

Write your name here

Surname

Other names

Centre Number

Candidate Number

Pearson Edexcel
Level 1/Level 2 GCSE (9–1)

Physics

Paper 1

Higher Tier

Sample Assessment Material for first teaching September 2016

Time: 1 hour 45 minutes

Paper Reference

1PH0/1H

You must have:
Calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- Calculators may be used.
- Any diagrams may NOT be accurately drawn, unless otherwise indicated.
- You must **show all your working out** with **your answer clearly identified** at the **end of your solution**.

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- In questions marked with an asterisk (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box .
If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

1 There are many different types of waves.

(a) Waves on the surface of water are transverse waves.

Sound waves are longitudinal waves.

Describe the difference between transverse waves and longitudinal waves.

(2)

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(b) Figure 1 shows a ripple tank.

This is used to study the behaviour of water waves.

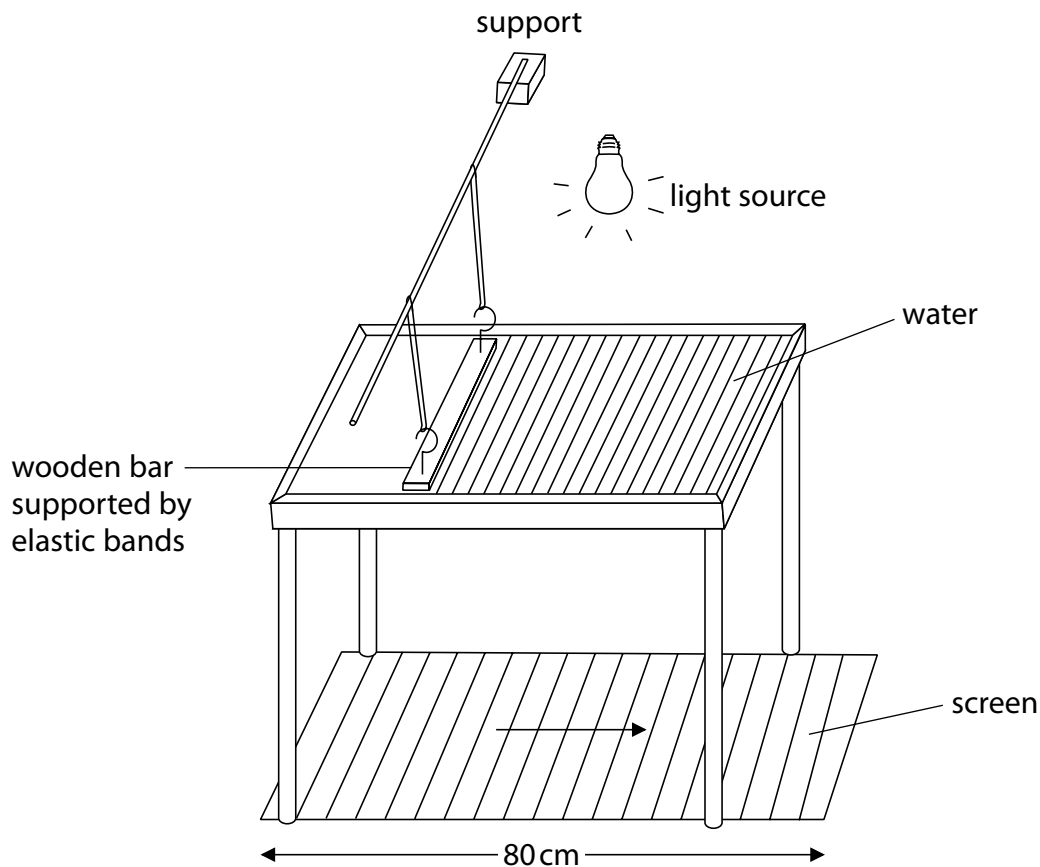


Figure 1

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Water waves are produced in the tank.

The shadow of the waves is projected onto the screen below the tank.

The waves appear to move in the direction of the arrow.

(i) Describe how to determine the frequency of the waves.

(2)

(ii) The screen is 80 cm long.

What is the approximate wavelength of the waves as seen on the screen?

(1)

- A 4 cm
- B 8 cm
- C 40 cm
- D 80 cm

(iii) A student uses the image to estimate the speed of the water wave as 75 cm/s.

Which of these is a reason why the estimate is not correct?

(1)

- A the student used a ruler without mm markings
- B the light was not bright enough
- C the student's measurement was inaccurate
- D the wave seen on the screen is magnified

(Total for Question 1 = 6 marks)

- 2 (a) Scientists no longer accept the geocentric model of the universe but it was the accepted theory for hundreds of years.

Explain why the evidence available at the time supported the geocentric model.

(3)

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- (b) The Big Bang theory and the Steady State theory are two theories about the origin of the universe.

The discovery of CMB led scientists to accept only one of the theories.

Explain why red shift supports both theories but CMB supports only one of them.

(3)

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(c) (i) A star with a mass very much larger than the Sun

(1)

- A** has a longer main sequence than the Sun and ends as a white dwarf
- B** has a longer main sequence than the Sun and ends as a black hole
- C** has a shorter main sequence than the Sun and ends as a white dwarf
- D** has a shorter main sequence than the Sun and ends as a black hole

(ii) Which row has two correct statements about black holes?

(1)

	the gravitational field of a black hole	a black hole is formed when
<input type="checkbox"/> A	allows only electromagnetic radiation to escape	a nebula collapses
<input type="checkbox"/> B	allows nothing to escape	a very large star collapses
<input type="checkbox"/> C	allows nothing to escape	a nebula collapses
<input type="checkbox"/> D	allows only electromagnetic radiation to escape	a very large star collapses

(Total for Question 2 = 8 marks)

3 (a) Figure 2 shows some lines in the absorption spectra from four different galaxies (A, B, C, and D) and from a laboratory source.

All the spectra are aligned and to the same scale.

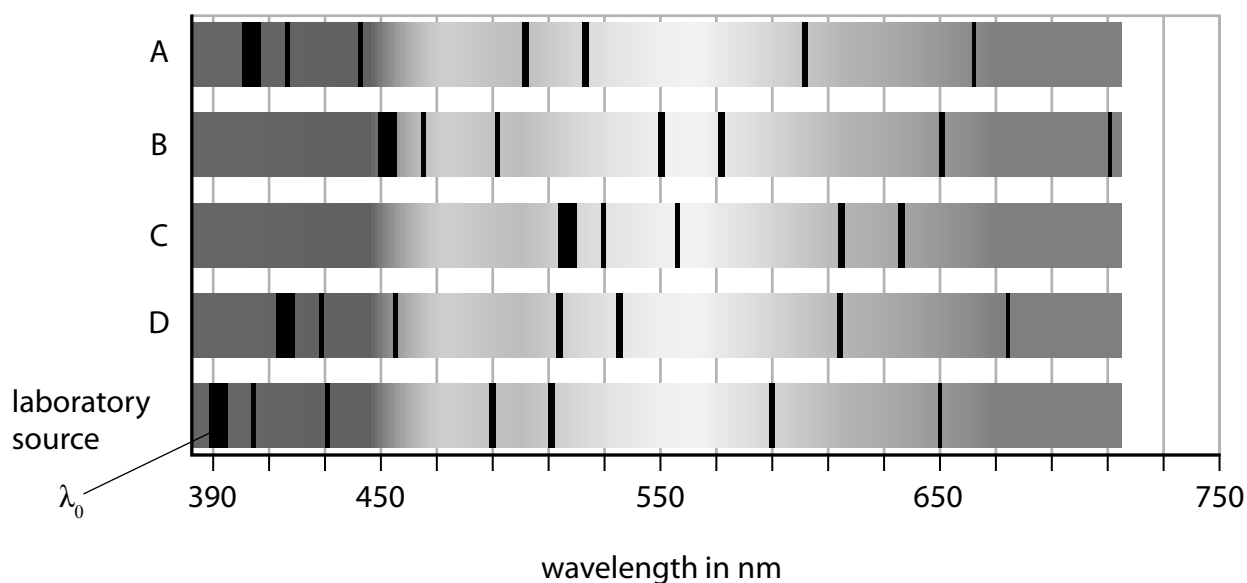


Figure 2

(i) Explain, using Figure 2, which galaxy is furthest away from us.

(3)

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(ii) In Figure 2, the reference wavelength, λ_0 , is shown at 390 nm.

Estimate the change in the reference wavelength, $\Delta\lambda$, for the light from galaxy D.

(1)

$\Delta\lambda = \dots\dots\dots$ nm

(iii) Calculate the speed, v , of galaxy D.

Use the equation

$$v = c \frac{\Delta\lambda}{\lambda_0}$$

[$c = \text{speed of light} = 3 \times 10^8 \text{ m/s}$]

(2)

$v = \dots\dots\dots$ m/s

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(b) Figure 3 shows a photograph of galaxy D.

This photograph was taken by a student at his home.



(Source: Paul Curtis)

Figure 3

State **two** ways that the student can improve the observational techniques so that the quality of the image is improved.

(2)

1

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2

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(Total for Question 3 = 8 marks)

4 Figure 4 shows two students investigating their reaction times.

Student B supports his left hand on a desk.

Student A holds a ruler so that the bottom end of the ruler is between the finger and thumb of student B.

When student A releases the ruler, student B catches the ruler as quickly as he can.

The investigation is repeated with the right hand of student B.

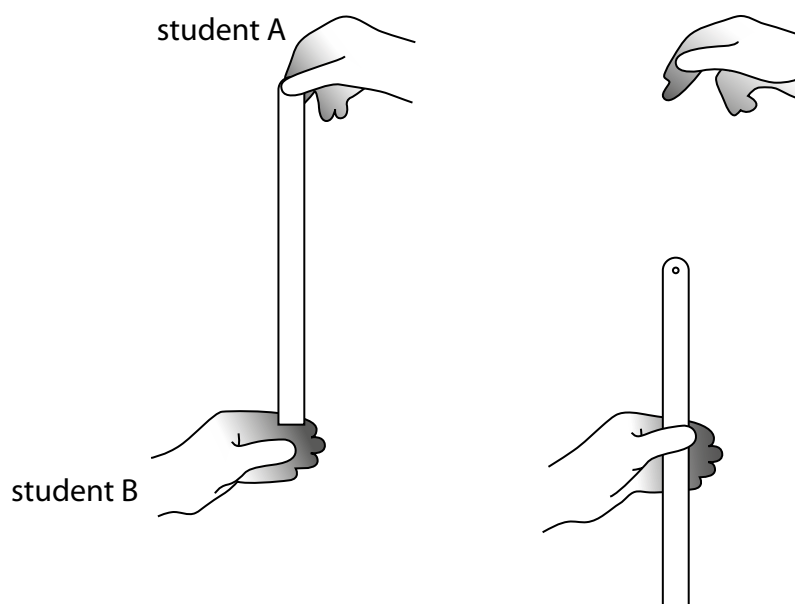


Figure 4

(a) The students took five results for the left hand and five results for the right hand.

Figure 5 shows their results.

which hand	distance dropped (cm)					average
	trial 1	trial 2	trial 3	trial 4	trial 5	
left	10.1	25.5	18.4	14.6	11.7	14
right	17.5	16.1	19.4	18.6	20.2

Figure 5

(i) Calculate the average distance dropped for the right hand.

Give your answer correct to 2 significant figures.

(2)

distance = cm

(ii) Calculate the average time for the left hand.

Use the equation

$$\text{time}^2 = \frac{\text{distance}}{500}$$

(2)

average time = s

(b) Explain whether any of the readings are anomalous.

(2)

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(c) Give **two** ways that the students can improve the quality of their data other than ignoring anomalous results.

(2)

1

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2

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(d) Describe how the students could develop their investigation to investigate how reaction time changes with another variable.

(2)

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(Total for Question 4 = 10 marks)

5 (a) A car accelerates at a constant rate of 1.83 m/s^2 along a flat straight road.

The force acting on the car is 1.870 kN .

Calculate the mass of the car.

Give your answer to three significant figures.

(3)

mass = kg

(b) The car accelerates from rest for 16 s .

Calculate the speed of the car after 16 s .

(3)

speed = m/s

(c) The car starts on another journey.

Figure 6 shows the graph of the car's movement.

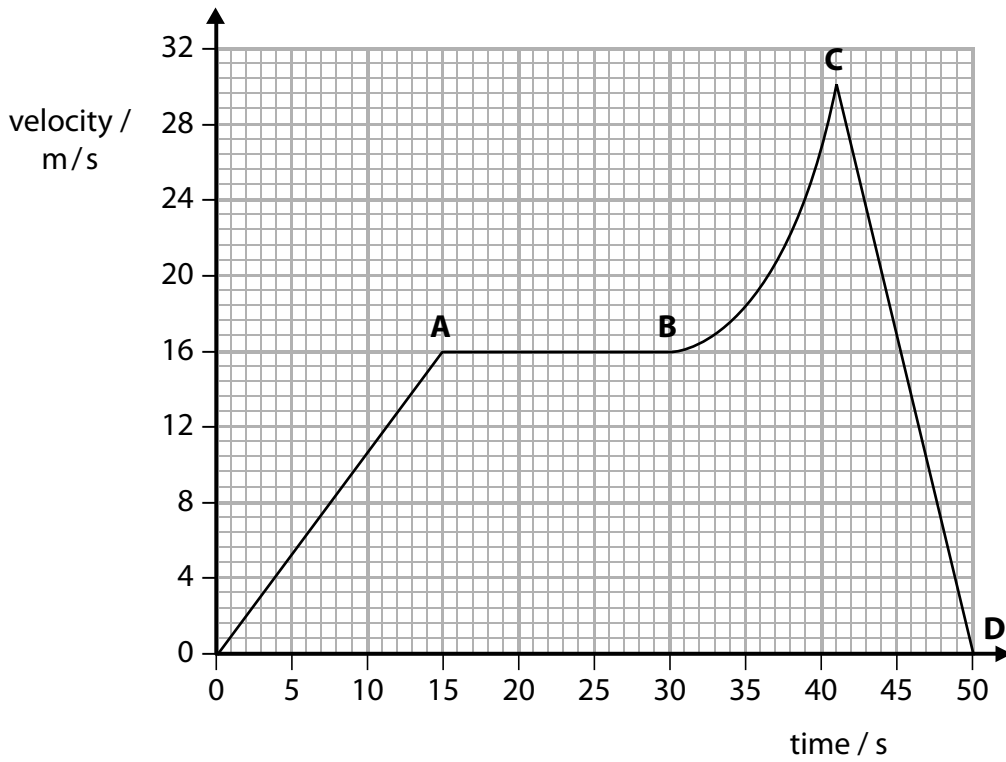


Figure 6

Show that the distance travelled when the car is moving at a constant speed is greater than the distance travelled when the car is slowing down.

(4)

(Total for Question 5 = 10 marks)

6 Figure 7 shows the nuclei of four atoms.

${}^{234}_{92}\text{U}$ uranium-234	${}^{235}_{92}\text{U}$ uranium-235	${}^{238}_{94}\text{Pu}$ plutonium-238	${}^{238}_{95}\text{Am}$ americium-238
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Figure 7

(a) Which two nuclei have the same number of neutrons?

(1)

- A plutonium-238 and uranium-235
- B uranium-235 and americium-238
- C uranium-234 and americium-238
- D americium-238 and plutonium-238

(b) (i) State what is meant by the term 'half-life'.

(1)

(ii) Plutonium-238 is used in spacecraft to provide heat to power generators.

One of these generators contains 925 g of plutonium-238 when it is manufactured.

One gram of plutonium-238 has a power density of 0.54 W/g.

Plutonium-238 has a half-life of 87.7 years.

Calculate the average energy released per second by the generator after 263 years.

(4)

average energy released per second = (J)

- (c) The nucleus of americium-238 can absorb an electron.

When this happens, one of the protons in the nucleus becomes a neutron, as shown in Figure 8.

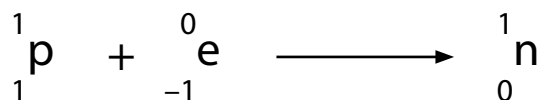


Figure 8

- (i) Describe how absorbing an electron affects the proton number and the nucleon number of a nucleus.

(2)

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- (ii) Deduce which nucleus is formed when americium-238 absorbs an electron.

(1)

- A** uranium-234
- B** uranium-235
- C** plutonium-238
- D** americium-238

(Total for Question 6 = 9 marks)

- 7 A student investigates how the average speed of the trolley varies with starting height.
Figure 9 shows the trolley and runway.

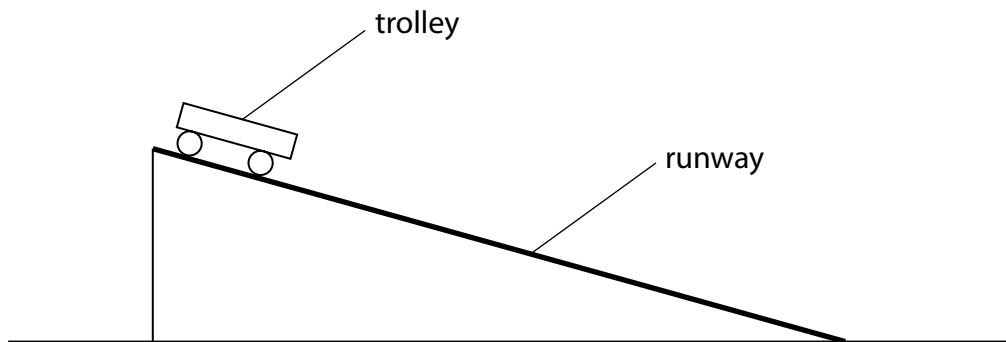


Figure 9

- (a) Describe how the student can determine the average speed of the trolley.

(4)

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(b) Figure 10 shows his results.

starting height / m	v / ms ⁻¹
0.01	0.22
0.02	0.31
0.04	0.44
0.09	0.66
0.12	0.77
0.14	0.83
0.18	0.94

Figure 10

Figure 11 shows the student's graph.

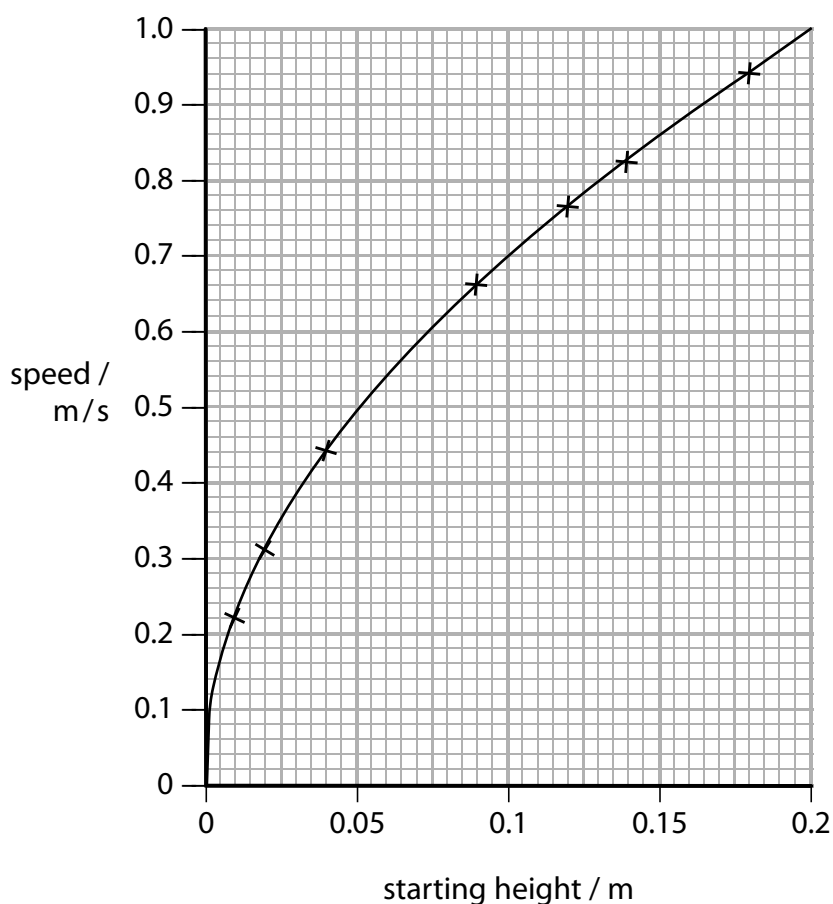


Figure 11

(i) The trolley has a mass of 650 g.

Calculate the average kinetic energy of the trolley which had a starting height of 0.075 m.

(2)

average kinetic energy = J

(ii) Determine the gradient of the graph when the height is 0.1 m.

(2)

gradient =

(iii) Describe how the speed of the trolley varies with the changes in height made by the student between 0.04 m and 0.12 m.

(2)

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- (c) The student wants to change his experiment to investigate how different surfaces of the runway affect the speed of the trolley down the slope.

Devise an experiment that would allow him to investigate the effect of different surfaces on the average speed of the trolley.

(3)

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(Total for Question 7 = 13 marks)

8 (a) All objects emit electromagnetic radiation.

The intensity and wavelength of the emitted radiation vary with the temperature of the object.

Figure 12 shows this variation for a filament lamp at two different temperatures.

The visible region of the electromagnetic spectrum is also shown.

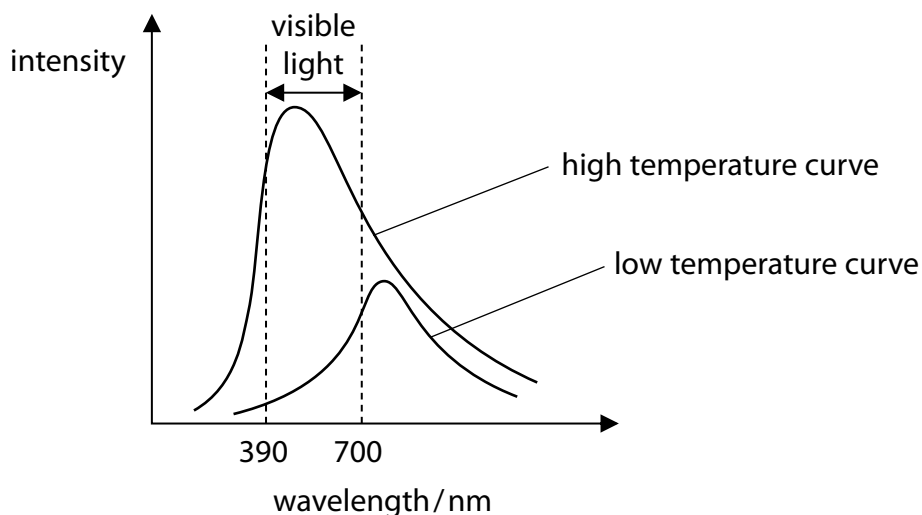


Figure 12

- (i) Explain why a filament lamp appears brighter and less red as its temperature increases. (4)

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- (ii) The intensity of gamma radiation can be measured using a Geiger-Müller tube and counter.

The count rate recorded by the counter tube depends on how far away the Geiger-Müller tube is from the gamma radiation source.

The equation relating count rate to distance from the source is

$$\text{count rate} = \frac{k}{d^2}$$

where d is the distance from the source and k is a constant.

A Geiger-Müller tube is placed 0.70 m from a source of gamma radiation. The counter displays a count rate of 85 000 count per minute.

Calculate the count rate recorded when the Geiger-Müller tube is placed 1.3 m away from the same gamma radiation source.

(3)

count rate = counts per minute

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- 9 (a) Explain what happens to the wavelength of light when it passes from air into glass. (2)

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- *(b) Figure 13 shows a beam of red light approaching one side of a rectangular glass block. The beam of light will pass through the block and leave through the opposite side. **AB** is a wavefront.

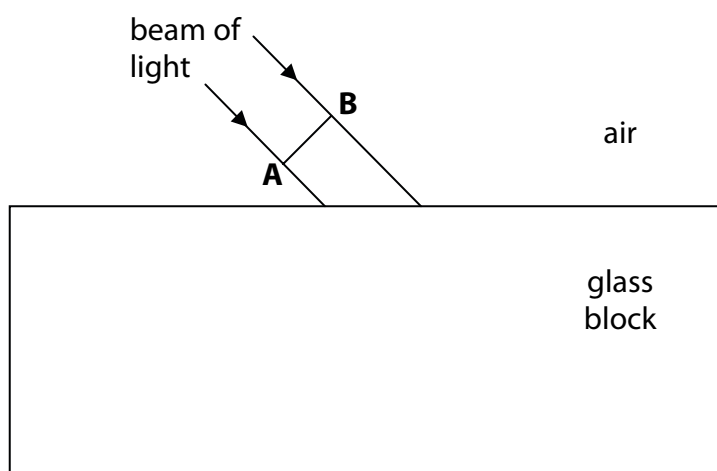


Figure 13

- Discuss the path of the wavefront **AB** as it enters and leaves the glass block. (6)

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(c) The distance between the Earth and the Sun is 1.50×10^{11} m.

Light takes 500 s to travel from the Sun to the Earth.

The wavelength of red light is 670 nm.

Calculate the frequency of red light, using only the data provided.

(4)

frequency = Hz

(Total for Question 9 = 12 marks)

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10 In a nuclear reactor, a chain reaction is produced and controlled.

(a) (i) Uranium-235 is the isotope used in many nuclear reactors.

Explain how the fission of uranium-235 can lead to a chain reaction.

(4)

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(ii) Nuclei of beryllium-9 do not absorb neutrons.

Instead, nuclei of beryllium-9 absorb alpha particles and emit neutrons.

Give a reason why a chain reaction can result from the emission of neutrons by uranium nuclei but not by beryllium nuclei.

(1)

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(b) Explain what happen inside a nuclear reactor if neutron speeds are not controlled.

(3)

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(c) Describe how the energy released in the chain reaction in a nuclear reactor is used to drive a turbine in a nuclear power station.

(3)

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(Total for Question 10 = 11 marks)

TOTAL FOR PAPER = 100 MARKS

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Equations

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

$$v^2 - u^2 = 2 \times a \times x$$

$$\text{force} = \text{change in momentum} \div \text{time}$$

$$F = \frac{(mv - mu)}{t}$$

$$\text{energy transferred} = \text{current} \times \text{potential difference} \times \text{time}$$

$$E = I \times V \times t$$

$$\text{force on a conductor at right angles to a magnetic field carrying a current} = \text{magnetic flux density} \times \text{current} \times \text{length}$$

$$F = B \times I \times l$$

$$\frac{\text{voltage across primary coil}}{\text{voltage across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\text{potential difference across primary coil} \times \text{current in primary coil} = \text{potential difference across secondary coil} \times \text{current in secondary coil}$$

$$V_p \times I_p = V_s \times I_s$$

$$\text{change in thermal energy} = \text{mass} \times \text{specific heat capacity} \times \text{change in temperature}$$

$$\Delta Q = m \times c \times \Delta\theta$$

$$\text{thermal energy for a change of state} = \text{mass} \times \text{specific latent heat}$$

$$Q = m \times L$$

$$P_1 V_1 = P_2 V_2$$

$$\text{to calculate pressure or volume for gases of fixed mass at constant temperature}$$

$$\text{energy transferred in stretching} = 0.5 \times \text{spring constant} \times (\text{extension})^2$$

$$E = \frac{1}{2} \times k \times x^2$$

$$\text{pressure due to a column of liquid} = \text{height of column} \times \text{density of liquid} \times \text{gravitational field strength}$$

$$P = h \times \rho \times g$$

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Paper 1 Higher

Question number	Answer	Mark
1(a)	<p>An answer that provides a description by making reference to:</p> <ul style="list-style-type: none"> transverse waves have oscillations perpendicular to direction of travel of the wave (1) whereas longitudinal waves have oscillations in the same direction as the direction of travel of the wave (1) 	(2)

Question number	Answer	Mark
1(b)(i)	<p>An answer that combines the following points of understanding to provide a logical description:</p> <ul style="list-style-type: none"> take time T for waves to pass a fixed point (1) and frequency = $\frac{\text{number of waves}}{\text{time taken}}$ (1) 	(2)

Question number	Answer	Mark
1(b)(ii)	A	(1)

Question number	Answer	Mark
1(b)(iii)	D	(1)

Question number	Answer	Additional guidance	Mark
2(a)	<p>An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks):</p> <ul style="list-style-type: none"> at the time, there was only naked-eye evidence (1) which indicated Sun/Moon/planets appear to move across the sky (1) in the same direction, same motion each day (1) 	allow valid alternatives, e.g. references to comets	(3)

Question number	Answer	Additional guidance	Mark
2(b)	<p>An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks):</p> <ul style="list-style-type: none"> • both theories predict an expanding universe and the Big Bang theory also predicts that the universe had a beginning (1) • the red shift theory indicates that the universe is expanding so supports both theories (1) • whereas CMB also indicates that the universe had a beginning, so supports Big Bang theory (1) 	provided evidence that the Steady State theory was incorrect	(3)

Question number	Answer	Mark
2(c)(i)	B	(1)

Question number	Answer	Mark
2(c)(ii)	B	(1)

Question number	Answer	Mark
3(a)(i)	<p>An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (2 marks):</p> <ul style="list-style-type: none"> • galaxy C has the greatest red shift (1) • so this galaxy has the greatest speed (1) • since the galaxy with the greatest speed will be furthest away, then galaxy C is at the furthest distance(1) 	(3)

Question number	Answer	Additional guidance	Mark
3(a)(ii)	20 (nm)	Allow answers in the range 19 to 25	(1)

Question number	Answer	Additional guidance	Mark
3(a)(iii)	Substitution (1) $v = \frac{(3 \times 10^8) \times (20 \times 10^{-9})}{(390 \times 10^{-9})}$ Answer (1) = 15 400 000 (m/s)	allow ecf from (c)(i) power of 10 error = max 1 accept 15 384 615 (m/s) award full marks for correct numerical answer without working	(2)

Question number	Answer	Additional guidance	Mark
3(b)	Any two from the following improvements: <ul style="list-style-type: none"> • use wider aperture telescope/camera (1) • better quality objective lens (1) • use longer exposure time while telescope is locked onto star (1) • move telescope to better seeing conditions, e.g. dry desert, higher up a mountain, dark skies (1) 	allow improvements from photography, e.g. use longer exposure time use a satellite telescope ignore use pc to adjust the sharpness of the image	(2)

Question number	Answer	Additional guidance	Mark
4(a)(i)	Calculating the mean (1) 18.36 Rounding to 2 s.f. (1) 18 (cm)	award full marks for correct numerical answer without working	(2)

Question number	Answer	Additional guidance	Mark
4(a)(ii)	Rearrangement (1) $t = \sqrt{\frac{\text{distance}}{500}}$ Substitution and answer (1) time = 0.17 (s)	award full marks for correct numerical answer without working allow answers which round to 0.17, e.g. 0.1673	(2)

Question number	Answer	Additional guidance	Mark
4(b)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): <ul style="list-style-type: none"> • 25.5 is an anomalous result (1) • (because) it is much further away from the mean than the other results (1) 	ignore 19	(2)

Question number	Answer	Mark
4(c)	<ul style="list-style-type: none"> • Take more readings (1) • Idea that a third student should also measure the reaction time (1) 	(2)

Question number	Answer	Additional guidance	Mark
4(d)	<p>An answer that combines the following points to provide a logical description of the plan/method/experiment:</p> <ul style="list-style-type: none"> • using a larger group of students/large population of students (1) • and measure how their reaction time varies with age/height (1) 	allow any suitable variable	(2)

Question number	Answer	Additional guidance	Mark
5(a)	<p>Rearrangement (1)</p> $m = \frac{f}{a}$ <p>Substitution and conversion (1)</p> $m = \frac{1870}{1.83}$ <p>Answer and rounding to 3 s.f. (1) 1020 (kg)</p>	<p>maximum 2 marks if kN not converted to N</p> <p>award full marks for correct numerical answer without working</p>	(3)

Question number	Answer	Additional guidance	Mark
5(b)	<p>Rearrangement of $\frac{(v-u)}{t} = a$ (1)</p> $v = u + at$ <p>Substitution (1)</p> $v = 0 + 1.83 \times 16$ <p>Answer (1) 29.3 (m/s)</p>	award full marks for correct numerical answer without working	(3)

Question number	Answer	Mark
5(c)	<p>Correctly identifies data points from the graph to calculate areas (1)</p> <p>Calculates area under AB (1) 240 m</p> <p>Calculates area under CD (1) 135 m</p> <p>distance travelled at constant speed = 240 m is greater than distance travelled when slowing down = 135 m (1)</p>	(4)

Question number	Answer	Mark
6(a)	B	(1)

Question number	Answer	Additional guidance	Mark
6(b)(i)	The time taken for the activity of a radioactive nuclide to halve (1)	accept for nuclide: isotope sample	(1)

Question number	Answer	Additional guidance	Mark
6(b)(ii)	<p>Determines number of half-lives and rounds (1) $263/87.7 = 3$</p> <p>Determines that 3 half-lives is $1/2 \times 1/2 \times 1/2 = 1/8$ (1)</p> <p>Determines mass of Pu-238 after 3 half-lives (1) $925/8 = 115.625$ (g)</p> <p>Determines average energy released per second (1) $115.625 \times 0.54 = 62.4$ (J)</p>	<p>allow repeated division by 2 allow ecf from step 2 for 1 mark (mass of Pu-238 after 1 half-life $925/2 = 462.5$ (g))</p> <p>allow ecf from 1 half-life or from step 3</p>	(4)

Question number	Answer	Mark
6(c)(i)	<p>An answer that combines the following points of application of knowledge and understanding to provide a logical description:</p> <ul style="list-style-type: none"> proton number/atomic number decreases by 1 (1) nucleon number/mass number remains unchanged (as p and n have same mass and mass of electron is (assumed) negligible) (1) 	(2)

Question number	Answer	Mark
6(c)(ii)	C	(1)

Question number	Answer	Additional guidance	Mark
7(a)	<p>An answer that combines the following points of understanding to provide a logical description:</p> <ul style="list-style-type: none"> measurement of time between(or at) two positions using suitable timing equipment (1) measurement of suitable distance along the runway with metre rule (1) measurement of vertical height to starting position (1) repeats AND averages AND use of a correct equation (1) 	<p>allow</p> <p>stopwatch, light gates</p> <p>minimum is 0.5 m metal tape measure</p> <p>average speed = distance/time OR average speed = (speed at A – speed at B)/2</p>	(4)

Question number	Answer	Additional guidance	Mark
7(b)(i)	Substitution of correct data from graph and mass conversion (1) $0.5 \times 0.65 \times (0.61)^2$ Answer (1) 0.12 (J)	maximum of 1 mark if mass in g used allow tolerance of ± 0.2 for speed	(2)

Question number	Answer	Additional guidance	Mark
7(b)(ii)	<ul style="list-style-type: none"> Tangent to the graph at $h = 0.1$ (1) Answer in the region 3.5 to 3.6 	either seen on graph or suitable pairs of values of Δv and Δh	(2)

Question number	Answer	Mark
7(b)(iii)	<p>An answer that combines points of interpretation/evaluation to provide a logical description:</p> <ul style="list-style-type: none"> for each change in height, as the height increases the speed of the trolley increases the greatest change in speed is between the change in height from 0.04 m to 0.9 m 	(2)

Question number	Answer	Additional guidance	Mark
7(c)	<p>An answer that combines the following points to provide a logical description of the plan/method/experiment:</p> <ul style="list-style-type: none"> identifies control variables (1) uses at least 3 different surfaces (1) calculates average speed for each surface and repeats (1) 	<p>constant height, constant slope, constant starting points and same length of surface</p>	(3)

Question number	Answer	Mark
8(a)(i)	<p>An explanation that combines identification via a judgement (2 marks) to reach a conclusion via justification/reasoning (2 marks):</p> <ul style="list-style-type: none"> intensity of radiation increases with temperature (1) the distribution of the emitted wavelengths of radiation is affected by temperature (1) at low temperatures the intensity of radiation emitted is low and the (range of) emitted wavelengths (of radiation) are high so the lamp appears dull red (1) at higher temperatures the intensity of the radiation is greater and the (range of) emitted wavelengths (of radiation) are low so the lamp appear to be brighter and less red (1) 	(4)

Question number	Answer	Additional guidance	Mark
8(a)(ii)	Substitution and rearrangement to find k (1) $k = 85000 \times 0.70^2$ Substitution to find new count rate (1) count rate = $\frac{85000 \times 0.70^2}{1.3^2}$ Answer (1) 25000 (counts per minute)	41650 24645 (counts per minute)	(3)

Question number	Indicative content	Mark
*8(b)	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p style="text-align: center;">AO2 (6 marks)</p> <ul style="list-style-type: none"> • the soot could make the ice black • black ice will absorb more IR radiation than white ice • black ice might cause an increase in the temperature of the Earth because absorption of IR radiation (can) cause an increase in temperature • reduction in soot might reduce warming because the ice will not be as black/will be more white • shiny sulfates (are good at) reflecting/scattering IR radiation which means less heat absorbed • sulfates scatter the IR and this reduces the amount of IR radiation falling on the Earth • sulfates might cause a decrease in the temperature of the Earth • reduction in sulfates might increase warming 	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	<ul style="list-style-type: none"> The discussion attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2) Lines of reasoning are unsupported or unclear. (AO2)
Level 2	3–4	<ul style="list-style-type: none"> The discussion is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2) Lines of reasoning mostly supported through the application of relevant evidence. (AO2)
Level 3	5–6	<ul style="list-style-type: none"> The discussion is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2) Lines of reasoning are supported by sustained application of relevant evidence. (AO2)

Question number	Answer	Additional guidance	Mark
9(a)	<p>An explanation that makes reference to: identification – knowledge (1 mark) and reasoning /justification – knowledge (1 mark):</p> <ul style="list-style-type: none"> the wavelength decreases because wavelength is the ratio of wave velocity to frequency (1) and the wave velocity reduces at the boundary but the frequency remains the same (1) 	<p>allow the same number of waves per second arrive at the boundary as leave it for no change in frequency at the boundary</p>	(2)

Question number	Indicative content	Mark
9(b)	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p style="text-align: center;">AO1 (6 marks)</p> <ul style="list-style-type: none"> • point A reaches the glass block before point B • A moves into the glass block and slows down • as light travels more slowly in glass than in air • B is still in air so is travelling faster than A • this causes part of the wavefront to change direction/refract • by the time B reaches the block it will have travelled further than A • therefore, the whole wavefront changes direction/refracts towards the normal • at the other face, A exits first so the process is reversed • the wavefront changes direction again so it is parallel to its original direction/refracts away from the normal 	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	<ul style="list-style-type: none"> • Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	<ul style="list-style-type: none"> • Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	<ul style="list-style-type: none"> • Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Question number	Answer	Additional guidance	Mark
9(c)	Substitution into $v = \frac{s}{t}$ to find v (1) $v = \frac{1.5 \times 10^{11}}{500}$ Substitution into $v = f \times \lambda$ and unit conversion (1) $v = \frac{1.5 \times 10^{11}}{500} = f \times 670 \times 10^{-9}$ Transposition (1) Rearrangement (1) $f = \frac{(1.50 \times 10^{11})}{500 \times (670 \times 10^{-9})}$ Answer (1) 4.5×10^{14} (Hz)	s is distance award full marks for correct numerical answer without working maximum 3 marks if λ in nm 4.4776×10^{14} (Hz)	(4)

Question number	Answer	Additional guidance	Mark
10(a)(i)	An explanation that combines identification – knowledge (1 mark) and reasoning/justification – knowledge (3 marks): <ul style="list-style-type: none"> • causes 2 or 3 neutrons to be released (1) • (and) one or more of these (released) neutrons are absorbed by other (U) nuclei (1) • which cause further fission of U nuclei (1) • and release further neutrons that can be absorbed, causing a chain reaction (1) 	ignore U nucleus 'splits up'/eq	(4)

Question number	Answer	Mark
10(a)(ii)	Idea that to get a chain reaction the particle that impacts the nucleus must be the same as the one released (1)	(1)

Question number	Answer	Additional guidance	Mark
10(b)	<p>An explanation that combines identification – knowledge (1 mark) and reasoning/justification – knowledge (2 marks):</p> <ul style="list-style-type: none"> • reaction will slow down (1) • because there are fewer fissions (1) • because fission more likely with slow neutrons (1) 	<p>allow</p> <p>reactor shuts down/eq</p> <p>fission requires slow neutrons</p> <p>thermal neutrons for slow neutrons</p>	(3)

Question number	Answer	Mark
10(c)	<p>An answer that combines the following points of understanding to provide a logical description:</p> <ul style="list-style-type: none"> • the reactor is surrounded by a coolant (1) • the thermal energy release from the chain reaction heats the coolant (1) • the hot coolant is used to generate steam which is used to drive the turbine (1) 	(3)