Physics 101 Formula Sheet

Constant acceleration (2-12): $x = x_0 + v_0 t + \frac{1}{2}at^2$, $v = v_0 + at$, $v^2 = v_0{}^2 + 2a(x - x_0)$

Vector components (3-2, 3-3): $V_x = V\cos\theta$; $V_y = V\sin\theta$

$$V = \sqrt{V_x^2 + V_y^2}; \qquad \tan\theta = \frac{V_y}{V_x}$$

Relative velocity (3-15): $\vec{v}_{BS} = \vec{v}_{BW} + \vec{v}_{WS}$

Circular motion (5-1): $a_c = \frac{v^2}{r}$, $v = \frac{2\pi r}{T}$, $T = \frac{1}{f}$

Newton's law of gravitation (6-1): $F = G\frac{m_1 m_2}{r^2}$; where $G = 6.67\times10^{-11}\, N\cdot m^2/kg^2$

Dot (or scalar) product of two vectors (7-2, 7-4): $\vec{A}\cdot\vec{B} = AB\cos(\theta) = A_x B_x + A_y B_y + A_z B_z$

Work (7-3): $W = \vec{F}\cdot\vec{d} = Fd\cos(\theta)$

Kinetic Energy (7-10): $K = \frac{1}{2}mv^2$

Work energy principle (7-11): $W_{net} = \Delta K = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

Potential Energy: Gravity (universal) (8-17): $U(r) = -\frac{GmM}{r}$

Gravity (near surface of the earth) (8-3): $U = mgy$

Spring (8-5) $U = \frac{1}{2}kx^2$

Power (8-21): $P = \frac{W}{\Delta t} = \vec{F}\cdot\vec{v}$

Centre of mass (9-11): $x_{CM} = \frac{\Sigma m_i x_i}{M}$, $y_{CM} = \frac{\Sigma m_i y_i}{M}$, $z_{CM} = \frac{\Sigma m_i z_i}{M}$

Linear and angular quantities for rotation (10-4,5,6): $v = R\omega$, $a_{\tan} = R\alpha$, $a_R = \omega^2 R$

Torque due to a force (10-10): $\tau = R_\perp F = RF_\perp = RF\sin\theta$

Newton's 2nd law for rotation (10-14): $\Sigma\tau = I\alpha$

Total kinetics energy (10-23): $K = \frac{1}{2}Mv_{MC}^2 + \frac{1}{2}I\omega^2$

Angular momentum of a rigid body (11-1): $L = I\omega$

Angular momentum of a moving particle: $L = r_\perp p = r p_\perp = r p \sin\theta$, where $p = mv$.

Static equilibrium (12-1,2): $\Sigma\vec{F} = 0$, $\Sigma\tau = 0$.

Pressure at a depth h **in a liquid (13-3):** $P = \rho g h$

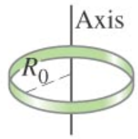
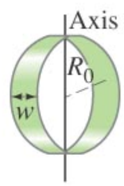
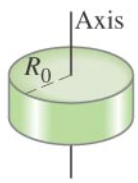
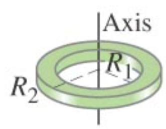
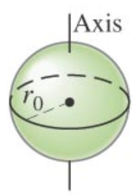
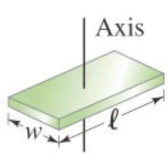
Bernoulli's equation (13-8): $P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

Viscosity (13-11): $F = \eta A \dfrac{v}{l}$

Poiseuille's equation (13-12): $Q = \dfrac{\pi R^4 (P_1 - P_2)}{8\eta l}$

Simple harmonic motion (SHM):

Moments of inertia (10-13): $I = \Sigma m_i R_i^2$

	Object	Location of axis		Moment of inertia
(a)	**Thin hoop,** radius R_0	Through center		MR_0^2
(b)	**Thin hoop,** radius R_0 width w	Through central diameter		$\frac{1}{2}MR_0^2 + \frac{1}{12}Mw^2$
(c)	**Solid cylinder,** radius R_0	Through center		$\frac{1}{2}MR_0^2$
(d)	**Hollow cylinder,** inner radius R_1 outer radius R_2	Through center		$\frac{1}{2}M(R_1^2 + R_2^2)$
(e)	**Uniform sphere,** radius r_0	Through center		$\frac{2}{5}Mr_0^2$
(f)	**Long uniform rod,** length ℓ	Through center		$\frac{1}{12}M\ell^2$
(g)	**Long uniform rod,** length ℓ	Through end		$\frac{1}{3}M\ell^2$
(h)	**Rectangular thin plate,** length ℓ, width w	Through center		$\frac{1}{12}M(\ell^2 + w^2)$

SHM (14–2):

$$x = A\cos(\omega t + \phi)$$
$$v = -\omega A\sin(\omega t + \phi)$$
$$a = -\omega^2 A\cos(\omega t + \phi) = -\omega^2 x$$

Mass and spring (14–5): $\omega = 2\pi f = \sqrt{\dfrac{k}{m}}$

Simple pendulum (14–12): $\omega = 2\pi f = \sqrt{\dfrac{g}{l}}$

Wave velocity (15–1): $v = \lambda f$

Transverse wave velocity on a cord (15–2): $v = \sqrt{\dfrac{F_T}{\mu}}$

Longitudinal wave velocity in a rod (15–3): $v = \sqrt{\dfrac{E}{\rho}}$

Longitudinal wave velocity in a fluid (15–4): $v = \sqrt{\dfrac{B}{\rho}}$

Wave energy (15-5): $E = 2\pi^2 \rho S v t f^2 A^2$

Wave power (15-6): $P = \dfrac{E}{t}$

Wave intensity (15-7): $I = \dfrac{P}{S}$

Wave function (15-10): $D(x,t) = A\sin\left[\left(\dfrac{2\pi}{\lambda}\right)(x - vt)\right] = A\sin(kx - \omega t)$

Wave number (15-11): $k = \dfrac{2\pi}{\lambda}$

Standing wave (15-17): $\lambda_n = \dfrac{2l}{n}$

Sound level (16-6): $\beta = 10\log\left(\dfrac{I}{I_0}\right)$

Doppler effect (16-11): $f' = f\left(\dfrac{v \pm v_o}{v \mp v_s}\right)$