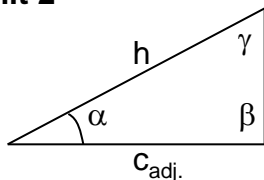


Unit 1

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

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

Unit 2



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

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

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

Unit 3

$$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2 \quad v_x = v_{0x} + a_x t$$

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2 \quad v_y = v_{0y} + a_y t$$

$$\text{General-launch angle: Range: } x_R = \frac{v_0^2 \sin(2\theta)}{g}$$

$$\text{Time to Range: } t_R = \frac{2v_0 \sin \theta}{g}$$

$$\text{Maximum height: } y_M = \frac{v_0^2 \sin^2 \theta}{2g}$$

$$\text{Time to Max. Height: } t_M = \frac{v_0 \sin \theta}{g}$$

Unit 4

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

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

Unit 5

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

$$\text{High speed} \quad R = \frac{1}{2}D\rho Av^2 \quad v_T = \sqrt{\frac{2mg}{D\rho A}}$$

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

Unit 6

$$W = \int \vec{F} \cdot d\vec{r} \left(= \vec{F} \cdot \vec{d} = Fd \cos \theta \right) \quad W_T = \sum_i W_i = \sum_i \vec{F}_i \cdot \vec{d}_i = \sum_i F_i d \cos \theta_i$$

$$E = K + U \quad K = \frac{1}{2}mv^2 \quad U_{spring} = \frac{1}{2}kx^2 \quad U_g = mgy \quad P = \frac{dW}{dt} \left(= \vec{F} \cdot \frac{d\vec{r}}{dt} = \vec{F} \cdot \vec{v} \right)$$

Conservative forces

$$\Delta E = 0$$

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

Non-conservative forces

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

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

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

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

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

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

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

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

2-D collisions $\sum_j p_{jxf} = \sum_j p_{jxi}$ 2-D elastic: $K_f = K_i$ with $v = \sqrt{v_x^2 + v_y^2}$

$\sum_j p_{jyf} = \sum_j p_{jyi}$

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

Unit 8 1 revolution = 2π radians $\Delta\theta = \theta_f - \theta_i$ $\omega_{av} = \frac{\Delta\theta}{\Delta t}$ $T = \frac{2\pi}{\omega}$ $\alpha_{av} = \frac{\Delta\omega}{\Delta t}$

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

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

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

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

Unit 9

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

Static equilibrium conditions:

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

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

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

Unit 10

$x = A\cos(\omega t)$

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

Mass+spring pendulum

Mass+spring

$f = 1/T$

$\omega = \sqrt{\frac{k}{m}}$

$\omega = \sqrt{\frac{g}{L}}$

$\omega_d = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$

$\omega = 2\pi f$