Summary of Mechanics for Physics 2A and 4A

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Quantity	Linear Motion		Rotational Motion	
Position	$\mathbf{r}$	Meters (m)	θ	Radians
Average Velocity	$\mathbf{v}_{av} = (\mathbf{r}_f - \mathbf{r}_i) / (t_f - t_i)$	Meters /Second (m/s)	$\omega_{av} = (\theta_f - \theta_i) / (t_f - t_i)$	Radians/Second (rad/s)
Average Acceleration	$\mathbf{a}_{av} = (\mathbf{v}_f - \mathbf{v}_i) / (t_f - t_i)$	Meters /Second^2(m/s^2)	$\alpha_{av} = (\omega_f - \omega_i) / (t_f - t_i)$	Radians/Second^2 (rad/s^2)
Instantaneous Velocity. or Acceleration	$\mathbf{v} = \lim \Delta t \to 0\ \Delta\mathbf{r} / \Delta t = d\mathbf{r}/dt$; $\mathbf{a} = \lim \Delta t \to 0\ \Delta\mathbf{v} / \Delta t = d\mathbf{v}/dt$;		$\omega = \lim \Delta t \to 0\ \Delta\theta / \Delta t = d\mathbf{r}/dt$; $\alpha = \lim \Delta t \to 0\ \Delta\omega / \Delta t = d\omega/dt$;	
Position under constant acceleration	$\mathbf{r}_f = \mathbf{r}_o + \mathbf{v}_o (t_f - t_i) + ½\, \mathbf{a}(t_f - t_i)^2$ $\mathbf{r}_f = \mathbf{r}_o + ½\, (\mathbf{v}_o + \mathbf{v}_f)(t_f - t_i)$	Meters (m)	$\theta_f = \theta_o + \omega_o (t_f - t_i) + ½\, \alpha\, (t_f - t_i)^2$ $\theta_f = \theta_o + ½\, (\omega_o + \omega_f)(t_f - t_i)$	$\theta_f = \theta_o + \omega_o (t_f - t_i) + ½\, \alpha\, (t_f - t_i)^2$
Velocity under constant acceleration	$\mathbf{v}_f = \mathbf{v}_o + \mathbf{a}\, t$; $\mathbf{v}_f^2 = \mathbf{v}_o^2 + 2\, \mathbf{a} \bullet (\mathbf{r}_f - \mathbf{r}_i)$	Meters/Second (m/s)	$\omega_f = \omega_o + \alpha\, t$ $\omega_f^2 = \omega_o^2 + 2\, \alpha \bullet (\theta_f - \theta_o)$	Radians/Second (rad/s)
Action >> Equal & Opposite Reaction	$\mathbf{F}_{12} = -\mathbf{F}_{21}$	Newton = kg - m/s^2 Kilogram =kg	$\tau_{12} = -\tau_{21}$	Newton –meter (N-m)
Force = Mass x Acceleration	$\mathbf{F} = m\, \mathbf{a}$	Newton = N = kg - m/s^2	$\tau = I\, \alpha$ (I & α same axis) $\tau = = \mathbf{r} \times \mathbf{F}$; $\tau = F\, D \sin\theta$	Newton –meter (N-m)
Impulse	$I = \int \mathbf{F}\, dt = \mathbf{F}_{av} (t_f - t_i)$	N-s = Kg-m/s	Not Used	
Momentum Conservation	$\mathbf{p} = m\, \mathbf{v}$ $\Sigma\, \mathbf{p} = \Sigma\, \mathbf{p} + \mathbf{I}$ (conserved)	kg-m/s	$\mathbf{L} = I\, \omega$ $\Sigma\, \mathbf{L} = \Sigma\, \mathbf{L} + \int \boldsymbol{\tau}\, dt$ (conserved)	Kg-m^2/s
Kinetic Energy (KE) (Energy of Motion)	KE = $½\, m\, v^2$	Joule (J) = N-m	KE = $½\, I\, \omega^2$	Joule (J) = N-m
Potential Energy (PE) (Energy associated with position)	PE = mgh (gravity near earth) PE = $- G\, m_1\, m_2/r$ (between spheres or points) PE = $½\, kx^2$ (Spring with compression constant k)	Joule (J) = N-m	PE = $½\, k\theta^2$ (Torsion spring with compression constant k)	Joule (J) = N-m
Work Done	$W = \int \mathbf{F} \bullet d\mathbf{s} = F_{av}\, D \sin\theta$	Joule (J) = N-m	$W = \int \boldsymbol{\tau} \bullet d\boldsymbol{\theta} = \tau\, (\theta_f - \theta_i)$	Joule (J) = N-m
Conservation of Energy	Sum of $KE_i + PE_i$ + Work by Outside Force = $KE_f + PE_f$		Rotational KE and PE must be included in energy equation where applicable. Rolling Objects: $\omega\, r = v$	
Force Gravity Near Earth	$F_g = m\, g$; $g = 9.8$ m/sec^2 Force of gravity is down.		Rotational Parameters: Moment of Inertia and Torque $I = \Sigma\, m_i\, r_i^2$ (kg – m^2)($r_i \perp$ distance from axis); $\tau = F\, r \sin\theta$ Center of Mass (or Gravity) $\mathbf{r}_{cm} = (\Sigma\, m_i\, \mathbf{r}_i)/(\Sigma\, m_i)$	
Force Gravity Between Two Objects	$F = G\, m_1\, m_2/r^2$; $G = 6.67 \times 10^{-11}$ N-m^2 kg^{-2} Force is attractive between the objects (points or uniform spheres).			