PHYS 101 Formulae

Vectors are in **bold**

General equations and constants:

Solution to quadratic:	$ax^2 + bx + c = 0 \rightarrow x = (-b \pm \sqrt{(b^2-4ac)})/2a$
Law of cosines:	$\lvert\mathbf{a}+\mathbf{b}\rvert^2 = a^2 + b^2 + 2ab\cos(\Theta)$
Acceleration due to gravity:	$g = 9.8\ m/s^2$
Gravitational constant:	$G = 6.67\times10^{-11}\ N\ m^2/kg^2$
Mass of the Earth :	$M_E = 6.0\times10^{24}\ kg$
Moment of inertia of a point mass:	$I = mr^2$
Moment of inertia of a sphere:	$I = (2/5)\ mr^2$
Speed of sound in air at sea level:	$v = 343\ m/s$
Speed of light	$c = 3.00 \times 10^8\ m/s$
Threshold intensity of audible sound:	$I_0 = 1.0 \times 10^{-12}\ W/m^2$
Threshold pressure of audible sound:	$p_0 = 3.0 \times 10^{-5}\ Pa$
Index of refraction of water:	$n = 1.33$
Index of refraction of glass:	$n = 1.5$

Motion at constant a:	$\mathbf{v} = \mathbf{v_0} + \mathbf{a}t$
	$x = x_0 + v_0t + \frac{1}{2}\ at^2$
	$v^2 = v_0^2 + 2a\ (x-x_0)$
	$v_{aver} = (v + v_0)/2$
Reference frames:	$\mathbf{v}_{\text{in frame A}} = \mathbf{v}_{\text{in frame B}} + \mathbf{v}_{\text{B in A}}$
Newton's 2nd law:	$\mathbf{F} = m\mathbf{a} = \Delta\mathbf{p}/\Delta t$
Force of friction	$F_{friction} = \mu_{(kinetic,\ static)}F_N$
Centripetal acceleration	$a = v^2/r$
Banked curve, frictionless surface:	$\tan\Theta = v^2/(rg)$
Force of gravity:	$F = G\ (m_1m_2)/r^2$
Kepler's 3rd law:	$T^2/r^3 = 4\pi^2/(GM)$
Work:	$W = \mathbf{F} \cdot \mathbf{d}$
Kinetic energy:	$KE = \frac{1}{2}\ mv^2$
Work-energy	$W_{net} = \Delta KE$
Gravitational potential:	$PE_{grav} = mgh$ (near Earth's surface)
Elastic potential energy:	$PE_{spring} = \frac{1}{2}\ kx^2$
Hooke's law:	$F = -k\ x$
Power:	power = energy/time = $W/t = \mathbf{F} \cdot \mathbf{v}$
Linear momentum	$\mathbf{p} = m\mathbf{v}$

Impulse:	$\Delta p = F\Delta t$
Center of mass:	$x_{CM} = (x_A m_A + x_B m_B + \ldots)/(m_A + m_B + \ldots)$
Linear and angular velocity:	$v = r\,\omega$
Angular motion at constant α:	$\omega = \omega_0 + \alpha t$
	$\Theta = \omega_0 t + \frac{1}{2}\alpha t^2$
	$\omega^2 = \omega_0^2 + 2\alpha\Theta$
	$\omega_{aver} = (\omega + \omega_0)/2$
Torque:	$\tau = F_\perp r$
Newton's second law for rotation:	$\tau = I\,\alpha$ $\qquad I = \Sigma\, m\, r^2$
Rotational kinetic energy	$KE_{rot} = \frac{1}{2} I\,\omega^2$
Rotational (angular) momentum:	$L = I\omega$
Frequency/period relationship:	$f = 1/T$
Period of SHM (spring):	$T = 2\pi\sqrt{(m/k)}$
Speed of object undergoing SHM:	$v = \pm v_{max}\sqrt{(1-x^2/A^2)}$ $\qquad v_{max} = 2\pi A/T$
Maximum acceleration:	$a_{max} = (k/m)\,A$
Sinusoidal motion of SHM:	$x = A\sin(2\pi\, t/T) = A\sin(\omega t)$
Pendulum SHM:	$T = 2\pi\sqrt{(L/g)}$
Wave speed, wavelength, frequency:	$v = \lambda\, f$
Speed of wave on a cord:	$v = \sqrt{(F_T/[m/L])}$
Intensity of wave:	$I = 2\pi^2 v\rho\, f^2\, A^2$
	$I = p^2/(2v\rho)$
Standing waves on string:	$\lambda_n = 2L/n$
Reflection:	$\Theta_{inc} = \Theta_{ref}$
Refraction (waves):	$v_1 \sin(\Theta_2) = v_2 \sin(\Theta_1)$
Sound intensity (decibels)	$\beta = 10 \log (I/I_0) = 20 \log (P/P_0)$
Harmonics of open tubes:	$f_n = nf_1 = n\,(v/2L)$ $\qquad$ for n=1,2,3…
Harmonics of closed tubes:	$f_n = n\, f_1 = n\, v/4L$ $\qquad$ for n=1,3,5… (only odd harmonics)
Beat frequency:	$f_b = \lvert f_1 - f_2 \rvert$
Doppler shift:	$f' = f\,[1/\{1 \pm (v_{source}/v_{wave})\}]$
	(source moving away from(+)/towards(-) observer)
	$f' = f\,[1 \pm (v_{obs}/v_{wave})]$
	(observer moving towards(+)/away from(-) source)
Focal length of spherical mirror:	$f = r/2$
Mirror and lens equation:	$1/f = 1/d_o + 1/d_i$

Magnification:	$m = h_i/h_o = -d_i/d_o$	
Index of refraction:	$n = c/v_{light}$	
Snell's law of refraction:	$n_1 \sin(\Theta_1) = n_2 \sin(\Theta_2)$	
Critical angle for TIR:	$\sin(\Theta_c) = n_2/n_1$	
Lens power:	$P = 1/f$	
Diffraction around object:	$\Theta_{diff} \approx \lambda/D$	
Constructive interference (2-slit):	$d \sin(\Theta) = m \lambda$	$m = 0,1,2\ldots$
Destructive interference (2-slit):	$d \sin(\Theta) = (m + \frac{1}{2}) \lambda$	$m = 0,1,2\ldots$
Single slit diffraction minima:	$D \sin(\Theta) = m \lambda$	$m = 1,2,3\ldots$ (<u>not</u> 0!)
Diffraction spot size/resolution:	$\Theta = 1.22 \lambda/D$	