PHYS 211X

General Physics I

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Formulae

Dot Product:

$$\vec{A} \cdot \vec{B} = \|A\| \, \|B\| \cos(\theta) \tag{1}$$

Cross Product:

$$\vec{A} \times \vec{B} = AB \sin(\theta) \tag{2}$$

Position:

$$x, y, s, \text{ or } p = \vec{v}\Delta t = \int \vec{v} dt \tag{3}$$
$$x = \left(\frac{v_0 + vf}{2}\right)\Delta t \tag{4}$$
$$x = v_0 t + \left(\frac{1}{2}\right)\vec{a}t^2 \tag{5}$$

Velocity, v:

$$\vec{v} = \vec{a}\Delta t = \frac{d}{dt}[p] = \int (\vec{a}) dt \tag{6}$$
$$\vec{v} = v_0 + \vec{a}t \tag{7}$$
$$\vec{v}_f^2 = v_0^2 + 2\vec{a}\Delta x \tag{8}$$

Acceleration, a:

$$\vec{a} = \frac{d}{dt}[\vec{v}] \tag{9}$$

Projectile Motion:

$$y_f = y_0 + v_0(\Delta t) + \frac{1}{2}a(\Delta t^2) \tag{10}$$

Force, F:

$$\vec{F} = m\vec{a} \tag{11}$$

Friction:

$$f = \mu N \tag{12}$$

Drag:

$$\vec{F_D} \text{ or } D = \frac{1}{2}pC_D A v^2 \tag{13}$$

Circular Motion:

$$\vec{v} = r \tag{14}$$
$$F_c = \frac{m\vec{v}^2}{r} \tag{15}$$
$$f = \mu n \tag{16}$$
$$v_c = \sqrt{gr} \tag{17}$$
$$N = mr\omega^2 \tag{18}$$
$$N = 3mg \tag{19}$$
$$\omega = \frac{\Delta\theta}{\Delta t} \tag{20}$$

Total Energy:

$$E = K + U \tag{21}$$
$$KE_i + U_i = KE_f + U_f \tag{22}$$
$$\frac{1}{2}mv_i^2 + mgy_i = \frac{1}{2}mv_f^2 + mgy_f \tag{23}$$

PE of a spring:

$$U = 1/2kx^2 \tag{24}$$
$$U_p = \frac{1}{2}k(x - L_0) \tag{25}$$

Potential Energy, U:

$$U_{tot} = mg + k\Delta y \tag{26}$$

Work, W:

$$W_{int} = -\frac{F_x}{\Delta} \tag{27}$$
$$F_x = -\frac{dU}{dx} \tag{28}$$

Momentum, p:

$$p = mv \tag{29}$$

Torque, τ:

$$\tau = r \times F \tag{30}$$
$$\tau = rF\sin(\theta) \tag{31}$$
$$N = I\alpha \tag{32}$$

Inertia, I:

$$I = \sum_i m_i r_i^2 = \int r^2 dm \tag{33}$$
$$I = r\omega^2 \tag{34}$$

Kinetic Energy of Rotation:

$$KE_{rot} = \frac{1}{2}I\omega^2 \tag{35}$$

Kinetic Energy of Rolling:

$$KE_{roll} = \frac{1}{2}I\omega^2 + \frac{1}{2}mv_c^2 \tag{36}$$

Angular Momentum:

$$L = I\omega \tag{37}$$

Newton's Laws of Gravity:

$$F = \frac{Gm_1m_2}{r^2} \tag{38}$$
$$U = -\frac{Gm_1m_2}{r^2} \tag{39}$$
$$G = 6.67 \times 10^{-11} Nm^2/kg^2 \tag{40}$$
$$a_{m_1} = \frac{Gm_2}{r^2} \tag{41}$$
$$v_e = \sqrt{\frac{GM}{r}} \tag{42}$$

Orbits:

$$\Delta T^2 = \frac{4\pi^2}{GM_\odot} r^3 \tag{43}$$
$$\frac{4\pi^2}{GM_\odot} = 1 \tag{44}$$
$$\Delta T^2 \propto r^3 \tag{45}$$
$$\vec{v} = \frac{2\pi r}{\Delta t} \text{ Valid for circular} \tag{46}$$

Density, ρ:

$$\rho = \frac{m}{V} \tag{47}$$

Pressure, ϕ:

$$\phi = \frac{F}{A} \tag{48}$$
$$\phi_h = \phi_0 e^{-\frac{mgh}{kT}} \tag{49}$$
$$\phi_h = \rho_l hg + \phi_a \tag{50}$$

Bernoulli's Law:

$$\phi_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = \phi_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2 \tag{51}$$

Continuity:

$$A_1 v_1 = A_2 v_2 \tag{52}$$

Power:

$$P = \frac{\Delta E}{\Delta t} = \frac{\Delta E}{\Delta t} = \frac{1}{2}\omega^2 A^2 \mu v \tag{53}$$
$$\Delta E = \frac{1}{2}\omega^2 \mu A^2 dx \tag{54}$$
$$\omega^2 = \frac{k}{m} \tag{55}$$

Intensity:

$$I = \frac{\text{Power}}{\text{Area}} = \frac{\text{Energy/Time}}{\text{Area}} \tag{56}$$

Waves:

$$\frac{\Delta r}{\lambda} = \frac{\Delta \phi}{2\pi}$$

Interference:

$$y = 2A\cos\left(\frac{\phi}{2}\right)\sin\left(kx - \omega + \frac{\phi}{2}\right) \tag{57}$$
$$\text{Max } \phi = 2n\pi \tag{58}$$
$$\text{Min } \phi = (2n+1)\pi \tag{59}$$

Key

$$
\begin{aligned}
v &= \text{velocity, meters/second} \\
y &= \text{height, meters} \\
x &= \text{distance, meters} \\
t &= \text{time, seconds} \\
m &= \text{mass, kilograms} \\
a &= \text{acceleration, meters/second}^2 \\
\theta &= \text{angle, degrees} \\
g &= \text{gravity: 9.8 meters/second}^2 \\
\omega &= \text{angular velocity, radians or degrees/second} \\
F &= \text{force, Newtons, kilogram} \cdot \text{meters/second}^2 \\
\mu &= \text{coefficient of friction} \\
N &= \text{normal force, Newtons} \\
A &= \text{area, meters}^2 \\
\rho &= \text{volumetric mass density, kilograms/meters}^3 \\
C_D &= \text{drag coefficient (geometry dependant)} \\
K &= \text{kinetic energy} \\
U &= \text{potential energy} \\
\alpha &= \text{angular acceleration, degrees—radians/second}^2
\end{aligned}
$$