

# Physics 11 Formulas

## Fundamental Constants and Equations

### 1 Physics Formulas

#### 1.1 CH1,2,3: Kinematics

$\vec{v} = \frac{\Delta \vec{d}}{\Delta t}$	$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$	$v_f = v_i + at$
$d = \left(\frac{v_i + v_f}{2}\right) t$	$d = v_i t + \frac{1}{2}at^2$	$v_f^2 = v_i^2 + 2ad$
$d = d_0 + \bar{v}t$	$\bar{v} = \frac{v_0 + v_f}{2}$	$v = v_0 + at$
$d = d_0 + v_0 t + \frac{1}{2}at^2$	$a = \frac{2d}{t^2}$ (if $d_0 = v_0 = 0$ )	$v^2 = v_0^2 + 2a(d - d_0)$

#### 1.2 CH4,5,6: Dynamics, Projectile Motion, and Rotational Motion

##### 1.2.1 Newton's Laws and Forces (CH4.1-4.4)

First Law:	$\mathbf{F}_{\text{net}} = 0$ or $\Sigma \mathbf{F} = 0$	(equilibrium)
Second Law:	$\vec{F}_{\text{net}} = m\vec{a}$	$\mathbf{W} = m\mathbf{g}$
Forces:	$F_g = G \frac{m_1 m_2}{r^2}$	$F_f = \mu F_N$
$F_s = k\Delta x$	$\mathbf{N} = m\mathbf{g}$ (horizontal)	$\mathbf{T} = m\mathbf{g}$ (at rest)

##### 1.2.2 Projectile Motion (CH5.1-5.3)

$$h = \frac{v_{0y}^2}{2g} \qquad R = \frac{v_0^2 \sin 2\theta_0}{g}$$

##### 1.2.3 Rotational Motion (CH6.1-6.2)

Angle & Angular Velocity:	$\Delta\theta = \frac{\Delta s}{r}$	$\omega = \frac{\Delta\theta}{\Delta t}$
Tangential Speed:	$v = r\omega$	
Centripetal Motion:	$\mathbf{a}_c = \frac{v^2}{r} = r\omega^2$	$\mathbf{F}_c = m\frac{v^2}{r} = mr\omega^2$

## 1.3 CH8: Momentum

Linear momentum	$\mathbf{p} = m\mathbf{v}$
Impulse-momentum theorem	$\Delta\mathbf{p} = \mathbf{F}_{\text{net}}\Delta t$
Conservation of momentum	$\mathbf{p}_{\text{tot}} = \text{constant, or } \mathbf{p}_{\text{tot}} = \mathbf{p}'_{\text{tot}}$
Elastic collision (1D)	$m_1\mathbf{v}_1 + m_2\mathbf{v}_2 = m_1\mathbf{v}'_1 + m_2\mathbf{v}'_2$
2D collision (x-axis)	$m_1\mathbf{v}_1 = m_1\mathbf{v}'_1 \cos \theta_1 + m_2\mathbf{v}'_2 \cos \theta_2$
Angular momentum	$\mathbf{L} = I\omega$

## 1.4 CH9: Work, Energy, and Power

### 1.4.1 Work, Power, and Work-Energy Theorem

Kinetic Energy:	$KE = \frac{1}{2}m\mathbf{v}^2$
Work:	$W = \mathbf{f}d$
Power:	$P = \frac{W}{t}$
Work Equivalencies:	$W = PE_e = \Delta KE = \mathbf{f}m\mathbf{g} = \frac{1}{2}m\mathbf{v}_2^2 - \frac{1}{2}m\mathbf{v}_1^2$

### 1.4.2 Conservation of Energy

$$KE_1 + PE_1 = KE_2 + PE_2$$

### 1.4.3 Simple Machines

General IMA: $IMA = \frac{\mathbf{F}_r}{\mathbf{F}_e} = \frac{d_e}{d_r}$	Lever IMA: $IMA = \frac{L_e}{L_r}$	Wheel and Axle IMA: $IMA = \frac{R}{r}$
Inclined Plane IMA: $IMA = \frac{L}{h}$	Wedge IMA: $IMA = \frac{L}{t}$	Pulley IMA: $IMA = N$
Screw IMA: $IMA = \frac{2\pi L}{P}$	Input Work: $W_i = \mathbf{F}_i d_i$	Output Work: $W_o = \mathbf{F}_o d_o$
Efficiency: % efficiency = $\frac{W_o}{W_i} \times 100$		

## 1.5 CH11: Thermal Physics

### 1.5.1 Temperature and Thermal Energy

C → F: $T_F^\circ = \frac{9}{5}T_C^\circ + 32$	C → K: $T_K = T_C^\circ + 273.15$	F → K: $T_K = \frac{5}{9}(T_F^\circ - 32) + 273.15$
F → C: $T_C^\circ = \frac{5}{9}(T_F^\circ - 32)$	K → C: $T_C^\circ = T_K - 273.15$	K → F: $T_F^\circ = \frac{9}{5}(T_K - 273.15) + 32$

### 1.5.2 Heat, Specific Heat, and Heat Transfer

$$\text{Heat Transfer: } Q = mc\Delta T$$

$$\text{Density: } \rho = \frac{m}{V}$$

### 1.5.3 Phase Change and Latent Heat

$$\text{Heat Transfer (Melting/Freezing): } Q = mL_f$$

$$\text{Heat Transfer (Vaporization/Condensation): } Q = mL_v$$

## 1.6 CH12: Laws of Thermodynamics

$$\text{First Law: } \Delta U = Q - W$$

$$\text{Pressure: } P = \frac{F}{A}$$

$$\text{P-V Work: } W = P\Delta V$$

$$\text{Ideal Gas Law: } PV = NkT$$

$$\text{Entropy Change: } \Delta S = \frac{Q}{T}$$

$$\text{Heat Engine Efficiency: } Eff = \frac{W}{Q_h}$$

$$\text{Cyclical Work: } W = Q_h - Q_c$$

## 1.7 CH5.5: Simple Harmonic Motion

$$\vec{F} = -k\vec{x} \text{ (Hooke's Law)}$$

$$T = 2\pi\sqrt{\frac{m}{k}}, \quad f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$T = 2\pi\sqrt{\frac{L}{g}} \text{ (Simple Pendulum)}$$

## 1.8 CH13-14: Waves and Sound

$$v = f\lambda, \quad T = \frac{1}{f}, \quad f = \frac{1}{T}$$

$$I = \frac{P}{A}, \quad I = \frac{(\Delta p)^2}{2\rho v_w}, \quad \beta \text{ (dB)} = 10 \log_{10} \left( \frac{I}{I_0} \right)$$

$$f_{obs} = f_s \left( \frac{v_w}{v_w \pm v_s} \right) \text{ (moving source)}$$

$$f_{obs} = f_s \left( \frac{v_w \pm v_{obs}}{v_w} \right) \text{ (moving observer)}$$

$$f_B = |f_1 - f_2| \text{ (beat frequency)}$$

$$f_n = n \frac{v}{4L}, \quad n = 1, 3, 5... \text{ (closed pipe)}$$

$$f_n = n \frac{v}{2L}, \quad n = 1, 2, 3... \text{ (open pipe)}$$

## 1.9 CH18: Electric Fields and Potential

$$\text{Coulomb's Law: } F = \frac{kq_1q_2}{r^2}$$

$$\vec{E} = \frac{\vec{F}}{q_{\text{test}}}, \quad E = \frac{k|Q|}{r^2}$$

$$\Delta U_E = -qE(x_f - x_i)$$

$$U_E = \frac{kQq}{r}$$

$$\Delta V = -E(x_f - x_i)$$

$$V = \frac{kQ}{r}$$

$$C = \frac{Q}{V}, \quad U_E = \frac{1}{2}CV^2$$

$$C = \kappa\epsilon_0 \frac{A}{d}$$

## 1.10 CH19: Current, Resistance, and Circuits

$$I = \frac{\Delta Q}{\Delta t}, \quad 1 \text{ A} = 1 \text{ C/s}$$

$$\text{Ohm's Law: } V = IR$$

$$\text{Series: } R_{\text{equiv}} = R_1 + R_2 + \cdots + R_N$$

$$\text{Parallel: } R_{\text{equiv}} = \frac{1}{1/R_1 + 1/R_2 + \cdots + 1/R_N}$$

$$P = IV$$

$$P = I^2 R = \frac{V^2}{R}$$

## 2 Mathematical Formulas

### 2.1 Right-angled Triangles

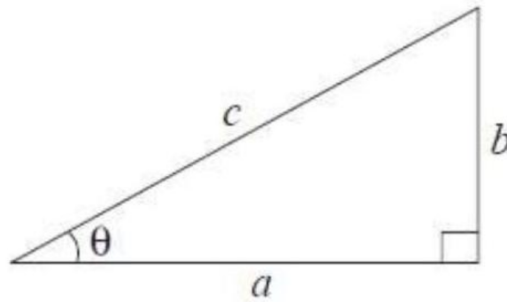


Figure 1: Right-angled triangle

$$a^2 + b^2 = c^2$$

$$\sin \theta = \frac{b}{c}$$

$$\cos \theta = \frac{a}{c}$$

$$\tan \theta = \frac{b}{a}$$

$$\text{area} = \frac{1}{2}ab$$

### 2.2 All Triangles

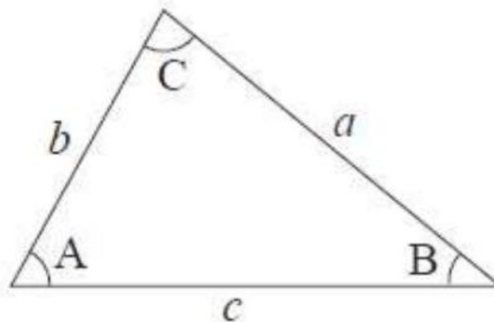


Figure 2: Non-Right-angled triangle

$$\text{area} = \frac{1}{2} \text{base} \times \text{height}$$

$$\text{Sine Law: } \frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$\text{Cosine Law: } c^2 = a^2 + b^2 - 2ab \cos C$$

### 2.3 Circle and Sphere

$$\text{Circle circumference: } 2\pi r$$

$$\text{Circle area: } \pi r^2$$

$$\text{Sphere surface area: } 4\pi r^2$$

$$\text{Sphere volume: } \frac{4}{3}\pi r^3$$

### 2.4 Quadratic Equation

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

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

### 3 Metric Prefixes and Cardinal Directions

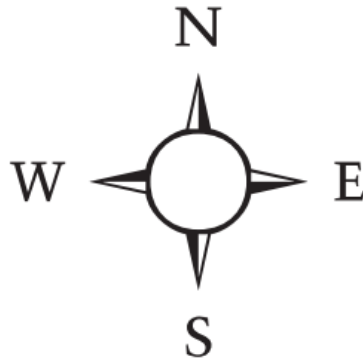


Figure 3: Cardinal directions: North, South, East, and West

Prefix	Symbol	Numerical	Exponential
mega	M	1000000	$10^6$
kilo	k	1000	$10^3$
hecto	h	100	$10^2$
deca	da	10	$10^1$
		1	$10^0$
deci	d	0.1	$10^{-1}$
centi	c	0.01	$10^{-2}$
milli	m	0.001	$10^{-3}$
micro	$\mu$	0.000001	$10^{-6}$

### 4 Fundamental Constants and Physical Data

Gravitational constant:  $G = 6.67 \times 10^{-11} \text{Nm}^2/\text{kg}^2$

Coulomb's Law constant:  $k = 9.00 \times 10^9 \text{Nm}^2/\text{C}^2$

Elementary charge:  $e = 1.60 \times 10^{-19} \text{C}$

Electron mass:  $m_e = 9.11 \times 10^{-31} \text{kg}$

Proton mass:  $m_p = 1.67 \times 10^{-27} \text{kg}$

Permeability of free space:  $\mu_0 = 4\pi \times 10^{-7} \text{Tm/A}$

Speed of light:  $c = 3.00 \times 10^8 \text{m/s}$

## 4.1 Earth

Radius:	$6.38 \times 10^6 \text{m}$	Mass:	$5.98 \times 10^{24} \text{kg}$
Surface gravity:	$g = 9.81 \text{m/s}^2$	Rotation period:	$8.61 \times 10^4 \text{s}$
Orbit radius (Sun):	$1.50 \times 10^{11} \text{m}$	Orbit period (Sun):	$3.16 \times 10^7 \text{s}$

## 4.2 Moon

Radius:	$1.74 \times 10^6 \text{m}$	Mass:	$7.35 \times 10^{22} \text{kg}$
Rotation period:	$2.36 \times 10^6 \text{s}$	Orbit radius (Earth):	$3.84 \times 10^8 \text{m}$
Orbit period (Earth):	$2.36 \times 10^6 \text{s}$	Surface gravity:	$1.67 \text{m/s}^2$

## 4.3 Sun

Mass:  $1.98 \times 10^{30} \text{kg}$