UNIVERSITY of INFORMATION TECHNOLOGY

Chapter-1

INTRODUCTION

LESSON TOPIC

- **Dimensional Analysis**
- **Uncertainty in Measurement and Significant Figures**
- **Conversion of Units**
- **Coordinate Systems**
- **Trigonometry**

“ The basic laws of physics involve such physical quantities as force, velocity, volume, and acceleration, all of which can be described in terms of more fundamental quantities.

In mechanics, it is conventional to use the quantities of length (L), mass (M), and time (T); all other physical quantities can be constructed from these three ”.

Dimensional Analysis

- The word dimension denotes the physical nature of a quantity.

- The dimensions of length, mass, and time are L, M, and T, respectively. Brackets [ ] will often be used to denote the dimensions of a physical quantity.

- **For example**

  the dimensions of velocity v are written [v] = L/T

  the dimensions of area A are [A] = L^2.

- The dimensions of other quantities, such as force and energy, will be described later as they are introduced.

Dimensional analysis, makes use of the fact that dimensions can be treated as algebraic quantities. The dimensions of area, volume, velocity, and acceleration are listed in following table.

Table 1.5 Dimensions and Some Units of Area, Volume, Velocity, and Acceleration

System	Area (L^2)	Volume (L^3)	Velocity (L/T)	Acceleration (L/T^2)
SI	m^2	m^3	m/s	m/s^2
cgs	cm^2	cm^3	cm/s	cm/s^2
U.S. customary	ft^2	ft^3	ft/s	ft/s^2

- Distance x has the dimension of length: $[x] = L$.
- Time t has dimension $[t] = T$.
- Velocity v has the dimension of length over time:

  $[v] = L/T$, and

  acceleration a has the dimension of length divided by time squared:

  $[a] = L/T^2$.

- Notice that velocity and acceleration have similar dimensions,

$$[v] = \frac{L}{T} = \frac{L}{T^2}\,T = [a][t]$$

  that is true for the special case of motion with constant acceleration starting at rest.

- Noticing that velocity has dimensions of length divided by time and distance has dimensions of length,

$$[x] = L = L\frac{T}{T} = \frac{L}{T}\,T = [v][t] = [a][t]^2$$

EXAMPLE 1.2

Find a relationship between a constant acceleration a, speed v, and distance r from the origin for a particle traveling in a circle.

Solution

the dimensions of a: $[a] = \frac{L}{T^2}$

the dimensions of speed : $[v] = \frac{L}{T} \Rightarrow T = \frac{L}{[v]}$

Substitute the expression for **T** into the equation for [a]:

$$[a] = \frac{L}{T^2} = \frac{L}{(\frac{L}{[v]})^2} = \frac{[v]^2}{L}$$

Substitute L = [r], and the equation becomes $[a] = \frac{[v]^2}{[r]}$

$$\boxed{a = \frac{v^2}{r}}$$

Uncertainty in Measurement and Significant Figures

- Physics is a science in which mathematical laws are tested by experiment.

- The two rules of significant figures are as follows:

1. When multiplying or dividing using two or more quantities, the result should have the same number of significant figures as the quantity having the fewest significant figures.

2. When quantities are added or subtracted, the number of decimal places in the result should be the same as in the quantity with the fewest decimal places.

NOTE : In multiplying (dividing) two or more quantities, the number of significant figures in the final product (quotient) is the same as the number of significant figures in the least accurate of the factors being combined, where least accurate means having the lowest number of significant figures.

When numbers are added (subtracted), the number of decimal places in the result should equal the smallest number of decimal places of any term in the sum (difference).

EXAMPLE 1.3

Several carpet installers make measurements for carpet installation in the different rooms of a restaurant, reporting their measurements with inconsistent accuracy, as compiled in Table 1.6. Compute the areas for (a) the banquet hall, (b) the meeting room, and (c) the dining room, taking into account significant figures. (d) What total area of carpet is required for these rooms?

Table 1.6 Dimensions of Rooms in Example 1.3

	Length (m)	Width (m)
Banquet hall	14.71	7.46
Meeting room	4.822	5.1
Dining room	13.8	9

Solution

(a) the area of the banquet hall =?

significant figures:

14.71 m $\rightarrow$ 4 significant figures

7.46 m $\rightarrow$ 3 significant figures

14.71 m x 7.46 m = 109.74 $m^2 \rightarrow 1.10 \times 10^2\ m^2$

(b) the area of the meeting room =?

significant figures:

4.822 m $\rightarrow$ 4 significant figures

5.1 m $\rightarrow$ 2 significant figures

4.822 m x 5.1 m = 24.59 $m^2 \rightarrow 25\ m^2$

(c) the area of the dinning room = ?

significant figures:

13.8 m $\rightarrow$ 3 significant figures

9 m $\rightarrow$ 1 significant figures

13.8 m x 9 m = 124.2 $m^2 \rightarrow 100\ m^2$

(d) total area of carpet =?

total area of carpet = $1.10 \times 102\ m^2 + 25\ m^2 + 100\ m^2 = 235\ m^2$

with one significant figure in the hundred's decimal place:

$235\ m^2 \rightarrow 2 \times 10^2\ m^2$

Conversion of Units

Sometimes it’s necessary to convert units from one system to another. Conversion factors between the SI and U.S. customary systems for units of length are as follows:

1 mi = 1 609 m = 1.609 km
1 ft = 0.304 8 m = 30.48 cm
1 m = 39.37 in. = 3.281 ft
1 in.= 0.025 4 m = 2.54 cm

EXAMPLE 1.4

If a car is traveling at a speed of 28.0 m/s, is the driver exceeding the speed limit of 55.0 mi/h?

Solutions

$$28.0\ \mathrm{m/s} = \left(28.0\ \frac{\cancel{\mathrm{m}}}{\mathrm{s}}\right)\left(\frac{1.00\ \mathrm{mi}}{1\ 609\ \cancel{\mathrm{m}}}\right) = 1.74 \times 10^{-2}\ \mathrm{mi/s}$$

$$\begin{aligned} 1.74 \times 10^{-2}\ \mathrm{mi/s} &= \left(1.74 \times 10^{-2}\ \frac{\mathrm{mi}}{\cancel{\mathrm{s}}}\right)\left(60.0\ \frac{\cancel{\mathrm{s}}}{\cancel{\mathrm{min}}}\right)\left(60.0\ \frac{\cancel{\mathrm{min}}}{\mathrm{h}}\right) \\ &= \boxed{62.6\ \mathrm{mi/h}} \end{aligned}$$

Yes, the driver is exceeding the speed limit of 55.0 mi/h.

EXAMPLE 1.5

The traffic light turns green, and the driver of a high-performance car slams the accelerator to the floor. The accelerometer registers 22.0 m/s^2. Convert this reading to km/min^2

Solutions

$$\frac{22.0\ \text{m}}{1.00\text{s}^2}\left(\frac{1.00\ \text{km}}{1.00\ \times 10^3}\right)\left(\frac{60.0\ \text{s}}{1.00\ \text{min}}\right)^2 = 79.2\ \frac{\text{km}}{\text{min}^2}$$

Coordinate Systems

A coordinate system used to specify locations in space consists of the following:

- ❖ A fixed reference point O, called the origin
- ❖ A set of specified axes, or directions, with an appropriate scale and labels on the axes
- ❖ Instructions on labeling a point in space relative to the origin and axes.
- ❖ There are two kinds of coordinate system.
  - Cartesian coordinate system, sometimes called the rectangular coordinate system.
  - plane polar coordinates system (r, θ) The standard reference line is usually selected to be the positive x-axis of a Cartesian coordinate system.

Cartesian coordinate system

The Cartesian coordinate system consists of two perpendicular axes, usually called the x-axis and y-axis, with each axis labeled with all numbers from negative infinity to positive infinity. Points are located by specifying the x- and y-values.

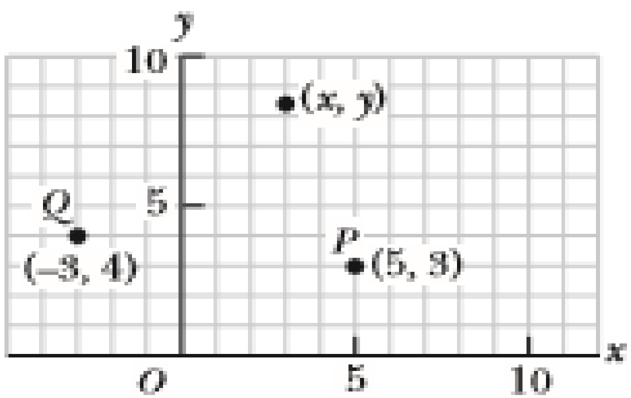
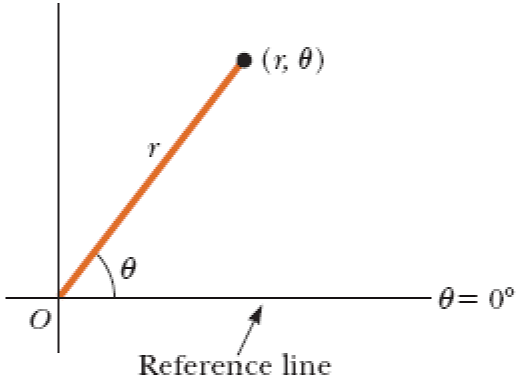


Figure 1.4 Designation of points in a two-dimensional Cartesian coordinate system. Every point is labeled with coordinates (x, y).

Polar coordinates system

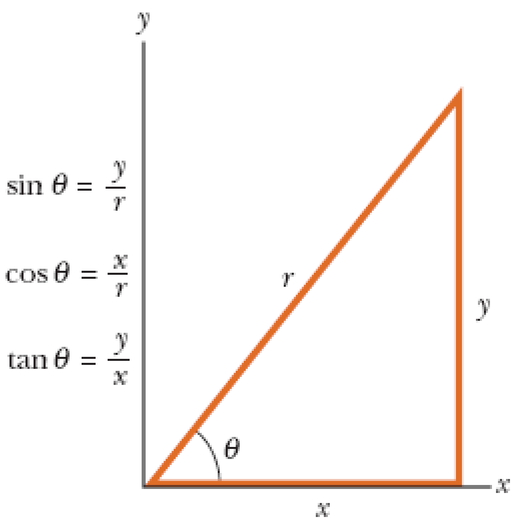
- Polar coordinates consist of a radial coordinate r, which is the distance from the origin, and an angular coordinate θ, which is the angular displacement from the positive x-axis.

- The standard reference line is usually selected to be the positive *x*-axis of a Cartesian coordinate system. The angle θ is considered positive when measured counterclockwise from the reference line and negative when measured clockwise.



Trigonometry

- The basic trigonometric functions defined by such a triangle are the ratios of the lengths of the sides of the triangle.
- The three most basic trigonometric functions of a right triangle are the sine, cosine, and tangent, defined as follows:

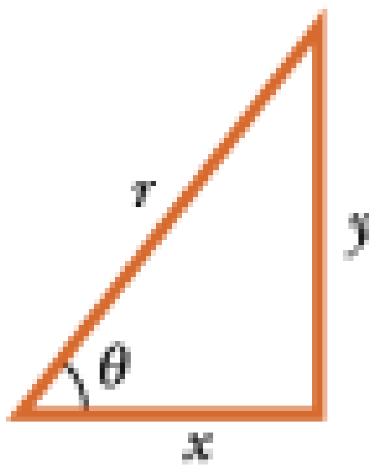


$$\sin\theta = \frac{\text{side opposite }\theta}{\text{hypotenuse}} = \frac{y}{r}$$

$$\cos\theta = \frac{\text{side adjacent to }\theta}{\text{hypotenuse}} = \frac{x}{r}$$

$$\tan\theta = \frac{\text{side opposite }\theta}{\text{side adjacent}} = \frac{y}{x}$$

The Pythagorean theorem is an important relationship between the lengths of the sides of a right triangle:



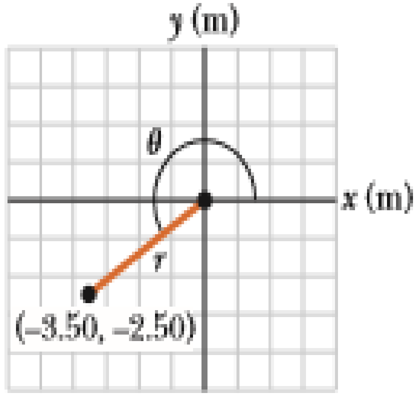
$$r^2 = x^2 + y^2$$

where r is the hypotenuse of the triangle and x and y are the other two sides.

EXAMPLE 1.9

(a) The Cartesian coordinates of a point in the xy-plane are (x, y) = (-3.50 m, -2.50 m), as shown in Active Figure 1.7. Find the polar coordinates of this point. (b) Convert (r, θ) = (5.00 m, 37.0°) to rectangular coordinates.

Active Figure 1.7
(Example 1.9) Converting from Cartesian coordinates to polar coordinates.



SOLUTION

(a) Cartesian to Polar conversion

$$r = \sqrt{x^2 + y^2} = \sqrt{(-3.50\,m)^2 + (-2.50\,m)^2} = 4.30\,m$$

$$\tan\theta = \frac{y}{x} = \frac{-2.50\text{ m}}{-3.50\text{ m}} = 0.714$$

$$\theta = \tan^{-1}(0.714) = 35.5° + 180° = 216°$$

(b) Polar to Cartesian conversion

$$x = r\cos\theta = (5.00\text{ m})\cos 37.0° = 3.99\text{ m}$$

$$y = r\sin\theta = (5.00\text{ m})\sin 37.0° = 3.01\text{ m}$$

Chapter 1

Assignment:

Problems no:

1, 5

8, 9, 12

23, 24

36, 39

43,45

Thank you for your attention