Physics 101

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Physics for Scientists and Engineers

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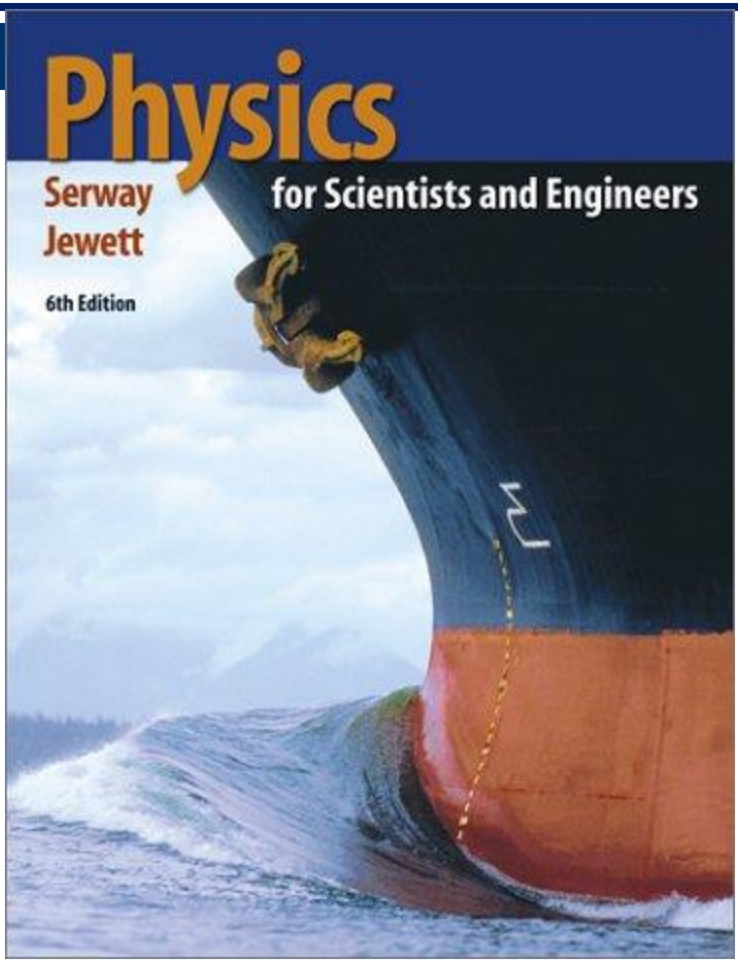
(6th edition)



First Lecture

Introduction

Chapter (1)

Introduction

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, the three most *fundamental (basic) quantities* are **length** (L), **mass** (M), and **time** (T).

All other physical quantities can be *constructed (derived)* from these three.

Units

Physics Experiments → Measurements → Accuracy → Unit systems

Measurements taken by different people in different places must yield the same result.

Unit Systems

SI Units

- System International

CGS

- Centimeter-gram-second

BE

- British Engineering system

Basic Units of Measurements in mechanics

	Length	Mass	Time
SI units	Meter(m)	Kilogram(kg)	Second(s)
CGS units	Centimeter(cm)	Gram(g)	Second(s)
BE	Foot(ft)	slug(sl)	Second(s)

TABLE 2–1 The Three Basic Unit Systems

QUANTITY	SI	CGS	BRITISH
Length	meter (m)	centimeter	foot
Time	second (sec)	second	second
Mass	kilogram (kg)	gram	slug

All other quantities can be derived from the basic units..
for example :

QUANTITY	SI	CGS	BRITISH
Velocity	m/sec	cm/sec	ft/sec
Acceleration	m/sec^2	cm/sec^2	ft/sec^2
Force	newton ($kg \cdot m/sec^2$)	dyne ($gm \cdot cm/sec^2$)	pound ($slug \cdot ft/sec^2$)
Work, energy	joule ($N \cdot m$)	erg ($dyne \cdot cm$)	$ft \cdot lb$
Power	watt (joule/sec)	erg/sec	$ft \cdot lb/sec$
Torque	$N \cdot m$	$dyne \cdot cm$	$lb \cdot ft$
Pressure	pascal (N/m^2)	$dyne/cm^2$	lb/ft^2

The Conversion of Units

- We can convert any unit from one system to another by using the conversion factors.

Table of Conversion

Length

1 in. = 2.54 em (exact)
1 m = 39.37 in. = 3.281 ft
1 ft= 0.304 8m
12 in. = 1 ft
3 ft= 1 yd
1yd = 0.9144m
1 km = 0.621 mi
1 mi = 1.609 km
1 mi = 5 280ft
1 J.Lm= 10^{-6} m = 10^{3} nm
1lightyear = 9.461 X 10^{15} m

Area

1m^2 = 10^4 cm^2 = 10.76ft^2
1 ft^2 = 0.092 9m2 = 144 in.2
1 in.^{2} = 6.452 cm^2

Volume

1m^3 = 10^6 cm^3 = 6.102 X 10^4 in.^{3}
1 ft^3 = 1728in.^{3} = 2.83 X 10-2m^3
1 L = 1 000 cm^3 = 1.0576 qt = 0.035 3 ft^3
1 ft^3 = 7.481 gal = 28.32 L = 2.832 X 10^{-2} m^3
1 gal = 3.786 L = 231 in.3

Mass

1 000 kg = 1 t (metric ton)
1 slug = 14.59 kg
1 u = 1.66 X 10^{-27} kg = 931.5 MeV/c^2

Some Approximations Useful for Estimation Problems

1 m= 1 yd
1 kg= 2lb
1 N = $\frac{1}{4}$lb
1L = $\frac{1}{4}$g

Force

1 N = 0.224 8lb
1lb = 4.448 N

Velocity

1 mi/h = 1.47ft/s = 0.447 m/s = 1.61 km/h
1 m/s = 100 cm/s = 3.281 ft/s
1 mi/min = 60 mi/h = 88ft/s

Acceleration

1 m/s^2 = 3.28ft/s^2 = 100 cm/s^2
1 ft/s^2 = 0.304 8 m/s^2 = 30.48 cm/s^2

Pressure

1 bar = 10^5 N/m^2 = 14.50 lb /in.^{2}
1 atm = 760 mm Hg = 76.0 em Hg
1 atm = 14.7lb/in.2 = 1.013 X 10^5 N/m2
1 Pa = 1 N/m^2 = 1.45 X 10^{-4} lb/in.^{2}

Time

1 yr = 365 days = 3.16 X 10^7 s
1 day= 24h = 1.44 X 10^3 min = 8.64 X 10^4 s

Energy

1J = 0.738ft·lb
1 cal = 4.186 J
1 Btu = 252 cal = 1.054 X 10^3J
1 eV = 1.6 X 10^{-19}J
1 kWh = 3.60 X 10^6J

Power

1 hp = 550ft·lb/s = 0.746kW
1 W = 1J/s = 0.738ft·lb/s
1 Btu/h = 0.293 W

1 m/s = 2mi/h
1 yr = π X 10^7 s
60 mi/h = 100 ft/s
1km = $\frac{1}{2}$mi

Example -1

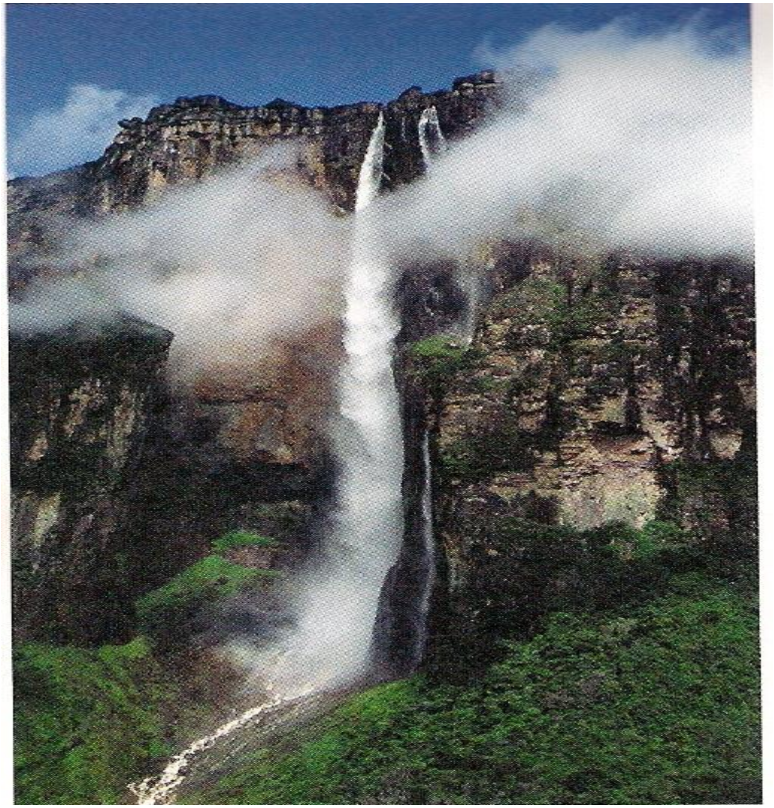
Convert 12 inches to centimeters.

Ans. : From the table: 1 inch = 2.54 cm

we find that 12 in. = (12 inches) x ($\frac{2.54\ \text{cm}}{1\,\text{inch}}$) = 30.5 cm

Example -2

The highest waterfall in the world is in Venezuela, with a total drop of 979.0 m. Express this drop in feet.



Ans. : From the table:

1 m = 3.281 ft

so Length = 3212 ft.

Dimensional Analysis

- The dimensional analysis is important in checking the validity of any mathematical expression. To be dimensionally correct, terms on both sides of an equation must have the same dimensions.

- The dimension of any quantity will be defined in brackets [ ].

For example, the dimension of velocity v is $[v] = L/T$

Dimensional Analysis

- Example:

This equation is for the position *x* of a car at a time *t* if it starts from rest and moves with constant acceleration *a*.

The dimensional form of this equation can be written as:

$$x = 1/2\, at^2$$

$$[x] = [at^2]$$

$$L = \frac{L}{T^2} \times T^2 = L$$

Dimensional Analysis

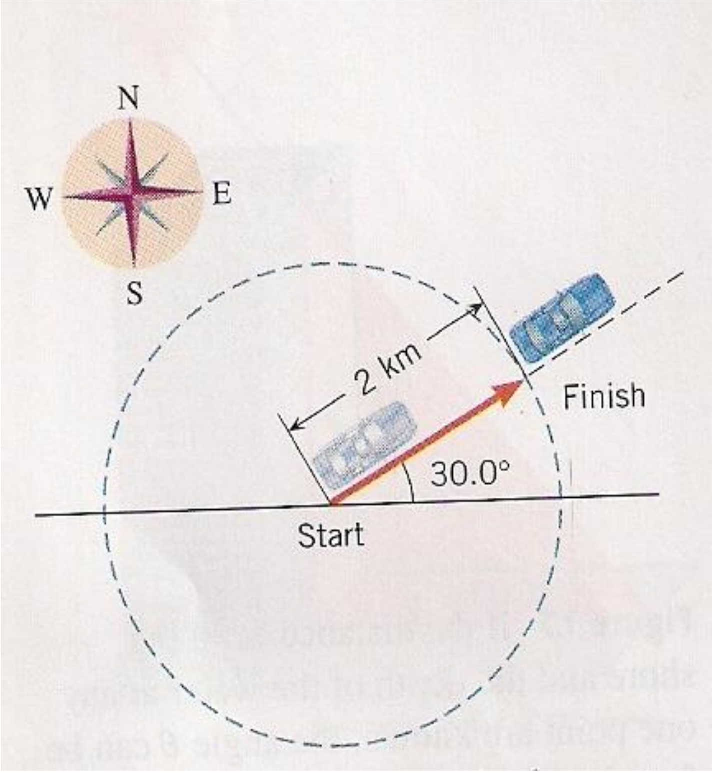
Problem: **Show that the expression** $v = v_0 + at$ **,**
is *dimensionally correct*, where v and v_0 represent velocities, a is acceleration, and t is a time interval.

Ans. :

$$[v] = [v_0] = \frac{L}{T}$$

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

Scalar and Vector Quantity



- A scalar quantity is one that can be described with a single number (including any units) giving its size or magnitude.
- A vector quantity is one that deals inherently with both magnitude and direction.

Note: arrows are used to present the direction of the vector, and the length of the arrow represents the magnitude.

Scalars and Vectors

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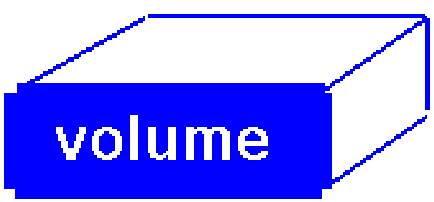
A **scalar quantity** has only **magnitude.**

A **vector quantity** has both **magnitude** and **direction.**

Scalar Quantities

length, area, volume
speed
mass, density
pressure
temperature
energy, entropy
work, power



Vector Quantities

displacement, direction
velocity
acceleration
momentum
force
lift , drag , thrust
weight

Trigonometry

$$\sin\theta = \frac{h_o}{h} \quad (1.1)$$

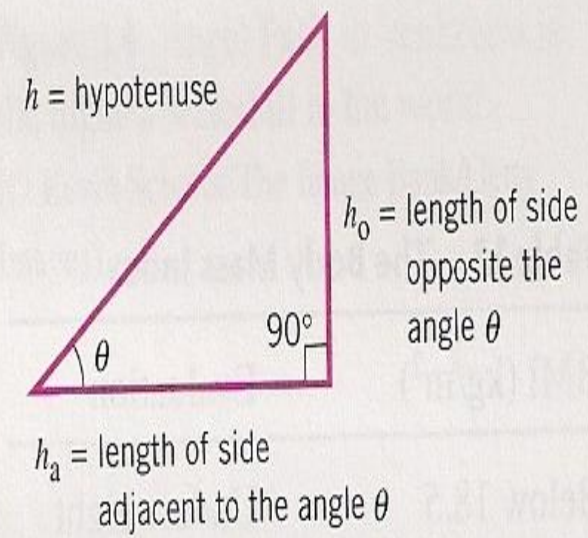
$$\cos\theta = \frac{h_a}{h} \quad (1.2)$$

$$\tan\theta = \frac{h_o}{h_a} \quad (1.3)$$

h = length of the **hypotenuse** of a right triangle

h_o = length of the side **opposite** the angle θ

h_a = length of the side **adjacent** to the angle θ



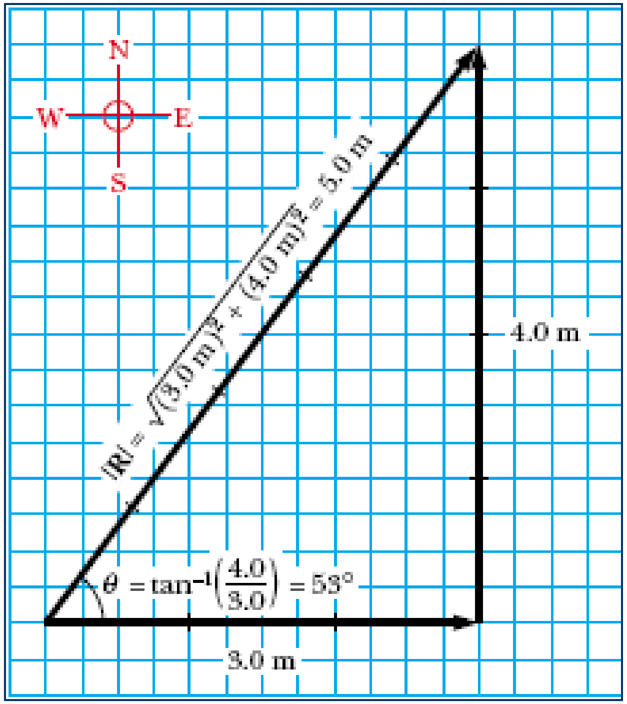
Pythagorean Theorem

The square of the length of the hypotenuse of a triangle is equal to the sum
Of the squares of the lengths of the other two sides:

$$h^2 = h_o^2 + h_a^2$$

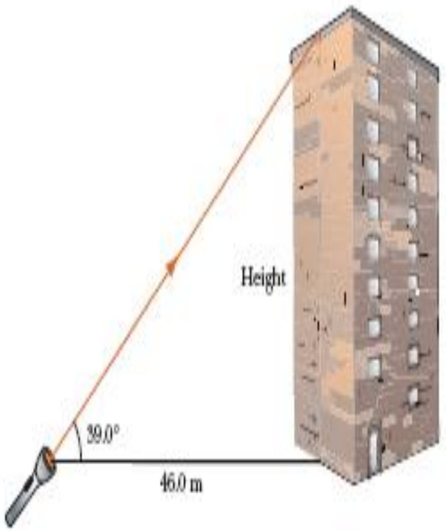
Example :

If you walked 3.0 m toward east and then 4.0 m toward north, you would find yourself 5.0 m from where you started, measured at an angle of 53° north of east.



Example :

A person measures the height of a building by walking out a distance of 46.0 m from its base and shining a flashlight beam toward the top. When the beam is elevated at an angle of 39.0˚ with respect to the horizontal, as shown in Figure, the beam just strikes the top of the building.



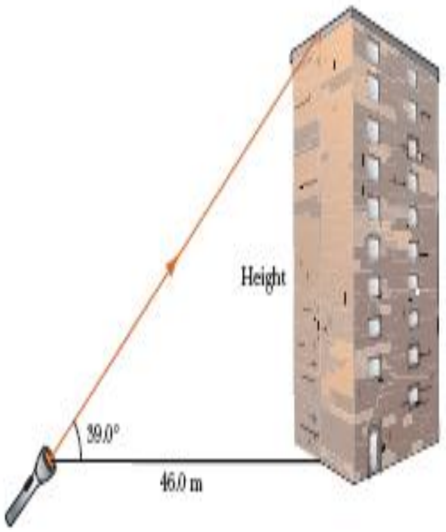
Find the height of the building , and the distance the flashlight beam has to travel before it strikes the top of the building.

Example Solution:

$$\tan\theta = \frac{h_0}{h_a} \rightarrow \tan 39^\circ = \frac{h_0}{46} \rightarrow \textit{Height } h_0 = 37 \text{ m}$$

$$h = \sqrt{{h_0}^2 + {h_a}^2} = \sqrt{37.25^2 + 46^2} = 59 \text{ m}$$

Distance h = 59 m



Home Work

Problem 1 : If a car is traveling at a speed of 28.0 m/s, is it exceeding the speed limit of 55.0 mi/h?

Problem 2 : 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.