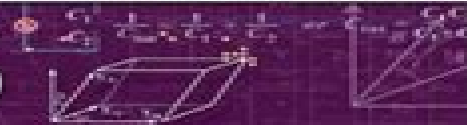




# PHYSICS



## WHAT IS PHYSICS ALL ABOUT?

Physics seeks to understand the natural phenomena that occur in our universe; a description of a natural phenomenon uses many specific terms, definitions and mathematical equations.

### Solving Problems in Physics

In physics, we use the SI units (International System) for data and calculations.

Base Quantity	Symbol	Unit
Length	$L, x$	Meter - m
Mass	$m, M$	Kilogram - kg
Temperature	$T$	Kelvin - K
Time	$t$	Second - s
Electric Current	$I$	Ampere - A (C/s)

Other physical quantities are derived from these basic units. Fractions denote fractions or multiples of units; many variable symbols are Greek letters.

**Math Skills:** Many physical concepts are only understood with the use of algebra, statistics, trigonometry and calculus.

## CLASSICAL MECHANICS

**A. Classical or Newtonian Mechanics:** The position of a body is given by an equation of motion with position, velocity and acceleration as variables; mass is the measure of the amount of matter; the standard unit for mass is kg,  $1 \text{ kg} = 1000 \text{ g}$ ; inertia is a property of matter, and as such, it occupies space.

1. Motion along a straight line is called rectilinear; the equation of motion describes the position of the particle and velocity for elapsed time,  $t$ .

a. **Velocity ( $v$ ):** The rate of change of the displacement

$$(x) \text{ with time } (t): v = \frac{dx}{dt} = \frac{\Delta x}{\Delta t}$$

b. **Acceleration ( $a$ ):** The rate of change of the velocity with time:  $a = \frac{dv}{dt} = \frac{\Delta v}{\Delta t}$

$a$  &  $v$  are vectors, with magnitude and direction.

c. **Speed** is the absolute value of the velocity; scalar with the same units as velocity.

### 2. Equations of Motion for One Dimension (1-D)

Equations of motion describe the future position ( $x$ ) and velocity ( $v$ ) of a body in terms of the initial velocity ( $v_0$ ), position ( $x_0$ ) and acceleration ( $a$ ).

a. For constant acceleration, the position is related to the time and acceleration by the following equation of motion:  $x(t) = x_0 + v_0 t + \frac{1}{2} a t^2$

b. For constant acceleration, the velocity vs. time is given by the following:  $v_1(t) = v_0 + a t$

c. If the acceleration is a function of time, the equation must be solved using  $a = a(t)$ .

### B. Motion in Two Dimensions (2-D)

1. For bodies moving along a straight line, derive  $x$ - and  $y$ -equations of motion

$$x = v_{x0} t + \frac{1}{2} a_x t^2$$

$$y = v_{y0} t + \frac{1}{2} a_y t^2$$

2. For a rotating body, use polar coordinates, an angle variable,  $\theta$ , and  $r$ , a radial distance from the rotational center.



$$\begin{aligned} \text{Polar: } (r, \theta) \\ x &= r \cos \theta \\ y &= r \sin \theta \\ r^2 &= x^2 + y^2 \end{aligned}$$

### C. Motion in Three Dimensions (3-D)

1. **Cartesian System:** Equations of motion with  $x$ ,  $y$  and  $z$  components.

2. **Spherical Coordinates:** Equations of motion based on two angles ( $\theta$  and  $\phi$ ) and  $r$ , the radial distance from the origin.



$$\begin{aligned} x &= r \sin \theta \cos \phi \\ y &= r \sin \theta \sin \phi \\ z &= r \cos \theta \\ r^2 &= x^2 + y^2 + z^2 \end{aligned}$$

### D. Newton's Laws of Motion

Newton's Laws are the core principles for describing the motion of classical objects in response to forces. The SI unit of force is the Newton, N;  $1 \text{ N} = 1 \text{ kg m/s}^2$ , the cgs unit is the dyne;  $1 \text{ dyne} = 1 \text{ g cm/s}^2$

1. **Newton's 1st Law:** A body remains at rest or in motion unless influenced by a force.

2. **Newton's 2nd Law:** Force and acceleration determine the motion of a body and predict future position and velocity:  $F = m a$  OR  $\Sigma F = m a$

3. **Newton's 3rd Law:** Every action is countered by an opposing action.

### E. Types of Forces

1. A body force acts on the entire body, with the force acting at the center of mass.

a. A gravitational force,  $F_g$ , pulls an object toward the center of the Earth;  $F_g = m g$

b. **Weight** =  $F_g$ ; gravitational force

c. Mass is a measure of the quantity of material, independent of  $g$  and other forces.

2. **Surface forces** act on the body's surface.

a. **Friction,  $F_f$ ,** is proportional to the force normal to the part of the body in contact with a surface.  $F_f = F_N = \mu F_N$

i. **Static friction** resists the move-ment of a body

ii. **Dynamic friction** slows the motion of a body

For an object on a horizontal plane:

$$F_f = \mu F_N = \mu m g$$

$$\text{Net force} = F_A - F_f$$



### F. Circular Motion

1. Motion along a circular path uses polar coordinates:  $(r, \theta)$

2. **Key Variables:**

$r$	Meter	The distance from the rotation center (center of mass)
$\theta$	Radian	The angle between $r$ and the ( $x$ ) axis
$\omega$	Radian/second	The angular velocity
$\alpha$	Radian/second <sup>2</sup>	The angular acceleration
$s$	Meter	The circular motion arc $s = r\theta$ ( $\theta$ in rad)

3. **Tangential acceleration & velocity:**

$$v_t = r \omega; a_t = r \alpha; v \text{ and } a \text{ along the path of the motion are}$$

4. **Centripetal acceleration:**  $a_c = \frac{v^2}{r}$ ;  $a$  is directed toward the rotational center

a. The centripetal force keeps the body in circular motion with a tangential acceleration and velocity.

### G. Kinetic Energy & Work

1. **Kinetic energy,  $K$ :** Kinetic energy is the energy of motion; mass,  $m$  and velocity,  $v$ ;  $K = \frac{1}{2} m v^2$

The SI energy unit is the Joule (J);  $1 \text{ J} = 1 \text{ kg m}^2/\text{s}^2$

2. **Momentum,  $p$ :** Momentum is a property of motion, defined as the product of mass and velocity:  $p = m v$

3. **Work ( $W$ ):** Work is a force acting on a body moving a distance; for a general force,  $F$ , and a body moving a path,  $s$ ;  $W = \int F ds$

For a constant force, work is the scalar product of the two vectors: force,  $F$ , and path,  $r$ :

$$W = F d \cos(\theta) = F \cdot r$$



4. **Power ( $P$ ):** energy expended per unit time:  $P = \frac{d \text{Work}}{d \text{time}} = \frac{d \text{Work}}{dt}$

$$\text{Work} = \int P(t) dt$$

The SI unit for power is the Watt (W);  $1 \text{ W} = 1 \text{ Joule/second} = 1 \text{ J/s}$

Work for a constant output of power:  $W = P \Delta t$

### H. Potential Energy & Energy Conservation

1. The total energy of a body,  $E$ , is the sum of kinetic,  $K$ , & potential energy,  $U$ ;  $E = K + \Sigma U$

2. **Potential energy** arises from the interaction with a potential from an external force.

Potential energy is energy of position;  $U(r)$ ; the form of  $U$  depends on the force generating the potential:

**Gravitation:**  $U(h) = m g h$

**Electrostatic:**  $U(r_{12}) = \frac{q_1 q_2}{r_{12}}$

If there are no other forces acting on the system,  $E$  is constant and the system is called **conservative**.

### I. Collisions & Linear Momentum

1. **Types of Collisions:**

a. **Elastic** conserve energy

b. **Inelastic:** energy is lost as heat or deformation.

2. **Relative Motion & Frames of Reference:** A body moves with velocity  $v$  in frame  $S$ ; in frame  $S'$  the velocity is  $v'$ ; if  $V_{S'}$  is the velocity of frame  $S'$  relative to  $S$ , therefore:  $v = V_{S'} + v'$

3. **Elastic Collision:**

Conserve Kinetic Energy:  $\Sigma \frac{1}{2} m v^2 = \Sigma \frac{1}{2} m v'^2$

Conserve Momentum:  $\Sigma m v_i = \Sigma m v_f$

4. **Impulse** is a force acting over time

Impulse =  $F \Delta t$  or  $\int F(t) dt$

Impulse is also the momentum change:  $p_{\text{fin}} - p_{\text{ini}}$

# Study Guide Physics And Problems

**John D. Cutnell**



## **Study Guide Physics And Problems:**

*A Guide to Physics Problems* Sidney B. Cahn, Boris E. Nadgorny, 1994-08-31 In order to equip hopeful graduate students with the knowledge necessary to pass the qualifying examination the authors have assembled and solved standard and original problems from major American universities Boston University University of Chicago University of Colorado at Boulder Columbia University of Maryland University of Michigan Michigan State Michigan Tech MIT Princeton Rutgers Stanford Stony Brook University of Wisconsin at Madison and Moscow Institute of Physics and Technology A wide range of material is covered and comparisons are made between similar problems of different schools to provide the student with enough information to feel comfortable and confident at the exam *Guide to Physics Problems* is published in two volumes this book Part 1 covers Mechanics Relativity and Electrodynamics Part 2 covers Thermodynamics Statistical Mechanics and Quantum Mechanics Praise for *A Guide to Physics Problems* Part 1 Mechanics Relativity and Electrodynamics Sidney Cahn and Boris Nadgorny have energetically collected and presented solutions to about 140 problems from the exams at many universities in the United States and one university in Russia the Moscow Institute of Physics and Technology Some of the problems are quite easy others are quite tough some are routine others ingenious From the Foreword by C N Yang Nobelist in Physics 1957 Generations of graduate students will be grateful for its existence as they prepare for this major hurdle in their careers R Shankar Yale University The publication of the volume should be of great help to future candidates who must pass this type of exam J Robert Schrieffer Nobelist in Physics 1972 I was positively impressed The book will be useful to students who are studying for their examinations and to faculty who are searching for appropriate problems M L Cohen University of California at Berkeley If a student understands how to solve these problems they have gone a long way toward mastering the subject matter Martin Olsson University of Wisconsin at Madison This book will become a necessary study guide for graduate students while they prepare for their Ph D examination It will become equally useful for the faculty who write the questions G D Mahan University of Tennessee at Knoxville **Physics Study Guide** McGraw-Hill/Glencoe, 1998-02 Study Guide and Reinforcement Worksheets allow for differentiated instruction through a wide range of question formats There are worksheets and study tools for each section of the text that help teachers track students progress toward understanding concepts Guided Reading Activities help students identify and comprehend the important information in each chapter **Glencoe Physics**, 1999 **A Guide to Physics Problems** Sidney B. Cahn, Boris E. Nadgorny, 1994

**Physics, Study Guide** John D. Cutnell, Kenneth W. Johnson, 1992-02-26 This Second Edition designed for a one year course in college physics includes the following new features Integration of Concepts explores the common ground between fundamental ideas in the current chapter and previous ones Problem Solving Insight provides reinforcement and emphasizes issues that students need to recognize as important and a reasoning step which appears before numerical solutions in each example Enhanced by hundreds of applications to biology medicine architecture and technology Worked out examples and

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**Physics, 11th Edition Student Study Guide** John D. Cutnell, 2018-01-23 The Student Study Guide to accompany Physics 11E contains chapter summaries and quick references to important equations and key chapter terms with definitions provided [Student Study Guide for University Physics Volumes 2 And 3 \(Chs. 21-44\)](#) Hugh D. Young, Laird Kramer, Roger A. Freedman, 2011-08 The Student Study Guide summarizes the essential information in each chapter and provides additional problems for the student to solve reinforcing the text's emphasis on problem solving strategies and student misconceptions

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