Mathematics

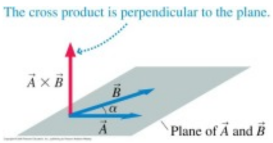
quadratic equation, $ax^2 + bx + c = 0$:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

cosine law:

$$c^2 = a^2 + b^2 - 2ab\cos\theta$$

vectors:



$$\begin{aligned} \vec{A} \cdot \vec{B} &= AB\cos\alpha \\ \vec{A} \times \vec{B} &= AB\sin\alpha \end{aligned}$$

Fundamental Constants

$g = 9.80 \text{ m s}^{-2}$

Mechanics

uniform linear acceleration $a = \text{const}$:

$$\begin{aligned} v_{\text{fs}} &= v_{\text{is}} + a_s \Delta t \\ s_f &= s_i + v_{\text{is}}\Delta t + \frac{1}{2} a_s (\Delta t)^2 \\ v_{\text{fs}}^2 &= v_{\text{is}}^2 + 2 a_s \Delta s \end{aligned}$$

Relative Velocity:

$$v_{\text{AD}} = v_{\text{AB}} + v_{\text{BC}} + v_{\text{CD}}$$

Newton's Laws:

Second: $\vec{a} = \frac{1}{m}\vec{F}_{\text{net}} = \frac{1}{m}\frac{dP}{dt}$

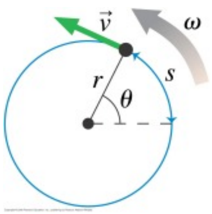
Third: $\vec{F}_{\text{A on B}} = -\vec{F}_{\text{B on A}}$

Hooke's Law: $F_s = -k\Delta s$

friction:

$$\begin{aligned} f_s &\leq \mu_s F_N \\ f_k &= \mu_k F_N \end{aligned}$$

Rotational motion:



$$\begin{aligned} \theta &= s/r \\ \omega &= d\theta/dt \\ v_r &= \omega r \\ \alpha &= d\omega/dt \\ a_t &= \alpha r \\ a_r &= \frac{v^2}{r} \end{aligned}$$

kinematics of uniform angular acceleration:

$$\begin{aligned} \omega_f &= \omega_i + \alpha\Delta t \\ \theta_f &= \theta_i + \omega_i \Delta t + \frac{1}{2}\alpha(\Delta t)^2 \\ \omega_f^2 &= \omega_i^2 + 2\alpha\Delta\theta \end{aligned}$$

Linear momentum: $\vec{p} = m\vec{v}$

Impulse:

$$\vec{J} = \overline{\vec{F}}\,\Delta t = \Delta\vec{p}$$

Torque:

$$\begin{aligned} \vec{\tau} &= \vec{r} \times \vec{F} \\ \vec{\alpha} &= \vec{\tau}_{\text{net}}/I \\ \Sigma\vec{\tau}_{\text{ext}} &= d\vec{L}/dt \end{aligned}$$

moment of inertia:

$$I = mr^2 \quad \text{or} \quad I_{\text{body}} = \textstyle\sum_i m_i r_i^2$$

about an axis through the geometrical centre:

$$I_{\text{hoop}} = mr^2 \quad I_{\text{disk}} = \frac{1}{2}mr^2$$

$$I_{\text{sphere}} = \frac{2}{5}mr^2 \quad I_{\text{thin rod}} = \frac{1}{12}ml^2$$

Parallel axis theorem:

$$I = I_{\text{cm}} + Md^2$$

Work:

$$\begin{aligned} dW &= F_s ds \\ &= \vec{F} \cdot \Delta\vec{r} && \text{(if } \vec{F} \text{ is constant)} \\ &= -\Delta U && \text{(if } \vec{F} \text{ is conservative)} \end{aligned}$$

Energy:

$$\begin{aligned} U_g &= mgy && \text{(gravitational potential)} \\ U_s &= \tfrac{1}{2}k(\Delta s)^2 && \text{(spring potential)} \\ K &= \tfrac{1}{2}mv^2 && \text{(translational kinetic)} \\ K_r &= \tfrac{1}{2}I\omega^2 && \text{(rotational kinetic)} \end{aligned}$$

Power:

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

Waves and Sound

simple harmonic oscillator, $F = -kx$, $U = \frac{1}{2}kx^2$

$$f = 1/T \quad \omega = 2\pi f = \sqrt{k/m}$$

$$\begin{cases} x = A\cos\theta = A\cos\omega t \\ v = -A\omega\sin\omega t \\ a = -A\omega^2\cos\omega t = -\omega^2 x \end{cases}$$

Standing waves: $A(x) = 2a\sin kx$

$$\lambda_m = \frac{2L}{m}, \text{ where } m = 1, 2, 3\ldots \text{ (fixed ends)}$$

Travelling wave: $y = A\sin(\omega t \mp \frac{2\pi}{\lambda}x)$