Contents

Introduction

This workbook is divided into six chapters. Each chapter features the following:

- bite-size sections of theory, with brief, clear explanations
- examples to illustrate key aspects of theory
- relevant Questions, with typical problems for student practice.

Answers to all Questions are provided in the back of the book.

The chapter on Achievement Standard 90937 (Physics 1.3) also covers the content needed to enable students to prepare for the Level 1 Science Achievement Standard 90941 (Science 1.2).

The chapter on Achievement Standard 90938 (Physics 1.4) also covers the content needed to enable students to prepare for the Level 1 Science Achievement Standard 90942 (Science 1.3).

The chapter on Achievement Standard 90939 (Physics 1.5) also covers the content needed to enable students to prepare for the Level 1 Science Achievement Standard 90943 (Science 1.4).

Physics is a subject with a very extensive vocabulary, which must be learned in order to understand Physics ideas. Key words are written **in bold** and form the index at the back of the book.

This write-on workbook provides a full year of classroom and homework activities, and offers a solid preparation for students as they sit assessments.

Acknowledgements

Thanks to Terry Bunn for editing this book.

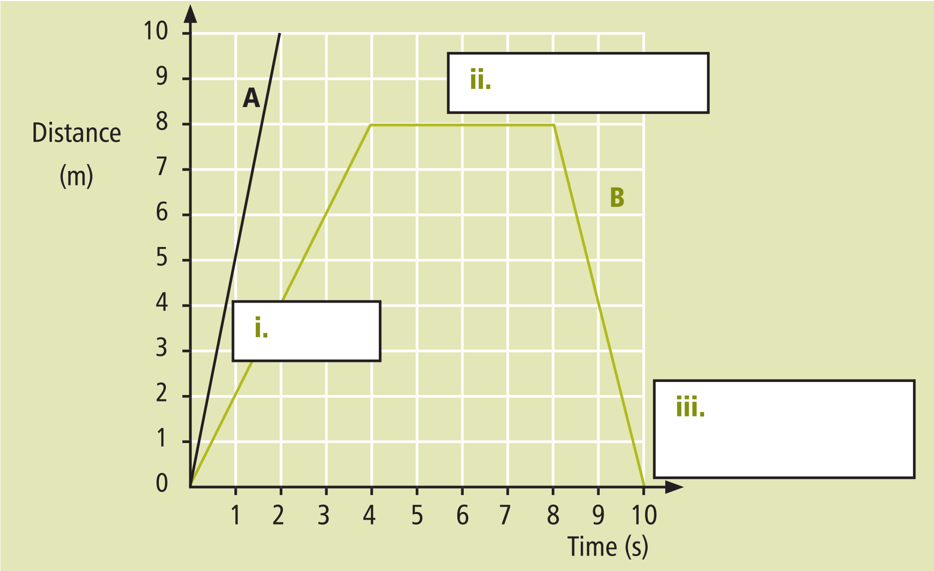
Pauline Bendall (Auckland), Mairi Borthwick (Palmerston North) and Glennis Moriarty (Hastings)

December 2011

Questions Unit 2: Distance-time graphs

1. a. Write the following labels in the correct boxes on the distance-time graph of moving object **B**:

stationary | steady speed | steady speed returning to start



b. i. After 1 second, what distance from the start was the moving object represented by line **A**? ________

ii. Calculate the speed of the moving object represented by line **A**.

____

____

c. From the graph, state the total number of seconds the moving object represented by line **B** was:

i. moving __________

ii. stationary. __________

2. The journey of a truck is shown in the following table.

Time	Distance from start (km)
9 am	0
10 am	20
11 am	40 – truck stops
	Long lunch break
2 pm	40
3 pm	70

The work done by the force of the racket strings (see picture alongside) first changes all the kinetic energy of the tennis ball to heat and elastic potential energy (because the ball has to stop before it can reverse its direction), then the work done by the forces between the ball and the racket strings give the ball its kinetic energy in the opposite direction.

Work is done to lift an object. The work done is the energy changed – the energy changed is the gravitational potential energy gained by the object.

$W = \Delta E_p \Rightarrow Fd = mg\Delta h$, where $d = \Delta h$

This means that $Fd = mgd$, and so F is mg

This means the size of the force needed to lift an object is equal to the weight of the object.

Example

At the gym, a person lifts a 2 kg ball from the floor to a height of 1.5 m above the floor.

a. Explain the size of the force that is needed from the person to lift the ball at constant speed.

b. Calculate the work that is done to lift the ball to its maximum height.

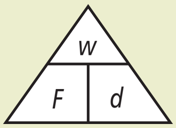
Solution

a. If the ball is lifted at constant speed, the forces on it are balanced. The downward force is the gravity force, so the upward force from the person must be equal to the downward gravity force.

$F = mg = 2 \times 10 = 20$ N

b. $W = Fd = 20 \times 1.5 = 30$ J

The triangle for the equation $W = Fd$ gives the other forms of the formula:



to calculate force from work and distance, use $F = \frac{W}{d}$

to calculate distance from work and force, use $d = \frac{W}{F}$

Questions Unit 11: Work

1. a. Describe the two factors that must be present for work to be done.

b. For each situation in the following table, say whether work is done or not, and give a reason. The first one has been done for you.

Situation	Work done?	Reason
i. A girl climbs a stepladder.	Yes	The force from the girl's arms and legs make her move upwards.
ii. A child pulls a toy along the floor.		
iii. A crane exerts a force of 10 000 N on a container but cannot move the container.		
iv. A rock falls off a cliff into a river.		

A **conductor** is a substance that allows charge (usually electrons) to *flow freely* through it. Most *metals* are conductors. An **insulator** is the opposite – electrons are *not able to flow easily* through a substance that is an insulator. Water, although obviously not a metal, is a relatively good conductor.

Questions Unit 1: Electric charge

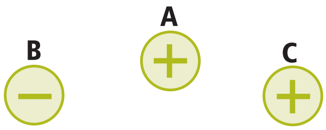
1. Name the particles of an atom that have electric charge, and state what type of charge each one has.

2. Even though an atom is made of lots of charged particles, it is neutral. Explain how this can be so.

3. Explain what will happen to the charge on an atom if an electron is removed from its outer shell.

4. Following is a list of different substances:
   rubber iron aluminium wood glass paper
   Explain which of the substances will allow charge to flow through them, and which will not.

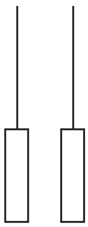
5. The diagram shows three charged objects resting on a frictionless surface. Object **A** is fixed and cannot move. Objects **B** and **C** are being held in the positions shown. Objects **A** and **C** are both positively charged, object **B** is negatively charged. Explain what will happen to **B** and **C** if they are released.



B:

C:

6. A long plastic rod was charged along its full length and then broken in half. Both halves were suspended by a length of insulating thread and brought close to each other, as shown in the diagram. State what would happen, and explain your answer.



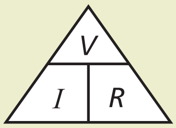
Unit 10 – Ohm's law

In both series and parallel circuits, the *size* of the current coming from (and therefore going into and through) the energy source depends on the *voltage* of the energy source and the *total resistance* of the circuit.

The mathematical relationship that allows the size of the current to be calculated is:

$$\text{current} = \frac{\text{source voltage}}{\text{total resistance}} \text{ or } I = \frac{V}{R}$$

The *triangle* for the equation $I = \frac{V}{R}$ gives the other forms of the equation:



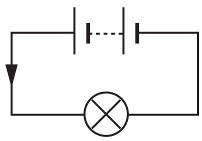
- to calculate the resistance, use $R = \frac{V}{I}$
- to calculate the voltage, use $V = IR$

The relationship between voltage, current and resistance is known as **Ohm's law**.

Ohm's law can be applied to each *individual* converter in the circuit as well as to the whole circuit. If it is applied to an individual converter, I is the current through the converter, R is the resistance of the converter and V is the voltage of the converter.

Questions Unit 10: Ohm's law

1. The diagram shows a simple circuit.



   a. Calculate the current in the circuit if the voltage of the battery is 1.5 V and the resistance of the lamp is 3 Ω.

   ---

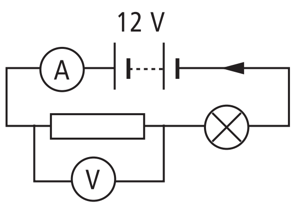
   b. Calculate the voltage of the lamp if the current in the circuit is 2 A and the resistance of the lamp is 4.5 Ω.

   ---

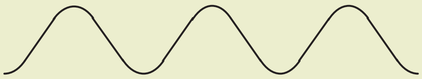
   c. Calculate the resistance of the lamp if the voltage of the battery is 3 V and the current in the lamp is 0.6 A.

   ---

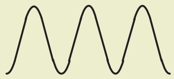
2. In the circuit shown, the voltmeter reads 7.5 V and the ammeter reads 1.5 A.



In a particular medium, the *frequency* of a wave determines the *wavelength* of the wave. The wave equation shows that if a wave has a *high* frequency it will have a *short* wavelength.

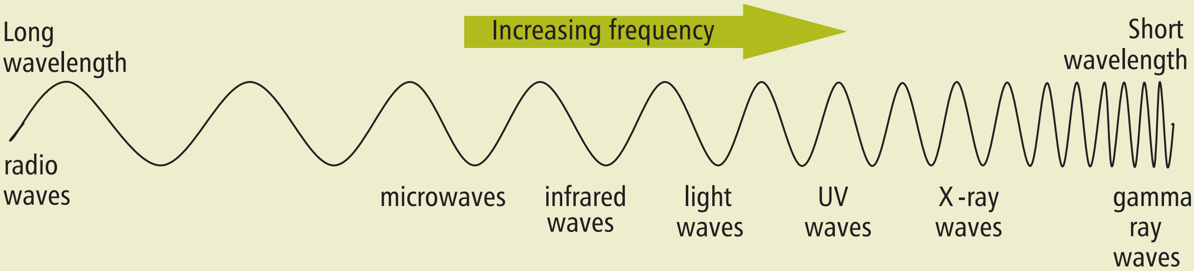


Long wavelength,
low frequency

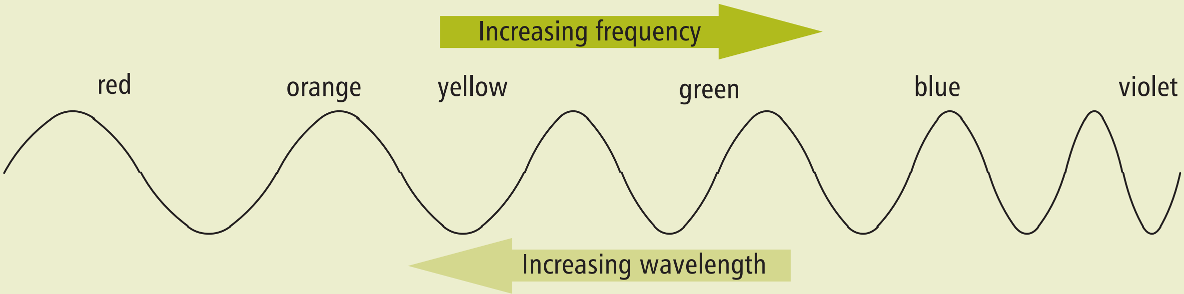


Short wavelength,
high frequency

The different *types* of electromagnetic waves (radio, microwaves, infrared, light, ultraviolet, X-ray and gamma) all have a different frequency range.



Light waves are just a small group in the complete range of electromagnetic waves. The different colours that make up the complete spectrum of light are shown in the following diagram.



Red light has a lower frequency and so a longer wavelength than blue light.

Questions Unit 2: Speed of a wave

The speed of light in air is 3×10^8 m s^{-1}

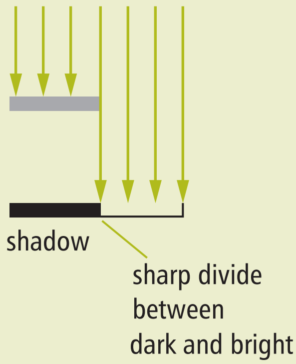
1. A flash of lightning occurs out at sea. The sound of the thunder and light from the flash have to travel a distance of 12 km before they are heard and seen by the people on land.

a. It takes 35 seconds for the sound of the thunder to travel the 12 km.

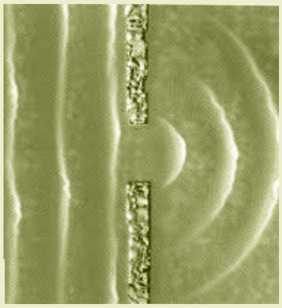
i. Change 12 km to metres.

ii. Calculate the speed of the sound of the thunder.

b. Calculate the time it takes for the light to travel 12 km.



If a wave passes through a *gap* in a barrier, diffraction occurs at *both* edges of the gap, so the wave passing through the gap tends to become circular in shape. The picture alongside shows water waves diffracting through a gap in a sea wall.



The bending of waves increases when the *width* of the gap is about the same as the *wavelength* of the wave. It is even possible to make light diffract through quite large angles by sending it through a gap that is approximately as wide as the wavelength of the light. As this gap has to be incredibly narrow, not much light gets through; so, to be able to *see* the effect, it is necessary to use a very intense source of light, such as laser light.

Questions Unit 3: Reflection, transmission and diffraction of a wave

1. When the Sun shines on to the sea, part of the light is reflected back into the air and part is transmitted into the water.

   a. Explain what will happen to the frequency, speed and wavelength of the reflected and transmitted light.

   b. Explain how the amplitude of the reflected and transmitted light will compare with the amplitude of the incident light.

Unit 8 – Putting it together

In the Achievement Standard 90938 examination, questions are not divided into sections as they are in this book. It is most likely that each question will relate to a situation which is characterised by the way a wave is experienced. You will have to decide which aspect of wave behaviour is relevant in the situation described. If you have to solve a numerical problem, you will have to choose which equation to use. The equations are given at the start of the examination paper. Sometimes, you will need to use the triangle method to find another form of an equation.

Following are the equations given, and four questions for practice.

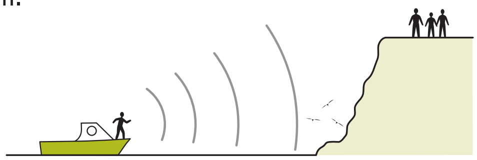
Equations

$v = \frac{d}{t}$ $v = f\lambda$ $f = \frac{1}{T}$

Questions Unit 8: Putting it together

1. ***All at sea***

Some seagulls are flying around the base of a cliff just above where the waves are crashing in. A group of trampers are walking along the top of the cliff. Someone is standing on the deck of a boat that is anchored 500 m from the base of the cliff.



The speed of light in air is 3×10^8 m s^{-1}, and the speed of sound in the air is 340 m s^{-1}.

a. Although the trampers cannot see the breaking waves, they can hear them. Explain why it is possible for the trampers to hear the sound of the waves even though they cannot see them.

b. The trampers cannot see the seagulls and nor can they hear the sound of their high-pitched screeching. Explain why the trampers can hear the sound of the waves but not the sound of the seagulls.

c. The high-pitched cries from the seagulls have a frequency of 750 Hz. Calculate the wavelength of the sound produced by the seagulls.

d. Calculate the time it takes for light from the cliff to reach the boat.

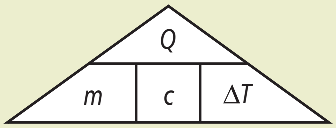
Example

How much heat energy is required to raise the temperature of 5 kg of water from 20 °C to 100 °C?

$Q = mc\Delta T = 5 \times 4\,200 \times (100 - 20) = 1\,680\,000$ J (1 680 kJ)

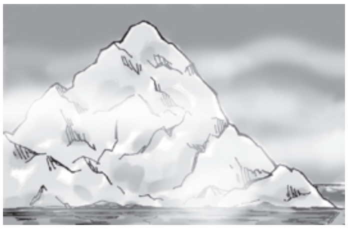
The triangle for the equation $Q = mc\Delta T$ gives other forms of the formula:

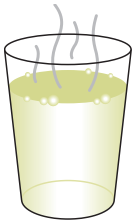
- to find mass, use $m = \dfrac{Q}{c\Delta T}$
- to find specific heat capacity, use $c = \dfrac{Q}{m\Delta T}$
- to find change in temperature, use $\Delta T = \dfrac{Q}{mc}$



Questions Unit 1: Heat and temperature

1. Which of the two objects, an iceberg or a glass of boiling water, has the most heat energy and why?





Object with most heat energy: ____________________

Reason: ____________________

2. Explain why people are not burned when the white-hot sparks (over 1 000 °C) from a sparkler hit their hands on Guy Fawkes Night, yet can be burned by a teaspoon of boiling water (only 100 °C).

3. **a.** In the box, write the formula for calculating the amount of heat energy required to change the temperature of a substance when the mass, specific heat capacity and temperature change are known.

b. Calculate the amount of heat energy required to increase the temperature of 2 kg of water from 15 °C to 70 °C. The specific heat capacity of water is 4 200 J kg^{-1} °C^{-1}.

4. **a.** In the box, write the formula for calculating the specific heat capacity of a substance when the mass, temperature change, and the amount of heat energy required are known.

b. The amount of heat energy required to change the temperature of a 0.5 kg piece of aluminium by 35 °C is 15 750 J. Calculate the specific heat capacity of aluminium.

Unit 5 – Power and heat energy

When a substance changes temperature, heat energy is either absorbed or released. The rate at which this occurs is called the **power**.

Power is measured in **watts** (**W**). 1 W is equal to 1 J s^{-1}

Power can be calculated using the formula:

$$P = \frac{E}{t}$$

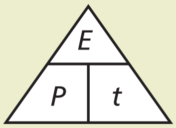
Where:

P is the power, measured in watts (W)

E is the energy used to change the temperature, measured in joules (J)

t is the time taken for the temperature change, measured in seconds (s)

The triangle for the equation $P = \frac{E}{t}$ gives other forms of the formula:



- to find energy, use $E = Pt$
- to find time taken, use $t = \frac{E}{P}$

Example

An electric jug uses 132 000 J of heat energy in 60 seconds. Calculate the power rating of the electric jug.

$$P = \frac{E}{t} = \frac{132\ 000}{60} = 2\ 200 \text{ W}$$

Questions Unit 5: Power and heat energy

1. 9 800 000 J of heat energy is required to heat a water tank back up to its original temperature of 80 °C after some cold water has been added. If it takes 90 minutes for this to happen, what is the power output of the heater inside the water tank?

2. The power output of a heat lamp is 250 W. Calculate the amount of time the lamp was on if 120 000 J of heat energy was produced.

3. Calculate the amount of heat energy produced by an iron, which has a power output of 650 W, if it is turned on for 3 minutes.

Example

In an investigation into the effect of air pressure in a basketball on the height the ball will bounce:

- the independent variable is the *air pressure* inside the ball, which you would *change* using a hand pump and pressure gauge for five evenly spaced values between zero pressure and as high as is safely possible for the ball, e.g. between 0 and 100 kPa
- the dependent variable is *height* the ball bounces, which you would *measure* using an appropriate instrument (e.g. a metre ruler), and in appropriate units (e.g. cm)
- controlled variables include always using the same ball, dropping the ball on the same surface for all trials, dropping from the same height for each trial.

Questions Unit 1: Variables

1. Describe the difference between an independent variable, a dependent variable and controlled variables.

2. For each of the following investigations, identify the independent variable and the dependent variable. State the variable(s) that must be controlled if the investigation is to be a fair test.

a. The relationship between force on a spring and how far the spring extends.

i. Independent variable:

ii. Dependent variable:

iii. Controlled variable(s):

b. The relationship between the drop height of a rubber ball and the height of the first bounce when the ball is dropped.

i. Independent variable:

ii. Dependent variable:

iii. Controlled variable(s):

c. The relationship between the vertical height of a ramp from which a toy car is released and the distance the toy car travels along a flat surface before stopping.

i. Independent variable:

ii. Dependent variable:

iii. Controlled variable(s):

3. Hannah wanted to find the relationship between the length of time water is heated from cold in a microwave oven and the increase in temperature of the water.

a. Describe the independent variable.

b. State the variables Hannah must control to make the experiment a fair test.

AS 90935

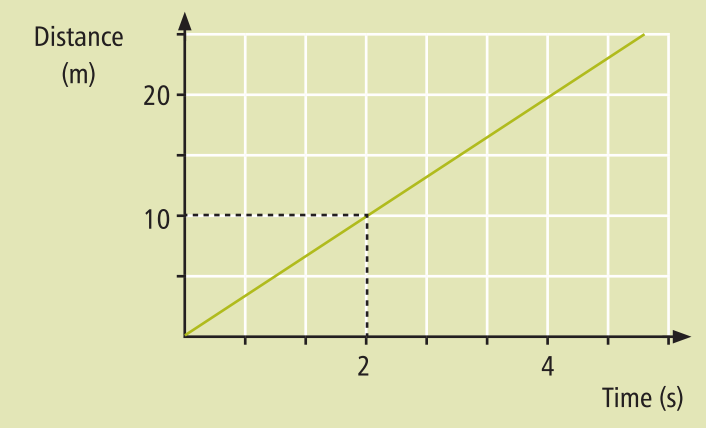
Physics theory

In some experiments, the graph line can be used to find the value of a **physical quantity**, e.g. speed can be found from the line on a distance-time graph.

From the line on the following graph,

$$\text{gradient} = \frac{\Delta d}{\Delta t} = \frac{10 - 0}{2 - 0} = 5.0$$

but $v = \dfrac{\Delta d}{\Delta t}$, so gradient of the graph is speed, $v = 5.0 \text{ m s}^{-1}$



The discussion should, if possible, give some of the physics theory behind what the investigation demonstrates. For example, for the stretched spring experiment in Unit 4, Question **2.**, pages 142–143, the information given in the investigation would have included a statement that the distance a spring extends when stretched has a proportional linear relationship with the mass causing the stretch. In their conclusion, the students will have stated the relationship between spring length and mass is linear, but not proportional. In the discussion, students may explain that the intercept on the graph is the length of the spring when there is no mass on the end – i.e. the unextended length of the spring. If this length is subtracted from each of the spring lengths – to give the spring extension for each mass – the graph line would go through the origin, showing the proportional relationship.

AS 90935

Questions Unit 6: Discussion

1. Explain why, in an investigation into the stopping distance of a toy car running off a ramp, the same car was used for all trials.

2. In an experiment to measure the speed of sound, a person had to click a stopwatch when she heard the sound from a starter's pistol. Explain why it was necessary to do at least four trials and obtain an average time.

Unit 4: Processing information

A **key word** is a word or phrase within a text that identifies the main ideas. Key words help answer a question and summarise what has been written in your *own words*. Identify and record key words as you read information, by underlining, highlighting, or listing them.

Questions Unit 4A – Identifying key words

1. Read the passage following then answer the questions that follow.

Half-life

It is impossible to predict when an atom in a particular sample of radioactive atoms will disintegrate (break apart or decay), because the decay of an atom is completely random. However, the proportion of atoms in a sample which disintegrate in a particular time can be predicted. The number disintegrating depends only on the actual substance and the number of undecayed atoms in the sample. If the number of disintegrations (measured with a Geiger counter) is plotted against time, an exponential decay curve results. The half-life is the time taken for *half* the undecayed atoms in a sample to disintegrate and is taken as a measure of the rate of decay. The half-life of a substance is used to compare the rate at which disintegration occurs for different substances.

Source: Housden, D (2011). *NCEA Level 2 Physics Study Guide.* p. 168. ESA Publications,

a. Underline or highlight *five* key words. **Note**: Some key words may occur more than once in the passage.

b. Use the text to help you work out the meanings of the *two* key words that follow.

i. Key word 1: undecayed

ii. Key word 2: half-life

2. Read the passage following then answer the questions that follow.

Alpha particle

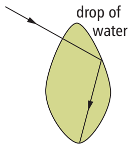
This is a high-speed helium *nucleus* (written ${}^{4}_{2}He^{2+}$) and usually called an alpha particle (written α-particle or ${}^{4}_{2}\alpha$). It is emitted from the nucleus of a larger atom. The helium nucleus can move with speeds up to 10% of the speed of light. Alpha particles have a range of only a few centimetres in air and most are stopped by a sheet of paper. Since it is highly charged, an alpha particle is deflected by a magnetic field.

Source: Housden, D (2011). *NCEA Level 2 Physics Study Guide*. p. 166. ESA Publications,

a. Underline or highlight *five* key words that help explain what an alpha particle is.

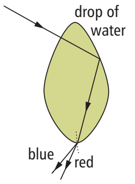
b. Using the key words you identified in **a.**, explain what an alpha particle is in your own words.

b. **i.** Both rays will be reflected, because the angle of incidence is greater than the critical angle. For both rays, the angle of incidence is equal to the angle of reflection; as both rays have the same angle of incidence, they will also have the same angle of reflection. This means they will both continue in the same straight line.

ii. 

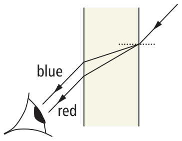
Again, the blue ray and the red ray are superimposed on each other – hence only the one single ray is shown.

c. **i.** Because the angle of incidence is less than the critical angle, both rays will be transmitted out into the air again. Because they are travelling at an angle to the normal, they will both be bent; because they both get faster, they will be bent away from the normal. Because the amount of bending depends on the frequency and because blue light has a greater frequency than red light, the blue ray is bent more than the red ray.

ii. 

d. Because the colours are fanned out, if they go into someone's eye, the person will see a rainbow of colours.

3. **Stargazing** ☆

a. 

The blue ray and the red ray came from white light that had passed through air through glass then back out into air. The amount of bending of the blue ray and the red ray as it comes out into air from glass is the same as the amount of bending that happened when the blue ray and the red ray went into the glass. This means that, even though the blue ray and the red ray are both bent by different amounts, they will both emerge travelling in the same direction.

b. The eye will only see a rainbow of colours if the different colours enter the eye in slightly different directions. In this situation, all the colours are travelling in the same direction and so the overall colour that is seen is white.

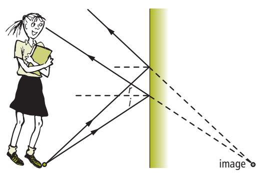
c. Sound is a wave that needs a medium through which to travel. As there is a vacuum between Jake and the star, it is impossible for a sound wave to be transmitted.

d. $t = \frac{d}{v} = \frac{4 \times 1\,000 \times 10^{13}}{3 \times 10^{8}} = 1.3333 \times 10^{8}\ \text{s} = \frac{1.3333 \times 10^{8}}{60}$

$= 2.2222 \times 10^{6}$ min

$= \frac{2.2222 \times 10^{6}}{60}$ 37 037 hours $= \frac{37\,037}{24} = 1\,543$ days

$= \frac{1\,543}{365} = 4.2$ years $= 4$ years and 3 months

4. **a.** 

In **i.**, the normal should be marked and the angle of incidence should be the same size as the angle of reflection.

In **ii.**, the second ray must have a reflected direction such that the image position is exactly the same distance behind the mirror as the foot position is in front of the mirror.

b. The image is the same size as Caitlin, and is the same way up.

c. The left hand of the image will wave back. This is because the image is laterally inverted.

d. The image will appear to be 2 metres away, because the image is the same distance behind the mirror as Caitlin is in front, so 1 metre from Caitlin to the mirror plus 1 metre from the mirror back to the image makes 2 metres altogether.

e. The mirror must be at least 0.6 m long, because the reflected ray from Caitlin's foot comes from the mirror at a point that is about half Caitlin's height up from the floor. None of the mirror below this point is needed.

Achievement Standard 90939 (Physics 1.5)

Unit 1: Heat and temperature (page 117)

1. Heat is the total energy of molecular motion in a substance; temperature is a measure of the average energy of molecular motion in a substance. Heat energy depends on the speed of the particles, the number of particles (the size or mass), and the type of particles in the object. Temperature does *not* depend on the size or type of object. The temperature of the glass of boiling water might be higher than the temperature of the iceberg, but the iceberg has more heat because it has *many* more water particles and thus more total thermal energy.

2. The white-hot sparks, although they have a high temperature (over 1 000 °C), they have a *very* small mass so overall do *not* contain much heat energy. $Q = mc\Delta T$ means that if m is very small even if T is high, the heat energy, Q, will be low. A teaspoon of boiling water, although 'only' 100 °C, has *much* more mass, so, overall, contains much more heat energy. $Q = mc\Delta T$ means that if m is relatively large, even if T is relatively low, heat energy, Q, will be high. It is the amount of heat energy transferred by an object to the skin that causes a burn, not the temperature of the object.

3. **a.** $Q = mc\Delta T$

b. $Q = 2 \times 4\,200 \times (70 - 15) = 462\,000$ J (462 kJ)

4. **a.** $c = \frac{Q}{m\Delta t}$

b. $c = \frac{15\,750}{0.5 \times 35} = 900\ \text{J kg}^{-1}\ {}^{\circ}\text{C}^{-1}$

5. $Q = mc\Delta T;\ \Delta T = \frac{Q}{mc} = \frac{420\,000}{5 \times 4\,200} = 20$

$\Delta T = T_F - T_I;\ T_F = \Delta T + T_I = 20 + 10 = 30\ {}^{\circ}\text{C}$

6. Because copper has a lower specific heat capacity than iron, it will require less heat energy to raise the piece of copper to a certain temperature than it will to raise the piece of iron to the same temperature; the piece of copper thus heats up quicker than the piece of iron.

Unit 2: Phase changes (page 118)

1. **a.** On hot days the metal on the roof heats up from the sun, and as a result expands. As this movement is restricted by the metal's attachment to the roof timber, the energy that is built up is released as noise.

b. This is to enable expansion to occur on hot days without the concrete cracking.

2. **a.** melting – energy added

b. condensation – energy removed

c. sublimation – energy added

3. Evaporation of water involves water changing from a liquid to a gas. To change to a gas, the particles in the liquid must move so quickly and with such energy that the attractive forces between the particles are broken. The particles gain sufficient energy to do this by the addition of heat energy.

INDEX