07. Electromagnetic Induction

7.0 Basic concepts :

Magnetic flux:

1. The total number of magnetic lines of force passing normally through the given surface is called as magnetic flux.
2. The magnetic flux passing through a coil of area A is given by

   $\phi = nAB\cos\theta$

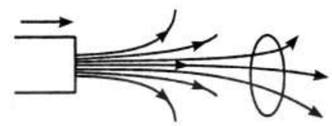
   where θ is angle between axis of coil i.e. normal to plane of the coil and direction of magnetic induction.
3. If plane of the coil is perpendicular to the magnetic induction, then $\phi = AB$ i.e. maximum.
4. If plane of the coil is parallel to the magnetic induction then $\phi = O$ i.e. (minimum).
5. Magnetic flux is also defined as the dot product of magnetic induction vector and area vector

   i.e. $\phi = \vec{A} \cdot \vec{B}$
6. In S.I. system, unit of magnetic flux is weber (Wb) and in c.G.S. system, unit of magnetic flux is maxwell.

   1 weber = 10^8 maxwell
7. Magnetic flux linked with the coil is directly proportional to the current flowing through the coil.
8. The magnetic flux due to the component ($B\sin\theta$) parallel to the plane is zero.
9. When the plane of coil makes an angle α with the magnetic field then flux passing through it $\phi = BA\,n\sin\alpha$, where as if the normal to the plane of coil makes an angle θ with the magnetic field then flux crossing the coil will be $\phi = BAn\cos\theta$.
10. If a body is placed in uniform or non uniform magnetic field, outward flux is taken as positive while inward flux is negative.

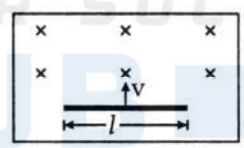
Change of magnetic flux:

1. As magnetic flux lined with a coil depends on B, A and θ, by changing anyone of these or any combination of these produces a change in flux.
2. i) If a bar magnet is moved along its axis towards or away from the plane of a coil, flux changes due to the change in the value of B. (If magnet is moved towards the coil, flux linked with the coil increase. If the magnet is moved away from the coil, flux linked with the coil decreases.

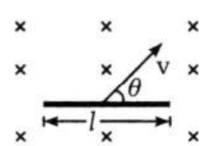


   ii) In this case if the bar magnet is fixed and the coil is moved towards or away, then also flux linked changes.

   iii) If the magnet and coil both are moved, flux changes if there is relative motion.
3. i) If the area of the closed path enclosing the flux changes, there will be change in flux linked with it.



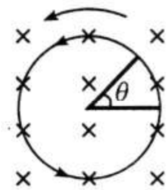
   ii) A uniform conducting rod of 'length 'L' is in translatory motion in a uniform field, the flux linked with the area generated by the. motion of conductor changes as the area changes. If the conductor moves at right angles to its length and perpendicular to the field direction, magnetic flux linked is,



   $\phi = Blvt$ ($\because A = l\,vt$)

   where v is velocity of rod and t is time of its motion.

iii) If uniform conducting rod is rotated about one end in the field such that G its plane of rotation is perpendicular to the field direction, flux linked is



$\phi = \frac{1}{2} B l^2 \theta$ $\quad (\because A = \frac{1}{2} l^2 \theta)$

where θ is angular displacement in time 't'.

$\Rightarrow \quad \phi = \frac{1}{2} B l^2 \omega t$

where ω is angular velocity.

If' f' is frequency of rotation of the rod,

$\phi = \pi B l^2 f t$

4. A coil of area A having n turns is placed in a uniform magnetic field B then there are following cases.

i) If the plane of the coil is perpendicular to the field, flux linked ϕ = nBA.

ii) If the coil is rotated through π or 180°, change in flux linked is

$d\phi = nBA - (-nBA)$
$= 2nBA$

iii) If the coil is rotated through $\pi/2$ or 90°, change in flux linked is,

$d\phi = nBA.$

iv) If the coil is rotated through an angle θ, change in flux is

$d\phi = nBA(1 - \cos\theta)$

Electromagnetic induction

1. In 1820, Oersted discovered magnetic effect of electric current i.e. the existence of a magnetic field due to the current flowing in a conductor.
2. In 1831, Michael Faraday discovered electromagnetic induction just converse to magnetic effect of electric current.
3. Electromagnetic induction : The phenomenon of producing electric current or e.m.f. in a coil due to the change in magnetic flux over it, is called as electromagnetic induction.
   The current so produced is called as induced current and e.m.f. is called as induced e.m.f.
4. In electromagnetic induction, electrical energy is produced at the expense of mechanical energy.

Faraday's experiments of electromagnetic induction:

1. Coil and magnet experiment:

i) When the N-pole of the magnet is moved towards the coil, the face of the coil, pointing towards the magnet, behaves like a N-pole and tries to repel the approaching N-pole of the magnet. To do this, the coil generates anticlockwise current in itself.

ii) When the N-pole of the magnet is moved away from the coil, the face of the coil, pointing towards the magnet, behaves like a S-pole and attracts the magnet and slows down the motion of the magnet.
To do this coil generates clockwise current.

2. Conclusions of experiment:

i) s long as change in flux take place induced e.m.f. is produced. The induced e.m.f. produced in the coil opposes the change which is responsible for its production.

ii) The induced e.m.f. increases with
   a) the speed of the magnet or coil,
   b) strength of the magnetic field,
   c) the area of the coil and
   d) number of turns of the coil.

iii) The induced e.m.f. in a coil can be produced in three ways, namely: by changing magnetic field B, by changing area of the coil or by changing inclination of the coil with the magnetic field.

iv) If magnetic flux increases, then negative induced e.m.f. is produced and if magnetic flux decreases, then positive induced e.m.f. is produced.

v) If both the coil and magnet are stationary or both moving in the same direction with the same velocity, then there is no change in flux and hence no e.m.f. is produced in the coil.

vi) Induced e.m.f. is produced only during the time when magnetic flux is changing.

vii) If a magnet is inserted into the coil then the e.m.f. induced does not depend on the magnetic moment of the magnet.

3. Coil and coil experiment

i) When the magnetic flux through the secondary coil changes due to the change in the current of primary coil, an e.m.f. is induced in the secondary coil.

ii) The e.m.f. induced in a secondary coil increases with
   a) rate of change of current in the primary coil,
   b) the area of cross section of secondary coil and
   c) the number of turns of the secondary coil.

7.1 Laws of etectromaqnetlc induction and proof of e = – dϕ/dt

1. Whenever magnetic flux linked with a coil changes, an induced e.m.f. is produced in it.
2. The induced e.m.f. lasts as long as change in flux take place.
3. The magnitude of induced e.m.f.. is directly proportional to the rate of change of magnetic flux linked with the coil.

   i.e. $e \propto \frac{d\phi}{dt}$ $\quad\therefore\quad e = \frac{d\phi}{dt}$

4. **Remark:**

i) Faradays laws of electromagnetic induction deals with the conservation of energy and magnetic field.

ii) In S.I. system, unit of induced e.m.f. is weber/second or volt.

iii) Faraday's law gives the magnitude of induced e.m.f.

iv) If the number of turns in the coil is n, then

$$e \propto \frac{d}{dt}(n\phi) \text{ or } e \propto \frac{nd\phi}{dt}$$

where $n\phi$ is effective flux linked with the coil.

$$\text{In SI Units } e = n\left(\frac{d\phi}{dt}\right) = \frac{n(\phi_2 - \phi_1)}{t}$$

v) If the area of coil of n turns is A and angle between $\vec{B}$ and $\vec{A}$ is θ. Then

$$e = \frac{d}{dt}(nBA \text{ cas } \theta) = \frac{d}{dt}(nBA \text{ cas } \omega t)$$

a) If only B is changing, then e = nA cas $\theta \left(\frac{dB}{dt}\right)$

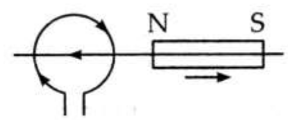
b) If only A is changing then e = nB cas $\theta\left(\frac{dA}{dt}\right)$

c) If only θ is changing, then e = nAB $\frac{d}{dt}$ (cas θ), $\Rightarrow$ e = – nABω sin ωt.

vi) Induced e.m.f. depends on the following factors
   a) On magnetic permeability μ
   b) On the number of turns n
   c) On rate of change of flux $\frac{d\phi}{dt}$
   d) On area A
   e) On relative motion between the coil and the magnet.

Lenz's law:

1. The direction of induced e.m.f. was given by Lenz in 1834.
2. Statement: Lenz's law states that, induced e.m.f. always flows in such a direction so as to oppose change in magnetic flux.
3. According the Lenz, e.m.f. induced in a coil is given by, $e = -\frac{d\phi}{dt}$. Where negative sign in the equation indiicates that e and $\frac{d\phi}{dt}$ are oppositely diirected.
4. Lenz's law deals with the conservation of energy. If a N-pole is moving away from the coil, induced current flows in clockwise direction. The nearer face of coil should be south pole. For a south pole, the induced currents are clockwise.



5. Lenz's law can be explained on the basis of electromagnetic inertia.
6. Lenz's law gives a relation between current and magnetic field.
7. The value of e is equal to the negative slope of $\phi - t$ curve.
8. The direction of e can also be determined by Fleming's right hand rule.
9. The increase in magnetic flux gives rise to inverse

/ (anticlockwise) induced current where as decrease in magnetic flux gives rise to direct (clock wise) induced current.

10. When flux decreases then e is positive and when it increases then e is negative.
11. In the case of electromagnetic induction, induced e.m.f $e = \frac{d\phi}{dt}$ always exists either the circuit is closed or open, but the current will exist only if the circuit is closed.
12. Induced current $I = \frac{e}{R} = \frac{nd\phi}{Rdt}$, where R is the total resistance of the circuit.
13. As i = dq/dt, there is induced charge in the closed circuit due to electromagnetic induction.

$$\Rightarrow \frac{dq}{dt} = \frac{e}{R} = \frac{nd\phi}{Rdt}$$

$$\Rightarrow q = \frac{nd\phi}{R} = \frac{n(\phi_2 - \phi_1)}{R}$$

Induced charge is independent of time in which the flux changes.

14. Induced power is P = eI (i.e. induced e.m.f. x induced current)

$$\Rightarrow P = e^2 / R \text{ or } P = I^2 / R \Rightarrow P = \frac{n^2}{R}\left(\frac{d\phi}{dt}\right)^2$$

Induced power depends on change in time.

15. If the rate of change of magnetic flux is constant, then a constant induced e.m.f. is generated.

16. Remark:

i) Induced current depends upon the resistance as well as time. But induced e.m.f. does not depend upon resistance of the circuit. So, the coil may be made of any substance.

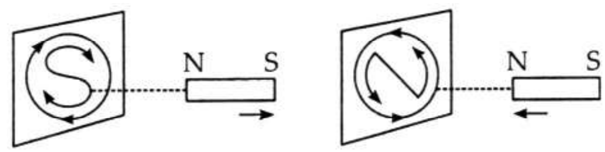
ii) Induced charge does not depend upon time of change of magnetic flux. So, whether the change in flux be rapid or slow, the charge in the circuit will remain the same.

iii) Electromagnetic induction is a source of e.m.f. It is based upon law of conservation of energy in which mechanical energy is converted into electrical energy.

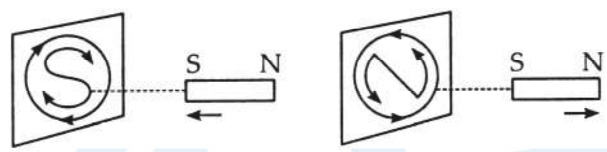
iv) If the coil is cut or made of an insulator, induced e.m.f. will be produced but the current will not flow, because R = ∞

Motion of a bar magnet towards a coil :

1. If the North pole of bar magnet is moved towards the coil along its axis then induced current in the coil is in anticlockwise when see from the magnet side. If the bar magnet is moved away, direction of induced current is clockwise when seen from the magnet side.

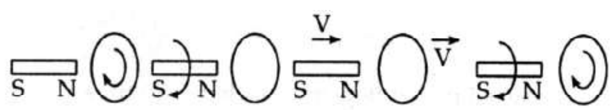


2. If the South pole of bar magnet is moved towards, the coil along its axis, the induced current in the coil is in clock wise direction when see from the magnet side. If the bar magnet is moved away, direction of induced current is anticlockwise when see from the magnet side.



3. In the above case if magnet is stationary and coil is moved towards or away from the magnet e.m.f. will be induced.

4. If there is no relative motion such that flux linked does not change, then no e.m.f. is induced. (Refer following figures)



Proof of e = – d ϕ /dt

1. The e.m.f. induced in a coil due to the change in magnetic flux is given by,

i) $e = -\frac{d\phi}{dt}$ where ϕ = nAB cos θ or

ii) $e = -B\frac{dA}{dt}$

iii) $e = -A\frac{dB}{dt}$

2. i) The e.m.f. produced in a conductor of length l, moving with a velocity v perpendicular to magnetic field B is given by $e = B\,l\,v$.
In this equation, all quantities, i.e. B, v and l are mutually perpendicular to each other.

ii) If the conductor moves along the direction of magnetic field then no e.m.f is induced in it.

iii) Direction of induced e.m.f. depends upon change in flux only. The direction of induced e.m.f in a conductor is given by Fleming's right hand rule.

iv) Flemings right hand rule: To apply Fleming's right hand rule, stretch the thumb, fore finger and middle finger of right hand so that they are perpendicular to each other. If thumb points in the direction of velocity, fore finger points in the direction of magnetic induction then middle finger points in the direction e.m.f. induced in a conductor.

v) If the rod is moving in the magnetic field of earth then there are different cases.

a) If horizontal rod moves horizontally, then induced e.m.f. is, $e = -B_v\,l\,v$.

b) If a horizontal rod kept along E – W moves vertically, then the e.m.f. induced in the rod is given by $e = -BH\,l\,v$.

c) If a horizontal rod kept along magnetic north-south moves vertically then magnetic flux passing through it due to B_H will remain zero. Due to no change of magnetic flux, no e.m.f. is induced in it i.e. $e = 0$.

d) If a vertical road moves along east-west, then $e = -BH\,l\,v$.

e) If a vertical rod moves along north-south, then $e = 0$.

3. When the rod is rotating about one of its end in a magnetic field (or when a disc of area A and radius r is kept perpendicular to magnetic field B and is rotating with a frequency (f) then the e.m.f. induced in it given by,

$$e = -BAf$$
$$= -B\pi r^2 f$$
$$= -B\pi l^2 f \quad \text{or}$$

or $e = \frac{1}{2}Br^2\omega$ where ω - angular velocity

Remember:

1. Induced e.m.f. depends on (i)A (ii)n (iii) Band (iv) e.
2. Direction of induced e.m.f. depends on
   i) direction of magnetic flux.
   ii) The rate of change of magnetic flux i.e. whether $\frac{d\phi}{dt}$ is positive or negative, increasing or decreasing.
3. The conditions when induced e.m.f. may be produced
   i) When there is relative motion between the coil and the magnet.
   ii) When a conducting wire is dropped freely in east-west direction.
   iii) When the aeroplane flies in the horizontal direction.
   iv) The plane of orbit of a metallic satellite is inclined at any angle from the equatorial plane.
   v) When a train runs in any direction then e.m.f. will be induced between the ends of its axle due to the vertical component of earth's magnetic field.
   vi) Landing or taking off of an aeroplane with its wings in east-west direction.
4. The conditions for induced e.m.f. not produced -
   i) If there is no relative motion between the magnet and the coil.
   ii) Magnet and coil are coaxial at fixed separation. One of it rotates about that axis.
   iii) When the magnet and the coil both move with same velocity in same direction.
   iv) When the aeroplane flies in north direction.
   v) Landing or taking off of an aeroplane with its wings in north-south direction.
   vi) When a conducting wire is freely dropped towards earth in north-south direction.
   vii) When the plane of orbit of a metallic satellite coincides with equatorial plane of earth.
   viii) When a conductor moves in the direction of magnetic flied.
5. The conditions for induced e.m.f. being maximum
   i) when the relative motion between the magnet and the coil is fast.
   ii) on increasing the number of turns in the coil.

iii) on placing core of high permeability inside the coil.

7.2 Eddy currents

1. Eddy currents were detected by Foucault in 1895. Hence eddy currents are also called as Foucault's currents.
2. Foucault currents look likes eddies or whirlpools, hence called as eddy currents.
3. Eddy currents are produced when the conductor is placed in changing magnetic field.
4. The circulating induced currents produced in a metal plate due to the change in magnetic flux over it are called as eddy currents.
5. Eddy currents always flows in such a direction so as to oppose change in flux. The large amount of eddy currents are produced in a conductor, because of negligible resistance of conductor.
6. The damping effect and heating effect of eddy currents is used in several application but eddy currents do not produce sparking.
7. The applications of eddy currents are
   i) dead beat galvanometer,
   ii) induction furnace,
   iii) electric breaks,
   iv) induction motor,
   v) energy meters,
   vi) speedometer,
   vii) diathermy (deep heat treatment) and
   viii) electromagnetic damping.
8. To ovoid undesirable heating effect of eddy currents, laminated or insulated iron core is used in several applications.

7.3 Self induction and mutual induction

Self induction:

1. Self induction was discovered by Henry in 1832.
2. The phenomenon of producing induced e.m.f. in a coil due to the changes of current in the same coil is called as self induction.
3. According to Lenz's law, self induced e.m.f. opposes the change responsible for its production. Therefore when the current is increasing, the self induced e.m.f. opposes the growth of current and when the current is decreasing, it opposes the decay of current. For this reason, self induced e.m.f. is also called as counter e.m.f. or back e.m.f.
4. Self induction opposes both the growth and decay of the current in the coil, hence it is called inertia of electricity.
5. Magnetic flux linked with the .coil is directly proportional to current i.e. $\phi \propto I \therefore \phi = LI$ where L is coefficient of self inductance. For 'n' turns of coil, total flux $= n\phi = LI$
6. The coefficient of self inductance depends on,
   i) number of tuns of coil
   ii) geometrical properties (shape and area) of the coil
   iii) permeability of the material on which coil is wound.
7. The self induced e.m.f. produced in coil is given by,
$$e = -L\frac{dI}{dt}$$
8. The self inductance of a coil is equal to the e.m.f. induced in a coil due to the unit rate of change of current in the same coil. OR
   The self inductance of a coil is equal to the magnetic flux produced when unit current flows through it.
9. The coefficient of self inductance of coil is given by,
   i) $L = -\frac{e}{dI/dt}$ or $L = -e\frac{dt}{dI}$ and ii) $L = \frac{\phi}{I}$
10. S.I. unit of self inductance is henry. Its dimensional formula is $[ML^2T^{-2}I^{-2}]$
$$\text{i.e. } 1 \text{ henry} = \frac{1 \text{ volt}}{1 \text{ ampere / second}}$$
$$= \frac{\text{volt} - \text{second}}{1 \text{ ampere}}$$
$$\text{or } 1 \text{ henry} = \frac{\text{Weber}}{\text{ampere}}$$
11. The self inductance of a coil is said to be one henry if an e.m.f. of 1 volt is induced in the coil due to the unit rate of change of current in the same coil.
12. The self inductance associated with a coil is independent of resistance of coil.
13. **Self induction of different coils:**
   i) Self inductance of a plane circular coil :

The magnetic induction at the centre of the coil is,

$$B = \frac{\mu_0 nI}{2a}$$

The magnetic flux linked with the coil is,

$$\phi = BA = \frac{\mu_0 nI}{2a} \pi a^2 \ (\because A = \pi a^2)$$

But self inductance of a coil is given by,

$$L = \frac{n\phi}{I} = \frac{n}{I} \frac{\mu_0 nI}{2a} \pi a^2 = \frac{\mu_0 \pi a n^2}{2}$$

Thus, $L \propto n^2$ i.e. self inductance. is directly proportional to square of number of turns.

Remark: If a rod of ferromagnetic material is placed inside the coil, then the magnetic flux linked with the coil increases. Hence, its self. inductance also increases. If Ilris relative permeability of rod then,

$$L = \frac{\mu_0 \mu_r \pi a n^2}{2}$$

ii) Self inductance of long solenoid: The magnetic field of a long solenoid of length l, area of cross section A is given by,

$B = \mu_0 n I$

where n is number of turns per unit length.

The magnetic flux linked with the solenoid is,

ϕ = Magnetic flux linked with one turn × total number of turns

$= \mu_0 nIA \times nl$

$\phi = \mu_0 IAln^2$

[$\because$ Magnetic flux of one turn =A.B.= $\mu_0 nIA$]

Thus, the self inductance of a solenoid is,

$$L = \frac{\phi}{I} = \mu_0 A\, l\, n^2$$

i.e. $L \propto n^2$ i.e. self inductance of a solenoid is directly proportional to square of number of turns per unit length of solenoid.

14. Energy stored in an inductor in the form of magnetic field is given by,

$$E = \frac{1}{2} L I^2.$$

If I = 1ampere than L = 2 E.

Thus, the coefficient of self inductance is equal to the twice the workdone in establishing a flow of one ampere current in the circuit.

15. If the two coils of inductances L_1 and L_2 are connected in series (the mutual induction between them is neglected) then, their equivalent inductance is given by,

$L_S = L_1 + L_2$.

16. If the two coils of inductances L_1 and L_2 are connected in parallel (the mutual induction between them is neglected) then, their equivalent inductance is given by,

$$\frac{1}{L_P} = \frac{1}{L_1} + \frac{1}{L_2} \qquad \therefore \quad L_P = \frac{L_1 L_2}{L_1 + L_2}$$

17. If M be the coefficient of mutual inductance between the two coils of inductance L_1 and L_2 when they have flux linkage in the same sense then their equivalent inductance, if they are connected in series is given by,

$L_S = L_1 + L_2 + 2M$

For the flux linkage in opposite sense, the equivalent inductance is given by,

$L_S = L_1 + L_2 - 2M$

18. If the two coils of inductances L_1 and L_2 are connected in parallel which are very close to each other then there equivalent inductance is,

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

where M is coefficient of mutual inductance.

19. The coefficient of coupling (K) between the two coils having self inductance L_1 and L_2 and coefficient of mutual inductance M is,

$$K = \frac{\pm M}{\sqrt{L_1 L_2}}$$

20. Remark:

i) An inductance is said to be ideal if it has no resistance. In real practice, due to finite resistance of conductors an inductance always has a resistance.

ii) One can have a resistance with or without having inductance a resistance withou t inductance is called non inductive resistance. (in resistance boxes the coil are wound back to have non inductive resistance)

iii) One cannot have inductance without having resistance.

Mutual induction:

1. The phenomenon of producing induced e.m.f. in a coil due to the change of current in the neighbouring coil is called as mutual induction.
2. The magnetic flux linked with the coil is directly proportional to current flowing through the coil.

   i.e. $\phi \propto I$

   $\therefore \phi = MI$

   where M is coefficient of mutual inductance.
3. The coefficient of mutual inductance depends on
   i) number of turns,
   ii) geometrical properties (shape, area) of the coil,
   iii) permeability of the material on which coil is wound,
   iv) separation between the coils,
   v) relative orientation between the two coils,
   vi) medium between the coils.
4. The mutual induced e.m.f. produced in a coil is given by,

$$e = -M\frac{dI}{dt}$$

5. The mutual inductance of a coil is equal to the e.m.f. induced in a coil due to the unit rate of change of current in the neighbouring coil. OR

   The mutual inductance is equal to the magnetic flux linked with one coil when unit current flows through the neighbouring coil.
6. The coefficient of mutual inductance is given by,

$$M = -\frac{e}{dI/dt} = -e\frac{dt}{dI}$$

7. In S.I. system, unit of coefficient of mutual inductance is henry or weber/ampere
8. The mutual inductance of a coil is said to be one henry, if an e.m.f. of 1 volt is induced in the coil due to the unit rate of change of current 10 the neighbouring coil.
9. **Calculation of mutual inductance:**
   i) If the two plane coils are placed co-axially near each other then the coefficient of mutual inductance between the two coils is given by,

$$M = \frac{\mu_0 n_1 n_2 \pi a_2^2}{2a_1} = \frac{\mu_0 \mu_r n_1 n_2 \pi a_2^2}{2a_1}$$

   ii) For a solenoid having a primary coil of nl turns and a secondary coil of n_2 turns, the coefficient of mutual inductance between the two coils is given by,

$$M = \frac{\mu_r \mu_0 n_1 n_2 A}{I}$$

   where l - length of solenoid and A - area of one turn of the secondary coil and μ_r - relative permeability.
10. Mutual inductance of two coils depends on geometry of coils and is same whether current flows in first coil or in second coil.

Elements of earth's magnetic field:

1. A magnetic needle rotating in a vertical plane about horizontal axis come to rest by dipping its
   i) North pole below the horizontal line in the northern hemisphere and
   ii) South pole below the horizontal line in southern hemisphere through a certain angle θ.

   The rest position of needle is earth's magnetic induction B_E.
2. The component of earth's magnetic induction along the horizontal line is called as horizontal component of earth's magnetic field. (B_H).

   It is given by, $B_H = B_E \cos\theta$.
3. The component of earth's magnetic induction along the vertical line is called vertical component of earth's magnetic induction (B_V).

   It is given by, $B_V = B_E \sin\theta$.
4. The earth's magnetic induction at a given place is,

$$BE = \sqrt{B_H^2 + B_v^2}$$

5. The angle between the horizontal component of earth's magnetic field (B_H) and earth's magnetic induction (B_E) is called as angle of dip or magnetic inclination. It is different for different places. It is given by,

$$\tan\theta = \frac{B_V}{B_H}$$

6. i) B_H is always zero at magnetic poles i.e. $\theta = 90°$

   ii) B_V is always zero at magnetic equator i.e. $\theta = 0$.

7.4 Need for displacement current

1. Ampere's circuital law was applied to an electrical circuit containing capacitor as one of the circuit component, the law is inconsistent or incomplete.
2. To overcome the inconsistency, James Clerk Maxwell introduced the concept of displacement current and modify the Amperes law.
3. "Displacement current is that current which is produced in a region, whenever the electric field and hence the electric flux is changing with time."
4. The displacement current is given by,

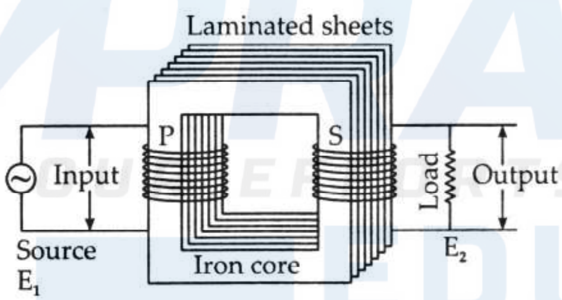
$$I_D = \varepsilon_0 \frac{d\phi_E}{dt}$$

5. Modified form of Ampere's circuital law is,

$$\oint_C \vec{B}.d\vec{l} = \mu_0 \left[I_C + \varepsilon_0 \frac{d\phi_E}{dt} \right]$$

7.5 Transformer

1. It is device used for converting low alternating voltage at high current into high voltage at low current and vice versa.



2. It works on the principle of mutual induction.
3. It works only with alternating current (A.C.) but not with direct current (D.C.).
4. To minimise eddy currents, the soft iron core is laminated.
5. On a laminated iron core two coils called primary and secondary are wound. It the primary is connected to an alternating source of e.m.f. (A.C.) by mutual induction an e.m.f. is induced in the secondary.
6. In an ideal transformer these coils are tightly coupled i.e., the magnetic flux generated in the primary is fully linked to the secondary.
7. Transformers are of two types. i) Step-up transformer and ii) Step-down transformer

i) Step-up transformer:

a) In a step-up transformer the number of turns in secondary coil (ns) is greater than the number of turns in primary coil (n_p).

b) The primary coil is made of a thick insulated wire and secondary coil is made of a thin insulated wire.

c) The alternating voltage across the ends of, secondary is more than that across primary.

d) The current flowing in the secondary is less than that in primary.

e) It converts a low voltage at high current into a high voltage at low current.

ii) Step-down transformer:

a) In a step-down transformer the number of turns in secondary coil (n_s) is less than that the number of turns in primary coil (n_p).

b) The primary coil is made of a thin wire and the secondary coil is made of a thick wire.

c) The alternating voltage across the ends of secondary is less than that across primary.

d) The current flowing in the secondary is greater than that in primary.

e) It converts a high voltage at low current into a low voltage at high current.

8. If e_p and e_s are the primary and secondary e.m.f.'s in a transformer and np and ns are the number of turns in the primary and secondary coils, then

$$\frac{e_s}{e_p} = \frac{n_s}{n_P}$$

The ratio $\frac{n_s}{n_P} = k$ is called transformation ratio.

9. For a step-up transformer, transformation ratio is greater than one, while for a step-down transformer its value is less than one.
10. For an ideal transformer transformation ratio is equal to one.
11. If I_p and I_s are the primary and secondary currents respectively, then

$$\frac{I_P}{I_s} = \frac{n_s}{n_P}$$

12. In a step-up transformer $n_s > n_p$ so $e_s > e_p$.
13. In a step-down transformer $n_s < n_p$ so $e_s < e_p$
14. The efficiency of a transformer is the ratio of the

output power to input power.

$$\therefore \quad \text{Efficiency, } \eta = \frac{\text{Ouput power}}{\text{Input power}} = \frac{e_s I_s}{e_p I_p}$$

Percentage of efficiency,

$$\eta = \frac{\text{Ouput power}}{\text{Input power}} \times 100$$

15. For an ideal transformer, $\eta = 100\%$ and for most of the transformer η varies in between 90% to 99%.

16. Energy losses in transformers:

i) **Copper losses:** Joule heat is generated in both the coils due to flow of current. i.e., electrical energy is dissipated in the form of heat energy. This type of energy loss is known as copper loss. To minimise this energy loss the primary and secondary coils are made of thick copper wire.

ii) **Magnetic flux leakage losses:** Certain amount of magnetic flux leaks between primary and secondary coils. Hence the flux produced in the primary does not wholly linked with secondary. This type of energy loss is known as magnetic flux leakage. This type of loss is minimised by winding the two coils one over the other.

iii) **Eddy current losses i.e. iron losses:** A transformer core is placed in a variable magnetic field then induced currents (Eddy currents) are produced in it. Due these currents some amount of energy is wasted. So laminated soft iron core is used to reduce this loss.

iv) **Hysteresis loss:** This is the loss of energy due to repeated magnetisation and demagnetisation of the iron core when ac is fed to it.

v) **Magnetostriction :** Magnetostriction is a humming noise of a transformer.

17. Uses of transformer:

i) A step-down transformer is used for obtaining large current for electric welding.

ii) A step-down transformer is used in induction furnace for melting the metals.

iii) A step-up transformer is used for the production of x-rays.

iv) Transformers are used in voltage regulators and stabilised power supplies.

v) Small transformers are used in radio sets, televisions, telephones, loud speakers etc.

7.6 Rotating coil in uniform magnetic induction

and

7.7 Alternating currents

1. A device which converts mechanical energy into electrical energy is called generator or dynamo.

2. Dynamois used for the production of A.C. e.m.f. It is based on the principle of electromagnetic induction. "When a coil is rotated rapidly in a strong magnetic field, the number of magnetic flux lines (magnetic flux) passing through the coil changes continuously. Hence, an e.m.f. is induced in the coil and a current flows in it."

   i) The e.m.f. induced in a coil, called as A.C. e.m.f. rotating in a magnetic field is given by,

   $$e = e_0 \sin \omega t.$$

   ii) The maximum value of e.m.f. induced in a coil called as peak e.m.f. or maximum e.m.f. It is given by,

   $$e_0 = nAB\omega = nAB\, 2\pi f$$

   iii) The e.m.f. or voltage, whose magnitude changes with time and direction reverses periodically is known as alternating e.m.f. The AC. e.m.f. changes its direction $\omega/2\pi$ times in 1second.

4. i) The electric current whose magnitude changes with time and direction reverses periodically is known as alternating current. It is given by,

   $$I = I_0 \sin \omega t.$$

   ii) The maximum value of current is called as maximum or peak current. It is given by,

   $$I_0 = \frac{e_0}{R}$$

5. **Mean (or) average value of A.C. :**

   i) Mean or average value of A.C. is defined as the steady current, which when passes through a circuit for half the time period of the alternating current sends the same amount of charge as is done by the alternating current in the same time through the same circuit.

      a) Mean or average value of A.C. e.m.f. or AC. current over a complete cycle is zero.

      b) The average value of A.C. e.m.f. over a half cycle is,

$$e_m = \frac{2e_0}{\pi} = 0.636\ e_0$$

c) The average value of A.C. current over a half cycle is,

$$I_m = \frac{2I_0}{\pi} = 0.636\ I_0$$

d) The mean value of alternating current or voltage during positive half cycle is 0.636 times or 63.6% of the peak value. Similarly the mean value of alternating current or voltage during negative half cycle is –0.636 times of the peak value.

e) The mean or average value of AC. or voltage in first half cycle is equal and opposite to that in second half cycle and hence the mean value or average value of A.C. or voltage over one completer cycle is zero.

6. **R.M.5. or virtual value of A.C. :**

i) I_{rms} : The r.m.s. value of A.C. current is that value of a steady direct current, which when passed through the same resistor, for the same interval of time, which produces the same quantity of heat as the A.C. current.

OR

The A.C. current of equivalent value of $I_0/\sqrt{2}$ is called as r.m.s. value of A.C. current. It is given by,

$$I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707\ I_0$$

ii) e_{rms} : The r.m.s. value of AC. e.m.f. is that value of a steady direct e.m.f. which when applied across a given resistance would produce the same heating effect per second in that resistance as the A.C. e.m.f. produce in that resistance in the same time. OR The A.C. e.m.f. of equivalent value of $e_0/\sqrt{2}$ is called as r.m.s. value of AC. e.m.f. It is given by,

$$e_{rms} = \frac{e_0}{\sqrt{2}} = 0.707\ e_0$$

iii) The r.m.s. value of A.C. current and voltage are called effective value or virtual value of A.C. and effective value or virtual value of voltage respectively.

iv) The ratio of rms value to the average value is called form factor.

a) Form factor of alternating current,

$$F = \frac{I_{rms}}{I_{mean}} = \frac{\pi}{2\sqrt{2}}$$

b) Form factor of alternating emf,

$$F = \frac{e_{rms}}{e_{mean}} = \frac{\pi}{2\sqrt{2}}$$

7. The r.m.s. value of AC. e.m.f. / current is always less than peak e.m.f. / current.

8. The A.C. current can be measured by A.C. ammeter (hot wire ammeter). It measures r.m.s. current. In A.C. ammeter, deflection is proportional to square of current. Thus, calibration in hot wire ammeter are very close at start but wider as we move away.

9. The A.C. e.m.f. can be measured by A.C. voltmeter (hot wire voltmeter). It measure r.m.s. e.m.f. In A.C. voltmeter, deflection is proportional to square of potential difference. Thus, calibration in hot wire voltmeter are very close at start but wider as we move away.

10. The D.C. instruments will not show any deflection if they are connected in AC. circuits.

11. The AC. quantities can not be measured by D.C. instruments, because average value of A.C. quantities over a complete cycle is zero.

12. The equivalent quantity of mass in electricity is inductance.

13. The AC. currents shows heating .effect only. A.C. does not show chemical and magnetic effects. The electrolysis, electroplating, electromagnets, charging of batteries is not possible with A.C.

14. The frequency of A.C. mains in India is 50Hz.

i) The time during which AC. completes one cycle is defined as its time period. Its value is equal to time taken by the coil to complete one rotation in magnetic field.

ii) The number of cycles completed by A.C. in one second is defined as its frequency. Its value is equal to the number of rotations made by the coil in magnetic field in one second.

15. The A.C. current/e.m.f. through the A.C. circuit becomes zero two times the frequency ofA.c. source.
16. The electric currents, whose magnitude very for a small time, while growing to maximum or decaying to zero are called transient currents.
17. A quantity, which varies sinusoidally with time and represented as the projection of a rotating vector is called as phase e.g. A.C. e.m.f. and A.C. current.
18. The diagram representing alternating e.m.f. and current as the rotating vector along with phase angle is called as phase diagram.

19. Advantages of A.C. over D.C. :

i) The generation of A.C. is found to be economical than that of D.C.

ii) The A.C. voltages can be easily stepped up or stepped down by using a transformer.

iii) The A.C. currents can be regulated by using a choke coil without any significant wastage of energy.

iv) The A.C. voltage can be transmitted to distant places at very small loss of the electrical power.

v) Further A.C. can be easily converted into D.C. by using rectifiers.

20. Disadvantages of A.C. over D.C. :

i) The A.C. supply is more suicidal and dangerous than D.C. Also, peak value of A.C. is more than indicated value.

ii) The A.C. currents con not be used in electrolytic process.

iii) The A.C. currents always flows on the outer layer of the wire. This is called as skin effect. Due to this instead of a single thick wire used for D.C., we take a number of thin laminated wires for transferring A.C.

7.8 Reactance and impedance

1. Inductance: The ability or property of a conductor to produce induced e.m.f. in it due to the change of current in it or in neighbouring circuit is called as inductance.
2. Inductor: An electrical component which produces induced e.m.f. in it due to change in current in it or in a neighbouring circuit is call as inductor.
3. Capacitance: The property of an insulated conductor to store electric charge is called as capacitance.
4. Capacitor: An electrical component which stores electric charge is called as condenser.
5. Resistance: The property of a conductor to oppose flow of electric current is called as resistance. The reciprocal of resistance is called as conductance.
6. Reactance (X) : The opposition offered by inductor and condenser to the flow of A.C. current is called as reactance. The reciprocal of reactance is called as susceptance (Y).
7. Impedance: The opposition offered by inductor, condenser and resistor to the flow of A.C. current is called as impedance.

   It is given by,

   $$Z = \sqrt{R^2 + X^2}$$

   The reciprocal of impedance is called as admittance.
8. The resistance / reactance / impedance is expressed in terms of ohm and the conductance / susceptance / admittance is expressed in terns of mho or siemen.
9. Phase angle: The angle between the applied A.C. e.m.f. and A.C. current through the circuit is called as phase angle.
10. Power factor: The cosine of lead or lag angle between the applied alternating e.m.f. and the alternating current through the circuit, is called as power factor i.e. power factor = cos ϕ. OR

    The ratio of true power to apparent power in alternating circuit is called as power factor.

    $$\text{i.e. power factor} = \frac{\text{True power}}{\text{Apparent power}}$$

Alternating currents :

1. Simple A.C. circuit containing resistance:

i) The A.C. current through a resistance is given by,

$$I = I_0 \sin \omega t$$

ii) The A.C. e.m.f. across a resistance is given by,

$$e = e_0 \sin \omega t$$

Thus, alternating current through the resistor is in phase with alternating e.m.f.

2. Simple A.C. circuit containing inductor:

i) The alternating current through the

inductance is given by,

$I = I_0 \sin \omega t$

ii) The alternating e.m.f. across inductor is given by,

$$e = e_0 \cos \omega t = e_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

Thus, alternating e.m.f. across inductor leads the alternating current by a phase of $\pi/2$ radian.

iii) The opposition offered by inductor to the flow of alternating current is called as inductive reactance.

It is given by,

$X_L = \omega L = 2\pi fL$ also $X_L \propto f$

i.e. inductive reactance is directly proportional to frequency of alternating source.

iv) Inductor offers low resistance path to D.C. and high resistance to path A.C.

3. Simple A.C. circuit containing capacitor:

i) The alternating current through the capacitance is given by,

$I = I_0 \sin \omega t$

ii) The alternating e.m.f. across capacitor is given by,

$$e = -e_0 \cos \omega t = e_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

Thus, alternating e.m.f. across capacitor lags behind the alternating current by a phase angle of $\pi/2$ radian.

iii) The opposition offered by capacitor to the flow of alternating current is called as capacitive reactance. It is given by,

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC} \text{ also } X_C \propto \frac{1}{f}$$

i.e. capacitive reactance is inversely proportional to frequency of alternating source.

iv) Condenser offers low resistance path to A.c. and high resistance path to D.C. i.e. condenser blocks D.C. and allows A.c. through it.

4. Application of A.C. to L and R in series:

i) The A.C. current through the LR circuit is,

$I = I_0 \sin \omega t$.

ii) The A.C. e.m.f. across LR circuit is given by,

$$e = \sqrt{e_R^2 + e_L^2} = I\sqrt{R^2 + X_L^2}$$

$$= e_0 \sin(\omega t + \phi)$$

Thus, in LR circuit alternating e.m.f. leads the current by a phase angle of ϕ which is given by

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$$

iii) The impedance of LR circuit is,

$$Z = \sqrt{R^2 + X_L^2}$$

Thus, as the frequency of A.C. source in RL circuit increases its impedance also increases

5. Application of A.C. to C and R in series:

i) The A.C current through the CR circuit is,

$I = I_0 \sin \omega t$

ii) The A.C. e.m.f. across CR circuit is given by,

$$e = \sqrt{e_R^2 + e_L^2} = I\sqrt{R^2 + X_L^2}$$

$$= e_0 \sin(\omega t + \phi)$$

Thus, in CR circuit alternating e.m.f. lags behind the alternating current by a phase angle of $ radian which is given by,

$$\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$$

iii) The impedance of CR circuit is given by,

$$Z = \sqrt{R^2 + X_L^2}$$

Thus, as the frequency of A.c. source in RC circuit increase its impedance decreases.

iv) The power factor of LR and CR circuit is given by,

$$\text{Power factor} = \cos \phi = \frac{R}{Z}$$

6. LCR series circuit :

i) The alternating current through LCR series circuit is given by, $I = I_0 \sin \omega t$

ii) The alternating e.m.f. across LCR series circuit is given by,

$$e = \sqrt{e_R^2 + (e_L - e_C)^2}$$

$$= I\sqrt{R^2 + (X_L - X_C)^2}$$

$$= e_0 \sin(\omega t + \phi)$$

Thus, alternating e.m.f. in LCR series circuit leads the current by phase angle ϕ which is given by,

$$\tan\phi = \frac{X_L - X_C}{R}$$

a) If $X_L > X_C$, then $\tan\phi$ is positive, hence e.m.f. leads the current.

b) If $X_L < X_C$, then $\tan\phi$ is negative, hence e.m.f. lags behind the current.

c) If $X_L = X_C$, then $\phi = 0$, hence e.m.f. is in phase with current.

d) The impedance of LCR series circuit is given by, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

Thus, as the frequency of A.C. source increases, impedance of the circuit decreases becomes minimum and then increases.

7.9 Power in ac circuits with resistance, inductance, capacitance and LCR series circuit

1. Simple A.C. circuit containing resistance:

i) The alternating power in purely resistive circuit is,

$$P = e_0 I_0 \sin^2 \omega t$$

ii) The average power in resistive circuit is given by,

$$\overline{P} = \frac{e_0 I_0}{2} = e_{rms} I_{rms}$$

Thus, there is consumption of electrical energy.

iii) The power factor of purely resistive circuit is one.

2. Simple A.C. circuit containing inductor :

i) The alternating power in purely inductive circuit is given by,

$$P = \frac{e_0 I_0}{2} = \sin 2\ \omega\ t$$

ii) The average power in inductive circuit is given by,

$$\overline{P} = 0.$$

Thus, there is no consumption of electrical energy in purely inductive circuit.

iii) The power factor of purely inductive circuit is zero.

3. Simple A.C. circuit containing capacitor:

i) The alternating power in purely capacitive circuit is given by,

$$P = \frac{e_0 I_0}{2} = \sin 2\ \omega\ t$$

ii) The average power in purely capacitive circuit is,

$$\overline{P} = 0.$$

Thus, there is no consumption of electrical energy in purely capacitive circuit.

iii) The power factor of purely capacitive circuit is zero.

6. LCR series circuit:

i) The alternating power in LCR series circuit is given by,

$$P = e_0 I_0 \cos\phi \sin^2 \omega t \pm \frac{e_0 I_0}{2} \sin\phi,$$

$$\sin 2\ \omega t$$

ii) The average power or power consumption or true power or power dissipation in LCR series circuit is given by

$$\overline{P} = \frac{e_0 I_0}{2} \cos\phi, = e_{rms} I_{rms} \cos\phi$$

$$\overline{P} = \text{Apparent power} \times \text{Power factor}$$

iii) The average power is given by,

$$P = e_{rms} I_{rms} \cos\phi.$$

If I_{rms} is resolved into two components like $I_{rms} \cos\phi$ and $I_{rms} \sin\phi$.

Now, average power for $I_{rms} \sin\phi = 0$, since $\phi = 90°$. As the component $I_{rms} \sin\phi$ does not contribute to power it is called as idle or wattless component of A.C. The current in a circuit is wattless if the resistance of the circuit is zero.

iv) The product of r.m.s. current and r.m.s. e.m.f. is called as apparent power.

v) The ratio of true power to apparent power is called as power factor. Thus, power factor of LCR series circuit is given by,

a) Power factor $= \cos\phi$

$$= \frac{R}{Z} = \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}}$$

b) power factor = $\dfrac{\text{True power}}{\text{Apparent power}}$

Remark:

i) The power factor of A.C. circuit varies between 0 to 1.

ii) Importance of power factor: In electric circuit, operating same electric appliance, the power factor is kept as low as possible. It is done so that power consumption in the electric circuit is low. Also, when the power is to be transmitted, power factor is made as large as possible.

Since $I = \dfrac{P}{\cos\phi}$. The large value of power factor will produce low current, hence power dissipation of electrical energy in the form of heat along the wire is low.

7.10 LC oscillations

1. "When a charged capacitor is allowed to discharge through a non-resistive inductor, electrical oscillations of some amplitude and frequency are produced. This oscillations are called L-C oscillations."
2. "The parallel combination of inductor of inductance L and capacitor of capacitance C is called as tank circuit."
3. The energy of system continuously changes between electric field of the capacitor and magnetic field of inductor. This produces electrical oscillations.
4. The frequency of LC oscillations is given by,

$$f = \frac{1}{2\pi\sqrt{LC}}$$

7.11 Resonant circuits

Series resonant circuit :

1. In LCR series circuit A.C. current is given by,

   $I = I_0 \sin \omega t$

2. The A.C. e.m.f. across LCR series circuit is

$$e = e_0 \sin(\omega t + \phi) = \sqrt{e_R^2 + (e_L - e_C)^2}$$

where $e_R = I_R$, $e_L = I X_L$ and $e_C = I X_C$

The impedance of LCR series circuit is given by,

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

3. The phase angle, in LCR series circuit is given by,

$$\sin\phi = \frac{X_L - X_C}{\sqrt{R^2 + (X_L - X_C)^2}},$$

$$\cos\phi = \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}} \text{ and}$$

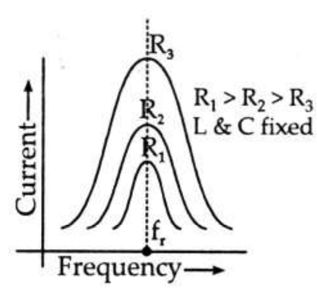
$$\tan\phi = \frac{X_L - X_C}{R}$$

5. In LCR series circuit resonance take place if $X_L = X_C$ then $Z = R$ i.e. impedance of the circuit is minimum and current through the circuit is maximum.
6. The LCR series circuit at resonance is called as series resonant circuit. OR
   The LCR series circuit, which admits maximum current corresponding to a particular frequency is called as series resonant circuit.
7. Resonant frequency (f_r) : The minimum or particular frequency of applied A.C. voltage at which inductive reactance is equal to capacitive reactance is called as resonant frequency. OR The frequency of applied A.C. voltage at which impedance of the circuit is minimum and current through the circuit is maximum is called as series resonant frequency. It is given by,

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

8. **Resonance curve :**

i) The graphical representation between the frequency of A.C. source and current through the circuit is called as resonance curve.



ii) From graph it is clear that the curve becomes sharp for small value of resistances. AS frequency increases, current increases becomes maximum and then decreases.

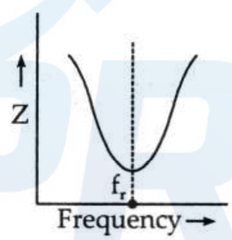
iii) Also, if the resistance of the circuit is low then for a small change in frequency there is large change in current. Thus, for a sharp resonance curve, ohmic resistance of LCR series circuit should be low.

iv) Band width: The difference between higher cut off (f_2) frequency and lower cut off frequency (f_1) is called as band width.

i.e. band width = $f_2 - f_1$ where f_2 and f_1 are two side frequencies for which current falls to $(1/\sqrt{2})$ times current at resonance.

9. Impedance curve : The graphical representation between frequency and impedance of the circuit is called as impedance curve.

As frequency increases, impedance first decreases, Frequencybecomes minimum and then increases.



10. Q factor: The selectivity or sharpness of a resonant circuit is measured by Q factor or quality factor or voltage magnification factor.

Definition - The ratio of voltage across inductor or condenser to the voltage across resistor at resonance is called as Q factor i.e.

$$Q = \frac{\omega L}{R} = \frac{1}{\omega CR} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Thus, Q factor is large or the circuit will have maximum selectivity if R is low or L is large or C is low.

The voltage magnification factor is also given by,

$$Q = \frac{f_r}{f_2 - f_1}$$

where f_r - resonant frequency, f_2 and f_1 cut off frequencies.

11. Properties of series resonant circuit:

i) At resonance, impedance of the circuit is minimum

i.e. $Z = R$

ii) At resonance, current through the circuit is maximum

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

iii) At resonance, circuit acts as resistive circuit.

iv) At resonance, A.C. current is in phase with A.C. e.m.f.

v) At resonance power factor of the circuit is unity.

12. Acceptor circuit: The series resonant circuit accepts the current of the resonant frequency, hence series resonant circuit is called as acceptor circuit.

Parallel resonant circuit :

1. In parallel resonant circuit, inductor and capacitor are connected in parallel.
2. The alternating e.m.f. in parallel LC circuit is given by,

$$e = e_0 \sin \omega t$$

3. The alternating current through parallel LC circuit is given by,

$$I = I_L + I_C$$

$$= \frac{e}{X_L} + \frac{e}{X_C} = e_0\left(\frac{1}{X_C} - \frac{1}{X_L}\right) \cos \omega t$$

$$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

4. The impedance of parallel LC circuit is given by,

$$Z = \frac{1}{\frac{1}{X_C} - \frac{1}{X_L}}$$

i) At low frequency, $\frac{1}{\omega L} > \omega C$ i.e. $I_L > I_C$, the line current will lag behind the applied e.m.f.

ii) At high frequency, $\omega C > \frac{1}{\omega L}$ i.e. $I_C > I_L$ the line current will lead the applied e.m.f.

iii) If $X_L = X_C$, then line current becomes zero but oscillating current flows in the circuit containing L and C in parallel.

5. In parallel LC circuit, resonance take place it $X_L = X_C$ then $Z = \infty$ i.e. impedance of the circuit is maximum and current through the circuit is

minimum.

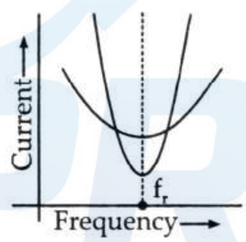
6. The parallel LC circuit at resonance is called as parallel resonant circuit. OR The parallel LC circuit which rejects the current of a particular frequency is called as parallel resonant circuit.

7. Resonant frequency (f_r) : The minimum or particular frequency of applied A.C. voltage at which inductive reactance is equal to capacitive reactance is called as resonant frequency. OR The frequency of applied A.C. voltage at which impedance of the circuit is maximum and line current is minimum is called as resonant frequency. It is given by,

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

8. Resonance curve :

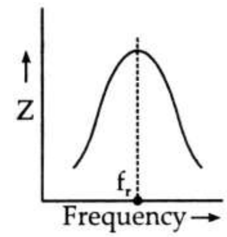
i) The graphical representation between the frequency of A.C source and current through the circuit is called as resonance curve.



ii) In parallel LC circuit, the impedance increases first (current decrease), it becomes maximum (current is minimum) then impedance decreases (current increases).

iii) The sharpness i.e. selectivity of parallel resonance curve increases as the impedance of the circuit increases.

9. Impedance curve: The graphical representation between frequency and impedance of the circuit is called as impedance curve. As frequency increases, impedance first increases, becomes maximum and then decreases:



10. Voltage magnification: At resonance, the line current is minimum and maximum oscillating current flows through LC loop. Hence, maximum voltage is obtained across LC loop which is greater than applied e.m.f. Thus, there is a voltage magnification.

11. Properties of parallel resonant circuit:
    - i) At resonance, impedance of the circuit is maximum.
    - ii) At resonance, line current is minimum.
    - iii) At resonance, A.C current is in phase with A.C e.m.f.
    - iv) At resonance, circuit acts as resistive circuit.
    - v) At resonance power factor of the circuit is unity.

12. Rejector circuit: The parallel resonant circuit rejects the current of the resonant frequency, hence parallel resonant circuit is called as rejector circuit.

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MULTIPLE CHOICE QUESTIONS

7.1 Laws of electromagnetic induction and proof of e = – d/dt

1. 'The rate of change of magnetic flux linked with the coil is equal to the magnitude of induced e.m.f.' This is the statement of
a) Lenz's law b) Gauss's law
c) Newton's law d) Faraday's law

2. The magnitude of induced emf during electromagnetic induction, is directly proportional to
a) electric flux b) magnetic flux
c) magnetic field d) electric field.

3. Whenever the magnetic flux linked, with a coil changes, then an induced e.m.f. is produced in the circuit. This e. m. f. lasts
a) for ever
b) for a long time
c) for a short time
d) so long as the change in flux take place

4. The induced emf can be produced by changing
a) strength of the magnetic field
b) area of the coil rotating in a field
c) direction of the magnetic field
d) either 'a' or 'b'

5. The magnitude of induced e. m. f. in a conductor, depends upon
a) resistance of the conductor
b) strength of the magnetic field
c) orientation of the conductor
d) rate of change of flux linkage with the conductor

6. Faraday's laws are consequence of the conservation of
a) energy b) magnetic field
c) charge d) both 'a' and 'b'

7. When a coil is rotated in a magnetic field, with steady speed, then
a) no e. m. f. is induced
b) a periodic e. m. f. is induced
c) unidirectional e. m. f. is induced
d) multidirectional e. m. f. is induced

8. When a magnet is inserted into a coil the emf induced does not depend upon
a) resistance of the coil
b) number of turns in the coil
c) magnetic moment of the magnet
d) speed of the approach of the magnet

9. If a straight conductor is moved with a uniform velocity at right angle to a uniform magnetic field then e.m.f. induced in itis
a) $e = -Blv$ b) $e = Blv^2$
c) $e = B/lv$ d) $e = l/vB$

10. If a conductor is rotating about its one end in a uniform magnetic field then an emf induced in it is
a) $e = -BAf$ b) $e = +BAf^2$
c) $e = B/Af$ d) $e = B$

11. The direction of induced e.m.f. in a conductor can be found by
a) right hand rule
b) right hand screw rule
c) Flemings right hand rule
d) Flemings left hand rule

12. The phenomenon of electromagnetic induction was discovered by
a) Fleming b) Oersted
c) Faraday d) Henry

13. Magnetic flux through a coil depends upon
a) number of turns b) area
c) magnetic field d) all of these

14. If any surface is parallel to magnetic lines of forces, then magnetic flux linked with it is
a) very small but not zero
b) infinite
c) large but not finite
d) zero

15. Negative sign appearing in Faraday's law of electromagnetic induction indicates that
a) the induced e. m. f. is produced only when magnetic flux decreases
b) the induced emf is opposite to the direction of magnetic flux
c) the induced emf opposes the changes in magnetic flux
d) none of the these

16. A bar magnet is being moved towards a stationary coil (i) rapidly (ii) slowly. The e.m.f. induced in the coil is
a) larger in case (i) b) smaller in case (i)
c) equal in both cases d) cannot say

17. A coil is being moved towards a stationary magnet (i) rapidly (ii) slowly. Induced current in the coil is
a) larger in case (i) b) smaller in case (ii)
c) equal in both cases d) both 'a' and 'b'

18. When a magnet is moved with its south pole towards the coil, then the nearer face of the coil behaves as a
a) N–pole b) S–pole
c) +ve charge d) –ve charge

19. When a magnet is moved with its N pole away from the coil, then the nearer face of the coil behaves as a
a) N–pole b) S–pole
c) +ve charge d) –ve charge

20. Which of the following phenomenon makes use of electromagnetic induction?
a) Magnetising an iron piece with a bar magnet
b) Magnetising a soft iron by placing it inside a current carrying solenoid
c) Charging a storage battery
d) Generation of hydro electricity

21. Induced e.m.f. can be produced by
a) moving a magnet near a circuit
b) moving a circuit near a magnet
c) changing the current in one circuit near the other
d) all of these

22. A copper rod moves parallel to the horizontal direction. The emf. induced will be maximum at the
a) equator b) latitude 30°
c) latitude 60° d) poles

23. The direction of induced e.m.f. during electromagnetic inductions is given by
a) Lenz's law b) Newton's law
c) Faraday's law d) Biot Savart's law

24. Lenz's law is a consequence of the law of conservation of
a) mass b) charge
c) energy d) momentum

25. Lenz's law provides a relation between
a) current and magnetic field
b) force on a conductor and magnetic field
c) induced e.m.f. and the rate of change in magnetic flux
d) all of these

26. When a magnet is moved towards a coil the direction of induced current is clockwise. If the magnet is moved away from the coil, the direction of induced current will be
a) clockwise b) anticlockwise
c) zero d) any direction

27. A horizontal straight conductor along east–west direction falls under gravity, then there is
a) no induced e.m.f. along the length
b) no induced current along the length
c) an induced current from west to east
d) an induced current from east to west

28. The total charge induced in a conducting loop, when it is moved in magnetic field depends on
a) rate of change of magnetic flux
b) initial magnetic flux only
c) total change in magnetic flux
d) final magnetic flux only

29. If the magnetic field is doubled through a coil of number of turns 'n' then the' induced e.m.f. will be
a) 4 times b) 3 times
c) two times d) 1 times

30. The 5×10^{-4} magnetic flux lines are passing through a coil of 100 turns. If the e.m.f. induced through the coil is 5m V, the time interval will be
a) 1 s b) 0.1 s
c) 0.01 s d) 0.001 s

31. A rectangular coil of 20 turns and area of cross section 25 cm^2 has a resistance of 100 Ω. If a magnetic field which is perpendicular to the plane of the coil, changes at a rate of 1000 Tis, then the current in the coil will be
a) 50 A b) 5 A
c) 1A d) 0.5 A

32. A coil of cross sectional area 100 cm^2 is placed in the magnetic field, which changes to 4×10^{-2} Wb/cm^2 within 5 s. What will be the current across 5 Ω resistance?
a) 0.016 A b) 0.16 A
c) 1.6 A d) 16.0 A

33. Flux ϕ (in webers) in a closed circuit of resistance $10\,\Omega$ varies with time t according to the equation $\phi = 6t^2 - 5t + 1$. The magnitude of induced current at t = 0.25 s should be
a) 1.2A b) 0.8A
c) 0.6 A d) 0.2 A

34. A wire is moving in the magnetic field of B, if the cross sectional area of wire becomes double, then what will be the direction of induced emf?
a) No change b) Reverse
c) Makes an angle θ d) Both b and c

35. A conductor is moving in the magnetic field B the induced current is I. If the magnetic field is doubled, the induced current will
a) remain the same b) be half
c) be double d) be four times

36. A magnetic field of 2×10^{-2} T acts at right angle to a coil of area 100 cm^2 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
a) 0.01 s b) 0.1 s
c) 1 s d) 10 s

37. A straight conductor of length 0.4 m is moved with a speed of 7 m/s perpendicular to a magnetic field of intensity 0.9 T. The induced emf across the conductor is
a) 1.26 V b) 2.52 V
c) 5.04 V d) 25.2 V

38. A conductor is moving with the velocity (v) in the magnetic field and the induced current is (I). If the velocity of the conductor becomes double the induced current will be
a) 0.51 b) $\sqrt{2}$ I
c) 2 I d) 4 I

39. A wire is moving with velocity 12×10^{-2} m/s in a magnetic field of 0.5 T. If the induced emf is 9 mV, the length of wire is
a) 150 cm b) 15 cm
c) 1.5 cm d) 0.15 cm

40. Induced emf produced in a coil rotating in a magnetic field will be maximum when the angle between the axis of coil and direction of magnetic field is
a) 0° b) 90°
c) 45° d) 180°

41. If a conductor is moving in the north direction and magnetic field is applied vertically upwards, the change in flux is 2×10^{-4} Wb within 2 s. If the resistance of conductor is 5 Ω, then the magnitude of induced current will be
a) 0.02 mA b) 0.2 mA
c) 0.002 mA d) 2 mA

42. A straight conductor of length 4 m moves at a speed of 10 m/s when the conductor makes an angle of 300 with the direction of magnetic induction 0.1 T. Then the induced emf is
a) 1 V b) 2 V
c) 4 V d) 8 V

43. If the flux associated with a coil varies at the rate of 1 Wb/min, the induced emf is
a) 1 V b) 1/60 V
c) 60 V d) zero

44. A metal disc of radius R rotates with an angular velocity ω about an axis perpendicular to its plane passing through its centre in a magnetic field of induction B acting perpendicular to the plane of the disc. The induced emf between the rim and axis of the disc is
a) $-\frac{BR^2\omega}{2}$ b) $-\frac{2B\pi^2R^2}{\omega^2}$
c) $-B\pi R^2\omega$ d) $-B\pi R^2$

45. A coil of area 500 cm^2 having 1000 turns is put perpendicular to a magnetic field of intensity 4×10^{-5} T. If it is rotated by 1800 in 0.1 s, the induced e.m.f. produced is
a) 20 mV b) 40 mV
c) 60 mV d) 80 mV

46. The magnetic flux linked with the coil changes from 0.1 Wb to 0.04 Wb in 3 s. The emf induced in the coil is
a) 2 V b) 0.2 V
c) 0.02 V d) 0.002 V

47. A metal rod of length 1m is rotated about one of its ends in a plane at right angle to a uniform magnetic field of induction 5×10^{-3} T. If it makes 1800 rotations per minute, then the e.m.f. induced between its ends is
a) 0.471 V b) 4.71 V
c) 4.17 V d) 1.47 V

48. A circular coil of radius 0.5 m and resistance 3.14 Ω is placed in a magnetic induction with its plane perpendicular to the field. The rate of change of magnetic induction so as to produce a current of 50 mA in a coil is
a) 0.2 Wb/m^2s b) 0.2 T/s
c) 0.02 T/s d) both 'a' and 'b'

49. The induced e.m.f. across the secondary coil depends upon
i) the number of turns n_1 and n_2 in primary and

secondary coil respectively

ii) the permeability of the medium between the two coils

iii) area of cross section of two coils

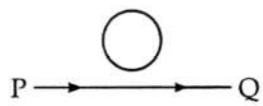
iv) resistance of wire of two coils

Which of the above is/are true?

a) All are true　　b) i, ii, iii

c) iii, iv,　　d) ii, iii, iv

50. A current 1 is flowing through a straight conductor PQ shown in the figure. A circular loop of metal wire is placed as shown and is coplanar. If the current in the wire is reduced to zero value, there will be



a) no induced current in the loop

b) clockwise current in the loop

c) anticlockwise induced current

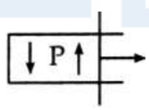
d) initially anticlockwise and then clockwise induced currents in the coil

51. If a coil of area 10 cm^2 and 10 turns in the magnetic field directed perpendicular to the plane, is changing at the rate of 10^8 gauss/so The resistance of the coil is 20 Ω. The current in the coil will be

a) 5 A　　b) 0.5 A

c) 0.005 A　　d) 500 A

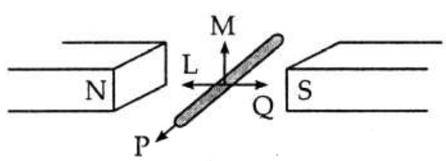
52. The movable wire is moved to the right causing an anticlockwise induced current. The direction of magnetic induction in the region P points



a) to the right　　b) to the left

c) up the paper　　d) down into the paper

53. The induced e.m.f. will be produced between the ends of the conductor shown in the figure, when the conductor moves in the direction of



a) P　　b) Q

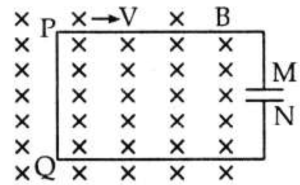
c) L　　d) M

54. A bar magnet of length L is dropped inside a vertical copper pipe of length l (l < L); it will experience an acceleration q such that

a) q > g　　b) q = g

c) q < g　　d) q = Ig/L

55. A rod PQ is connected to the capacitor plates. The rod is placed in a magnetic field B directed downward perpendicular to the plane of the paper. If the rod is pulled out of the magnetic field with velocity v as shown in figure



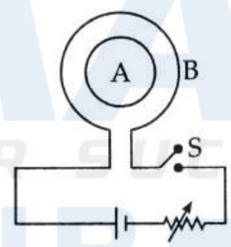
a) plate M will be positively charged

b) plate N will be positively charged

c) both plates will be similarly charged

d) no charge will be collected on plates

56. A closed circular wire loop A lies in the plane of longer loop B, which is connected to the battery as shown in the figure. The direction of current induced in the loop A when the switch S is closed is



a) clockwise

b) anti clockwise

c) no current is induced in A and loop A remains stationary

d) no current is induced in A, but A rotates clockwise

57. A car moves up on a plane road. The induced e.m.f. in the axle connecting the two wheels is maximum when it

a) moves at the poles

b) moves at equator

c) remains stationary

d) no e.m.f. is induced at all

58. The magnetic flux linked with coil is proportional to

a) voltage　　b) current

c) length of coil　　d) resistance of coil

7.2 Eddy currents

59. The circulating induced current produced in a metal plate due to the change in magnetic flux are
a) eddy currents b) Foucault's currents
c) Amperes current d) both 'a' and 'b'

60. Which of the following is not the application of eddy currents?
a) Induction furnace
b) Dead beat galvanometer
c) Speedometer
d) x–ray crystallography

61. Induction furnace works on the principle of
a) self induction b) mutual induction
c) eddy currents d) Lenz's law

62. Eddy currents are developed, when
a) conductor is kept in changing magnetic field
b) conductor is kept in steady magnetic field
c) conductor is kept in electric field
d) none of these

63. Eddy currents do not cause
a) damping b) heating
c) sparking d) loss of energy

64. The plane in which eddy currents are produced in a conductor is inclined to the plane of the magnetic field at an angle equal to
a) 45° b) 0°
c) 180° d) 90°

7.3 Self induction and mutual induction

65. Production of induced e.m.f. in a coil due to the changes of current in the same coil is
a) self induction b) mutual induction
c) dynamo d) none of these

66. When the rate of change of current is unity, e.m.f. induced in the same coil is equal to
a) thickness of the coil
b) number of turns in the coil
c) coefficient of self induction
d) total flux linked with the coil

67. The coefficient of self inductance of a coil is
a) $L = e\dfrac{dI}{dt}$ b) $L = e\dfrac{dI}{dr}$
c) $L = -e\dfrac{dI}{dr}$ d) $L = -e\dfrac{dt}{dI}$

68. The inductance of a coil depends on
a) number of turns of the coil
b) geometrical properties of the coil
c) both 'a' and 'b'
d) neither 'a' nor 'b'

69. Henry is the S. I. unit of
a) resistance b) capacity
c) inductance d) current

70. If an e.m.f. of 1 volt is induced in the coil due to the change of current of 1A/s then the inductance is
a) a henry b) a farad
c) a ohm d) none of these

71. The self inductance of a coil does not depend upon
a) the diameter of the coil
b) the length of the coil
c) the resistance of the wire of coil
d) the number of turns in the coil

72. The self inductance associated with a coil is independent of
a) current b) time
c) induced voltage d) resistance of coil

73. The coils in resistance boxes are made from doubled insulated wire to nullify the effect of
a) heating b) magnetism
c) pressure d) self induced e.m.f.

74. If the number of turns per unit length of a solenoid is doubled, the self inductance of the solenoid will
a) become double b) become half
c) become four times d) remain unchanged

75. A coil of insulated wire is connected to a battery. If it is connected to galvanometer, its pointer is deflected, because
a) induced current is set up
b) no induced current is set up
c) the coil behaves as a magnet
d) the number of turns is changed

76. If the rate of change of current of 1A / s in one coil, induces an e.m.f. of 1 V in the neighbouring coil, the mutual inductance of two coil is
a) 1 H b) 1.5 H
c) 2 H d) 2.5 H

77. If the rate of change of current in primary coil is doubled, the induced e.m.f. in secondary coil become
a) half b) same

c) double d) 4 times

78. Mutual induction is the production of induced e.m.f. in a coil due to the changes of current in the
a) same coil b) neighbouring coil
c) both a and b d) neither a nor b

79. The mutual inductance depends upon
a) number of turns of a coil
b) geometrical properties of a coil
c) medium between the two coil
d) all of these

80. The self inductance of a coil is a measure of
a) electrical inertia b) electrical friction
c) induced e.m.f. d) induced current

81. If N is the number of turns in a coil, the value of self inductance varies as
a) N^0 b) N^1
c) N^2 d) N^{-2}

82. An inductor may store energy in
a) its electric field
b) its coils
c) its magnetic field
d) both in electric and magnetic fields

83. One henry is equal to
a) 1 weber/ampere b) 1 weber/volt
c) 1 weber ampere d) 1 weber volt

84. When the number of turns in a coil is doubled without any change in the length of the coil, its self inductance becomes
a) four times b) doubled
c) halved d) squared

85. Two pure inductors each of self inductance L are connected in series, the net inductance is
a) L b) 2 L
c) L/2 d) L/4

86. The inductance of a coil is proportional to
a) its length
b) the resistance of the coil
c) the number of turns
d) square of number of turns

87. The average emf induced in a coil in which the current changes from 2 A to 4 A in 0.05 s is 8 V. The self inductance of the coil is
a) 0.1 H b) 0.2 H
c) 0.3 H d) 0.4 H

88. The self inductance of coil, which produces 5 V, when the current changes from 3 A to 2 A in one millisecond is
a) 5 mH b) 50 mH
c) 5H d) 50 H

89. If the rate of change of current per second in one coil induces an e.m.f. of 2 V in the neighbouring coil, the mutual inductance of two coils is
a) 2 H b) 1.5 H
c) 1 H d) 2.5 H

90. If the current increases from zero to 1A in 0.1 sin a coil of 5 mH then magnitude of induced e.m.f. will be
a) 5 V b) 0.5 V
c) 0.05 V d) 0.005 V

91. The self inductance of the coil of 100 turns, in which a current of 4A produces a flux of 40 Wb is
a) 10 H b) 1H
c) 0.1H d) 0.01 H

92. A current of 3 A, in one coil, causes a flux in the second coil of 2000 turns to change by 6×10^{-4} Wb per turn of the secondary coil. The mutual inductance of the pair of coils is
a) 6 H b) 2 H
c) 0.4 H d) 4 H

93. A coil with air inside it has self inductance of 0.05 H. A soft iron rod of relative permeability 100 is introduced inside the coil. The value of self inductance is
a) 5H b) 0.05H
c) 2.5 H d) 10H

94. A 100 mH coil carries 1 A current. Energy stored in its magnetic field is
a) 1 J b) 0.5 J
c) 0.05 J d) 0.1 J

95. A wheel with metal spokes 1.2 m long, rotates in a field of induction 5×10^{-5} T normal to the plane of the wheel. If 10^{-2} V is emf induced between its rim and axle, the speed of rotation of the wheel is
a) 44 rps b) 88 rps
c) 22 rps d) 11 rps

96. A choke coil has
a) high inductance and high resistance
b) high inductance and low resistance
c) low inductance and high resistance
d) low inductance and low resistance

7.4 Need for displacement current

97. Ampere's circuital law is not applicable for
a) inductor b) resistor
c) condenser d) diode

98. The concept of displacement current was introduced by
a) Coulomb
b) Faraday
c) Maxwell
d) Van–de Graff

99. The current produced in a region whenever the electric field and hence electric flux is changing with time is
a) displacement current
b) eddy current
c) alternating current
d) convection current

100. The displacement current is given by
a) $I_D = \varepsilon_0 \frac{d\phi_E}{dt}$ b) $I_D = \frac{1}{\varepsilon_0}\frac{d\phi_E}{dt}$
c) $I_D = \varepsilon_0 \frac{d^2\phi_E}{dt}$ d) $I_D = \frac{1}{\varepsilon_0}\frac{d^2\phi_E}{dt}$

101. Maxwell's modification of Ampere's circuital law is
a) $\oint \vec{B}.\vec{d}l = \mu_0 I$
b) $\oint \vec{B}.\vec{d}l = \frac{I}{\mu_0}$
c) $\oint \vec{B}.\vec{d}l = \mu_0[I + e_0 \frac{d\phi_E}{dt}]$
d) $\oint \vec{B}.\vec{d}l = \mu_0[I - e_0 \frac{d\phi_E}{dt}]$

102. Magnetic field is produced by
a) steady conduction current
b) time varying electric field
c) both 'a' and 'b'
d) neither 'a' nor 'b'

103. The wave of electric and magnetic field both varying in space and time is
a) matter wave
b) sound wave
c) longitudinal wave
d) electromagnetic wave

7.5 Transformer

104. A transformer is based on the principle of
a) mutual induction
b) self induction
c) Ampere's law
d) x–ray crystallography

105. The core of a transformer is laminated to reduce energy losses due to
a) eddy currents
b) hysteresis
c) resistance in winding
d) none of these

106. The device that does not work on the principle of mutuai induction is
a) induction coil b) motor
c) tesla coil d) transformer

107. A transformer is employed to
a) obtain a suitable de voltage
b) convert dc into ac
c) obtain a suitable ac voltage
d) convert ac into de

108. What is increased in step–down transformer
a) voltage b) current
c) power d) current density

109. A device which converts low ac voltage at high current into high ac voltage at low current is
a) electrochemical cell
b) photo cell
c) transformer
d) rectifier

110. In transformer, core is made of soft iron to reduce
a) hysteresis losses
b) eddy current losses
c) force opposing electric current
d) none of the above

111. The transformation ratio in the step–up transformer is
a) one
b) greater than one
c) less than one
d) the ratio greater or less than one depends on the other factor

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

a) 200 b) 100
c) 50 d) 20

113. 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
a) 5 P b) 1.5 P
c) P d) 2/5 P

114. 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 10A. The voltage and the current in the secondary are
a) 240 V, 5 A b) 240 V, 10 A
c) 60 V, 20 A d) 120 V, 20 A

115. 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) 1.5A

116. 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
a) 100 V, 16 A b) 40 V, 40 A
c) 160 V, 10 A d) 80 V, 20 A

117. 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
a) 50 V b) 70 V
c) 100 V d) 40 V

118. The alternating voltage induced in the secondary coil of a transformer is mainly due to
a) a varying electric field
b) a varying magnetic field
c) the vibrations of the primary coil
d) the iron core of the transformer

119. We can reduce eddy currents in the core of transformer
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

120. 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

121. The efficiency of transformer is very high because
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

122. 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
a) 0.08 A b) 0.4 A
c) 5 A d) 10 A

123. A transformer connected to 220 V line shows an output of 2 A at 11000 V. The efficiency is 100%. The current drawn from the line is
a) 100 A b) 200 A
c) 22 A d) 11 A

124. 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
a) 4 A b) 0.4 A
c) 0.04 A d) 0.2 A

125. 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
a) 50 b) 100
c) 150 d) 200

126. A transformer is used to
a) change the alternating potential
b) change the alternating current
c) to prevent the power loss in alternating current flow
d) to increases the power of current source

127. 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

a) 48 V b) 24 V
c) 12 V d) 6 V

128. 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

129. A step–down transformer is connected to main supply 200 V to operate a 6 V, 30 W bulb. The current in primary is
a) 3A b) 1.5 A
c) 0.3 A d) 0.15 A

130. Voltage in the secondary coil of a transformer does not depend upon.
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'

131. 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

132. 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
a) 5 A b) 50 A
c) 500 A d) 0.05 A

133. 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
a) 100 b) 200
c) 400 d) 300

134. In a primary coil 5 A current is flowing on 220 V. In the secondary coil 2200 V voltage produces. Then ratio of number of turns in secondary coil and primary coil will be
a) 1 : 10 b) 10 : 1
c) 1 : 1 d) 11 : 1

135. The output voltage of a transformer connected to 220 volt line is 2200 volt at 1 amp current. Its efficiency is 100%. The current coming from the line is
a) 20 A b) 5 A
c) 11A d) 22 A

136. Quantity that remains unchanged in a transformer is
a) voltage b) current
c) frequency d) none of the above

137. In a transformer, the number of turns in primary and secondary are 500 and 2000 respectively. If current in primary is 48 A, then the current in the secondary will be
a) 12 A b) 48 A
c) 192 A d) 144 A

138. The turn ratio of a transformer is given as 2 : 3. If the current through the primary coil is 3 A, then the current through load resistance is
a) 1A b) 4.5 A
c) 2 A d) 1.5 A

139. Core of transformer is made up of
a) soft iron b) steel
c) iron d) alnico

140. 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
a) 40 A, 16 A b) 16 A, 40 A
c) 20 A, 40 A d) 40 A, 20 A

141. 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
a) 20 A b) 10 A
c) 2 A d) 1A

142. 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
a) 3 A b) 30 A
c) 0.3 A d) 2.4 A

7.6 Rotating coil in uniform magnetic induction

and

7.7 Alternating currents

143. Alternating currents can be produced by a
a) dynamo b) choke coil
c) transformer d) electric motor

144. An emf induced in a coil rotating in a uniform magnetic field is given by
a) $e = e_0 \sin \omega t$ b) $e_0 = e \sin \omega t$
c) $e = \sin \omega t$ d) $e = e_0 \tan \omega t$

145. The maximum value of e.m.f. induced in a coil rotating in a uniform magnetic field is called as
a) peak e.m.f. b) r.m.s. e.m.f.
c) D. C. e.m.f. d) all of these

146. The alternating current of equivalent value of $I_0/\sqrt{2}$ is
a) peak current b) r.m.s. current
c) D. C. current d) all of these

147. The peak value of the a. c. current flowing throw a resistor is given by
a) $I_0 = e_0/R$ b) $I = e/R$
c) $I_0 = e_0$ d) $I_0 = R/e_0$

148. The alternating current can be measured with the help of
a) hot wire ammeter
b) hot wire voltmeter
c) moving magnet galvanometer
d) suspended coil type galvanometer

149. D. C. ammeter is connected in a circuit through which an a. c. emf of 50 Hz is flowing. The ammeter will read
a) zero
b) maximum current
c) peak value of current
d) r. m. s. value of the current

150. The r.m.s. value of an alternating current is
a) less than zero
b) equal to its peak value
c) less than its peak value
d) greater than its peak value

151. The maximum value of A. C. emf in a complete cycle is
a) $2nAB\omega$ b) $nAB\omega$
c) $nAB\omega/2$ d) $3nAB\omega$

152. A voltmeter reads V volts in an A. C. circuit. Then V is
a) peak value of the voltage
b) peak value of the current
c) r. m. s. value of the current
d) r. m. s. value of the voltage

153. The measuring instrument used for alternating current/emf value, measures its
a) peak value b) r. m. s. value
c) average value d) square of current

154. In an A. C. circuit, I_{rms} and I_0 are related as
a) $I_{rms} = I_0/\pi$ b) $I_{rms} = I_0/\sqrt{2}$
c) $I_{rms} = \pi I_0$ d) $I_{rms} = \sqrt{2} I_0$

155. If an A. C. ammeter reads I A in an A. C. circuit, then the peak value of the current is
a) $1/\sqrt{2}$ b) 1
c) $\sqrt{2}$ I d) 2I

156. The average value of alternating current, over a complete cycle is
a) 0 b) $2I_0$
c) $I_0/\sqrt{2}$ d) $I_0/2$

157. Alternating current can not be measured by D. C. ammeter, because
a) A. C. is virtual
b) A. C. changes its direction
c) A. C. can not pass through D. C. ammeter
d) average value of A. C. for complete cycle is zero

158. A device which converts mechanical energy into electrical energy is called as
a) dynamo b) generator
c) both 'a' and 'b' d) neither 'a' nor 'b'

159. In a simple circuit with resistance, phase between A.c. emf and A.C. current is
a) 0^o b) 90^o
c) 180^o d) 270^o

160. Dynamo is based on the principle of'
a) electromagnetic induction
b) self induction
c) mutual induction
d) none of these

161. A coil having number of turns n and area A is rotated in a uniform magnetic field B with angular velocity ω. The maximum emf induced in it is given by
a) $nAB\omega$ b) nAB/ω
c) $nA\omega/B$ d) $B\omega/nA$

162. If the instantaneous current in a circuit is given by $I = 2 \cos(\omega t + \phi)$ amperes, the r.m.s. value of the current is
a) 2 A b) $\sqrt{2}$ A
c) $2\sqrt{2}$ A d) 0 A

163. The frequency of A. C. mains in India is
a) 30 Hz b) 50 Hz
c) 60 Hz d) 120 Hz

164. The peak value of alternating voltage is 423 V. Its root mean square value is
a) 300 V b) 423 V
c) 423 $\sqrt{2}$ v d) zero

165. A generator produces an e.m.f. of e = 240 sin 120 t volt, where t is in seconds. The frequency and r.m.s. voltage are
a) 60 Hz and 240 V b) 19 Hz and 120 V
c) 19 Hz and 170 V d) 754 Hz and 170 V

166. The r.m.s. value of an alternating current of 50 Hz frequency is 10 A. The time taken by the A.C. current in reaching from zero to maximum value and the peak value of current will be
a) 0.02 s and 14.14 A b) 0.01 s and 7.07 A
c) 0.005 s and 7.07 A d) 0.005 s and 14.14 A

167. Alternating current shows which of the following effects?
a) Chemical effect b) Magnetic effect
c) Heating effect d) All of these

168. The equivalent quantity of mass in electricity is
a) charge b) current
c) inductance d) potential

169. An alternating e.m.f., e = 300 sin 100 π t volt, is applied to a pure resistance of 100 Ω. The r.m.s. current through the circuit is
a) 2.12 A b) 0.212 A
c) 20.12 A d) 0.0212 A

170. What would be the equation of a sinusoidal voltage of amplitude 5 V, frequency 1 kHz and phase difference zero?
a) e = 5 sin 6080 t b) e = 5 sin 6284 t
c) e = 0.5 sin 3140 t d) e = 5 sin 314 t

171. A coil of 50 turns, each of area 0.12 m^2 is rotated at a constant speed of 600 revolutions per minute in a uniform magnetic field of induction 0.02 T about an axis in the plane of the coil and perpendicular to the direction of the field. The maximum e.m.f. induced in a coil is
a) 7.536 V b) 0.75 V
c) 0.075 V d) 0.0075 V

7.8 Reactance and impedance

172. The opposition offered by an inductance to flow of A.C. current through it is
a) inductive reactance
b) capacitive reactance
c) impedance
d) all of these

173. The opposition offered by condenser to the flow of A.C. current is
a) inductive reactance
b) capacitive reactance
c) impedance
d) all of these

174. The opposition offered by ohmic and non ohmic components is
a) inductive reactance b) capacitive reactance
c) impedance d) all of these

175. A ohm is S. I. unit of
a) resistance b) reactance
c) impedance d) all of these

176. The inductive reactance of an inductor of inductance L is
a) $\frac{1}{2\pi fC}$ b) $\frac{1}{2\pi fL}$
c) $2\pi fC$ d) $2\pi fL$

177. The capacitive reactance of a condenser of capacitance C is
a) $\frac{1}{2\pi fC}$ b) $\frac{1}{2\pi fL}$
c) $2\pi fC$ d) $2\pi fL$

178. The impedance of a LCR series circuit is
a) $\sqrt{R^2+(X_L-X_C)^2}$ b) $\sqrt{R^2+(X_L+X_C)^2}$
c) $\sqrt{R+(X_L+X_C)^2}$ d) $\sqrt{X_L-X_C+R}$

179. If A.C. source is connected to a resistive circuit, then
a) current lags behind voltage in phase
b) current and voltage are in same phase
c) current leads ahead of voltage in phase
d) current and voltage are in opposite phase

180. In a purely inductive circuit, the current
a) lead the applied emf by $\pi/2$
b) lags behind of applied emf by $\pi/2$
c) in same phase of applied emf
d) none of these

181. In a purely capacitive circuit, the current
a) lead the applied emf by $\pi/2$
b) lags behind the applied emf by $\pi/2$

c) in same phase of applied emf
d) none of these

182. Current in a circuit is wattless, if
a) current is alternating
b) resistance in the circuit is zero
c) inductance in the circuit is zero
d) resistance and inductance both are zero

183. With an increase in the frequency of an A.C. supply, the inductive reactance
a) increases b) decreases
c) remains constant d) decreases sharply

184. With an increase in the frequency of an A.C. supply the capacitive reactance
a) increases b) decreases
c) remains constant d) decreases sharply

185. Resistance of a resistor is independent on
a) length b) area of cross section
c) temperature d) frequency

186. An A.C. of frequency f is flowing in a circuit containing a resistance R and an inductance L in series. The impedance of the circuit is equal to
a) R + f b) R + 2fL
c) R + 2nfL d) $\sqrt{R^2+4\pi^2f^2L^2}$

187. An A.C. of frequency f is flowing in a circuit containing a resistance R and capacitance C in series. The impedance of the circuit is equal to
a) R + f b) R + 2 π fC
c) $R+\frac{1}{2\pi fC}$ d) $\sqrt{R^2+X_C^2}$

188. When the frequency of A. C. is doubled, the impedance of an RC circuit is
a) doubled b) halved
c) increases d) decreases

189. When the frequency of A. C. is doubled, the impedance of an LCR, circuit is
a) halved b) doubled.
c) increases d) decreases

7.9 Power in ac circuits with resistance, inductance, capacitance and LCR series circuit

190. The average power dissipated in an A.C. circuit containing a resistance alone is
a) $e_{rms} I_{rms}$ b) $e_{rms}I_{rms}\cos\phi$
c) 0 d) none of these

191. Power consumed in an A. C. circuit is zero if it is purely
a) resistive circuit b) inductive circuit
c) capacitive circuit d) both 'b' and 'c'

192. The cos ϕ, in an electric circuit, is called
a) phase factor b) power factor
c) frequency factor d) resonance factor

193. The ratio of true power to apparent power, is
a) phase factor b) power factor
c) frequency factor d) Q factor

194. The product ermsIrmsis called as
a) true power b) apparent power
c) power factor d) Q factor

195. The power factor in the circuit is unity, when the circuit contains an ideal
a) resistance b) conductance
c) capacitance d) reactance

196. Power in an A. C. circuit is rated per second at which
a) charge flows b) work is done
c) energy is spent d) current alternates

197. In an A.C. circuit, the electrical energy is consumed in
a) L b) C
c) R d) 'L' and 'C'

198. The average power in LCR series circuit is
a) $e_{rms}I_{rms}\cos\phi$ b) $e_{rms}I_{rms}\sin\phi$
c) $e_{rms}I_{rms}$ d) $e_{rms}I_{rms}\tan\phi$

199. For purely reactive circuit containing only L or C, power factor is
a) 0 b) 1
c) 2 d) 4

200. An inductor of 0.5 H is connected across a 100 V, 50 Hz supply. The reactance of the circuit is
a) 157 Ω b) 1.57 Ω
c) 15.7 Ω d) 0.157 Ω

201. An inductance of 100 mH and a resistance of 100 Ω are connected in series and an alternating emf of peak value 100 V, 50 Hz is applied across the combination. The power factor of the circuit is
a) 0.9540 b) 9.54
c) 95.4 d) 0.845

202. A resistance of 50 Ω is connected in series with a 10 μF capacitance and these are connected to a 20V, 50Hz a. c. supply. The total impedance is
a) 121.5 Ω b) 155.6 Ω

c) 322 Ω d) 195.5 Ω

203. A capacitor of capacitive reactance 79.62 Ω and a resistance of 100 Ω are connected in series across a.c. source. The phase difference between applied emf and current is
a) 38° 32' b) 58°
c) 30° d) 45° 42'

204. An inductance of 0.5 H, a capacitance of 1 μF and a resistance of 100 Ω are connected in series and a source of A. C. emf of r. m. s. value 20V and frequency 50 Hz is connected across the combination. The average power consumed over one cycle is
a) 0.0044 W b) 0.255 W
c) 2.55 W d) 5.25 W

205. The current flowing through a circuit of resistance 109 Ω and an inductance of 0.5 H connected to an A. C. supply of 100 V and 50 Hz in series is
a) 0.25 A b) 0.5232 A
c) 0.75 A d) 0.85 A

206. In an LCR circuit, inductive reactance and capacitive reactance was found to be equal. The resistance was found to be 20 Ω. The probable. impedance of the combination is
a) zero b) 20 Ω
c) $40\sqrt{2}\ \Omega$ d) 400 Ω

207. In an A. C. circuit, the current flowing is $I = 5 \sin[100\,t - (\pi/2)]$A and the potential difference is $e = 200 \sin(100\,t)$ V. The power consumption is equal to
a) 1000 W b) 40 W
c) 20 W d) 0 W

208. A (100 W, 200 V) bulb is connected to a 160 V supply. The power consumption would be
a) 64 W b) 80 W
c) 100 W d) 125 W

209. In an A. C. circuit voltage applied is e = 220 sin 100 t. If the impedance is 110 Ω and phase difference between the current and voltage is 60° the power consumption is equal to
a) 55 W b) 110 W
c) 220 W d) 330 W

210. An a. c. emf of $e = 220 \sin \omega t$ is applied across the capacitor, the power consumption is
a) 0 b) 55 W
c) 110 W d) 220 W

211. An a. c. emf of $e = 220 \sin 100\pi t$ is passed through the resistance of 1 kΩ. The average power of the a. c. circuit is
a) 48.4 W b) 34.2 W
c) 24.2 W d) 12.1W

212. In an A. C. circuit with phase voltage V and 222. current I, the power dissipated is
a) VI/2
b) $VI/\sqrt{2}$
c) VI
d) depends on phase voltage V and current I

213. The reactance of an inductor at 50 Hz is 10 Ω. The reactance of it at 200 Hz is
a) 10 Ω b) 40 Ω
c) 2.5 Ω d) 20 Ω

214. Power factor of the A. C. circuit varies between
a) 0 to 0.5 b) 0.5 to 1
c) 0 to 1 d) 1 to 2

215. The capacitive reactance of a capacitor in d.c. circuit in ohm is
a) zero b) ωC
c) $1/\omega C$ d) ∞

216. The graph between inductive reactance and frequency is
a) parabola b) straight line
c) hyperbola d) an arc of a circle

217. The alternating e.m.f. of $e = e_0 \sin \omega t$ is applied across LR series circuit. The impedance and phase angle between current and voltage is
a) $\sqrt{R^2 + X_L^2}$, $\tan^{-1}\left(\frac{X_L}{R}\right)$
b) $\sqrt{R^2 - X_L^2}$, $\tan^{-1}\left(\frac{X_L}{R}\right)$
c) $R + X_L$, $\tan^{-1}\left(\frac{R}{X_L}\right)$
d) $R - X_L$, $\tan^{-1}\left(\frac{R}{X_L}\right)$

218. The alternating e.m.f. of $e = e_0 \sin \omega t$ is applied across capacitor C. The current through the circuit is given by
a) $I = I_0 \sin \omega t$ b) $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

c) $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$ d) $I = I_0 \sin(\omega t - \pi)$

219. The current leads the voltage by an angle ϕ which is given by

a) $\tan^{-1}\left(\frac{1}{\omega CR}\right)$ b) $\tan^{-1}(\omega CR)$

c) $\tan^{-1}\left(\frac{\omega C}{R}\right)$ d) $\tan^{-1}\left(\frac{R}{\omega C}\right)$

220. The power dissipated in alternating circuit with vol tage $e = e_0 \sin \omega t$ and current $I = I_0 \sin(\omega t - \phi)$ is

a) $e_0 I_0$
b) $e_{rms} I_{rms} \cos \phi$
c) $e_{rms} I_{rms}$
d) 0

221. The power factor in CR circuit is given by

a) $\frac{R}{\omega C}$ b) $\frac{1}{\omega CR}$

c) $\frac{R}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$ d) $\frac{R}{R + \frac{1}{\omega C}}$

222. For minimum dissipation of energy in the circuit, the power factor should be
a) large b) small
c) moderate d) can not say

223. Two electric appliances of power rating W_1 and W_2 at 220 V are connected in' series with a source of alternating voltage $e = 220\sqrt{2} \sin \omega t$.
The resultant power consumed is
a) $W_1 + W_2$ b) $W_1 - W_2$

c) $\frac{1}{W_1} + \frac{1}{W_2}$ d) $\frac{W_1 W_2}{W_1 + W_2}$

224. Two electric appliances of power rating W_1 and W_2 at 240 V are connected in parallel with a source of alternating voltage $e = 240\sqrt{2} \sin \omega t$.
The resultant power consumed is
a) $W_1 + W_2$ b) $W_1 - W_2$

c) $\frac{1}{W_1} + \frac{1}{W_2}$ d) $\frac{W_1 W_2}{W_1 + W_2}$

225. The r.m.s. value of alternating current which when passed through a resistor produces heat energy four times that produced by direct current of 2 A through the same resistor in same time is
a) 2 A
b) 4 A
c) 8 A
d) 16 A

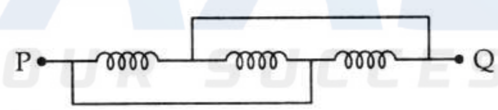
226. The applied e.m.f. lags behind the current by an angle of 45° in the circuit which contains
a) resistance only
b) resistance and inductance
c) capacitance only
d) capacitance and resistance

227. The values of current and voltage in an A.C. circuits are respectively $I = 4 \sin \omega t$ and $e = 100 \cos[\omega t + (\pi/3)]$. The phase difference between voltage and current is

a) $\frac{7\pi}{6}$ b) $\frac{6\pi}{5}$

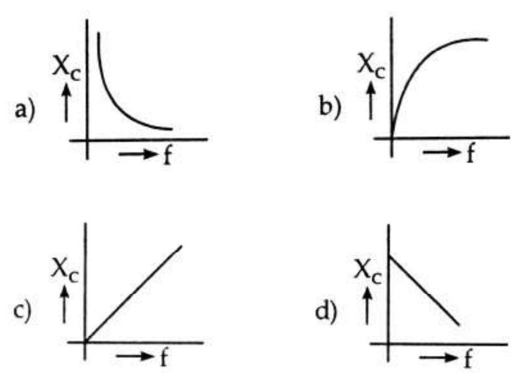
c) $\frac{5\pi}{6}$ d) $\frac{\pi}{3}$

228. Pure inductors each of inductance 3 H are connected as shown in figure: The equivalent inductance of the circuit is

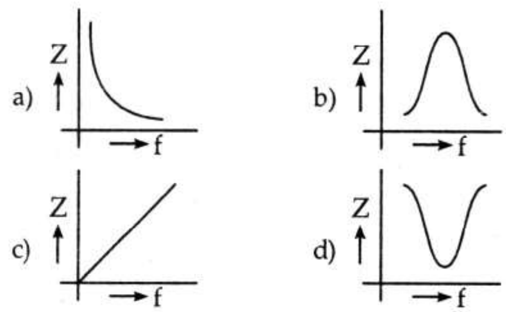


a) 1 H b) 2 H
c) 3 H d) 9 H

229. Which one of the following curve represents variation of capacitive reactance with frequency?



230. Which one of the following curve represents the variation of impedance (Z) with frequency (f) in LCR series circuit?



231. The phase angle between current and potential difference in an A.C. circuit containing of resistance 4 Ω and reactance 3 Ω will be

a) $\cos^{-1}(3/5)$ b) $\cos^{-1}(3/4)$
c) $\sin^{-1}(4/5)$ d) $\cos^{-1}(4/5)$

232. Electric power is transmitted over long distance through conducting wires at high voltage because
a) it reduces the possibility of theft of wire
b) this entails less power losses
c) A.C. generators produce electric power at high voltages
d) A.c. signal of high voltage travels faster

7.10 LC oscillations

233. The parallel combination of inductor and capacitor is called as
a) rectifier circuit b) tank circuit
c) acceptor circuit d) filter circuit

234. When a charged condenser is allowed to discharge through inductor the electrical oscillations are produced called as
a) LC oscillations
b) RC oscillations
c) RL oscillations
d) none of these

235. The frequency of LC oscillation is given by

a) $f = \dfrac{1}{2\pi\sqrt{LC}}$ b) $f = 2\pi\sqrt{LC}$

c) $f = \dfrac{1}{\pi\sqrt{LC}}$ d) $f = \dfrac{1}{4\pi\varepsilon_0}\sqrt{LC}$

236. The system in which energy of the system continuously changes between electric field of capacitor and magnetic field of oscillator to produce oscillations is
a) acepter circuit b) tank circuit
c) rectifier circuit d) amplifier circuit

7.11 Resonant circuits

237. In an LCR series circuit the current is
a) in phase with applied emf
b) lags the applied voltage
c) lead the applied voltage
d) may lead or lag behind the applied voltage

238. At resonance, the source current is
a) maximum in a LCR series circuit
b) minimum in a parallel LCR circuit
c) maximum in both series and parallel LCR circuit
d) both 'a' and 'b'

239. In series LCR circuit, the voltage across R, L and C are e_R, e_L and e_C respectively. Then the voltage of applied a. c. source must be

a) $e_R + e_L + e_C$ b) $\sqrt{e_R^2 + (e_L - e_C)^2}$

c) $e_R + e_C - e_L$ d) $\sqrt{(e_R + e_L)^2 + e_C^2}$

240. With increase in frequency of an a.c. supply, the impedance of an LCR series circuit
a) remains constant
b) increases
c) decreases
d) decreases at first becomes minimum and then increases

241. An a. c. source is connected in parallel with an LCR parallel circuit. Let I_S, I_R, I_L, and I_C be the currents across source, R,L, and C respectively Then
a) $V_S = V_R + V_L + V_C$
b) $I_S = I_R + I_L + I_C$
c) $(I_R, I_L, I_C) < I_S$
d) I_L, I_C may be $> I_S$

242. The frequency of A. C. is 50 Hz. How many times the current becomes zero in one second?
a) 50 times b) 100 times
c) 200 times d) 25 times

243. At resonance the peak value of current in a series LCR circuit is
a) $e_0 Z$ b) e_0/Z
c) e_0 d) e_0/R

244. In a series LCR circuit, the voltage across the inductance and capacitance are not
a) out of phase with voltage across resistance by 90°
b) equal in magnitude at resonance
c) out of phase with each other by 180°

d) in phase with the source voltage

245. In an LCR series a.c. circuit, the current is
a) always in phase with the voltage
b) lags the generator voltage
c) leads the generator voltage
d) none of these

246. In a series LCR circuit, at resonance the
a) total impedance is $L\omega - (1/C\omega)$
b) total impedance is R
c) voltage across C and L are in phase
d) the voltage across C lags the source voltage by $\pi/2$

247. In LCR circuit, the capacitance is changed from C to 4 C. For the same resonant frequency, the inductance should be changed from L to
a) 2 L b) L/2
c) L/4 d) 4 L

248. In an A. C. circuit $X_C = X_L$. The phase difference between the current and voltage will be
a) 0 b) π
c) $\pi/2$ d) $\pi/4$

249. A resistor, a capacitor and inductor are connected in series with a source of a.c. Which of the following statement is true? The current in resistor lags behind the
a) current in capacitor
b) current in inductor
c) voltage across capacitor
d) voltage across inductor

250. In a LCR series circuit, if the phase difference between applied voltage and current is zero then
a) $X_L = X_C$ b) $X_L > X_C$
c) $X_L < X_C$ b) none of these

251. The LCR series circuit at resonance is called as
a) series resonant b) parallel resonant
c) reactive circuit d) none of these

252. In series resonant circuit, at resonance
a) $Z = \sqrt{R^2 + (X_L - X_C)^2}$
b) $Z = R$
c) $Z = X_L - X_C$
d) $Z = X_C$

253. In series LCR circuit at resonance,
a) current is maximum and impedance is maximum
b) current is maximum and impedance is minimum
c) current is minimum and impedance is maximum
d) current is minimum and impedance is minimum

254. At resonance power factor of the resonant circuit is
a) equal to 1 b) less than 1
b) greater than 1 d) none of these

255. At resonance series/parallel resonant circuit acts as purely
a) resistive circuit b) inductive circuit
c) capacitive circuit d) none of these

256. In resonant circuit, at resonant frequency
a) $X_L = X_C$ b) $Z = R$
c) $X_L > X_C$ d) both 'a' and 'b'

257. The resonant frequency of a series/parallel resonant circuit is given by,
a) $f = \frac{1}{2\pi\sqrt{LC}}$ b) $f = \frac{1}{\sqrt{LC}}$
c) $f = \frac{2\pi}{\sqrt{LC}}$ b) $f = 2\pi\sqrt{LC}$

258. Resonance curve of a resonant circuit is graphical representation between
a) frequency and current
b) frequency and impedance
c) frequency and reactance
d) none of these

259. In resonant circuits, at resonance, the phase difference between current and emf.is
a) 0 b) π
c) $\pi/4$ d) $\pi/2$

260. In series resonant circuit, at resonance the phase difference between the voltage across inductor and voltage across condenser is
a) $3\pi/2$ b) $\pi/2$
c) 0 d) π

261. Voltage magnification factor of a series resonant circuit is
a) $Q = \omega L/R$ b) $Q = 1/\omega CR$
c) both a and b d) neither a nor b

262. The ratio of voltage across inductor/condenser to the voltage across resistor in a series resonant circuit is
a) voltage magnification factor
b) Q factor
c) both 'a' and 'b'
d) neither 'a' nor 'b'

263. The voltage across inductor and condenser at resonance is

a) zero
b) of equal magnitude and in phase
c) of equal magnitude and out of phase by π
d) of different magnitudes and out of phase by π

264. In an A.C. circuit resistance, inductance and capacitance are connected in series. The values of potential differences across the three are 70 V, 90 V and 65 V respectively. The value of the potential difference of the A.C. source is
a) 70 V b) 225 V
c) 85 V d) 74.3 V

265. In LCR series A.C. circuit, the current
a) is always in phase with voltage
b) always lags behind the generator voltage
c) always leads the generator voltage
d) may be in phase, lag behind or lead by the generator voltage depending on the values of L, C and R

266. Power delivered by an a.c. source of an angular frequency ro to an LCR series circuit is maximum when
a) $\omega L = \omega C$ b) $\omega L = \frac{1}{\omega C}$
c) $\omega L = R - \frac{1}{\omega C}$ d) $\omega C = R - \frac{1}{\omega C}$

267. The phase angle between voltage and current during resonance in an LCR series circuit is
a) zero b) $\pi/4$
c) $\pi/2$ d) π

268. The LCR series circuit containing a resistance of 120 Ω has angular resonance frequency 4×10^5 rad/sec. At resonance voltage across resistance and inductance are 60 V and 40 V respectively. The values of L and C are
a) 0.2 mH, 32 m μF b) 0.4 mH, 64 m μF
c) 0.2 mH, 64 m μF d) 0.4 mH, 32 m μF

269. In parallel resonant circuit, at resonance
a) current is maximum and impedance is maximum
b) current is maximum and impedance is minimum
c) current is minimum and impedance is maximum
d) current is minimum and impedance is minimum

270. In parallel resonant circuit, the current through condenser leads the current through inductor by
a) 0° b) 90°
c) 180° d) 270°

271. With increase in frequency of an a. c. supply the impedance of the parallel resonant circuit
a) remains constant
b) increases
c) decreases
d) increases at first, becomes maximum and then decreases

272. In parallel resonant circuit current through condenser leads the source voltage by
a) 0° b) 90°
c) 170° d) 180°

273. The series resonant circuit is called as
a) acceptor circuit b) rejector circuit
c) rectifier circuit d) transfer circuit

274. The parallel resonant circuit is called as
a) acceptor circuit b) rejector circuit
c) rectifier circuit d) transfer circuit

275. An A. C. circuit consists of a resistor of 5 Ω and inductor of 10 mH connected in series with 50 V, 50 Hz supply. What capacitance should be connected in series with the circuit to obtain maximum current?
a) 1014 μF b) 10.14 μF
c) 1.014 μF d) 101.4 μF

276. An inductance of 0.5 H, a capacitor of capacitance 10^{-9} F and a resistance of 100 Ω are connected in series across A. C. source of e.m.f. 10V.The current through the circuit at resonance is
a) 1 A b) 10 A
c) 0.1 A d) 0.01 A

277. A circuit of negligible resistance has an inductance of 10 mH and a capacitance of 0.1 μF. The resonant frequency of the circuit is nearly
a) 5 kHz b) 2.5 kHz
c) 31.4 kHz d) 3.14 kHz

278. The currents flowing in two branches of parallel resonant circuit at resonance are
a) in phase
b) out of phase by Ω
c) differ in phase by $\Omega/2$
d) differ in phase by $\Omega/4$

279. In parallel resonant circuit, the current and voltage at resonance are
a) both maximum
b) both minimum
c) maximum and minimum respectively

d) minimum and maximum respectively

280. The sharpness of resonance or Q value of resonant circuit with resonant frequency fTand half power frequency f_1 and f_2 is

a) $Q = \dfrac{f_r}{f_2 - f_1}$ b) $Q = \dfrac{f_2 - f_1}{f_r}$

c) $Q = \dfrac{f_r}{f_2 + f_1}$ d) $Q = \dfrac{1}{f_r(f_2 + f_1)}$

281. The value of impedance in parallel LC circuit at resonance is (assuming inductor and capacitor to be ideal)

a) minimum b) maximum

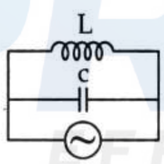
c) infinite d) zero

282. An A.C. voltage of r.m.s. value 2 V is applied to a parallel combination of L and C in which L = 2 mH and C = 3.2 μF. The current through each branch at resonance is

a) 80 m A, 80 mA b) 80 m A, 60 mA

c) 60 m A, 80 mA d) 40 mA, 40 mA

283. For the circuit shown in figure the L current through the inductor is 0.8 A, while the current through c the capacitor is 0.6 A. The current drown from the generator is



a) 1.4 A b) 0.2 A

c) 1.0 A d) 0.1 A

284. A coil is wound on a frame of rectangular cross section. If all the linear dimensions of the frame are increase by a factor 2 and the number of turns per unit length of the coil remain unchanged, the self inductance of the coil increases by a factor of

a) 2 b) 4

c) 6 d) 8

285. A coil of 100 turns and area 5 cm^2 is placed in a magnetic field 0.2 T. The normal to the plane of the coil makes an angle 60° with the direction of magnetic field. The magnetic flux linked with the coil is

a) 5×10^{-3} Wb b) 2.5×10^{-3} Wb

c) 3.5×10^{-3} Wb d) 4.5×10^{-3} Wb

286. A metallic conductor of length 1 m rotates vertically about one of its ends at angular velocity 5 rad/sec. If the horizontal component of earth's magnetic filed be 0.2×10^{-4} T, then the e.m.f. developed between the two ends of the conductor is

a) 25 μV b)30 μV

c) 50 μV d) 60 μV

287. The magnetic field in a coil of 100 turns and 40 cm^2 area is increased from 1 T to 6 T in 2 s. The magnetic field is parallel to the coil. The e.m.f. generated in its is

a) 0.5 V b) 1 V

c) 1.5 V d) 2 V

288. A coil of area 80 cm^2 and 50 turns is rotating with 2000 rev/min. about an axis perpendicular to a magnetic field of 0.05 T. The maximum value of e.m.f. developed in it is

a) $\dfrac{2\pi}{3}$ V b) $\dfrac{4\pi}{3}$ V

c) $\dfrac{5\pi}{3}$ V d) $\dfrac{\pi}{3}$ V

289. 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 induction of the coil will now be

a) 4 L b) 8 L

c) 16 L d) 12 L

290. The inductance of a coil in which a current of 0.1 A yields an energy storage of 0.05 J is

a) 5 H b) 10 H

c) 12 H d) 100 H

291. The inductance of a coil in which current increases linearly from zero to 0.1 A in 0.2 s producing a voltage of 5 V is

a) 10 H b) 100 H

c) 1 H d) 0.1 H

292. The inductance of a coil in which a current of 0.2 A is increasing at the rate of 0.5 A/s represents a power flow of 0.5 W is

a) 10 H b) 5 H

c) 15 H d) 50 H

293. A coil of wire of radius r has 600 turns and a self inductance of 108 mH. The self inductance of a similar coil of 500 turns will be

a) 25 mH b) 50 mH

c) 7.5 mH d) 75 mH

294. The flux (in weber) in a closed circuit of a resistance 10 Ω varies with time t (in seconds)

according to equation $\phi = 12t^2 - 5t + 1$. What is the magnitude of induced current at t = 0.25 s ?

a) 2 A b) 0.1 A
c) 20 A d) 0.02 A

295. In an induction coil, the coefficient of mutual inductance is 5 H. If current of 5 A in the primary coil is cut off in 10^{-3} s. The e.m.f. at the terminals of the secondary coil will be

a) 2.5 kV b) 25 kV
c) 250 kV d) 0.25 kV

296. A 50 Hz a.c. current of crest value 2 A flows through the primary of a transformer. If the mutual inductance between the primary and secondary be 0.25 H, the crest voltage induced in the secondary is

a) 15.7 V b) 1.57 V
c) 17.5 V d) 157 V

297. A coil of resistance 20 Ω and inductance 5 H has been connected to a 100 V battery. The energy stored in the coil is

a) 6.25 J b) 62.5 J
c) 65.2 J d) 26.5 J

298. A coil is placed in a magnetic field directed downward and increasing from 0 to 18 T in 0.1 s. Area of coil is 2 m^2 and resistance 5 Ω. Induced current will be

a) 72 A anti clockwise direction
b) 27 A anti clockwise direction
c) 72 A clockwise direction
d) 27 A clockwise direction

299. A large coil of 10 turns has a resistance 2 Ω. It is kept in a magnetic field of 0.5 T.If the coil is pulled out of the magnetic field uniformly such that its area coming out of the magnetic field is 200 cm^2/s, the current induced in it is

a) 5 mA b) 50 mA
c) 2.5 mA d) 25 mA

300. 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

a) 20 mH b) 50 mH
c) 52 mH d) 25 mH

301. The length I of a wire is shaped to form a coil of 1 turn. This coil has self inductance 1. If the same length is bent more sharply to form 3 turns, the self inductance will become/remain

a) L b) 2 L
c) 3 L d) 4 L

302. Two coils have mutual inductance 0.005 H. The current changes in the first coil according to the equation $I = I_0 \sin \omega t$, where $I_0 = 10$ A and $\omega = 100\pi$ radian/s. The maximum value of e.m.f. in second coil is

a) 5π V b) 7π V
c) 2.5π V d) π V

303. A copper coil having 1000 turns is placed in a magnetic field ($B = 4 \times 10^{-5}$ T) perpendicular to its axis. The cross sectional area of the coil is 0.05 m^2. If it is turned through 180° in 0.01 s, then e.m.f. induced in the coil is

a) 0.2 V b) 0.3 V
c) 0.1 V d) 0.4 V

304. A coil having resistance 40 Ω, number of turns 100 and radius 6 mm is connected to an ammeter of resistance 160 Ω. The coil is placed perpendicular to the magnetic field. When the coil is taken out of the field, a charge of 32 μC passes through it. The intensity of magnetic field will be

a) 0.265 T b) 0.856 T
c) 0.566 T d) 0.966 T

305. The mutual inductance between primary and secondary circuits is 0.5 H. The resistance of the primary and its secondary circuits are 20 Ω and 5 Ω respectively. To generate a current of 0.4 A in the secondary, the current in the primary must be changed at the rate of

a) 4 A/s b) 2 A/s
c) 0.4 A/s d) 0.2 A/s

306. In an A.C. circuit voltage V and current I are given by V = 100 sin 100 tvolt and I = 100 sin $\left(100t + \frac{\pi}{3}\right)$ mA. The power dissipated in the circuit is

a) 1.5 W b) 2.5 W
c) 2 W d) 3 W

307. A pure resistive circuit element X when connected to an a.c. supply of peak value 200 V, gives a peak current of 5 A which is in the phase with the voltage. A second circuit element Y, when connected to same a.c. supply also gives the same value of peak current but the current lags behind by 90°. If the series combination of X and Y is connected to the same supply. What will be value of r.m.s. current?

a) 2.5 A b) 2 A
c) 1 A d) 0 A

308. In LR circuit the a.c. source has voltage 220 V. If the potential difference across the inductance is 176 V, the potential difference across the resistance will be
a) 13.2 V b) 12 V
c) 132 V d) 1.32 V

309. An a.c. source is 120 V – 60 Hz. The value of voltage after 1/720 s from start will be
a) 8.48 V b) 6.48 V
c) 84.8 V d) 88.4 V

310. A coil having an inductance of $1/\pi$ H is connected in series with a resistance of 300 Ω. If 20 V–200 Hz. A.C. source is impressed across the combination, the phase angle between voltage and current is
a) $\tan^{-1}\left(\frac{4}{3}\right)$ b) $\tan^{-1}\left(\frac{3}{4}\right)$
c) $\tan^{-1}\left(\frac{2}{3}\right)$ d) $\tan^{-1}\left(\frac{3}{2}\right)$

311. A resistor, an inductor and a capacitor are connected in series to an a.c. power supply. When measured with the help of an a.c. voltmeter, the voltages across them are found to be 80 V, 30 V and 90 V respectively. What is the supply voltage?
a) 10 V b) 1 V
c) 100 V d) 90 V

312. An inductive circuit contains a resistance of 10 Ω and an inductance of 2 H. If an a.c. voltage of 120 V and frequency 60 Hz is applied to this circuit, the current in the circuit would be nearly.
a) 1.6 A b) 0.16 A
c) 2.6 A d) 6.2 A

313. When 100 V D.C. is applied across a solenoid, a current of 1.0 A flows in it. When 100 V a.c. is applied across the same coil, the current drops to 0.5 A. If the frequency of a.c. source is 50 Hz, the impedance and inductance of solenoid are
a) 100 Ω, 5.05 H b) 210 Ω, 5.50 H
c) 200 Ω, 5.55 H d) 200 Ω, 0.55 H

314. In LCR circuit the capacitance is changed from C to 4 C. For the same resonant frequency, the inductance should be changed from L to
a) L/4 b) L/2
c) L d) 2L

315. The reactance of an inductor at 50 Hz is 100 Ω. If the frequency is increased to 60 Hz, the reactance of the same inductor becomes
a) 12 Ω b) 21 Ω
c) 1.2 Ω d) 120 Ω

316. An e.m.f. e = 4 cos 1000 t volt is applied to LR circuit of inductance 3 mH and resistance 4 Ω. The amplitude of current in the circuit is
a) 8 A b) 4 A
c) 0.8 A d) 0.4 A

Examples for practice

317. The magnetic flux associated with a coil changes from zero to 5×10^{-5} Wb in 25 s. The emf induced in the coil is
a) 2 μ V b) 1.5 μ V
c) 2.5 μ V d) 0.5 μ V

318. A coil having 50 turns and an area of 800 cm^2 is held with its plane perpendicular to uniform magnetic field of induction 5×10^{-5} Wb/m^2. If it is pulled out of the field in 2 second, then the e.m.f. induced in the coil will be
a) 10^{-4} V b) 10^{-5} V
c) 10^{-6} V d) 10^{-8} V

319. The horizontal telegraph wire 100 m long, oriented along magnetic east west falls freely under gravity to the ground with a speed of 20 cm/s. The horizontal component of earth's magnetic field is 4.0×10^{-5} tesla. The e.m.f. induced in the wire at the instant, the wire strikes the ground is
a) 0.4 mV b) 0.2 mV
c) 0.8 mV d) 0.6 mV

320. A coil of effective area 4 m^2 is placed with its plane perpendicular to magnetic induction of 0.04 Wb/m^2. The induced emf in the coil if magnetic induction reduces to (1/4)th of its original value in 0.5 s will be
a) 0.5 V b) 0.75 V
c) 0.4 V d) 0.24 V

321. A coil having an area of 0.4 m^2 and 100 turns is kept perpendicular to a uniform magnetic field of induction of 0.5 Wb/m^2. The coil is rotated about one of is diameter so as to cut the lines of induction of the magnetic field. The average value of emf induced in the coil if it is rotated through 60° in 2 seconds will be
a) 5 V b) 2.5 V
c) 1.5 V d) 5.5 V

322. A square wire loop with sides 0.5 m is placed with its plane perpendicular to the magnetic field. The resistance of the loop is 5 Ω. The rate at which the magnetic induction should be changed so that a current of 0.1 A is induced in the loop is
a) 4 T/s b) 3 T/s
c) 2 T/s d) 1 T/s

323. A meter gauge train runs northwards with a constant speed of 22 m/s on a horizontal track. If the vertical component of the earth's magnetic field at that place is 3×10^{-4} T. The emf induced in its axle is
a) 6.6 mV b) 5.5 mV
c) 4.5 mV d) 4.4 mV

324. The axle of a railway engine is of length 150 cm. The engine moves with a speed of 60 km/hr in horizontal direction. The angle of dip is 46° and horizontal component of earth's magnetic induction is 3.6×10^{-5} Wb/m^2. The e.m.f. that will exist between the ends of the axle is
a) 1.0 m V b) 0.39 m V
c) 0.93 m V d) 0.5 m V

325. A vertical metal rod of length 1.5 m is at rest in the earth's magnetic field of $B_H = 4 \times 10^{-5}$ T. If it starts moving at right angle to the magnetic meridian with a uniform acceleration of 5m/s^2, then the instantaneous emf induced in it at the end of 2 s will be
a) 0.6 mV b) 0.3 mV
c) 0.5 mV d) 0.4 mV

326. A vertical metal rod 1 m long performs linear S.H.M. at right angles to B_H of 4×10^{-5} Wb/m^2 with an amplitude of 5 cm and a period of π s. The values of maximum and minimum emfs induced in it are
a) 0 μV, 4 V b) 4 μV, 0 V
c) O μV, 0 V d) 4 μV, 4 V

327. A vertical metal rod of length 1 m moves at right angles to its length with a speed of 45 km/hour in a direction making an angle of 60° with B_H. The emf induced in it is. ($B_H = 3.6 \times 10^{-5}$ T)
a) 0.93 mV b) 0.74 mV
c) 0.50 mV d) 0.39 mV

328. A metal rod of length 0.5 m rotates ata uniform angular speed about one of its ends in a plane at right angle to a uniform magnetic field of induction 10^{-5} T. If it turns through an angle of 60° in 0.1 s. Then the emf induced between its ends will be
a) 13 μV b) 31 μV
c) 15 μV d) 20 μV

329. A coil of 500 turns and mean radius 10 cm makes 3000 rotations per minute about one of its diameter in a uniform magnetic field of induction 4×10^{-2} Wb/m^2 perpendicular to its axis of rotation. The r.m.s. current through the coil if its resistance is 100 Ω , is
a) 4.1 A b) 1.4 A
c) 4.4 A d) 1.1 A

330. A coil of 1000 turns each of area 1.2 m^2 is rotating about an axis in its plane and perpendicular to uniform magnetic field of induction 2×10^{-3} T. If it performs 300 rpm. The peak value of induced emf is
a) 65.4 V b) 25.4 V
c) 70.4 V d) 75.4 V

331. An alternating e.m.f., e = 200 sin rotis applied to a lamp, whose filament has a resistance of 1000 Ω. The r.m.s. valve of current is
a) 0.5 A b) l.4 A
c) 0.14 A d) 0.04 A

332. When an alternating emf, e = 300 sin 100 π t volt is applied across a bulb, the peak value of current is found to be 2 A. The average power is
a) 100 W b) 200 W
c) 300 W d) 400 W

333. An alternating emf of peak value of 350 V is applied across an ammeter of resistance 100 Ω. The reading of ammeter is
a) 2.5 A b) 1.5 A
c) 5.2 A d) 2.2 A

334. A circular coil of 50 turns and diameter 24 cm is rotated continuously in a uniform magnetic field of induction 3.6×10^{-4} T so as to cut the lines of induction of the field. If the speed of rotation is 5 π rad/s, The instantaneous induced emf when the plane of the coil is inclined at 30° to the direction of the field is nearly
a) 15 mV b) 14 mV
c) 10 mV d) 11 mV

335. The self inductance of a circuit in which an emf of 10 V is induced when the current in the circuit changes uniformly from 1 A to 0.5 A in 0.2 s is
a) 4 H b) 2 H
c) 6 H d) 8 H

336. The mutual inductance of a pair of a coil is 0.75 H. If the current in primary coil changes from

0.5 A to 0 A in 0.01 s. The average induced emf in secondary coil is

a) 73.5 V b) 3.75 V
c) 37.5 V d) 3.5 V

337. The reactance of 2 H inductance in an ac circuit of frequency 50 Hz is

a) 628 Ω b) 826 Ω
c) 286 Ω d) 862 Ω

338. The reactance of 1 μF condenser in an ac circuit of frequency 50 Hz is nearly

a) 2.3 kΩ b) 3.2 kΩ
c) 3.5 kΩ d) 5.3 kΩ

339. A coil has an inductance of 0.5 H is connected in series with a resistance of 50 Ω to 240 V, 50 Hz AC. The maximum current in the circuit is

a) 2.5 A b) 14.5 A
c) 1.50 A d) 1.45 A

340. A capacitor of capacitance 20 μF is connected in series with 25 Ω resistance to 240 V, 50 Hz AC. The maximum current in the circuit is

a) 14.9 A b) 1.49 A
c) 2.49 A d) 2.89 A

341. The frequency of voltage source used in a.c. circuit is 5 kHz. The circuit contains a coil of inductance of 0.5 mH, a capacitor of capacitance of 10 μF and resistor of resistance 8 Ω are connected in series with source. The impedance of circuit is

a) 14.9 Ω b) 16.9 Ω
c) 1.49 Ω d) 18.9 Ω

342. The power factor of a circuit containing a lamp of resistance 100 Ω, a choke coil of inductance 0.2 H and a condenser of capacitance 1 mF connected in series with an alternating emf of frequency 50 Hz is

a) 1.86 b) 86.6
c) 8.66 d) 0.86

343. A capacitor of capacitance 2 μF and resistance of 100 Ω are connected in series and an alternating emf of frequency 1 kHz is applied across the combination. The phase difference between applied emf and current is nearly

a) 84° b) 48°
c) 38° d) 83°

344. An alternating emf of 200 V, 50 Hz is applied to a circuit containing a resistance of 100 Ω and inductance of 0.1 H in series. The power dissipated in the circuit is

a) 463 W b) 364 W
c) 634 W d) 346 W

345. An A.C. circuit consists of a resistor of 5 Ω and inductor of 10mH connected in series with 50 volt, 50 Hz supply. The capacitance that should be connected in series with the circuit to obtain maximum current is

a) 1 mF b) 1.5 mF
c) 2.5 mF d) 2 mF

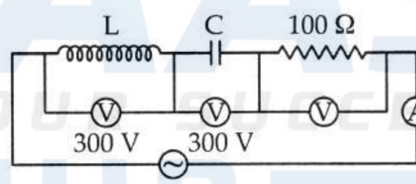
346. A 50 Ω resistor is connected in series with an inductance of 450 mH and capacitance 9 μF. The resonant frequency is nearly

a) 79 Hz b) 97 Hz
c) 85 Hz d) 65 Hz

347. An inductance of $(4/\pi)$ H and the resistor R, are connected in series and an alternating emf of frequency 50 Hz is applied across combination. If phase difference between applied emf and current is 45° then the value of R is

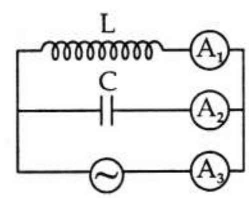
a) 200 Ω b) 400 Ω
c) 600 Ω d) 800 Ω

348. In a circuit shown in figure. What will be the readings of a voltmeter. and ammeter, if A.C. source of 220 V and 100 Hz is connected?



a) 800 V; 2 A b) 300 V; 2 A
c) 220 V; 2.2 A d) 100 V; 2 A

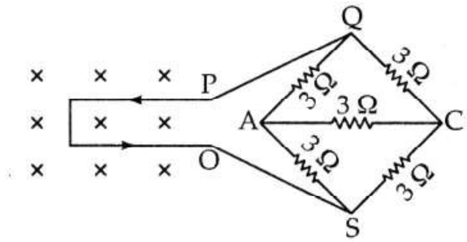
349. An inductor L and 'a' capacitor C are connected in the circuit. The frequency L of power supply is equal to the resonance frequency of the circuit. Which ammeter will read zero ampere?



a) A_1 b) A_2
c) A_3 d) none of these

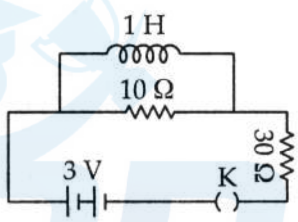
350. A square metal wire loop of side 10 cm and resistance 1 Ω is moved with a constant velocity v in a uniform magnetic field of induction

B = 2Wb/m² as shown in figure. The magnetic field lines are perpendicular to the plane of loop (directed into the paper). The loop is connected to a network of resistors each of value 3 Ω. The resistance of the lead wire as and PQ are negligible. The speed of the loop so as to induce a steady current of 1 mA in the loop will be



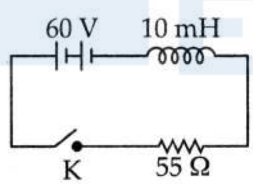
a) 0.04 m/s b) 0.4 m/s
c) 0.2 m/s d) 0.02 m/s

351. The value of current in 10 Ω resistor, when plug of key K is inserted in the adjoining figure is



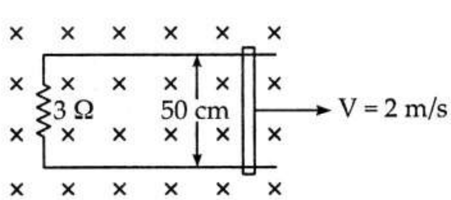
a) 0.5 A b) 0 A
c) 0.3 A d) 0.2 A

352. The rate of charge of current is 500 A/s at the instant key is pressed in the circuit shown in the figure. The current through the circuit is



a) 0.5 A b) 2 A
c) 1 A d) 3.5 A

353. A shown in figure a metal rod makes contact and complete the circuit. The circuit is perpendicular to the magnetic field with B = 0.15 T. If the resistance is 3 Ω, force needed to move the rod with a constant speed of 2 m/s is



a) 2.75×10^{-3} N b) 1.75×10^{-3} N
c) 3.75×10^{-3} N d) 4.75×10^{-3} N

Questions given in MHT–CET

354. A varying current in a coil changes from 10 A to zero in 0.5 sec. If the average e.m.f. induced in the coil is 220 V, then the self inductance of the coil is
a) 5 H b) 10H
c) 11 H d) 22 H

355. In an A.C. circuit, the flowing current is I = 5 sin (100 t – π/2) A and the potential difference is V = 200 sin (100 t) V. The power consumption is equal to
a) 100 W b) 40 W
c) 20 W d) 0 W

356. A straight line conductor of length 0.4m is moved with a speed of 7 m/s perpendicular to a magnetic field of intensity 0.9 Wb/m². The induced e.m.f. across the conductor will be
a) 1.26 V b) 2.52 V
c) 5.04 V d) 7.2 V

357. An e.m.f. of 20 mV is induced in a solenoid by a rate of change of current 4 A/s. The self inductance of the solenoid is
a) 3 mH b) 4 mH
c) 5 mH d) 6 mH

358. When the number of turns and length of a solenoid are doubled keeping the area of cross section same, the inductance becomes
a) half b) zero
c) two times d) four times

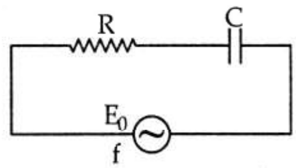
359. A coil having effective area A, is held with its plane normal to a magnetic field of induction B. The magnetic induction is quickly reduced to 25% of its initial value in 2 s. Then e.m.f. induced across the coil will be

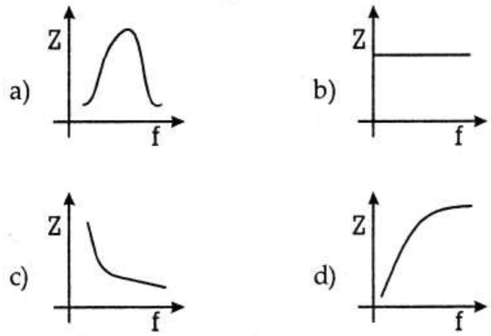
a) $\frac{3AB}{8}$ b) $\frac{3AB}{4}$

c) $\frac{AB}{4}$ d) $\frac{AB}{2}$

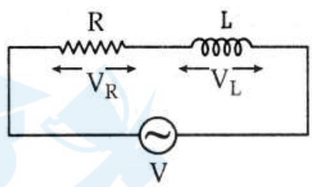
360. Dimensions of magnetic flux is
a) $[M^1 L^2T^{-2}A^1]$ b) $[M^1L^1T^{-2}A^{-1}]$
c) $[M^1L^1T^{-2}A^1]$ d) $[M^1L^2T^{-2}A^{-1}]$

361. Which graph gives the correct relation between Z and f for the given R–C circuit?





362. In the given L–R circuit, which of the following gives correct relation between V, V_R and V ?



a) $V < V_R + V_L$ b) $V > V_R + V_L$
c) $V = V_R + V_L$ d) none of these

363. Reactance of capacitor of capacitance C μF for ac frequency 400/π Hz is 25 Ω. The value of C is
a) 50 μF b) 25 μF
c) 100 μF d) 75 μF

364. In a coil, L = 5 H, current changes at rate of 2 A/s. The e.m.f. induced
a) – 10 V b) 10 V
c) 5 V d) – 5 V

365. E.m.f. is given bye = 200 sin 50 t. The r.m.s. value of current in a circuit of resistance 50 Ω is
a) 0.02828 b) 0.2828
c) 2.828 d) 28.28

366. Flux passes through coil changes from 2×10^{-3} Wb to 3×10^{-3} Wb during 25 s. The induced e.m.f. is
a) 0.02 mV b) 0.03 mV
c) 0.05 mV d) 0.04 mV

367. A metal rod, 10 cm long is moving with a speed of 376. 10 m/s perpendicular to a uniform magnetic field of 10^{-4} Wb/m^2. The magnitude of e.m.f. induced is
a) 10^{-4} V b) 10^{-2} V
c) 0 V d) 10^{-6} V

368. In an a.c. circuit containing only capacitor,
a) current leads voltage by π
b) current is in phase with voltage
c) current leads voltage by $\pi/2$
d) current lags voltage by $\pi/2$

369. Wattless current is obtained
a) when resistance is zero
b) when current is minimum
c) when inductance is zero
d) when current is alternating current

370. For a coil of unit area, induction is doubled in 0.2s. Then the induced e.m.f. is
a) 5 B b) 10 B
c) 8 B d) 4 B

371. Dead beat galvanometer works on the principle of
a) eddy current
b) self ind uctance
c) mutual inductance
d) magnetic effect of electric current

372. The capacitive reactance is 20 Ω, when the frequency is 100 Hz. Find the reactance, when frequency is 150 Hz.
a) 13 Ω b) 12.5 Ω
c) 12.3 Ω d) 13.3 Ω

373. In a series resonant L–C–R circuit, the power factor is
a) 0 b) 1
c) 0.3 d) 1.5

374. A half metre rod is rotating about one fixed end perpendicular to uniform magnetic field 4×10^{-5} T with angular velocity 720 rpm. The e.m.f. induced across its ends is
a) 0.24 V b) 0.36 V
c) 0.12 V d) 0.36 mV

375. In L–C–R circuit, the capacitance is changed from C to 2 C. For same resonant frequency, the inductance should be changed from L to
a) 4 L b) L/4
c) L/2 d) 2L

376. A copper rod of length 1 is rotated about one end perpendicular to uniform magnetic field B with constant angular velocity ω. The induced e.m.f. between two ends is
a) B ω l^2 b) 2B ω l^2
c) $\frac{1}{2}$ B ω l^2 d) $\frac{3}{2}$ B ω l^2

377. Resistance of earth coil is 7 Ω. If flux associated with coil changes from 1.35 Wb to 0.79 Wb within 0.1 s, the charge produced by the earth coil is
a) 0.08 C b) 0.008 C
c) 0.8 C d) 0.04 C

378. In the induction coil, across secondary coil, the output voltage is practically
a) unidirectional, high, intermittent
b) directional, low, intermittent
c) unidirectional, high, constant
d) unidirectional, low, constant

379. A wire of length 2.5 km and resistance 35 a has fallen from a height of 10 m in a earth horizontal field of 2×10^{-5} T. The current through the coil
a) 0.02 A b) 0.002 A
c) 0.2 A d) 2 A

380. The average value dissipated by resistance is (I_0 = peak value of current)
a) $\frac{1}{2} I_0^2 R$ b) $I_0^2 R$
c) $\frac{1}{2} I_0^2 R \cos \phi$ d) $I_0^2 R \cos \phi$

381. An inductor of inductance 100 mH, a capacitor of capacitance 400 pF and resistor of resistance 2 a are connected in series with a battery provided the rms voltage of 0.1 V.
a) 25 V b) 50 V
c) 75 V d) 100 V

382. If the p.d across the inductor (3 mH) is same as that across the condenser (30 μF) in a series R–L–C circuit, then the frequency of the applied emf is
a) 180 Hz b) 500 Hz
c) 890 Hz d) 5 kHz

383. A rod of length 1 is rotated about its one end, perpendicular to the magnetic field of induction B. The emf induced in the order is
a) $Bl^2 \omega$ b) $0.5\ Bl^2 \omega$
c) $Bl^2 \omega$ d) $0.5\ Bl^2 \omega$

384. A coil of self inductance 20 mH, having 50 turns, carries a current of 300 mA. If the area of the coil is 2 cm^2, the magnetic induction at the centre of the coil is
a) 7.5×10^{-3} T b) 7.5×10^{-2} T
c) 6×10^{-1} T d) 0.5 T

385. One A.C. voltmeter is connected to alternating source of peak value 141.4 V. The reading of voltmeter is
a) 50 V b) 150 V
c) 100 V d) 141.4 V

386. Inductance of a coil is 5 mH is connected to A.C. source of 220 V, 50 Hz., The ratio of A.C. to D.C. resistance of the coil is
a) 5 Ω b) 0 Ω
c) infinity d) data is incomplete

387. A rectangular coil of 25 turns, area of 25 cm^2 and resistance 4 a/turn is placed perpendicular to a varying magnetic field which changes at the rate of 500 T/S. Calculate the induced current in the coil.
a) 0.3125 A b) 31.25 A
c) 4.25 A d) 9.8 A

388. Henry is equivalent to
a) ampere / second b) ampere second
c) Ohm / second d) Ohm second

389. In the purely resistive A.C. circuit
a) current leads e.m.f. by a phase angle of π radians
b) current leads e.m.f. by a phase angle of $\pi/2$ radians
c) current and e.m.f. are in phase
d) current lags behind e.m.f. by a phase angle of $\pi/2$ radians

390. In LCR series circuit, at resonance, the power factor is
a) zero b) 0.5
c) 1 d) ∞

391. An alternating voltage $E = 200\sqrt{2}\sin 100\,t$ is connected to 1 μF capacitor through ac ammeter shall be
a) 10 mA b) 20 mA
c) 40 mA d) 80 mA

392. Some current is flowing in the alternating circuits. The first circuit contains only inductance and the other contains only a capacitor. If the frequency of the emf of ac is increased, the effect on the value of the current will be
a) increases in the first and decrease in the other
b) increase in both the circuits
c) decreases in both the circuits
d) decreases in the first and increase in the other

393. In a circuit the current lags behind the voltage by a phase different of II, the circuit contain which

of the following

a) only R b) only C

c) only L d) R and C

394. Average power in LCR circuits depends upon

a) current

b) phase different only

c) emf

d) current, emf and phase difference

395. A transformer is having 2100 turns in primary and 4200 turns in secondary. An ac source of 120V, 10 A A is connected to its primary. The secondary voltage and current are

a) 240 V, 5 A b) 120 V, 10 A

c) 240 V, 10 A d) 120 V, 20 A

396. When the number of turns and length of a solenoid are doubled keeping the area of cross section same, the inductance becomes

a) half b) zero

c) two times d) four times

397. If the current through the coil changes from +2 A to –2A in 0.05 sec and 8 V emf is developed in the coil then the self inductance of the coil is

a) 0.05 H b) 0.1 H

c) 0.2 H d) 0.4 H

398. An emf e = 200 $\sqrt{2}$ sin (100t) volt is applied across capacitor of capacitance 2 μF then current through capacitor is

a) 4 mA b) 40 mA

c) 2 mA d) 3 mA

399. In LCR series circuit power factor at resonance is

a) less than one b) greater than one

c) unity/one d) can not be predicted

400. In series LCR circuit at resonance,

a) current is maximum and voltage is minimum

b) current is maximum and voltage is maximum

c) current is minimum and voltage is maximum

d) current is minimum and voltage is minimum

401. The self inductance of coil of 400 turns is 8 mH. If current of 5 mA flows in it, then flux associated with the coil is

a) $(\mu_0/4\pi)$ b) μ_0

c) $\frac{\mu_0}{100\pi}$ d) $(4\pi/\mu_0)$

402. In LCR series circui t an ac emf of 2 volt and frequency 50 Hz is applied across the combination. If resistance is 4 Ω, capacitance is 8 μF and inductance is 10^{-2} H then the voltage across inductor will be

a) (3/5 V) b) (5/3 V)

c) (2/3 V) d) (0.02 V)

403. A coil of self–inductance L is connected in series with a bulb B and an AC source. Brightness of the bulb decreases when

a) number of turns in the coil is reduced

b) a capacitance of reactance $X_C = X_L$ is included in the same circuit

c) an iron rod is inserted in the coil

d) frequency of the AC source is decreased

404. A wire loop is rotated in a magnetic field. The frequency of change of direction of the induced e.m.f. is

a) twice per revolution

b) four times per revolution

c) six times per revolution

d) once per revolution

405. If 'N' is the number of turns in a circular coil then the value of self inductance varies as

a) N^0 b) N

c) N^2 d) N^{-2}

406. In LCR series circuit, an alternating e.m.f. 'e' and current 'i' are given by the equations e = 100 sin (100t) volt, i = 100 sin $\left(100t + \frac{\pi}{3}\right)$ mA.

The average power dissipated in the circuit will be

a) 100 W b) 10 W

c) 5 W d) 2.5 W

407. In electromagnetic wave, according to Maxwell, changing electric field gives

a) stationary magnetic field

b) conduction current

c) eddy current

d) displacement current

408. Same current is flowing in two a.c. circuits. First contains only inductance and second contains only capacitance. If frequency of a.c. is increased for both, the current will

a) increase in first circuit and decrease in second

b) increase in both circuits

c) decrease in both circuits

d) decrease in first circuit and increase in second

409. Two coils A and B have mutual inductance 2×10^{-2} henry. If the current in the primary is $i = 5 \sin (10 \pi t)$ then the maximum value of e.m.f. induced in coil B is

a) π volt b) $\pi/2$ volt

c) $\pi/3$ volt d) $\pi/4$ volt

410. The capacity of a parallel plate air capacitor is 2 μF and voltage between the plates is changing at the rate of 3 V/S. The displacement current in the capacitor is

a) 2 μA b) 3 μA

c) 5 μA d) 6 μA

❍❍❍

Answers

1. (d)	2. (b)	3. (d)	4. (d)	5. (d)	6. (d)	7. (b)	8. (c)	9. (a)	10. (a)
11. (c)	12. (c)	13. (d)	14. (d)	15. (c)	16. (a)	17. (d)	18. (b)	19. (b)	20. (d)
21. (d)	22. (d)	23. (a)	24. (c)	25. (c)	26. (b)	27. (c)	28. (c)	29. (c)	30. (b)
31. (d)	32. (b)	33. (d)	34. (a)	35. (c)	36. (b)	37. (b)	38. (c)	39. (b)	40. (b)
41. (a)	42. (b)	43. (b)	44. (a)	45. (b)	46. (c)	47. (a)	48. (d)	49. (b)	50. (c)
51. (a)	52. (d)	53. (d)	54. (c)	55. (a)	56. (b)	57. (b)	58. (b)	59. (d)	60. (d)
61. (c)	62. (a)	63. (c)	64. (d)	65. (a)	66. (c)	67. (d)	68. (c)	69. (c)	70. (a)
71. (c)	72. (d)	73. (d)	74. (c)	75. (a)	76. (a)	77. (c)	78. (b)	79. (d)	80. (a)
81. (c)	82. (c)	83. (a)	84. (b)	85. (b)	86. (d)	87. (b)	88. (a)	89. (a)	90. (c)
91. (a)	92. (c)	93. (a)	94. (c)	95. (a)	96. (b)	97. (c)	98. (c)	99. (a)	100. (a)
101. (c)	102. (c)	103. (d)	104. (a)	105. (a)	106. (c)	107. (c)	108. (b)	109. (c)	110. (a)
111. (b)	112. (a)	113. (c)	114. (a)	115. (c)	116. (b)	117. (a)	118. (b)	119. (b)	120. (a)
121. (a)	122. (d)	123. (a)	124. (b)	125. (b)	126. (a)	127. (c)	128. (a)	129. (d)	130. (c)
131. (c)	132. (d)	133. (c)	134. (b)	135. (b)	136. (c)	137. (a)	138. (b)	139. (a)	140. (a)
141. (a)	142. (a)	143. (a)	144. (a)	145. (a)	146. (b)	147. (a)	148. (a)	149. (a)	150. (c)
151. (b)	152. (d)	153. (b)	154. (b)	155. (c)	156. (a)	157. (d)	158. (c)	159. (a)	160. (a)
161. (a)	162. (b)	163. (b)	164. (a)	165. (c)	166. (d)	167. (c)	168. (c)	169. (a)	170. (b)
171. (a)	172. (a)	173. (a)	174. (c)	175. (d)	176. (d)	177. (a)	178. (a)	179. (b)	180. (b)
181. (a)	182. (b)	183. (a)	184. (b)	185. (d)	186. (d)	187. (d)	188. (d)	189. (c)	190. (a)
191. (a)	192. (b)	193. (b)	194. (b)	195. (a)	196. (b)	197. (c)	198. (a)	199. (a)	200. (a)
201. (a)	202. (c)	203. (a)	204. (a)	205. (b)	206. (b)	207. (d)	208. (a)	209. (b)	210. (a)
211. (c)	212. (d)	213. (b)	214. (c)	215. (d)	216. (b)	217. (a)	218. (b)	219. (a)	220. (b)
221. (c)	222. (a)	223. (d)	224. (a)	225. (b)	226. (d)	227. (c)	228. (a)	229. (a)	230. (d)
231. (d)	232. (b)	233. (b)	234. (a)	235. (a)	236. (b)	237. (d)	238. (a)	239. (b)	240. (d)
241. (d)	242. (b)	243. (d)	244. (d)	245. (d)	246. (b)	247. (c)	248. (a)	249. (d)	250. (a)
251. (a)	252. (b)	253. (b)	254. (a)	255. (a)	256. (d)	257. (a)	258. (a)	259. (a)	260. (d)
261. (c)	262. (c)	263. (c)	264. (d)	265. (d)	266. (b)	267. (a)	268. (a)	269. (c)	270. (c)
271. (d)	272. (b)	273. (a)	274. (b)	275. (a)	276. (c)	277. (a)	278. (b)	279. (d)	280. (a)
281. (c)	282. (a)	283. (b)	284. (d)	285. (a)	286. (c)	287. (b)	288. (b)	289. (c)	290. (b)
291. (a)	292. (b)	293. (d)	294. (b)	295. (b)	296. (d)	297. (b)	298. (a)	299. (b)	300. (d)
301. (c)	302. (a)	303. (d)	304. (c)	305. (a)	306. (b)	307. (a)	308. (c)	309. (c)	310. (a)
311. (c)	312. (b)	313. (d)	314. (a)	315. (d)	316. (c)	317. (a)	318. (a)	319. (c)	320. (d)
321. (a)	322. (c)	323. (a)	324. (c)	325. (a)	326. (b)	327. (d)	328. (a)	329. (b)	330. (d)
331. (c)	332. (c)	333. (a)	334. (d)	335. (a)	336. (c)	337. (a)	338. (b)	339. (d)	340. (b)
341. (a)	342. (d)	343. (c)	344. (b)	345. (a)	346. (a)	347. (b)	348. (c)	349. (c)	350. (d)
351. (b)	352. (c)	353. (c)	354. (c)	355. (d)	356. (b)	357. (c)	358. (c)	359. (a)	360. (d)
361. (b)	362. (a)	363. (a)	364. (a)	365. (c)	366. (d)	367. (a)	368. (c)	369. (a)	370. (a)
371. (a)	372. (d)	373. (b)	374. (d)	375. (c)	376. (c)	377. (a)	378. (a)	379. (a)	380. (a)
381. (a)	382. (b)	383. (b)	384. (c)	385. (c)	386. (c)	387. (a)	388. (d)	389. (c)	390. (c)
391. (a)	392. (d)	393. (c)	394. (d)	395. (a)	396. (c)	397. (b)	398. (b)	399. (c)	400. (a)
401. (c)	402. (d)	403. (d)	404. (d)	405. (c)	406. (d)	407. (d)	408. (d)	409. (a)	410. (d)

30. $e = \frac{d\phi}{dt}$

$\therefore \quad dt = \frac{d\phi}{e} = \frac{5\times10^{-4}}{5\times10^{-3}} = 0.1$ s

31. $e = nA\frac{dB}{dt}$

$= 20 \times 25 \times 10^{-4} \times 1000 = 50V$

$I = \frac{e}{R} = \frac{50}{10} = 0.5$ A

32. $e = A\frac{dB}{dt}$

$= \frac{100\times10^{-4}\times4\times10^{2}}{5} = 0.8$ V

$I = \frac{e}{R} = \frac{0.8}{5} = 0.16$ A

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

$= 12\,t - 5 = 12 \times 0.25 - 5$

$= 2$ V

$I = \frac{e}{R} = \frac{2}{10} = 0.2$ A

35. The induced e.m.f. is proportional to B. Thus, induced current is also proportional to B.

36. $e = n\frac{dB}{dt}$

$\therefore \quad dt = \frac{nAB}{e}$

$= \frac{50\times100\times10^{-4}\times2\times10^{-2}}{0.1} = 0.1$ s

37. $e = B\,l\,v = 0.9 \times 0.4 \times 7 = 2.52$ V

38. Induced e.m.f. is proportional to B. Thus, induced current is also proportional to B.

39. $l = \frac{e}{Bv}$

$= \frac{9\times10^{-3}}{0.5\times12\times10^{-2}} = 15$ cm

40. If the angle between the axis of coil and direction of magnetic field is 90° then magnetic flux through the coil is maximum. Hence, induced e.m.f. produced in a coil is maximum.

41. $e = \frac{d\phi}{dt} = \frac{2\times10^{-4}}{2} = 1 \times 10^{-4}$ V

$I = \frac{e}{R} = \frac{1\times10^{-4}}{5} = 0.02$ mA

42. $e = B\,v\,l\sin\theta$

$= 0.1 \times 10 \times 4 \times \sin 30 = 2$ V

43. $e = \frac{d\phi}{dt} = \frac{1}{60}$ V

45. $e = \frac{d\phi}{dt} = \frac{nAB}{dt}(\cos\theta_1 - \cos\theta_2)$

$e = \frac{2\times1000\times500\times10^{-4}\times4\times10^{-5}}{0.1} = 40$ mV

46. $e = \frac{d\phi}{dt} = \frac{0.1-0.04}{3} = 0.02$ V

47. $e = BAf = B\pi r^2 f = B\pi l^2 f$

$= 5 \times 10^{-3} \times 3.14 \times 1 \times 30 = 0.471$ V

48. $e = A\frac{dB}{dt}$

$\therefore \quad \frac{dB}{dt} = \frac{e}{A} = \frac{IR}{A} = \frac{IR}{\pi r^2} = \frac{50\times10^{-3}\times3.14}{3.14\times0.5\times0.5}$

$= 0.2$ T/s or 0.2 Wb/m^{2}s

50. The current through wire PQ is reduced, the magnetic flux through the coil also decreases. Its direction is upward and towards you. Induced current will flow so as to maintain this flux towards you. Hence, induced current will be anticlockwise.

54. Current induced in pipe opposes the approach of magnet so $q < g$.

55. When rod is pulled out of the field e.m.f. is induced in the rod. The electrons will move from P to Q so plate M will be positively charged.

56. When switch S is closed then the current in loop is clockwise. Thus, e.m.f. induced in secondary coil is anticlockwise.

85. $L_S = L_1 + L_2 = L + L = 2L$

87. $e = L\frac{dI}{dt}$

$\therefore \quad L = \frac{e}{dI/dt} = \frac{8}{2/0.05} = 0.2$ H

88. $L = \frac{e}{dI/dt}$

$= \frac{5}{(3-2)/1\times10^{-3}} = 5$ mH

90. $e = L\frac{dI}{dt}$

$= \frac{5\times10^{-3}\times1}{0.1} = 0.05$ V

91. $\phi = LI \therefore L = \frac{\phi}{I} = \frac{40}{4} = 10\ H$

92. $n\phi = MI$

$\therefore M = \frac{n\phi}{I} = \frac{2000 \times 6 \times 10^{-4}}{3} = 0.4\ H$

93. $L_m = \mu_r L_a$
$= 100 \times 0.05 = 5\ H$

94. $E = \frac{1}{2} LI^2$

$= \frac{1}{2} \times 0.1 \times 1 = 0.05\ J$

164. $e_{rms} = \frac{e_0}{\sqrt{2}} = \frac{423}{1.414} \approx 300\ V$

165. $e = 240 \sin 120\, t,$

Comparing this equation with

$e = e_0 \sin \omega t$, we have,

$e_0 = 240\ V$ and $\omega = 120$ rad/sec.

$\therefore f = \frac{120}{2\pi} \approx 19\ Hz$

$e_{rms} = \frac{e_0}{\sqrt{2}}$

$= \frac{240}{1.414} \approx 170\ V$

166. $\theta = \omega t = 2\pi ft$

$\therefore t = \frac{\theta}{2\pi f}$

$= \frac{\pi}{2 \times 2\pi \times 50} = 0.005$ sec.

$I_0 = \sqrt{2}\ I_{rms} = 1.414 \times 10 = 14.14\ A$

169. Comparing given equation with

$e = e_0 \sin \omega t$, we have, $e_0 = 300\ V$

$\therefore I_{rms} = \frac{I_0}{\sqrt{2}}$

$= \frac{e_0}{R\sqrt{2}} = \frac{300}{100 \times 1.414} = 2.12\ A$

170. $e = e_0 \sin \omega t = e_0 \sin 2\pi f t$
$= 5 \sin (2 \times 3.14 \times 1000)\, t$
$= 5 \sin 6280\, t$

171. $e_0 = nAB\, \omega = nAB\, 2\pi f$
$= 50 \times 0.12 \times 0.02 \times 6.28 \times 10$
$\approx 7.536\ V$

200. $X_L = 2\pi f L = 2 \times 3.14 \times 50 \times 0.5$
$= 157\ \Omega$

201. $X_L = 2\pi fL = 2 \times 3.14 \times 50 \times 0.1$
$= 31.4\ \Omega$

Power factor $= \frac{R}{Z} = \frac{R}{\sqrt{R^2 + X_L^2}}$

$= \frac{100}{\sqrt{100^2 + (31.4)^2}} = 0.954$

202. $X_C = \frac{1}{2\pi f C}$

$= \frac{1}{2 \times 3.14 \times 50 \times 10 \times 10^{-6}} = 318.4\ \Omega$

$Z = \sqrt{R^2 + X_C^2} = \sqrt{50^2 + (318.4)^2}$
$\approx 322\ \Omega$

203. $Z = \sqrt{R^2 + X_C^2} = \sqrt{100^2 + (79.62)^2}$
$= 127.8\ \Omega$

$\therefore \phi = \cos^{-1}\left(\frac{R}{Z}\right) = \cos^{-1}\left(\frac{100}{127.8}\right)$
$= 38° 32'$

204. $X_L = 2\pi fL$
$= 2 \times 3.14 \times 50 \times 0.5$
$= 157\ \Omega$

$X_C = \frac{1}{2\pi f C}$

$= \frac{1}{2 \times 3.14 \times 50 \times 1 \times 10^{-6}} = 3184\ \Omega$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$
$= \sqrt{100^2 + (157 - 3184)^2} = 3028.6\ \Omega$

$I_{rms} = \frac{e_{rms}}{Z} = \frac{20}{3028.6} = 0.006603\ A$

$\cos\phi = \frac{R}{Z} = \frac{100}{3028.6} = 0.03301$

Thus, power consumed in one cycle is,

$\overline{P} = e_{rms}\, I_{rms} \cos\phi$
$= 20 \times 0.006603 \times 0.03301$
$\approx 0.0044\ W$

205. $X_L = 2\pi fL = 2 \times 3.14 \times 50 \times 0.5$
$= 157\ \Omega$

$Z = \sqrt{R^2 + X_L^2}$

$= \sqrt{109^2 + (157)^2} = 191.12\ \Omega$

$I = \frac{e}{Z} = \frac{100}{191.12} = 0.5232\ A$

206. If $X_L = X_C$ then $Z = R$

$\therefore \quad Z = 20\ \Omega$

207. In the given problem e.m.f. leads the current by 90°.

Thus, $\overline{P} = e_{rms} I_{rms} \cos\phi = e_{rms} I_{rms} \cos 90 = 0$

208. $$R_b = \frac{V_b^2}{P} = \frac{200 \times 200}{100} = 400\ \Omega$$

$$I = \frac{e}{R} = \frac{160}{400} = 0.4\ A$$

$$\overline{P} = e\,I = 160 \times 0.4 = 64\ W$$

209. $$\overline{P} = e\,I \cos\phi = \frac{e^2}{Z}\cos\phi$$

$$= \frac{220 \times 220 \times \cos 60}{110} = 110\ W$$

211. $$\overline{P} = \frac{e_0 I_0}{2} = \frac{e_0^2}{2R}$$

$$= \frac{220 \times 220}{2000} = 24.2\ W$$

213. $X_L \propto f \quad \therefore \frac{X_1}{X_2} = \frac{f_1}{f_2}$

$$\therefore X_2 = \frac{f_2}{f_1} X_1$$

$$= \frac{200 \times 10}{50} = 40\ \Omega$$

215. For D.C., $f = \infty \quad \therefore X_C = \frac{1}{2\pi f C} = \infty$

223. $R_1 = \frac{V^2}{W_1}$ and $R_2 = \frac{V^2}{W_2}$ and $R_S = \frac{V^2}{W_S}$

Now, $R_S = R_1 + R_2$

$$\therefore \frac{V^2}{W_S} = \frac{V^2}{W_1} + \frac{V^2}{W_2} \qquad \therefore W_S = \frac{W_1 W_2}{W_1 + W_2}$$

224. In parallel combination,

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\therefore \frac{1}{V^2/W_P} = \frac{1}{V^2/W_1} + \frac{1}{V^2/W_2}$$

$$\therefore W_P = W_1 + W_2$$

225. $H_{dc} = I_{dc}^2\ Rt = 4\ Rt = W$ .....(1)

$H_{ac} = I_{ac}^2\ Rt = 4\ W$ .....(2)

$$\therefore \frac{4W}{W} = \frac{I_{ac}^2 Rt}{4Rt}$$

$$\therefore I_{ac}^2 = 16$$

$$\therefore I_{ac} = 4\ A$$

228. In figure, three inductors are connected in parallel.

Thus, $$\frac{1}{L_P} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$$

$$\therefore L_P = 1\ H$$

231. $$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + X_L^2}} = \frac{4}{5}$$

$$\therefore \phi = \cos^{-1}\left(\frac{4}{5}\right)$$

247. $f_1 = f_2$

$$\frac{1}{2\pi\sqrt{L_1 C_1}} = \frac{1}{2\pi\sqrt{L_2 C_2}}$$

But, $C_2 = 4\,C_1$

$\therefore L_1 = 4\,L_2$

$$\therefore L_2 = \frac{L_1}{4} = \frac{L}{4}$$

248. If $X_L = X_C$ then alternating e.m.f. is in phase with alternating current.

264. $$e = \sqrt{e_R^2 + (e_L - e_C)^2}$$

$$= \sqrt{(70)^2 + (90 - 65)^2} = 74.3\ V$$

268. $$I = \frac{V_R}{R} = \frac{60}{120} = 0.5\ A$$

$$I = \frac{e_L}{X_L} = \frac{e_L}{\omega L}$$

$$\therefore L = \frac{e_L}{\omega I}$$

$$= \frac{40}{4 \times 10^5 \times 0.5} = 0.2\ mH$$

Now, $\omega^2 = \frac{1}{LC}$

$$\therefore C = \frac{1}{\omega^2 L} = \frac{1}{16 \times 10^{10} \times 0.2 \times 10^{-3}}$$

$$\approx 32\ m\mu F$$

275. $$f = \frac{1}{2\pi\sqrt{LC}} \qquad \therefore f^2 = \frac{1}{4\pi^2 LC}$$

$$\therefore C = \frac{1}{4\pi^2 L f^2}$$

$$= \frac{1}{4 \times 9.87 \times 10 \times 10^{-3} \times 2500} = 1014\ \mu F$$

276. At resonance, $I = \frac{e}{R}$

$$= \frac{10}{100} = 0.1\ A$$

277. $f = \dfrac{1}{2\pi\sqrt{LC}}$

$= \dfrac{1}{2\times 3.14\times\sqrt{10\times10^{-3}\times0.1\times10^{-6}}}$

$= 5.036$ kHz

≈ 5 kHz

282. $f = \dfrac{1}{2\pi\sqrt{LC}}$

$= \dfrac{1}{2\times 3.14\sqrt{2\times10^{-3}\times3.2\times10^{-6}}} = 1989$ Hz.

$I_L = \dfrac{e_{rms}}{X_L} = \dfrac{e_{rms}}{2\pi f L} = \dfrac{2}{2\times3.14\times1989\times2\times10^{-3}}$

≈ 80 mA

At resonance, current through inductor and condenser is same. Thus $I_C = 80$ mA

283. $I = I_C \sim I_L = 0.8 - 0.6 = 0.2$ A

284. Self inductance of solenoid,

$L = \mu_0 n^2 Al$

$\therefore L \propto Al \propto$ (linear dimension)

$\therefore L \propto (2)^3 = 8$

285. $\phi = nAB \cos 60$

$= 5\times10^{-3}$ Wb

286. $e = \dfrac{1}{2} B\omega l^2 = 50\ \mu V$

287. $e = nA\dfrac{dB}{dt} = 1$ V

288. $e_0 = nAB\omega = \dfrac{4\pi}{3}$ V.

289. $L \propto n^2 \Rightarrow \dfrac{L_2}{L_1} = \dfrac{n_2^2}{n_1^2} \quad \therefore L_2 = 16\,L$

290. $E = \dfrac{1}{2} L I^2 \quad \therefore L = 10$ H

291. $e = L\dfrac{dI}{dt} \quad \therefore L = 10$ H

292. $E = \dfrac{1}{2} LI^2$

$\Rightarrow P = \dfrac{dE}{dt} = \dfrac{1}{2} L\times 2I\dfrac{dI}{dt}$

$P = LI\dfrac{dI}{dt}$

$\Rightarrow L = \dfrac{P}{I\dfrac{dI}{dt}} = 5$ H

293. $L \propto N^2 \quad \therefore \dfrac{L_2}{L_1} = \left(\dfrac{N_2}{N_1}\right)^2$

$\therefore L_2 = 75$ mH

294. $e = \dfrac{d\phi}{dt} = 24t - 5 = 24\times0.25 - 5 = 1$ V

Now, $I = \dfrac{e}{R} = \dfrac{1}{10} = 0.1$ A

295. $e = M\dfrac{dI}{dt} = 25$ kV

296. $e = M\dfrac{dI}{dt}$

$= M\dfrac{d}{dt} I_0 \sin\omega t = M I_0 \omega \cos\omega t$

$\therefore e_0 = M I_0 \omega$

$= 0.25\times2\times2\pi\times50 = 157$ V

297. $I = \dfrac{V}{R} = \dfrac{100}{20} = 5$ A

$E = \dfrac{1}{2} L I^2 = 62.5$ J

298. $I = \dfrac{e}{R} = \dfrac{1}{R}\dfrac{d\phi}{dt}$

$= \dfrac{A}{R}\dfrac{dB}{dt} = 72$ A

Current induced will oppose the increase of downward magnetic field, so current will be anticlockwise.

299. $I = \dfrac{e}{R}$

$= \dfrac{n}{R}\dfrac{d\phi}{dt} = \dfrac{nB}{R}\dfrac{dA}{dt} = 50$ mA.

300. $L = \dfrac{\mu_0 n^2 A}{2a}$

$= \dfrac{\mu_0 n^2 \pi a}{2} = 25$ mH

301. $L = \dfrac{\mu_0 n^2 \pi a}{2} \therefore \dfrac{L_1}{L_2} = \left(\dfrac{n_1}{n_2}\right)^2 \dfrac{a_1}{a_2}$

$\therefore L_2 = 3\,L$

302. $e = M\dfrac{dI}{dt} = M I_0 \omega \cos\omega t$

$\therefore e_0 = M I_0 \omega = 5\pi$ V

303. $e = \dfrac{d\phi}{dt} = \dfrac{2nAB}{dt} = 0.4$ V

304. $\phi = \dfrac{\phi_1 - \phi_2}{R} = \dfrac{nAB}{R}$

$\therefore B = \dfrac{\phi R}{nA} = 0.566$ T

305. $e_2 = M\frac{dI_1}{dt} \quad \therefore I_2 = \frac{e_2}{R_2} = \frac{M}{R_2}\frac{dI_1}{dt}$

$\Rightarrow \quad \frac{dI_1}{dt} = \frac{I_2 R_2}{M} = 4 \text{ A/s}$

306. $\bar{P} = \frac{e_0 I_0}{2}\cos\frac{\pi}{3} = 2.5 \text{ W}$

307. For X, current is in phase

$\therefore \quad R = \frac{e}{I} = 40\ \Omega$

For Y current lags by is 90°

$\therefore \quad X_L = \frac{e}{I} = 40\ \Omega$

$\therefore \quad Z = \sqrt{R^2 + X_L^2} = 40\sqrt{2}\ \Omega$

$I_{rms} = \frac{e_{rms}}{Z} = 2.5 \text{ A}$

308. $e = \sqrt{e_R^2 + e_L^2} \quad \therefore e_R = \sqrt{e^2 - e_L^2} = 132 \text{ V}$

309. $e = e_0 \sin \omega t$

$= e_{rms}\sqrt{2}\sin 2\pi f t$

$= 120\sqrt{2}\sin 2\pi 60 \times \frac{1}{720}$

$= 120\sqrt{2}\sin\frac{\pi}{6}$

$= 84.8 \text{ V.}$

310. $\tan\phi = \frac{\omega L}{R}$

$= \frac{2\pi f L}{R} = \frac{4}{3}$

$\therefore \quad \phi = \tan^{-1}\left(\frac{4}{3}\right)$

311. $e = \sqrt{e_R^2 + (e_C - e_L)^2} = 100 \text{ V}$

312. $I = \frac{e}{Z}$

$= \frac{e}{\sqrt{R^2 + X_L^2}} = 0.16 \text{ A.}$

313. $R = \frac{V_{dc}}{I_{dc}}$

$= \frac{100}{1} = 100\ \Omega$

$Z = \frac{e_{rms}}{I_{rms}}$

$= \frac{100}{0.5} = 200\ \Omega$

$\therefore \quad X_L = \sqrt{Z^2 - R^2} = 173\ \Omega$

$L = \frac{X_L}{2\pi f} = 0.55 \text{ H.}$

314. $f = \frac{1}{2\pi\sqrt{LC}}$

For resonant frequency LC is constant

$\therefore \quad LC = L_1 C_1$

$\therefore \quad L_1 = \frac{C}{C_1}L = \frac{L}{4}$

315. $\frac{X_{L1}}{X_{L2}} = \frac{f_1}{f_2} = \frac{50}{60}$

$\therefore \quad X_{L2} = \frac{f_2}{f_1}X_{L1} = 120\ \Omega$

316. $e_0 = 4 \text{ V}, X_L = \omega L = 3\ \Omega$

$Z = \sqrt{R^2 + X_L^2} = 5\ \Omega$

$I_0 = \frac{e_0}{Z} = \frac{4}{5} = 0.8 \text{ A.}$

317. $e = \frac{d\phi}{dt} = \frac{5\times10^{-5}}{25} = 2\ \mu\text{V}$

318. $e = \frac{d\phi}{dt} = \frac{\phi_1 - \phi_2}{dt}$

$= \frac{nAB_1\cos\theta - nAB_2\cos\theta}{dt}$

$= \frac{50\times800\times10^{-4}\times5\times10^{-5}\times\cos 0 - 0}{2}$

$= 10^{-4} \text{ V}$

319. $e = B_H l v$

$= 4\times10^{-5}\times100\times20\times10^{-2}$

$= 8\times10^{-4} \text{ V}$

320. $e = \frac{d\phi}{dt} = \frac{\phi_1 - \phi_2}{dt} = \frac{A\cos\theta[B_1 - B_2]}{dt}$

$= \frac{4\times\cos 0\times[0.04 - 0.01]}{0.5}$

$= 0.24 \text{ V}$

321. $e = \frac{d\phi}{dt} = \frac{\phi_1 - \phi_2}{dt}$

$= \frac{nAB\cos\theta_1 - nAB\cos\theta_2}{dt}$

$= \frac{100\times0.4\times0.5\times[\cos 0 - \cos 60]}{2} = 5 \text{ V}$

322. $e = \frac{d\phi}{dt}$

$IR = \frac{AdB}{dt}$

$\frac{dB}{dt} = \frac{IR}{A} = \frac{0.1\times5}{0.25} = 2 \text{ T/s}$

323. $e = B_V l v$
$= 3 \times 10^{-4} \times 1 \times 22$
$= 66 \times 10^{-4}$ V
$= 6.6$ mV

324. $e = B_V l v$
$= B_H \tan\theta \, l v$
$$= \frac{3.6\times10^{-5}\times\tan 46\times1.5\times60\times10^3}{3600}$$
$= 0.93$ mV

325. $e = B_H l v$
$= B_H l (u + at)$
$= 4 \times 10^{-5} \times 1.5 [0 + 5 \times 2]$
$= 0.6$ mV

326. $e_{max} = B_H l v_{max}$
$= B_H l a \omega$
$$= B_H l a \frac{2\pi}{T}$$
$$= \frac{4\times10^{-5}\times1\times5\times10^{-5}\times2\pi}{\pi}$$
$= 4 \times 10^{-6}$ V
$= 4\ \mu$V

$e_{min} = B_H l v_{min} = B_H l \times 0 = 0$ V

327. $e = B_H l v \sin\theta$
$$= \frac{3.6\times10^{-5}\times1\times45\times10^3\times\sin 60}{3600}$$
$= 0.39$ mV

328. $\theta = \omega t = 2\pi f t$
$$\therefore \quad f = \frac{\theta}{2\pi t}$$
$$= \frac{\pi}{3\times2\pi\times0.1} = \frac{1}{0.6}$$
$e = B \pi r^2 f$
$$= \frac{10^{-5}\times\pi\times0.25\times1}{0.6} = 13\ \mu V$$

329. $e_0 = nAB\, 2\pi f$
$$I_{rms} = \frac{e_{rms}}{R}$$
$$= \frac{e_0}{R\sqrt{2}} = \frac{nAB\,2\pi f}{R\sqrt{2}}$$
$$= \frac{500\times3.14\times10^{-2}\times4\times10^{-2}\times2\times3.14\times50}{100\times1.414}$$
$= 1.4$ A

330. $e_0 = nAB\, 2\pi f$
$$= \frac{1000\times1.2\times2\times10^{-3}\times2\times3.14\times300}{60}$$
$= 75.4$ V

331. $$I_{rms} = \frac{e_{rms}}{R}$$
$$= \frac{e_0}{\sqrt{2}\,R}$$
$$= \frac{200}{\sqrt{2}\times1000} = 0.1414 \text{ A}$$

332. $$\overline{P} = \frac{e_0 I_0}{2}$$
$$= \frac{300\times2}{2} = 300 \text{ W}$$

333. $$I_{rms} = \frac{e_{rms}}{R}$$
$$= \frac{e_0}{\sqrt{2}\,R} = \frac{350}{1.414\times100} = 2.474$$
≈ 2.5 A

334. $e = e_0 \sin\omega t$
$= nAB\,\omega \sin\theta$
$= 50 \times 3.14 \times 144 \times 10^{-4} \times 5 \times 3.14 \times \sin 60$
$= 11.08 \times 10^{-3}$ V
≈ 11 mV

335. $$L = \frac{e dt}{dI} = \frac{10\times0.2}{0.5} = 4 \text{ H}$$

336. $$e = M\frac{dI}{dt}$$
$$= \frac{0.75\times0.5}{0.01} = 37.5 \text{ V}$$

337. $X_L = 2\pi f L$
$= 2 \times 3.14 \times 50 \times 2 = 628\ \Omega$

338. $$X_C = \frac{1}{2\pi f C}$$
$$= \frac{1}{2\times3.14\times50\times1\times10^{-6}}$$
$= 0.3185 \times 10^4$
$= 3.18 \times 10^3\ \Omega \approx 3.2$ kΩ

339. $X_L = 2\pi f L = 2 \times 3.14 \times 50 \times 0.5$
$= 157\ \Omega$

$Z = \sqrt{R^2 + X_L^2} = 164.8\ \Omega$

$$I = \frac{e}{Z} = \frac{240}{164.8} = 1.45 \text{ A}$$

340. $$X_C = \frac{1}{2\pi f C} = \frac{1}{2\times3.14\times50\times20\times10^{-6}}$$
$$= 159.2\ \Omega$$
$$Z = \sqrt{R^2+X_C^2} = 160.9\ \Omega$$
$$I = \frac{e}{Z} = \frac{240}{160.9} = 1.49 \text{ A}$$

341. $$X_L = 2\pi f L$$
$$= 2 \times 3.14 \times 5 \times 10^3 \times 0.5 \times 10^{-3}$$
$$= 15.7\ \Omega$$
$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\times3.14\times5\times10^3\times10\times10^{-6}}$$
$$= 3.185\ \Omega$$
$$Z = \sqrt{R^2+(X_L-X_C)^2}$$
$$= \sqrt{64+(15.7-3.2)^2} = 14.84\ \Omega$$

342. $$X_L = 2\pi f L = 2 \times 3.14 \times 50 \times 1 \times 0.2$$
$$= 62.8\ \Omega$$
$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\times3.14\times50\times1\times10^{-6}}$$
$$= 3.185\ \Omega$$

Power factor $= \cos\phi = \dfrac{R}{Z}$
$$= \frac{R}{\sqrt{R^2+(X_L-X_C)^2}}$$
$$= \frac{100}{\sqrt{100^2+(62.8-3.185)^2}}$$
$$= 0.859 \approx 0.86$$

343. $$X_C = \frac{1}{2\pi f C} = \frac{1}{2\times3.14\times1\times10^3\times2\times10^{-6}}$$
$$= 79.61\ \Omega$$
$$\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$$
$$= \tan^{-1}\left(\frac{79.61}{100}\right) = 38°\ 31' \approx 38°$$

344. $$X_L = 2\pi f L$$
$$= 2 \times 3.14 \times 50 \times 0.1$$
$$= 31.4\ \Omega$$
$$Z = \sqrt{R^2+X_L^2}$$
$$= \sqrt{(100)^2+(31.4)^2}$$
$$= \sqrt{10000+985.9} = 104.8\ \Omega$$
$$\overline{P} = e I \cos\phi$$
$$= e\cdot\frac{e}{Z}\cdot\frac{R}{Z}$$
$$= \frac{200\times200\times100}{104.8\times104.8} = 364 \text{ W}$$

345. $$f = \frac{1}{2\pi\sqrt{LC}}$$
$$f^2 = \frac{1}{4\pi^2 LC}$$
$$C = \frac{1}{4\pi^2 L f^2}$$
$$= \frac{1}{4\times9.87\times10\times10^{-3}\times2500}$$
$$= 1 \times 10^{-3} \text{ F}$$
$$= 1 \text{ mF}$$

346. $$f_r = \frac{1}{2\pi\sqrt{LC}}$$
$$= \frac{1}{2\times3.14\sqrt{450\times10^{-3}\times9\times10^{-6}}}$$
$$\approx 79 \text{ Hz}$$

347. $$\tan\phi = \frac{X_L}{R}$$
$$\therefore\ R = \frac{2\pi f L}{\tan\phi}$$
$$= \frac{2\pi\times50\times4}{\tan 45\times\pi} = 400\ \Omega$$

391. $$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{e_0}{X_C\sqrt{2}} = \frac{e_0}{\sqrt{2}}\, wc$$
$$= \frac{200\sqrt{2}\times100\times1\times10^{-6}}{\sqrt{2}} = 10 \text{ mA}$$

392. $I \propto \dfrac{1}{X}$

for inductor decreases $X \propto f$ $\therefore I$

for capacitor increases $X \propto \dfrac{1}{f}$ $\therefore I$

393. In case of inductor current lags behind the emf by 90°.

394. $\bar{P} = e_{rms} I_{rms} \cos\phi.$

395. $\dfrac{e_S}{e_P} = \dfrac{n_S}{n_P}$

$$e_S = \frac{4200}{2100} \times 120 = 240 \text{ V.}$$

396. $L \propto \dfrac{N^2}{l}$

$$\frac{L_2}{L_1} = \left(\frac{N^2}{l}\right)^2 \cdot \frac{l_1}{l_2}$$

$$= \left(\frac{2n_1}{n_1}\right)^2 \times \frac{l_1}{2l_1} = \frac{2}{1}$$

$$L_2 = 24.$$

397. $e = L \cdot \dfrac{dI}{dt}$

$$L = \frac{edt}{dI} = \frac{8 \times 0.05}{4} = 0.1 \text{ H.}$$

398. $I_0 = \dfrac{e_0}{X_C}$

$$I_0 = \frac{e_0}{\frac{1}{wC}} = w\,c\,e_0$$

$$I = 100 \times 2 \times 10^{-6} \times 200\sqrt{2}$$

$$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{100 \times 2 \times 10^{-6} \times 200\sqrt{2}}{\sqrt{2}}$$

$$= 40 \text{ mA.}$$

399. At resonance phase angle $\phi = 0$

$\therefore$ Power factor $= \cos\phi = \cos 0$

$= I.$

401. $\phi = LI$

$$= 8 \times 10^{-3} \times 5 \times 10^{-3}$$

$$= 40 \times 10^{-6}$$

$$= \frac{\mu_0}{100\pi}$$

402. $I = \dfrac{e}{Z}$

$$X_L = 2\pi f L$$

$$= 2 \times 3.14 \times 50 \times 10^{-2} = 3.14\ \Omega$$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2 \times 3.14 \times 50 \times 8 \times 10^{-6}}$$

$$= \frac{0.3185 \times 10^4}{8} = \frac{3185}{8} = 397\ \Omega$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = 397\ \Omega$$

$$e_R = I \cdot R = \frac{e}{Z} \cdot R$$

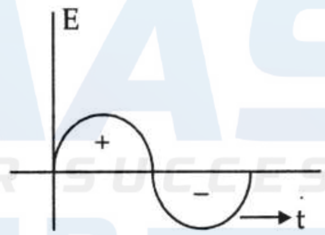
$$= \frac{2}{397} \times 4 = 0.02 \text{ V.}$$

403. $\because$ When an iron rod is inserted in the coil, then value of X_L increases $\left(\because X_L = \omega L = \omega \dfrac{\mu_0 N^2 A}{l}\right)$

($\therefore$ μ (Permeability of soft iron) > absolute permeability (μ_0))

In LR series ckt, $I_v = \dfrac{E_v}{\sqrt{R^2 + x_L^2}}$

404. Once per revolution



405. The self inductance of plane circular coil is given by,

$$L = \frac{1}{2}\mu_0 \pi a n^2$$

$\left(\because \dfrac{\mu_0 \pi a}{2}\text{ is constant}\right)$

$\therefore$ $L \propto n^2.$

406. $\bar{p} = \dfrac{e_0 I_0}{2}\cos\phi$

$$= \frac{100 \times 100 \times 10^{-3}}{2}\cos\frac{\pi}{3}$$

$$= \frac{10}{2} \times \frac{1}{2} = \frac{10}{4}$$

$$= 2.5 \text{ W.}$$

407. From the defination of displacement current.

409. $e_0 = \omega M I_0 = 10\pi \times 2 \times 10^{-2} \times 5 = \pi.$

410. $Q = CV$

$$\frac{Q}{t} = \frac{CV}{t}$$

$$I = 2 \times 10^{-6} \times 3 = 6 \times 10^{-6} \text{ A} = 6\ \mu\text{A.}$$