Physics

Ch15: Oscillations

* ~~displa~~ angular frequency

$$\omega(t+T) = \omega t + 2\pi$$

$$\omega T = 2\pi$$

$$\boxed{\omega = \frac{2\pi}{T} = 2\pi f}$$

* displacement

$$\boxed{x = x_m \cos(\omega t + \phi)}$$

* velocity

$$\boxed{v = \dot{\theta} - \omega x_m \sin(\omega t + \phi)}$$

$$v_{max} = \omega x_m$$

* acceleration

$$\boxed{a = -\omega^2 x_m (\cos \omega t + \phi)}$$

$$a_{max} = \omega^2 x_m.$$

* Force

$$\boxed{F = ma = -(m\omega^2)x = -kx.}$$

*

* angular frequency and spring constant

$$\boxed{\omega = \sqrt{\frac{k}{m}} \qquad T = 2\pi\sqrt{\frac{m}{k}}}$$

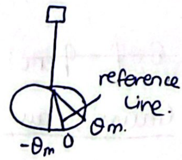
* Angular SHM

Torsional Pendulum.

$$\tau = -k\theta \qquad \tau = \text{torque.}$$

$$I\alpha = -k\theta \qquad I = \text{rotational inertia.}$$

$$I\frac{d^2\theta}{dt^2} = -k\theta$$



$$I \cdot \frac{d^2\theta}{dt^2} + k\theta = 0$$

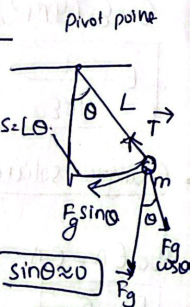
$$\frac{d^2\theta}{dt^2} + \frac{k}{I}\theta = 0$$

$$\frac{d^2x}{dt^2} + \omega^2 x = 0$$

$$\omega^2 = \frac{k}{I} \qquad \boxed{\omega = \sqrt{\frac{k}{I}}}$$

$$\boxed{T = 2\pi\sqrt{\frac{I}{k}}}$$

* Simple Pendulum.



$$\tau = la = -LF_g \sin\theta.$$

$$\tau = -L(mg)\sin\theta.$$

$$\tau = I\alpha \qquad \alpha = \frac{d^2\theta}{dt^2}$$

$$I \cdot \frac{d^2\theta}{dt^2} = -Lmg\theta \qquad \boxed{\sin\theta \approx 0}$$

$$I\frac{d^2\theta}{dt^2} + (mgL)\theta = 0 \qquad \boxed{I = mL^2}$$

$$\frac{d^2\theta}{dt^2} + \left(\frac{mgL}{I}\right)\theta = 0 \qquad \frac{g}{L} = \omega^2$$

$$\boxed{\omega = \sqrt{\frac{g}{L}}} \qquad \boxed{T = 2\pi\sqrt{\frac{L}{g}}}$$

Ch: 23: Gauss's Law

* electric flux through a Gaussian surface

$$\boxed{\Phi = \oint \vec{E} \cdot d\vec{A}}$$

E = electric field.

~~$\varepsilon_0 \phi = q_{enc}$~~

* Gauss's Law

$$\varepsilon_0 \Phi = q_{enc}$$

q_{enc} = net charge that is enclosed.

$$\boxed{\varepsilon_0 \oint \vec{E} \cdot d\vec{A} = q_{enc}.}$$

* Gauss's Law + Coulomb's Law

$$\varepsilon_0 \oint \vec{E} \cdot d\vec{A} = \varepsilon_0 \oint E\,dA = q_{enc}$$

$$\varepsilon_0 E \oint dA = q$$

$$\varepsilon_0 E\,(4\pi r^2) = q$$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}}$$

* Charged Isolated Conductor

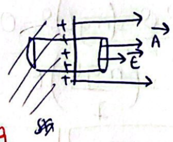
$$\varepsilon_0 E A = \sigma A$$

σ = charge per unit area.

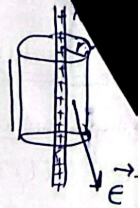
$$\boxed{E = \frac{\sigma}{\varepsilon_0}}$$

→ ~~ELOT~~

(conducting surface)



* Cylindrical Symmetry



λ = uniform positive linear charge density.

$$\phi = EA\cos\theta$$
$$= E(2\pi r h)\cos\theta$$
$$= E(2\pi r h)$$

* flux only through curved surface.

$$\varepsilon_0 \phi = q_{enc}$$

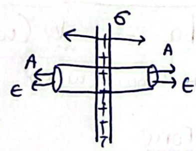
$$\varepsilon_0 E(2\pi r h) = \lambda h.$$

$$\boxed{E = \frac{\lambda}{2\pi\varepsilon_0 r}}$$

(line of charge)

* Planar Symmetry – Non-conducting Sheet

$$\varepsilon_0 \oint \vec{E} \cdot d\vec{A} = q_{enc}$$

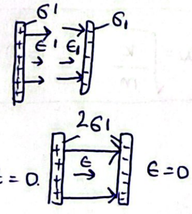


$$\varepsilon_0 (EA + EA) = \sigma A$$

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

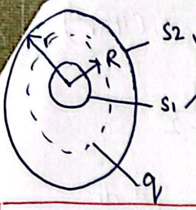
(sheet of charge)

* Planar Symmetry – Two conducting plates



$$\boxed{E = \frac{2\sigma_1}{\varepsilon_0} = \frac{\sigma}{\varepsilon_0}}$$

al symmetry



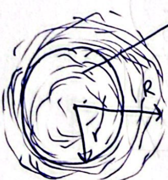
2 gaussian surface.

~~outside~~ inside.

$$\boxed{E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2} \quad r \geq R. \qquad E = 0 \quad r < R.}$$

spherical shell

enclosed charge is 'q''



(~~inside~~).

$$\boxed{E = \frac{1}{4\pi\varepsilon_0} \frac{q'}{r^2} \quad r \leq R.}$$

spherical distribution.

$$\boxed{E = \left(\frac{q}{4\pi\varepsilon_0 R^3}\right) r \quad r \leq R.}$$

uniform charge (~~outside~~).

Conducting Sphere :-

$E = 0$ (inside)

$E = \dfrac{q}{4\pi\varepsilon_0 r^2}$ (outside)

Non conducting :- $E = \dfrac{1}{4\pi\varepsilon_0} \cdot \dfrac{q}{r^2}$ (outside)

$E = \dfrac{q}{4\pi\varepsilon_0 R^3} \cdot r$ (inside)

Ch 25. capacitance

derivation of

$$E = \frac{q}{4\pi\varepsilon_0 R^3} \cdot r$$

~~$E =$~~

$$\frac{\text{charge enclose by r}}{\text{Volum " "}} = \frac{\text{full charge}}{\text{full volume}}$$

$$\frac{q'}{\frac{4\pi}{3} \cdot r^3} = \frac{q}{\frac{4\pi R^3}{3}}$$

$$q' = q\frac{r^3}{R^3}$$

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q'}{r^2}$$

$$E = \frac{1}{4\pi\varepsilon_0} \cdot q \cdot \frac{\cancel{r^3}\, r}{R^3} \cdot \frac{1}{\cancel{r^2}}$$

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qr}{R^3}.$$

Ch: 25: Capacitance.

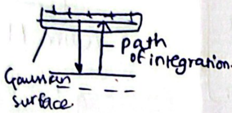
* Capacitance

$$\boxed{q = CV}$$

q = charge on 1 plate
V = potential diff.

* Capacitance with Gauss's Law

$$\varepsilon_0 \oint \vec{E} \cdot d\vec{A} = q$$



$$q = \varepsilon_0 E A$$

$$V_f - V_i = -\int_i^f \vec{E} \cdot d\vec{s}$$

$$V = \int_-^+ E\,ds = E \int_0^d ds = Ed$$

$$CV = \varepsilon_0 E A$$

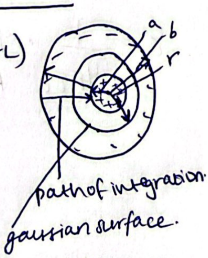
$$\cancel{E}d \cdot C = \varepsilon_0 \cancel{E} A$$

$$\boxed{C = \frac{\varepsilon_0 A}{d}}$$

* Cylindrical capacitor

$$q = \varepsilon_0 E A = \varepsilon_0 E (2\pi r L)$$

$$E = \frac{q}{2\pi \varepsilon_0 L r}$$



$$V = \int_-^+ E\,ds$$

$$V = \frac{-q}{2\pi\varepsilon_0 L} \int_b^a \frac{dr}{r}$$

L = ~~εo~~ length of cylinder

$$V = \frac{q}{2\pi\varepsilon_0 L} \ln\left(\frac{b}{a}\right)$$

$$\boxed{C = 2\pi\varepsilon_0 \frac{L}{\ln(b/a)}}$$

* A spherical Capacitor

$$q = \varepsilon_0 E A = \varepsilon_0 E (4\pi r^2)$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}$$

$$V = \int_-^+ E\,ds = -\frac{q}{4\pi\varepsilon_0} \int_b^a \frac{dr}{r^2}$$

$$V = \frac{q}{4\pi\varepsilon_0} \left(\frac{1}{a} - \frac{1}{b}\right)$$

$$V = \frac{q}{4\pi\varepsilon_0} \left(\frac{b-a}{ab}\right)$$

$$\boxed{C = 4\pi\varepsilon_0 \left(\frac{ab}{b-a}\right)}$$

* Capacitor with dielectric.

$$\boxed{C = k C_{Air}}$$

k = dielectric constant of the material.

$$\boxed{V' = \frac{V}{k}}$$ → voltage changes, charge doesn't

* Gauss's Law with dielectric

$$q - q^- = \frac{q}{k}.$$

$$\boxed{\varepsilon_0 \oint k\vec{E} \cdot d\vec{A} = q.}$$

$$E = \frac{E_0}{k} = \frac{q}{k\varepsilon_0 A}.$$

E_0 = original field.

B: Magnetic Fields

magnetic force.

$$\vec{F_B} = q\vec{v} \times \vec{B}$$

$$\boxed{F_B = |q| vB \sin\theta}$$

* Hall potential

$eE = ev_d B$

$V = Ed.$

V_d = drift velocity.

$V_d = \frac{J}{ne} = \frac{i}{neA}$.

J = current density.

$$\boxed{n = \frac{Bi}{VLe}}$$

$L = \frac{A}{d}$ = thickness of the strip.

$F_E = F_B.$

$J = iA$

$E = v_d B.$

$V_d = \frac{i}{Ane}$

$J = nev_d$

$A = l \times d.$

$\frac{J}{ne} = V_d.$

$V_d = \frac{i}{Ldne}$

$\frac{V}{d} = \frac{i}{ldne} B$

$$\boxed{V = \frac{iB}{lne}}$$

* Circulating charged particle.

$F = \frac{mv^2}{r} = qvB$ r = radius.

~~qv~~ $r = \frac{mv}{qB}$

$T = \frac{2\pi r}{v} = \frac{2\pi}{v} \cdot \frac{mv}{qB} = \frac{2\pi m}{qB}$

T = time period.

$f = \frac{1}{T} = \frac{qB}{2\pi m}$ → frequency.

$\omega = 2\pi f = \frac{qB}{m}$ → angular frequency.

* ~~Magnetic force on a current~~ carrying wire

V_d = drift velocity

$t = \frac{L}{V_d}$

$q = it = i\frac{L}{V_d}$

$F_B = qv_d B\sin\theta = \frac{iL}{V_d} v_d B \sin 90$

$F_B = iLB$

$\vec{F_B} = i\vec{L} \times \vec{B}$ (force on a current)

$d\vec{F_B} = i d\vec{L} \times \vec{B}$

Ch:29: Magnetic Fields due to Currents

* **Magnetic field due to a long straight wire.**

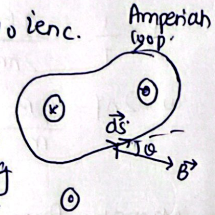
$$\boxed{B = \frac{\mu_0 i}{2\pi R}}$$

$\mu_0 = 1.26 \times 10^{-6}\ \mathrm{T \cdot m/A}$.

* **Ampere's Law.**

$$\oint \vec{B} \cdot \vec{ds} = \mu_0 i_{enc}.$$

* ds → current-length element vector along the direction of an amperican loop.

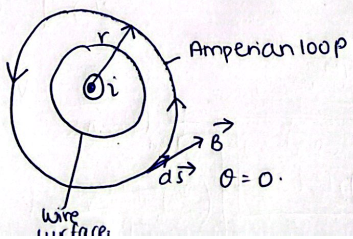


* **Magnetic field outside a long straight wire carrying current.**

$$\oint \vec{B} \cdot \vec{ds} = \oint B \cos\theta\, ds = B \oint ds$$

$$B(2\pi r) = \mu_0 i$$

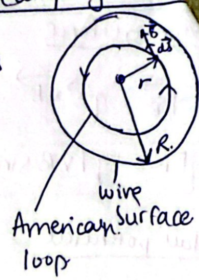
$$\boxed{B = \frac{\mu_0 i}{2\pi r}}$$ → outside straight wire.



* **Magnetic field inside a long straight wire carrying current**

$$\oint \vec{B} \cdot \vec{ds} = B \oint ds = B(2\pi r).$$

$$i_{enc} = i\left(\frac{\pi r^2}{\pi R^2}\right)$$



$$B(2\pi r) = \mu_0 i \left(\frac{\pi r^2}{\pi R^2}\right)$$

$$\boxed{B = \left(\frac{\mu_0 i}{2\pi R^2}\right) r}$$ → inside straight wire.

* $\boxed{i_{enc} = \int J\, dA}$

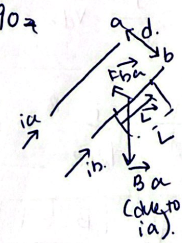
* **Force b/w 2 parallel wires.**

$$B_a = \frac{\mu_0 i_a}{2\pi d}$$

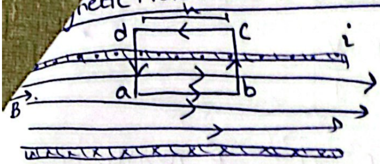
$$\vec{F}_{ba} = i_b \vec{L} \times \vec{B}_a$$

$$F_{ba} = i_b L B_a \sin 90$$

$$F_{ba} = \frac{\mu_0 \cdot L i_a i_b}{2\pi d}.$$



Magnetic Field inside a Solenoid



$$\oint \vec{B}\cdot\vec{ds} = \int_a^b Bds + \int_b^c Bds + \int_c^d Bds + \int_d^a Bds.$$

$$\int_a^b Bds = Bh. \quad \int_b^c = \int_c^d = \int_d^a = 0.$$

* only ab is inside, cd is outside.
* θ of cb and ad is 90, $\cos 90 = 0$.

$$\oint Bds = Bh. \quad i_{enc} = nhi$$

$$\oint Bds = \mu_0 i_{enc}$$

$$Bh = \mu_0 nhi$$

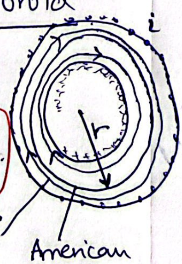
$$\boxed{B = \mu_0 ni}$$

n = no. of turns per unit length of solenoid.

* Magnetic Field of a Toroid

$$B\,2\pi r = \mu_0 i N.$$

$$\boxed{B = \frac{\mu_0 i N}{2\pi}\cdot\frac{1}{r}}$$



N = total no. of turns.

* Biot-Savart's Law

$$dB \propto ids$$

$$dB \propto \frac{1}{r^2}$$

$$dB \propto \sin\theta.$$

$$dB \propto \frac{ids(\sin\theta)}{r^2}$$

$$dB = \frac{\mu_0}{4\pi}\left[\frac{ids(\sin\theta)}{r^2}\right]$$

$$= \frac{\mu_0}{4\pi}\left[\frac{ids \times \vec{r}}{r^3}\right]$$

$$\hat{r} = \frac{\vec{r}}{|r|} \qquad \hat{r}|r| = \vec{r}$$

$$dB = \frac{\mu_0}{4\pi}\left[\frac{ids\cdot\hat{r}\cdot\cancel{|r|}}{\cancel{r^3}\,2}\right]$$

$$dB = \frac{\mu_0}{4\pi}\left[\frac{ids\,\hat{r}}{r^2}\right]$$

Ch: 5: Force and Motion

(No as such formulas)

γ^s

* gravitational force.

$$\boxed{F_g = mg}$$

* Third Law

$$\boxed{F_{BC} = F_{CB}.}$$

$$\vec{F}_{BC} = -\vec{F}_{CB}$$

Ch: 26: Current and Resistance

$$\boxed{i = \frac{q}{t}}$$

$$\boxed{i = \int \vec{J} \cdot d\vec{A}}$$

~~J i~~

* if current is uniform, parallel to dA, the

$$i = JA$$

$$J = \frac{i}{A}.$$

* $\boxed{\vec{J} = (ne)\vec{v_d}}$

* $\boxed{i = nAev_d}$

* $\boxed{R = \frac{V}{I}}$

* $\boxed{\vec{E} = \rho\vec{J}}$ ρ = resistivity

* $\boxed{\vec{J} = \sigma\vec{E}}$ σ = conductivity.

* $\boxed{R = \frac{\rho L}{A}}$

* $\boxed{\rho - \rho_0 = \rho_0 \alpha (T - T_0)}$

↳ variation with temp.