CHEAT SHEETS HERO

# Physics Fundamentals Cheatsheet

A concise reference guide to fundamental concepts, formulas, and principles in Physics. Ideal for students and professionals seeking a quick review.

## Mechanics

### Kinematics

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|---|---|
| Displacement ($\Delta x$) | $\Delta x = x_f - x_i$ (final position - initial position) |
| Average Velocity ($v_{avg}$) | $v_{avg} = \frac{\Delta x}{\Delta t}$ (displacement / time) |
| Average Acceleration ($a_{avg}$) | $a_{avg} = \frac{\Delta v}{\Delta t}$ (change in velocity / time) |
| Final Velocity ($v_f$) (constant acceleration) | $v_f = v_i + at$ (initial velocity + acceleration * time) |
| Displacement ($\Delta x$) (constant acceleration) | $\Delta x = v_i t + \frac{1}{2}at^2$ |
| Final Velocity Squared ($v_f^2$) (constant acceleration) | $v_f^2 = v_i^2 + 2a\Delta x$ |
| Position (x) as a function of time (t) | $x(t) = x_0 + v_0t + (1/2)at^2$ |
| Average Speed | Total distance traveled / Total time |

### Dynamics

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| Newton's First Law (Inertia) | An object at rest stays at rest, and an object in motion stays in motion with the same speed and in the same direction unless acted upon by a force. |
| Newton's Second Law | $F = ma$ (Force = mass * acceleration) |
| Newton's Third Law | For every action, there is an equal and opposite reaction. |
| Weight (W) | $W = mg$ (mass * acceleration due to gravity) |
| Frictional Force ($F_f$) | $F_f = \mu F_N$ (coefficient of friction * normal force) |
| Static Friction | $F_s \le \mu_s F_N$ |
| Kinetic Friction | $F_k = \mu_k F_N$ |

### Work and Energy

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|---|---|
| Work (W) | $W = Fd \cos(\theta)$ (force * distance * cosine of the angle between them) |
| Kinetic Energy (KE) | $KE = \frac{1}{2}mv^2$ (1/2 * mass * velocity squared) |
| Potential Energy (PE) - Gravitational | $PE = mgh$ (mass * gravity * height) |
| Potential Energy (PE) - Spring | $PE = \frac{1}{2}kx^2$ (1/2 * spring constant * displacement squared) |
| Power (P) | $P = \frac{W}{\Delta t}$ (work / time) |
| Work-Energy Theorem | $W_{net} = \Delta KE$ |
| Conservation of Mechanical Energy (no non-conservative forces) | $KE_i + PE_i = KE_f + PE_f$ |
| Efficiency | $\frac{W_{out}}{W_{in}}$ |

## Thermodynamics

### Thermodynamic Definitions

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|---|---|
| Temperature (T) | A measure of the average kinetic energy of the particles in a system. |
| Heat (Q) | The transfer of energy between objects due to a temperature difference. |
| Internal Energy (U) | The total energy of all the molecules within a substance. |
| Specific Heat (c) | The amount of heat required to raise the temperature of 1 gram of a substance by 1 degree Celsius. |
| Latent Heat (L) | The heat required to cause a phase change (e.g., solid to liquid). |

### Laws of Thermodynamics

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| Zeroth Law | If two systems are each in thermal equilibrium with a third system, then they are in thermal equilibrium with each other. |
| First Law | $\Delta U = Q - W$ (change in internal energy = heat added - work done by the system) |
| Second Law | The entropy of an isolated system always increases or remains constant. Heat cannot spontaneously flow from a cold body to a hot body. |
| Third Law | The entropy of a system approaches a constant value as the temperature approaches absolute zero. |

### Heat Transfer

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|---|---|
| Conduction | $Q = \frac{kA\Delta T t}{L}$ (heat transfer through a material) |
| Convection | Heat transfer by the movement of a fluid. |
| Radiation | $Q = \epsilon \sigma A T^4 t$ (heat transfer by electromagnetic radiation) |
| Stefan-Boltzmann Constant | $\sigma = 5.67 \times 10^{-8}$ $W/m^2K^4$ |

## Electromagnetism

### Electrostatics

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|---|---|
| Coulomb's Law | $F = k \frac{\|q_1 q_2\|}{r^2}$ (force between two point charges) |
| Electric Field (E) | $E = \frac{F}{q}$ (force per unit charge) |
| Electric Potential (V) | $V = \frac{PE}{q}$ (potential energy per unit charge) |
| Electric Potential Energy (PE) | $PE = qV$ |
| Capacitance (C) | $C = \frac{Q}{V}$ (charge / voltage) |

### Magnetism

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|---|---|
| Magnetic Force on a Moving Charge | $F = qvB \sin(\theta)$ (charge * velocity * magnetic field * sine of the angle) |
| Magnetic Force on a Current-Carrying Wire | $F = ILB \sin(\theta)$ (current * length * magnetic field * sine of the angle) |
| Magnetic Field due to a Long Straight Wire | $B = \frac{\mu_0 I}{2 \pi r}$ |
| Permeability of Free Space | $\mu_0 = 4\pi \times 10^{-7} T \cdot m/A$ |

### Electromagnetic Induction

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|---|---|
| Faraday's Law | $\mathcal{E} = -N \frac{\Delta \Phi_B}{\Delta t}$ (induced emf = -number of turns * change in magnetic flux / time) |
| Magnetic Flux ($\Phi_B$) | $\Phi_B = BA \cos(\theta)$ (magnetic field * area * cosine of the angle) |

## Waves and Optics

## Wave Properties

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|---|---|
| Wave Speed (v) | $v = f\lambda$ (frequency * wavelength) |
| Period (T) | $T = \frac{1}{f}$ (1 / frequency) |
| Wave Number (k) | $k = \frac{2\pi}{\lambda}$ |

## Optics

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|---|---|
| Snell's Law | $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$ (refractive index * sine of the angle) |
| Index of Refraction (n) | $n = \frac{c}{v}$ (speed of light in vacuum / speed of light in the medium) |
| Critical Angle ($\theta_c$) | $\sin(\theta_c) = \frac{n_2}{n_1}$ (for total internal reflection, $n_1 > n_2$) |
| Lens Equation | $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ (focal length, object distance, image distance) |
| Magnification (M) | $M = - \frac{d_i}{d_o}$ |

## Interference and Diffraction

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|---|---|
| Constructive Interference (Double Slit) | $d \sin(\theta) = m \lambda$ (path difference = integer * wavelength) |
| Destructive Interference (Double Slit) | $d \sin(\theta) = (m + \frac{1}{2}) \lambda$ |