PHYSICS FORMULAS

I. Motion

a. General

Velocity $v_{avg} = \frac{\Delta x}{\Delta t}$

Acceleration $a_{avg} = \frac{\Delta v}{\Delta t}$

$v_{avg} = \frac{1}{2}(v_f + v_i)t$

Straight line motion with constant acceleration

$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$

$v_f = v_i + a\Delta t$

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$

$v_f{}^2 = v_i{}^2 + 2a\Delta x$

II. Force

a. **General**

$F = ma$

b. **Equilibrium**

$\sum F = 0$

III. Work

a. Done by constant force

$W_{Net} = F_{Net} d(\cos\theta)$

b. Work-Energy Theorem

$W_{Net} = \Delta K.E.$

IV. Energy

a. **Kinetic energy** $K.E. = \frac{1}{2}mv^2$

b. Gravitational Potential Energy $U_{grav} = mgh$

c. **Elastic Potential Energy** $U_{elastic} = \frac{1}{2}kx^2$

d. Conservation of Mechanical Energy

$M.E._{\cdot i} = M.E._{\cdot f}$

e. **Power**

$P = \frac{W}{\Delta t}$ *or* $P = Fv$

V. Momentum

a. General $p = mv$

b. **Impulse-Momentum Theorem** $\Delta p = F\Delta t = mv_f - mv_i$

c. Conservation of Momentum $p_i = p_f$

VI. Angular Motion

a. Angular Displacement $\Delta\theta = \frac{\Delta s}{r}$

b. Angular Speed $\omega_{avg} = \frac{\Delta\theta}{\Delta t}$

c. Angular Acceleration $\alpha_{avg} = \frac{\Delta\omega}{\Delta t}$

d. Tangential Speed $v_t = r\omega$

e. Tangential Acceleration $a_t = r\alpha$

f. **Centripetal Acceleration** $a_c = \frac{v_t^2}{r} = r\omega^2$

g. Centripetal Force $F_C = \frac{mv_t^2}{r}$

h. **Newton's Universal Law of Gravity** $F_g = \frac{Gm_1m_2}{r^2}$

i. Friction $F_{\mu_{k/s}} = \mu_{k/s} F_N$

j. **General Torque**

$\tau = Fd\sin\theta$

VII. Fluid Mechanics

a. Mass Density

$$\rho = \frac{m}{v}$$

b. Buoyant Force

$$F_B = F_g = mg$$

c. Pressure

$$P = \frac{F}{A}$$

d. Fluid Pressure as a Function of Depth

$$P = P_o + \rho g h$$

e. Bernoulli's Equation

$$\text{constant} = P + \tfrac{1}{2}\rho v^2 + \rho g h$$

VIII. Heat and Thermodynamics

a. Conservation of Energy

$$\Delta P.E. + \Delta K.E. + \Delta U = 0$$

b. **Specific Heat Capacity**

$$Q = C_p m \Delta T$$

c. **Ideal Gas Law**

$$PV = nRT$$

d. Work done by a Gas

$$W = -PAd = -P\Delta V$$

e. **1st Law of Thermodynamics**

$$\Delta U = Q + W$$

f. Combined Gas Law

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

g. Efficiency of Engines

$$eff = \frac{W_{out}}{W_{in}}$$

IV. Harmonic Motion

a. Hooke's Law

$$F_{elastic} = -kx$$

b. **Period of Simple Pendulum**

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

c. **Period of Mass-Spring**

$$T = 2\pi\sqrt{\frac{m}{K}}$$

d. Period and Frequency

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

X. Sound

a. Intensity

$$I = \frac{p}{4\pi r^2}$$

b. Velocity on Rope

$$v = \sqrt{\frac{F_T}{m/L}}$$

c. Harmonic Series

Vibrating String

$$f_n = \frac{nv}{2L}$$

Open Pipe at both Ends

$$f_n = \frac{nv}{2L}$$

Pipe Closed at one end

$$f_n = \frac{nv}{4L} \quad n = 1,3,5,...$$

XI. Waves

a. **General Speed**

$$v = f \cdot \lambda$$

XII. Light

a. **Speed**

$$C = f \cdot \lambda$$

b. **Mirror**

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} = \frac{2}{R}$$

c. **Magnification**

$$M = \frac{h'}{h} = \frac{-d_i}{d_o}$$

d. Index of Refraction

$$n = \frac{c}{v}$$

e. Snell's Law

$$n_i \sin\theta_i = n_r(\sin\theta_r)$$

f. Critical Angle

$$\sin\theta_C = \frac{n_r}{n_i}$$

g. Destructive Interference

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

h. **Constructive Interference**

$$d(\sin\theta) = m\lambda$$

XIII. Electricity

a. Electric Field Strength

1. **General** $F_{elecrtic} = qE$

2. Between 2 charges $F_{electric} = k_C \frac{q_1 q_2}{r^2}$

3. Point Charge $E = k_C \frac{q}{r^2}$

b. Electric Potential

1. Uniform Electric Field $U_{elec} = -qEd$

2. Pair of Charges $U_{elec} = k_C \frac{q_1 q_2}{r}$

c. Potential Difference

1. **General**

$\Delta V = \frac{\Delta U_{electric}}{q}$ or $\Delta U = q\Delta V$

2. **Uniform Field** $\Delta v = -E\Delta d$

3. **Point Charge and Infinity** $\Delta v = k_C \frac{q}{r}$

d. Capacitance

1. **General** $C = \frac{Q}{V}$

2. **Parallel** $C = \varepsilon_o = \frac{A}{d}$

3. Work to move charge across capacitor $W = \frac{1}{2} CV^2$

e. Potential Energy Stored in a Capacitor

$P.E._{elec} = \frac{1}{2} Q\Delta V$

f. Electric Current $I = \frac{\Delta Q}{\Delta t}$

g. **Ohm's Law** $\Delta V = I \cdot R$

h. **Electric Power** $P = I\Delta V$

i. Battery Voltage $V = \varepsilon - IR$

j. Resistance

1. **In Series** $R_{eq} = R_1 + R_2 + R_3 + \ldots$

2. **In parallel** $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

3. **Resistance** $R = \rho \frac{L}{A}$

k. Capacitors

1. In Series $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$

2. In parallel $C_{eq} = C_1 + C_2 + C_3 + \ldots..$

IX. Magnetism

a. **Magnetic Field Strength** $B = \frac{F_{mag}}{qV \sin\theta}$ *or* $F_{mag} = qvB\sin\theta$

b. Magnetic Field Around Wire $B = \frac{\mu_o I}{2\pi r}$

c. Force on current-carrying conductor perpendicular to magnetic field

$F_{mag} = BIl \sin\theta$

d. Faraday's Law of Magnetic Induction

$$\varepsilon = emf = -N\frac{\Delta[AB\cos\theta]}{\Delta t} = N\frac{\Delta\Phi}{\Delta t} = NBlv$$

XV. Quantum

a. Rest Energy and Mass

$E_R = mc^2$

b. Binding Energy of Nucleus

$E_{BIND} = \Delta mc^2$

c. Half-Life

$$T_{1/2} = \frac{0.693}{\tau}$$

d. **Energy of light Photon**

$$E = hf$$

e. **Kinetic Energy of photoelectron(Work function)**

$$E = KE = hf - W_o$$

f. Radioactive Decay Rate

$$N = N_o e^{-\frac{t}{\tau}} = N_o e^{-\frac{t\ln 2}{T_{1/2}}}$$

g. **Wavelength and Frequency of Matter Waves**

$$\lambda = \frac{h}{p} = \frac{h}{mv} \qquad f = \frac{E}{h}$$

XVI. Modern

a. Time Dilation

$$\Delta t = \frac{\Delta t_o}{\sqrt{1-\frac{v^2}{c^2}}}$$

b. Length Contraction

$$L = L_o\sqrt{1-\frac{v^2}{c^2}}$$