General Physics (1) For Engineering

Textbook:

Physics for Scientists and Engineers, seventh edition, Jewett / Serway

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Final mark will be divided as follows:

10% Homework and Quiz

20% First exam.

20% Second exam.

50% Final exam.

Physics for Scientists and Engineers

Introduction

and

Chapter 1

Physics

- The study of Physics can be divided into six main areas:
  - **Classical mechanics**, Concerning the motion of objects that are large relative to atoms and move at speeds much slower than the speed of light.
  - **Relativity**, a theory describing objects moving at any speed, even speeds approaching the speed of light.
  - **Thermodynamics**, dealing with heat, work, temperature, and the statistical behavior of systems with large numbers of particles.

Physics

- The study of Physics can be divided into six main areas:
  - **Electromagnetism**, concerned with electricity, magnetism, and electromagnetic fields.
  - **Optics,** the study of the behavior of light and its interaction with materials.
  - **Quantum mechanics**, a collection of theories connecting the behavior of matter at the submicroscopic level to microscopic observations.

Objectives of Physics

- **To find the limited number of fundamental laws that govern natural phenomena**

- **To use these laws to develop theories that can predict the results of future experiments**

- **Express the laws in the language of mathematics**

  - **Mathematics provides the bridge between theory and experiment**

Measurements

- Used to describe natural phenomena
- Needs defined standards
- Characteristics of standards for measurements
  - Readily accessible
  - Possess some property that can be measured reliably
  - Must yield the same results when used by anyone anywhere
  - Cannot change with time

Standards of Fundamental Quantities

- Standardized systems
  - Agreed upon by some authority, usually a governmental body
- SI – Systéme International
  - Agreed to in 1960 by an international committee
  - Main system used in this text

Fundamental Quantities and Their Units

Quantity	SI Unit
Length	meter
Mass	kilogram
Time	second
Temperature	Kelvin
Electric Current	Ampere
Luminous Intensity	Candela
Amount of Substance	mole

Quantities Used in Mechanics

- In mechanics, three *basic quantities* are used
  - Length
  - Mass
  - Time
- Will also use *derived quantities*
  - These are other quantities that can be expressed in terms of the basic quantities
    - Example: Area is the product of two lengths
      - Area is a derived quantity
      - Length is the fundamental quantity

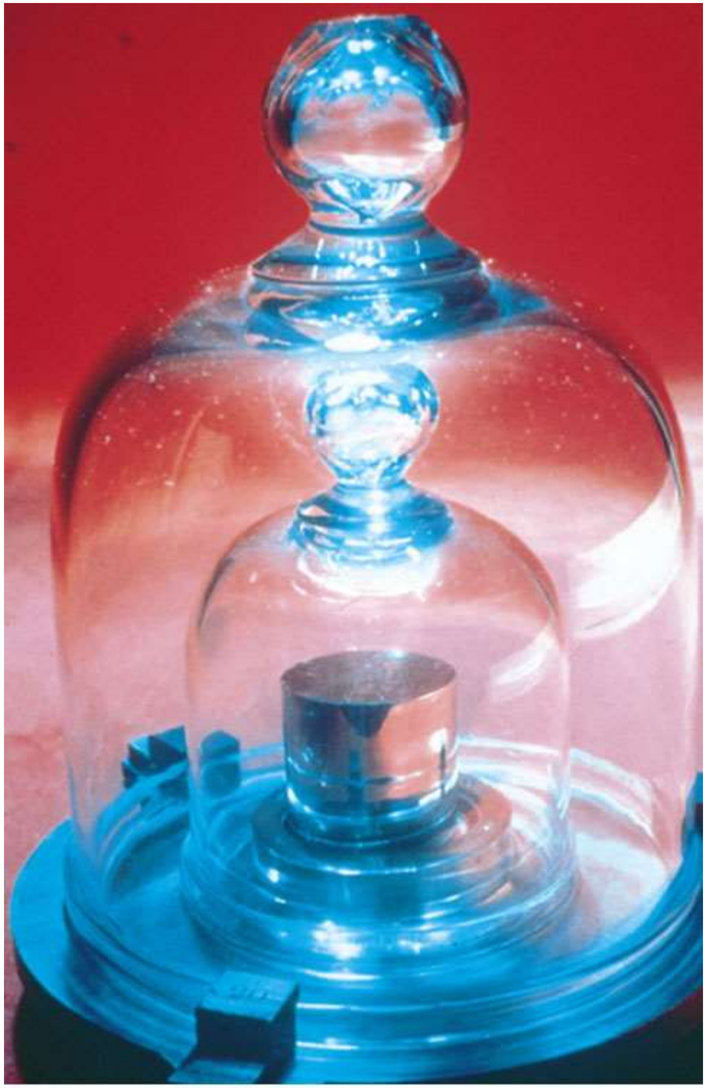
Length

- *Length* is the distance between two points in space
- Units
  - SI – meter, m
- Defined in terms of a meter – the distance traveled by light in a vacuum during a given time
- See Table 1.1 for some examples of lengths

Mass

- Units
  - SI – kilogram, kg
- Defined in terms of a kilogram, based on a specific cylinder kept at the International Bureau of Standards
- See Table 1.2 for masses of various objects

Standard Kilogram



Time

- Units
  - seconds, s
- Defined in terms of the oscillation of radiation from a cesium atom
- See Table 1.3 for some approximate time intervals

US Customary System

- Still used in the US, but text will use SI

Quantity	Unit
Length	foot
Mass	slug
Time	second

The British System

- **Length: 1 inch = 2.54 cm**
- **Force: 1 pound = 4.448221615260 newtons**
- **For time, the British unit is second. British units are used only in mechanics and thermodynamics. No British units for electrical units.**

Unit Prefixes

Once we have defined the fundamental units, it is easy to introduce larger and smaller units for the same physical quantities.

The names of the additional units are derived by adding a prefix to the name of the fundamental unit. For example, the prefix "kilo-" abbreviated k; thus

1 kilometre = 1 km = 10^3 meter = 10^3 m

1 kilogram = 1 kg = 10^3 grams = 10^3 g

1 kilowatt = 1 kW = 10^3 watts = 10^3 W

Length

- 1 nanometer = 1 nm = 10^{-9} m (a few times the size of the largest atom)
- 1 micrometer = 1 µm = 10^{-6} m (size of some bacteria and living cells)
- 1 millimetre = 1 mm = 10^{-3} m (diameter of the point of a ballpoint pen)
- 1 centimetre = 1 cm = 10^{-2} m (diameter of your litter finger)
- 1 kilometre = 1 km = 10^{3} m (a 10-minute walk)

Mass

- 1 microgram = 1 μg $=10^{-6}$ g = 10^{-9} kg (mass of a very small dust particle)
- 1 milligram = 1 mg = 10^{-3} g = 10^{-6} kg (mass of a grain of salt)
- 1 gram = 1 g = 10^{-3} kg (mass of a paper clip)

Time

- **1 nanosecond = 1 ns = 10^{-9} s (time for light to travel 0.3 m)**
- **1 microsecond = 1 μs = 10^{-6} s (time for an orbiting space shuttle to travel 8 mm)**
- **1 millisecond = 1 ms = 10^{-3} s (time for sound to travel 0.35 m)**

Prefixes, some more examples

TABLE 1.4

Prefixes for Powers of Ten

Power	Prefix	Abbreviation	Power	Prefix	Abbreviation
10^{-24}	yocto	y	10^{3}	kilo	k
10^{-21}	zepto	z	10^{6}	mega	M
10^{-18}	atto	a	10^{9}	giga	G
10^{-15}	femto	f	10^{12}	tera	T
10^{-12}	pico	p	10^{15}	peta	P
10^{-9}	nano	n	10^{18}	exa	E
10^{-6}	micro	μ	10^{21}	zetta	Z
10^{-3}	milli	m	10^{24}	yotta	Y
10^{-2}	centi	c			
10^{-1}	deci	d			

Basic Quantities and Their Dimension

- Dimensions are denoted with square brackets
  - Length [L]
  - Mass [M]
  - Time [T]

Dimensions and Units

- Each dimension can have many actual units
- Table 1.5 for the dimensions and units of some derived quantities

TABLE 1.5

Dimensions and Units of Four Derived Quantities

Quantity	Area	Volume	Speed	Acceleration
Dimensions	L^2	L^3	L/T	L/T^2
SI units	m^2	m^3	m/s	m/s^2
U.S. customary units	ft^2	ft^3	ft/s	ft/s^2

Dimensional Analysis

- Technique to check the correctness of an equation or to assist in deriving an equation
- Dimensions (length, mass, time, combinations) can be treated as algebraic quantities
  - add, subtract, multiply, divide
- Both sides of equation must have the same dimensions
- Any relationship can be correct only if the dimensions on both sides of the equation are the same

Dimensional Analysis, example

- Given the equation: $x = ½ at^2$
- Check dimensions on each side:

$$\mathrm{L} = \frac{\mathrm{L}}{\cancel{\mathrm{T}^2}} \cdot \cancel{\mathrm{T}^2} = \mathrm{L}$$

- The T^2's cancel, leaving L for the dimensions of each side
  - The equation is dimensionally correct
  - There are no dimensions for the constant

Dimensional Analysis to Determine a Power Law

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- Determine powers in a proportionality
  - Example: find the exponents in the expression $x \propto a^m t^n$
    - You must have lengths on both sides
    - Acceleration has dimensions of L/T^2
    - Time has dimensions of T
    - Analysis gives $x \propto at^2$

Conversion of Units

- When units are not consistent, you may need to convert to appropriate ones
- See Appendix A for an extensive list of conversion factors
- Units can be treated like algebraic quantities that can cancel each other out

Conversion

- Always include units for every quantity, you can carry the units through the entire calculation
- Multiply original value by a ratio equal to one
- Example

$$15.0\,in = ?\,cm$$

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

  - Note the value inside the parentheses is equal to 1 since 1 in. is defined as 2.54 cm

Conversion, Examples:

$$\rho = 5 \ \mathrm{kg/m^3} = \ ? \ \mathrm{g/cm^3}$$

$$v = 100 \ \mathrm{km/hr} = ? \ \mathrm{m/s}$$

$$m = 3 \ \mathrm{mg} = ? \ \mu\mathrm{g} = ? \ \mathrm{g} = ? \ \mathrm{kg}$$

$$L = 3 \ \mathrm{mm} = ? \ \mathrm{nm} = ? \ \mathrm{cm} = ? \ \mathrm{km}$$

$$T = 3 \ \mathrm{ms} = ? \ \mathrm{ns} = ? \ \mu\mathrm{s} = ? \ \mathrm{s}$$

$$x = 3 \ \mathrm{MW} = ? \ \mathrm{kW} = ? \ \mathrm{GW} = ? \ \mathrm{W}$$