

# Phys 206 — Exam II Formulae

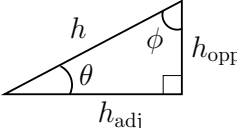
## Trigonometry and Vectors:

$$\sin 30^\circ = \cos 60^\circ = \frac{1}{2} \quad \sin 36.9^\circ \approx \cos 53.1^\circ \approx \frac{3}{5}$$

$$\sin 45^\circ = \cos 45^\circ = \frac{1}{\sqrt{2}} \quad \sin 53.1^\circ \approx \cos 36.9^\circ \approx \frac{4}{5}$$

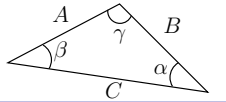
$$\sin 60^\circ = \cos 30^\circ = \frac{\sqrt{3}}{2}$$

$$h_{\text{adj}} = h \cos \theta = h \sin \phi \quad h^2 = h_{\text{adj}}^2 + h_{\text{opp}}^2$$

$$h_{\text{opp}} = h \sin \theta = h \cos \phi \quad \tan \theta = \frac{h_{\text{opp}}}{h_{\text{adj}}}$$


Law of cosines:  $C^2 = A^2 + B^2 - 2AB \cos \gamma$

Law of sines:  $\frac{\sin \alpha}{A} = \frac{\sin \beta}{B} = \frac{\sin \gamma}{C}$



$$\vec{A} = A_x \hat{i} + A_y \hat{j} + A_z \hat{k} \quad \hat{A} = \frac{\vec{A}}{|\vec{A}|}$$

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z = AB \cos \theta = A_{\parallel} B = AB_{\parallel}$$

$$\vec{A} \times \vec{B} = (A_y B_z - A_z B_y) \hat{i} + (A_z B_x - A_x B_z) \hat{j} + (A_x B_y - A_y B_x) \hat{k}$$

$$|\vec{A} \times \vec{B}| = AB \sin \theta = A_{\perp} B = AB_{\perp} \quad (\text{direction via right-hand rule})$$

## Kinematics:

$$\langle \vec{v} \rangle = \frac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1} \quad \vec{v} = \frac{d\vec{r}}{dt}$$

$$\langle \vec{a} \rangle = \frac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1} \quad \vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2 \vec{r}}{dt^2}$$

$$\vec{r}(t) = \vec{r}_0 + \int_0^t \vec{v}(t') dt'$$

$$\vec{v}(t) = \vec{v}_0 + \int_0^t \vec{a}(t') dt'$$

— constant acceleration only —

$$\vec{r}(t) = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2} \vec{a} t^2$$

$$\vec{v}(t) = \vec{v}_0 + \vec{a} t$$

$$v_x^2 = v_{x,0}^2 + 2a_x(x - x_0)$$

(and similarly for y and z)

$$\vec{r}(t) = \vec{r}_0 + \frac{1}{2}(\vec{v}_i + \vec{v}_f)t$$

## Work-energy:

$$U_{\text{grav}} = Mgy_{\text{cm}}; \quad U_{\text{elas}} = \frac{1}{2}k(r - r_{\text{equil}})^2$$

$$W = \Delta K = K_f - K_i = \frac{1}{2}m(v_f^2 - v_i^2)$$

$$= \vec{F} \cdot \Delta \vec{r} = \int_{P_1}^{P_2} \vec{F} \cdot d\vec{r}$$

$$P = dW/dt = \vec{F} \cdot \vec{v}$$

$$E_{\text{tot},f} = E_{\text{tot},i} + W_{\text{other}}$$

$$\Leftrightarrow K_f + U_{\text{grav},f} + U_{\text{elas},f} = K_i + U_{\text{grav},i} + U_{\text{elas},i} + W_{\text{other}}$$

$$F_x(x) = -\frac{dU(x)}{dx}; \quad \vec{F} = -\vec{\nabla}U = -\left[\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j} + \frac{\partial U}{\partial z}\hat{k}\right]$$

## Quadratic:

$$ax^2 + bx + c = 0 \Rightarrow x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

## Derivatives:

$$\frac{d}{dt}(at^n) = nat^{n-1}$$

$$\frac{d}{dt} \sin at = a \cos at$$

$$\frac{d}{dt} \cos at = -a \sin at$$

## Integrals:

if  $f(t) = at^n$ , then  $\begin{cases} \int_{t_1}^{t_2} f(t) dt = \frac{a}{n+1}(t_2^{n+1} - t_1^{n+1}) \\ \int f(t) dt = \frac{a}{n+1}t^{n+1} + C \end{cases}$   
( $n \neq -1$ )

$$\int \sin at dt = -\frac{1}{a} \cos at$$

$$\int \cos at dt = \frac{1}{a} \sin at$$

## Constants/Conversions:

$$g = 9.80 \text{ m/s}^2 = 32.15 \text{ ft/s}^2 \quad (\text{Earth, sea level})$$

$$\approx 10 \text{ m/s}^2 \approx 33 \text{ ft/s}^2$$

$$1 \text{ mi} = 1609 \text{ m}$$

$$1 \text{ lb} = 4.448 \text{ N}$$

$$1 \text{ ft} = 12 \text{ in}$$

$$\Leftrightarrow 0.454 \text{ kg (Earth, sea level)} \quad 1 \text{ in} = 2.54 \text{ cm}$$

$$1 \text{ rev} = 360^\circ = 2\pi \text{ radians}$$

Circular motion:  $a_{\text{rad}} = \frac{v^2}{R} \quad a_{\text{tan}} = \frac{d|\vec{v}|}{dt}$

$$T = \frac{2\pi R}{v}$$

Relative velocity:  $\vec{v}_{A/C} = \vec{v}_{A/B} + \vec{v}_{B/C}$   
 $\vec{v}_{A/B} = -\vec{v}_{B/A}$

## Forces:

Newton's:  $\sum \vec{F} = m\vec{a}, \quad \vec{F}_{B \text{ on } A} = -\vec{F}_{A \text{ on } B}$

Hooke's:  $F_x = -k\Delta x$

friction:  $|\vec{f}_s| \leq \mu_s |\vec{n}|, \quad |\vec{f}_k| = \mu_k |\vec{n}|$