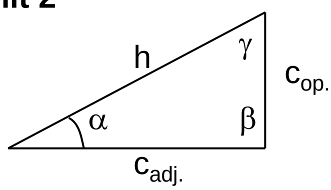
Unit 1

$$\Delta x = x_f - x_i \qquad v_{av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} \qquad v = \frac{dx}{dt} \qquad (a = cnt.) \quad v_{av} = \frac{v_i + v_f}{2} \qquad a_{av} = \frac{\Delta v}{\Delta t} \qquad a = \frac{dv}{dt} = \frac{d^2 x}{dt^2}$$

$$x = x_0 + v_{0x} t + \tfrac{1}{2} a_x t^2 \qquad v_x = v_{ox} + a_x t \qquad Az^2 + Bz + C = 0 \;\rightarrow\; z = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

Unit 2



$$h^2 = c_{adj.}^2 + c_{op.}^2 \qquad \alpha + \beta + \gamma = 180^o$$

$$\sin\alpha = \frac{c_{op.}}{h} \qquad \cos\alpha = \frac{c_{adj.}}{h} \qquad \tan\alpha = \frac{c_{op.}}{c_{adj.}} = \frac{\sin\alpha}{\cos\alpha}$$

$$\vec{v}_{13} = \vec{v}_{12} + \vec{v}_{23} \qquad \vec{v}_{ij} = -\vec{v}_{ji}$$

Unit 3

$$x = x_0 + v_{ox} t + \tfrac{1}{2} a_x t^2 \qquad v_x = v_{ox} + a_x t$$

$$y = y_0 + v_{oy} t + \tfrac{1}{2} a_y t^2 \qquad v_y = v_{oy} + a_y t$$

General-launch angle: Range: $x_R = \dfrac{v_0^2 \sin(2\theta)}{g}$ *Time to Range:* $t_R = \dfrac{2 v_0 \sin\theta}{g}$

Maximum height: $y_M = \dfrac{v_0^2 \sin^2\theta}{2g}$ *Time to Max. Height:* $t_M = \dfrac{v_o \sin\theta}{g}$

Unit 4

$$\sum \vec{F} = m\vec{a} \;\rightarrow\; \sum F_x = ma_x \qquad \sum F_y = ma_y$$

$$W = mg \;\rightarrow\; W_a - W = (\pm) ma \qquad F_k = \mu_k N \qquad F_{s,\max} = \mu_s N \qquad \vec{N} = -\sum \vec{F}_\perp \qquad F = -kx$$

Unit 5

Low speed $\vec{R} = -b\vec{v}$ $\quad v(t) = v_T\left(1 - e^{-t/\tau}\right)$ $\quad v_T = \dfrac{mg}{b}$ $\quad \tau = m/b$

High speed $R = \tfrac{1}{2} D\rho A v^2$ $\quad v_T = \sqrt{\dfrac{2mg}{D\rho A}}$

$$a_c = \frac{v^2}{r} \qquad a_t = \frac{dv_t}{dt} \qquad \vec{a} = \vec{a}_c + \vec{a}_t \qquad a = \sqrt{a_c^2 + a_t^2} \qquad F_{cp} = m\frac{v^2}{r}$$

Unit 6

$$W = \int \vec{F} \cdot d\vec{r} \left(= \underbrace{\vec{F} \cdot \vec{d} = Fd\cos\theta}_{\text{constant force}} \right) \qquad W_T = \sum_i W_i = \sum_i \vec{F}_i \cdot \vec{d}_i = \sum_i F_i d\cos\theta_i$$

$$E = K + U \qquad K = \tfrac{1}{2} m v^2 \qquad U_{spring} = \tfrac{1}{2} k x^2 \qquad U_g = mgy \qquad P = \frac{dW}{dt} \underbrace{\left(= \vec{F} \cdot \frac{d\vec{r}}{dt} = \vec{F} \cdot \vec{v} \right)}_{\text{constant force}}$$

Conservative forces

$\Delta E = 0$

$E_f = K_f + U_f = E_i = K_i + U_i$

Non-conservative forces

$\Delta E = W_{NC} \qquad E_f \neq E_i$

In general

$W_T = \Delta K = K_f - K_i$

$W_C = -\Delta U = U_i - U_f$

$W_{NC} = \Delta E = E_f - E_i = K_f + U_f - (K_i + U_i)$

Unit 7

$\vec{p} = m\vec{v}$ $\quad \Delta\vec{p} = \vec{p}_f - \vec{p}_i$ $\quad \vec{I} = \vec{F}_{av}\Delta t = \Delta t \sum_i \vec{F}_i = \Delta\vec{p} = \vec{p}_f - \vec{p}_i = m\vec{v}_f - m\vec{v}_i$

System of several objects $\quad \vec{p}_T = \sum_i \vec{p}_i = \sum_i m_i\vec{v}_i$

$\vec{F}_{net} = \sum \vec{F} = \sum \vec{F}_{ext} + \sum \vec{F}_{\text{int}}$ $\quad \sum \vec{F}_{\text{int}} = 0$ so if $\sum \vec{F}_{ext} = 0 \longrightarrow \vec{p}_{Tf} = \vec{p}_{Ti}$

Collisions $\quad \vec{p}_{Tf} = \vec{p}_{Ti}$ $\quad$ Inelastic: $K_f < K_i$ $\quad$ Elastic: $K_f = K_i$

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v_{1i} + \left(\frac{2m_2}{m_1 + m_2}\right)v_{2i}$$

$$v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right)v_{1i} + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)v_{2i}$$

1-D collisions $\quad$ Comp. inelastic $\quad v_f = \dfrac{m_1 v_{1i} + m_2 v_{2i}}{m_1 + m_2}$

2-D collisions $\quad \sum_j p_{jxf} = \sum_j p_{jxi}$ $\quad \sum_j p_{jyf} = \sum_j p_{jyi}$

2-D elastic: $K_f = K_i$ with $v = \sqrt{v_x^2 + v_y^2}$

$$\vec{R}_{CM} = \frac{1}{M}\sum_j m_j \vec{r}_j \quad \vec{V}_{CM} = \frac{1}{M}\sum_j m_j \vec{v}_j \quad \vec{A}_{CM} = \frac{1}{M}\sum_j m_j \vec{a}_j \quad M\vec{A}_{CM} = \sum \vec{F}_{ext} \quad M = \sum_j m_j$$

Unit 8

1 revolution = 2π radians $\quad \Delta\theta = \theta_f - \theta_i \quad \omega_{av} = \dfrac{\Delta\theta}{\Delta t} \quad T = \dfrac{2\pi}{\omega} \quad \alpha_{av} = \dfrac{\Delta\omega}{\Delta t}$

$$\theta = \theta_0 + \omega_0 t + \tfrac{1}{2}\alpha t^2 \qquad \omega = \omega_0 + \alpha t$$

$$v_t = r\omega = r\frac{2\pi}{T} \quad a_t = r\alpha = r\frac{\Delta\omega}{\Delta t} = \frac{\Delta v_t}{\Delta t} \quad a_{cp} = \frac{v_t^2}{r} = r\omega^2 = r\left(\frac{2\pi}{T}\right)^2 \quad a = \sqrt{a_t^2 + a_{cp}^2} \quad \phi = \tan^{-1}\left(\frac{a_{cp}}{a_t}\right)$$

$$E_f = E_i \quad E = K_T + U \quad K_T = K + K_R = \tfrac{1}{2}mv^2 + \tfrac{1}{2}I\omega^2 \quad K_R = \tfrac{1}{2}I\omega^2$$

$$\vec{\tau}_{net} = \sum_i \vec{\tau}_i = \sum_i \vec{r}_i \times \vec{F}_i = \sum_i r_i F_i \sin\theta_i \quad \vec{L} = I\vec{\omega} \quad \vec{L} = \vec{r}\times\vec{p} = rp\sin\theta \quad \vec{\tau} = I\vec{\alpha} = \frac{\Delta\vec{L}}{\Delta t} \quad \Delta\vec{L} = L_f - L_i = \vec{\tau}\Delta t$$

Unit 9

Young's modulus = $\dfrac{\text{tensile stress}}{\text{tensile strain}} = \dfrac{F/A}{\Delta L/L}$

Static equilibrium conditions:

$$\sum \vec{F} = m\vec{a} = 0 \quad \sum \vec{\tau} = \left(\sum I\right)\vec{\alpha} = 0$$

Shear modulus = $\dfrac{\text{shear stress}}{\text{shear strain}} = \dfrac{F/A}{\Delta x/h}$

Bulk modulus = $\dfrac{\text{volume stress}}{\text{volume strain}} = \dfrac{\Delta\, F/A}{\Delta V/V} = -\dfrac{\Delta P}{\Delta V/V}$

Unit 10

$$x = A\cos(\omega t) \qquad x = Ae^{-(b/2m)t}\cos(\omega_d t)$$

$f = 1/T$

$\omega = 2\pi f$

Mass+spring $\quad \omega = \sqrt{\dfrac{k}{m}}$

pendulum $\quad \omega = \sqrt{\dfrac{g}{L}}$

Mass+spring $\quad \omega_d = \sqrt{\dfrac{k}{m} - \left(\dfrac{b}{2m}\right)^2}$