Mathematics

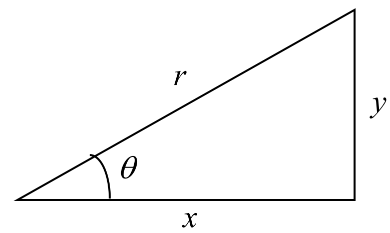
Quadratic equation:

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

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

Trigonometry:

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



Kinematics (for constant acceleration)**:**

$$v = v_0 + at$$

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

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

$$v^2 = v_0^2 + 2ax$$

$$x = vt - \tfrac{1}{2}at^2$$

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: $F = G\frac{m_1 m_2}{r^2}$

$g = 9.80$ m/s^2 $G = 6.67\times10^{-11}$ N·m^2/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: $T = \frac{2\pi r}{v}$, where v is the speed of the object and r is the radius of the circle

Frequency: $f = \frac{1}{T}$ θ (in radians) = $\frac{\text{Arc length}}{\text{radius}}$

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

Centripetal Force: $F_c = \frac{mv^2}{r}$ (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): $\bar{P} = \frac{W}{t}$

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

Elastic collisions, $v_{2i} = 0$:

$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i}$$

$$v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i}$$

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: $\frac{Q}{t} = \frac{k\,A\,\Delta T}{L}$

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

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

$\overline{\text{KE}} = \frac{1}{2}mv_{rms}^2 = \frac{3}{2}kT$ 0°C = 273.15 K

Table of Constants

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Fundamental Constants

Constant	Symbol	SI value	Value in non-SI units
Gravitational Constant	G	6.674×10^{-11} $m^3kg^{-1}s^{-2}$	
Avogadro's Number	N_A	6.022×10^{-23} mol^{-1}	
Boltzmann's constant	k	1.381×10^{-23} J/K	8.61×10^{-5} eV/K
Gas Constant	R	8.314 J/(mol K)	

Other useful physical data

Constant	Symbol	SI value	Value in non-SI units
Acceleration due to earth's gravity	g	9.80 m/s^2	980 cm/s^2
Standard atmospheric pressure		101.3 kPa	1.013 bar, 760 Torr
Density of air (0 ºC, 1 atm)		1.29 kg/m^3	1.29 g/L
Speed of sound in air (20 ºC)		343 m/s	
Water:			
Density (liquid)		1000 kg/m^3	1 g/cm^3, 1 g/mL
Spec. heat capacity (liquid at 20 ºC)		4184 J/(kg K)	1 cal/(g K)
Spec. heat capacity (ice at -10 ºC)		2030 J/(kg K)	0.49 cal/(g K)
Spec. heat capacity (steam at 100 ºC)		2080 J/(kg K)	0.50 cal/(g K)
Latent heat of fusion		3.35×10^5 J/kg	80 cal/g
Latent heat of vaporization		2.26×10^6 J/kg	540 cal/g
Earth			
Mass	$M_\oplus$	5.97×10^{24} kg	
Radius (equatorial)	$R_\oplus$	6.38×10^6 m	
Orbital radius (mean)		1.496×10^{11} m	1 AU, 149.6 million km
Moon			
Mass		7.35×10^{22} kg	
Radius (mean)		1.74×10^6 m	
Orbital radius (mean) (*lunar distance*)	LD or $\Delta_{\oplus L}$	3.85×10^8 m	
Sun			
Mass	$M_\odot$	1.988×10^{30} kg	
Radius	$R_\odot$	6.957×10^8 m	

Conversion factors

1 kcal = 4184 J
1 kWh = 3.6 MJ
1 u = 1 Da = 1.6605×10^{-27} kg
1 bar = 100 kPa = 760 Torr
1 L = 1000 cm^3 = 10^{-3} m^3
π rad = 180º