

ENGINEERING SCIENCE

2ND EDITION



SITI MORNI AB RAHMAN · RUSLAWATI ABDUL WAHAB
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SECOND EDITION

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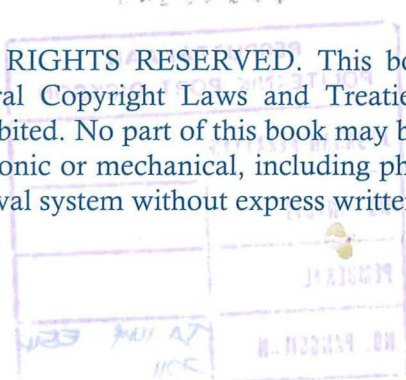
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Preface

Engineering Science is the working book specially written for Polytechnic students for long life learning and presented in English. It is adapted from Physic SPM and based on the latest syllabus prepared by the Polytechnic Department, Ministry of High Education. The contents of this book are comprehensive and concise to help students learn this subject more effectively in order to achieve excellent results in continues assessments and final examination.

The features of this book include:

Theories Concept, Examples, Do It Yourself, Self Learning and Examination Format.

I want to thank you to all the writers for the teamwork and the commitment to produce 2nd edition of the Engineering Science Workbook. This workbook is written by;

- ✿ *Aziyati Ibrahim in Topic 1-Physical Quantity and Measurement,*
- ✿ *Ayuni Md Yusof in Topic 2- Linear Motion,*
- ✿ *Siti Morni Ab. Rahman in Topic 3- Force,*
- ✿ *Zamzarina Daud @ Bukhari in topic 4 Work Energy and Power,*
- ✿ *Fara Nur Asma Mohd Basri in topic 5- Solids and Liquids and*
- ✿ *Ruslawati Abdul Wahab in Topic 6 and Topic 7- Temperature & Heat and Electricity.*

I'll like to invite all the students to get benefit from this work book as they embark on their journey to gain lifelong leaning in this module.

Editor

Ruslawati Abdul Wahab

November 2011

Symbols and Standard International Units

These are the symbols and the units that are used in the lessons:

- s Displacement (meters: m)
- t Time (seconds: s)
- u Initial velocity (meters per second: m/s)
- v_{av} Average Velocity (meters per second: m/s)
- v Final Velocity (meters per second: m/s)
- a Acceleration (meters per second per second: m/s^2)
- g Acceleration of Gravity on Earth (meters per second per second: $9.81 m/s^2$)
- m Mass (kilograms: kg)
- w Weight($N = kg m/s^2$)
- F Force (Newtons: $N = kg m/s^2$)
- F_N Normal Force (Newtons: $N = kg m/s^2$)
- W Work (Joules: $J = kg m^2/s^2$)
- E_p Potential Energy (Joules: $J = kg m^2/s^2$)
- E_K Kinetic Energy (Joules: $J = kg m^2/s^2$)
- ρ Density (kg/m^3)
- V Volume (m^3)
- P Pressure (Pascal, Pa)
- Q Quantity of heat (J)
- C specific heat $J/kg/^\circ C$
- $\Delta\theta$ the change of temperature (Kelvin, K)
- I Current (Ampere)
- Q Quantity of Charge(Coulombs, C)
- C Capacitance(Farad, F)
- P Power (Watts: $W = kg m^2/s^2 /s$)

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Chapter

1

Physical Quantity and Measurement



Physical Quantities & Measurement

1.1 Physical Quantities

A physical quantity is a quantity that can be measured. It can be defined in terms of the operations necessary to measure it. All physical quantities have numerical value and unit of measurement. For example, if a person weighs 70 kilogram, then “70” is the numerical value and “kilogram” is the unit. This physical quantity would be written as 70kg.

Person weight = 70 kilogram = 70 kg
Physical quantity = numerical value x unit measurement

- If the temperature outside is 30 degrees Celsius, then “30” is the numerical value and “degree Celsius” is the unit. This quantity would be written as "30 °C".

Temperature = 30 degree Celsius = 30°C
Physical quantity = numerical value x unit measurement

- Physical quantities can be classified into:
 - Base quantity
 - Derived quantity

1.2 Base Quantities

Base quantities are physical quantities that cannot be derived from other physical quantities. All base quantities are measured in units based on the International Systems of Units, which is also commonly known as SI units. Table 1 shown seven base quantities in SI units are based on the metric system:

Table 1: Base quantities in SI units

Name	Symbol for quantity	SI base unit	Symbol for unit
Length	l, x, r, etc.	meter	m
Time	t	second	s
Mass	m	kilogram	kg
Electric current	I, i	ampere	A
Temperature	T	Kelvin	K
Amount of	n	mole	mol

substance			
Luminous intensity	Iv	candela	cd

1.3 Derived Quantities

Derived quantities are physical quantities obtained from the combination of base quantities by multiplication, division or both.

Quantities such as force, pressure and power can be calculated or expressed in terms of base quantities. Table 2 shows some derived quantities and their units as well as their relationship with base quantities.

Table 2: Derived quantities and their units

Derived Quantities	Symbol	Definition	Unit
Area	A	Length x Breadth	m x m = m ²
Volume	V	Length x Breadth x Height	m x m x m = m ³
Velocity	v	Distance / Time	m/s = ms ⁻¹
Accelaration	a	Velocity change / Time	m/s = ms ⁻²
Density	ρ	Mass / Volume	kg/m ³ = kgm ⁻³
Force	F	Mass x Accelaration & Mass x Gravity	kgm/s ⁻² atau Newton
Work	W	Force x Distance	N x m = Nm = Joule (J)
Power	P	Work / Time	Js ⁻¹

Do it Your self

Examples	Notes
1Q1- A helicopter is flying at a height of 1500m with the velocity of 2.0ms ⁻¹ . Two sky drivers of mass 60kg and 65kg jump down respectively from the helicopter. They accelerate downwards and they take about 30 minutes to reach the ground. a. State the quantities refer to the question above; Base Quantity - Derived Quantity - b. From the above passage, list the base and derived quantities and	

Examples	Notes
their SI units. Base Quantity - Derived Quantity - 1Q2- eat, Power, Current, Period From the above physical quantities, list the base and derived quantities and their SI units. Base Quantity - Derived Quantity - 1Q3- Study the following picture and list the physical quantities that can be measured.  The list of physical quantities- 1Q4- State the dimension and unit for: a. Area b. Volume c. Velocity	

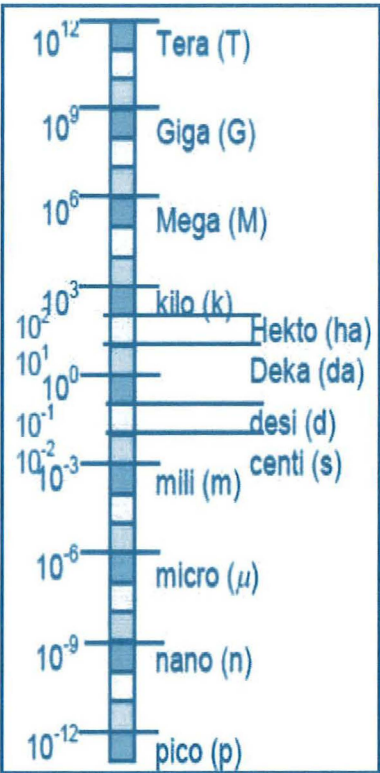
Examples	Notes
d. Acceleration	
e. Force	
f. Weight	
g. Energy	

1.4 Prefix

We also use prefixes, in addition to SI units. Prefixes are used when the quantities measured have very big values or very small values. Each prefix has its own abbreviation and value. Table 3 shows the abbreviations and values of some prefixes.

Table 3: Prefixes

Prefix	Abbreviation	Factor	Example
Tera	T	$\times 10^{12}$	$5\text{Tm} = 5 \times 10^{12}\text{m}$
Giga	G	$\times 10^9$	$2\text{Gm} = 2 \times 10^9\text{m}$
Mega	M	$\times 10^6$	$8\text{Mm} = 8 \times 10^6\text{m}$
Kilo	k	$\times 10^3$	$7\text{km} = 7 \times 10^3\text{m}$
Hekto	h	$\times 10^2$	$6\text{hm} = 6 \times 10^2\text{m}$
Deka	da	$\times 10^1$	$9\text{dam} = 9 \times 10^1\text{m}$
		$\times 10^0$	
Desi	d	$\times 10^{-1}$	$5\text{dm} = 5 \times 10^{-1}\text{m}$
Senti	c	$\times 10^{-2}$	$3\text{cm} = 3 \times 10^{-2}\text{m}$
Mili	m	$\times 10^{-3}$	$4\text{mm} = 4 \times 10^{-3}\text{m}$
Mikro	μ	$\times 10^{-6}$	$8\mu\text{m} = 8 \times 10^{-6}\text{m}$
Nano	n	$\times 10^{-9}$	$1\text{nm} = 1 \times 10^{-9}\text{m}$
Piko	p	$\times 10^{-12}$	$6\text{pm} = 6 \times 10^{-12}\text{m}$



1.5 Conversion Of Units

- In certain specific situations, the values of physical quantities need to be changed from one unit to another. Skills of conversion from one system of unit to another or from one prefix to another by using simple and systematic approach in the conversion process.

- Table 4 lists examples of basic conversion factors that one should know to facilitate unit conversion at fundamental level.

Quantity		Conversion Factors
1)	Length	
	a) 1 km	1000 m
	b) 1 m	100 cm
	c) 1 cm	10 mm
	d) 1 inch	25.4 mm @ 2.54 cm
	e) 1 feet	30.48 cm @ 0.3048 m
	f) 1 mile	1.61 km
2)	Mass	
	a) 1 ton	1000 kg
	b) 1 kg	1000 g
	c) 1 g	1000 mg
	d) 1 pound (lb)	0.4536 kg
3)	Time	
	a) 1 year	365 days / 12 months
	b) 1 month	4 weeks
	c) 1 week	7 days
	d) 1 day	24 hours
	e) 1 hour	60 min
	f) 1 min	60 s
	g) 1 year	3600 s
4)	Volume	
	a) 1 m ³	1000 liter
	b) 1 liter	0.001m ³
5)	Angle	
	a) 1 circle	2 π radian
6)	Electric	
	a) 1 kW	1000 watt
	b) 1 watt	1000 m
	c) 1 k Ω	1000 g Ω
	d) 1 g Ω	1000 m Ω
7)	Temperature	
	a)	Fahrenheit $T_F = 9/5 T_C + 32$
	b)	Celcius $T_C = 5/9 (T_F - 32)$
	c)	Kelvin $T_K = T_C + 273.15$

1.6 Conversion of Prefixes-

Examples	Notes
Prefixes to Numerical Value 1Q5- The thickness of a film is 245Nm. What is the thickness in unit meter? $= 2.45 \times 10^2 \times 10^{-9} \text{ m}$ $= \underline{2.45 \times 10^{-7} \text{ m}}$ 1Q6- Convert 60 mm² to m². $= 60 \times 10^{-3 \cdot (0)} \times 10^{-3 \cdot (0)}$ $= 60 \times 10^{-3+(-3)}$ $= \underline{60 \times 10^{-6} \text{ m}^2}$ Numerical Value to Prefixes 1Q7- 0.306 s is equal to how many ms. $= 0.306 \text{ s} \times \frac{1 \text{ ms}}{10^{-3} \text{ s}}$ $= 0.306 \times 10^3 \text{ ms}$ @ $= 0.306 \times 10^{0+(-3)}$ $= 0.306 \times 10^3 \text{ ms}$ 1Q8- Convert 0.00034W into μW. $= 0.00034 \text{ W} \times \frac{1 \mu \text{ W}}{10^{-6} \text{ W}}$ $= 0.00034 \times 10^6 \mu \text{ W} \quad @$ $= 0.00034 \times 10^{0+(-6)}$ $= 0.00034 \times 10^6 \mu \text{ W}$ 1Q9- 23 m² is equal to how many mm² $= 23 \text{ m}^2 \times \frac{1 \text{ mm}}{10^{-3} \text{ m}} \times \frac{1 \text{ mm}}{10^{-3} \text{ m}}$ $= 23 \times 10^6 \mu \text{ W}$ @ $= 23 \times 10^{0+(-3)} \times 10^{0+(-3)}$ $= 23 \times 10^{3+3}$	

Examples	Notes
$= 23 \times 10^6 \text{ mm}^2$ <i>Prefixes to Prefixes</i> 1Q10- Convert 0.000012 km into cm. $= 0.000012 \times 10^3 \text{ m} \times \frac{1 \text{ cm}}{10^{-2} \text{ m}}$ $= 0.000012 \times 10^3 \text{ m} \times 10^2 \text{ m}$ $= 0.000012 \times 10^5 \text{ m}$ @ $= 0.000012 \times 10^{3+(-2)}$ $= 0.000012 \times 10^5 \text{ m}$	
1Q11- Convert 630,000 MJ into kJ. $= 630,000 \times 10^6 \text{ J} \times \frac{1 \text{ KJ}}{10^3 \text{ J}}$ $= 630,000 \times 10^6 \text{ J} \times 10^{-3} \text{ J}$ $= 630,000 \times 10^3 \text{ J}$ $= 630,000 \times 10^{6-3}$ $= 630,000 \times 10^3$	
1Q12- Convert 569.54 km² to mm² $= 569.54 \text{ km}^2 \times 10^3 \text{ m} \times 10^3 \text{ m} \times \frac{1 \text{ mm}}{10^{-3} \text{ m}} \times \frac{1 \text{ mm}}{10^{-3} \text{ m}}$ $= 569.54 \times 10^3 \times 10^3 \times 10^3 \times 10^3$ $= 569.54 \times 10^{12} \text{ mm}^2$ @ $= 569.54 \times 10^{3+(-3)} \times 10^{3+(-3)}$ $= 569.54 \times 10^{12} \text{ mm}^2$	

Self Learning 1

Prefixes to Numerical Value

Do it yourself 1

Change the following quantities

a. $25 \text{ mg} = \dots \text{g}$

Answer: $25 \times 10^{-3} \text{g}$

Do it yourself 2

b. Earth Radius = $6367 \text{ km}^2 = \dots \text{m}^2$

Answer: $6367 \times 10^6 \text{m}^2$

Do it yourself 3

c. $689 \text{ mN} = \dots \text{N}$

Answer: $689 \times 10^{-3} \text{N}$

Do it yourself 4

d. Electric current = $83721 \text{ } \mu\text{A} = \dots \text{A}$

Answer: $83721 \times 10^{-6} \text{A}$

Do it yourself 5

e. $60 \text{ mm}^3 = \dots \text{ m}^3$

Answer: $60 \times 10^{-9} \text{ m}^3$

Numerical Value to Prefixes

Do it yourself 6

Change the following quantities to the units shown.

a. $1 \text{ day} = 86400 \text{ s} = \dots \mu\text{s}$

Answer: $86400 \times 10^6 \mu\text{s}$

Do it yourself 7

b. Electric current = $83,721 \text{ A} = \dots \text{ mA}$

Answer: $83,721 \times 10^3 \text{ mA}$

Do it yourself 8

c. Beaker diameter = $0.0072 \text{ m} = \dots \text{ mm}$

Answer: $0.0072 \times 10^3 \text{ mm}$

Do it yourself 9

d. Land area = $689 \text{ m}^2 = \dots \text{km}^2$

Answer: $689 \times 10^{-6} \text{km}^2$

Do it yourself 10

59 kN/m to N/mm

Do it yourself 11

e. Water volume = $99 \text{m}^3 = \dots \text{cm}^3$.

Answer: $99 \times 10^6 \text{cm}^3$

Do it yourself 12

$35.69 \text{ cm}^2/\text{s}$ to m^2/hr

Do it yourself 13

Convert the following quantities

a. 50 km/hr to m/s

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Do it yourself 14

e. 100kg/m^3 to g/cm^3

Do it yourself 15

b. $78900\ \Omega/\text{m}$ to $\text{k}\Omega/\text{km}$

Do it yourself 16

c. $59\ \text{kN/m}$ to N/mm

Do it yourself 17

d. $35.69\ \text{cm}^2/\text{s}$ to m^2/hr

Do it yourself 18

e. 100kg/m^3 to g/cm^3

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2.0 Measurement

In science, measurement is the process of obtaining the magnitude of a quantity, such as length or mass, relative to a unit of measurement, such as a meter or a kilogram. A measurement answers the general question, "how many?" as in how many miles, or millimeters, or gigahertz. As measurement is basically about counting, measurement is conducted in numbers and is quantitative, in comparison to other observations which may be made in words and are qualitative. The term measurement can also be used to refer to a specific result obtained from the measurement process.

2.1 Error in Measurement

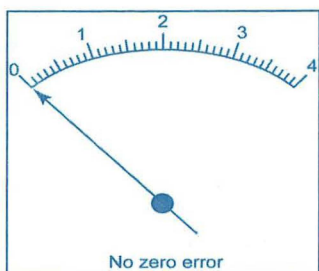
- Any measurement made with a measuring device is approximate. If you measure the same object two different times, the two measurements may not be exactly the same. The difference between two measurements is called a error in the measurements.
- Error is the difference between the actual value of a quantity and the value obtained in measurement. There are 2 main types of error;
 - **Systematic Error**
 - **Random Error**

Systematic Error

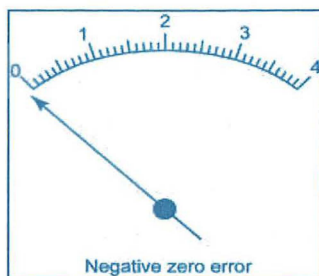
- Systematic errors are errors which tend to shift all measurements in a systematic way so their mean value is displaced. Systematic errors can be compensated if the errors are known.
- Examples of systematic errors are
 1. Zero error, which cause by an incorrect position of the zero point,
 2. An incorrect calibration of the measuring instrument.
 3. Consistently improper use of equipment.
- Systematic error can be reduced by
 1. Conducting the experiment with care.
 2. Repeating the experiment by using different instruments.

Zero error

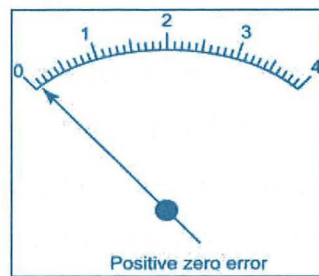
- A zero error arises when the measuring instrument does not start from exactly zero.
- Zero errors are consistently present in every reading of a measurement.
- The zero error can be positive or negative.



(NO ZERO ERROR: The pointer of the ammeter place on zero when no current flow through it.)



(NEGATIVE ZERO ERROR: The pointer of the ammeter does not place on zero but a negative value when no current flow through it.)



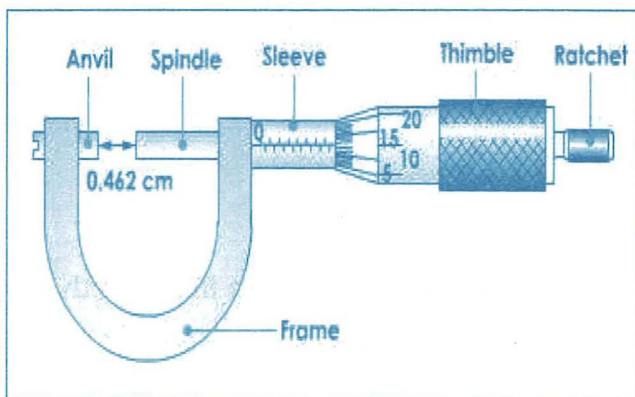
(POSITIVE ZERO ERROR: The pointer of the ammeter does not place on zero but a negative value when no current flow through it.)

Random errors

- Random errors arise from unknown and unpredictable variations in condition. It fluctuates from one measurement to the next. Random errors are caused by factors that are beyond the control of the observers.
- Random error can cause by:-
 - Personal errors such as human limitations of sight and touch.
 - Lack of sensitivity of the instrument: the instrument fails to respond to the small change.
 - Natural errors such as changes in temperature or wind, while the experiment is in progress.
 - Wrong technique of measurement.
- One example of random error is the parallax error. Random error can be reduced by:
 - Taking repeat readings
 - Find the average value of the reading.

Parallax error

- A parallax error is an error in reading an instrument due to the eye of the observer and pointer are not in a line perpendicular to the plane of the scale.



Ways to Improve Accuracy in Measurement

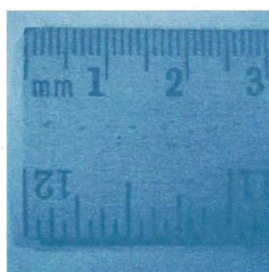
1. Make the measurement with an instrument that has the highest level of precision. The smaller the unit, or fraction of a unit, on the measuring device, the more precisely the device can measure. The precision of a measuring instrument is determined by the smallest unit to which it can measure.
2. Know your tools! Apply correct techniques when using the measuring instrument and reading the value measured. Avoid the error called "parallax" -- always take readings by looking straight down (or ahead) at the measuring device. Looking at the measuring device from a left or right angle will give an incorrect value.
3. Repeat the same measure several times to get a good average value.
4. Measure under controlled conditions. If the object you are measuring could change size depending upon climatic conditions (swell or shrink), be sure to measure it under the same conditions each time. This may apply to your measuring instruments as well.

1.4 Measuring Instruments

Using Appropriate Instruments to Measure

- When we measure a physical quantity, we need to consider its magnitude and then choose a suitable instrument.
- The magnitude of the quantity should not exceed the maximum capacity of the instrument, and the instrument must be sensitive enough to detect and give a meaningful measurement of the quantity.
- For example; meter rule is used to measure the length of a book, measuring tape is used to measure the length of a table and micrometer screw gauge is used to measure the diameter of a glass rod.

Ruler



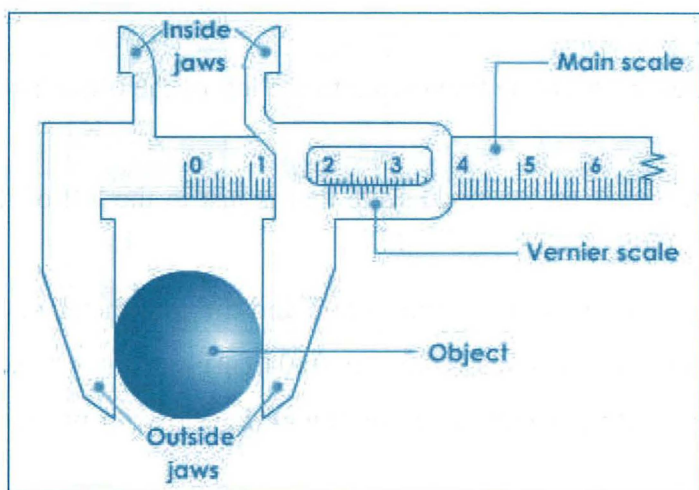
- A ruler or rule is an instrument used in geometry, technical drawing and engineering or building to measure distances and to rule straight lines.
- Strictly speaking, the ruler is essentially a straightedge used to rule lines and the calibrated instrument used for determining measurement is called a 'measure'. However, common usage is that a ruler is a calibrated straightedge that can be used for making measurements.
- The smallest division on a meter rule is 0.1cm. A meter rule can therefore measure length accurately up to 0.1cm only. All measurements of length using the meter rule have to be recorded accurate to 0.1cm. For example, a length of 12cm will have to be recorded as 12.0cm.
- To avoid parallax error when reading the scale of a meter rule, the eye must look perpendicularly at the mark on the scale. If the end of the meter rule has worn off, then the measurement should start from the 1cm.

To read a ruler

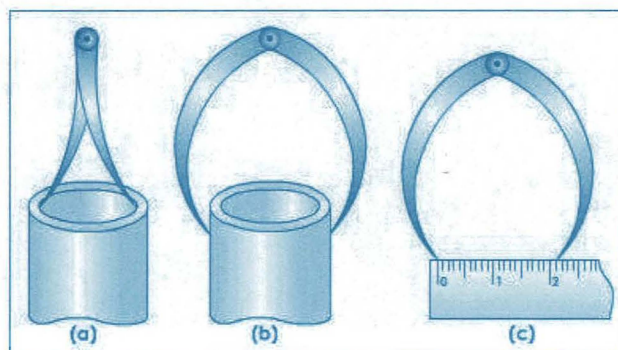
1. Before you begin, take a moment to study the markings on the ruler. The larger lines denote centimeters (cm). The smaller lines denote millimeters (mm). Note that 1 cm equals 10 mm.
2. Align the metric ruler next to the object you wish to measure, just as you would a ruler with imperial measurements.
3. Read the number next to or just prior to the end of your object. The larger line denoting the number of centimeters comes first. For instance, if the end of the object falls at a larger line labeled with the number six, the object is 6 cm.
4. Count the smaller, or millimeter, markings if applicable. For instance, if the object extends three small markings after the 6 cm point, the object is 6.3 cm long. Alternatively, you may measure the object in millimeters by multiplying the centimeter measurement by 10. So, in this example, you could also say that the object is 63 mm long.

Vernier Caliper

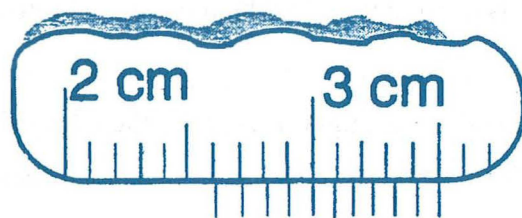
- The meter scale enables us to measure the length to the nearest millimeter only. Engineers and scientists need to measure much smaller distances accurately. For this a special type of scale called Vernier scale is used.



- The Vernier scale consists of a main scale graduated in centimeters and millimeters. On the Vernier scale 0.9 cm is divided into ten equal parts.
- The Vernier calliper consists of a main scale fitted with a jaw at one end. Another jaw, containing the vernier scale, moves over the main scale. When the two jaws are in contact, the zero of the main scale and the zero of the vernier scale should coincide. If both the zeros do not coincide, there will be a positive or negative zero error.
- To measure the inner and outer diameter of a hollow cylinder or ring, inner and outer callipers are used. Take measurements by the two methods as shown in figure below.



To read a vernier caliper



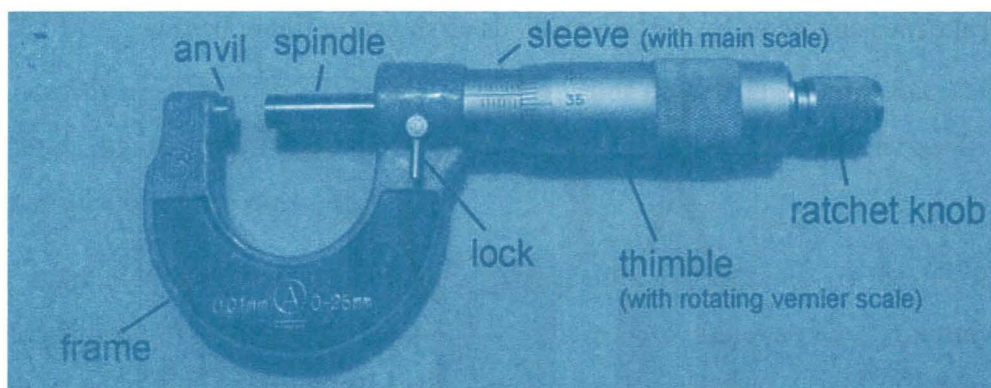
Reading: 2.64 cm

Steps:

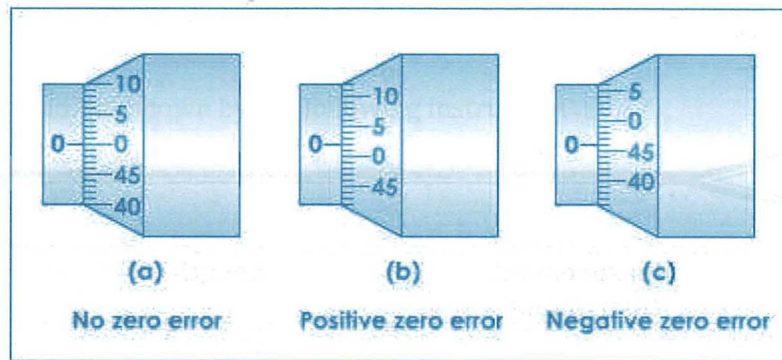
1. Read the centimeter mark on the fixed scale to the left of the 0-mark on the vernier scale. (2 cm on caliper seen above)
2. Find the millimeter mark on the fixed scale that is just to the left of the 0-mark on the vernier scale. (2.6 cm)
3. Look along the ten marks on the vernier scale and the millimeter marks on the adjacent fixed scale, until you find the two that most nearly line up. (0.04 cm)
4. To get the correct reading, simply add this found digit to your previous reading. ($2.6 + 0.05 = 2.64\text{cm}$)

Micrometer Screw Gauge

- Micrometer screw-gauge is another instrument used for measuring accurately the diameter of a thin wire or the thickness of a sheet of metal.
- It consists of a U-shaped frame fitted with a screwed spindle which is attached to a thimble.

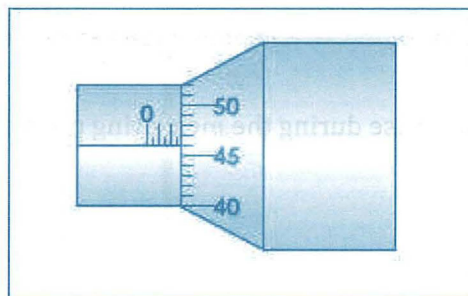


- The screw has a known pitch such as 0.5 mm. Pitch of the screw is the distance moved by the spindle per revolution. Hence in this case, for one revolution of the screw the spindle moves forward or backward 0.5 mm. This movement of the spindle is shown on an engraved linear millimeter scale on the sleeve. On the thimble there is a circular scale which is divided into 50 or 100 equal parts.
- When the anvil and spindle end are brought in contact, the edge of the circular scale should be at the zero of the sleeve (linear scale) and the zero of the circular scale should be opposite to the datum line of the sleeve. If the zero is not coinciding with the datum line, there will be a positive or negative zero error as shown in figure below.



To read Micrometer Screw Gauge

Example



Reading: 2.96 mm

Steps:

1. Determine the reading on the main scale. In this case, the reading on the main scale is 2.50 mm.
2. Determine the reading on the circular scale, which is the marking on the circular scale that coincides with the horizontal line of the main scale. In this case, the reading on the circular scale is 0.46 mm (46×0.01).
3. The total reading is then obtained by adding the reading on the main scale with the reading on the circular scale, which is $2.50 \text{ mm} + 0.46 \text{ mm}$ or 2.96 mm.

Reading = Linear scale reading + (Coinciding circular scale $\times$ Least count)

$$\begin{aligned}
 &= 2.5 \text{ mm} + (46 \times 0.01) \\
 &= (2.5 + 0.46) \text{ mm} \\
 &= 2.96 \text{ mm}
 \end{aligned}$$

Self Learning 2

Do it yourself 19

Measurement Instrument	Length
X	12.0 cm
Y	8.75 cm
Z	0.633 cm

Table show three readings of length measured using three different instrument, X, Y and Z. Name the three instruments used.

X =

Y =

Z =

Do it yourself 20

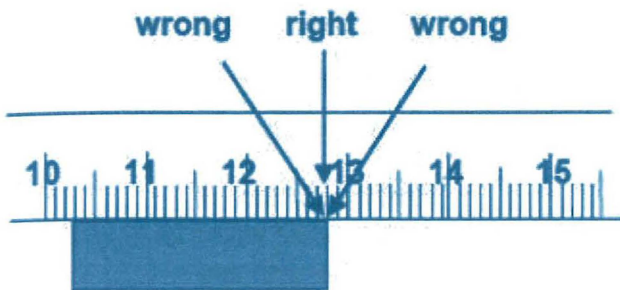
List three experimental errors that may arise during the measuring process.

Do it yourself 21

Suggest two ways to reduce errors in measurement

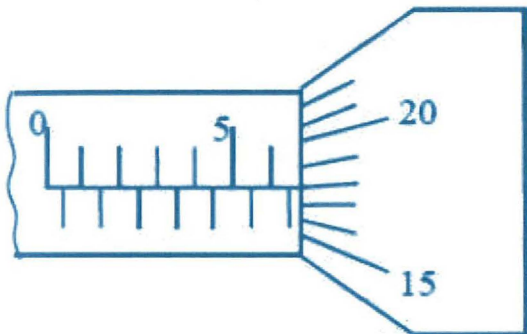
Write down the readings shown by the following instrument

i. Ruler

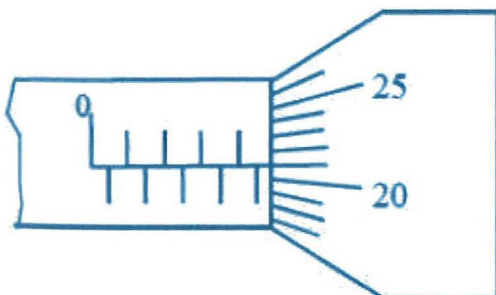


Answer : _____

ii. Micrometer Screw gauge



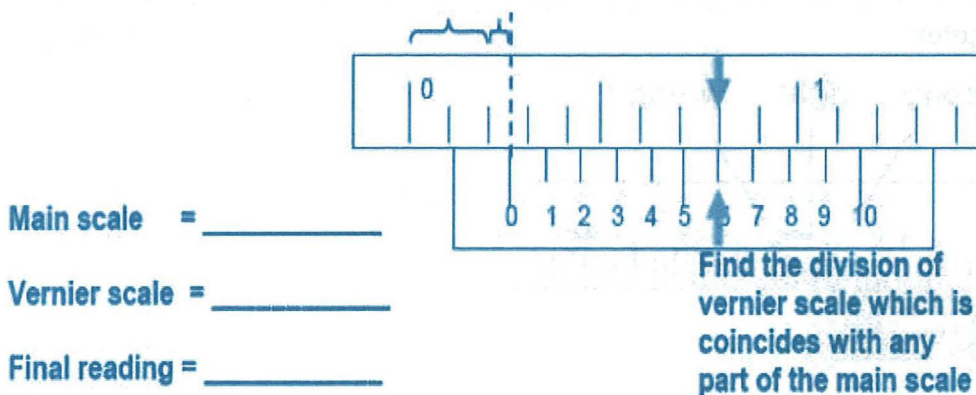
Answer : _____



Answer : _____

Answer:

iii. Vernier Calipers



Self Learning 3

- Physical Quantities is a physical characteristic that can be _____.
- The value of the measurement consists of a numerical _____ and a _____.
- All physical quantities can be classified into two groups:
 - _____
 - _____
- What are base quantities?
Base quantities are quantities that cannot be _____ in terms of other base quantities.
- What are derived quantities?
Derived quantity is one which obtained by _____ base quantities by multiplication, division or both these operations. Its unit is derived from a similar combination of the base units.
- Complete the table below;

Physical Quantity		SI Unit /Derived Unit	
Quantity	Symbol	S.I Unit	Unit Symbol
Length	<i>L</i>	Meter	m
Mass			

Time			
Temperature			
Electric Current			
Velocity			
Acceleration			
Force			
Weight			

7. A cube with sides 4 mm is made from a material of density 14 g/cm³.
- i. Find the volume of the cube in cm³
 - ii. State the density of material in kg/m³
 - iii. Find the mass of the cube

Conversion of Units

8. Convert:
- a) 1 Tm = _____ m
 - b) 1 m = _____ Tm
 - c) 1 Gm = _____ m
 - d) 1 m = _____ Gm
 - e) 1 Mm = _____ m
 - f) 1 m = _____ Mm
 - g) 1 km = _____ m
 - h) 1 m = _____ km
 - i) 1 hm = _____ m
 - j) 1 m = _____ hm
 - k) 1 cm = _____ m
 - l) 1 m = _____ cm
 - m) 1 mm = _____ m

9. Change the following quantities to the unit shown

- | | | | |
|----|------------|---|---------|
| a) | 3.68 kg | = | _____g |
| b) | 568 cm | = | _____m |
| c) | 8700 ml | = | _____l |
| d) | 25 mg | = | _____g |
| e) | 0.101 cm | = | _____mm |
| f) | 250 ml | = | _____l |
| g) | 600 g | = | _____kg |
| h) | 8900 mm | = | _____μm |
| i) | 0.000004 m | = | _____mm |
| j) | 0.250 kg | = | _____mg |

10. Convert each of the following measurements into metre (m).

- a) 12000 μm c) 0.34 km
b) 230 mm d) 0.012 Mm

11. Complete the following unit conversion

- | | | |
|----|--------------------------|-----------------------|
| a) | 12.34 kHz | = _____ Hz |
| b) | 120 Mm | = _____ m |
| c) | 0.12 μg | = _____ g |
| d) | 7.1×10^3 mJ | = _____ J |
| e) | 8.34×10^{-1} cA | = _____ A |
| f) | 5.1×10^2 dW | = _____ W |
| g) | 1.11×10^{-3} nm | = _____ m |
| h) | 7.134×10^4 pm | = _____ m |
| i) | 14500 g | = _____ kg |
| j) | 12.34 N | = _____ MN |
| k) | 0.134 s | = _____ ms |
| l) | 756.6 Hz | = _____ kHz |
| m) | 0.00034 J | = _____ μJ |
| n) | 3.12 A | = _____ dA |

12. A car is moving with speed 2km minute^{-1} , what is the speed in m s^{-1} ?

13. Change 4500 kJ/hour to Watt (J/s).

14. Complete the following unit conversion of speed.

- a) 90 kmh^{-1} = _____ ms^{-1}
b) 110 kmh^{-1} = _____ ms^{-1}
c) 1.3 ms^{-1} = _____ kmh^{-1}
d) 8.12 ms^{-1} = _____ kmh^{-1}

15. Complete the following unit conversion of density.

- a) 760 kgm^{-3} = _____ gcm^{-3}
b) 12000 kgm^{-3} = _____ gcm^{-3}
c) 5.1 gcm^{-3} = _____ kgm^{-3}
d) 3600 Nm^{-2} = _____ Ncm^{-2}
e) $12 \times 106 \text{ Nm}^{-2}$ = _____ Ncm^{-2}

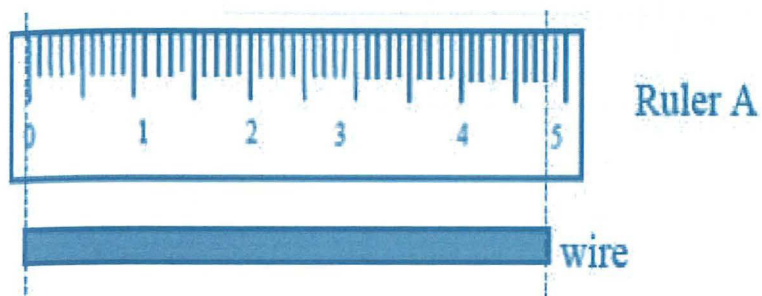
$$f) 1.5 \times 10^+ \text{ Nm}^{-2} = \underline{\hspace{2cm}} \text{ Ncm}^{-2}$$

$$g) 3.16 \times 10^{-5} \text{ Ncm}^{-2} = \underline{\hspace{2cm}} \text{ Nm}^{-2}$$

$$h) 7.1 \times 10^{-3} \text{ Ncm}^{-2} = \underline{\hspace{2cm}} \text{ Nm}^{-2}$$

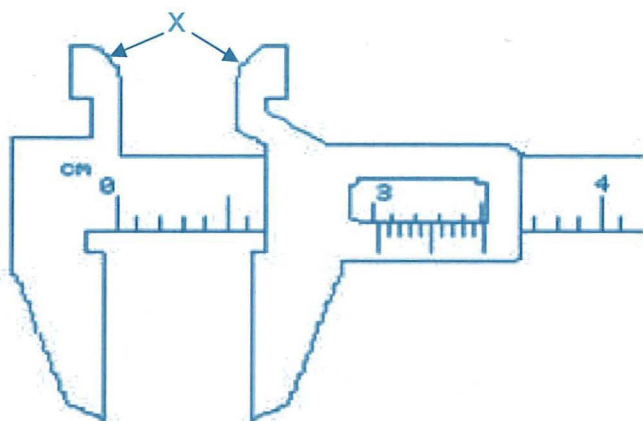
Measurement of Length

16. The reading of ruler



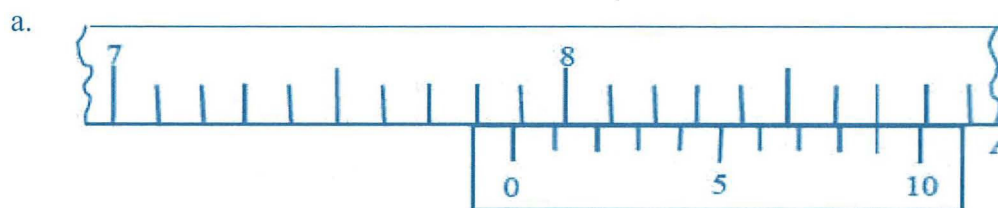
Answer : _____

17. Diagram 1 show vernier calipers used to measure external diameter of a hollow cylinder.



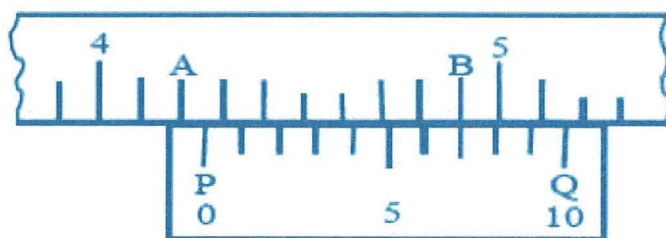
- What is the function of X?
- What is the reading of the vernier calipers?

18. Write down the readings shown by the following vernier caliper



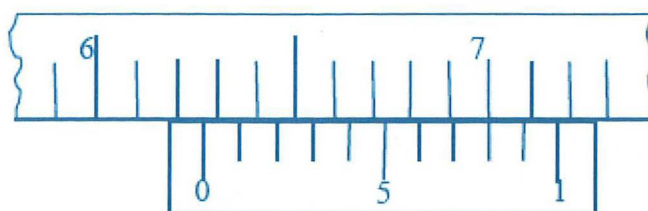
Answer : _____

b.



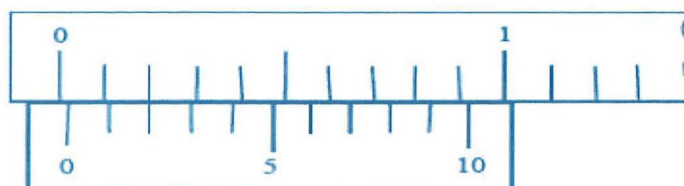
Answer : _____

c.



Answer : _____

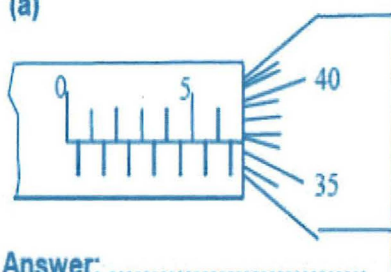
d.



Answer : _____

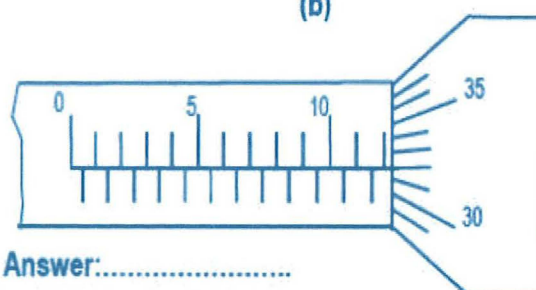
19. Write down the readings shown by the following Micrometer Screw gauge

(a)



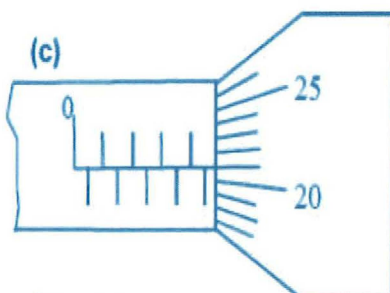
Answer:

(b)



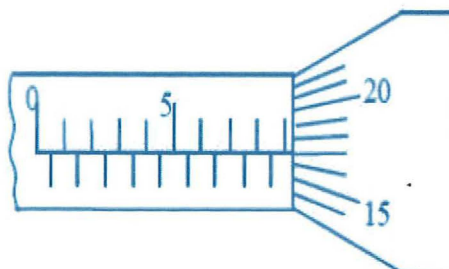
Answer:

(c)



Answer: _____

(d)



Answer: _____

Chapter

2

Linear Motion

Chapter 2

Linear Motion

2.0 Introduction

Linear Motion is about the moving of object from one point to another point. When the object is moving the quantities that will produced are time, distance or displacement, speed or velocity and acceleration. Example; walking to the shop, ride the motorcycle to friend house, cycle, jogging and climbing.

2.1 Distance and Displacement

Distance

- The total length of the path travelled from one location to another.
- Scalar quantity
- Measured in metres (m)

Displacement

- The distance travelled from its initial position to its final position
- The shortest distance called displacement
- Vector quantity
- Measured in metres (m)

The Difference between Distance and Displacement

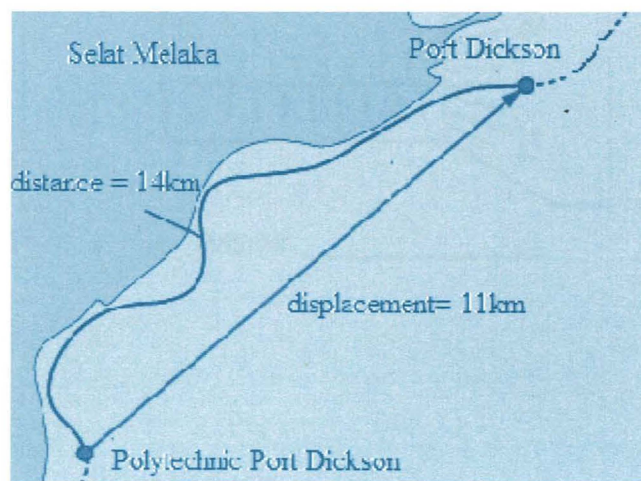


Figure 3.1

Based on Figure 3.1, distance from Polytechnic to Port Dickson town is 14km. While displacement (shortest distance is only 11km)

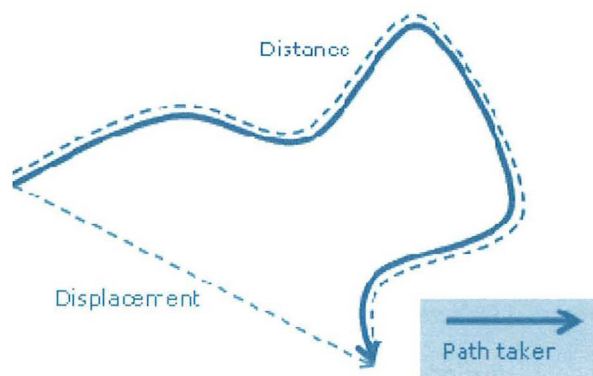


Figure 3.2 shows difference between distance and displacement.

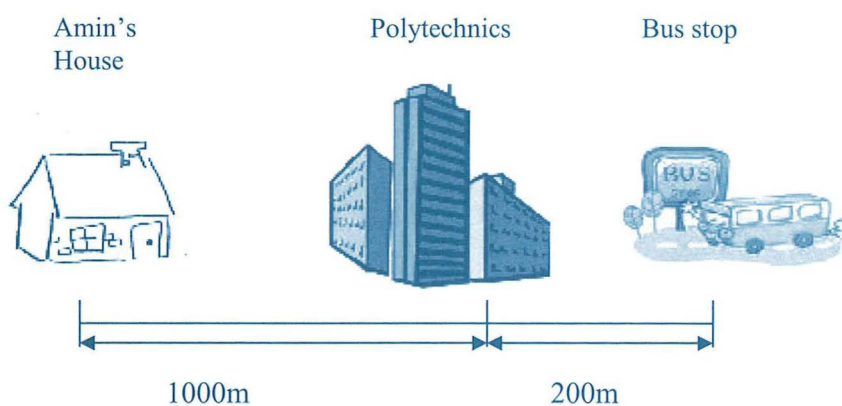


Figure 3.3

Amin walked from his house to bus stop then return back to polytechnic. Calculate the:

- Distance traveled
- Displacement

Solution:

a) Distance = $1000\text{m} + 200\text{m} + 200\text{m} = 1400\text{m}$ or 1.4km

b) Displacement = $1000\text{m} + 200\text{m} - 200\text{m} = 1000\text{m}$ or 1km

2.2 Speed and Velocity

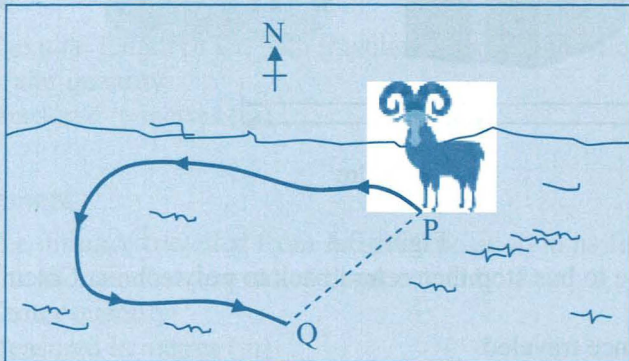
Speed

- The distance travelled per unit time
- The rate of change of distance
- Scalar quantity
- Measured in metres per second ($\frac{\text{m}}{\text{s}}$)
- Formula: $\text{speed} = \frac{\text{distance}}{\text{time}}$

Speed, Velocity, $v(m/s)$, Distance, $d(m)$, Displacement, $s(m)$, Acceleration, $a(m/s^2)$, Deceleration, $-a(m/s^2)$, time, $t(s)$

Velocity

- The speed in a specified direction
- The rate of change of displacement with time
- Vector quantity
- Measured in metres per second ($\frac{m}{s}$)
- Formula: $\text{velocity} = \frac{\text{displacement}}{\text{time}}$

Examples	Notes
2Q1- A goat walk along a path from P to Q, which is 70m away from P. Q lies to the south-west of P. The distance traveled by the goat is 240m and the time taken is 160s.  Calculate the; - average speed - average velocity of the goat moving from P to Q. Solution: Total distance traveled = 240m Displacement = 70m Time Taken = 160s a) $\begin{aligned} \text{Average speed} &= \frac{\text{Total distance travelled}}{\text{Time taken}} \\ &= \frac{240 \text{ m}}{160 \text{ s}} \\ &= 1.5 \frac{\text{m}}{\text{s}} \end{aligned}$	

Examples	Notes
b) $\begin{aligned}\text{Average velocity} &= \frac{\text{Displacement}}{\text{Time taken}} \\ &= \frac{70\text{m}}{160\text{s}} \\ &= 0.44 \frac{\text{m}}{\text{s}} \text{ in the south} \\ &\quad \text{--west direction of P}\end{aligned}$	

2.3 Acceleration

- The rate of change of velocity with time
- Vector quantity
- Measured in metres per second per second square ($\frac{\text{m}}{\text{s}^2}$)
- Formula: $a = \frac{v - u}{t}$

Deceleration / Retardation

- Negative acceleration
- An object is undergoing
- The rate of change of velocity of the object has a negative value
- Measured in metres per second per second square ($\frac{\text{m}}{\text{s}^2}$)
- Formula: $-a = \frac{v - u}{t}$

Example	Notes
2Q2- A van accelerated uniformly from velocity of 15ms^{-1} to 20ms^{-1} in 2.5s. What was the acceleration of the van? <i>Solution:</i> Initial velocity, $u = 15\text{ms}^{-1}$ Final velocity, $v = 20\text{ms}^{-1}$ Time taken, $t = 2.5\text{s}$	

Example	Notes
Acceleration, $a = \frac{v - u}{t}$ $= \frac{20 - 15}{2.5}$ $= 2.0 \frac{\text{m}}{\text{s}^2}$ 2Q3- A school bus accelerates with an acceleration of 4.0 ms^{-2} after picking up some students at bus atop. Calculate the: a) velocity, b) distance travelled by the bus after 5s. <i>Solution:</i> c) Initial velocity, $u = 0 \text{ ms}^{-1}$ Acceleration, $a = 4.0 \text{ ms}^{-2}$ Time, $t = 5 \text{ s}$ $v = u + at$ $= 0 + (4.0 \times 5)$ $= 20.0 \frac{\text{m}}{\text{s}}$ d) $s = ut + \frac{1}{2}at^2$ $= (0 \times 5) + \left(\frac{1}{2} \times 4.0 \times 5^2\right)$ $= 50 \text{ m}$ 2Q4-- In the long jump event, Abu was running at a velocity of 5 m^{-1} towards the long jump pit. He needed to achieve a velocity of 10 ms^{-1} after covering a distance of 4.5m before lifting himself off the ground from the jumping board. a) Calculate the required acceleration for Abu to do so. b) Calculate the time taken for him to cover the horizontal distance of 4.5m. <i>Solution:</i> a) $u = 5 \text{ ms}^{-1}$, $v = 10 \text{ ms}^{-1}$, $s = 4.5 \text{ m}$	

Example	Notes
$v^2 = u^2 + 2as$ $10^2 = 5^2 + 2 \times a \times 4.5$ $a = 8.3 \frac{\text{m}}{\text{s}^2}$ b) $u = 5\text{ms}^{-1}$, $v = 10\text{ms}^{-1}$, $a = 8.3\text{ms}^{-2}$ $v = u + at$ $10 = 5 + 8.3t$ $t = 0.6\text{s}$	

2.4 Equations Of Motion

1. Objects moving with uniform velocity

$$s = v \times t$$

2. Objects moving with uniform acceleration

$$a = \frac{v - u}{t}$$

$$s = \left(\frac{u + v}{2} \right) \times t$$

$$s = ut + \frac{1}{2} at^2$$

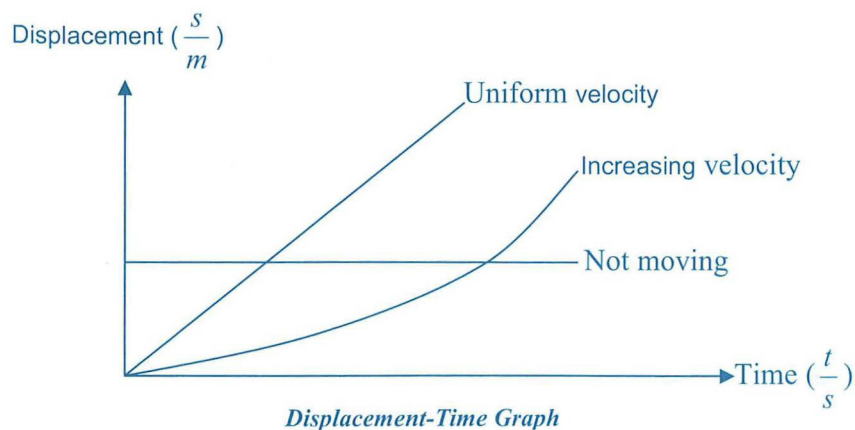
$$v = u + at$$

$$v^2 = u^2 + 2as$$

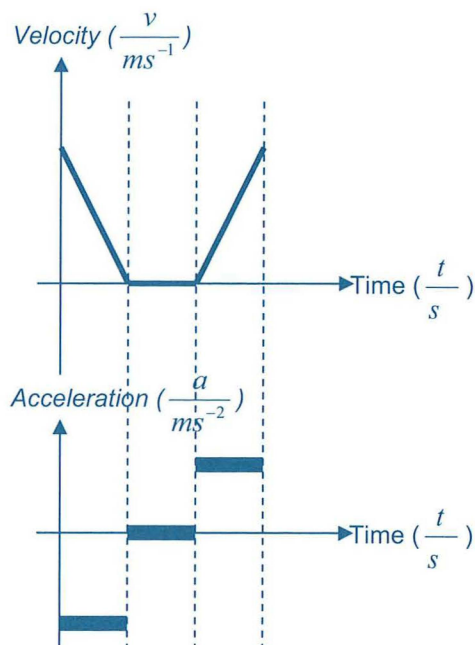
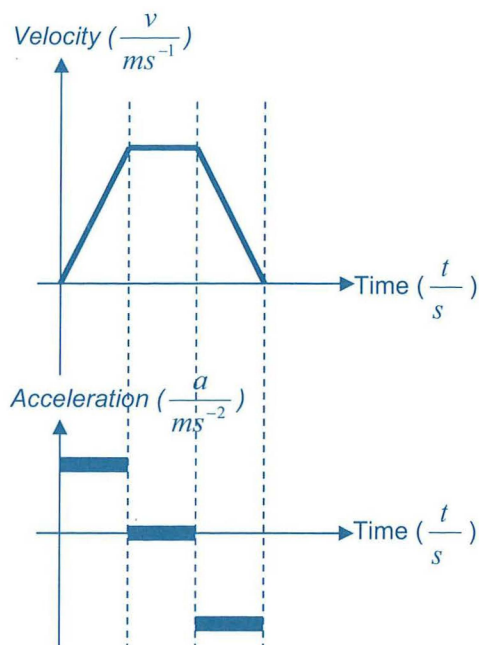
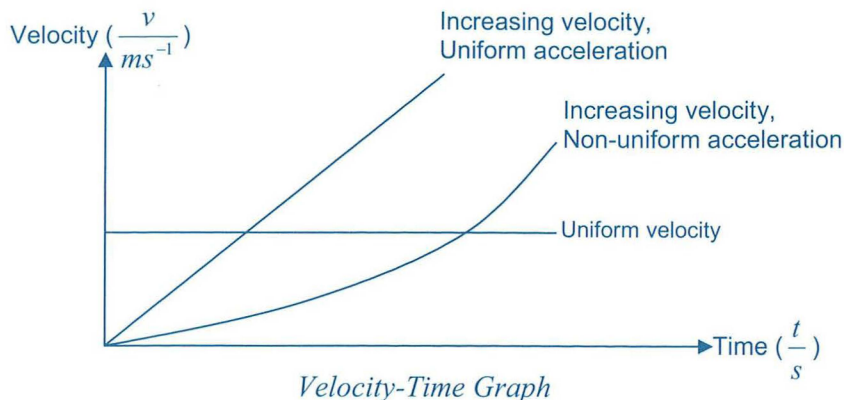
u = initial velocity ($\frac{\text{m}}{\text{s}}$)

v = final velocity ($\frac{\text{m}}{\text{s}}$)

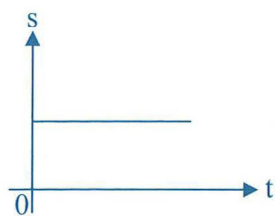
2.5 Motion Graphs



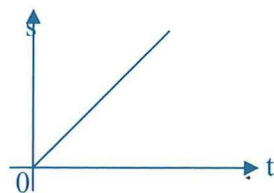
Speed, Velocity, v (m/s), Distance, d (m), Displacement, s (m), Acceleration, a (m/s^2), Deceleration, $-a$ (m/s^2), time, t (s)



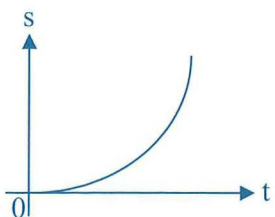
1. The gradient of a displacement-time graph determines the velocity of a moving object



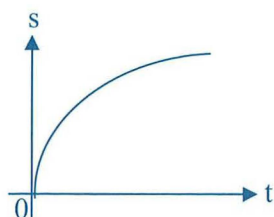
At rest



Moving with uniform velocity



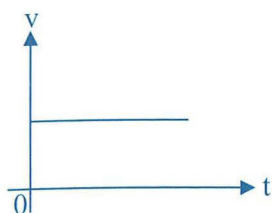
Moving with uniform acceleration



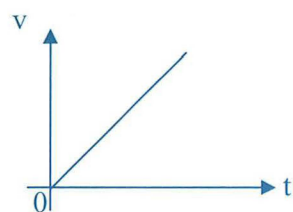
Moving with uniform deceleration

2. Velocity-time graph

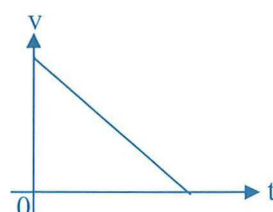
- gradient of the graph = acceleration
- area under the graph = displacement



Uniform velocity



Uniform acceleration



Uniform deceleration

Determining the Area on a v-t Graph

For velocity versus time graphs, the area bound by the line and the axes represents the displacement. The diagram below shows three different velocity-time graphs; the shaded regions between the line and the time-axis represents the displacement during the stated time interval.

The shaded area is representative of the displacement during from 0 seconds to 6 seconds. This area takes on the shape of a rectangle can be calculated using the appropriate equation.	
The shaded area is representative of the displacement during from 0 seconds to 4 seconds. This area takes on the shape of a triangle can be calculated using the appropriate equation.	
The shaded area is representative of the displacement during from 2 seconds to 5 seconds. This area takes on the shape of a trapezoid can be calculated using the appropriate equation.	

The method used to find the area under a line on a velocity-time graph depends upon whether the section bound by the line and the axes is a rectangle, a triangle or a trapezoid. Area formulas for each shape are given below.

Rectangle

$$\text{Area} = b \times h$$

Triangle

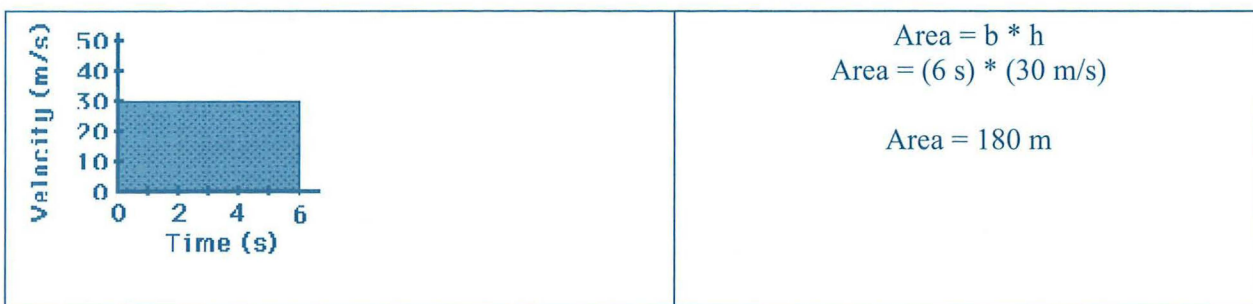
$$\text{Area} = \frac{1}{2} \times b \times h$$

Trapezoid

$$\text{Area} = \frac{1}{2} \times b \times (h_1 + h_2)$$

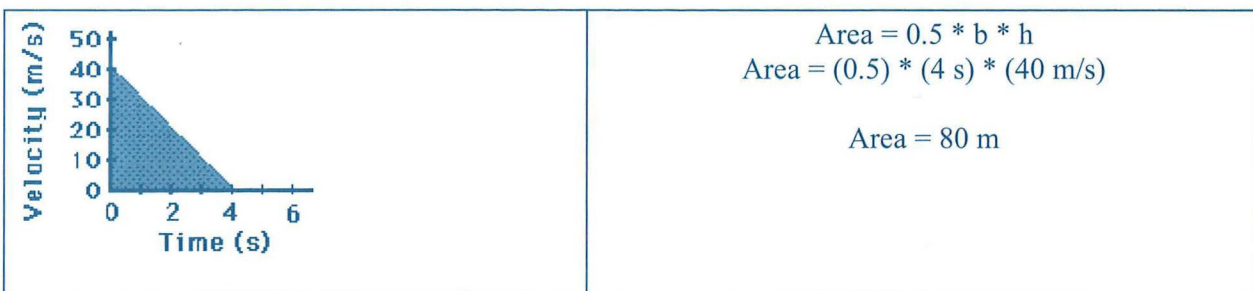
Calculating the Area of a Rectangle

Now we will look at a few example computations of the area for each of the above geometric shapes. First consider the calculation of the area for a few rectangles. The solution for finding the area is shown for the first example below. The shaded rectangle on the velocity-time graph has a base of 6 s and a height of 30 m/s. Since the area of a rectangle is found by using the formula $A = b \times h$, the area is 180 m (6 s $\times$ 30 m/s). That is, the object was displaced 180 meters during the first 6 seconds of motion.



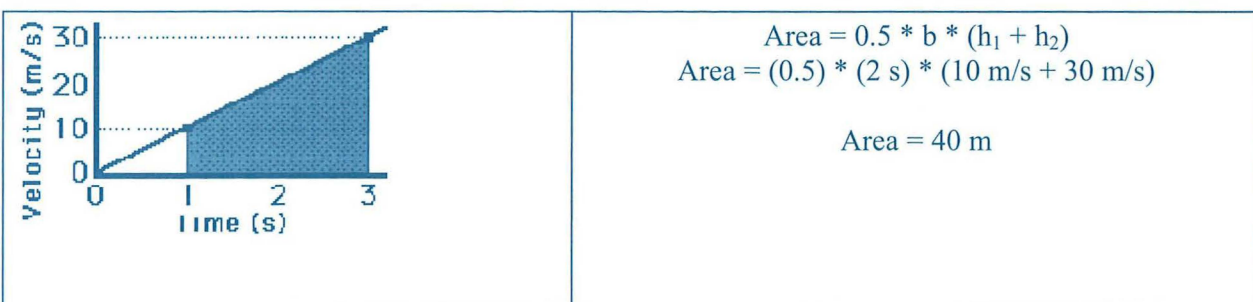
Calculating the Area of a Triangle

The shaded triangle on the velocity-time graph has a base of 4 seconds and a height of 40 m/s. Since the area of triangle is found by using the formula $A = 0.5 \times b \times h$, the area is $(.5) \times (4 \text{ s}) \times (40 \text{ m/s}) = 80 \text{ m}$. That is, the object was displaced 80 meters during the four seconds of motion.



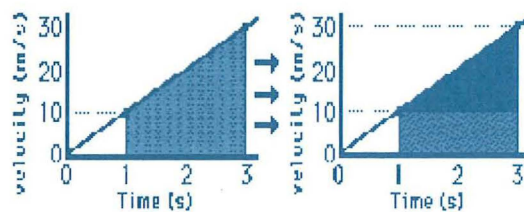
Calculating the Area of a Trapezoid

The solution for finding the area is shown for the first example below. The shaded trapezoid on the velocity-time graph has a base of 2 seconds and heights of 10 m/s (on the left side) and 30 m/s (on the right side). Since the area of trapezoid is found by using the formula $A = (0.5) \times (b) \times (h_1 + h_2)$, the area is 40 m $[(0.5) \times (2 \text{ s}) \times (10 \text{ m/s} + 30 \text{ m/s})]$. That is, the object was displaced 40 meters during the time interval from 1 second to 3 seconds.



Alternative Method for Trapezoids

An alternative means of determining the area of a trapezoid involves breaking the trapezoid into a triangle and a rectangle. The areas of the triangle and rectangle can be computed individually; the area of the trapezoid is then the sum of the areas of the triangle and the rectangle. This method is illustrated in the graphic below.



Rectangle Triangle

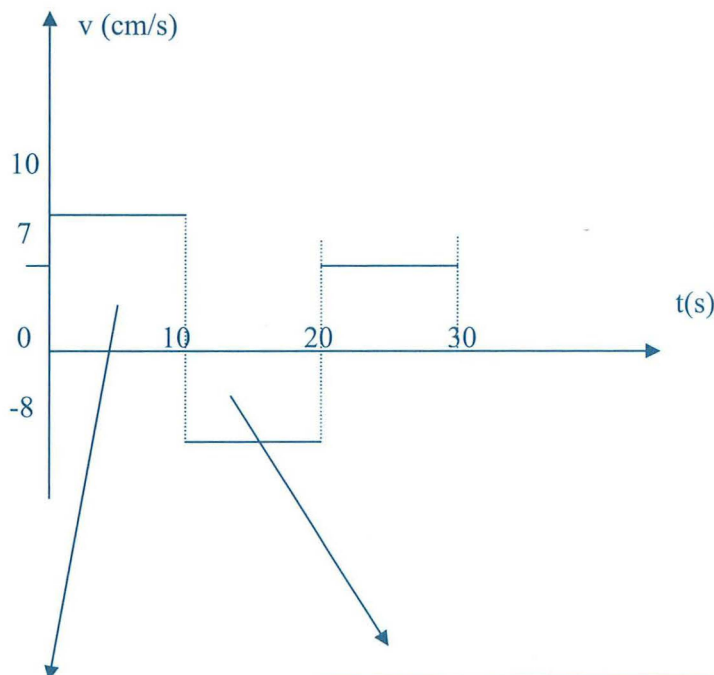
Triangle: Area = $(0.5) * (2 \text{ s}) * (20 \text{ m/s}) = 20 \text{ m}$

Rectangle: Area = $(2 \text{ s}) * (10 \text{ m/s}) = 20 \text{ m}$

Total Area = $20 \text{ m} + 20 \text{ m} = 40 \text{ m}$

Area under v-t graph as displacement and distance

Let's assume v-t graph is given and ask the question "what is the displacement from time t_1 , to time t_2 ?"



Area of this rectangle is the displacement from $t = 0$ to $t = 10\text{s}$

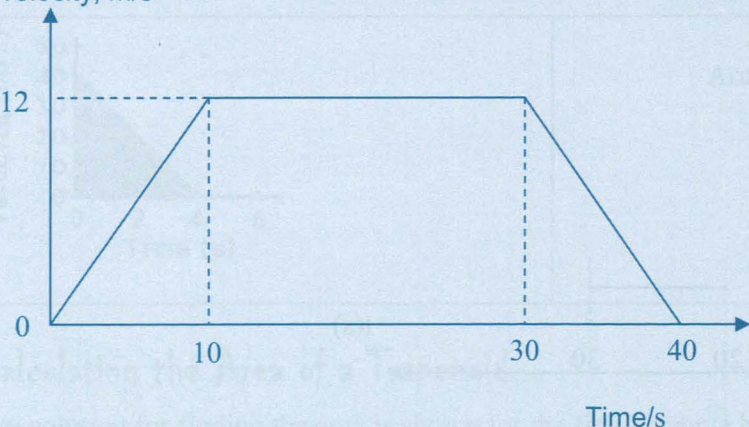
This is a negative area; height of the rectangle is -8 , width is 10 seconds. It represents a negative displacement, which means that the object is now displacing toward the origin. Its direction of motion is opposite to its initial displacement.

Speed, Velocity, v (m/s), Distance, d (m), Displacement, s (m), Acceleration, a (m/s^2), Deceleration, $-a$ (m/s^2), time, t (s)

Time(s)	Displacement (cm)
0-10	area = $10 \times 10 = 100$
10-20	area = $-8 \times (20-10) = -80$
20-30	area = $7(30-20) = 70$

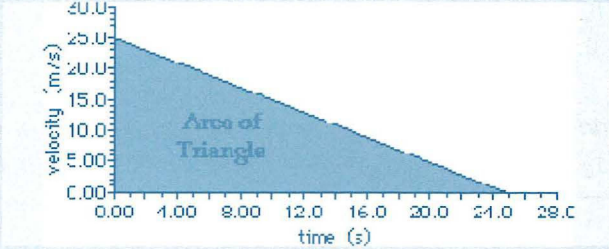
Total distance covered = $100 + 80 + 70 = 250$ cm

Total Displacement = $100 + (-80) + 70 = 90$ cm, this means that object is 90 cm away from the origin, in the positive direction

Examples	Notes
2Q 5: A velocity-time graph of a motorcycle is shown in figure above.  Calculate the: - initial acceleration - final acceleration - total distance traveled - average velocity of the motorcycle. Solution: - From the graph: $y_2 = 12$, $y_1 = 0$, $x_2 = 10$, $x_1 = 0$	

Examples	Notes
<i>initial acceleration = gradient of the graph</i> $a = \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{12 - 0}{10 - 0}$ $= 1.2 \frac{m}{s}$ b) From the graph: $y_2 = 12$, $y_1 = 0$, $x_2 = 30$, $x_1 = 40$ <i>initial acceleration = gradient of the graph</i> $a = \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{12 - 0}{30 - 40}$ $= -1.2 \frac{m}{s}$ b) Total distance of the motorcycle. <i>distance = area under the graph</i> $distance = \frac{1}{2}(a + b)t$ $= \frac{1}{2} \times (40 + 20) \times 12$ $= 360m$ c) Average velocity $Average\ velocity = \frac{Total\ distance}{Total\ time\ taken}$ $= \frac{360}{40}$ $= 9 \frac{m}{s}$	
2Q6: Rossa is driving through town at 25m/s and begins to accelerate at a constant rate of 1.0m/s². Eventually Rossa comes to a complete stop. a) Represent Rossa's accelerated motion by sketching a velocity-time graph. Use the velocity graph to determine this	

Speed, Velocity, $v(\text{m/s})$, Distance, $d(\text{m})$, Displacement, $s(\text{m})$, Acceleration, $a(\text{m/s}^2)$, Deceleration, $-a(\text{m/s}^2)$, time, $t(\text{s})$

Examples	Notes
distance b) Use kinematic equation to calculate the distance which Rossa travels while decelerating Answers  a) Distance from graph $0.5 (25) (25) = 313\text{m}$ b) Distance using kinematic equations $v^2 = u^2 + 2 a s$ $0 = 25^2 + 2(-1)s$ $s = 313\text{m}$	

Self Learning

- The distance traveled by an object with a constant speed of 2ms^{-1} in a time of 6s is? (answer: 12m)
- A student starts cycling from rest and reaches a speed of 12ms^{-1} in 2 seconds. The distance traveled by him is? (answer: 36m)
- A car accelerates from rest to 4ms^{-2} for a period of 2 minutes. What is the velocity of the car after 1

minute? (answer: 240ms^{-1})

4. A van has traveled 10m in 2 seconds. If the acceleration was 2ms^{-2} , its initial velocity would be? (answer: 3ms^{-1})

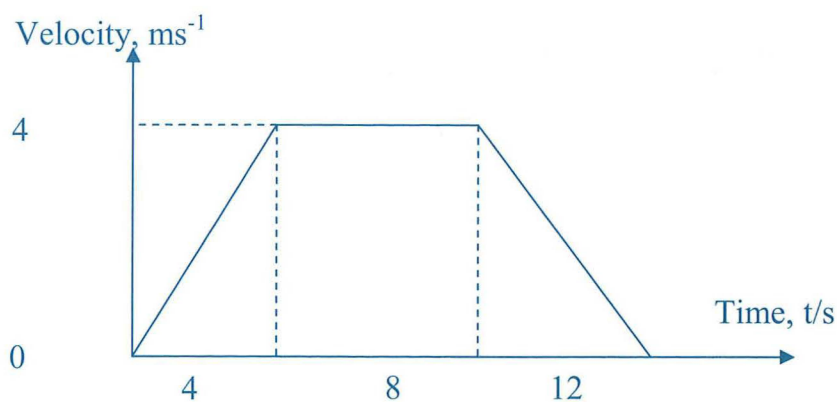
5. A bus decreases its velocity from 8ms^{-1} to 4ms^{-1} in a distance of 12m. What is the acceleration of the bus, in ms^{-2} ? (answer: -2)

6. A bullet is traveling with a velocity of 400ms^{-1} before it strikes a cement wall. If it penetrates the wall with a depth of 4cm before it stops, what is the deceleration of the bullet? (answer: $2 \times 10^6 \text{ms}^{-2}$)

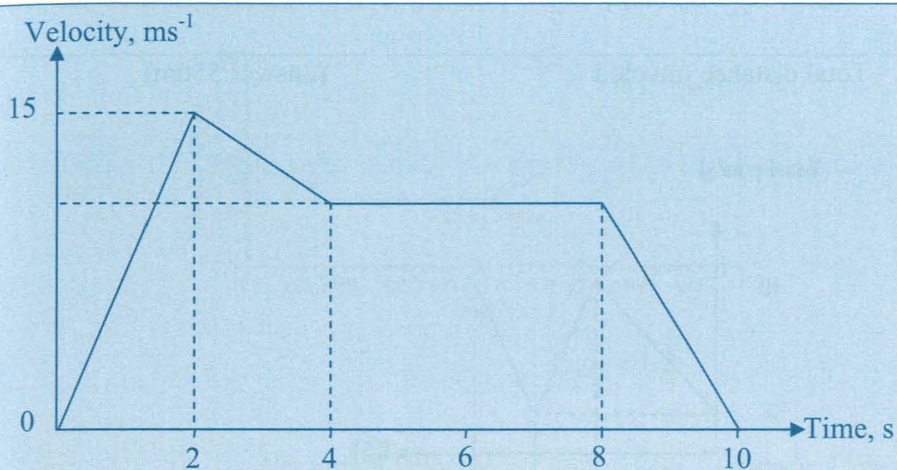
7. A stone is being thrown vertically upwards with an initial velocity of 20ms^{-1} . Calculate the time taken for the stone to go up and come down to the ground. (answer: 4.0775s)

8. A model rocket is launched vertically with a velocity of $24ms^{-1}$. Estimate the total distance traveled by the model rocket. (answer: $58.7156m$)

9. A velocity-time graph of a car is shown in figure above. Calculate the initial acceleration of the car and the total distance. (answer: $1.5ms^{-2}$)



10. Figure above shows the graph of velocity, v against time, t of an object. The average velocity of the object for the whole motion is? (answer: $9ms^{-1}$)



11) Define:

- i. Uniform velocity
- ii. Uniform acceleration

12) A train moving in static condition with uniform acceleration of 0.2m/s^2 . Calculate the :

- i. Velocity after 20 second after the starting (answer: 4m/s)
- ii. Total of time that needed to reach 60km/h of velocity (answer: 83.35s)
- iii. Displacement that passed to reach 60km/h of velocity (answer: 694.72m)

13) Figure 1.1 represent the movement of the car. Determine :

- i. Initial acceleration (answer: 4m/s^2)
- ii. Value of v if that time the acceleration is -2m/s^2 (answer: 30)

Speed, Velocity, v (m/s), Distance, d (m), Displacement, s (m), Acceleration, a (m/s^2), Deceleration, $-a$ (m/s^2), time, t (s)

iii. Total distance traveled

(answer: 550m)

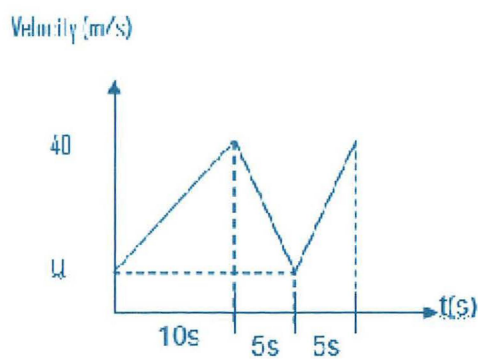


Figure 1.1

14) Give the definition and unit of the terms:

- i. Acceleration
- ii. Displacement
- iii. Velocity

15)

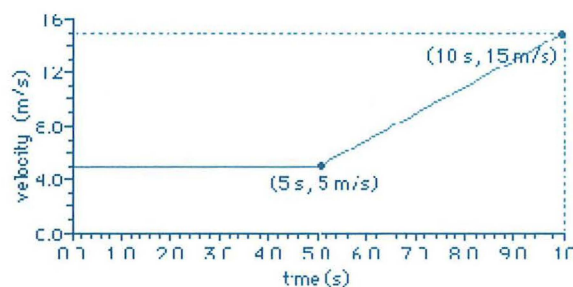


Figure 1.2

- | | | |
|------|-----------------------------|------------------------------|
| i) | Maximum velocity | (answer: 15m/s) |
| ii) | Acceleration | (answer: 2m/s ²) |
| iii) | Displacement until 8 second | (answer: 47.5m) |

16 A car decelerates uniformly from 22m/s to 10m/s in a distance of 100m. Calculate :

- | | | |
|------|--|----------------------------------|
| i. | The deceleration of the car | (answer: -1.92m/s ²) |
| ii. | The time taken for the speed to decrease from 22m/s to 10m/s | (answer: 0.16s) |
| iii. | The time taken for the car to come to a stop from the speed of 22m/s | (answer: 9.09s) |

17 Figure 1.3 shows a velocity-time graph of an object for a period of 7 seconds:

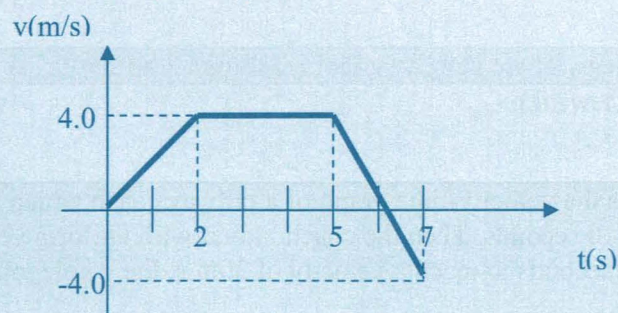


Figure 1.3

Speed, Velocity, v (m/s), Distance, d (m), Displacement, s (m), Acceleration, a (m/s^2), Deceleration, $-a$ (m/s^2), time, t (s)

Calculate :

- a) the acceleration of the object for the first 2s (answer: $2m/s^2$)
- b) the displacement of the object for the first 6 seconds (answer: $18m$)
- c) the displacement of object for the whole journey (answer: $16m$)
- d) the average velocity of the object for the whole journey (answer: $2.29m/s$)

18 A bus initially rest rolls down a hill with a uniform acceleration of $5m/s^2$. How long will the bus take to travel 150 m, the distance to the bottom of the hill? (answer: $7.75s$)

19 Diagram 1.4 shows the velocity-time graph of a railway coach which initially decelerates from $40m/s$ to $10m/s$ in 10 seconds. Then the coach moves with uniform velocity and finally accelerates from 7 seconds to reach a velocity of $30m/s$. the whole journey from A to D is 1000m. Calculate:

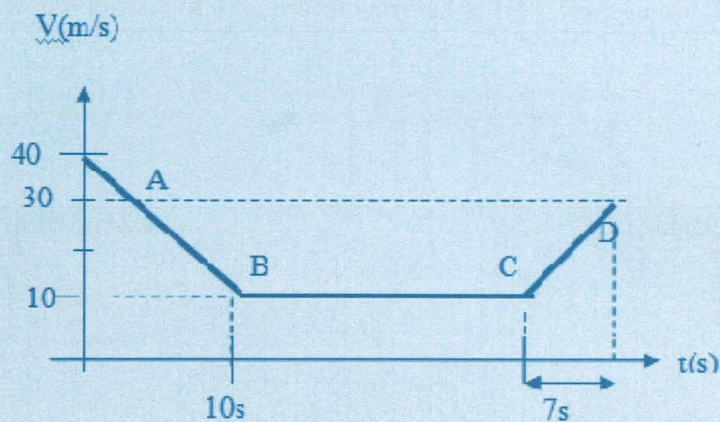


Figure 1.4: Velocity-time graph

i. Acceleration of the coach

(answer: 2.86 m/s^2)

ii. Distance travel when the coach is accelerating

(answer: 140m)

iii. Distance travel when the coach is decelerating

(answer: 250M)

iv . The total time taken for the whole AB journey

(answer: 78s)

20. A car is accelerated at 7 m/s^2 from an initial velocity of 3 m/s for 10 seconds. What is the:

i. Final velocity

(answer: 73s)

ii. Distance traveled

(answer:380m)

21-A car starts from rest and accelerates at a constant acceleration of $5 m/s^2$ for 5 seconds. The car then travels at a constant velocity for 10 seconds. The brakes are then applied and car stops in 7 seconds.

i. Find the maximum velocity attained by the car? (answer:25m/s)

ii. Plot a velocity time graph for the whole journey

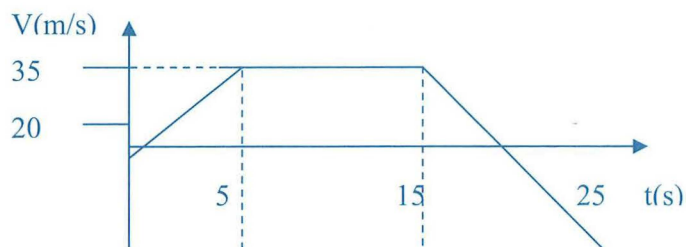
iii. From the graph plotted determine the total distance traveled

(answer:400m)

- 22 A bus leaves a station A at 1430 hours and arrived at 1600 from station B about 85km. What is average speed for the journey? (answer:17.74m/s)

- 23 A car travels on a straight line road. It increases its velocity from 20m/s to 35m/s in 5 seconds. The car maintains its velocity for 10 seconds before it stops in 10 second.

- i. Sketch velocity versus time graph



- ii. Calculate the acceleration in first 5 seconds (answer:3m/s)
iii. Calculate the total distance (answer:662.5m)
iv. Calculate the average velocity (answer:26.5m/s)

Speed, Velocity, v (m/s), Distance, d (m), Displacement, s (m), Acceleration, a (m/s^2), Deceleration, $-a$ (m/s^2), time, t (s)

Try your best.....

Chapter

3

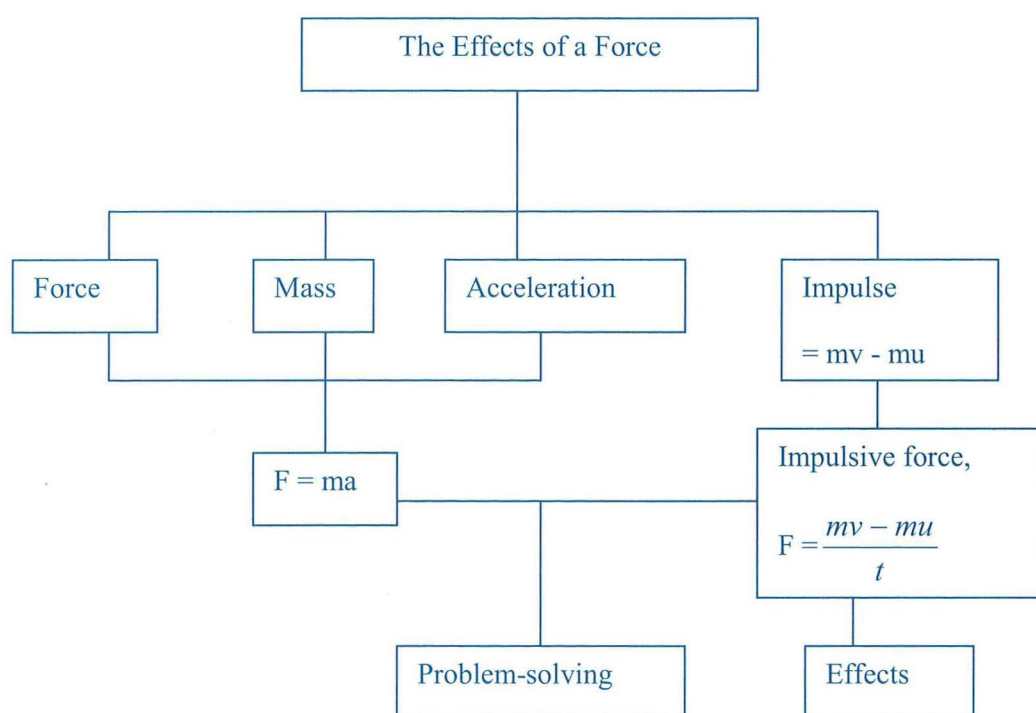
Force

Chapter 3

Force

3.0 Introduction

A force is not something that's directly observable; what is perceived is the effect, that is, the change produced by the force (e.g., something is compressed, or twisted, or moved).



Definition

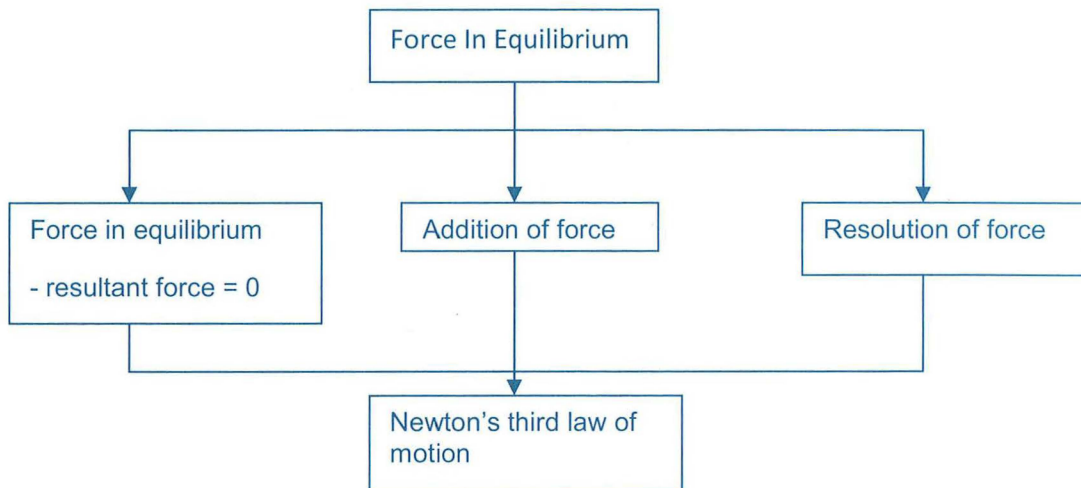
Force is defined in terms of pushes and pulls **OR** Force is defined as an action which will alter the state of motion of body in a straight line.

The symbol for force is F and its SI unit is the Newton (N). A force is a vector quantity which has **magnitude** and **direction**. A force will alter the body in the aspect of; size, shape, state of motion, direction of motion and speed.

The following are examples of forces that are used in our daily activities: pushing a trolley; hitting a golf ball; resistance force that slows down the motion of a wooden block.



3.1 Force In Equilibrium

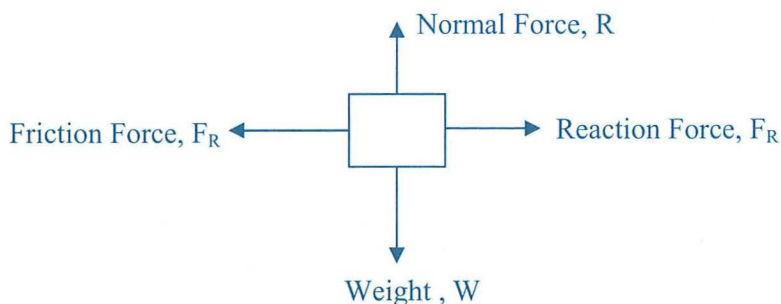


When an object is in equilibrium

When all the forces acting on an object **are balanced/ in equilibrium**, they cancel out one another and the net force or resultant **force is zero**. The object behaves as if there is no force acting on it.

Therefore, a **stationary/static** object will remain stationary and a **moving** object will continue moving with the same velocity in a straight line or acceleration is zero.

$$\begin{aligned}
 \text{Resultant force, } F &= ma \\
 &= m(0) \\
 &= 0
 \end{aligned}$$



$$\begin{aligned}
 \text{Normal Force, } R &= \text{Weight, } W \\
 \text{Reaction Force, } F_R &= \text{Friction Force, } F_G
 \end{aligned}$$

Balanced forces do not change the state of rest or state of motion of an object.
Examples of balanced forces:

- Forces acting on a stationary lorry are balanced forces.

Force, F (N) weight, w (N) mass, m (kg) acceleration, a (m/s^2) gravity, $g=9.81m/s^2$ Moment, M (Nm)

The weight of the lorry is balanced by the reaction from the ground acting upwards on the lorry at the tyres. The net force acting on the lorry is zero.

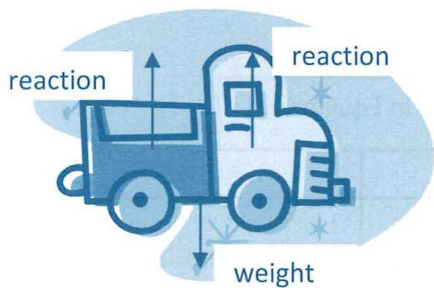


Figure : The lorry is at rest

- b) Forces acting on an aeroplane causing it to move at constant velocity are balanced forces. The lift force is equal to the weight of the aeroplane and the forward thrust is equal to the drag. The net force acting on the aero plane is zero.

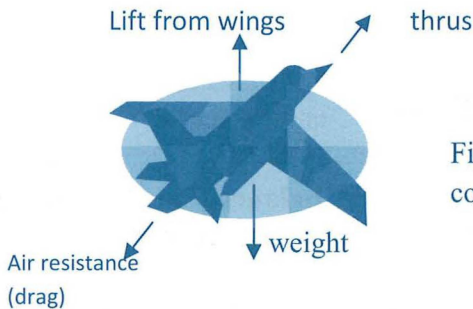


Figure: An aeroplane flying at constant velocity

Unbalanced forces acting on an object

When the forces acting on an object are not balanced, there will be a net force acting on it. This net force is known as the unbalanced force or the resultant force.

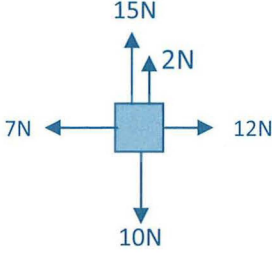
So, unbalanced forces cause a stationary object to move or a moving object to accelerate (change its velocity- change magnitude, direction or both).

Action of balanced and unbalanced force

Table 3.1 shows the action of balanced and unbalanced forces.

Force acting on an object	Resultant force
	(Assume the object moves to the right is (+) and the object moves to the left is (-))
10N ← □ → 10N	Resultant force = $(-10) + (+10) = 0$. Force are balanced . The object not moves
10N ← □ → 15N	Resultant force = $(-10) + (+15) = +5$. Forces are unbalanced. The object moves to right

Force, F (N) weight, w (N) mass, m (kg) acceleration, a (m/s^2) gravity, $g=9.81\text{m/s}^2$ Moment, M (Nm)

	Resultant force = $(-10) + (-7) + (+12) = -5$. Forces are unbalanced. The object moves to left.
	Resultant force, $F_x = (-7) + (+12) = +5$. Forces are unbalanced. The object moves to right. Resultant force, $F_y = (+15) + (+2) + (-10) = +7$. Forces are unbalanced. The object moves up.

3.2 Newton's Law

Newton's first law states that an object will remain at rest or in uniform motion in straight line unless acted upon by an external force.

Newton's second law of motion states that the rate of change of momentum is directly proportional to the resultant force and in the same direction as the force. A body of mass m is applied with a force F and its velocity changes from u to v . The force can be written as

$F \propto$ rate of change of momentum

$$F \propto \frac{(mv - mu)}{t} \quad \text{or} \quad F \propto m \frac{(v - u)}{t}$$

$$\text{but } \frac{(v - u)}{t} = a$$

hence, $F \propto ma$

$F = kma$ where k is a constant

hence k is 1, the formula becomes $\therefore$

$$F = ma$$

In SI units, F is the force in newtons, N

m is the mass in kilograms, kg

a is the acceleration in $\frac{\text{m}}{\text{s}^2}$

Force, F (N) weight, w (N) mass, m (kg) acceleration, a (m/s^2) gravity, $g=9.81m/s^2$ Moment, M (Nm)

$F \propto$ rate of change of momentum

$$F \propto \frac{(mv - mu)}{t} \quad \text{or} \quad F \propto m \frac{(v - u)}{t}$$

$$\text{but } \frac{(v - u)}{t} = a$$

hence, $F \propto ma$

$F = kma$ where k is a constant

hence k is 1, the formula becomes $\therefore$

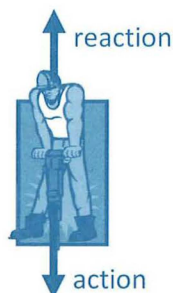
$$F = ma$$

In SI units, F is the force in newtons, N

m is the mass in kilograms, kg

a is the acceleration in $\frac{m}{s^2}$

Newton's Third Law of motion states that for any action, there is a reaction which has the same magnitude but acts in the opposite direction. The following figures show Newton's third law of motion.



Examples	Notes
3Q1- Calculate the action forces experienced by a body of mass 50 g moving with an acceleration $1.5m/s^2$. Solution: $F=?$; $m=50g$; $a=1.5m/s^2$ $m=50/1000=0.05kg$ $F=ma = 0.05 \times 1.5 = 0.075N$ 3Q2- A box of mass 4 kg is put on floor. The box is pulled horizontally with a force 13N. Find the acceleration of the box if: - The floor is smooth surface. - The rough surface and friction force is 5N. Solution: $F = 13 N$, $m = 4 kg$, $F = ma$	

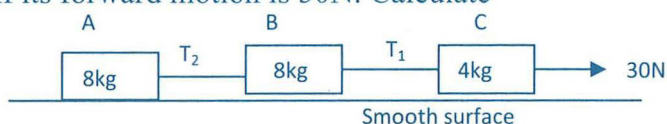
Examples

Notes

i. $a = \frac{F}{m} = \frac{13}{4} = 3.25 \text{ ms}^{-2}$

ii. $a = \frac{F}{m} = \frac{13-5}{4} = 2 \text{ ms}^{-2}$

1. From the figure below, a toy train has three coaches A, B and C respectively mass 8kg, 8kg and 4 kg. Each carriage is connected with a chain. If its forward motion is 50N. Calculate



- i. What is the acceleration of the objects?
ii. What is the tension of the string between the objects?

Solution:

- i. Assume that force 30N acts on the combined mass of 8 kg , 8 kg and 4 kg

total mass. $m = 8 + 8 + 4 = 20 \text{ kg}$

$F = 30\text{N}$

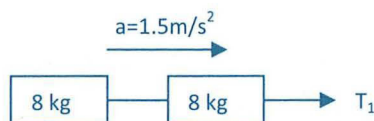
Resultant force, $F = ma$, $a = \frac{30}{20} = 1.5 \text{ ms}^{-2}$

- ii. Consider the object of mass 8 kg , 8 kg and the force T_1 that pulls the object to the front.

T_1 , $m_A = 8 \text{ kg}$, $m_B = 8\text{kg}$, $a = 1.5 \text{ ms}^{-2}$

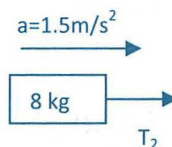
$T_1 = (m_A + m_B) a$

$T_1 = 16 \times 1.5 = 24 \text{ N}$



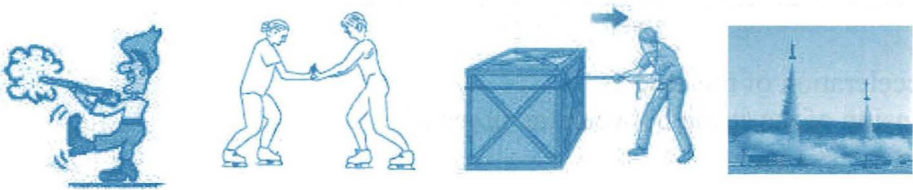
Consider the object of mass 8 kg and the force T_2 that pulls the object to the front.

(try your best) Ans: 12N.....



.....
.....
.....

3Q3- A car of mass 1500kg moving from the speed of 30km/h to

Examples	Notes
60km/h in 20 seconds. Calculate the action forces experienced by the car by neglecting the friction force. Solution: $F=ma = m \left(\frac{v-u}{t} \right) = 1500 \left(\frac{60-30}{\dots\dots\dots} \right) = 8.1 \times 10^6 N$ 2. The following diagram involving Newton's Third Law 	

3.3 Weight

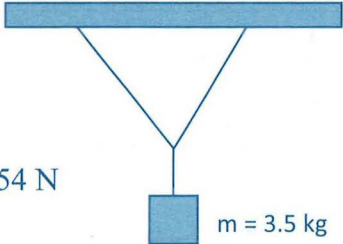
The weight of an object an object is defined as the force of gravity acting on the object. The symbol for weight is **W**, and the SI unit of weight is the **Newton (N)**. Formula of weight, **W = mg**.

g is the acceleration due to gravity. The acceleration due to gravity is **always acting downwards**. Value of g is 9.81 ms^{-2} or 9.81 Nkg^{-1} .

What is the difference between mass and weight?

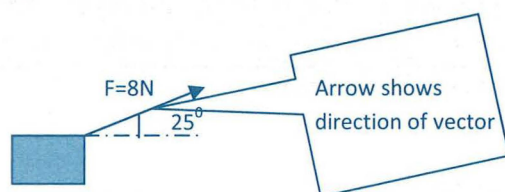
- Mass is the amount of matter in an object. This does not change in an object as it moves away from the earth.
- Weight is caused by gravity. Therefore, the greater the distance, the less the force of attraction. The less the distance the greater the force of attraction.
- Your weight is dependent upon the mass of the earth. If you were able to go to the planet, Jupiter, your weight would be 27 time greater, because the mass of Jupiter is 27 times greater.

Examples	Notes
3Q4- A student has to consider its mass. If its mass is 72kg, calculate the weight. Solution: $m= 72\text{kg}$	

Examples	Notes
$W=mg = 72 \times 9.81 = 706.32N$ 3Q5- An object with a mass of 3.5 kg is supported by two forces as shown in figure 1. Calculate the weight of object. Solution: Weight of the object, $W = mg$ $= 3.4 \times 9.81 = 33.354 N$  $m = 3.5 \text{ kg}$ Figure 1	

3.4 Addition Of Force

Force is a vector quantity. It can be represented by a long line which shows the magnitude of the force and an arrow head on it which shows the direction of the force.



The force obtained from the addition of two or more force is called the **resultant force**.

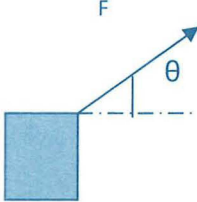
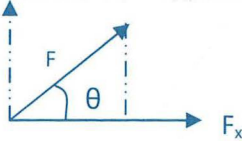
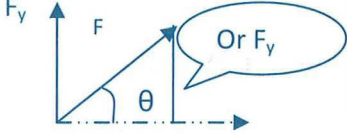
The additions of vector quantities such as forces must take into account **both the direction and magnitude**.

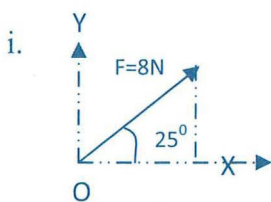
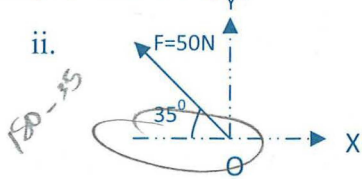
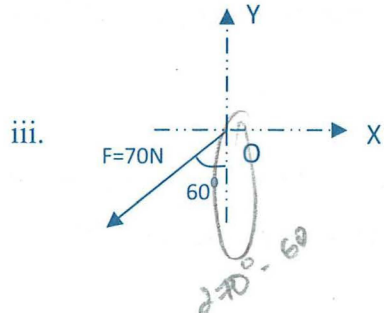
For vectors which are parallel (whether in the same direction or in opposite directions), the resultant vector can be determined by the **addition of every vector** (such as Table 1.1).

For **non-parallel** vector quantities, the resultant vector can be determined using the **triangle of forces**, or the **parallelogram of forces**.

3.5 Components Of Force

Components of force can divided to component axis -X and component axis -Y

	Component axis -X, F_x	Component axis -Y
	 $\cos \theta = \frac{\text{beside}}{\text{hypotenuse}}$ $= \frac{F_x}{F}$ $F_x = F \cos \theta$	 $\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}}$ $= \frac{F_y}{F}$ $F_y = F \sin \theta$

Examples	Notes
3Q6-. Find the magnitude of the components of the following vectors in the direction of OX (F_x) and OY (F_y). i.  ii.  iii.  Solution: i. $F_x = F \cos \theta$ $= 8 \cos 25^\circ$ $= 7.25 \text{ N}$ $F_y = F \sin \theta$ $= 8 \sin 25^\circ$ $= 3.38 \text{ N}$	

Examples

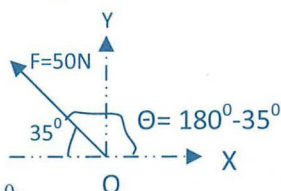
Notes

- ii. $F_x = F \cos \theta$
 $= 50 \cos (180^\circ - 35^\circ)$
 $= -40.95 \text{ N}$ (negative sign indicates that the direction of Ox /
 F_x is backwards/ from figure, F_x is left direction)

$$F_y = F \sin \theta$$

$$= 50 \sin (180^\circ - 35^\circ)$$

$$= 28.67 \text{ N}$$



- iii. $F_x = F \cos \theta$
 $= 70 \cos (270^\circ - 60^\circ)$
 $= -60.62 \text{ N}$

$$F_y = F \sin \theta$$

$$= 70 \sin (270^\circ - 60^\circ)$$

$$= -35 \text{ N}$$

3Q7- Figure c shows worker pushing a concrete roller along a floor with force 80 N. The force is acting 35° below the horizontal.

- Calculate the horizontal component of force.
- Calculate the vertical component.

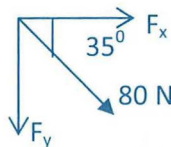


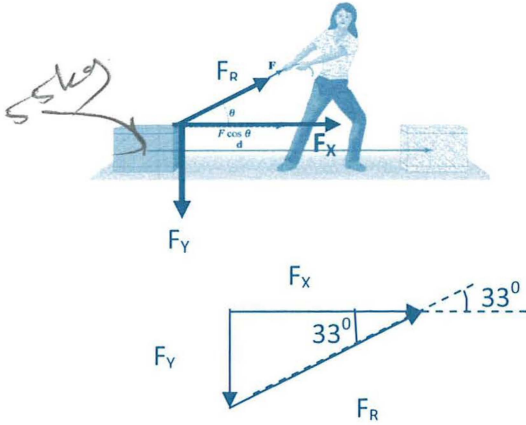
Figure c

F_y

Solution:

- $F_x = F \cos \theta$
 $= 80 \cos (360^\circ - 35^\circ)$
 $= 65.53 \text{ N}$
- $F_y = F \sin \theta$
 $= 80 \sin (360^\circ - 35^\circ)$
 $= -45.88 \text{ N}$ (negative sign indicates that the direction of F_y is downward)

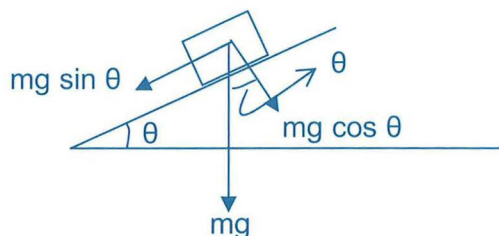


Examples	Notes
3Q8- From figure below, Rina pulling a box of 55 kg mass on a smooth surface at an angel of 33° from horizontal. Find the F_R, F_X and F_Y.  Solution: $F_Y = mg = 55 \times 9.81 = 539.55N$ $F_Y = F_R \sin 33^\circ$ $F_R = \frac{F_Y}{\sin 33^\circ} = \frac{539.55}{0.5446} = 990.727N$ $F_X = (\text{try your best}) \text{ Ans: } 830.229N \dots\dots\dots$	

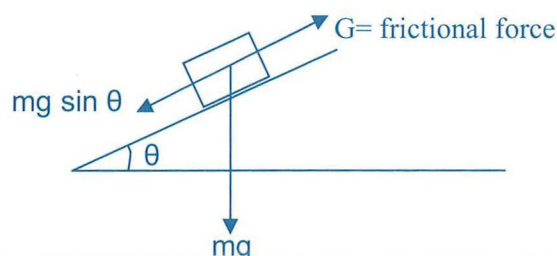
Application Of Vector Resolution

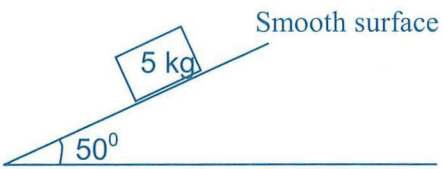
For an object moving along an inclined plane, the acceleration due to gravity can be resolved into two components, one which is **parallel** to the surface and one which is **perpendicular** to the surface.

Figure below shows that, the force acting along the surface is $mg \sin \theta$.

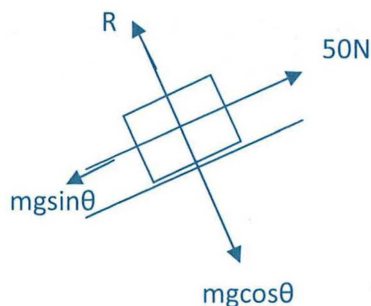


A **friction-compensated** inclined plane is set up when the frictional force G is balanced by the component of the force of gravity along the surface, i.e. $mg \sin \theta = G$



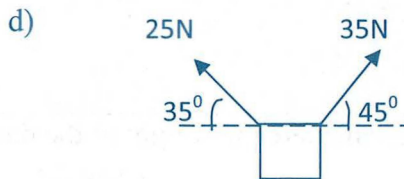
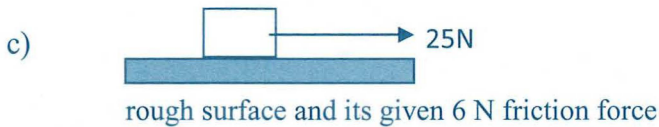
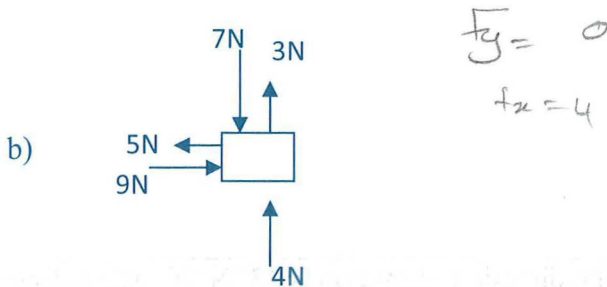
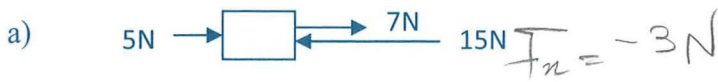
Examples	Notes
3Q9- An object with a mass of 5 kg moves down a plane inclined at an angle of 50°. Calculate the object action force.  Solution: The force of gravity can be resolved into the component OX (F_x) which is parallel to the surface because the object is moving along the inclined plane Therefore $OX = mg \sin \theta$ $= 5(9.81) \sin 50^\circ$ $= 37.57 \text{ N}$ The force acting parallel to the surface, $F = 37.57 \text{ N}$,	

Examples	Notes
3Q10- A child playing slide as shown in the figure below. If the mass of the child is 30 kg, calculate the - The force action by the child. - The acceleration of the child with ignore the frictional force. - The acceleration of the child if the frictional force is 55N. Solution: - The force action is F_x. $F_x = mg \sin \theta = 30 \times 9.81 \times \sin 55^\circ = 241.076 \text{ N}$ $F = ma$ $241.076 = 30a, \quad a = \frac{241.076}{30} = 8.0358 \text{ m/s}^2$ $F = ma$ (try your best) Ans: 6.202 m/s^2	
3Q11- An object with a mass m kg is placed on a plane inclined at an angel of 35°. A force of 50 N pulls it up along the surface. Calculate value of m if the acceleration of the object is 1.05 m/s^2. Solution : The reaction force $= mg \sin \theta$ $= m(9.81) \sin 35^\circ = 5.627m \text{ N}$ Net force $= ma$ $50 - 5.627m = m \times 1.05$ $50 = 1.05m + 5.627m$ $50 = 6.677m$ $m = 50 / 6.677 = 7.488 \text{ kg}$	An object moving along s friction-compensated plane will have a constant velocity, its acceleration is zero.



Self Learning 1

1. Find magnitude of the resultant force for each situation below:



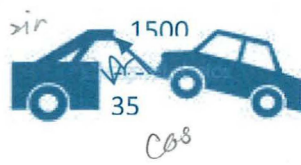
2. A lorry of mass m is moving with an accelerates of $7.66 ms^{-2}$. If the force at the lorry is $15kN$, calculate the value of m in unit gram. (Ans: $1.95 \times 10^6 g$)

$$F = ma$$

$$15 = m \times 7.66$$

$$1.958 = m$$

3. A car broke is towed by truck with a force $1500N$ at an angel 35° from horizontal as shown in figure below. Calculate the force on the direction of motion.



(Ans: $1228.72N$)

$$1500 \cos 35^\circ$$

4. A mother push a baby stroller with a force in the direction of motion is 132N. If action force is used to push the baby stroller is 150N and θ from the horizontal, calculate the value of θ . (Ans: 28.35°)

5. A durian falling from tree. If the mass of the durian is 2.5 kg, calculate the weight of the durian. (Ans: 24.525N)

6. A blok with a mass 550g is dropped from a building of height 8m. What is the force of the stone? (Ans: 5.395N)

7. A worker is pulling a box with a rope which makes an angle of 55° with the vertical. If the tension of the string is 3500N, find:

- i. the horizontal force
- ii. the vertical force

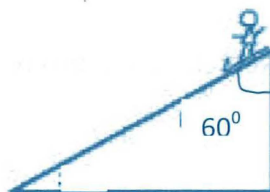
(2867.03N; 2007.517N)

8. A block is pushed along rough surface with 130 N forces. If the force makes an angle of 35° with the horizontal and the friction force is 50 N, find the net force.

(56.48N)

9. A 60 kg skier slides down a 60° slope. Calculate

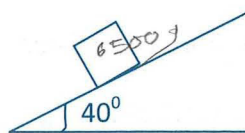
- a) the horizontal force
- b) the vertical force



(294.3N; 509.74N)

10. From figure below, shown an object with mass 6500g moves down a plane inclined at an angle 40° . Calculate :

- the component of force (axis-X)
- the component of force (axis- Y)
- the acceleration of the object if the friction force is 15 N.



(40.987N; 48.847N; 3.998m/s^2)

3.5 Multiple Of Forces

Resultant force and its direction can also be determined by using method as shown in examples below.

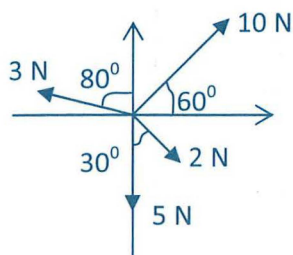
Examples

Notes

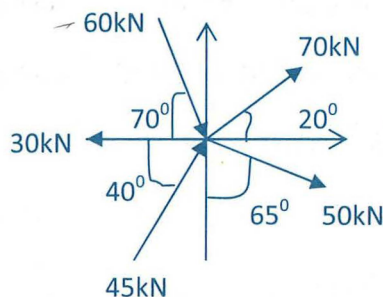
3Q1-

a. Find the resultant force, R and its direction, θ from the Figure below:

i.



ii.



20
110, 80
280
335

Solution:

- Firstly, make sure all θ value is calculated against positive x axes in anticlockwise direction.
- Assign inward arrow ($\leftarrow$) as negative and outward arrow ($\rightarrow$) as positive.
- Then draw a table below:

i.

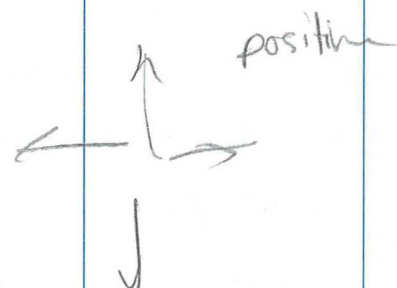
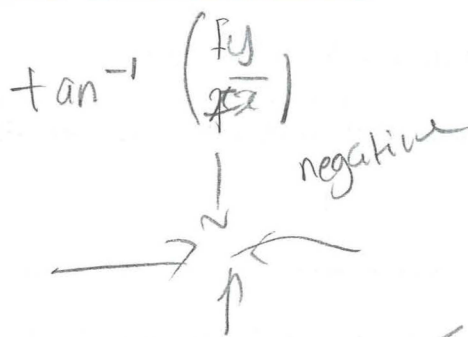
Force (N)	F_x (N)	F_y (N)
10	$10\cos 60^\circ = 5$	$10\sin 60^\circ = 8.66$
3	$3\cos 170^\circ = -2.95$	$3\sin 170^\circ = 0.52$
5	$5\cos 270^\circ = 0$	$5\sin 270^\circ = -5$
2	$2\cos 300^\circ = 1$	$2\sin 300^\circ = -1.73$
total	$(3.05)^2$	$(2.45)^2$

$$\sum F = \sqrt{(3.05)^2 + (2.45)^2}$$

$$= \sqrt{15.305} = 3.91$$

$$\tan \theta = \frac{F_y}{F_x} = \frac{2.45}{3.05}$$

$$\theta = \tan^{-1} 0.803 = 38.77^\circ$$



- ii. Remember, assign inward arrow ($\leftarrow$) as negative and outward arrow ($\rightarrow$) as positive.

Examples				Notes
	Force (kN)	F_x (kN)	F_y (kN)	
	70	$70\cos20^0 = 65.78$	$70\sin20^0 = 23.94$	
	60	$-(60\cos110^0) = 20.52$	$-(60\sin110^0) = -56.38$	
	30	$30\cos180^0 = -30$	$30\sin180^0 = 0$	
	45	$-(45\cos230^0) = 28.92$	$-(45\sin230^0) = 34.47$	
	50	$50\cos335^0 = 45.31$	$50\sin335^0 = -21.13$	
	total	130.53	-19.1	
$\sum F = \sqrt{(130.53)^2 + (-19.1)^2}$ $= \sqrt{17402.89} = 131.92kN$ $\tan \theta = \frac{F_y}{F_x} = \frac{-19.1}{130.53}$ $\theta = \tan^{-1} - 0.146 = -8.32^0$ Negative sign, to show that the θ in 4th quadrant.				

3.6 Moment

A moment is defined as a force multiplied by the perpendicular distance from the line of action of the force to the pivot.

The moment can be calculate using the formula:

Moment, M = Force x Perpendicular distance of force from pivot

= $F \times d$

The unit of moment of is Newton meter (Nm) and moment is a vector quantity.

Principle of Moments

For equilibrium: (i.e. an object is balanced and not moving or turning).

Force, F (N) weight, w (N) mass, m (kg) acceleration, a (m/s^2) gravity, $g=9.81m/s^2$ Moment, M (Nm)

Principle of Moments - If a body is in equilibrium under the action of a number of forces, then the algebraic sum of the **moments** of the forces about any point is equal to **zero**. In other words,

The sum of the clockwise moments about a point equal sum of the anticlockwise moments about that point.

When several coplanar force acting on a rigid body, the body will be in static equilibrium and has neither translation nor rotation. In order to maintain the body in this state, we must have the following conditions:

Condition 1:

To avoid translation, the net force acting through the centre of the mass of the body must be zero. Hence, we have

$$\sum F_x = 0 \text{ and } \sum F_y = 0$$

Condition 2:

The body will rotate if the forces produce a net moment on the body about any point or axis. Therefore, the total moment $\sum M$ about any point or axis must be zero if the body does not rotate. Hence, we have

$$\sum M = 0$$

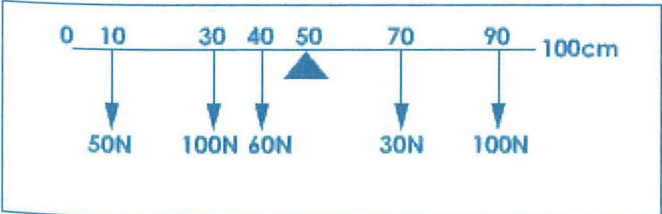
Wherever the sum of clockwise moments equal the sum of anticlockwise moments in magnitude, the total moment will be zero.

$$\sum +(\text{clockwise moments}) + \sum -(\text{anticlockwise moments}) = 0$$

Or

$$\sum (\text{clockwise moments}) = \sum (\text{anticlockwise moments})$$

Solving problems related to equilibrium and centre of gravity.

Examples	Notes
a.  Clockwise moment equal to anticlockwise moments In the figure above, Solution:	

Examples

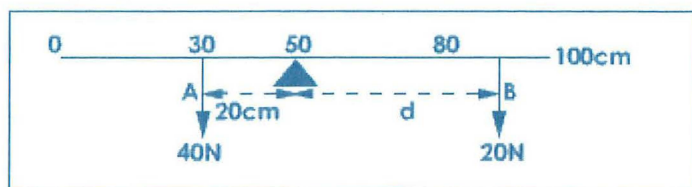
Notes

$$\Sigma(\text{anticlockwise moments}) = \Sigma(\text{clockwise moments})$$

$$(50 \times 40) + (100 \times 20) + (60 \times 10) = (30 \times 20) + (100 \times 40)$$

$$4600 = 4600$$

b. A metre scale is supported at the centre. It is balanced by two weight A and B as shown in figure below, find the distance of B from the pivot.



Clockwise moment and anticlockwise moment about 50 cm divisions are equal.

Solution:

$$\Sigma(\text{anticlockwise moments}) = \Sigma(\text{clockwise moments})$$

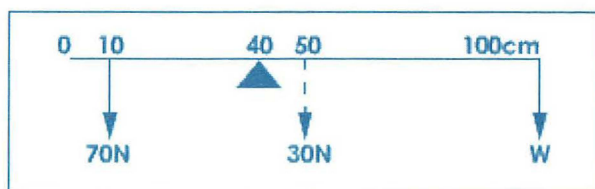
$$20 \times d = 40 \times 20$$

Therefore,

$$d = \frac{800}{20} = 40 \text{ cm}$$

Hence the 20N force of B is acting from 90cm mark.

c. The illustration in figure below shows a uniform meter rule weighing 30 N pivoted on a wedge placed under the 40 cm mark and carrying a weight of 70 N hanging from the 10 cm mark. The ruler is balanced horizontally by a weight W hanging from the 100 cm mark. Calculate the value of the weight. W .



Solution:

$$\Sigma(\text{anticlockwise moments}) = \Sigma(\text{clockwise moments})$$

$$W \times (100 - 40) + 30(50 - 40) = 70 \times (40 - 10)$$

Examples

Notes

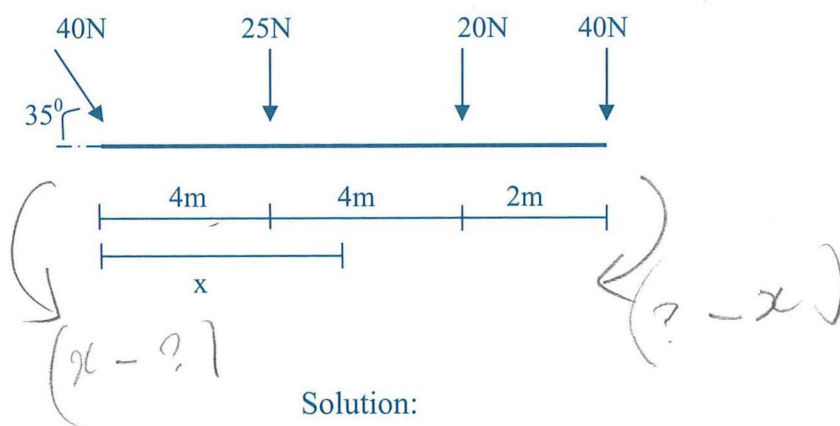
$$60W + 300 = 2100$$

$$60W = 2100 - 300$$

$$W = 1800/60 = 30 \text{ N}$$

d. Identify the gravitational point for action forces system below for the bar is in equilibrium.

i.



Solution:

The force moment method can determine the centre of gravity for several forces acting on a system, so that the bar will be in equilibrium horizontally, like example above.

Firstly, we must find F_y for force 40N acting 35° above the horizontal.

$$F_y = 40\sin 35^\circ = 22.94\text{N}$$

$$\Sigma(\text{anticlockwise moments}) = \Sigma(\text{clockwise moments})$$

$$22.95(x) + 25(x-4) = 20(8-x) + 40(10-x)$$

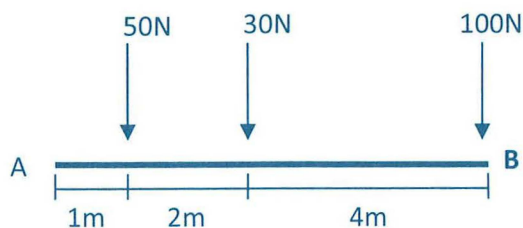
$$22.95x + 25x - 100 = 160 - 20x + 400 - 40x$$

$$X(22.95 + 25 + 20 + 40) = 100 + 160 + 400$$

$$107.95 x = 660$$

$$X = 660/107.95 = 6.11 \text{ m}$$

ii.

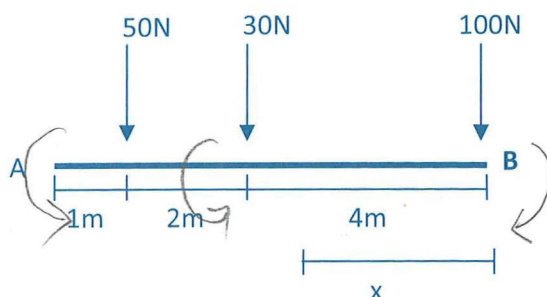


Examples

Notes

Solution:

Let say center of gravity at X from B. So, the figure like below:



$$\Sigma(\text{anticlockwise moments}) = \Sigma(\text{clockwise moments})$$

$$50(6-x) + 30(4-x) = 100x$$

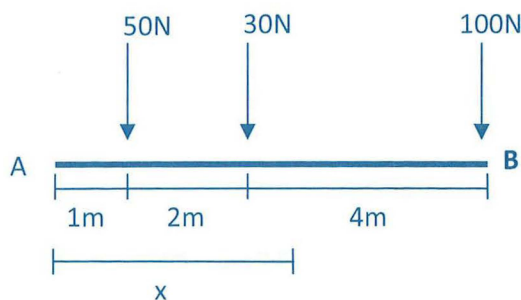
$$300 - 50x + 120 - 30x = 100x$$

$$300 + 120 = 100x + 50x + 30x$$

$$420 = 180x$$

$$X = 420/180 = 2.33 \text{ m}$$

You can also say the center of gravity at X from A, but the answer is not same. Let us calculate.



Solution:

$$\Sigma(\text{anticlockwise moments}) = \Sigma(\text{clockwise moments})$$

$$50(x-1) + 30(x-3) = 100(7-x)$$

$$50x - 50 + 30x - 90 = 700 - 100x$$

$$50x + 30x + 100x = 700 + 50 + 90$$

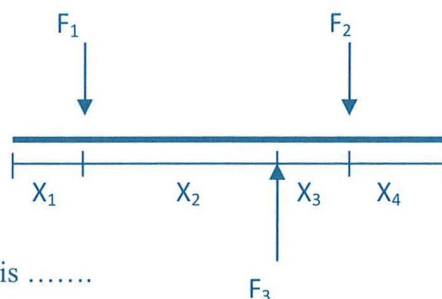
$$180x = 840$$

$$X = 840/180 = 4.67 \text{ m}$$

3.7 Resultant Moment

Center of gravity can also be determined by using the **Resultant Moment** method.

Resultant moment force = total moment force acting



From left, the center of gravity is

Resultant Moment = total of force $\times$ center of gravity

$$= (F_1 + F_2 + (-F_3)) \times$$

F_3 is directed to the upward, so the sign of F_3 is negative ($-F_3$)

Total of moment of force = $F_1(x_1) + F_2(x_1 + x_2 + x_3) + (-F_3)(x_1 + x_2)$

Therefore,

Resultant moment force = total moment force acting

$$(F_1 + F_2 + (-F_3)) \times = F_1(x_1) + F_2(x_1 + x_2 + x_3) + (-F_3)(x_1 + x_2)$$

$$x = \frac{F_1(x_1) + F_2(x_1 + x_2 + x_3) - F_3(x_1 + x_2)}{F_1 + F_2 - F_3}$$

Examples	Notes
a. Identify the gravitational point for action forces system below for the bar is in equilibrium. i. We use the same example (d i) to show the answer is same if you use any method (principle moment or resultant moment).	

Examples

Notes

Solution:

From left, the center of gravity is

Resultant Moment = total of force x center of gravity

$$= (40\sin 35^\circ + 25 + 20 + 40)x$$

$$= 107.94x$$

Total of moment of force = $(40\sin 35^\circ)0 + 25(4) + 20(8) + 40(10)$

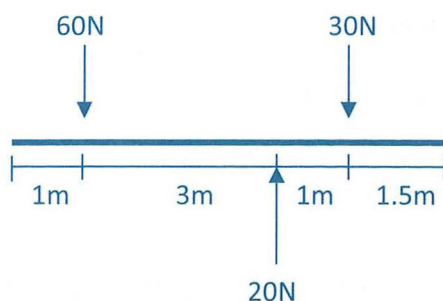
$$= 660$$

Resultant moment force = total moment force acting

$$107.94x = 660$$

$$x = 660/107.94 = 6.11 \text{ m}$$

ii.



Solution:

From left,

Resultant moment force = total moment force acting

$$(60 + 30 - 20) x = 60(1) + 30(1 + 3 + 1) + (-20)(1 + 3)$$

$$70x = 60 + 150 - 80$$

$$x = 130 / 70 = 1.857 \text{ m}$$

Self Learning 2

1. A box of mass 3 kg is put on a smooth floor. The box is pushed horizontally with a force 3.5N. What is the acceleration of the box? (ans: 1.17 ms^{-2})

2. A object is pulled horizontally on smooth surface with the acceleration 6 ms^{-2} . If the mass of the object is 5 kg, calculate the force acting. (ans: 30N)

3. Object A of mass 9 kg and object B of mass 4 kg are tied together with a light string and placed on a smooth surface. The objects are pulled with a 15 N force.

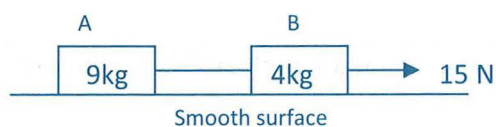


Figure 1

- i. What is the acceleration of the objects? (ans: 1.15ms^{-2})
- ii. What is the tension of the string between the objects? (ans: 10.35N)

4. From Figure 2, calculate:

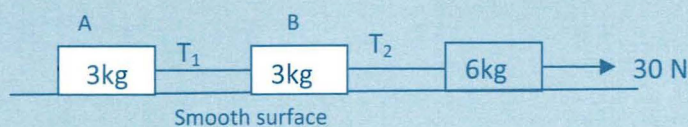


Figure 2

- i. The acceleration (ans: 2.5ms^{-2})
- ii. T_1 (ans: 7.5N)
- iii. T_2 (ans: 15N)

5. A car of mass 500kg is moving with a uniform velocity of 10 ms^{-1} . The car brakes suddenly and it stops within a distance of 25m . What is the force acting on the brakes of the car?
(ans: -1000N)

6 An object is moved by a constant force of 15N acting at an angle 55° to the horizontal as shown in Figure 3.

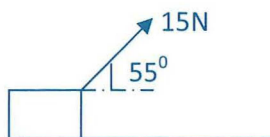


Figure 3

- a. If the object is moved in smooth surface ,
 - i. Calculate the horizontal component and state the direction. (8.60)
 - ii. Calculate the vertical component and state the direction. (12.29)
- b. If the object is moved in rough surface with the frictional force is 3N , calculate the force acting. (5.60)

7. A student is pulling a trolley with an iron chain which makes an angle of 60° with the horizontal. If the tension of the string is 5500N, what is the horizontal force?. (2750N)

8. A load of mass 4 kg is suspended by strings T, Q and R attached to retort stands as shown in Figure 4. Use the resolving method, calculate the tension of string R, T and Q. (assume $g = 10 \text{ ms}^{-2}$)
($R=20\text{N}$, $T=31.11\text{N}$, $Q=23.835\text{N}$)

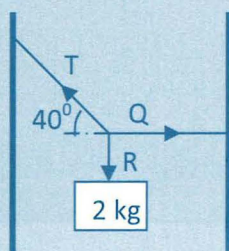
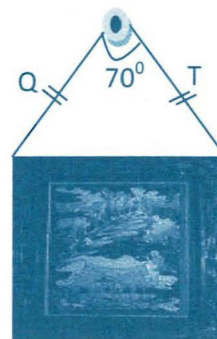


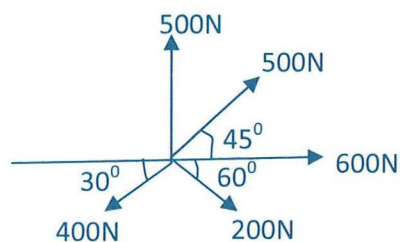
Figure 4

9. A picture is hung as shown in figure below. If the mass of the picture is 500g, calculate the tension of string T and Q if the system in equilibrium. ($Q=T=2.995N$)



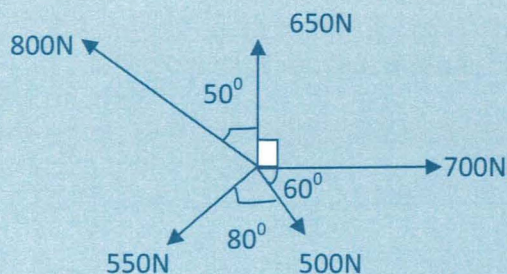
10. Determine the resultant force and its direction for Figures below if the system in equilibrium.

a)



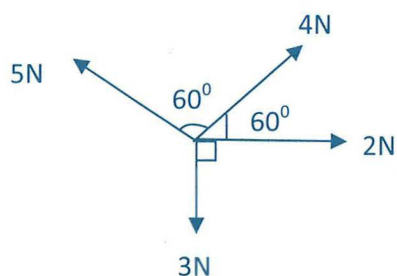
(ans: $F_R = 854.86N$, $\theta = 34.187^\circ$)

b)



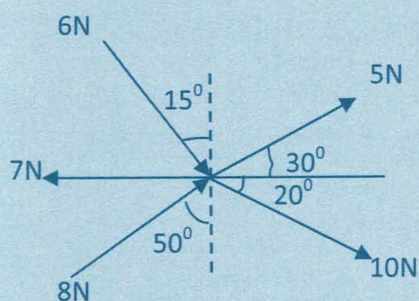
(ans: $F_R=386.95\text{N}$, $\theta=77.44^\circ$)

c)



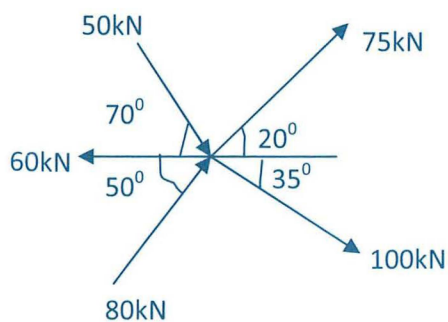
(ans: $F_R=5.019\text{N}$, $\theta=72.51^\circ$)

d)



(ans: $F_R=14.489\text{N}$, $\theta=6.12^\circ$)

e)

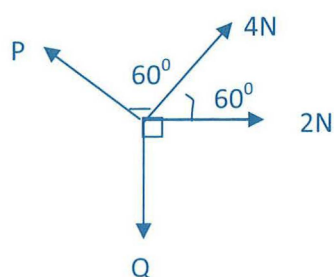


($F_R=161.849\text{N}$, $\theta=6.18^\circ$)

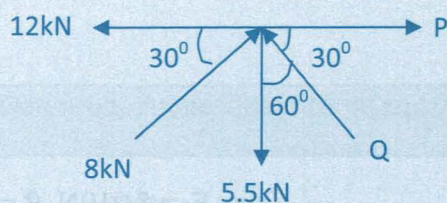
11. From Figures below, calculate P and Q if the system in equilibrium.

($P=8N$, $Q=10.39N$; $P=7.67kN$, $Q=3kN$)

a)

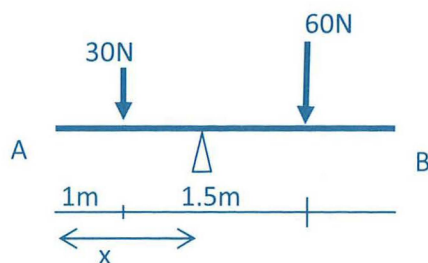


b)



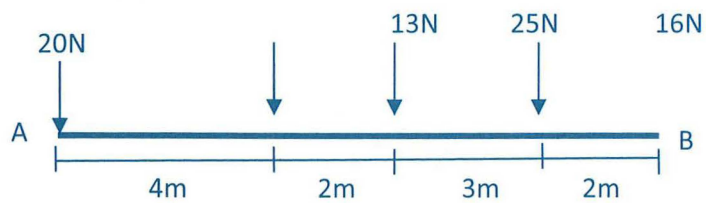
12. From Figures below, determine the center of gravity if the system in equilibrium. (use principle of moment/ force moment and resultant moment).

a)



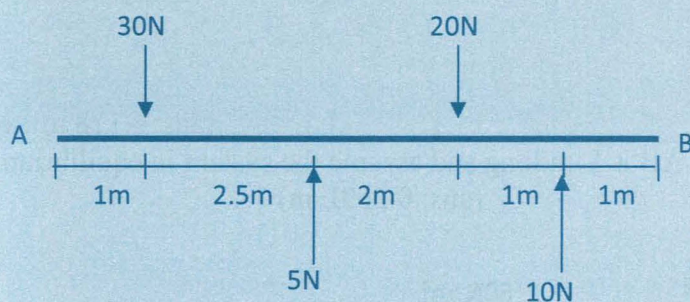
(ans: 2m from A)

b)



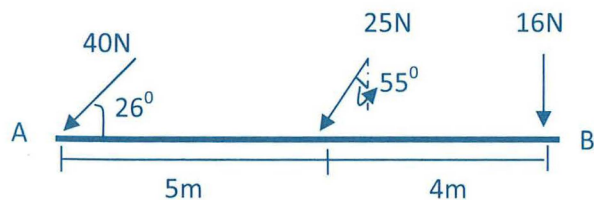
(ans: 4.67 m from A)

d)



(ans: 5.86 m from B)

e)



so we can ignore it.

- a. Find the weights of the children. (A= 343.35N; B=245.25N; C=392.4N)

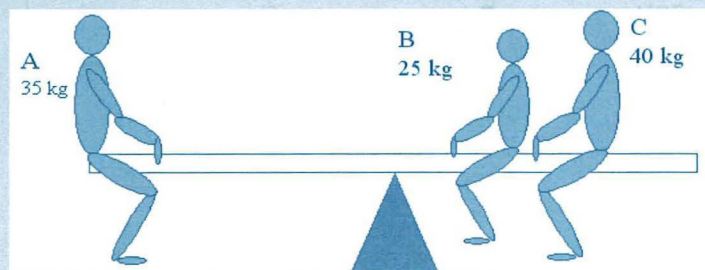
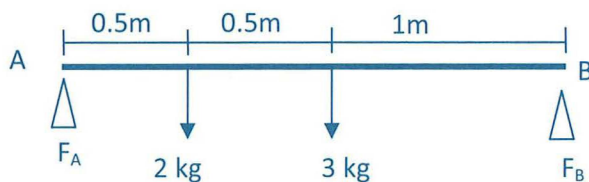


Figure 2

- b. Child B is sitting 0.4 m from the pivot. Where should (determine) child C sit so that the see-saw remains level? (1.06 m)
- c. Child C misses its footing and falls off the end. What will happen to the others and give the reason?

13. Find the F_A and F_B for a beam below if the system in equilibrium.

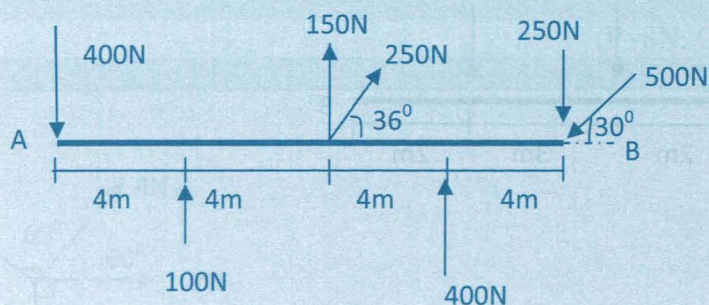
a.



(ans: $F_A= 29.43N$, $F_B=19.62N$)

(ans: 4.51 m from A)

f)



(ans: 4.118 m from A)

- g). Find the centre of gravity for beam AB is L m long and assume the system in equilibrium, as shown in Figure 1.
(ans: $0.269L$ m)

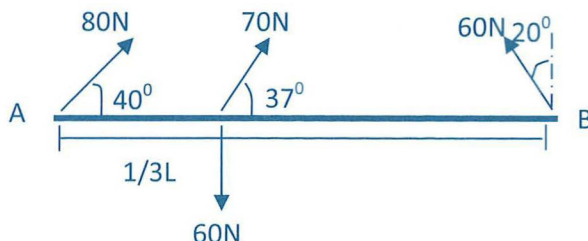
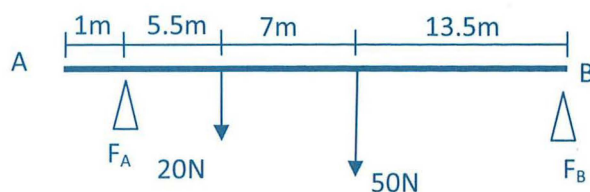


Figure 1

- h) Some children are playing on a see-saw as shown in Figure 2. The see-saw is a plank of wood 3.0 m long, with a pivot exactly in the middle. The centre of mass is directly above the pivot,

b.



$$(F_A=28.65\text{N}; F_B=41.35\text{N})$$

1.. Test 1 Sesi Jun 2010

- a) Define:
 - i. Force.
 - ii. Newton's Second Law.
- b) State one scalar quantities and one vector quantities with its units.
- c) A bus with a mass of 2010kg accelerates from 0 to 25m/s in 35s. Assuming the acceleration is constant, find is the total force on the bus.
- d) From the Figure 1, a block suspended from two ropes, so that it hangs motionless in the air. If the magnitude of $T_2=12\text{N}$, calculate the magnitude of T_1 .

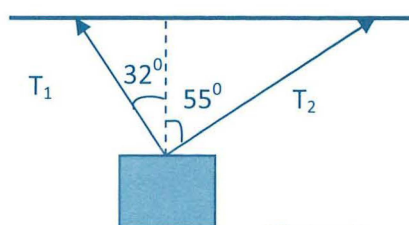


Figure 1

- e)
 - i. Define moment.
 - ii. From the Figure 2, convert each unit from kg to N.
 - iii. Find value of force acting at F_2 and F_3 .

iv. Calculate the centre of gravity from point P using Resultant moment method.

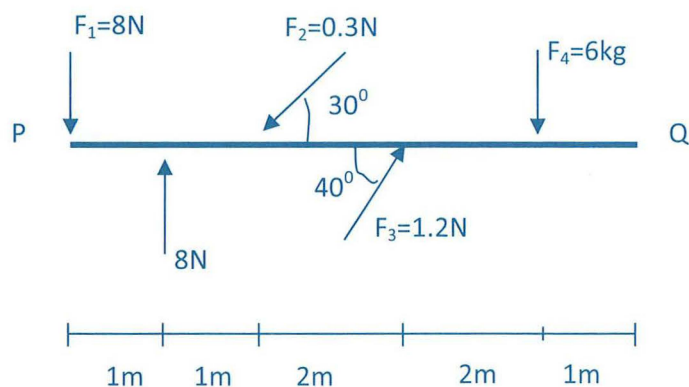


Figure 2

2. Test 1 Sesi Dec 2010

- a) Define:
- Scalar quantity
 - Vector quantity
- b) A box of mass 4.2 kg is put on a smooth surface. The box is pulled horizontally with a force 3.5N. Find the acceleration of box?
- c) The six ropes tight to the ring are pulled on with force as shown as Figure 1. Calculate the resultant force to the forces acting on the ring.

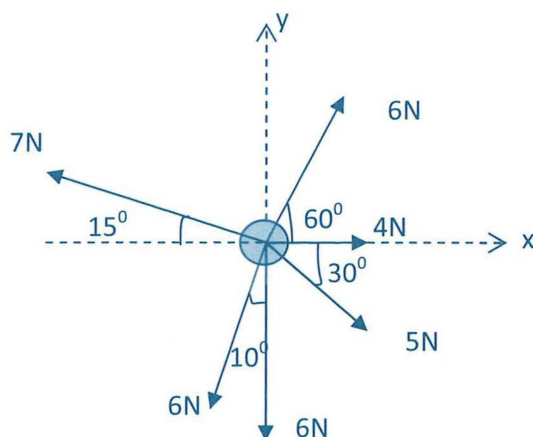


Figure 1

- d) Define:
- Newton's First Law
 - Newton's Second Law
- e) From Figure 2 calculate the centre of gravity from point A if the system in equilibrium.

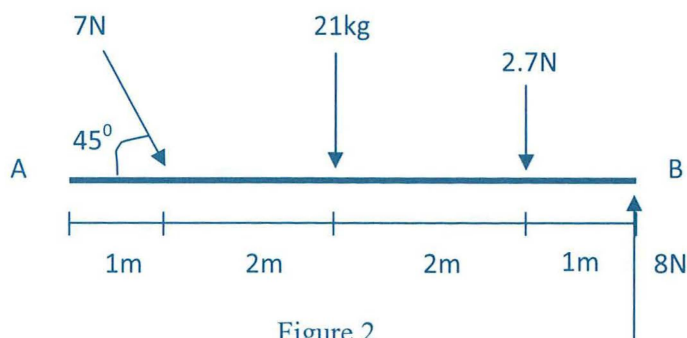


Figure 2

3. Test 1 Sesi Jun2011

a) Define:

- i) Force
- ii) Second Newton Law

b) Differentiate weight and mass

c) Based on Figure 1, below, there are two teams pulling the ropes. Team A has total force of 240 N while team B has total force of 270N. Describe which group will win this game relate to force in equilibrium.



Figure 1

c) The 4 ropes tight to the ring are pulled on with force as shown as Figure 2. Determine the resultant force and its direction for the figure.

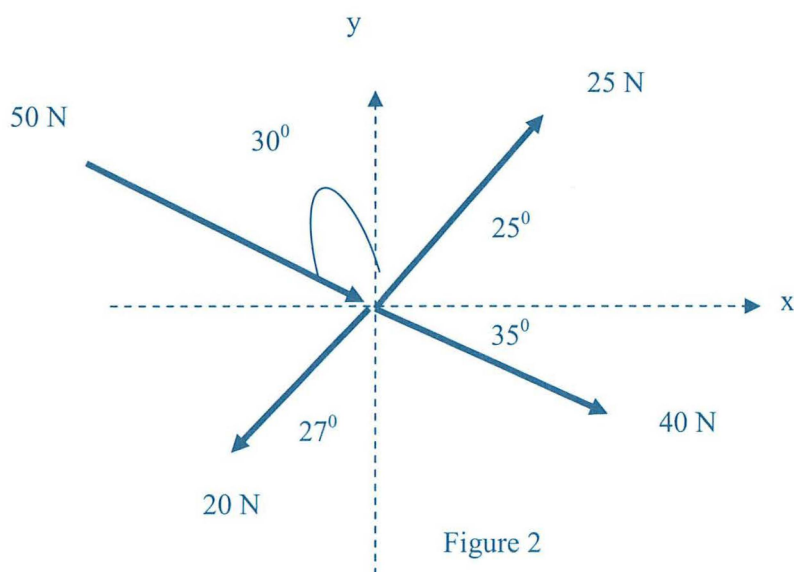


Figure 2

e) Define moment and gives it SI unit

f) States TWO types of method to solve moment problem

g) From Figure 3,

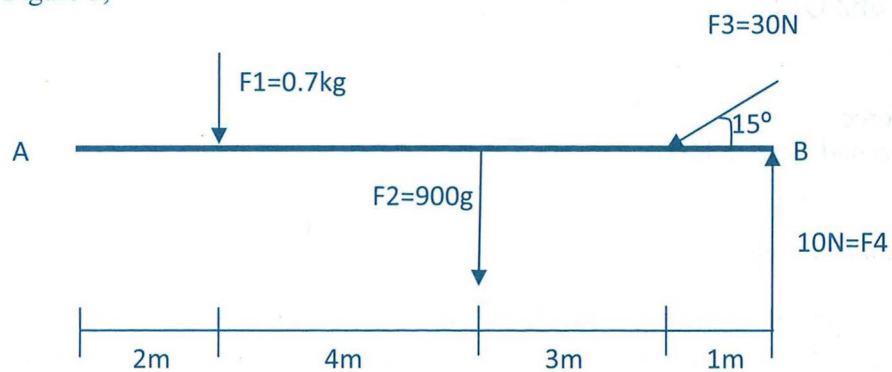


Figure3

- (i) convert value of F_1 and F_2 to unit Newton
- (ii) calculate the centre of gravity from point A

Chapter

4

Work, Energy & Power

Work, Energy & Power

4.1 Work

Work done is the product of an applied force and the displacement of an object in the direction of the applied force. This word of “work” brings to mind pushing, pulling and walking back and forth. The very unusual thing about the day-to-day usage is that it is almost identical to the Physics usage of the term. Work done can happen when the point at which a force acts moves. When the force is constant, the work done is also can be defined as the product of the force and distance moved.

“Work done on an object, is the product of the average force on it and the distance traveled in the direction of the force.”

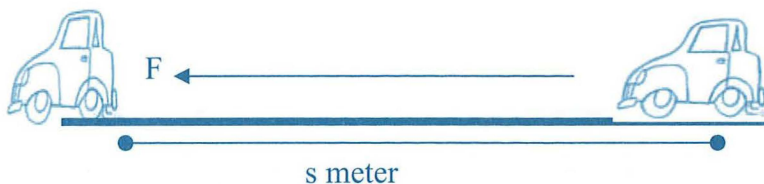


Figure 4.1

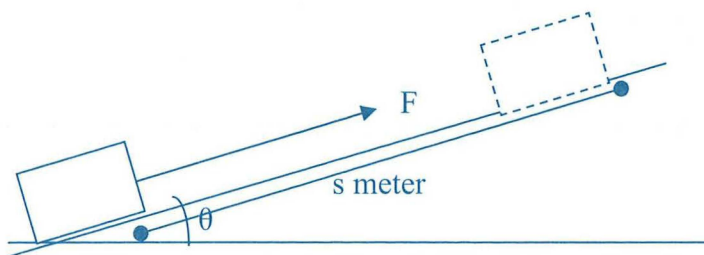


Figure 4.2

$$\text{Work} = \text{Force} \times \text{Distance moved in the direction of the force}$$

So if we have a constant force of magnitude F Newtons, which moves a body a distance s meter along a flat surface, the work done is $F \times s$ and the unit of Work is Joules (J); Figure 4.1 and 4.2 shows that the situation of movement of an object where the force applied is parallel with the distance. So, the work done can be happen when the force acting by the distance traveled.

$$W = F \times s$$

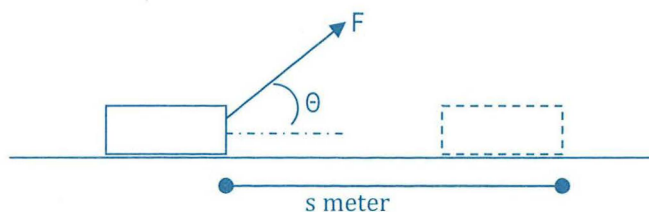


Figure 4.3

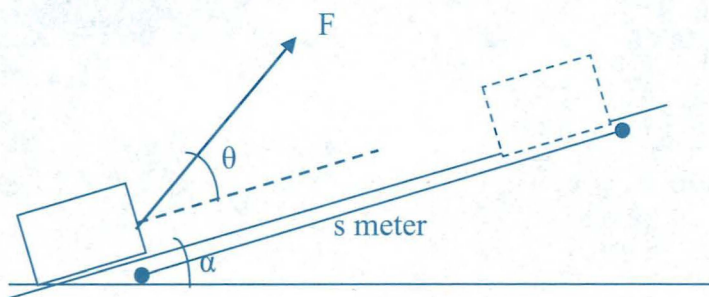


Figure 4.4

Now suppose that this force is at an angle of a horizontal. If the body moves a distance of s meters along the ground, then the work done is $F \cos \theta \times s$ (since $F \cos \theta$ is the component of the force in the direction of the motion)

Figure 4.3 and 4.4 shows that the motions of the object is applied force at an angle of a horizontal of the distance. If the force acting is not parallel with the distance, we use the component of the force which is parallel to the distance. So we can find the work done by the object with the formula ;

$$W = F \cos \theta \times s$$

The SI unit of work is Joule (J) and is the work done when a force of 1 Newton (N) moves through a distance of 1 meter (m). (1 Joule is the work done when an object is moved 1 m under the application of force of 1 N in the direction of motion.

$$1 \text{ J} = 1 \text{ Nm}$$

The work done by an object can be positive or negative. Since force, F and displacement, s are both vectors, the result of the above equation depends on their directions:

- If F acts in the same direction as the motion then positive work is done. That means the object on which the force is applied gained energy.
- If the direction of motion and F are opposite, then negative work is done. This means that energy is transferred in the opposite direction.

Example:

“If you try to push a car uphill by applying a force up the slope and instead the car rolls down the hill you are doing negative work on the car. Alternatively, the car is doing positive work on you.”

No work is done when a force is applied when no displacement occurs. From the Figure 4.1, the student pushes as hard as he can against a stationary wall but there is no work done because the force exerted on the wall produces no displacement.

Work is also not done when an object undergoes a displacement with no applied force acting on it. This happens when a satellite moves at a constant velocity in space. (Refer 4.2)

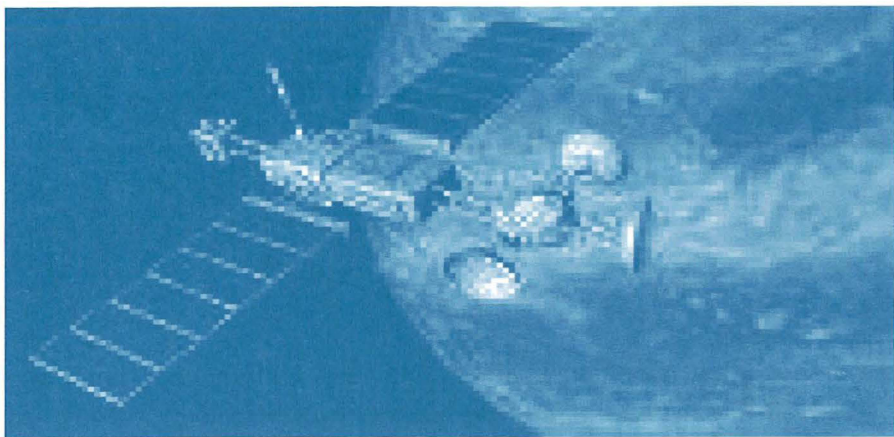


Figure 4.2

Example	Notes
4Q1. How much work is done by an applied force to lift a 17 Newton block 4.2 meters vertically at a constant speed? <u>Solution:</u> Given ; $F = 17\text{ N}$ $s = 4.2\text{ m}$ $W = F \times D$ $= 17 \times 4.2$ $= 71.4\text{ Nm @ J}$ 4Q2. A man lifts a 15 kg bag onto his shoulders through a vertical distance of 160 cm. What is the work done by the man? <u>Solution:</u> Given ; mass , $m = 15\text{ kg}$, $w = mg = 15 \times 9.81 = 147.15\text{ N}$ $d = 160\text{ cm} = 1.6\text{ m}$ $W = F \times d$ $= 147.15 \times 1.6$ $= 235.44\text{ J}$ 4Q3- A rigid 1.45 kg block are pulled at a constant speed through a horizontal at a distance of 220cm at the Earth’s surface. Determine the work done on the blok. <u>Solution</u> Given ; mass = 1.45 kg $d = 220\text{ cm}$	

(Answer = 31.29J)

4Q4- A man is sitting on a sheet of plastic is pulled a distance 5.5 m along a smooth floor by a woman exerting a constant force 75 N at an angle 35° with respect to the direction of the motion as shown as the Figure 4.3. What is the work done by the women?

Solution:

Given ; $F = 75 \text{ N}$
 $s = 5.5$
 $\theta = 35^\circ$

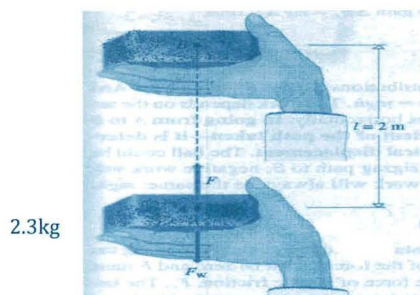
$$\begin{aligned} W &= F \times s \\ &= F \cos \theta \times s \\ &= 75 \cos 35^\circ \times 5.5 \\ &= 61.4 \times 5.5 \\ &= 337.9 \text{ N m @ J} \end{aligned}$$

4Q5- A horizontal force pulls a body of mass 7.5 kg at a distance of 320 cm across a horizontal surface at an angle of 32° . Find the work done if the body moves with uniform velocity .

(Answer = $1.997 \times 10^6 \text{ J}$)

Solution :

4Q6- From the Figure, a rigid 2.3 kg block is raised at a constant speed through a vertical distance of 2.0 m at the Earth surface . Determine the work done on the block by the hand. (Using $g = 9.81 \text{ m/s}^2$)



Example

Notes

Solution :

Given ; $m = 2.3 \text{ kg}$
 $h = 2.0 \text{ m}$
 $g = 9.81 \text{ m/s}^2$

$$\begin{aligned} W &= F \times s \\ &= mg \times h \\ &= 2.3 \times 9.81 \times 2.0 \\ &= 45.1 \text{ Nm @ J} \end{aligned}$$

4Q7- A man pushes a 12 kg box at a constant velocity over a distance of 370 cm.

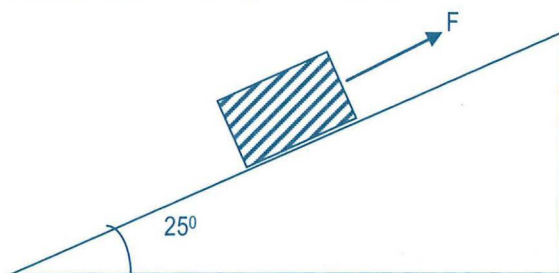
How much work does the man do in pushing the box?

Solution:

Given ; mass, $m = 12 \text{ kg}$
 $d = 370 \text{ cm} = \underline{\hspace{2cm}} \text{ m}$

$$\begin{aligned} W &= F \times s \\ &= \\ &= \\ &= 435.564 \text{ J} \end{aligned}$$

4Q8- A cube is moves up a 37° incline under the action of certain forces by 52 N, as shown in Figure. Determine the work done by the force as the block moves 78 cm up the incline.



Solution:

Given ; $F = 52 \text{ N}$
 $s = 78 \text{ cm}$
 $= 0.78 \text{ m}$

$$\begin{aligned} W &= F \times s \\ &= 52 \times 0.78 \\ &= 40.56 \text{ Nm @ J} \end{aligned}$$

Example

Notes

4Q9- A smooth surface is inclined at angle of 30° to the horizontal. A block of mass of 18 kg lies on the surface and is pulled at a uniform speed a distance of 11.2 m up a line of greatest slope. Find the work done by the block.

(Answer = 1.97×10^3)

Solution:

4Q10- Several blocks , having a total weight of 400 N are loaded into a 12 kg cabin that is then pulled up a wooden ramp 12 m long making an angle of 27.2° . Knowing that friction was negligible, how much work was done?

Solution:

Given ; $W = 400\text{N}$

Mass of cabin = 12 kg

$\theta = 27.2^\circ$

$s = 12\text{ m}$

$$F = 400 + (12 \times 9.81) \\ = 517.72\text{ N}$$

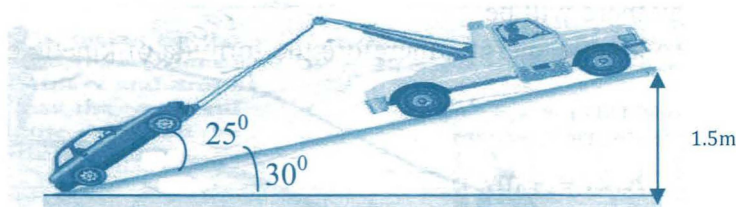
$$W = F \times s$$

$$W = F \cos \theta \times s$$

$$= 517.72 \cos 27.2^\circ \times 12$$

$$= 5.525 \times 10^3 \text{ Nm @ J}$$

4Q11- Determine the work done by the truck with the force 155 N if the height of slope given 1.5m



4.2 Energy

Energy – Energy is the ability to do work. When work is done, energy is transferred. Some kinds of energy can be stored, while others cannot. Energy is also a capacity a physical system to perform work. It exists in several forms such as heat, kinetic energy (mechanical energy), light, potential energy, electrical or other forms.

Energy is the capacity to do work. When positive work is done on an object, the system doing the work loses energy. In fact, **the energy lost by a system is exactly equal to the work done by the system**. An object with larger potential energy has a greater capacity to do work.

$$\text{Work done} = \text{Energy needed}$$

The SI unit for energy is Nm @ Joule (J). The SI unit of energy is same with the SI unit of work.

Energy can be taken from almost anywhere. Power plants use many different types of energy sources, including oil, coal, nuclear, biomass (organic gases), wind, solar, geothermal (the heat from the earth's rocks is very hot underground and is used to turn water to steam), tidal and hydroelectric (waterfalls). Most power stations work by using steam to turn turbines which then drive generators and create an electric current.

Most of these sources are dependent upon the sun's energy, because without it we would not have weather for wind and tides. The sun is also responsible for growing plants which decompose into fossil fuels like oil and coal. All these sources can be put under 2 headings, renewable and non-renewable. Renewable sources are sources which will not run out, like solar energy and wind power. Non-renewable sources are ones which will run out eventually, like oil and coal.

Kinetic Energy (KE)

Kinetic Energy is the energy an object possesses due to its motion. Any object which is moving has kinetic energy.

The word of “kinetic” is derived from the Greek word meaning to move and the word of “energy” is the ability to move. So, the “kinetic energy” is the energy of the motions or it is an ability to do work. The faster the body moves the more kinetic energy is produced. The greater the mass and speed of an object, the more kinetic energy there will be.

A body which isn't moving will have zero kinetic energy, therefore the formula of kinetic energy is

....

$$K.E. = \frac{1}{2}mv^2$$

Where ; m = mass (kg)
 v = velocity (m/s)

Example

Notes

4Q12- The record average speed for the men's 10 km walks is 4.2 m/s. How much kinetic energy would a 74 kg athlete have at that speed?

Solution:

Given ; $v = 4.2 \text{ m/s}$

$m = 74 \text{ kg}$

$$\begin{aligned} \text{K.E.} &= \frac{1}{2}mv^2 \\ &= \frac{1}{2}(74)(4.2)^2 \\ &= 652.68 \text{ Nm @ J} \end{aligned}$$

4Q13- The record average speed for the men is 5.3 m/s. How much kinetic energy would a 72 kg athlete have at that speed?

(answer ; 1011.24 J)

4Q14- The velocity of a 3.5 kg trolley is increased from 12 m/s to 18 m/s over a distance of 10 m. Find ;

- The change in the kinetic energy of the trolley.
- The force that acts on the trolley.

Solution :

Given ; $m = 3.5 \text{ kg}$

$u = 12 \text{ m/s}$

$v = 18 \text{ m/s}$

$$\begin{aligned} \text{a) Change in kinetic energy} &= \frac{1}{2}mv^2 - \frac{1}{2}mu^2 \\ &= \frac{1}{2}(3.5)(18)^2 - \frac{1}{2}(3.5)(12)^2 \\ &= 567 - 252 \\ &= 315 \text{ J} \end{aligned}$$

- The work done to accelerate the trolley is equal to the change in its kinetic energy.

$$\begin{aligned} \text{Work done} &= F \times d \\ 315 &= F \times 10 \\ F &= 31.5 \text{ N} \end{aligned}$$

Example	Notes
<u>4Q15-</u> The velocity of a 5 kg bicycle is increased from 10 m/s to 12 ms⁻¹ through 50m distance. Find; - The change in the kinetic energy of the trolley. - The force that acts on the trolley.	

Potential Energy

Potential Energy (P.E) is the energy which an object has because of its position. The change in the potential energy of a body incurred in moving from one point to another equals the work done in overcoming the interaction that stores the energy.

The “potential energy is the same as stored of energy where it’s held within the gravitational field. When you lift the heavy object you exert energy which later will become kinetic energy when the object is dropped.

For example, A lift motor from a roller coaster exerts potential energy when lifting the train to the top of the hill. The higher the train is lifted by the motor the more potential energy is produced; thus, forming a greater amount if kinetic energy when the train is dropped. At the top of the hills the train has a huge amount of potential energy, but it has very little kinetic energy.

“**Potential Energy** is the stored energy of position possessed by an object”

GRAVITATIONAL POTENTIAL ENERGY – Gravitational Potential Energy is the energy stored in an object as the result of its vertical position or height. The energy is stored as the result of the gravitational attraction of the Earth for the object.

Gravitational energy is the potential energy associated with gravitational force. If the object falls from one point to another point inside a gravitational field, the force of gravity will do positive work on the object, and the gravitational potential energy will decrease by the same amount.

“ The gravitational potential energy depends on the initial position and the final position of the object”

For example, a book placed on top of a table. As the book is raised from the floor, to the table, some external force works against the gravitational force. If the book falls back to the floor, the "falling" energy the book receives is provided by the gravitational force. Thus, if the book falls off the table, this potential energy goes to accelerate the mass of the book and is converted into kinetic energy. When the book hits the floor this kinetic energy is converted into heat and sound by the impact.

The factors that affect an object's gravitational potential energy are its height relative to some reference point, its mass, and the strength of the gravitational field it is in. Thus, a book lying on a table has less gravitational potential energy than the same book on top of a taller cupboard, and less gravitational potential energy than a heavier book lying on the same table. An object at a certain height above the Moon's surface has less gravitational potential energy than at the same height above the Earth's surface because the Moon's gravity is weaker.

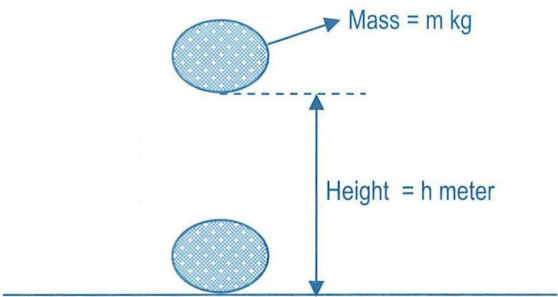


Figure 4.7

From the Figure 4.7, when an object of mass , m kg is raised to a height , h meters above the Earth’s surface , the object possesses gravitational potential energy. The gravitational potential energy is equal to the work done to raise an object to a particular height.

Work Done, $W = F \times s$
 $= mg \times s$

Gravitational Potential Energy, $P.E = \text{Work Done}$

$P.E = mgh$

Where;
 m = mass, kg
 h = height, meter
 g = gravitational= acceleration = 9.81 m/s^2

Example	Notes
4Q16- A hammer of mass 2 kg does more work when dropped from a height of 10 m than when dropped from a height of 5 m. what is the potential energy y hammer when it dropped from a height of 5 m. <u>Solution :</u> Given ; mass = 2 kg s = 5 m	

Example	Notes
$W = F \times s$ $= mg \times s$ $= 2 \times 9.81 \times 5$ $= 98.1 J$ P.E = Work Done = 98.1 J A boy has a mass of 3800 gram. He climbs 15 m up a tree. What is his gain in gravitational potential energy. (Answer = $5.59 \times 10^3 J$) Solution : 4Q17- An astronaut has a total mass of 112 kg. On the moon, he climbs into his spacecraft 7 m up a ladder. His gravitational potential energy increases by 825 J. What is the strength of gravity on the moon. (Answer = $1.052 m/s^2$) Solution : 4Q00 A box of mass 4.5 kg is placed on a shelf which is 0.17 m above a table. If the table is 0.7 m above the floor as shown in, find the potential energy of the box with reference a) The table top b) The floor	

Example	Notes
<u>Solution:</u> a) From the table top $P.E = mgh$ $= 4.5 \times 9.81 \times 0.17$ $= 7.5 \text{ J}$ b) From the floor $P.E = mgh$ $= 4.5 \times 9.81 \times (0.7 + 0.17)$ $= 38.41 \text{ J}$	

Extra Knowledge for Long Life Learning

Elastic Potential Energy

Elastic Potential Energy is the energy which an object possessed when it is compressed or stretched. (Figure 4.12)

Elastic is defined as the ability of a material to recover its original shape and size after the force that distorts it is removed. Springs are normally very elastic. However, a spring can be permanently stretched if it is overloaded.

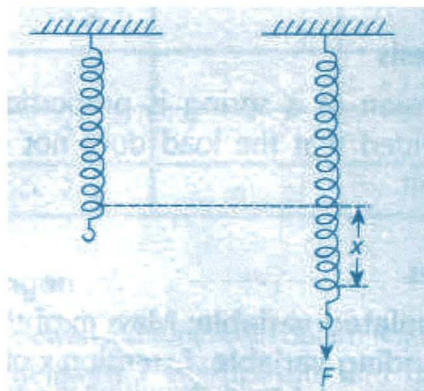


Figure 4.12

The elastic potential energy P.E stored in a spring extended by x is thus given by:

$$P.E = \frac{1}{2}Fx$$

Hooke's Law states that if a spring is not stretched beyond its elastic limit, the force that acts on it is directly proportional to the extension of the spring.

If the extension of a spring produced by a force F is x , then;

$$F \propto x$$

$$F = kx$$

Where k is the spring constant. The spring constant, k can be defined as the force that is needed to extend a spring by a unit length. Since $F = kx$, the elastic potential energy stored in a spring extended by x is also given by:

$$P.E = \frac{1}{2}kx^2$$

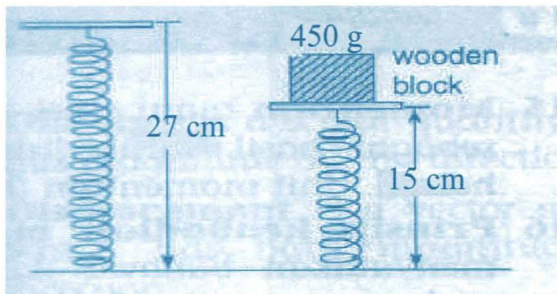
Which is ;

x = Distance of spring when it is to compressed or stretched

k = is the spring constant

The spring has constant of a spring depends on

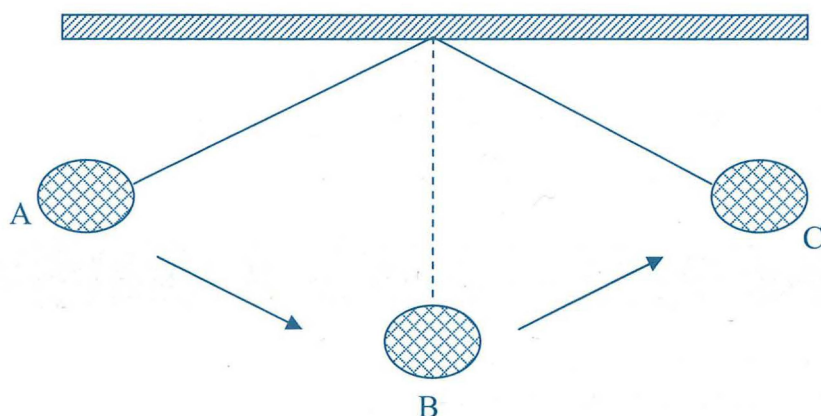
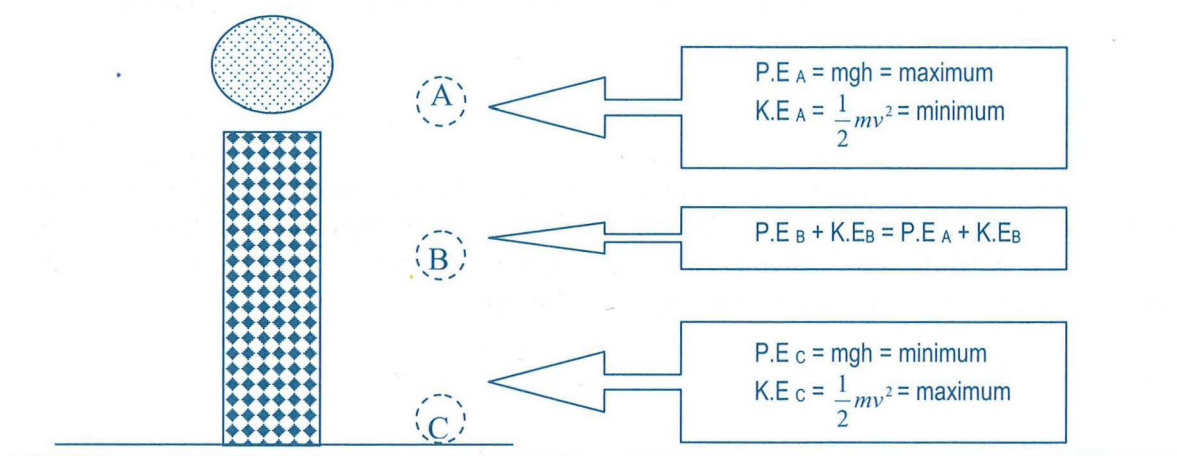
- The length of the spring
- The diameter of the spring
- The size of the spring
- The material used to built the spring

Example	Notes
<u>4Q17-</u> A spring is fixed vertically as shown in Figure. When a 450 g block of wood is placed on top of the spring, its length is reducing from 27 cm to 15 cm. Find the elastic potential energy stored in the spring. (Assume that the elastic limit is not exceeded)  <u>Solution :</u> Compressed, x $= 27 - 15$ $= 12 \text{ cm}$ $= 0.12 \text{ m}$ Compressed Force, $F = mg$ $= 0.45 \times 9.81$ $= 4.41 \text{ N}$ Elastic Potential Energy, $P.E = \frac{1}{2}Fx$ $= \frac{1}{2} \times 4.41 \times 0.12$ $= 0.26 \text{ J}$	

Principle Of Conservation Of Energy

The principle of conservation of energy states energy can neither be destroyed nor created, but it can change from one to another.

The total energy of any system that is isolated from the rest of the Universe remains constant, even though energy may go from one form to another within the system



Position A:

- P.E = maximum , K.E = 0 (The pendulum stop for a moment)

Position A to B :

- The potential energy of the pendulum gradually decreases as it is changed to K.E.

Position B :

- P.E = 0 (h = 0 , v = maximum)

Position B to C :

- The K.E gradually changes back to P.E

Position C :

- P.E = maximum , K.E = 0 (pendulum stops for a while). Now the pendulum will oscillate from C to B and back to A.
- The oscillation cycle will repeat.

4.3 POWER

Definition – is rate at which work done or the rate change of energy or power is the rate of doing work.

The quantity work has to do with a force causing a displacement. Work has nothing to do with the amount of time that this force acts to cause the displacement. Sometimes, the work is done very quickly and other times the work is done rather slowly.

For example, a rock climber takes an abnormally long time to elevate her body up a few meters along the side of a cliff. On the other hand, a trail hiker (who selects the easier path up the mountain) might elevate her body a few meters in a short amount of time. The two people might do the same amount of work, yet the hiker does the work in considerably less time than the rock climber. The quantity that has to do with the rate at which a certain amount of work is done is known as the power. The hiker has a greater *power rating* than the rock climber.

- S.I unit of power is J/s or Watt (W).
- 1 hp = 746 Watt

$$\text{Power} = \frac{\text{Work Done}}{\text{Time Taken}} \quad \text{or} \quad \text{Power} = \frac{\text{Change of Energy}}{\text{Time Taken}}$$

$$P = \frac{W}{t} = \frac{FD}{t} = FV \quad P = \frac{E}{t}$$

Example	Notes
4Q18- A car moves at a constant velocity of 65 km/h. Find the power generated by the car if the force of friction that acts on it is 1450 N. <u>Solution :</u> Given ; $v = 65 \text{ km/h} = 18.06 \text{ m/s}$ $F = 1450 \text{ N}$ $P = ?$ $P = \frac{W}{t} = FV$ $P = 1450 \times 18.06$ $= 26180.56$ $= 2.618 \times 10^4 \text{ W}$ 4Q19- How much power does it take to raise an object weighing 100 N a	

distance of 18.0 m in 52.0 s ?

Solution :

$$\begin{aligned}\text{Given; } F &= 100 \text{ N} \\ d &= 18.0 \text{ m} \\ t &= 52.0 \text{ s}\end{aligned}$$

$$\begin{aligned}P &= \frac{W}{t} = \frac{100 \times 18.0}{52.0} \\ &= \frac{1800}{52.0} \\ &= 34.6 \text{ Watt}\end{aligned}$$

4Q20

A man of mass 62 kg walks up a flight of stairs 2.7 m high. What is

- The work done by the man.
- The energy required to walk up the stairs
- The power generated by the man if he takes 4 minute to the top of the stairs.

Solution :

Given ;

$$\begin{aligned}m &= 62 \text{ kg} \\ h &= 2.7 \text{ m} \\ t &= 3 \text{ minute} = 180 \text{ second}\end{aligned}$$

- $$\begin{aligned}W &= mgh \\ &= 62 \times 9.81 \times 2.7 \\ &= 1642.19 \text{ J}\end{aligned}$$
- $$\begin{aligned}\text{Energy needed} &= \text{Work done} \\ &= 1642.19 \text{ J}\end{aligned}$$
- $$\begin{aligned}\text{Power Generated} &= \frac{\text{WorkDone}}{\text{TimeTaken}} \\ &= \frac{1642.19}{180} \\ &= 9.12 \text{ W}\end{aligned}$$

4Q21- Siti of mass of 48 kg walks up a stairs of 2.2 m high. Find.....

- The work done by Siti
- The energy required to walk up the stairs
- The power generated by Siti if she takes 3 minute to the top of the stairs.

Solution ;

Example	Notes
<u>4Q22</u> A 67 kg skydiver moving at terminal speed falls 45 m in 1 second. What power is the skydiver expending on the air?	$W = F \cdot d$ $W = m \cdot g \cdot h$ $W = 67 \cdot 9.8 \cdot 45$ $W = 29410.5 J$ $P = \frac{W}{t}$ $P = \frac{29410.5}{1}$ $P = 29410.5 W$

Efficiency

The efficiency of a machine can be defined as the ratio of use output energy to the energy put into the machine. This ratio is normally expressed as a percentage. Thus;

$$\text{Efficiency} = \frac{\text{use output of energy}}{\text{input of energy}} \times 100\%$$

Example	Notes
4Q23 What is the efficiency of a pulley system that will raise a 2000-N load a vertical distance of 1 m when 3000 J of effort is involved? <u>Solution :</u> Given ; Output of work = $F \times d$ $= 2000 \times 1$ $= 2000 \text{ J}$ Input of work = 3000 J $\text{Efficiency} = \frac{\text{use output of work}}{\text{input of work}} \times 100\%$ $= \frac{2000}{3000} \times 100\%$ $= 66.7 \%$	
4Q24 A machine this is 42% efficient is used to lift a mass of 1050kg to a height of 17 meters. How much work must be done by the machine? (Answer = 73545.57 J)	
4Q25 A machine requires 2200 J of energy to raise a 32 kg block a distance of 5.5 meters. What is the machine's efficiency? (Answer = 78.5 %)	

Formula

Work	$W = Fs$
Work Done by Gravity	$W = mgh$
Kinetic Energy	$K.E = \frac{1}{2}mv^2$
Potential Energy	$PE = mgh$
Power	$P = \frac{W}{t} \text{ or } \frac{E}{t}$

Self Learning

1. A box is pushed 4.2 m across a room with a force of 30 N. What is the work done and how much energy is used?

(Work done = 126 J , Energy= 126 J)

2. A 2.2 kg block is thrown upward from a point 22 m Earth's surface. At what height above Earth's surface will the gravitational potential energy of the Earth block system have increased by 550 J?

(P.E = 75.196 J)

3. /How many watts of power are expended when a force of 1 N moves a cube 115 cm in a time interval of 2 second ?

(Power = 0.575 Watt)

4. A 2.0 kg block is thrown upward from a point 20m above Earth's surface. At what height

above Earth's surface will the gravitational potential energy of the Earth block system have increased by 500J?

(height = 45.51m)

5. A forklift is used to raise a 232 kg load from the floor to a height of 2.45 m. If the forklift expends 1764 Watt of power , how many seconds does it take to lift the load,

6. Assuming an efficiency of 25% for the muscle system in the process of converting food energy into mechanical work, how much energy would be used by a person of mass 75 kg (weight 165lb) in the process of climbing four flights of stairs for a total height of 15 metres? Find the answer in joules and convert to dietary calories (1 dietary calorie = 4186 Joules)

(Energy = 10.5 dietary calorie)

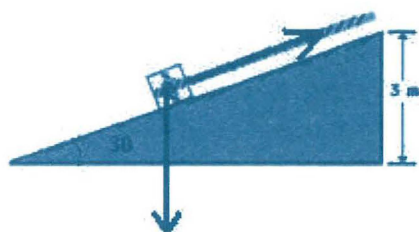
7. A man of 75 kg runs up a stairs of 12 steps each of 20 cm high. What is the power generated by the man if he takes 17 s to the top of the stairs? ($g = 9.81 \text{ m/s}$) (A=103.87 W)

8. A ball of mass 1 kg is dropped from a height of 10 m. Calculate the work done on the ball at

the point it hits the ground assuming that there is no air resistance?

(Work done = 98 J)

9. A rope is attached to a 50.0-kg crate to pull it up a frictionless incline at constant speed to a height of 3-meters. A diagram of the situation and a free-body diagram are shown below. Note that the force of gravity has two components (parallel and perpendicular component); the parallel component balances the applied force and the perpendicular component balances the normal force. Calculate the amount of work done upon the crate.



(Work = 1470 J)

10. A box has a mass of 6.2 kg. The box is lifted from the garage floor and palced on a shelf. If the box gains 165 J of Potential Energy, how high is the shelf?

11. A person on the street wants to throw an 7 kg book up to a person leaning out of a window 6 m above street level. With what velocity must the person throw the book so that it reaches the person in the window?

($V = 10.85 \text{ m/s}$)

12. A 770 N marine in basic training climbs a 10.0 m vertical rope at a constant speed of 7.5 s. What is his power output?

13. A dog with a mass of 60 kg runs up three flights of stairs in 15 s, covering a vertical distance of 10 m. Determine the amount of work done by the dog to elevate her body to this height.

Assume that her speed is constant.

($W = 5886 \text{ J}$)

14. Eddie has made a long gun. The bullet has a mass of 25 g. A force of 4 N pushes the bullet down the barrel, but the barrel has a frictional force of 1 N in the opposite direction. The barrel is 6 meter long and the bullet starts off at rest. What is the final speed of the bullet as it leaves the barrel?
($v = 37.95 \text{ m/s}$)

15. Determine the work done in the following situations.

- a) Jim is applying a 20.6 N force downward at an angle of 53.7° with the horizontal to the displace a broom a distance of 5.25 m(64.03 J)

- b) Samad applies an upward force to lift a 136 kg barbell to a height of 2.01 m at a

constant speed. (2.681×10^3 J)

16. A small hoist can raise 100 kg of bricks to the top of a construction project 30 m above the street in half a minute. Determine the power provided. (16.35 Watt)

17. Mike and Hasni have races up the hill at an angle of 21° from the horizontal with the force of 415 N and 403 N for each. They runs for 650 mm and stop at the top of the hill for 55 s.

- How much the work done by each student? (269.75 J & 261.95J)

- Calculate the total kinetic energy both of them. (531.7 J)

18. The flagpole painter is carrying a 2.11 kg can of white paint. He has climbed (raising the can 10.0 m) up the pole from its base, where he just finished having lunch on the roof of a 35.0 m tall tower.

- a) What is the increase in the potential energy of the can just as a result of his climbing the pole? (207 J)

- b) What is the total increase in the can's potential energy above the value it had while it sat on the ground? (931.46J)

19. A man whose mass is 70 kg walks up to the third floor of a building. This is a vertical height

of 12 m above the street level.

a) How many joules of work has he done? (8.240×10^3 J)

b) By how much has he increased his potential energy? (8.240×10^3 J)

c) If he climbs the stairs in 20s, what was his power? (412.02 J)

20. A block is released from rest at a vertical height of 57.3 cm on a plane inclined at an angle of 23.8° from the horizontal and slides down the plane, reaching a speed of 1.02 m/s at the bottom. What is the coefficient of friction between the block and the plane?

Chapter

5

Solid and Liquid



Solids and Fluids

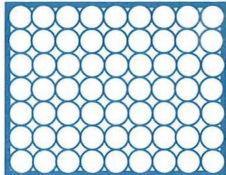
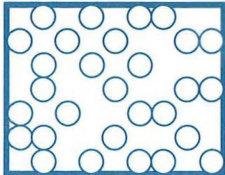
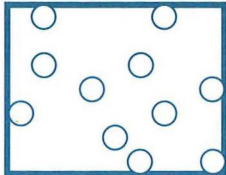
5.1 Introduction

Solid, liquid and gas are the most common states of matter on Earth. The state or *phase* of a matter can change depending on pressure and temperature conditions, transitioning to other phases as conditions stated; for example, solid transitions to liquid and liquid to gas with an increase in temperature or pressure.

5.2 Particles of Molecules

Gases, liquids and solids are all made up of atoms, molecules, and/or ions, but the behaviors of these particles differ in the three phases. The following table summarizes properties of solids, liquids and gases.

Table 5.1: Properties of Solids, Liquids and Gases

	BEHAVIOUR	SOLIDS	LIQUIDS	GASES
1	Microscopic view			
2	Particles arrangement	Particles in a solid are tightly packed, usually in a regular pattern	Particles in a liquid are close together with no regular arrangement	Particles in a gas are well separated with no regular arrangement
3	Particles movement	Particles in a solid vibrate (jiggle) but generally do not move from place to place	Particles in a liquid vibrate, move about, and slide past each other	Particles in a gas vibrate and move freely at high speeds
4	Compressible	Not compressible; there are no free spaces between particles.	Not easily compressible; little free space between particles.	Compressible. Lots of free spaces between particles.
5	Shape	Holds its shape.	Shape of container.	Fills any space.
6	Volume	Fixed by the shape of the solid.	Fixed volume of the container.	No definite volume
7	Example	Paper, rock, wood.	Water, alcohol, oil.	Air, carbon dioxide, oxygen.

5.2 Density

- A material's density is defined as its mass per unit volume.
- It is essentially, a measurement of how tightly matter is crammed together.
- The principle of density was discovered by the Greek scientist Archimedes.
- To calculate the density, ρ (usually represented by the Greek letter "rho") of an object, take the mass (m) and divide by the volume (v):

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$\rho = \frac{m}{v}$$

- The SI unit of density is kilogram per cubic meter (kg/m^3). It is also frequently represented in grams per cubic centimeter (g/cm^3).

$$\text{SI unit of density} = \frac{kg}{m^3}$$

Using of Density

One of the most common uses of density is in how different materials interact when mixed together.

- Wood floats in water because it has a lower density.
- An anchor sinks because the metal has a higher density.
- Helium balloons float because the density of the helium is lower than the density of the air.
- The density of ice is less than water, so ice cubes float on the surface of your drinks and doesn't sink down to the bottom.
- The density of carbon monoxide and carbon dioxide are heavier than air, so place your carbon monoxide/dioxide detector near the ground so that it can go off if there's a build up of these dangerous gases in your home.

Density of water

- Distilled water has a density of $1g/mL = g/cm^3$.
- Water is the only substance whose MASS = VOLUME.
- That is why water density
 - = 1 g/mL
 - = 1 g/cm³
 - = 1000 kg/m³
- An object with a density greater than 1000 kg/m³ will SINK in water.
- An object with a density less than 1000 kg/m³ will FLOAT in water.

Density of various materials

Table shows a few examples on densities of other materials.

	Materials	Density (kg/m^3)
1	Gold	19300
2	Tungsten	19250
3	Mercury	13593
4	Lead (Plumbum)	11340
5	Copper	8920 – 8960
6	Iron	7900
7	Aluminum	2700
8	Rock (typical)	2500
9	Sea Water	1025.18
10	Liquid Water	1000
11	Plastics	850 – 1400
12	Wood (typical)	800
13	Alcohol, ethyl	785.06
14	Alcohol, methyl	786.51
15	Alcohol, propyl	799.96
16	Styrofoam	30 – 120
17	Carbon dioxide	1.977
18	Oxygen	1.4290
19	Air (dry, at sea level)	1.2
20	Helium	0.1785
21	Hydrogen	0.0899

Figure 5.1 below shows a simple experiment on how we can differentiate material base on their density values.

- Three liquids, Mercury, water and an Alcohol are poured slowly into a glass-cylinder.
- It is okay if the liquids mix a little during the pouring. This is because the layers will always even themselves out due to the varying in densities.
- The liquids will layer on top of one another.
- And we can see that there are three-layers of liquids in the cylinder.

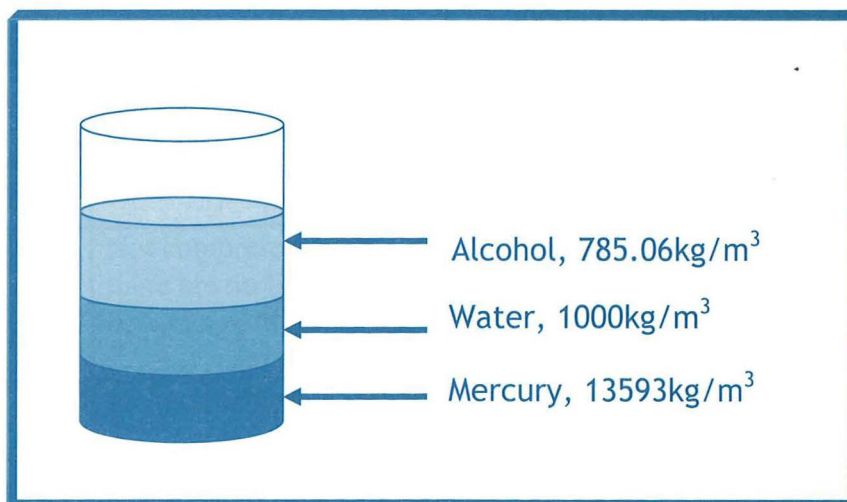
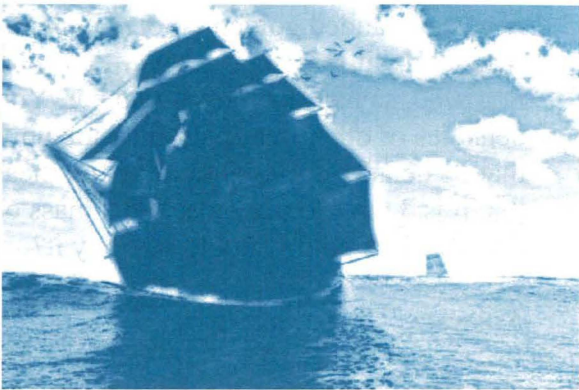


Figure 5.1: Three layers of liquids when mixed together

A ship floating on water is a great illustration of the difference between mass and density. A ship must have a density of less than 1025 kgm^{-3} (the density of sea water), or it will sink. Ships have a large mass, because they are made of steel, but because they have a large volume, their density is less than 1025 kgm^{-3} . If enough mass is added to them such their density goes above 1025 kgm^{-3} , it will sink.



Examples	Notes
5.1 a) What is a density of a rock with a volume of 18m^3 and a mass of 54 kg? $\text{Density} = \frac{\text{mass}}{\text{volume}}$ $\rho = \frac{m}{v}$ $= \frac{54\text{kg}}{18\text{m}^3}$ $= 3\text{kgm}^{-3}.$ b) A different rock with a volume of 40m^3 and a mass of 80kg. What is its density? $\text{Density} = \frac{\text{mass}}{\text{volume}}$ $\rho = \frac{m}{v}$ $= \frac{80\text{kg}}{40\text{m}^3}$ $= 2\text{kgm}^{-3}.$	In the above two examples, which rock is heavier? <i>Answer:</i> Heavier in the question refers to mass or weight. Therefore, a rock in question (b) is heavier since it has a mass of 80kg comparing to the rock in question (a) which has a mass of 54kg. (d) In the above two examples, which rock is more dense? <i>Answer:</i> Density is the ratio of mass to volume. Therefore, the first rock is denser with a density of 3kgm^{-3} and the second rock is less dense even though it weighs more, because its density is only 2kgm^{-3}. <i>*Notes:</i> This example shows why it is important to be careful to not use the words heavier/lighter when you means more or less dense.

Examples	Notes
5.2 A person handed golden-colored cube to you. The person wants you to buy it for RM2000, saying that it is a gold bar. You refer to your table of densities of other materials and look up for 'Gold'. You found out that its density is 19300 kg/m^3. You measure the cube and find that it is 3 cm on each side, and a mass of 50 g. What is its density? Is it gold? Should you buy it? Answer: Given that the dimension of each side is 3cm $= 0.03\text{m}$ Volume of cube $= 0.03\text{m} \times 0.03\text{m} \times 0.03\text{m}$ $= 0.000027\text{m}^3$ Mass of cube $= 50\text{g}$ $= 0.05\text{kg}$ Density of cube $= \frac{\text{mass}}{\text{volume}}$ $\rho = \frac{m}{v}$ $= \frac{0.05\text{kg}}{0.000027\text{m}^3}$ $= 1851.85 \text{ kgm}^{-3}.$	*Since the density is 1851.85 kgm^{-3}, the cube is obviously NOT A GOLD cube! The real gold's density is 19300 kg/m^3. The person selling the cube is trying to lie to you, so DONT BUY the cube!

5.3 Relative Density

- Relative density is also known as specific gravity.
- Specific gravity usually means relative density with respect to water
- Relative density of a material is the *ratio* of its density to the density of water, which the density of water is 1000 kgm^{-3} .
- This ratio is a pure number, containing no units.
- As water is most often used as the reference, if a liquid has a density less than 1000 kgm^{-3} , then it will float in water. Hence methyl alcohol, with a density less than 800 kgm^{-3} , floats on the top of water, which explains why oil tends to float in the sea. On the other hand, as an ice cube has a density of about 910 kgm^{-3} , if it is placed into methyl alcohol, it will sink to the bottom.

- The formula of relative density, $\rho_{\text{relative}} = \frac{\rho_{\text{material}}}{\rho_{\text{water}}}$

Examples

Notes

5.3 A sample of iron has density of 7900 kg/m^3 . The density of water is 1000 kg/m^3 . What is the relative density of iron?

$$\begin{aligned}\rho_{\text{relative}} &= \frac{\rho_{\text{material}}}{\rho_{\text{water}}} \\ &= \frac{7900 \text{ kg/m}^3}{1000 \text{ kg/m}^3} \\ &= 7.9\end{aligned}$$

Do it yourself 1

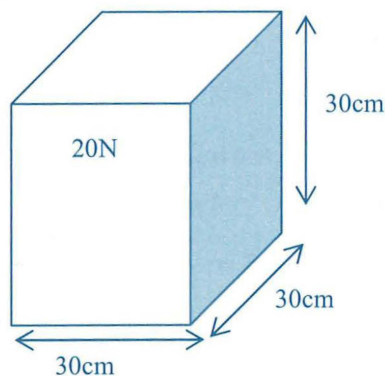
1. A cube is given to a student in an experiment. The Dimension of the cube is $30 \text{ cm} \times 30 \text{ cm} \times 30 \text{ cm}$ and weighs 20 Newton . The student needs to find the density and the relative density of the cube.

Weight, $w = mg$

$$\underline{\hspace{2cm}} = m \times \underline{\hspace{2cm}}$$

$$m = \underline{\hspace{2cm}} / \underline{\hspace{2cm}}$$

$$m = 2.04 \text{ kg}$$



Dimension of cube = $\underline{\hspace{2cm}}$ cm x $\underline{\hspace{2cm}}$ cm x $\underline{\hspace{2cm}}$ cm

Volume of cube, $v = \underline{\hspace{2cm}}$ m x $\underline{\hspace{2cm}}$ m x $\underline{\hspace{2cm}}$ m

$$= \underline{\hspace{2cm}} \text{ m}^3$$

$$\therefore \text{Density of cube, } \rho = \frac{m}{v}$$

$$\text{Relative density, } \rho_{\text{relative}} = \frac{\rho_{\text{material}}}{\rho_{\text{water}}}$$

$$= \frac{\underline{\hspace{2cm}} \text{ kgm}^{-3}}{\underline{\hspace{2cm}} \text{ kgm}^{-3}}$$

$$= \text{ kg/m}^3$$

$$=$$

Examples	Notes
Do it yourself 2 Given two types of liquids, X and Y. Liquid X has a mass of 2000kg and a volume of 2m^3 while liquid Y has a mass of 5000kg and a volume of 0.368m^3. Find the density, relative density and name the liquids (refer table of densities of various material). Liquid x; $\therefore$ Density of liquid x, $\rho = \frac{m}{v}$ = = Relative density, $\rho_{\text{relative}} = \frac{\rho_{\text{material}}}{\rho_{\text{water}}}$ = = Liquid x is : _____ Liquid y; $\therefore$ Density of liquid y, $\rho = \frac{m}{v}$ = = Relative density, $\rho_{\text{relative}} = \frac{\rho_{\text{material}}}{\rho_{\text{water}}}$ = = Liquid y is : _____	

5.4 Pressure

- Pressure is defined as the **force per unit area**, which is calculated by taking the total force and dividing it by the area over which the force acts.
- Force and pressure are related but different concepts.
- A very small pressure, if applied to a large area, can produce a large total force.

$$\text{Pressure, (symbol, } P) = \frac{\text{Force, } F}{\text{Area, } A}$$

- The pressure exerted by a column of liquid of height h and density ρ is given by the hydrostatic pressure equation:

$$\text{Pressure, } P = \rho gh$$

Which ρ is density, g is gravity (9.81 ms^{-2}) and h is height.

- Fluid density and local gravity can vary from one reading to another depending on local factors, so the height of a fluid column does not define pressure precisely
- In the international system pressure is measured in Newton per square meter, which are defined as Pascal (abbreviated Pa).

- $P = \frac{F}{A}$

- Units of Pressure = $\frac{\text{Newton, } N}{\text{Meter}^2, m^2}$

- Pressure = $\frac{\text{Newton, } N}{\text{Meter}^2, m^2} = \text{Pascal, Pa}$

- $1 \frac{N}{m^2} = 1 \text{ Pa}$

- Another common units of pressure is *Bar* which **1bar = 100,000 Pa**.
- Pressure can also be measured in mm of mercury (Hg). This unit stems from old fashioned *barometers* that are designed to use atmospheric pressure to lift a column of mercury. The number of mm of mercury is simply the number of mm that the pressure pushes up the mercury column.
- To convert among these units use 1 mm of mercury = 133 Pascal = 0.02 pounds per square inch.

(Notes: A barometer is an instrument used to measure atmospheric pressure. It can measure the pressure exerted by the atmosphere by using water, air, or mercury. A manometer is an instrument for measuring pressure of gas)

Examples on the use of Pressure

Why does a sharp knife cut more easily than a dull one? A sharp knife blade has a smaller area. Therefore for the same amount of force, the sharp knife blade exerts more pressure and cuts more easily

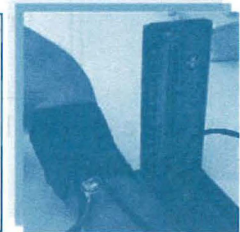


Density, ρ ($\frac{kg}{m^3}$) Relative density=specific gravity, $RD = \rho_{relative}$ (no unit) Pressure, P (Pa) Buoyant force, F_b (N)



A woman wearing spiked high heel shoes can damage a floor more easily than when she is wearing flat shoes. With the spiked heels, the force of her weight is concentrated on a smaller area to exert more pressure

Blood pressure is the force that the blood exerts on a unit area of our artery walls. If the blood pressure is too low, there is not enough force to push the blood to our brains and we pass out. If this pressure is too high, it can burst a weak blood vessel.



- Atmospheric pressure is the force from the weight of the atmosphere above us pushing down on a unit area. In a fluid which is a liquid or a gas, the pressure increases with the depth of the fluid because there is a greater weight of fluid pushing down on each unit of area. This effect can cause our ears to pop as we go up or down mountains.

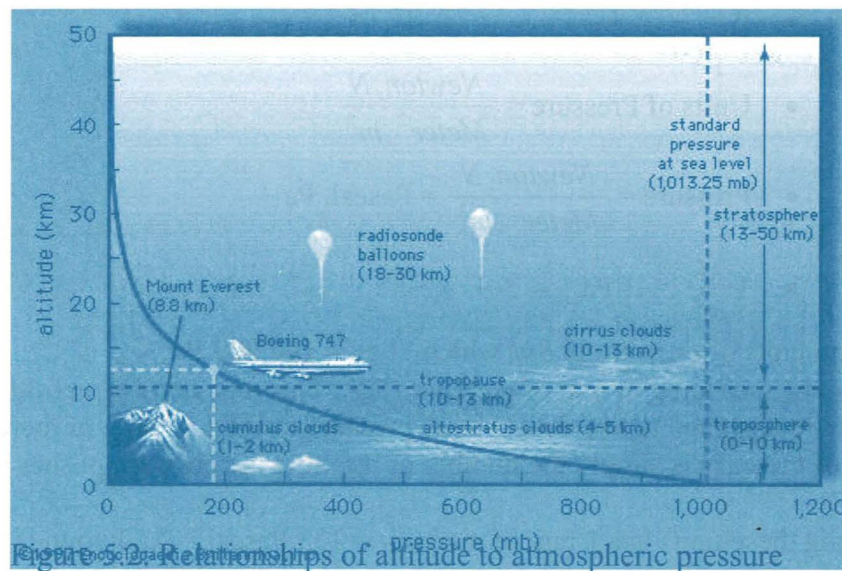


Figure 5.2 Relationships of altitude to atmospheric pressure

Examples	Notes
5.3 A sample of iron has density of $7900kg/m^3$. The density of water is $1000 kg/m^3$. What is the relative density of iron? $\rho_{relative} = \frac{\rho_{material}}{\rho_{water}}$	

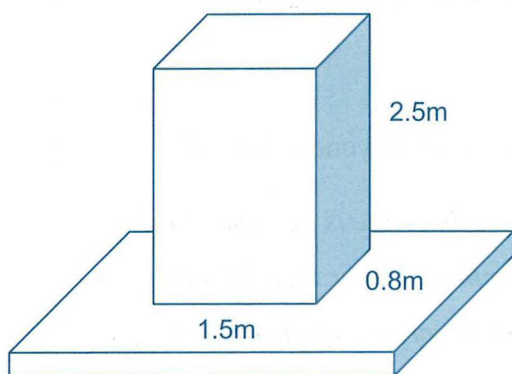
Examples

$$= \frac{7900 \text{ kg/m}^3}{1000 \text{ kg/m}^3}$$

$$= 7.9$$

Do it yourself 3

A cube as in figure below has a mass of 200kg. The dimension of the cube is 0.8m x 1.5m x 2.5m. If the cube is placed on a bench, find the maximum pressure the cube can exerts to the surface of the bench.



$$\begin{aligned} \text{Mass of cube} &= 200 \text{ kg} \\ \therefore \text{Weight of cube} &= mg \\ &= 200 \times 9.81 \\ &= 1962 \text{ N} \end{aligned}$$

To find the maximum pressure, first we must find the minimum surface area of the cube.

$$\begin{aligned} \text{Area 1} &= 0.8 \times 1.5 \\ &= 1.2 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Area 2} &= 0.8 \times 2.5 \\ &= 2 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Area 3} &= 1.5 \times 2.5 \\ &= 3.75 \text{ m}^2 \end{aligned}$$

The minimum surface area is $\text{Area 1} = 1.2 \text{ m}^2$
So the maximum pressure exerts to the surface of the bench is;

$$\begin{aligned} P &= \frac{\text{Force, } F}{\text{Area, } A} \\ &= \frac{1962}{1.2} \\ &= 1635 \text{ Nm}^{-2} \end{aligned}$$

Notes

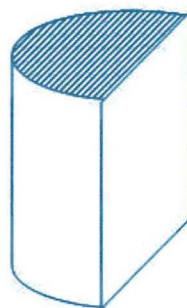
Examples	Notes
5.6 A submarine can go to a depth of 50m from the sea level. The density of sea water is given as $\rho_{\text{seawater}} = 1.03 \times 10^3 \text{ kgm}^{-3}$. Question:; a) What will happen if the submarine goes beyond that level? b) Calculate the maximum pressure that can exert to the submarine's surfaces. c) If the total surface area of the submarine is 200m^2, what is the maximum load (Newton) the submarine can carry? Answers: a) What will happen if the submarine goes beyond that level? <i>Pressure increases with depth, and a submarine is designed to a certain amount of pressure. For a depth of deeper than 50 meters, it could cause damage to the submarine regarding of the exceeding of pressure.</i> b) Calculate the maximum pressure that can exert to the submarine's surfaces $ \begin{aligned} P &= \rho gh \\ &= (1.03 \times 10^3) (9.81) (50) \\ &= 5.05 \times 10^5 \text{ Pa} \end{aligned} $ c) If the total surface area of the submarine is 200m^2, what is the maximum load (Newton) the submarine can carry? $ \begin{aligned} P &= \frac{\text{Force, } F}{\text{Area, } A} \\ F &= P A \\ &= (5.05 \times 10^5) (200) \\ &= 10.1 \times 10^7 \text{ N} \end{aligned} $	

Density, ρ ($\frac{\text{kg}}{\text{m}^3}$) Relative density=specific gravity, $RD = \rho_{\text{relative}}$ (no unit) Pressure, P (Pa) Buoyant Force, F_b (N)

Do it yourself 4

- Given the weight of a semi-cylinder wood is 14N. It has a diameter of 0.1m and height of 0.3m. It is placed on a surface of a table. Calculate the
 - Maximum pressure, and
 - The minimum pressure
 That the wood can transfer to the surface of the table

Weight, $w =$
 Diameter =
 Height =
 Area 1 =

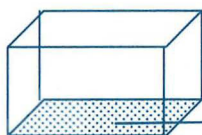


Area 2 =

$P_{\text{max}} =$

$P_{\text{min}} =$

- Figure shows a rectangular block on a table.



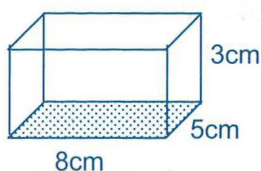
Area = 2 m²

The pressure exerted by the block on the table is 40000Pa. Find the weight of the block.

- What is the **pressure** at a point 50m below the surface of a sea? Given the density of sea water is 1025.18 kg/m³

Density, ρ ($\frac{\text{kg}}{\text{m}^3}$) Relative density=specific gravity, $RD = \rho_{\text{relative}}$ (no unit) Pressure, P (Pa) Buoyant Force, F_b (N)

4. Given the mass of the block is 160 kg. Calculate the pressure which is exerted by the block on the floor.



5.5 Pascal's Principle

- Pascal's principle states that *when a force applied to a surface of an enclosed fluid, the pressure is transmitted undiminished to every part of the fluid, as well as to the walls of the container.*
- A common application of this is a hydraulic lift used to raise a car off the ground so it can be repaired at a garage.
- If a car sits on top of the large piston, it can be lifted by applying a relatively small force to the smaller piston, the ratio of the forces being equal to the ratio of the areas of the pistons.
- A small force applied to a small-area piston is transformed to a large force at a large-area piston.

Pressure on surface 1 = Pressure on surface 2

$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

- The volume of fluid being pushed down under the smaller piston is equal to the volume of fluid that lifts the larger piston upwards.

$$P_1 = P_2$$

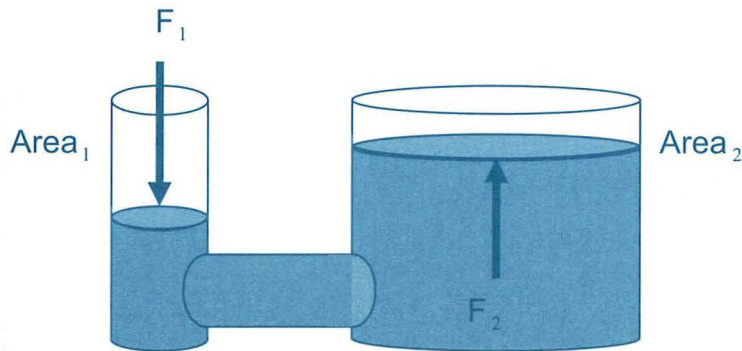
$$V_1 = V_2$$

Density, ρ ($\frac{kg}{m^3}$) Relative density=specific gravity, $RD = \rho_{relative}$ (no unit) Pressure, P (Pa) Buoyant force, F_b (N)

Which by substitution, the equation can be written as

$$A_1 h_1 = A_2 h_2$$

*h is the height or distance moved



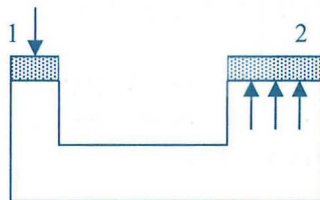
Examples

Notes

5.6

A hydraulic machine has a small piston with a diameter of 0.10m and a bigger piston with a diameter of 0.25m. Find the force that acts on the small piston and the force that pushes the bigger piston upwards. Given that the hydraulic pressure in the liquid is $300N/m^2$.

Force, $F_1 = ?$
diameter = 0.1m



Force, $F_2 = ?$
diameter = 0.25m

Answer:

$$\begin{aligned} \text{Diameter 1} &= 0.1m \\ \therefore \text{Area 1} &= \frac{\pi d^2}{4} \\ &= \frac{\pi(0.1)^2}{4} \\ &= 7.85 \times 10^{-3} m^2 \end{aligned}$$

$$\begin{aligned} \text{Diameter 2} &= 0.25m \\ \therefore \text{Area 2} &= \frac{\pi d^2}{4} \\ &= \frac{\pi(0.25)^2}{4} \\ &= 0.049m^2 \end{aligned}$$

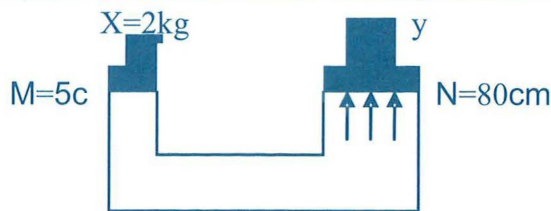
Examples	Notes
$P = 300 \text{ N/m}^2$ $P_1 = P_2$ $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ $P_1 = \frac{F_1}{A_1}$ $\therefore F_1 = P_1 A_1$ $= (300) (7.85 \times 10^{-3})$ $= 2.355 \text{ N}$ $P_2 = \frac{F_2}{A_2}$ $\therefore F_2 = P_2 A_2$ $= (300) (0.049)$ $= 14.7 \text{ N}$	
5.7 Figure shows a simple hydraulic system. i) A 35N force is placed on piston A. Calculate the force acting on piston B. ii) Find the mass of object Q that can be lifted by piston B iii) If piston A moved 1.5m downwards, what is the distance moved by piston B iv) If the mass of object Q is replaced with a 150kg load, how much force is needed to move piston A so that it can lift the load on piston B. Force, $F_a = ?$ $A = 0.15\text{m}^2$ Force, $F_b = ?$ $B = 1.4\text{m}^2$ Answers i) A 35N force is placed on piston A. Calculate the force acting on piston B. $P_A = P_B$ $\frac{F_A}{A_A} = \frac{F_B}{A_B}$	

Examples	Notes
$F_A = \frac{35 \times 1.4}{0.15}$ $F_A = 326.7\text{N}$	
ii) Find the mass of object Q that can be lifted by piston B $W = mg$ $m = \frac{W}{g}$ $= \frac{326.7}{9.81}$ $= 33.3\text{kg}$	
iii) If piston A moved 1.5m downwards, what is the distance moved by piston B $P_A = P_B$ $V_A = V_B$ $A_A h_A = A_B h_B$ $0.15 (1.5) = (1.4)(h_B)$ $h = 0.1607\text{m}$	
iv) If the mass of object Q is replaced with a 150kg load, how much force is needed to move piston A so that it can lift the load on piston B. $Q = 150 \times 9.81$ $= 1471.5\text{N}$ $\frac{F_A}{A_A} = \frac{F_B}{A_B}$ $F_A = \frac{1471.5 \times 0.15}{1.4}$ $= 157.66\text{N}$	

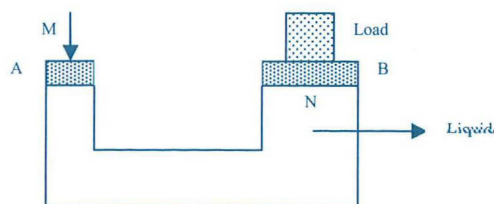
Density, ρ ($\frac{kg}{m^3}$) Relative density=specific gravity, $RD = \rho_{relative}$ (no unit) Pressure, P (Pa) Buoyant force, F_b (N)

Do it yourself 5

1. The mass of X is 2kg and it is placed on piston M. The cross sectional area of piston M and N is $5cm^2$ and $80cm^2$ respectively. Calculate:
 - a. The force that acts on piston M
 - b. Find the pressure that is exerted on piston N
 - c. Find the mass of object Y that can be lifted by piston N
 - d. If piston M moves downwards for 20cm, what is the distance of piston B moving upwards



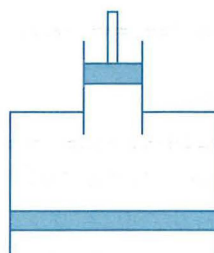
2. Figure shows a simple hydraulic system.



The cross-section areas of piston A and piston B are $0.04m^2$ and $0.8m^2$ respectively. A force of 300N is applied to the piston M. Find the force exerted by piston N on the load.

Density, ρ ($\frac{kg}{m^3}$) Relative density=specific gravity, $RD = \rho_{relative}$ (no unit) Pressure, P (Pa) Buoyant force, F_b (N)

3. Figure shows a force of 100N which is applied to the piston P. Find the pressure which is exerted on piston Q.



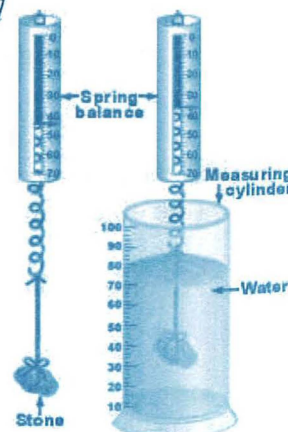
Piston P (20cm diameter)

Liquid

Piston Q (80cm diameter)

5.6 Archimedes' Principle

- When an object is immersed in water, it feels lighter.
- This is because the water exerts an upward force or the upthrust upon the object.
- This upthrust is a force produced by water in reaction to the force of the weight of the object that is immersed in the water.
- This upthrust or the upward force is termed as **Buoyancy**.
- In a cylinder filled with water, the action of inserting a mass in the liquid causes it to displace upward.
- Archimedes Principle states that *the buoyant force on a submerged object is equal to the weight of the fluid that is displaced by the object*.
- The weight of the displaced fluid can be found mathematically.
- The fluid displaced has a weight $W = mg$.
- The mass can now be expressed in terms of the density and its volume, $m = \rho V$.
- Hence, $F_b = \rho V g$



Density, ρ ($\frac{kg}{m^3}$) Relative density=specific gravity, $RD = \rho_{relative}$ (no unit) Pressure, P (P_a) Buoyant force, F_b (N)

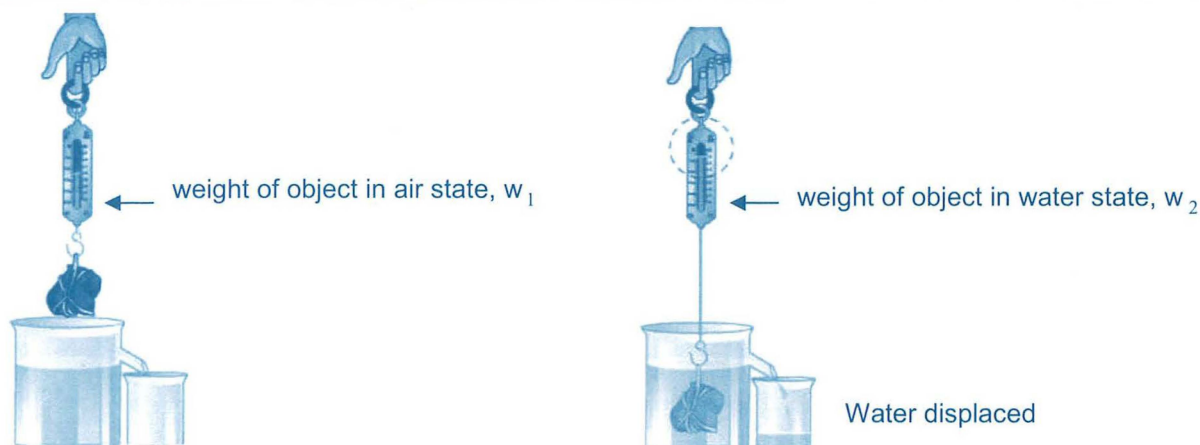
Buoyant Force = weight of water displaced, (w)
 = mass of water displaced, (m) x gravity, (g)
 = density of water displaced, (ρ) x volume of water displaced, (v) x gravity, (g)

Hence, $F_b = \rho v g$

- Another way to evaluate the Buoyant force is

Buoyant Force = weight of object in air state – weight of object in water state

Hence, $F_b = w_1 - w_2$



For example, weight of a stone in air state is 8.9N, and when it is immersed in water, the spring balance reads 7.7N. So the buoyant force is:

$$\begin{aligned} \text{Buoyant Force} &= \text{weight of object in air state} - \text{weight of object in water state} \\ F_b &= w_1 - w_2 \\ &= 8.9N - 7.7N \\ &= 1.2N \end{aligned}$$

The difference between the object's weight and the buoyancy force of the displaced fluid is called the net force, F_{net} .

$$\begin{aligned} F_{net} &= \text{weight of object} - \text{buoyant force of displaced fluid} \\ &= mg - \rho v g \end{aligned}$$

- If the Buoyancy of an object exceeds its weight, it tends to rise (the object floats)
- An object whose weight exceeds its buoyancy tends to sink.

Examples

Notes

5.8

A ball floats in a pail full of water. The ball has a mass of 0.5 kg and a diameter of 22 cm.

- What is the buoyant force?
- What is the volume of water displaced by the ball?
- What is the average density of the basketball?

Answers

- What is the buoyant force?

The ball floats **on** water so there is no net force. The weight is balanced by the **buoyant** force. So:

$$\begin{aligned} \text{Buoyant force } F_b &= m g \\ &= 0.5 \times 9.81 \\ &= 4.905 \text{ N} \quad \text{*remember....the ball floats on} \end{aligned}$$

water...

- What is the volume of water displaced by the ball?

By Archimedes' **principle**, the buoyant force is equal to the weight of fluid displaced.

$$\text{Buoyant force } F_b = \rho v g$$

$$\begin{aligned} \text{So, } v &= \frac{F_b}{\rho g} \\ &= \frac{4.905}{1000 \times 9.81} \\ &= 0.0005 \text{ m}^3 \end{aligned}$$

- What is the average density of the ball?

To find the density of **the** ball, we need to determine the volume. This is given by:

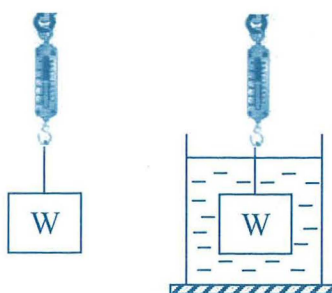
$$\begin{aligned} \text{Volume of ball} &= \frac{4}{3} \pi r^3 \\ &= \frac{4}{3} \pi (0.11)^3 \\ &= 0.0056 \text{ m}^3 \end{aligned}$$

The density is then just the mass divided by this volume, so:

Examples	Notes
Density, $\rho = \frac{m}{v}$ $= \frac{0.5}{0.0056}$ $= 89.3 \text{ kg/m}^3$	

Do it yourself 6

6.5.1 Figure shows the weight of block W in the air is 4N. The block is immersed in a beaker of water and its weight becomes x N. Given that the density of block W is $1.6 \times 10^3 \text{ kgm}^{-3}$. Find the value of x.



Density, ρ ($\frac{kg}{m^3}$) Relative density=specific gravity, $RD = \rho_{relative}$ (no unit) Pressure, P (Pa) Buoyant force, F_b (N)

6.5.2 A marble has a mass of 500g and density $800kgm^{-3}$ is placed inside a fish-tank filled with water. Calculate:

- The volume of water displaced by the marble
- The apparent loss in weight of the marble
- The weight of marble in water.

Self Learning

1. What are the 3 types of particles?

2. Give four (4) differences between solid, fluid and gases.

3. What is the definition of density?

4. What is the symbol of density? State the formula.

5. What is the SI unit for density?

6. An object has a mass of 300g and volume of 0.025 m^3 . Find the density of this object.

7. A wood has a mass of 800g and a dimension of 10cm x 20cm x 5.5cm.

- Calculate its density
- Calculate its relative density.

c. If the wood is placed in water, will it sink? Explain your answer.

8. If sea water and plain natural water is poured in a same beaker, what will happen? Support your answer with some facts and theories.

9. What is the definition of pressure?

10. Give the formula and units for pressure.

11. A metal plate is thrown in a liquid to a depth of 1.7m and the pressure acted on it was 17094Pa. What do you think the type of liquid it was? (Ans: seawater)

12. As referred to a Figure 1 given below, what is the pressure that acts on the surface of the cube if the liquid is water? (Ans: 24525 Pa)

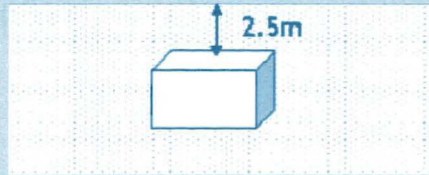


Figure 1

13. A lady with a mass of 52kg wears high-heeled shoes. The heel which is in a shape of a circle has a diameter of 5mm. If the lady stands on one leg, how much pressure do you think she exerts on the floor? (Ans: 25.98×10^6 Pa)

14. The density of sea-water is 1025 kg m^{-3} and the air pressure on the surface of the ocean is 1.013×10^5 Pa. Calculate the absolute pressure 150m depth from the ocean surface. (Ans: 1.6096×10^6 Pa)

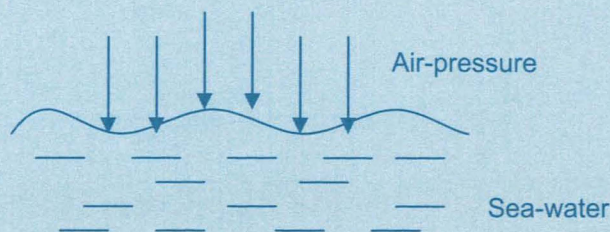


Figure 2

15. A simple hydraulic system with a small piston of 0.8m^2 area and a larger piston of 1.35m^2 area. If 526.3N force is applied at the smaller piston, how much force that will move the larger piston? (Ans: 887.63N)

16. Figure 3 shows a simple hydraulic system. Given piston R has a diameter of 10cm and piston S has a diameter of 40cm .

- Find the force that is needed to lift piston S upwards if piston R is applied with 98N of force. (Ans: 1569.25N)
- How much pressure experienced by the liquid between these two piston?

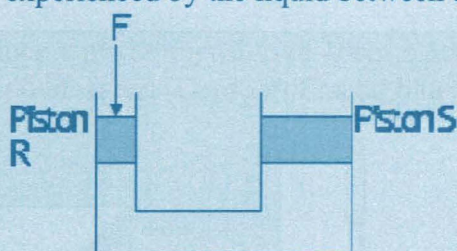


Figure 3

(Ans: $1.25 \times 10^6 \text{ Pa}$)

17. A hydraulic pump with a large piston B has a radius of 17cm and a small piston A with a radius of 5cm.
- If a force of 35N is applied on the small piston, how much force is experienced by the large piston (*Ans: 404.6N*)
 - What is the mass of load Q (*Ans: 41.24kg*)
 - If piston A moves downwards 0.3m as the 35N is applied, what is the distance moved by piston B. (*Ans: 0.026m*)
 - If load Q is replaced with a 150kg load, how much force is needed on piston A to support piston B? (*Ans: 16207.73N*)

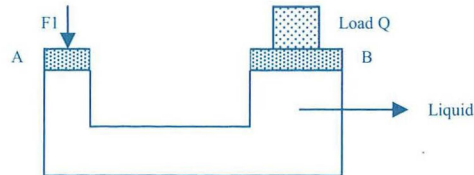


Figure 4

18. Archimedes Principle states that

.....

.....

19. An object weighs 19.4N in the air but when it is soaked in water, it weighs 13.8N.
- Why is the object weigh lighter when it is soaked in water?
 - Calculate the buoyant force that acts on it. (Ans: 5.6N)

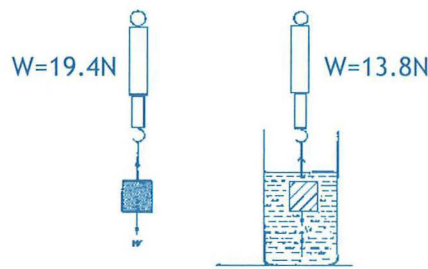


Figure 5

20. Figure 6 shows a metal block with a dimension of 10cm x 5cm x 2cm is hung on a spring balance. It is later immersed in water. (Density of metal block is $3.2 \times 10^3 \text{ kgm}^{-3}$ and density of water is 1000 kgm^{-3})

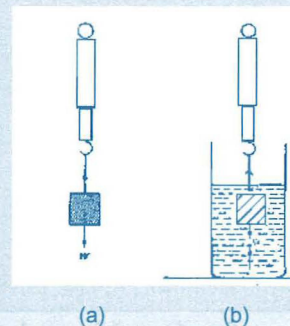
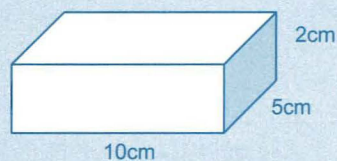


Figure 6

- Find the reading of spring balance in figure (a) (Ans: 3.14N)
- Calculate the Buoyant Force which acts on the metal block (Ans: 0.981N)
- What is the reading of the spring balance in figure (b) (Ans: 2.159N)

21. An object of density, 80gcm^{-3} and mass 900g is immersed in a liquid of density 50gcm^{-3} . Calculate:

- the volume of liquid displaced (*Ans: $1.125 \times 10^{-5} \text{m}^3$*)
- the mass of the liquid displaced (*Ans: 0.56kg*)
- the buoyant force experienced by the object (*Ans: 5.52N*)

give all your answers in SI units.

22. A porcelain plate weighs 7.8N in air. However when it is completely immersed in water, it weighs 5.3N. Find the volume of the plate. (*Ans: 0.0002m^3*)

23. Find the buoyancy of a piece of wood with a mass of 12 kg and has a volume of 0.086m^3 . Will the wood floats or sinks? (Density of seawater = 1025.18kg/m^3)

(*Ans: 747.18N , it will float*)

24. James went diving in Pulau Perhentian. He has a mass of 90kg and and displaced 0.085m^3 of seawater. What is the net force? (*Answer: 28.05N , James sank into the sea*)

1-final Exam Question -January 2010

a) Give the definition for each of the following

i) Density (ρ) (2m)

ii) Relative Density (2m)

b) A block of volume 800cm^3 is immersed in water. Calculate:

a. The actual weight of the block (5m)

b. The apparent weight when it is immersed (6m)

(The density of block = 2500kgm^{-3} , density of water = 1000kgm^{-3})

c) A person with a mass 85kg stand on piston A (diameter = 0.6m) of a hydraulic system. Determine the minimum diameter of piston B to support an elephant with 1500kg mass. (10m)

$d = 2.52\text{m}$

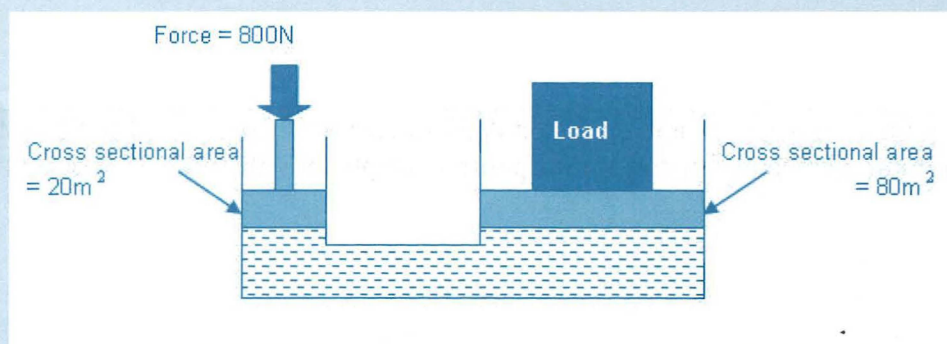
2-final Exam Question-July 2009

a) Give the definition and formula of pressure and density (6m)

b) A glass block of volume $200cm^3$ is immersed in water. Calculate the actual weight of the glass. (Density of the glass = $2500 kg/m^3$) (9m)

c. Figure shows a hydraulic jack. Given the cross-sectional areas of the smaller piston and larger piston are $20m^2$ and $80m^2$ respectively. If the smaller piston is pushed with a force of $800N$, calculate:

- the mass of Load in kg (6m)
- the Specific gravity of fluid in piston if the density is $800 kg/m^3$ (4m)



$$m = 326.2kg, \rho_r = 0.8$$

3-final Exam Questions- Jan 2009

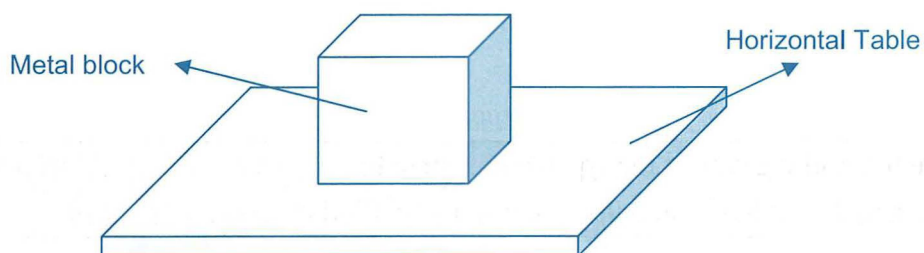
a) Define the terms below:

i. Pressure (2m)

ii. Archimedes Principle (2m)

iii. Density (2m)

b) A metal block which has the mass of 1.2 kg is placed horizontally on the table as shown in the figure. The area of the block that touches the horizontal table is 8.0m^2 .



- Calculate the pressure that acted on the block on the table (3m)
- If the block volume is 150m^3 , calculate the density of the metal block (3m)

c) Liquid A has a density of 2500 kg/m^3 and a mass of 5 kg is mixed into a container that consists of liquid B with a density of 1500 kg/m^3 . Calculate:

i. The volume of liquid A and B (5m)

ii. The mixed volume of liquid A and B (2m)

iii. The density of 150 m^3 of the mixed liquids (3m)

d) A pressure hydraulic gauge at the equilibrium state has the force of $F_1 = 250 \text{ N}$ and having the area of A_1 and A_2 , 0.6 m^2 and 0.9 m^2 respectively. Find the force of F_2 . (3m)

Answers:

- | | | |
|----|------|--|
| b) | i. | $P = 13471 \text{ Pa}$ |
| | ii. | $\rho = 0.008 \text{ kg/m}^3$. |
| c) | i. | $V_a = 0.002 \text{ m}^3$, $V_b = 0.0067 \text{ m}^3$, |
| | ii. | $V_{\text{mix}} = 0.0087 \text{ m}^3$, |
| | iii. | $\rho = 0.1 \text{ kg/m}^3$. |
| d) | | $F_2 = 375 \text{ N}$ |

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Chapter

6

Temperature and Heat



Temperature and Heat

6.1 Introduction

Heat always refers to the transfer of energy between systems (or bodies), not to energy contained within the systems (or bodies).

Example: The iron is hot, so it's reasonable to say it must have a lot of heat in it. Reasonable, but wrong. It's more appropriate to say that it has a lot of energy in it (i.e. it has a high temperature), and touching it will cause that energy to transfer to your hand ... in the form of heat.

6.2 Temperature

Temperature is a physical property of matter that quantitatively expresses the common notions of hot and cold. Objects of low temperature are cold, while various degrees of higher temperatures are referred to as warm or hot. The symbol for temperature is T. There are three temperature scales in common use. These are: Fahrenheit Scale, Celsius Scale or Centigrade Scale, Kelvin or Absolute Scale.

Some of the world uses the Celsius scale ($^{\circ}\text{C}$) for most temperature measurements. It has the same incremental scaling as the Kelvin scale used by scientists, but fixes its null point, at $0^{\circ}\text{C} = 273.15\text{K}$, the freezing point of water. A few countries, most notably the United States, use the Fahrenheit scale for common purposes, a historical scale on which water freezes at 32°F and boils at 212°F . The Fahrenheit scale chooses the freezing point of water to be at 32 degrees, and the boiling point at 212 degrees, under a pressure of one atmosphere. The Celsius Scale, , puts the freezing point of water at 0°C and the boiling point at 100°C . The Kelvin scale has hache marks the same distance apart as the Celsius scale. However, it starts measuring temperatures at absolute zero, which corresponds to $-273.15^{\circ}\text{Celsius}$.

6.3 Comparison of Temperature Scales

Table 6.1

Physical State	$^{\circ}\text{C}$	$^{\circ}\text{F}$	K
Absolute zero	-273	-460	0
Freezing point of water	0	32	273.15
Boling point of water	100	212	373.15

To convert from Celsius to Kelvin, use the following simple formula:

$$K = ^\circ C + 273.15^\circ$$

so if we want to change Kelvin to Celsius, it will be,

$$^\circ C = K - 273.15^\circ$$

To convert from Celsius to Fahrenheit, use

$$^\circ F = \frac{9}{5}^\circ C + 32$$

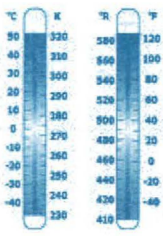
while the inverse relationship Fahrenheit to Celsius is

$$^\circ C = \frac{5}{9} (^\circ F - 32)$$

Examples	Notes
6Q1- Convert 100 Kelvin to Fahrenheit. Hint: We know that there is no directly formula to convert Kelvin to ° Fahrenheit, but we can convert Kelvin to ° Celsius then from ° Celsius to Fahrenheit as shown; Solution $^\circ C = K - 273.15^\circ$ $= 100 - 273.15$ $= \underline{-173.15 \text{ K}}$ $F = \frac{9}{5}C + 32$ $= \frac{9}{5}(-173.15) + 32$ $= \underline{-279.67^\circ F}$ 6Q2- Calculate: (a) The typical room temperature of 20°C and a cold temperature of -18°C on the Fahrenheit scale; and	

Examples	Notes
(b) Another cold temperature of -10°F and normal body temperature, 98.6°F, on the Celsius scale? c) The absolute zero on the Fahrenheit scale? Solution: a) Celsius-to-Fahrenheit conversion $20^{\circ}\text{C} = 68^{\circ}\text{F}$, $-18^{\circ}\text{C} = -0.4^{\circ}\text{F}$.....is it true? Prove it! b) Please try.... $-10^{\circ}\text{F} = -23.3^{\circ}\text{C}$ c) Also try this.....absolute zero = $0\text{ K} = -459.67^{\circ}\text{F}$ (refer to the table 6.1) d) show the calculation method $98.6^{\circ}\text{F} = ?$, find it... 6Q3- Compute the conversion below; - Convert 100°C to Fahrenheit. - Convert 100°F to Celsius. - Convert 0 Kelvin to Fahrenheit <i>Good luck!</i>	

Examples	Notes
Solution: 6Q4- Solve the question below, 1. Convert 15° Celsius to: a. Fahrenheit scale. b. Kelvin scale 2. Find 78° Fahrenheit to: a. Celsius scale. b. Kelvin scale 3. Find the summation of 54° Celsius and 212 Kelvin in Fahrenheit scale. Good luck!	

Examples	Notes
Solution:  The image shows three vertical thermometers. The leftmost thermometer has a Celsius scale from -40 to 50. The middle thermometer has a Kelvin scale from 235 to 320. The rightmost thermometer has a Fahrenheit scale from -60 to 120. The scales are aligned such that 0°C corresponds to 273K and 32°F, and 100°C corresponds to 373K and 212°F.	

6.4 Heat

Heat is energy transferred from one physical entity to another due to thermal contact or thermal radiation when the systems are at different temperatures. The heat is transferred by particles bouncing into each other. The heat or amount of heat or the quantity of heat use symbol Q and the unit is in Joule. Heat is also measured in calories, or kilocalories. One kilocalorie equals 4,186 Joules. Another common unit, on your monthly electric bill, is the kilowatt-hour, which equals 3.6×10^6 J.

In other words, under kinetic theory, the heat is transferred by particles bouncing into each other. When heat, (i. e., energy), goes into a substance one of two things can happen:

The substance can experience a raise in temperature. That is, the heat can be used to speed up the molecules of the substance.

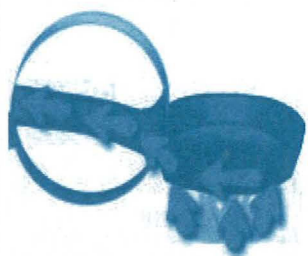
Heat vs. Temperature

Note that temperature is different from heat, though the two concepts are linked. Temperature is a measure of the internal energy of the system, while heat is a measure of how energy is transferred from one system (or body) to another. The greater the heats absorbed by a material, the more rapidly the atoms within the material begin to move and thus the greater the rise in temperature.

6.5 The Method of Heat Transfer

Heat transfers through our environment all the time. In this module you will learn three ways that heat transfer in our environment; CONDUCTION, CONVECTION AND RADIATION.

Conduction

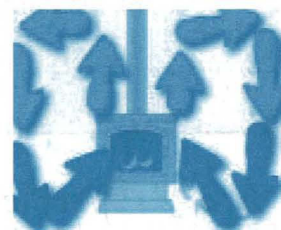


The energy is transferred by the direct contact of molecules through a medium not by the movement of the material. Energy transfer by heat between objects is classified as either heat conduction.

Example: putting your hand on a stove burner. The amount of energy transferred depends on how conductive the material is. Metals are good conductors, so they are used to transfer energy from the stove to the food in pots and pans. Air is the best insulator, so good insulating products try to trap air and not allow it to move.

Convection

Convection is the up and down movement of gases and liquids. The energy is transferred by the mass motion of groups of molecules resulting in transport and mixing of properties. By fluid convection, this is the mixing of hot and cold fluid regions.



Example: holding your hand over a stove burner, wind currents and hot air balloon.



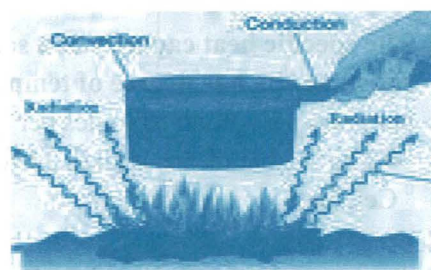
Radiation

The energy is transferred form of waves through space by electromagnetic radiation.

Example: heat felt when standing away from a large fire on a calm night. Another example; a camp fire, a light bulb and microwave oven.

Another examples for conduction, convection and radiation

Often, heat transfer occurs as a combination of the methods we've discussed. For example, fire heats a pot by convection. The heat is then transferred from one side of the pot to the other by conduction.



Do it yourself

After the study, can you describe the method of heat energy transfer in our life,

6.6 Specific Heat Capacity, c

Specific heat is another physical property of matter. All matter has a temperature associated with it. The temperature of matter is a direct measure of the motion of the molecules; the greater the motion the higher the temperature. For most purposes, these details can be all accounted for in an empirical quantity called the specific heat capacity, c. Therefore:

$$c = \frac{Q}{m \Delta T}$$

where Q is the heat energy,(Joules), m is the mass,(kg), c is the specific heat capacity,(J/kg/°C)

and ΔT or $\Delta\theta$ is the change in temperature (°C)

The specific heat capacity of a solid or liquid is defined as the heat required raising a unit mass of substance by one degree of temperature. Specific heat is typically quoted in units of J/g/K or J/g/°C (Joules per gram per Kelvin or Joules per gram per degree Celcius). For example, if a substance has a heat capacity of 30 J/kg/°C that means it takes 30 Joules of energy to raise the temperature of 1 kilogram of the substance by 1 °Celsius.

Table 6.2 shows the specific heat for common substances.

Substance(Solid)	Specific heat(J/kg/C)	Substance(liquid)	Specific heat (J/kg/C)
Aluminum	900	Water	4186=4200

Q=Amount of heat(J)

$\Delta\theta$ = the change of temperature(C or K)

c= specific heat(J/kg/C)

Ice	2100	Seawater	3900
Iron	460	Glycerin	2400
Glass	670	Mercury	140
Cuprum/Copper	390	Olive oil	2000
Plumbum /Lead	130	Kerosene	2200
Zinc	390	Spirit methyl	2500
Gold	129	Ethanol	2440
Brick	900	Milk	3930
Cement	1550	Petroleum	2130
Diamond	630	Sulfuric acid	1340
Paper	1336	Turpentine	1720

Notes: the lowest specific heat capacity registers the highest temperature rise (refer to the table, the gold is the hottest)

6.7 Calculating Heat Energy Changes

The amount of heat transferred can be readily determined by changes in temperature of the surroundings. When a substance undergoes a temperature change without a phase, three factors determine the amount of heat (Q) a substance will absorb or release. The three factors are:

- 1) **mass** of the substance (m).
- 2) **specific heat capacity** of the substance (a measure of how much energy the substance absorbs to change the temperature 1°C).
- 3) **temperature change** the substance undergoes (ΔT). If the temperature increase, the substance gain heat energy, if the temperature decrease, the substance loss energy(the sign is -ve energy)

Heat Calculation formula

The factors indicated above all have a direct relationship with the amount of heat transferred. Therefore the following formula can be developed for the *calculation of heat when a temperature change occurs*.

$$Q = m c \Delta T$$

Example	Notes
6Q6- mass of water = 300 grams temperature change in water = 15 °C specific heat capacity = 4.19 J/ g * °C Determine amount of heat in joules Solution: $Q = (300 \text{ g}) * (4.19 \text{ J/g} * ^\circ\text{C}) * (15 ^\circ\text{C})$ $Q = 18,855 \text{ J or } 19 \text{ kJ}$	

Example	Notes
6Q7- Calculate the specific heat capacity of concrete if 3,620 J of heat causes the temperature of a 250 gram sample to change from 10.15 °C to 26.50 °C? Given Information Heat = 3,620 Joules Mass = 250 grams Temperature change = 10.15 - 26.50 °C. The specific heat capacity of concrete in J/g* °C=? Solution Step 1: $c = \frac{Q}{m\Delta T}$ Step 2: $\Delta T = 26.50\text{ }^{\circ}\text{C} - 10.15\text{ }^{\circ}\text{C} = 16.45\text{ }^{\circ}\text{C}.$ Step 3: $c = \frac{3620}{0.25(16.45)}$ The specific heat capacity of the concrete = 0.880 J/g °C. 6Q8- Find the heat necessary to boiling 5 kilograms of water from a temperature of 25 degrees Celsius to the point of 100 degrees Celsius. (Heat capacity, $C_{\text{(H}_2\text{O)}} = 4186\text{ J/kg }^{\circ}\text{C}$) Solution: Check the data in symbol; m water = 5kg, $\Delta T = 100 - 25 = 75$ and $c = 4186\text{ J/kg }^{\circ}\text{C}$. Find the heat, Q =? $Q = mc\Delta T$ $= 5(4186)(100 - 25)$ $= 1.57 \times 10^6\text{ Joules}$ 6Q9- How many joules of energy are required to raise the temperature of 100g of gold from 20°C to 100°C? Solution: $m = 100\text{ g} \times \frac{1\text{ kg}}{1000\text{ g}} = 0.1\text{ kg}$	Hint; Gold gained heat energy, therefore gold is heating....

Example

$$\Delta T = 100 - 20 = 80^\circ\text{C}$$

$$\begin{aligned} Q &= mc \Delta T \\ &= (0.1 \text{ kg})(129 \text{ J/kg}^\circ\text{C})(80^\circ\text{C}) \\ &= 1032 \text{ J} . \end{aligned}$$

Notes

6Q10-

A 0.250 kg block of a pure material is heated from 20°C to 65°C by the addition of 1.04 kcal of heat. Calculate its specific heat, and identify the substance of which it is most likely composed.

Solution :

$$Q = mc \Delta T,$$

$$c = \frac{Q}{m \Delta T}$$

..... It is copper. Is it true?

Do It Yourself-1

A half liter of water at 30°C is cooled, with the removal of 63 kJ of heat. What is the final temperature of the water?

Some guides; point the data from the underline items and write them into symbol. Do you realize the unit of volume? You must convert unit liter to m^3 and get the mass from density of water formula...don't forget the energy remove meaning the heat loss, so use -ve Q...Good luck

$$T_f = 0^\circ\text{C}$$

Example	Notes
<i>Do It Yourself-2</i> A 0.05 kg mass of metal is heated to 200 °C. If the final equilibrium temperature is 22.4 °C, and the amount of heat is 50 000J, find the specific heat of this metal. Good luck! Solution: C= 5630.63 J/kg/C	

Self Learning 1

Using the following table of specific heat capacities to solve the following problems. Show all your work.

1. May uses a child's wading pool in the back yard. During a morning the temperature of 3500 L of water in the pool was raised by the sun's energy from 23 °C to 33 °C throughout the morning. How much solar energy did the water absorb?

2. Calculate the energy lost by a 15 g sample of liquid glycerin when it changes temperature from 64 °C to 42 °C.
3. Calculate the mass of ethanol needed, if it's temperature increases 12 °C when it absorbs 1100 J of heat energy.
4. Compute temperature change results from the loss of 21.5 kJ of energy from 820 grams of water?
5. Determine the final temperature of a 6700 gram sample of water when it absorbs 325 kJ of energy. It's initial temperature is 25 °C.

6.8 Thermal Equilibrium

Thermal equilibrium is achieved when two objects or systems reach the same temperature. When two objects are placed together, the object with more heat energy will lose that energy to the object with less heat energy. Eventually, their temperatures will be equal and exchange heat energy as neither object is warmer or cooler than the other. At this point, the rate of heat flow between the two substances are equal with no net heat transfer.

The temperature is found by solving the equation of thermal equilibrium, which may be written schematically as,

$$\text{Heating} = - \text{Cooling}$$

,Symbol -ve for heat loss

This is solved simultaneously with the condition of charge conservation, and thermal equilibrium equation will be;

$$\text{Heating} + \text{Cooling} = 0$$

, let Q= quantity of heat,

$$Q_{\text{heating}} + Q_{\text{cooling}} = 0$$

, let heating be =1 and cooling =2.



$$Q_1 + Q_2 = 0$$

$$m_1 c_1 \Delta\theta + m_2 c_2 \Delta\theta = 0$$

$$m_1 c_1 (\theta_f - \theta_1) + m_2 c_2 (\theta_f - \theta_2) = 0$$

Symbol to Remember:

$\theta_f =$ final temperature,

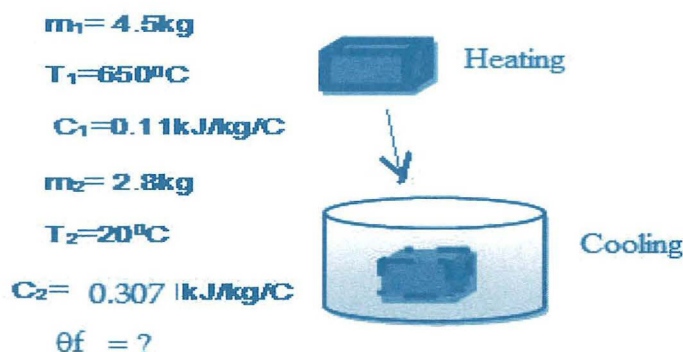
$\theta_i =$ initial temperature

We also use symbol T for temperature....

Example 6Q.11

A 4.5 kg block of metal is heated until the temperature is raised to 650°C . Then this block is dropped into a container holding of oil with temperature 20°C . Finally, the temperature of metal block and the oil are remaining constant at $\theta_f^{\circ}\text{C}$. If the specific heat capacity, c , of metal is $0.11\text{ kJkg}^{-1}\text{ }^{\circ}\text{C}^{-1}$. Calculate the mixture temperature, θ_f if the specific heat of oil given $0.307\text{ kJ/kg/}^{\circ}\text{C}$.

Solution:



$$\begin{aligned}
 &\text{Heating} + \text{Cooling} = 0 \\
 &\text{Quantity of heat while heating} + \text{Quantity of heat while cooling} = 0 \\
 &Q_h + Q_c = 0 \\
 &mc(\Delta\theta) + mc(\Delta\theta) = 0 \\
 &4.5(0.11)(\theta_f - 650) + 2.8(0.307)(\theta_f - 20) = 0 \\
 &0.495(\theta_f - 650) + 0.8596(\theta_f - 20) = 0 \\
 &0.495\theta_f + 0.8596\theta_f - 321.75 - 17.192 = 0 \\
 &1.354\theta_f = 338.942 \\
 &\theta_f = 250.033^{\circ}\text{C}
 \end{aligned}$$

Or

Substances	Mass, m (kg)	C (kJ/kg/ $^{\circ}\text{C}$)	T_f $^{\circ}\text{C}$	T_i $^{\circ}\text{C}$	Quantity of heat, $Q=mc(\Delta T)$
Metal block	4.5	0.11	θ_f	650	$0.495(\theta_f - 650)$
Oil	2.8	0.307	θ_f	20	$1046.5(\theta_f - 20)$

Finally, sum up the heat transfers

$$\begin{aligned}
 Q_{\text{metal}} + Q_{\text{oil}} &= 0 \\
 0.495(\theta_f - 650) + 1046.5(\theta_f - 20) &= 0 \\
 \theta_f &= 250^{\circ}\text{C}
 \end{aligned}$$

Example 6Q12

Into a cup of water put 0.2 kg of aluminum at 50°C and 0.25 kg of water at 85°C . Assuming there is no heat exchange with the outside and a material of cup, find the final equilibrium temperature. ($c_{\text{al}}=900\text{ J/kg/C}$, $c_{\text{water}}=4186\text{ J/kg/C}$)

Solution:

To avoid errors in more elaborate problems, it's best to make a table.

Substances	Mass, m (kg)	C (J/kg/C)	T_f $^{\circ}\text{C}$	T_i $^{\circ}\text{C}$	Quantity of heat, $Q=mc(\Delta T)$
Aluminum, al	0.2	900	T	50	$180(T-50)$
Water, H_2O	0.25	4186	T	85	$1046.5(T-85)$

Finally, sum up the heat transfers: Note how water dominates, due its large heat capacity.

$$Q_{\text{al}} + Q_{\text{H}_2\text{O}} = 0$$

$$180(T-50) + 1046.5(T-85) = 0$$

$$(180 + 1046.5)T - (180 \times 50 + 1046.5 \times 85) = 0$$

$$1226.5T = 97952.5$$

$$T = 79.86^{\circ}\text{C}$$

Do it yourself 3

Put 0.3 kg of **aluminum** at 50°C and 0.5 kg of **water** at 85°C . Assuming there is no heat exchange with the outside, find the **final equilibrium temperature**, T_f . ($c_{\text{al}}=900\text{ J/kg/C}$, $c_{\text{water}}=4186\text{ J/kg/C}$) *Good luck!*

Solution:

Substances	Mass, m (kg)	C (J/kg/C)	T_f $^{\circ}\text{C}$	T_i $^{\circ}\text{C}$	Quantity of heat, $Q=mc(\Delta T)$

$$Q_1 + Q_2 = 0$$

Example 6Q13

A zinc block with mass 150 g is at temperature of 55°C . A plate of glass with mass 0.5kg has initial temperature at 78°C . Both of them are dropped into a volume of 450 cm^3 into water with a temperature 26°C . Calculate the final temperature of the mixture.

Solution:

$$m = 150\text{ g convert to kg} \dots \text{so, } 150\text{ g} \times \frac{1\text{kg}}{1000\text{g}} = 0.15\text{ kg}$$

How to convert volume to mass? Remember volume in unit liter or cm^3 but mass is kg....

$V = 450\text{ cm}^3$,
find the mass from the density of water,
(we know that $\rho_w = 1000\text{ kg/m}^3 = 1\text{ g/cm}^3$)

$$\rho = \frac{m}{V}, \quad m = \rho V = (1)(450)$$

$$m = 450\text{ g},$$

$$m = 450\text{ g} \times \frac{1\text{kg}}{1000\text{g}} = 0.45\text{ kg}$$

Do it yourself 4

Please continue..

	Mass, m	c	T_f	T_i	Quantity of heat, $Q=mc\Delta T$
Zinc block	0.15 kg	390	T_f	55	$58.5(T_f-55)$
Plate of glass	0.5kg	670	T_f	78	
Water	0.45 kg	4200	T_f	26	

Sum up all the substances:

$$Q_{\text{zinc}} + Q_{\text{glass}} + Q_{\text{water}} = 0$$

$$58.5(T-55) + \quad (T-78) + \quad (T- \quad) = 0$$

$$(\quad)T - (\quad) = 0$$

$$T = \quad^{\circ}\text{C}$$

Can you get the correct answer? If yes, **very good** but if not **don't give up**.....try again!

Do it yourself 5

Q1- A 4.5 kg piece of metal is heated until the temperature is raised to 200°C . Then this block is dropped into a container holding of 3kg water with temperature 70°C . Finally, the temperature of metal block and the water are remaining constant temperature. If the specific heat capacity, c , of metal is $0.11\text{kJ}^{-1}\text{kg}^{-1}\text{ }^\circ\text{C}^{-1}$. Calculate the final temperature if the specific heat of water is $4200\text{J/kg/}^\circ\text{C}$.

Good luck!

Solution:

1st step you can list all the substance of heating and cooling. Can you guess? Very good the heating substance is the metal (recognize from high temperature)

Do it yourself 6

Q2- Beaker P contains 50cm^3 of water at 60°C while beaker Q contains 100cm^3 of water at 40°C . When the water in both beakers are mixed and allowed to stand, they attain a common temperature. Find the mixed temperature? (Heat capacity, $C_{\text{(H}_2\text{O)}} = 4186\text{ J/kg }^\circ\text{C}$)

Solution: (Hint: find the mass in kg, from density of water)

Do it yourself 7

Q3. A 0.05 kg mass of glass is heated to T_i $^\circ\text{C}$ then put in a bowl containing 0.4 kg of water that is initially at 20 $^\circ\text{C}$. If the final equilibrium temperature is 18.4 $^\circ\text{C}$, find the value of T_i if the specific heat of this glass is 670 J/kg/ $^\circ\text{C}$. Good luck!

Self Learning 2

1. The average human body temperature is 98.60 F. What is the equivalent temperature on the Celsius scale? Show the method of calculation.

- (A). 22.8° Celsius.
- (B). 37° Celsius.
- (C). 51.2° Celsius.
- (D). 209.48° Celsius.

2. A science article refers to a temperature of 300 K. What is the equivalent Fahrenheit temperature?

- (A). 17° F.
- (B). 80.6° F.
- (C). 549° F.
- (D). 572° F.

3. This morning I have measuring my body temperature 102 ° F. Find the temperature in ° C and decide if I can go for a lecture?

- (A). 25 ° C.
- (B). 39 ° C.
- (C). 53 ° C.
- (D). 152° C

4. If the boiled water in degree of Celsius is 100 what is the equivalent scale of temperature in Fahrenheit and Kelvin?

- (A). 212° F and -173.15 K
- (B). 278° F and 373.15 K
- (C). 212° F and 373.15 K
- (D). 278° F and -173.15 K

5. Convert all the temperature below?

- (a). 17° F to ° C
- (b). 80.6° C to ° F
- (c). 549° F to K
- (d). 572 K to ° F.

Q=Amount of heat (J)

$\Delta\theta=\Delta T$ = the change of temperature (C or K)

c= specific heat (J/kg/C)

6. How much heat must be supplied to a 1 kg iron pan to raise its temperature from 20 ° C to 100° C?
(c_{iron}= 460J/kg ° C)

7. A bicycle and rider have a combined mass of 120 kg. How many energy of heat are generated in the brakes when the temperature change from 27 ° C to 35° C.(The specific heat of iron is 450 J/kg/K) Answer= 432kJ

8. Rose has cooked French fries using deep fryer with 500g oil (250 kilocalories) with high temperature 70 o C and wishes to serve the dinner for her children on 8.00pm. what is the specific gravity of oil?(1kcal.= 4184J)

Answer= 29.886 kJ/kg°C

Q =Amount of heat(J)

$\Delta\theta$ = the change of temperature($^{\circ}\text{C}$ or K)

c = specific heat($\text{J}/\text{kg}/^{\circ}\text{C}$)

9. A 300 watt immersion heater is used to heat 250.0 g of water from 10 degree C to 70 degree C. Find the total of heat? ($C_{\text{water}} = 4200\text{J}/\text{kg}/^{\circ}\text{C}$)

Answer= 63kJ

10. Explain and sketch 3 concept of heat transfer?

11. How much heat is needed to change 250 g ice at 0°C to at 10°C ? (specific heat of ice $2100\text{J}/\text{kg}/^{\circ}\text{C}$)

12. The initial temperature of 150g of ethanol was 22°C . What will be the final temperature of the ethanol if 3240 J was needed to raise the temperature of the ethanol? (Specific heat capacity of ethanol is $2.44\text{ J }^{\circ}\text{C}^{-1}\text{ kg}^{-1}$).

Answer= 110.525°C

13. Calculate the amount of heat needed to increase the temperature of 250g of water from 20°C to 56°C .

Answer= 38 kJ

14. Calculate the specific heat capacity of copper given that 204.75 J of energy raises the temperature of 15g of copper from 25°C to 60°C .

15. 216 J of energy is required to raise the temperature of aluminum from 15°C to 35°C . Calculate the mass of aluminum. (Specific Heat Capacity of aluminum is $0.90\text{ J}^\circ\text{C}^{-1}\text{g}^{-1}$) (12g)

Answer = 12g

16. 2.56 kJ quantity of heat is needed to increase a temperature of marble from 25°C to 38°C . The mass of marble is given 0.40kg. Find the specific heat of marble?

Q = Amount of heat (J)

$\Delta\theta$ = the change of temperature (°C or K)

c = specific heat (J/kg/°C)

17. The 1050 g mass of iron spoon heated from 25 °C to 100 °C. How much heat the spoon gained if the specific heat of iron 452 J/kg/°C.

Answer = 35595J

18. A, B and C are the type of liquid which mass A is 8 kg and mass B 22kg. The initial temperature of A liquid is 65°C, liquid B 45°C and liquid C 15°C. The final temperature when all the liquid mixed is 40°C. If the specific heat A, B and C is 2.1×10^3 J/kg/°C, 3.3×10^3 J/kg/°C, 4.2×10^3 J/kg/°C, find :

- Find the heat energy of liquid A and B
- The mass of liquid C.

Answer = 420kJ, 363kJ

19. 3 kg of gold at a temperature of 20 °C is placed into contact with 1 kg of copper at a temperature of 80°C. The specific heat of gold is 130 J/kg °C and the specific heat of copper is 390 J/kg °C. At what temperature do the two substances reach thermal equilibrium?

Answer = 50°C

20. Self Learning I: (try to do within 30 minutes)

- a. Define the specific heat energy and its unit. 4 marks
- b. Determine the mass of water if the heat energy 200kJ required to increasing the temperature of water from 30 degree Celsius to 80 degree Celsius. 4 marks
- c. 500 g of hot water at 75°C is added into a ceramic mug with mass 200g and its initial temperature 27°C . If the final temperature both of them is 58°C when it arrives at thermal equilibrium, find the specific heat of ceramic mug? 7 marks
- d. A block of 0.2 kg metal with temperature 110°C are put in 300g of water which have initial temperature 20°C . Assuming there is no heat exchange with the outside, find the final equilibrium temperature. ($c_{\text{metal}}= 500\text{J/kg/}^{\circ}\text{C}$, $c_{\text{water}}= 4200 \text{ J/kg/}^{\circ}\text{C}$) 8 marks

Try your best!

21. Self Learning II; (Duration < 30 minutes)

- a. Gives definition for change of temperature. 3 marks
- b. A metal fork with mass 500g at 20°C temperature is heated till 100°C . Calculate the thermal quantity absorbed by that kitchenware tool. (Specific heat capacity for metal fork is $452\text{Jkg}^{-1}\text{C}^{-1}$). 5 marks
- c. A 50g silver spoon at 20°C is used to mix fresh milk at 40°C . After a few moment the spoon and milk achieved 35°C . If mass of the milk the specific heat is 3.93kJ/kg/C ,
- Calculate the thermal absorbed by spoon(specific heat of silver = 0.23kJ/kg/C)
 - Find the mass of milk.

17 marks

22. Self Learning III: (<30 minutes)

- a. Gives 3 processes of heat energy and describe ONE of them. 5 marks
- b. The heat 8000J is required to raise temperature of 5 kg of steel? Find the change of temperature if given specific heat of steel is 500 J/kg/C. 5 marks
- c. A 0.1kg of metal cube has been heated to 100 C and then transferred into the copper container with dimension 35cm x 20cm x 5cm filled half of seawater with initial temperature 14 C. Mass of container is 500 g while the specific heat of copper and seawater is 400 J/kg C and 3.93 kJ/kg/C respectively. If temperature of water and container increases to 21 C, find the specific heat capacity of metal cube. (15 marks)

Please Do ALL THE EXERCISE And Check It With Your Lecturer for THE METHOD of SOLUTION to gets MAXIMUM MARKS.....Try your best!



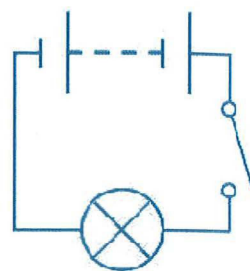
Electricity



Electricity

7.0 Introduction

Electricity is the flow of charge around a circuit carrying energy from the battery (or power supply) to components such as lamps and motors. Electricity can flow only if there is a complete circuit from the battery through wires to components and back to the battery again. The diagram shows a simple circuit of a battery, wires, a switch and a lamp. The quantities in basic of electricity are Charge, Current, Voltage, Resistance and Power.



7.1 Charge of Electricity

There are two kinds of charge, negative and positive. The electric charge on an electron is very small and it is **NEGATIVE**: -1.6×10^{-19} Coulombs. The protons found at the center of atoms have the same amount of charge as the electron except it is a **POSITIVE** electric charge: $+1.6 \times 10^{-19}$ Coulombs.

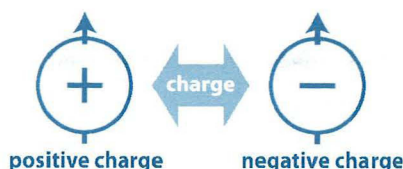


Fig. 7.1 Two kinds of charge

The coulomb is defined as the quantity of charge that has passed through the cross-section of an electrical conductor carrying one ampere within one second. The symbol Q is often used to denote a quantity of electricity or charge. The quantity of electric charge can be directly measured with an electrometer, or indirectly measured with a ballistic galvanometer.

$$Q = ne, Q = It, Q = CV$$

— — —

where;

Q = the electric charge in coulombs transferred, $Q = ne = CV$, t = the time in seconds, n = number of electrons, e = electron, 1.602×10^{-19} C, C = Capacitance in Farad, V is Voltage in Volt.

7.2 Current

The flow of charge is called the current and it is the rate at which electric charges pass through a conductor.

This flowing electric charge is typically carried by moving electrons. One terminal of a cell or battery is **positive**, while the other is **negative**. The current is flowing from positive to negative. This is called **conventional current**. Current arrows in circuit diagrams *always* point in the conventional direction. However, be aware that this is the direction of flow for a *positively-charged* particle. In a copper wire, the charge carriers are electrons. Electrons are *negatively-charged* and therefore flow from negative to positive. This means that **electron flow** is opposite in direction to conventional current.

The SI unit for measuring the rate of flow of electric charge is the **ampere**, A. Electric current is measured using an ammeter. When a metal wire is connected across the two terminals of a DC voltage source such as a battery, the source places an electric field across the conductor.

Direct current (DC) is the unidirectional flow of electric charge. Direct current is produced by such sources as batteries, thermocouples, solar cells, and electric machines. Direct current may flow in a conductor such as a wire, but can also flow through semiconductors, insulators, or even through a vacuum as in electron or ion beams. The electric charge flows in a constant direction, distinguishing it from alternating current (AC).

Alternating current (AC) the movement of electric charge periodically reverses direction. This means that the direction of current flowing in a circuit is constantly being reversed back and forth. AC is created by generators in power plants, and other sources. This AC current is delivered to our homes and businesses by the power lines.

7.3 Coulomb's Law

The electric force acting on a point charge q_1 as a result of the presence of a second point charge q_2 is given by Coulomb's Law:

$$\text{Electric Force, } F_e = \frac{kq_1q_2}{r^2}$$

r =distance of charge, k = constant, q = quantity of charge

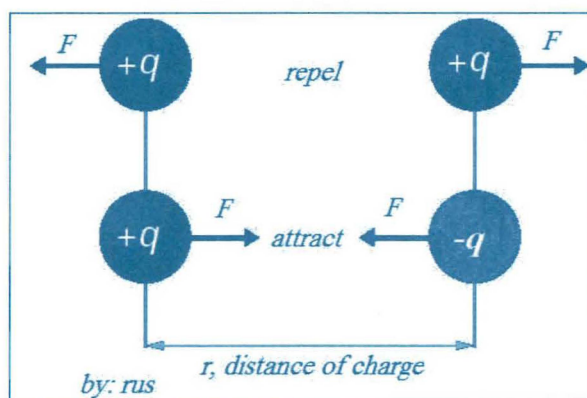


Figure 7.3: Like charges repel, unlike charges attract.

The electric force between charges may be calculated using Coulomb's law.

Normal household circuits operate on an AC voltage of about $V = 120$ volts. Connected to such a circuit, the electric power relationship $P = IV$ tells us that to use power at the rate of $P = 120$ watts on a 120 volt circuit would require an electric current of $I = 1$ ampere. One ampere of current transports one Coulomb of charge

Q = electric charge (C), n = number of electrons, $e = 1.602 \times 10^{-19}$ (C), C = Capacitance(F), V =Voltage (V)

per second through the conductor. So one Coulomb of charge represents the charge transported through a 120 watt light bulb in one second.

7.4 Calculate Electric Charge

Examples	Notes						
7Q1- From the experiment of cuprum electrolysis, the current 1.5 Ampere flow for 25 minutes. Determine the electric charge transferred? Find the magnitude of current if the electric charge is 5000 Coulombs in the same time? Solution Data: $I = 1.5 \text{ A}$, $t= 25 \text{ minutes} = 25 \text{ min} \times \frac{60 \text{ sec}}{1 \text{ min}} = 1500 \text{ seconds}$, $Q=?$ $Q= It$ $Q= 1.5(120)$ $= 2250 \text{ C}$ Data: $I = ?$, $t= 25 \text{ minutes} = 1500 \text{ seconds}$, $Q= 5000 \text{ Coulombs}$ Can you finish it? Answer :3.33 A							
7Q2- Fill the blank. <table><tr><th>Item</th><th>Symbol</th><th>Unit</th></tr><tr><td>Electric Charge</td><td>Q</td><td></td></tr></table>	Item	Symbol	Unit	Electric Charge	Q		
Item	Symbol	Unit					
Electric Charge	Q						

Examples			Notes
		Capacitance	
		Volt	
7Q3- A positive charge of $2.90 \mu\text{C}$ is at rest at the origin. An electric current of 0.00655 Ampere acts on the charge with voltage 1.5 Volt. Find the capacitance and the time taken flow in the wire? Solution: Data: $Q = 2.9\mu\text{C} = 2.9 \times 10^{-6} \text{ C}$, $I = 0.00655 \text{ A}$, $C = ?$ $t = ?$ $Q = CV$ $2.9 \times 10^{-6} = C (1.5)$ $C = 1.933 \times 10^{-6} \text{ Farad.}$ $Q = It$ $2.9 \times 10^{-6} \text{ C} = 0.00655 t$ $t = 4.4275 \times 10^{-4} \text{ second}$ Try to convert the answer in minute and hour? Can you do it yourself?			

7.5 Capacitors

Capacitors follow the law using the reciprocals.

7.5.1 Capacitors in series

The total capacitance of capacitors in series is equal to the reciprocal of the sum of the reciprocals of their individual capacitances:

Q = electric charge (C), n = number of electrons, $e = 1.602 \times 10^{-19}$ (C), C = Capacitance (F), V = Voltage (V)



Figure 7.6

$$\frac{1}{C_{\text{total}}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}$$

The working voltage of a series combination of identical capacitors is equal to the sum of voltage ratings of individual capacitors provided that equalizing resistors are used to ensure equal voltage division. This is all because of Ohm's law $V = RI$

7.5.2 Capacitors in parallel

Capacitors follow the same law using the reciprocals. The total capacitance of capacitors in parallel is equal to the sum of their individual capacitances:

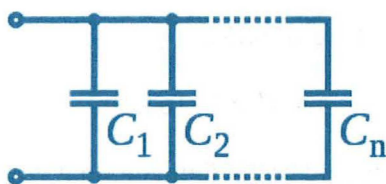


Figure 7.3

$$C_{\text{total}} = C_1 + C_2 + \dots + C_n$$

The working voltage of a parallel combination of capacitors is always limited by the smallest working voltage of an individual capacitor.

	Examples	Notes
7Q4- There are four capacitors which have the magnitude 5F, 6F, 8F and 3 F. Find the total capacitance if the arrangement of capacitors i) in parallel ii) in series Given $C_1=5$ F, $C_2=6$F, $C_3=8$ F and $C_4=3$ F		

i) in parallel, $C_{\text{total}} = C_1 + C_2 + \dots + C_n$

$$= 5 + 6 + 8 + 3$$

$$= 22 \text{ F}$$

ii) Please try in series....

7.6 Energy Storage in Capacitors

We can now talk about the energy stored in the electric field of or, equivalently, stored in the arrangement of electric charges within the capacitor. Again, we use the parallel-plate capacitor because it is reasonably simple. First, note that we will use schematic representations of circuit elements to save drawing time. For a source of EMF, or voltage that can move charges, we have the symbol in figure 7.4.



Figure 7.4: Symbol for a source of EMF within a circuit.

To calculate the energy stored, we hook the EMF source to a capacitor, e.g. by closing a switch that allows conducting lines to link the EMF source and a capacitor together.

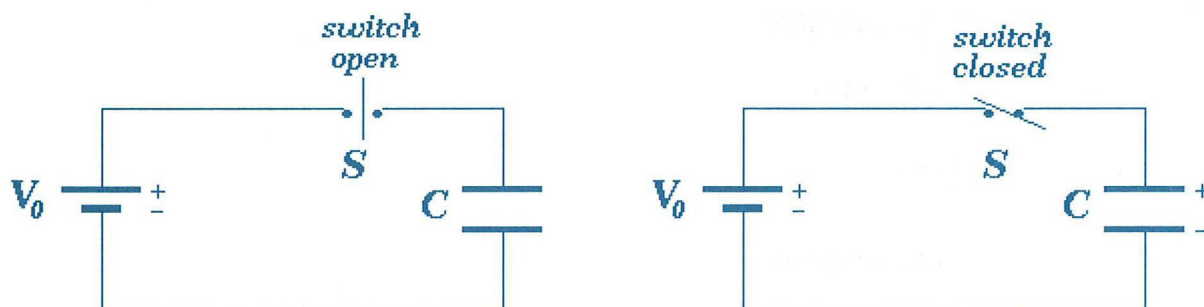


Figure 7.5: Closing a switch to charge a capacitor.

the capacitance through the relationship define as,

$$C = \frac{Q}{V}$$

C = Capacitance in farad, Q = the electric charge in coulombs and V = Voltage in volt

7.7 Batteries and Capacitor

We are more familiar with the concept of storing electrical energy in batteries. Hence, it makes some sense to distinguish between batteries and capacitors. The purpose of a battery is to use chemical (or other) processes to produce the EMF needed to move charges around. This is done by using the chemical or other process to maintain a constant potential between the poles (i.e. the positive and negative parts of the battery). This constant potential provides the EMF for moving charges from one conductor of a capacitor to another, for example. Hence, this is the principal distinguishing feature of a battery and a capacitor: a battery maintains a constant potential difference between its poles whereas a capacitor can maintain a potential difference between its positive and negatively charged conductors, but there is no need for that potential difference to be constant - the potential difference depends on the magnitude of the charge on the conductors. Thus, while **batteries store energy, capacitors store both energy and charge.**

$$Ep = \frac{1}{2} CV^2$$

Ep = Potential energy in J, C = Capacitance in farad, V = Voltage in volt

Examples	Notes
7Q5- 30 volt voltage is used to charge a capacitor with rate $2\mu\text{F}$. Determine: i- The charge stored in capacitor plate ii- The potential energy stored in capacitor i- $Q = CV = (2 \times 10^{-6})(30)$ $= 6 \times 10^{-5} \text{ C}$ ii- $Ep = \frac{1}{2} CV^2$ $= \frac{1}{2} (2 \times 10^{-6})(30)^2$ $= 9.0 \times 10^{-4} \text{ J}$ 7Q6- If the 230 volt voltage is used to charge a capacitor with rate 5 GF. Determine: i. The charge stored in capacitor plate ii. The potential energy stored in capacitor	

Examples	Notes
	

7.8 Ohm's Law

Ohm's Law defines the relationships between (P) power, (V) voltage, (I) current, and (R) resistance. One ohm is the resistance value through which one volt will maintain a current of one ampere.

Current, I	Current is flows on a wire or conductor. Current is measured in (A) amperes or amps.
Voltage, V	Voltage is the difference in electrical potential between two points in a circuit. It's the push or pressure behind current flow through a circuit, and is measured in (V) volts.
Resistance, R	Resistance is defined as the ability of a substance to prevent or resist the flow of electrical current. A substance resists electrical current because of a collision between electrons and atoms, which slows the electrons down and converts some of their energy to heat energy. A very high resistance allows a small amount of current to flow. A very low resistance allows a large amount of current to flow. Resistance is measured in Ω ohms.
Power, P	Power is the amount of current times the voltage level at a given point measured in wattage or watts.

In electrical circuits, **Ohm's law** states that the current through a conductor between two points is directly proportional to the potential difference or voltage across the two points, and inversely proportional to the resistance between them.



Figure 7.5

V, I, and R are the parameters of Ohm's law. The mathematical equation that describes this relationship is:

Q = electric charge (C), n = number of electrons, $e = 1.602 \times 10^{-19}$ (C), C = Capacitance (F), V = Voltage (V)

$$I = \frac{V}{R}$$

Where,

V is the potential difference measured across the resistance in units of volts;

I is the current through the resistance in units of amperes and

R is the resistance of the conductor in units of ohms.

More specifically, Ohm's law states that the R in this relation is constant, independent of the current.

The power dissipated by a linear resistor may be calculated from its resistance, and voltage or current. The formula is a combination of Ohm's law and Joule's laws:

$$P = V \cdot I = \frac{V^2}{R} = I^2 \cdot R$$

where P is the power in watts, R the resistance in ohms, V the voltage across the resistor, and I the current through it.

Examples	Notes
7Q7- Find the power lost as heat energy in the wire cable if the current 500 A through the resistance 0.3 ohm. After that compute the equivalence voltage to generate the power lost. Solution: Data: $I = 500$ A, $R = 0.3$ ohm, $\Delta P = ?$ Power lost, $\Delta P = I^2 R$ $= 500^2 (0.3)$ $= 75000$ Watt $P = VI$ $75000 = V (500)$ $V = 150$ Volt	

Examples	Notes
7Q8- Find the power if given the voltage 30 V with the resistance 9 ohms, then compute the current that can flow through.	

Answer: 0.075 Watt

7.9 Resistant in Wire

Resistance is defined as the ability of a substance to prevent or resist the flow of electrical current. The factor of resistance in wire is dependence on the dimensional of wire; the cross sectional area of wire and the length. The relationship of the resistance of a wire is inversely proportional to its cross-sectional area and directly proportional to its length; Resistance increases with length because the electrons have further to go, so greater collisions with atoms in the material. Look at these wires:

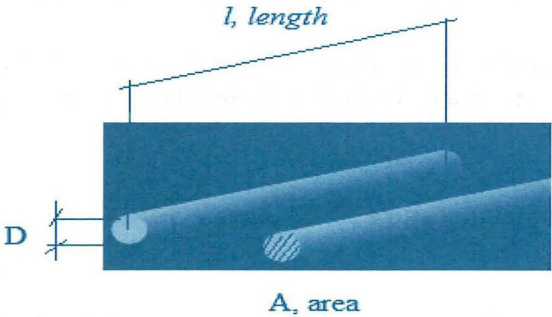


Figure 7.6

Electrons moving through the short wire only feel resistance for a short time compared to the longer one. This means its resistance is less.

Q = electric charge (C), n = number of electrons, $e = 1.602 \times 10^{-19}$ (C), C = Capacitance(f), V =Voltage (V)

Thickness (cross sectional area of the wire), length, and temperature all have some effect on the amount of resistance created in a wire. Another factor is the conductivity of the material. Some metals are just more electrically conductive than others.

Cross Sectional Area

The thicker the wire, the less resistant it is. This is because there are more electrons in the metal that are free to move as a current. Also, there is more space for the electrons to flow, so more can fit down. This is often compared to water in a pipe; the thicker the pipe, the more water that can flow through it.

Temperature

The temperature of the wire also affects the resistance. This happens because as the metal gets warmer, the metal ions in the wire gain kinetic energy and start to vibrate. As their motion becomes more erratic they are more likely to get in the way and disrupt the flow of the electrons and therefore increase the resistance.

Length of the wire

Voltage can be thought of as the pressure pushing charges along a conductor, while the electrical resistance of a conductor is a measure of how difficult it is to push the charges along. Using the flow analogy, electrical resistance is similar to friction. For water flowing through a pipe, a long narrow pipe provides more resistance to the flow than does a short fat pipe. The same applies for flowing currents: long thin wires provide more resistance than do short thick wires.

The resistance (R) of a material depends on its length, cross-sectional area, and the resistivity (the Greek letter rho), a number that depends on the material:

$$R = \frac{\rho l}{A}$$

- R

A

l

ρ
- is the resistance of the conductor in Ohm

is the cross sectional area in m^2

is the length of the wire in meters

is the resistivity of the material in Ohm-meter

Electric resistivity or ρ is a measure of how strongly a material opposes the flow of electric current. The resistivity and conductivity are inversely related. Good conductors have low resistivity, while poor conductors (insulators) have resistivity that can be 20 orders of magnitude larger.

Resistance also depends on temperature, usually increasing as the temperature increases. For reasonably small changes in temperature, the change in resistivity, and therefore the change in resistance, is proportional to the temperature change.

Table of various resistivity at temperature 20° C (Source from Wikipedia) ;

Material	Resistivity ($\Omega \cdot m$) at 20 °C
Silver	1.59×10^{-8}

Copper	1.68×10^{-8}
Gold	2.44×10^{-8}
Aluminum	2.82×10^{-8}
Tungsten	5.60×10^{-8}
Zinc	5.90×10^{-8}
Nickel	6.99×10^{-8}
Iron	1.0×10^{-7}
Platinum	1.06×10^{-7}
Tin	1.09×10^{-7}
Lead	2.2×10^{-7}

Examples	Notes
7Q9- A copper wire has a length of 160 m and a diameter of 1.00 mm. the wire is connected to a 1.5-volt battery, how much current flows through the wire? (Use the resistivity for copper, $\rho = 1.72 \times 10^{-8} \Omega \text{m}$ in normal temperature) Solution: L is the length, 1.60 m. The resistivity given, For copper, $\rho = 1.72 \times 10^{-8} \Omega \text{m}$ The area is the cross-sectional area of the wire. This can be calculated using: $A = \pi r^2 = \pi (0.0005)^2 = 7.85 \times 10^{-7} \text{m}^2$ The resistance of the wire is then: $R = \rho L / A = (1.72 \times 10^{-8}) (160) / (7.85 \times 10^{-7}) = 3.50 \Omega$ The current can now be found from Ohm's Law: $I = V / R = 1.5 / 3.5 = \underline{0.428 \text{ A}}$	

Examples	Notes
7Q10- One zinc wire is connected to a 2-volt battery has a diameter of 2.5×10^{-3} and a length of 350 cm. Find the current flows through the wire? Solution:	Data= V= L= D= R= A= ρ= I=?

7.10 Series and parallel circuits

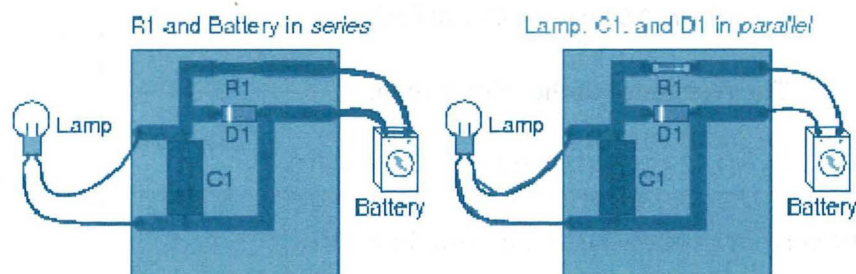


Figure 7.7

Components of an electrical circuit or electronic circuit can be connected in many different ways. The two simplest of these are called series and parallel and occur very frequently. Components connected in series are connected along a single path, so the same current flows through all of the components. Components connected in parallel are connected so the same voltage is applied to each component. A circuit composed solely of components connected in series is known as a series circuit; likewise, one connected completely in parallel is known as a parallel circuit.

In a series circuit, every device must function for the circuit to be complete. One bulb burning out in a series circuit breaks the circuit. In parallel circuits, each light has its own circuit, so all but one light could be burned out, and the last one will still function.

7.10.1 Series circuits

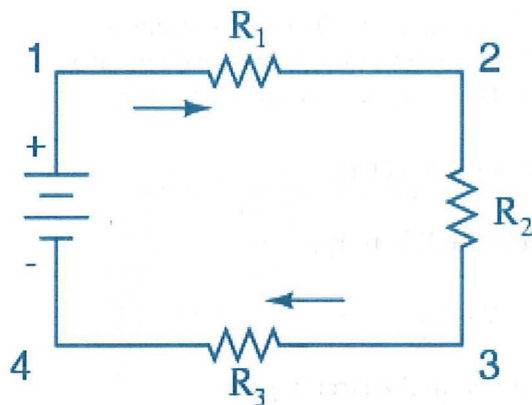


Figure 7.7 : A series circuit with a voltage source (such as a battery) and 3 resistors

Series circuits are sometimes called *current-coupled*. The current that flows in a series circuit will flow through every component in the circuit. Therefore, all of the components in a series connection carry the same current.

Notes:

Voltage drops add to equal total voltage.

All components share the same (equal) current.

Resistances add to equal total resistance.

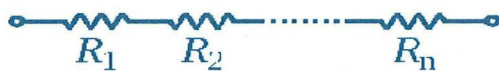


Figure 7.8

So that,

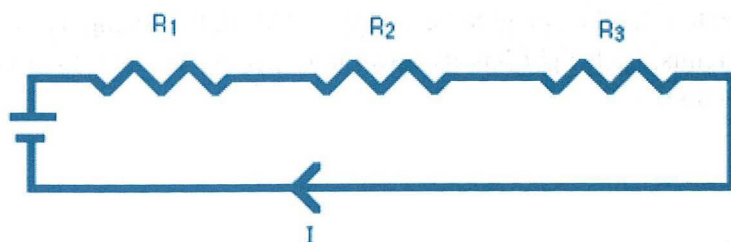
$$R_{\text{total}} = R_1 + R_2 + R_3 + \cdots + R_n$$

Q = electric charge (C), n = number of electrons, $e = 1.602 \times 10^{-19}$ (C), C = Capacitance (F), V = Voltage (V)

Examples

Notes

7Q11-



A series circuit is shown in the diagram above. The current flows through each resistor in turn. If the values of the three resistors are given $R_1 = 8\Omega$, $R_2 = 8\Omega$ and $R_3 = 4\Omega$, while the voltage is 10 volt.

$$R_T = 8 + 8 + 4 = 20 \Omega$$

With a $V = 10$ V battery,

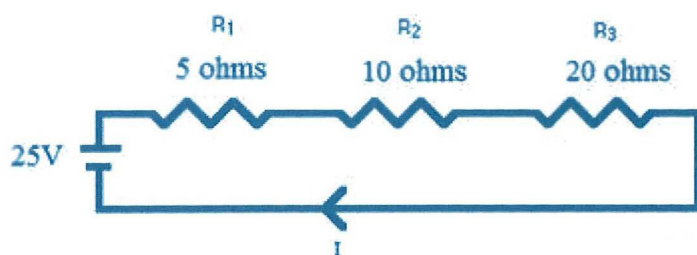
$$V = I R$$

the total current in the circuit is:

$$I = \frac{V}{R} = \frac{10}{20} = 0.5 \text{ A.}$$

The current through each resistor would be 0.5 A.

7Q12-



From figure above, calculate:

- Effective resistance of the circuit.
- Current, I in the circuit.

$$\begin{aligned} \text{a. } R &= 5 + 10 + 15 \\ &= 30 \Omega \end{aligned}$$

$$\begin{aligned} \text{b. } V &= IR \\ I &= V/R \\ &= 25/30 \\ &= 0.833 \text{ A} \end{aligned}$$

7.10.2 Parallel Circuits

If two or more components are connected in parallel they have the same potential difference (voltage) across their ends. The potential differences across the components are the same in magnitude, and they also have identical polarities. Hence, the same voltage is applicable to all circuit components connected in parallel. The total current I is the sum of the currents through the individual components, in accordance with Kirchhoff's circuit laws. The current in each individual resistor is found by Ohm's law. Factoring out the voltage gives

$$I_{\text{total}} = V \left(\frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n} \right)$$

To find the total resistance of all components, add the reciprocals of the resistances R_i of each component and take the reciprocal of the sum:

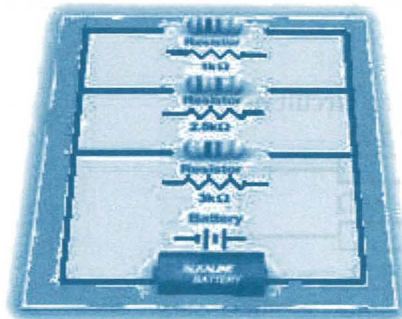


Figure 7.11

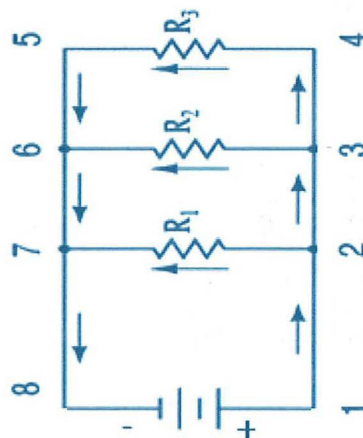


Figure 7.12

$$\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$$

To find the current in a component with resistance R_i , use Ohm's law again:

Q = electric charge (C), n = number of electrons, $e = 1.602 \times 10^{-19}$ (C),

C = Capacitance (F),

V = Voltage (V)

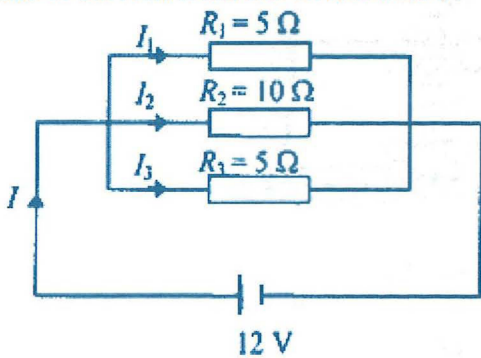
$$I_i = \frac{V}{R_i}$$

Notes:

All components share the same (equal) voltage.

Branch currents add to equal total current.

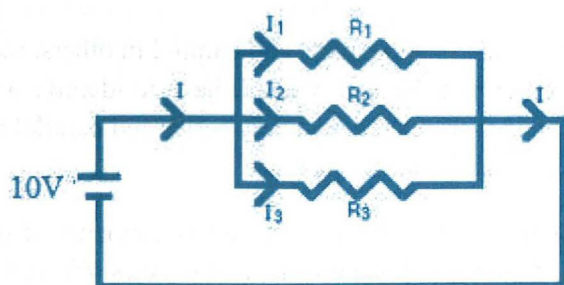
Resistances diminish to equal total resistance.

Examples	Notes
7Q13- Find the magnitude of current from the circuit below.  Solution: Step 1: Find R total, $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ $\frac{1}{R_{eq}} = \frac{1}{5} + \frac{1}{10} + \frac{1}{5} = \frac{5}{10}$ $R_{eq} = 2\Omega$ Step 2: Find the total current in the circuit , $I = \frac{V}{R} = \frac{12}{2} = 6\text{ A}$	

Examples

Notes

7Q14-



A parallel circuit is shown in the diagram above. In this case the current supplied by the battery splits up, and the amount going through each resistor depends on the resistance. If the values of the three resistors are given $R_1 = 10\Omega$, $R_2 = 8\Omega$ and $R_3 = 4\Omega$, while the voltage is 10 volt, find the total of current.

Solution:

Step 1 : Find the total of R_{eq} resistant

Step 2: Current, $I = \frac{V}{R}$

Step3-

The individual currents can also be found using $I = V / R$. The voltage across each resistor is 10 V, so:

$$I_1 = 10 / 8 = 1.25 \text{ A}$$

$$I_2 =$$

$$I_3 =$$

Note that the currents add together to 5A, the total current.

$$I_{\text{total}} = I_1 + I_2 + I_3 =$$

7.10.3 A series-parallel combination circuit

However, if circuit components are series-connected in some parts and parallel in others, we won't be able to apply a *single* set of rules to every part of that circuit. Instead, we will have to identify which parts of that circuit are series and which parts are parallel, and then selectively apply series and parallel rules as necessary to determine what is happening. Take the following circuit, for instance:

This circuit is neither simple series nor simple parallel. Rather, it contains elements of both. Because the circuit is a combination of both series and parallel, we cannot apply the rules for voltage, current, and resistance "across the table" to begin analysis like we could when the circuits were one way or the other.

Solution

- Step 1: Calculate total resistance of parallel circuit.
- Step 2: Re-draw the circuit, replacing each of those parallel resistor combinations
- Step 3: Calculate total resistance.
- Step 4: Calculate total current from total voltage and total resistance ($I=V/R$).
- Step 5: From known resistances and total voltage / total current values from step 4, use Ohm's Law to calculate unknown values (voltage or current) ($V=IR$ or $I=V/R$).

Examples	Notes
7Q15- The diagram shows a 20V DC voltage source on the left. A wire goes from the positive terminal, up and then right to a junction. From this junction, the circuit splits into two parallel branches: one with resistor R1 (100Ω) and another with resistor R2 (250Ω). These two branches rejoin at a bottom junction. From this junction, a wire goes down and then left to the negative terminal of the 20V source. Resistor R3 (350Ω) is connected in series with the parallel combination, between the junction after R1/R2 and the negative terminal of the source. Figure 7.15—parallel circuit In the example circuit Figure 7.15, R_1 and R_2 are connected in a simple parallel arrangement, to the series circuit R_3.	The "--" symbol is used here to represent "series," just as the "/" symbol is used to represent "parallel."

Examples

Notes

Solution:

Step 1: Having been identified, these sections (R_1 and R_2) need to be converted into equivalent single resistors; calculate parallel R_1 and R_2 ,

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R = \left(\left(\frac{1}{100} + \frac{1}{250} \right) \right)^{-1}$$

$$R = 71.429 \, \Omega$$

Step 2: Then the circuit re-draws:

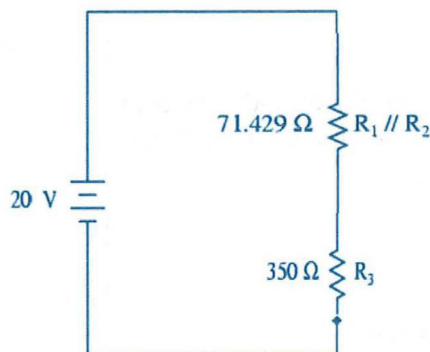


Figure 7.16

Step 3: After calculate the total resistant by series circuit, then redraw the circuit again,

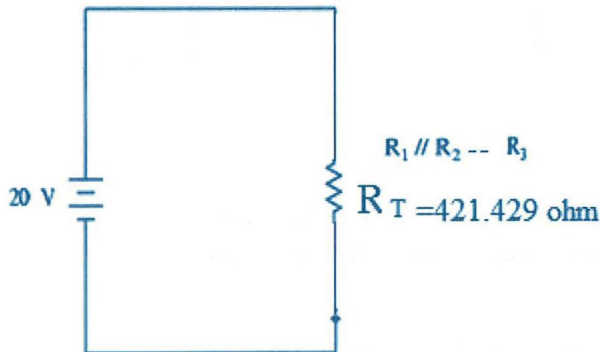
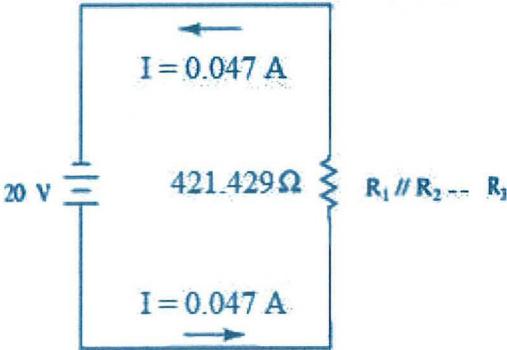
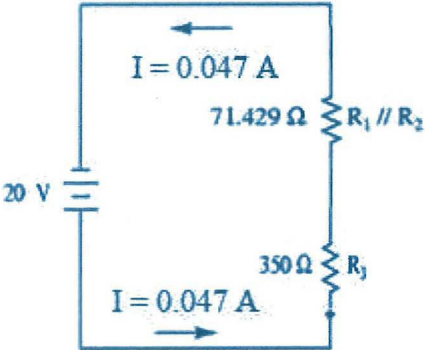


Figure 7.17

Step 4: Calculate the total current from total voltage and total resistance. Now, total circuit current can be determined by applying Ohm's Law ($I = V/R$)

$$\begin{aligned} I &= V/R \\ &= 20/421.429 \\ &= \underline{\underline{0.0475 \, \text{A}}} \end{aligned}$$

Back to our equivalent circuit drawing, our total current value of 0.0475 amps is shown as the only current here:

Examples	Notes
 Figure 7.18 Now we start to work backwards in our progression of circuit re-drawings to the original configuration. The next step is to go to the circuit where $R_1//R_2$ and R_3 are in series:  Figure 7.19 Step 5: From known resistances and total voltage / total current values from step 4, use Ohm's Law to calculate unknown values voltage or current for each resistant. Knowing the current through the equivalent resistors $R_1//R_2$ and R_3, we can apply Ohm's Law ($V=IR$) to the two right vertical columns to find voltage drops across them: $V= IR, V = 0.0475(71.429) = 3.393\text{ V}$$V= IR, V = 0.0475(350) = 16.625\text{ V}$$\text{Check, } V\text{ total} = 3.393 + 16.625 = 20.0\text{ Volt}$	

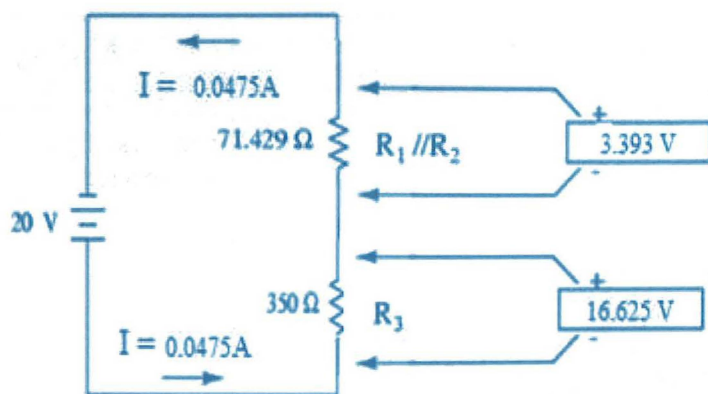


Figure 7.20

Finally, the original section of the table (columns R_1 through R_4) is complete with enough values to finish. Applying Ohm's Law to the remaining vertical columns ($I=V/R$), we can determine the currents through R_1 , R_2 , and R_3 individually:

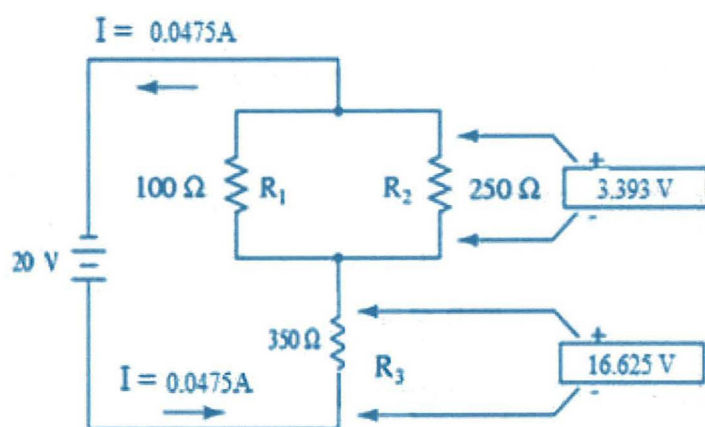


Figure 7.21

Calculate all the magnitudes,

$$I_1 = V/R_1,$$

$$I_1 = 3.393/100 = 0.0339 \text{ A.}$$

$$I_2 = V/R_2,$$

$$I_2 = 3.393/250 = 0.0136 \text{ A.}$$

$$\text{Check; } I_1 + I_2 = 0.0475 \text{ A}$$

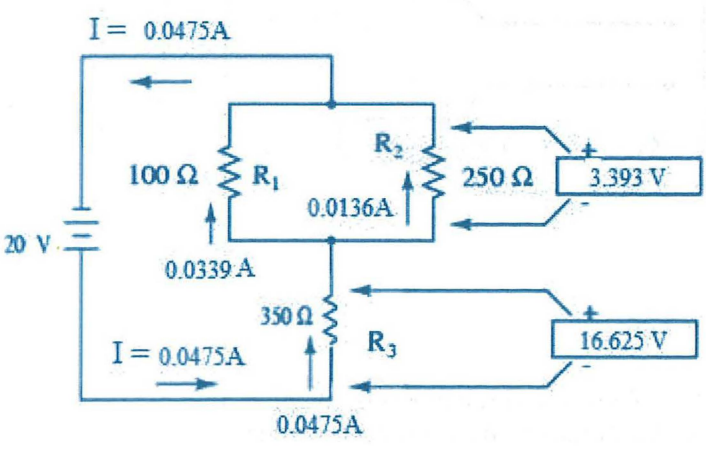
$$I_3 = V/R_3,$$

$$I_3 = 16.625/350 = 0.0475 \text{ A.}$$

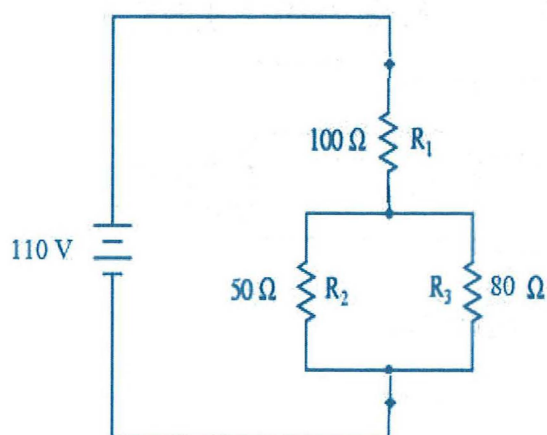
Having found all voltage and current values for this circuit, we can show

As a final check of our work, we can see if the calculated current values add up as they should to the total. Since R_1 and R_2 are in parallel, their combined currents should add up to the total of 0.0475 A. Likewise, since R_3 currents should also same to the total of 0.0475A. You can

Q = electric charge (C), n = number of electrons, $e = 1.602 \times 10^{-19}$ (C), C = Capacitance (F), V = Voltage (V)

Examples	Notes
those values in the schematic diagram as such:  Figure 7.2	check for yourself to verify that these figures do add up as expected.

Do it yourself



Determine the currents through R_1 , R_2 , and R_3 individually.

Step 1



Self Learning

1. What is the meaning of charge and current?

2. What is ohm's law?

3. Given voltage is 60V had passed through the capacitor in $4.5\mu\text{F}$ to charge it. Calculate;

a. Amount of charge on capacitor plat

Answer: $2.7 \times 10^{-4} \text{ C}$

b. Potential energy on capacitor plat

Answer: $8.1 \times 10^{-3} \text{ J}$

4. How much electrical potential energy will $5.7 \mu\text{F}$ of charge transfer if it passes through a voltage drop of 6V?

5. If $4.8 \times 10^{-6} \text{ J}$ of energy is used to move a charge through an electric potential difference of $2.0 \times 10^{-6} \text{ V}$, what is the magnitude of the charge?

Answer: $9.6 \times 10^{-6} \text{ C}$

6. Find the current flows through the wire which is connected to a 5-volt battery and the wire has a diameter of 0.5 cm and a length of 5.55 m if the material of wire is from:

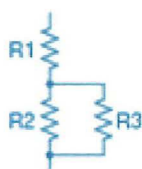
a. Iron

- b. Gold
- c. Platinum

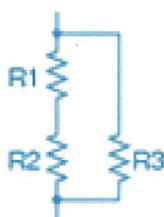
Answer: 0.028 A, 0.0069 A, 0.03 A

7. Find the total resistance which of these components are connected directly in series with each other, and which are connected directly in parallel with each other if $R_1 = 2\Omega$, $R_2 = 3\Omega$, $R_3 = 5\Omega$ and $R_4 = 7\Omega$;

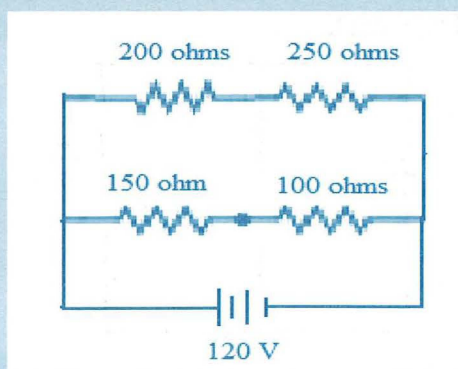
a.



b.

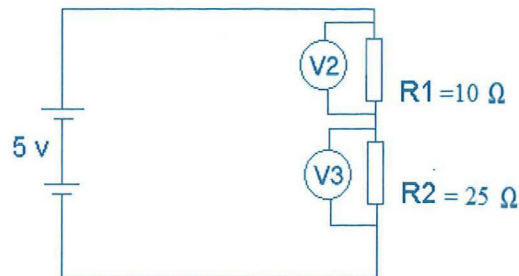


8. Calculate the resistance between points A and B (R_{AB}) for the following resistor networks and find the total current.

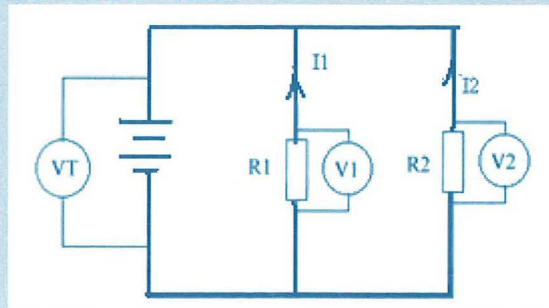


Q = electric charge (C), n = number of electrons, $e = 1.602 \times 10^{-19}$ (C), C = Capacitance (F), V = Voltage (V)

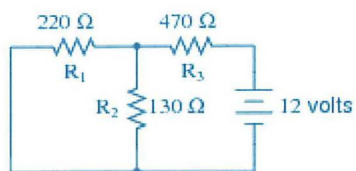
9. From the circuit presented below, calculate the total effective resistance of the resistors in the series-resistance circuit depicted above. What basic rule of series-resistance can you deduce from your results? Then using the ohm's law to find the total current?



10. Measure the voltage (V_1) across resistor R_1 and then the voltage (V_2) across resistor R_2 in formula symbol if the $R_1 = 10\ \Omega$ and $R_2 = 25\ \Omega$.

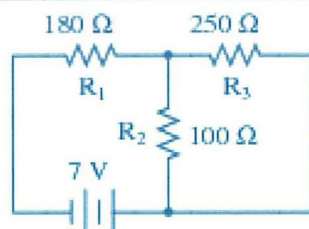


11. From schematic diagram calculate the current for R1, R2 and R3 :



Answer: 0.0255 A, 0.0923 A, 0.0545 A. Total Current = 0.1723 A

12. Find the current and the voltage values for each resistor in this circuit:



Q = electric charge (C),

n = number of electrons, $e = 1.602 \times 10^{-19}$ (C),

C = Capacitance (F),

V = Voltage (V)

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Answer

$I_1 = 27.84\text{A}$, $I_2 = 19.89\text{A}$, $I_3 = 7.95\text{A}$
 $V_1 = 5.01\text{V}$, $V_2 = 1.99\text{V}$, $V_3 = 1.99\text{V}$

14. Final Exam Format:-Answer within 30 minutes

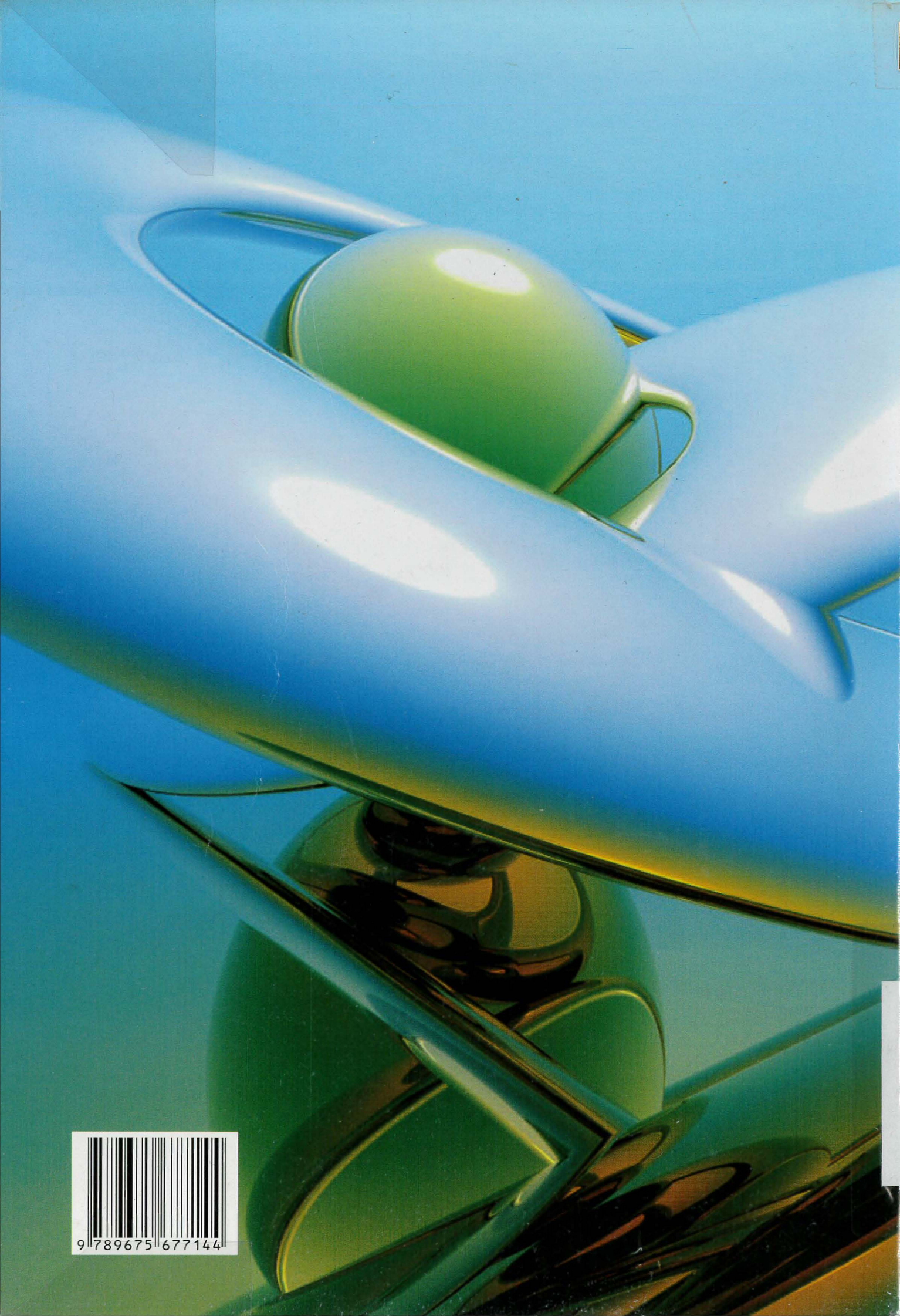
- a. Describe the charge and the current. 4 marks
- b. Find capacitance of TWO capacitors, $C_1 = 2\text{F}$ and $C_2 = 3\text{F}$ in parallel connection. 2 marks
- c. Three resistors $R_1 = 5\Omega$, $R_2 = 25\Omega$, $R_3 = 18\Omega$, are connected parallel to a battery of 1.5V in circuit. Sketch the diagram and calculate:
- i- The equivalent resistance for the three resistors 4 marks
 - ii- The current flowing through each resistors 6 marks
 - iii- The total amount of current flowing through the circuit 2 marks
- d. 100 volt voltage is used to charge capacitors with rate $25\mu\text{F}$ and $15\mu\text{F}$ in series connection. Determine:
- i- Find the total of capacitances 2 marks
 - ii- The charge stored in capacitor plate 3 marks
 - iii- The potential energy stored in capacitor 2 marks

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TARIKH DIPULANGKAN
(DATE DUE)

0 APR 2023





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