Chapter1

#Density $\rho = \frac{m}{V}$

Chapter2

#Displacement $\Delta x = x_2 - x_1$

#Average velocity

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

#Average speed

$$S_{avg} = \frac{total \text{ distance}}{\Delta t}$$

#Instantaneous Velocity

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

#Average acceleration $a_{avg} = \frac{\Delta v}{\Delta t}$

#Instantaneous acceleration

$$a = \frac{dv}{dt} = \frac{d^2 x}{dt^2}$$

#Constant acceleration

$$v = v_0 + at$$

$$x - x_0 = v_0 t + \frac{1}{2}at^2$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$x - x_0 = \frac{1}{2}(v_0 + v)t$$

$$x - x_0 = v_0 t - \frac{1}{2}at^2$$

Chapter3

#Components of a Vector

$$a_x = a\cos\theta \ , \quad a_y = a\sin\theta$$

$$a = \sqrt{a_x^2 + a_y^2} \ , \quad \tan\theta = \frac{a_y}{a_x}$$

#The scalar product $\vec{a} \cdot \vec{b} = ab\cos\phi$

#The vector product $\vec{c} = \vec{a} \times \vec{b}$, $c = ab\sin\phi$

Chapter4

Position vector $\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$

#Displacement $\Delta\vec{r} = \vec{r}_2 - \vec{r}_1$

#Average velocity $\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t}$

#Instantaneous velocity $\vec{v} = \frac{d\vec{r}}{dt}$

#Average acceleration $\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t}$

#Instantaneous acceleration $\vec{a} = \frac{d\vec{v}}{dt}$

#Trajectory of projectile motion

$$y = (\tan\theta_0)x - \frac{gx^2}{2(v_0\cos\theta_0)^2}$$

#Horizontal range $R = \frac{v_0^2}{g}\sin 2\theta_0$

#Uniform circular motion

$$a = \frac{v^2}{r} \qquad T = \frac{2\pi r}{v}$$

#Relative motion $\vec{v}_{PA} = \vec{v}_{PB} + \vec{v}_{BA}$

Chapter5

Newton's second law $\vec{F}_{net} = m\vec{a}$

#A gravitational force $F_g = mg$

#The weight of a body $W = mg$

#Newton's third law $\vec{F}_{BC} = -\vec{F}_{CB}$

Chapter6

#The maximum static friction force

$$f_{s,\max} = \mu_s F_N$$

#The kinetic friction force

$$f_k = \mu_k F_N$$

#Drag force $D = \frac{1}{2}C\rho A v^2$

#Terminal speed $v_t = \sqrt{\frac{2F_g}{C\rho A}}$

#Uninform circular motion

$$a = \frac{v^2}{R} \qquad F = m\frac{v^2}{R}$$

Chapter7

#Kinetic energy $K = \frac{1}{2}mv^2$

#Work done by a constant force

$$W = Fd\cos\phi = \vec{F} \cdot \vec{d}$$

#Work-kinetic energy theorem

$$\Delta K = K_f - K_i = W$$

#Work done by the gravitational force

$$W_g = mgd\cos\theta$$

#Work done in lifting and lowering an object $\Delta K = K_f - K_i = W_a + W_g$

#Spring force

$$\vec{F}_S = -k\vec{d} \qquad F_x = -kx$$

#Work done by a spring force

$$W_s = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$$

#Work done by a variable force

$$W = \int_{x_i}^{x_f} F_x dx + \int_{y_i}^{y_f} F_y dy + \int_{z_i}^{z_f} F_z dz$$

#Power $P_{avg} = \frac{W}{\Delta t} \qquad P = \frac{dW}{dt}$

$$P = Fv\cos\phi = \vec{F} \cdot \vec{v}$$

Chpater8

Potential energy

$$\Delta U = -W \qquad \Delta U = -\int_{x_i}^{x_f} F(x)dx$$

#Gravitational potential energy

$$\Delta U = mg(y_f - y_i) = mg\Delta y$$

$$U(y) = mgy$$

#Elastic potential energy

$$U(x) = \frac{1}{2}kx^2$$

#Mechanical energy $E_{mec} = K + U$

#Principle of conservation of mechanical energy

$$K_2 + U_2 = K_1 + U_1$$

$$\Delta E_{mec} = \Delta K + \Delta U = 0$$

#Potential energy curves

$$F(x) = -\frac{dU(x)}{dx}$$

$$K(x) = E_{mec} - U(x)$$

#Work done on a system by an external force

$$W = \Delta E_{mec} = \Delta K + \Delta U$$

$$W = \Delta E_{mec} + \Delta E_{th}$$

$$\Delta E_{th} = f_k d$$

#Conservation of energy

$$W = \Delta E = \Delta E_{mec} + \Delta E_{th} + \Delta E_{\text{int}}$$

#Power $P_{avg} = \frac{\Delta E}{\Delta t}$ $\quad P = \frac{dE}{dt}$

Chapter9

#Center of mass $\vec{r}_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i \vec{r}_i$

$$x_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i x_i \,,$$

$$y_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i y_i \,,$$

$$z_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i z_i$$

#Newton's second law for a system

$$\vec{F}_{net} = M\vec{a}_{com}$$

#Linear momentum and newton's second law

$$\vec{p} = m\vec{v} \,, \quad \vec{F}_{net} = \frac{d\vec{p}}{dt}$$

$$\vec{P} = M\vec{v}_{com} \,, \quad \vec{F}_{net} = \frac{d\vec{P}}{dt}$$

#Collision and impulse

$$\vec{p}_f - \vec{p}_i = \Delta\vec{p} = \vec{J}$$

$$\vec{J} = \int_{t_i}^{t_f} \vec{F}(t)dt \,, \quad J = F_{avg}\Delta t$$

$$F_{avg} = -\frac{n}{\Delta t}\Delta p = -\frac{n}{\Delta t} m\Delta v$$

$$F_{avg} = -\frac{\Delta m}{\Delta t}\Delta v$$

#Conservation of linear momentum

$$\vec{P} = \text{constant} \,, \quad \vec{P}_i = \vec{P}_f$$

#Inelastic collision in one dimension

$$\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$$

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

#Elastic collisions in one dimension

$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i} \,,$$

$$v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i}$$

#Collisions in two dimensions

$$\vec{P}_{1i} + \vec{P}_{2i} = \vec{P}_{1f} + \vec{P}_{2f}$$

$$K_{1i} + K_{2i} = K_{1f} + K_{2f}$$

#Variable-mass system

$$Rv_{rel} = Ma \,, \quad v_f - v_i = v_{rel} \ln\frac{M_i}{M_f}$$

Chapter10

Angular velocity and speed

$$\omega_{avg} = \frac{\Delta\theta}{\Delta t}, \quad \omega = \frac{d\theta}{dt}$$

#Angular acceleration

$$\alpha_{avg} = \frac{\Delta\omega}{\Delta t}, \quad \alpha = \frac{d\omega}{dt}$$

#The kinetic equations for constant angular acceleration

$$\omega = \omega_0 + \alpha t$$

$$\theta - \theta_0 = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$\theta - \theta_0 = \frac{1}{2}(\omega_0 + \omega)t$$

$$\theta - \theta_0 = \omega_0 t - \frac{1}{2}\alpha t^2$$

#Linear and angular variables related

$$s = \theta r \,, \quad v = \omega r \,, \quad a_t = \alpha r \,,$$

$$\alpha_r = \frac{v^2}{r} = \omega^2 r \,, \quad T = \frac{2\pi r}{v} = \frac{2\pi}{\omega}$$

#Rotational kinetic energy and rotational inertia

$$K = \frac{1}{2} I\omega^2$$

$$I = \sum m_i r_i^2 \,, \quad I = \int r^2 dm$$

#The parallel-axis theorem

$$I = I_{com} + Mh^2$$

#Torque $\tau = rF_t = r_\perp F = rF\sin\phi$

#Newton's second law in angular form

$$\tau_{net} = I\alpha$$

#Work and rotational kinetic energy

$$W = \int_{\theta_i}^{\theta_f} \tau d\theta \,, \quad P = \frac{dW}{dt} = \tau\omega$$

$$W = \tau(\theta_f - \theta_i)$$

$$\Delta K = K_f - K_i = \frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_i^2 = W$$

Chapter11

#Rolling bodies

$$v_{com} = \omega R \,, \quad a_{com} = \alpha R \,,$$

$$K = \frac{1}{2} I_{com}\omega^2 + \frac{1}{2} M v_{com}^2$$

$$a_{com,x} = -\frac{g\sin\theta}{1 + I_{com}/MR^2}$$

Torque as a vector

$$\vec{\tau} = \vec{r} \times \vec{F}$$

#Angular momentum of a particle

$$\vec{l} = \vec{r} \times \vec{p} = \vec{r} \times (m\vec{v})$$

$$l = rmv\sin\phi$$

#Newton's second law in angular form

$$\vec{\tau}_{net} = \frac{d\vec{l}}{dt}$$

#Angular momentum of a system

$$\vec{L} = \vec{l}_1 + \vec{l}_2 + \cdots + \vec{l}_n = \sum_{i=1}^{n} \vec{l}_i$$

$$\vec{\tau}_{net} = \frac{d\vec{L}}{dt}$$

#Angular momentum of rigid body

$$L = I\omega$$

#Conservation of angular momentum

$$\vec{L} = \text{constant}\,,\quad \vec{L}_i = \vec{L}_f$$

#Precession of a gyroscope

$$\Omega = \frac{Mgr}{I\omega}$$

Chapter12

#Static equilibrium

$$\vec{F}_{net} = 0\,,\quad F_{net,x} = 0 \quad F_{net,y} = 0$$

$$\vec{\tau}_{net} = 0\,,\quad \tau_{net,z} = 0$$

#Elastic moduli

$$\frac{F}{A} = E\frac{\Delta L}{L}\,,\quad \frac{F}{A} = G\frac{\Delta x}{L}\,,$$

$$p = B\frac{\Delta V}{V}$$

Chapter13

#The law of gravitation

$$F = G\frac{m_1 m_2}{r^2}$$

Superposition

$$\vec{F}_{1,net} = \sum_{i=1}^{n} \vec{F}_{1i}\,,\quad \vec{F}_1 = \int d\vec{F}$$

#Gravitational acceleration

$$F = ma_g\,,\quad a_g = \frac{GM}{r^2}$$

#Gravitation with a spherical shell

$$F = \frac{GmM}{R^3}r$$

#Gravitational potential energy

$$U = -\frac{GMm}{r}$$

#Potential energy of a system

$$U = -(\frac{Gm_1m_2}{r_{12}} + \frac{Gm_1m_3}{r_{13}} + \frac{Gm_2m_3}{r_{23}})$$

#Escape speed

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

#Law of periods

$$T^2 = (\frac{4\pi^2}{GM})r^3$$

#Energy in planetary motion

$$U = -\frac{GMm}{r}\,,\quad K = \frac{GMm}{2r}$$

$$E = K + U$$

$$E = -\frac{GMm}{2r}\,,\quad E = -\frac{GMm}{2a}$$

Chapter15

Period $T = \frac{1}{f}$, $\omega = \frac{2\pi}{T} = 2\pi f$

#Simple harmonic motion

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

$$v = -\omega x_m \sin(\omega t + \phi)$$

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

#The linear oscillator

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

#Pendulums

$$T = 2\pi\sqrt{I/\kappa}\,,\quad T = 2\pi\sqrt{L/g}$$

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

#Damped harmonic motion

$$x(t) = x_m e^{-bt/2m}\cos(\omega' t + \phi)$$

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

$$E(t) \approx \frac{1}{2}kx_m^2 e^{-bt/m}$$

#Forced oscillations and resonance

$$\omega_d = \omega$$

Chapter16

#Sinusoidal waves

$$y(x,t) = y_m \sin(kx - \omega t)$$

$$k = \frac{2\pi}{\lambda}\,,\qquad \frac{\omega}{2\pi} = f = \frac{1}{T}$$

$$v = \frac{\omega}{k} = \frac{\lambda}{T} = \lambda f$$

#Equation of a traveling wave

$$y(x,t) = h(kx \pm \omega t)$$

#Wave speed on stretched string

$$v = \sqrt{\frac{\tau}{\mu}}$$

#Power $P_{avg} = \frac{1}{2}\mu v\omega^2 y_m^2$

#Interference of waves

$$y'(x,t) = [2y_m \cos\tfrac{1}{2}\phi]\sin(kx - \omega t + \tfrac{1}{2}\phi)$$

#Standing waves

$$y'(x,t) = [2y_m \sin kx]\cos\omega t$$

#Resonance

$f = \frac{v}{\lambda} = n\frac{v}{2L}$, for n=1,2,3,…

Chapter17

#Sound waves

$$s = s_m \cos(kx - \omega t)$$

$$\Delta p = \Delta p_m \sin(kx - \omega t)$$

$$\Delta p_m = (v\rho\omega)s_m\,,\quad v = \sqrt{\frac{B}{\rho}}$$

Interference $\phi = \frac{\Delta L}{\lambda}2\pi$

#Fully constructive interference

$$\phi = m(2\pi)\,,\quad \frac{\Delta L}{\lambda} = 0,1,2,\cdots$$

#Fully destructive interference

$$\phi = (2m+1)\pi\,,$$

$$\frac{\Delta L}{\lambda} = 0.5, 1.5, 2.5, \cdots$$

#Sound intensity

$$I = \frac{P}{A}\,,\quad I = \tfrac{1}{2}\rho v\omega^2 s_m^2\,,\quad I = \frac{P_s}{4\pi r^2}$$

#Sound level in decibels

$$\beta = (10dB)\log\frac{I}{I_0}\,,$$

$$I_0 = 10^{-12}\,W/m^2$$

#Standing wave patterns in pipe

$$f = \frac{v}{\lambda} = \frac{nv}{2L}, \quad n=1,2,3,\dots$$

$$f = \frac{v}{\lambda} = \frac{nv}{4L}, \quad n=1,3,5,\dots$$

#Beats $f_{beat} = f_1 - f_2$

#The Doppler effect

$$f' = f\frac{v \pm v_D}{v \pm v_S}$$

#Shock wave $\sin\theta = \frac{v}{v_S}$

Chapter18

#The Kelvin temperature scale

$$T = (273.16K)(\lim_{gas\to 0}\frac{p}{p_3})$$

#Celsius and Fahrenheit scales

$$T_C = T - 273.15^0, \quad T_F = \tfrac{9}{5}T_C + 32^0$$

#Thermal expension $\beta = 3\alpha$

$$\Delta L = L\alpha\Delta T, \qquad \Delta V = V\beta\Delta T,$$

#Heat capacity and specific heat

$$Q = C(T_f - T_i), \quad Q = cm(T_f - T_i)$$

#Heat of transformation $Q = Lm$

#Work associated with volume change

$$W = \int dW = \int_{V_i}^{V_f} pdV$$

#First law of thermodynamics

$$\Delta E_{\text{int}} = E_{\text{int},f} - E_{\text{int},i} = Q - W$$

$$dE_{\text{int}} = dQ - dW$$

#Conduction $P_{con} = \frac{Q}{t} = kA\frac{T_H - T_C}{L}$

#Radiation

$$P_{rad} = \sigma\varepsilon AT^4, \quad P_{abs} = \sigma\varepsilon AT_{env}^4$$

Chapter19

#Avogadro's number $M = mN_A$

$$n = \frac{N}{N_A} = \frac{M_{sam}}{M} = \frac{M_{sam}}{mN_A}$$

#Ideal gas

$$PV = nRT, \quad PV = NkT$$

#Work in an isothermal volume change

$$W = nRT\ln\frac{V_f}{V_i}$$

#Pressure, temperature, and molecular speed $p = \frac{nMv_{rms}^2}{3V}$, $v_{rms} = \sqrt{\frac{3RT}{M}}$

#Temperature and kinetic energy

$$K_{avg} = \tfrac{3}{2}kT$$

#Mean free path $\lambda = \frac{1}{\sqrt{2}\pi d^2\, N/V}$

#Maxwell speed distribution

$$P(v) = 4\pi(\frac{M}{2\pi RT})^{3/2}v^2e^{-Mv^2/2RT}$$

$$v_{avg} = \sqrt{\frac{8RT}{\pi M}}, \quad v_P = \sqrt{\frac{2RT}{M}}$$

#Molar specific heats

$$Q = nC_V\Delta T, \quad Q = nC_p\Delta T$$

$$\Delta E_{\text{int}} = nC_V\Delta T, \quad E_{\text{int}} = nC_VT$$

$$C_p = C_V + R$$

#Degrees of freedom and Cv

$$C_V = \frac{f}{2}R$$

#Adiabatic process

$$PV^\gamma = \text{a constant}, \quad \gamma = C_p/C_V$$

Chapter20

#Calculating entropy change

$$\Delta S = S_f - S_i = \int_i^f \frac{dQ}{T}$$

$$\Delta S = S_f - S_i = \frac{Q}{T}$$

$$\Delta S = S_f - S_i \approx \frac{Q}{T}$$

$$\Delta S = S_f - S_i = nR\ln\frac{V_f}{V_i} + nC_V\ln\frac{T_f}{T_i}$$

#The second law of thermodynamic

$$\Delta S \ge 0$$

#Engines

$$\varepsilon = \frac{\text{energy we get}}{\text{energy we pay for}} = \frac{|W|}{|Q_H|}$$

#A Carnot engine

$$\varepsilon = 1 - \frac{|Q_L|}{|Q_H|} = 1 - \frac{T_L}{T_H}$$

#Refrigerators

$$K = \frac{\text{what we want}}{\text{what we pay for}} = \frac{|Q_L|}{|W|}$$

#A Carnot refrigerator

$$K_C = \frac{|Q_L|}{|Q_H| - |Q_L|} = \frac{T_L}{T_H - T_L}$$

#Entropy from a statistics view

$$W = \frac{N!}{n_1!n_2!}, \qquad S = k\ln W$$

Constants

#Speed of light $c = 3.00\times10^8\, m/s$

#Free-fall acceleration $g = 9.81\, m/s^2$

#Gravitational constant

$$G = 6.67\times10^{-11}\, m^3/s^2\cdot kg$$

#Universal gas constant

$$R = 8.31\, J/mol\cdot K$$

#Avogadro constant

$$N_A = 6.02\times10^{23}\, mol^{-1}$$

#Boltzmann constant

$$k = 1.38\times10^{-23}\, J/K$$

#Electron mass

$$m_e = 9.109\times10^{-31}\, kg$$

#Proton mass $m_p = 1.673\times10^{-27}\, kg$

#Neutron mass

$$m_n = 1.675\times10^{-27}\, kg$$

#Mass of the sun $1.99\times10^{30}\, kg$

#Mass of the earth $5.98\times10^{24}\, kg$

#Mass of the moon $7.36 \times 10^{22} kg$

#Mean radius of the sun $6.96 \times 10^{8} m$

#Mean radius of the earth

$6.37 \times 10^{6} m$

#Mean radius of the moon

$1.74 \times 10^{6} m$

#Some rotational inertias

(a) Hoop about central axis $I = MR^2$

(b) Annular cylinder (or ring) about central axis $I = \frac{1}{2}M(R_1^2 + R_2^2)$

(c)Solid cylinder (or disk) about central axis $I = \frac{1}{2}MR^2$

(d) Solid cylinder (or disk) about central diameter $I = \frac{1}{4}MR^2 + \frac{1}{12}ML^2$

(e)Thin rod about axis through center perpendicular to length $I = \frac{1}{12}ML^2$

(f) Solid sphere about any diameter $I = \frac{2}{5}MR^2$

(g) Thin spherical shell about any diameter $I = \frac{2}{3}MR^2$

(h) Hoop about any diameter $I = \frac{1}{2}MR^2$

(i) Slab about perpendicular axis through center $I = \frac{1}{12}M(a^2 + b^2)$

Chapter21

#Electric current $i = \frac{dq}{dt}$

#Coulomb's law $F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}$

Chapter22

#Definition of Electric field $\vec{E} = \frac{\vec{F}}{q_0}$

#Field Due to a Point Charge

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

#Field Due to an Electric Dipole

$$E = \frac{1}{2\pi\varepsilon_0}\frac{p}{z^3}$$

#Field Due to Charged disk

$$E = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{z}{\sqrt{z^2+R^2}}\right)$$

#Force on a Point charge in an Electric Field $\vec{F} = q\vec{E}$

#Dipole in an Electric Field

$\vec{\tau} = \vec{p}\times\vec{E}$, $U = -\vec{p}\cdot\vec{E}$

Chapter23

#Gauss' law

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

#conducting surface $E = \frac{\sigma}{\varepsilon_0}$

#line of charge $E = \frac{\lambda}{2\pi\varepsilon_0 r}$

#sheet of charge $E = \frac{\sigma}{2\varepsilon_0}$

#spherical shell, for r>R

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

#spherical shell, for r<R $E = 0$

#A uniform sphere of charge

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

Chapter24

#Electric potential $V = \frac{-W_\infty}{q_0} = \frac{U}{q_0}$

#Electric potential energy

$U = qV$, $\Delta U = q\Delta V = q(V_f - V_i)$

#Mechanical energy

$\Delta K = -q\Delta V$, $\Delta K = -q\Delta V + W_{app}$

#Finding V from E

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

$V = -\int_i^f \vec{E}\cdot d\vec{s}$, $\Delta V = -E\Delta x$

#Potential Due to a Charged Particle

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}, \quad V = \sum_{i=1}^{n} V_i = \sum_{i=1}^{n}\frac{q_i}{r_i}$$

#Potential Due to an Electric Dipole

$$V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2} \quad (r \gg d)$$

#Potential Due to a Continuous Charge Distribution $V = \frac{1}{4\pi\varepsilon_0}\int\frac{dq}{r}$

#Calculating E from V

$$E_s = -\frac{\partial V}{\partial s}, \quad E = -\frac{\Delta V}{\Delta s}$$

#Potential energy for two particles

$$U = W = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$$

Chapter25

#Definition of Capacitance

$q = CV$

#A parallel-plate capacitor $C = \frac{\varepsilon_0 A}{d}$

#A cylindrical capacitor

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

#A spherical capacitor

$$C = 4\pi\varepsilon_0\frac{ab}{b-a}$$

#An isolated sphere $C = 4\pi\varepsilon_0 R$

#capacitors in parallel $C_{eq} = \sum_{j=1}^{n} C_j$

#capacitors in series $\frac{1}{C_{eq}} = \sum_{j=1}^{n}\frac{1}{C_j}$

#Potential energy $U = \frac{q^2}{2C} = \frac{1}{2}CV^2$

#Energy density $u = \frac{1}{2}\varepsilon_0 E^2$

#Gauss' Law with a Dielectric

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

Chapter26

#Electric current $i = \frac{dq}{dt}$

#Current density $i = \int \vec{J}\cdot d\vec{A}$

#Drift speed $\vec{J} = (ne)\vec{v}_d$

#Definition of R $R = \frac{V}{i}$

#Definitions of ρ and σ

$$\rho = \frac{1}{\sigma} = \frac{E}{J}$$

\# $\vec{E} = \rho\vec{J}$, $R = \rho\frac{L}{A}$

#Change of ρ with temperature

$$\rho - \rho_0 = \rho_0\alpha(T - T_0)$$

#Resistivity of a metal $\rho = \frac{m}{e^2 n\tau}$

#Power $P = iV$

#Resistivity dissipation $P = i^2 R = \frac{V^2}{R}$

Chapter27

Emf $\varepsilon = \dfrac{dW}{dq}$

#Single loop circuit $i = \dfrac{\varepsilon}{R+r}$

#Power

$P = iV$, $P_r = i^2 r$, $P_{emf} = i\varepsilon$

#Resistances in series $R_{eq} = \sum_{j=1}^{n} R_j$

#Resistance in parallel $\dfrac{1}{R_{eq}} = \sum_{j=1}^{n} \dfrac{1}{R_j}$

#Charging a capacitor, $RC = \tau$

$q = C\varepsilon(1 - e^{-t/RC})$

$i = \dfrac{dq}{dt} = (\dfrac{\varepsilon}{R})e^{-t/RC}$

#Discharging a capacitor, $RC = \tau$

$q = q_0 e^{-t/RC}$

$i = \dfrac{dq}{dt} = -(\dfrac{q_0}{RC})e^{-t/RC}$

Chpater28

#Magnetic field B $\vec{F}_B = q\vec{v} \times \vec{B}$

#A charged particle circulating in a magnetic field

$|q|vB = \dfrac{mv^2}{r}$, $r = \dfrac{mv}{qB}$

$f = \dfrac{\omega}{2\pi} = \dfrac{1}{T} = \dfrac{|q|B}{2\pi m}$

#The Hall Effect

$n = \dfrac{Bi}{Vle}$, $V = vBd$

#Magnetic force

$\vec{F}_B = i\vec{L} \times \vec{B}$, $d\vec{F}_B = id\vec{L} \times \vec{B}$

#Magnetic dipole moment

$\mu = NiA$, $\vec{\tau} = \vec{\mu} \times \vec{B}$

#Orientation energy of a Magnetic dipole $U(\theta) = -\vec{\mu} \cdot \vec{B}$

#Work done on dipole by the agent

$W_a = \Delta U = U_f - U_i$

Chapter29

#The Biot-Savart Law

$d\vec{B} = \dfrac{\mu_0}{4\pi} \dfrac{id\vec{s} \times \hat{r}}{r^2}$

#A long straight wire $B = \dfrac{\mu_0 i}{2\pi r}$

#A circular Arc $B = \dfrac{\mu_0 i\phi}{4\pi R}$

#Force between parallel currents

$F_{ba} = i_b L B_a \sin 90^0 = \dfrac{\mu_0 L i_a i_b}{2\pi d}$

#Ampere's Law

$\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{enc}$

#Field of an ideal solenoid $B = \mu_0 in$

#Field of an ideal toroid $B = \dfrac{\mu_0 iN}{2\pi} \dfrac{1}{r}$

#Field of a magnetic dipole

$\vec{B}(z) = \dfrac{\mu_0}{2\pi} \dfrac{\vec{\mu}}{z^3}$

Chapter30

#Magnetic flux $\Phi_B = \int \vec{B} \cdot d\vec{A}$

#Faraday's Law $\varepsilon = -\dfrac{d\Phi_B}{dt}$

#Faraday's Law (N turns)

$\varepsilon = -N\dfrac{d\Phi_B}{dt}$

#Emf $\varepsilon = \oint \vec{E} \cdot d\vec{s}$

#The induced electric field

$\oint \vec{E} \cdot d\vec{s} = -\dfrac{d\Phi_B}{dt}$

#Definition of inductance $L = \dfrac{N\Phi_B}{i}$

#Inductance of solenoid $\dfrac{L}{l} = \mu_0 n^2 A$

#Self-induction $\varepsilon_L = -L\dfrac{di}{dt}$

#Series RL Circuit $\tau_L = \dfrac{L}{R}$

$i = \dfrac{\varepsilon}{R}(1 - e^{-t/\tau_L})$ (rise of current)

$i = i_0 e^{-t/\tau_L}$ (decay of current)

#Magnetic energy $U_B = \dfrac{1}{2}Li^2$

#Magnetic energy density $u_B = \dfrac{B^2}{2\mu_0}$

#Mutual induction

$\varepsilon_2 = -M\dfrac{di_1}{dt}$, $\varepsilon_1 = -M\dfrac{di_2}{dt}$

Chapter31

#LC Oscillations

$L\dfrac{d^2q}{dt^2} + \dfrac{1}{C}q = 0$, $\omega = \dfrac{1}{\sqrt{LC}}$

$q = Q\cos(\omega t + \phi)$,

$i = -\omega Q \sin(\omega t + \phi)$

#Damped Oscillations

$L\dfrac{d^2q}{dt^2} + R\dfrac{dq}{dt} + \dfrac{1}{C}q = 0$

$q = Qe^{-Rt/2L}\cos(\omega' t + \phi)$,

$\omega' = \sqrt{\omega^2 - (R/2L)^2}$

#Forced Oscillations

$\varepsilon = \varepsilon_m \sin(\omega_d t)$; $i = I\sin(\omega_d t - \phi)$

#Resonance

Maximum $I=\frac{\varepsilon_m}{R}$, $\phi=0$,

$\omega_d=\omega=\frac{1}{\sqrt{LC}}$, $X_C=X_L$,

#Single circuit elements

$V_R=IR$, $V_C=IX_C$, $X_C=\frac{1}{\omega_d C}$,

$V_L=IX_L$, $X_L=\omega_d L$

#Series RLC circuits

$$I=\frac{\varepsilon_m}{\sqrt{R^2+(X_L-X_C)^2}}=\frac{\varepsilon_m}{\sqrt{R^2+(\omega_d L-1/\omega_d C)^2}}$$

$\tan\phi=\frac{X_L-X_C}{R}$ (phase constant)

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

#Power $I_{rms}=I/\sqrt{2}$

$V_{rms}=V/\sqrt{2}$ $\varepsilon_{rms}=\varepsilon_m/\sqrt{2}$

$P_{avg}=I_{rms}^2R=\varepsilon_{rms}I_{rms}\cos\phi$

#Transformers

$V_s=V_p\frac{N_s}{N_p}$, $I_s=I_p\frac{N_p}{N_s}$,

$R_{eq}=(\frac{N_p}{N_s})^2$

Chapter32

#Gauss' Law for magnetic field

$\Phi_B=\oint\vec{B}\cdot d\vec{A}=0$

#Maxwell's law of induction

$$\oint\vec{B}\cdot d\vec{s}=\mu_0\varepsilon_0\frac{d\Phi_E}{dt}$$

#Ampere-Maxwell law

$$\oint\vec{B}\cdot d\vec{s}=\mu_0\varepsilon_0\frac{d\Phi_E}{dt}+\mu_0 i_{enc}$$

#Displacement current

$$i_d=\varepsilon_0\frac{d\Phi_E}{dt}$$

Chapter33

#Electromagnetic waves

$E=E_m\sin(kx-\omega t)$

$B=B_m\sin(kx-\omega t)$

$c=\frac{E}{B}=\frac{1}{\sqrt{\mu_0\varepsilon_0}}$

$\omega=2\pi f$, $v=\lambda f$

#Energy flow

$\vec{S}=\frac{1}{\mu_0}\vec{E}\times\vec{B}$, $E_{rms}=E_m/\sqrt{2}$

$I=\frac{1}{c\mu_0}E_{rms}^2$, $I=\frac{P_s}{4\pi r^2}$

#Total absorption

$F=\frac{IA}{c}$, $p_r=\frac{I}{c}$

#Total reflection

$F=\frac{2IA}{c}$, $p_r=\frac{2I}{c}$

#Polarizing sheets

$I=\frac{1}{2}I_0$, $I=I_0\cos^2\theta$

#Law of refraction

$n_2\sin\theta_2=n_1\sin\theta_1$

#Critical angle $\theta_c=\sin^{-1}(\frac{n_2}{n_1})$

#Brewster angle $\theta_B=\tan^{-1}(\frac{n_2}{n_1})$

Chapter35

#Wavelength and index of refraction

$\lambda_n=\frac{\lambda}{n}$

#Young's experiment(for m=0,1,2,…)

Maxima $d\sin\theta=m\lambda$

Minima $d\sin\theta=(m+\frac{1}{2}\lambda)$

#Intensity in Two-slit interference

$I=4I_0\cos^2\frac{1}{2}\phi$, $\phi=\frac{2\pi d}{\lambda}\sin\theta$

#Thin-film interference

Maxima $2L=(m+\frac{1}{2})\frac{\lambda}{n_2}$

Minima $2L=m\frac{\lambda}{n_2}$

Chapter36

#Single-slit diffraction $m=1,2,3,\ldots$

Minima $a\sin\theta=m\lambda$

$I(\theta)=I_m(\frac{\sin\alpha}{\alpha})^2$, $\alpha=\frac{\pi a}{\lambda}\sin\theta$

#Circular aperture diffraction

First minimum $\sin\theta=\frac{1.22\lambda}{d}$

#Rayleigh's criterion $\theta_R=1.22\frac{\lambda}{d}$

#Double-slit diffraction

$I(\theta)=I_m(\cos^2\beta)(\frac{\sin\alpha}{\alpha})^2$

$\beta=(\pi d/\lambda)\sin\theta$, α as single-slit

#Diffraction gratings

$d\sin\theta=m\lambda$ for m=0,1,2,3,…

#Half width $\Delta\theta_{hw}=\frac{\lambda}{Nd\cos\theta}$

#Dispersion $D=\frac{\Delta\theta}{\Delta\lambda}=\frac{m}{d\cos\theta}$

#Resolving power $R=\frac{\lambda_{avg}}{\Delta\lambda}=Nm$

#Bragg's Law

$2d\sin\theta=m\lambda$, m=1,2,3,…

Chapter37

#Time dilation $\Delta t=\gamma\cdot\Delta t_0$

$\beta=v/c$, $\gamma=1/\sqrt{1-\beta^2}$

#Length contraction $L = \dfrac{L_0}{\gamma}$

#The Lorentz transformation

$x' = \gamma(x - vt)$, $y' = y$, $z' = z$,

$t' = \gamma(t - vx/c^2)$

#Relativity of velocities

$$u = \frac{u' + v}{1 + u'v/c^2}$$

#Relativistic Doppler Effect

$$\lambda = \lambda_0 \sqrt{\frac{1+\beta}{1-\beta}}, \quad v = \frac{|\Delta\lambda|}{\lambda_0}$$

(source and detector separating)

#Transvers Doppler Effect

$$f = f_0\sqrt{1-\beta^2}$$

#Momentum and energy

$\vec{p} = \gamma m\vec{v}$, $K = mc^2(\gamma - 1)$,

$$E = mc^2 + K = \gamma mc^2$$

$$(pc)^2 = K^2 + 2Kmc^2$$

$$E^2 = (pc)^2 + (mc^2)^2$$

$$Q = M_i c^2 - M_f c^2 = -\Delta M \cdot c^2$$

Chapter38

#Light quanta-photons

$$E = hf \qquad p = \frac{hf}{c} = \frac{h}{\lambda}$$

#Photoelectric Effect

$$hf = K_{\max} + \Phi$$

#Compton shift

$$\Delta\lambda = \frac{h}{mc}(1 - \cos\phi)$$

#Ideal blackbody radiation

$$S(\lambda) = \frac{2\pi c^2 h}{\lambda^5}\frac{1}{e^{hc/\lambda kT} - 1}$$

$$\lambda_{\max} T = 2898\mu m \cdot K$$

#Matter waves $\lambda = \dfrac{h}{p}$

#The wave function

$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m}{h^2}[E - U(x)]\psi = 0$$

#Heisenberg's uncertainty principle

$\hbar = h/(2\pi)$

$\Delta x \cdot \Delta p_x \ge \hbar$, $\Delta y \cdot \Delta p_y \ge \hbar$, $\Delta z \cdot \Delta p_z \ge \hbar$

#Potential step $T = 1 - R$

#Barrier tunneling $T \approx e^{-2bL}$

$$b = \sqrt{\frac{8\pi^2 m(U_b - E)}{h^2}}$$

Chapter39

#Electron in an infinite potential well

$E_n = (\dfrac{h^2}{8mL^2})n^2$, for $n = 1, 2, 3\ldots$

$$\Delta E = E_{high} - E_{low}$$

$$hf = \frac{hc}{\lambda} = \Delta E = E_{high} - E_{low}$$

$\psi_n(x) = \sqrt{\dfrac{2}{L}}\sin(\dfrac{n\pi}{L}x)$,

for $n = 1, 2, 3\ldots$

$$\int_{-\infty}^{+\infty}\psi_n^2(x)dx = 1$$

#Two dimensional electron trap

$$E_{nx,ny} = \frac{h^2}{8m}\left(\frac{n_x^2}{L_x^2} + \frac{n_y^2}{L_y^2}\right)$$

$$\psi_{nx,ny} = \sqrt{\frac{2}{L_x}}\sin\left(\frac{n_x\pi}{L_x}x\right)\sqrt{\frac{2}{L_y}}\sin\left(\frac{n_y\pi}{L_y}y\right)$$

Constants

#Speed of light $c = 3.00 \times 10^8\ m/s$

#Elementary charge

$$e = 1.60 \times 10^{-19}\,C$$

#Free-fall acceleration $g = 9.81 m/s^2$

#Gravitational constant

$$G = 6.67 \times 10^{-11}\ m^3/s^2 \cdot kg$$

#Universal gas constant

$$R = 8.31 J/mol \cdot K$$

#Avogadro constant

$$N_A = 6.02 \times 10^{23} mol^{-1}$$

#Boltzmann constant

$$k = 1.38 \times 10^{-23}\ J/K$$

#Permittivity constant

$$\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$$

$$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9\ N \cdot m^2/C^2$$

#Permeability constant

$$\mu_0 = 4\pi \times 10^{-7}\,T \cdot m/A = 1.26 \times 10^{-6}\,T \cdot m/A$$

#Plank constant

$h = 6.63 \times 10^{-34}\,J \cdot s$

#Electron mass

$$m_e = 9.109 \times 10^{-31} kg$$

#Proton mass $m_p = 1.673 \times 10^{-27}\,kg$

#Neutron mass

$$m_n = 1.675 \times 10^{-27} kg$$

#

$\int \dfrac{1}{x}dx = \ln|x| + C$