Mathematics

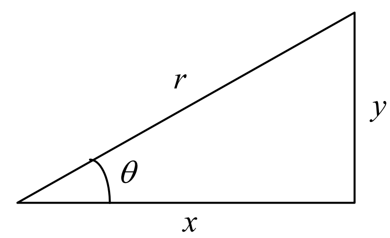
Quadratic equation:

$$ax^2 + bx + c = 0$$

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

Trigonometry:

$$r^2 = x^2 + y^2$$
$$\sin\theta = y/r$$
$$\cos\theta = x/r$$
$$\tan\theta = y/x$$



Kinematics (for constant acceleration)**:**

$$v = v_0 + at \qquad x = \tfrac{1}{2}(v_0 + v)t$$

$$x = v_0 t + \tfrac{1}{2}at^2 \qquad v^2 = v_0^2 + 2ax$$

Forces:

Newton's second law: $\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$

First condition for equilibrium: $\sum \vec{\mathbf{F}} = 0$

Gravity:

Gravitational force near the earth: $F = mg$

Newton's law of universal gravitation: $F = G\dfrac{m_1 m_2}{r^2}$

$g = 9.80\ \text{m/s}^2$ $\qquad G = 6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$

Friction:

Static: $0 \le f_s \le \mu_s F_N$ direction is always opposite to motion (or tendency to motion)

Kinetic: $f_k = \mu_k F_N$

Uniform Circular Motion

Period: $T = \dfrac{2\pi r}{v}$, where v is the speed of the object and r is the radius of the circle

Frequency: $f = \dfrac{1}{T}$ $\qquad \theta$ (in radians) $= \dfrac{\text{Arc length}}{\text{radius}}$

Centripetal Acceleration: $a_c = \dfrac{v^2}{r}$

Centripetal Force: $F_c = \dfrac{mv^2}{r}$ (directed towards the centre)

Work, Energy, and Power:

Work: $W = (F\ \cos\theta)\, s$

Kinetic energy: $\text{KE} = \tfrac{1}{2} mv^2$

Potential energy:

Gravitational (near Earth): $\text{PE} = mgh$

Work-energy theorem: $W_{nc} = \Delta\text{KE} + \Delta\text{PE} = E_f - E_i$

Total mechanical energy: $E = \text{KE} + \text{PE}$

Conservation of mechanical energy: $E = \text{KE} + \text{PE} = \text{constant};\ E_f = E_i$

Power (rate of doing work): $\overline{P} = \dfrac{W}{t}$

Linear Momentum

Impulse: $\vec{\mathbf{J}} = \overline{\vec{\mathbf{F}}}\Delta t = \Delta\vec{\mathbf{p}} = m\vec{\mathbf{v}}_f - m\vec{\mathbf{v}}_i$

Conservation of Momentum: $\vec{\mathbf{p}}_i = \vec{\mathbf{p}}_f$, if no external forces

Torque and Angular Momentum

Torque: $\tau = Fl = Fr\sin\theta$; l = (lever arm) = $r\sin\theta$

Second condition of equilibrium: $\sum\vec{\tau} = 0$

Angular momentum: $L = I\omega$ is conserved, in the absence of external torques

Moment of inertia: $I = \sum mr^2$

Simple Harmonic Motion

Hooke's law: Restoring force = $F = -kx$

Elastic potential energy: PE $= \frac{1}{2}kx^2$

Displacement: $x = A\cos(\omega t)$ (when $x = A$ at $t = 0$)

Velocity: $v = -A\omega\sin(\omega t)$ Acceleration: $a = -A\omega^2\cos(\omega t)$

Frequency, Period $\omega^2 = \frac{k}{m}$; $f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$; $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$

Simple pendulum $T = 2\pi\sqrt{\frac{L}{g}}$

Energy $E = \text{KE} + \text{PE} = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

Fluids

Pressure: P = Force/Area

Pressure and Depth: $P_2 = P_1 + \rho gh$

Continuity Equation: $\rho_1 v_1 A_1 = \rho_2 v_2 A_2$

Bernoulli's Equation: $P + \rho gh + \frac{1}{2}\rho v^2$ = constant

Heat, Temperature and Kinetic Theory

Linear thermal expansion: $\Delta L = \alpha L_0 \Delta T$

Volume thermal expansion: $\Delta V = \beta V_0 \Delta T$

Heat and temperature change: $Q = c\,m\,\Delta T$

Heat required for change of phase: $Q = mL$

Conduction of heat through a material: $\frac{Q}{t} = \frac{k\,A\,\Delta T}{L}$

$n = \frac{N}{N_A} = \frac{m}{\text{mass per mole}}$ $N_A = 6.022\times10^{23}\ \text{mol}^{-1}$

$PV = nRT = \frac{2}{3}N\,\overline{\text{KE}}$ $R = 8.314$ J/(mol·K)

$\overline{\text{KE}} = \frac{1}{2}mv_{rms}^2 = \frac{3}{2}kT$