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Physics (Quick Study Academic)

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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, s	Meter - m
Mass	m, M	Kilogram - kg
Temperature	T	Kelvin - K
Time	t	Second - s
Electric Current	I	Ampere - A (A/C)

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. Kinematics of 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 so is such, it resists change.

- Motion along a straight line is called **rectilinear**; the equation of motion describes the position of the particle and velocity for elapsed time, s .
- Velocity (V)**: The rate of change of the displacement (s) with time (t), $v = \frac{ds}{dt}$.
- Acceleration (a)**: The rate of change of the velocity with time, $a = \frac{dv}{dt}$.
- a & v are vectors, with magnitude and direction.
- Speed** is the absolute value of the velocity, scalar with the same units as velocity.

Equations of Motion for One Dimension (1-D)
Equations of motion describe the future position (s), velocity (v) of a body in terms of the initial velocity (u), position (s_0) and acceleration (a).

- For constant acceleration, the position is related to the time and acceleration by the following equation of motion: $s - s_0 = ut + \frac{1}{2}at^2$
- For constant acceleration, the velocity vs. time is given by the following: $v - u = at$
- If the acceleration is a function of time, the equation must be solved using $\int v = at$

B. Motion in Two Dimensions (2-D)

- Free bodies moving along a straight line, derive s - and v -equations of motion: $s = v_0t + \frac{1}{2}at^2$, $v = v_0 + at$
- For a rotating body, use **polar coordinates**, as angle variables, θ , and r , a radial distance from the rotational center.

C. Motion in Three Dimensions (3-D)

- Cartesian System:** Equations of motion with x , y and z components.
- Spherical Coordinate:** Equations of motion based on true angles (θ and ϕ) and r , the radial distance from the origin.

D. Newton's Laws of Motion
Newton's Laws are the basic 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: $F = ma$ OR $\Sigma F = ma$

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

E. Types of Forces

- A body force acts on the entire body, with the force acting at the center of mass.
 - A gravitational force, F_g , pulls an object toward the center of the Earth, $F_g = mg$.
 - Weight** = F_g , gravitational force.
 - Mass** is a measure of the quantity of material, independent of g and other forces.
- Surface forces** act on the body's surface.
 - Friction, F_f ,** is proportional to the force normal to the part of the body in contact with a surface, $F_f = \mu F_N$.
 - Static friction** resists the movement of a body.
 - Dynamic friction** shows the motion of a body. For an object on a horizontal plane: $F_f = \mu F_N = \mu mg$. Net force = $F - F_f$.

F. Circular Motion

- Motion along a circular path uses **polar coordinates** (r, θ).
- Key Variables:**

r	Radius	The distance from the rotation center (center of mass)
θ	Angle	The angle between r and the (x) axis
ω	Radian/second	The angular velocity
α	Radian/second ²	The angular acceleration
v	Meter	The circular motion arc, $s = R\theta$ (θ in rad)
- Tangential acceleration & velocity:** $v_t = r\omega$, $a_t = r\alpha$; v and a along the path of the motion are.
- Centripetal acceleration:** $a_c = \frac{v^2}{r}$, a_c is directed toward the rotational center.
 - The centripetal force keeps the body in circular motion with a tangential acceleration and velocity.

G. Kinetic Energy & Work

- 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): $1 \text{ J} = 1 \text{ kg m}^2/\text{s}^2$.
- Momentum, p ,** momentum is a property of motion, defined as the product of mass and velocity: $p = mv$.
- Work (W):** Work is a force acting on a body moving a distance; for a constant force, F , and a body moving a path, s , $W = F \cdot s$.

For a constant force, work is the scalar product of the two vectors: force, F , and path, s : $W = F \cdot s \cos(\theta) = F \cdot s$.

4. Power (P) is energy expended per unit time: $P = \frac{dW}{dt}$, $1 \text{ Watt} = 1 \text{ J/s}$. Work = $\int P dt$. 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: $W = P \cdot t$.

H. Potential Energy & Energy Conservation

- The total energy of a body, E , is the sum of kinetic, K , & potential energy, U : $E = K + U$.
- Potential energy** arises from the interaction with a potential from an external force. Potential energy is energy of position. (Unit, the form of U depends on the force producing the potential. Gravitational: $U_g = mgh$. Electrostatic: $U_e = \frac{q_1q_2}{4\pi\epsilon_0 r}$.) If there are no other forces acting on the system, E is constant and the system is called **conservative**.

I. Collisions & Linear Momentum

- Types of Collisions:**
 - Elastic: conserve energy
 - Inelastic: energy is lost as heat or deformation.
- Reference Motion & Frames of Reference:** A body moves with velocity v in frame S ; in frame S' the velocity is v' ; if u is the velocity of frame S' relative to S , then $v = v' + u$.
- Elastic Collision:**
 - Conserve Kinetic Energy: $\Sigma \frac{1}{2}mv^2 = \Sigma \frac{1}{2}m'v'^2$
 - Conserve Momentum: $\Sigma mv = \Sigma m'v'$
- Impulse** is a force acting over time: $\text{Impulse} = \int F dt = \Delta p$. Impulse is also the momentum change: $P_{\text{in}} - P_{\text{out}}$.



Synopsis

Reference and outline to concepts in physics.

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This chart has errors in some of the equations. Equations listed for magnetic force (such as $F = qv \times B$) that should have a cross product have a dot product instead. I was disappointed to find this because it means this product is not properly refined and therefore useless to me as a student. I really like it otherwise, as it covers all the stuff seen in standard sophomore level physics classes.

BarCharts are a great little reference. I would not recommend them as a study aid, but as a quick reference, they are great! I have used them for Chem, Physics, Electronics and Math. They are great for what they are.

Mine may be a different edition because there is a cross product in the magnetic force formula, but I am missing a dot in the definition of magnetic flux and the magnetic field of a long conducting wire (for the Biot-Savart Law sample) is incorrect. It shows division by 4π when it should be 2π . I would recommend students using these guides double check the formulas with their textbooks the first time they use them.

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