

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

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Forename(s)

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Candidate signature

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I declare this is my own work.

# GCSE PHYSICS

# H

Higher Tier Paper 2

Friday 14 June 2024

Afternoon

Time allowed: 1 hour 45 minutes

## Materials

For this paper you must have:

- a ruler
- a scientific calculator
- a protractor
- the Physics Equations Sheet (enclosed).

## Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided.
- Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- In all calculations, show clearly how you work out your answer.

## Information

- The maximum mark for this paper is 100.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
<b>TOTAL</b>	



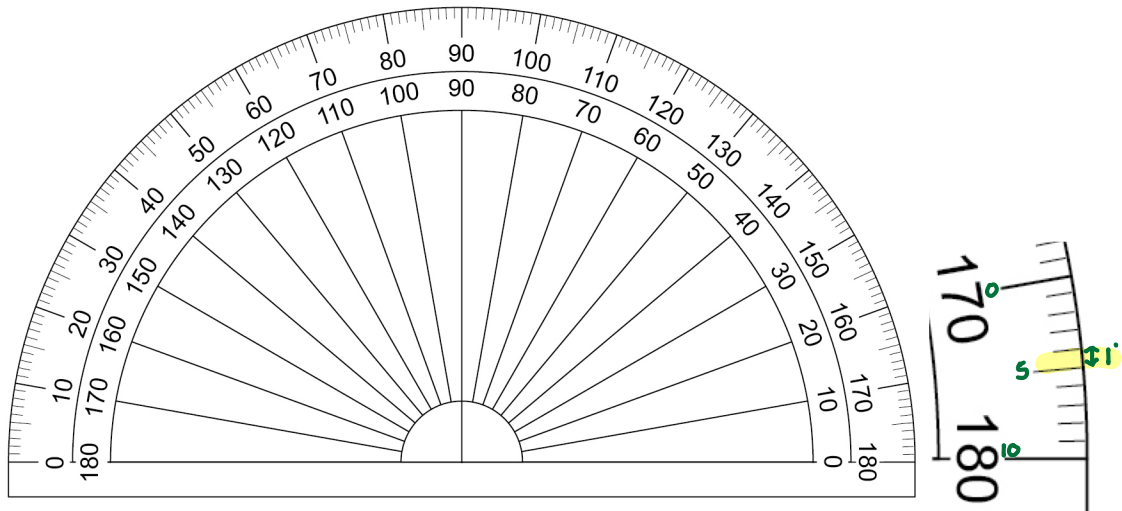
Answer **all** questions in the spaces provided.

0 1

A student investigated the refraction of light by a glass block.

**Figure 1** shows the protractor used to measure the angles of incidence and the angles of refraction.

**Figure 1**



0 1 . 1

What is the resolution of the protractor used to measure the angles?

[1 mark]

Resolution = 1 °

**Table 1** shows the results.

**Table 1**

Angle of incidence in degrees	Angle of refraction in degrees
10	6
20	12
30	18
40	23
50	28
60	32



0 1 . 2

Describe a method the student could have used to obtain the data in **Table 1**.

You may include a labelled diagram.

**[6 marks]**

Place glass block on piece of paper

Draw around glass block

Use ray box to shine a ray of light through glass block

Mark the ray of light entering the glass block

Mark the ray of light emerging from the glass block

Join the points to show the path of the complete ray through the block, and draw a normal line at  $90^\circ$  to the surface.

Use a protractor to measure the angle of incidence

Use a protractor to measure the angle of refraction

Use ray box to shine a ray of light at a range of different angles of incidence, increasing in  $10^\circ$  intervals, from  $10^\circ$  to  $60^\circ$

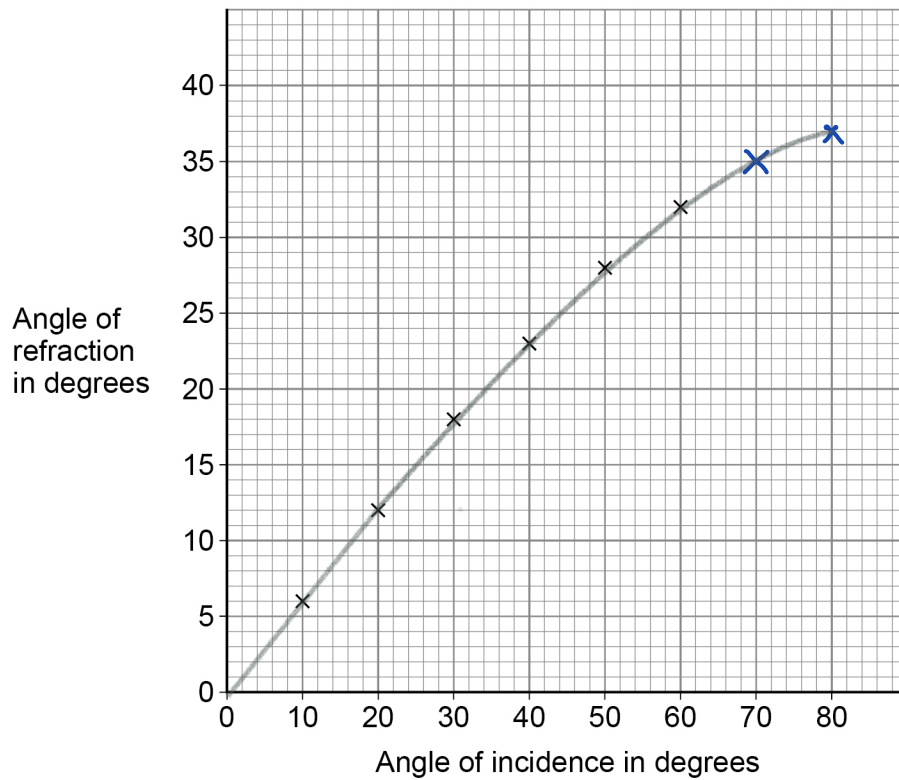
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Figure 2 shows some of the results.

Do not write  
outside the  
box

Figure 2



The student measured the angles of refraction for two additional angles of incidence.

Table 2 shows the additional results.

Table 2

Angle of incidence in degrees	Angle of refraction in degrees
70	35
80	37

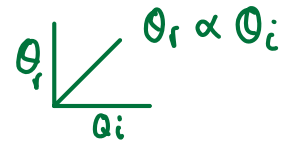


0 1 . 3 Complete **Figure 2**.

You should:

- plot the results from **Table 2**
- draw the line of best fit.

[2 marks]



0 1 . 4 How does **Figure 2** show that the angle of refraction is **not** directly proportional to the angle of incidence?

[1 mark]

The line curves.

Question 1 continues on the next page

Turn over ►

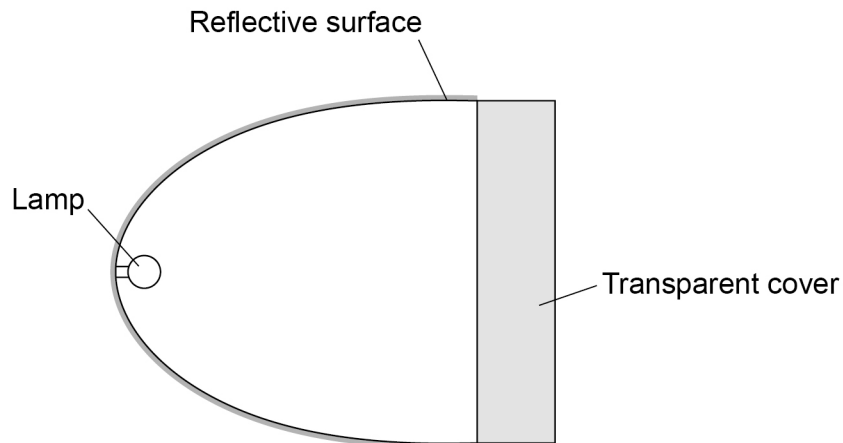


**Figure 3** shows a diagram of a car headlight.

The headlight has a lamp, a **reflective surface** and a transparent cover.

**Figure 3**

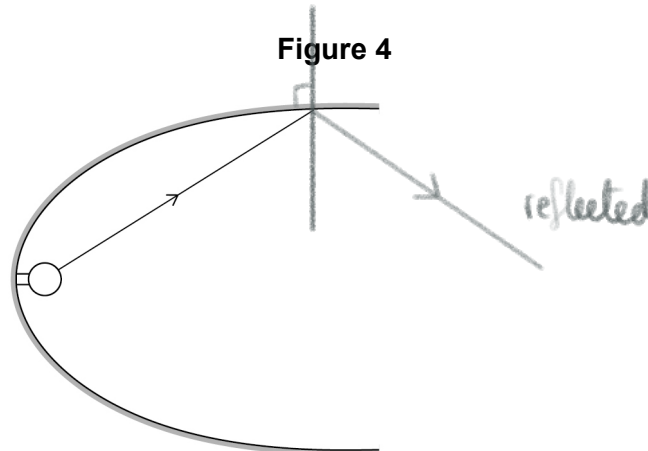
$$Q_r = Q_i$$



0 1 . 5

**Figure 4** shows a ray of light incident on the reflective surface.

**Figure 4**



Complete **Figure 4** to show the reflected ray of light.

You should include the normal line at the point where the incident ray meets the reflecting surface.

**[2 marks]**

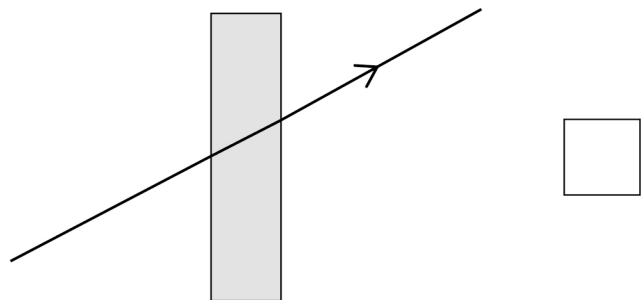
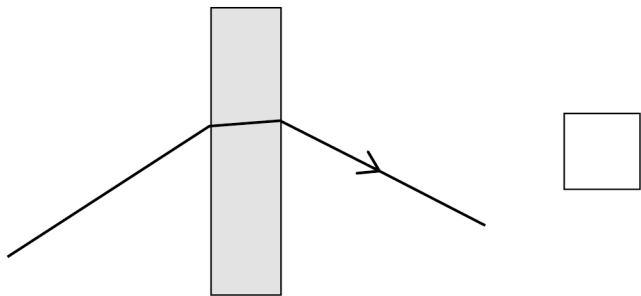
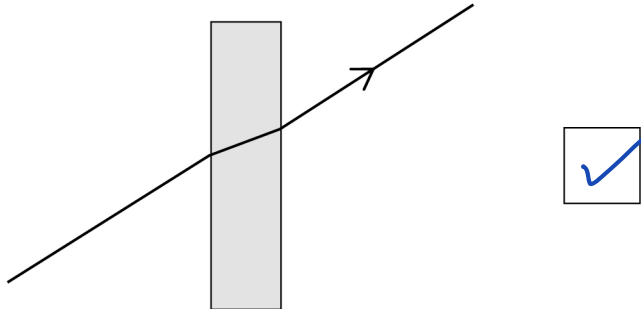


**0 1 . 6** Rays of light pass through the transparent cover of the headlight.

Which diagram shows how a ray of light passes through the transparent cover?

**[1 mark]**

Tick (✓) **one** box.



Turn over for the next question



0 2

Figure 5 shows a young child using a baby walker.

Figure 5



0 2 . 1

The child is standing still.

*No acceleration*

What is the resultant **vertical** force on the child?

Give a reason for your answer.

[2 marks]

Resultant vertical force = 0 N

Reason Child is not accelerating vertically  
(upwards forces = downwards forces)



Use the Physics Equations Sheet to answer questions **02.2** and **02.3**.

**0 2 . 2** Write down the equation which links distance ( $s$ ), force ( $F$ ) and work done ( $W$ ).

[1 mark]

$$W = F \times s$$

work done = force  $\times$  distance (along the line of action of the force)

$$W = F s$$

**0 2 . 3** The child pushed the baby walker  <sup>$s$</sup>  2.8 m across a horizontal floor.

The work done by the child was  <sup>$W$</sup>  35 J.

<sup>$F$</sup>  Calculate the horizontal force the child applied to the baby walker.

[3 marks]

$$W = 35 \text{ J}$$

$$W = F s$$

$$F = ?$$

$$F s = W$$

$$s = 2.8 \text{ m}$$

$$F = \frac{W}{s}$$

$$F = \frac{35 \text{ J}}{2.8 \text{ m}} = 12.5 \text{ J/m} = 12.5 \text{ N}$$

Horizontal force = 12.5 N

**0 2 . 4** The child pushed the baby walker **from a carpet onto a hard floor**.

The child applied the **same horizontal force** to the baby walker.

**Explain why the speed** of the baby walker **increased**.

[2 marks]

*Friction decreases!*  
The resistive force of friction has decreased

so the resultant force increases

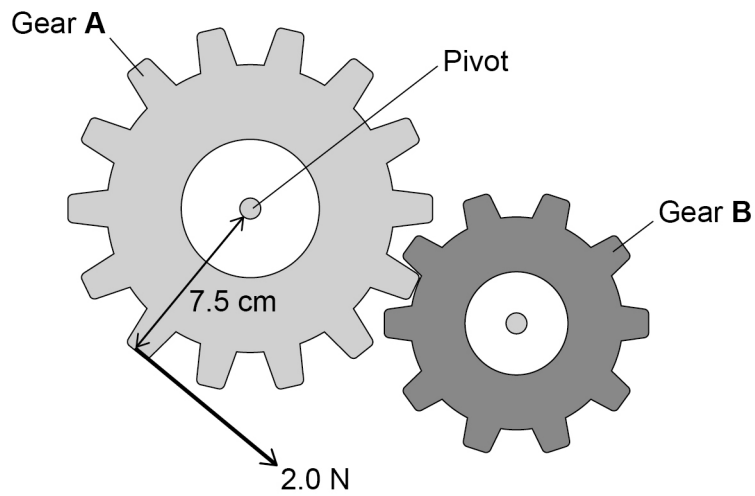
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There are some toy gears on the front of the baby walker.

**Figure 6** shows the gears.

**Figure 6**



The child applies a force to gear **A**.

This causes a **moment** about the pivot, so gear **A** rotates.



Use the Physics Equations Sheet to answer questions **02.5** and **02.6**.

- 0 2 . 5** Write down the equation which links distance ( $d$ ), force ( $F$ ) and moment of a force ( $M$ ).

[1 mark]

$$M = F \times d$$

moment of a force = force  $\times$  distance (normal to direction of force)

$$M = F d$$

- 0 2 . 6** The child applies a force of 2.0 N on gear **A**.

The perpendicular distance between the force and the pivot is 7.5 cm. m'

Calculate the moment of the force about the pivot.

[3 marks]

$$M = ?$$

$$M = Fd$$

$$F = 2.0 \text{ N}$$

$$M = 2.0 \text{ N} \times 0.075 \text{ m}$$

$$d = 7.5 \text{ cm} = \frac{7.5}{100}$$

$$M = 0.15 \text{ Nm}$$

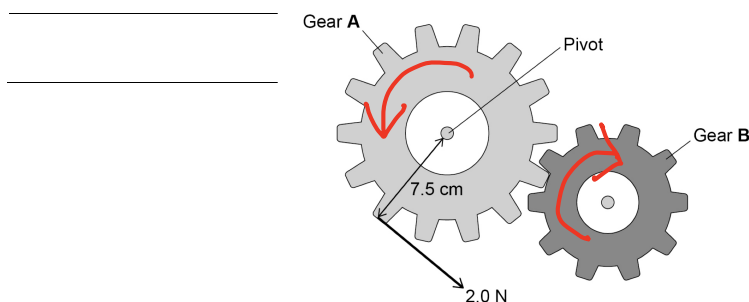
$$= 0.075 \text{ m}$$

Moment of force = 0.15 Nm

- 0 2 . 7** Explain what happens to gear **B** when the child applies the force to gear **A**.

[2 marks]

Gear B rotates in the opposite direction to Gear A, because Gear A exerts a force on Gear B



0 3

The Universe contains many stars.

0 3 . 1

The Sun is the star at the centre of our solar system.

Give **three** other types of object that form our solar system.

[3 marks]

- 1 Planets
- 2 Moons
- 3 'dwarf planets' or natural satellites.

Some **main sequence stars** will eventually form **black holes**.**Table 3** gives the mass of four stars.**Table 3**

Star	Mass in kg
Arcturus	$2.2 \times 10^{30}$
<b>Betelgeuse</b>	<b><math>2.2 \times 10^{31}</math></b>
Cygni A	$1.4 \times 10^{30}$
The Sun	$2.0 \times 10^{30}$

 $10^{31}$  most massive

0 3 . 2

Which **star** in **Table 3** is **most likely** to form a black hole?

[1 mark]

Betelgeuse



**0 3 . 3** The distance from Cygni A to the Earth is  $1.1 \times 10^8$  gigametres.

Which distance is the same as  $1.1 \times 10^8$  gigametres?

[1 mark]

Tick (✓) **one** box.

$1.1 \times 10^{11}$  m

$1.1 \times 10^{14}$  m

$1.1 \times 10^{17}$  m

$1.1 \times 10^{20}$  m

$$\begin{aligned}
 1 \text{ Gm} &= 10^9 \text{ m} \\
 10^8 \text{ Gm} &= 10^8 \times 10^9 \text{ m} \\
 &= 10^{8+9} \text{ m} \\
 &= 10^{17} \text{ m}
 \end{aligned}$$

Question 3 continues on the next page

Giga	G	$10^9$
Mega	M	$10^6$
kilo	k	$10^3$

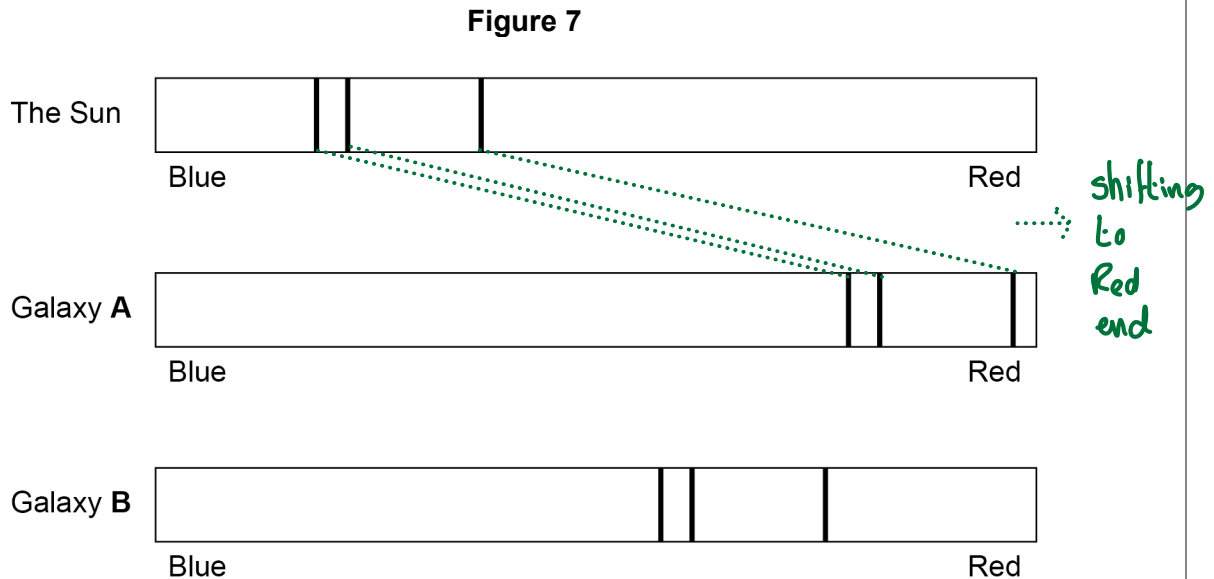
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0 3 . 4 The light spectrum from every galaxy includes dark lines.

The lines have the same pattern.

**Figure 7** shows the position of dark lines in the visible spectra of light from the Sun and from two distant galaxies.



Explain what these light spectra tell us about the velocities of galaxy A and galaxy B. [3 marks]

Both spectra show red-shift, so both are moving away from us

A shows a greater red-shift than B, so A is travelling faster than B



0 3 . 5

The distance between Arcturus and the Earth is  $3.6 \times 10^{14}$  km.

speed of light =  $3.0 \times 10^8$  m/s

Calculate the time taken for light from Arcturus to reach the Earth.

Use the Physics Equations Sheet.

distance travelled = speed  $\times$  time

$$s = vt$$

[4 marks]

$$s = vt$$

$$s = 3.6 \times 10^{14} \text{ km}$$

$$= 3.6 \times 10^{14} \times 10^3 \text{ m}$$

$$= 3.6 \times 10^{17} \text{ m}$$

$$v = 3.0 \times 10^8 \text{ m/s}$$

$$t = ?$$

$$vt = s$$

$$t = \frac{s}{v}$$

$$t = \frac{3.6 \times 10^{17} \text{ m}}{3.0 \times 10^8 \text{ m/s}} = 1.2 \times 10^9 \text{ s}$$

Time taken =  $1.2 \times 10^9$  s

0 3 . 6

When stars are formed, they contain mostly hydrogen.

Describe how stars produce all other naturally occurring elements.

[4 marks]

Fusion occurs at high temperatures  
 Fusion produces new elements  
 H nuclei fuse to form He nuclei  
 H in the core begins to run out  
 He nuclei fuse to make heavier elements,  
 upto iron, Fe  
 Some massive stars become supernovae,  
 creating elements heavier than Fe.

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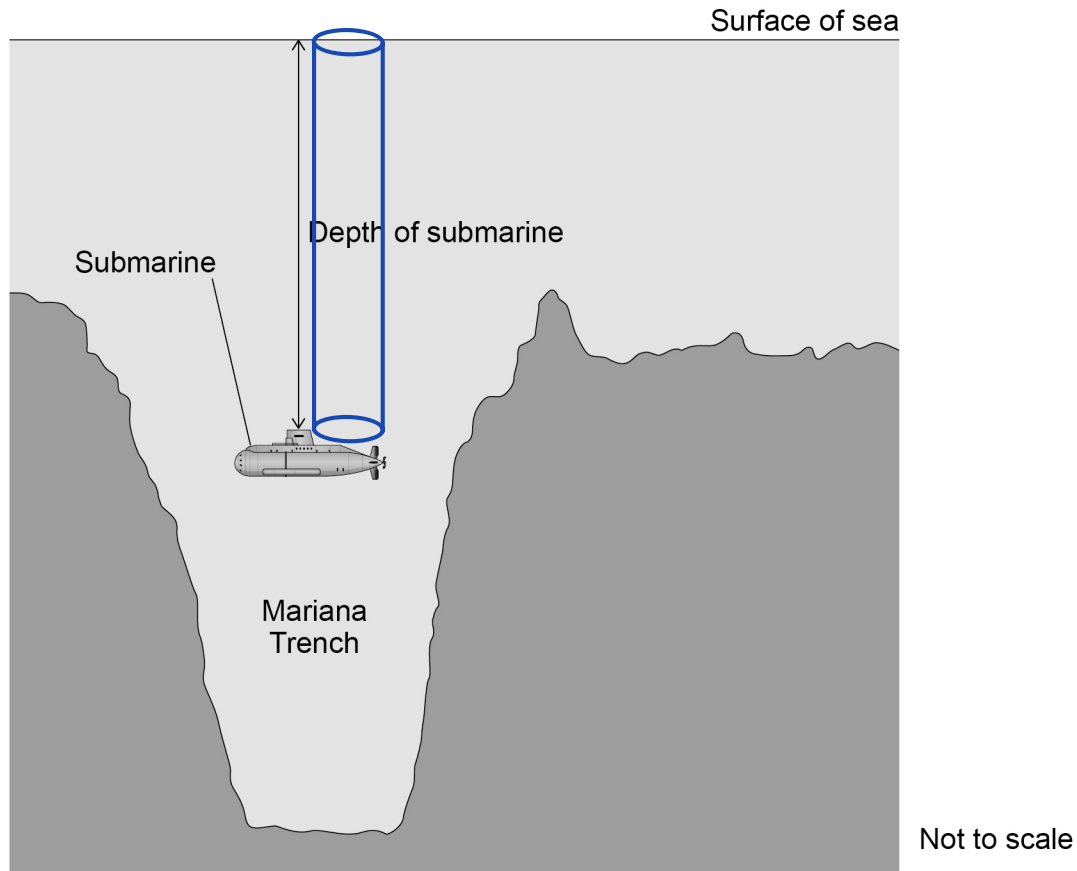


0 4

The Mariana Trench is the deepest part of the Pacific Ocean.

**Figure 8** shows a submarine going to the bottom of the Mariana Trench.

**Figure 8**



0 4 . 1

The depth of the submarine increases.

Explain what happens to the pressure on the submarine.

[2 marks]

The height of the column of water above the submarine increases.

Which increases the force/weight of water acting on the submarine, so pressure increases.



0 4 . 2

The submarine moved from the surface of the water to the bottom of the Mariana Trench.

The change in pressure was 110 000 kPa. Pa!

mean density of sea water = 1026 kg/m<sup>3</sup>

gravitational field strength = 9.8 N/kg

Calculate the depth of the Mariana Trench.

Use the Physics Equations Sheet.

[4 marks]

pressure due to a column of liquid =  
height of column × density of liquid × gravitational field strength

$$p = h \rho g$$

$$p = 110\,000 \text{ kPa}$$

$$= 1.1 \times 10^5 \times 10^3 \text{ Pa}$$

$$= 1.1 \times 10^8 \text{ Pa}$$

$$h = ?$$

$$\rho = 1026 \text{ kg/m}^3$$

$$g = 9.8 \text{ N/kg}$$

$$p = h \rho g$$

$$h \rho g = p$$

$$h = \frac{p}{\rho g}$$

$$h = \frac{1.1 \times 10^8}{1026 \times 9.8} = 10940 \text{ m}$$

$$\text{Depth} = 10\,940 \text{ m}$$

Question 4 continues on the next page

Turn over ►



Earthquakes often occur at the Mariana Trench.

P-waves and S-waves are produced by earthquakes.

**0 4 . 3** Which statement describes P-waves and S-waves?

**[1 mark]**

Tick (✓) **one** box.

Both P-waves and S-waves are longitudinal.

Both P-waves and S-waves are transverse.

P-waves are longitudinal and S-waves are transverse.

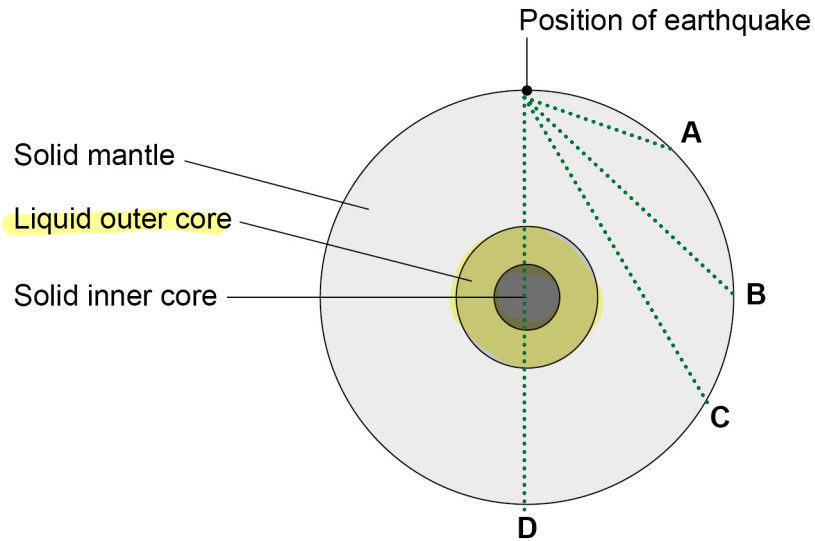
P-waves are transverse and S-waves are longitudinal.



0 4 . 4 **Figure 9** shows the layers inside the Earth.

An earthquake occurs at the position shown.

**Figure 9**



Which letter shows the position where **only** P-waves will be detected?

Give a reason for your answer.

[2 marks]

Tick (✓) **one** box.

A       B       C       D

Reason Only P-waves can travel through liquids

Question 4 continues on the next page

Turn over ►



0 4 . 5 An S-wave has a frequency of 3.6 Hz.

The S-wave has a speed of 4.5 km/s.

Calculate the wavelength of this S-wave.

Use the Physics Equations Sheet.

wave speed = frequency  $\times$  wavelength

$$v = f \lambda$$

[3 marks]

$$v = 4.5 \text{ km/s}$$

$$= 4.5 \times 10^3 \text{ m/s}$$

$$f = 3.6 \text{ Hz}$$

$$\lambda = ?$$

$$v = f \lambda$$

$$f \lambda = v$$

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

$$\lambda = \frac{4.5 \times 10^3}{3.6} = 1250 \text{ m}$$

Wavelength = 1250 m

0 4 . 6 A seismometer is a device that detects earthquakes.

P-waves travel at a known speed between an earthquake and a seismometer.

S-waves travel at a slower speed than P-waves.

A P-wave and an S-wave from the earthquake arrive at the seismometer at different times.

Describe the relationship between the distance from the earthquake to the seismometer and the time between the P-wave and the S-wave arriving.

[2 marks]

The distance is directly proportional to the time between the two waves arriving at the seismometer

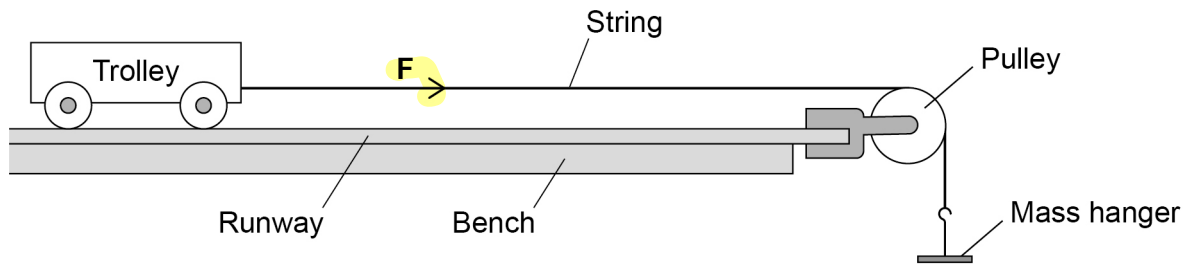


0 5

A student investigated how the acceleration of a trolley varies with the resultant force on the trolley.

Figure 10 shows some of the equipment used.

Figure 10



0 5 . 1

Figure 10 shows the force  $F$  which acts through the string.

What name is given to force  $F$ ?

[1 mark]

Tension

0 5 . 2

Give **one** variable that should have been a **control variable** in this investigation.

[1 mark]

Combined mass of trolley and mass hanger

Question 5 continues on the next page

Turn over ►



0 5 . 3 The student held the trolley stationary and then released it.

The trolley moved along the runway with a constant acceleration.

The student recorded the time taken for the trolley to travel a measured distance along the runway.

Describe how the acceleration of the trolley can be calculated using the time taken and distance travelled by the trolley.

[3 marks]

Divide the distance travelled by time taken to get average/mean velocity.

Double the mean to get the maximum velocity

Divide change in velocity by time taken to give acceleration.

For one set of results, the force acting through the string was 2.0 N.

0 5 . 4 The student released the trolley three times and determined the following values for acceleration:

1.36 m/s<sup>2</sup>

1.39 m/s<sup>2</sup>

1.33 m/s<sup>2</sup>

Calculate the uncertainty in the values of acceleration.

[2 marks]

$$\text{Uncertainty} = \frac{\text{Range}}{2} \quad \text{Range} = 1.39 - 1.33 = 0.06$$

$$\text{Uncertainty} = \frac{0.06}{2} = 0.03$$

Uncertainty =  $\pm 0.03$  m/s<sup>2</sup>

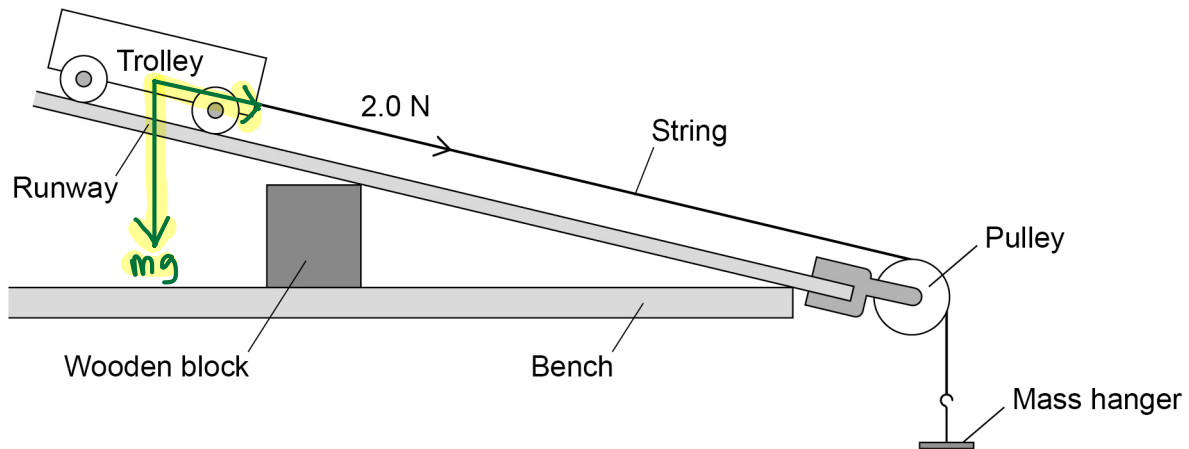


0 5 . 5 The runway was then raised at one end.

The force acting through the string remained the same.

Figure 11 shows this.

Figure 11



Explain how the acceleration was affected by raising the end of the runway.

[2 marks]

A component of the weight of the trolley acts parallel to the runway,  
So resultant force increases so acceleration increases

9

Turn over for the next question

Turn over ►



0	6
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Radio waves and gamma rays both transfer energy.

0	6	.	1
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Give **three** other similarities between radio waves and gamma rays.

[3 marks]

- 1 Both travel at the same speed in a vacuum
- 2 They can travel through a vacuum
- 3 They are (transverse) electromagnetic waves



Both radio waves and gamma rays are used in medicine.

0 6 . 2 Give one medical use of gamma rays.

[1 mark]

Medical imaging (or treatments)  
(MRI) (radiotherapy)

0 6 . 3 Explain why exposure to gamma rays can be harmful but exposure to radio waves is not harmful.

[2 marks]

Gamma rays are weakly ionising, but radio waves are not ionising.  
So gamma rays can cause mutations in genes/DNA increasing the risk of cancer

0 6 . 4 Some medical scanners produce radio waves at a specific frequency.

Explain how radio waves are produced at a specific frequency.

[2 marks]

Radio waves are produced by oscillations in electrical circuits of the scanner.  
The radio waves have the same frequency as the oscillations.

8

Turn over for the next question

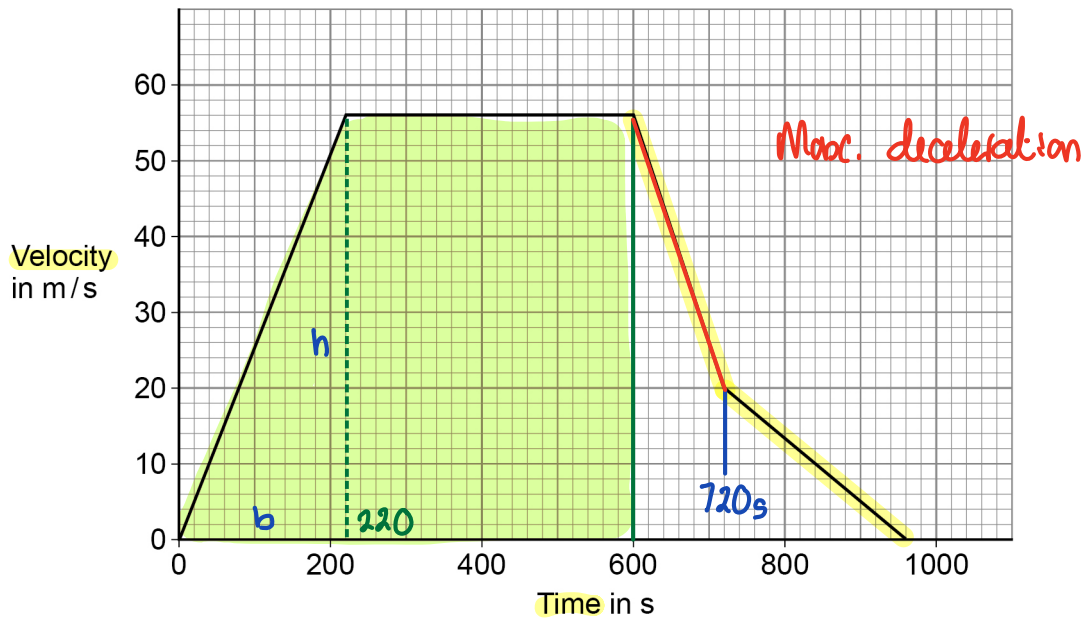
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0 7

Figure 12 shows a velocity–time graph for a train travelling between two stations.

Figure 12



0 7 . 1

Determine the distance travelled by the train in the first 600 s of the journey.

[3 marks]

$$\begin{aligned} \text{Distance travelled} &= \text{Area under curve} \\ &= \text{Triangle (0-220s)} + \text{Rectangle (220-600)} \\ \text{Area of Triangle} &= \frac{1}{2}bh = \frac{1}{2} \times 220 \times 56 \\ &= 6160 \text{ m} \end{aligned}$$

$$\text{Area of rectangle} = (600-220) \times 56 = 21280 \text{ m}$$

$$\text{Distance} = \underline{27440} \text{ m}$$

$$\begin{array}{r} \text{Total distance} = \\ 6160 \\ + 21280 \\ \hline 27440 \end{array}$$



0 7 . 2

Explain what happens to the braking force as the train decelerates.

Use information from **Figure 12**.

[3 marks]

As the train decelerates, the gradient is negative.  
The gradient is less after 720s,  
so the deceleration is smaller,  
so the braking force is smaller.

0 7 . 3

Determine the maximum deceleration of the train.

[3 marks]

Maximum deceleration occurs between 600 - 720s

Gradient: between points =  $\frac{\text{change in } y \text{ (v)}}{\text{change in } x \text{ (t)}}$

$$= \frac{52 - 20 \text{ m/s}}{600 - 720 \text{ s}} = -0.26 \text{ m/s}^2$$

Deceleration = 0.3 m/s<sup>2</sup>

Question 7 continues on the next page

Turn over ►



0 7 . 4 Another train travels at a speed of 60 m/s.

A constant braking force of 270 000 N causes the train to decelerate and stop.

mass of train = 240 000 kg

Calculate the distance travelled while the braking force is applied.

Use the Physics Equations Sheet.

resultant force = mass × acceleration

$$F = m a \quad [6 \text{ marks}]$$

$$F = ma$$

$$a = \frac{F}{m} = \frac{-270\,000 \text{ N}}{240\,000 \text{ kg}}$$

$$a = \text{deceleration} = -1.125 \text{ m/s}^2$$

$$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$$

$$v^2 - u^2 = 2 a s$$

$$v = 0 \text{ m/s}$$

$$v^2 - u^2 = 2as$$

$$u = 60 \text{ m/s}$$

$$2as = v^2 - u^2$$

$$a = -1.125 \text{ m/s}^2$$

$$s = \frac{v^2 - u^2}{2a} = \frac{0 - 60^2}{2 \times (-1.125)}$$

$$s = ?$$

$$s = 1600 \text{ m}$$

Distance travelled = 1600 m



0 7 . 5

It is illegal for train drivers to drink alcohol before driving a train.

Explain how drinking alcohol would affect the stopping distance of a train.

[3 marks]

Stopping distance includes both braking distance and thinking distance.

Alcohol increases the driver's reaction time, which will increase the thinking distance, so stopping distance increases.

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Turn over for the next question

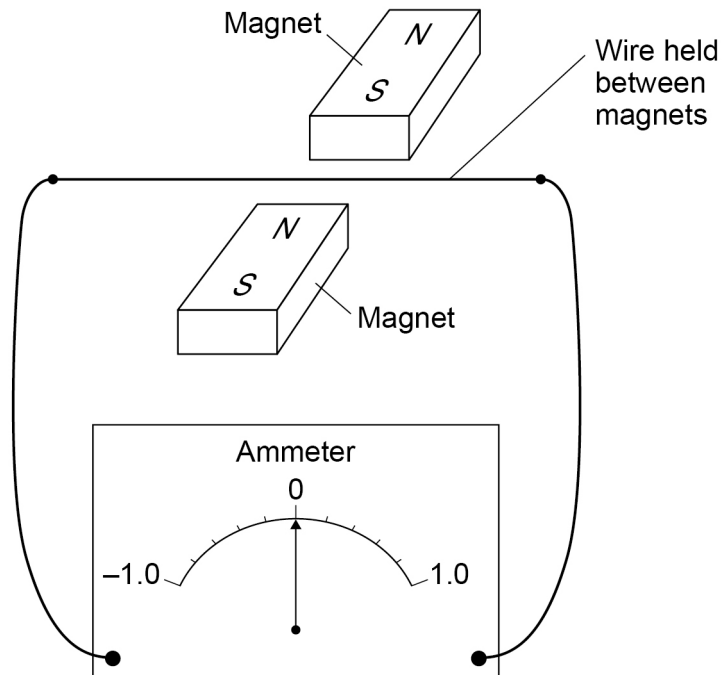
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0 8

Figure 13 shows some apparatus used by a teacher in a demonstration.

Figure 13



The teacher moved the wire upwards between the magnets.

The needle on the ammeter deflected to a value of  $+0.4$  mA and then returned to zero.

0 8 . 1

What effect did this demonstrate?

[1 mark]

*Generator effect*



0 8 . 2

Explain why a current was detected when the wire in **Figure 13** was moved upwards.

[3 marks]

The wire cuts through the magnetic field between the magnets.

A potential difference was induced across the wire as it was part of the complete circuit.  
(There was a current in the circuit.)

$\therefore$  reverse current

0 8 . 3

The teacher reversed the direction of the magnetic field.

The teacher replaced the wire in its original position.

The teacher moved the wire upwards in the same way as before.

What was the deflection of the needle on the ammeter?

[1 mark]

Tick (✓) **one** box.

The needle will deflect to  $-0.4$  mA.

The needle will not move.

The needle will deflect to  $+0.4$  mA.

Question 8 continues on the next page

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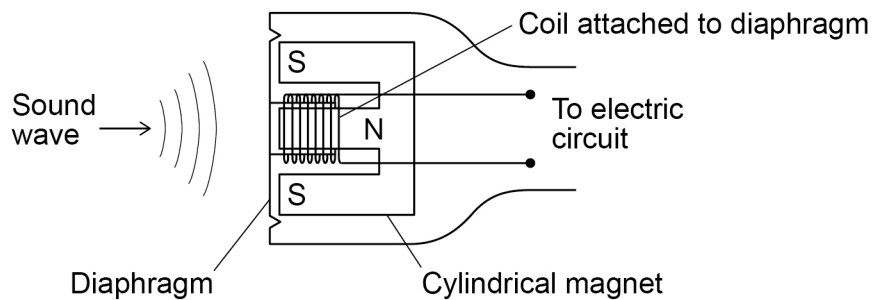


0 8 . 4

**Figure 14** shows a sound wave incident on the diaphragm of a moving-coil microphone.

The inside of the microphone includes a small coil of wire and a magnet.

**Figure 14**



Explain why the sound waves have an effect on the electric circuit.

[3 marks]

The pressure variations in the sound waves cause the diaphragm to vibrate.

The diaphragm causes the coil/wire to vibrate

The coil repeatedly changes direction, inducing an alternating current in the circuit.

8

**END OF QUESTIONS**



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