PHYSICS 111: Laws, Constants and Equations

Laws and Constants

Cosine law: $c^2 = a^2 + b^2 - 2ab\cos\gamma$		Sine law: $\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma}$
$G = 6.67 \times 10^{-11}\,\frac{\mathrm{Nm}^2}{\mathrm{kg}^2}$	$g = 9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Linear Kinematics / Angular (Rotational) Kinematics

Linear Kinematics	Angular (Rotational) Kinematics
$\vec{v}_{avg} = \frac{\Delta\vec{d}}{\Delta t}$; $\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t}$; $\vec{v} = \vec{v}_0 + \vec{a}\Delta t$	$\omega_{avg} = \frac{\Delta\theta}{\Delta t}$; $\alpha_{avg} = \frac{\Delta\omega}{\Delta t}$; $\omega = \omega_0 + \alpha\Delta t$
$\Delta\vec{d} = \vec{v}_0\Delta t + \frac{1}{2}\vec{a}(\Delta t)^2$	$\Delta\theta = \omega_0\Delta t + \frac{1}{2}\alpha(\Delta t)^2$
$\Delta\vec{d} = \vec{v}\Delta t - \frac{1}{2}\vec{a}(\Delta t)^2$	$\Delta\theta = \omega\Delta t - \frac{1}{2}\alpha(\Delta t)^2$
$\Delta\vec{d} = \frac{\vec{v} + \vec{v}_0}{2}\Delta t$	$\Delta\theta = \frac{\omega + \omega_0}{2}\Delta t$
$v^2 = {v_0}^2 + 2a\Delta d$	$\omega^2 = {\omega_0}^2 + 2\alpha\Delta\theta$

Relative Velocity	From Angular to Linear World
$\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC}$	$s = r\theta$; $v = r\omega$; $a = r\alpha$

Linear Dynamics / Angular (Rotational) Dynamics

Linear Dynamics	Angular (Rotational) Dynamics
$\sum\vec{F} = m\vec{a}$; $\vec{F}_{AB} = -\vec{F}_{BA}$	$\vec{\tau} = \vec{r} \times \vec{F}$, $\lvert\vec{\tau}\rvert = \lvert\vec{r}\rvert\lvert\vec{F}\rvert\sin\theta$; $\sum\vec{\tau} = I\vec{\alpha}$; $\vec{\tau}_{AB} = -\vec{\tau}_{BA}$

Friction (Linear and Angular)		
	$f_S \le \mu_S n$	$f_K = \mu_K n$

Circular Motion	Circular Motion & the Angular World
$a_C = \frac{v^2}{r} = 4\pi^2 r f^2 = \frac{4\pi^2 r}{T^2}$; $F_C = m a_C$	$a_C = r\omega^2$

Work and Energy

Linear Kinetic Energy	$KE_{Lin} = \frac{1}{2}mv^2$	Gravitational Potential Energy		$PE_g = mgh$
		Spring Potential Energy		$PE_s = \frac{1}{2}kx^2$
Rotational Kinetic Energy	$KE_{Rot} = \frac{1}{2}I\omega^2$	**Moment of Inertia**	**Object Type**	***k***
		Object with mass, m & radius, r; $I = kmr^2$	Point mass about r	1
			Hoop, hollow cylinder	1
			Disc, solid cylinder	½
			Hollow Sphere	2/3
			Solid Sphere	2/5
		Object with mass, m & length, l; $I = kml^2$	Rod, length l, mass m, about its centre	1/12
$KE_{Tot} = KE_{Lin} + KE_{Rot}$			Rod, length l, mass m, about its end	1/3

Work done (in general)	$W = \vec{F}\cdot\vec{d} = Fd\cos\theta$
Conservation of Mechanical Energy (true if $W_{nc} = 0$)	$\Delta E = \Delta KE + \Delta PE = 0$
Non-conservative Work (done by non-conservative forces like friction)	$W_{nc} = \Delta KE + \Delta PE$
Conservative Work (done by conservative forces like gravity or springs)	$W_c = -\Delta PE$
Net Work or Total Work	$W_{Net} = F_{Net}\Delta x$
	$W_{Net} = W_c + W_{nc} = \Delta KE$

Power			
	$P_{avg} = \frac{W}{\Delta t}$	$P = \vec{F}\cdot\vec{v}$	$P = \vec{\tau}\cdot\vec{\omega}$

Linear Momentum / Angular Momentum

Linear Momentum	Angular Momentum
$\vec{P} = m\vec{v}$	$\vec{L} = I\vec{\omega}$
Conservation of Linear Momentum: $\vec{P}_i = \vec{P}_f$	Conservation of Angular Momentum: $\vec{L}_i = \vec{L}_f$
1-D and 2-D Collisions: $m\Delta\vec{v} = \Delta\vec{P} = \vec{F}\Delta t$	Angular (Rotational) Collisions: $I\Delta\vec{\omega} = \Delta\vec{L} = \vec{\tau}\Delta t$

Static Equilibrium		
	$\sum\vec{F}_{Ext} = 0$, meaning $\sum F_x = 0, \sum F_y = 0$	and $\sum\vec{\tau}_{Ext} = 0$