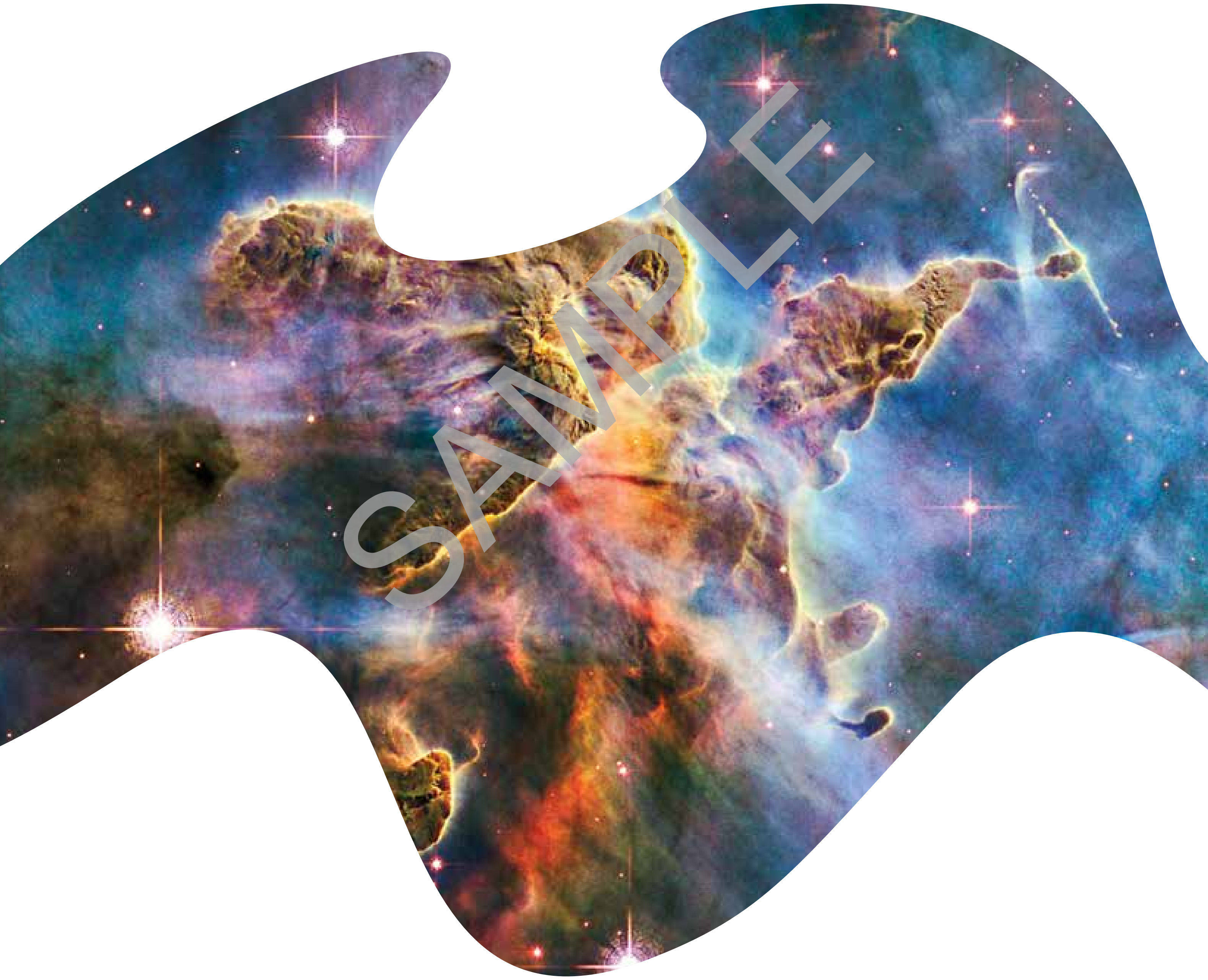
HEINEMANN PHYSICS 11

SKILLS AND ASSESSMENT



Doug Bail

VCE UNITS 1 AND 2 • 2023-2027

Contents

Unit 1 How is energy useful to society?

AREA OF STUDY 1

How are light and heat explained?

AREA OF STUDY 2

How is energy from the nucleus utilised?

AREA OF STUDY 3

How can electricity be used to transfer energy?

Contents

Unit 2 How does physics help us to understand the world?

AREA OF STUDY 1

How is motion understood?

WORKSHEETS

PRACTICAL ACTIVITIES

AREA OF STUDY 2

Options: How does physics inform contemporary issues and applications in society?

WORKSHEETS

AREA OF STUDY 3

How do physicists investigate questions?

ISBN 978 0 6557 0016 6

How to use this book

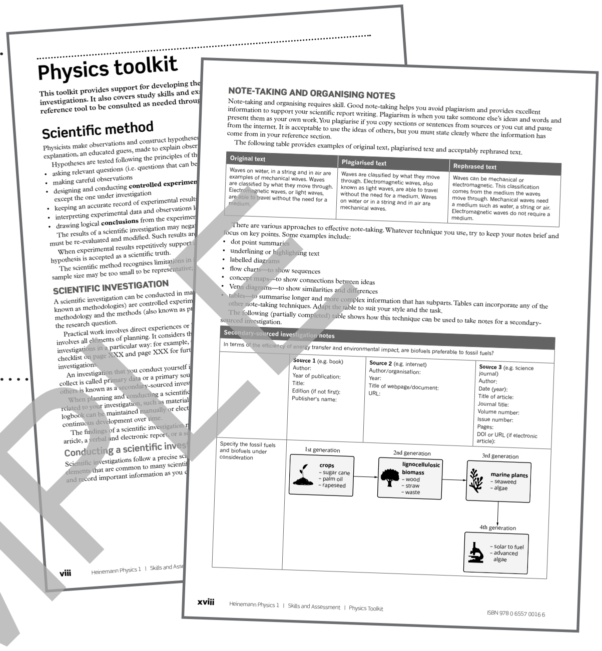
The *Heinemann Physics 11 Skills and Assessment* book provides the opportunity to practise, apply and extend your learning through a range of supportive and challenging activities. These activities reinforce key concepts and skills, and enable a flexible approach to learning. There are also regular opportunities for reflection and self-evaluation in the final worksheet in each Area of Study.

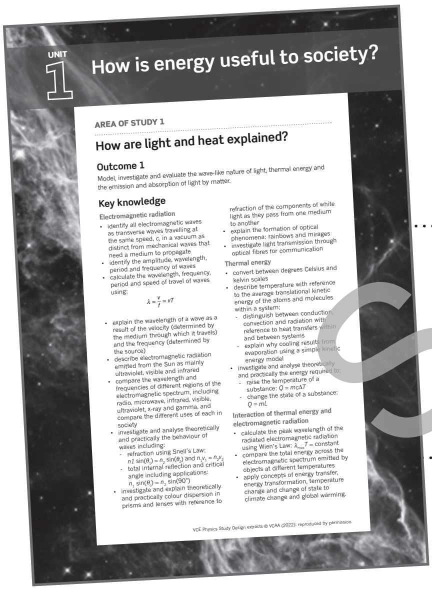
This resource has been written to the VCE Physics Study Design 2023–2027 and is divided into six areas of study: three in Unit 1 and three in Unit 2. Areas of Study 1–3 in Unit 1 and Area of Study 1 in Unit 2 consist of four main sections:

- key knowledge
- worksheets
- practical activities
- exam-style questions.

PHYSICS TOOLKIT

The Physics toolkit supports development of the skills and techniques needed to undertake practical and secondary-sourced investigations, and covers examination techniques and study skills. It also includes checklists, models, exemplars and scaffolded steps. The toolkit can serve as a reference tool and be consulted as needed.



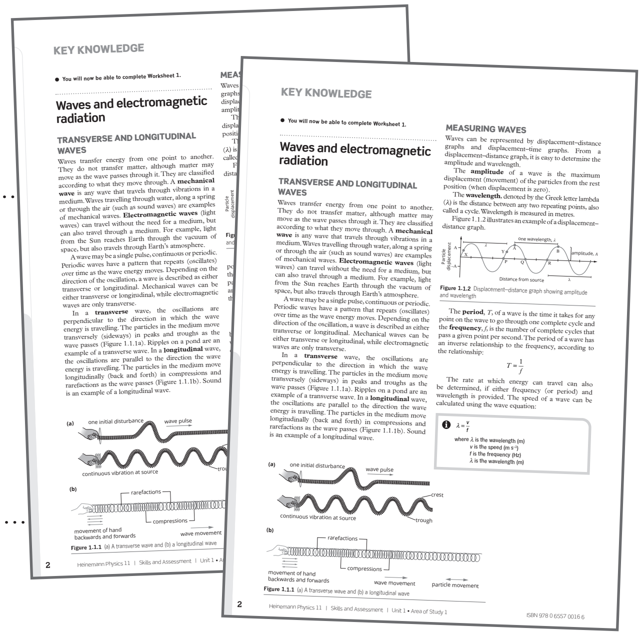


AREA OF STUDY OPENER

Heinemann Physics 11 Skills and Assessment is structured to follow the study design units and areas of study. The area of study opening page lists the study design key knowledge for easy reference to the activities that follow.

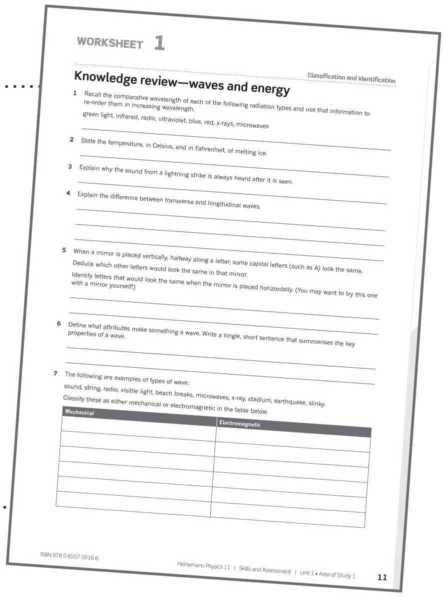
KEY KNOWLEDGE

Each area of study begins with a key knowledge section. This consists of a set of summary notes that cover the key knowledge for that area of study. Key terms are in bold and are included in the glossary of the student book. The section also serves as a ready reference for completing the worksheets and practical activities.



WORKSHEETS

The worksheets feature questions that allow you to practise and apply your knowledge and skills. Each area of study includes a 'Knowledge review' worksheet to activate prior knowledge, a 'Literacy review' worksheet that provides opportunities for vocabulary and literacy support, and a 'Reflection' worksheet, which you can use for self-assessment. Other worksheets provide opportunities to revise, consolidate and further your understanding. All worksheets function as formative assessment and are clearly aligned with the study design. A range of questions building from foundation to challenging is included in each worksheet.


WORKSHEET 1

Classification and identification

Knowledge review—waves and energy

1 Recall the comparative wavelength of each of the following radiation types and use that information to re-order them in increasing wavelength.
green light, infrared, radio, ultraviolet, blue, red, x-rays, microwaves

2 State the temperature, in Celsius, and in Fahrenheit, of melting ice.

3 Explain why the sound from a lightning strike is always heard after it is seen.

4 Explain the difference between transverse and longitudinal waves.

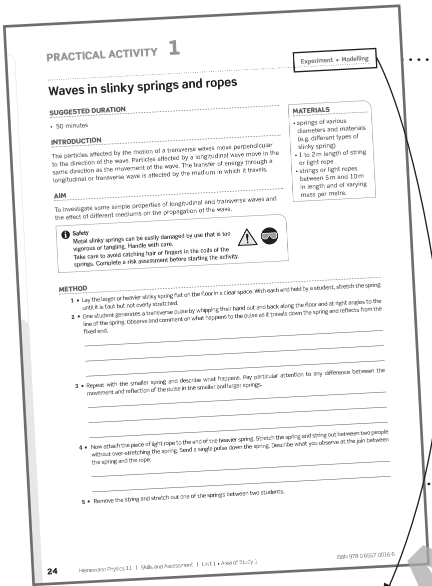
5 When a mirror is placed vertically, halfway along a letter, some capital letters (such as A) look the same. Deduce which other letters would look the same in that mirror.
Identify letters that would look the same when the mirror is placed horizontally. (You may want to try this one with a mirror yourself!)

6 Define what attributes make something a wave. Write a single, short sentence that summarises the key properties of a wave.

7 The following are examples of types of wave:
sound, string, radio, visible light, beach breaks, microwaves, x-ray, stadium, earthquake, slinky.
Classify these as either mechanical or electromagnetic in the table below.

Mechanical	Electromagnetic

ISBN 978 0 6557 0016 6 Heinemann Physics 11 | Skills and Assessment | Unit 1 • Area of Study 1 11


PRACTICAL ACTIVITY 1

Experiment • Modelling

Waves in slinky springs and ropes

SUGGESTED DURATION
• 50 minutes

INTRODUCTION
The particles affected by the motion of a transverse waves move perpendicular to the direction of the wave. Particles affected by a longitudinal wave move in the same direction as the movement of the wave. The transfer of energy through a longitudinal or transverse wave is affected by the medium in which it travels.

MATERIALS
• springs of various diameters and materials (e.g. different types of slinky spring)
• 1 to 2 m length of string or light rope
• strings or light ropes between 5 m and 10 m in length and of varying mass per metre.

AIM
To investigate some simple properties of longitudinal and transverse waves and the effect of different mediums on the propagation of the wave.

Safety
Metal slinky springs can be easily damaged by use that is too vigorous or tangling. Handle with care.
Take care to avoid catching hair or fingers in the coils of the springs. Complete a risk assessment before starting the activity.

METHOD
1 • Lay the larger or heavier slinky spring flat on the floor in a clear space. With each end held by a student, stretch the spring until it is taut but not overly stretched.
2 • One student generates a transverse pulse by whipping their hand out and back along the floor and at right angles to the line of the spring. Observe and comment on what happens to the pulse as it travels down the spring and reflects from the fixed end.
3 • Repeat with the smaller spring and describe what happens. Pay particular attention to any difference between the movement and reflection of the pulse in the smaller and larger springs.
4 • Now attach the piece of light rope to the end of the heavier spring. Stretch the spring and string out between two people without over-stretching the spring. Send a single pulse down the spring. Describe what you observe at the join between the spring and the rope.
5 • Remove the string and stretch out one of the springs between two students.

24 Heinemann Physics 11 | Skills and Assessment | Unit 1 • Area of Study 1 ISBN 978 0 6557 0016 6

Experiment • Modelling

PRACTICAL ACTIVITIES

Practical activities offer you the chance to complete practical work related to the various themes covered in the study design. You have the opportunity to design and conduct scientific investigations; generate, evaluate and analyse data; appropriately record results; and prepare evidence-based conclusions. Where relevant, you will also need to conduct risk assessments to identify any potential hazards.

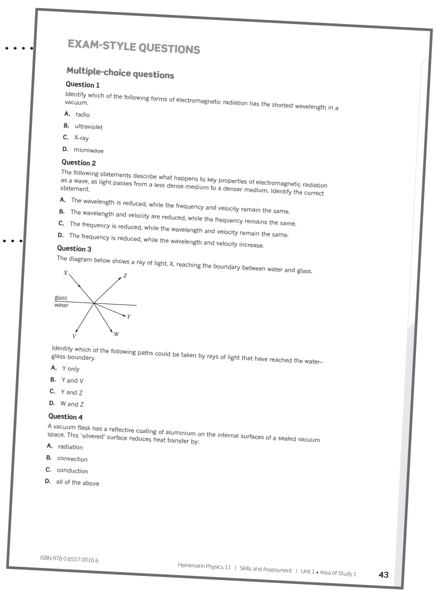
Each practical activity includes a suggested duration. Together with the Unit 2 Area of Study 3 scientific investigation, the practical activities meet the 32 hours of practical work mandated for Units 1 and 2 in the study design.

METHODOLOGIES

Each worksheet and practical activity is mapped to one or more of the scientific investigation methodologies outlined in the study design. Completing these activities gives you experience in applying the methodologies in a wide variety of contexts and prepares you for designing and conducting your own scientific investigation in Unit 2 Area of Study 3.

EXAM-STYLE QUESTIONS

Each area of study finishes with a selection of exam-style questions. These give you the opportunity to gain valuable experience applying your knowledge and understanding to exam-style questions.


EXAM-STYLE QUESTIONS

Multiple-choice questions

Question 1
Identify which of the following forms of electromagnetic radiation has the *shortest* wavelength in a vacuum.
A. radio
B. ultraviolet
C. X-ray
D. microwave

Question 2
The following statements describe what happens to key properties of electromagnetic radiation as a wave, as light passes from a less dense medium to a denser medium. Identify the correct statement.
A. The wavelength is reduced, while the frequency and velocity remain the same.
B. The wavelength and velocity are reduced, while the frequency remains the same.
C. The frequency is reduced, while the wavelength and velocity remain the same.
D. The frequency is reduced, while the wavelength and velocity increase.

Question 3
The diagram below shows a ray of light, X, reaching the boundary between water and glass.

Identify which of the following paths could be taken by rays of light that have reached the water–glass boundary.
A. Y only
B. Y and V
C. Y and Z
D. W and Z

Question 4
A vacuum flask has a reflective coating of aluminium on the internal surfaces of a sealed vacuum space. This 'silvered' surface reduces heat transfer by:
A. radiation
B. convection
C. conduction
D. all of the above

ISBN 978 0 6557 0016 6 Heinemann Physics 11 | Skills and Assessment | Unit 1 • Area of Study 1 43

TEACHER SUPPORT

Comprehensive answers and fully worked solutions for all worksheets, practical activities and exam-style questions are provided via the *Heinemann Physics 11 eBook + Assessment* or Pearson Places. In-depth support for Unit 2 Area of Study 3 in the form of samples, templates and teacher notes is also included, along with an interactive SPARKlab for every practical activity.

 ISBN 978 0 6557 0016 6

Physics toolkit

This toolkit provides support for developing the skills required to undertake scientific investigations. It also covers study skills and examination preparation. The toolkit can serve as a reference tool to be consulted as needed throughout the year.

Scientific method

Physicists make observations and construct hypotheses to account for their observations. A **hypothesis** is a possible explanation, an educated guess, made to explain observations.

Hypotheses are tested following the principles of the **scientific method**. These include:

- asking relevant questions (i.e. questions that can be tested)
- making careful observations
- designing and conducting **controlled experiments**; in controlled experiments all **variables** are kept constant, except the one under investigation
- keeping an accurate record of experimental results
- interpreting experimental data and observations logically
- drawing logical **conclusions** from the experimental results.

The results of a scientific investigation may negate or refute the hypothesis being tested. In this case the hypothesis must be re-evaluated and modified. Such results are useful in redirecting scientific investigation.

When experimental results repetitively support a hypothesis, it may become a **theory** or **principle**; that is, the hypothesis is accepted as a scientific truth.

The scientific method recognises limitations in investigations. For example, some factors cannot be measured; a sample size may be too small to be representative; or unknown factors may influence investigations.

SCIENTIFIC INVESTIGATION

A scientific investigation can be conducted in many ways. Examples of scientific investigation approaches (also known as methodologies) are controlled experiments, literature reviews and modelling. The scientific investigation methodology and the methods (also known as procedures) selected will depend on the aim of the investigation and the research question.

Practical work involves direct experiences or hands-on practical activities. Scientific investigation methodology involves all elements of planning. It considers the focus of the investigation and the rationale for approaching investigations in a particular way: for example, through controlled experiments, fieldwork or modelling. See the checklist on page XXX and page XXX for further information about methodology versus method in scientific investigations.

An investigation that you conduct yourself is known as a primary investigation, and the data and information you collect is called primary data or a primary source. An investigation that involves the analysis of data collected by others is known as a secondary-sourced investigation (see page XXX).

When planning and conducting a scientific investigation, you must maintain a logbook. This records information related to your investigation, such as materials and methods, raw data, data analysis, and sources of information. A logbook can be maintained manually or electronically. In either case, a record of dates of all work is needed to confirm continuous development over time.

The findings of a scientific investigation may be presented in a variety of formats, such as a scientific report, an article, a verbal and electronic report, or a scientific poster.

Conducting a scientific investigation

Scientific investigations follow a precise scientific method. The checklist on the following page summarises the elements that are common to many scientific investigation methodologies and scientific reports. Refer to the checklist and record important information as you conduct your scientific investigation.

 ISBN 978 0 6557 0016 6

EXAMPLES OF SCIENTIFIC REPORTS

Two sample scientific reports are provided in the Heinemann Physics 11 Skills and Assessment book. They include annotations to draw your attention to key points to note on each scientific report. These points are also reflected in the checklist, so you are able to use this as a tool to evaluate whether all requirements of the scientific investigation are complete. As it can be hard to tell whether you have attained a high standard in your completed scientific report, looking at sample scientific reports can help you identify what is required.

High standard practical report

Heading is clear and short.

Investigation of motion using timed intervals

The reason for doing the investigation is stated.

Aim

To investigate the motion of a student using timed intervals of measured distance.

The hypothesis is based on the aim of the investigation.

Hypothesis

If the position of an object is known at regular timed intervals, the velocity can be calculated using the equations of motion.

The different variables are identified.

Variables

Independent variable: Distance travelled

Dependent variable: Time

Controlled variables: Student running; students standing at 5-metre intervals

All materials are listed, including numbers of specific items.

Materials

- plastic cones or other position markers
- 30-metre tape measure
- stopwatches

Warnings are given of potential hazards and how these can be reduced or eliminated.

Risk assessment

Make sure the space is clear of trip hazards before running. If a student trips, report this to the teacher immediately.

The overall approach undertaken has been described and reasons for taking this approach are given.

Methodology

Controlled experiment measuring distance and time.

Clear instructions are provided for each step of the experiment. These have been written in recipe style, with easy-to-follow, detailed instructions.

Method

1 In a large, clear space, stretch out the tape measure on the ground in a straight line. Mark out the beginning and end of the distance as well as every 5-metre interval.
2 Station a student with a stopwatch at each 5-metre marker. Zero each stopwatch and ensure that students are familiar with the basic operation of the stopwatch.
3 Select a student for testing and position them ready to run, walk, crawl or hop from the start of the 30 metres. On a call of 'GO', the student starts to move along the marked distance, and all student timers start their stopwatches.
4 As the moving student passes each 5-metre marker, have each student timer stop their stopwatch and note the time. Collate all times for the first trial.
5 Repeat the trial two or three times. Repeat any trials where times noted are incomplete or obviously wrong.
6 Average your results and use them to graph position versus time either manually or using a calculator or computer. Using the position–time graph, construct a graph of velocity versus time for a particular trial.

Results

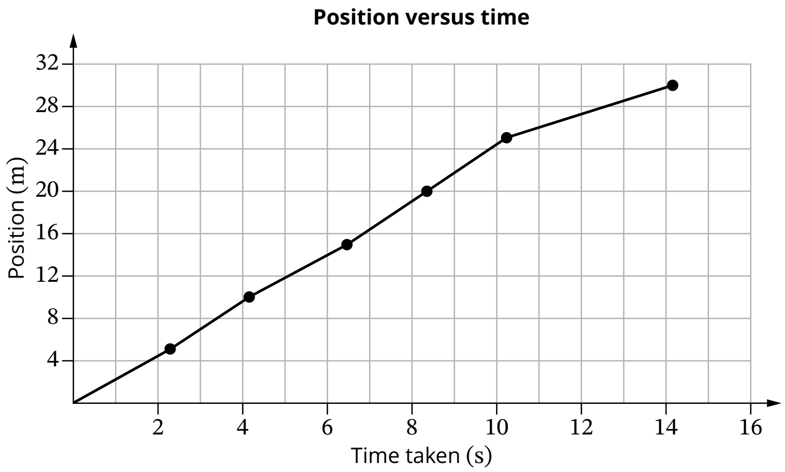
Results have been checked for consistency between trials. The number of significant figures shown indicates a good understanding of the limitations of the measuring technique.

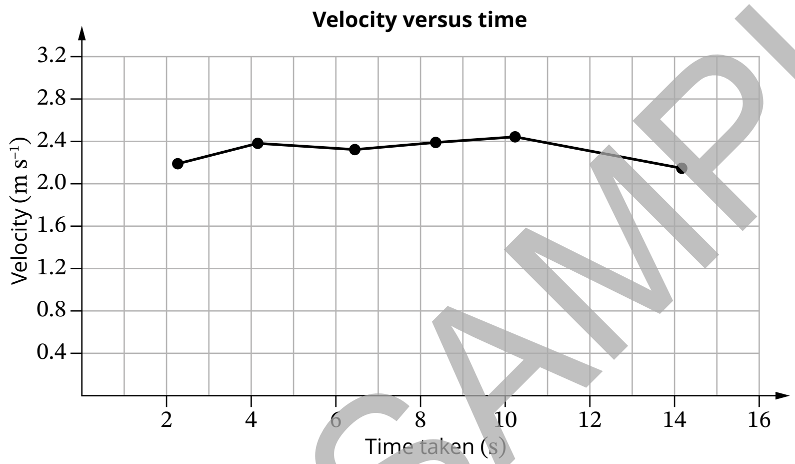
If you take multiple measurements, calculating the mean (or average) gives a single representative value and can provide a clearer understanding of the data.

Table 1 Results of trials

Distance travelled (m)	Trial 1 Time taken (s)	Trial 2 Time taken (s)	Trial 3 Time taken (s)	Trial 4 Time taken (s)	Average time taken (s)
0.0	0.0	0.0	0.0	0.0	0.0
5.0	2.3	2.2	2.3	2.4	2.3
10.0	4.2	4.1	4.2	4.3	4.2
15.0	6.5	6.6	6.4	6.5	6.5
20.0	8.4	8.4	8.3	8.4	8.4
25.0	10.3	10.2	10.4	10.3	10.3
30.0	14.2	14.1	14.3	14.2	14.2

ISBN 978 0 6557 0016 6





Axes have been labelled correctly and the graph includes a suitable descriptive title. An appropriate scale has been chosen to make best use of the space available.

Discussion

1 Describe the means by which you found velocity from the position versus time graph.

The gradient of a position–time graph can be used to calculate velocity because the change in position is displacement. Alternatively, the individual 5-metre intervals can be used to calculate the velocity for each interval, i.e. $v = \frac{\Delta s}{\Delta t} = \frac{5}{t}$.

2 Comment on the reliability of this means of measuring position, time and velocity.

The error in position can be expected to be small using a 30-metre tape to mark 5-metre intervals. Hand-held timing and watching students pass each marker introduces errors that can be significant if the student's velocity is large.

3 What is the major source of error in this activity?

Timing errors are the largest. A reaction time of 0.2 s is a large part of the time per interval.

4 Suggest an alternative that would improve the reliability of results.

Electronic timing methods such as a timing gate, as used in electronics, would eliminate errors associated with hand-held timing.

Discussion shows good understanding of the method and consideration of real sources of error. Avoid general comments unrelated to the specific investigation.

UNIT 1

How is energy useful to society?

AREA OF STUDY 1

How are light and heat explained?

Outcome 1

Model, investigate and evaluate the wave-like nature of light, thermal energy and the emission and absorption of light by matter.

Key knowledge

Electromagnetic radiation

- identify all electromagnetic waves as transverse waves travelling at the same speed, *c*, in a vacuum as distinct from mechanical waves that need a medium to propagate
- identify the amplitude, wavelength, period and frequency of waves
- calculate the wavelength, frequency, period and speed of travel of waves using:

$$\lambda = \frac{v}{f} = vT$$

- explain the wavelength of a wave as a result of the velocity (determined by the medium through which it travels) and the frequency (determined by the source)
- describe electromagnetic radiation emitted from the Sun as mainly ultraviolet, visible and infrared
- compare the wavelength and frequencies of different regions of the electromagnetic spectrum, including radio, microwave, infrared, visible, ultraviolet, x-ray and gamma, and compare the different uses of each in society
- investigate and analyse theoretically and practically the behaviour of waves including:
  - refraction using Snell's Law: $n1 \sin(\theta_1) = n_2 \sin(\theta_2)$ and $n_1 v_1 = n_2 v_2$
  - total internal reflection and critical angle including applications: $n_1 \sin(\theta_c) = n_2 \sin(90°)$
- investigate and explain theoretically and practically colour dispersion in prisms and lenses with reference to refraction of the components of white light as they pass from one medium to another
- explain the formation of optical phenomena: rainbows and mirages
- investigate light transmission through optical fibres for communication

Thermal energy

- convert between degrees Celsius and kelvin scales
- describe temperature with reference to the average translational kinetic energy of the atoms and molecules within a system:
  - distinguish between conduction, convection and radiation with reference to heat transfers within and between systems
  - explain why cooling results from evaporation using a simple kinetic energy model
- investigate and analyse theoretically and practically the energy required to:
  - raise the temperature of a substance: $Q = mc\Delta T$
  - change the state of a substance: $Q = mL$

Interaction of thermal energy and electromagnetic radiation

- calculate the peak wavelength of the radiated electromagnetic radiation using Wien's Law: $\lambda_{max}T$ = constant
- compare the total energy across the electromagnetic spectrum emitted by objects at different temperatures
- apply concepts of energy transfer, energy transformation, temperature change and change of state to climate change and global warming.

- **You will now be able to complete Worksheet 1.**

Waves and electromagnetic radiation

TRANSVERSE AND LONGITUDINAL WAVES

Waves transfer energy from one point to another. They do not transfer matter, although matter may move as the wave passes through it. They are classified according to what they move through. A **mechanical wave** is any wave that travels through vibrations in a medium. Waves travelling through water, along a spring or through the air (such as sound waves) are examples of mechanical waves. **Electromagnetic waves** (light waves) can travel without the need for a medium, but can also travel through a medium. For example, light from the Sun reaches Earth through the vacuum of space, but also travels through Earth's atmosphere.

A wave may be a single pulse, continuous or periodic. Periodic waves have a pattern that repeats (oscillates) over time as the wave energy moves. Depending on the direction of the oscillation, a wave is described as either transverse or longitudinal. Mechanical waves can be either transverse or longitudinal, while electromagnetic waves are only transverse.

In a **transverse** wave, the oscillations are perpendicular to the direction in which the wave energy is travelling. The particles in the medium move transversely (sideways) in peaks and troughs as the wave passes (Figure 1.1.1a). Ripples on a pond are an example of a transverse wave. In a **longitudinal** wave, the oscillations are parallel to the direction the wave energy is travelling. The particles in the medium move longitudinally (back and forth) in compressions and rarefactions as the wave passes (Figure 1.1.1b). Sound is an example of a longitudinal wave.

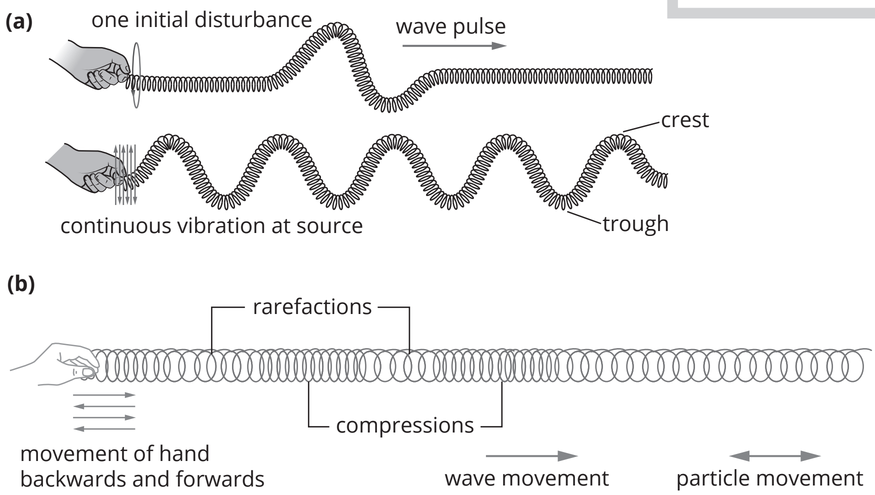


Figure 1.1.1 (a) A transverse wave and (b) a longitudinal wave

MEASURING WAVES

Waves can be represented by displacement–distance graphs and displacement–time graphs. From a displacement–distance graph, it is easy to determine the amplitude and wavelength.

The **amplitude** of a wave is the maximum displacement (movement) of the particles from the rest position (when displacement is zero).

The **wavelength**, denoted by the Greek letter lambda (λ) is the distance between any two repeating points, also called a cycle. Wavelength is measured in metres.

Figure 1.1.2 illustrates an example of a displacement–distance graph.

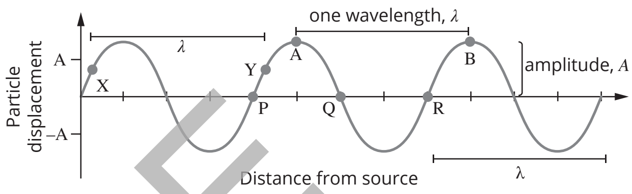


Figure 1.1.2 Displacement–distance graph showing amplitude and wavelength

The **period**, T, of a wave is the time it takes for any point on the wave to go through one complete cycle and the **frequency**, f, is the number of complete cycles that pass a given point per second. The period of a wave has an inverse relationship to the frequency, according to the relationship:

$$T = \frac{1}{f}$$

The rate at which energy can travel can also be determined, if either frequency (or period) and wavelength is provided. The speed of a wave can be calculated using the wave equation:

> $$\lambda = \frac{v}{f}$$
>
> where λ is the wavelength (m)
> v is the speed (m s^{-1})
> f is the frequency (Hz)
> λ is the wavelength (m)

 ISBN 978 0 6557 0016 6

KEY KNOWLEDGE

Amplitude, wavelength, frequency and period can all be determined from a displacement–time graph. The amplitude and period can be read straight from the graph (Figure 1.1.3).

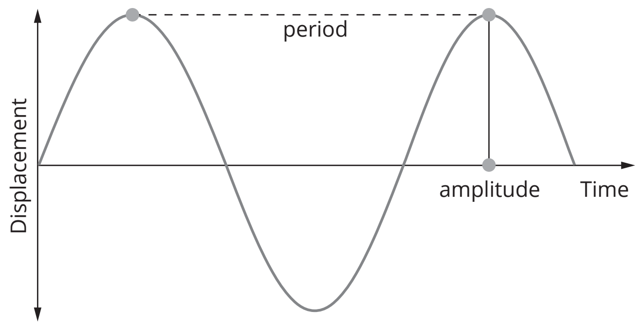


Figure 1.1.3 Reading amplitude and period from a displacement–time graph

- *You will now be able to complete Worksheet 2 and conduct Practical activity 1.*

THE ELECTROMAGNETIC SPECTRUM

Electromagnetic radiation includes ultraviolet, visible and infrared light, which are each a part of the **electromagnetic spectrum** (Figure 1.1.4). So, electromagnetic radiation behaves as we know light to behave: i.e. it travels at the speed of light, *c*, and it can be reflected and **absorbed**. Different types of electromagnetic radiation are described in Table 1.1.1.

Electromagnetic radiation, or light, travels at the speed of light in a vacuum. Light travels through a vacuum at approximately $c = 3.0 \times 10^8\,\text{m s}^{-1}$. The speed of light is so reliable that it is a fixed SI unit. The wave equation can therefore be changed to:

$$c = f\lambda$$

where c is the speed of light (m s^{-1}),

f is the frequency of the wave (s^{-1} or Hz),

λ is the wavelength of the wave (m).

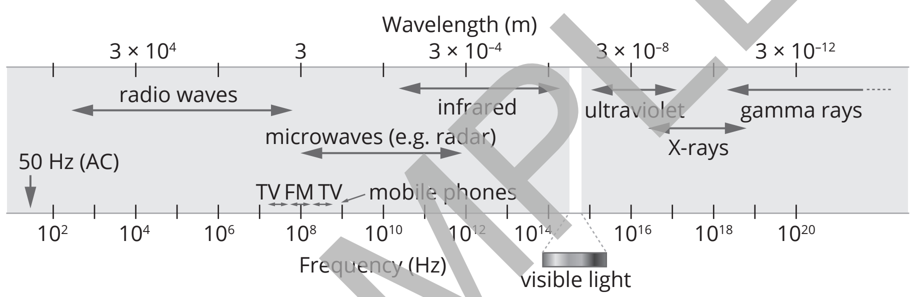


Figure 1.1.4 The electromagnetic spectrum

Table 1.1.1 Types of electromagnetic radiation

Gamma rays (γ-rays)	The highest energy, shortest wavelength energy, which is produced within the nucleus of an atom. Gamma rays are one of the three types of emissions that come from radioactive (unstable) atoms.
X-rays	When fast-moving electrons are fired into an atom, X-rays are produced. X-rays got their name as a result of scientists at first not knowing what they were, hence the letter 'X'.
Ultraviolet (UV)	UV light has a shorter wavelength than visible violet light and is less energetic than gamma rays or X-rays. It is known to cause skin cancer, particularly with frequent exposure. Wavelengths are less than 10 nm (1 nm = 10^{-9} m).
Visible light	This is the small portion of wavelengths around the middle of the electromagnetic spectrum that can be detected by human eyes. Many other life forms, for example insects and birds, can perceive wavelengths well into the ultraviolet range.
Infrared (IR)	Infrared or heat radiation is emitted by all objects that are not at a temperature of absolute zero. The hotter the object, the more radiation emitted, and the shorter the wavelength within the IR band.
Microwaves	Microwaves are produced by the spin of electrons or nuclei. They can be used to heat your dinner and allow remote communications and radar to work. Wavelengths range from about 1 nm to 10 cm.
Radio and television waves	Electrons oscillating in a conducting wire, such as an antenna, produce the radio and television waves that bring music and pictures to your home and carry voice and data to your phone. Long wavelength, low-energy electromagnetic radio and television waves can be transmitted across very long distances.

Light

REFLECTION AND REFRACTION

When light reflects off a surface, the angle from the normal at which the wave strikes a surface will equal the angle from the **normal** to the reflected wave. The normal is an imaginary line at 90° (i.e. perpendicular) to the surface.

The **angle of incidence** and **angle of reflection** from the normal are labelled θ_i and θ_r, respectively (Figure 1.1.5). This is referred to as the law of reflection.

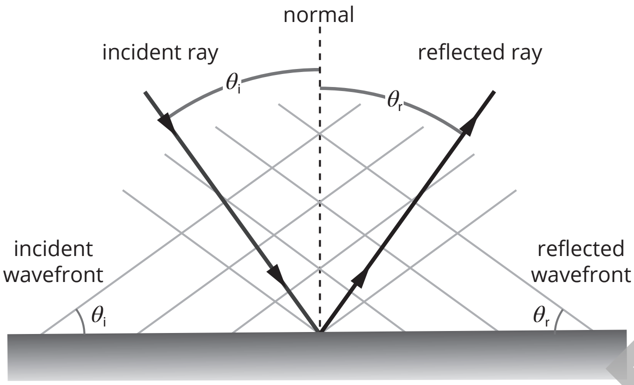


Figure 1.1.5 The law of reflection. The angle between the direction of the incident wave and the normal (θ_i) is the same as the angle between the normal and the reflected wave (θ_r).

Refraction is a change in the direction of light when it moves from one medium to another. Refraction is caused by changes in the speed of light rays. A convenient way to describe the change in speed of a wave is a property called the **refractive index.** The refractive index determines how far light is refracted when entering a material.

The refractive index, n, in a medium is given by the following formula:

> $n = \frac{c}{v}$
>
> n is the refractive index (Note that n is dimensionless; i.e. it has no units, it is just a number.)
> c is the speed of light in a vacuum ($3 \times 10^8 \text{ m s}^{-1}$)
> v is the speed of light in the medium.

When light moves from one medium to another, the changes in speed can be calculated using the following formula:

> $n_1 v_1 = n_2 v_2$
>
> where n_1 is the refractive index of the first material
> v_1 is the speed of light in the first material
> n_2 is the refractive index of the second material
> v_2 is the speed of light in the second material.

This relationship can be linked to **Snell's law**. Snell's law relates to the geometry of the situation when a light ray refracts as it moves from one medium to another.

> Snell's law
>
> $n_1 \sin \theta_1 = n_2 \sin \theta_2$
>
> where n_1 is the refractive index of the first material
> θ_1 is the angle the light makes in the first material between the wave and the normal
> n_2 is the refractive index of the second material
> θ_2 is the angle the light makes in the second material between the wave and the normal.

When waves travel from a medium with a high refractive index to one with a lower refractive index, **total internal reflection** can occur. Total internal reflection is when a light ray does not undergo refraction when it hits the boundary between two mediums; instead, the light ray is reflected back into the original medium, as if it was striking a mirror. Figure 1.1.6 shows internal reflection at an air–water boundary.

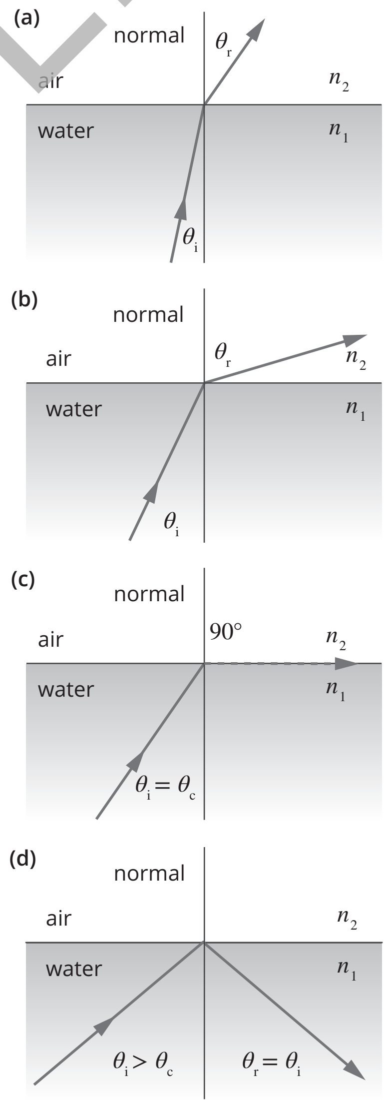


Figure 1.1.6 Internal reflection at an air–water boundary

 ISBN 978 0 6557 0016 6

Knowledge review—waves and energy

1 Recall the comparative wavelength of each of the following radiation types and use that information to re-order them in increasing wavelength.

green light, infrared, radio, ultraviolet, blue, red, x-rays, microwaves

2 State the temperature, in Celsius, and in Fahrenheit, of melting ice.

3 Explain why the sound from a lightning strike is always heard after it is seen.

4 Explain the difference between transverse and longitudinal waves.

5 When a mirror is placed vertically, halfway along a letter, some capital letters (such as A) look the same.

Deduce which other letters would look the same in that mirror.

Identify letters that would look the same when the mirror is placed horizontally. (You may want to try this one with a mirror yourself!)

6 Define what attributes make something a wave. Write a single, short sentence that summarises the key properties of a wave.

7 The following are examples of types of wave:

sound, string, radio, visible light, beach breaks, microwaves, x-ray, stadium, earthquake, slinky.

Classify these as either mechanical or electromagnetic in the table below.

Mechanical	Electromagnetic

Literacy review—energy

1 Complete the paragraph relating electromagnetic radiation using the word list supplied.

speed	medium	frequency	refraction	wavelength	propagation

- When light passes from one _______________ to another, one property of electromagnetic radiation behaving as a transverse wave can be observed. _______________ is the same; however, _______________ and _______________ differ. _______________ is the change in direction of _______________ of a wave that occurs when there is a change in _______________ of the waves.

2 Complete the paragraph relating to thermodynamics using the word list supplied. Not every word will be used and some may be used more than once.

kinetic	potential	Kelvin	Celsius	Fahrenheit	velocity temperature	heat	energy

- Two common temperature scales used in science are the _______________ and _______________ scales. _______________ is related to the average _______________ energy of the particles in a material. _______________ energy depends upon the mass and _______________ of particles.

3 Complete the paragraph relating to thermodynamics using the word list supplied. Not every word will be used and some may be used more than once.

kinetic energy	thermal energy	cold	hot	transfer

- The word 'heat' is loosely used in common language. However, in science it specifically relates to the _______________ of _______________ from one material to another. Sometimes the term 'heat' is used interchangeably with the term '_______________'. _______________ is in fact the total amount of energy contained in a material. Heat is transferred spontaneously from a _______________ object to a _______________ object.

4 From the key knowledge of this area of study, your text or other suitable source, define each of the following means of heat transfer.

Conduction:

____

Convection:

____

Radiation:

____

5 The following paragraph explains the application of latent heat of vaporisation to variation in climate.

Complete the paragraph from words and background found in the key knowledge section of this area of study.

- The transfer of _______________ during a _______________ change between liquid water and water vapour has a profound effect on our environment. The temperature doesn't cool much at night in regions of _______________ humidity. However, the temperature in deserts (_______________ humidity) quickly drops after the sun goes down. This is because regions of high humidity have lots of _______________ _______________ in the air. _______________ _______________ condensing back into a liquid releases _______________ to the air.

 ISBN 978 0 6557 0016 6

WORKSHEET 9

Reflection—How are light and heat explained?

The following table lists the key knowledge covered in this area of study.

1 Reflect on how well you understand the concepts listed. Rate your learning by shading the circle that corresponds to your current level of understanding for each one.

Key knowledge	Not confident ◄				► Very confident
Wave properties: the wave equation $\lambda = \frac{v}{f} = vT$, speed, frequency, period and wavelength	○	○	○	○	○
Electromagnetic waves: transverse waves, speed of light *c*, the electromagnetic spectrum	○	○	○	○	○
Refraction: Snell's law, total internal reflection, dispersion	○	○	○	○	○
Optical effects: rainbows, mirages	○	○	○	○	○
Temperature: units of measurement Celsius and Kelvin, the kinetic energy model	○	○	○	○	○
Heat transfer: Conduction, convection and radiation	○	○	○	○	○
Specific heat capacity: $Q = mc\Delta T$	○	○	○	○	○
Latent heat: $Q = mL$, change of state	○	○	○	○	○
Internal energy: work done on or by the system	○	○	○	○	○
Wien's law: blackbody radiation, $\lambda_{max}T$ = constant	○	○	○	○	○
Climate change and global warming: energy transfer, energy transformation, temperature change	○	○	○	○	○

2 Consider the points you have shaded from Not confident to Very confident. List specific ideas you can identify that were challenging.

3 Write down two different strategies that you will apply to help further your understanding of these ideas.

ISBN 978 0 6557 0016 6

PRACTICAL ACTIVITY 1

Experiment • Modelling

Waves in slinky springs and ropes

SUGGESTED DURATION

- 50 minutes

MATERIALS

- springs of various diameters and materials (e.g. different types of slinky spring)
- 1 to 2 m length of string or light rope
- strings or light ropes between 5 m and 10 m in length and of varying mass per metre.

INTRODUCTION

The particles affected by the motion of a transverse waves move perpendicular to the direction of the wave. Particles affected by a longitudinal wave move in the same direction as the movement of the wave. The transfer of energy through a longitudinal or transverse wave is affected by the medium in which it travels.

AIM

To investigate some simple properties of longitudinal and transverse waves and the effect of different mediums on the propagation of the wave.

Safety

Metal slinky springs can be easily damaged by use that is too vigorous or tangling. Handle with care.

Take care to avoid catching hair or fingers in the coils of the springs. Complete a risk assessment before starting the activity.

METHOD

1 ▪ Lay the larger or heavier slinky spring flat on the floor in a clear space. With each end held by a student, stretch the spring until it is taut but not overly stretched.

2 ▪ One student generates a transverse pulse by whipping their hand out and back along the floor and at right angles to the line of the spring. Observe and comment on what happens to the pulse as it travels down the spring and reflects from the fixed end.

3 ▪ Repeat with the smaller spring and describe what happens. Pay particular attention to any difference between the movement and reflection of the pulse in the smaller and larger springs.

4 ▪ Now attach the piece of light rope to the end of the heavier spring. Stretch the spring and string out between two people without over-stretching the spring. Send a single pulse down the spring. Describe what you observe at the join between the spring and the rope.

5 ▪ Remove the string and stretch out one of the springs between two students.

ISBN 978 0 6557 0016 6

6 ▪ Create a longitudinal pulse by asking one student to move their hand holding the spring sharply in and out along the length of the spring (longitudinally). Observe what happens as the pulse travels down the spring and reflects off the fixed end. Compare your observations with the behaviour of the transverse wave.

7 ▪ Join the two springs together and stretch them out along the floor.

8 ▪ Keeping the end of the heavier spring fixed, generate a transverse pulse in the smaller spring. Observe and sketch what happens to the pulse as it reaches the point where the two springs join.

9 ▪ Repeat the previous step, this time generating the pulse in the heavier spring while keeping the end of the smaller spring fixed. Describe the differences you observe.

10 ▪ Fix one end of a long rope. For example, tie it to a nail in a wall or the handle of a door. Hold the other end with your hand and take up the slack in the rope without pulling it tight. Tie a small ribbon or rubber band anywhere along the rope. (It doesn't have to be in the centre, but don't make it too close to either end.)

11 ▪ Moving your hand up and down sharply, flick the rope to produce a single transverse pulse that travels along the rope. Observe closely the movement of the point in the rope that you have marked with the ribbon. Describe the movement of the ribbon.

12 ▪ Repeat the activity with ropes of varying mass per metre and composition.

13 ▪ Describe what happens to the pulse in the rope when it reaches the fixed end.

14 ▪ Now tie a loop at the end of the rope around a thin, upright object such as the leg of a desk so that the rope is free to move up and down. Once again, flick the rope to produce a single transverse pulse that travels along the rope.

15 ▪ Describe what you observe when the pulse in the rope reaches the fixed end.

ISBN 978 0 6557 0016 6

DISCUSSION

1 In this practical activity, the waves generated have been referred to as pulses. Explain why the term 'pulse' is appropriate.

2 Try holding the rope at different tensions. Discuss whether the tension in the rope has any effect on the speed of the pulse along the rope.

3 Based on your observations, determine whether the speed of the pulse is affected by the mass or diameter of the rope.

4 Determine whether the direction of travel of the point marked with the ribbon is different from the direction of propagation of the pulse itself. Describe your observations.

5 List examples of naturally occurring transverse and longitudinal waves.

CONCLUSION

ISBN 978 0 6557 0016 6

EXAM-STYLE QUESTIONS

Multiple-choice questions

Question 1

Identify which of the following forms of electromagnetic radiation has the *shortest* wavelength in a vacuum.

A. radio

B. ultraviolet

C. X-ray

D. microwave

Question 2

The following statements describe what happens to key properties of electromagnetic radiation as a wave, as light passes from a less dense medium to a denser medium. Identify the correct statement.

A. The wavelength is reduced, while the frequency and velocity remain the same.

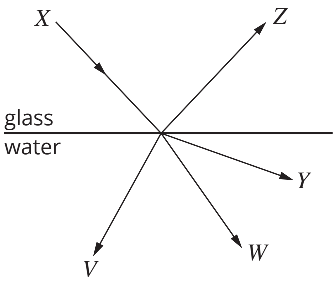
B. The wavelength and velocity are reduced, while the frequency remains the same.

C. The frequency is reduced, while the wavelength and velocity remain the same.

D. The frequency is reduced, while the wavelength and velocity increase.

Question 3

The diagram below shows a ray of light, X, reaching the boundary between water and glass.



Identify which of the following paths could be taken by rays of light that have reached the water–glass boundary.

A. Y only

B. Y and V

C. Y and Z

D. W and Z

Question 4

A vacuum flask has a reflective coating of aluminium on the internal surfaces of a sealed vacuum space. This ‘silvered’ surface reduces heat transfer by:

A. radiation

B. convection

C. conduction

D. all of the above

EXAM-STYLE QUESTIONS

Question 5

Identify which of the following is the best example of heat transfer by conduction.

A. heat transfer from the Sun to Earth

B. heat transfer from the bottom of the ocean to the top

C. heat transfer from Earth's crust to the layer below (the mantle)

D. heat transfer from Earth's surface to the upper atmosphere

Question 6

Water is poured into a stainless-steel pot, which is heated over a gas flame. As the water at the bottom of the pan is heated, begins to rise to the surface. The order of heat transfer during this entire process is:

A. conduction, convection, radiation

B. convection, conduction, radiation

C. radiation, convection, conduction

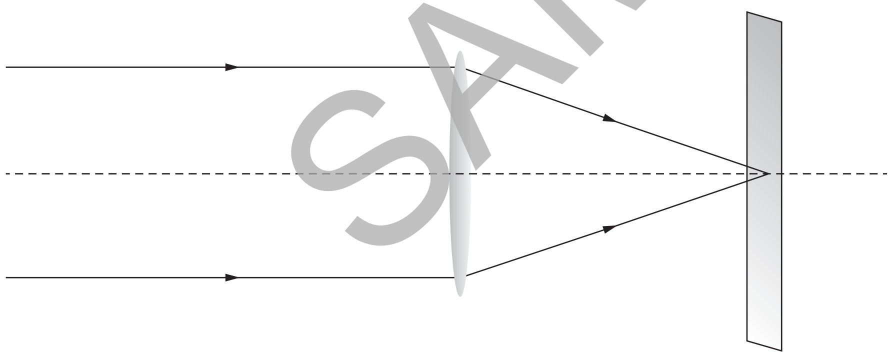
D. radiation, conduction, convection

Short-answer questions

Question 1 (3 marks)

Isaac Newton famously passed white light through a prism and showed that light was composed of many different colours. This phenomenon is known as dispersion and is due to different colours of light having slightly differing refractive indices in most transparent materials. For example, in crown glass, violet light ($\lambda = 400$ nm) has a refractive index of 1.53, whereas red light ($\lambda = 700$ nm) has a refractive index of 1.51.

The diagram below depicts the ideal image formation of a star on a white screen using a lens made of crown glass.



a. If we assume that the rays depicted are produced by a wavelength of 450 nm, draw the paths taken by the red and the violet light. (You will need to exaggerate the rays.) 2 marks

b. Describe the effect this will have on the star's image. 1 mark

ISBN 978 0 6557 0016 6