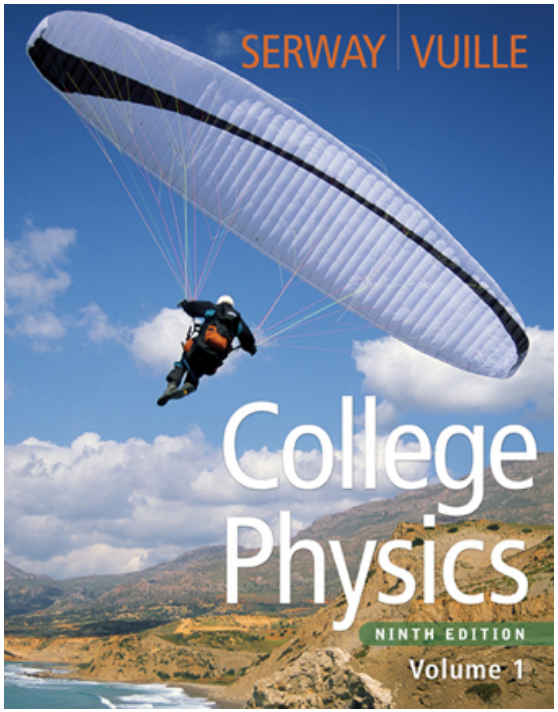

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CENGAGE Learning

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Chapter One

Introduction

Theories and Experiments

- The goal of physics is to develop theories based on experiments
- A physical theory, usually expressed mathematically, describes how a given system works
- The theory makes predictions about how a system should work
- Experiments check the theories' predictions
- Every theory is a work in progress

Fundamental Quantities and Their Dimension

- Mechanics uses three fundamental quantities
  - Length [L]
  - Mass [M]
  - Time [T]
- Other physical quantities can be constructed from these three

Units

- To communicate the result of a measurement for a quantity, a *unit* must be defined
- Defining units allows everyone to relate to the same fundamental amount

SI System of Measurement

- SI – Systéme International
  - Agreed to in 1960 by an international committee
  - Main system used in this text

Length

- Units
  - meter, m
- The meter is currently defined in terms of the distance traveled by light in a vacuum during a given time
  - Also establishes the value for the speed of light in a vacuum

Mass

- Units
  - kilogram, kg
- The kilogram is currently defined as the mass of a specific cylinder kept at the International Bureau of Weights and Measures

Standard Kilogram

Time

- Units
  - seconds, s
- The second is currently defined in terms of the oscillation of radiation from a cesium atom

Approximate Values

- Various tables in the text show approximate values for length, mass, and time
  - Note the wide range of values
  - Lengths – Table 1.1
  - Masses – Table 1.2
  - Time intervals – Table 1.3

Other Systems of Measurements

- cgs – Gaussian system
  - Named for the first letters of the units it uses for fundamental quantities
- US Customary
  - Everyday units
  - Often uses weight, in pounds, instead of mass as a fundamental quantity

Units in Various Systems

System	Length	Mass	Time
SI	meter	kilogram	second
cgs	centimeter	gram	second
US Customary	foot	slug	second

Prefixes

- Prefixes correspond to powers of 10
- Each prefix has a specific name
- Each prefix has a specific abbreviation
- See table 1.4

Expressing Numbers

- Numbers with more than three digits are written in groups of three digits separated by spaces
  - Groups appear on both sides of the decimal point
- 10 000 instead of 10,000
- 3.141 592 65

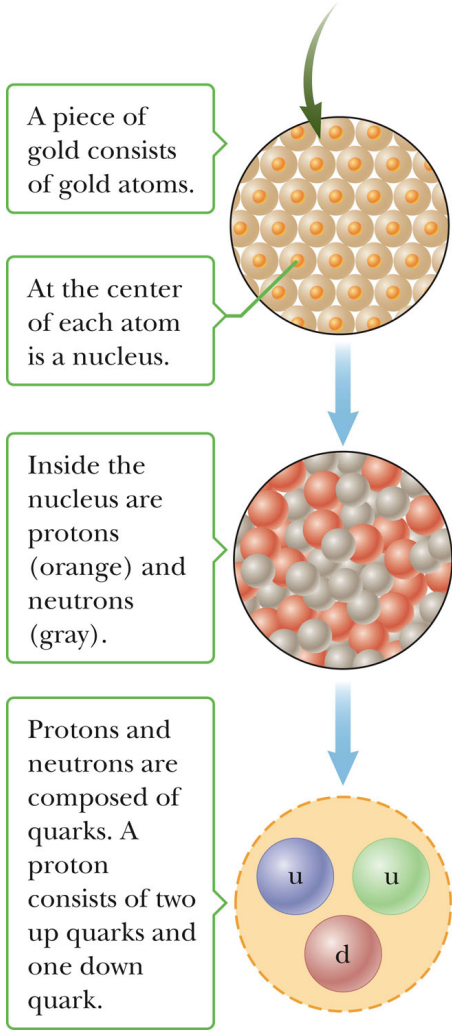
Structure of Matter

- Matter is made up of molecules
  - The smallest division that is identifiable as a substance
- Molecules are made up of atoms
  - Correspond to elements

More structure of matter

- Atoms are made up of
  - Nucleus, very dense, contains
    - Protons, positively charged, “heavy”
    - Neutrons, no charge, about same mass as protons
      - Protons and neutrons are made up of quarks
  - Orbited by
    - Electrons, negatively charges, “light”
      - Fundamental particle, no structure

Structure of Matter



Dimensional Analysis

- Technique to check the correctness of 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

Dimensional Analysis, cont.

- Cannot give numerical factors: this is its limitation
- Dimensions of some common quantities are listed in Table 1.5
- Allows a check for calculations which can show up in the units

Uncertainty in Measurements

- There is uncertainty in every measurement, this uncertainty carries over through the calculations
  - Need a technique to account for this uncertainty
- We will use rules for significant figures to approximate the uncertainty in results of calculations

Significant Figures

- A significant figure is a reliably known digit
- All non-zero digits are significant
- Zeros are not significant when they only locate the decimal point
  - Using scientific notion to indicate the number of significant figures removes ambiguity when the possibility of misinterpretation is present

Operations with Significant Figures

- When *multiplying or dividing* two or more quantities, the number of significant figures in the final result is the same as the number of significant figures in the least accurate of the factors being combined
  - Least accurate means having the lowest number of significant figures
- When *adding or subtracting*, round the result to the smallest number of decimal places of any term in the sum (or difference)

Rounding

- Calculators will generally report many more digits than are significant
  - Be sure to properly round your results
- Slight discrepancies may be introduced by both the rounding process and the algebraic order in which the steps are carried out
  - Minor discrepancies are to be expected and are not a problem in the problem-solving process
- In experimental work, more rigorous methods would be needed

Conversions

- When units are not consistent, you may need to convert to appropriate ones
- See the inside of the front cover for an extensive list of conversion factors
- Units can be treated like algebraic quantities that can "cancel" each other
- Example:

$$15.0\,in \times \frac{2.54\,cm}{1\,in} = 38.1\,cm$$

Estimates

- Can yield useful approximate answers
  - An exact answer may be difficult or impossible
    - Mathematical reasons
    - Limited information available
- Can serve as a partial check for exact calculations

Order of Magnitude

- Approximation based on a number of assumptions
  - May need to modify assumptions if more precise results are needed
- Order of magnitude is the power of 10 that applies

Coordinate Systems

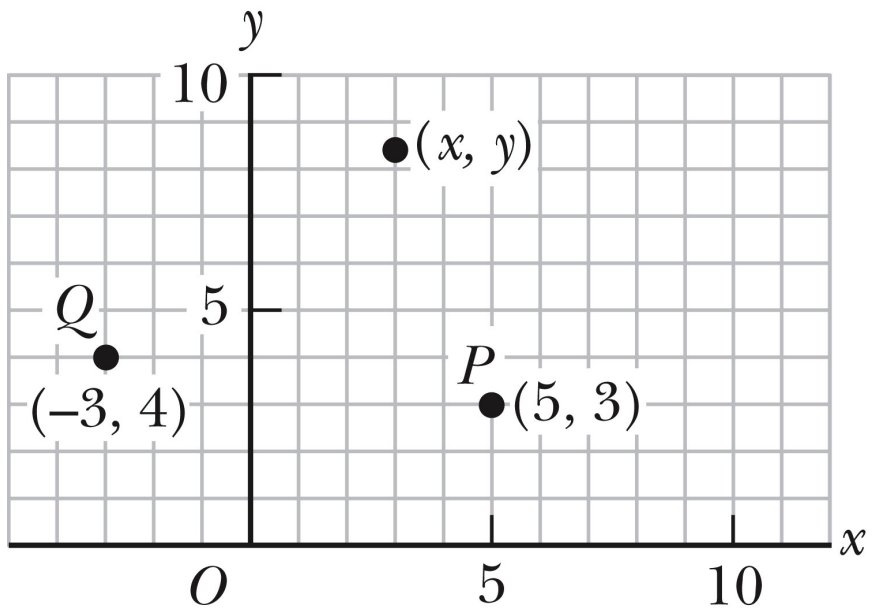
- Used to describe the position of a point in space
- Coordinate system consists of
  - A fixed reference point called the origin, *O*
  - Specified axes with scales and labels
  - Instructions on how to label a point relative to the origin and the axes

Types of Coordinate Systems

- Cartesian (rectangular)
- Plane polar

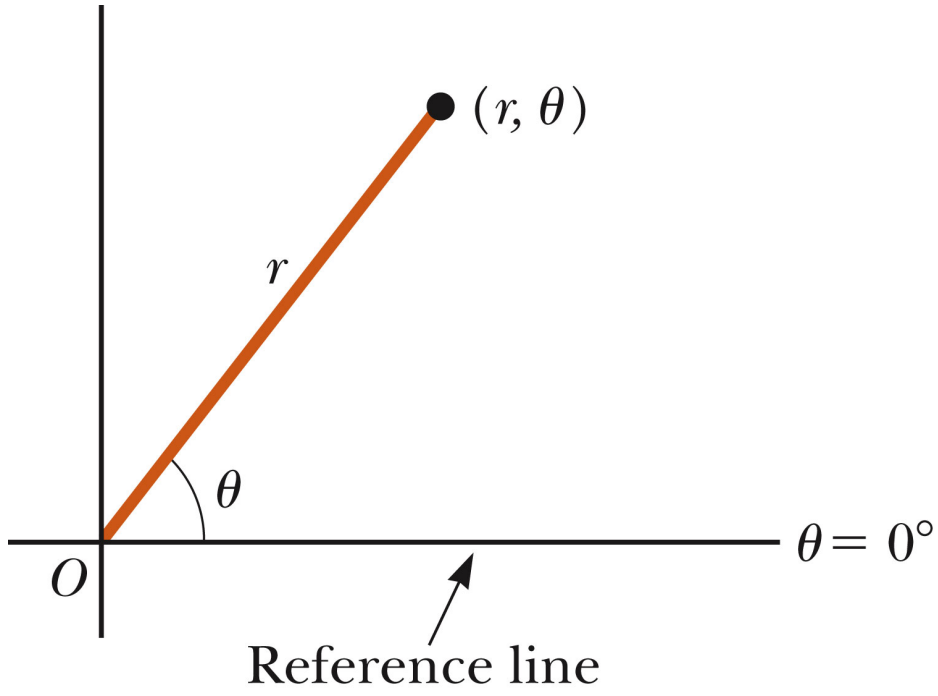
Cartesian coordinate system

- x- and y- axes
- Points are labeled (x,y)
- Positive x is usually selected to be to the right of the origin
- Positive y is usually selected to be to upward from the origin



Plane polar coordinate system

- Origin and reference line are noted
- Point is distance *r* from the origin in the direction of angle θ
- Positive angles are measured ccw from reference line
- Points are labeled (r,θ)
- The standard reference line is usually selected to be the positive *x* axis

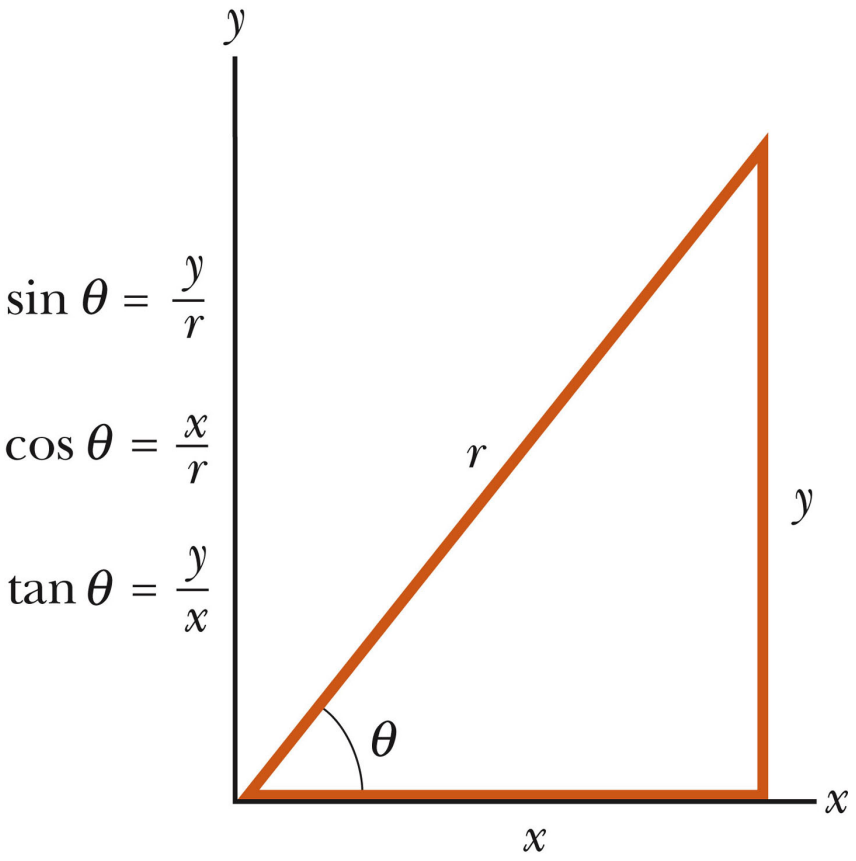


Trigonometry Review

$$\sin\theta = \frac{\textit{opposite side}}{\textit{hypotenuse}}$$

$$\cos\theta = \frac{\textit{adjacent side}}{\textit{hypotenuse}}$$

$$\tan\theta = \frac{\textit{opposite side}}{\textit{adjacent side}}$$



More Trigonometry

- Pythagorean Theorem
  - $r^2 = x^2 + y^2$
- To find an angle, you need the inverse trig function
  - For example, $\theta = \sin^{-1} 0.707 = 45°$

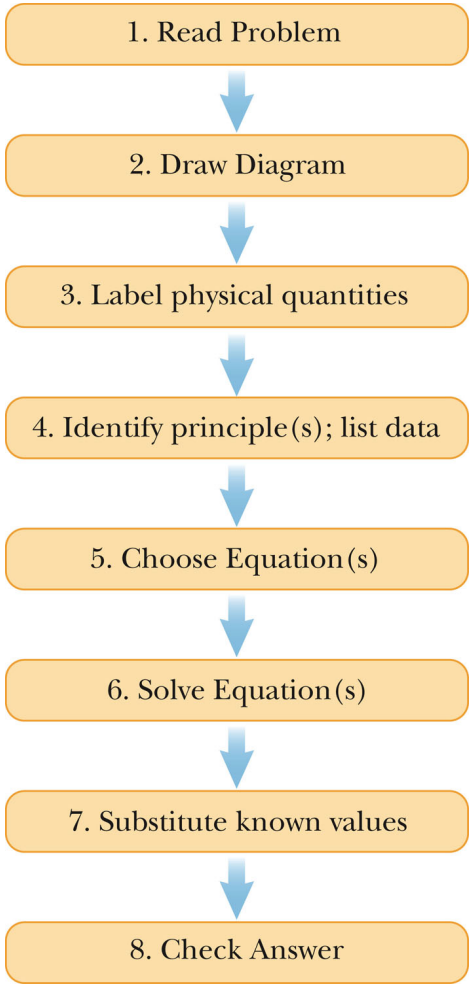
Degrees vs. Radians

- Be sure your calculator is set for the appropriate angular units for the problem
- For example:
  - $\tan^{-1} 0.5774 = 30.0°$
  - $\tan^{-1} 0.5774 = 0.5236$ rad

Rectangular ⇔ Polar

- Rectangular to polar
  - Given x and y, use Pythagorean theorem to find r
  - Use x and y and the inverse tangent to find angle
- Polar to rectangular
  - $x = r \cos \theta$
  - $y = r \sin \theta$

Problem Solving Strategy



Section 1.9

Problem Solving Strategy

- Problem
  - Read the problem
    - Read at least twice
    - Identify the nature of the problem
  - Draw a diagram
    - Some types of problems require very specific types of diagrams

Problem Solving cont.

- Problem, cont.
  - Label the physical quantities
    - Can label on the diagram
    - Use letters that remind you of the quantity
      - Many quantities have specific letters
    - Choose a coordinate system and label it
- Strategy
  - Identify principles and list data
    - Identify the principle involved
    - List the known(s) (given information)
    - Indicate the unknown(s) (what you are looking for)
      - May want to circle the unknowns

Problem Solving, cont.

- Strategy, cont.
  - Choose equation(s)
    - Based on the principle, choose an equation or set of equations to apply to the problem
- Solution
  - Solve for the unknown quantity
  - Substitute into the equation(s)
    - Substitute the data into the equation
    - Obtain a result
    - Include units

Problem Solving, final

- Check
  - Check the answer
    - Do the units match?
      - Are the units correct for the quantity being found?
    - Does the answer seem reasonable?
      - Check order of magnitude
    - Are signs appropriate and meaningful?

Problem Solving Summary

- Equations are the tools of physics
  - Understand what the equations mean and how to use them
- Carry through the algebra as far as possible
  - Substitute numbers at the end
- Be organized