

My Formulas List

"My formulas list" is available at "<http://members.fortunecity.com/nhan01/index.html>".
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Physics 4A

Translational Kinematics

Displacement:	$\Delta x = x_2 - x_1$	Average Velocity:	$v_{\text{avg}} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$
Average Speed:	$s_{\text{avg}} = \frac{\text{total distance}}{\Delta t}$	Instantaneous Velocity:	$v = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$
Average Acceleration:	$a_{\text{avg}} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$	Instantaneous Acceleration:	$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$
Constant Acceleration:	$v = v_0 + at$	$x - x_0 = v_0 t + \frac{1}{2}at^2$	
$x - x_0 = vt - \frac{1}{2}at^2$	$v^2 = v_0^2 + 2a(x - x_0)$	$x - x_0 = \frac{1}{2}(v_0 + v)t$	
Uniform Circular Motion:	$a_c = \frac{v^2}{r}$ (centripetal)	$T = \frac{2\pi r}{v}$ (period)	

Vectors

Scalar/Dot Product:	$\vec{a} \bullet \vec{b} = a_x b_x + a_y b_y + a_z b_z$	$\vec{a} \bullet \vec{b} = ab \cos \phi$
Vector/Cross Product:	$\vec{a} \times \vec{b} = (a_y b_z - a_z b_y)\hat{i} - (a_x b_z - a_z b_x)\hat{j} + (a_x b_y - a_y b_x)\hat{k}$	$\vec{a} \times \vec{b} = ab \sin \phi$
	$\vec{a} \times \vec{b} = (a_y b_z - b_y a_z)\hat{i} + (a_z b_x - b_z a_x)\hat{j} + (a_x b_y - b_x a_y)\hat{k}$	
Vector Properties:	$\vec{a} - \vec{b} = \vec{a} + (-\vec{b})$ (vector subtraction)	
$a_x = \cos \theta$	$\vec{a} + \vec{b} = \vec{b} + \vec{a}$ (commutative law)	$ \vec{a} = \sqrt{a_x^2 + a_y^2}$
$a_y = \sin \theta$	$(\vec{a} + \vec{b}) + \vec{c} = \vec{a} + (\vec{b} + \vec{c})$ (associative law)	$\theta = \tan^{-1}(\frac{a_y}{a_x})$

Force and Motion

$\vec{F}_{\text{net}} = m\vec{a}$	$\vec{F}_g = mg$	$\vec{W} = mg$	
$f_{s, \text{max}} = \mu_s \vec{F}_n$	$f_k = \mu_k \vec{F}_n$	$F_{\text{drag}} = \frac{1}{2}C\rho A v^2$	$v_{\text{terminal}} = \sqrt{\frac{2\vec{F}_g}{C\rho A}}$

Energy

$K = \text{KE} = \frac{1}{2}mv^2$	$W = \vec{F}d \cos \phi$	$W = \vec{F} \bullet \vec{d}$	$W_g = mgd \cos \phi$
$\Delta \text{KE} = \text{KE}_f - \text{KE}_i = W$	$\vec{F} = -kx$ (Hooke's)	$W_{\text{spring}} = -\Delta \frac{1}{2}kx^2$	$W = \int_{x_i}^{x_f} F(x) \bullet dx$
$P_{\text{avg}} = \frac{W}{\Delta t}$	$dP = \frac{dW}{dt}$	$\frac{dW}{dt} = \vec{F} \bullet \vec{v}$	$\text{PE} = U = mgy$
$\Delta \text{PE} = -\int_{x_i}^{x_f} F(x) \bullet dx$	$\text{PE}_{\text{elastic}} = \frac{1}{2}kx^2$	$E_{\text{mech}} = \text{KE} + \text{PE}$	$F(x) = -\frac{dU(x)}{dx}$
$W = \Delta E_{\text{mech}} + \Delta E_{\text{th}} + \Delta E_{\text{int}}$			

System of Particles

$x_{\text{com}} = \frac{1}{M} \sum_{i=1}^n m_i x_i$	$y_{\text{com}} = \frac{1}{M} \sum_{i=1}^n m_i y_i$	$z_{\text{com}} = \frac{1}{M} \sum_{i=1}^n m_i z_i$	$\vec{r}_{\text{com}} = \frac{1}{M} \sum_{i=1}^n m_i \vec{r}_i$
$\vec{F}_{\text{net}} = M \vec{a}_{\text{com}}$	$\vec{p} = m \vec{v}$	$\vec{F}_{\text{net}} = \frac{m \vec{v}}{\Delta t} = \frac{\vec{p}}{\Delta t}$	$R v_{\text{rel}} = Ma$
$v_f - v_i = v_{\text{rel}} \ln \frac{M_i}{M_f}$	$x_{\text{com}} = \frac{1}{M} \int x dm$	$y_{\text{com}} = \frac{1}{M} \int y dm$	$z_{\text{com}} = \frac{1}{M} \int z dm$
	$x_{\text{com}} = \frac{1}{V} \int x dV$	$y_{\text{com}} = \frac{1}{V} \int y dV$	$z_{\text{com}} = \frac{1}{V} \int z dV$

Collisions

Impulse and Linear Momentum:	$\vec{p}_f - \vec{p}_i = \Delta \vec{p} = \vec{J}$	$\vec{J} = \int_{t_i}^{t_f} \vec{F}(t) dt$
One-Dimensional Inelastic Collision:	$(m_1 \vec{v}_{1i} + m_2 \vec{v}_{2i}) = (m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f})$	
One-Dimensional Completely Inelastic Collision:	$m_1 \vec{v}_{1i} = (m_1 + m_2) \vec{v}_f$	$\vec{v}_f = \frac{m_1}{m_1 + m_2} \vec{v}_{1i}$
One-Dimensional Elastic Collision: (Stationary Target)	$\vec{v}_{1f} = \frac{m_1 - m_2}{m_1 + m_2} \vec{v}_{1i}$	$\vec{v}_{2f} = \frac{2m_1}{m_1 + m_2} \vec{v}_{1i}$
One-Dimensional Elastic Collision: (Moving Target)	$\vec{v}_{1f} = \frac{m_1 - m_2}{m_1 + m_2} \vec{v}_{1i} + \frac{2m_2}{m_1 + m_2} \vec{v}_{2i}$	$\vec{v}_{2f} = \frac{2m_1}{m_1 + m_2} \vec{v}_{1i} + \frac{m_2 - m_1}{m_1 + m_2} \vec{v}_{2i}$
Two-Dimensional Collisions:	$\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$ (inelastic)	$K_{1i} + K_{2i} = K_{1f} + K_{2f}$ (elastic)
	$\vec{v}_{\text{com}} = \frac{\vec{p}_{1i} + \vec{p}_{2i}}{m_1 + m_2}$	

Rotational Kinematics/Energy

$\theta = \frac{s}{r}$	1 rev = $360^\circ = \frac{2\pi r}{r} = 2\pi$ rad	1 rad = $57.3^\circ = 0.159$ rev	$\omega = \frac{d\theta}{dt}$
$\omega_{\text{avg}} = \frac{\Delta\theta}{\Delta t}$	$\alpha_{\text{avg}} = \frac{\Delta\omega}{\Delta t}$	$\alpha = \frac{d\omega}{dt}$	$v_{\text{tan}} = \omega r$
$a_{\text{tan}} = \alpha r$	$a_c = \frac{v^2}{r} = \omega^2 r$	$\text{KE}_{\text{rot}} = \frac{1}{2} I \omega^2$	$I = \sum m_i r_i^2$
$I = \int r^2 dm$	$I = I_{\text{com}} + Mh^2$	$\vec{\tau} = \vec{r} \times \vec{f}$	$\tau_{\text{net}} = I \alpha$
$W = \Delta \frac{1}{2} I \omega^2$	$W = \int_{\theta_i}^{\theta_f} \tau d\theta$	$W = \tau \Delta\theta$	$P = \frac{dW}{dt} = \tau \omega$
$\omega = \omega_0 + \alpha t$	$\Delta\theta = \omega_0 t + \frac{1}{2} \alpha t^2$	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$	
$\Delta\theta = \frac{1}{2}(\omega_0 + \omega)t$	$\Delta\theta = \omega t - \frac{1}{2} \alpha t^2$		

Rolling, Torque, and Angular Momentum

$v_{\text{com}} = \omega R$	$\text{KE} = \frac{1}{2} I_{\text{com}} \omega^2 + \frac{1}{2} M v_{\text{com}}^2$	$a_{\text{com}} = -\frac{g \sin \theta}{1 + I_{\text{com}} / MR_0^2}$
$\vec{L} = \vec{r} \times \vec{p} = m(\vec{r} \times \vec{v})$	$\vec{\tau}_{\text{net}} = \frac{d\vec{L}}{dt}$	$\vec{L} = I \omega$

Equilibrium and Elasticity

$\vec{F}_{\text{net},x} = 0$	$\vec{F}_{\text{net},y} = 0$	$\vec{F}_{\text{net},z} = 0$	$\vec{\tau}_{\text{net}} = 0$
stress = $\frac{F}{A} = E \frac{\Delta l}{l}$ E="Young's modulus" l="length" A="cross-sectional area"	$\frac{F}{A} = G \frac{\Delta x}{\Delta t}$ (shearing) G="shear modulus"	$p = B \frac{\Delta V}{V}$ B="bulk modulus" V="volume"	strain = $\frac{\Delta l}{l}$

Gravitation

The Law of Gravitation:	$\vec{F}_g = G \frac{m_1 m_2}{r^2}$ $G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2$	
Superposition:	$\vec{F}_{1,\text{net}} = \sum_{i=2}^n \vec{F}_{1i}$	$\vec{F}_1 = \int d\vec{F}$
Gravitational Acceleration:	$\vec{F} = m a_g$	$a_{g,\text{surface}} = \frac{GM}{r^2}$
Gravitation Within a Spherical Shell:	$M_{\text{in sph shell}} = \rho \frac{4\pi r^3}{3}$	
Gravitational Potential Energy:	$\text{PE} = U = -\frac{GMm}{r}$	
Escape Speed:	$v_e = \sqrt{\frac{2GM}{R_{\text{surface}}}}$	
Kepler's Laws	1. Law of orbits/ellipses 2. Law of areas (c of "L") 3. Law of periods	$T^2 = \left(\frac{4\pi^2}{GM}\right)r^3$
Energy in Planetary Motion:	$\text{PE} = U = -\frac{GMm}{r}$	$\text{KE} = \frac{GMm}{2r}$
	$E_{\text{mech}} = \text{PE} + \text{KE} = -\frac{GMm}{2r}$	$E_{\text{mech}} = -\frac{GMm}{2a}$ $a = \text{"semimajor axis of ellipse"}$
Others:	$W_{\text{ext}} = \Delta \text{PE}$	$W_{\text{sys}} = -\Delta \text{PE}$
$\text{KE}_{\text{orbit}} = \frac{1}{2} \text{PE}_{\text{orbit}} $	$\rho = \frac{M}{V} = \frac{M}{(4/3)\pi r^3}$	

Oscillations

$T = \frac{1}{f}$	$\omega = \sqrt{\frac{k}{m}}$ (angular freq)	$T_{\text{SHM}} = 2\pi\sqrt{\frac{m}{k}}$ (period)
$x(t) = x_m \cos(\omega t + \phi)$	$v(t) = -\omega x_m \sin(\omega t + \phi)$	$a(t) = -\omega^2 x_m \cos(\omega t + \phi)$
$K(t) = \frac{1}{2} m v^2 = \frac{1}{2} k x^2 \sin^2(\omega t + \phi)$	$\omega = \frac{2\pi}{T} = 2\pi f$	$a(t) = -\omega^2 x(t)$
$U(t) = \frac{1}{2} k x^2 = \frac{1}{2} k x_m^2 \cos^2(\omega t + \phi)$	$E = U + K = \frac{1}{2} k x_m^2$	
$T_{\text{torsion pendulum}} = 2\pi\sqrt{\frac{I}{k}}$	$T_{\text{pendulum}} = 2\pi\sqrt{\frac{L}{g}}$ (simple, small amplitude)	$T_{\text{pendulum}} = 2\pi\sqrt{\frac{I}{mgh}}$ (physical, small amplitude)
$x(t)_{\text{damp}} = x_m e^{-bt/2m} \cos(\omega t + \phi)$	$\omega_{\text{damp}} = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$	$E_{\text{mech,damp}} \approx \frac{1}{2} k x_m^2 e^{-bt/m}$

Waves

Sinusoidal Waves:	$y(x, t) = y_m \sin(kx - \omega t)$	$k = \frac{2\pi}{\lambda}$
	$\frac{\omega}{2\pi} = f = \frac{1}{T}$	$v = \frac{\omega}{k} = \frac{\lambda}{T} = \lambda f$
Equation of a Traveling Wave:	$y(x, t) = h(kx \pm \omega t)$	
Wave speed on Stretched String:	$v = \sqrt{\frac{\tau}{\mu}}$	
Power:	$P_{\text{avg}} = \frac{1}{2} \mu v \omega^2 y_m^2$	
Interference of Waves:	$y(x, t) = \left[2y_m \cos \frac{1}{2}\phi \right] \sin(kx - \omega t + \frac{1}{2}\phi)$	
Standing Waves:	$y(x, t) = [2y_m \sin kx] \cos \omega t$	
Resonance:	$f = \frac{v}{\lambda} = n \frac{v}{2L}, \quad (n=1, 2, 3, \dots)$	

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