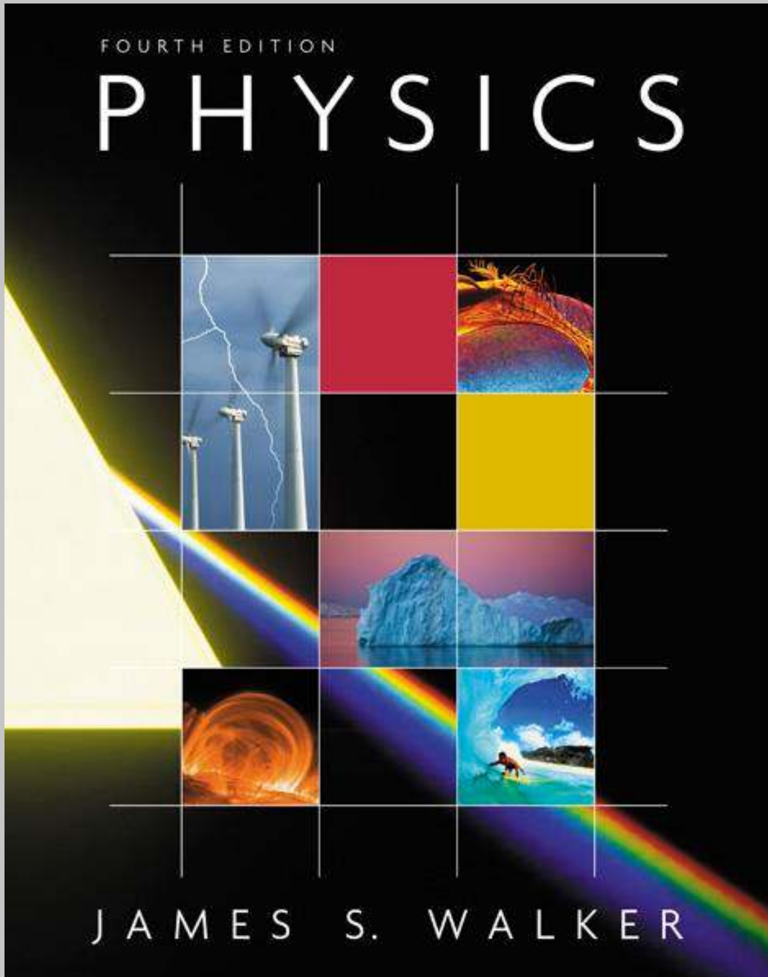

Lecture Outline

Chapter 1

***Physics*, 4th Edition**

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Chapter 1
Introduction to Physics

Units of Chapter 1

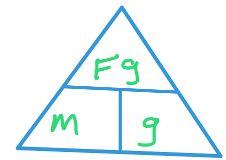
- Physics and the Laws of Nature
- Units of Length, Mass, and Time
- Dimensional Analysis
- Converting Units
- Scalars and Vectors
- Problem Solving in Physics

1-1 Physics and the Laws of Nature

Physics: **The science of nature**

Speed in free fall = 9.81 m/s

Gravity Acceleration= g = 9.81m/s^2



Fg (Gravity Force) = mass * g

each object has a different gf, because of the different mass.

mass=Gravity Force /g

the study of the fundamental laws of nature

- **these laws can be expressed as mathematical equations**
- **much complexity can arise from relatively simple laws**

↳

From $F_g = m\,g$ we can find:

$$F_g = m\,a \rightarrow \text{because } g = a$$

$$F_g = m\,\frac{\Delta v}{\Delta t} \rightarrow \text{because } a = \frac{\Delta v}{\Delta t}$$

$$F_g = m\,\frac{\frac{\Delta x}{\Delta t}}{\Delta t} \rightarrow \text{because } \Delta v = \frac{\Delta x}{\Delta t}$$

Physical Quantity

we never write number without unit.

- Any quantity which can be measured is called a **physical quantity**. 5 min . 4 cm , 67 cm . 6 kg

Example:

- L (Length)
- M (Mass)
- T (Time) etc.
- To measure a physical quantity, we must define its **unit.**

Types of physical quantities

- Physical quantities are classified into 2 types:

1)Fundamental quantities

These quantities do not depend on other physical quantities and the units used to measure these quantities are called fundamental units.

- Quantaties that can be found only through meauserments.
- Has their own Fundamntel units

- **2) Derived quantities: Depend on Fundamental**
- These quantities are defined in terms of fundamental quantities.

Examples:

- Area=length x length → m^2
- Density = Mass/Volume → Kg/m^3
- Velocity= Displacement/Time → m/s

Force = $Kg \times m/s^2$ = Newton

Work = $N.m \rightarrow (Kg.m/s^2).m = J$

Physical Quantity	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Temperature	Kelvin	K

mech

Heat

They depend on Fundamental

Derived Quantity	derived	Unit
Area	L×L	m^2
Volume	L×L×L	m^3
Density	Mass÷volume	kg/m^3
Speed	distance÷time	m/s
Acceleration	Δvelocity÷time	m/s^2
Force	mass×acc	N
Pressure	force÷area	N/m^2
work	force× displacement	J

Rules of writing units

- Units named after scientists

Physical Quantity	Unit	Symbol
Force	newton	N
Energy	joule	J
Power	watt	W

→ $kg \cdot m/s^2$

Fundamental units of L,M and T taken together to form a system of units

Name of the system	Units			
	Length	Mass	Time	
1) British engineering	foot	slug	second	FSS
2) CGS	centimeter	gram	second	CGS
3) MKS Standard Metric system SI	meter	kilogram	second	MKS

System International

- The system of units used by scientists and engineers around the world is commonly called the “metric system”
- But since 1960 it has been officially known as System International or SI

1-2 Units of Length, Mass, and Time

comes before the unit

10^3 meter = Kilometer = km

10^-2 meter=1/100 m = centimeter

10^-3 second= millisecond

10^9 = 1* 1000000000 =

giga second

1/1000000000= 10^-9= Nano

1/1000000000000=10^-12=PICO

LASER Pulses

$\frac{1}{100}$

TABLE 1–4 Common Prefixes

Power	Prefix	Abbreviation
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

1-3 Dimensional Analysis

- Any valid physical formula must be dimensionally consistent – each term must have the same dimensions

TABLE 1–5 Dimensions of Some Common Physical Quantities	
Quantity	**Dimension**
Distance	[L]
Area	$[L^2]$
Volume	$[L^3]$
Velocity	[L]/[T]
Acceleration	$[L]/[T^2]$
Energy	$[M][L^2]/[T^2]$

From the table:

Distance = velocity × time

$$[L] = \frac{[L]}{\cancel{[T]}} \times \cancel{[T]}$$

$$[L] = [L]$$

Velocity = acceleration × time

$$\frac{[L]}{[T]} = \frac{[L]}{[T]^{\cancel{2}}} \times \cancel{[T]}$$

EXERCISE 1–2

Show that $x = x_0 + v_0t + \frac{1}{2}at^2$ is dimensionally consistent. The quantities x and x_0 are distances, v_0 is a velocity, and a is an acceleration.

SOLUTION

Using the dimensions given in Table 1–5, we have

$$[L] = [L] + \frac{[L]}{[T]}[T] + \frac{[L]}{[T]^2}[T^2] = [L] + [L] + [L]$$

Note that $\frac{1}{2}$ is ignored in this analysis because it has no dimensions.

5. • **CE** Which of the following equations are dimensionally consistent? **(a)** $x = vt$, **(b)** $x = \frac{1}{2}at^2$, **(c)** $t = (2x/a)^{1/2}$.

6. • **CE** Which of the following quantities have the dimensions of a distance? **(a)** vt, **(b)** $\frac{1}{2}at^2$, **(c)** $2at$, **(d)** v^2/a.

7. • **CE** Which of the following quantities have the dimensions of a speed? **(a)** $\frac{1}{2}at^2$, **(b)** at, **(c)** $(2x/a)^{1/2}$, **(d)** $(2ax)^{1/2}$.

8. • Velocity is related to acceleration and distance by the following expression: $v^2 = 2ax^p$. Find the power p that makes this equation dimensionally consistent.

9. • Acceleration is related to distance and time by the following expression: $a = 2xt^p$. Find the power p that makes this equation dimensionally consistent.

10. • Show that the equation $v = v_0 + at$ is dimensionally consistent. Note that v and v_0 are velocities and that a is an acceleration.

5) a) $x = vt$

$L = \left[\frac{L}{T}\right][T] = \quad L = L$ ✓

b) $x = \frac{1}{2} a t^2$

$L = \frac{L}{T^2} T^2 = L = L$ ✓

c) $t = (2x/a)^{1/2}$

$[T] = \frac{L}{\frac{L}{T^2}}$ X

6. • CE Which of the following quantities have the dimensions
a distance? (a) vt, (b) $\frac{1}{2}at^2$, (c) $2at$, (d) v^2/a. a) $\frac{L}{T} T$ b) $\frac{L}{T^2} T^2$

7. • CE Which of the following quantities have the dimensions
a speed? (a) $\frac{1}{2}at^2$, (b) at, (c) $(2x/a)^{1/2}$, (d) $(2ax)^{1/2}$.

8. • Velocity is related to acceleration and distance by the follo
ing expression: $v^2 = 2ax^p$. Find the power p that makes t
equation dimensionally consistent.

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expression: $a = 2xt^p$. Find the power p that makes this equati
dimensionally consistent.

10. • Show that the equation $v = v_0 + at$ is dimensionally cons
tent. Note that v and v_0 are velocities and that a is an accelerati

6) a) $vt \rightarrow \frac{[L]}{[T]} [T] = [L]$

b) $\frac{1}{2} a t^2 \rightarrow \frac{[L]}{[T]^2} [T]^2 = [L]$

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

d) $v^2/a \rightarrow \frac{[L]^2}{[T]^2} \div \frac{L}{[T]^2} = [L]$

7) a) $\frac{1}{2} a t^2 = \frac{[L}{[T]^2} [T]^2 = [L]$

b) $at \qquad \frac{L}{T^2} [T] = \left[\frac{L}{T}\right]$

c) $2\sqrt{\frac{x}{a}} \qquad \sqrt[2]{L \div \frac{L}{T^2}} \rightarrow \sqrt{L} \div \frac{\sqrt{L}}{T}$

Units

Length

- 1 mile = 1609 m
- 1 m = 3.281 ft $\longrightarrow \frac{1\,m}{3.281\,ft}, \frac{1\,m}{100\,cm}, \frac{1\,Km}{1000\,m}$
- 1millimeter = 1mm = $10^{-3}\,m$
- 30 mm = 30×10^{-3} m = 0.03 m
- 1centimeter = 1cm = $10^{-2}\,m$
- 61 cm = 61×10^{-2} m = 0.61 m
- 1meter = 1m = 100cm
- 1kilometer = 1km = 1000 m = 10^3 m

Length

$$\frac{1\,\text{mile}}{1609\,\text{m}}$$

$$\frac{1\,\text{m}}{3.281\,\text{ft}}$$

$$\frac{1\,\text{m}}{100\,\text{cm}}$$

$$\frac{1\,\text{m}}{1000\,\text{mm}}$$

$$\frac{1\,\text{Km}}{1000\,\text{m}}$$

Mass

$$\frac{1\,\text{g}}{1000\,\text{mg}}$$

$$\frac{1\,\text{Kg}}{1000\,\text{g}}$$

Time

$$\frac{1\,\text{s}}{1000\,\text{ms}}$$

$$\frac{1\,\text{min}}{60\,\text{s}}$$

$$\frac{1\,\text{h}}{3600\,\text{s}}$$

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① $316\,\text{ft} \rightarrow \text{m}$

$$316\,\cancel{\text{ft}} \times \frac{1\,\text{m}}{3.281\,\cancel{\text{ft}}} = \frac{316\,\text{m}}{3.281} = 96.3\,\text{m}$$

(2) $96.3\ m \longrightarrow ft$

$$96.3\ \cancel{m} \times \frac{3.281\ ft}{1\ \cancel{m}} = 96.3 \times 3.281\ ft$$

$$= 315.96\ ft$$

$$= 316$$

(3) $3.0\ \frac{mile}{h} \longrightarrow m/s$

$$3.0\ \frac{\cancel{mile}}{\cancel{h}} \times \frac{1609\ m}{1\ \cancel{mile}} \times \frac{1\ \cancel{h}}{3600\ s}$$

$$= \frac{3.0 \times 1609\ m}{3600\ s} \longrightarrow 1.34\ m/s$$

- 1 mile = 1609 m $\frac{1\ mile}{1609\ m}$ $\frac{1\ 609m}{1\ mile}$
- 1 m = 3.281 ft
- l m = 1000 mm
- 1 m = 100 cm
- 1 km = 1000 m $\frac{1\ km}{100\ m}$

Mass

- 1 milligram = 1mg = $10^{-3}\ g$

- 1 gram = 1g = $10^{-3}\ kg$

- 1kilogram = 1kg = 1000 g = 10^3 g

- 30 g to be in kg = $30\ \cancel{g} \times \frac{1\ kg}{1000\cancel{g}}$ = $30*10^{-3}$ kg

Time

- 1millisecond $=10^{-3}$ s = 1 ms = $\frac{1ms}{10^{-3}\,s}$

$$45\text{ ms} = 45\text{ms} \times \frac{10^{-3}\,s}{1ms} = 45 \times 10^{-3}\text{ s}$$

- 1min = 60 s $\frac{1min}{60\,s}$

- 1 hour = 3600 s $\frac{1\,h}{3600s}$
- 1 day = 24 hr = 24x60x60 = 86400 s
- 1 year = $3\text{x}10^{7}$ s

1-5 Converting Units

Converting feet to meters:

1 m = 3.281 ft (this is a conversion factor)

Or: 1 = 1 m / 3.281 ft

1 mile = 1609m

316 ft × (1 m / 3.281 ft) = 96.3 m

Note that the units cancel properly – this is the key to using the conversion factor correctly!

Convert : $3.00\, mi/h\ to\ m/s$ or $(3.00 \frac{mi}{h}\ to \frac{m}{s})$

Ans: 1.34m/s

1-7 Scalars and Vectors

Scalar – a numerical value. May be positive or negative.
Examples: temperature, speed, height (No direction).

Vector – a quantity with both magnitude and direction.
Examples: displacement (e.g., 10 feet north), force, magnetic field (direction).

1-8 Problem Solving in Physics

No recipe or plug-and-chug works all the time, but here are some guidelines:

1. Read the problem carefully
2. Sketch the system
3. Visualize the physical process
4. Strategize
5. Identify appropriate equations
6. Solve the equations
7. Check your answer
8. Explore limits and special cases

Summary of Chapter 1

- Physics is based on a small number of laws and principles
- Units of length are meters; of mass, kilograms; and of time, seconds
- All terms in an equation must have the same dimensions

Summary of Chapter 1

- Convert one unit to another by multiplying by their ratio

- Scalars are numbers; vectors have both magnitude and direction

- Problem solving: read, sketch, visualize, strategize, identify equations, solve, check, explore limits