INTERNATIONAL ADVANCED LEVEL

Physics

SAMPLE ASSESSMENT MATERIALS

Pearson Edexcel International Advanced Subsidiary in Physics (XPH01)

Pearson Edexcel International Advanced Level in Physics (YPH01)

For first teaching in September 2013
First examination January 2014

Contents

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number ☐☐☐☐☐

Candidate Number ☐☐☐☐

Physics

Advanced Subsidiary
Unit 1: Physics on the Go

Sample Assessment Material
Time: 1 hour 30 minutes

Paper Reference
WPH01/01

You must have:
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.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*****) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

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

Turn over ▶

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S 4 5 3 6 6 A 0 1 2 8

PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒.
If you change your mind, put a line through the box ~~☒~~ and then
mark your new answer with a cross ☒.

1 Which pair of quantities does **not** contain a vector and a scalar?

☒ **A** acceleration and time

☒ **B** force and displacement

☒ **C** mass and acceleration

☒ **D** velocity and time

(Total for Question 1 = 1 mark)

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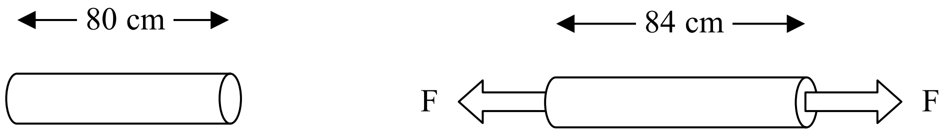
2 A wire of length 80 cm has a force F applied. The new length of the wire is 84 cm.



The strain is given by

☒ **A** $\frac{4}{84}$

☒ **B** $\frac{4}{80}$

☒ **C** $\frac{80}{84}$

☒ **D** $\frac{84}{80}$

(Total for Question 2 = 1 mark)

3 Which of the following is a derived SI quantity?

☒ **A** force

☒ **B** length

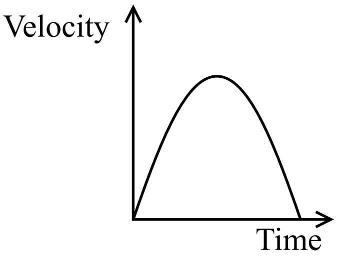
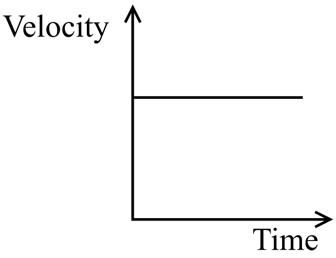
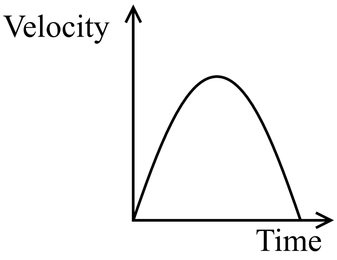
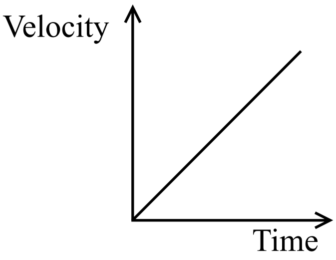
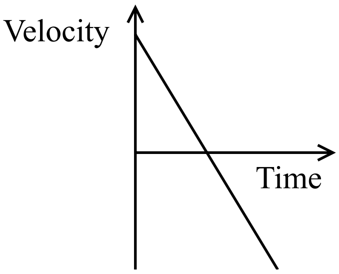
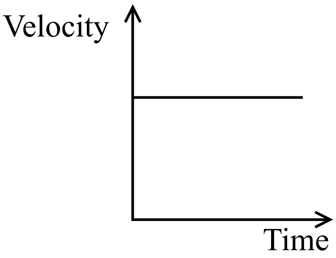
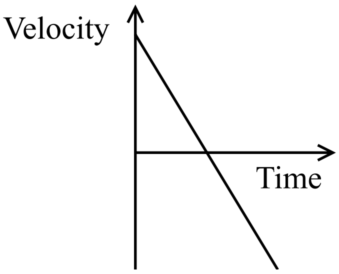
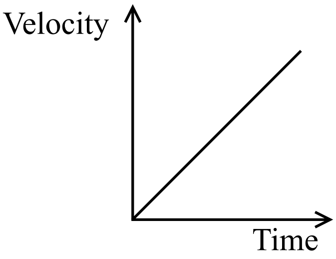
☒ **C** second

☒ **D** watt

(Total for Question 3 = 1 mark)

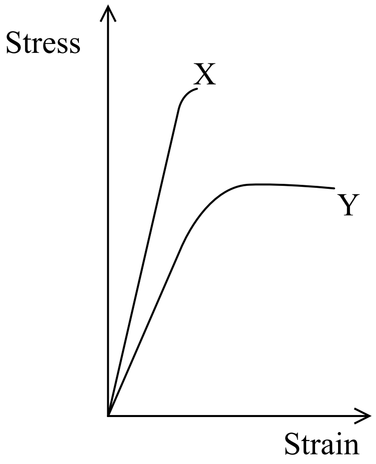
4 A projectile is launched at an angle of 45° to the horizontal.

Ignoring air resistance, which pair of graphs correctly shows how the vertical and horizontal components of velocity vary with time for the projectile until it lands?

	Vertical component	**Horizontal component**
☒ **A**		
☒ **B**		
☒ **C**		
☒ **D**		

(Total for Question 4 = 1 mark)

5 The graph shows stress against strain up to the breaking point for two materials X and Y.

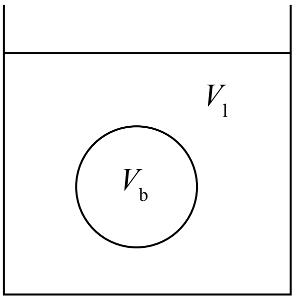


Which row in the table correctly identifies the behaviour of each material?

	X	**Y**
☒ **A**	brittle	ductile
☒ **B**	ductile	brittle
☒ **C**	ductile	hard
☒ **D**	brittle	hard

(Total for Question 5 = 1 mark)

6 A ball of volume V_b and density ρ_b is released in a volume V_l of liquid with density ρ_l.



The upthrust on the ball is given by

☒ **A** $V_b \rho_b g$

☒ **B** $V_b \rho_l g$

☒ **C** $V_l \rho_b g$

☒ **D** $V_l \rho_l g$

(Total for Question 6 = 1 mark)

7 A hanging basket of weight W is supported by three chains of equal length, each at an angle θ to the vertical.

The tension, T, in each chain is given by

☒ **A** $T = \dfrac{3W}{\cos\theta}$

☒ **B** $T = \dfrac{3W}{\sin\theta}$

☒ **C** $T = \dfrac{W}{3\cos\theta}$

☒ **D** $T = \dfrac{W}{3\sin\theta}$

(Total for Question 7 = 1 mark)

8 Which of the following descriptions of a material implies that it undergoes significant plastic deformation?

☒ **A** brittle

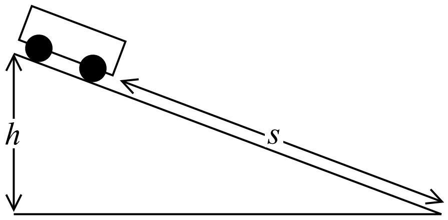
☒ **B** hard

☒ **C** malleable

☒ **D** stiff

(Total for Question 8 = 1 mark)

9 A trolley rolls down a slope from rest. The trolley moves through a vertical height h while rolling a distance s along the slope.



The maximum possible speed is given by

☒ **A** $2gs$

☒ **B** $2gh$

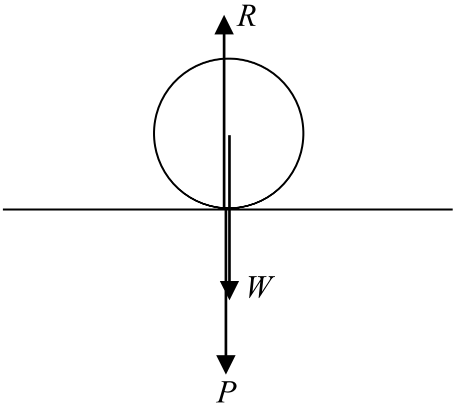
☒ **C** $\sqrt{(2gs)}$

☒ **D** $\sqrt{(2gh)}$

(Total for Question 9 = 1 mark)

10 An apple is at rest on the ground.

The diagram shows three forces of equal magnitude.



W = weight of apple

P = push of apple on ground

R = normal contact force of ground on apple

Which row in the table shows Newton's first and third laws being applied correctly.

	Newton's first law	Newton's third law
☒ **A**	$P = W$	$R = P$
☒ **B**	$R = P$	$W = R$
☒ **C**	$W = R$	$P = W$
☒ **D**	$W = R$	$R = P$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 Viscosity is sometimes given units of kg m^{-1} s^{-1} and sometimes Pa s.

Show that these are equivalent.

(2)

(Total for Question 11 = 2 marks)

12 (a) State what is meant by centre of gravity.

(1)

(b) The picture shows a snooker cue. It is made from wood of uniform density and takes the form of a rod with decreasing diameter towards one end.

(i) On the picture, mark the position of the centre of gravity of the snooker cue.

(1)

(ii) State a simple method to test if this is the correct position.

(1)

(Total for Question 12 = 3 marks)

13 Queues of cars often form behind cyclists on narrow, rural roads.

Sometimes cars that would normally travel at 65 km hour^{-1} may be limited to about 20 km hour^{-1} by a cyclist.

(a) Show that 65 km hour^{-1} is about 18 m s^{-1}.

(1)

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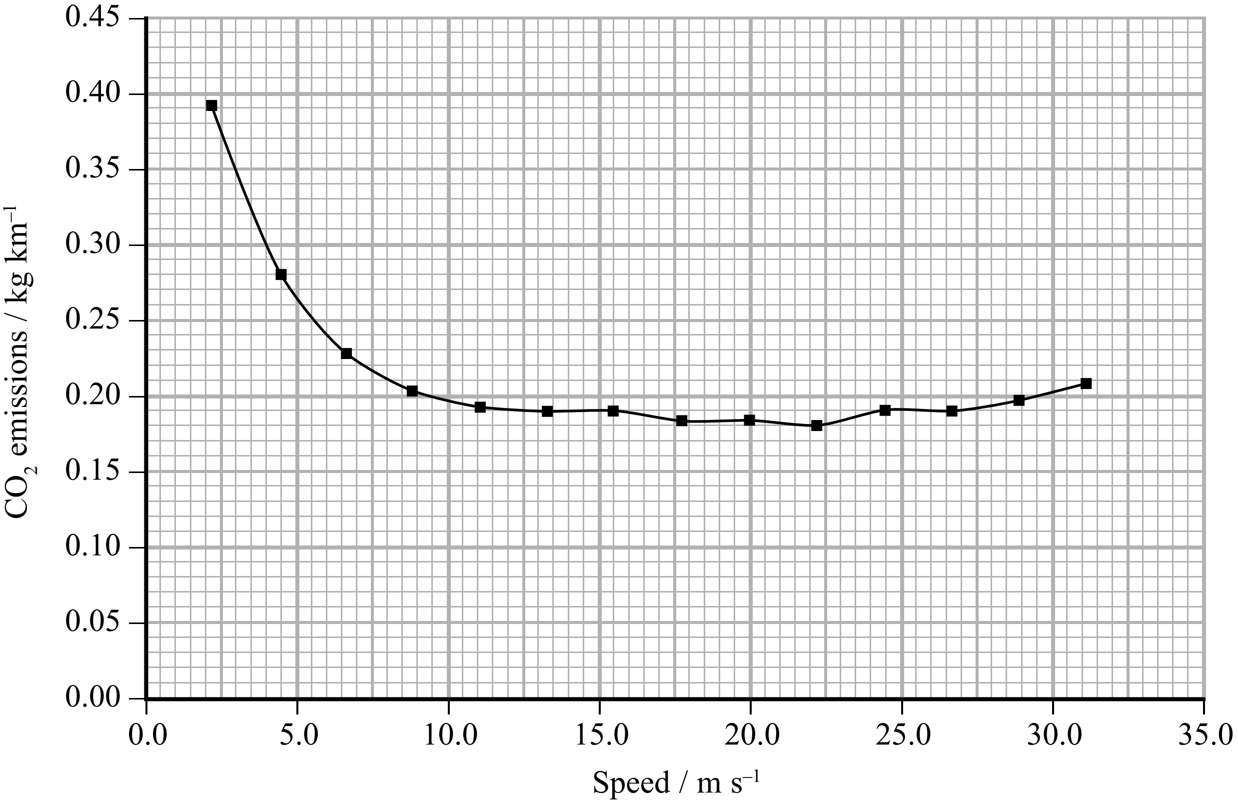
(b) The graph shows the amount of carbon dioxide emitted per kilometre by a typical car at different speeds.



During a 10 minute journey a cyclist, travelling at 5 m s^{-1}, has an average of three cars queuing behind him. The cars would otherwise be travelling at 18 m s^{-1}. The cars emit more carbon dioxide because they are travelling slowly.

(i) Calculate the extra carbon dioxide emitted by the 3 cars due to travelling at this reduced speed for 10 minutes.

(4)

Extra carbon dioxide emitted = ...

(ii) If the cyclist had made the same journey in his car at 18 m s^{-1}, his car would have emitted 0.54 kg of carbon dioxide. Comment on the significance of this.

(1)

(Total for Question 13 = 6 marks)

14 The gravitational field strength on the Moon is about 1/6 of the gravitational field strength on the Earth.

(a) On the Moon, an astronaut dropped a golf ball. He later wrote "When I dropped the ball, it took about three seconds to land."

Show that the astronaut would need to be over 7 m tall for the ball to take 3 s to land.

(2)

(b) The astronaut hit the ball with a golf club. He wrote "The ball, which would have gone thirty to forty yards on the Earth, went over two hundred yards. The ball stayed up in the black sky for almost thirty seconds."

Assume an initial velocity of 18 m s^{-1} at 34° to the horizontal.

(i) Show that the astronaut's suggested time of flight of 30 s is over twice the actual value.

(3)

(ii) Show that the value given for the initial velocity leads to a value for the horizontal distance travelled by the ball in agreement with his stated value.

200 yards = 183 m

(3)

*(c) A projectile would have a greater range on the Moon than the Earth because of the lower gravitational field strength and because of the lack of an atmosphere.

Explain how each of these factors would increase the range of the projectile.

(3)

(Total for Question 14 = 11 marks)

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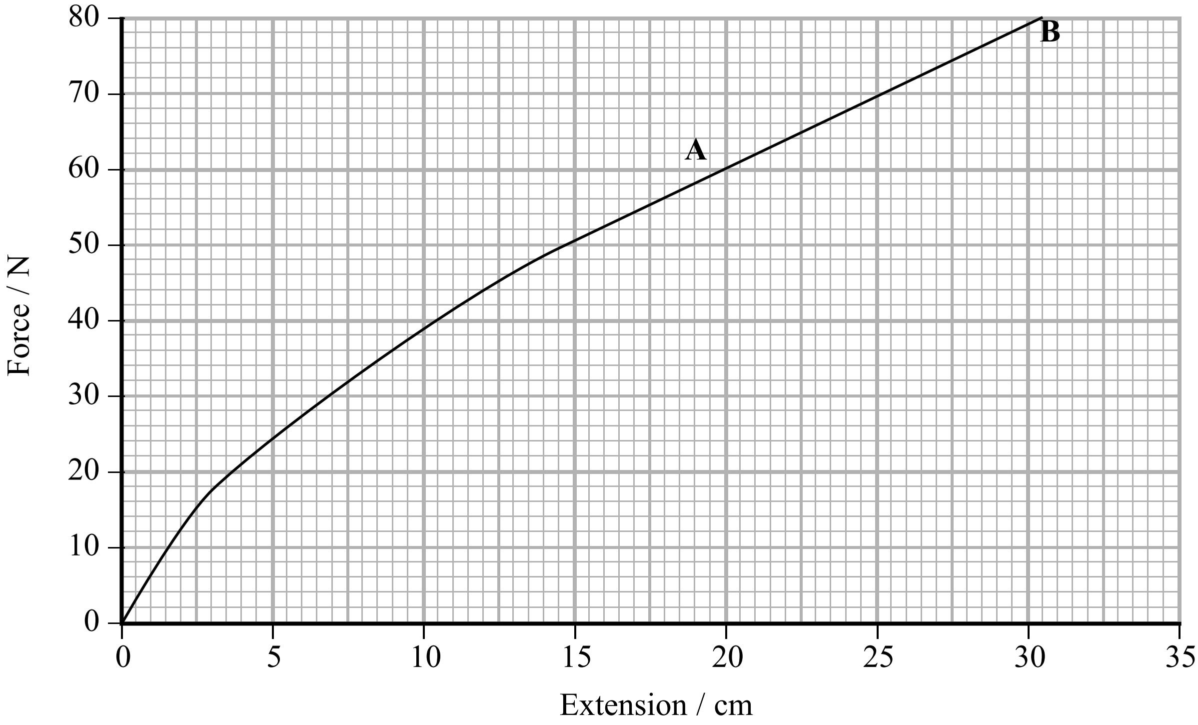
15 The photographs show an exercise device and someone using it. The device contains two rubber cords which are extended when the device is used.

A student investigates the properties of the device by hanging weights on it and measuring the extension.

The student obtains the following graph for her results.



(a) The student notices that her graph is a straight line between A and B and concludes that the device obeys Hooke's law.

Comment on this conclusion.

(2)

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(b) (i) Describe how the student could use the graph to obtain an estimate of the total work done.

(2)

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(ii) The student sets up a spreadsheet to investigate the work done in stretching the device each time a weight is added.

	A	B	C	D
1	Total stretching force / N	Extension / cm	Change in extension / m	Work done (force × change in extension) / J
2	0	0.0	0.000	0.00
3	10	1.6	0.016	0.16
4	20	3.5	0.019	0.38
5	30	7.0	0.035	1.05
6	40	10.5	0.035	1.40
7	50	14.5	0.040	2.00
8	60	20.0	0.055	3.30
9	70	25.2	0.052	3.64
10	80	30.5	0.053	4.24
11			Total work done	16.17

Explain why this spreadsheet results in an over-estimate for the total work done.

(2)

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(c) The student eats a packet of crisps and then uses the exercise device. The energy content in a packet of crisps is 540 kJ. During exercise this energy is converted and 25% of it is transferred to mechanical work.

The student extends the device fully 15 times in 1 minute. An accurate value for the work done in fully extending the device is 14.7 J.

Calculate the time it would take the student, working at this rate, to transfer 25% of the energy from the crisps to mechanical work.

(3)

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Time = ...

(d) Explain whether more or less work would be done applying the same maximum total stretching force to a similar exercise device with rubber cords of twice the cross-sectional area.

(2)

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(Total for Question 15 = 11 marks)

16 The ‘Stealth’ roller coaster at the Thorpe Park theme park is advertised as reaching 135 km hour^{-1} from rest in 2.3 seconds.

Most roller coasters are driven slowly up to the top of a slope at the start of the ride. However the carriages on ‘Stealth’ are initially accelerated horizontally from rest at ground level by a hydraulic launch system, before rising to the top of the first slope.

(a) (i) Calculate the average acceleration of the carriages.

135 km hour^{-1} = 37.5 m s^{-1}

(2)

Average acceleration = ...

(ii) Calculate the minimum average power which must be developed by the launch system.

mass of carriages and passengers = 10 000 kg

(3)

Minimum average power = ...

(iii) Suggest why the power in (ii) is a minimum value.

(1)

*(b) The force required to launch ‘Stealth’ is not always the same. The ride is monitored and the data from preceding launches is used to calculate the required force.

If the mass of the passengers for a particular ride is significantly more than for preceding launches, this can lead to ‘rollback’. This is when the carriages do not quite reach the top of the first slope and return backwards to the start.

Explain why ‘rollback’ would occur in this situation.

(3)

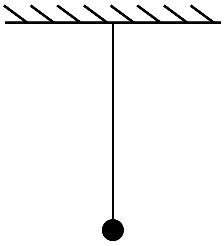
(c) Suggest why roller coasters may have a greater acceleration when the lubricating oil between the moving parts has had time to warm up.

(2)

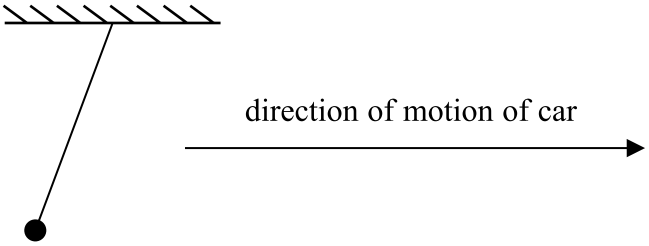
(Total for Question 16 = 11 marks)

17 Many hand held devices such as smartphones and tablet computers contain accelerometers. These allow changes in orientation of the device to be tracked.

A student models a simple accelerometer by attaching a small mass on a string to the roof of a car.



When the car starts moving, the string is seen to change position as shown below.



(a) (i) Complete a free body force diagram for the mass when the car starts moving.

(2)

(ii) Draw a vector diagram, in the space below, to show how the resultant force on the mass is produced.

(2)

(iii) When the string is at 7° to the vertical, show that the acceleration of the car is about 1 m s^{-2}.

(2)

(b) Sketch the positions of the mass and string when the car is moving in the same direction and is:

(i) moving with constant velocity,

(ii) undergoing a much greater acceleration than in (a)(iii),

(iii) decelerating.

(3)

(i) moving with constant velocity,

(ii) undergoing a much greater acceleration than in (a)(iii),

(iii) decelerating.

(c) Explain why the string would **not** become horizontal, however great the acceleration.

(2)

(d) Suggest why many devices contain 3 accelerometers, arranged at right angles to each other.

(1)

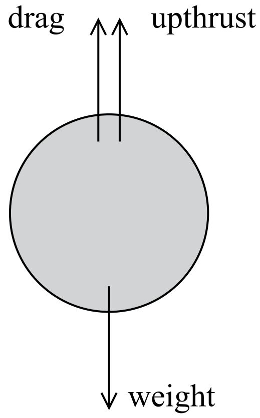
(Total for Question 17 = 12 marks)

18 The Greek philosopher Aristotle (4th Century BC) stated that heavy objects fall more quickly than lighter objects.

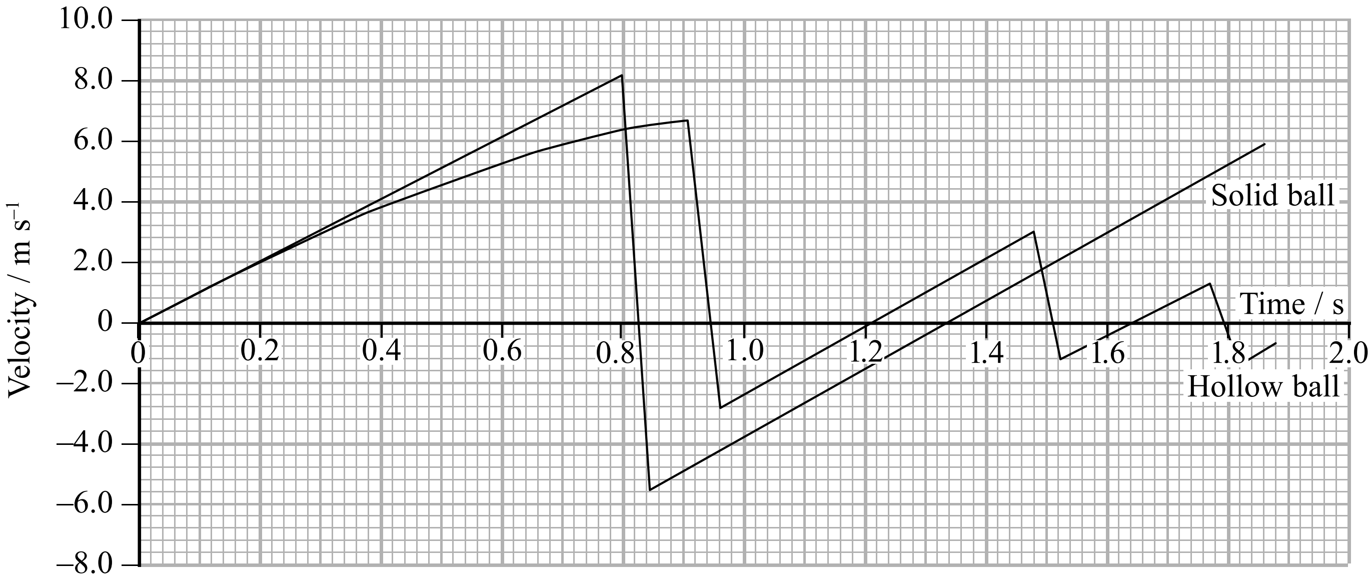
In the 17th Century Galileo reported that a cannon ball and a much smaller musket ball, dropped at the same time, reached the ground together.

A student carries out an experiment, dropping two balls of the same size at the same time. One of the balls is hollow and the other is solid.

The diagram shows the forces acting on each ball as it falls.



The velocity-time graph shows the motion of the two balls from the time they are dropped.



(a) State how the graphs show that neither ball reaches terminal velocity.

(1)

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(b) (i) By drawing a tangent to the graph, show that the acceleration of the hollow ball at time $t = 0.60$ s is about 7 ms^{-2}.

(2)

(ii) Show that the resultant force on the hollow ball at $t = 0.60$ s is about 0.02 N.

mass of hollow ball = 2.4 g

(2)

(iii) Show that the drag force on the hollow ball at $t = 0.60$ s is about 0.01 N. You may neglect upthrust.

(2)

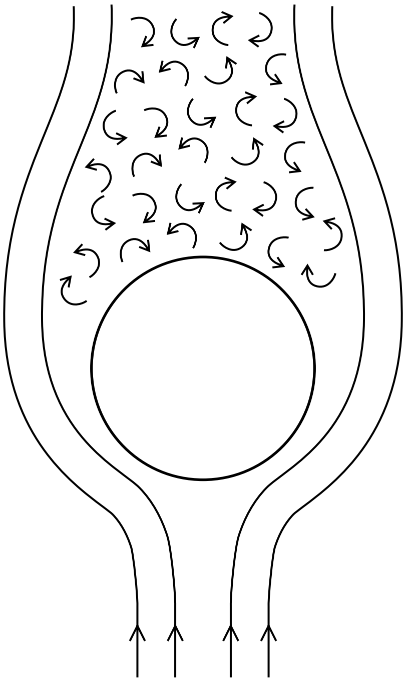
(iv) Demonstrate that the Stokes' law force is **not** sufficient to produce this drag force.

radius of hollow ball = 2.0 cm

viscosity of air = 1.8×10^{-5} Pa s

(2)

(c) The diagram shows the air flow around the hollow ball as it falls.



(i) Add labels to show laminar flow and turbulent flow.

(1)

(ii) Suggest why the drag is much greater than the Stokes' law force.

(1)

(d) Without further calculation, use the graph to describe the motion of the solid ball.

(3)

....

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....

....

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	

Unit 1

Mechanics

Kinematic equations of motion
$$v = u + at$$
$$s = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Forces
$$\Sigma F = ma$$
$$g = F/m$$
$$W = mg$$

Work and energy
$$\Delta W = F\Delta s$$
$$E_k = \tfrac{1}{2}mv^2$$
$$\Delta E_{grav} = mg\Delta h$$

Materials

Stokes' law $F = 6\pi\eta rv$

Hooke's law $F = k\Delta x$

Density $\rho = m/V$

Pressure $p = F/A$

Young modulus $E = \sigma/\varepsilon$ where
Stress $\sigma = F/A$
Strain $\varepsilon = \Delta x/x$

Elastic strain energy $E_{el} = \tfrac{1}{2}F\Delta x$

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Mark Scheme (SAM)

Pearson Edexcel International Advanced Subsidiary in Physics

Unit 1: Physics on the Go

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.

Further notes

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii)	Horizontal force of hinge on table top 66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [Some examples of direction: acting from right (to left)/to the left/West/opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	**(1)**

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

Mark scheme format

1. You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the mark scheme has specified specific words that must be present. Such words will be indicated by underlining, e.g. 'resonance'.
2. Bold lower case will be used for emphasis.
3. Round brackets ( ) indicate words that are not essential, e.g. '(hence) distance is increased'.
4. Square brackets [ ] indicate advice to examiners or examples, e.g. [Do not accept gravity] [ecf].

Unit error penalties

1. A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
2. Incorrect use of case, e.g. 'Watt' or 'w' will **not** be penalised.
3. There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
4. The same missing or incorrect unit will not be penalised more than once within one question (one clip in e-pen).
5. Occasionally, it may be decided not to penalise a missing or incorrect unit, e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
6. The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

Significant figures

1. Use of an inappropriate number of significant figures (sf) in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
2. The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}.

Calculations

1. Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
2. If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.
3. **Use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors, e.g. power of 10 error.
4. **Recall** of the correct formula will be awarded when the formula is seen or implied by substitution.
5. The mark scheme will show a correctly worked answer for illustration only.
6. Example of mark scheme for a calculation:

'Show that' calculation of weight		
Use of L × W × H	✓	
Substitution into density equation with a volume and density	✓	
Correct answer [49.4 (N)] to at least 3 significant figures [No ue] [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark][Bald answer scores 0, reverse calculation 2/3]	✓	**(3)**
Example of answer: 80 cm × 50 cm × 1.8 cm = 7200 cm^3 7200 cm^3 × 0.70 g cm^{-3} = 5040 g 5040 × 10^{-3} kg × 9.81 N/kg = 49.4 N		

Quality of Written Communication

1. Indicated by 'Quality of Written Communication' in the mark scheme. Work must be clear and organised in a logical manner using technical wording where appropriate.
2. Usually it is part of a maximum mark, the final mark not being awarded unless the Quality of Written Communication condition has been satisfied.

Graphs

1. A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
2. Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.
3. A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale, e.g. multiples of 3, 7 etc.
4. Points should be plotted to within 1 mm:
   - Check the two points furthest from the best line. If both OK award mark.
   - If either is 2 mm out do not award mark.
   - If both are 1 mm out do not award mark.
   - If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.
5. For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

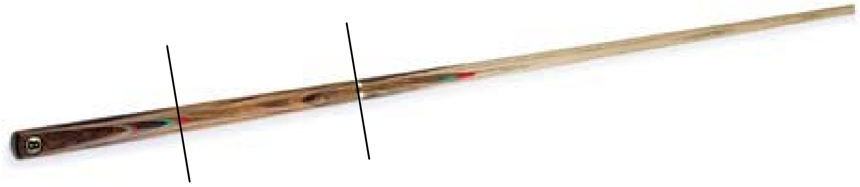
Section A

Question Number	Answer	Mark
1	B	(1)
2	B	(1)
3	A	(1)
4	C	(1)
5	A	(1)
6	B	(1)
7	C	(1)
8	C	(1)
9	D	(1)
10	D	(1)

Total for Section A = 10 Marks

Section B

Question Number	Answer	Mark
11	Pa = N m^{-2} **(1)** N = kg m s^{-2} **(1)** (Pa = kg m s^{-2} m^{-2} scores both marks) (The use of fractions rather than indices can still score both marking points)	(2)
	Total for Question 11	**(2)**

Question Number	Answer	Mark
12(a)	A point/position at which all the weight (of an object can be assumed to) act **Or** the point/position at which all the weight is centred upon **(1)** **Or** the point/position that can be used to represent the whole weight	(1)
12(b)(i)	Correct position marked **(1)**  Looking at the words below the cue it must be between the 'm' of mark and the 'o' of the first 'of'. An arrow close to the cue in range is acceptable	(1)
12(b)(ii)	A simple method described to see if it will balance on a pivot **(1)**	(1)
	Total for Question 12	**(3)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>13(a)</td><td>Calculation leading to $v = 18.1$ (m s^{-1}) (1)

(A reverse argument gives 64.8 (km h^{-1}) and scores the mark)

<u>Example of calculation</u>
$v = 65\,000$ m / 60 × 60 s
= 18.06 m s^{-1}</td><td>(1)</td></tr>
<tr><td>13(b)(i)</td><td>Use of distance = speed × time (see the calculation or use of 3 km) (1)

Use of emission = distance × reading from graph (1)

Use of difference between emissions at different speeds for 1 or 3 cars (1)

(This mark may still be awarded if the difference is between a 5 m s^{-1} for 10 minutes journey and an 18 m s^{-1} for 10 minutes journey)

CO_2 emission = 0.72 kg (1)

(Allow range 0.63 kg to 0.81 kg)

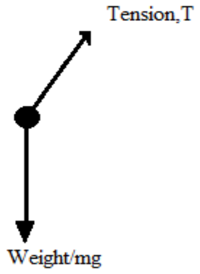
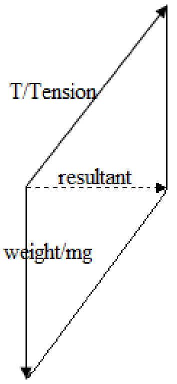
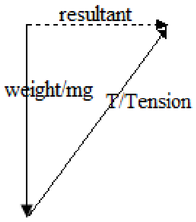
<table>
<tr><td>Journey</td><td>CO_2 emission</td><td>Range</td><td>Marks</td></tr>
<tr><td>1 car 1 km</td><td>0.08 kg</td><td>0.07 to 0.09</td><td>1 (MP3)</td></tr>
<tr><td>3 cars 1 km</td><td>0.24 kg</td><td>0.21 to 0.27</td><td>1 (MP3)</td></tr>
<tr><td>1 car 3 km</td><td>0.24 kg</td><td>0.21 to 0.27</td><td>3 (MP1, 2 & 3)</td></tr>
<tr><td>1 car travelling for 10 minutes at 5 m s^{-1} and 18 m s^{-1}</td><td>(-) 1.164 kg</td><td>1.02 to 1.31</td><td>3 (MP1, 2 & 3)</td></tr>
<tr><td>3 cars travelling for 10 minutes at 5 m s^{-1} and 18 m s^{-1}</td><td>(-) 3.49 kg</td><td>3.06 to 3.93</td><td>3 (MP1, 2 & 3)</td></tr>
</table>

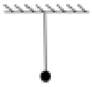
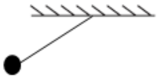
<u>Example of calculation</u>
Distance = 5 ms^{-1} × 10 × 60 s = 3000 m = 3 km
3 × 3 km × (0.26 kg km^{-1} – 0.18 kg km^{-1}) = 0.72 kg</td><td>(4)</td></tr>
<tr><td>13(b)(ii)</td><td>Quantitative comparison of values 0.72 kg and 0.54 kg to indicate that the cyclist causes more CO_2 emissions
Or qualitative statement, e.g. more carbon dioxide emitted when he cycles (1)
Candidates answer must be consistent with their value from part (i)</td><td>(1)</td></tr>
<tr><td></td><td>Total for Question 13</td><td>(6)</td></tr>
</table>

Question Number	**Answer**	**Mark**
14(a)	Use of suitable equation(s) of motion to find distance **(1)** Height = 7.4 (m) **(1)** (Accept 9.8(1)/6 or 1.635 for acceleration but do not accept g/6 as a substitution if final answer is wrong and looking to award MP1 only) (A reverse argument leading to t = 2.9 s can score both marks) <u>Example of calculation</u> $s = ½\, at^2$ s = ½ x (9.81 m s^{-2} / 6) x (3 s)^2 s = 7.4 m	**(2)**
14(b)(i)	Use of trig function appropriate to calculate vertical component of velocity **or** 10.1 (m s^{-1}) seen **(1)** Use of suitable equation(s) of motion to find time **(1)** t = 12.4 (s) **(1)** (If v and u not consistent with sign of g maximum 2 marks. Calculation can be done for total time of 12.3 s with either total displacement = 0 or u= -v) <u>Example of calculation</u> u = 18 ms^{-1} x sin 34º = 10.1 m s^{-1} $v = u + at$ 0 = 10.1 m s^{-1} – (9.81 m s^{-2} / 6) x t t = 6.2 s to maximum height time of flight = 12.4 s	**(3)**
14(b)(ii)	Use of trig function appropriate to calculate horizontal component of velocity **or** 14.9 (m s^{-1}) seen **or** use of Pythagoras **(1)** Use of suitable equation(s) of motion to find distance **(1)** Distance = 185 (m) (ecf time value from part (i)) **(1)** <u>Example of calculation</u> v= 18 ms^{-1} × cos 34º = 14.9 ms^{-1} $s = vt$ =14.9 m s^{-1} ×12.4 s s = 185.0 m	**(3)**
***14(c)**	(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate) Lower gravitational field strength: Lower acceleration **(1)** The idea of an increased time of flight **(1)** (Do not accept slower in place of lower) Lack of atmosphere: No work done against friction **Or** no slowing/deceleration due to friction **(1)** (Accept air resistance or drag for friction)	**(3)**
	Total for Question 14	**(11)**

Question Number	Answer	Mark
15(a)	(The line) AB (extended) does not pass through the origin/initially **Or** the graph is curved as it passes through the origin **Or** the graph (before A) is not a straight line through the origin. **(1)** The device does not obey Hooke's law (conditional mark) **(1)**	**(2)**
15(b)(i)	Reference to finding area **(1)** **Detail** count squares **OR** approximate the shape of the graph to a triangle **or** reference to using a trapezium (could be described as rectangles and triangles) **(1)**	**(2)**
15(b)(ii)	Identifies that force is the problem. **(1)** Explains why force used is an overestimate, e.g. maximum force has been used (each time) **Or** average force was not used (each time) **Or** the force is changing (continuously) **Or** should have used the trapezium rule **Or** area of rectangle has been used **(1)**	**(2)**
15(c)	Use of 25% of 540 kJ, i.e. find the energy to be used **(1)** Use of $\frac{\text{total available energy (either 540 000 J or 135 000 J)}}{\text{energy per stretch or energy per unit time}}$ **(1)** Time = 612 min **(1)** Example of calculation 540 000 J x 25% = 135 000 J 135 000 J / 14.7 J = 9184 stretches 9184/15 stretches per minute = 612 minutes (36 720 s **or** 10.2 h)	**(3)**
15(d)	Smaller extension **or** will not stretch as much **(1)** Less work with reference to either same force applied **or** to work done being force x extension **(1)** (Do not accept displacement or distance in place of extension for MP1or MP2)	**(2)**
	Total for Question 15	**(11)**

Question Number	Answer	Mark
16(a)(i)	Use of equation of motion suitable for a, e.g. $v = u + at$ **(1)** $a = 16.3\ \mathrm{m\ s^{-2}}$ ($2.1 \times 10^5\ \mathrm{km\ h^{-2}}$ or $58.7\ \mathrm{km\ h^{-1}\ s^{-1}}$) **(1)** Example of calculation $a = (37.5\ \mathrm{m\ s^{-1}} - 0)/2.3\ \mathrm{s}$ $a = 16.3\ \mathrm{m\ s^{-2}}$	**(2)**
16(a)(ii)	Use of $E_k = ½ mv^2$ **(1)** Use of $P = E/t$ **(1)** Power = 3.1×10^6 W **(1)** **Or** Use of $F = ma$ (must be a from (i)) **and** use of equation to find distance **and** use of work done = Fd **(1)** Use of $P = E/t$ **(1)** Power = 3.1×10^6 W **(1)** (distance = 43 m) Examples of calculations $E_k = ½ \times 10\ 000\ \mathrm{kg} \times (37.5\ \mathrm{m\ s^{-1}})^2 = 7.03 \times 10^6\ \mathrm{J}$ Power = $7.03 \times 10^6\ \mathrm{J} / 2.3\ \mathrm{s} = 3.1 \times 10^6\ \mathrm{W}$	**(3)**
16(a) (iii)	Energy transferred by heating **Or** energy transferred due to friction **Or** work done against friction **Or** idea that more energy required (due to energy transfer) due to friction. **(1)** (Do not accept 'lost' but accept air resistance as an alternative to friction)	**(1)**
***16(b)**	(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate) Larger force is needed **or** the (same) force is insufficient **(1)** Need same acceleration/(maximum) velocity **or** acceleration/(maximum) velocity is too small **(1)** More energy needed (to reach top) **or** insufficient energy (to reach top) **(1)**	**(3)**
16(c)	Viscosity of oil decreases (with increasing temperature) **or** the (warm) oil is less viscous **(1)** (Accept a reverse argument, e.g. when cold oil is more viscous) Lower frictional/resistive force **or** less viscous drag **(1)**	**(2)**
	Total for Question 16	**(11)**

Question Number	Answer	Mark
17(a)(i)	Weight **(1)** (Accept *W* or mg or gravitational pull/force) ('gravity' doesn't get the mark) Tension (Accept *T*) **(1)** (Both arrows and labels required for each marking point)  (Arrows must touch mass for marks; ignore any arrows, for correct or incorrect forces, not touching (Minus one from maximum possible mark for each additional force (e.g. resultant, pull) or other arrow (e.g. speed or motion) touching mass)	**(2)**
17(a)(ii)	A triangle or parallelogram with W and T in correct position for vector addition with correct labels and directions. **(1)** Triangle or parallelogram completed correctly with resultant in correct directions. **(1)** (Can score 2 marks even if the resultant is not horizontal), e.g. (scores 2 marks)  	**(2)**
17(a) (iii)	ma/mg = tan θ OR T cos θ = mg and T sin θ = ma **(1)** (seen or substituted into) a = 1.2 (m s^{-2}) **(1)** Example of calculation a = tan 7° x g = tan 7° x 9.81 m s^{-2} = 1.2 m s^{-2}	**(2)**

Question Number	Answer	Mark
17(b)(i)	Straight down (by eye) **(1)** 	**(1)**
17(b)(ii)	To left, angle between string and roof to be less than 83º but not horizontal **(1)** 	**(1)**
17(b) (iii)	To right, at any angle except horizontal **(1)** 	**(1)**
17 (c)	Always has weight **or** gravitational force **or** force due to gravity so **(1)** tension needs a vertical component **(1)** **Or** Use of the equation *ma*/*mg* = tan θ **(1)** Leading to the idea of infinite value of tan θ requiring infinite acceleration **(1)**	**(2)**
17 (d)	Any correct physics answer that uses the concept of the independence of motion at right angles, e.g. (to detect movement) in the x, y, z directions/planes/axes **(1)** **Or** up-down, left-right and forwards-backwards	**(1)**
	Total for Question 17	**(12)**

Question Number	Answer	Mark
18(a)	Graph does not have a zero gradient **Or** graph does not show constant velocity **Or** the velocity is constantly changing **Or** graph always shows an acceleration (or deceleration) **Or** graph not horizontal/flat **Or** graph not parallel to the time/x-axis **(1)** (Accept 'line/gradient/tangent' in place of 'graph')	**(1)**
18(b)(i)	Use of gradient of tangent **(1)** a = 6.5 to 7.4 (m s^{-2}) (conditional mark) **(1)** (Check graph to make sure that the values have been read accurately from the graph, misreading from the graph will only score 1 mark even if the answer falls in the above range) <u>Example of calculation</u> Acceleration = 8.0 m – 1.2 m/1.0 s Acceleration = 6.8 m s^{-2}	**(2)**
18(b)(ii)	Use of $F = ma$ **(1)** F = 0.016 to 0.018(N) (ecf acceleration from (b)(i)) **(1)** <u>Example of calculation</u> F = 6.9 m s^{-2} × 0.0024 kg = 0.017 N	**(2)**

Question Number	Answer	Mark
18(b) (iii)	Use of W = mg **(1)** Drag = 0.006 to 0.008(N) (ecf) **(1)** Example of calculation $W = 0.0024 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 0.0235 \text{ N}$ $0.017 = 0.0235 - \text{drag}$ $\text{Drag} = 0.0065 \text{ N}$	**(2)**
18(b) (iv)	Use of Stokes' law equation with velocity either 5.2 m s^{-1} or 6.6 m s^{-1} **(1)** $F = 3.5 \times 10^{-5}$ (N) or 4.5×10^{-5} (N) (no unit error) **(1)** Example of calculation $F = 6\pi\eta rv$ $= 6\pi \times 1.8 \times 10^{-5} \times 2 \times 10^{-2} \times 5.2 \text{ m s}^{-1}$ $= 3.5 \times 10^{-5} \text{ N}$	**(2)**
18(c)(i)	Correctly identifies a region of laminar flow and region of turbulent flow **(1)**	**(1)**
18(c)(ii)	The idea that there is turbulent flow **Or** ball is moving fast **Or** this is a large sphere **Or** statement about Stokes law force for laminar flow only **Or** Stoke's law assumes that the ball is moving slowly (which this is not) **Or** Stoke's law is for a small sphere (and the hollow ball is large) **Or** a large amount of eddies increases the drag **(1)**	**(1)**
18(d)	**Maximum of three marks.** Falls with constant acceleration. **(1)** At about 0.8 s: the ball bounces **or** the ball changes direction. **(1)** Speed of ball after the bounce is less than the speed before the bounce. **(1)** Maximum height reached at about 1.3 s. **(1)** Accelerations are the same before and after the bounce. **(1)**	**(3)**
	Total for Question 18	**(14)**

Total for Section B = 70 Marks

Total for Paper = 80 Marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number ☐☐☐☐☐

Candidate Number ☐☐☐☐

Physics

Advanced Subsidiary
Unit 2: Physics at Work

Sample Assessment Material
Time: 1 hour 30 minutes

Paper Reference
WPH02/01

You do not need any other materials.

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.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*****) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

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

Turn over ▶

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S 4 5 3 6 7 A 0 1 2 8

PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.

1 Which of the following is a standing wave?

☒ **A** light emitted as a line spectrum

☒ **B** ripples on water from a stone thrown into a pond

☒ **C** sound from an opera singer in a theatre

☒ **D** vibrations on a violin string as it is played

(Total for Question 1 = 1 mark)

---

2 An electric motor with potential difference V and current I lifts a mass m through a height h in time t at a steady speed v.

The efficiency of the motor is given by

☒ **A** $\frac{\frac{1}{2}mv^2}{VIt}$

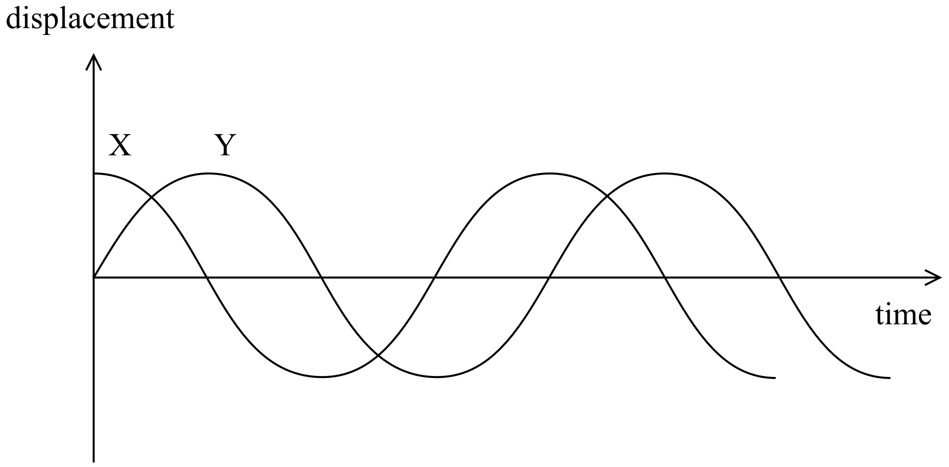
☒ **B** $\frac{VI}{mg}$

☒ **C** $\frac{VIt}{mv}$

☒ **D** $\frac{mgh}{VIt}$

(Total for Question 2 = 1 mark)

3 The diagram shows displacement-time graphs for two oscillations, X and Y.



Which of the following statements correctly describes their phase relationship?

☒ **A** X and Y are in antiphase

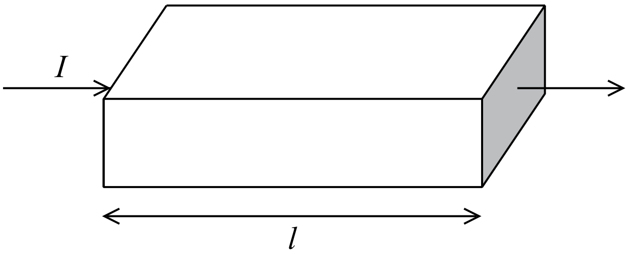
☒ **B** X and Y are in phase

☒ **C** X is $\pi/2$ radians ahead of Y

☒ **D** Y is $\pi/2$ radians ahead of X

(Total for Question 3 = 1 mark)

4 The diagram shows a current *I* flowing through a sample of material of length *l* and cross-sectional area *A*.



The drift velocity of the free electrons is *v*.

If the area and length are both doubled, but the current remains the same, the drift velocity will be

☒ **A** $v / 4$

☒ **B** $v / 2$

☒ **C** $2v$

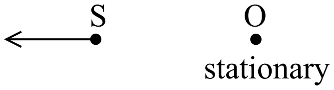
☒ **D** $4v$

(Total for Question 4 = 1 mark)

---

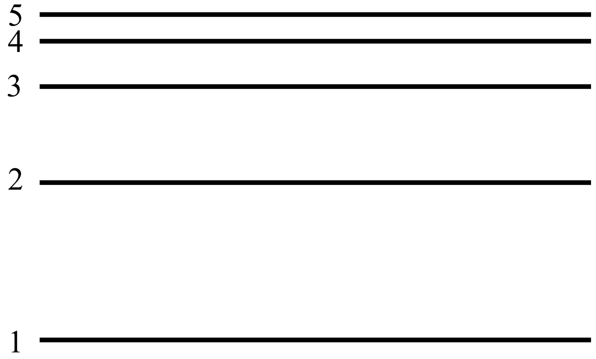
5 The diagrams show the motions of a source of sound, S, and an observer, O.

Which line of the table correctly shows the effect this relative motion has on the frequency of the sound heard by the observer.

	Motions of S and O	**Frequency**
☒ **A**		increased
☒ **B**		decreased
☒ **C**		decreased
☒ **D**		increased

(Total for Question 5 = 1 mark)

6 The diagram shows five energy levels in an atom.



Electromagnetic radiation is incident on the atom.

Which transition would be caused by the absorption of the lowest frequency of radiation?

☒ **A** 1 to 5

☒ **B** 1 to 2

☒ **C** 4 to 5

☒ **D** 5 to 4

(Total for Question 6 = 1 mark)

7 Light is shone perpendicularly onto a photovoltaic cell of area 0.01 m^2. In 60 seconds, the total energy falling on the cell is 3 J.

The radiation flux is

☒ **A** 18 000 W m^{-2}

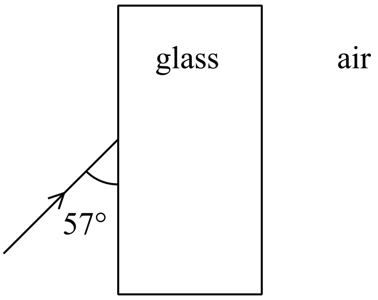
☒ **B** 5 W m^{-2}

☒ **C** 1.8 W m^{-2}

☒ **D** 0.0005 W m^{-2}

(Total for Question 7 = 1 mark)

8 The diagram shows a ray of light incident upon the surface of a glass block.



Which line could correctly show the angle of incidence and the angle of refraction?

	Angle of incidence	**Angle of refraction**
☒ **A**	33°	21°
☒ **B**	33°	55°
☒ **C**	57°	34°
☒ **D**	57°	38°

(Total for Question 8 = 1 mark)

9 A current of 0.2 A flows through a lamp for 3 hours.

The total charge passing through the lamp in this time is

☒ **A** 2160 C

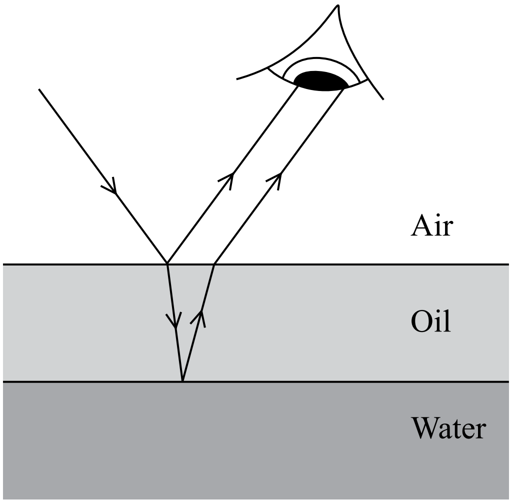
☒ **B** 600 C

☒ **C** 36 C

☒ **D** 0.6 C

(Total for Question 9 = 1 mark)

10 The diagram shows a ray of white light striking a thin layer of oil on water. Light reflects from the upper and lower surfaces of the oil, so that two rays reach the eye of an observer. With the eye in different positions the observer sees different colours from the oil.



Which of the following phenomena is not involved in the production of the colours seen?

☒ **A** polarisation

☒ **B** reflection

☒ **C** refraction

☒ **D** superposition

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 (a) Some radio signals have a frequency of 218.6 MHz.

Calculate their wavelength.

(2)

Wavelength = ...

(b) State what is meant by:

(i) frequency

(1)

(ii) wavelength.

(1)

(Total for Question 11 = 4 marks)

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12 (a) You are asked to find the refractive index for light passing from air to glass by tracing the path of a ray of light through a glass block.

State the measurements you would take, the graph you would plot and how you would use the graph to determine a value for the refractive index.

(3)

(b) (i) State what is meant by critical angle.

(2)

....

....

....

....

....

(ii) Calculate the critical angle for light passing from water to air.

refractive index of water = 1.33

(2)

....

....

....

....

....

....

Critical angle = ...

(Total for Question 12 = 7 marks)

13 A strain gauge measures changes in the resistance of a metal under strain to find the applied force. The kitchen balance in the photograph uses strain gauges to measure the weight of cooking ingredients.

A student tests this method by measuring the resistance of a wire before a force is applied and while it is under tension.

(a) Calculate the initial resistance of the wire.

length of wire = 1.0 m

cross sectional area of wire = 2.9×10^{-8} m^2

resistivity of wire = 4.9×10^{-7} Ω m

(2)

Resistance of wire = ...

(b) The student applies a force to the wire and measures the new length. He calculates the increase in the resistance to be 0.035 Ω. He measures the increase in resistance and finds it to be 0.070 Ω.

The student suggests that the difference between these two values is because the cross-sectional area of the wire changes under strain.

Explain why a change in cross-sectional area would cause this difference.

(3)

(Total for Question 13 = 5 marks)

14 Films made to be watched in three dimensions (3D) are produced by projecting two slightly different images on to the screen, one to be seen by each eye.

In one technique the images are polarised. The viewers wear special glasses where the lenses are replaced by two separate plane polarising filters.

(a) Explain what is meant by plane polarised light.

(3)

(b) The light from the screen reaching each eye passes through a different filter so each eye sees a different image. The filter for one eye has a plane of polarisation of 45° and the filter for the other eye has a plane of polarisation of 135°.

Explain this choice of angles.

(2)

(c) One complaint about 3D films seen through polarising filters is that they appear darker compared to ordinary films.

Suggest why this is the case.

(2)

(d) 3D film viewing is no longer done with plane polarised glasses because these require the viewers to keep their heads exactly level for the whole film. Tilting of the head causes partial viewing of the left image by the right eye and vice versa.

Explain why one eye would see a faint image intended for the other eye if the head is tilted slightly.

(2)

(Total for Question 14 = 9 marks)

15 When the photoelectric effect was first observed in the nineteenth century, scientists could not explain it using the wave theory of light.

In 1905 Albert Einstein published a paper, for which he won a Nobel Prize, explaining the photoelectric effect by using a photon model of light, rather than a wave model.

(a) Explain what is meant by a photon.

(2)

*(b) Explain why the following observations may be understood by using a photon model of light, rather than a wave model.

- Light above a certain frequency causes the emission of electrons from the surface of a metal. This emission occurs instantaneously.
- Light below a certain frequency will not result in the emission of electrons however long it illuminates the surface.

(5)

(c) Zinc has a work function of 4.3 eV.

(i) Calculate the threshold frequency for zinc.

(3)

Threshold frequency =

(ii) State the part of the electromagnetic spectrum to which radiation of this frequency belongs.

(1)

(Total for Question 15 = 11 marks)

16 Ultrasonic testing can be used for detecting corrosion inside metal pipes.

(a) Describe how the ultrasound travels through a metal.

(3)

(b) A steel pipe was manufactured with a wall thickness of 4.0 cm.

After several years of use this pipe is tested for corrosion. A pulse of ultrasound is sent into the steel from the outer surface and the reflection from the inner surface is detected after a time of 5.1×10^{-6} s.

Determine whether the steel is corroded at this point.

speed of sound in steel = 5900 m s^{-1}

(4)

(c) In this technique the ultrasound is emitted as pulses.

Explain why pulses are used rather than a continuous wave and how the duration of the pulse affects the thickness of the pipe wall that can be accurately measured.

(3)

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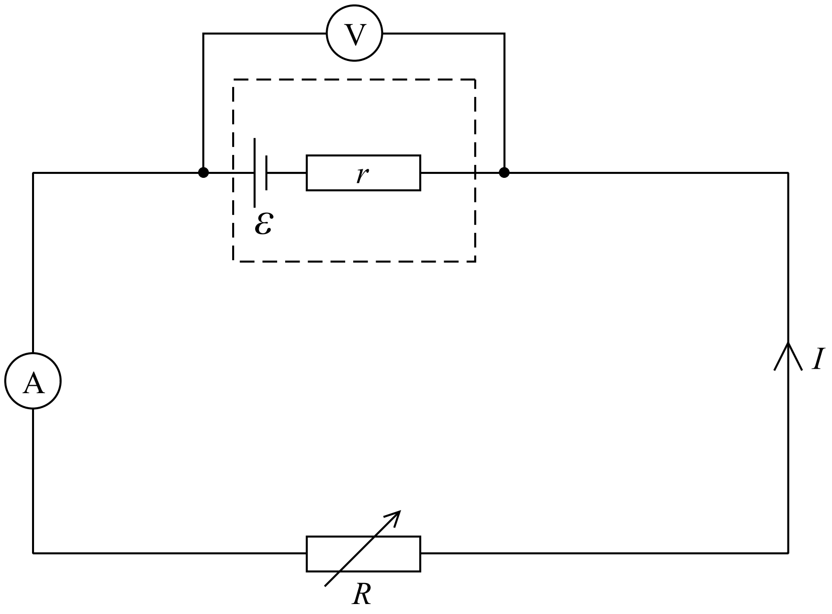
(Total for Question 16 = 10 marks)

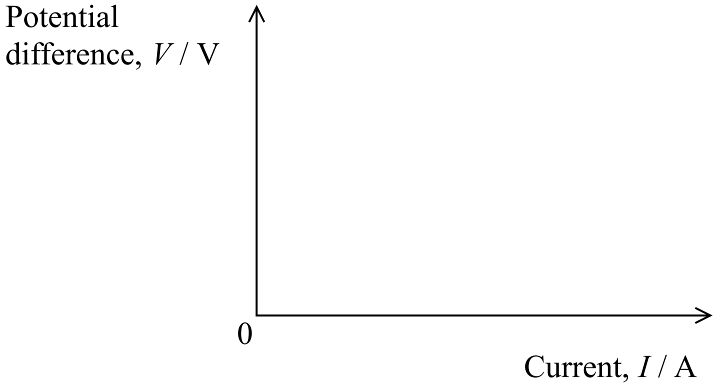
17 The diagram shows a circuit which may be used to find the emf $\mathcal{E}$ and internal resistance r of a cell.



(a) As the resistance R of the variable resistor is varied, values of the current I in the circuit and the terminal potential difference V across the cell are recorded.

Sketch the graph of V against I and explain how it may be used to determine $\mathcal{E}$ and r.

(5)



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*(b) We usually assume that ammeters have negligible resistance and voltmeters have infinite resistance.

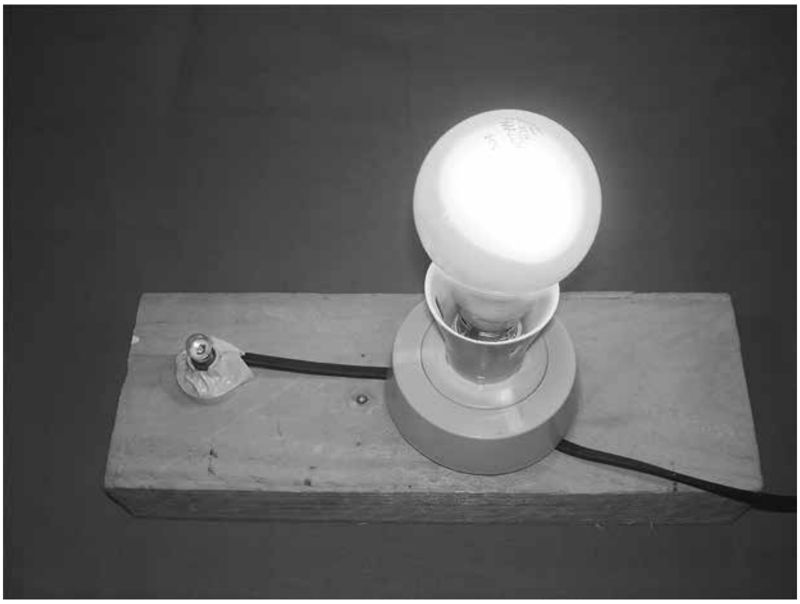
The determination of $\mathcal{E}$ and r is not affected by using an ammeter with non-negligible resistance but is affected by using a voltmeter with a low resistance.

Explain why.

(4)

(Total for Question 17 = 9 marks)

18 The photograph shows a piece of apparatus in which a mains light bulb and a torch bulb are both connected to the mains.



Students were surprised to see both bulbs shining normally when the apparatus was switched on.

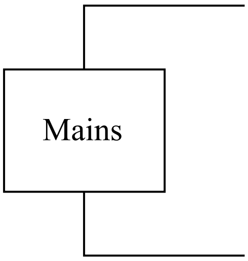
It is impossible to tell from looking at the apparatus whether the bulbs are connected in series or in parallel.

To test this, the apparatus was switched off and the mains bulb was removed. When it was switched on again the torch bulb did not light up. When this was repeated, removing the torch bulb, the mains bulb did not light up.

When the circuit was tried again with both bulbs, they still operated normally.

(a) Complete the circuit diagram to show how the bulbs are connected and explain why they must be connected in this way and not the alternative.

(3)



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(b) The mains bulb is marked 40 W, 230 V.

(i) Show that the current in the mains bulb is about 0.2 A when it is operating normally.

(2)

....

....

....

....

(ii) Calculate the resistance of the mains bulb when it is operating normally.

(2)

....

....

....

....

Resistance = ...

(iii) The torch bulb is marked 2.5 V, 0.20 A.

Calculate the resistance of the torch bulb when it is operating normally.

(2)

Resistance = ...

(c) Explain, with reference to both current and potential difference, why it is possible to operate both bulbs at the same time from the same power supply.

(2)

(d) Earlier in the question you were asked to calculate the resistances of the bulbs when operating normally.

Explain the effect on the resistances of the bulbs if they are operated at a much smaller current so that neither bulb lights up.

(4)

(Total for Question 18 = 15 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\ s^{-2}}$	(close to Earth's surface)
Electron charge	$e = -1.60 \times 10^{-19}\ \mathrm{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Gravitational field strength	$g = 9.81\ \mathrm{N\ kg^{-1}}$	(close to Earth's surface)
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\ s}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$	

Unit 1

Mechanics

Kinematic equations of motion
$$v = u + at$$
$$s = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Forces
$$\Sigma F = ma$$
$$g = F/m$$
$$W = mg$$

Work and energy
$$\Delta W = F\Delta s$$
$$E_k = \tfrac{1}{2}mv^2$$
$$\Delta E_{grav} = mg\Delta h$$

Materials

Stokes' law $F = 6\pi\eta rv$

Hooke's law $F = k\Delta x$

Density $\rho = m/V$

Pressure $p = F/A$

Young modulus $E = \sigma/\varepsilon$ where
Stress $\sigma = F/A$
Strain $\varepsilon = \Delta x/x$

Elastic strain energy $E_{el} = \tfrac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{\text{max}}$

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Mark Scheme (SAM)

Pearson Edexcel International Advanced Subsidiary in Physics

Unit 2: Physics at Work

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate’s response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate’s response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.

Further notes

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii)	Horizontal force of hinge on table top 66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [Some examples of direction: acting from right (to left)/to the left/West/opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	**(1)**

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

Mark scheme format

1. You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the mark scheme has specified specific words that must be present. Such words will be indicated by underlining, e.g. 'resonance'.
2. Bold lower case will be used for emphasis.
3. Round brackets ( ) indicate words that are not essential, e.g. '(hence) distance is increased'.
4. Square brackets [ ] indicate advice to examiners or examples, e.g. [Do not accept gravity] [ecf].

Unit error penalties

1. A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
2. Incorrect use of case, e.g. 'Watt' or 'w' will **not** be penalised.
3. There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
4. The same missing or incorrect unit will not be penalised more than once within one question (one clip in e-pen).
5. Occasionally, it may be decided not to penalise a missing or incorrect unit, e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
6. The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

Significant figures

1. Use of an inappropriate number of significant figures (sf) in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
2. The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}.

Calculations

1. Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
2. If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.
3. **Use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors, e.g. power of 10 error.
4. **Recall** of the correct formula will be awarded when the formula is seen or implied by substitution.
5. The mark scheme will show a correctly worked answer for illustration only.
6. Example of mark scheme for a calculation:

'Show that' calculation of weight		
Use of L × W × H	✓	
Substitution into density equation with a volume and density	✓	
Correct answer [49.4 (N)] to at least 3 significant figures [No ue] [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark][Bald answer scores 0, reverse calculation 2/3]	✓	**(3)**
Example of answer: 80 cm × 50 cm × 1.8 cm = 7200 cm^3 7200 cm^3 × 0.70 g cm^{-3} = 5040 g 5040 × 10^{-3} kg × 9.81 N/kg = 49.4 N		

Quality of Written Communication

1. Indicated by 'Quality of Written Communication' in the mark scheme. Work must be clear and organised in a logical manner using technical wording where appropriate.
2. Usually it is part of a maximum mark, the final mark not being awarded unless the Quality of Written Communication condition has been satisfied.

Graphs

1. A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
2. Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.
3. A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale, e.g. multiples of 3, 7 etc.
4. Points should be plotted to within 1 mm:
    - Check the two points furthest from the best line. If both OK award mark.
    - If either is 2 mm out do not award mark.
    - If both are 1 mm out do not award mark.
    - If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.
5. For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Section A

Question Number	Answer	Mark
1	D	**(1)**
2	D	**(1)**
3	C	**(1)**
4	B	**(1)**
5	C	**(1)**
6	C	**(1)**
7	B	**(1)**
8	A	**(1)**
9	A	**(1)**
10	A	**(1)**

Total for Section A = 10 Marks

Section B

Question Number	Answer		Mark
11(a)	Use of $c = f\lambda$ with $c = 3.00 \times 10^8$ m s^{-1}	**(1)**	**(2)**
	$\lambda = 1.37$ m	**(1)**	
	<u>Example of calculation</u> $\lambda = 3.00 \times 10^8$ m s^{-1}/2.186 × 10^8 Hz $\lambda = 1.37$ m		
11(b)	Frequency – number of oscillations/vibrations/cycles/waves per second **Or** number of oscillations/vibrations/cycles in unit time (ignore 'complete') (Do not accept 1/period, unless period is defined appropriately) [accept number of wavelengths per second]	**(1)**	**(2)**
	Wavelength – distance travelled during one complete oscillation/vibration/cycle **Or** shortest distance between two points at the same stage of the cycle/in phase **Or** distance between identical points on adjacent waves (Accept distance between adjacent/neighbouring peaks/crests/troughs but not just 'distance between peaks' or 'length of wave')	**(1)**	
	Total for Question 11		**(4)**

Question Number	**Answer**	**Mark**
12(a)	Measure angles of incidence and refraction (clear variants accepted or correct angles shown on a diagram)('*i*' and '*r*' accepted) **(1)** Plots sin *i* vs sin *r* **(1)** Correct gradient identified for their graph (assume sin *i* on *y* axis unless stated otherwise, assume statements using 'vs' or 'against' state *y* axis first) **(1)** [If angle of reflection referred to instead of refraction, only allow 2nd mark] (Allow 3rd but not 2nd mark if *i* vs *r* and point from line used in $\mu = \sin i/\sin r$)	**(3)**
12(b)(i)	Angle of incidence (for light travelling from denser medium) **(1)** Has angle of refraction of 90˚ (may refer to leaving along surface/boundary) **(1)**	**(2)**
12(b)(ii)	Use of $\mu = \sin i/\sin r$ (accept stating $\sin c = 1/\mu$) **(1)** $c = 49^\circ$ (n.b. ue applies) **(1)** <u>Example of calculation</u> $\sin c = 1/\mu = 1/1.33$ $c = 49^\circ$	**(2)**
	Total for Question 12	**(7)**

Question Number	**Answer**	**Mark**
13(a)	Use of $R = \rho l/A$ **(1)** $R = 17\ \Omega$ **(1)** <u>Example of calculation</u> $R = 4.9 \times 10^{-7}\ \Omega\ \text{m} \times 1.0\ \text{m}/2.9 \times 10^{-8}\ \text{m}^2$ $R = 17\ \Omega$	**(2)**
13(b)	Area decreases **(1)** Resistance inversely proportional to area **Or** quote $R = \rho l/A$ **(1)** So this change (also) increases resistance **(1)** (Accept for 2nd mark, $I = nAqv$, *I* decreases if *A* decreases, $R = V/I$) (Final mark dependent on presenting a logical explanation linking area change and resistance – not just stating increased resistance.)	**(3)**
	Total for Question 13	**(5)**

Question Number	**Answer**	**Mark**
14(a)	Reference to oscillations of electric/magnetic field (accept vibrations) **(1)** Oscillations/vibrations in one plane only **(1)** Plane includes direction of propagation/travel (of the light) **Or** plane includes direction of energy transfer **(1)** (3rd mark dependent on 2nd mark) **Alternative mark scheme** Reference to oscillations of electric/magnetic field (accept vibrations) **(1)** Oscillations/vibrations in one direction only… **(1)** Perpendicular to direction of propagation/travel (of the light) **Or** perpendicular to direction of energy transfer **(1)** (3rd mark dependent on 2nd mark)	**(3)**
14(b)	Identifies 90 degree difference **(1)** Light aligned/intended for one filter will be blocked/absorbed/stopped by the other filter **Or** light aligned/intended for one filter will be transmitted only by that filter (2nd mark dependent on 1st)[accept reference to lens] **(1)**	**(2)**
14(c)	(Polarisation) absorbs/blocks/stops the unaligned part of the radiation **Or** only aligned part of radiation is transmitted **(1)** So intensity/flux/amplitude (reaching each eye) reduced **(1)**	**(2)**
14(d)	Angle between one filter/lens/eye and plane (of polarisation) of the light (intended for the other filter) has changed **(1)** The light for one eye has component in plane of polarisation of the other filter (and passes through to the other eye) **(1)**	**(2)**
	Total for Question 14	**(9)**

Question Number	Answer	Mark
15(a)	Quantum of … **or** (discrete) packet of … **or** discrete quantity of … (1) (To score the mark must refer to something relevant, e.g. light/energy) Of electromagnetic radiation/energy (1)	**(2)**
***15(b)**	(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate) Describe relevant interaction between single photon and single electron (1) Photon energy depends on frequency **or** reference to $E = hf$ (must be link to photons/light) (1) If photon energy greater than work function, electron emitted (immediately) (1) Whereas for waves energy could build up **or** with waves that the electron can absorb energy continuously or over time (1) So any frequency should work **or** but this build up doesn't happen (1)	**(5)**
15(c)(i)	Use of $4.3 \times 1.6 \times 10^{-19}$ (1) Use of $E = hf$ (1) $f = 1.0 \times 10^{15}$ Hz (1) Example of calculation $E = 4.3 \text{ V} \times 1.6 \times 10^{-19} \text{ C}$ $= 6.9 \times 10^{-19}$ J $6.9 \times 10^{-19} \text{ J} = 6.63 \times 10^{-34} \text{ Js} \times f$ $f = 1.0 \times 10^{15}$ Hz	**(3)**
15(c)(ii)	Ultraviolet (1) Accept ultraviolet even if frequency in c(i) is incorrect, but allow ecf from candidate's value of frequency to appropriate part of electromagnetic spectrum	**(1)**
	Total for Question 15	**(11)**

Question Number	Answer	Mark
16(a)	Particles/atoms/ions/molecules (in metal) oscillate/vibrate **(1)** Along direction of propagation **or** parallel to direction of wave travel **or** in direction of energy transfer (along direction of motion/movement is insufficient) **(1)** Making compressions and rarefactions **or** as a longitudinal wave **(1)**	**(3)**
16(b)	Use of *s* = *vt* **(1)** Correct application of factor of 2 **(1)** Answer *s* = 0.015 m **or** total journey time for thickness 4 cm = 1.4×10^{-5} s **(1)** Comparison – steel is corroded because thickness less than 4 cm (allow even if no division by 2) **Or** steel is corroded because detected time less than for 4 cm (Allow even if no division by 2) **(1)** (For 3rd mark, accept *s* = 0.030 m where final comparison is with total uncorroded journey distance, 8 cm **or** time = 6.8×10^{-6} s where final comparison is with half of corroded journey time 2.6×10^{-6} s) <u>Example of calculation</u> $s = 5900 \text{ m s}^{-1} \times 5.1 \times 10^{-6}$ s = 0.030 m Thickness = 0.030 / 2 = 0.015 m	**(4)**
16(c)	Need to measure time at which the echo arrives back **or** need to measure time taken for echo to return **(1)** If continuous couldn't tell when this was **or** so pulse must return before next is emitted **(1)** Shorter pulses means smaller thickness can be measured **or** longer pulses means only larger thickness can be measured **(1)**	**(3)**
	Total for Question 16	**(10)**

Question Number	**Answer**	**Mark**
17(a)	Negative gradient (accept curve) **(1)** Straight line (dependent on first marking point) **(1)** Reference to terminal p.d. = e.m.f. – 'lost volts' **or** $V = \varepsilon - Ir$ **(1)** Intercept on V axis = ε **or** intercept on y axis = ε **or** ε **=** value of V on graph when $I = 0$ (accept from labelled graph)(mark not awarded if line passes through origin) **(1)** Gradient = $-r$ **or** magnitude of gradient is r (accept gradient = **-**r marked on graph) **(1)**	**(5)**
***17(b)**	(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate) **Ammeter explanation:** If ammeter has resistance, current decreased but doesn't affect the determination because current through cell/r is measured **(1)** **Or** doesn't affect the determination because the voltmeter measures the terminal p.d. for that current **(1)** **Or** the resistance of the ammeter contributes to the load/circuit/total resistance **(1)** Values of p.d. corresponding to given values of current will be unchanged **(1)** **Voltmeter explanation:** If voltmeter has smaller resistance it would draw current **(1)** Measured current not current through cell/r **(1)**	**(4)**
	Total for Question 17	**(9)**

Question Number	**Answer**	**Mark**
18(a)	Series sketch with two bulbs **(1)** Connected in series: Because when one is removed there is a break in the circuit **Or** Because when one is removed there is no current **Or** So the bulbs could have different p.d.s **(1)** Not connected in parallel because: If one removed, still complete circuit (for the other) **Or** If one removed, still current (through the other) **Or** Full mains voltage would have blown small bulb **(1)**	**(3)**
18(b)(i)	Use of $P = IV$ **(1)** $I = 0.17$ (A) (at least 2 sf required) **(1)** <u>Example of calculation</u> $40\text{ W} = I \times 230\text{ V}$ $I = 0.17\text{ A}$	**(2)**
18(b)(ii)	Use of appropriate equation **(1)** $R = 1300\ \Omega$ **(1)** <u>Example of calculation</u> $P = V^2/R$ $40\text{ W} = (230\text{ V})^2 / R$ $R = 1323\ \Omega$	**(2)**
18(b) (iii)	Use of $R = V/I$ **(1)** $R = 13\ \Omega$ **(1)** <u>Example of calculation</u> $R = 2.5\text{ V}/0.2\text{ A}$ $R = 12.5\ \Omega$	**(2)**
18(c)	Current – both require about the same (not just both have 0.2 A) **(1)** Potential difference – total (required) p.d. is very close to mains supply **Or** (Operating) p.d. for mains bulb much greater than (operating) p.d. for torch bulb **(1)**	**(2)**
18(d)	Lower resistance **(1)** (Smaller current so) lower temperature (so less vibration of lattice ions) Or (Smaller current so) smaller drift velocity **(1)** Fewer collisions of electrons with lattice ions or less frequent collisions of electrons with lattice ions **(1)** Less energy dissipation (as heat) or less KE lost in collisions **(1)**	**(4)**
	Total for Question 18	**(15)**

Total for Section B = 70 Marks

Total for Paper = 80 Marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number ☐☐☐☐☐

Candidate Number ☐☐☐☐

Physics

Advanced Subsidiary
Unit 3: Exploring Physics

Sample Assessment Material
Time: 1 hour 20 minutes

Paper Reference
WPH03/01

You must have:
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.*

Information

- The total mark for this paper is 40.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

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

Turn over ▶

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S 4 5 3 6 8 A 0 1 1 6

PEARSON

SECTION A

Answer ALL questions.

For questions 1–5, in Section A, select one answer from A to D and put a cross in the box ☒.
If you change your mind put a line through the box ☒ and then
mark your new answer with a cross ☒.

1 Which of the following is the correct unit for resistivity?

☒ **A** Ω

☒ **B** Ω m

☒ **C** Ω m^{-1}

☒ **D** Ω m^{-2}

(Total for Question 1 = 1 mark)

---

2 In an experiment to find the resistivity of a wire, the following three measurements of the diameter were recorded.

0.71 mm, 0.72 mm, 0.69 mm

How should the average measurement be stated?

☒ **A** $(7.06 \pm 0.13) \times 10^{-3}$ m

☒ **B** $(7.1 \pm 0.2) \times 10^{-3}$ m

☒ **C** $(7.06 \pm 0.13) \times 10^{-4}$ m

☒ **D** $(7.1 \pm 0.2) \times 10^{-4}$ m

(Total for Question 2 = 1 mark)

---

3 A falling ball is used in an experiment to determine the acceleration of free fall.

Which of the following measurements would **not** be needed?

☒ **A** distance fallen

☒ **B** initial velocity

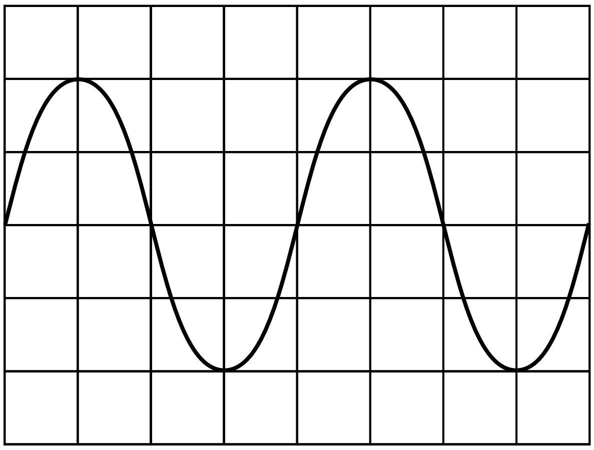
☒ **C** mass of the ball

☒ **D** time taken

(Total for Question 3 = 1 mark)

4 A computer screen is used to display a sound wave. On the horizontal axis 1 division represents 1 ms.

What is the frequency of the wave?



☒ **A** 100 Hz

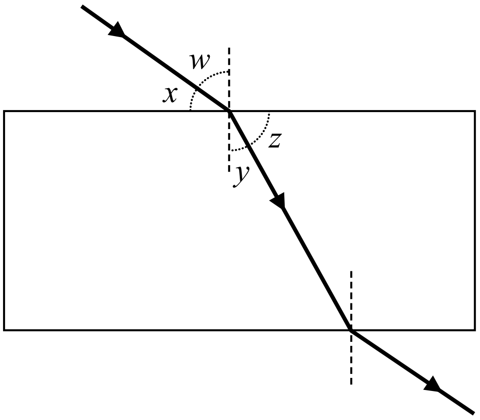
☒ **B** 250 Hz

☒ **C** 500 Hz

☒ **D** 1000 Hz

(Total for Question 4 = 1 mark)

5 The refractive index of glass can be found by tracing a ray of light through a block of glass.



A student uses the equation ${}_1\mu_2 = \dfrac{\sin i}{\sin r}$ to calculate the refractive index.

Which of the following pairs of angles could the student measure and substitute directly into the equation?

☒ **A** x and y

☒ **B** x and z

☒ **C** w and y

☒ **D** w and z

(Total for Question 5 = 1 mark)

TOTAL FOR SECTION A = 5 MARKS

SECTION B

Answer ALL questions in the spaces provided.

6 Two students are given 10 coins of the same type, a metre rule measuring in millimetres and a micrometer screw gauge. The diameter of each coin is approximately 20 mm.

They are asked to determine the best value for the diameter of one coin. Student A says that it is better to measure the diameter of just one coin using the micrometer. Student B suggests that they put the coins in a straight line and use the metre rule.

Discuss the advantages and disadvantages of each method. You should refer to uncertainties in your answer.

(4)

(Total for Question 6 = 4 marks)

7 A student is asked to determine the spring constant of a spiral spring.

Write a plan for an experiment to do this using standard laboratory apparatus and a graphical method.

You should:

(a) draw a labelled diagram of the experimental set-up to be used,

(2)

(b) list any additional apparatus you might need,

(1)

(c) state what quantity is the independent variable and what quantity is the dependent variable,

(2)

(d) describe how you would take your measurements and explain your choice of measuring instruments,

(4)

(e) explain how the data collected will be used to find the spring constant,

(2)

(f) identify the main sources of uncertainty and/or systematic error,

(1)

(g) comment on safety.

(1)

(Total for Question 7 = 13 marks)

8 A school experiment to find an approximate value for the Planck constant *h* uses light emitting diodes (LEDs) of different colours.

The results from one such experiment are shown in the table. The wavelengths λ are taken from the data provided by the manufacturer of the diodes. The potential difference *V* is measured across the LED when it just lights.

λ /nm	**V/V**	**λ^{-1}/**
630	1.06	1.59
610	1.11	1.64
595	1.12	1.68
570	1.24	
465	1.64	
400	1.92	

(a) Complete the final column of the table with the missing unit and values.

(3)

(b) The equation used for the experiment is derived from

$$eV = hf$$

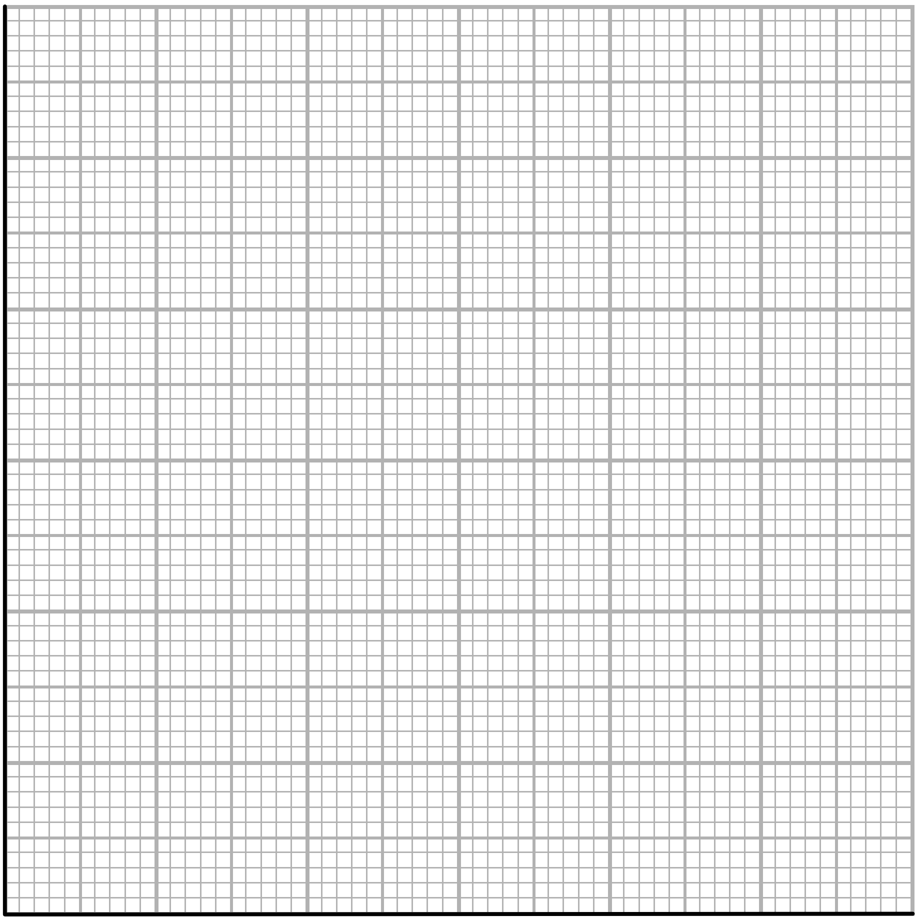
where *f* is the frequency of the light emitted by the LED.

Explain why a graph of *V* on the *y*-axis against $1/\lambda$ on the *x*-axis should be a straight line and show that the gradient of the line will be hc/e.

(3)

(c) Plot the graph on the grid provided and draw a line of best fit.

(5)



TURN OVER FOR QUESTION 8(d).

(d) Use your graph to find a value for the gradient and use it to calculate a value for *h*.

(6)

h = ...

(e) The accepted value for *h* is 6.63 × 10^{-34} J s.

Assuming your calculations are correct, suggest why there is a difference between your value for *h* and the accepted value.

(1)

....

....

....

....

....

(Total for Question 8 = 18 marks)

TOTAL FOR SECTION B = 35 MARKS

TOTAL FOR PAPER = 40 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{\text{max}}$

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Mark Scheme (SAM)

Pearson Edexcel International Advanced Subsidiary in Physics

Unit 3: Exploring Physics

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.

Further notes

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii)	Horizontal force of hinge on table top 66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [Some examples of direction: acting from right (to left)/to the left/West/opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	**(1)**

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

Mark scheme format

1. You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the mark scheme has specified specific words that must be present. Such words will be indicated by underlining, e.g. '<u>resonance</u>'.
2. Bold lower case will be used for emphasis.
3. Round brackets ( ) indicate words that are not essential, e.g. '(hence) distance is increased'.
4. Square brackets [ ] indicate advice to examiners or examples, e.g. [Do not accept gravity] [ecf].

Unit error penalties

1. A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
2. Incorrect use of case, e.g. 'Watt' or 'w' will **not** be penalised.
3. There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
4. The same missing or incorrect unit will not be penalised more than once within one question (one clip in e-pen).
5. Occasionally, it may be decided not to penalise a missing or incorrect unit, e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
6. The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

Significant figures

1. Use of an inappropriate number of significant figures (sf) in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
2. The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}.

Calculations

1. Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
2. If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.
3. **Use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors, e.g. power of 10 error.
4. **Recall** of the correct formula will be awarded when the formula is seen or implied by substitution.
5. The mark scheme will show a correctly worked answer for illustration only.
6. Example of mark scheme for a calculation:

'Show that' calculation of weight		
Use of L × W × H	✓	
Substitution into density equation with a volume and density	✓	
Correct answer [49.4 (N)] to at least 3 significant figures [No ue] [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark][Bald answer scores 0, reverse calculation 2/3]	✓	**(3)**
Example of answer: $80\ \text{cm} \times 50\ \text{cm} \times 1.8\ \text{cm} = 7200\ \text{cm}^3$ $7200\ \text{cm}^3 \times 0.70\ \text{g cm}^{-3} = 5040\ \text{g}$ $5040 \times 10^{-3}\ \text{kg} \times 9.81\ \text{N/kg}$ $= 49.4\ \text{N}$		

Graphs

1. A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
2. Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.
3. A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale, e.g. multiples of 3, 7 etc.
4. Points should be plotted to within 1 mm:
   - Check the two points furthest from the best line. If both OK award mark.
   - If either is 2 mm out do not award mark.
   - If both are 1 mm out do not award mark.
   - If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.
5. For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Section A

Question Number	Answer	Mark
1	B	**(1)**
2	D	**(1)**
3	C	**(1)**
4	B	**(1)**
5	C	**(1)**

Total for Section A = 5 Marks

Section B

Question Number	Answer	Mark
6	**Student A** Micrometer can measure to 0.01 mm **or** 0.001 mm **(1)** This gives uncertainty of 0.01/20 (0.05%) **or** 0.001/20 (0.005%) **(1)** **Student B** The idea that uncertainty is 1 mm in 200 mm (0.5%) **(1)** [allow ecf in calculation for marks 2 and 3] **Any one from** Measuring 10 gives average for all coins **or** measuring one coin several times across different diameters gives an average **(1)** One coin may be abnormal **or** all coins may not be identical **(1)** [Do not allow comments about cost, complexity, parallax, zero error or skill]	**(4)**
	Total for Question 6	**(4)**

Question Number	Answer	Mark
7(a)	*Draw a labelled diagram of the experimental set-up to be used* Diagram of a workable set-up **(1)** [will include spring, mass/weight and support] rule [shown on diagram or mentioned in text] **(1)**	**(2)**
7(b)	*List any additional apparatus you might need* Appropriate additional apparatus **(1)** [e.g. set square, pin, balance] [This may appear later or earlier in the answer.]	**(1)**
7(c)	*State what quantity is the independent variable and what quantity is the dependent variable* **(1)** Mass/weight/force **and** extension/length **(1)**	**(2)**
7(d)	*Describe how you would take your measurements and explain your choice of measuring instruments* Describes measuring length/distance using metre rule **(1)** Describes how to determine extension **(1)** Explanation of how force is varied **Or** Explanation of how mass varied and hence force determined **(1)** Choice of a measuring instrument with reference to scale (precision or range) **(1)**	**(4)**

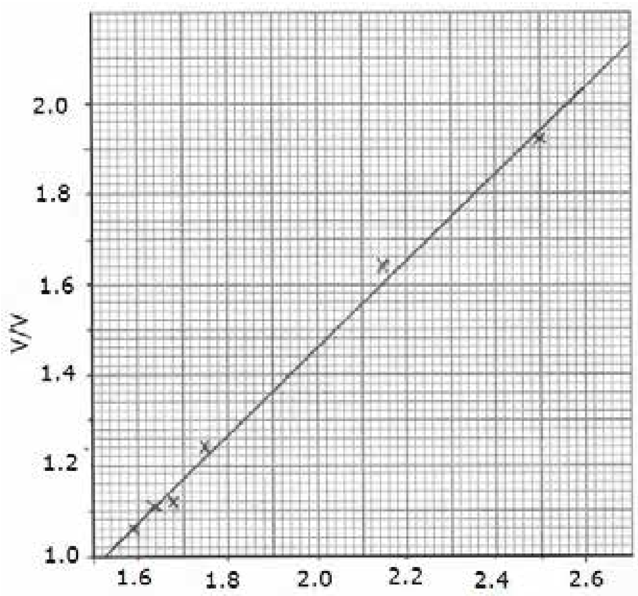
Question Number	**Answer**	**Mark**
7(e)	*Explain how the data collected will be used to find the spring constant* Plot force/mass against extension/length **(1)** Explain how **this** graph is used to determine the force constant **(1)**	**(2)**
7(f)	*Identify the main sources of uncertainty and/or systematic error* **Maximum 1** Reference to measurement of length or extension, e.g. parallax, small measurement, zero error **(1)** Comment on not exceeding elastic limit **(1)**	**(1)**
7(g)	*Comment on safety* Sensible identification of risk **and** precaution **(1)** [e.g. risk from falling weights so use foot protection, risk from breaking spring so use goggles]	**(1)**
	Total for Question 7	**(13)**

This question has to be marked holistically and in the context of the experiment described.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>8(a)</td><td>Unit which is a reciprocal of length (1)
Power of 10 corresponding to unit (1)

Examples
<table>
<tr><th>Power of 10</th><th>Unit</th></tr>
<tr><td>10^{-3}</td><td>nm^{-1}</td></tr>
<tr><td>none</td><td>μm^{-1}</td></tr>
<tr><td>10^{3}</td><td>mm^{-1}</td></tr>
<tr><td>10^{6}</td><td>m^{-1}</td></tr>
<tr><td>10^{12}</td><td>Mm^{-1}</td></tr>
</table>
3 correct values to 3 sig fig (including 2.50) (1)

Example
<table>
<tr><th>Wavelength/nm</th><th>Potential difference/V</th><th>Wavelength^{-1}/ x10^{6} m^{-1}</th></tr>
<tr><td>630</td><td>1.06</td><td>1.59</td></tr>
<tr><td>610</td><td>1.11</td><td>1.64</td></tr>
<tr><td>595</td><td>1.12</td><td>1.68</td></tr>
<tr><td>570</td><td>1.24</td><td>1.75</td></tr>
<tr><td>465</td><td>1.64</td><td>2.15</td></tr>
<tr><td>400</td><td>1.92</td><td>2.50</td></tr>
</table>
</td><td>(3)</td></tr>
<tr><td>8(b)</td><td>Use of $c = f\lambda$ and explicit or implicit comparison to $y = mx$ or $y = mx+c$ (1)
Statement that h, c and e are constants therefore straight line (through origin) (1)
Or hc/e is constant therefore straight line (through origin)
Identification of hc/e as gradient (1)</td><td>(3)</td></tr>
</table>

Question Number	Answer	Mark
8(c)	Axes labelled (1) With units (allow ecf from (a)) (1) Sensible scales (1) Correct plotting of candidate's data from table (1) Best fit line (1)  λ^{-1}/ x10^{-6} m^{-1}	**(5)**
8(d)	Gradient from triangle using more than half the drawn line in either direction (1) Points read correctly from graph (1) Correct calculation of gradient (ignore powers of 10) (expect answer in range 0.9 to 1.1) (1) Use of gradient = hc/e (1) Value for h in range 4.8 x 10^{-34} to 5.9 x 10^{-34} (consistent with the power of 10 on the gradient) (1) 2 or 3 sig fig and unit (1) <u>Example of calculation</u> 0.97 x 10^{-6} V m x 1.60 x 10^{-19} C /3.00 x 10^{8} m s^{-1} = 5.2 x 10^{-34} J s	**(6)**
8(e)	**Maximum 1** Hard to judge when LED just lights (1) No repeated results (1) Should have checked/measured wavelengths (1) Allow any sensible physics alternatives For example: Systematic/zero error on voltmeter (1) Parallax error of (analogue) voltmeter (1) Random errors in voltmeter reading (1) [Do not allow: resistance of either LEDs or wires as p.d. is measured directly across the LED, unspecified errors in the voltmeter/voltmeter reading]	**(1)**
	Total for Question 8	**(18)**

Total for Section B = 35 Marks

Total for Paper = 40 Marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number ☐☐☐☐☐

Candidate Number ☐☐☐☐

Physics

Advanced

Unit 4: Physics on the Move

Sample Assessment Material

Time: 1 hour 35 minutes

Paper Reference

WPH04/01

You must have:
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.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*****) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

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

Turn over ▶

S45369A

S 4 5 3 6 9 A 0 1 2 4

PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.

1 The nucleus of one of the isotopes of nickel is represented by $^{60}_{28}\mathrm{Ni}$.

Which line correctly identifies a neutral atom of this isotope?

	Number of protons	**Number of neutrons**	**Number of electrons**
☒ **A**	28	32	28
☒ **B**	28	32	32
☒ **C**	28	60	28
☒ **D**	60	28	28

(Total for Question 1 = 1 mark)

2 A charged, non-magnetic particle is moving in a magnetic field.

Which of the following would **not** affect the magnetic force acting on the particle?

☒ **A** the magnitude of the charge on the particle

☒ **B** the strength of the magnetic field

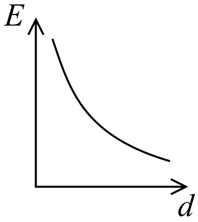
☒ **C** the velocity component parallel to the magnetic field direction

☒ **D** the velocity component perpendicular to the magnetic field direction

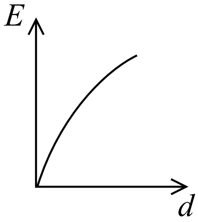
(Total for Question 2 = 1 mark)

3 Two parallel, conducting plates are connected to a battery. One plate is connected to the positive terminal and the other plate to the negative terminal. The plate separation d is gradually increased while the plates stay connected to the battery.

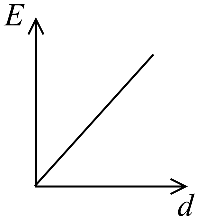
Select the graph that shows how the electric field strength E between the plates varies with separation d.



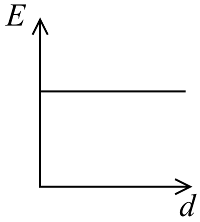
A



B



C



D

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 3 = 1 mark)

---

4 A fairground roundabout makes 8 revolutions in 1 minute. The angular velocity of the roundabout is

☒ **A** 0.10 rad s^{-1}

☒ **B** 0.42 rad s^{-1}

☒ **C** 0.84 rad s^{-1}

☒ **D** 0.94 rad s^{-1}

(Total for Question 4 = 1 mark)

---

5 A correct re-statement of the equation $E_k = p^2/2m$ is

☒ **A** $\frac{1}{2}mv^2 = p^2$

☒ **B** $p^2 = m^2v^2$

☒ **C** $p^2/m = 2v^2$

☒ **D** $mv^2 = \frac{1}{2}p^2$

(Total for Question 5 = 1 mark)

6 A muon has a mass of 106 MeV/c^2.

The mass of a muon, to two significant figures, is

☒ **A** 1.7×10^{-11} kg

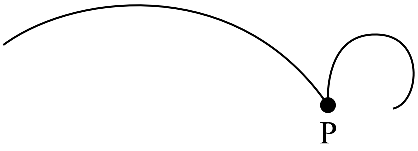
☒ **B** 5.7×10^{-20} kg

☒ **C** 1.9×10^{-28} kg

☒ **D** 1.9×10^{-34} kg

(Total for Question 6 = 1 mark)

7 The diagram shows the tracks from an event at a point P in a bubble chamber. A magnetic field is directed into the page.



The tracks cannot show the production of a proton-antiproton pair with equal kinetic energies because

☒ **A** the curvature is perpendicular to the magnetic field.

☒ **B** the tracks curve in different directions.

☒ **C** the tracks have different curvatures.

☒ **D** there is no track before point P.

(Total for Question 7 = 1 mark)

8 A racing car of mass 1200 kg travels at 0.63 rad s^{-1} around a bend of radius 50 m. The force on the car necessary for this motion is

☒ **A** 2.4×10^4 N away from the centre of the circle.

☒ **B** 2.4×10^4 N towards the centre of the circle.

☒ **C** 3.8×10^4 N away from the centre of the circle.

☒ **D** 3.8×10^4 N towards the centre of the circle.

(Total for Question 8 = 1 mark)

9 A cyclotron is a type of particle accelerator. It consists of two metal Dees which are connected to a high frequency voltage supply and are in a strong magnetic field.

The particles change their speed because

☒ **A** of the magnetic field they are in.

☒ **B** the voltage supply is alternating.

☒ **C** there is a potential difference between the two Dees.

☒ **D** the magnetic field is at right angles to the Dees.

(Total for Question 9 = 1 mark)

10 The de Broglie wavelength for neutrons used to study crystal structure is 1.2 nm.
mass of a neutron = 1.67×10^{-27} kg

The speed of these neutrons would be

☒ **A** 3.0×10^{6} m s^{-1}

☒ **B** 3.3×10^{2} m s^{-1}

☒ **C** 3.0×10^{-3} m s^{-1}

☒ **D** 3.3×10^{-7} m s^{-1}

(Total for Question 10 = 1 mark)

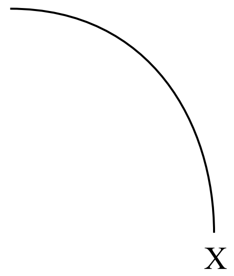
TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 Scientists studying anti-matter recently observed the creation of a nucleus of anti-helium 4, which consists of two anti-protons and two anti-neutrons.

The diagram represents the path of a proton through a magnetic field starting at point X.



Add to the diagram the path of an anti-helium 4 nucleus also starting at point X and initially travelling at the same velocity as the proton.

Explain any differences between the paths.

(5)

(Total for Question 11 = 5 marks)

12 The table gives some of the properties of the up, down and strange quarks.

Type of quark	**Charge/*e***	**Strangeness**
u	+2/3	0
d	–1/3	0
s	–1/3	–1

There are nine possible ways of combining u, d and s quarks and their antiquarks to make nine different mesons. These are listed below

$u\bar{u}$ $u\bar{d}$ $u\bar{s}$ $d\bar{d}$ $d\bar{u}$ $d\bar{s}$ $s\bar{s}$ $s\bar{u}$ $s\bar{d}$

(a) From the list select the four strange mesons and state the charge and strangeness of each of them.

(4)

Meson	**Charge/*e***	**Strangeness**

(b) Some of the mesons in the list have zero charge and zero strangeness.

Suggest what might distinguish these mesons from each other.

(1)

(Total for Question 12 = 5 marks)

13 In an experiment to investigate the structure of the atom, α-particles are fired at a thin metal foil, which causes the α-particles to scatter.

(a) (i) State the direction in which the number of α-particles detected will be a maximum.

(1)

....

(ii) State what this suggests about the structure of the atoms in the metal foil.

(1)

....

(b) Some α-particles are scattered through 180°.

State what this suggests about the structure of the atoms in the metal foil.

(2)

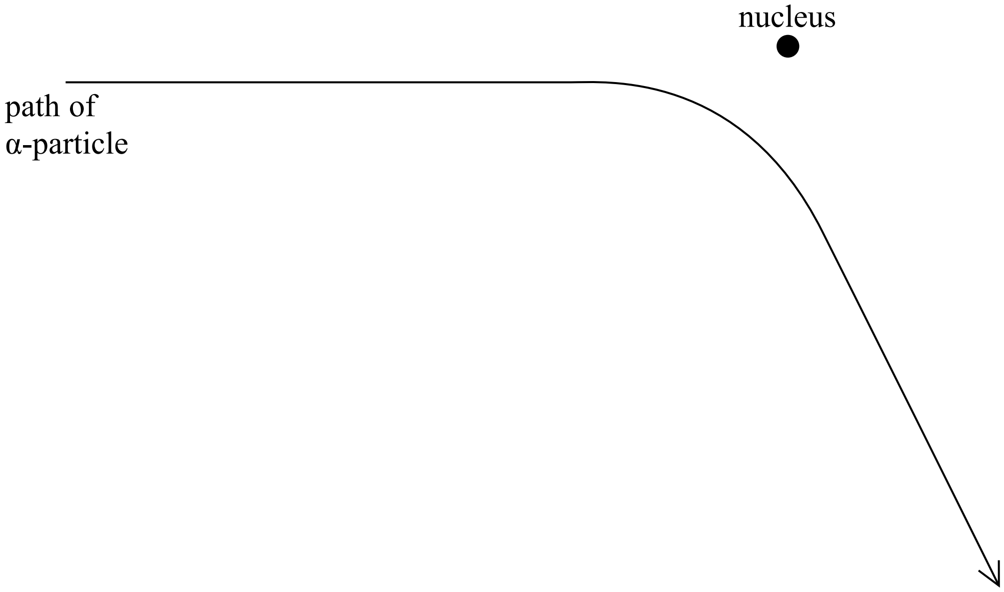
....

....

....

....

(c) The diagram shows the path of an α-particle passing near to a single nucleus in the metal foil.



(i) Name the force that causes the deflection of the α-particle.

(1)

....

(ii) On the diagram, draw an arrow to show the direction of the force acting on the α-particle at the point where the force is a maximum. Label the force F.

(2)

(iii) The foil is replaced by a metal of greater proton number.

Draw the path of an α-particle that has the same initial starting point and velocity as the one drawn in the diagram.

(2)

(Total for Question 13 = 9 marks)

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14 A student is investigating how the potential difference across a capacitor varies with time as the capacitor is charging.

He uses a 100 μF capacitor, a 5.0 V d.c. supply, a resistor, a voltmeter and a switch.

(a) (i) Draw a diagram of the circuit he should use.

(2)

(ii) Suggest why a voltage sensor connected to a data logger might be a suitable instrument for measuring the potential difference across the capacitor in this investigation.

(1)

....

....

Turn over for Question 14(b)

(b) Calculate the maximum charge stored on the capacitor.

(2)

....

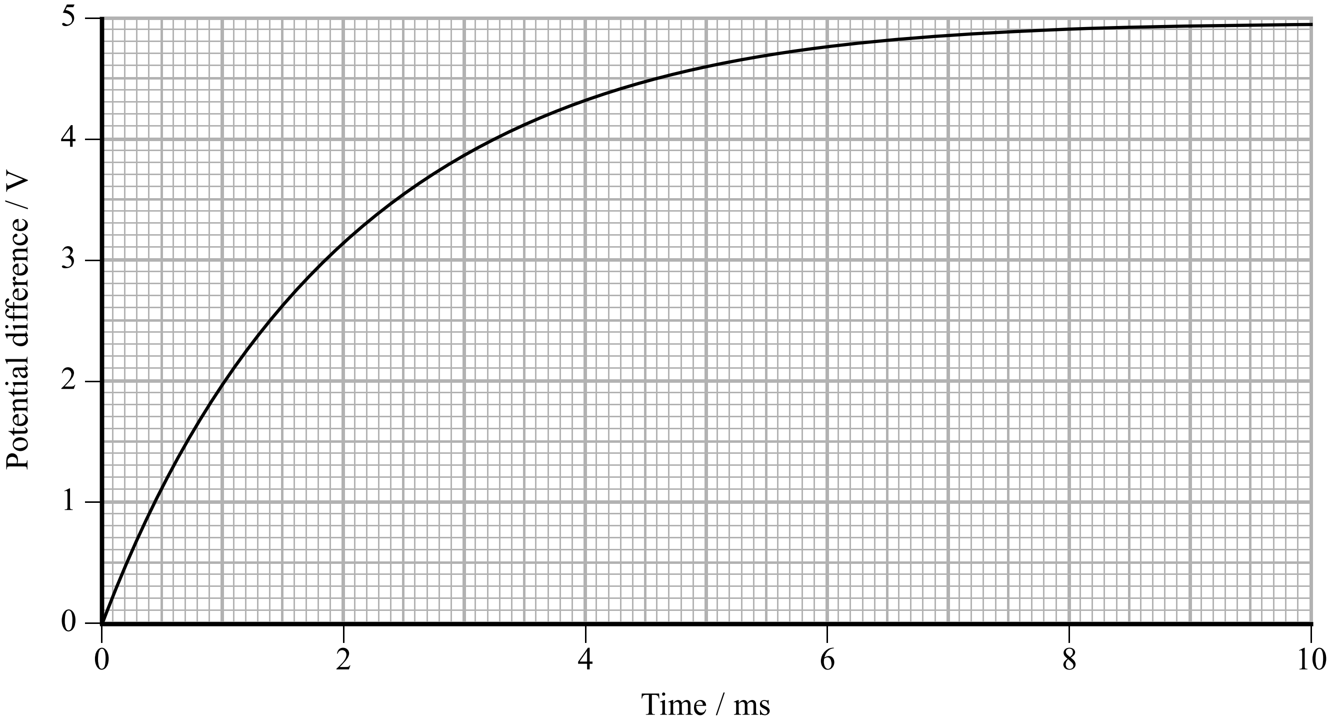
....

....

....

Charge = ...

(c) The graph shows how the potential difference across the capacitor varies with time as the capacitor is charging.



(i) Estimate the average charging current over the first 10 ms.

(2)

....

....

....

Average charging current = ...

(ii) Use the graph to estimate the initial rate of increase of potential difference across the capacitor and hence find the initial charging current.

(3)

Initial charging current = ...

(iii) Use the value of the initial charging current to find the resistance of the resistor.

(2)

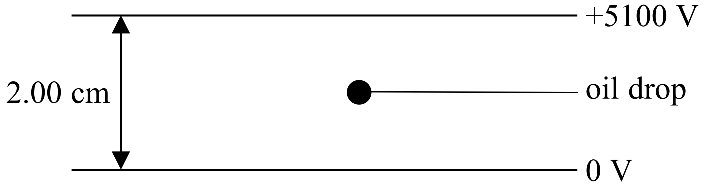
Resistance = ...

(Total for Question 14 = 12 marks)

15 The charge on an electron was originally measured in an experiment called the Millikan Oil Drop experiment.

In a simplified version of this experiment, an oil drop with a small electric charge is placed between two horizontal, parallel plates with a large potential difference (p.d.) across them. The p.d. is adjusted until the oil drop is stationary.

For a particular experiment, a p.d. of 5100 V was required to hold a drop of mass 1.20×10^{-14} kg stationary.



(a) Add to the diagram to show the electric field lines between the plates.

(3)

(b) State whether the charge on the oil drop is positive or negative.

(1)

(c) Complete the free-body force diagram to show the forces acting on the oil drop. You should ignore upthrust.

(2)

(d) (i) Calculate the magnitude of the charge on the oil drop.

(4)

Charge = ……………………………

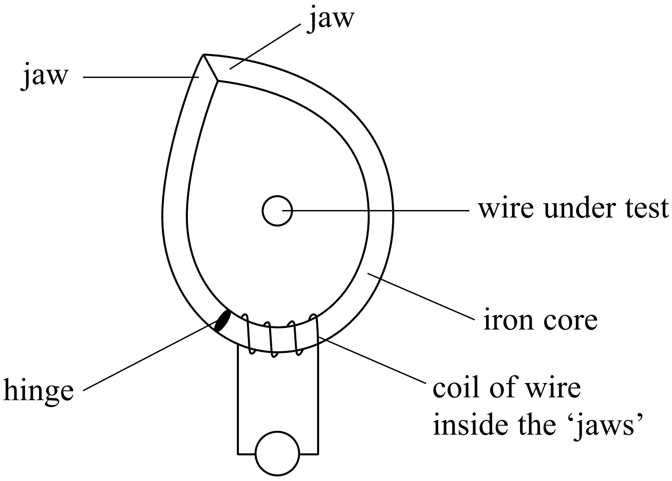
(ii) Calculate the number of electrons that would have to be removed or added to a neutral oil drop for it to acquire this charge.

(2)

Number of electrons = ……………………………

(Total for Question 15 = 12 marks)

16 The photograph shows a digital clamp meter or ‘amp-clamp’. This can be used to measure the current in the live wire coming from the mains supply without breaking the circuit.



The ‘jaws’ of the clamp are opened, placed around the wire carrying the current and then closed. Inside the ‘jaws’ is an iron core with a coil of wire wrapped around it.

*(a) Explain how an e.m.f. would be produced in the coil of wire inside the amp-clamp when the ‘jaws’ are placed around a wire carrying an alternating current.

(4)

(b) State why the amp-clamp cannot be used with a steady direct current.

(1)

....

....

(c) The amp-clamp cannot be used with a cable that is used to plug a domestic appliance like a lamp into the mains supply.

Explain why not.

(2)

....

....

....

....

(d) (i) Explain why the amp-clamp can be used to determine the magnitude of different alternating currents with the same frequency.

(2)

....

....

....

....

(ii) The amp-clamp may **not** be reliable when comparing alternating currents of different frequencies.

Suggest why not.

(2)

....

....

....

....

....

(Total for Question 16 = 11 marks)

17 (a) Explain what is meant by the principle of conservation of momentum.

(2)

....

....

....

(b) The picture shows a toy car initially at rest with a piece of modelling clay attached to it.

A student carries out an experiment to find the speed of a pellet fired from an air rifle. The pellet is fired horizontally into the modelling clay. The pellet remains in the modelling clay as the car moves forward. The motion of the car is filmed for analysis.

The car travels a distance of 69 cm before coming to rest after a time of 1.3 s.

(i) Show that the speed of the car immediately after being struck by the pellet was about 1 m s^{-1}.

(2)

....

....

....

(ii) State an assumption you made in order to apply the equation you used.

(1)

....

....

(iii) Show that the speed of the pellet just before it collides with the car is about 120 m s^{-1}

mass of car and modelling clay = 97.31g
mass of pellet = 0.84 g

(3)

(c) The modelling clay is removed and is replaced by a metal plate of the same mass. The metal plate is fixed to the back of the car. The experiment is repeated but this time the pellet bounces backwards.

*(i) Explain why the speed of the toy car will now be greater than in the original experiment.

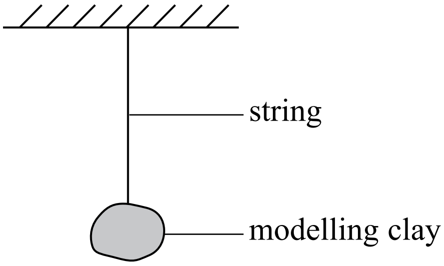
(3)

(ii) The film of this experiment shows that the pellet bounces back at an angle of 72° to the horizontal.

Explain why the car would move even faster if the pellet bounced directly backwards at the same speed.

(1)

(d) The student tests the result of the first experiment by firing a pellet into a pendulum with a bob made of modelling clay. She calculates the energy transferred.



The student's data and calculations are shown:

Data
mass of pellet = 0.84 g
mass of pendulum and pellet = 71.6 g
change in vertical height of pendulum = 22.6 cm

Calculations
change in gravitational potential energy of pendulum and pellet
$= 71.6 \times 10^{-3}$ kg $\times$ 9.81 N kg^{-1} $\times$ 0.226 m = 0.16 J
therefore kinetic energy of pendulum and pellet immediately after collision = 0.16 J
therefore kinetic energy of pellet immediately before collision = 0.16 J
therefore speed of pellet before collision = 19.5 m s^{-1}

There are no mathematical errors but her answer for the speed is too small.

State and explain which of the statements in the calculations are correct and which are not.

(4)

(Total for Question 17 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \text{kg}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\%\ \text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\%\ \text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{\text{max}}$

Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$
	$T = 2\pi/\omega$
	$F = ma = mv^2/r$
	$a = v^2/r$
	$a = r\omega^2$

Fields

Coulomb’s law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$
	$E = kQ/r^2$
	$E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0\mathrm{e}^{-t/RC}$
In a magnetic field	$F = BIl \sin \theta$
	$F = Bqv \sin \theta$
	$r = p/BQ$
Faraday’s and Lenz’s Laws	$\varepsilon = -\mathrm{d}(N\phi)/\mathrm{d}t$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

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Mark Scheme (SAM)

Pearson Edexcel International Advanced Level in Physics

Unit 4: Physics on the Move

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate’s response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate’s response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.

Further notes

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii)	Horizontal force of hinge on table top 66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [Some examples of direction: acting from right (to left)/to the left/West/opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	**(1)**

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

Mark scheme format

1. You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the mark scheme has specified specific words that must be present. Such words will be indicated by underlining, e.g. '<u>resonance</u>'.
2. Bold lower case will be used for emphasis.
3. Round brackets ( ) indicate words that are not essential, e.g. '(hence) distance is increased'.
4. Square brackets [ ] indicate advice to examiners or examples, e.g. [Do not accept gravity] [ecf].

Unit error penalties

1. A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
2. Incorrect use of case, e.g. 'Watt' or 'w' will **not** be penalised.
3. There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
4. The same missing or incorrect unit will not be penalised more than once within one question (one clip in e-pen).
5. Occasionally, it may be decided not to penalise a missing or incorrect unit, e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
6. The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

Significant figures

1. Use of an inappropriate number of significant figures (sf) in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
2. The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}.

Calculations

1. Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
2. If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.
3. **Use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors, e.g. power of 10 error.
4. **Recall** of the correct formula will be awarded when the formula is seen or implied by substitution.
5. The mark scheme will show a correctly worked answer for illustration only.
6. Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>		
Use of L × W × H	✓	
Substitution into density equation with a volume and density	✓	
Correct answer [49.4 (N)] to at least 3 significant figures [No ue] [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark][Bald answer scores 0, reverse calculation 2/3]	✓	**(3)**
Example of answer:		
80 cm × 50 cm × 1.8 cm = 7200 cm^3 7200 cm^3 × 0.70 g cm^{-3} = 5040 g 5040 × 10^{-3} kg × 9.81 N/kg = 49.4 N		

Quality of Written Communication

1. Indicated by 'Quality of Written Communication' in the mark scheme. Work must be clear and organised in a logical manner using technical wording where appropriate.
2. Usually it is part of a maximum mark, the final mark not being awarded unless the Quality of Written Communication condition has been satisfied.

Graphs

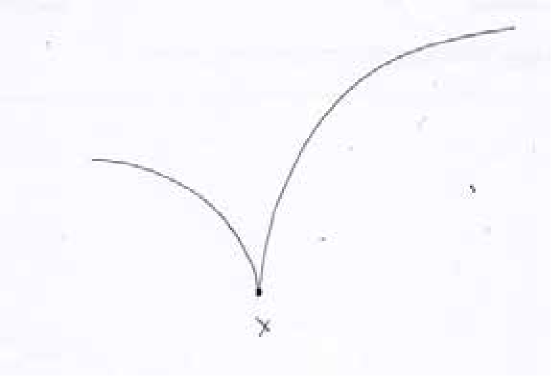
1. A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
2. Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.
3. A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale, e.g. multiples of 3, 7 etc.
4. Points should be plotted to within 1 mm:
   - Check the two points furthest from the best line. If both OK award mark.
   - If either is 2 mm out do not award mark.
   - If both are 1 mm out do not award mark.
   - If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.
5. For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Section A

Question Number	Answer	Mark
1	A	**(1)**
2	C	**(1)**
3	A	**(1)**
4	C	**(1)**
5	B	**(1)**
6	C	**(1)**
7	C	**(1)**
8	B	**(1)**
9	C	**(1)**
10	B	**(1)**

Total for Section A = 10 Marks

Section B

Question Number	Answer	Mark
11	**Diagram** Path curves in opposite sense **(1)** With a greater radius of curvature **(1)** [For MP2 drawn line must start at X, upwards at less than 45° to vertical and go above printed line. Look at curvature close to X, do not penalise if later it curves more/less.]  **Explanation: (these marks are independent of the diagram)** (Antihelium) has opposite charge (to proton) **(1)** **Or** reference to proton +ve **and** antihelium -ve See $r = p/BQ$ **(1)** r is doubled **Or** p/Q is doubled [equation may appear near diagram] **(1)**	**(5)**
	Total for Question 11	**(5)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>**12(a)**</td><td>
<table>
<tr><th>Meson</th><th>Charge/*e*</th><th>Strangeness</th><th></th></tr>
<tr><td>$u\bar{s}$</td><td>+1</td><td>+1</td><td>(1)</td></tr>
<tr><td>$d\bar{s}$</td><td>0</td><td>+1</td><td>(1)</td></tr>
<tr><td>$s\bar{u}$</td><td>-1</td><td>-1</td><td>(1)</td></tr>
<tr><td>$s\bar{d}$</td><td>0</td><td>-1</td><td>(1)</td></tr>
</table>
1 mark for each correct row. Antiquark can be before quark.
(If the + are missing. e or 1.6× 10^{-19} appears in charge column apply a 1 mark total penalty.)</td><td>(4)</td></tr>
<tr><td>**12(b)**</td><td>(Different) masses/lifetimes/stabilities/decay products
(accept mass-energy but not energy or weight). (1)</td><td>(1)</td></tr>
<tr><td></td><td>**Total for Question 12**</td><td>**(5)**</td></tr>
</table>

Question Number	Answer	Mark
13(a)(i)	Straight through, zero deflection, direction fired in. (Do not accept 'through' or 'directly behind' on its own.) (1)	(1)
13(a)(ii)	(Atom consists) mainly/mostly of empty space **Or** Volume of atom very much greater than volume of nucleus. (Do not credit if part of a list.) (1)	(1)
13(b)	Most of the mass is in the nucleus/centre (1) [It is not enough to say that the nucleus is dense/concentrated. Looking for idea that nearly all of the atom's mass is in the nucleus.] Nucleus/centre is charged (1) [Ignore references to the charge being positive. Just saying the nucleus is positive does not get the mark.]	(2)
13(c)(i)	Electrostatic/electromagnetic/electric/coulomb. (1)	(1)
13(c)(ii)	Arrow starting on the path at closest point to the nucleus. (1) Arrow pointing radially away from nucleus (1) (correct direction starting on the nucleus scores 2nd mark only).	(2)
13(c)(iii)	Deflection starts earlier. (1) Final deflection is greater (1) (paths should diverge).	(2)
	Total for Question 13	**(9)**

Question Number	Answer	Mark
14(a)(i)	Capacitor, resistor, supply and switch all in series (ignore voltmeter). **(1)** Voltmeter directly across capacitor. **(1)**	**(2)**
14(a)(ii)	Datalogger allows large number of readings to be taken **Or** graph can be plotted directly/automatically **Or** simultaneous reading of *t* and *V* can be taken **Or** idea that people can't record quickly enough, (Treat as neutral accuracy, precision misreading or human reaction time.) **(1)**	**(1)**
14(b)	Use of $C = Q/V$ **(1)** $Q = 5.0 \times 10^{-4}$ C **(1)** <u>Example of calculation</u> $Q = 100 \times 10^{-6}$ F × 5.0 V $Q = 5.0 \times 10^{-4}$ C	**(2)**
14(c)(i)	Use of $I = \Delta Q/ \Delta t$ e.c.f their value of C from (b) **(1)** $I = 0.05$ A **(1)** (accept recalculation of *Q* using $V = 4.90$ or 4.95 V) <u>Example of calculation</u> $I = 5.0 \times 10^{-4}$ C / 10×10^{-3} s $I = 0.05$ A	**(2)**
14(c)(ii)	tangent drawn at t = 0 **(1)** $\Delta V/ \Delta t = 2000 - 3300$ V s^{-1} **(1)** Initial current = 0.22 - 0.28 A **(1)** (MP2 & 3 can be scored even if no tangent drawn) (No credit for exponential calculation) <u>Example of calculation</u> $\Delta V/ \Delta t = 1.1$ V/ 0.5 ms = 2200 V s^{-1} $I =(\Delta V/ \Delta t) \times C$ $I = 2200$ V s^{-1} × 100 × 10^{-6} F $I = 0.22$ A	**(3)**
14(c)(iii)	Use of $V = IR$ using answer from (ii) **(1)** correct evaluation of *R* (5V used with current range in (ii) gives 18 - 23 Ω) **(1)** <u>Example of calculation</u> 5 V = 0.22 A × *R* *R* = 23 Ω	**(2)**
	Total for Question 14	**(12)**

Question Number	**Answer**	**Mark**
15(a)	At least three vertical lines spread over symmetrically over more than half of the plate length and touching both plates. **(1)** (Ignore edge ones that might curve.) All equispaced and parallel [don't allow gaping to avoid oil drop]. **(1)** Arrow pointing downwards **(1)**	**(3)**
15(b)	Negative/-/-ve **(1)** (Negative and/or positive does not get the mark.)	**(1)**
15(c)	Upward force labelled: Electric (force) **or** Electrostatic (force) **Or** force due to electric field **or** electromagnetic (force) **(1)** [Do not accept repulsive/attractive force. If EQ used, the symbols must be defined.] Downward force labelled: mg, weight, W, gravitational force **(1)** (For both marks the lines must touch the drop and be pointing away from it. Ignore upthrust if drawn but one mark lost for each extra force added.)	**(2)**
15(d)(i)	E = 5100 V/ 2 cm **(1)** Conversion of cm to m **(1)** Use of $QE = mg$ (1.18×10^{-13} kg) **(1)** $Q = 4.6 \times 10^{-19}$ C **(1)** (E = 255 000 (V m^{-1}) scores MP1 & 2. unit conversion missed → $Q = 4.62 \times 10^{-17}$ C scores MP1 & 3 if V is halved → $Q = 9.23 \times 10^{-19}$ C scores MP1 , 2 & 3) <u>Example of calculation</u> $E = V/d$ $F = EQ = mg$ $Q = mg / E = mgd/V$ Q = (1.20×10^{-14} kg × 9.81m s^{-2}× 0.02 m) / (5100 V) Q = 4.62×10^{-19} C	**(4)**
15(d)(ii)	Answer to (d)(i) divided by e **(1)** 3 electrons **or** sensible integer number less than 500 **(1)** (Answers with very large numbers of electrons can get MP1 only.) <u>Example of calculation</u> Number of electrons = 4.62×10^{-19} C / 1.6×10^{-19} C Number = 2.9 i.e. 3 electrons.	**(2)**
	Total for Question 15	**(12)**

Question Number	Answer		Mark
***16(a)**	(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate.) A clear statement that an alternating/changing current produces an alternating/changing magnetic field/flux. Reference to the iron core becomes magnetised **or** increases magnetic field. the idea that the field produced in the core/wire is linked to the coil (e.m.f. produced) due to EM induction **or** reference to induced e.m.f. **or** Faraday's law in words (do not accept induced current/voltage on its own) [Be careful not to credit the random use of words/phrases like, there is flux linkage, flux cutting takes place or the field lines are cut by the coil. Also watch out for candidates who think there is a current in the coil creating the flux linkage.]	 **(1)** **(1)** **(1)** **(1)**	**(4)**
16(b)	(Constant current means) no change of flux (linkage) **or** no changing (magnetic) field **or** flux/field is constant [Do not credit 'flux won't be changing direction' or 'no flux linkage being cut' or alternating.]	**(1)**	**(1)**
16(c)	More than one wire in cable. Cable carries current in both directions **or** Magnetic fields will cancel.	**(1)** **(1)**	**(2)**
16(d)(i)	The larger the current the greater the (magnetic) flux/field (produced) **or** the larger the change in current the larger the change in the (magnetic) flux/field. Gives a greater rate of change of flux **or** bigger change in flux in the same time **or** a greater (induced) e.m.f./voltage/reading.	**(1)** **(1)**	**(2)**
16(d)(ii)	The idea that frequency changes the value of (induced) e.m.f/voltage/reading **or** the idea that the frequency changes the rate of change of (magnetic)flux. An understanding that there are now two factors (current and frequency) altering (induced) e.m.f/voltage/reading.	**(1)** **(1)**	**(2)**
	Total for Question 16		**(11)**

Question Number	Answer	Mark
17(a)	Sum of momenta before (collision) = sum of momenta after (collision) **Or** the total momentum before (a collision) = the total momentum after (a collision) **Or** total momentum remains constant **Or** the momentum of a system remains constant **(1)** Providing no external/unbalanced/resultant force acts **Or** in a closed system. **(1)**	**(2)**
17(b)(i)	Use of equation(s) of motion sufficient to get answer **(1)** Initial speed = 1.1 (m s^{-1}) **(1)** <u>Example of calculation</u> $s = (u + v)t/2$ 0.69 m = $(u + 0) \times 1.3$ s /2 $u = 1.06$ m s^{-1}	**(2)**
17(b)(ii)	Constant acceleration/deceleration **(1)** (accept constant force).	**(1)**
17(b)(iii)	Use of momentum = mv ecf v from (b)(i) **(1)** Calculates momentum after collision using correct mass **(1)** Speed of pellet = 117 or 124 or 129 (m s^{-1}) **(1)** <u>Example of calculation</u> Momentum after = (97.31 + 0.84) g × 1.06 m s^{-1} = 104 g m s^{-1} Momentum before = momentum after Speed of pellet = 104 g m s^{-1} / 0.84 g = 124 m s^{-1}	**(3)**
***17(c)(i)**	(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate.) Mention of momentum. **(1)** Pellet (bounces back so) has negative momentum /velocity. **Or** momentum after = momentum of car - momentum of pellet. **(1)** Pellet undergoes a bigger momentum/velocity change **Or** mass of car is less. **(1)**	**(3)**
17(c)(ii)	Reference to greater horizontal momentum/force. **(1)**	**(1)**
17(d)	[The question says that the calculations are correct, the question is about the assumptions made. Do not credit a statement that the GPE is correct. MP1 is for the assumption that the KE after firing is the same as the max GPE. Do not credit energy loss due to air resistance or sound.] Ek → Egrav of pendulum correct Or KE after collision is correct. **(1)** Ek in collision not conserved Or not an elastic collision Or inelastic collision (do not credit just 'KE is lost'). **(1)** Some energy becomes heat. **(1)** Ek (of pellet before collision)is greater than 0.16J **(1)**	**(4)**
	Total for Question 17	**(16)**

Total for Section B = 70 Marks

Total for Paper = 80 Marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number	Candidate Number

Physics

Advanced
Unit 5: Physics from Creation to Collapse

Sample Assessment Material
Time: 1 hour 35 minutes

Paper Reference
WPH05/01

You do not need any other materials.

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.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*****) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

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

Turn over ▶

S45370A

S 4 5 3 7 0 A 0 1 2 8

PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒.
If you change your mind, put a line through the box ~~☒~~ and then
mark your new answer with a cross ☒.

1 A mass is bouncing on the end of a vertical spring. Its motion will be simple harmonic if the spring

☒ **A** can store energy.

☒ **B** has elasticity.

☒ **C** is hung vertically.

☒ **D** obeys Hooke's law.

(Total for Question 1 = 1 mark)

2 When energy is supplied to a substance, changes in the average molecular kinetic energy (E_k) and the average molecular potential energy (E_p) can occur.

When energy is supplied to an ideal gas

☒ **A** both E_k and E_p increase.

☒ **B** E_k may increase.

☒ **C** E_p may increase.

☒ **D** E_k increases but E_p decreases.

(Total for Question 2 = 1 mark)

3 The force between two masses and the force between two charges can be modelled in a similar way, using gravitational and electric fields. A difference between these models is that

☒ **A** an electric field is always a radial field.

☒ **B** an electric field is always the stronger field.

☒ **C** a gravitational field cannot be shielded.

☒ **D** a gravitational field extends over an infinite range.

(Total for Question 3 = 1 mark)

4 α-Centauri is one of the nearest stars to our Sun. The surface temperatures of these two stars are about the same. α-Centauri has a 20% greater diameter than the Sun.

The ratio of the luminosity of α-Centauri to the luminosity of the Sun is about

☒ **A** 1.2

☒ **B** 1.4

☒ **C** 1.7

☒ **D** 2.1

(Total for Question 4 = 1 mark)

---

5 Scientists cannot be sure what their current models predict for the ultimate fate of the universe because

☒ **A** of the matter-antimatter asymmetry.

☒ **B** the average density of the universe is uncertain.

☒ **C** the Big Bang is just a theory.

☒ **D** the nature of dark matter is unknown.

(Total for Question 5 = 1 mark)

---

6 When measuring the count rate from a radioactive source it is usual to also measure the background count rate.

The background count rate must be

☒ **A** as large as possible for an accurate experiment.

☒ **B** measured when the source is in place.

☒ **C** recorded for the same time as the count rate.

☒ **D** subtracted from the count rate measured from the source.

(Total for Question 6 = 1 mark)

7 Air is a mixture of mostly nitrogen and oxygen molecules. The mass of an oxygen molecule is slightly greater than the mass of a nitrogen molecule.

On average, in a sample of air at a given temperature

☒ **A** the nitrogen and oxygen molecules have the same speed.

☒ **B** the nitrogen molecules are travelling more slowly than the oxygen molecules.

☒ **C** the oxygen molecules are travelling more slowly than the nitrogen molecules.

☒ **D** the molecules have relative speeds that depend upon the amount of each gas present.

(Total for Question 7 = 1 mark)

---

8 A lamp consists of a filament in a vacuum. Under normal working conditions the filament has a temperature of 1600 K. A similar filament lamp that is gas-filled has a filament temperature of 3200 K.

The ratio of the wavelength at which maximum intensity of radiation is emitted by the vacuum lamp to that for the gas-filled lamp is

☒ **A** 1:2

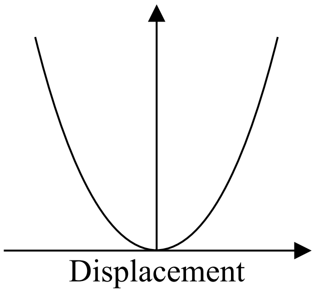
☒ **B** 1:1

☒ **C** 2:1

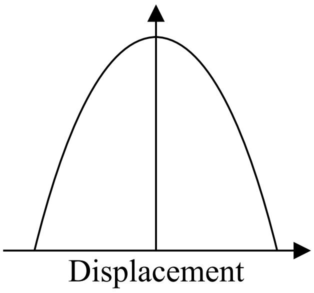
☒ **D** 16:1

(Total for Question 8 = 1 mark)

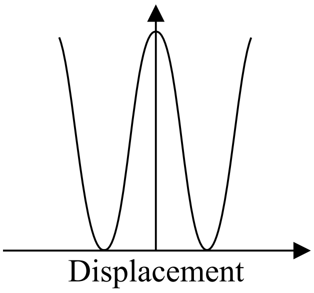
Questions 9 and 10 refer to the graphs below.



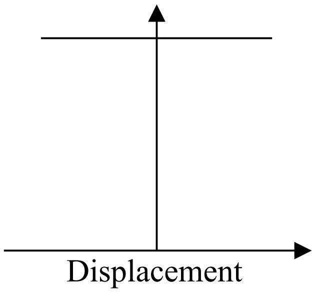
A



B



C



D

9 For an object undergoing simple harmonic motion select the graph that represents the variation of kinetic energy with displacement.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 For an object undergoing simple harmonic motion select the graph that represents the variation of the total energy with displacement.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

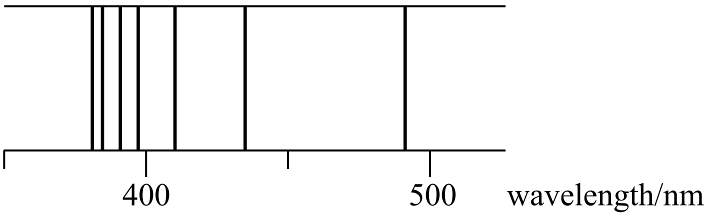
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

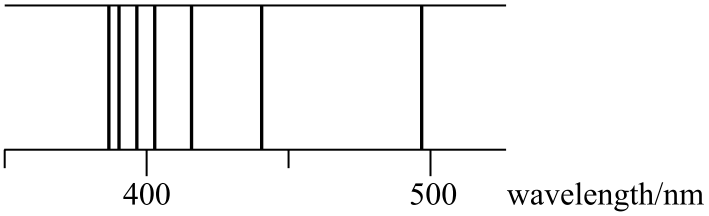
SECTION B

Answer ALL questions in the spaces provided.

11 The diagram shows part of the hydrogen line spectra obtained for radiation emitted from hydrogen in the laboratory and received from hydrogen in a distant galaxy.



Laboratory Spectrum



Distant Galaxy Spectrum

The lines in the distant galaxy spectrum are all shifted in wavelength compared to the lines in the laboratory spectrum.

State why the lines are shifted and what we can conclude about this distant galaxy.

(2)

(Total for Question 11 = 2 marks)

12 The heating element of an electric shower has a power of 6.0 kW.

(a) The shower is operated from a 230 V mains supply.

Calculate the resistance of the heating element.

(2)

Resistance = ...

(b) Water enters the shower at a temperature of 7.5 °C.

Calculate the water flow rate required to give an output temperature of 37.5 °C.

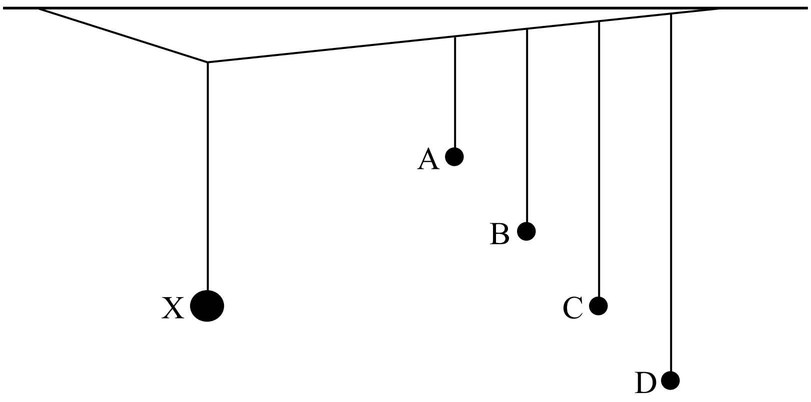
specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(3)

Flow rate = ...

(Total for Question 12 = 5 marks)

13 The diagram shows a number of pendulums hanging from a single thread. Pendulum X has a heavy lead sphere as the bob and the others have low mass bobs. When X is set into motion energy is transferred to the others which all begin to oscillate.

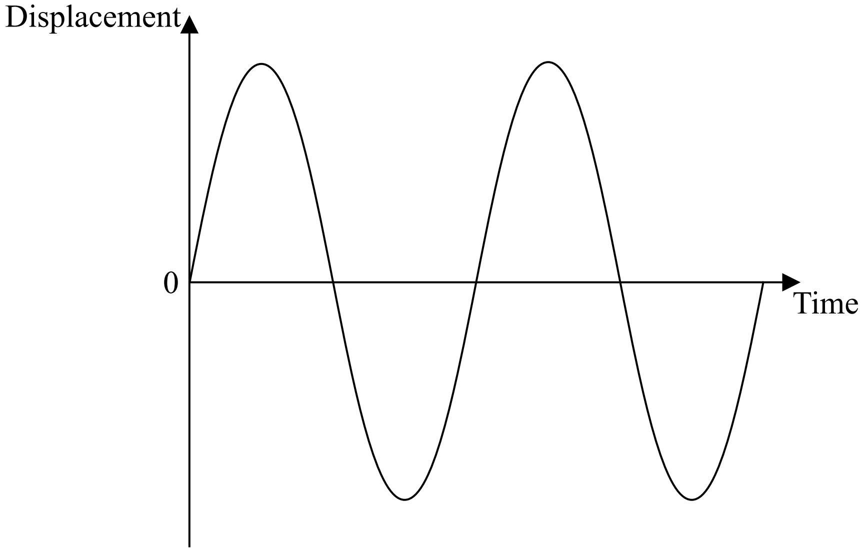


After a short time C is observed to have the largest amplitude of oscillation.

(a) Explain why pendulum C has the largest amplitude of oscillation.

(3)

(b) For an efficient energy transfer pendulum C must be at rest when pendulum X has its maximum kinetic energy. The graph below shows how the displacement of pendulum X varies with time.



Mark a point P on this graph showing an instant when pendulum X has a maximum kinetic energy, and add a curve to show how the displacement of pendulum C varies over the same time interval.

(2)

(Total for Question 13 = 5 marks)

***14** Parallax measurements are used to determine the distance to nearby stars, but this method is unsuitable for more distant objects.

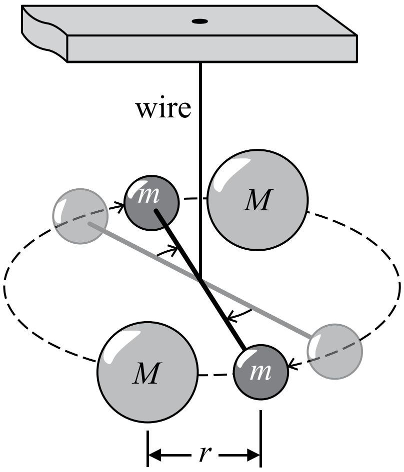
Outline how parallax measurements are used to determine the distance to nearby stars and explain how the use of a standard candle enables the distance to more distant objects to be determined.

(6)

(Total for Question 14 = 6 marks)

15 In the 18th century Henry Cavendish devised an experiment to determine the average density of the Earth. This involved the first laboratory determination of the universal gravitational constant *G*.

A light horizontal rod with a small metal sphere at each end was hung from a fixed point by a very thin wire. Two large lead spheres were then brought close to the small spheres causing the rod to oscillate and then settle into a new position of equilibrium.



(a) In a modern version of the experiment the following data was obtained:

mass of large lead sphere $M = 160$ kg

mass of small sphere $m = 0.75$ kg

distance $r = 0.23$ m

gravitational force between adjacent large and small spheres $F = 1.5 \times 10^{-7}$ N.

Use this data to calculate a value for *G*.

(2)

....

....

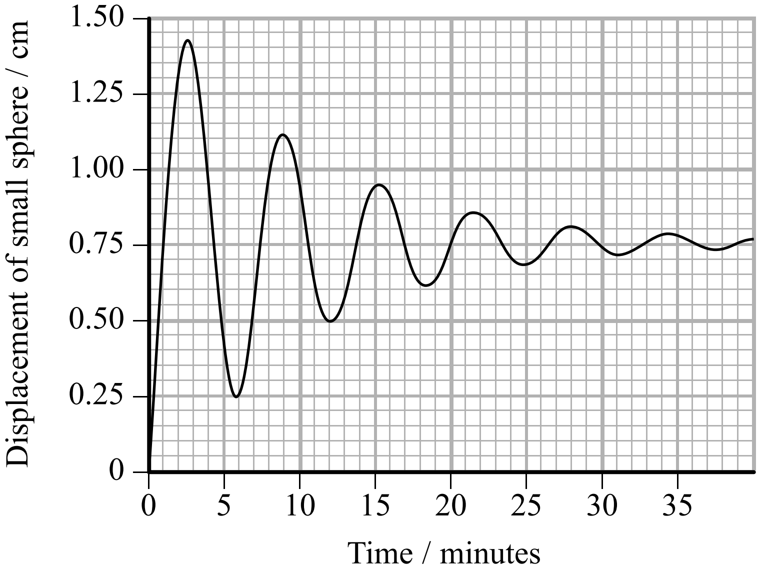
....

....

....

$G =$ .... Nm^2 kg^{-2}

(b) The graph shows how the displacement of one of the small spheres varies with time.



(i) Use the graph to determine the period of oscillation of the sphere.

(2)

Period = ...

(ii) The amplitude of the oscillation decreases with each cycle.

Explain why this effect is observed.

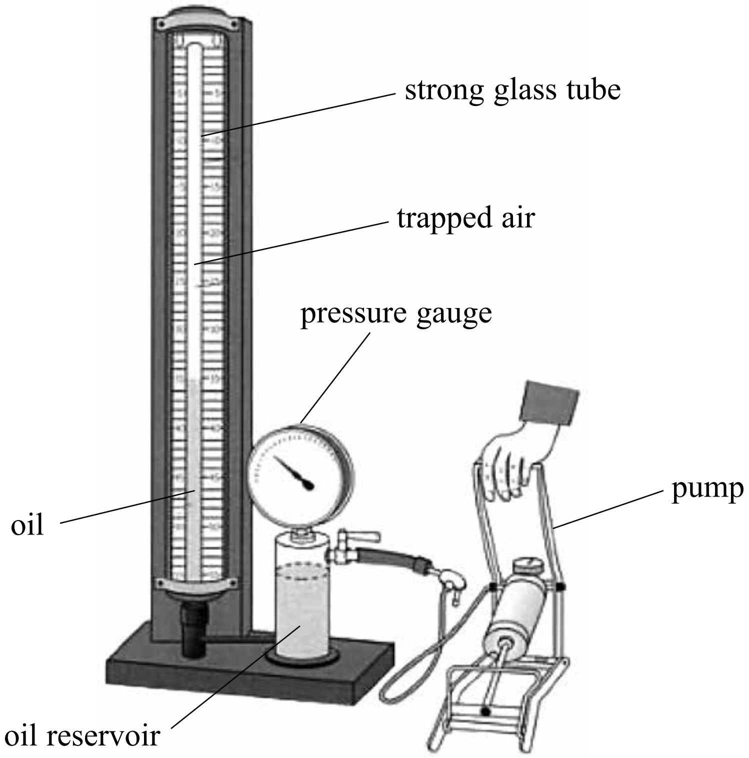
(2)

(iii) It is suggested that the decrease in amplitude is exponential. Use the graph to determine if this is approximately true.

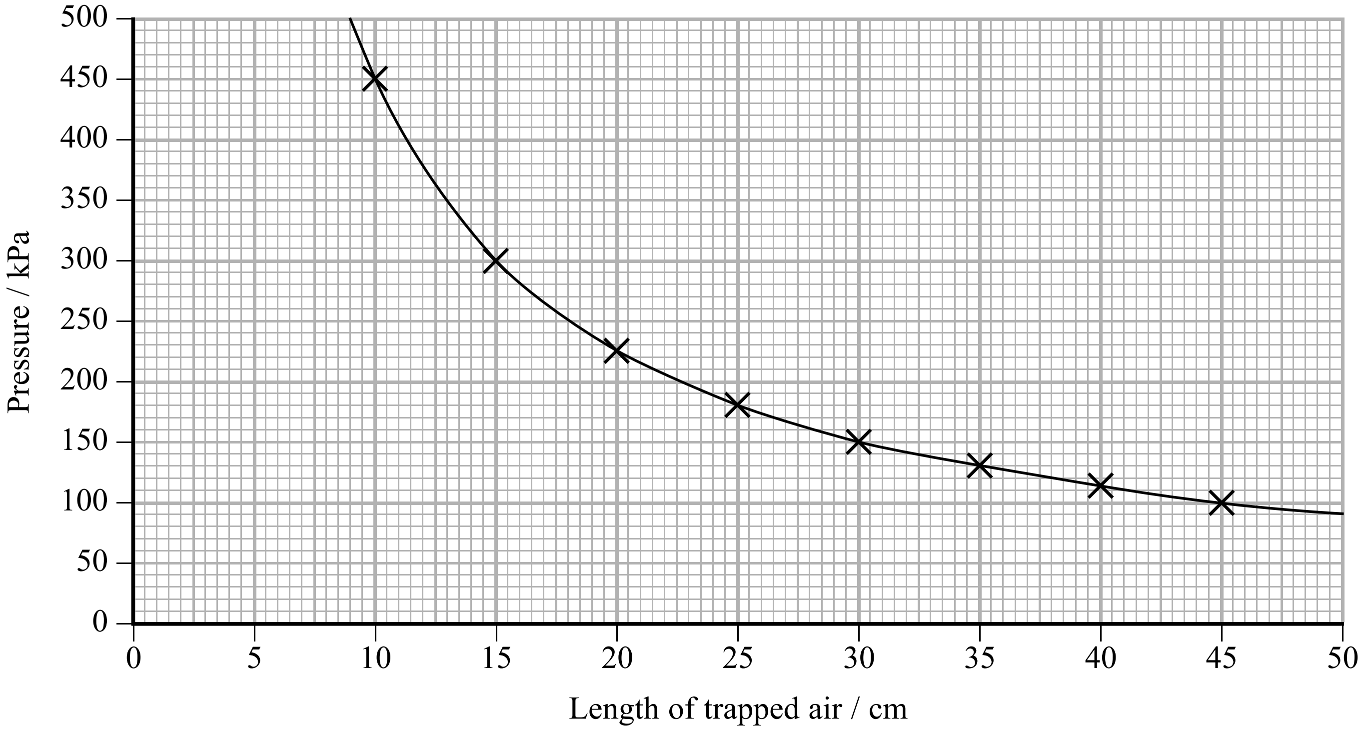
(3)

(Total for Question 15 = 9 marks)

16 A student uses the apparatus shown to investigate the relationship between pressure and volume of a gas.



Air is trapped in a glass tube of uniform cross-sectional area. As the pressure of the trapped air is increased, the length of trapped air decreases. The student collects data and plots the following graph.



(a) State the variables that should be controlled in this investigation.

(2)

....

....

....

....

(b) Theory suggests that, for the air trapped in the tube, the pressure p is inversely proportional to the volume V.

Use the graph to show that this relationship is correct. State an assumption that you are making.

(4)

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(c) On the day that the investigation was carried out, the temperature in the laboratory was 20 °C.

Calculate the number of air molecules trapped in the tube.

cross-sectional area of tube = 7.5×10^{-5} m^2

(3)

Number of air molecules = ...

(d) State how the graph would change if

(i) the air molecules in the tube were replaced by the same number of molecules of hydrogen gas.

(1)

(ii) the temperature of the laboratory was substantially higher.

(2)

(Total for Question 16 = 12 marks)

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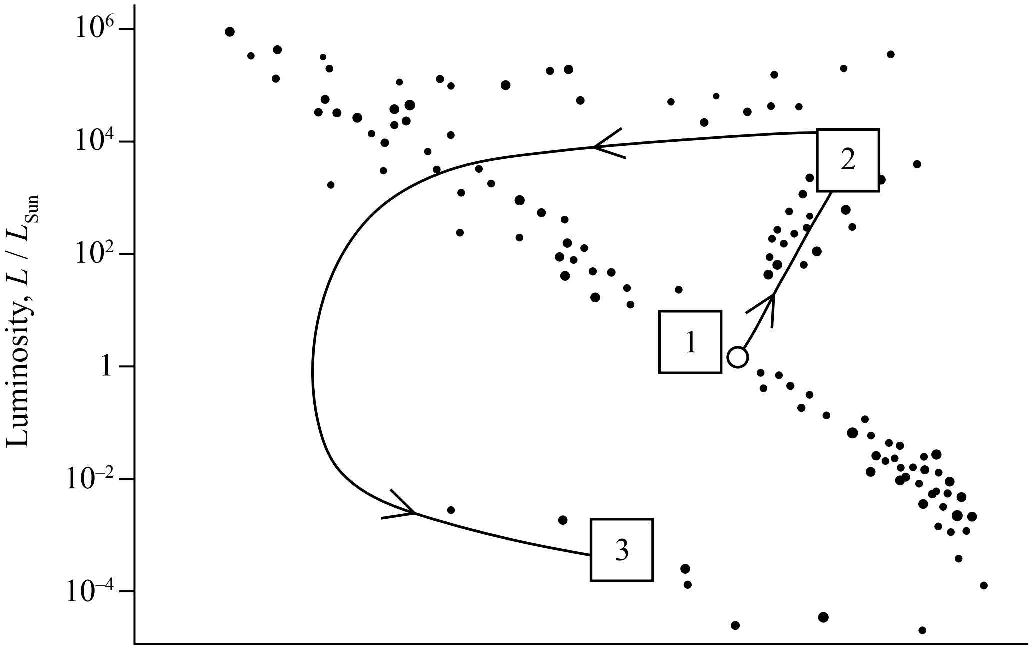
17 The Sun has a surface temperature of 5800 K and is approximately 4.5 billion years old.

The Hertzsprung-Russell diagram maps the future evolution of the Sun, from its current position in area 1 of the diagram, through to its final position in area 3 of the diagram.



(a) (i) Complete a suitable temperature scale on the x-axis.

(2)

*(ii) Use the diagram to describe the lifecycle of the Sun starting from its present position in area 1 and concluding in area 3.

(6)

....

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(b) The energy source for the Sun is the fusion of light nuclei to heavy nuclei. In its present stage of evolution hydrogen is being converted into helium in the core of the Sun.

(i) State and explain the conditions necessary for fusion to occur in a star.

(3)

(ii) In a star the fusion of hydrogen into helium takes place in a number of stages. The final stage is:

$$^{3}_{2}\mathrm{He} + ^{3}_{2}\mathrm{He} \rightarrow ^{4}_{2}\mathrm{He} + 2 \times ^{1}_{1}\mathrm{H}$$

Calculate the energy released in MeV when one nucleus of the normal isotope of helium is produced.

(4)

Isotope	**Mass / 10^{-27} kg**
^{3}He	5.008238
^{4}He	6.646483
^{1}H	1.673534

Energy released = ... MeV

(Total for Question 17 = 15 marks)

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18 On 1st November 2006, the former Russian spy Alexander Litvinenko fell ill. Twenty one days later he died from the radiation effects of polonium-210. Experts suggest that as little as 0.89 μg of polonium-210 would be enough to kill, although Mr Litvinenko's death was linked to a much larger dose of the radioactive isotope. Traces of the isotope were later found in washrooms at five locations around London visited by the Russian.

Polonium-210 has a half life of 138 days.

(a) (i) In a 0.89 μg sample of polonium-210 there are 2.54×10^{15} atoms of polonium. Show that the decay constant for polonium-210 is about 6×10^{-8} s^{-1}, and hence calculate the activity of a sample of this size.

(4)

Activity = ...

(ii) Calculate the fraction of polonium-210 nuclei that have decayed after a time of 21 days.

(3)

Fraction decayed = ...

(b) Polonium-210 emits alpha particles. Explain why polonium-210 is virtually harmless unless it is taken into the body.

(2)

(c) (i) Complete the equation below for the decay of polonium.

(2)

$$^{210}_{84}\text{Po} \rightarrow \,^{\cdots\cdots}_{\cdots\cdots}\text{Pb} + \,^{\cdots\cdots}_{\cdots\cdots}\alpha$$

(ii) State why the Pb nuclei would recoil from the alpha particles emitted during the decay.

(1)

(d) Radioactive decay is said to occur spontaneously and randomly. Explain what is meant by spontaneous and random in this context.

(2)

Spontaneous

Random

(e) Suggest why traces of the isotope were found in locations visited by the Russian.

(2)

(Total for Question 18 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\,s^{-2}}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$	
	$= 8.99 \times 10^{9}\ \mathrm{N\,m^{2}\,C^{-2}}$	
Electron charge	$e = -1.60 \times 10^{-19}\,\mathrm{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\,\mathrm{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$	
Gravitational field strength	$g = 9.81\ \mathrm{N\,kg^{-1}}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$	
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\,m^{-2}\,K^{-4}}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + ½at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = ½mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = ½F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{\text{max}}$

Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0\mathrm{e}^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
Faraday's and Lenz's Laws	$\varepsilon = -\mathrm{d}(N\phi)/\mathrm{d}t$

Particle physics

Mass-energy	$\Delta E = c^2\,\Delta m$
de Broglie wavelength	$\lambda = h/p$

Unit 5

Energy and matter

Heating	$\Delta E = mc\Delta\theta$
Molecular kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Ideal gas equation	$pV = NkT$

Nuclear Physics

Radioactive decay	$\mathrm{d}N/\mathrm{d}t = -\lambda N$ $\lambda = \ln 2/t_{1/2}$ $N = N_0 \mathrm{e}^{-\lambda t}$

Mechanics

Simple harmonic motion	$a = -\omega^2 x$ $a = -A\omega^2 \cos \omega t$ $v = -A\omega \sin \omega t$ $x = A \cos \omega t$ $T = 1/f = 2\pi/\omega$
Gravitational force	$F = Gm_1m_2/r^2$

Observing the universe

Radiant energy flux	$F = L/4\pi d^2$
Stefan-Boltzmann law	$L = \sigma T^4 A$ $L = 4\pi r^2 \sigma T^4$
Wien's Law	$\lambda_{\max} T = 2.898 \times 10^{-3}$ m K
Redshift of electromagnetic radiation	$z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$
Cosmological expansion	$v = H_0 d$

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Mark Scheme (SAM)

Pearson Edexcel International Advanced Level in Physics

Unit 5: Physics from Creation to Collapse

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.

Further notes

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii)	Horizontal force of hinge on table top 66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [Some examples of direction: acting from right (to left)/to the left/West/opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	**(1)**

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

Mark scheme format

1. You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the mark scheme has specified specific words that must be present. Such words will be indicated by underlining, e.g. 'resonance'.
2. Bold lower case will be used for emphasis.
3. Round brackets ( ) indicate words that are not essential, e.g. '(hence) distance is increased'.
4. Square brackets [ ] indicate advice to examiners or examples, e.g. [Do not accept gravity] [ecf].

Unit error penalties

1. A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
2. Incorrect use of case, e.g. 'Watt' or 'w' will **not** be penalised.
3. There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
4. The same missing or incorrect unit will not be penalised more than once within one question (one clip in e-pen).
5. Occasionally, it may be decided not to penalise a missing or incorrect unit, e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
6. The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

Significant figures

1. Use of an inappropriate number of significant figures (sf) in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
2. The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}.

Calculations

1. Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
2. If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.
3. **Use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors, e.g. power of 10 error.
4. **Recall** of the correct formula will be awarded when the formula is seen or implied by substitution.
5. The mark scheme will show a correctly worked answer for illustration only.
6. Example of mark scheme for a calculation:

'Show that' calculation of weight Use of L × W × H Substitution into density equation with a volume and density Correct answer [49.4 (N)] to at least 3 significant figures [No ue] [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark][Bald answer scores 0, reverse calculation 2/3] Example of answer: 80 cm × 50 cm × 1.8 cm = 7200 cm^3 7200 cm^3 × 0.70 g cm^{-3} = 5040 g 5040 × 10^{-3} kg × 9.81 N/kg = 49.4 N	 ✓ ✓ ✓	**(3)**

Quality of Written Communication

1. Indicated by 'Quality of Written Communication' in the mark scheme. Work must be clear and organised in a logical manner using technical wording where appropriate.
2. Usually it is part of a maximum mark, the final mark not being awarded unless the Quality of Written Communication condition has been satisfied.

Graphs

1. A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
2. Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.
3. A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale, e.g. multiples of 3, 7 etc.
4. Points should be plotted to within 1 mm:
   - Check the two points furthest from the best line. If both OK award mark.
   - If either is 2 mm out do not award mark.
   - If both are 1 mm out do not award mark.
   - If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.
5. For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Section A

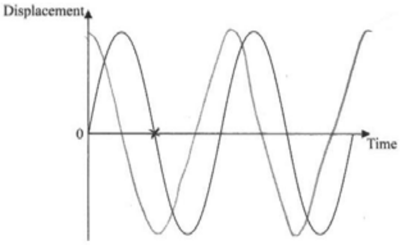
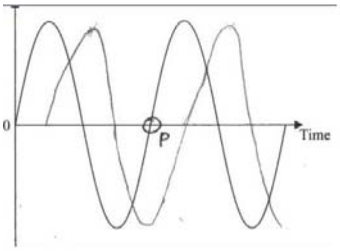
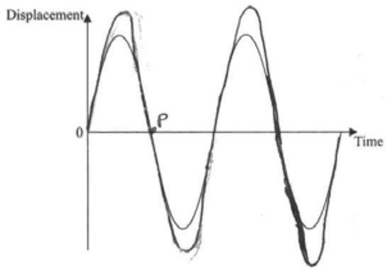
Question Number	Answer	Mark
1	D	**(1)**
2	B	**(1)**
3	C	**(1)**
4	B	**(1)**
5	B	**(1)**
6	D	**(1)**
7	C	**(1)**
8	C	**(1)**
9	B	**(1)**
10	D	**(1)**

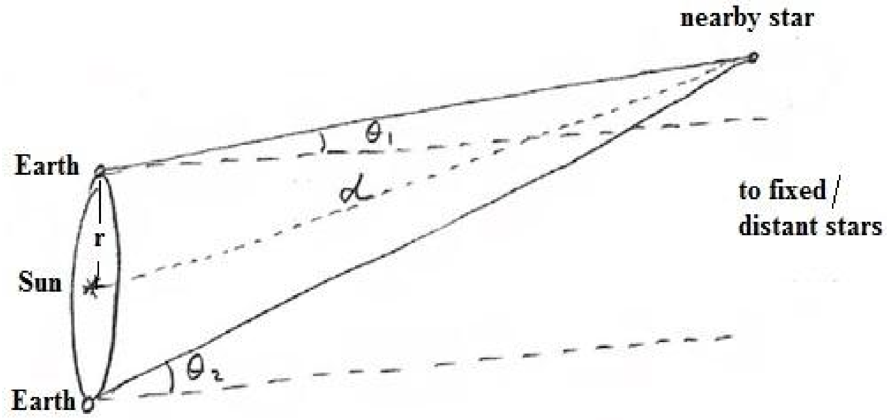
Total for Section A = 10 Marks

Section B

Question Number	Answer		Mark
11	There is a red shift [accept Doppler shift]. The galaxy is receding **or** the galaxy is moving away from us [Do not accept 'the universe is expanding'.]	**(1)** **(1)**	**(2)**
	Total for Question 11		**(2)**

Question Number	Answer		Mark
12(a)	Use of electrical power equation, e.g. $P = (V)^2/R$ $R = 8.8\ \Omega$ [Use of V=IR and P=VI gains mp1] Example of calculation $R = \frac{(230V)^2}{6000W} = 8.82\Omega$	**(1)** **(1)**	**(2)**
12(b)	See 30 K [30 ^{o}C] **Or** 6000 J s^{-1} Use of ΔE = mcΔθ [do not penalise wrong temperature conversions, but Δθ must be a temperature difference]. $\frac{\Delta m}{\Delta t} = 0.048\,\text{kg}\,\text{s}^{-1}$ [accept 0.048 litre s^{-1} and other volume flow rates with correct units] Example of calculation $\Delta\theta = (37.5 - 7.5)\ ^{o}\text{C} = 30\ ^{o}\text{C}$ $\frac{\Delta m}{\Delta t} = \frac{6000\,\text{W}}{4200\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1} \times 30\,\text{K}} = 0.0476\,\text{kg}\,\text{s}^{-1}$	**(1)** **(1)** **(1)**	**(3)**
	Total for Question 12		**(5)**

Question Number	Answer	Mark
13(a)	Pendulum C has same/similar length as pendulum X **(1)** Therefore C has the same/similar natural frequency as pendulum X **(1)** **Or** idea that C is driven at its natural frequency (Hence) the energy transfer from X to C is most efficient **Or** There is a maximum transfer of energy from X to C **Or** A correct reference to resonance **(1)**	**(3)**
13(b)	Any zero displacement point marked on original graph [do not insist on 'P'] **(1)** (Minus) cosine graph drawn with same period as original graph **(1)** [Ignore amplitude of graph drawn] Examples of graphs:  This candidate has identified 'P' (although not used 'P') and the cosine graph is well drawn. [2 marks]  This candidate has identified 'P' correctly, and has drawn a minus cosine graph. Their graph starts from a time of T/4, which is just about acceptable. [2 marks]  This candidate has identified 'P' correctly, but has drawn a sine curve. [1 mark]	**(2)**
	Total for Question 13	**(5)**

Question Number	Answer	Mark
***14**	(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate.) **Parallax:** The star is viewed from two positions at 6 month intervals **or** the star is viewed from opposite ends of its orbit diameter about the Sun **(1)** The (change in) angular position of the star relative to fixed/distant stars is measured **(1)** The diameter/radius of the Earth's orbit about the Sun must be known and trigonometry is used (to calculate the distance to the star) [do not accept Pythagoras] **(1)** The marks above may be obtained with the aid of a suitably annotated diagram, e.g  [Accept the symmetrical diagram seen in many textbooks] **Standard candle:** Flux/brightness/intensity of standard candle is measured **(1)** Luminosity of standard candle is known [accept reference to absolute magnitude **or** total power output of star] **(1)** Inverse square law is used (to calculate distance to standard candle) **(1)**	**(6)**
	Total for Question 14	**(6)**

Question Number	**Answer**	**Mark**
15(a)	Use of $F = \frac{G m_1 m_2}{r^2}$ **(1)** G = 6.6×10^{-11} (N m^2 kg^{-2}) [must see 6.6×10^{-11} when rounded to 2 sf] **(1)** Example of calculation $G = \frac{1.5\times10^{-7}\,\text{N}\times(0.23\,\text{m})^2}{160\,\text{kg}\times 0.75\,\text{kg}} = 6.61\times10^{-11}\,\text{N}\,\text{m}^2\,\text{kg}^{-2}$	**(2)**
15(b)(i)	Read (peak) times from graph for at least 3 cycles **(1)** T = 6.4 min (±0.2 min) [T = (380 ±12) s] **(1)** [Maximum 1 mark if correct answer shown without working] Example of calculation $T = \frac{(28.0-2.5)\ \text{min}}{4} = 6.38\ \text{min}$	**(2)**
15(b)(ii)	Air resistance acts on the sphere [accept frictional forces **or** (viscous) drag for air resistance] **(1)** Energy is removed from the oscillation/system **Or** the oscillation/system is damped **(1)** [For mp 2 do not credit 'energy is lost' but accept 'energy is dissipated'; answer must indicate idea of transfer of energy]	**(2)**
15(b)(iii)	Evidence of values of at least 3 consecutive peaks read from graph [accept values of 3 points separated by equal time intervals] **(1)** Attempt to obtain amplitudes, by subtracting 0.75 **(1)** Calculation of two values of A_{n+1}/A_n with corresponding conclusion **Or** Calculation of two values of difference of ln A_{n+1} and ln A_n with corresponding conclusion **(1)** **Or** Use peaks of graph to sketch curve **(1)** Use curve to determine 'half-life' [accept other ratio] **(1)** Calculation of two values of 'half-life' with corresponding conclusion **(1)** Example of calculation A_0 = 1.45-0.75 = 0.7, A_1 = 0.75-0.25 = 0.5, A_2 = 1.1-0.75 = 0.35, A_4 = 0.75 – 0.5 = 0.25 $\frac{A_1}{A_0} = \frac{0.50}{0.70} = 0.71$ $\frac{A_2}{A_1} = \frac{0.35}{0.50} = 0.70$ $\frac{A_3}{A_2} = \frac{0.25}{0.35} = 0.71$	**(3)**
	Total for Question 15	**(9)**

Question Number	Answer	Mark
16(a)	Temperature (of gas) [treat references to oil/room as neutral] **(1)** Mass of air/gas **or** number of atoms/molecules/moles of air/gas **(1)** [accept amount of air/gas, number of particles of air/gas]	**(2)**
16(b)	Assumption: idea that volume occupied by trapped air ∝ length of air in tube [e.g. volume = cross-sectional area × length] **(1)** pL = a constant [accept pV = a constant] **or** if p doubles, L halves **(1)** At least 2 pairs of p, L values correctly read from graph **(1)** Readings show that pL = 4500 (kPa cm) [± 100 kPa cm] **Or** readings show that p doubles when L is halved **(1)** [Accept references to V instead of L] <u>Example of calculation</u> p = 400 kPa, L = 11.0 cm pL=400 × 11.0 = 4400 p = 200 kPa, L = 23.0 cm pL=200 × 23.0 = 4600	**(4)**
16(c)	Use of $pV=NkT$ [Allow use of pV=nRT **and** $N=n.N_A$] **(1)** Conversion of temperature to kelvin **(1)** $N = 8.4 \times 10^{20}$ [Accept answers in range 8.1×10^{20} to 8.4×10^{20}] **(1)** [Answer in range but with an incorrect temperature conversion score maximum 2] <u>Example of calculation</u> $N = \dfrac{450 \times 10^3\,\text{Pa} \times 0.10\,\text{m} \times 7.5 \times 10^{-5}\,\text{m}^2}{1.38 \times 10^{-23}\,\text{JK}^{-1} \times (273+20)\text{K}} = 8.35 \times 10^{20}$	**(3)**
16(d)(i)	No change **(1)**	**(1)**
16(d)(ii)	Similar curve **(1)** Shifted higher **or** shifted to the right **(1)** [an annotated diagram can score full marks]	**(2)**
	Total for Question 16	**(12)**

Question Number	Answer	Mark
17(a)(i)	Reverse direction for temperature [at least 2 values seen] **(1)** Logarithmic/power temperature variation [at least 3 realistic values seen increasing by the same factor] **(1)**	**(2)**
***17(a)(ii)**	(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate) **Area 1: maximum 2** The Sun is fusing/burning hydrogen (into helium in its core) **(1)** When (hydrogen) fusion/burning ceases the core of the Sun cools [accept radiation pressure drops when fusion/burning ceases in the core] **(1)** The core collapses/contracts (under gravitational forces) **(1)** **Area 2: maximum 2** The Sun expands and becomes a red giant **(1)** The core becomes hot enough for helium fusion/burning to begin (in the core) **(1)** Helium begins to run out and the core collapses again (under gravitational forces) **(1)** **Area 3: maximum 2** Idea that outer layers of Sun are ejected into space **(1)** The temperature doesn't rise enough for further fusion to begin **(1)** The core/Sun becomes a (white) dwarf star **(1)**	**(6)**
17(b)(i)	Idea of a very high temperature [accept value of about 10^7 K] **(1)** To overcome repulsive/electrostatic forces between protons/nuclei **Or** so that protons/nuclei get close enough together for the strong (nuclear) force to act **Or** so that protons/nuclei get close enough to fuse **(1)** Idea of a very high density [accept pressure] to give a sufficient collision rate **(1)**	**(3)**
17(b)(ii)	Attempt at calculation of mass deficit **(1)** Use of $\Delta E = c^2 \Delta m$ **(1)** Attempt at conversion from J to (M)eV **(1)** $\Delta E = 12.9$ (MeV) **(1)** [If correct mass defect in kg is converted into u and then 1u = 931 Mev used, then full marks may be awarded.] Example of calculation $\Delta m = \left(\left(5.008238 \times 2\right) - 6.646483 - \left(1.673534 \times 2\right)\right) \times 10^{-27}\,\text{kg}$ $\Delta m = 2.2925 \times 10^{-29}$ kg $\Delta E = \left(3.00 \times 10^{8}\,\text{ms}^{-1}\right)^2 \times 2.2925 \times 10^{-29}\,\text{kg} = 2.063 \times 10^{-12}\,\text{J}$ $\Delta E = \dfrac{2.063 \times 10^{-12}\,\text{J}}{1.60 \times 10^{-13}\,\text{J MeV}^{-1}} = 12.9\,\text{MeV}$	**(4)**
	Total for Question 17	**(15)**

Question Number	Answer	Mark
18(a)(i)	Use of $\lambda . t_{1/2} = \ln 2$ **(1)** $\lambda = 5.8 \times 10^{-8}$ (s^{-1}) **(1)** Use of $\frac{\Delta N}{\Delta t} = -\lambda N$ **(1)** $\frac{\Delta N}{\Delta t} = (-)1.5 \times 10^{8}$ Bq [accept s^{-1} **or** counts s^{-1}] **(1)** Example of calculation $\lambda = \frac{0.693}{(138 \times 24 \times 3600)s} = 5.81 \times 10^{-8} s^{-1}$ $\frac{\Delta N}{\Delta t} = -5.81 \times 10^{-8} s^{-1} \times 2.54 \times 10^{15} = -1.48 \times 10^{8}$ Bq	**(4)**
18(a)(ii)	Use of $N = N_0 e^{-\lambda t}$ **(1)** Fraction of nuclei remaining = 0.90 **(1)** 10% of nuclei have decayed [accept 0.1 **or** 1/10] **(1)** Example of calculation t = 21 × 24 × 3600 s = 1 814 400 s $\frac{N}{N_0} = e^{-5.81 \times 10^{-8} s^{-1} \times 1.81 \times 10^{6} s}$ $\frac{N}{N_0} = e^{-0.105} = 0.900$ Fraction decayed = 1- 0.9 = 0.1	**(3)**
18(b)	Idea that α-particles are not able to penetrate the (dead layer of) skin (from outside the body) **(1)** Damage/danger if energy is transferred to cells/DNA **Or** damage/danger to cells/DNA due to ionisation **(1)**	**(2)**
18(c)(i)	${}^{210}_{84}Po \rightarrow {}^{206}_{82}Pb + {}^{4}_{2}\alpha$ Top line correct **(1)** Bottom line correct **(1)**	**(2)**
18(c)(ii)	So that momentum is conserved **(1)**	**(1)**
18(d)	Spontaneous means that the decay cannot be influenced by any external factors. **(1)** Random means that we cannot identify which atom/nucleus will (be the next to) decay **Or** we cannot identify when an individual atom/nucleus will decay **Or** we cannot state exactly how many atoms/nuclei will decay in a set time **Or** we can only estimate the fraction of the total number that will decay in the next time interval. **(1)**	**(2)**
18(e)	Idea that traces of the isotope will be excreted from the body (and deposited in the surroundings). **(1)** Idea that the half life is long enough for the activity to be detectable for a long time. **(1)**	**(2)**
	Total for Question 18	**(16)**

Total for Section B = 70 Marks

Total for Paper = 80 Marks

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number ☐☐☐☐☐

Candidate Number ☐☐☐☐

Physics

Advanced
Unit 6: Experimental Physics

Sample Assessment Material
Time: 1 hour 20 minutes

Paper Reference
WPH06/01

You must have:
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.*

Information

- The total mark for this paper is 40.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

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

Turn over ▶

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PEARSON

Answer ALL questions in the spaces provided.

1 A student is asked to determine the density of two coins, X and Y, to decide if they are made from the same material. The diameter of each coin is about 25 mm.

(a) (i) She uses vernier callipers to measure the diameter of coin X.

Show that the percentage uncertainty for this measurement is less than 1%.

(1)

(ii) Apart from repeating her readings, state one precaution she could take to ensure each measurement is as accurate as possible.

(1)

(iii) The student measures the thickness of coin X using a micrometer screw gauge. She takes measurements at different points on the coin.

Explain why this would make the mean value for the thickness more accurate.

(1)

(b) She records the following values for coin X:

diameter/mm 25.9, 25.9, 25.9

thickness/mm 1.80, 1.84, 1.82

(i) Use these measurements to calculate the mean value for the volume of coin X.

(2)

Mean value for the volume of coin X = ...

(ii) Use the measurements to estimate the percentage uncertainty in the volume.

(3)

Percentage uncertainty = ...

(c) She measures the mass of coin X as 7.08 g with negligible uncertainty.

Calculate the density of coin X.

(2)

Density of coin X = ...

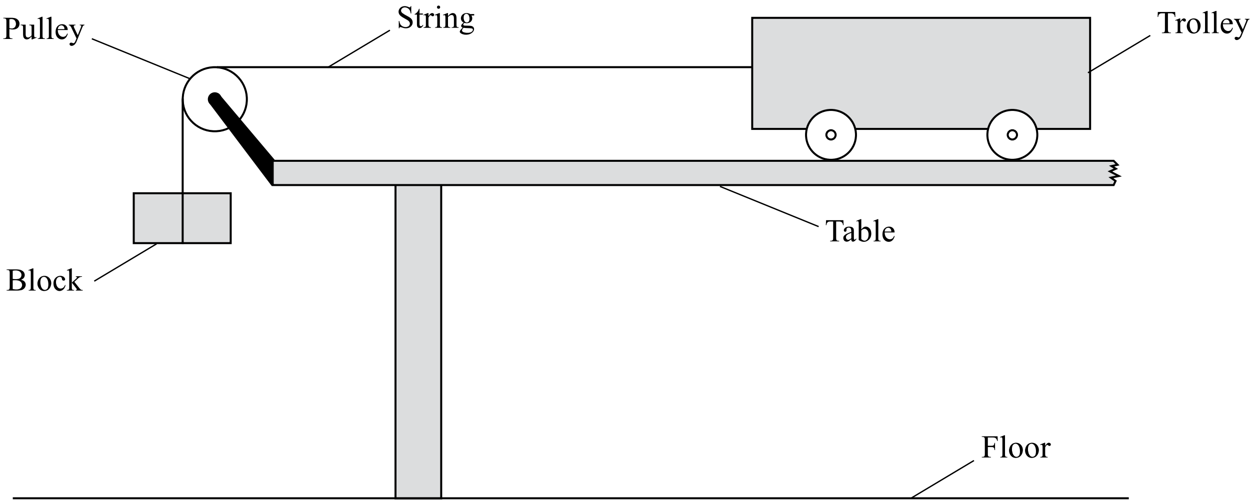
(d) The student makes the same measurements for coin Y. The value of the density for coin Y is 6900 kg m^{-3}. The percentage uncertainties in the measurements are the same for both coins.

Use these measurements to decide if the coins are made from the same material.

(2)

(Total for Question 1 = 12 marks)

2 A student is asked to carry out an experiment about the energy transferred when a trolley is pulled across a table. The apparatus is set up as shown.



As the block falls it loses gravitational potential energy and the trolley and block together gain kinetic energy. The student is asked to find out what fraction of the gravitational potential energy becomes kinetic energy.

The student writes an outline plan for an experiment and produces a table.

1. Measure the mass M of the trolley and the mass m of the falling block and set up the apparatus as shown.
2. Pull back the trolley so that the block is close to the pulley and release the trolley.
3. Measure the distance d fallen by the block.
4. Measure the time t it takes to fall.
5. The final velocity is given by $v = \frac{2d}{t}$.
6. Calculate the gravitational potential energy lost and the kinetic energy gained.
7. Divide the kinetic energy by the gravitational potential energy. This is the fraction required.

Quantity to be measured	**Measuring instrument**	**Precision of measuring instrument**
Masses, M and m		At least 0.1 g
Distance, d	Metre rule	
Time, t	Stopwatch	

Add more detail to improve this plan. You should do the following:

(a) complete the table,

(3)

(b) add a line to the diagram to show the distance *d*,

(1)

(c) describe how you would measure *d* accurately (you may add more to the diagram if you wish),

(2)

(d) describe how you would make each measurement of *t* accurate,

(1)

(e) comment on any safety aspect of this experiment.

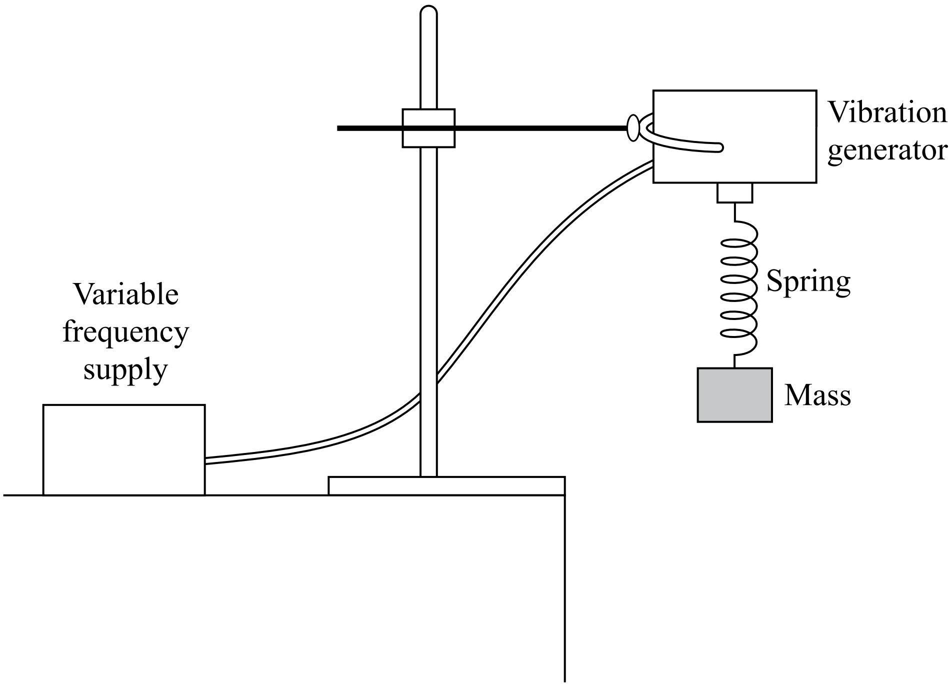
(1)

(Total for Question 2 = 8 marks)

3 A mass is hung on a spring as shown in the diagram. When the mass is pulled down and released, it oscillates at the natural frequency of the system.

When the top of the spring is forced to move up and down at this natural frequency, resonance occurs.

The system below is set up to observe what happens to the oscillations of the mass as the frequency *f* of the vibration generator is varied.



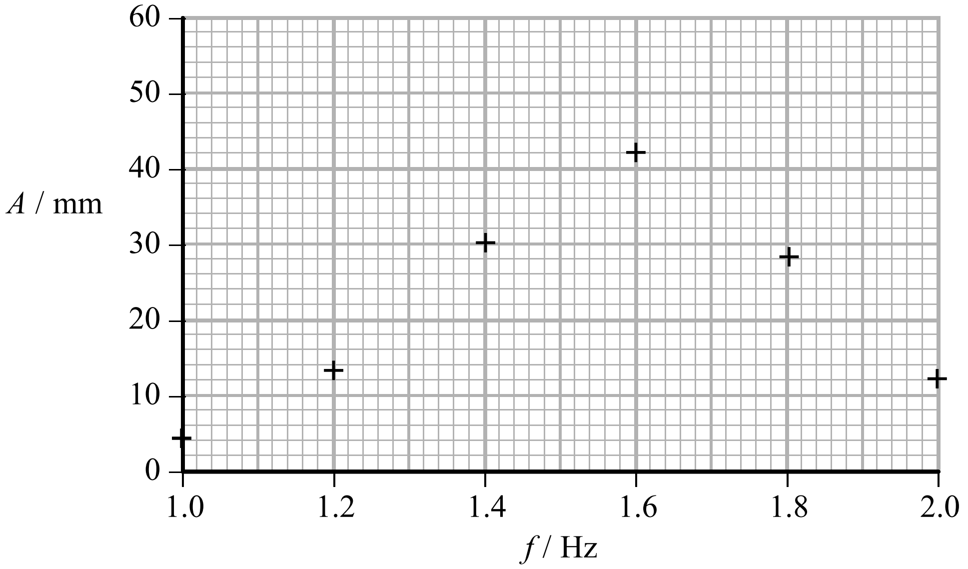
(a) State what you would observe as *f* gets close to the resonant frequency.

(1)

....

....

(b) As *f* is varied, the amplitude of oscillation *A* of the mass is recorded. The results are shown on the graph.



(i) Use the graph to estimate the resonant frequency.

(1)

Resonant frequency = ... Hz

(ii) Describe how you would improve the experiment to obtain a more accurate value for the resonant frequency.

(2)

....

....

....

....

....

(iii) Suggest why it would be better to use an ultrasound position sensor and data logger to record the position of the mass.

(1)

....

....

....

....

(Total for Question 3 = 5 marks)

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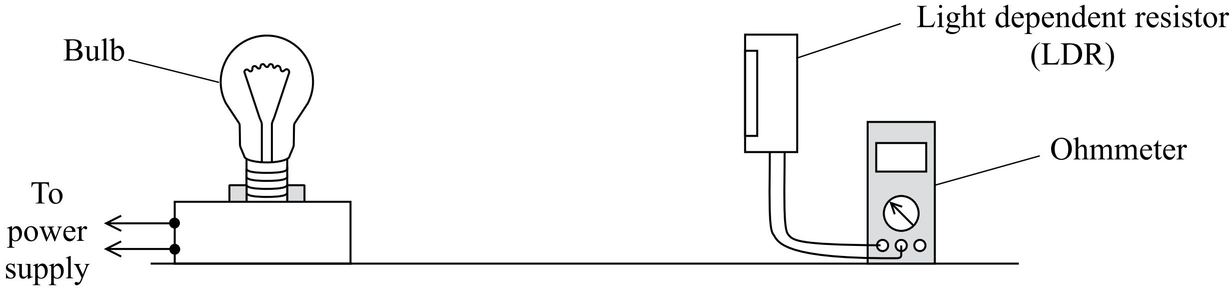
4 A physicist investigates how light intensity varies with distance from a light bulb. He sets up the apparatus as shown.



(a) Mark on the diagram the exact distance *d* he should measure.

(1)

(b) State why the resistance *R* of the LDR will increase as it gets further away from the bulb.

(1)

(c) State the most important quantity to control to ensure a fair test and explain how the physicist might control it.

(2)

(d) The relationship between *R* and *d* is given by

$$R = k\,d^{\mathrm{p}}$$

where *k* and p are constants.

Explain why a graph of ln *R* against ln *d* will give a straight line.

(2)

(e) He measures R for different values of d and records the following results.

d/m	R/kΩ		
1.00	1.79		
1.20	2.24		
1.60	3.32		
2.00	4.04		
2.20	4.70		
2.60	5.50		

Plot a graph of ln R against ln d. Use the column(s) provided to show any processed data.

(5)

(f) (i) Use your graph to find a value for p.

(2)

p = ...

(ii) Use your graph to find a value for *k*.

(2)

k = ...

(Total for Question 4 = 15 marks)

TOTAL FOR PAPER = 40 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\ s^{-2}}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\ K^{-1}}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9}\ \mathrm{N\ m^2\ C^{-2}}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \mathrm{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\ m^2\ kg^{-2}}$	
Gravitational field strength	$g = 9.81\ \mathrm{N\ kg^{-1}}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\ m^{-1}}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\ s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{\text{max}}$

Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$
In a magnetic field	$F = BIl \sin \theta$ $F = Bqv \sin \theta$ $r = p/BQ$
Faraday's and Lenz's Laws	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

Unit 5

Energy and matter

Heating	$\Delta E = mc\Delta\theta$
Molecular kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Ideal gas equation	$pV = NkT$

Nuclear Physics

Radioactive decay	$\mathrm{d}N/\mathrm{d}t = -\lambda N$ $\lambda = \ln 2/t_{1/2}$ $N = N_0\mathrm{e}^{-\lambda t}$

Mechanics

Simple harmonic motion	$a = -\omega^2 x$ $a = -A\omega^2 \cos \omega t$ $v = -A\omega \sin \omega t$ $x = A \cos \omega t$ $T = 1/f = 2\pi/\omega$
Gravitational force	$F = Gm_1m_2/r^2$

Observing the universe

Radiant energy flux	$F = L/4\pi d^2$
Stefan-Boltzmann law	$L = \sigma T^4 A$ $L = 4\pi r^2\sigma T^4$
Wien's Law	$\lambda_{\mathrm{max}} T = 2.898 \times 10^{-3}\ \mathrm{m\ K}$
Redshift of electromagnetic radiation	$z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$
Cosmological expansion	$v = H_0 d$

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Mark Scheme (SAM)

Pearson Edexcel International Advanced Level in Physics

Unit 6: Experimental Physics

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.

Further notes

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii)	Horizontal force of hinge on table top 66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [Some examples of direction: acting from right (to left)/to the left/West/opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	**(1)**

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

Mark scheme format

1. You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the mark scheme has specified specific words that must be present. Such words will be indicated by underlining, e.g. 'resonance'.
2. Bold lower case will be used for emphasis.
3. Round brackets ( ) indicate words that are not essential, e.g. '(hence) distance is increased'.
4. Square brackets [ ] indicate advice to examiners or examples, e.g. [Do not accept gravity] [ecf].

Unit error penalties

1. A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
2. Incorrect use of case, e.g. 'Watt' or 'w' will **not** be penalised.
3. There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
4. The same missing or incorrect unit will not be penalised more than once within one question (one clip in e-pen).
5. Occasionally, it may be decided not to penalise a missing or incorrect unit, e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
6. The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

Significant figures

1. Use of an inappropriate number of significant figures (sf) in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
2. The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}.

Calculations

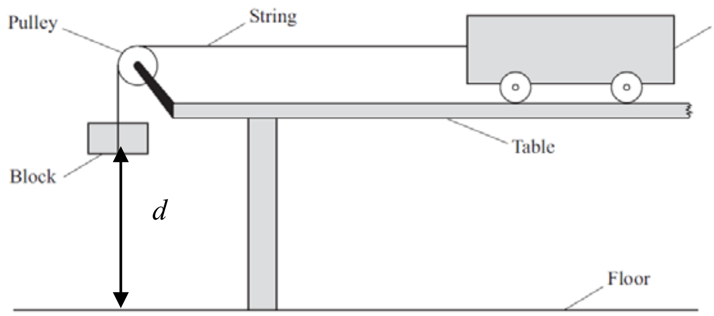
1. Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
2. If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.
3. **Use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors, e.g. power of 10 error.
4. **Recall** of the correct formula will be awarded when the formula is seen or implied by substitution.
5. The mark scheme will show a correctly worked answer for illustration only.
6. Example of mark scheme for a calculation:

'Show that' calculation of weight		
Use of L × W × H	✓	
Substitution into density equation with a volume and density	✓	
Correct answer [49.4 (N)] to at least 3 significant figures [No ue] [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark][Bald answer scores 0, reverse calculation 2/3]	✓	**(3)**
Example of answer: 80 cm × 50 cm × 1.8 cm = 7200 cm^3 7200 cm^3 × 0.70 g cm^{-3} = 5040 g 5040 × 10^{-3} kg × 9.81 N/kg = 49.4 N		

Graphs

1. A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
2. Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.
3. A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale, e.g. multiples of 3, 7 etc.
4. Points should be plotted to within 1 mm:
   - Check the two points furthest from the best line. If both OK award mark.
   - If either is 2 mm out do not award mark.
   - If both are 1 mm out do not award mark.
   - If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.
5. For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1(a)(i)	Divides precision by 25 mm for % uncertainty **(1)** Example of calculation Callipers precise to 0.1 mm giving %U = 100 × (0.1/25) = 0.4% less than 1%	**(1)**
1(a)(ii)	Check for zero error **(1)** **Or** Any valid method to ensure a 'maximum' diameter measured, e.g. measure diameter at several places **(1)**	**(1)**
1(a)(iii)	Thickness of coins varies **Or** Identifies anomalies **Or** Enables her to discard anomalies **(1)**	**(1)**
1(b)(i)	Use of Area × thickness **(1)** Volume = 9.59×10^{-7} m^3 to 3 SF allow any correct unit **(1)** Example of calculation $V = \pi/4 \times (25.9 \times 10^{-3}\ m)^2 \times 1.82 \times 10^{-3}\ m = 9.59 \times 10^{-7}\ m^3$	**(2)**
1(b)(ii)	Calculates %U in thickness **(1)** Calculates %U for diameter **(1)** Doubles their %U for diameter adds their %U for thickness **(1)** Example of calculation (2×(1/259) + (2/182)) × 100% = 0.8% + 1.1% = 1.9%	**(3)**
1(c)	Substitutes correctly **(1)** Density = 7380 kg m^{-3} to 3 SF with unit **(1)** Allow ecf from (b) (i) Example of calculation 7.08×10^{-3} kg / 9.59×10^{-7} m^3 = 7380 kg m^{-3} Allow corresponding answer in a correct unit, e.g. g cm^{-3}	**(2)**
1(d)	Calculates %Difference between their value and 6900 (allow as denominator either of the values or the mean) **(1)** Compares with 2 × %U to reach conclusion (Allow ecf from (b) and (c)) **(1)** **Or** Adds their %U to 6900 and subtracts their %U from 7380 **(1)** Draws a conclusion based on their answer **(1)** Example of calculation %D = (7380 – 6900)/7140 = 6.7% Total %U = 2 × 1.9% = 3.8% < 6.7%, so (probably) not the same material	**(2)**
	Total for Question 1	**(12)**

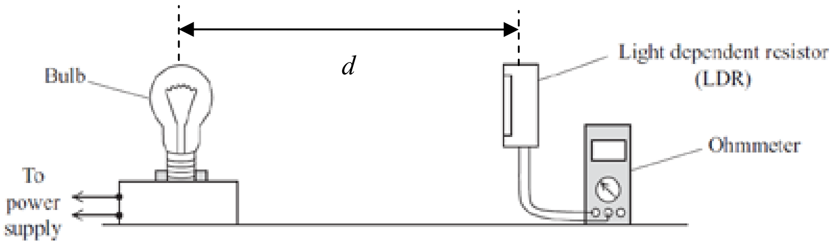
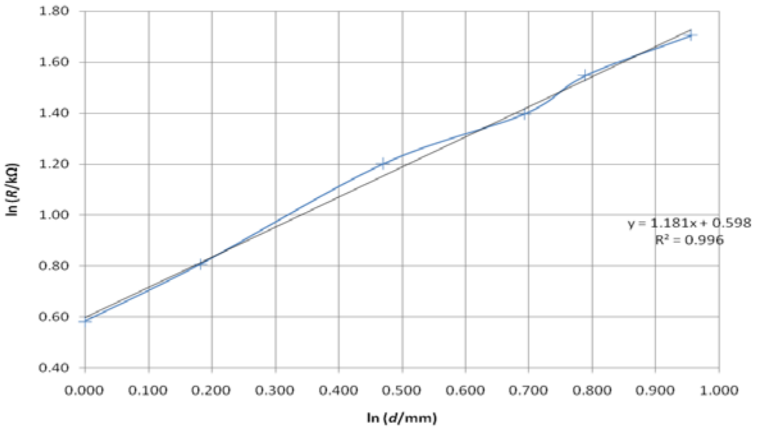
<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>2(a)</td><td>
<table>
<tr><th>Quantity to be measured</th><th>Measuring instrument</th><th>Precision of measuring instrument</th></tr>
<tr><td>Masses, <i>M</i> and <i>m</i></td><td>Balance</td><td>At least 0.1 g</td></tr>
<tr><td>Distance, <i>d</i></td><td>Metre rule</td><td>1 mm</td></tr>
<tr><td>Time, <i>t</i></td><td>Stopwatch</td><td>0.01 s</td></tr>
</table>
Award 1 mark for each correct insertion, distance & time must have units (3)</td><td>(3)</td></tr>
<tr><td>2(b)</td><td><i>d</i> from bottom of mass to floor as shown on diagram (1)

</td><td>(1)</td></tr>
<tr><td>2(c)</td><td>Maximum 2
(Vertical) rule with use of set square (1)

Use of set square at bottom of block
Or Eye level with bottom of block (do not credit just ‘avoid parallax’) (1)

Rule close to block
Or Marker shown (1)

Marks can be awarded from diagram</td><td>(2)</td></tr>
<tr><td>2(d)</td><td>Maximum 1
Start stopwatch when block/trolley released and stop when block hits floor (1)
Or Repeat several times and average (1)</td><td>(1)</td></tr>
<tr><td>2(e)</td><td>Identifies an appropriate risk and suitable precaution
Or explains why risk is insignificant (1)</td><td>(1)</td></tr>
<tr><td></td><td>Total for Question 2</td><td>(8)</td></tr>
</table>

Question Number	Answer	Mark
3(a)	The amplitude of the oscillation increases **(1)**	**(1)**
3(b)(i)	Maximum correctly read to 3 SF from properly drawn curve **(1)** e.g. 1.60 Hz	**(1)**
3(b)(ii)	Take more readings **(1)** At the turning point **Or** Around the resonant frequency **(1)**	**(2)**
3(b)(iii)	More accurate **Or** Reduces random errors **Or** Reduces (percentage) uncertainty **Or** Allows many more readings to be taken in a given time **(1)**	**(1)**
	Total for Question 3	**(5)**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>4(a)</td><td>Distance marked from filament (allow centre of bulb) to front surface of LDR
 </td><td>(1)</td><td>(1)</td></tr>
<tr><td>4(b)</td><td>(As distance increases) light <u>intensity</u> decreases (and resistance increases with decreasing intensity)</td><td>(1)</td><td>(1)</td></tr>
<tr><td>4(c)</td><td>Light from other sources
Any suitable means of controlling outside light such as excluding it (darkened room) or using a tube as a shield on the LDR</td><td>(1)
(1)</td><td>(2)</td></tr>
<tr><td>4(d)</td><td>Shows expansion ln R = pln$d$ + ln$k$
Compares with y = mx + c Or States that the gradient is p</td><td>(1)
(1)</td><td>(2)</td></tr>
<tr><td>4(e)</td><td>
<table>
<tr><th>d/m</th><th>R/kΩ</th><th>ln (d/m)</th><th>ln (R/kΩ)</th></tr>
<tr><td>1.00</td><td>1.79</td><td>0</td><td>0.582</td></tr>
<tr><td>1.20</td><td>2.24</td><td>0.182</td><td>0.806</td></tr>
<tr><td>1.60</td><td>3.32</td><td>0.470</td><td>1.200</td></tr>
<tr><td>2.00</td><td>4.04</td><td>0.693</td><td>1.396</td></tr>
<tr><td>2.20</td><td>4.70</td><td>0.788</td><td>1.548</td></tr>
<tr><td>2.60</td><td>5.50</td><td>0.956</td><td>1.705</td></tr>
</table>

Ln & log values correct and to 3 SF consistently (allow 4SF for the values for ln R greater than one)
Labels & units on table & graph
Scales
Plots
Line of Best Fit</td><td>(1)
(1)
(1)
(1)
(1)</td><td>(5)</td></tr>
<tr><td>4(f)(i)</td><td>Determines gradient with large triangle (at least half of the drawn line)
1.13 < p < 1.23 3 SF and no units</td><td>(1)
(1)</td><td>(2)</td></tr>
<tr><td>4(f)(ii)</td><td>Records intercept 0.56 < c < 0.62
k found from anti-log of their intercept</td><td>(1)
(1)</td><td>(2)</td></tr>
<tr><td></td><td>Total for Question 4</td><td></td><td>(15)</td></tr>
</table>

Total for Paper = 40 Marks

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