QuickStudy ACADEMIC

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: **Prefixes** 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 kg = 1000 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) 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_o), position (x_o) and acceleration (a)
   a. For constant acceleration, the position is related to the time and acceleration by the following equation of motion: $x(t) = x_o + v_o t + \frac{1}{2} a t^2$
   b. For constant acceleration, the velocity vs. time is given by the following: $v_x(t) = v_x + a t$
   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
 $x = v_x t + \frac{1}{2} a_x t^2$
   $y = v_y t + \frac{1}{2} a_y t^2$
2. For a **rotating body**, use **polar coordinates**, an angle variable, θ, and r, a radial distance from the rotational center

Polar: (r, θ)
$x = r \cos\theta$
$y = r \sin\theta$
$r^2 = x^2 + y^2$

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 (θ and φ) and r, the radial distance from the origin

Spherical
$x = r \sin\theta \cos\phi$
$y = r \sin\theta \sin\phi$
$z = r \cos\theta$
$r^2 = x^2 + y^2 + z^2$
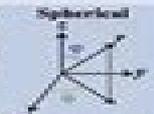
D. Newton's Laws of Motion
Newton's Laws are the core principles for describing the motion of classical objects in response to forces. The SI unit of force is the Newton, N: $1N = 1kg \cdot m/s^2$; the cgs unit is the **dyne**; 1 dyne = 1g cm/s²

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: $\mathbf{F} = m\,\mathbf{a}$ OR $\sum \mathbf{F} = m\,\mathbf{a}$
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: $\mathbf{F_g} = m\mathbf{g}$
   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 movement of a body
      ii. **Dynamic friction** slows the motion of a body
      For an object on a **horizontal plane:**
      $F_f = \mu F_N = \mu m g$
      Net force = $F_a - F_f$

Dynamic Friction

Circular Motion

F. Circular Motion
1. Motion along a circular path uses polar coordinates: (r, θ)
2. **Key Variables:**

r	Meter	The distance from the rotation center (center of mass)
θ	Radian	The angle between r and the (x) axis
ω	Radian/second	The angular velocity
α	Radian/second²	The angular acceleration
s	Meter	The circular motion arc $s = r\theta$ (θ in rad)

3. **Tangential** acceleration & velocity:
   $v_t = r\omega$, $a_t = r\alpha$; v and a 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: $K = \frac{1}{2}mv^2$
   The SI energy unit is the **Joule** (J):
   $1J = 1$ kg m²/s²
2. **Momentum, p:** Momentum is a property of motion, defined as the product of mass and velocity: $\mathbf{p} = m\,\mathbf{v}$
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:
   $W = \mathbf{F} \cdot \mathbf{d} \cos(\theta) = \mathbf{F} \cdot \mathbf{r}$

Maximum work | No work

4. **Power (P)** is energy expended per unit time: $P = \frac{\Delta Work}{\Delta time} = \frac{\Delta Work}{\Delta t}$
   $Work = \int P(t)\,dt$
   The SI unit for power is the **Watt (W):**
   $1 W = 1$ Joule/second = 1 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: $E = K + \sum U$
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: $U(h) = mgh$
   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; the velocity is v' in frame S'; if V_s' is the velocity of frame S' relative to S, therefore: $\mathbf{v} = \mathbf{V_s'} + \mathbf{v'}$
3. **Elastic Collision**
   Conserve Kinetic Energy: $\sum \frac{1}{2} m_i v_i^2 = \sum \frac{1}{2} m_i v_i'^2$
   Conserve Momentum: $\sum m_i v_i = \sum m_i v_i'$
4. **Impulse** is a force acting over time
   $Impulse = F \Delta t$ or $\int F(t) dt$
   Impulse is also the **momentum change:** $p_{final} - p_{initial}$

Collisions

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KJ Lindholm-Leary

Intro To Physics Study Guide:

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