ANSWERS- Assignment 1

MULTIPLE CHOICE QUESTION

1. (a) ωL =ωC
2. (b) 1
3. (a) 0
4. (a) 90°
1. (d) If the assertion and reason both are false
2. (b) a.c. generator
3. (a) Mutual inductance
4. (c) Obtain a suitable ac voltage
5. (c) Frequency

10.(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

SHORT ANSWER TYPE I (2MARKS EACH)

11. When pure inductor and/or pure capacitor is connected to ac source, the current flows in the circuit, but with no power loss; the phase difference between voltage and current is $\pi/2$.

12. Two characteristic properties: (i) Low hysteresis loss (ii) Low coercivity

13. R= E-V/I = 0.2Ω.

SHORT ANSWER TYPE II (3MARKS EACH)

14. $X_L = \omega L = 2\pi\nu L = 100\Omega$

$$Z = \sqrt{R^2 + (Xc - XL)^2} \quad = 100\sqrt{2}\ \Omega$$

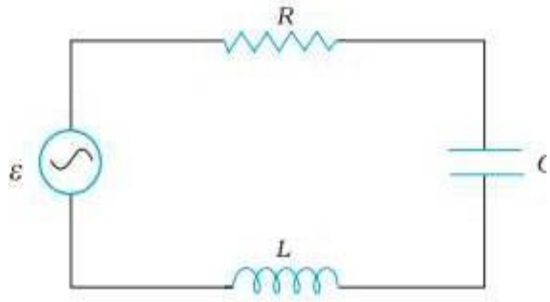
$$P_{dissipated} = (Vrms/Z)^2 R = 225W$$

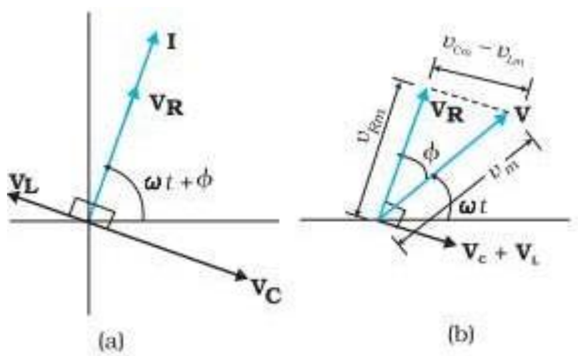
LONG ANSWER TYPE (5MARKS EACH)

15.(a) The opposition offered by the combination of a resistor and reactive component to the flow of ac is called impedance. Mathematically it is the ratio of rms voltage applied and rms current produced in circuit i.e., $Z=\frac{Vrms}{Irms}$. Its unit is ohm (Ω)

(b)

From the circuit shown in Fig. , the resistor, inductor and capacitor are in series. Therefore, the ac current in each element is the same at any time, having the same amplitude and phase. Let it be $i = i_m \sin(\omega t+\varphi)$ where φ is the phase difference between the voltage across the source and the current in the circuit





Let **I** be the phasor representing the current in the circuit. Further, let $\mathbf{V_L}$**,** $\mathbf{V_R}$**,** $\mathbf{V_C}$**,** and **V** represent the voltage across the inductor, resistor, capacitor and the source, respectively. We know that $\mathbf{V_R}$ is parallel to **I**, $\mathbf{V_C}$ is $\pi/2$ behind **I** and $\mathbf{V_L}$ is $\pi/2$ ahead of **I**. $\mathbf{V_L}$**,** $\mathbf{V_R}$**,** $\mathbf{V_C}$**,** and **I** are shown in Fig. with appropriate phase-relations.

The length of these phasors or the amplitude of $\mathbf{V_L}$**,** $\mathbf{V_R}$**,** and $\mathbf{V_C}$**,** are:

$v_{Rm} = i_m R$, $v_{Cm} = i_m X_C$, $v_{Lm} = i_m X_L$

From phasor diagram we have

$\mathbf{V_L} + \mathbf{V_R} + \mathbf{V_C} = \mathbf{V}$

Since $\mathbf{V_C}$ and $\mathbf{V_L}$ are always along the same line and in opposite directions, they can be combined into a single phasor **(**$\mathbf{V_C} + \mathbf{V_L}$**)** which has a magnitude $|V_{cm} - V_{Lm}|$Since **V** is represented as the hypotenuse of a right-traingle whose sides are $\mathbf{V_R}$ and **(**$\mathbf{V_C} + \mathbf{V_L}$),

The Pythagorean Theorem gives

$$V_m^2 = V_{Rm}^2 + (V_{Cm} - V_{Lm})^2$$

$$V_m^2 = (i_m R)^2 + (i_m X_C - i_m X_L)^2$$

$$V_m^2 = i_m^2 [(R)^2 + (X_C - X_L)^2]$$

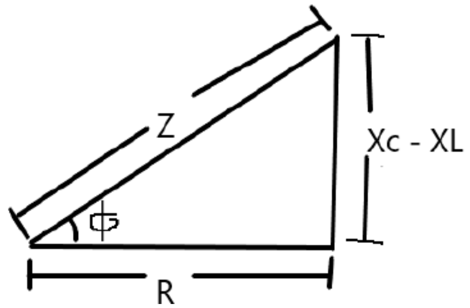
$i_m = V_m / \sqrt{R^2 + (Xc - X_L)^2}$

$i_m = V_m / Z$

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

Where Z is called impedance of the LCR series circuit which is opposition offered to the current in LCR series circuit.

And $\tan \varphi = \frac{V_{Cm} - V_{Lm}}{V_{Rm}} = \frac{X_C - X_L}{R}$



Impedance Triangle

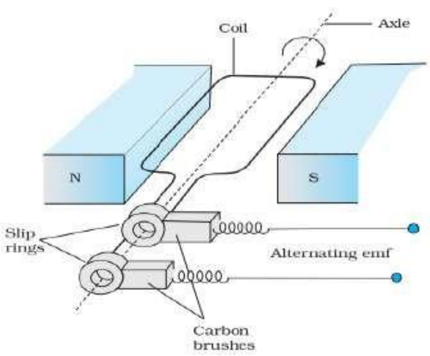
Instantaneous Current $I = \frac{V_m \, Sin\, wt + \varphi}{\sqrt{R^2 + (Xc - X_L)^2}}$

At resonance $X_C = X_L$

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

Resonance frequency $\omega_r = \frac{1}{\sqrt{LC}}$

16. Principle: Rotating coil kept in magnetic field produce ac current.



Construction: It consists of the four main parts:

Field Magnet: It produces the magnetic field.

Armature: It consists of a large number of turns of insulated wire in the soft iron drum or ring. It can revolve round an axle between the two poles of the field magnet. The drum or ring serves the two purposes: (a) It serves as a support to coils and (b) It increases the magnetic field due to air core being replaced by an iron core.

Slip Rings: The slip rings are the two metal rings to which the ends of armature coil are connected. These rings are fixed to the shaft which rotates the armature coil so that the rings also rotate along with the armature.

Brushes: These are two flexible metal plates or carbon rods) which are fixed and constantly touch the revolving rings. The output current in external load R_L is taken through these brushes.

Expression for induced emf

When the coil is rotated with a constant angular speed ω, the angle θ between the magnetic field vector B and the area vector A of the coil at any instant t is $\theta = \omega t$ (assuming $\theta = 0^o$ at $t = 0$). As a result, the effective area of the coil exposed to the magnetic field lines changes with time, the flux at any time t is $\Phi_B = BA \cos\theta = BA \cos \omega t$

From Faraday's law, the induced emf for the rotating coil of N turns is then,

$$E = - N \frac{d\phi B}{dt} = - NBA \frac{d\, cos\omega t}{dt}$$

Thus, the instantaneous value of the emf is

$\varepsilon = NBA\, \omega \sin \omega t$

where NBAω is the maximum value of the emf, which occurs when $\sin \omega t = \pm 1$.

If we denote NBAω as ε_0,

then $\varepsilon = \varepsilon_0 \sin \omega t$

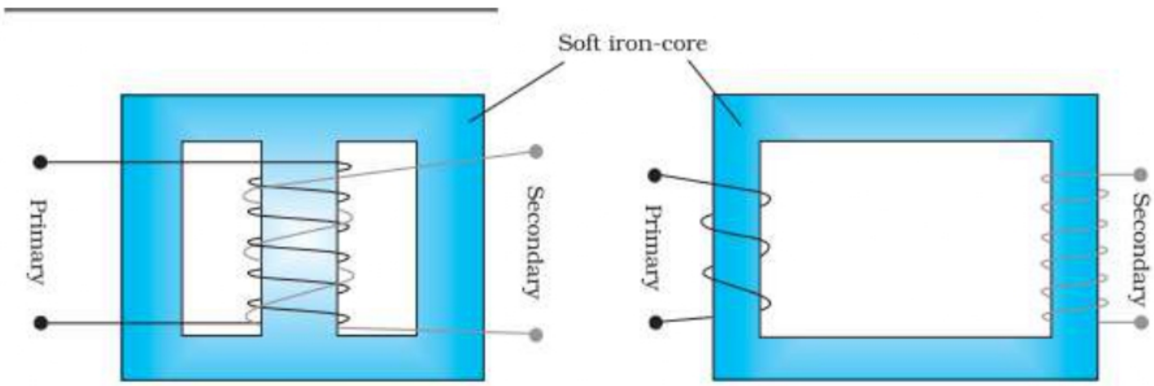
Obviously, the emf produced is alternating and hence the current is also alternating. Current produced by an ac generator cannot be measured by moving coil ammeter; because the average value of ac over full cycle is zero

17. Same as question no 2

18. Same as question no 2

The source of energy generation is the mechanical energy of rotation of armature coil.

19.



(a) (b)

Principle : Based on Mutual inductance.

Construction : A transformer consists of two sets of coils, insulated from each other. They are wound on a soft-iron core, either one on top of the other or on separate limbs of the core. One of the coils called the primary coil has N p turns. The other coil is called the secondary coil; it has Ns turns. Often the primary coil is the input coil and the secondary coil is the output coil of the transformer

Working : When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it. The value of this emf depends on the number of turns in the secondary. We consider an ideal transformer in which the primary has negligible resistance and all the flux in the core links both primary and secondary windings.

Let φ be the flux in each turn in the core at time t due to current in the primary when a voltage v_p is applied to it.

Induced emf E_S or voltage in secondary coil of Ns turns will be

$$\varepsilon_{S} = -N_s \frac{d\phi}{dt}$$

The alternate flux φ induced back emf in the primary coil is

$$\varepsilon_{p} = -N_p \frac{d\phi}{dt}$$

But $\varepsilon_p = v_p$. If this were not so, the primary current would be infinite since the primary has zero resistance (as assumed). If the secondary is an open circuit or the current taken from it is small, then to a good approximation $\varepsilon_s = v_s$

$v_{s=-}\ N_s\ \frac{d\phi}{dt}$ and $v_{p=-}\ N_p\ \frac{d\phi}{dt}$

Thus

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

If the transformer is assumed to be 100% efficient (no energy losses), the power input is equal to the power output, and since p = i v,

$$V_p\, i_p = V_s i_s$$

Thus $\frac{i_p}{i_c} = \frac{V_s}{V_p} = \frac{N_s}{N_p}$

(b)Transformer Losses

Flux Leakage: There is always some flux leakage; that is, not all of the flux due to primary passes through the secondary due to poor design of the core or the air gaps in the core. It can be reduced by winding the primary and secondary coils one over the other.

Resistance of the windings: The wire used for the windings has some resistance and so, energy is lost due to heat produced in the wire ($I^2 R$). In high current, low voltage windings, these are minimised by using thick wire.

Eddy currents: The alternating magnetic flux induces eddy currents in the iron core and causes heating. The effect is reduced by having a laminated core.

Hysteresis: The magnetisation of the core is repeatedly reversed by the alternating magnetic field. The resulting expenditure of energy in the core appears as heat and is kept to a minimum by using a magnetic material which has a low hysteresis loss.

(b) When output voltage increases, the output current automatically decreases to keep the power same. Thus, there is no violation of conservation of energy in a step up / step down transformer.

CASE STUDY TYPE (4 MARKS EACH)

20. Ans 1. Copper loss, Eddy current loss, Hysteresis loss, flux loss

Ans2. Eddy current losses are reduced by using a laminated core.

Ans3. Choosing a material having small Hysteresis loop area

Ans 4. Step down transformer.