placed in an uniform magnetic field B of 0.01 *Telsa* oscillating with frequency 100 *Hz* with its plane at right angles to B. What will be the induced electric field [AIIMS 2005]

(a) $\pi\, volt/m$ (b) $2\, volt/m$

(c) $10\, volt/m$ (d) $62\, volt/m$

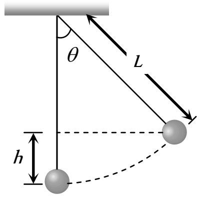
48. A simple pendulum with bob of mass m and conducting wire of length L swings under gravity through an angle 2θ. The earth's magnetic field component in the direction perpendicular to swing is B. Maximum potential difference induced across the pendulum is [MP PET 2005]

(a) $2BL\sin\left(\frac{\theta}{2}\right)(gL)^{1/2}$

(b) $BL\sin\left(\frac{\theta}{2}\right)(gL)$

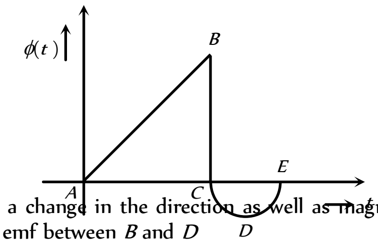
(c) $BL\sin\left(\frac{\theta}{2}\right)(gL)^{3/2}$

(d) $BL\sin\left(\frac{\theta}{2}\right)(gL)^2$



Graphical Questions

1. The graph Shows the variation in magnetic flux $\phi(t)$ with time through a coil. Which of the statements given below is not correct



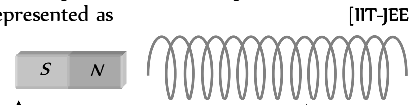
(a) There is a change in the direction as well as magnitude of the induced emf between B and D

(b) The magnitude of the induced emf is maximum between B and C

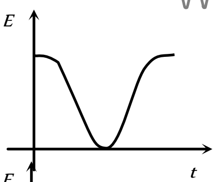
(b) There is a change in the direction as well as magnitude of induced emf between A and C

(d) The induced emf is zero at B

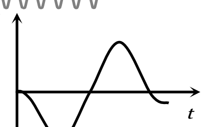
2. The variation of induced emf (E) with time (t) in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as [IIT-JEE (Screening) 2004]



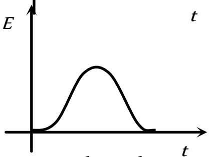
(a)



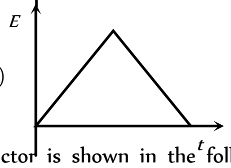
(b)



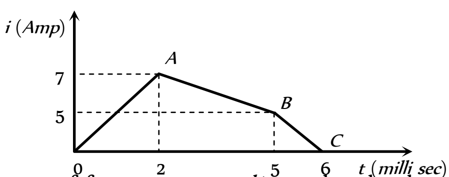
(c)



(d)



3. The current through a 4.6 H inductor is shown in the following graph. The induced emf during the time interval t = 5 *milli-sec* to 6 *milli-sec* will be



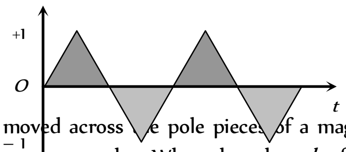
(a) 10 V

(b) – 23 ×10 V

(c) 23 × 10 V

(d) Zero

4. An alternating current of frequency 200 *rad/sec* and peak value 1A as shown in the figure, is applied to the primary of a transformer. If the coefficient of mutual induction between the primary and the secondary is 1.5 H, the voltage induced in the secondary will be



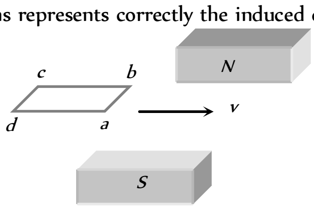
(a) 300 V

(b) 191 V

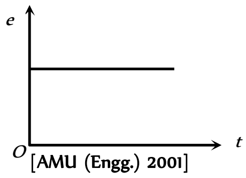
(c) 220 V

(d) 471 V

5. A horizontal loop $abcd$ is moved across the pole pieces of a magnet as shown in fig. with a constant speed v. When the edge ab of the loop enters the pole pieces at time t = 0 *sec*. Which one of the following graphs represents correctly the induced emf in the coil

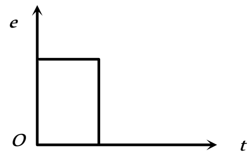


(a)

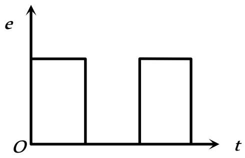


[AMU (Engg.) 2001]

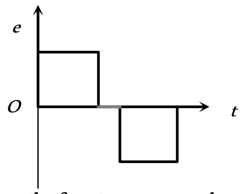
(b)



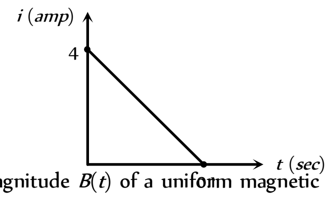
(c)



(d)



6. 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



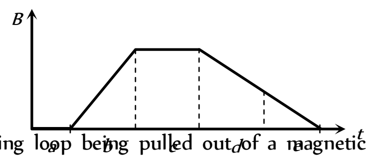
(a) 2

(b) 4

(c) 6

(d) None of these

7. The graph gives the magnitude $B(t)$ of a uniform magnetic field that exists throughout a conducting loop, perpendicular to the plane of the loop. Rank the five regions of the graph according to the magnitude of the emf induced in the loop, greatest first



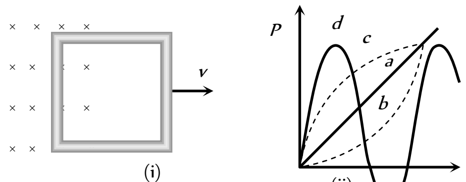
(a) $b > (d = e) < (a = c)$

(b) $b > (d = e) > (a = c)$

(c) $b < d < e < c < a$

(d) $b > (a = c) > (d = e)$

8. Figure (i) shows a conducting loop being pulled out of a magnetic field with a speed v. Which of the four plots shown in figure (ii) may represent the power delivered by the pulling agent as a function of the speed v



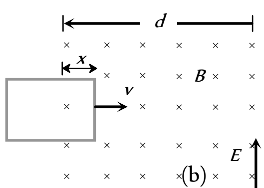
(a) a

(b) b

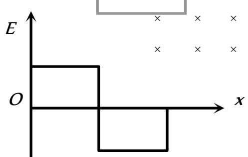
(c) c

(d) d

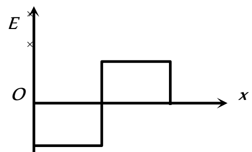
9. A rectangular loop is being pulled at a constant speed v, through a region of certain thickness d, in which a uniform magnetic field B is set up. The graph between position x of the right hand edge of the loop and the induced emf E will be



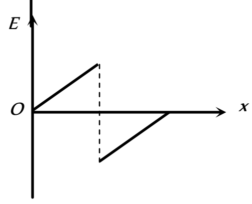
(a)



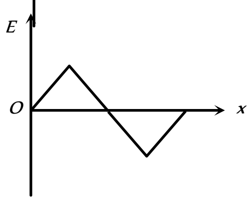
(b)



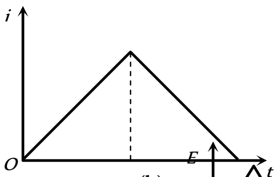
(c)

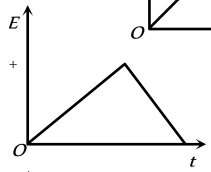


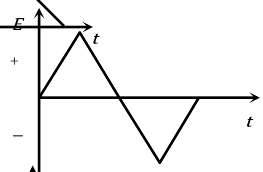
(d)

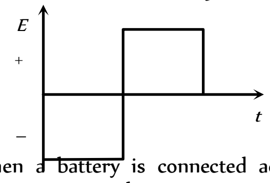


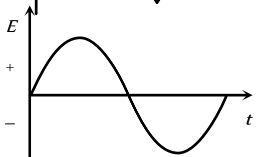
10. The current i in an inductance coil varies with time, t according to the graph shown in fig. Which one of the following plots shows the variation of voltage in the coil with time



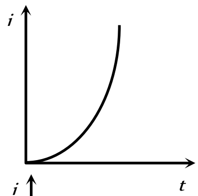
(a) 

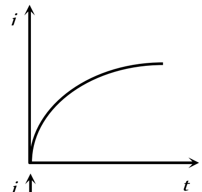
(b) 

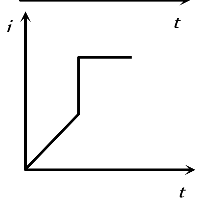
(c) 

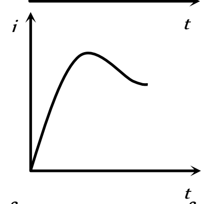
(d) 

11. When a battery is connected across a series combination of self inductance L and resistance R, the variation in the current i with time t is best represented by [MP PET 2004]

(a) 

(b) 

(c) 

(d) 

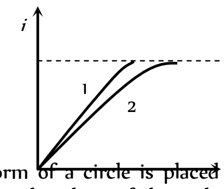
12. When a certain circuit consisting of a constant e.m.f. E an inductance L and a resistance R is closed, the current in, it increases with time according to curve 1. After one parameter (E, L or R) is changed, the increase in current follows curve 2 when the circuit is closed second time. Which parameter was changed and in what direction

(a) L is increased

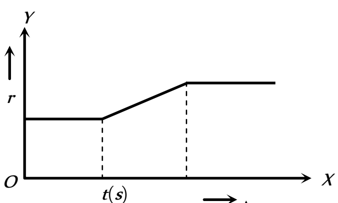
(b) L is decreased

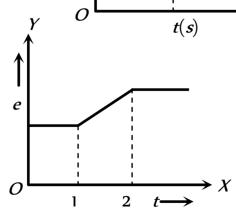
(c) R is increased

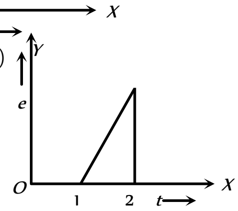
(d) R is decreased

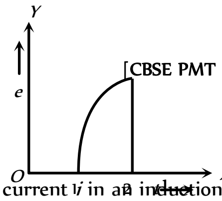


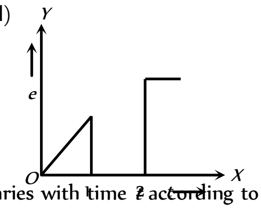
13. A flexible wire bent in the form of a circle is placed in a uniform magnetic field perpendicular to the plane of the coil. The radius of the coil changes as shown in figure. The graph of induced emf in the coil is represented by



(a) 

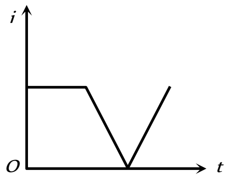
(b) 

(c) 

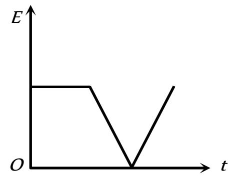
(d) 

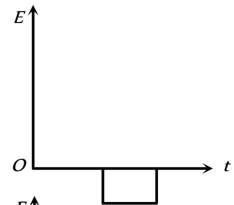
[CBSE PMT 1994]

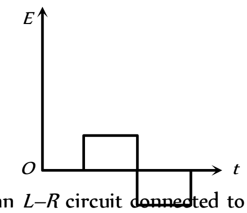
14. The current i in an induction coil varies with time t according to the graph shown

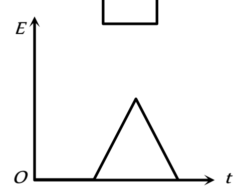


in figure. Which of the following graphs shows the induced emf (e) in the coil with time

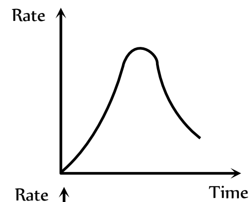
(a) 

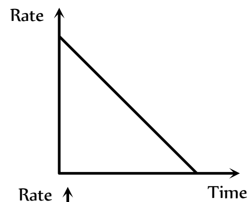
(b) 

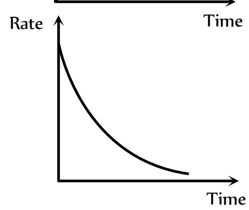
(c) 

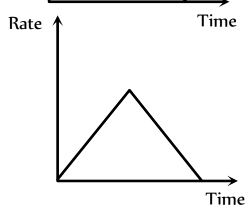
(d) 

15. In an L–R circuit connected to a battery the rate at which energy is stored in the inductor is plotted against time during the growth of the current in the circuit. Which of the following best represents the resulting curve

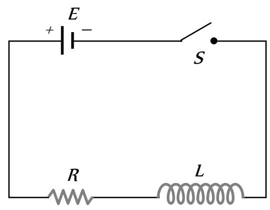
(a) 

(b) 

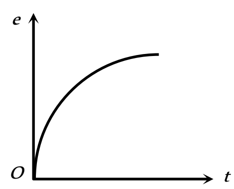
(c) 

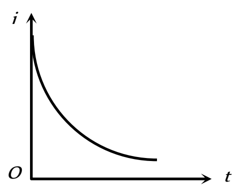
(d) 

16. Switch S of the circuit shown in figure. is closed at $t = 0$. If e denotes the induced



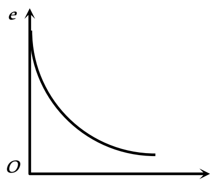
emf in L and i, the current flowing through the circuit at time t, which of the following graphs is correct



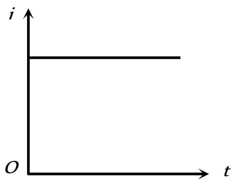


(a) (b) IV.

(c)

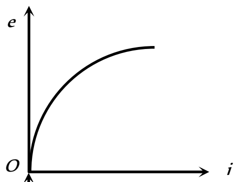


(d)

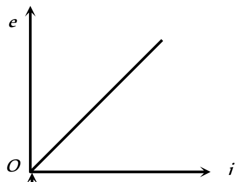


17. For previous objective, which of the following graphs is correct

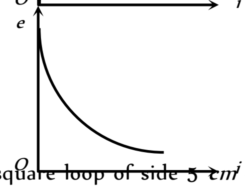
(a)



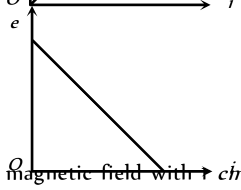
(b)



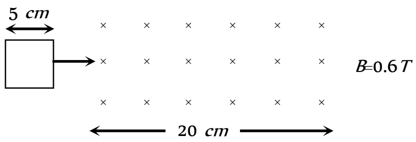
(c)



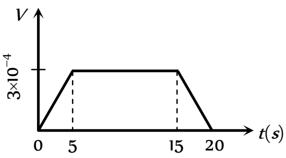
(d)



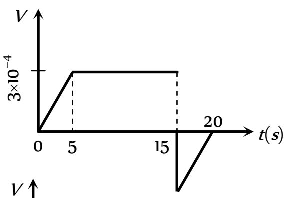
18. A square loop of side 5 *cm* enters a magnetic field with 1 *cm/s*. The front edge enters the magnetic field at $t = 0$ then which graph best depicts *emf*



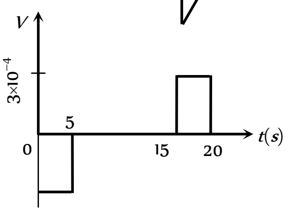
(a)



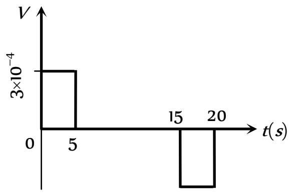
(b)



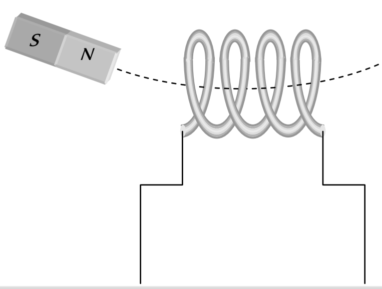
(c)



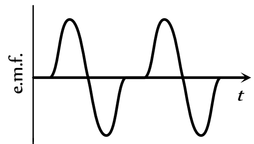
(d)



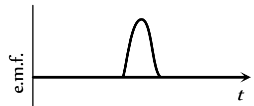
19. A magnet is made to oscillate with a particular frequency, passing through a coil as shown in figure. The time variation of the magnitude of e.m.f. generated across the coil during one cycle is



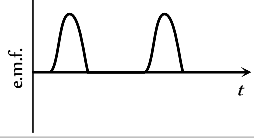
(a)



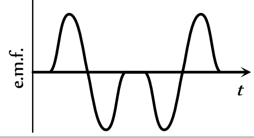
(b)



(c)



(d)



Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : Eddy currents is produced in any metallic conductor when magnetic flux is changed around it.
Reason : Electric potential determines the flow of charge. [AIIMS 1995]

2. Assertion : The quantity L/R possesses dimensions of time.
Reason : To reduce the rate of increases of current through a solenoid should increase the time constant (L/R). [AIIMS 2002]

3. Assertion : Faraday's laws are consequences of conservation of energy.
Reason : In a purely resistive ac circuit, the current lags behind the e.m.f. in phase. [AIIMS 2002]

4. Assertion : Only a change in magnetic flux will maintain an induced current the coil.
Reason : The presence of large magnetic flux through a coil maintains a current in the coil if the circuit is continuous. [AIIMS 1999]

5. Assertion : Magnetic flux can produce induced e.m.f.
Reason : Faraday established induced e.m.f. experimentally.

6. Assertion : The induced e.m.f. and current will be same in two identical loops of copper and aluminium, when rotated with same speed in the same magnetic field.
Reason : Induced e.m.f. is proportional to rate of change of magnetic field while induced current depends on resistance of wire.

7. Assertion : Inductance coil are made of copper.
Reason : Induced current is more in wire having less resistance.

8. Assertion : Self-inductance is called the inertia of electricity.
Reason : Self-inductance is the phenomenon, according to which an opposing induced e.m.f. is produced in a coil as a result of change in current or magnetic flux linked in the coil.

9. Assertion : When two coils are wound on each other, the mutual induction between the coils is maximum.
Reason : Mutual induction does not depend on the orientation of the coils. [AIIMS 2005]

10. Assertion : Acceleration of a magnet falling through a long solenoid decreases.
Reason : The induced current produced in a circuit always flow in such direction that it opposes the change or the cause the produced it.

11. Assertion : An aircraft flies along the meridian, the potential at the ends of its wings will be the same.
Reason : Whenever there is change in the magnetic flux e.m.f. induces.

12. Assertion : A spark occur between the poles of a switch when the switch is opened.
Reason : Current flowing in the conductor produces magnetic field.

13. Assertion : In the phenomenon of mutual induction, self induction of each of the coils persists.
Reason : Self induction arises when strength of current in same coil changes. In mutual induction, current is changing in both the individual coils.

14. Assertion : Lenz's law violates the principle of conservation of energy.
Reason : Induced e.m.f., opposes always the change in magnetic flux responsible for its production.

15. Assertion : The induced emf in a conducting loop of wire will be non zero when it rotates in a uniform magnetic field.
Reason : The emf is induced due to change in magnetic flux.

16. Assertion : An induced emf is generated when magnet is withdrawn from the solenoid.
Reason : The relative motion between magnet and solenoid induces emf.

17. Assertion : An artificial satellite with a metal surface is moving above the earth in a circular orbit. A current will be induced in satellite if the plane of the orbit is inclined to the plane of the equator.
Reason : The current will be induced only when the speed of satellite is more than 8 km/sec.

18. Assertion : A bar magnet is dropped into a long vertical copper tube. Even taking air resistance as negligible, the magnet attains a constant terminal velocity. If the tube is heated, the terminal velocity gets increased.
Reason : The terminal velocity depends on eddy current produced in bar magnet.

19. Assertion : A metal piece and a non-metal (stone) piece are dropped from the same height near earth's surface. Both will reach the earth's surface simultaneously.
Reason : There is no effect of earth's magnetic field on freely falling body.

20. Assertion : A transformer cannot work on dc supply.
Reason : dc changes neither in magnitude nor in direction.

21. Assertion : Soft iron is used as a core of transformer.
Reason : Area of hysteresis is loop for soft iron is small.

22. Assertion : An ac generator is based on the phenomenon of self-induction.
Reason : In single coil, we consider self-induction only.

23. Assertion : An electric motor will maximum efficient when back e.m.f. is equal to applied e.m.f.
Reason : Efficiency of electric motor is depends only on magnitude of back e.m.f..

24. Assertion : The back emf in a dc motor is maximum when the motor has just been switched on.
Reason : When motor is switched on it has maximum speed.

Answers

Faraday's and Lenz's Law

1	c	2	d	3	b	4	d	5	b
6	c	7	a	8	c	9	a	10	b
11	a	12	b	13	b	14	a	15	d
16	d	17	c	18	b	19	b	20	b
21	b	22	c	23	b	24	b	25	d
26	c	27	d	28	b	29	d	30	d
31	b	32	a	33	b	34	a	35	b
36	b	37	d	38	a	39	a	40	c
41	c	42	b	43	c	44	c	45	d
46	d	47	d	48	d	49	d	50	c
51	b	52	a	53	d	54	b	55	b
56	a	57	c	58	a	59	d	60	b
61	a	62	a	63	d	64	d	65	c
66	c	67	a	68	b				

Motional EMI

1	a	2	b	3	d	4	c	5	b
6	b	7	b	8	c	9	d	10	d
11	b	12	c	13	b	14	c	15	d
16	c	17	c	18	b	19	c	20	b
21	d	22	d	23	d	24	d	25	c
26	a	27	c	28	c	29	c	30	d
31	b	32	b	33	b				

Static EMI

1	d	2	d	3	b	4	a	5	d
6	d	7	c	8	c	9	c	10	c
11	a	12	b	13	b	14	d	15	d
16	b	17	a	18	b	19	b	20	b
21	a	22	d	23	c	24	c	25	b
26	c	27	b	28	c	29	c	30	d
31	b	32	a	33	b	34	c	35	d
36	a	37	a	38	c	39	c	40	a
41	d	42	a	43	a	44	b	45	b
46	abcd	47	c	48	b	49	d	50	c
51	c	52	b	53	a	54	a	55	a
56	a	57	a	58	d	59	a	60	b
61	d	62	b	63	a	64	d	65	a
66	d	67	c	68	c	69	c	70	b
71	a	72	b	73	c	74	b	75	a
76	c	77	c	78	c	79	c	80	d
81	b	82	c	83	a	84	b	85	a
86	a	87	a	88	c	89	b	90	d
91	d	92	a	93	d	94	c	95	b
96	c	97	a	98	c	99	d	100	d
101	b	102	c	103	b	104	a	105	c
106	d	107	c	108	c				

Application of EMI (Motor, Dynamo, Transformer ...)

1	b	2	d	3	c	4	c	5	a
6	d	7	a	8	a	9	c	10	a
11	b	12	b	13	a	14	b	15	b
16	c	17	d	18	b	19	d	20	c
21	d	22	d	23	d	24	a	25	d
26	b	27	a	28	c	29	c	30	a
31	a	32	c	33	b	34	c	35	a
36	b	37	a	38	c	39	a	40	c
41	b	42	a	43	d	44	d	45	b
46	b	47	a	48	a	49	d	50	a
51	c	52	b	53	b	54	b	55	a
56	b	57	c	58	a	59	a	60	a
61	d	62	b	63	d	64	c	65	b
66	b	67	c	68	d	69	b	70	c
71	a	72	b	73	c	74	c	75	b
76	c	77	c	78	a	79	a	80	c
81	a	82	b	83	a	84	a	85	b
86	a								

Critical Thinking Questions

1	d	2	a	3	acd	4	b	5	d
6	d	7	b	8	b	9	d	10	c
11	b	12	b	13	b	14	b	15	d
16	a	17	d	18	d	19	c	20	d
21	b	22	a	23	d	24	a	25	c
26	b	27	b	28	a	29	b	30	b
31	a	32	b	33	d	34	c	35	b
36	a	37	a	38	c	39	b	40	c
41	c	42	d	43	a	44	c	45	d
46	b	47	b	48	a				

Graphical Questions

1	d	2	a	3	c	4	b	5	d
6	a	7	b	8	b	9	b	10	c
11	b	12	a	13	b	14	c	15	a
16	c	17	d	18	c	19	a		

Assertion and Reason

1	b	2	b	3	c	4	c	5	e
6	e	7	a	8	b	9	c	10	a
11	a	12	b	13	a	14	e	15	a
16	a	17	c	18	b	19	d	20	a
21	a	22	e	23	d	24	d		

Answers and Solutions

Faraday's and Lenz's Law

1. (c) Because induced e.m.f. is given by $E = -N\dfrac{d\phi}{dt}$.

2. (d) The energy of the field increases with the magnitude of the field. Lenz's law infers that there is an opposite field created due to increase or decrease of magnetic flux around a conductor so as to hold the law of conservation of energy.

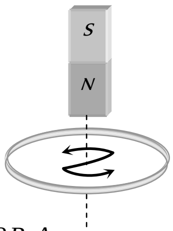
3. (b) We know that $e = \dfrac{d\phi}{dt}$

But $e = iR$ and $i = \dfrac{dq}{dt} \Rightarrow \dfrac{dq}{dt}R = \dfrac{d\phi}{dt} \Rightarrow dq = \dfrac{d\phi}{R}$

4. (d) Similar to Q.3

5. (b) Because there is no change in flux linked with coil

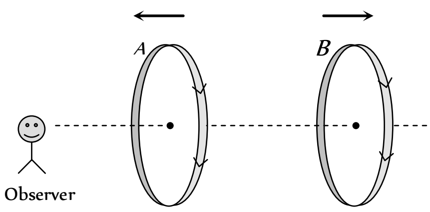
6. (c) As it is seen from the magnet side induced current will be anticlockwise.



7. (a) $e = -\dfrac{d\phi}{dt} = \dfrac{-3B_0A_0}{t}$

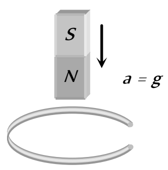
8. (c) $e = -\dfrac{d\phi}{dt} = -(16t+3) = -67 units$

9. (a) Induced current in both the coils assist the main current so current through each coil increases.



10. (b) When the magnet is allowed to fall vertically along the axis of loop with its north pole towards the ring. The upper face of the ring will become north pole in an attempt to oppose the approaching north pole of the magnet. Therefore the acceleration in the magnet is less than g.

Note : If coil is broken at any point then induced *emf* will be generated in it but no induced current will flow. In this condition the coil will not oppose the motion of magnet and the magnet will fall freely with acceleration g. (*i.e.* $a = g$)



11. (a) $\phi = BA = 10\ weber$

12. (b) The magnitude of induced e.m.f. is directly proportional to the rate of change of magnetic flux. Induced charge doesn't depend upon time.

13. (b)

14. (a) $I = \dfrac{e}{R} = \dfrac{-N(d\phi/dt)}{R} = \dfrac{10\times10^{8}\times10^{-4}\times10^{-4}\times10}{20} = 5\ A$

15. (d) Induced charge doesn't depend upon the speed of magnet.

16. (d) $|e| = N\left(\dfrac{\Delta B}{\Delta t}\right).A\cos\theta = 500\times1\times(10\times10^{-2})^2\cos 0 = 5V.$

17. (c) When frequency is high, the galvanometer will not show deflection.

18. (b) $e = -\dfrac{N(B_2 - B_1)A\cos\theta}{\Delta t}$

$= -\dfrac{500\times(0-0.1)\times100\times10^{-4}\cos 0}{0.1} = 5V$

19. (b) $e = -\dfrac{N(B_2 - B_1)A\cos\theta}{\Delta t}$

$= -\dfrac{50(0.35-0.10)\times\pi(3\times10^{-2})^2\times\cos 0^o}{2\times10^{-3}} = 17.7\ V.$

20. (b) $|e| = A.\dfrac{\Delta B}{\Delta t} = 2\times\dfrac{(4-1)}{2} = 3\ V.$

21. (b) $e = -\dfrac{NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

$= -2000\times0.3\times70\times10^{-4}\dfrac{(\cos 180 - \cos 0)}{0.1}$

$\Rightarrow e = 84\ V$

22. (c) The induced current will be in such a direction so that it opposes the change due to which it is produced.

23. (b)

24. (b)

25. (d) According to Lenz's law.

26. (c) $e = -N\left(\dfrac{\Delta B}{\Delta t}\right).A\cos\theta = -100\times\dfrac{(6-1)}{2}\times(40\times10^{-4})\cos 0$

$\Rightarrow |e| = 1\ V$

27. (d)

28. (b)

29. (d)

30. (d) Emf induces in ring and it will opposes the motion. Hence due to the resistance of the ring all energy dissipates.

31. (b) $\Delta Q = \dfrac{NBA}{R}(\cos\theta_1 - \cos\theta_2)$

$= \dfrac{500\times0.2\times0.1(\cos 0 - \cos 180)}{50} = 0.4\ C$

32. (a) $\phi = NBA\cos\theta = 100\times0.2\times5\times10^{-4}\cos 60^o$

$= 5\times10^{-3}Wb$

33. (b) $\Delta Q = \frac{\Delta\phi}{R} = \frac{(10-2)}{2} = 4C$

34. (a)

35. (b)

36. (b) $\phi = \mu_0 niA = 4\pi \times 10^{-7} \times \frac{3000}{1.5} \times 2 \times \pi (2 \times 10^{-2})^2$

$= 6.31 \times 10^{-6} Wb$

37. (d) $q = -\frac{N}{R}(B_2 - B_1)A\cos\theta$

$32 \times 10^{-6} = -\frac{100}{(160+40)}(0 - B) \times \pi \times (6 \times 10^{-3})^2 \times \cos 0^o$

$\Rightarrow B = 0.565\ T$

38. (a) Faraday's laws involve conversion of mechanical energy into electric energy. This is in accordance with the law of conservation of energy.

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

$\Rightarrow 0.1 = \frac{-50 \times (0 - 2\times 10^{-2}) \times 100 \times 10^{-4} \times \cos 0^o}{t}$

$\Rightarrow t = 0.1 sec.$

40. (c) $q = \frac{N}{R} d\phi \quad \therefore q \propto d\phi$

41. (c) $i = \frac{|e|}{R} = \frac{N}{R} \cdot \frac{\Delta B}{\Delta t} A\cos\theta = \frac{20}{100} \times 1000 \times (25 \times 10^{-4}) \cos 0^o$

$\Rightarrow i = 0.5\ A$

42. (b) According to Lenz's law.

43. (c)

44. (c) E.m.f. or current induces, only when flux linked with the coil changes.

45. (d) $e = -\frac{d\phi}{dt} = -\frac{d}{dt}(3t^2 + 4t + 9) = -(6t + 4)$

$e = -[6(2) + 4] = -16 \Rightarrow |e| = 16\ volt$

46. (d) $e = -\frac{NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

$= -\frac{800 \times 4 \times 10^{-5} \times 0.05 (\cos 90^o - \cos 0^o)}{0.1} = 0.016\ V$

47. (d)

48. (d)

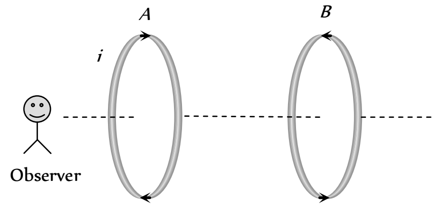
49. (d) $e = -\frac{d\phi}{dt} = -(10t - 4) \Rightarrow (e)_{t=2} = -(10 \times 0.2 - 4) = 2\ volt$

50. (c)

51. (b)

52. (a) If bar magnet is falling vertically through the hollow region of long vertical copper tube then the magnetic flux linked with the copper tube (due to 'non-uniform' magnetic field of magnet) changes and eddy currents are generated in the body of the tube by Lenz's law the eddy currents opposes the falling of the magnet which therefore experience a retarding force. The retarding force increases with increasing velocity of the magnet and finally equals the weight of the magnet. The magnet then attains a constant final terminal velocity *i.e.* magnet ultimately falls with zero acceleration in the tube.

53. (d)



If current through A increases, crosses (X) linked with coil B increases, hence anticlockwise current induces in coil B. As shown in figure both the current produces repulsive effect.

54. (b) $e = -\frac{d\phi}{dt} = -\frac{d}{dt}(5t^3 - 100t + 300)$

$= -(15t^2 - 100)$ at $t = 2 sec$; $e = 40\ V$

55. (b) By using $e = -\frac{NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

$e = -\frac{1000 \times 2 \times 10^{-5} \times 500 \times 10^{-4} (\cos 180^o - \cos 0^o)}{0.2}$

$= 10^{-2} volt = 10 mV$

56. (a) Similar to Q. 52

57. (c)

58. (a) Induced charge $Q = -\frac{N}{R}(\phi_2 - \phi_1) = \frac{1}{100}(60 - 10) = 0.5C$

59. (d)

60. (b) $i = \frac{e}{R} = \frac{-N}{R}\frac{(\phi_2 - \phi_1)}{\Delta t} = \frac{-n(W_2 - W_1)}{5Rt}$

61. (a) Magnetic flux linked with the ring changes so current flows through it.

62. (a) $|e| = \frac{d\phi}{dt} = \frac{d}{dt}(5t^2 + 3t + 16) = (10t + 3)$

when $t = 3$ sec, $e_3 = (10 \times 3 + 3) = 33\ V$

when $t = 4$ sec, $e_4 = (10 \times 4 + 3) = 43\ V$

Hence emf induced in fourth second

$= e_4 - e_3 = 43 - 33 = 10\ V$

63. (d) $e = \frac{-NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

$= -\frac{500 \times 4 \times 10^{-4} \times 0.1(\cos 90 - \cos 0)}{0.1} = 0.2\ V$

64. (d) $q = \frac{N}{R}(\Delta\phi) = \frac{1}{2} \times (10 - 2) = 4C$

65. (c) At low frequency of 1 to 2 Hz, oscillations may be observed as our eyes will be able to detect it.

66. (c) Since the magnetic field is uniform therefore there will be no change in flux hence no current will be induced.

67. (a) $\phi = BA$

$\Rightarrow$ change in flux $d\phi = B.dA = 0.05\,(101 - 100)\,10^{-4}$

$= 5.10^{-6}$ Wb.

Now, charge $dQ = \frac{d\phi}{R} = \frac{5\times10^{-6}}{2} = 2.5\times10^{-6}\ C$.

68. (b) $\Delta Q = \frac{\Delta\phi}{R} = \frac{n\times BA}{R}$

$\Rightarrow B = \frac{\Delta Q.R}{nA} = \frac{2\times10^{-4}\times80}{40\times4\times10^{-4}} = 1\ Wb/m^2$

Motional EMI

1. (a) Emf $= e = e_0 \sin\theta$; e will be maximum when θ is 90° *i.e.* plane of the coil will be horizontal.

2. (b) Induced e.m.f. $= Blv = 0.3\times10^{-4}\times10\times5$

$= 1.5\times10^{-3}\ V = 1.5\ mV$

3. (d) Conductor cuts the flux only when, if it moves in the direction of M.

4. (c) $e = B_v.vl = 0.2\times10^{-4}\times\left(\frac{180\times1000}{3600}\right)\times1 = 10^{-3}\ V$

5. (b) $e = Bvl = 3\times10^{-3}\times10^2 = 0.3\ volt$

6. (b) This is the case of periodic EMI

7. (b) $e = B_v.v.l = 2\times10^{-4}\times\left(\frac{360\times1000}{3600}\right)\times50 \Rightarrow e = 1\ V$

8. (c) $e = \frac{1}{2}B\omega r^2 = \frac{1}{2}\times0.1\times2\pi\times10\times(0.1)^2 = \pi\times10^{-2}\ V$

9. (d) $e = \frac{1}{2}B\omega r^2 = \frac{1}{2}\times0.2\times10^{-4}\times5\times(1)^2 = 50\mu V$

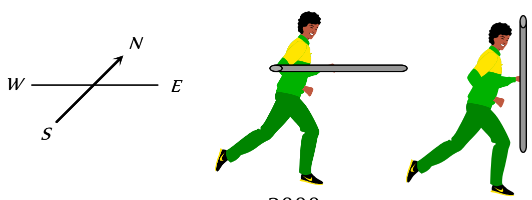
10. (d) No flux change is taking place because magnetic field exists everywhere and is constant in time and space.

11. (b) If player is running with rod in vertical position towards east, then rod cuts the magnetic field of earth perpendicularly (magnetic field of earth is south to north).

Hence Maximum emf induced is

$e = Bvl = 4\times10^{-5}\times\frac{30\times1000}{3600}\times3 = 1\times10^{-3}\ volt$

When he is running with rod in horizontal position, no field is cut by the rod, so $e = 0$.



12. (c) $e = NBA\omega$; $\omega = 2\pi f = 2\pi\times\frac{2000}{60}$

$\therefore e = 50\times0.05\times80\times10^{-4}\times2\pi\times\frac{2000}{60} = \frac{4\pi}{3}$

13. (b)

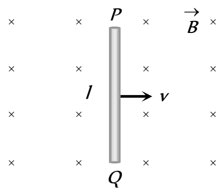
14. (c) According to Fleming right hand rule, the direction of B will be perpendicular to the plane of paper and act downward.

15. (d) By Fleming's right hand rule.

16. (c) $e = Bvl \Rightarrow e \propto v \propto gt$

17. (c) $e = Bvl = 0.5\times2\times1 = 1\ V$

18. (b) A motional emf $e = Bvl$ is induced in the rod, or we can say, a potential difference is induced between the two ends of the rod AB, with P at higher potential and Q at lower potential. Due to this potential difference, there is an electric field in the rod.



19. (c)

20. (b) $e = Bvl \Rightarrow e = 0.7\times2\times(10\times10^{-2}) = 0.14\ V$

21. (d) $e = Bvl \Rightarrow e = 0.9\times7\times0.4 = 2.52\ V$

22. (d)

23. (d)

24. (d) $e = Bl^2\pi\nu = 0.4\times10^{-4}\times(0.5)^2\times(3.14)\times\frac{120}{60}$

$= 6.28\times10^{-5}\ V$

25. (c) $e = \frac{1}{2}Bl^2\omega = \frac{1}{2}\times0.3\times(2)^2\times100 = 60V$

26. (a) $e = Bvl = 5\times10^{-5}\times\frac{360\times1000}{3600}\times20 = 0.1V$

27. (c)

28. (c) Peak value of $emf = e_0 = \omega NBA = 2\pi\nu NBA$

$= 2\pi\times50\times300\times4\times10^{-2}\times(25\times10^{-2}\times10\times10^{-2})$

$= 30\ \pi\ volt$

29. (c) $e = \frac{1}{2}Bl^2\omega = Bl^2\pi\nu$

$\Rightarrow e = 0.5(20\times10^{-2})^2\times3.14\times100 = 6.28\ V$

30. (d)

31. (b) $e_0 = \omega NBA = (2\pi\nu)NB(\pi r^2) = 2\times\pi^2\nu\ NBr^2$

$= 2\times(3.14)^2\times\frac{1800}{60}\times4000\times0.5\times10^{-4}\times(7\times10^{-2})^2$

$= 0.58\ V$

32. (b) Two emf's induces in the closed circuit each of value $Bl\,v$. These two emf's are additive. So $E_{net} = 2Bl\,v$.

33. (b) When a conductor lying along the magnetic north-south, moves eastwards it will cut vertical component of B_0. So induced *emf*

$e = vB_V l = v(B_0 \sin\delta\, l) = B_0 l v \sin\delta$.

Static EMI

1. (d) $e=-L\frac{di}{dt}$ but $e=4V$ and $\frac{di}{dt}=\frac{0-1}{10^{-3}}=-1/10^{-3}$

$\therefore \frac{-1}{10^{-3}}(-L)=4 \Rightarrow L=4\times 10^{-3}\,henry$

2. (d) $L=\frac{e}{di/dt}=\frac{5}{(3-2)/10^{-3}}=\frac{5}{1}\times 10^{-3}=5\,millihenry$

3. (b) Energy stored $E=\frac{1}{2}Li^2=\frac{1}{2}\times 50\times 10^{-3}\times 4=0.1\,J$

4. (a) Given $\frac{di}{dt}=2A/sec.,\ L=5\,H\ \therefore e=L\frac{di}{dt}=5\times 2=10\,V$

5. (d) As we know $e=-\frac{d\phi}{dt}=-L\frac{di}{dt}$

Work done against back e.m.f. *e* in time *dt* and current *i* is

$dW=-eidt=L\frac{di}{dt}idt=Li\,di \Rightarrow W=L\int_0^i i\,di=\frac{1}{2}Li^2$

6. (d) Induced emf $e=M\frac{di}{dt}=\frac{\mu_0 N_1 N_2 A}{l}.\frac{di}{dt}$

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

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

7. (c) Self inductance $L=\mu_0 N^2 A/l=\mu_0 n^2 lA$

Where *n* is the number of turns per unit length and *N* is the total number of turns and $N=nl$

In the given question *n* is same. *A* is increased 4 times and *l* is increased 2 times and hence *L* will be increased 8 times.

8. (c) $M=-\frac{e_2}{di_1/dt}=-\frac{e_1}{di_2/dt}$

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

$M^2=\frac{e_1e_2}{\left(\frac{di_1}{dt}\right)\left(\frac{di_2}{dt}\right)}=L_1L_2 \Rightarrow M=\sqrt{L_1L_2}$

9. (c) Inductance is inherent property of electrical circuits. It will always be found in an electrical circuit whether we want it or not. The circuit in which a large emf is induced when the current in the circuit changes is said to have greater inductance. A straight wire carrying current with no iron part in the circuit will have lesser value of inductance while if the circuit contains a circular coil having many number of turns, the induced emf to oppose the cause will be greater and the circuit is therefore said to have greater value of inductance.

10. (c) Magnetic flux $\phi=LI$

By analogy, since physical quantities mass *(m)* and linear velocity *(v)* are equivalent to electrical quantities inductance *(L)* and current *(I)* respectively. Thus magnetic flux $\phi=LI$ is equivalent to momentum $\mathbf{p}=m\times\mathbf{v}$.

11. (a) Energy stored $=\frac{1}{2}Li^2$, where *Li* is a magnetic flux.

12. (b) $L=\mu ni \Rightarrow \frac{L_2}{L_1}=\frac{\mu}{\mu_0}$ (*n* and *i* are same)

$\Rightarrow L_2=\mu_r L_1=900\times 0.18=162\,mH$

13. (b) $e=M\frac{di}{dt}=0.2\times 5=1\,V$

14. (d) $e=-L\frac{di}{dt} \Rightarrow 2=-L\left(\frac{8-2}{3\times 10^{-2}}\right) \Rightarrow L=0.01\,H=10\,mH$

15. (d) $e=M\frac{di}{dt}=1.25\times 80=100\,V$

16. (b) $\frac{L_B}{L_A}=\left(\frac{n_B}{n_A}\right)^2 \Rightarrow L_B=\left(\frac{500}{600}\right)^2\times 108=75\,mH$

17. (a) $L\propto N^2$ i.e. $\frac{L_1}{L_2}=\left(\frac{N_1}{N_2}\right)^2 \Rightarrow L_2=L_1\left(\frac{N_2}{N_1}\right)^2=4L_1$

18. (b) $e=-L\frac{di}{dt} \Rightarrow 8=L\frac{(4-2)}{0.05} \Rightarrow L=0.2\,H$

19. (b) $e=M\frac{di}{dt} \Rightarrow M=\frac{15000}{3}\times 0.001=5\,H$

20. (b) $L=\frac{e}{di/dt}=\frac{12}{48/60}=15\,H$

21. (a) $B=\frac{\mu_0 Ni}{2r}=\frac{4\pi\times 10^{-7}\times 100\times 2\times\sqrt{\pi}}{2\times 10^{-2}}=0.022\,wb/m^2$

22. (d) $e=M\frac{di}{dt}=0.09\times\frac{20}{0.006}=300\,V$

23. (c)

24. (c) Inductors obey the laws of parallel and series combination of resistors.

25. (b) There will be self induction effect when soft iron core is inserted.

26. (c) $L=\mu_0 N^2 A/l$

27. (b)

28. (c) $e=-L\frac{di}{dt} \Rightarrow e=5\times\frac{1}{5}=1\,volt$

29. (c) $e=L\frac{di}{dt} \Rightarrow L=\frac{Volt-sec}{Ampere}$

30. (d) $e=-L\frac{di}{dt}=-0.4\times 10^{-3}\times\frac{250\times 10^{-3}}{0.1}=-1\,mV$

31. (b) In steady state current passing through solenoid

$i=\frac{E}{R}=\frac{10}{10}=1\,A$

32. (a) $e=L\frac{di}{dt} \Rightarrow 2=L\times\frac{6}{3\times 10^{-3}} \Rightarrow L=1\,mH$

33. (b) From $i = i_0[1 - e^{-Rt/L}]$, where $i_0 = \frac{5}{5} = 1\,amp$

$\therefore i = 1\left(1 - e^{\frac{-5\times 2}{10}}\right) = (1 - e^{-1})amp$

34. (c) $M = \frac{\mu_0 N_1 N_2 A}{l}$

35. (d) $e = L\frac{di}{dt} = 60\times 10^{-6}.\frac{(1.5 - 1.0)}{0.1} = 3\times 10^{-4}\,volt$

36. (a) $\phi = Li \Rightarrow NBA = Li$

Since magnetic field at the centre of circular coil carrying current is given by $B = \frac{\mu_0}{4\pi}.\frac{2\pi Ni}{r}$

$\therefore N.\frac{\mu_0}{4\pi}.\frac{2\pi Ni}{r}.\pi r^2 = Li \Rightarrow L = \frac{\mu_0 N^2 \pi r}{2}$

Hence self inductance of a coil

$= \frac{4\pi\times 10^{-7}\times 500\times 500\times \pi\times 0.05}{2} = 25\,mH$

37. (a) Induced $e.m.f.$ $e = M\frac{di}{dt} \Rightarrow 100\times 10^{-3} = M\left(\frac{10}{0.1}\right)$

$\therefore M = 10^{-3}H = 1\,mH$

38. (c) $\frac{\Delta i}{\Delta t} = \frac{10}{2} = 5\,A/\sec \Rightarrow e = L\frac{\Delta i}{\Delta t} = 0.5\times 5 = 2.5\,volts$

39. (c) Time in which the current will decay to $\frac{1}{e}$ of its steady value is $t = \tau = \frac{L}{R} = \frac{50}{10} = 5$ *seconds*

40. (a)

41. (d) $L \propto N^2$

42. (a) $e_2 = M\frac{di_1}{dt} \Rightarrow i_2R_2 = M\frac{di_1}{dt} \Rightarrow 0.4\times 5 = 0.5\times\frac{di_1}{dt}$

$\Rightarrow \frac{di_1}{dt} = 4\,A/\sec.$

43. (a) $U = \frac{1}{2}Li^2 = \frac{1}{2}\times(50\times 10^{-3})\times(4)^2 = 400\times 10^{-3} = 0.4\,J$

44. (b) $e = -L\left(\frac{di}{dt}\right) \Rightarrow 8 = -L\times\left(-\frac{2}{0.05}\right) \Rightarrow L = 0.2H$

45. (b) $U = \frac{1}{2}Li^2$ i.e. $\frac{U_2}{U_1} = \left(\frac{i_2}{i_1}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4} \Rightarrow U_2 = \frac{1}{4}U_1$

46. (a, b, c, d)

47. (c) $|e| = L\frac{di}{dt} \Rightarrow 220 = L\times\frac{10}{0.5} \Rightarrow L = 11\,H$

48. (b)

49. (d) $t = \tau = \frac{L}{R} = \frac{2.5}{0.5} = 5$ sec

50. (c) $L = \mu_0\frac{N^2}{l}A$. When N and l are doubled. L is also doubled.

51. (c) Energy $= \frac{1}{2}LI^2 = \frac{1}{2}\times 100\times 10^{-3}\times 1^2 = 0.05\,J$

52. (b) $e = -M\frac{di}{dt} = -5\times\frac{(-5)}{10^{-3}} = 25000\,V$

53. (a) $L \propto n$ (Number of turns), For straight conductor $n = 0$, hence $L = 0$.

54. (a) $\Delta\phi = L\Delta I \Rightarrow L = \frac{\Delta\phi}{\Delta I} = \frac{2\times 10^{-2}}{0.01} = 2H$

55. (a) $e = L\frac{di}{dt} \Rightarrow 100 = L\times\frac{4}{0.1} \Rightarrow L = 2.5\,H$

56. (a) The inductances are in parallel $\Rightarrow L_{eq} = \frac{L}{3} = \frac{3}{3} = 1\,H$

57. (a) $|e| = M\frac{di}{dt} \Rightarrow 8\times 10^{-3} = M\times 3 \Rightarrow A_1 = 2.66mH$

58. (d) $|e| = L\frac{di}{dt} \Rightarrow 10 = L\times\frac{10}{1} \Rightarrow L = 1H$

59. (a) $N\phi = Li \Rightarrow \phi = \frac{Li}{N} = \frac{8\times 10^{-3}\times 5\times 10^{-3}}{400} = 10^{-7} = \frac{\mu_0}{4\pi}wb$

60. (b) According to Lenz's law.

61. (d) $N\phi = Li \Rightarrow \frac{Nd\phi}{dt} = \frac{Ldi}{dt} \Rightarrow NB\frac{dA}{dt} = \frac{Ldi}{dt}$

$\Rightarrow \frac{1\times 1\times 5}{10^{-3}} = L\times\left(\frac{2-1}{2\times 10^{-3}}\right) \Rightarrow L = 10H$

62. (b) $L = \frac{\mu_0 N^2 A}{l} = \frac{4\pi\times 10^{-7}\times(500)^2\times 20\times 10^{-4}}{0.5} = 1.25\,mH$

63. (a) $L_S = L_1 + L_2 = 10H$ ..... (i)

$L_P = \frac{L_1L_2}{L_1 + L_2} = 2.4H$ ..... (ii)

On solving (i) and (ii) $L_1L_2 = 24$ ..... (iii)

Also $(L_1 - L_2)^2 = (L_1 + L_2)^2 - 4L_1L_2$

$\Rightarrow (L_1 - L_2)^2 = (10)^2 - 4\times 24 = 4 \Rightarrow L_1 - L_2 = 2H$

64. (d) $e = L\frac{di}{dt} \Rightarrow 12 = L\times\frac{45}{60} \Rightarrow L = 16H$

65. (a) $|e| = L\frac{di}{dt} \Rightarrow 1 = \frac{L\times\{10 - (-10)\}}{0.5} \Rightarrow L = 25mH$

66. (d) $U = \frac{1}{2}Li^2 \Rightarrow U = \frac{1}{2}\times 5\times\left(\frac{100}{10}\right)^2 = 250\,J$

67. (c) $\phi = Mi \Rightarrow M = \frac{1.2\times 10^{-2}}{0.01} = 1.2H$

68. (c) $U = \frac{1}{2}Li^2 \Rightarrow U = \frac{1}{2}\times 40\times 10^{-3}\times(2)^2 = 0.08\,J$

69. (c) $L \propto N^2$

70. (b) $N_2\phi_2 = Mi_1 \Rightarrow 9\times10^{-5} = M\times 3 \Rightarrow M = 3\times10^{-5}\,H$

71. (a) $|e| = L\frac{di}{dt} \Rightarrow 20 = L\times\frac{(18-2)}{0.05} \Rightarrow L = 62.5\,mH$

72. (b) $|e| = L\frac{di}{dt} \Rightarrow |e| = 10\times10^{-6}\times\frac{1}{10} = 1\mu V$

73. (c)

74. (b) $\phi_T = Li \Rightarrow L = \frac{10^{-5}}{5\times10^{-3}} = 2mH$

75. (a) $L \propto N^2$

76. (c) $e = -L\frac{di}{dt}$, since current decreases so $\frac{di}{dt}$ is negative, hence $e = -5\times(-2) = +10V$

77. (c) $e = L\frac{di}{dt} \Rightarrow e = 0.1\times 200 = 20V$

78. (c) $e = M\frac{di}{dt} \Rightarrow e = 0.1\times\frac{(20-0)}{0.02} = 100V$

79. (c) $L = \frac{\mu_0 N^2 A}{l} = \frac{4\pi\times10^{-7}\times(1000)^2\times10\times10^{-4}}{1}$

=1.256 mH

80. (d) In secondary e.m.f. induces only when current through primary changes.

81. (b)

82. (c)

83. (a) $e = L\frac{di}{dt} \Rightarrow 8 = L\times\frac{(2-(-2))}{0.05} \Rightarrow L = 0.1H$

84. (b) $U = \frac{1}{2}Li^2 = \frac{1}{2}L\left(\frac{E}{R}\right)^2 = \frac{1}{2}\times5\times\left(\frac{100}{20}\right)^2 = 62.50J$

85. (a)

86. (a)

87. (a) $e = -L\frac{di}{dt} \Rightarrow 0.4 = -\frac{L(0.2-1)}{10} \Rightarrow L = 5\,H$

88. (c) $|e| = L\frac{di}{dt} \Rightarrow 30 = L\times\frac{(6-0)}{0.3} \Rightarrow L = 1.5\,H$

89. (b) $i = i_0\left(1-e^{-\frac{Rt}{L}}\right) \Rightarrow \frac{di}{dt} = -i_0\left(-\frac{R}{L}\right)e^{-\frac{Rt}{L}} = \frac{i_0 R}{L}.e^{-\frac{Rt}{L}}$

At $t = 0$; $\frac{di}{dt} = \frac{i_0 R}{L} = \frac{E}{L} \Rightarrow 4 = \frac{E}{20} \Rightarrow E = 80\,V$

90. (d) $N\phi = Li \Rightarrow 100\times10^{-5} = L\times5 \Rightarrow L = 0.2\,mH.$

91. (d) When the two coils are joined in series such that the winding of one is opposite to the other, then the emf produced in first coil is 180° out of phase of the emf produced in second coil.

Thus, emf produced in first coil is negative and the emf produced in second coil is positive so, net inductance is

$L = L_1 + L_2 = L + L \Rightarrow L = -\frac{\phi}{i} + \frac{\phi}{i} = 0$

92. (a) $e = M\frac{di}{dt} \Rightarrow 1.5 = M\times\frac{30}{0.1} \Rightarrow M = 0.05\,H$

93. (d)

94. (c) Current in B_1 will promptly become zero while current in B_2 will slowly tend to zero.

95. (b)

96. (c) When battery disconnected current through the circuit start decreasing exponentially according to $i = i_0 e^{-Rt/L}$

$\Rightarrow 0.37 i_0 = i_0 e^{-Rt/L} \Rightarrow 0.37 = \frac{1}{e} = e^{-Rt/L} \Rightarrow t = \frac{L}{R}$

97. (a) Current at any instant of time t after closing an L-R circuit is given by $I = I_0\left[1-e^{\frac{-R}{L}t}\right]$

Time constant $t = \frac{L}{R}$

$\therefore I = I_0\left[1-e^{\frac{-R}{L}\times\frac{L}{R}}\right] = I_0(1-e^{-1}) = I_0\left(1-\frac{1}{e}\right)$

$= I_0\left(1-\frac{1}{2.718}\right) = 0.63 I_0 = 63\%$ of I_0

98. (c) $i = \frac{V}{R} = \frac{10}{2} = 5A$

$U = \frac{1}{2}Li^2 = \frac{1}{2}\times2\times25 = 25\,J$

99. (d)

100. (d) Time constant $= \frac{L}{R} = \frac{40}{8} = 5$ sec.

101. (b) $t = \tau = \frac{L}{R} = \frac{60}{30} = 2\,\text{sec}.$

102. (c)

103. (b)

104. (a) $\nu_0 = \frac{1}{2\pi\sqrt{(0.25)\times(0.1\times10^{-6})}} = \frac{10^4}{9.93} = 1007\,Hz$

105. (c) $\nu_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\times3.14\sqrt{5\times10^{-4}\times20\times10^{-6}}}$

$\nu_0 = \frac{10^4}{6.28} = 1592\,Hz$

106. (d) $i = i_0\left(1-e^{\frac{-Rt}{L}}\right) \Rightarrow$ For $i = \frac{i_0}{2}$, $t = 0.693\frac{L}{R}$

$\Rightarrow t = 0.693\times\frac{300\times10^{-3}}{2} = 0.1\,sec$

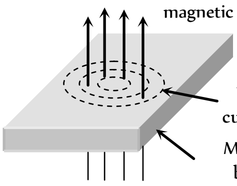
107. (c) $|e| = L\left|\frac{di}{dt}\right| = 0.5 \times \frac{10}{2} = 2.5V$

108. (c) Time period of LC circuit oscillations

$T = 2\pi\sqrt{LC} \Rightarrow$ dimensions of $\sqrt{LC}$ is Time.

Application of EMI (Motor, Dynamo, Transformer...)

1. (b) Hot wire ammeter is not based on the phenomenon of electromagnetic induction.
2. (d)
3. (c) Direction of eddy currents is given by Lenz's rule.



4. (c) In a generator. e.m.f. is induced according as Lenz's rule.
5. (a)
6. (d)
7. (a) Circulation of eddy currents is prevented by use of laminated core.
8. (a)
9. (c)
10. (a)
11. (b) $e \propto \omega$
12. (b)
13. (a) Rotation of magnet in the dynamo creates the variable flux which in turn produces the induced current.
14. (b)
15. (b) With the increasing speed, ω increases. Thus current reduces due to increase in the back e.m.f.

Moreover $i = \frac{V - K\omega}{R}$. More ω will lead to the lesser current.

16. (c) Commutator converts ac into fluctuating dc.
17. (d) Only ac dynamo have slip rings.
18. (b) $e \propto \frac{d\phi}{dt}$; if $\phi \rightarrow$ maximum then $e \rightarrow$ minimum.
19. (d)
20. (c) Motor e.m.f. equation $E_b = V - I_a R_a$

At starting $E_b = 0$, so I_a will be maximum.

21. (d) $i = \frac{E-e}{R} \Rightarrow 1.5 = \frac{220 - e}{20} \Rightarrow e = 190\ V$
22. (d)
23. (d) $e_0 = \omega NBA = (2\pi\nu)\ NBA$

$= 2 \times 3.14 \times 1000 \times 5000 \times 0.2 \times 0.25 = 157\ kV$

24. (a) Back emf $\propto$ speed of motor.
25. (d)
26. (b)
27. (a) Efficiency $\eta = 50\%$ So $e = E/2$

and $i = \frac{E-e}{R} \Rightarrow i = \frac{E - E/2}{R} = \frac{E}{2R}$

$\Rightarrow R = \frac{E}{2i} = \frac{60}{2 \times 10} = 3\Omega$

28. (c)
29. (c) $\eta = \frac{e}{E} \times 100 \Rightarrow e = 0.3\ E$

Now, $i = \frac{E-e}{R} \Rightarrow 12 = \frac{50 - (0.3 \times 50)}{R} \Rightarrow R = 2.9\Omega$

30. (a) $i = \frac{E-e}{R} = \frac{220 - 210}{2} = \frac{10}{2} = 5A$
31. (a)
32. (c) A transformer is a device to convert alternating current at high voltage into low voltage and *vice-versa.*
33. (b) We know that for step down transformer

$V_p > V_s$ but $\frac{V_p}{V_s} = \frac{i_s}{i_p}$; $\therefore i_s > i_p$

Current in the secondary coil is greater than the primary.

34. (c)
35. (a)
36. (b) Transformation ratio $k = \frac{N_s}{N_p} = \frac{V_s}{V_p}$

For step-up transformers, $N_s > N_p$ *i.e.* $V_s > V_p$, hence $k > 1$.

37. (a) $\frac{V_p}{V_s} = \frac{N_p}{N_s} \Rightarrow N_p = \left(\frac{220}{2200}\right) 2000 = 200$
38. (c) Provided no power looses, being assumed.
39. (a) $\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow \frac{200}{100} = \frac{V_s}{120} \Rightarrow V_s = 240\ V$

also $\frac{V_s}{V_p} = \frac{i_p}{i_s} \Rightarrow \frac{240}{120} = \frac{10}{i_s} \Rightarrow i_s = 5\ A$

40. (c) $\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow \frac{1}{20} = \frac{V_s}{2400} \Rightarrow V_s = 120\ V$

For 100% efficiency $V_s i_s = V_p i_p$

$\Rightarrow 120 \times 80 = 2400\ i_p \Rightarrow i_p = 4\ A$

41. (b) $\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{500}{2500} = \frac{1}{5} \Rightarrow V_p = \frac{200}{5} = 40\ V$

Also $i_p V_p = i_s V_s \Rightarrow i_p = i_s \frac{V_s}{V_p} = 8 \times 5 = 40\ A$

42. (a) $\frac{N_s}{N_p}=\frac{V_s}{V_p}\Rightarrow\frac{250}{100}=\frac{V_s}{28/\sqrt{2}}\Rightarrow V_s=50\ V$

43. (d) $\eta=\frac{V_s i_s}{V_p i_p}\times100=\frac{11\times90}{220\times5}\times100=90\ \%$

44. (d) Transformer doesn't work on dc

45. (b)

46. (b)

47. (a) For 100% efficient transformer

$V_s i_s=V_p i_p\Rightarrow\frac{V_s}{V_p}=\frac{i_p}{i_s}=\frac{N_s}{N_p}\quad\Rightarrow\frac{i_p}{4}=\frac{25}{100}\Rightarrow i_p=1\ A$

48. (a)

49. (d) $\frac{N_s}{N_p}=\frac{i_p}{i_s}\Rightarrow i_s=i_p\times\frac{N_p}{N_s}=2\times\frac{100}{20}=10\ A$

50. (a) $\frac{V_s}{V_p}=\frac{i_p}{i_s}\Rightarrow i_p=\frac{11000\times2}{220}=100\ A$

51. (c) $\frac{N_p}{N_s}=\frac{V_p}{V_s}=\frac{i_s}{i_p}$. The transformer is step-down type, so primary coil will have more turns. Hence

$\frac{5000}{500}=\frac{2200}{V_s}=\frac{i_s}{4}\Rightarrow V_s=220\ V,\ i_s=40\ amp$

52. (b) $i_s=\frac{P_s}{V_s}=\frac{4.4\times10^3}{11\times10^3}=0.4\ A$

53. (b) $\frac{N_s}{N_p}=\frac{V_s}{V_p}=\frac{22000}{220}=100$

54. (b)

55. (a)

56. (b) $\frac{N_s}{N_p}=\frac{i_p}{i_s}$ or $\frac{25}{1}=\frac{i_p}{2}\Rightarrow i_p=50A$

57. (c) $\frac{V_s}{V_p}=\frac{N_s}{N_p}\Rightarrow V_s=\frac{N_s}{N_p}\times V_p=\frac{10}{200}\times240=12\ volts$

58. (a) $\frac{V_s}{V_p}=\frac{N_s}{N_p}\Rightarrow\frac{V_s}{20}=\frac{5000}{500}\quad\Rightarrow V_s=200\ V$

Frequency remains unchanged.

59. (a) $\frac{V_s}{V_p}=\frac{N_s}{N_p}=k\Rightarrow\frac{V_s}{30}=\frac{3}{2}\Rightarrow V_s=45\ V$

60. (a) $\frac{N_s}{N_p}=\frac{i_p}{i_s}\Rightarrow\frac{i_p}{i_s}=\frac{4}{5}$

61. (d) $V_p=200\ V,\ V_s=6V$

$P_{out}=V_s i_s\Rightarrow30=6\times i_s\Rightarrow i_s=5\ A$

From $\frac{V_s}{V_p}=\frac{i_p}{i_s}\Rightarrow\frac{6}{200}=\frac{i_p}{5}\Rightarrow i_p=0.15\ A$

62. (b) $\frac{E_p}{E_s}=\frac{N_p}{N_s}\Rightarrow\frac{200}{E_s}=\frac{100}{20}\Rightarrow E_s=40\ V$

63. (d) Since all the losses are neglected.

So $P_{out}=P_{in}$

64. (c)

65. (b) $\frac{i_p}{i_s}=\frac{N_s}{N_p}\Rightarrow\frac{i_p}{4}=\frac{1}{100}\Rightarrow i_p=0.04\ A$

66. (b) $N_p:N_s=1:10$ and $V_s=0.5\times200=100\ V$

$\frac{V_s}{V_p}=\frac{N_s}{N_p}\Rightarrow\frac{100}{V_p}=\frac{10}{1}\Rightarrow V_p=10\ V$

$\frac{i_p}{i_s}=\frac{N_s}{N_p}\Rightarrow\frac{i_p}{0.5}=\frac{10}{1},\ i_p=5\ amp$

67. (c)

68. (d) $\frac{V_p}{V_s}=\frac{i_s}{i_p}\Rightarrow\frac{220}{22000}=\frac{i_s}{5}\Rightarrow i_s=0.05\ amp$

69. (b) $\frac{V_p}{V_s}=\frac{i_s}{i_p}\Rightarrow i_s=4\times\frac{140}{280}=2A$

70. (c) $P_s=V_s i_s\Rightarrow1000=V_s\times8\Rightarrow V_s=\frac{1000}{8}$

$\frac{V_p}{V_s}=\frac{N_p}{N_s}\Rightarrow\frac{(1000/8)}{500}=\frac{100}{N_s}\Rightarrow N_s=400$

71. (a) Transformer works on ac only.

72. (b) $\frac{N_s}{N_p}=\frac{V_s}{V_p}=\frac{2200}{220}=\frac{10}{1}$

73. (c) Transformation ratio $k=\frac{V_s}{V_p}\Rightarrow\frac{5}{3}=\frac{V_s}{60}\Rightarrow V_s=100\ V$

74. (c) $\frac{N_s}{N_p}=\frac{V_s}{V_p}\Rightarrow\frac{N_s}{600}=\frac{2200}{220}\Rightarrow N_s=6000$

75. (b) For 100% efficiency $V_s i_s=V_p i_p$

$\Rightarrow1100\times2=220\times i_p\Rightarrow i_p=10A$

76. (c)

77. (c) Amplitude of the current $i_0=\frac{e_0}{R}=\frac{\omega NBA}{R}=\frac{2\pi\nu NB(\pi r^2)}{R}$

$i_0=\frac{2\pi\times1\times10^{-2}\times\pi(0.3)^2}{\pi^2}=6\times10^{-3}A=6mA$

78. (a) $\frac{N_s}{N_p}=\frac{i_p}{i_s}\Rightarrow\frac{2000}{500}=\frac{48}{i_s}\Rightarrow i_s=12A$

79. (a) $U=\frac{1}{2}Li^2=\frac{1}{2}\times100\times10^{-3}\times(10)^2=5J$

80. (c) As $\frac{I_P}{I_s}=\frac{n_p}{n_s}$; i.e. $\frac{3}{I_s}=\frac{3}{2}\Rightarrow I_s=2A$.

81. (a)

82. (b)

83. (a) $\eta=\frac{\text{outputpower}}{\text{inputpower}}=\frac{E_s I_s}{E_p I_p}\Rightarrow\frac{80}{100}=\frac{200\times I_s}{4\times10^3}$

$\Rightarrow I_S=\frac{80}{100}\times\frac{4\times1000}{200}=16A$

Also, $E_p I_p = 4KW \Rightarrow I_p = \frac{4\times 10^3}{100} = 40A$

84. (a) $\frac{N_P}{N_S} = \frac{I_S}{I_P} \Rightarrow I_P = \frac{N_S}{N_P} I_S = \frac{10}{1} \times 2 = 20\ A$.

85. (b)

86. (a) $\eta = \frac{\text{Output}}{\text{Input}} \Rightarrow \frac{80}{100} = \frac{20\times 20}{1000\times i_l}$

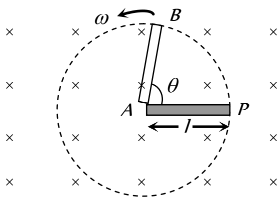
$\Rightarrow i_l = \frac{20\times 120\times 100}{1000\times 80} = 3A$.

Critical Thinking Questions

1. (d) If electron is moving from left to right, the flux linked with the loop (which is into the page) will first increase and then decrease as the electron passes by. So the induced current in the loop will be first anticlockwise and will change direction as the electron passes by.

2. (a) If in time *t* the rod turns by an angle θ, the area generated by the rotation of rod will be

$= \frac{1}{2} l \times l\theta = \frac{1}{2} l^2\theta$



So the flux linked with the area generated by the rotation of rod

$$\phi = B\left(\frac{1}{2} l^2\theta\right)\cos 0 = \frac{1}{2} Bl^2\theta = \frac{1}{2} Bl^2\omega t$$

And so $e = \frac{d\phi}{dt} = \frac{d}{dt}\left(\frac{1}{2} Bl^2\omega t\right) = \frac{1}{2} Bl^2\omega$

3. (a, c, d) From Faraday's Law, the induced voltage $V \propto L$

rate of change of current is constant $\left(V = -L\frac{di}{dt}\right)$

$\therefore \frac{V_2}{V_1} = \frac{L_2}{L_1} = \frac{2}{8} = \frac{1}{4} \Rightarrow \frac{V_1}{V_2} = 4$

Power given to the two coils is same, *i.e.,*

$V_1 i_1 = V_2 i_2 \Rightarrow \frac{i_1}{i_2} = \frac{V_2}{V_1} = \frac{1}{4}$

Energy stored $W = \frac{1}{2} Li^2$

$\Rightarrow \frac{W_2}{W_1} = \left(\frac{L_2}{L_1}\right)\left(\frac{i_2}{i_1}\right)^2 = \left(\frac{1}{4}\right)(4)^2 = 4 \Rightarrow \frac{W_1}{W_2} = \frac{1}{4}$

4. (b) $i = i_0(1 - e^{-Rt/L})$

$i_0 = \frac{E}{R}$ (Steady current) when $t = \infty$

$i_\infty = \frac{E}{R}(1 - e^{-\infty}) = \frac{5}{10} = 1.5$

$i_1 = 1.5(1 - e^{-R/L}) = 1.5(1 - e^{-2}) \Rightarrow \frac{i_\infty}{i_1} = \frac{1}{1 - e^{-2}} = \frac{e^2}{e^2 - 1}$

5. (d) Mutual inductance between two coil in the same plane with their centers coinciding is given by

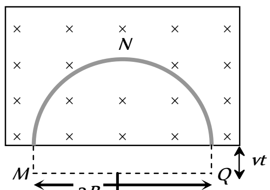
$M = \frac{\mu_0}{4\pi}\left(\frac{2\pi^2 R_2^2 N_1 N_2}{R_1}\right)$ *henry.*

6. (d) Rate of decrease of area of the semicircular ring

$-\frac{dA}{dt} = (2R)\,V$

According to Faraday's law of induction induced emf

$e = -\frac{d\phi}{dt} = -B\frac{dA}{dt} = -B(2RV)$



The induced current in the ring must generate magnetic field in the upward direction. Thus *Q* is at higher potential.

7. (b) Induced potential difference between two ends $= Blv = B_H lv$

$= 3\times 10^{-5} \times 2\times 50 = 30\times 10^{-3} volt = 3\,millivolt$

By Fleming's right hand rule, end *A* becomes positively charged.

8. (b) Effective length between *A* and *B* remains same.

9. (d) Circular loop behaves as a magnetic dipole whose one surface will be *N*-pole and another will be *S*-pole. Therefore magnetic lines a force emerges from *N* will meet at *S*. Hence total magnetic flux through *x-y* plane is zero.

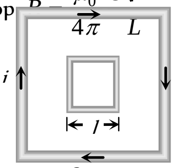
10. (c) If the current increases with time in loop *A*, then magnetic flux in *B* will increase. According to Lenz's law, loop –*B* is repelled by loop –*A*.

11. (b) $e = M\frac{di}{dt} = 0.005 \times \frac{d}{dt}(i_0 \sin\omega t) = 0.005 \times i_0\omega\cos\omega t$

$\therefore e_{max} = 0.005 \times 10 \times 100\pi = 5\pi$

12. (b) Magnetic field produced due to large loop $B = \frac{\mu_0}{4\pi}\frac{8\sqrt{2}i}{L}$

Flux linked with smaller loop



$\phi = B(l^2) = \frac{\mu_0}{4\pi}\frac{8\pi i l^2}{L}$

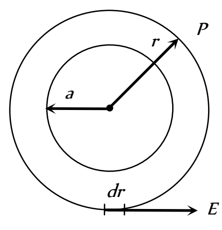
$\therefore \phi = Mi \Rightarrow M = \frac{\phi}{i} = \frac{\mu_0}{4\pi}.\frac{8\sqrt{2}l^2}{L} \Rightarrow M \propto \frac{l^2}{L}$

13. (b) Rate of work $= \frac{W}{t} = P = Fv$; also $F = Bil = B\left(\frac{Bvl}{R}\right)l$

$\Rightarrow P = \frac{B^2v^2l^2}{R} = \frac{(0.5)^2\times(2)^2\times(1)^2}{6} = \frac{1}{6}W$

14. (b) Construct a concentric circle of radius *r*. The induced electric field (*E*) at any point on the circle is equal to that at *P*. For this circle

$\oint \vec{E}.d\vec{l} = \left|\frac{d\phi}{dt}\right| = A\left|\frac{dB}{dt}\right|$



or $E\times(2\pi r) = \pi a^2.\left|\frac{dB}{dt}\right|$

$\Rightarrow E = \frac{a^2}{2r}\left|\frac{dB}{dt}\right| \Rightarrow E \propto \frac{1}{r}$

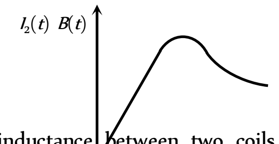
15. (d) Using *k*, *k* etc, as different constants.

$I_1(t) = k_1[1 - e^{-t/\tau}],\ B(t) = k_2 I_1(t)$

$$I_2(t) = k_3 \frac{dB(t)}{dt} = k_4 e^{-t/\tau}$$

$$\therefore I_2(t)\, B(t) = k_5 [1 - e^{-t/\tau}][e^{-t/\tau}]$$

This quantity is zero for $t = 0$ and $t = \infty$ and positive for other value of t. It must, therefore, pass through a maximum.



16. (a) The mutual inductance between two coils depends on their degree of flux linkage, *i.e.*, the fraction of flux linked with one coil which is also linked to the other coil. Here, the two coils in arrangement (a) are placed with their planes parallel. This will allow maximum flux linkage.

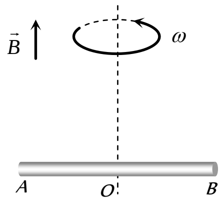
17. (d) Both AD and BC are straight conductors moving in a uniform magnetic field and emf will be induced in both. This will cause electric fields in both, but no net current flows in the circuit.

18. (d) Potential difference between

O and A is $V_0 - V_A = \frac{1}{2} Bl^2 \omega$

O and B is $V_0 - V_B = \frac{1}{2} Bl^2 \omega$

so $V_A - V_B = 0$



19. (c) $i = i_0 \left(1 - e^{\frac{-Rt}{L}}\right) \Rightarrow \frac{di}{dt} = \frac{d}{dt} i_0 - \frac{d}{dt} i_0 e^{\frac{-Rt}{L}}$

$$\Rightarrow \frac{di}{dt} = 0 - i_0 \left(-\frac{R}{L}\right) e^{-\frac{Rt}{L}} = \frac{i_0 R}{L} e^{-\frac{Rt}{L}}$$

Initially, $t = 0 \Rightarrow \frac{di}{dt} = \frac{i_0 \times R}{L} = \frac{E}{L} = \frac{5}{2} = 2.5\ amp/sec.$

20. (d) When switch S is closed magnetic field lines passing through Q increases in the direction from right to left. So, according to Lenz's law induced current in Q *i.e.* I_{Q_1} will flow in such a direction so that the magnetic field lines due to I_{Q_2} passes from left to right through Q. This is possible when I_{Q_1} flows in anticlockwise direction as seen by E. Opposite is the case when switch S is opened *i.e.* I_{Q_2} will be clockwise as seen by E.

21. (b) Power $P = \frac{e^2}{R}$; hence $e = -\left(\frac{d\phi}{dt}\right)$ where $\phi = NBA$

$\therefore e = -NA\left(\frac{dB}{dt}\right)$ Also $R \propto \frac{l}{r^2}$

Where R = resistance, r = radius, l = Length

$$\therefore P \propto \frac{N^2 r^2}{l} \Rightarrow \frac{P_1}{P_2} = 1$$

22. (a) $H = \frac{V^2 t}{R}$ and $V = \frac{N(B_2 - B_1) A \cos\theta}{t}$

$$V = \frac{1 \times (1-2) \times 0.01 \times \cos 0^o}{10^{-3}} = 10\ V$$

So, $H = \frac{(10)^2 \times 10^{-3}}{0.01} = 10\ J$

23. (d) Peak current in the circuits $i_0 = \frac{12}{6} = 2A$

Current decreases from $2A$ to $1A$ *i.e.,* becomes half in time

$$t = 0.693 \frac{L}{R} = 0.693 \times \frac{8.4 \times 10^{-3}}{6} = 1 millisec.$$

24. (a) Induced current in the circuit $i = \frac{Bvl}{R}$

Magnetic force acting on the wire $F_m = Bil = B\left(\frac{Bvl}{R}\right) l$

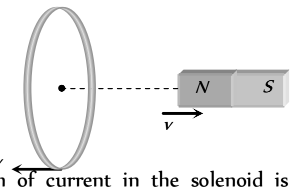
$\Rightarrow F_m = \frac{B^2 vl^2}{R}$ External force needed to move the rod with constant velocity

$$(F_m) = \frac{B^2 vl^2}{R} = \frac{(0.15)^2 \times (2) \times (0.5)^2}{3} = 3.75 \times 10^{-3} N$$

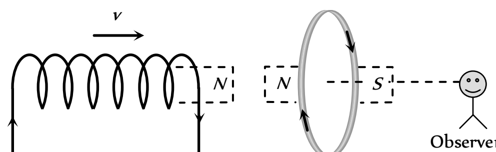
25. (c) According to Lenz's Law

26. (b) $\left(\frac{d\phi}{dt}\right)_{\text{In first case}} = e$

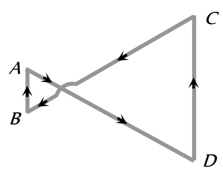
$$\left(\frac{d\phi}{dt}\right)_{\text{relative velocity} 2v} = 2\left(\frac{d\phi}{dt}\right)_{\text{I case}} = 2e$$



27. (b) The direction of current in the solenoid is anti-clockwise as seen by observer. On displacing it towards the loop a current in the loop will be induced in a direction so as to oppose the approach of solenoid. Therefore the direction of induced current as observed by the observer will be clockwise.



28. (a) Inward magnetic field (×) increasing. Therefore, induced current in both the loops should be anticlockwise. But as the area of loop on right side is more, induced *emf* in this will be more compared to the left side loop $\left(e = -\frac{d\phi}{dt} = -A.\frac{dB}{dt}\right)$. Therefore net current in the complete loop will be in a direction shown below. Hence only option (a) is correct.

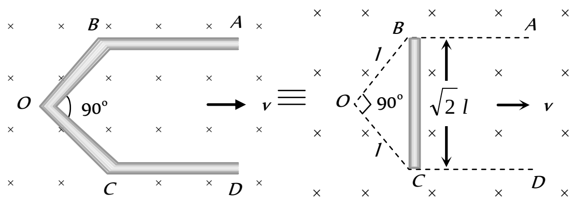


29. (b) Equivalent resistance of the given Wheatstone bridge circuit (balanced) is 3Ω so total resistance in circuit is $R = 3 + 1 = 4\Omega$. The emf induced in the loop $e = Bvl$.

So induced current $i = \frac{e}{R} = \frac{Bvl}{R}$

$\Rightarrow 10^{-3} = \frac{2 \times v \times (10 \times 10^{-2})}{4} \Rightarrow v = 2 cm/sec.$

30. (b) There is no induced emf in the part AB and CD because they are moving along their length while emf induced between B and C *i.e.* between A and D can be calculated as follows

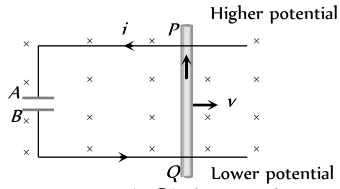


Induced emf between B and C = Induced emf between A and B

$= Bv(\sqrt{2}\, l) = 1 \times 1 \times 1 \times \sqrt{2} = 1.41 volt.$

31. (a) $Q = CV = C\,(Bvl) = 10 \times 10^{-6} \times 4 \times 2 \times 1 = 80\ \mu C$

According to Fleming's right hand rule induced current flows from Q to P. Hence P is at higher potential and Q is at lower potential. Therefore A is positively charged and B is negatively charged.



32. (b) If resistance is constant (10Ω) then steady current in the circuit $i = \frac{5}{10} = 0.5\ A$. But resistance is increasing it means current through the circuit start decreasing. Hence inductance comes in picture which induces a current in the circuit in the same direction of main current. So $i > 0.5\ A$.

33. (d) $P = \frac{e^2}{R}$; $e = -\frac{d}{dt}(BA) = A\frac{d}{dt}(B_o e^{-t}) = AB_o e^{-t}$

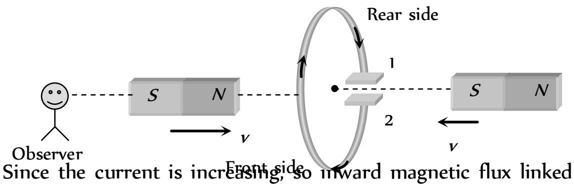
$\Rightarrow P = \frac{1}{R}(AB_o e^{-t})^2 = \frac{A^2 B_o^2 e^{-2t}}{R}$

At the time of starting $t = 0$ so $P = \frac{A^2 B_o^2}{R}$

$\Rightarrow P = \frac{(\pi r^2)^2 B_o^2}{R} = \frac{B_o^2 \pi^2 r^4}{R}$

34. (c) When key k is pressed, current through the electromagnet start increasing *i.e.* flux linked with ring increases which produces repulsion effect.

35. (b) By the movement of both the magnets, current will be anticlockwise, as seen from left side *i.e.* plate 1 will be positive and 2 will be negative.



36. (a) Since the current is increasing, so inward magnetic flux linked with the ring also increasing (as viewed from left side). Hence induced current in the ring is anticlockwise, so end x will be positive.

Induced emf $|e| = A\frac{dB}{dt} = A\frac{d}{dt}(B_o + \alpha t) \Rightarrow |e| = A\alpha$

37. (a) Current in the inner coil $i = \frac{e}{R} = \frac{A_1}{R_1}\frac{dB}{dt}$

length of the inner coil $= 2\pi a$

so it's resistance $R_1 = 50 \times 10^{-3} \times 2\pi\,(a)$

$\therefore i_1 = \frac{\pi a^2}{50 \times 10^{-3} \times 2\pi\,(a)} \times 0.1 \times 10^{-3} = 10^{-4} A$

According to lenz's law direction of i is clockwise.

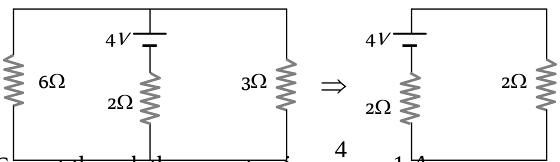
Induced current in outer coil $i_2 = \frac{e_2}{R_2} = \frac{A_2}{R_2}\frac{dB}{dt}$

$\Rightarrow i_2 = \frac{\pi b^2}{50 \times 10^{-3} \times (2\pi b)} \times 0.1 \times 10^{-3} = 2 \times 10^{-4} A\,(CW)$

38. (c) Motional emf $e = Bvl \Rightarrow e = 2 \times 2 \times 1 = 4\ V$

This acts as a cell of emf $E = 4\ V$ and internal resistance $r = 2\Omega$.

This simple circuit can be drawn as follows



Current through the connector $i = \frac{4}{2+2} = 1\ A$

$\therefore$ magnetic force on connector $F_m = Bil = 2 \times 1 \times 1 = 2\ N$

(Towards left)

39. (b) Due to magnetic field, wire will experience an upward force $F = Bil = B\left(\frac{Bvl}{R}\right)l \Rightarrow F = \frac{B^2 vl^2}{R}$

If wire slides down with constant velocity then

$F = mg \Rightarrow \frac{B^2 vl^2}{R} = mg \Rightarrow v = \frac{mgR}{B^2 l^2}$

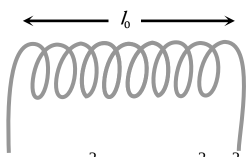
40. (c) By using $e = \frac{1}{2}Bl^2\omega$

For part AO; $e_{OA} = e_O - e_A = \frac{1}{2}Bl^2\omega$

For part OC; $e_{OC} = e_O - e_C = \frac{1}{2}B(3l)^2\omega$

$\therefore e_A - e_C = 4\ Bl^2\omega$

41. (c) Suppose solenoid has N turns, each of radius r and length of wire is l.



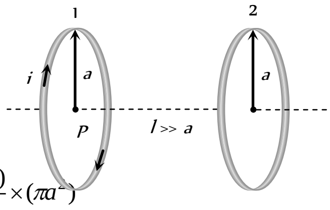
It's self inductance $L = \frac{\mu_0 N^2 A}{l_0} = \frac{\mu_0 N^2 \pi r^2}{l_0}$ .... (i)

Also length of the wire $l = N \times 2\pi r$

$\Rightarrow N^2 r^2 = \frac{l^2}{4\pi^2}$ .... (ii)

From equation (i) and (ii) $l = \sqrt{\dfrac{4\pi L l_o}{\mu_o}}$

42. (d) Magnetic field at the location of coil (2) produced due to coil (1)



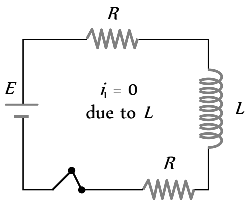
$B_1 = \dfrac{\mu_o}{4\pi}.\dfrac{2M}{l^3}$

Flux linked with coil (2)

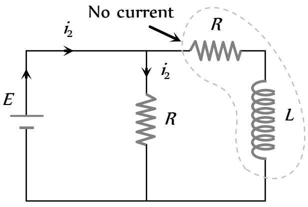
$\phi_2 = B_1 A_2 = \dfrac{\mu_o}{4\pi}\dfrac{2i(\pi a^2)}{l^3} \times (\pi a^2)$

Also $\phi_2 = Mi \Rightarrow M = \dfrac{\mu_o \pi a^4}{2l^3}$

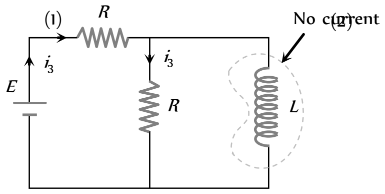
43. (a) Just before closing the switch.



(1)



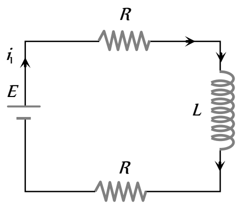
(2)



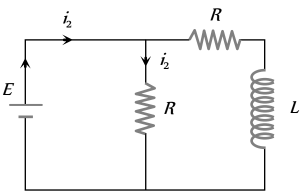
(3)

$i_1 = 0,\ i_2 = \dfrac{E}{R},\ i_3 = \dfrac{E}{2R}$ so $i_2 > i_3 > i_1$ $(i_1 = 0)$

After a long time closing the switch

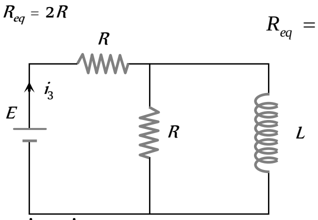


(1)



(2)

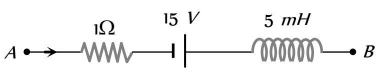
$R_{eq} = 2R$ $R_{eq} = \dfrac{R}{2}$



Hence $i_2 > i_3 > i_1$ (3)

44. (c) By using Kirchoff's voltage law

$V_A - iR + E - L\dfrac{di}{dt} = V_B \Rightarrow V_B - V_A = 15\ volt.$



45. (d) The rate of increase of current

$= \dfrac{di}{dt} = \dfrac{d}{dt} i_0\left(1 - e^{-Rt/L}\right) = \dfrac{d}{dt} i_0 - \dfrac{d}{dt} i_0 e^{-Rt/L}$

$= 0 - i_0 e^{-Rt/L}.\dfrac{d}{dt}\left(-\dfrac{Rt}{L}\right) = i_0 \dfrac{R}{L} e^{-Rt/L}$

$= \dfrac{50}{180} \times \dfrac{180}{5\times10^{-3}} \times e^{-(180\times0.001)/(5\times10^{-3})} = 10^4 \times e^{-36}\ A/\sec$

46. (b) We know that $i = i_o\left[1 - e^{\frac{-Rt}{L}}\right]$ or $\dfrac{3}{4}i_o = i_o\left[1 - e^{-t/\tau}\right]$

(where $\tau = \dfrac{L}{R} =$ time constant)

$\dfrac{3}{4} = 1 - e^{-t/\tau}$ or $e^{-t/\tau} = 1 - \dfrac{3}{4} = \dfrac{1}{4}$

$e^{t/\tau} = 4$ or $\dfrac{t}{\tau} = \ln 4$

$\Rightarrow \tau = \dfrac{t}{\ln 4} = \dfrac{4}{2\ln 2} \Rightarrow \tau = \dfrac{2}{\ln 2} sec.$

47. (b) In a constant magnetic field conducting ring oscillates with a frequency of 100 *Hz.*

i.e. $T = \dfrac{1}{100}$ s, in time $\dfrac{T}{2}$ flux links with coil changes from

BA to zero. $\Rightarrow$ Induced emf = $\dfrac{\text{change in flux}}{\text{time}}$

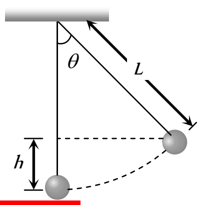
$= \dfrac{BA}{T/2} = \dfrac{2BA}{T} = \dfrac{2B\times\pi r^2}{T} = \dfrac{2\times0.01\times\pi\times1^2}{1/100} = 4\pi V$

Induced electric field along the circle, using Maxwell equation

$\oint E.dl = -\dfrac{d\phi}{dt} = A\dfrac{dB}{dt} = e$

$\Rightarrow E = \dfrac{1}{2\pi r}\times\left(\pi r^2 \times \dfrac{dB}{dt}\right) = \dfrac{e}{2\pi r} = \dfrac{4\pi}{2\pi r} = 2\ V/m$

48. (a)



$\Rightarrow h = L(1 - \cos\theta)$ ....(i)

Maximum velocity at equilibrium is given by

$\therefore\ v^2 = 2gh = 2g\,L(1-\cos\theta) = 2g\,L\left(2\sin^2\dfrac{\theta}{2}\right)$

$\Rightarrow v = 2\sqrt{gL}\,\sin\dfrac{\theta}{2}$

Thus, max. potential difference

$V_{\max} = BvL = B\times 2\sqrt{gL}\,\sin\dfrac{\theta}{2} L = 2BL\sin\dfrac{\theta}{2}(gL)^{1/2}.$

Graphical Questions

1. (d) At B, flux is maximum, so from $|e| = \frac{d\phi}{dt}$ at $B\ |e| = 0$

2. (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.

3. (c) Rate of decay of current between t = 5 ms to 6 ms

$$= \frac{di}{dt} = -(\text{Slope of the line } BC)$$

$$= -\left(\frac{5}{1\times 10^{-3}}\right) = -5\times 10^3\, A/s.$$ Hence induced emf

$$e = -L\frac{di}{dt} = -4.6\times(-5\times 10^3) = 23\times 10^3\, V.$$

4. (b) $e = -M\frac{di}{dt} = -1.5\frac{(1-0)}{(T/4)} = -\frac{6}{T}$, $T = \frac{2\pi}{\omega} = \frac{2\pi}{200} = \frac{\pi}{100}$

$$\Rightarrow |e| = \frac{600}{\pi} = 190.9\, V \simeq 191 V$$

5. (d) When loop enters in field between the pole pieces, flux linked with the coil first increases (constantly) so a constant emf induces, when coil entered completely within the field, no flux change so $e = 0$.

When coil exit out, flux linked with the coil decreases, hence again emf induces, but in opposite direction.

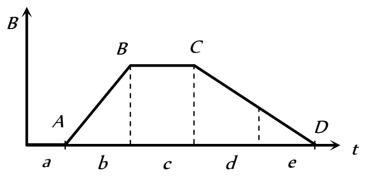
6. (a) $|dq| = \frac{d\phi}{R} = i\,dt =$ Area under $i-t$ graph

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

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

7. (b) Induced emf $e = A\frac{dB}{dt}$

i.e. $e \propto \frac{dB}{dt}$ (= slope of $B-t$ graph)



In the given graph slope of AB > slope of CD, slope in the 'a' region = slope in the 'c' region = 0, slope in the 'd' region = slope in the 'e' region $\neq 0$. That's why $b > (d = e) > (a = c)$

8. (b) $P = Fv = Bil\times v = B\left(\frac{Bvl}{R}\right)l\times v = \frac{B^2v^2l^2}{R} \Rightarrow P \propto v^2$

9. (b) As x increases so $\frac{dB}{dt}$ increases *i.e.* induced emf (e) is negative.

When loop completely entered in the magnetic field, emf = 0

When it exit out x increases but $\frac{dB}{dt}$ decreases *i.e.* e is positive.

10. (c) According to $i-t$ graph, in the first half current is in-creasing uniformly so a constant negative emf induces in the circuit.

In the second half current is decreasing uniformly so a constant positive emf induces

Hence graph (c) is correct

11. (b) $i = i_0\left(1 - e^{-\frac{R}{L}t}\right)$

12. (a) $\frac{di}{dt}$ = slope of $i-t$ graph slope of graph (2) < slope of graph (1) so $\left(\frac{di}{dt}\right)_2 < \left(\frac{di}{dt}\right)_1$

Also $L \propto \frac{1}{(di/dt)} \Rightarrow L_2 > L_1$

13. (b) $\phi = BA = B\times\pi r^2$

$\therefore \phi \propto r^2 \Rightarrow \phi = kr^2$ (k = constant)

$$\therefore e = \frac{d\phi}{dt} = k.2r\frac{dr}{dt}$$

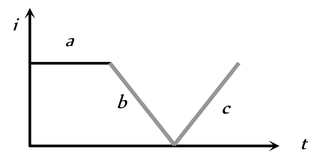
From 0 – 1, r is constant, $\therefore \frac{dr}{dt} = 0$ hence, e = 0

From 1 – 2, $r = \alpha t$, $\therefore \frac{dr}{dt} = \alpha$ hence $e \propto r \Rightarrow e \propto t$

From 2 – 3, again r is constant, $\therefore \frac{dr}{dt} = 0$ hence e = 0

14. (c) Emf induces during 'a' = 0

emf induced during 'b' is constant throughout emf induced during 'c' is constant throughout magnitude of emf induced during 'b' is equal to the magnitude of emf induced during 'c'. But the direction opposite.



15. (a) $U = \frac{1}{2}Li^2$

$$\therefore \text{Rate } = \frac{dU}{dt} = Li\left(\frac{di}{dt}\right)$$

At $t = 0, i = 0\ \therefore$ rate $= 0$

At $t = \infty, i = i_0$ but $\frac{di}{dt} = 0$, therefore rate = 0

16. (c) At the time t = 0, e is max and is equal to E, but current i is zero.

As the time passes, current through the circuit increases but induced emf decreases.

17. (d) If at any instant, current through the circuit is i then applying Kirchoffs voltage law, $iR + e = E \Rightarrow e = E - iR$. Therefore, graph between e and i will be a straight line having negative slope and having a positive intercept.

18. (c) When loop is entering in the field, magnetic flux (*i.e.* $\times$) linked with the loop increases so induced emf in it $e = Bvl = 0.6 \times 10^{-2} \times 5 \times 10^{-2} = 3 \times 10^{-4} V$ (Negative).

When loop completely entered in the field (after 5 *sec*) flux linked with the loop remains constant so $e = 0$.

After 15 *sec*, loop begins to exit out, linked magnetic flux decreases so induced emf $e = 3 \times 10^{-4} V$ (Positive).

19. (a)

Assertion and Reason

1. (b) When a metallic conductor is moved in a magnetic field; magnetic flux is varied. It disturbs the free electrons of the metal and set up an induced emf in it. As there are no free ends of the metal *i.e.* it will be closed in itself so there will be induced current.

2. (b) The relation of induced emf is $e = \frac{Ldi}{dt}$ and current i is given by $i = \frac{e}{R} = \frac{1}{R} \cdot \frac{L.di}{dt} \Rightarrow \frac{di}{dt} = i\frac{R}{L} = \frac{i}{L/R}$.

In order to decreases the rate of increase of current through solenoid. We have to increase the time constant $\frac{L}{R}$.

3. (c) According to Faraday's laws, the conversion of mechanical energy into electrical energy. This is in accordance with the law of conservation of energy. It is also clearly known that in pure resistance, the emf is in phase with the current.

4. (c) Presence of magnetic flux cannot produce current.

5. (e) E.M.F. induces, when there is change in magnetic flux. Faraday did experiment in which, there is relative motion between the coil and magnet, the flux linked with the coil changes and e.m.f. induces.

6. (e) Since both the loops are identical (same area and number of turns) and moving with a same speed in same magnetic field. Therefore same emf is induced in both the coils. But the induced current will be more in the copper loop as its resistance will be lesser as compared to that of the aluminium loop.

7. (a) The inductance coils made of copper will have very small ohmic resistance. Due to change in magnetic flux a large induced current will be produced in such an inductance, which will offer appreciable opposition to the flow of current.

8. (b) Self-inductance of a coil is its property virtue of which the coil opposes any change in the current flowing through it.

9. (c) The manner in which the two coils are oriented, determines the coefficient of coupling between them.

$M = K^2.L_1L_2$

When the two coils are wound on each other, the coefficient of coupling is maximum and hence mutual inductance between the coil is maximum.

10. (a) The induced current in the ring opposes the motion of falling magnet. Therefore, the acceleration of the falling magnet will be less than that due to gravity.

11. (e) As the aircraft flies, magnetic flux changes through its wings due to the vertical component of the earth's magnetic field. Due to this, induced emf is produced across the wings of the aircraft. Therefore, the wings of the aircraft will not be at the same potential.

12. (b) According to Lenz's law, induced emf are in a direction such as to attempt to maintain the original magnetic flux when a change occurs. When the switch is opened, the sudden drop in the magnetic field in the circuit induces an emf in a direction that attempts to keep the original current flowing. This can cause a spark as the current bridges the air gap between the poles of the switch. (The spark is more likely in circuits with large inductance).

13. (b) Mutual inductance is the phenomenon according to which an opposing e.m.f. produce flux in a coil as a result of change in current or magnetic flux linked with a neighboring coil. But when two coils are inductively coupled, in addition to induced e.m.f. produced due to mutual induction, also induced e.m.f. is produced in each of the two coils due to self-induction.

14. (e) Lenz's Law is based on conservation of energy and induced emf always opposes the cause of it *i.e.*, change in magnetic flux.

15. (a) As the coil rotates, the magnetic flux linked with the coil (being $\vec{B} \,.\, \vec{A}$) will change and emf will be induced in the loop.

16. (a)

17. (c) When the satellite moves in inclined plane with equatorial plane (including orbit around the poles), the value of magnetic field will change both in magnitude and direction. Due to this, the magnetic flux through the satellite will change and hence induced currents will be produced in the metal of the satellite. But no current will induced if satellite orbits in the equatorial plane because the magnetic flux does not change through the metal of the satellite in this plane.

18. (b) When the tube is heated its resistance gets increased due to which eddy currents produced in copper tube becomes weak. Hence opposing force also gets reduced and the terminal velocity of magnet gets increased.

19. (d) When a metal piece falls from a certain height then eddy currents are produced in it due to earth's magnetic field. Eddy current oppose the motion of piece. Hence metal piece falls with a smaller acceleration (as compared to g). But no eddy current are produced in non-metal piece, hence it drops with acceleration due to gravity. Therefore non-metal piece will reach the earth's surface earlier.

20. (a) Transformer works on *ac* only, *ac* changes in magnitude as well as in direction.

21. (a) Hysteresis loss in the core of transformer directly proportional to the hysteresis loop area of the core material. Since soft iron has narrow hysteresis loop area, that is why soft iron core is used in the transformer.

22. (e) *ac* generator is based on the principle of the electromagnetic induction. When a coil is rotated about an axis perpendicular to the direction of uniform magnetic field, an induced emf is produced across it.

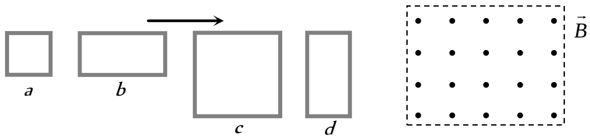
23. (d) Efficiency of electric motor is maximum when the back emf set up in the armature is half the value of the applied battery *emf.*

24. (d) Backs *emf.* $e \propto \omega$. At start $\omega = 0$ so $e = 0$

Electromagnetic Induction

SET Self Evaluation Test - 23

1. The figure shows four wire loops, with edge lengths of either L or $2L$. All four loops will move through a region of uniform magnetic field $\vec{B}$ (directed out of the page) at the same constant velocity. Rank the four loops according to the maximum magnitude of the e.m.f. induced as they move through the field, greatest first



(a) $(e_c = e_d) < (e_a = e_b)$ (b) $(e_c = e_d) > (e_a = e_b)$

(c) $e_c > e_d > e_b > e_a$ (d) $e_c < e_d < e_b < e_a$

2. A circular coil and a bar magnet placed near by are made to move in the same direction. The coil covers a distance of 1 m in 0.5 sec and the magnet a distance of 2 m in 1 sec. The induced emf produced in the coil

(a) Zero

(b) 1 V

(c) 0.5 V

(d) Cannot be determined from the given information

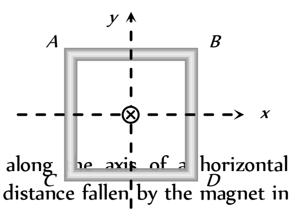
3. A square coil $ABCD$ lying in x-y plane with it's centre at origin. A long straight wire passing through origin carries a current $i = 2t$ in negative z-direction. The induced current in the coil is

(a) Clockwise

(b) Anticlockwise

(c) Alternating

(d) Zero



4. A short magnet is allowed to fall along the axis of a horizontal metallic ring. Starting from rest, the distance fallen by the magnet in one second may be

(a) 4 m (b) 5 m

(c) 6 m (d) 7 m

5. The horizontal component of the earth's magnetic field at a place is 3×10^{-4} T and the dip is $\tan^{-1}\left(\frac{4}{3}\right)$. A metal rod of length 0.25 m placed in the north-south position and is moved at a constant speed of 10 cm/s towards the east. The emf induced in the rod will be

(a) Zero (b) 1 μV

(c) 5 μV (d) 10 μV

6. A copper disc of radius 0.1 m rotates about its centre with 10 revolutions per second in a uniform magnetic field of 0.1 $Tesla$. The emf induced across the radius of the disc is

(a) $\frac{\pi}{10} V$ (b) $\frac{2\pi}{10} V$

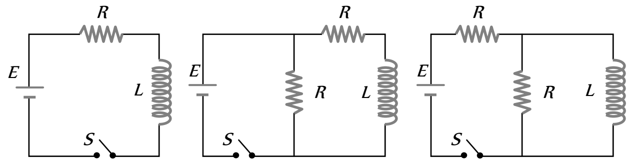
(c) 10 π mV (d) 20 π mV

7. A coil of Cu wire (radius-r, self inductance-L) is bent in two concentric turns each having radius $\frac{r}{2}$. The self inductance now

(a) $2L$ (b) L

(c) $4L$ (d) $L/2$

8. In which of the following circuit is the current maximum just after the switch S is closed



(i) (ii) (iii)

(a) (i) (b) (ii)

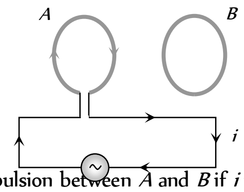
(c) (iii) (d) Both (ii) and (iii)

9. A small coil is introduced between the poles of an electromagnet so that its axis coincides with the magnetic field direction. The number of turns is n and the cross sectional area of the coil is A. When the coil turns through 180° about its diameter, the charge flowing through the coil is Q. The total resistance of the circuit is R. What is the magnitude of the magnetic induction

(a) $\frac{QR}{nA}$ (b) $\frac{2QR}{nA}$

(c) $\frac{Qn}{2RA}$ (d) $\frac{QR}{2nA}$

10. Two circular coils A and B are facing each other as shown in figure. The current i through A can be altered



(a) There will be repulsion between A and B if i is increased

(b) There will be attraction between A and B if i is increased

(c) There will be neither attraction nor repulsion when i is changed

(d) Attraction or repulsion between A and B depends on the direction of current. It does not depend whether the current is increased or decreased

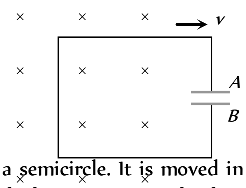
11. A conducting loop having a capacitor is moving outward from the magnetic field then which plate of the capacitor will be positive

(a) Plate – A

(b) Plate – B

(c) Plate – A and Plate – B both

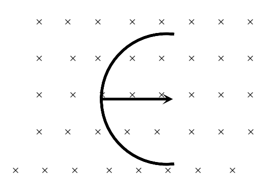
(d) None



12. A straight wire of length L is bent into a semicircle. It is moved in a uniform magnetic field with speed v with diameter perpendicular to the field. The induced emf between the ends of the wire is

(a) BLv

(b) $2BLv$



(c) $2\pi BLv$

(d) $\frac{2BvL}{\pi}$

13. If in a coil rate of change of area is $\frac{5\, metre^2}{millisecond}$ and current become 1 *amp* form 2 *amp* in 2×10^{-3} *sec*. If magnetic field is 1 *Tesla* then self inductance of the coil is

(a) 2 *H* (b) 5 *H*

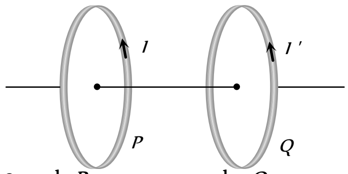
(c) 20 *H* (d) 10 *H*

14. In series with 20 *ohm* resistor a 5 *henry* inductor is placed. To the combination an e.m.f. of 5 *volt* is applied. What will be the rate of increase of current at $t = 0.25$ *sec*

(a) *e* (b) e^{-2}

(c) e^{-1} (d) None of these

15. Two coils *P* and *Q* are placed co-axially and carry current *I* and I' respectively



(a) If $I = 0$ and *P* moves towards *Q*, a current in the same direction as I is induced in *Q*

(b) If $I = 0$ and *Q* moves towards *P*, a current opposite in direction to that of I' is induced in *P*

(c) When $I \neq 0$ and $I' \neq 0$ are in the same direction, then two coil tend to move apart

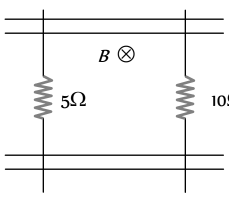
(d) None of these

16. The phase difference between the flux linkage and the induced e.m.f. in a rotating coil in a uniform magnetic field

(a) π (b) $\pi / 2$

(c) $\pi / 4$ (d) $\pi / 6$

17. A pair of parallel conducting rails lie at right angle to a uniform magnetic field of 2.0 *T* as shown in the fig. Two resistors 10 Ω and 5 Ω are to slide without friction along the rail. The distance between the conducting rails is 0.1 *m*. Then



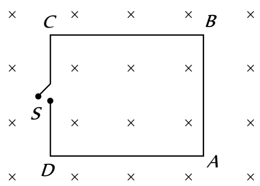
(a) Induced current $= \frac{1}{150} A$ directed clockwise if 10 Ω resistor is pulled to the right with speed 0.5 ms^{-1} and 5Ω resistor is held fixed

(b) Induced current $= \frac{1}{300} A$ directed anti-clockwise if 10 Ω resistor is pulled to the right with speed 0.5 ms^{-1} and 5Ω resistor is held fixed

(c) Induced current $= \frac{1}{300} A$ directed clockwise if 5 Ω resistor is pulled to the left at 0.5 ms^{-1} and 10 Ω resistor is held at rest

(d) Induced current $= \frac{1}{150} A$ directed anti-clockwise if 5 Ω resistor is pulled to the left at 0.5 ms^{-1} and 10 Ω resistor is held at rest

18. The magnetic field in the cylindrical region shown in figure increases at a constant rate of 20 *mT/sec*. Each side of the square loop *ABCD* has a length of 1 *cm* and resistance of 4Ω. Find the current in the wire *AB* if the switch *S* is closed



(a) $1.25 \times 10^{-7} A$, (anti-clockwise)

(b) $1.25 \times 10^{-7} A$ (clockwise)

(c) $2.5 \times 10^{-7} A$ (anti clockwise)

(d) $2.5 \times 10^{-7} A$ (clockwise)

19. An aircraft with a wing-span of 40 *m* flies with a speed of 1080 $km\, h^{-1}$ in the eastward direction at a constant altitude in the northern hemisphere, where the vertical component of earth's magnetic field is 1.75×10^{-5} *T*. Then the emf that develops between the tips of the wings is

(a) 0.5 *V* (b) 0.35 *V*

(c) 0.21 *V* (d) 2.1 *V*

20. A hundred turns of insulated copper wire are wrapped around an iron cylinder of area 1×10^{-3} m^2 and are connected to a resistor. The total resistance in the circuit is 10 *ohms*. If the longitudinal magnetic induction in the iron changes from 1 *weber* m^{-2}, in one direction to 1 *Weber* m^{-2} in the opposite direction, how much charge flows through the circuit

(a) 2×10^{-2} *C* (b) 2×10^{-3} *C*

(c) 2×10^{-4} *C* (d) 2×10^{-5} *C*

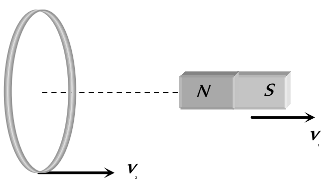
Answers and Solutions

(SET -23)

1. (b) Emf induces across the length of the wire which cuts the magnetic field. (Length of *c* = Length *d*) > (Length of *a* = *b*).

So $(e_c = e_d) > (e_a = e_b)$

2. (a) Speed of the magnet



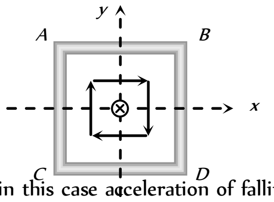
$v_1 = \frac{2}{1} = 2\, m/s$

Speed of the coil

$v_2 = \frac{1}{0.5} = 2\, m/s$

Relative speed between coil and magnet is zero, so there is no induced emf in the coil.

3. (d) Magnetic lines are tangential to the coil as shown in figure. Thus net magnetic flux passing through the coil is always zero or the induced current will be zero.



4. (a) We know that in this case acceleration of falling magnet will be lesser than g. If 'g' would have been acceleration, then distance covered $= \frac{1}{2}gt^2 = 5m$.

Now the distance covered will be less than 5 m. hence only option (a) is correct.

5. (d) Rod is moving towards east, so induced emf across it's end will be $e = B_V vl = (B_H \tan\phi)vl$

$\therefore e = 3\times10^{-4}\times\frac{4}{3}\times(10\times10^{-2})\times0.25 = 10^{-5}\,V = 10\,\mu V$

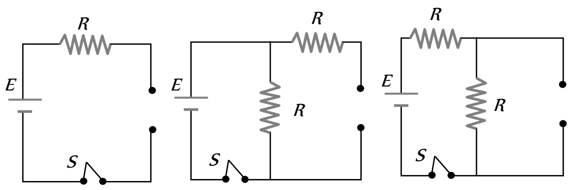
6. (c) The induced emf between centre and rim of the rotating disc is

$E = \frac{1}{2}B\omega R^2 = \frac{1}{2}\times0.1\times2\pi\times10\times(0.1)^2 = 10\pi\times10^{-3}\,volt$

7. (a) $\because\ L \propto N^2 r$; $\frac{L_1}{L_2} = \left(\frac{N_1}{N_2}\right)^2 \times \frac{r_1}{r_2}$

$\Rightarrow \frac{L}{L_2} = \left(\frac{1}{2}\right)^2 \times \left(\frac{r}{r/2}\right) = \frac{1}{2}$; $L_2 = 2L$

8. (b) At $t = 0$ current through L is zero so it acts as open circuit. The given figures can be redrawn as follow.



$i_1 \overset{(i)}{=} 0$ $\quad i_2 \overset{(ii)}{=} \frac{E}{R}$ $\quad i_3 \overset{(iii)}{=} \frac{E}{2R}$

Hence $i_2 > i_3 > i_1$.

9. (d) Induced charge $Q = -\frac{NBA}{R}(\cos\theta_2 - \cos\theta_1)$

$= -\frac{NBA}{R}(\cos180^o - \cos0^o) \Rightarrow B = \frac{QR}{2NA}$

10. (a) With rise in current in coil A flux through B increases. According to Lenz's law repulsion occurs between A and B.

11. (a) Crosses (×) linked with the loop are decreasing, so induced current in it is clockwise *i.e.* from $B \to A$. Hence electrons flow from plate A to B so plate A becomes positively charged.

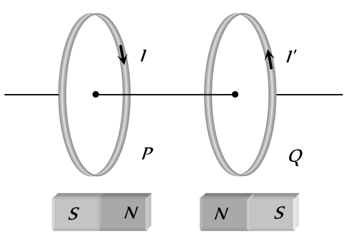
12. (d) Induced emf $e = Bvl \Rightarrow e = Bv(2R) = \frac{2BvL}{\pi}$

13. (d) $e = B.\frac{dA}{dt} = L\frac{di}{dt} \Rightarrow 1\times\frac{5}{10^{-3}} = L\times\frac{(2-1)}{2\times10^{-3}} \Rightarrow L = 10H$

14. (c) $i = i_0(1 - e^{-Rt/L}) \Rightarrow \frac{di}{dt} = i_0\left(\frac{R}{L}\right)e^{-Rt/L} = \frac{E}{L}e^{-Rt/L}$

On putting values $\frac{di}{dt} = \frac{1}{e} = e^{-1}$.

15. (b)



16. (b) $\phi = BA\cos\theta$ where θ is the angle between area and field

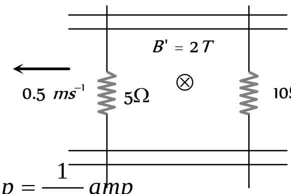
$e = \frac{-d\phi}{dt} = -BA\sin\theta.\frac{d\theta}{dt} = BA\left(\frac{d\theta}{dt}\right)\cos(90+\theta)$

Here phase difference = 90°.

17. (d) When 5Ω resistor is pulled left at 0.5 m/sec induced emf, in the said resistor $= e = vBl = 0.5\times2\times0.1 = 0.1\,V$

Resistor 10Ω is at rest so induced emf in it $(e = vBl)$ be zero.

Now net emf, in the circuit $= 0.1V$ and equivalent resistance of the circuit $R = 15\ \Omega$



Hence current $i = \frac{0.1}{15}amp = \frac{1}{150}amp$

And its direction will be anti-clockwise (according to Lenz's law)

18. (a) $i = \frac{e}{R} = \frac{A}{R}.\frac{dB}{dt} = \frac{(1\times10^{-2})^2}{16}\times20\times10^{-3} = 1.25\times10^{-7}A$

(Anti-clockwise).

19. (c) $L = 40\ m$, $v = 1080\,km\ h^{-1} = 300\,m\ sec^{-1}$ and $B = 1.75\times10^{-5}\ T \Rightarrow$

$e = Blv = 1.75\times10^{-5}\times40\times300 = 0.21\,V$

20. (a) $dQ = \frac{d\phi}{R} = \frac{nAdB}{R} = \frac{100\times1\times10^{-3}\times2}{10} = 2\times10^{-2}C$

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