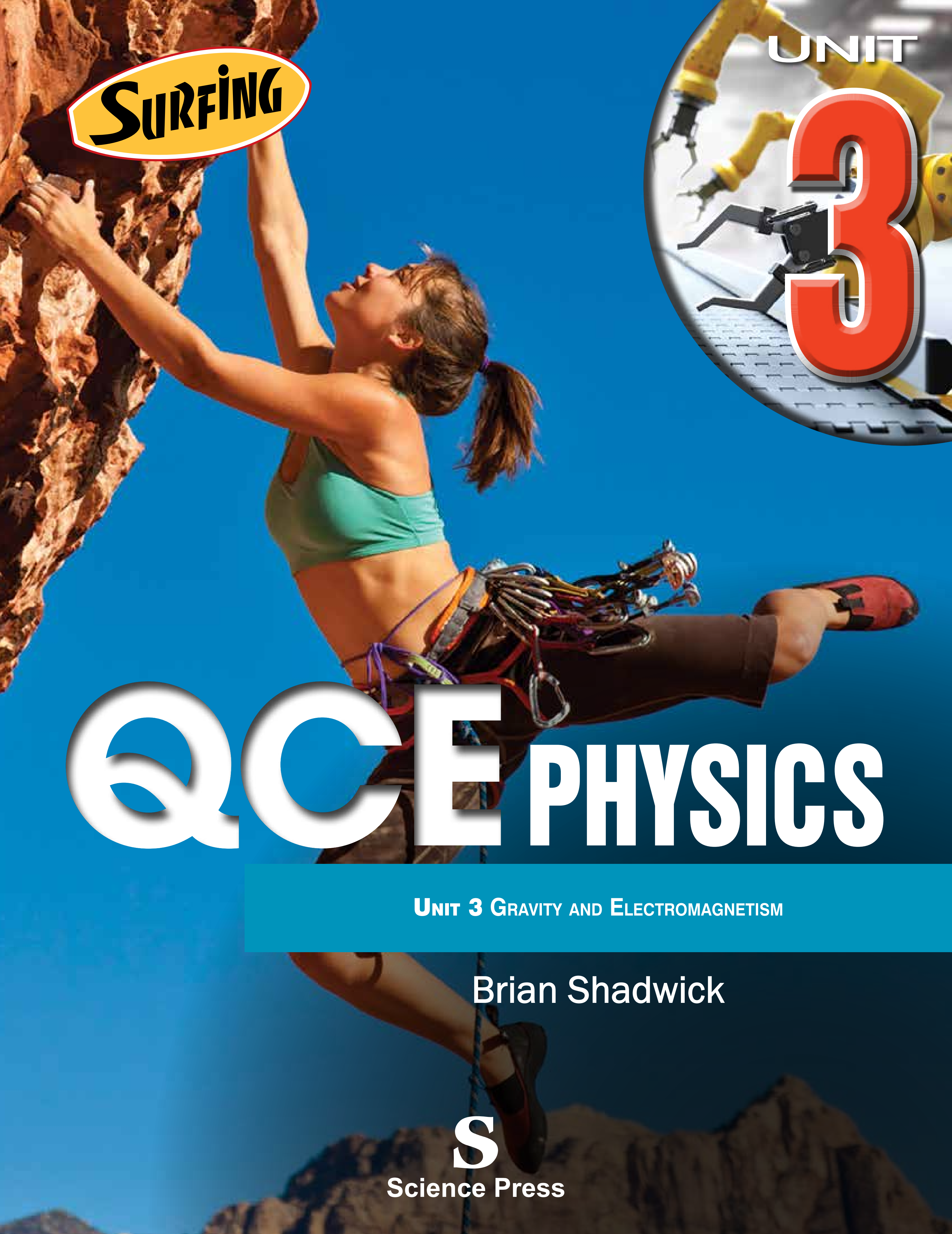


Surfing

Unit 3

QCE PHYSICS

Unit 3 Gravity and Electromagnetism

Brian Shadwick

Science Press

First published 2020

Science Press
Unit 7, 23-31 Bowden Street
Alexandria NSW 2015 Australia
Tel: +61 2 9020 1840 Fax: +61 2 9020 1842
sales@sciencepress.com.au
www.sciencepress.com.au

Contents

SCIENCE AS A HUMAN ENDEAVOUR

The human endeavour subject matter will not be assessed in the external examination, but could be used in the development of claims and questions for a research investigation. The material contained within the book should be considered only as a start for any research task you undertake in these areas.

SCIENCE AS A HUMAN ENDEAVOUR:
You could explore the international collaboration required in the discovery of gravity waves and associated technologies, e.g. Laser Interferometer Gravitational Wave Observatory (LIGO).

SCIENCE AS A HUMAN ENDEAVOUR:
You could explore the difficulties experienced by scientists who supported a heliocentric model of the Solar System and the hindrances to the acceptance of their discoveries by society.
You could also consider the international collaboration required to monitor the orbits of satellites, and the management of space debris.

SCIENCE AS A HUMAN ENDEAVOUR:
Forensic science: Forensic evidence is often used in court, however, despite messages in the popular media, forensic science cannot always provide sufficient conclusive evidence to lead to convictions.

SCIENCE AS A HUMAN ENDEAVOUR:
Artificial satellites: Knowledge of orbital heights and speeds allows satellites to be best positioned for observation of weather, natural phenomena, traffic and military movements.

SCIENCE AS A HUMAN ENDEAVOUR:
Developing understanding of planetary motion: From Ptolemy to Newton, the accepted model of the Solar System slowly shifted under the influence of carefully collected and analysed data.

Topic 7 Electromagnetism

Electrostatics

Define Coulomb's law and recognise that it describes the force exerted by electrostatically charged objects on other electrostatically charged objects.
Solve problems involving Coulomb's law.

Define the terms electric fields, electric field strength and electrical potential energy.

Solve problems involving electric field strength.

Solve problems involving the work done when an electric charge is moved in an electric field.

Magnetic Fields

Define the term magnetic field.

Recall how to represent magnetic field lines, including sketching magnetic field lines due to a moving electric charge, electric currents and magnets.

Mandatory practicals:
- Conduct an experiment to investigate the force acting on a conductor in a magnetic field.
- Conduct an experiment to investigate the strength of a magnet at various distances.

Determine the magnitude and direction of a magnetic field around electric current carrying wires.
Solve problems involving the magnitude and direction of magnetic fields around a straight electric current carrying wire.

Determine the magnitude and direction
of a magnetic field inside solenoids.
Solve problems involving the magnitude and
direction of magnetic fields inside a solenoid.

Recall that a moving electric charge generates a magnetic field.
Recall that electric current-carrying conductors and moving electric
charges experience a force when placed in a magnetic field.

Solve problems involving the magnetic force on an electric
current carrying wire and moving charge in a magnetic field.

Electromagnetic Induction

Define the terms magnetic flux and magnetic flux density.
Solve problems involving the magnetic flux
in an electric current carrying loop.

Define the terms electromagnetic induction,
emf, Faraday's law and Lenz's law.
Describe the process of inducing an emf across
a moving conductor in a magnetic field.
Explain how Lenz's law is consistent with
the principle of conservation of energy.
Solve problems involving Faraday's law and Lenz's law.

Explain how transformers work in terms of
Faraday's law and electromagnetic induction.

Electromagnetic Radiation

Define and explain electromagnetic radiation
in terms of electric fields and magnetic fields.

SCIENCE AS A HUMAN ENDEAVOUR

The human endeavour subject matter will not be assessed in the external examination, but could be used in the development of claims and questions for a research investigation. The material contained within the book should be considered only as a start for any research task you undertake in these areas.

SCIENCE AS A HUMAN ENDEAVOUR:
You could explore how scientific knowledge has been used to develop methods of renewable energy production (e.g. wind and wave power generation).

SCIENCE AS A HUMAN ENDEAVOUR:
You could explore scientific evidence about the risks of electromagnetic phenomena and associated technologies (e.g. wi-fi and mobile phones) as reported in the media.

SCIENCE AS A HUMAN ENDEAVOUR:
You could explore the international collaboration involved in the development of the Square Kilometre Array (SKA) and the associated technologies.

SCIENCE AS A HUMAN ENDEAVOUR:
Medical imaging: Due to the strong magnetic fields used in MRI machines, many safety procedures must be followed, such as excluding patients with some metallic implants from receiving MRI scans.

SCIENCE AS A HUMAN ENDEAVOUR:
The Square Kilometre Array: The Square Kilometre Array (SKA), a joint scientific project between Australia, New Zealand and South Africa, aims to gather information to advance our knowledge of dark matter, dark energy, cosmic magnetism and general relativity.

SCIENCE AS A HUMAN ENDEAVOUR:
Superconductivity: A series of discoveries caused a number of theories to be put forward to explain superconductivity, but it was not until the late 1950s that a complete atomic scale theory of superconductivity was proposed.

Introduction

This book covers the Physics content specified in the Queensland Certificate of Education Physics Syllabus. Sample data has been included for suggested experiments to give you practice to reinforce practical work in class.

Each book in the *Surfing* series contains a summary, with occasional more detailed sections, of all the mandatory parts of the syllabus, along with questions and answers.

All types of questions – multiple choice, short response, structured response and free response – are provided. Questions are written in exam style so that you will become familiar with the concepts of the topic and answering questions in the required way.

Answers to all questions are included.

A topic test at the end of each topic contains an extensive set of summary questions. These cover every aspect of the topic, and are useful for revision and exam practice.

Words To Watch

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Interpret data to reach conclusions.

annotate Add brief notes to a diagram or graph.

apply Put to use in a particular situation.

assess Make a judgement about the value of something.

calculate Find a numerical answer.

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

comment Give a judgement based on a given statement or result of a calculation.

compare Estimate, measure or note how things are similar or different.

construct Represent or develop in graphical form.

contrast Show how things are different or opposite.

create Originate or bring into existence.

deduce Reach a conclusion from given information.

define Give the precise meaning of a word, phrase or physical quantity.

demonstrate Show by example.

derive Manipulate a mathematical relationship(s) to give a new equation or relationship.

describe Give a detailed account.

design Produce a plan, simulation or model.

determine Find the only possible answer.

discuss Talk or write about a topic, taking into account different issues or ideas.

distinguish Give differences between two or more different items.

draw Represent by means of pencil lines.

estimate Find an approximate value for an unknown quantity.

evaluate Assess the implications and limitations.

examine Inquire into.

explain Make something clear or easy to understand.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

hypothesise Suggest an explanation for a group of facts or phenomena.

identify Recognise and name.

interpret Draw meaning from.

investigate Plan, inquire into and draw conclusions about.

justify Support an argument or conclusion.

label Add labels to a diagram.

list Give a sequence of names or other brief answers.

measure Find a value for a quantity.

outline Give a brief account or summary.

plan Use strategies to develop a series of steps or processes.

predict Give an expected result.

propose Put forward a plan or suggestion for consideration or action.

recall Present remembered ideas, facts or experiences.

relate Tell or report about happenings, events or circumstances.

represent Use words, images or symbols to convey meaning.

select Choose in preference to another or others.

sequence Arrange in order.

show Give the steps in a calculation or derivation.

sketch Make a quick, rough drawing of something.

solve Work out the answer to a problem.

state Give a specific name, value or other brief answer.

suggest Put forward an idea for consideration.

summarise Give a brief statement of the main points.

synthesise Combine various elements to make a whole.

Surfing

QCE PHYSICS

UNIT 3

UNIT 3

Gravity and Electromagnetism

In this unit you will:

- Investigate motion and its causes by using Newton's laws of motion and the gravitational field model.
- Analyse motion on inclined planes and the motion of projectiles and satellites.
- Explore the technologies behind artificial satellites and modern communication systems.
- Develop an understanding of electrical power generation and distribution systems.
- Learn about field theories of gravity and electromagnetism.
- Examine the production of electromagnetic waves.

Surfing

QCE PHYSICS

UNIT 3

TOPIC 6

Gravity and Motion

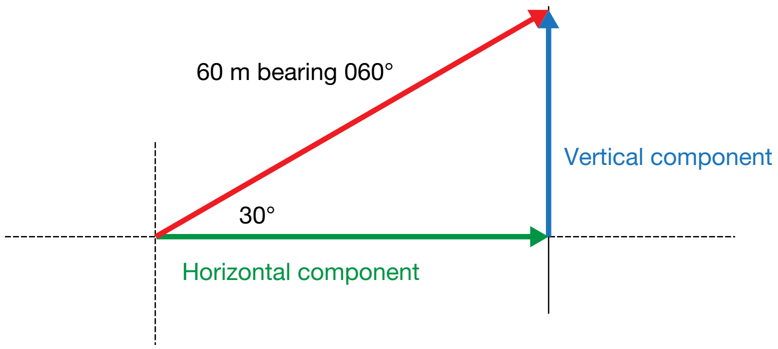
In this topic you will:

- Solve vector problems by resolving vectors into components and determining the resultant vector.
- Use vector analysis to solve problems involving projectile motion.
- Calculate the net force acting on an object on an inclined plane.
- Examine uniform circular motion and solve problems involving average speed of objects undergoing uniform circular motion.
- Investigate gravitational force and fields.
- Explore orbits and solve problems involving Kepler's third law.

1 Components Of Vectors

The **components** of a vector are any other vectors which when added together result in that vector. There are millions of pairs of components for any vector, but very useful components are the horizontal and vertical components.

Example: Consider the vector shown representing a displacement of 60 m bearing 060°.



The vertical and horizontal components can be found by dropping a vertical (blue) from the vector head, and drawing in the horizontal component from the origin to the *x*-axis intercept of the vertical drop (green). This process is known as **resolving** the vector.

Notice from trigonometry that *x*-component = 60 cos 30°
and *y*-component = 60 sin 30°

In general:

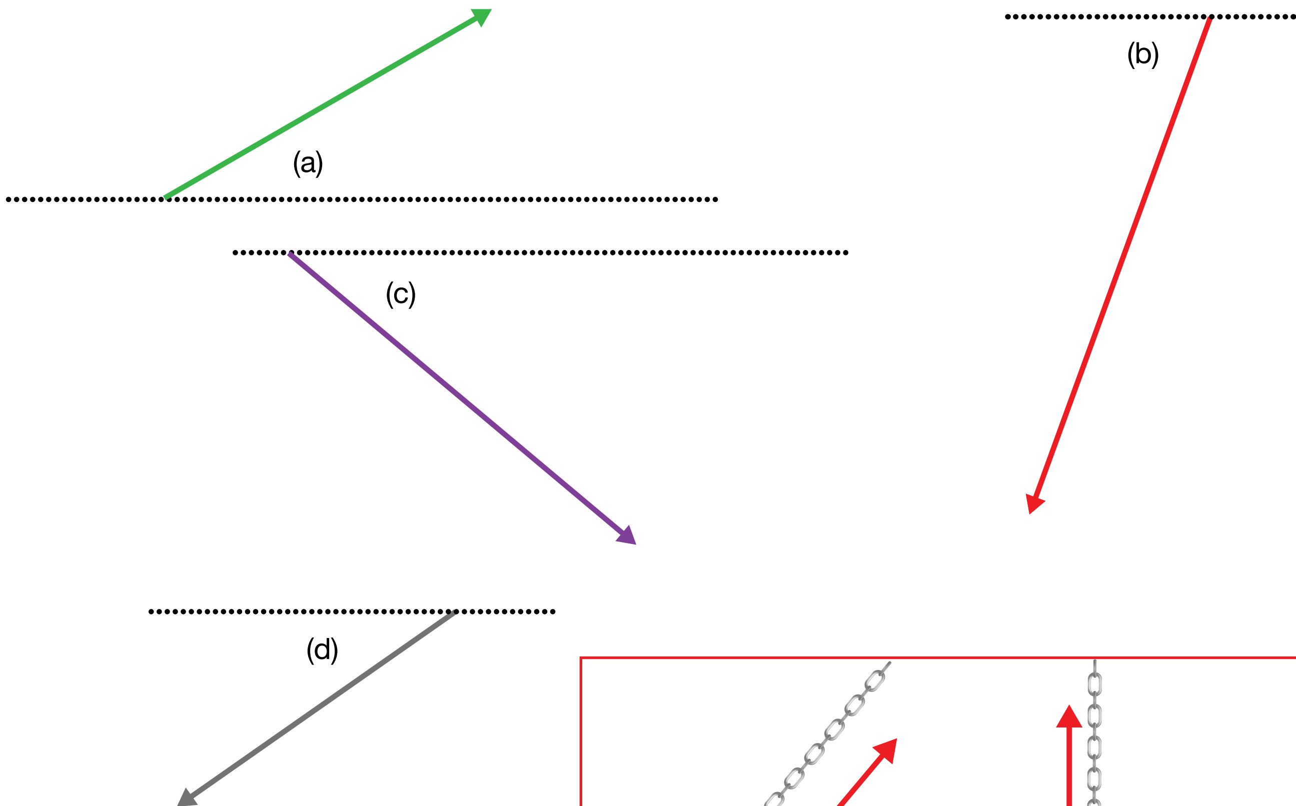
***x*-component = vector cos θ**
***y*-component = vector sin θ**

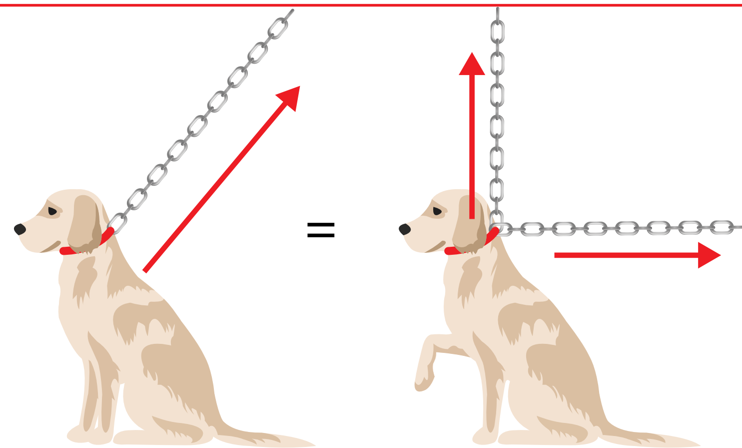
QUESTIONS

1. Calculate the missing values in the table.

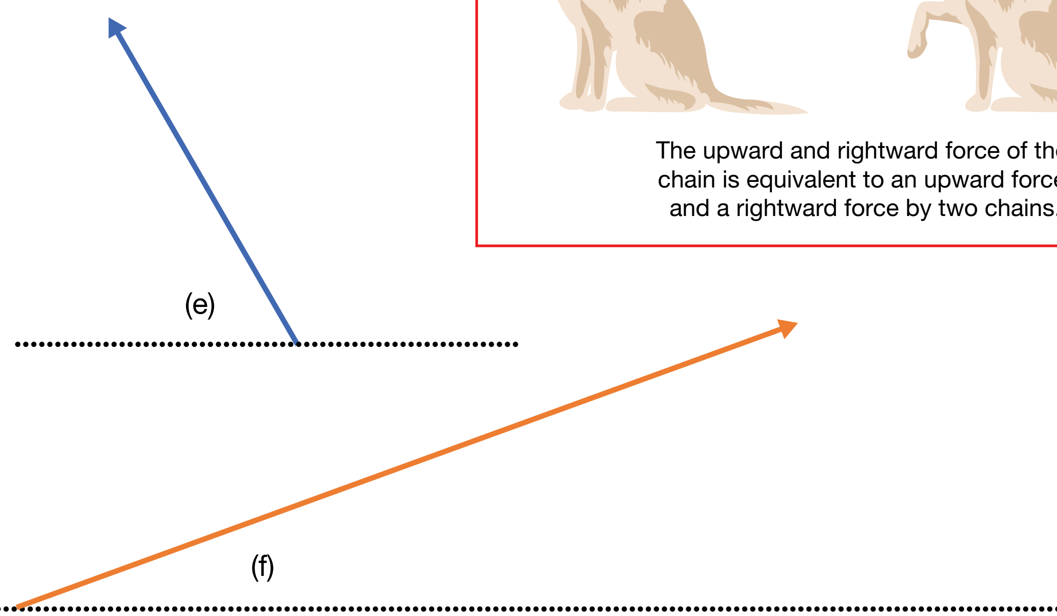
Vector	Magnitude	Angle of inclination from horizontal	Horizontal component	Vertical component
1	50	60	A =	B =
2	60	85	C =	D =
3	E =	75	20	F =
4	G =	H =	30	80
5	70	I =	J =	70

2. Find the horizontal and vertical components of each of the following vectors. All vectors are drawn to a scale where 1 cm = 10 m.





The upward and rightward force of the chain is equivalent to an upward force and a rightward force by two chains.

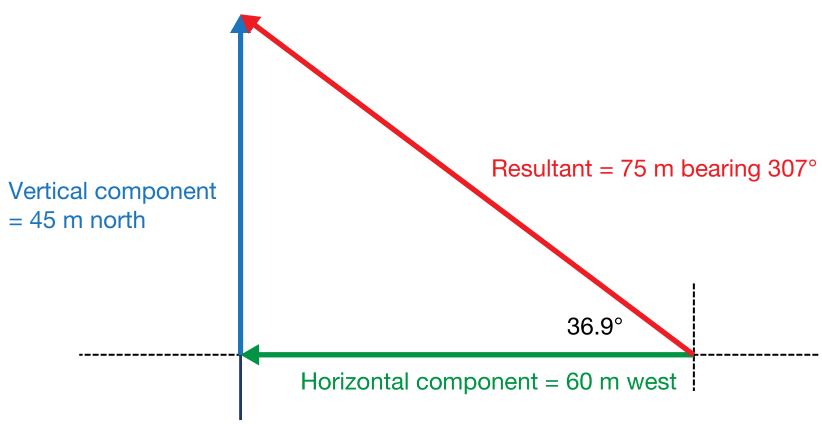


Solve vector problems by resolving vectors into components, adding or subtracting the components and recombining them to determine the resultant vector.

2 Adding Vector Components

This process is simply the reverse of resolving a vector into its components.

Example: Consider the following vector components: Horizontal component = 60 m west
Vertical component = 45 m north



The vector we find by adding these components together is known as the **resultant vector**. Its magnitude can be found using Pythagoras, and its direction by trigonometry.

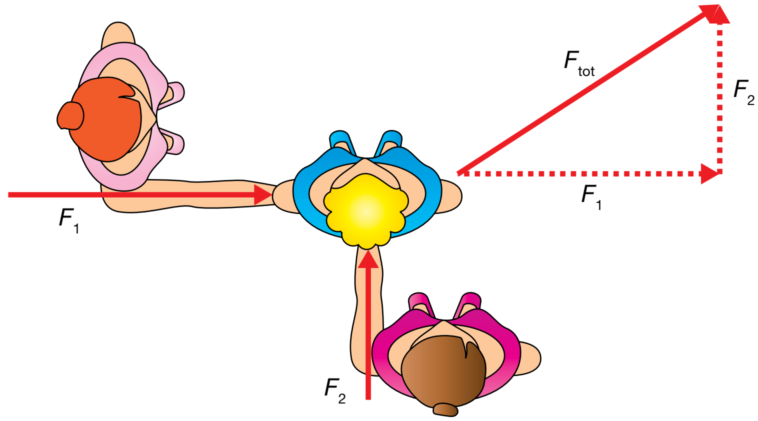
Resultant vector = $\sqrt{45^2 + 60^2} = 75$ m

Direction from $\tan^{-1}\left(\frac{45}{60}\right) = 36.9°$

Which converts to a bearing of 323.1°.

The two people push on the third in directions which are perpendicular to each other.

The person pushed will have a resultant force acting on them in the direction of the vector total of those two forces.



QUESTIONS

1. The table shows several pairs of perpendicular vector components. Combine them to find the resultant vectors.

	Horizontal component	Vertical component
(a)	56 m N	38 m E
(b)	32 m s^{-1} E	18 m s^{-1} N
(c)	85 m s^{-1} W	36 m s^{-1} S
(d)	25 m S	48 m E
(e)	460 m s^{-1} N	2250 m s^{-1} W
(f)	3475 m E	1500 m N

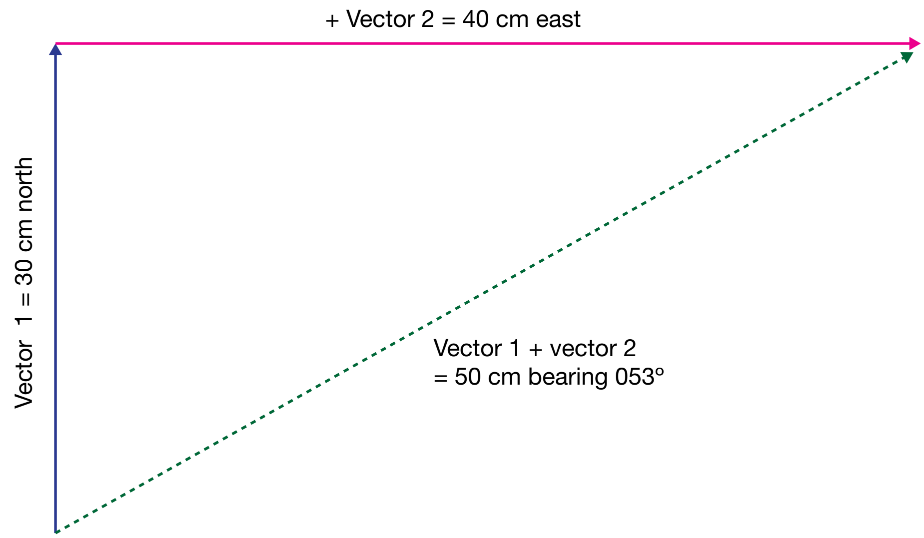
3 Vectors in Two Dimensions 1

When adding vectors in two dimensions we also simply follow the procedures learnt in the previous chapters. To add, we join the tail of the second vector to the head of the previous vector. To subtract, we join the tail of the second vector to the head of the previous vector but draw in the second vector in the opposite direction to the direction given.

The vectors we add together are called the **components** of the resultant. The **resultant** is the vector measured from the tail of the first vector to the head of the last vector.

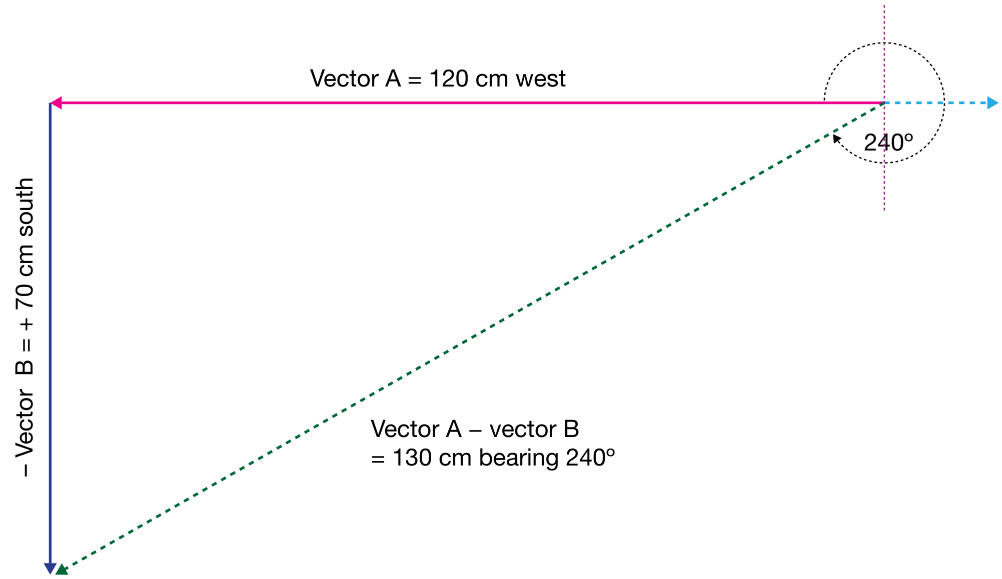
Addition of vectors

Example: An ant walks 30 cm north then turns and walks a further 40 cm to the east. What is the final displacement of the ant? *Note:* The solution to this question requires you to add the two displacement vectors and then find the resultant (diagram not to scale).



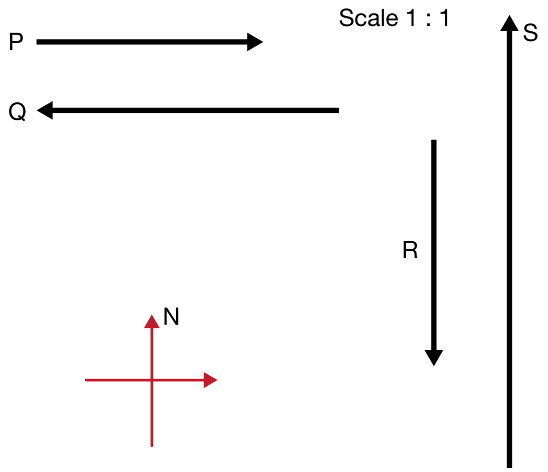
Subtraction of vectors

Example: If vector A = 120 m west and vector B = 70 m north, find the value of vector A – vector B. *Note:* When we subtract a vector we reverse its direction and add it (diagram not to scale).



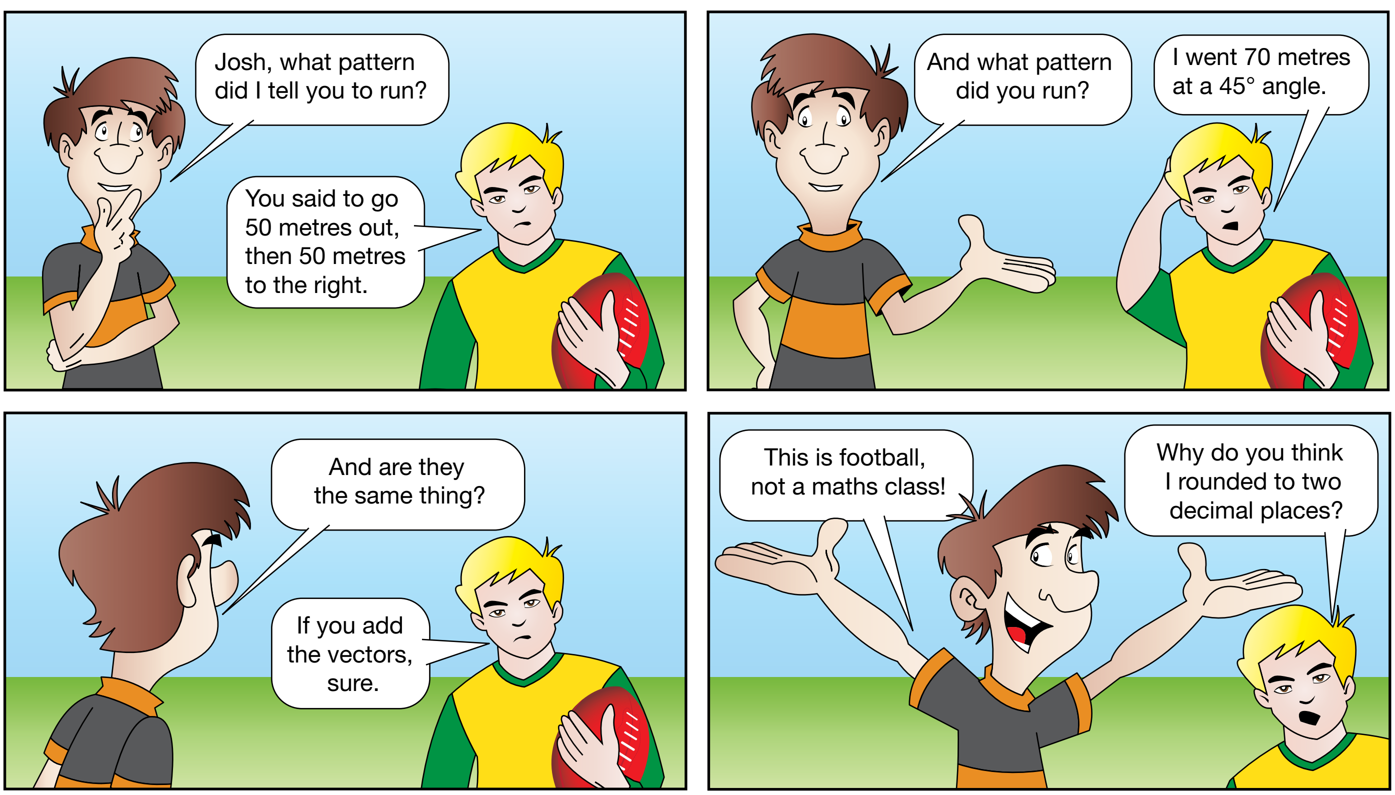
QUESTIONS

The diagram shows several vectors that could represent any vector quantity – displacement, velocity, acceleration, force – whatever.



Use the diagram to answer the following questions. Use a scale where one major grid division equals one unit.

1. Add these.
   (a) P + Q (b) Q + R
   (c) R + S (d) S + P
   (e) P + Q + R (f) Q + R + S
   (g) R + S + P (h) Q + S + P
   (i) P + Q + R + S
2. Subtract these.
   (a) P – Q (b) Q – R
   (c) R – S (d) S – P
   (e) P – Q – R (f) Q – R – S
   (g) R – S – P (h) Q – S – P
   (i) P – Q – R – S
3. Add and subtract these.
   (a) P + Q – R (b) Q + R – P
   (c) Q – P + R (d) Q – R + P
   (e) R – S + P (f) R + S – P
   (g) R – S + Q – P (h) S + P – Q + R
   (i) Q – S + R + P



4 Vectors in Two Dimensions 2

QUESTIONS

1. Vector X is 12 N north, vector Y is 8 N east, and vector Z is 17 N south. What is:
(a) X + Y + Z?
(b) X – Y – Z?
(c) Y – Z + X?

2. An car drives 40 km east then turns and drives a further 40 km to the south. What is the final displacement of the car?

3. A plane flies 800 km on a bearing of 060° then turns and flies a further 600 km bearing 150°. What is its final displacement?

4. A boy runs 90 km west, then turns and runs 50 km south, then turns and runs another 120 km east. Find his final displacement.

5. A car moves 240 km west, turns and moves in a different direction. Its final displacement is 260 km bearing 247°. What was the magnitude and direction of the second move the car made?

6. A car moves 40 km N, then 60 km W, then 75 km W 32°S. Find its final displacement.

7. An object moves 50 km S, then 60 km E, then 90 km NE, then turns again and moves 40 km S. What is its final displacement?

8. A car moves 80 km E, then 100 km N, then 60 km W, then 40 km S. What is its final displacement?

9. A car moves 100 km W, then 100 km N, then 75 km NW, then 60 km S. What is its final displacement?

10. A car moves 25 km on a bearing of 053°, turns and moves in a different direction. It then moves 30 km west ending up where it started.
(a) What was its second displacement in this journey?
(b) What was its last displacement of the trip?

11. An object moves from P to Q, 4.0 m E. It then moves from Q to R, 3.0 m N then it moves 6.0 m W to S. Calculate its displacement.

12. X walks 5 km E from O, turns, and then walks 7 km bearing 345°. Calculate its displacement.

13. A vector is 15 cm long. It acts 30° east of north. It has two components at right angles to each other. One is in the direction 30° west of north.
(a) Calculate the direction of the other.
(b) Calculate its magnitude.

14. A plane flies 1600 km on a bearing of 160°, then turns and flies 500 km on a bearing of 135°. Calculate its final displacement.

15. A car drives 270 km E from X to Y in 3 hours, and then 360 km S to Z in the next 4 hours.
(a) Calculate its average speed.
(b) Calculate its average velocity.
(c) If it drove directly from X to Z at the same average speed, how long would it take?

16. A car travels north at 60 km h^{-1} for 2 hours, then west for 5 hours at 80 km h^{-1}. Calculate its average speed and its average velocity.

17. Draw a vector diagram to find the resultant displacement of a car, which drives 10 km N, then 15 km E, then 7 km SW, then 4 km N.

18. Three towns, X, Y and Z are joined by straight roads. XY is 6 km, YZ is 4 km, and XZ is 5 km. Y is north of X.
(a) Where is Z relative to X?
(b) Where is X relative to Z?

19. A car goes 50 km E, then 30 km N, then 25 km bearing 030°. Find its final displacement.

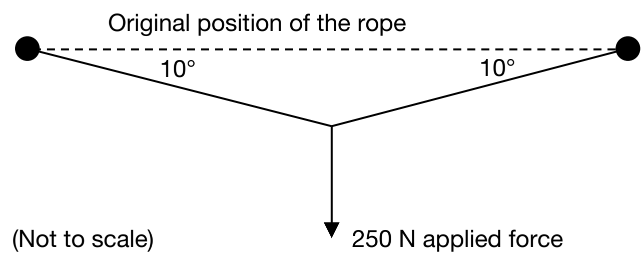
20. A vector of magnitude 4 is added to a vector of magnitude 9. What are the maximum and minimum values for the resultant?

21. A billiard ball moving north at 15 m s^{-1} hits a second ball and bounces off at the same speed in an easterly direction. Find its change in speed, change in velocity and if the change took 0.1 s, calculate its acceleration.

22. A car travels at 10 m s^{-1} E for 120 s then turns to the left and drives at 15 m s^{-1} for another 60 s. Find how far the car travelled, its total displacement, its average speed and velocity.

23. A car travels at 10 km h^{-1} N for 30 s then turns to the west and drives at 15 km h^{-1} for a minute.
(a) How far has the car travelled?
(b) What is its displacement, again in metres, at the end of this time?
(c) Calculate its average speed.
(d) Calculate it average velocity.

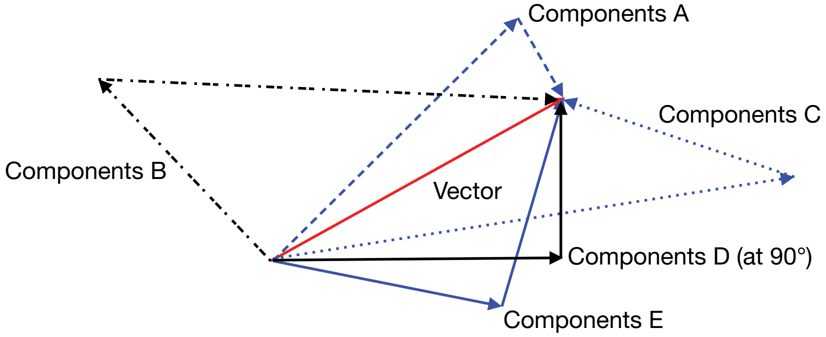
24. A rope is fixed to two posts and pulled from the middle by a force of 250 N. This causes the rope to make an angle of 10° to its original position as shown in the diagram. Find the tension in the rope.



Recall that the horizontal and vertical components of a velocity vector are independent of each other. Apply vector analysis to determine horizontal and vertical components of projectile motion.

5 Resolution Of Vectors

The projectile motion we analyse in this course involves analysis of vectors and the addition of vector components. Any vector has many components. The components are the vectors we add together to get the required vector. For example, the vector shown below (in red) has many pairs of components (shown in various blues) and one pair at right angles (black).



Normally though, when we refer to the components of a vector we specifically refer to the two vectors at 90° to each other, one **horizontal** and the other **vertical**, which would need to be added together to give that vector. In the diagram, these would be components D, drawn in black. When we **resolve** a vector into its components, then we are finding these two vectors at right angles.

Mathematically:

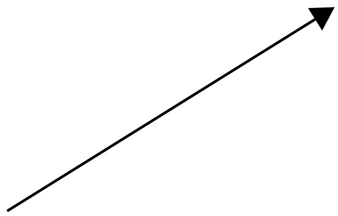
Horizontal component = vector cos θ

Vertical component = vector sin θ

QUESTIONS

1. Resolve the following vectors into their vertical and horizontal components. Use a scale where 1 cm = 5 N and state any directions as normal compass directions.

(a)

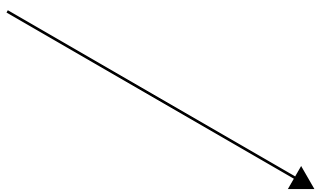


....

....

....

(b)

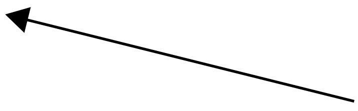


....

....

....

(c)

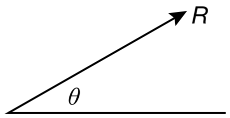
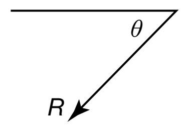
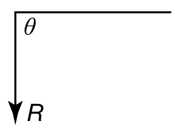
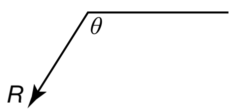
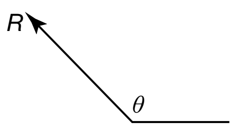
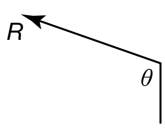
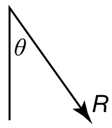
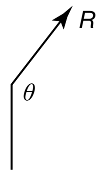
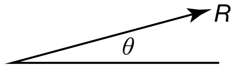
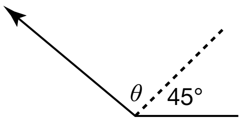


....

....

....

2. Resolve the following vectors into their vertical and horizontal components.

	Diagram	Angle	Resultant	Horizontal Component	Vertical Component	Answers
(a)		30°	6	A	B	A = B =
(b)		45°	C	10.6	D	C = D =
(c)		E	10	0	F	E = F =
(d)		120°	G	H	21.65	G = H =
(e)		I	J	12.95	12.5	I = J =
(f)		K	7.5	L	2.57	K = L =
(g)		36°25´	M	N	14.65	M = N =
(h)		O	72.05	42.65	P	O = P =
(i)		15°12´	Q	0.66	R	Q = R =
(j)		S	236	T	143.7	S = T =

6 Projectile Motion

Galileo and projectiles

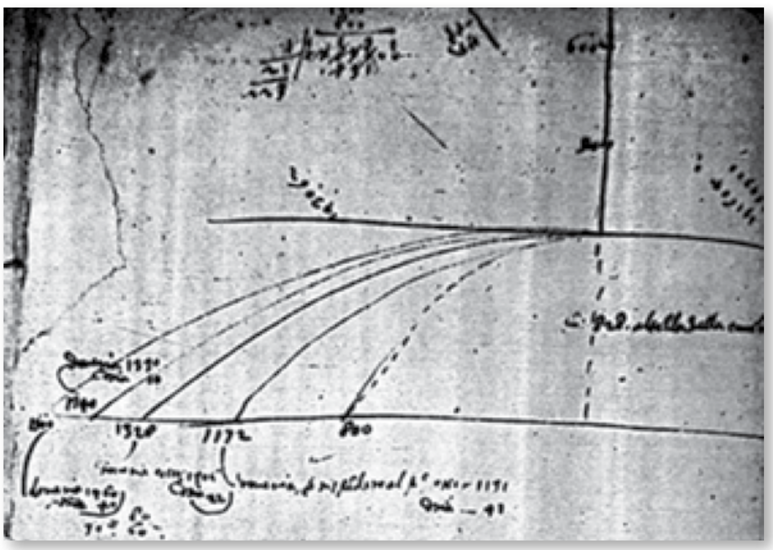
Galileo was one of the first scientists to study moving objects. He reputedly dropped masses from the Leaning Tower of Pisa to show that all objects fall at the same rate.

He also studied the relationship between the vertical and horizontal components of the velocity of a projectile by dropping a cannonball from the mast of a moving ship. The ball landed at the base of the mast and was not 'left behind' as those who supported Aristotle's ideas of motion believed.

In this way he showed that the components of the motion of a projectile were independent of each other.

In essence, Galileo's work showed that:

1. The horizontal motion of a moving object is not subject to gravitational forces, and therefore experiences no acceleration.
2. The vertical motion of an object is affected by the downwards force of gravity which gives it an acceleration of 9.8 m s^{-2} (slightly varying depending on where the object is).



Part of Galileo's original analysis of projectile motion.

Galileo's analysis of projectiles

- Horizontal and vertical components of projectile motion are independent of each other.
- Horizontal motion of a moving object is not subject to gravitational forces, and therefore experiences no acceleration.
- Vertical motion of an object near the surface of the Earth is affected by the downwards force of gravity which gives it an acceleration of 9.8 m s^{-2}.

Projectile motion and Newton's equations of motion

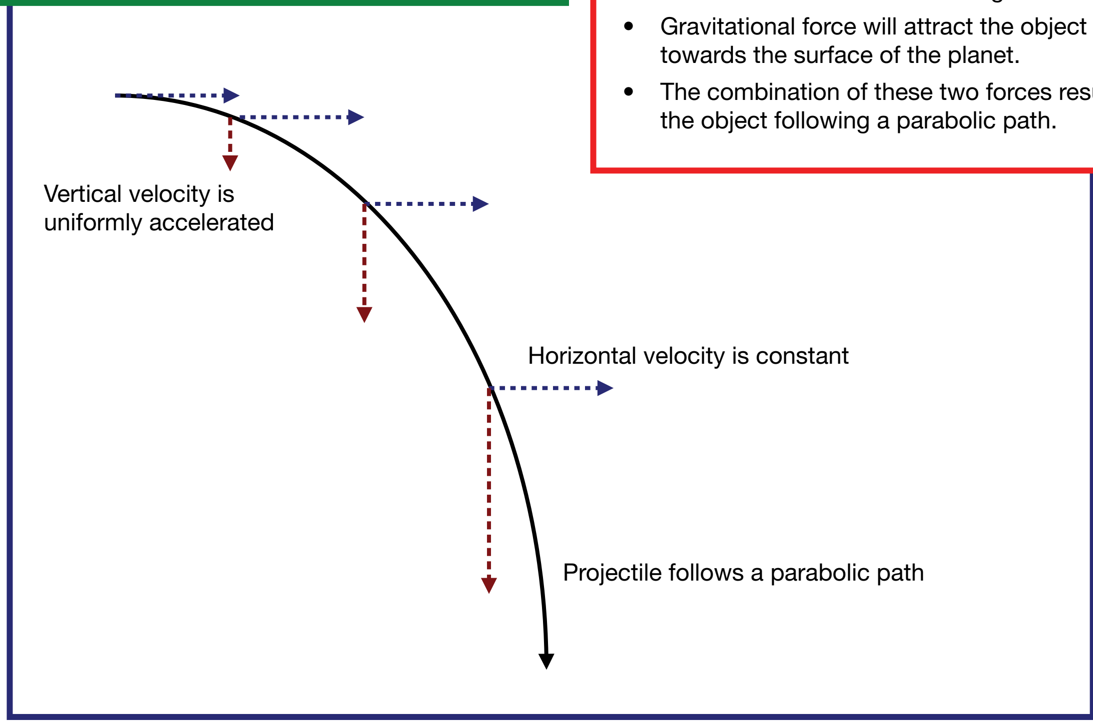
Three different types of projectile situations are detailed in the chapters that follow. Each type has specific data that assists in solving problems centred on that type. For all types, the basic equations used are derived from Newton's equations of linear motion. When applied to projectile motion, each equation is adapted to suit the characteristics of the horizontal and vertical components of the motion. The table summarises these equations.

Equations used in straight line motion	Horizontal component of motion	Vertical component of motion
$v = u + at$	$u_x = u \cos \theta$	$u_y = u \sin \theta$
$v^2 = u^2 + 2as$	$v_x = u_x$ ($a_x = 0$)	$v_y = u_y + a_y t$
$s = ut + \frac{1}{2}at^2$	$v_x^2 = u_x^2$	$v_y^2 = u_y^2 + 2a_y \Delta y$
	$\Delta x = u_x t$	$\Delta y = u_y t + \frac{1}{2}a_y t^2$

A projectile is any object thrown or shot into the air at any angle.

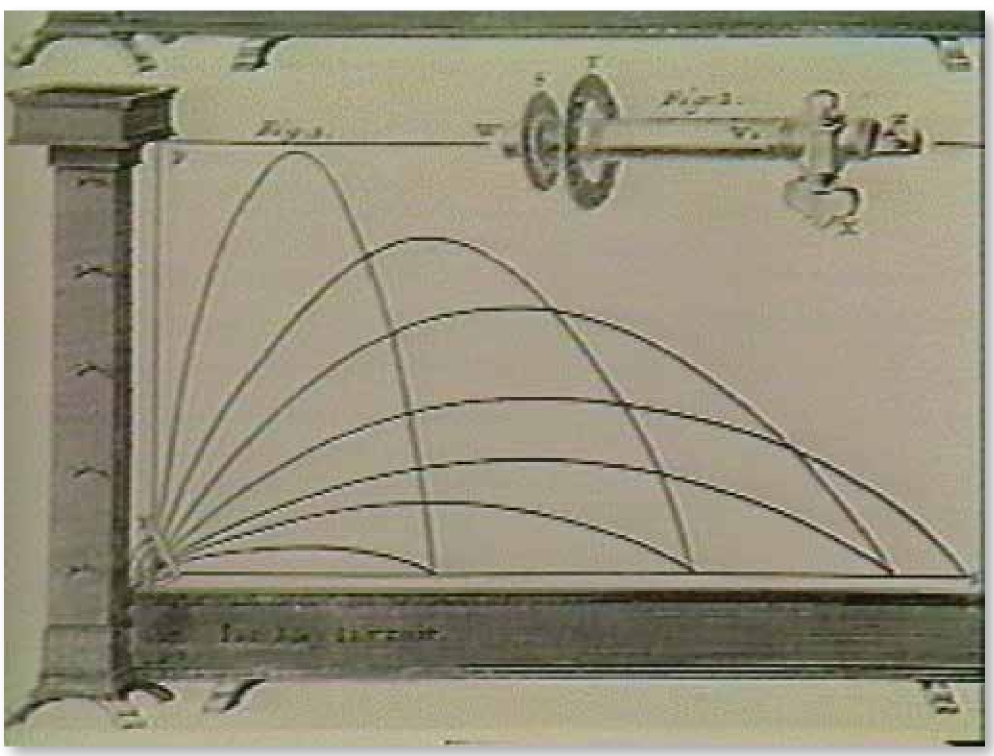
Trajectory of a projectile

- A projectile within a gravitational field is subject to its own inertia and to gravitational force.
- Inertia will cause it to continue to move in the direction of its motion in a straight line.
- Gravitational force will attract the object towards the surface of the planet.
- The combination of these two forces results in the object following a parabolic path.



QUESTIONS

1. The diagram shows more of Galileo's analysis of projectile motion. In this diagram he is predicting that projectiles fired at complementary angles with the same velocities will have the same range.
By considering projectiles fired at 40 m s^{-1} at both 30° and 60° to the horizontal, show that Galileo's prediction is supported.



7 Projectile Motion Problems 1

Object projected from a horizontal surface

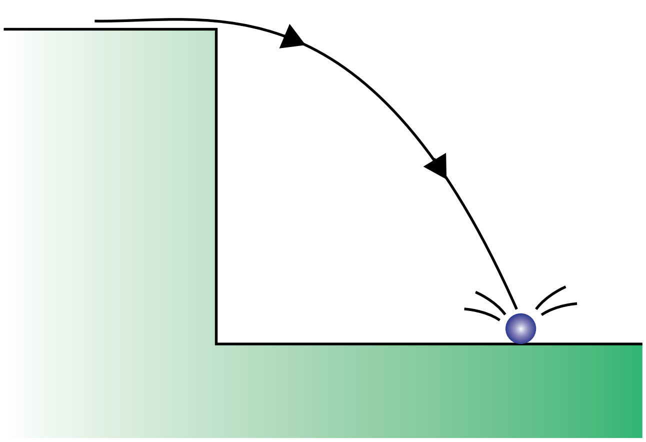
Special considerations:

- Initial vertical velocity = 0
- $\theta = 0°$

QUESTIONS

For each of the problems below, consider a projectile dropped vertically out of a moving object such as a plane, thrown horizontally out from the top of a cliff, or fired horizontally and landing on a surface as shown in the diagram. For each find any of the quantities which are not in the given data (not necessarily in the order given).

(a) The initial velocity of the projectile.
(b) Its initial horizontal velocity.
(c) Its initial vertical velocity.
(d) Its range.
(e) Its final horizontal velocity.
(f) Its final vertical velocity.
(g) Its final velocity.
(h) The time taken to fall.
(i) The height from which it was thrown or dropped.
(j) Its velocity 3 seconds after dropping.
(k) Its height 5 seconds after dropping.



1. A lifeboat is dropped from a plane moving at 140 m s^{-1} from a height of 1102.5 m.
2. A box of supplies is dropped from a helicopter moving at 80 m s^{-1}. They hit the ground 9.0 s later.
3. A ball is thrown horizontally from the top of a building and lands in a bucket on the ground 50 m in front of the building 3.0 s later.
4. A rock is thrown horizontally out from the top of a 147 m cliff. It hits the ground 80 m from the base of the cliff.
5. A ball thrown horizontally out from the top of a cliff hits the ground 6 s later at 30° to the vertical, and moving at 67.9 m s^{-1}.
6. A cannonball is fired horizontally from a castle. It hits its target 150 m away after 7.5 s.
7. An arrow is fired horizontally at the centre of a target 50 m away. Unfortunately, the archer made no allowance for gravity, and the arrow hit 0.8 m below centre.
8. A cannon fires a ball at 150 m s^{-1} which hits its target 675 m away.
9. A lifeboat is dropped from a plane moving at 80 km h^{-1}. It lands in the water 8 s later.
10. A projectile hits the centre of a target at an angle of 15° to the vertical 15 s after being dropped from a helicopter.
11. A car, moving at 30 m s^{-1}, goes over the edge of a cliff and into the water 58.8 m below.
    (a) Calculate the time it takes the car to hit the water.
    (b) Calculate the distance from the cliff that the car hits the water.
    (c) Calculate the speed of the car just as it hits the water.
12. A group of lemmings run over the edge of a 200 m cliff at 0.6 m s^{-1}.
    (a) Calculate their time to fall to the bottom of the cliff.
    (b) Calculate their velocity halfway down.
    (c) Calculate the time their speed will be 30.0 m s^{-1}.
    (d) Calculate the speed at which they hit the ground.

TOPIC 6 Gravity and Motion

Topic 6 Test

For each question, choose the most correct answer.

1. What is weight?
   (A) A measure of the amount of matter in an object.
   (B) A measure of the strength of the gravitational field the object is placed in.
   (C) A measure of the gravitational acceleration of the planet.
   (D) A measure of the force of gravity acting on an object.

2. Which statement about the weight of an object is correct?
   (A) If gravitational acceleration is zero, then weight is zero.
   (B) The weight of a particular object is constant on a particular planet.
   (C) The weight of an object will not change when it is taken to a different planet.
   (D) Weight is independent of the value of the acceleration due to gravity.

3. Which equation could be used to determine the weight of an object?
   (A) $m = \frac{F}{a}$ (B) $F = ma$
   (C) $m = \frac{F}{g}$ (D) $F = mg$

4. A traveller weighs herself at sea level and on top of a high mountain using the same set of scales. Which statement about her weight is correct?
   (A) Weight will be the same at both locations because weight is independent of position.
   (B) Weight will be greater on the mountain, since weight is proportional to distance from the Earth's centre.
   (C) Weight will be more at sea level because weight is inversely proportional to distance above the Earth's surface.
   (D) Weight will be less at sea level because weight is dependent on position above Earth's surface.

5. An object has a mass of 15 kg on Earth. What would be its mass on Mars where the acceleration due to gravity is 0.38 that of Earth?
   (A) 5.7 kg
   (B) 15 kg
   (C) 55.86 N
   (D) 147 N

6. An object has a weight of 35.93 N on the Moon where the gravitational acceleration is about one sixth that of Earth. What would be the mass of the object on Earth?
   (A) 3.67 kg
   (B) 6.0 kg
   (C) 22 kg
   (D) 35.93 kg

7. An object has a mass of 10 kg. On which planet would its weight be greatest?
   (A) Saturn
   (B) Jupiter
   (C) Mercury
   (D) Mars

Use the following equation for the period of a swinging pendulum to answer the next TWO questions.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

8. Which two variables, when plotted, would produce a straight line graph?
   (A) T versus $\sqrt{L}$
   (B) T versus L
   (C) T versus L^2
   (D) T^2 versus $\sqrt{L}$

Answers

Topic 6 Gravity and Motion

1 Components Of Vectors

1. A = 25
   B = 43.3
   C = 5.2

2.

	Horizontal component	Vertical component
(a)	43.3	25.0
(b)	23.9	65.8
(c)	46.0	38.6
(d)	36.9	25.8
(e)	25.0	43.3
(f)	103.4	37.6

2 Adding Vector Components

1. (a) 67.7 m bearing 034° (all to nearest degree)
   (b) 36.7 m s^{-1} bearing 060°
   (c) 92.3 m s^{-1} bearing 247°
   (d) 54 m bearing 117.5°
   (e) 2296.5 m s^{-1} bearing 282°
   (f) 3785 m bearing 067°

3 Vectors In Two Dimensions 1

(*Note*: All bearings to nearest degree.)
P = 3 cm E; Q = 4 cm W; R = 3 cm S; S = 6 cm N

1. (a) P + Q = 3 – 4 = –1 cm or 1 cm bearing 270°
   (b) Q + R = 5 cm bearing 233°
   (c) 3 cm bearing 000°
   (d) 6.7 cm bearing 027°
   (e) 3.16 cm bearing 198°
   (f) 5 cm bearing 307°
   (g) 4.2 cm bearing 045°
   (h) 6.1 cm bearing 351°
   (i) 3.16 cm bearing 342°