Materials
For this paper you must have:
• Ruler
• Pencil, Rubber, Protractor and Compass
• Scientific calculator, which you are expected to use when appropriate

Instructions
• Answer all questions
• Answer questions in the space provided
• All working must be shown
• Do all rough work in this book. Cross out any rough work you don't want to be marked

Information
• The marks for the questions are shown in brackets
Figure 1 shows a slinky spring used to model a sound wave.

(a) Label the arrows on Figure 1
Choose the answers from the box.

<table>
<thead>
<tr>
<th>amplitude</th>
<th>compression</th>
<th>frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>rarefaction</td>
<td>wavelength</td>
<td></td>
</tr>
</tbody>
</table>

(b) What type of wave is a sound wave?
Tick one box.

- electromagnetic  
- longitudinal  
- transverse
Figure 2 shows two students measuring the speed of sound in air.

Figure 2

One student bangs two bricks together.
The sound wave produced is reflected from the wall and travels back to the students.
Describe how they can determine the speed of sound.

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(4)
(Total 8 marks)
The diagram below shows types of waves within the electromagnetic spectrum.

Some of the types of waves are represented by letters.

| P | microwaves | Q | visible light | R | S | gamma rays |

(a) Which letter shows the position of ultraviolet (UV) radiation within the electromagnetic spectrum?

Tick one box.

- P
- Q
- R
- S

(1)

(b) A special lamp can produce UV radiation.

Which two statements describe the electromagnetic waves emitted by a UV lamp?

Tick two boxes.

- They have a higher frequency than X-rays.
- They have the same wave speed as visible light.
- They have a longer wavelength than microwaves.
- They have a lower frequency than gamma rays.
- They have a greater wave speed than radio waves.
(c) UV radiation is used to treat a vitamin D deficiency.

People should **not** use a UV lamp for long periods of time.

State **two** risks of exposure to high levels of UV radiation.

1. _________________________________________________________________
   ___________________________________________________________________

2. _________________________________________________________________
   ___________________________________________________________________

   (2)

(d) Ionising radiation is used for some medical imaging.

Name **two** types of electromagnetic waves that are used.

1. _________________________________________________________________

2. _________________________________________________________________

   (2)

   (Total 7 marks)

(a) Complete the sentences.

Choose the answers from the box.

| ionising | light | sound | transmitted | waves |

X-rays travel at the speed of ________________.

X-rays can cause cancer because they are ________________.

   (2)

(b) How do X-rays compare with gamma rays?

Tick **one** box.

- X-rays have a longer wavelength and a higher frequency
- X-rays have a longer wavelength and a lower frequency
- X-rays have a shorter wavelength and a higher frequency
- X-rays have a shorter wavelength and a lower frequency

   (1)
A scientist measured the radiation dose that a person received at different distances from an X-ray machine.

The table shows the results.

<table>
<thead>
<tr>
<th>Distance from machine in m</th>
<th>Dose in millisieverts/</th>
<th>Mean dose in millisieverts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test 1</td>
<td>Test 2</td>
</tr>
<tr>
<td>0.5</td>
<td>0.152</td>
<td>0.146</td>
</tr>
<tr>
<td>1.0</td>
<td>0.039</td>
<td>0.035</td>
</tr>
<tr>
<td>1.5</td>
<td>0.017</td>
<td>0.018</td>
</tr>
<tr>
<td>2.0</td>
<td>0.012</td>
<td>0.007</td>
</tr>
<tr>
<td>2.5</td>
<td>0.007</td>
<td>0.006</td>
</tr>
</tbody>
</table>

(c) Calculate value X in the table.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Mean dose = ________________ millisieverts

(2)

(d) What conclusion can be made from the results in the table?

Tick one box.

The dose decreases if you stand further from the machine. 

The dose is directly proportional to the distance. 

The dose is the same at all distances from the machine. 

There is a linear relationship between dose and distance. 

(1)
(e) An X-ray gives a radiation dose of 0.180 millisieverts.
Natural sources give a dose of 0.012 millisieverts per day.
Calculate the time it would take for natural sources to give a dose of 0.180 millisieverts.

\[
\text{Time} = \frac{0.180}{0.012} \text{ days}
\]

\[
\text{Time} = 15 \text{ days}
\]

(f) Suggest why doctors use X-rays even though this increases the risk of cancer to the patient.

\[
\text{(1)}
\]

(g) X-rays can also be used to treat cancer.
A patient receives a dose of 20 millisieverts from an X-ray.
Proton beam therapy delivers 40% of this dose.
Calculate the dose delivered by proton beam therapy.

\[
\text{Dose} = 20 \times 0.40 \text{ millisieverts}
\]

\[
\text{Dose} = 8 \text{ millisieverts}
\]

\[
\text{(2)}
\]

(Total 11 marks)
(a) The visible light spectrum has a range of frequencies.

Figure 1 shows that the frequency increases from red light to violet light.

![Figure 1]

Use the correct answers from the box to complete the sentence.

<table>
<thead>
<tr>
<th>decreases</th>
<th>stays the same</th>
<th>increases</th>
</tr>
</thead>
</table>

As the frequency of the light waves increases, the wavelength of the light waves \[\text{increases}\] and the energy of the light waves \[\text{increases}\].
(b) Bottled beer will spoil if the intensity of the light passing through the glass bottle into the beer is too high.

Figure 3 shows the intensity of the light that is transmitted through three different pieces of glass.

Figure 3

(i) The pieces of glass all had the same thickness.

Suggest why.

________________________________________________________________________

________________________________________________________________________

(1)

(ii) Bottles made of brown glass are suitable for storing beer.

Suggest why.

________________________________________________________________________

________________________________________________________________________

(1)

(Total 4 marks)
(a) Sound and light are different types of waves.

Give two similarities and two differences between sound waves and light waves.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(b) A student does an experiment to investigate the speed of sound in different liquids.

The student uses the apparatus shown.

A loudspeaker makes a sound wave. The sound wave travels through the liquid in the tank. The time it takes to travel this distance is used to calculate the speed of sound.
The bar chart shows the student's results.

(i) When a sound wave with a frequency of 4800 hertz passes through one of the liquids, it has a wavelength of 0.25 m.

Calculate the speed of the wave and identify the liquid used.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Speed = ____________________ m/s

The liquid used was ________________________

(3)
The student’s hypothesis was:
‘There is a link between the density of a liquid and the speed of sound in the same liquid.’

<table>
<thead>
<tr>
<th>Liquid</th>
<th>Density in g/cm³</th>
<th>Speed of sound in m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethoxyethane</td>
<td>0.71</td>
<td>985</td>
</tr>
<tr>
<td>Ethanol</td>
<td>0.80</td>
<td>1150</td>
</tr>
<tr>
<td>Kerosene</td>
<td>0.82</td>
<td>1300</td>
</tr>
<tr>
<td>Water</td>
<td>1.00</td>
<td>1500</td>
</tr>
<tr>
<td>Mercury</td>
<td>13.50</td>
<td>1450</td>
</tr>
</tbody>
</table>

Use the information in the table to decide whether the student’s hypothesis was completely correct or not.

Was the student’s hypothesis completely correct?

Draw a ring around your answer. Yes / No

Give reasons for your answer.

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

(2)
(Total 9 marks)

**Figure 1** is a wave front diagram showing light travelling through the air and into a glass block.

(a) Complete **Figure 1** by drawing wave fronts after they have left the glass block.
(b) Figure 2 shows a ray of light incident on a semi-circular glass block.

![Figure 2](image)

Complete the ray diagram in Figure 2.

- Draw the ray of light passing through and leaving the glass block.
- Label the angle of refraction.

(c) Explain why the light is refracted.

___________________________________________________________________
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(d) A student investigated how different coloured light was refracted by glass.

The student aimed rays of different coloured light at a glass block.

She measured the angle of refraction for each colour.

Give two variables that the student should control.

1. _________________________________________________________________
2. _________________________________________________________________
The table shows the student's results.

<table>
<thead>
<tr>
<th>Colour of light</th>
<th>Angle of refraction in degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>27.94</td>
</tr>
<tr>
<td>Orange</td>
<td>27.90</td>
</tr>
<tr>
<td>Yellow</td>
<td>27.82</td>
</tr>
<tr>
<td>Green</td>
<td>27.78</td>
</tr>
<tr>
<td>Blue</td>
<td>27.70</td>
</tr>
</tbody>
</table>

(e) Explain why these results could not have been obtained with a normal protractor.

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___________________________________________________________________
___________________________________________________________________

(2)

(f) What conclusion can be made about the relationship between the wavelength of light and the angle of refraction?

___________________________________________________________________
___________________________________________________________________

(1)

(g) Glass does not transmit ultraviolet radiation.

Suggest what happens to ultraviolet radiation when it is incident on glass.

___________________________________________________________________
___________________________________________________________________

(1)

(Total 13 marks)
A solar water bag can be used to heat water for an outdoor swimming pool.

A student wanted to find out if the colour of the solar water bag affects the temperature increase of the water inside the bag.

The diagram below shows some of the equipment used.

This is the method used.

1. Fill each bag with water.
2. Place the four bags on the ground outside.
3. After three hours, measure the temperature of the water inside each bag.
4. Repeat steps 1−3 on the next two days.

(a) Suggest three changes the student should make to this method to get valid results.

1. __________________________________________________________________________
2. __________________________________________________________________________
3. __________________________________________________________________________
The student repeated the investigation using an improved method.
The results obtained were valid.
The table below shows the results.

<table>
<thead>
<tr>
<th>Colour of bag</th>
<th>Temperature increase in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1</td>
</tr>
<tr>
<td>Black</td>
<td>44.0</td>
</tr>
<tr>
<td>Pale blue</td>
<td>38.5</td>
</tr>
<tr>
<td>Pale green</td>
<td>37.9</td>
</tr>
<tr>
<td>White</td>
<td>25.3</td>
</tr>
</tbody>
</table>

(b) The student used a thermometer to measure the temperature of the water inside each bag.
What was the resolution of the thermometer?

Resolution = _____________ °C

(1)

(c) Suggest one reason why the temperatures increased less on Day 2 than on Day 1 and Day 3.

___________________________________________________________________
___________________________________________________________________

(1)

(d) Calculate the mean temperature increase for the white bag.

___________________________________________________________________
___________________________________________________________________

Mean temperature increase = _______________ °C

(1)
(e) Which colour of bag would be best to use to heat water?
Give a reason for your answer.

Colour ____________________________________________________________
Reason ____________________________________________________________
___________________________________________________________________
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(Total 8 marks)

A car aerial receives radio waves from a radio transmitter.
Radio waves are transverse waves.
Sound waves are longitudinal waves.

(a) Describe the difference between transverse waves and longitudinal waves.
___________________________________________________________________
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(2)

(b) The radio waves have a frequency of \(4.8 \times 10^9\) Hz
Wave speed of electromagnetic waves = \(3.0 \times 10^8\) m/s
Calculate the wavelength of the radio waves.
Give your answer to 2 significant figures.
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Wavelength = ___________________ m

(3)
(c) Describe how the radio waves reaching the car aerial produce signals in the electrical circuit of the car radio.

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___________________________________________________________________

9 A group of students investigate the features of waves.

Figure 1 shows some of the equipment they use.

**Figure 1**

(a) Write the equation which links frequency, wavelength and wave speed.

___________________________________________________________________

(1)
(b) The students want to determine the wave speed of water waves in the ripple tank. Describe a method the students could use.

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Figure 2 and Figure 3 show the 'magic coin' trick.

A coin is glued to the bottom of a bowl and an observer stands where they cannot see the coin (Figure 2).

Figure 2

Another person fills the bowl with water.

The observer and the coin do not move.

After the water is added the observer can see the coin (Figure 3).

Figure 3
(c) Explain why the observer can now see the coin in **Figure 3**.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________


(3)

(d) Some types of wave are longitudinal and some types of wave are transverse. Describe the difference between longitudinal waves and transverse waves.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
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(2)
(Total 10 marks)