

0.1: Physical Constants

Speed of light	c	$3 \times 10^8 \text{ m/s}$
Planck constant	h	$6.63 \times 10^{-34} \text{ J s}$
	hc	1242 eV-nm
Gravitation constant	G	$6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$
Boltzmann constant	k	$1.38 \times 10^{-23} \text{ J/K}$
Molar gas constant	R	8.314 J/(mol K)
Avogadro's number	N_A	$6.023 \times 10^{23} \text{ mol}^{-1}$
Charge of electron	e	$1.602 \times 10^{-19} \text{ C}$
Permeability of vacuum	μ_0	$4\pi \times 10^{-7} \text{ N/A}^2$
Permittivity of vacuum	ϵ_0	$8.85 \times 10^{-12} \text{ F/m}$
Coulomb constant	$\frac{1}{4\pi\epsilon_0}$	$9 \times 10^9 \text{ N m}^2/\text{C}^2$
Faraday constant	F	96485 C/mol
Mass of electron	m_e	$9.1 \times 10^{-31} \text{ kg}$
Mass of proton	m_p	$1.6726 \times 10^{-27} \text{ kg}$
Mass of neutron	m_n	$1.6749 \times 10^{-27} \text{ kg}$
Atomic mass unit	u	$1.66 \times 10^{-27} \text{ kg}$
Atomic mass unit	u	$931.49 \text{ MeV}/c^2$
Stefan-Boltzmann constant	σ	$5.67 \times 10^{-8} \text{ W/(m}^2 \text{ K}^4)$
Rydberg constant	R_∞	$1.097 \times 10^7 \text{ m}^{-1}$
Bohr magneton	μ_B	$9.27 \times 10^{-24} \text{ J/T}$
Bohr radius	a_0	$0.529 \times 10^{-10} \text{ m}$
Standard atmosphere	atm	$1.01325 \times 10^5 \text{ Pa}$
Wien displacement constant	b	$2.9 \times 10^{-3} \text{ m K}$

1.1: Vectors

Notation: $\vec{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k}$

Magnitude: $a = |\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$

Dot product: $\vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z = ab \cos \theta$

Cross product:



$$\vec{a} \times \vec{b} = (a_y b_z - a_z b_y) \hat{i} + (a_z b_x - a_x b_z) \hat{j} + (a_x b_y - a_y b_x) \hat{k}$$

$$|\vec{a} \times \vec{b}| = ab \sin \theta$$

1.2: Kinematics

Average and Instantaneous Vel. and Accel.:

$$\vec{v}_{av} = \Delta \vec{r} / \Delta t$$

$$\vec{v}_{inst} = d\vec{r}/dt$$

$$\vec{a}_{av} = \Delta \vec{v} / \Delta t$$

$$\vec{a}_{inst} = d\vec{v}/dt$$

Motion in a straight line with constant a :

$$v = u + at, \quad s = ut + \frac{1}{2}at^2, \quad v^2 - u^2 = 2as$$

Relative Velocity: $\vec{v}_{A/B} = \vec{v}_A - \vec{v}_B$

Projectile Motion:



$$x = ut \cos \theta, \quad y = ut \sin \theta - \frac{1}{2}gt^2$$

$$y = x \tan \theta - \frac{g}{2u^2 \cos^2 \theta} x^2$$

$$T = \frac{2u \sin \theta}{g}, \quad R = \frac{u^2 \sin 2\theta}{g}, \quad H = \frac{u^2 \sin^2 \theta}{2g}$$

1.3: Newton's Laws and Friction

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

Newton's first law: inertial frame.

Newton's second law: $\vec{F} = \frac{d\vec{p}}{dt}$, $\vec{F} = m\vec{a}$

Newton's third law: $\vec{F}_{AB} = -\vec{F}_{BA}$

Frictional force: $f_{static, max} = \mu_s N$, $f_{kinetic} = \mu_k N$

Banking angle: $\frac{v^2}{rg} = \tan \theta$, $\frac{v^2}{rg} = \frac{\mu + \tan \theta}{1 - \mu \tan \theta}$

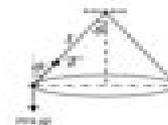
Centripetal force: $F_c = \frac{mv^2}{r}$, $a_c = \frac{v^2}{r}$

Pseudo force: $\vec{F}_{pseudo} = -m\vec{a}_0$, $F_{centrifugal} = -\frac{mv^2}{r}$

Minimum speed to complete vertical circle:

$$v_{min, bottom} = \sqrt{5gl}, \quad v_{min, top} = \sqrt{gl}$$

Conical pendulum: $T = 2\pi \sqrt{\frac{l \cos \theta}{g}}$



1.4: Work, Power and Energy

Work: $W = \vec{F} \cdot \vec{S} = FS \cos \theta$, $W = \int \vec{F} \cdot d\vec{S}$

Kinetic energy: $K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$

Potential energy: $F = -\partial U / \partial x$ for conservative forces.

$$U_{gravitational} = mgh, \quad U_{spring} = \frac{1}{2}kx^2$$

Work done by conservative forces is path independent and depends only on initial and final points: $\oint \vec{F}_{conservative} \cdot d\vec{r} = 0$.

Work-energy theorem: $W = \Delta K$

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SJ Ball



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