PHYN001

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Unit 01 Physics and Measurement

Dr. Tamer Ashour Ali

Physics and Measurement

Contents

Physics and Measurement

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- Introduction
- Dimensional Analysis
- Conversion of Units

INTRODUCTION

- Physics is the most fundamental physical science. It is concerned with the basic principles of the universe.
- Main areas of basic physics:
  - Classical Mechanics
  - Classical Electromagnetics
  - Thermodynamics
  - Relativity
  - Quantum Mechanics

Classical Physics
Developed before 1900

Modern Physics

INTRODUCTION
EXPERIMENTAL NATURE OF PHYSICS

- Physics is an experimental science in which physicists seek patterns that relate the phenomena of nature.
- The patterns are called physical theories.
- A very well established or widely used theory is called a physical law or principle.

INTRODUCTION
PHYSICAL QUANTITIES

Basic physical quantities

- Defined through the way they are measured.

Other physical quantities

- Derived from the basic ones

The most widely used system of units now is the SI “Système International”.

INTRODUCTION
BASIC PHYSICAL QUANTITIES

In the SI system the basic physical quantities are:

- Length (the meter)
- Mass (the kilogram)
- Time (the second)
- Electric current (the ampere)
- Temperature (the kelvin)
- …

INTRODUCTION
BASIC PHYSICAL QUANTITIES

- In studying mechanics the basic quantities needed are length, mass and time.

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Dimensional Analysis

Dimensions of a certain physical quantity is

- The nature of this quantity in terms of the nature of the basic physical quantities.

Examples

- [velocity] $= L/T$
- [density] $= M/L^3$
- [acceleration] $= L/T^2$

DIMENSIONAL ANALYSIS

Various terms in an equation must have the same dimensions.

Example

- For an object moving in a straight line with constant acceleration the speed v at any time t is given by:

$$v = v_o + at$$

where a is the acceleration

DIMENSIONAL ANALYSIS

$$v = v_o + at$$

$$[v] = \frac{L}{T}$$

$$[v_o] = \frac{L}{T}$$

$$[at] = \frac{L}{T^2}T = \frac{L}{T}$$

- Therefore the equation is correct from dimensions point of view (within dimensionless factors)

DIMENSIONAL ANALYSIS

Dimensional Analysis can be used to

1. Verify the validity of a certain equation from a dimensional point of view
2. Deduce the relationship between a certain physical quantity and the physical quantities it depends on.

Dimensional Analysis

Example

Use dimensional analysis to derive the relationship between the time of small oscillations T of a simple pendulum and the small mass m of the pendulum, the length ℓ of the pendulum and the acceleration of gravity g.

Solution

- We write the period as $T = C\, m^{\alpha} \ell^{\beta} g^{\gamma}$

  where C is a dimensionless constant

DIMENSIONAL ANALYSIS

- $T = C\, m^{\alpha} \ell^{\beta} g^{\gamma}$
- $\left[C\, m^{\alpha} \ell^{\beta} g^{\gamma}\right] = M^{\alpha} L^{\beta} \left(\frac{L}{T^2}\right)^{\gamma}$
- $T = M^{\alpha} L^{\beta} \left(\frac{L}{T^2}\right)^{\gamma}$
- Equating the powers
  - $0 = \alpha$
  - $0 = \beta + \gamma$
  - $1 = -2\gamma$

$$\left.\begin{array}{c} \alpha = 0 \\ \gamma = -\frac{1}{2} \\ \beta = \frac{1}{2} \end{array}\right\} \quad T = C\sqrt{\frac{\ell}{g}}$$

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Conversion of Units

- Units can be treated as algebraic quantities that cancel each other, e.g.

$$15.0\ \text{in.} = (15.0\ \text{in.})\left(\frac{2.54\ \text{cm}}{1\ \text{in.}}\right) = 38.1\ \text{cm}$$

- A more complete list of conversion factors can be found in Appendix A of the textbook

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