

Physics

XI & XII

FORMULA SHEET

MADE WITH LOVE

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PHYSICAL CONSTANTS

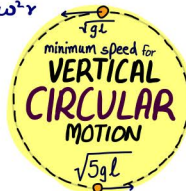
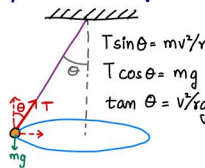
Speed of Light $c = 3 \times 10^8 \text{ m/s}$
 Plank constant $h = 6.63 \times 10^{-34} \text{ Js}$ $hc = 1242 \text{ eV-nm}$
 Gravitation constant $G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$
 Boltzmann constant $k = 1.38 \times 10^{-23} \text{ J/K}$
 Molar gas constant $R = 8.314 \text{ J/mol K}$
 Avogadro's number $N_A = 6.023 \times 10^{23}/\text{mol}$
 Charge of electron $e = 1.602 \times 10^{-19} \text{ C}$
 Permeability of vacuum $\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$
 Permittivity of vacuum $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$
 Coulomb constant $1/4\pi\epsilon_0 = 9 \times 10^9 \text{ N m}^2/\text{C}^2$
 Faraday constant $F = 96485 \text{ C/mol}$
 Mass of electron $m_e = 9.1 \times 10^{-31} \text{ kg}$
 Mass of proton $m_p = 1.6726 \times 10^{-27} \text{ kg}$
 Mass of neutron $m_n = 1.6749 \times 10^{-27} \text{ kg}$
 Atomic mass unit $u = 1.66 \times 10^{-27} \text{ kg}$
 Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$
 Rydberg constant $R_\infty = 1.097 \times 10^7/\text{m}$
 Bohr magneton $\mu_B = 9.27 \times 10^{-24} \text{ J/T}$
 Bohr radius $a_0 = 0.529 \times 10^{-10} \text{ m}$
 Standard atmosphere $atm = 1.01325 \times 10^5 \text{ Pa}$
 Wien displacement constant $b = 2.9 \times 10^{-3} \text{ mK}$



LAWS OF MOTION

1st LAW: INERTIA 2nd LAW: $F = d\vec{p}/dt = m\vec{a}$ 3rd LAW: Action \Rightarrow Reaction
 Friction: $f_{static, maximum} = \mu_s N$ $f_{kinetic} = \mu_k N$

Centripetal force $= \frac{mv^2}{r} = m\omega^2 r$



CURVED BANKING

$$\frac{v^2}{rg} = \tan \theta \quad \frac{v^2}{rg} = \frac{\mu + \tan \theta}{1 + \mu \tan \theta}$$

WORK, POWER & ENERGY

Work $= \vec{F} \cdot \vec{s} = F s \cos \theta$
 $= \int \vec{F} \cdot d\vec{s}$

KE $= \frac{1}{2} mv^2$ (K)

POTENTIAL ENERGY (U)

$U_g = mgh$ $\vec{F} = -\frac{dU}{dx}$ FOR CONSERVATIVE FORCES
 $U_{spring} = \frac{1}{2} kx^2$
 K + U = Conserved

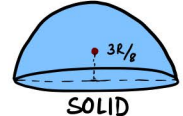
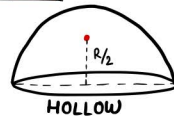
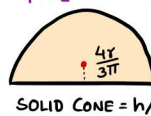
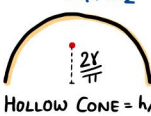
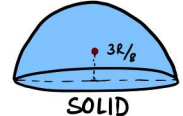
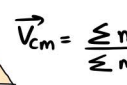
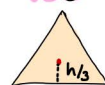
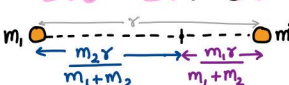
$\oint \vec{F} \cdot d\vec{s} = 0$ {Work by Conservative force in a closed path}

WORK-ENERGY THEOREM
 $W_{net} = \Delta K$

POWER $= dW/dt = \vec{F} \cdot \vec{v}$

CENTER OF MASS

$x_{cm} = \frac{\sum x_i m_i}{\sum m_i} = \frac{\int x dm}{\int dm}$



VECTORS

$\vec{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k}$ $|\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$
 Dot Product $\vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z$
 $= ab \cos \theta$

Cross Product $\vec{a} \times \vec{b} = ab \sin \theta$ (Area)
 $\vec{a} \times \vec{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix} = (a_y b_z - b_y a_z) \hat{i} - (a_x b_z - b_x a_z) \hat{j} + (a_x b_y - b_x a_y) \hat{k}$ (Don't forget)

KINEMATICS

$\vec{v}_{avg} = \Delta \vec{s} / \Delta t$ $\vec{v}_{inst} = d\vec{s} / dt$
 $\vec{a}_{avg} = \Delta \vec{v} / \Delta t$ $\vec{a}_{inst} = d\vec{v} / dt$

$s = ut + \frac{1}{2} at^2$ **RELATIVE VELOCITY**
 $v = u + at$ $\rightarrow v_{A/B} = v_A - v_B$
 $v^2 = u^2 + 2as$

PROJECTILE MOTION

$u_x = u \cos \theta$ $u_y = u \sin \theta$ $H = u^2 \sin^2 \theta / 2g$
 Time of Flight $= 2u_y / g \Rightarrow T = 2u \sin \theta / g$
 Range $= u_x T \Rightarrow R = \frac{u^2 \sin 2\theta}{g}$
 $y = \tan \theta \cdot x - \left(\frac{g}{2u^2 \cos^2 \theta} \right) \cdot x^2$

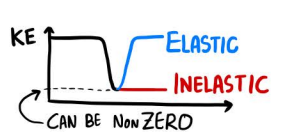
COLLISION

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

MOMENTUM CONSERVATION {Always}

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$m_1 \gg m_2$
 $m_1 \rightarrow$ undisturbed motion
 Solve using CoR in m_1 Frame



$CoR = e = \frac{v_{separation}}{v_{approach}} = \frac{v_2 - v_1}{u_1 - u_2}$

ENERGY CONSERVATION {Elastic}
 $\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$

RIGID BODY DYNAMICS

$\omega = \frac{\Delta \theta}{\Delta t} = \frac{d\theta}{dt}$ $\alpha = \frac{\Delta \omega}{\Delta t} = \frac{d\omega}{dt}$ $\vec{v} = \vec{\omega} \times \vec{r}$ $\vec{a}_{tan} = \vec{\omega} \times \vec{v}$ $\vec{a}_{centri} = \omega^2 r$

$\vec{L} = \vec{r} \times \vec{p} = m \vec{r} \times \vec{v}$
 $\vec{L} = I \vec{\omega} = d\vec{L} / dt$
 $\vec{\tau} = \vec{r} \times \vec{F} = r_\perp F = r F \sin \theta$

EQUILIBRIUM: $F_{net} = 0 = \sum F_{net}$ $\omega = 2\pi f$ $T = 1/f$
 $\omega = v_\perp / r$

MOMENT OF INERTIA

$$I = \frac{ml^2}{12}$$

$$I = \frac{m(a^2 + b^2)}{12}$$

$$I = mr^2$$

$$I = mr^2$$

$$I = \frac{1}{2}mr^2$$

$I = \sum m_i r_i^2$
 $I = \int r^2 dm$
 $R_{GYRATION} mk^2 = I$

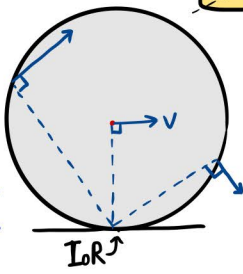
KINETIC ENERGY

$$K = \frac{1}{2}mv_c^2 + \frac{1}{2}I_c\omega^2$$

$$K = \frac{1}{2}I_H\omega^2 \quad \left\{ \begin{array}{l} \text{About Hinge} \\ \text{or } I_{OR} \end{array} \right\}$$

$$a = \frac{g \sin \theta}{1 + \frac{I}{mr^2}}$$

$$v = \sqrt{\frac{2gH}{1 + \frac{I}{mr^2}}}$$

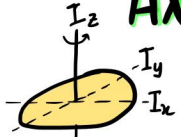


ROLLING MOTION

$$v = \omega r \quad (\text{no slip condition})$$

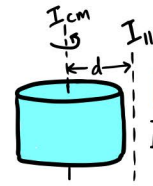
I_{OR} INSTANTANEOUS AXIS OF ROTATION
 $\vec{v} = \vec{\omega} \times \vec{r}$

AXIS THEOREMS



PERPENDICULAR

$$I_z = I_x + I_y$$



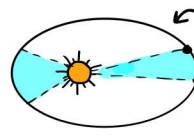
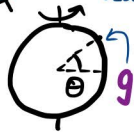
PARALLEL

$$I_{||} = I_{cm} + md^2$$

GRAVITATION

$$F = G \frac{Mm}{R^2} \quad \text{POT. ENERGY } (U) = -GMm/R$$

$$g = G \frac{M}{R^2} \quad g' = g \left[1 - \frac{d}{R_e} \right] \quad g' \approx g \left[1 - \frac{2h}{R_e} \right]$$



KEPLER'S LAWS

- 1st Elliptical Orbits, Sun @ foci
- 2nd Equal Area in Equal time (\vec{L})
- 3rd $T^2 \propto a^3$ [semi major axis]

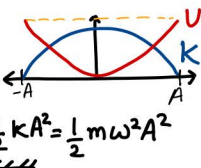
MHS

HOOKE'S LAW $F = -kx$
 $x = A \sin(\omega t + \phi)$
 $v = A\omega \cos(\omega t + \phi)$
 $a = -\omega^2 x = -k/m x$
 $T = \frac{2\pi}{\omega} = 2\pi \sqrt{m/k}$

$$K = \frac{1}{2}mv^2$$

$$U = \frac{1}{2}kx^2$$

$$E = K + U = \frac{1}{2}kA^2 = \frac{1}{2}m\omega^2 A^2$$

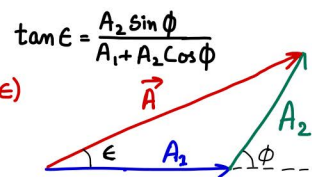


$$x_1 = A_1 \sin(\omega t)$$

$$x_2 = A_2 \sin(\omega t + \phi)$$

$$x = x_1 + x_2 = A \sin(\omega t + \epsilon)$$

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos \phi}$$



$$T = 2\pi \sqrt{l/g}$$

$$T = 2\pi \sqrt{I/mgl}$$

$$T = 2\pi \sqrt{I/k}$$

SERIES
 $\frac{1}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2}$

PARALLEL
 $K_{eq} = K_1 + K_2$

PROPERTIES OF MATTER

YOUNG'S MODULUS $(Y) = \frac{F/A}{\Delta l/l}$

SHEAR MODULUS $(\eta) = \frac{F/A}{\tan \theta}$

BULK MODULUS $(B) = -V \frac{\Delta P}{\Delta V}$

COMPRESSIBILITY $(K) = \frac{1}{B} = -\frac{1}{V} \frac{\Delta V}{\Delta P}$

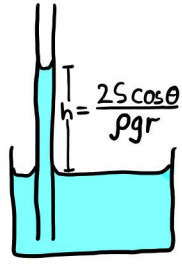
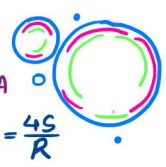
POISSON'S RATIO $(\sigma) = \frac{\text{LATERAL STRAIN}}{\text{LONGITUDINAL STRAIN}} = \frac{\Delta D/D}{\Delta l/l}$

ELASTIC ENERGY $(U) = \frac{1}{2} \text{STRESS} \times \text{STRAIN} \times \text{VOLUME}$

SURFACE TENSION $(S) = F/l$

SURFACE ENERGY $(U) = S \cdot \text{AREA}$

$P_{EXCESS} = \Delta P_{AIR} = \frac{2S}{R} \quad \Delta P_{SOAP} = \frac{4S}{R}$



HYDROSTATIC $= \rho g h$ **BUOYANT** $= \rho g V$

CONTINUITY $A_1 v_1 = A_2 v_2$

BERNOULLI'S $p + \rho g h + \frac{1}{2} \rho v^2 = \text{Const}$

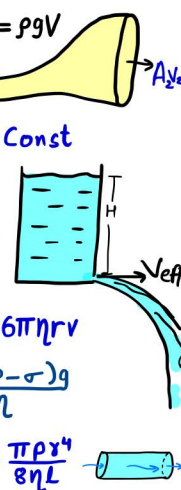
$F_{VISCOUS} = -\eta A \frac{dv}{dx}$

TORRICELLI'S $V_{EFFLUX} = \sqrt{2gh}$

STOKE'S LAW $F = 6\pi \eta r v$

$V_{TERMINAL} = \frac{2r^2(\rho - \sigma)g}{9\eta}$

POISEUILL'S EQN $\frac{VOLUME FLOW}{\Delta t} = \frac{\pi r^4 \Delta p}{8\eta l}$



WAVES

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 y}{\partial t^2}$$

$$y = A \sin(kx - \omega t) = A \sin\left[2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right)\right]$$

$$T = \frac{1}{\nu} = \frac{2\pi}{\omega} \quad v = \nu \lambda \quad \text{Wave Number } (k) = \frac{2\pi}{\lambda}$$

$$y_1 = A_1 \sin(kx - \omega t) \quad y_2 = A_2 \sin(kx - \omega t + \phi)$$

$$y = A \sin(kx - \omega t + \epsilon) \quad A^2 = \sqrt{(A_1 + A_2 \cos \phi)^2 + (A_2 \sin \phi)^2}$$

$$\phi = 2n\pi \text{ (even) : Constructive} \\ \phi = (2n+1)\pi \text{ (odd) : Destructive}$$

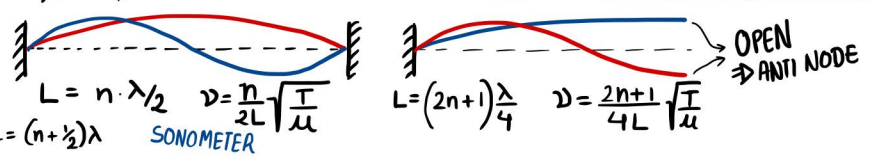
$$\tan \epsilon = \frac{A_2 \sin \phi}{A_1 + A_2 \cos \phi}$$

$$P_{\text{avg}} = 2\pi^2 \mu \nu A v^2 \quad v = \sqrt{\frac{T}{\mu}}$$

STANDING WAVES

$$y_1 = A \sin(kx - \omega t) \quad y_2 = A \sin(kx + \omega t)$$

$$y = 2A \cos kx \sin \omega t \quad \text{Node if } \cos kx \text{ is zero} \Rightarrow x = (n + \frac{1}{2})\lambda$$



SOUND WAVES

$$S = S_0 \sin[\omega(t - x/v)] \quad v_{\text{solid}} = \sqrt{Y/\rho}$$

$$P = P_0 \cos[\omega(t - x/v)] \quad v_{\text{liq}} = \sqrt{B/\rho}$$

$$P_0 = \left[\frac{\partial \phi}{\partial x}\right] S_0 \quad v_{\text{gas}} = \sqrt{\gamma P/\rho}$$

$$I = \frac{2\pi^2 B S_0 v^2}{2B} = \frac{P_0^2 v}{2\rho} = \frac{P_0}{2\rho v}$$

STANDING LONGITUDINAL WAVES

$$P_1 = P_0 \sin[\omega(t - x/v)] \quad P_2 = P_0 \sin[\omega(t + x/v)]$$

$$P = P_1 + P_2 = 2P_0 \cos kx \sin \omega t$$

CLOSED ORGAN PIPE

$$L = (2n+1) \frac{\lambda}{4} \quad v = (2n+1) \frac{v}{4L}$$

OPEN ORGAN PIPE

$$L = n \frac{\lambda}{2} \quad v = n \frac{v}{2L}$$

RESONANCE COLUMN

$$L_1 + d = \frac{\lambda}{2} \quad L_2 + d = \frac{3\lambda}{2}$$

$$v = 2(L_2 - L_1)\nu$$

BEATS (if $\omega_1 \approx \omega_2$)

$$P_1 = P_0 \sin \omega_1(t - x/v) \quad P_2 = P_0 \sin \omega_2(t - x/v)$$

$$P = 2P_0 \cos \Delta\omega(t - x/v) \sin \omega(t - x/v)$$

$$\omega = \frac{(\omega_1 + \omega_2)}{2} \quad \text{Beats} \rightarrow \Delta\omega = \omega_1 - \omega_2$$

DOPPLER

$$v = \frac{v + v_o}{v - v_s} v_o$$

LIGHT WAVES

PLANE WAVES $E = E_0 \sin \omega(t - x/v); I = I_0$

SPHERICAL WAVES $E = \frac{A E_0}{r} \sin \omega(t - r/v); I = \frac{I_0}{r^2}$

DIFFRACTION

$$\Delta x = b \sin \theta \approx b \theta$$

Minima $b \theta = n \lambda$

Resolution $\sin \theta = \frac{1.22 \lambda}{b}$

YOUNG'S DOUBLE SLIT EXPERIMENT

Path diff: $\Delta x = y \frac{\lambda}{D}$ Phase diff: $\delta = \frac{2\pi}{\lambda} \Delta x$

CONSTRUCTIVE | DESTRUCTIVE

$$\delta = 2n\pi; \Delta x = n\lambda \quad \delta = (2n+1)\pi; \Delta x = (n + \frac{1}{2})\lambda$$

Intensity $I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \delta$ $I_{\text{max/min}} = (\sqrt{I_1} \pm \sqrt{I_2})^2$

Fringe Width $w = \lambda \frac{D}{\lambda}$ Optical Path $\Delta x' = \mu \Delta x$

LAW of MALUS

$$I = I_0 \cos^2 \theta$$

INTERFERENCE THROUGH THIN FILM

$$\Delta x = 2\mu d = \frac{n\lambda}{(2n+1)\lambda/2} \rightarrow \text{Constructive}$$

OPTICS

REFLECTION

(i) $\angle i = \angle r$

(ii) i, r & normal in same plane

$$f = R/2$$

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

Magnification $m = -\frac{v}{u}$

REFRACTION

$$\mu = \frac{c}{v} = \frac{(\text{vacuum})}{(\text{medium})}$$

SNELL'S LAW $\mu_1 \sin i = \mu_2 \sin r$

APPARENT DEPTH $d' = d/\mu$

TIR CRITICAL ANGLE

$$\mu \sin \theta_c = \sin 90^\circ$$

PRISM

$$S = i + i' - A$$

$$\mu = \frac{\sin \left(\frac{A + \delta_{\min}}{2}\right)}{\sin \left(\frac{A}{2}\right)}$$

$$\delta_{\min} = (\mu - 1)A$$

For small 'A'

SPHERICAL SURFACE

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$m = \frac{\mu_1 v}{\mu_2 u}$$

LENS MAKER'S

$$\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

LENS FORMULA $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}; m = \frac{v}{u}$

POWER $P = \frac{1}{f}$

THIN LENSES $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

MICROSCOPE

Simple $m = D/f$

Compound

$$m = \frac{v}{u} \frac{D}{f_e} \quad \text{Resolving Pow } R = \frac{1}{\Delta d} = \frac{2\mu \sin \theta}{\lambda}$$

TELESCOPE

$$m = -f_o/f_e$$

$$L = f_o + f_e$$

$$R = \frac{1}{\Delta \theta} = \frac{1}{1.22 \lambda}$$

DISPERSION

Cauchy's $\mu = \mu_0 + A/\lambda^2 \quad A > 0$

For small A & i

mean deviation $\delta_y = (\mu_y - 1)A$

Angular dispersion $\theta = (\mu_y - \mu_r)A$

Dispersive Power

$$\omega = \frac{\mu_v - \mu_r}{\mu_y - 1} \approx \frac{\theta}{\delta_y}$$

DISPERSION only

$$(\mu_y - 1)A + (\mu'_y - 1)A' = 0$$

DEVIATION only

$$(\mu_v - \mu_r)A = (\mu'_v - \mu'_r)A'$$

PHYSICS

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HEAT AND TEMP

$$F = 32 + \frac{9}{5}C$$

$$K = C + 273.16$$

Ideal Gas $\rightarrow PV = nRT$
van der Waals

$$(p + \frac{a}{V^2})(V - b) = nRT$$

$$L = L_0(1 + \alpha \Delta T)$$

$$A = A_0(1 + 2\alpha \Delta T)$$

$$V = V_0(1 + 3\alpha \Delta T)$$

THERMAL STRESS

$$\frac{F}{A} = Y \frac{\Delta L}{L}$$

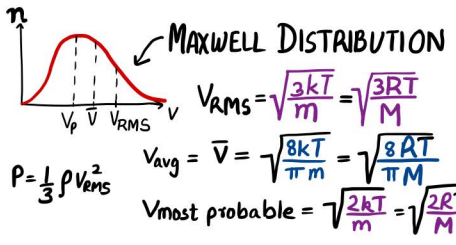
KINETIC THEORY

EQUIPARTITION OF ENERGY

$$K = \frac{1}{2} kT \text{ for each DoF}$$

$$K = \frac{f}{2} kT \text{ for } f \text{ Degrees of Freedom}$$

$$\text{Internal Energy } U = \frac{f}{2} nRT$$



$$f = 3 \text{ (monatomic)}; 5 \text{ (diatomic)}$$

SPECIFIC HEAT

$$\text{Specific heat } s = \frac{Q}{m \Delta T}$$

$$\text{Latent heat } L = Q/m$$

$$C_v = \frac{f}{2} R \quad C_p = C_v + R \quad r = C_p/C_v$$

$$C_v = \frac{n_1 C_{v1} + n_2 C_{v2}}{n_1 + n_2} \quad r = \frac{n_1 C_{p1} + n_2 C_{p2}}{n_1 C_{v1} + n_2 C_{v2}}$$

THERMODYNAMICS

$$1^{st} \text{ LAW } \Delta Q = \Delta U + W \quad W = \int p dV$$

$$\text{ADIABATIC } W = \frac{p_1 V_1 - p_2 V_2}{\gamma - 1}$$

$$\text{ISOTHERMAL } W = nRT \ln(\frac{V_2}{V_1})$$

$$\text{ISOBARIC } W = p(V_2 - V_1)$$

$$\text{ADIABATIC: } \Delta Q = 0; pV^\gamma = \text{const}$$

$$2^{nd} \text{ LAW } \text{ENTROPY } dS = \frac{dQ}{T}$$

$$\eta = \frac{W}{Q_1} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1} \quad \text{COP} = \frac{Q_2}{W} = \frac{T_{cold}}{\Delta T}$$

HEAT TRANSFER

$$\text{CONDUCTION } \frac{\Delta Q}{\Delta t} = -KA \frac{\Delta T}{x}$$

$$\text{Thermal Resistance} = \frac{x}{KA}$$

$$\text{SERIES } R = R_1 + R_2 = \frac{x_1}{k_1 A_1} + \frac{x_2}{k_2 A_2}$$

$$\text{PARALLEL } \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\text{KIRCHHOFF'S LAW } \frac{\text{Emissive Power}}{\text{Absorptive Power}} = \frac{E_{body}}{a_{body}} = E_{blackbody}$$

$$\text{WIEN'S DISPLACEMENT } \lambda_m T = b \quad \text{STEFAN-BOLTZMANN } \Delta \theta / \Delta t = \sigma e A T^4$$

$$\text{NEWTON'S COOLING } \frac{dT}{dt} = -bA(T - T_c)$$

ELECTROSTATICS

$$\text{COULOMB'S LAW } F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{r}$$

$$\vec{E} = \vec{F}/q = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \hat{r}$$

$$\text{POTENTIAL (V)} = \frac{q}{4\pi\epsilon_0 r}$$

$$\text{PE (U)} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r} \quad \vec{E} = -\frac{dV}{dr}$$

DIAPOLE MOMENT

$$\vec{p} = q\vec{d}$$

$$\frac{1}{4\pi\epsilon_0} \frac{p \cos \theta}{r^2} = V(r)$$

DIAPOLE IN FIELD

$$\vec{\tau} = \vec{p} \times \vec{E}$$

$$U = -\vec{p} \cdot \vec{E}$$

$$E_r = \frac{1}{4\pi\epsilon_0} \frac{2p \cos \theta}{r^3}$$

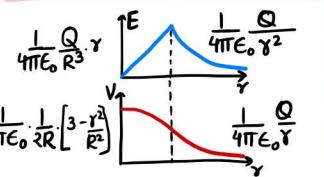
$$E_\theta = \frac{1}{4\pi\epsilon_0} \frac{p \sin \theta}{r^3}$$

GAUSS'S LAW

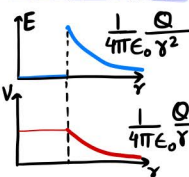
$$\phi = q_{in}/\epsilon_0 \quad \text{FLUX } \phi = \oint \vec{E} \cdot d\vec{s}$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \cos \theta$$

UNIFORMLY CHARGED SPHERE



UNIFORM SHELL



LINE CHARGE $E = \frac{\lambda}{2\pi\epsilon_0 r}$

$$\infty\text{-sheet } E = \frac{\sigma}{2\epsilon_0}$$

$$\vec{E} \text{ near } \text{CONDUCTING SURFACE } E = \frac{\sigma}{\epsilon_0}$$



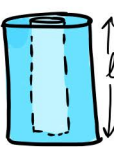
CAPACITORS

$$C = q/V \quad C = \epsilon_0 A/d$$



$$C = \frac{2\pi\epsilon_0 L}{\ln(r_2/r_1)}$$

$$C = 4\pi\epsilon_0 \frac{r_1 r_2}{r_2 - r_1}$$



$$\text{PARALLEL } C_{eq} = C_1 + C_2$$

$$\text{SERIES } \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\text{WITH DIELECTRIC } C = \frac{\epsilon_0 K A}{d}$$

$$\text{Force b/w plates} = \frac{Q^2}{2A\epsilon_0}$$

$$U = \frac{1}{2} CV^2 = \frac{Q^2}{2C} = \frac{1}{2} QV$$

CURRENT ELECTRICITY

$$\text{Density } j = i/A = \sigma E$$

$$v_{drift} = \frac{eE\tau}{2m} = \frac{i}{neA}$$

$$R_{wire} = \rho L/A \quad \rho = \frac{1}{\sigma}$$

$$R = R_0(1 + \alpha \Delta T)$$

$$\text{OHM'S LAW } V = iR$$



$$\text{PARALLEL } \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$



$$\text{SERIES } R_{eq} = R_1 + R_2$$

KIRCHHOFF'S LAWS

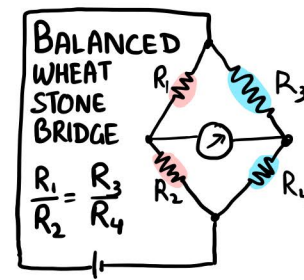
$$\text{* JUNCTION LAW } \sum I_i = 0$$

$$\text{Sum of all } i \text{ towards a node} = 0$$

$$\text{* LOOP LAW } \sum \Delta V = 0$$

$$\text{Sum of all } \Delta V \text{ in closed loop} = 0$$

$$\text{POWER} = i^2 R = V^2/R = iV$$



GALVANOMETER

Ammeter
 $i_g G = (i - i_g) S$
 $V_{AB} = i_g (R + G)$

Voltmeter
 $V_{AB} = i_g (R + G)$

CAPACITOR

Charging
 $q(t) = CV(1 - e^{-t/\tau})$
 Discharging
 $q(t) = q_0 e^{-t/\tau}$
 Time Constant $\tau = RC$

MAGNETISM

LORENTZ
 $\vec{F} = q\vec{v} \times \vec{B} + qE$
 $qvB = mv^2/r$
 $T = \frac{2\pi m}{qB}$

BIOT-SAVART LAW
 $d\vec{B} = \frac{\mu_0}{4\pi} \frac{i d\vec{l} \times \vec{r}}{r^3}$

MAGNETIC DIPOLE

$\vec{\mu} = i \text{Area} \vec{\hat{n}}$
 $\vec{\tau} = \vec{\mu} \times \vec{B}$
 $U = -\vec{\mu} \cdot \vec{B}$

HALL EFFECT

$V_H = \frac{Bi}{ned}$

PELTIER EFFECT

emf $e = \frac{\Delta H}{\Delta \theta}$

THOMSON EFFECT

emf $e = \frac{\Delta H}{\Delta \theta} = \sigma \Delta T$

SEEBACK EFFECT

$e = aT + \frac{1}{2}bT^2$
 $T_{\text{neutral}} = -a/b$
 $T_{\text{inversion}} = -2a/b$

FARADAY'S LAW OF ELECTROLYSIS

$m = Zit = \frac{1}{F} Fit$
 $E = \text{Chem equivalent}$
 $Z = \text{Electrochem eq}$
 $F = 96485 \text{ C/g}$

$\vec{F} = i \vec{L} \times \vec{B}$

STRAIGHT CONDUCTOR

$B_{\infty} = \frac{\mu_0 i}{2\pi d}$
 $B = \frac{\mu_0 i}{4\pi d} [\cos \theta_1 - \cos \theta_2]$

WIRE

$\frac{dF}{dl} = \frac{\mu_0 i_1 i_2}{2\pi d}$

AXIS OF RING

$B_p = \frac{\mu_0 i r^2}{2(a^2 + r^2)^{3/2}}$

CENTER OF ARC

$B = \frac{\mu_0 i \theta}{4\pi r}$
 $B = \frac{\mu_0 i}{2r} (\text{ring})$

SOLENOID

$B = \mu_0 n i$
 $n = N/L$

TOROID

$B = \mu_0 n i$
 $n = N/2\pi r$

AMPERE'S LAW

$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{in}}$

BAR MAGNET

$B_1 = \frac{\mu_0}{4\pi} \frac{2M}{d^3}$
 $B_2 = \frac{\mu_0}{4\pi} \frac{M}{d^3}$

ANGLE OF DIP

$B_h = B \cos \delta$
 $B_v = B \sin \delta$

crash UP
 SUBSCRIBE

TANGENT GALVANOMETER

$B_h \tan \theta = \mu_0 n i / 2r$
 $i = K \tan \theta$

MOVING COIL GALVANOMETER

$n i A B = k \theta$
 $i = \frac{k}{nAB} \theta$

PERMEABILITY

$\vec{B} = \mu \vec{H}$

MAGNETOMETER

$T = 2\pi \sqrt{I/M B_h}$

ELECTROMAGNETIC INDUCTION

MAGNETIC FLUX

$\Phi = \oint \vec{B} \cdot d\vec{s}$

FARADAY'S LAW

$e = - \frac{d\Phi}{dt}$

LENZ'S LAW

Induced current produces \vec{B} that opposes change in Φ

SELF INDUCTANCE

$\Phi = Li$
 $e = -L \frac{di}{dt}$

SOLENOID

$L = \mu_0 n^2 \pi r^2 l$

MUTUAL INDUCTANCE

$\Phi = M i$
 $e = -M \frac{di}{dt}$

GROWTH

$i = \frac{V}{R} [1 - e^{-t/\tau}]$

DECAY

$i = i_0 e^{-t/\tau}$

ALTERNATING CURRENT

$i = i_0 \sin(\omega t + \phi)$
 $i_{\text{rms}} = i_0 / \sqrt{2}$
 POWER = $i_{\text{rms}}^2 \cdot R$

RC-CIRCUIT

$\tan \phi = \frac{1}{\omega CR}$
 $Z = \sqrt{R^2 + X_C^2}$
 $X_C = \frac{1}{\omega C}$

LR-CIRCUIT

$\tan \phi = \frac{\omega L}{R}$
 $Z = \sqrt{R^2 + X_L^2}$
 $X_L = \omega L$

LCR-CIRCUIT

$\tan \phi = \frac{X_C - X_L}{R}$
 $Z = \sqrt{R^2 + (X_C - X_L)^2}$
 $\omega_{\text{RESONANCE}} = \frac{1}{\sqrt{LC}}$
 $(X_C = X_L)$
 $P = e_{\text{rms}} i_{\text{rms}} \cos \phi$
 POWER FACTOR

Time Const. $\tau = L/R$
 ENERGY $U = \frac{1}{2} Li^2$
 ENERGY DENSITY OF B-FIELD
 $u = \frac{U}{V} = \frac{B^2}{2\mu_0}$
 ROTATING COIL $e = NAB\omega \sin \omega t$
 TRANSFORMER $\frac{N_1}{N_2} = \frac{e_1}{e_2}$
 $C = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$

MODERN PHYSICS

$E = h\nu = hc/\lambda$
 $p = h/\lambda = E/c$
 $E = mc^2$
 Ejected photo-electron $K_{\text{max}} = h\nu - \phi$
 THRESHOLD $\nu_0 = \phi/h$
 STOPPING $V_0 = \frac{hc}{e} \left(\frac{1}{\lambda} - \frac{1}{\lambda_0} \right)$
 de Broglie $\lambda = h/p$

BOHR'S ATOM

$E_n = -\frac{mZ^2 e^4}{8\epsilon_0^2 h^2 n^2} = -\frac{13.6 Z^2}{n^2} \text{ eV}$
 $\gamma_n = \frac{e h \nu}{\pi m Z e^2} = \frac{0.529 n^2 \text{ \AA}}{Z}$
 $E_{\text{TRANSITION}} = 13.6 Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \text{ eV}$
 QUANTIZATION OF ANGULAR MOMENTUM
 $L = \frac{nh}{2\pi}$

HEISENBERG $\Delta x \Delta p \geq h/2\pi$
 $\Delta E \Delta t \geq h/2\pi$
 MOSLEY'S LAW $\sqrt{\nu} = a(Z - b)$
 X-RAY DIFFRACTION $2d \sin \theta = n\lambda$

NUCLEUS

$R = R_0 A^{1/3}$
 $R_0 = 1.1 \times 10^{-15} \text{ m}$

RADIOACTIVE DECAY

 $\frac{dN}{dt} = -\lambda N$
 $N = N_0 e^{-\lambda t}$
 HALF LIFE $t_{1/2} = 0.693/\lambda$
 Avg LIFE $t_{\text{avg}} = 1/\lambda$

Mass DEFECT

$\Delta m = [Z m_p + (A-Z) m_n] - M$
 BINDING $E = \Delta m \cdot c^2$
 Q-VALUE $Q = U_i - U_f$

X-Ray SPE $\lambda_{\text{min}} = \frac{hc}{eV}$

SEMICONDUCTORS

HALF WAVE RECTIFIER

FULL WAVE RECTIFIER

TRIODE VALVE

Cathode, Filament, Grid, Plate

TRIODE

Plate Resistance $r_p = \frac{\Delta V_p}{\Delta i_p} \bigg|_{\Delta V_g = 0}$
 Trans-conductance $g_m = \frac{\Delta i_p}{\Delta V_g} \bigg|_{\Delta V_p = 0}$
 Amplification $\mu = \frac{-\Delta V_p}{\Delta V_g} \bigg|_{\Delta i_p = 0}$
 $\mu = r_p \cdot g_m$

TRANSISTOR

$I_e = I_b + I_c$
 $\alpha = \frac{I_c}{I_e}$
 $\beta = \frac{I_c}{I_b}$
 $\beta = \frac{\alpha}{1-\alpha}$
 Transconductance $g_m = \frac{\Delta I_c}{\Delta V_{be}}$

LOGIC GATES

AND, OR, NOT, NAND, NOR, XOR

A	B	AB	A+B	AB	A+B	AB + AB
0	0	0	0	0	0	0
0	1	0	1	0	1	0
1	0	0	1	0	1	0
1	1	1	1	1	1	1

NOW, YOU'RE ONE STEP CLOSER TO YOUR GOAL