BRAIN MAP

CLASS XI

GRAVITATION

Newton's Law of Gravitation

Gravitational force (F) between two bodies is directly proportional to product of masses and inversely proportional to square of the distance between them.

$$\vec{F} = -\frac{Gm_1m_2}{r^2}\cdot\hat{r}$$

Acceleration due to gravity

- For a body falling freely under gravity, the acceleration in the body is called acceleration due to gravity.
- Relationship between g and G

$$g = \frac{GM_e}{R_e^2} = \frac{4}{3}\pi G R_e \rho$$

where G = gravitational constant

ρ = density of earth

M_e and R_e be the mass and radius of earth

Characteristics of gravitational force

- It is always attractive.
- It is independent of the medium.
- It is a conservative and central force.
- It holds good over a wide range of distance.

Kepler's Laws of Planetary Motion

Law of orbits : Every planet revolves around the sun in an elliptical orbit and the sun is situated at one of its foci.

Law of areas : The areal velocity of the planet around the sun is constant

i.e., $\frac{dA}{dt}$ = a constant

Law of periods : The square of the time period of revolution of a planet is directly proportional to the cube of semi major axis of the elliptical orbit.

$$T^2 \propto a^3$$

Gravitational Potential Energy

Work done in bringing the given body from infinity to a point in the gravitational field.

$$U = -GMm/r$$

Gravitational potential

Work done in bringing a unit mass from infinity to a point in the gravitational field.

$$V = \frac{-GM}{r}$$

Escape speed

The minimum speed of projection of a body from surface of earth so that it just crosses the gravitational field of earth.

$$v_e = \sqrt{\frac{2GM}{R}}$$

Variation of acceleration due to gravity (g)

Due to altitude (h)

$$g_h = g\left(1 - \frac{2h}{R_e}\right)$$

The value of g goes on decreasing with height.

Due to depth (d)

$$g_d = g\left(1 - \frac{d}{R_e}\right)$$

The value of g decreases with depth.

Due to rotation of earth

$g_\lambda = g - R_e\omega^2\cos^2\lambda$

At equator, $\lambda = 0°$

$g_{\lambda_{min}} = g - R_e\omega^2$

At poles, $\lambda = 90°$

$g_{\lambda_{max}} = g_p = g$

Earth's Satellite

Types of Satellite

Polar satellilte

- Time period : 100 min
- Revolves in polar orbit around the earth.
- Height : 500-800 km.
- Uses : Weather forecasting, military spying

Geostationary satellite

- Time period : 24 hours
- Same angular speed in same direction with earth.
- Height : 36000 km.
- Uses : GPS, satellite communication (TV)

Orbital speed of satellite

The minimum speed required to put the satellite into a given orbit.

$$v_0 = R_e\sqrt{\frac{g}{R_e + h}}$$

For satellite orbiting close to the earth's surface

$$v_0 = \sqrt{gR_e}$$

Time period of satellite

$$T = \frac{2\pi}{R_e}\sqrt{\frac{(R_e + h)^3}{g}}$$

For satellite orbiting close to the earth's surface

$$T = 2\pi\sqrt{\frac{R_e}{g}} = 84.6 \text{ min}$$

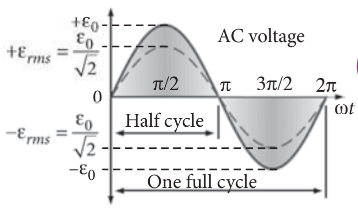
Energy of satellite

- Kinetic energy $K = \frac{GM_e m}{2(R_e + h)}$
- Potential energy $U = \frac{-GM_e m}{R_e + h}$
- Total energy

$$E = K + U = -\frac{GM_e m}{2(R_e + h)}$$

ALTERNATING CURRENT
ELECTROMAGNETIC WAVES

BRAIN MAP
CLASS XII



Alternating Current
Current which changes continuously in magnitude and periodically in direction.

Alternating voltage
$\varepsilon = \varepsilon_0 \sin \omega t$

Applied across capacitor

Purely capacitive circuit
Current leads the voltage by a phase angle of $\pi/2$.
$I = I_0 \sin(\omega t + \pi/2)$; $I_0 = \frac{\varepsilon_0}{X_C} = \omega C \varepsilon_0$
where $X_C = 1/\omega C$

Applied across resistor

Purely resistive circuit
Alternating voltage is in phase with current.
$I = \varepsilon/R = I_0 \sin\omega t$

Applied across inductor

Purely inductive circuit
Current lags behind the voltage by a phase angle of $\pi/2$.
$I = I_0 \sin(\omega t - \pi/2)$; $I_0 = \varepsilon_0/X_L = \varepsilon_0/\omega L$
where $X_L = \omega L$

Transformer
- Transformer ratios
$$\frac{\varepsilon_S}{\varepsilon_P} = \frac{I_P}{I_S} = \frac{N_S}{N_P} = k$$
- Efficiency of a transformer,
$$\eta = \frac{\text{output power}}{\text{input power}} = \frac{\varepsilon_S I_S}{\varepsilon_P I_P}.$$

Step-up transformer,
$\varepsilon_S > \varepsilon_P$, $I_S < I_P$ and $N_S > N_P$.

Step-down transformer,
$\varepsilon_S < \varepsilon_P$, $I_S > I_P$ and $N_S < N_P$.

Combining LCR in series

Series *LCR* circuit
- $\varepsilon = \varepsilon_0 \sin\omega t$, $I = I_0 \sin(\omega t - \phi)$
  Impedance of the circuit: $Z = \sqrt{R^2 + (X_L - X_C)^2}$
- Phase difference between current and voltage is ϕ
$$\tan\phi = \frac{X_L - X_C}{R}$$
- For $X_L > X_C$, ϕ is +ve. (Predominantly inductive)
- For $X_L < X_C$, ϕ is –ve. (Predominantly capacitive)

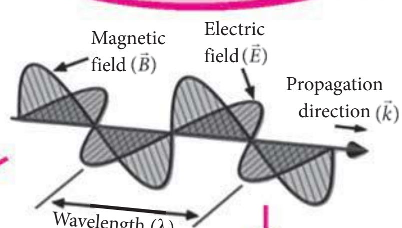
Power in ac circuit
Average power (P_{av})
$$P_{av} = \varepsilon_{rms} I_{rms} \cos\phi = \frac{\varepsilon_0 I_0}{2}\cos\phi$$

Power factor
- **Power factor:** $\cos\phi = \frac{R}{Z}$
- In pure resistive circuit, $\phi = 0°$; $\cos\phi = 1$
- In purely inductive or capacitive circuit
$$\phi = \pm\frac{\pi}{2};\ \cos\phi = 0$$
- In series *LCR* circuit, At resonance, $X_L = X_C$
$\therefore$ $Z = R$ and $\phi = 0°$, $\cos\phi = 1$

Resonant series *LCR* circuit
When $X_L = X_C$, $Z = R$, current becomes maximum.
Resonant frequency $\omega_r = \frac{1}{\sqrt{LC}}$

Quality factor
It is a measure of sharpness of resonance.
$$\therefore\quad Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Electromagnetic Waves
Waves having sinusoidal variation of electric and magnetic field at right angles to each other and perpendicular to direction of waves propagation.



Displacement current
Displacement current arises wherever the electric flux is changing with time.
$I_D = \varepsilon_0 d\phi_E/dt$

Energy density of electromagnetic waves
Average energy density
$$\langle u \rangle = \frac{1}{2}\varepsilon_0 E_0^2 = \frac{1}{2}\frac{B_0^2}{\mu_0}$$
Intensity of electromagnetic wave $= \frac{1}{2}\varepsilon_0 E_0^2 c$

Production of electromagnetic waves
- Through accelerating charge
- By harmonically oscillating electric charges.
- Through oscillating electric dipoles.

Maxwell's equations
$\oint \vec{E}\cdot d\vec{S} = \frac{q}{\varepsilon_0}$ (Gauss's law for electrostatics)

$\oint \vec{B}\cdot d\vec{S} = 0$ (Gauss's law for magnetism)

$\oint \vec{E}\cdot d\vec{l} = -\frac{d\phi_B}{dt}$ (Faraday's law of electro-magnetic induction)

$\oint \vec{B}\cdot d\vec{l} = \mu_0\left(I + \varepsilon_0\frac{d\phi_E}{dt}\right)$ (Maxwell-Ampere's circuital law)