

Physics for Scientists and Engineers

Introduction
and
Chapter 1



Physics

- Fundamental Science
 - Concerned with the fundamental principles of the Universe
 - Foundation of other physical sciences
 - Has simplicity of fundamental concepts
- Divided into five major areas
 - Classical Mechanics
 - Relativity
 - Thermodynamics
 - Electromagnetism
 - Optics
 - Quantum Mechanics

Classical Physics

- Mechanics and electromagnetism are **basic** to all other branches of classical and modern physics
- Classical physics
 - Developed before 1900
 - Our study will start with Classical Mechanics
 - Also called Newtonian Mechanics or Mechanics
- Modern physics
 - From about 1900 to the present



Objectives of Physics

- To find the limited number of fundamental laws that govern natural phenomena
- To use these laws to develop theories
- Express the laws in the language of mathematics
 - Mathematics provides the bridge between theory and experiment



Theory and Experiments



- Should complement each other
- When a discrepancy occurs, theory may be modified
 - Theory may apply to limited conditions
 - Example: Newtonian Mechanics is confined to objects traveling slowly with respect to the speed of light
 - Try to develop a more general theory

Classical Physics Overview



- Classical physics includes principles in many branches developed before 1900
- Mechanics
 - Major developments by Newton, and continuing through the 18th century
- Thermodynamics, optics and electromagnetism
 - Developed in the latter part of the 19th century

Modern Physics



- Began near the end of the 19th century
- Phenomena that could not be explained by classical physics
- Includes theories of relativity and quantum mechanics

Quantum Mechanics



- Formulated to describe physical phenomena at the atomic level
- Led to the development of many practical devices

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

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

Reasonableness of Results



- When solving a problem, you need to check your answer to see if it seems reasonable

Prefixes



- Prefixes correspond to powers of 10
- Each prefix has a specific name
- Each prefix has a specific abbreviation

Prefixes, cont.



- The prefixes can be used with any basic units
- They are multipliers of the basic unit
- Examples:
 - $1 \text{ mm} = 10^{-3} \text{ m}$
 - $1 \text{ mg} = 10^{-3} \text{ g}$

TABLE 1.4

Prefixes for Powers of Ten

Power	Prefix	Abbreviation	Power	Prefix	Abbreviation
10^{-24}	yucto	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			

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Basic Quantities and Their Dimension

- Dimension has a specific meaning – it denotes the physical nature of a quantity
- 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

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Dimensional Analysis, example

- Given the equation: $x = \frac{1}{2} at^2$
- Check dimensions on each side:



Significant Figures

- A significant figure is one that is reliably known
- Zeros may or may not be significant
 - Those used to position the decimal point are not significant
 - To remove ambiguity, use scientific notation
- In a measurement, the significant figures include the first estimated digit



Significant Figures, examples



- 0.0075 m has _____ significant figures
 - The leading zeros are placeholders only
 - Can write in scientific notation to show more clearly:
 7.5×10^{-3} m for 2 significant figures
- 10.0 m has _____ significant figures
 - The decimal point gives information about the reliability of the measurement
- 1500 m is ambiguous
 - Use 1.5×10^3 m for 2 significant figures
 - Use 1.50×10^3 m for 3 significant figures
 - Use 1.500×10^3 m for 4 significant figures

Operations with Significant Figures – Multiplying or Dividing



- When multiplying or dividing, the number of significant figures in the final answer is the same as the number of significant figures in the quantity having the lowest number of significant figures.
- Example: $25.57 \text{ m} \times 2.45 \text{ m} = 62.6 \text{ m}^2$
 - The 2.45 m limits your result to 3 significant figures

Operations with Significant Figures – Adding or Subtracting



- When adding or subtracting, the number of decimal places in the result should equal the smallest number of decimal places in any term in the sum.
- Example: $1.23 \text{ cm} + 4.567 \text{ cm} = \cancel{5.797} = \mathbf{5.80 \text{ cm}}$
 - Since there is no third decimal place in 1.23, the answer of 5.80 only has two decimal places and thus three significant figures.