



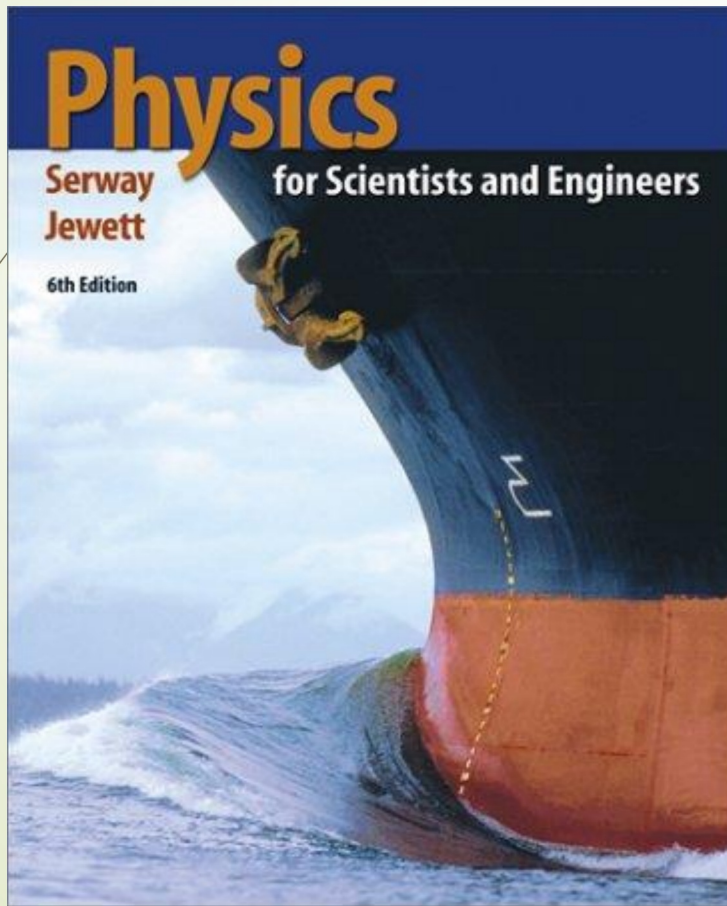
Physics 102

Faculty of Sciences – Physics Department

Assessment Tasks

Assessment task		Week Due	Proportion of Total Assessment
Theoretical			
1	Midterm Written Exams	5 th - 7 th week	20 %
2	Quizzes, class participation and home assignments.	2 nd - 14 th week	10 %
3	Final exam	By the end of the semester	40 %
Practical			
5	Lab reports	weekly	10%
6	Lab midterm exams	4 th - 6 th week	5%
7	Lab final exam	12 th -13 th week	15%
Total		100 %	

Course Book



**Physics for Scientists
and Engineers**

Author: Serway Jewett

(7th edition)



CHAPTER 1

Mechanics

Units and Dimensions

Motion in One Dimension





Topics to be covered

Units & Dimensions

- Base and Derived Units
- Definition of SI Units
- Scalar and Vector Quantities
- Dimensional Analysis

Motion in One Dimension

- Displacement
- Average and Instantaneous Velocity
- Average and Instantaneous Acceleration



Objectives

In the first part of this chapter you will learn:

- The difference between base and derived units
- How to use units to check equations
- How to use significant figures
- How to deal with vectors

In the second part you will learn:

- How to describe motion in terms of distance , displacement, speed, velocity, acceleration and time

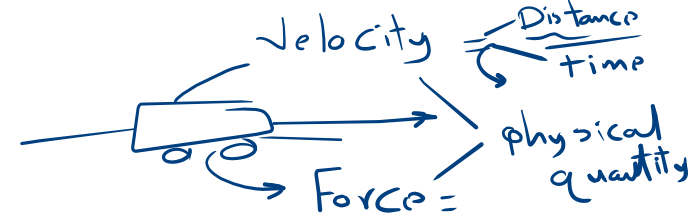


Introduction

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

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

All other physical quantities can be constructed from these three.



$$\begin{aligned} \text{Length} &= 4 \text{ m} \text{ — unit} \\ \text{Mass} &= 3 \text{ kg} \\ \text{Time} &= 10 \text{ s} \end{aligned}$$

Metric Unit of Measure	
Measures of Length	
1 meter (m)	→ 1000 millimeters (mm)
1 meter (m)	→ 100 centimeters (cm)
1 Kilometer (km)	= 1000 meters
1 decimeter (dm)	= 1/10 meter
Measure of Weight	
1 gram (g)	= 1000 milligrams (mg)
1 Kilogram (kg)	= 1000 grams
Liquid Measures	
1 liter (L)	= 1000 milliliters (mL)
1 deciliter (dL)	= 1/10 liter



Units

Physics Experiments Measurements

Unit systems Accuracy

SI Units

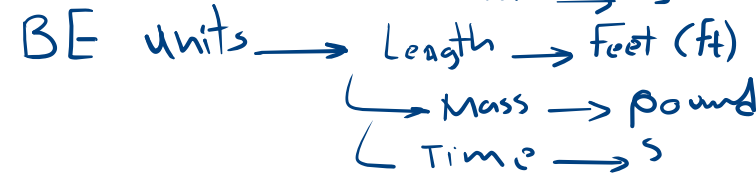
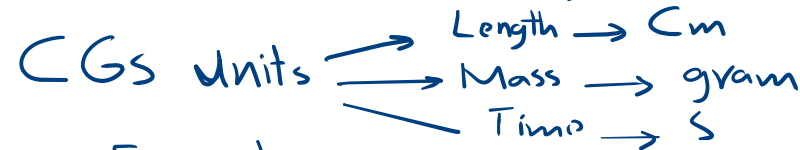
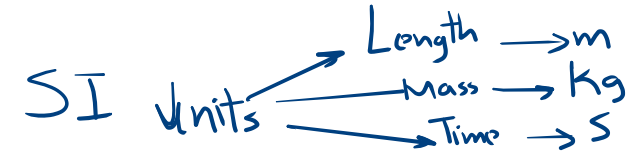
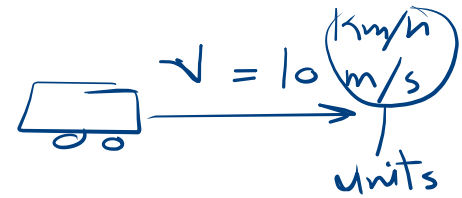
- International system of units

CGS

- Centimeter-gram-second

BE

- British Engineering system












Basic Units of Measurements

	Length	Mass	Time
SI units	<u>Meter(m)</u>	<u>Kilogram(kg)</u>	<u>Second(s)</u>
CGS units	<u>Centimeter (cm)</u>	<u>Gram(g)</u>	<u>Second(s)</u>
BE	<u>Foot(ft)</u>	<u>Slug(sl)</u>	<u>Second(s)</u>

SI units

Physical quantity measured	Base unit	SI abbreviation
	<u>mole</u>	<u>mol</u>
	<u>meter</u>	<u>m</u>
	<u>kilogram</u>	<u>kg</u>
	<u>second</u>	<u>s</u>
Temp 	<u>kelvin</u>	<u>K</u>
Current 	<u>ampere</u>	<u>A</u>
	<u>candela</u>	<u>cd</u>

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



QUANTITY	SI	CGS	BRITISH
Length	meter (m)	centimetre	foot
Time	second (sec)	second	second
Mass	kilogram (kg)	gram	slug
Velocity	m/sec	cm/sec	ft/sec
Acceleration	m/sec ²	cm/sec ²	ft/sec ²
Force	newton. (kg.m/sec ²)	dyne (g.cm/sec ²)	pound (lbf) (slug.ft/ sec ²)
Work, energy	Joule (N.m)	erg (dyne.cm)	ft.lbf
Power	watt (joule/sec)	erg/sec	ft.lbf/sec
Torque	N.m	dyne.cm	ft.lbf
Pressure	pascal (N/m ²)	dyne/cm ²	lbf/ft ²

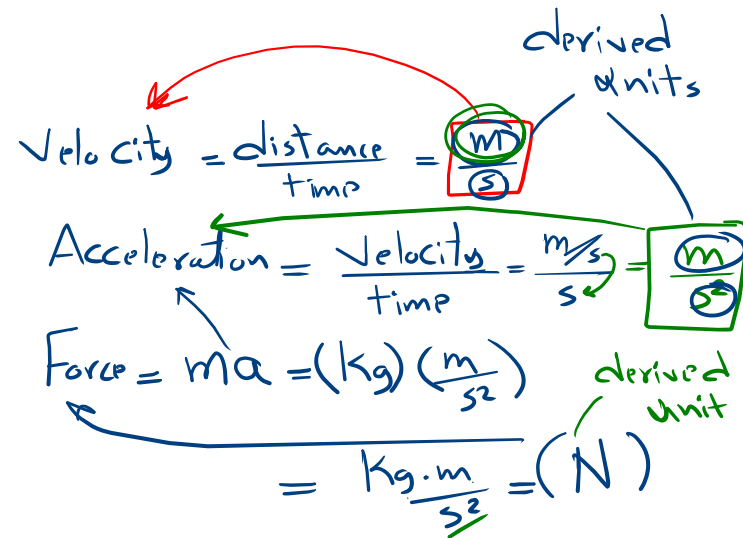




Table of Conversion

CONVERSION TABLE

LINEAR MEASURE CONVERSIONS

1 mm	=	1000 μ m
1 m	=	1000 mm
1 km	=	0,821 372 7 miles
1 mil	=	0,025 4 mm
1 mil	=	0,001 inch
1 yard	=	0,914 4 m
1 English foot	=	0,304 8 m
1 Cape foot	=	0,314 858 m
1 inch	=	25,4 mm
1 mile	=	1,609 34 km
1 nautical mile	=	1852 m
1 geographic mile	=	7420 m
1 chain (22 yards)	=	20,110 m
1 Cape rod	=	3,778 301 m
1 rod	=	5,029 m
1 furlong	=	201,168 m (40 rods)
1 fathom (6 feet)	=	1,829 m
1 cable's length	=	185,319 m
1 yard	=	3 feet
1 cm	=	10 mm or 0,3937 inch

MASS CONVERSIONS

1 mg	=	0,001 g
1 g	=	0,001 kg or 1 000 mg
1 kg	=	0,001 t (ton)
1 t	=	1000 kg
1 pound (lb)	=	0,453 6 kg
1 ounce (oz)	=	28,350 g
1 short ton	=	907,208 kg
	=	0,907 2 t (metric ton)
1 long ton	=	1 016 kg
	=	1,016 t (metric ton)
1 grain	=	0,064 798 9 g
1 dram (av)	=	1,771 85 g
1 drachm (apoth)	=	3,887 93 g
1 slug (32,174 lb)	=	14,593 9 kg
1 carat	=	200 mg or 0,2g

SQUARE MEASURE CONVERSIONS

1 cm ²	=	0,000 1 m ²
	=	0,155 inch ²
1 m ²	=	10,760 feet ²
	=	1,196 yards ²
1 km ²	=	1 000 000 m ²
	=	0,386 104 0 miles ²
1 hectare	=	10 000 m ²
1 acre	=	0,404 888 hectare
1 morgen	=	0,856 531 8 hectare
1 yard ²	=	0,836 127 m ²
1 foot ²	=	0,092 903 m ²
1 Cape foot ²	=	0,099 135 623 1 m ²
1 Cape rod ²	=	14,275 529 73 m ²
1 inch ²	=	6,452 cm ²
1 mile ²	=	2,589 99 km ²
1 superficial square	=	9,29 m ²
1 chain ²	=	404,686 m ²
1 mile ²	=	640 acres
1 acre	=	4 046,860 m ²
1 morgen	=	8 565,320 m ²

PRESSURE & STRESS

1 Pa (Pascal)	=	1 N/m ²
	=	0,000 001 N/mm ²
	=	0,000 01 bar
1 lbf / inch ² (psi)	=	6,895 kPa
1 short tonf / inch ²	=	13,79 MPa
1 short tonf / ft ²	=	95,76 kPa
1 long tonf / inch ²	=	15,44 MPa
1 long tonf / ft ²	=	107,3 kPa
1 bar	=	100 kPa
1 kgf / cm ² or 1 atm.	=	98 100 Pa
1 torr (1 mm Hg, 0°C)	=	133 Pa
1 atm. (atmosphere)	=	101 325 N/m ²

TEMPERATURE

n °F	=	0,555 6 (n-32) °C
n °C	=	(1,8n + 32) °F

CUBIC MEASURE CONVERSIONS

1 yard ³	=	0,764 6 m ³
1 foot ³	=	0,028 32 m ³
	=	28,320 litres
1 inch ³	=	16 387 mm ³
	=	0,016 39 litres
	=	16,39 ml
	=	16,39 cm ³
1 gallon (imperial)	=	4,546 dm ³
1 gallon (US)	=	3,785 dm ³
1 m ³	=	1000 litres
1 cm ³ or 1000 mm ³	=	1 ml
1 m ³	=	1 000 000 000 mm ³
	=	1 000 000 cm ³
	=	1 000 dm ³
1 dm ³	=	1 litre
1 gallon (imperial)	=	4,546 litres
1 gallon (US)	=	3,785 litres
1 litre	=	0,219 973 gallon (imp.)
	=	0,264 200 gallon (US)
1 pint	=	0,568 litres

VELOCITY (LINEAR)

1 m/s	=	1000 mm/s
1 ft/s	=	0,304 8 m/s
1 mile/h	=	1,609 km/h
1 km/h	=	0,621 372 miles /hour
1 knot	=	1 nautical mile/hour
	=	1,852 km/h
	=	0,514 445 m/s
1 km/h	=	0,529 860 knot

FORCE CONVERSIONS

1 N (newton)	=	1 kg.m/s ²
1 kN	=	1000 N
1 lbf	=	4,448 N
1 short ton force	=	8,896 kN (8896 N)
1 long ton force	=	9,964 kN (9964 N)
1 poundal	=	0,138 265 N



LENGTH

Ordinary Units

1 foot	= 12 inches
1 yard	= 3 feet
1 mile	= 5280 feet
1 nautical mi	= 1.1516 statute mi
1° of latitude at the equator	= 69.16 statute mi
	= 60 nautical mi
1 acre	= 208.71 ft on one side of square

Metric Units

1000 picometres	= 1 nanometre
1000 nanometres	= 1 micrometre
1000 micrometres	= 1 millimetre
10 millimetres	= 1 centimetre
100 millimetres	= 1 decimetre
10 centimetres	= 1 decimetre
1000 metres	= 1 metre
100 centimetres	= 1 metre
10 decimetres	= 1 metre
100 metres	= 1 hectometre
1000 metres	= 1 kilometre
10 hectometres	= 1 kilometre
1000 kilometres	= 1 megametre
1852 nautical metres	= 1 international nautical mile

Equivalents

1 inch	= 2.5400 centimetres
1 foot	= 0.3048 metre
1 statute mi	= 1.60935 kilometres
1 nautical mi	= 1.853 kilometres
1 centimetre	= 0.39370 inch
1 metre	= 3.28 feet
1 kilometre	= 3280.83 feet
	= 0.62137 mile

AREA

Ordinary Units

1 square foot	= 144 square inches
1 square yard	= 9 sq ft
	= 1296 sq ft in.
1 acre	= 43,560 sq ft
	= 4840 sq yds
1 sq mile	= 640 acres
	= 1 section of land (U.S.)

Metric Units

100 sq millimetres	= 1 sq centimetre
100 sq centimetres	= 1 sq decimetre
10000 sq centimetres	= 1 sq metre
100 sq decimetres	= 1 sq metre
100 sq metres	= 1 are
10 ares	= 1 dekaare
10000 sq metres	= 1 sq hectometre
	= 1 hectare
100 ares	= 1 hectare
10 dekaares	= 1 hectare
100 sq hectometres	= 1 sq kilometre
100 hectares	= 1 sq kilometre

Equivalents

1 square centimetre	= 0.155 square inch
1 square metre	= 10.76 square feet
	= 1.196 square yards
1 square kilometre	= 0.386 square mile
1 square inch	= 6.45 square centimetres
1 square foot	= 0.0929 square metre
1 square yard	= 0.836 square metre
1 square mile	= 2.59 square kilometres

VOLUME AND CAPACITY

Ordinary Units

1 cu ft of water at 39.1°F	= 62.425 lbs
1 United States gallon	= 231 cu in.
1 imperial gallon	= 277.274 cu in.
1 cubic foot of water	= 1728 cu in.
	= 7.480519 U. S. gallons
	= 6.232103 imperial gallons
1 cubic yard	= 27 cu ft
	= 46,656 cu in.
1 quart	= 2 pints
1 gallon	= 4 quarts
1 U. S. gallon	= 231 cu in.
	= 0.133681 cu ft
	= 0.83311, imperial gallon
	= 8.345 lbs
1 barrel	= 31.5 gallons
	= 4.21 cu ft
1 U. S. bushel	= 1.2445 cu ft
1 fluid ounce	= 1.8047 cu in.
1 acre foot	= 43,560 cu ft
	= 1,613.3 cu yds
1 acre inch	= 3,630 cu ft
1 million U. S. gallons	= 133,681 cu ft
	= 3.0689 acre-ft
1 ft depth on 1 sq mi	= 27,878, 400 cu ft
	= 640 acre-ft

Metric Units

1000 cu millimetres	= 1 cu centimetre
1000 cu centimetres	= 1 cu decimetre
1000 cu decimetres	= 1 cu metre
1000 cu metres	= 1 cu dekametre
1000 dekametres	= 1 hectometre
1000 cu hectometres	= 1 cu kilometre
1000 microlitres	= 1 millilitre
	= 1 cu centimetre
10 millilitres	= 1 centilitre
10 centilitres	= 1 decilitre
1000 millilitres	= 1 litre
100 centilitres	= 1 litre
100 litres	= 1 hectolitre
1000 litres	= 1 kilolitre
	= 1 cu metre
10 hectolitres	= 1 kilolitre

Equivalents

1 cu in.	= 16.387 cu cm
1 cu ft	= 0.0283 cu m
1 cu yd	= 0.765 cu m
1 cu cm	= 0.0610 cu in.
1 cu m	= 35.3 cu ft
	= 1.308 cu yds
1 litre	= 61.023378 cu in.
	(about 1 quart)
	= 0.264170 U. S. liquid gallon
	= 0.2201 imperial gallon
1 U. S. liquid quart	= 0.946 litre
1 U. S. liquid gallon	= 3.785 litres

WEIGHT (MASS)

Ordinary Units

1 pound	= 16 ounces (avoirdupois)
1 ton	= 2000 lbs
1 long ton	= 2240 lbs
1 lb of water (39.1° F)	= 27.681217 cu in.
	= 0.016019 cu ft
	= 0.119832 U. S. gallon
	= 0.453617 liter

Equivalents

1 kilogram	= 2.205 avoirdupois pounds
1 metric ton	= 0.984 gross or long ton
	= 1.102 net or short tons
1 avoirdupois pound	= 28.35 grams
1 avoirdupois	= 0.4536 kilogram

To Convert

ounces into grams	28.3495
pounds into grams	453.6
pounds into kilograms	0.4536
tons into kilograms	1016.047
tahils into grams	37.799
kati into kilograms	0.60479
grains into grams	0.0648

To Convert

grams into ounces	0.03527
grams into grains	15.4324
grams into tahil	0.02646
kilograms into pounds	2.2046
kilograms into tons	0.0009842
kilograms into katis	1.653
kilograms into stones	0.1575
kilograms into hundreweights	0.01968

NON-METRIC TO METRIC LINEAR

To Convert

inches into centimetres	2.540
inches into metres	2,540 x 10 ²
inches into millimetres	25.4
feet into metres	0.3048
yards into metres	0.9144
miles into kilometres	1.609344
miles into metres	1609.344
feet into centimetres	30.48

METRIC TO NON-METRIC LINEAR

To Convert

millimetres into feet	3.281 x 10 ¹
millimetres into inches	0.03937
centimetres into inches	0.3937
metres into feet	3.281
metres into yards	1.09361
kilometres into yards	1093.61
kilometres into miles	0.62137

VELOCITY

To Convert

miles per hour into kilometres per hour	1.609344
feet per second into metres per second	0.3048
feet per second into centimetres per second	30.48
centimetres per second into feet per second	0.03281
metres per second into feet per minute	196.9
metres per second into feet per second	3.281
kilometres per hour into miles per hour	0.6214



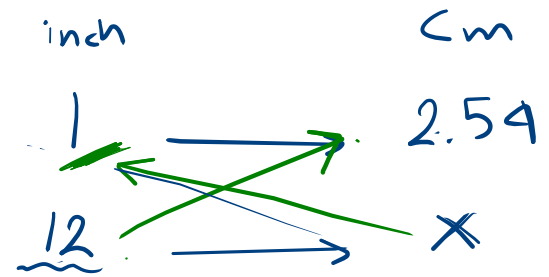
The Conversion of Units

► Using the table of conversion, answer these questions.

Q1 Convert 12 inches to centimeters.

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

12 inch x (———) = cm



$$x = \frac{12 \times 2.54}{1} = \boxed{30.5 \text{ cm}}$$



The Conversion of Units

► Using the table of conversion, answer these questions.

Q1 Convert 12 inches to centimeters.

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

$$\underline{12 \text{ inch}} \times \left(\frac{2.54 \text{ cm}}{1 \text{ inch}} \right) = \underline{30.5 \text{ cm}}$$

Base quantities and units



- The international system (SI) has seven base quantities and units

Base Quantity		Base unit	
Name	Symbol	Name	Symbol
time ←	t	second	s
length	l	meter	m
mass	m	kilogram	kg
temperature	T, θ	kelvin	K
Electric current	I	ampere	A
Amount of substance	n	mole	mol
Luminous intensity		candela	Cd

t = 5 s



Some common derived quantities and their units:

Physical quantity	Defined as	unit	Special name
density	Mass \div volume	kg/m ³	
momentum	Mass x velocity	kg.m/s	
force	Mass x acceleration	kg.m/s ²	newton N
pressure	Force \div Area	kg/ms ²	pascal
Work(energy)	Force x distance	kg m ² /s ²	joule
power	Work \div time	kg m ² /s ³	watt
Electric charge	Current x time	As	coulomb
Velocity	distance \div time	m/s	
acceleration	velocity \div time	m/s ²	



Difference between base and derived quantities

Base quantities

- They do not depend on any quantities
- They are seven in number
- Examples : length , mass, time etc
- Their units are called as base units

Derived quantities

- They depend on base quantities
- They are many
- Examples : force, velocity, acceleration etc
- Their units are known as derived units because they are derived from base units

$$\text{Length} = 5\text{m}$$
$$\text{time} = 10\text{s}$$

$$v = \frac{\text{distance}}{\text{time}} = \frac{\text{m}}{\text{s}}$$



Homogeneous equations

- ▶ This means that in any correct equation the base units of each part must be the same
- ▶ The base units on the right hand side of the equation should be the same as left hand side

Example

- ▶ Kinetic energy = $\frac{1}{2}mv^2$
- ▶ Joule = $\frac{1}{2}(\text{kg})(\text{m}^2/\text{s}^2)$
- ▶ $\text{kg} \cdot \text{m}^2/\text{s}^2$ = $\text{kg} \cdot \text{m}^2/\text{s}^2$
- ▶ $\frac{1}{2}$ is a pure number and has no units.

To check an equation we can make use of units.

$$a = \frac{v}{t}$$
$$a \left(\frac{\text{m}}{\text{s}^2} \right) = \frac{v \left(\frac{\text{m}}{\text{s}} \right)}{t \left(\text{s} \right)} = \frac{\text{m}}{\text{s}^2}$$
$$a \left(\frac{\text{m}}{\text{s}^2} \right) = \frac{v \left(\text{km/h} \right)}{t \left(\text{s} \right)}$$



Prefixes

- For very large or small numbers, we can use standard prefixes

Prefix	Symbol	Multiplier
<u>giga</u>	<u>G</u>	<u>10^9</u>
<u>mega</u>	M	<u>10^6</u>
<u>kilo</u>	<u>k</u>	<u>10^3</u>
<u>milli</u>	<u>m</u>	<u>10^{-3}</u>
micro	μ	<u>10^{-6}</u>
nano	n	<u>10^{-9}</u>
pico	p	<u>10^{-12}</u>
femto	f	<u>10^{-15}</u>

$$5 \times 10^9 \text{ (s)} = 5 \text{ G(s)}$$

$$2 \text{ k} = 2000$$

$$\checkmark = 10 \text{ m} \times 10^{-3} = 0.01$$

Significant figures

Significant figures are the digits within a number that help determine accuracy

Rules	Example	# s.f
All numbers that are <u>not zero</u> are significant	<u>43</u>	<u>2 s.f</u>
Zeros in the <u>middle</u> of <u>non-zero</u> numbers are significant	<u>201</u>	<u>3 s.f</u>
Zeros after the decimal are significant	<u>14.90</u>	<u>4 s.f</u>
Zeros and coefficients in scientific notation are significant	<u>14.0</u> × 10 ³	<u>3 s.f</u>
<u>Leading</u> or <u>beginning</u> zeros are not significant	0.000 <u>66</u>	<u>2 s.f</u>
Zeros in a number without a decimal are not significant	<u>4000000</u>	<u>1 s.f</u>
When adding or subtracting look for the least amount of decimal places	103+2.3=105.3 RD to 105	<u>3 s.f</u>
When multiplying or dividing look for the least amount of significant figures	1.1×0.5 = 0.55 RD to 0.6	<u>1 s.f</u>

45 2 s.f



L = 20 cm (1 s.f)
 L = 20.33 cm (4 s.f)
 accuracy

00.00
 103 + 2.3 = 105.3
 ≈ 105
 1.1 × 0.5 = 0.55
 0.6



Example of significant figures

A man covers a distance of 100.0m in 68s. Calculate his average speed.

Speed = distance/time

$$= 100.0/68$$

$$= \underline{1.4705882} \text{ m/s}$$

This is the answer from your calculator

Distance: 4 s.f., time 2 s.f.

See the smaller one.

We round to 2 s.f.

So our answer will be = 1.5m/s

$$\begin{aligned} \text{Speed} &= \frac{\text{distance}}{\text{time}} = \frac{100.0}{68} \\ &= 1.4705882 \text{ m/s} \\ &\quad \text{4 s.f.} \\ &\quad \text{2 s.f.} \\ &\quad \text{2 s.f.} \end{aligned}$$

1.5

Examples

How many significant figures are there?

a) 40 1 s.f. 1 s.f.

b) 80.30 4 4 s.f.

c) 0.032 2 2 s.f.

d) 5.801×10^{-2} 4 s.f. 4 s.f.

e) $486 - 421.23 = 65$ 2 s.f.

f) $100.0 \times 20.0 = 2.00 \times 10^3$ 3 s.f.

$\frac{4 \text{ s.f.}}{100.0} \times \frac{3 \text{ s.f.}}{20.0} = 2.00 \times 10^3$ 3 s.f.

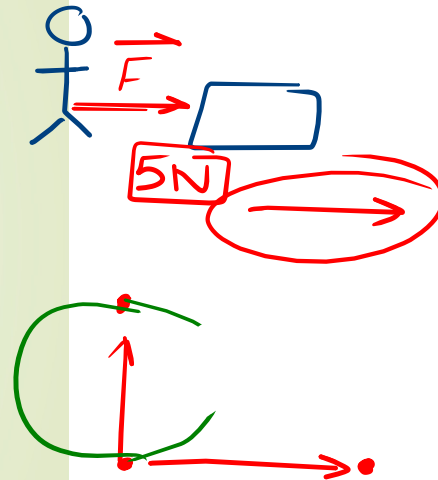
$486 - 421.23$
 $= 64.76$
65 2 s.f.



Vectors and Scalars

- Vectors have both magnitude and direction.
- Scalars have only magnitude but no direction

<u>Scalars</u>	<u>Vectors</u>
<u>Distance</u>	<u>Displacement</u>
Speed	<u>Velocity</u>
<u>Mass</u>	<u>Weight</u>
<u>Pressure</u>	<u>Force</u>
Energy	Momentum
<u>Temperature</u>	Acceleration
Volume	Electric current
Density	Torque





Scalars and Vectors

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.

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



scalar quantities
 $T = 30^{\circ}\text{C}$



$F = 6\text{N}$ in west direction
vector quantity



Dimensional Analysis

► The dimensional analysis is important in checking the validity of any mathematical expression. The dimension of any quantity will be defined in brackets []. The dimension of velocity v is $[v] = L/T$

► Example:

is the expression of $x = 1/2 at^2$ correct dimensionally

$$[L] = \frac{L}{T^2} \times T^2 = [L] \text{ dimensionally correct}$$

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

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

PHYS
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$$x^d = \frac{\text{speed}}{t} \text{ time}$$

$$(L) = \frac{(\frac{L}{t})}{t} = \frac{L}{t^2}$$

$$\otimes = \frac{v}{t} = \frac{\frac{L}{t}}{t} = \frac{L}{t^2}$$

$$\neq \frac{L}{t^2}$$

not correct