Physics 11 Formulas

Fundamental Constants and Equations

1 Physics Formulas

1.1 CH1,2,3: Kinematics

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

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

1.2.2 Projectile Motion (CH5.1-5.3)

$$h = \frac{\mathbf{v}_{0y}^2}{2\mathbf{g}} \qquad R = \frac{\mathbf{v}_0^2 \sin 2\theta_0}{\mathbf{g}}$$

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:	$\mathbf{a}_\mathrm{c} = \frac{v^2}{r} = r\omega^2$	$\mathbf{F}_\mathrm{c} = m\frac{v^2}{r} = mr\omega^2$

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	$\mathbf{p}_{\text{tot}} = \text{constant},\ \text{or}\ \mathbf{p}_{\text{tot}} = \mathbf{p}'_{\text{tot}}$
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: $\%\ \text{efficiency} = \frac{W_o}{W_i} \times 100$

1.5 CH11: Thermal Physics

1.5.1 Temperature and Thermal Energy

C $\to$ F:
$T_{\text{F}}^\circ = \frac{9}{5}T_{\text{C}}^\circ + 32$

C $\to$ K:
$T_{\text{K}} = T_{\text{C}}^\circ + 273.15$

F $\to$ K:
$T_{\text{K}} = \frac{5}{9}(T_{\text{F}}^\circ - 32) + 273.15$

F $\to$ C:
$T_{\text{C}}^\circ = \frac{5}{9}(T_{\text{F}}^\circ - 32)$

K $\to$ C:
$T_{\text{C}}^\circ = T_{\text{K}} - 273.15$

K $\to$ F:
$T_{\text{F}}^\circ = \frac{9}{5}(T_{\text{K}} - 273.15) + 32$

1.5.2 Heat, Specific Heat, and Heat Transfer

Heat Transfer: $Q = mc\Delta T$

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

1.5.3 Phase Change and Latent Heat

Heat Transfer (Melting/Freezing): $Q = mL_f$

Heat Transfer (Vaporization/Condensation): $Q = mL_v$

1.6 CH12: Laws of Thermodynamics

First Law: $\Delta U = Q - W$

Pressure: $P = \dfrac{F}{A}$

P-V Work: $W = P\Delta V$

Ideal Gas Law: $PV = NkT$

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

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

Cyclical Work: $W = Q_h - Q_c$

1.7 CH5.5: Simple Harmonic Motion

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

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

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

1.8 CH13-14: Waves and Sound

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

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

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

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

$f_B = |f_1 - f_2|$ (beat frequency)

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

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

1.9 CH18: Electric Fields and Potential

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

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

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

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

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

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

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

$C = \kappa\varepsilon_0\frac{A}{d}$

1.10 CH19: Current, Resistance, and Circuits

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

Ohm's Law: $V = IR$

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

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

$P = IV$

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

2 Mathematical Formulas

2.1 Right-angled Triangles

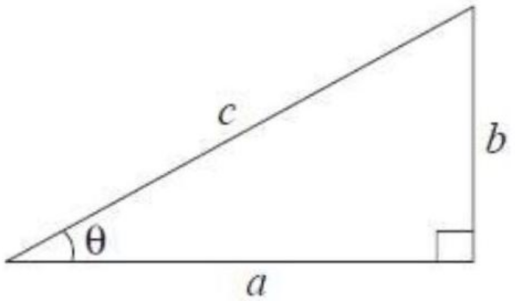

Figure 1: Right-angled triangle

$a^2 + b^2 = c^2$ $\quad \sin\theta = \frac{b}{c}$ $\quad \cos\theta = \frac{a}{c}$

$\tan\theta = \frac{b}{a}$ $\quad$ area $= \frac{1}{2}ab$

2.2 All Triangles

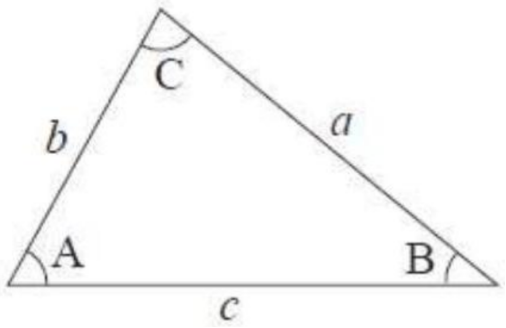

Figure 2: Non-Right-angled triangle

area $= \frac{1}{2}$base $\times$ height $\quad$ Sine Law: $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$

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

2.3 Circle and Sphere

Circle circumference: $2\pi r$ $\quad$ Circle area: πr^2 $\quad$ Sphere surface area: $4\pi r^2$

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

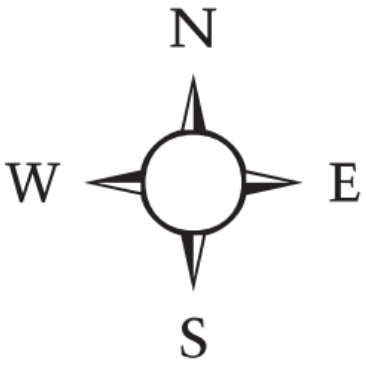

Figure 3: Cardinal directions: North, South, East, and West

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

4.2 Moon

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

4.3 Sun

Mass: 1.98×10^{30}kg