- The constant value of dc which produces same heat through a resistive element, as due to the alternating current, is known as root mean square value of ac.
- 240 V ac is the rms value of ac voltage. The amplitude of this voltage is $V_M = 240 \times \sqrt{2} = 340$ volt.
- The power rating in ac circuit is the average power rating.
- Power consumed in a circuit is non-negative.
- Phase relationships in a.c. circuits is best represented by phasor diagram. A phasor is a vector which rotates with the angular velocity ω. The magnitude of phasor is the peak value of voltage or current (V_o or I_o).
- In purely resistive AC circuit, voltage and current are in the same phase $V = V_o \sin \omega t$ and $I = I_o \sin \omega t$, where $I_o = V_o/R$.
- In purely resistive circuit, average power loss = $I_{rms}^2 \times R$, $I_{rms} = \frac{I_0}{\sqrt{2}}$ similarly $V_{rms} = \frac{V_0}{\sqrt{2}}$
- The only element which dissipates energy in ac circuit is resistor (R).
- In purely inductive circuit, inductive reactance $X_L = 2\pi fL = \omega L$ voltage is ahead of current by $\frac{\pi}{2}$, $V = V_o \sin \omega t$, $I = I_o \sin\left(\omega t - \frac{\pi}{2}\right)$, $I_0 = \frac{V_0}{X_L}$. *In this circuit, average power loss = 0*.
- In purely inductive or capacitive circuit, $\cos \phi = 0 \Rightarrow \phi = \frac{\pi}{2}$. Average power loss is zero. Although current is flowing in the circuit. Such a current is known as *wattless current*.
- In AC L-R circuit, total voltage $V = \sqrt{V_R^2 + V_L^2}$.

- In purely capacitive A/C circuit, capacitive reactance $X_C = \frac{1}{2\pi f} = 1/\omega$. The current leads the applied voltage by $\pi/2$ or 90^o. $V = V_o \sin \omega t$, $I = I_o \sin\left(\omega + \frac{\pi}{2}\right)$, $I_o = \frac{V_0}{X_C} = 2\pi f V_0 m$ $V = V_0 \sin \omega t$, $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$, $I_0 = \frac{V_0}{X_C} = 2\pi f V_0$. The average power loss per cycle is ZERO.
- In AC C-R circuit, total voltage $V = \sqrt{V_R^2 + V_C^2}$
- A circuit containing an inductor L and a capacitor (initially charged) with no ac source and no resistors, exhibits free oscillations. The charge of the capacitor is given by the differential equation $\frac{d^2q}{dt^2} + \frac{1}{LC}q = 0$.

  The sum of energy of capacitor and inductor is constant.
- For a given RLC circuit driven by voltage $V = V_o \sin \omega t$, the current is given by $I = I_o \sin(\omega t + \phi)$ where $I_o = \frac{V_m}{\sqrt{R^2+(X_C-X_L)^2}}$ and $\phi = \tan^{-1}\frac{X_C-X_L}{R}$, impedance $z = \sqrt{R^2 + (X_C - X_L)^2}$.
- The phase difference between voltage across L and voltage across capacitor C, is 180^o Thus $V_{LC} = V_L - V_C$.
- The voltage in series LCR A/C circuit is given by

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}.$$

- The average power consumed = $V_{rms} \times I_{rms} \times \cos\phi$, where $\cos\phi$ is the power factor.
- In series LCR circuit, at resonance, $X_L = X_C$, the impedance Z is minimum and equal to R. In this case, the source frequency $\omega = \frac{1}{\sqrt{LC}}$ which equals resonant frequency.
- The quality factor $Q = \omega_0 \frac{L}{R} = \frac{1}{\omega_0 CR} = \frac{1}{R}\sqrt{\frac{1}{C}}$ is an indicator or **"sharpness of resonance."**

- The power factor in a RLC circuit is a measure of how close the circuit is to consuming maximum power.
- A step-up transformer converts low ac voltage to high ac voltage but reduces the current.
- A step-down transformer converts high ac voltage to a low ac voltage but increases the currents accordingly.
- In transformer, the primary and secondary voltage are given by $V_S = \left(\frac{N_S}{N_P}\right) V_P$ and the current are given by $I_S = \left(\frac{N_P}{N_S}\right) I_P$. In step up transformer, $N_S > N_P$ and step-down transformer $N_S < N_P$.
- A generator converts mechanical energy into electrical energy, whereas an electric motor converts electrical energy into mechanical energy.
- A transformer does not violate the law of conservation of energy. A step-up transformer changes low voltage to a high voltage but reduces the current in the same proportion.

- **Four Maxwell's Equations**
  1. $\oint \vec{E} \cdot \vec{ds} = \frac{q}{\varepsilon_0}$
  2. $\oint \vec{B} \cdot \vec{ds} = 0$
  3. $\oint \vec{E} \cdot \vec{dl} = -\frac{d}{dt}\phi_B = \frac{-d}{dt}\int \vec{B} \cdot \vec{ds}$
  4. $\oint \vec{B} \cdot \vec{dl} = -\mu_0(I_C + I_D) = \mu_0\left(I_C + \varepsilon_0 \frac{d\phi_E}{dt}\right)$
- Displacement current $I_D = \varepsilon_0 \frac{d}{dt}\phi_E = \varepsilon_0 \frac{d\oint \vec{E}\cdot\vec{ds}}{dt} = \frac{CdV}{dt}$
- $E_y = E_0 \sin(\omega t - kx)$ and $B_z = B_0 \sin(\omega t - kx)$
- $C_{vacuum} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$; $C_{medium} = \frac{1}{\sqrt{\mu_r \mu_0 \varepsilon_r \varepsilon_0}}$
- $\frac{E_0}{B_0} = \frac{E_{RMS}}{B_{RMS}} = \frac{E}{B} = c$
- Average intensity of wave I_{av} = average energy density (speed of light) of

  $$I_{av} = U_{av} \cdot c = \frac{E_0 B_0}{2\mu_0} = \frac{E_0^2}{2c\mu_0} = \frac{cB_0^2}{2\mu_0}$$
- Instantaneous energy density $u = \frac{1}{2}\varepsilon_0 E^2 + \frac{B_0^2}{2\mu_0} = \varepsilon_0 E^2 = \frac{B^2}{\mu_0}$
- Average energy density $u_{av} = \frac{1}{4}\varepsilon_0 E_0^2 + \frac{B_0^2}{4\mu_0} = \frac{\varepsilon_0 E_0^2}{2} = \frac{B_0^2}{2\mu_0}$
- Energy = (momentum). c or U = Pc
- Radiation pressure

  $= \frac{\text{Intensity}}{c}$ (when the wave is completely absorbed)

  $= \frac{2(\text{Intensity})}{c}$ (when the wave is completely reflected)
- Intensity of wave from a source at a distance r from it is proportional to

  $\frac{1}{r^2}$ (for a point source), $\frac{1}{r}$ (for a line source)

  For a plane source intensity is constant & independent of r.