AQA A-LEVEL PHYSICS

PHYSICS



EXAM QUESTION PACK

UNIT 2 OLD SPECIFICATION PAPERS

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Centre number | | | | | | Candidate number | | | | |

Surname _____

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AS PHYSICS A

Unit 2 Mechanics, Materials and Waves

Thursday 9 June 2016 Afternoon Time allowed: 1 hour 15 minutes

Materials

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator, where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

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

1 (a) State what is meant by the centre of mass of an object.

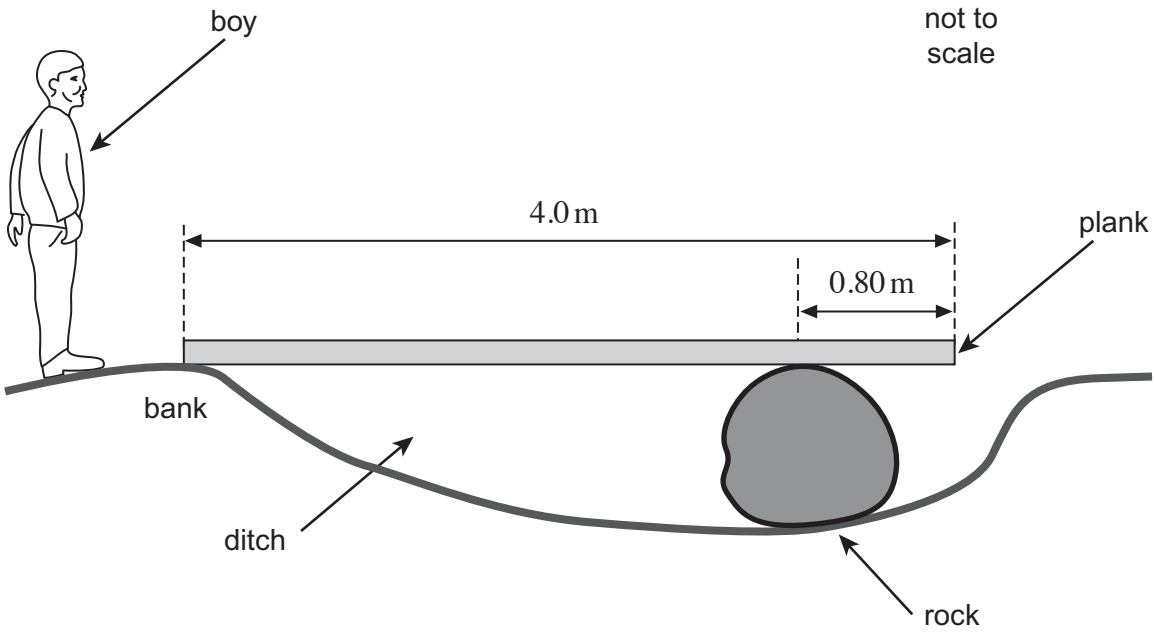
[1 mark]

_____

_____

1 (b) A uniform plank of wood of mass $32\ \text{kg}$ and length $4.0\ \text{m}$ is used by a boy to help him cross a ditch. In the ditch is a rock, which is used to support the plank horizontally $0.80\ \text{m}$ from one end, as shown in **Figure 1**. The other end of the plank is supported by the bank.

Figure 1



Calculate the vertical supporting force from the rock when the plank is placed in position as shown in **Figure 1**.

[2 marks]

supporting force = _____ N

Do not write outside the box

1 (c) The boy has a mass of $46\ \text{kg}$.

Determine whether the boy can walk to the far end of the plank without it tipping.
Support your answer with a calculation.

[3 marks]

6

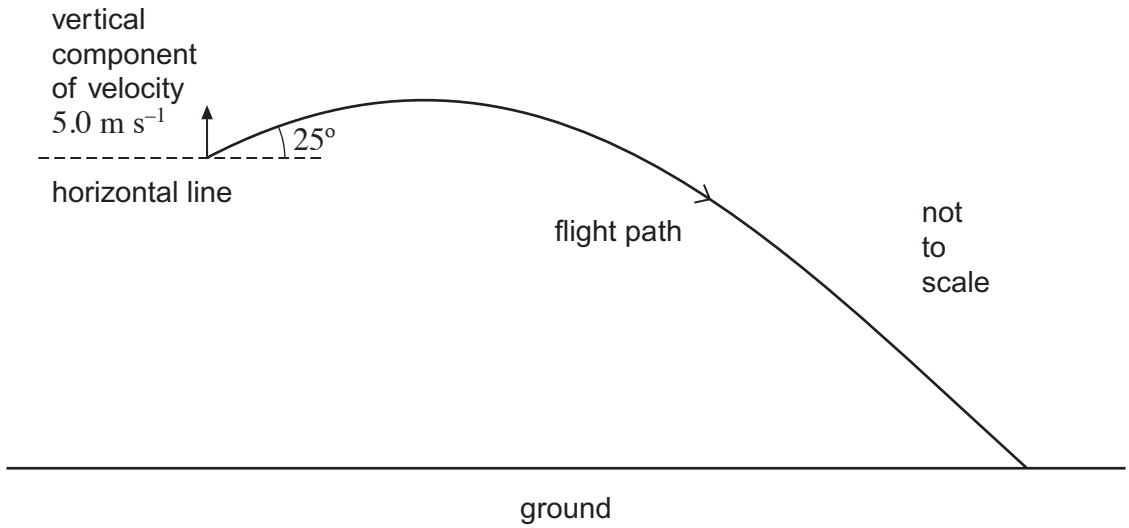
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2 A projectile is launched some distance above the ground at an angle of 25° above the horizontal with a vertical component of velocity of $5.0\ \text{m s}^{-1}$. **Figure 2** shows the flight path of the projectile. The flight takes $1.3\ \text{s}$.

Ignore the effects of air resistance throughout this question.

Figure 2



2 (a) (i) Show that the initial speed of the projectile is about $12\ \text{m s}^{-1}$.

[2 marks]

2 (a) (ii) Calculate the horizontal component of velocity as the projectile hits the ground.

[2 marks]

horizontal component of velocity = _____ m s^{-1}

Do not write outside the box

2 (b) (i) Calculate the maximum height above the starting point reached by the projectile. Give your answer to an appropriate number of significant figures.

[2 marks]

maximum height reached = _____ m

2 (b) (ii) Calculate the total horizontal distance travelled by the projectile from its starting point.

[1 mark]

horizontal distance = _____ m

2 (c) (i) Mark with an **A** on the flight path in **Figure 2** the position where the speed of the projectile is greatest.

[1 mark]

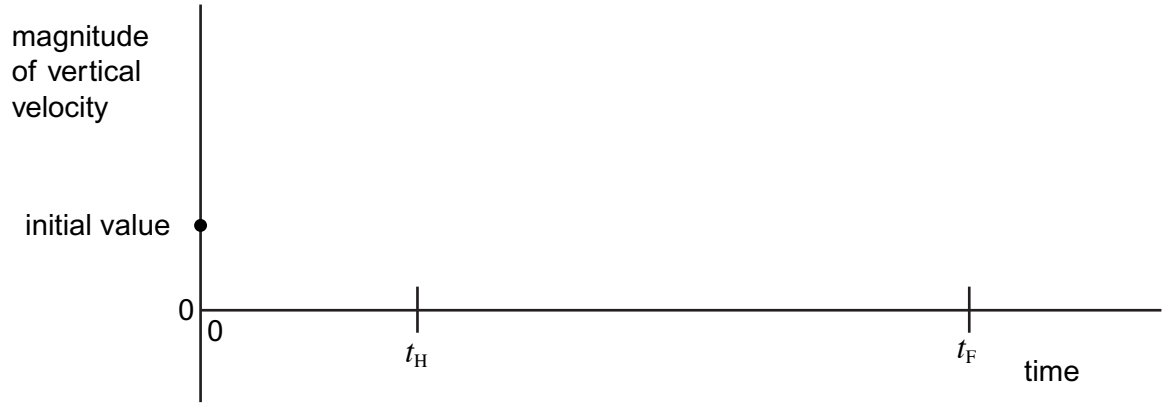
2 (c) (ii) Mark with a **B** on the flight path in **Figure 2** the position where the speed of the projectile is least.

[1 mark]

2 (d) The projectile reaches its maximum height at time t_H and finishes its flight at time t_F. Draw on **Figure 3** a graph to show how the **magnitude** of the vertical component of velocity of the projectile varies with time. Numerical values are **not** required.

[2 marks]

Figure 3



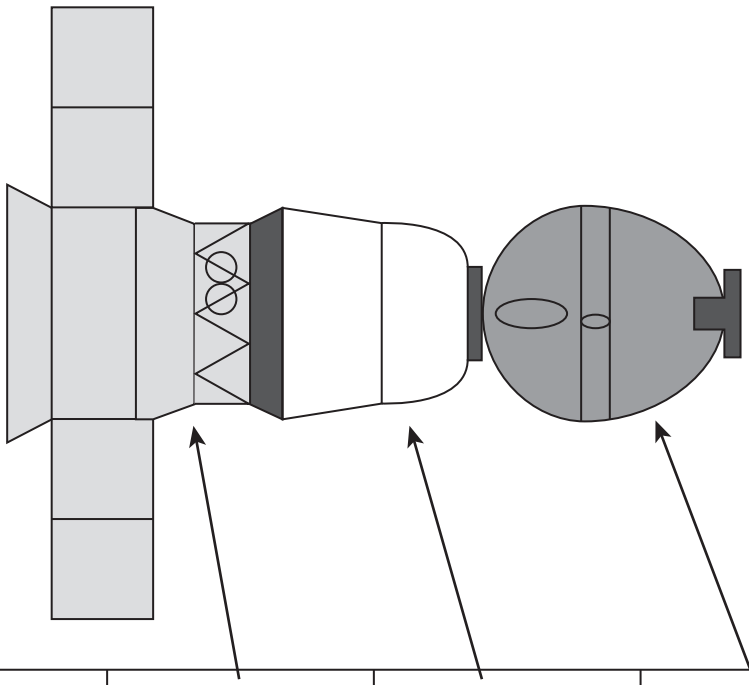
11

Turn over ▶

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3 The Soyuz Spacecraft is used to transport astronauts to and from an orbiting space station. The spacecraft is made up of three sections as shown in **Figure 4**.

Figure 4



Section	Service module	Descent module	Orbital module
Mass / kg	2600	2900	1300

3 (a) On leaving the space station the spacecraft is given an initial horizontal thrust of 1400 N. Calculate the initial acceleration of the spacecraft during the firing of the thruster engines.

[2 marks]

acceleration = _____ m s^{-2}

Do not write outside the box

3 (b) Newton's Third Law refers to pairs of forces.

3 (b) (i) State **one** way in which a pair of forces referred to in Newton's Third Law are the same.

[1 mark]

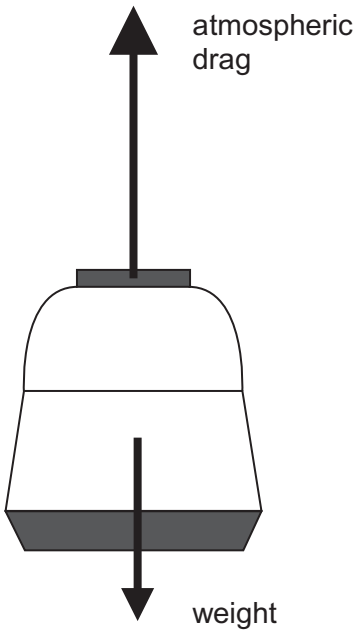
3 (b) (ii) State **one** way in which a pair of forces are different.

[1 mark]

3 (c) When the spacecraft returns to the Earth's atmosphere the orbital module and the service module are separated from the descent module. This descent module has its speed greatly reduced by drag from the atmosphere.

Figure 5 shows two of the forces acting on the descent module as it travels down through the atmosphere.

Figure 5



State **one** reason why the two forces shown in **Figure 5** are **not** a pair of forces as referred to in Newton's Third Law.

[1 mark]

Question 3 continues on the next page

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3 (d) In one particular descent, the descent module has its speed reduced to $5.5\ \text{m s}^{-1}$ by parachutes. The descent module also releases its empty tanks and shield to reduce its mass to $890\ \text{kg}$.

A final speed reduction can be carried out by using engines which operate for a maximum time of $3.5\ \text{s}$. When the engines are in use, the resultant upward force on the descent module is $670\ \text{N}$. The safe landing speed of the descent module is $3.0\ \text{m s}^{-1}$.

Determine whether these engines are able to reduce the speed of the descent module to its safe value.

At these landing speeds atmospheric drag is negligible.

[3 marks]

8

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

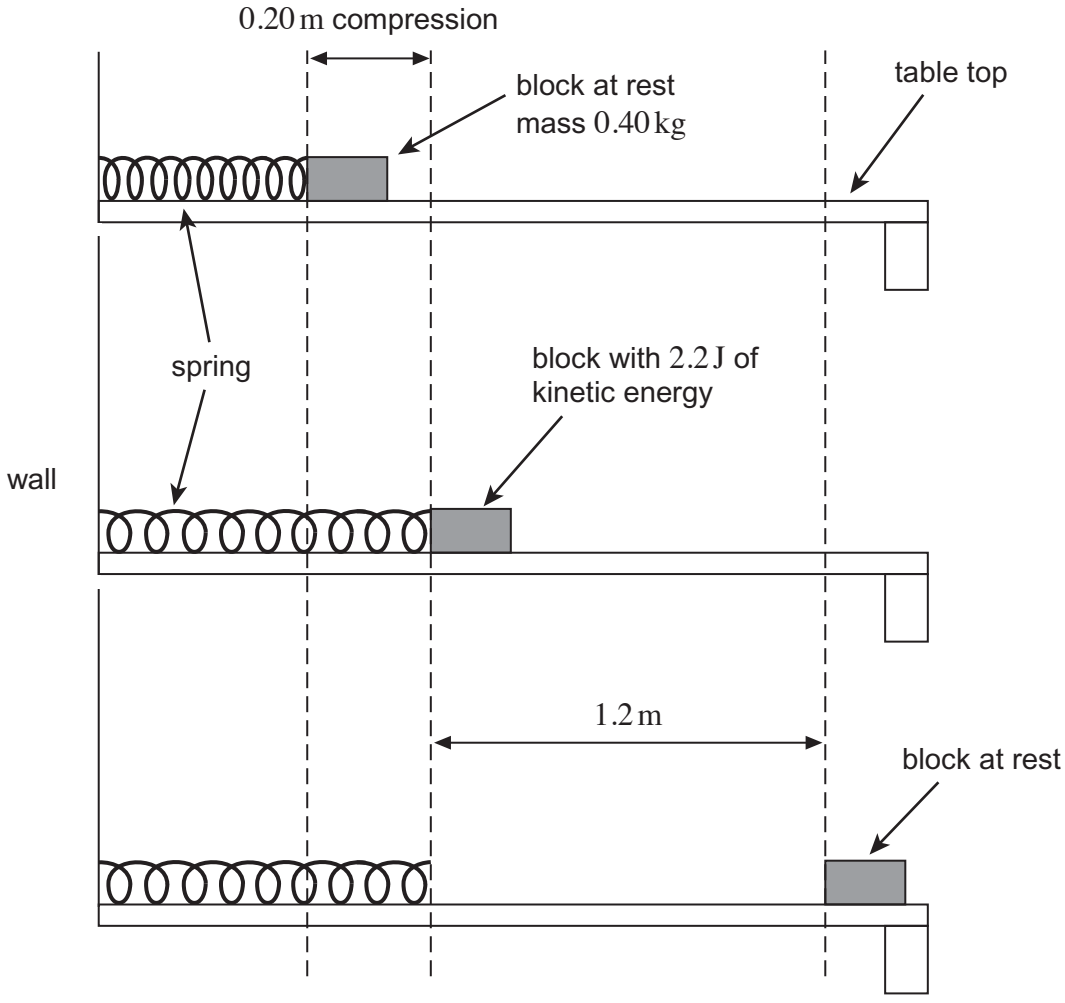
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4 (a) State the law of conservation of energy.

[2 marks]

4 (b) **Figure 6** shows a block on a horizontal table top initially held against a spring so that the spring is compressed. The other end of the spring is fixed to a wall. When released the block is pushed away by the spring. When the spring reaches its natural length the block leaves the spring and then slides along the table top. A constant frictional force acting between the moving block and the table top eventually brings the block to rest.

Figure 6



Do not write outside the box

4 (b) (i) When the block leaves the spring, the block has a kinetic energy of 2.2 J. The mass of the block is 0.40 kg.
Calculate the maximum velocity of the block.

[1 mark]

maximum velocity = _____ m s^{-1}

4 (b) (ii) The block travels 1.2 m after leaving the spring before coming to rest.
Show that the frictional force between the block and the table top is about 1.8 N.

[1 mark]

4 (b) (iii) The spring was initially compressed through 0.20 m. The constant frictional force acts on the block whenever it is moving.
Calculate the elastic potential energy in the spring when in its initial compressed position.
Assume the spring has negligible mass.
State an appropriate unit for your answer.

[3 marks]

elastic potential energy = _____ unit = _____

4 (b) (iv) The force exerted on the block by the spring is proportional to the compression of the spring.
Calculate the maximum force exerted on the block by the spring.

[1 mark]

maximum force = _____ N

8

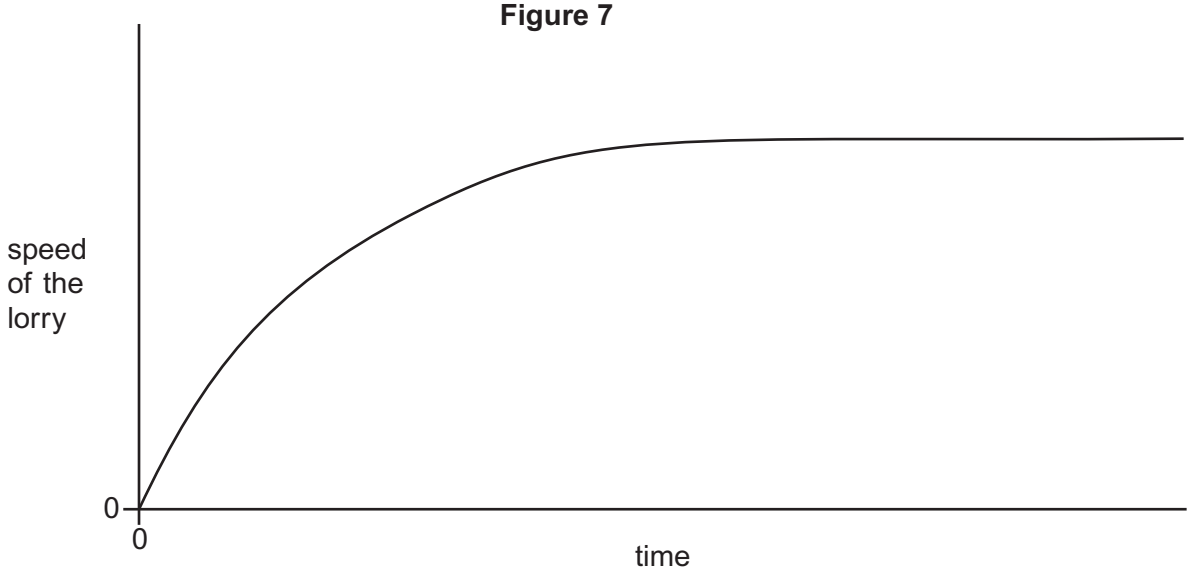
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5 A fully-loaded lorry transporting water starts from rest and travels along a straight road. **Figure 7** is a graph showing how the speed of the lorry varies with time. The driving force on the lorry remains constant.

The total resistive force acting on the lorry increases with both speed and mass of the lorry. A large proportion of the mass of the lorry is due to the water which it is carrying.

Figure 7



A similar lorry, also loaded with water, has the same initial mass. However, at the instant it begins to move, a large leak develops and all the water leaks out during the time covered by the graph.

Discuss how the speed–time graph will be different from that shown in **Figure 7**.

Your answer should include an explanation of:

- the shape of the graph in **Figure 7**
- the effect of water loss on the initial gradient of the graph
- the effect of water loss on the final speed of the lorry.

You may draw on **Figure 7** to help you with your answer.

The quality of your written communication will be assessed in your answer.

[6 marks]

Do not write outside the box

6

Do not write outside the box

6 (a) Explain what is meant by a progressive wave.

[2 marks]

6 (b) **Figure 8** shows the variation with time of the displacement of one point in a progressive wave.

Figure 8

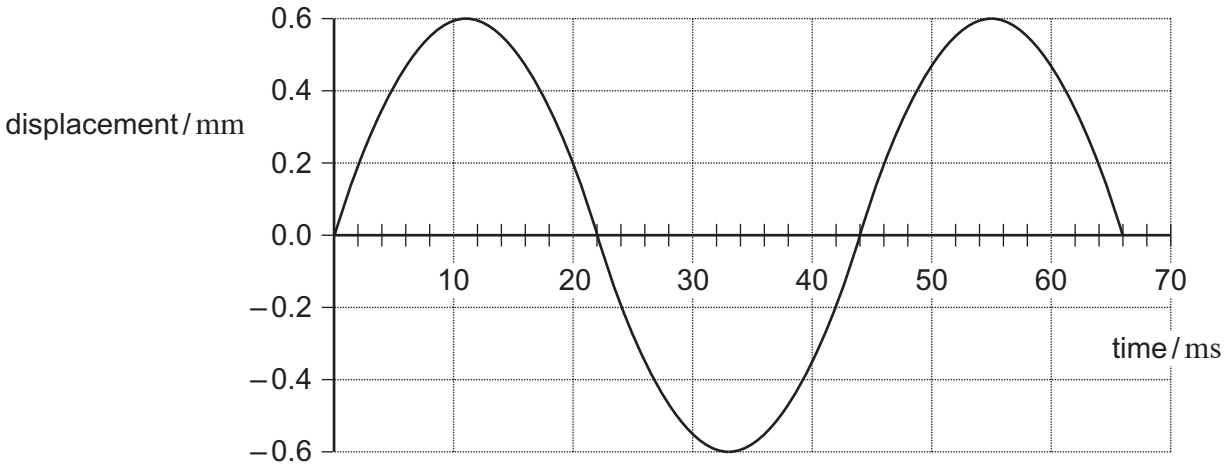
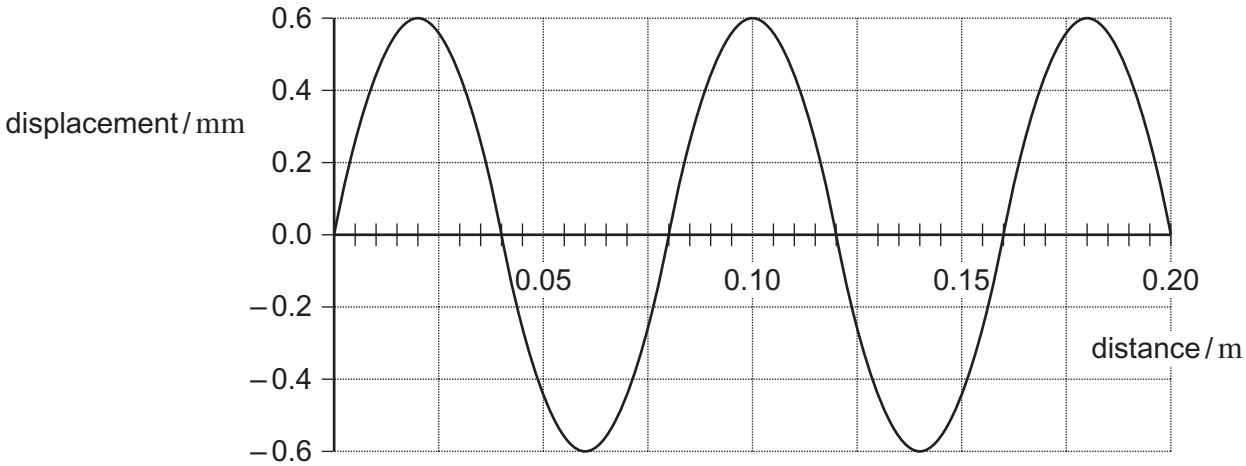


Figure 9 shows the variation of displacement of the same wave with distance.

Figure 9



Do not write outside the box

Use **Figures 8 and 9** to determine

6 (b) (i) the amplitude of the wave

[1 mark]

amplitude = _____ mm

6 (b) (ii) the wavelength of the wave

[1 mark]

wavelength = _____ m

6 (b) (iii) the frequency of the wave

[1 mark]

frequency = _____ Hz

6 (b) (iv) the speed of the wave.

[1 mark]

speed = _____ m s^{-1}

Question 6 continues on the next page

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6 (c) Which of the following statements apply?
Place a tick (✓) in the right-hand column for each correct statement.

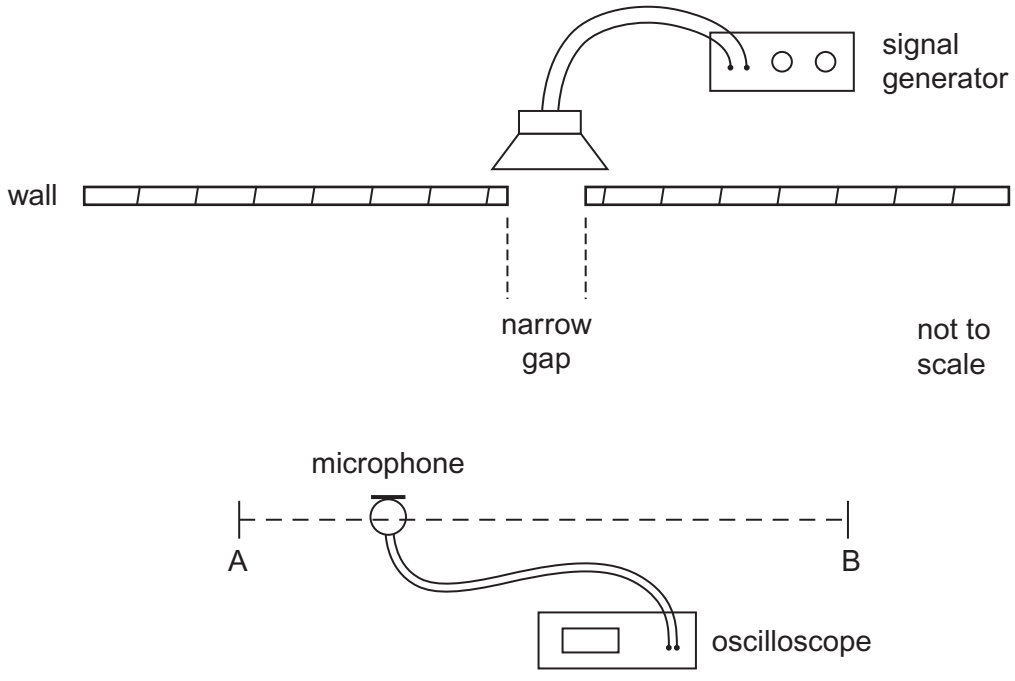
[1 mark]

	✓ if correct
sound waves are transverse	
sound waves are longitudinal	
sound waves can interfere	
sound waves can be polarised	

6 (d) In an investigation, a single loudspeaker is positioned behind a wall with a narrow gap as shown in **Figure 10**.

A microphone attached to an oscilloscope enables changes in the amplitude of the sound to be determined for different positions of the microphone.

Figure 10

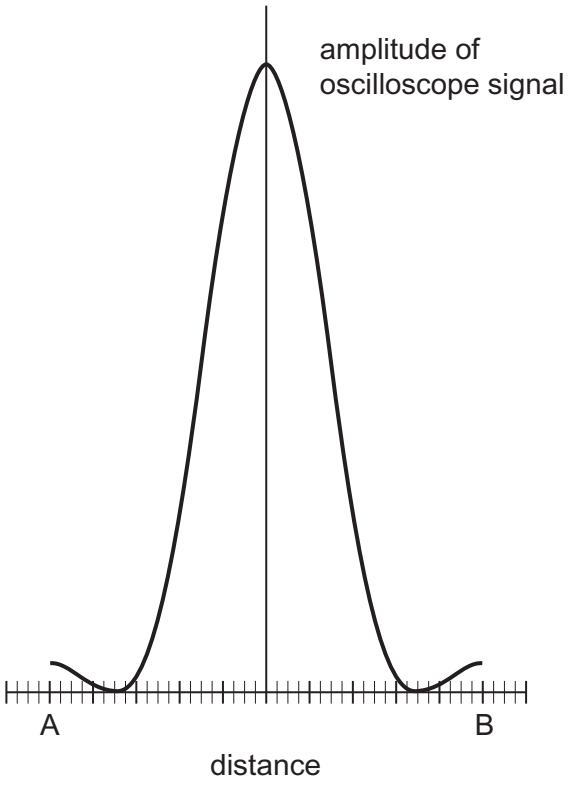


The amplitude of sound is recorded as the microphone position is moved along the line AB a large distance from the gap.

Do not write outside the box

The result of the measurements is shown in **Figure 11**.

Figure 11



The signal generator is adjusted so that sound waves of the same amplitude but of a higher frequency are emitted by the loudspeaker. The investigation using the apparatus shown in **Figure 10** is then repeated.
Explain the effect this has on **Figure 11**.

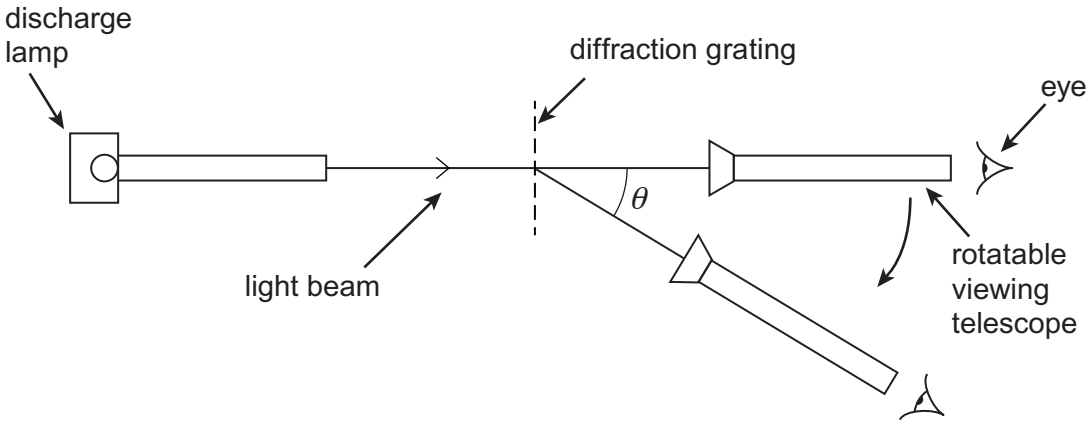
[3 marks]

10

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7 A discharge lamp emits light of four colours: red, green, blue and violet. **Figure 12** shows light from the lamp incident normally on a diffraction grating with slit separations of 1.8×10^{-6} m. The light is viewed through a telescope which can be rotated as shown.

Figure 12



As the telescope is rotated from the straight-through position, each of the four colours is observed as a bright line at its corresponding first-order diffraction angle.

7 (a) Which colour would be observed first as the telescope is rotated from the straight-through position?
Place a tick (✓) in the right-hand column to show the correct answer.

[1 mark]

	✓ if correct
red	
green	
blue	
violet	

7 (b) Explain how a bright line is formed by the diffraction grating at the first-order diffraction angle.

[3 marks]

Do not write outside the box

7 (c) (i) The wavelength of the green light is 5.3×10^{-7} m.
Calculate the first-order diffraction angle for this colour.

[2 marks]

angle = _____ degree

7 (c) (ii) As the telescope is rotated further, higher-order diffraction maxima are observed.
Calculate the highest order observed for the green light.

[3 marks]

highest order = _____

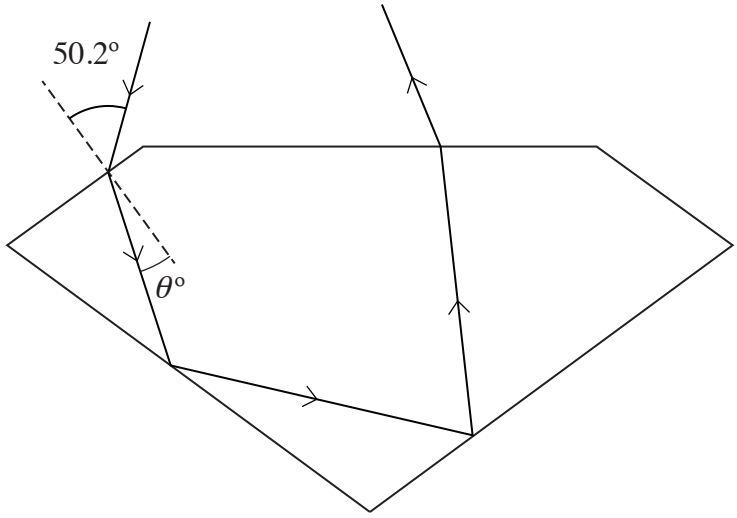
9

Turn over for the next question

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8 Diamond jewels sparkle because light that enters the diamond at different incident angles is reflected back to an observer. **Figure 13** shows the path of one of these incident rays through a diamond.

Figure 13



8 (a) (i) Calculate the critical angle for diamond.

[2 marks]

Refractive index of diamond = 2.42

critical angle = _____ degree

8 (a) (ii) The ray shown in **Figure 13** enters at an angle of incidence of 50.2°. Calculate the angle of refraction θ.

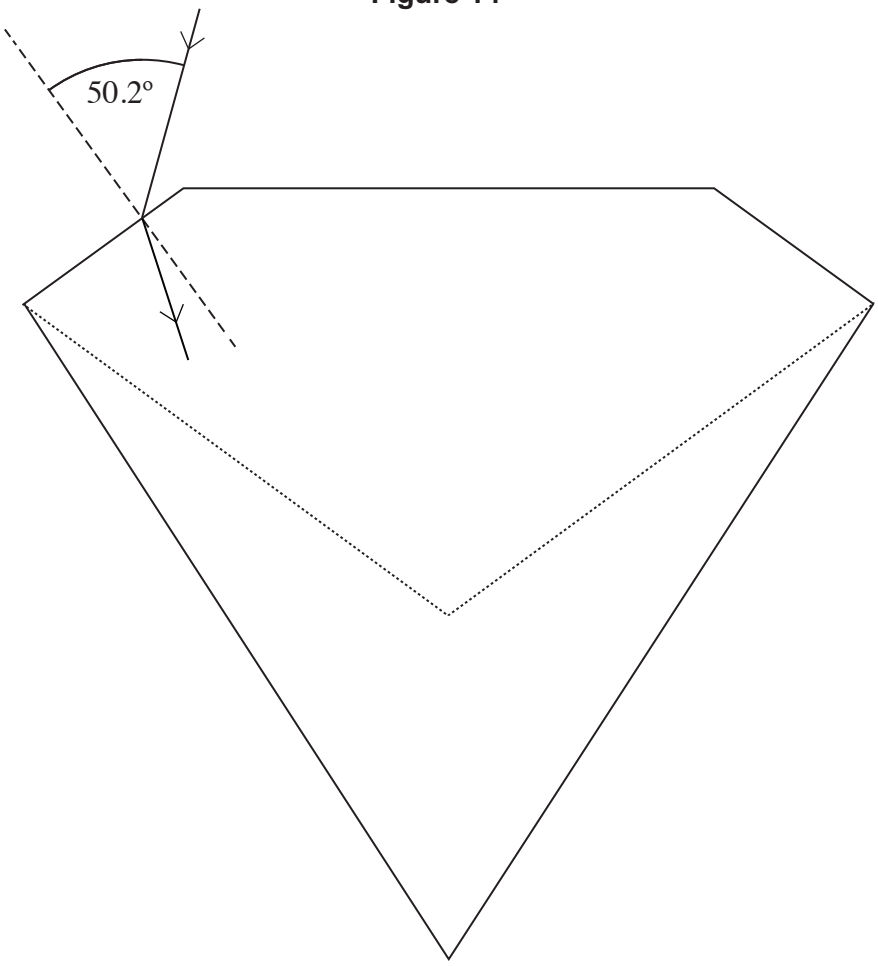
[2 marks]

θ = _____ degree

Do not write outside the box

8 (a) (iii) The angles of a diamond are chosen to maximise the amount of light reflected.
Figure 14 shows a diamond with different angles to that of a normally shaped diamond.
The dotted lines show the normal shape of a diamond.

Figure 14



Draw on **Figure 14** the path of the ray until it leaves the diamond.

[2 marks]

Question 8 continues on the next page

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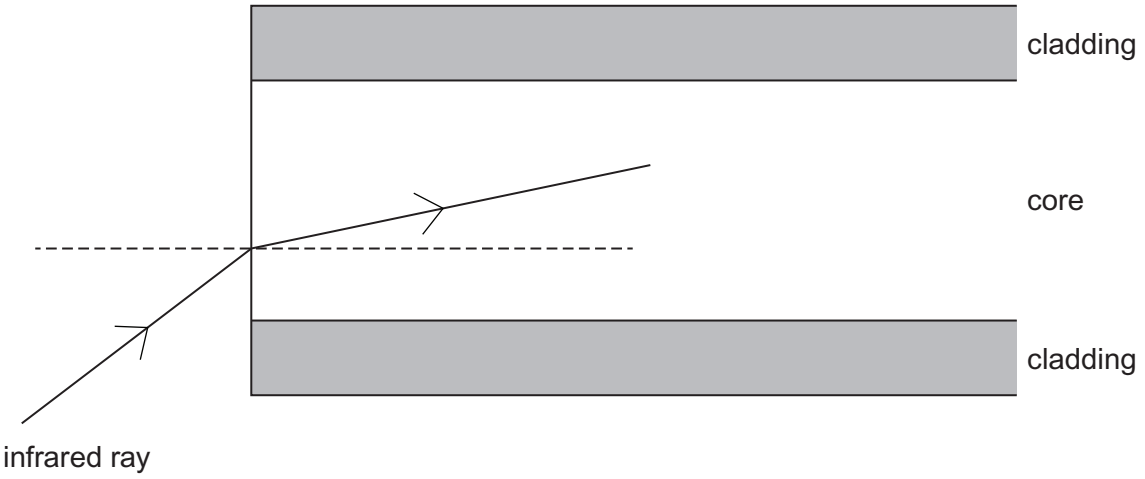
8 (a) (iv) Moissanite is a transparent material with a refractive index of 2.67.

Discuss whether this material, if made to the diamond shape shown in **Figure 13**, would reflect light back more or less than diamond.

[2 marks]

8 (b) **Figure 15** shows an infrared ray entering an optical fibre. The refractive index of the core is 1.55 at infrared frequencies.

Figure 15



8 (b) (i) Calculate the speed at which infrared radiation travels in the core.

[1 mark]

speed = _____ m s^{-1}

Do not write outside the box

8 (b) (ii) The wavelength of this infrared radiation is 1300 nm in air.
Calculate the wavelength of infrared in the core.

[2 marks]

wavelength = _____ m

8 (b) (iii) State **one** reason for surrounding the core with cladding.

[1 mark]

_____

_____

12

END OF QUESTIONS

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AS
Physics

PHYA2 – Mechanics, Materials and Waves
Mark scheme

2450
June 2016

Version: 1.0 Final

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Question	Answers	Additional Comments/Guidance	Mark	ID details
1(a)	a (resultant) force directed through the centre of mass of an object will not give it a moment/will not cause the object to rotate owtte or all the mass of the object appears to be concentrated at the centre of mass owtte or point at which all the (object's) weight acts ✓ owtte	We are not distinguishing between c of g and c of m. So allow point at which all the mass acts. If a balance idea is given the situation described must be achievable. Don't allow answers like: Where mass is most concentrated It has the same mass on both sides All forces act through this point	1	
1(b)	(moment of plank from the bank = $mg \times d$) = $32 \times 9.81 \times 2.0$ or $32 \times g \times 2.0$ ✓ this moment is balanced by $F \times 3.2$ giving F = 200 (N) ✓ (196 N)	Award 2 marks if 196 (N) is seen but 200 (N) only gains 1 mark with the second mark available if working is shown 9.8 m s^2 is ok for g.	2	
1(c)	(At the point of tipping) there is no (reaction) force from the bank ✓ (This point must be in words not implied from a calculation) Taking moments about the rock LHS = $1.2 \times 32 \times g = 38.4 \times g = 380$ (Nm) ✓ (377 N m) RHS = $0.80 \times 46 \times g = 36.8 \times g = 360$ (Nm) ✓ (361 N m) Or show a moment calculation that gives the maximum boy's weight that can be supported (471 N) Or show a moment calculation that gives the maximum distance the boy can be from the rock without tipping (0.83 m) Score any two of the above marks (Therefore) plank will not tilt ✓ (to score this mark the answer must be justified)	NB the first 3 marking points score a maximum of 2 marks. The last mark makes up the total to 3 marks Note it is the RHS mark that has the alternative approaches Condone missing 'g' provided it is cancelled/missed out in both moment calulations. The last mark can come from an ecf as long as the reason is clearly stated in terms of the answers given earlier.	3	

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Total			6

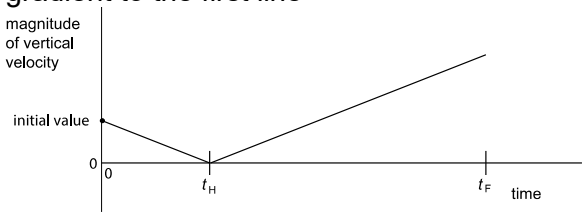
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Question	Answers	Additional Comments/Guidance	Mark	ID details
2(a)(i)	(using sin 25° = V_V/V $V = V_V$ / sin 25°) = 5.0 / sin 25° ✓ 11.8 (m s^{-1}) ✓ (working and answer is required)	Look out for cos 65° = sin 25° in first mark. Also calculating the horizontal component using cos 25° followed by Pythagoras is a valid approach. Working backwards is not acceptable.	2	
2(a)(ii)	(using tan 25° = V_V / V_H) $V_H = V_V$ / tan 25° ✓ = 5 / tan 25° = 11 (m s^{-1}) ✓ (10.7 m s^{-1}) Or (using cos 25° = V_H / V) V_H = V cos 25° ✓ = 11.8 cos 25° = 11 (m s^{-1}) ✓ (10.7 m s^{-1}) Or (using $V_H^2 + V_V^2 = V^2$) $V_H^2 + 5^2 = 11.8^2$ ✓ (0r 12^2) V_H = 11 (m s^{-1}) ✓ (10.7 m s^{-1})	Note 1/cos 65° = sin 25° and tan 25° = 1/ tan 65° Rounding means answers between 10.7 and 11 m s^{-1} are acceptable.	2	
2(b)(i)	(using $v^2 = u^2 + 2as$ with up being positive $0 = 5.0^2 + 2 \times -9.81 \times s$) s = 1.3 (m) ✓ (1.27→1.28 m) or (loss of KE = gain of PE ½ ~~m~~ v^2 = ~~m~~ g h ½ 5.0^2 = 9.81 x h) h = 1.3 (m) ✓ (1.27→1.28 m) quoted to 2 sig figs ✓	for the sig fig mark the answer line takes priority. If a choice of sig figs given and not in answer line – no sig fig mark Sig fig mark stands alone provided some working is shown	2	
2(b)(ii)	(using $s = (u + v)t/2$) or horizontal distance = speed × time) s = 11 × 1.3 = 14 (m) ✓ (using 10.7 gives the same answer)	allow CE s = (aii) × 1.3 but working must be seen	1	
2(c)(i)	**A** marked at the point of landing or immediately before ✓	The **A** or its marked position must not be further to the left than the 'c' in the word 'scale'.	1	

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2(c)(ii)	**B** marked at the maximum height of the path ✓	The B must lie vertically between the 'r' and 'a' in the word 'resistance above figure 2.	1	

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2(d)	straight line from point given down to point t_H on the axis ✓ straight line starting where first line stops (t_H) but with opposite gradient to the first line ✓  	(A measure of accuracy for the second mark) The second line must end (t_F) between the height of the vertical axis and half this height. Obviously straight lines drawn by hand are acceptable.	2	
Total			11	

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Question	Answers	Additional Comments/Guidance	Mark	ID details
3(a)	(using $F = ma$) a (= F/m) = 1400 / (any mass/masses taken from the table) ✓(any arrangement gains mark) = (1400/(2600 + 2900 + 1300) = 0.206 m s^{-2}) = 0.21 (m s^{-2}) ✓	Allow any single or combination of masses from the table for first mark. 0.21 m s^{-2} on its own gains 2 marks but 0.2 m s^{-2} on its own gains 1 mark 1 sig fig is not acceptable	2	
3(b)(i)	they have the same line of action they have the same magnitude (not size) the forces are of the same kind ✓ any one statement	The statement must be of a general nature. The statement 'equal magnitude + opposite direction does not make the similarity clear and so gains zero marks. If forces act against each other or cancel or act on the same body this mark is lost.	1	
3(b)(ii)	they are in opposite directions they act on different bodies ✓ any one statement	The statement must be of a general nature. If forces act against each other or cancel or act on the same body this mark is lost.	1	
3(c)	they do not have the same magnitude/size the forces are of different types they do not act on different bodies drag is greater than the weight there is a resultant force (as deceleration occurs) ✓ any one statement	Statements can be written negatively	1	
3(d)	actual deceleration (= F/m) = 670 / 890 = 0.75 (m s^{-2}) ✓ (0.753 m s^{-2}) minimum required deceleration = $\Delta v / \Delta t$ = (5.5 – 3.0) / 3.5 = 0.71 (m s^{-2}) ✓ (0.714 m s^{-2}) therefore (compared to 0.75 m s^{-2}) there is sufficient deceleration, yes ✓ Or actual deceleration	ignore any interchange between acceleration and deceleration	3	

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	(= F/m) = 670 / 890 = 0.75 (m s^{-2}) ✓ (0.753 m s^{-2}) maximum required time = $\Delta t = \Delta v/a$ = (5.5 – 3.0) / 0.753 = 3.3 s (3.32 s) ✓ therefore (compared to 3.5 s) there is sufficient time, yes ✓ Or actual deceleration (= F/m) = 670 / 890 = 0.75 (m s^{-2}) ✓ (0.753 m s^{-2}) (using v = u + at) v = 5.5 – 0.753 x 3.5 = 2.8 (m s^{-1}) ✓ which is a safe landing speed ✓ Or (using $Ft = \Delta mv$) 670 × 3.5 = 890 × Δv ✓ Δv =2.7 landing speed = 5.5 – 2.7 = 2.8 (m s^{-1}) ✓ which is a safe landing speed ✓	3rd mark is dependent on having a valid attempt at the calculation. 3rd mark can be given for wrong answer if it follows from an arithmetic error.		
Total			8	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4(a)	energy cannot be created or destroyed ✓ it can only be transferred/changed/converted from one form to another ✓	'Transformed' can be taken to mean transferred from one form to another.	2	
4(b)(i)	(using $E_k = ½ mv^2$) 2.2 = ½ × 0.40 × v^2 v = 3.3 (ms^{-1}) ✓	Ignore errors in 3 sig fig. Answer only can gain mark.	1	
4(b)(ii)	(using work done = $F \times s$) 2.2 = F × 1.2 ✓ (F = 1.83 N) or (using $a = (v^2 – u^2) / 2 s$) a = ($0^2 – 3.32^2$) /2 x 1.2 = (-) 4.59 (m s^{-1})	A substitution of numbers are necessary for the mark	1	

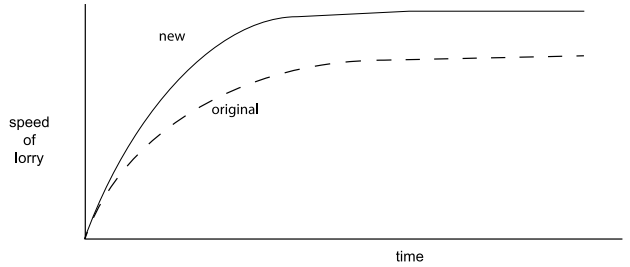
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	(F = ma) = 0.4 x 4.59 ✓ = (1.84 N)			
4(b)(iii)	(work done in moving 0.2 m) =1.8 × 0.2 (J) ✓ (= 0.36 J) (allow ecf (bii) × 0.2) total work done = 2.2 + 0.36 = 2.6 ✓ (same answer is achieved if F = 2N) J or joule ✓		3	
4(b)(iv)	(use of energy = ½ F x) 2.6 = ½ F_{max} 0.2 F_{max} = 26 N ✓ (allow ecf 10 × (biii))	Allow mark for answer only even for ecf.	1	
Total			8	

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Question	Answers	Additional Comments/Guidance	Mark	ID details
5	The mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC).			
	Descriptor (references to parts 1 to 9 are given in the final row of the table)	A part is only credited if the writing makes the physics content unambiguous.	**Mark**	
	High Level – Good to Excellent The relationship between the acceleration and the gradient of the graph or how it changes should be given including the reason why the initial acceleration would remain the same. Also a reference to terminal velocity should be made and an explanation of why the terminal speed is greater. *The information presented as a whole should be well organised using appropriate specialist vocabulary. There should only be one or two spelling or grammatical errors for this mark.*	6 marks = 6 points given from the descriptor list but at least one must come from each Group. 5 marks = 5 points given from the descriptor list but at least one must come from each Group.	5 - 6	
	Intermediate Level – Modest to Adequate The relationship between the acceleration and the gradient of the graph or how it changes should be given. Also something should be said about the initial acceleration being the same and/or the terminal velocity being larger. With this restriction marks can come from any marking point that is clearly given. *The grammar and spelling may have a few shortcomings but the ideas must be clear.*	4 marks = 4 points from the descriptor list but at least one must come from two Groups. 3 marks = 3 points from the descriptor list but at least one must come from two Groups.	3 - 4	
	Low Level – Poor to Limited Any two valid statements that cover any of the parts given below. *There may be many grammatical and spelling errors and the information may be poorly organised.*	2 marks = any 2 points from the descriptor list with no restriction on which Group they come from 1 mark = any point from the descriptor list	1 - 2	
	The description expected in a competent answer should include: **First Group:**			

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	1. the acceleration is the gradient of the graph (or the link between acceleration and gradient is clearly made) 2. the acceleration is greatest initially/(continuously) decreases 3. a constant final velocity/terminal velocity is shown by the graph becoming <u>horizontal/flat</u>. **Second Group:** 4. initial acceleration or the initial gradient is the same or only <u>slightly</u> greater (as initially the mass is the same) 5. $a = F/m$ (in words or symbols) **Third Group:** 6. at the end/eventually/at terminal velocity <u>resistance force = drive force</u> 7. resistance force is now less at the same speed (because mass is less) 8. speed will be higher or graph has higher line (this may come from the Figure 7) 9. in the middle of the graph the acceleration will be greater.			
Total			6	

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<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr><td>6(a)</td><td>A wave transfers energy <u>from one point to another</u> ✓
without transferring material/(causing permanent displacement of the medium) ✓ owtte</td><td></td><td>2</td><td></td></tr>
<tr><td>6(b)(i)</td><td>0.6 (mm) or 0.60 (mm) ✓</td><td></td><td>1</td><td></td></tr>
<tr><td>6(b)(ii)</td><td>0.080 (m) ✓</td><td>Allow 1 sig fig</td><td>1</td><td></td></tr>
<tr><td>6(b)(iii)</td><td>$f = 1/T = 1/0.044 = 23$ (Hz) ✓ (22.7 Hz)</td><td></td><td>1</td><td></td></tr>
<tr><td>6(b)(iv)</td><td>$v = f\lambda = 22.7 \times 0.080 = 1.8$ (m s^{-1}) ✓ (1.82 m s^{-1})</td><td>allow CE v = (biii) × (bii) but working must be shown
1 sig fig not acceptable</td><td>1</td><td></td></tr>
<tr><td>6(c)</td><td><table><tr><th>s und waves are transverse</th><th>sound waves are longitudinal</th><th>sound waves can interfere</th><th>sound waves can be polarised</th></tr><tr><td></td><td>√</td><td>√</td><td></td></tr></table></td><td></td><td>1</td><td></td></tr>
<tr><td>6(d)</td><td>the wavelength would be smaller
smaller spread in main peak or more peaks (between A and B)
the central peak is higher (owtte)
as the energy is concentrated over a smaller area (owtte)
reference to (sin $\theta_{min} = \lambda/d$)
✓✓✓ any 3 lines max 3</td><td>Note that the marks here are for use of knowledge rather than performing calculations.

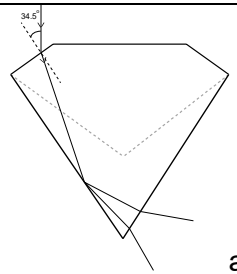
No bod if writing does not make <u>in</u>crease or <u>de</u>crease clearly distinct.

Marking should be lenient.</td><td>3</td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td>10</td><td></td></tr>
</table>

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Question	Answers	Additional Comments/Guidance	Mark	ID details
7(a)	Answer D ✓ (violet)		1	
7(b)	(light from each slit) <u>superpose</u> light from adjacent slits have a path difference of <u>one</u> wavelength (at this angle all) the waves are in phase constructive interference/peaks coincide/(positively)reinforce any 3 points ✓✓✓ max 3	Ignore reference to nodes or antinodes If general statements are made only give marks for parts related to 'Bright line' or 'First order' which appears in the question.	3	
7(c)(i)	use of $\sin\theta = \lambda/d = 5.3 \times 10^{-7} / 1.8 \times 10^{-6}$ ✓ (= 0.294) $\theta = 17^{o}$ ✓ (17.1^{o})	Answer alone scores both marks	2	
7(c)(ii)	(use of $n = d \sin\theta/\lambda$) $n_{max} = (d \sin 90^{o}/\lambda) = d/\lambda$ = ✓ $= 1.8 \times 10^{-6} / 5.3 \times 10^{-7} = 3.4$ ✓ max order = 3 ✓	Showing that n=4 is not possible is not answering the question but the first mark (equation mark) can be gained this way Max order is an independent mark from reducing a calculated value for n to the next lowest integer.	3	
Total			9	

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Question	Answers	Additional Comments/Guidance	Mark	ID details
8(a)(i)	sin$C$ = 1/n = 1/2.42 ✓ (= 0.413) C = 24.4° ✓ (allow 2 or more sig figs)	Answer only gains both marks	2	
8(a)(ii)	sinθ_{dia} = sinθ_{air} / n = sin 50.2 / 2.42 ✓ (= 0.317) θ_{dia} = 18.5° ✓ (allow 2 or more sig figs)	Answer only gains both marks Answer can be 18° or 19 ° depending on rounding	2	
8(a)(iii)	TIR shown at bottom left surface ✓ (If the reflected ray were extended it would pass through the writing below the diagram between the 'i' in 'it' and the full stop at the end of 'diamond'.) ray leaves bottom right surface either with an increased emergent angle or straight though if hitting normally ✓ (The second mark is consequential on gaining the first mark)	 acceptable emergent rays	2	
8(a)(iv)	it has smaller critical angle / critical angle is 22° allowing more/same number/greater chance/increased probability of TIR's occurring greater/same sparkle ✓✓ max 2	'reflect more' is insufficient for a mark	2	
8(b)(i)	c_{core} = c_{air} / n = 3.00 × 10^8 / 1.55 = 1.9 × 10^8 (ms^{-1}) ✓ (1.94 × 10^8 ms^{-1})	1 sig fig is not acceptable if no other answer is given	1	
8(b)(ii)	(n = c_{air} / c_{core} = $f\lambda_{air}$ / $f\lambda_{core}$ = λ_{air} / λ_{core}) λ_{core} = λ_{air} / n or 1300 × (10^{-9}) / 1.55 ✓ = 8.4 × 10^{-7} (m) ✓ (8.39 × 10^{-7} m or 839 nm)	The first mark is for the equation or substitution ignoring powers of 10 errors 1st mark can be gained from calculating the frequency (f = 3.0 x 10^8 / 1300 x 10^{-9} = 2.3 x 10^{14} (Hz) which then can be used to find the the wavelength Using this method the answer can range between 8.4 × 10^{-7} → 8.7 × 10^{-7} (m) and	2	

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		consider ecf's from 8(b)(i)		
8(b)(iii)	protects the core (from scratches etc) prevents crosstalk/stops signal crossing from one fibre to another/increases critical angle/reduces pulse broadening/reduces smearing/prevents multipath dispersion allows fibre to be supported/touched (without losing light) ✓ any one point	Preventing signal loss is not enough for the mark.	1	
Total			12	

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2015

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Thursday 4 June 2015 1.30 pm to 2.45 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator, where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

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Do not write outside the box

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

1 (a) Indicate with ticks (✓) in **Table 1** which of the quantities are vectors and which are scalars.

[2 marks]

Table 1

	Velocity	Speed	Distance	Displacement
vector				
scalar				

1 (b) A tennis ball is thrown vertically downwards and bounces on the ground. The ball leaves the hand with an initial speed of $1.5\ \text{m s}^{-1}$ at a height of $0.65\ \text{m}$ above the ground. The ball rebounds and is caught when travelling upwards with a speed of $1.0\ \text{m s}^{-1}$.

Assume that air resistance is negligible.

1 (b) (i) Show that the speed of the ball is about $4\ \text{m s}^{-1}$ just before it strikes the ground.

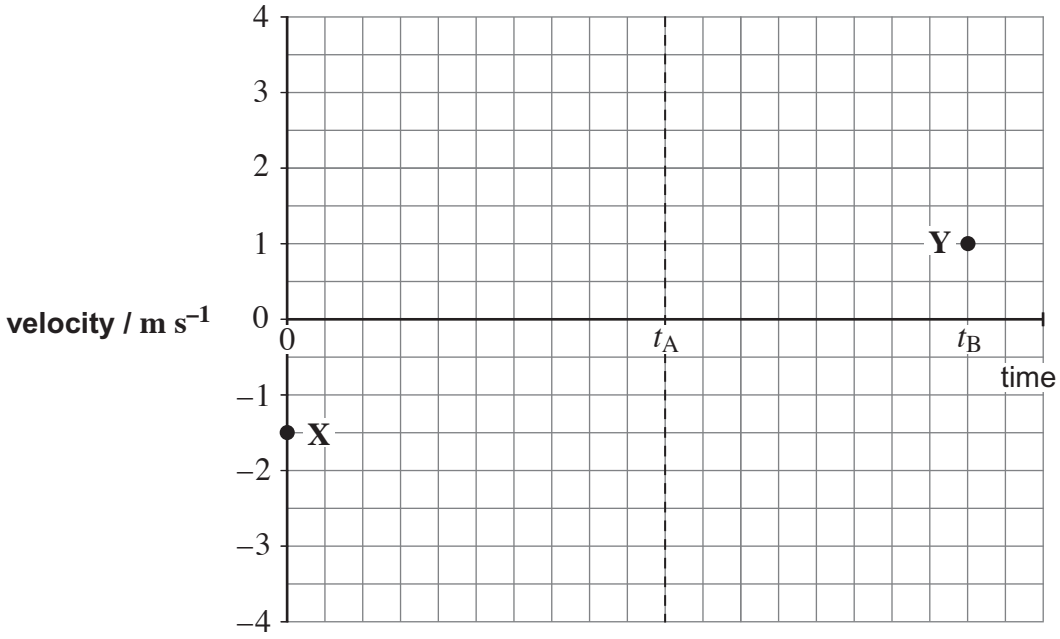
[3 marks]

Do not write outside the box

1 (b) (ii) The ball is released at time $t = 0$. It hits the ground at time t_A and is caught at time t_B. On **Figure 1**, sketch a velocity–time graph for the vertical motion of the tennis ball from when it leaves the hand to when it returns. The initial velocity **X** and final velocity **Y** are marked on **Figure 1**.

[3 marks]

Figure 1



1 (c) In a game of tennis, a ball is hit horizontally at a height of 1.2 m and travels a horizontal distance of 5.0 m before reaching the ground. The ball is at rest when hit.

Calculate the initial horizontal velocity given to the ball when it was hit.

[3 marks]

horizontal velocity = ... m s^{-1}

11

Turn over ▶

Do not write outside the box

2 (a) Define the moment of a force about a point.

[2 marks]

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2 (b) **Figure 2** shows a gripper which is used for hand strengthening exercises.

Figure 2

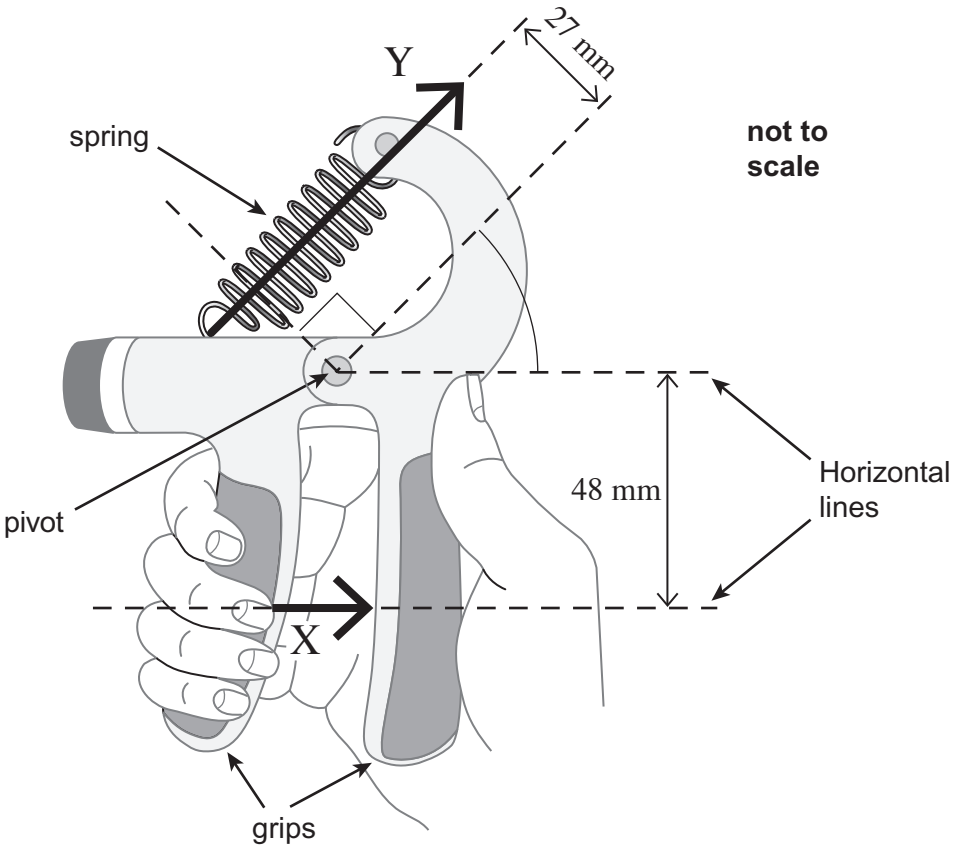


Figure 2 shows the gripper being squeezed. In this situation, the gripper is in equilibrium. The force produced by the fingers is equivalent to the single force **X** of magnitude 250 N acting in the direction shown in **Figure 2**. A force, **Y**, is exerted by the spring which obeys Hooke's law.

Do not write outside the box

2 (b) (i) Calculate the moment of force **X** about the pivot. State an appropriate unit.

[2 marks]

moment = ... unit .....

2 (b) (ii) Calculate force **Y**.

[2 marks]

force = ... N

2 (b) (iii) The extension of the spring is 15 mm.

Calculate the spring constant k of the spring. Give your answer in $\mathrm{N\ m^{-1}}$.

[2 marks]

spring constant = ... $\mathrm{N\ m^{-1}}$

2 (b) (iv) Calculate the work done on the spring to squeeze it to the position shown in **Figure 2**.

[2 marks]

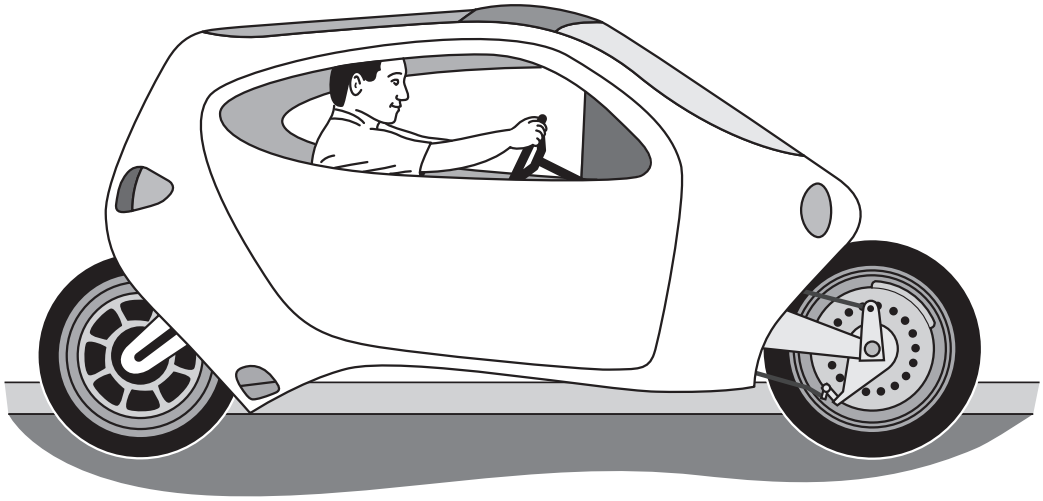
work done = ... J

10

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3 **Figure 3** shows an electric two-wheeled vehicle and driver.

Figure 3



3 (a) The vehicle accelerates horizontally from rest to $27.8\ \text{m s}^{-1}$ in a time of $4.6\ \text{s}$. The mass of the vehicle is $360\ \text{kg}$ and the rider has a mass of $82\ \text{kg}$.

3 (a) (i) Calculate the average acceleration during the $4.6\ \text{s}$ time interval.
Give your answer to an appropriate number of significant figures.

[2 marks]

acceleration = ... m s^{-2}

3 (a) (ii) Calculate the average horizontal resultant force on the vehicle while it is accelerating.

[2 marks]

resultant force = ... N

Do not write outside the box

3 (b) State and explain how the horizontal forward force on the vehicle has to change for **constant** acceleration to be maintained from 0 to $27.8\ \text{m s}^{-1}$.

[3 marks]

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3 (c) The electric motors drive both wheels of the vehicle.

Add labelled force arrows to **Figure 3** to show the horizontal forces acting on the vehicle when it is moving at a constant speed.

[2 marks]

3 (d) The vehicle now accelerates to a constant speed of $55\ \text{m s}^{-1}$. The useful power output of the motors is $22\ \text{kW}$ at this speed.

Calculate the horizontal resistive force acting on the vehicle.

[2 marks]

horizontal resistive force = ... N

11

Turn over ▶

Do not write outside the box

4 An aerospace engineer has built two differently designed wings. One wing is made from an aluminium alloy and the other is made from a carbon fibre composite.

The engineer tests a sample of each material by applying a varying stress.

4 (a) Tick (✓) **two** of the boxes in **Table 2** to indicate which are properties of the material from which the wing is made.

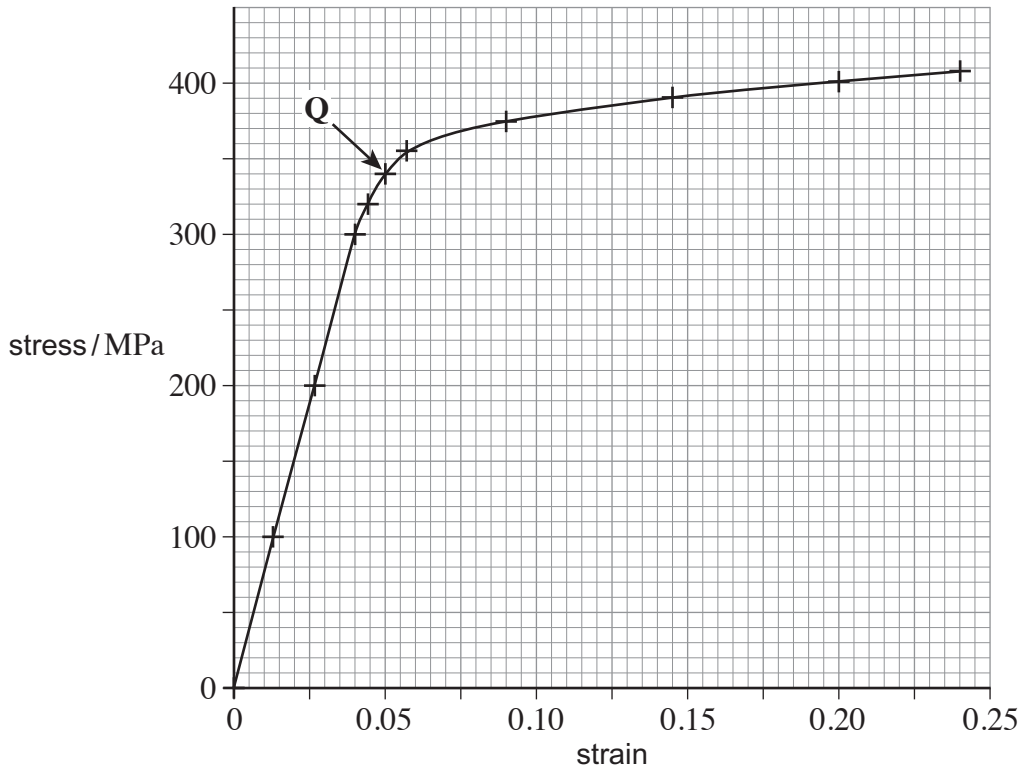
[1 mark]

Table 2

breaking stress	
stiffness constant, k	
tensile strain	
tensile stress	
Young modulus	

4 (b) **Figure 4** shows the stress–strain graph that the engineer obtains for the aluminium alloy.

Figure 4



4 (b) (i) The engineer has labelled a point **Q** on the graph in **Figure 4**. This is a point beyond which the behaviour of the material changes irreversibly. State the name for this point.

[1 mark]

.....

Do not write outside the box

4 (b) (ii) Use the graph to determine the Young modulus of the aluminium alloy. Show your working.

[2 marks]

Young modulus = ... Pa

4 (c) The engineer who carried out the experiment to obtain the stress–strain graph decided to stretch another sample to a strain of 0.10. She then gradually reduced the stress to zero.

Show by drawing on **Figure 4** how you would expect the stress to vary with strain as the stress is reduced.

[2 marks]

Question 4 continues on the next page

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4 (d) Calculate the volume of $25.0\ \text{kg}$ of the aluminium alloy.

density of aluminium alloy = $2.78 \times 10^3\ \text{kg m}^{-3}$.

[1 mark]

volume = ... m^3

4 (e) 1.28% of the aluminium alloy's volume is copper.
Calculate the mass of pure aluminium needed to make $25.0\ \text{kg}$ of the aluminium alloy.

density of pure aluminium = $2.70 \times 10^3\ \text{kg m}^{-3}$.

[2 marks]

mass of pure aluminium = ... kg

9

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

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5 (a) Tick (✓) the appropriate boxes in **Table 3** to indicate how the wavelength, frequency and speed of light are affected when a ray of light travels from air into glass.

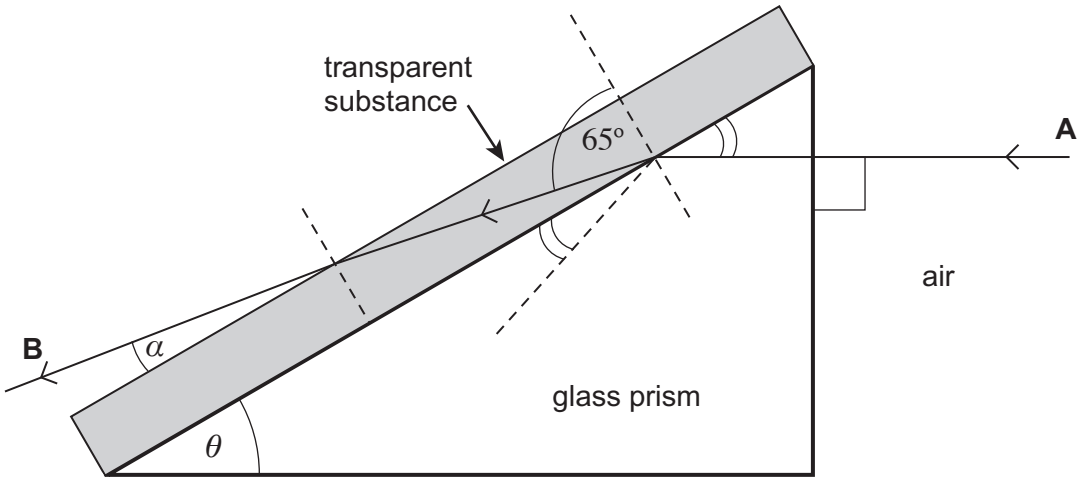
[2 marks]

Table 3

	Wavelength	Frequency	Speed
increases			
stays the same			
decreases			

5 (b) **Figure 5** shows a right-angled glass prism in contact with a transparent substance on one of the faces. One of the other angles of the prism is θ.

Figure 5



refractive index of glass prism = 1.70
refractive index of transparent substance = 1.09

angles are not shown to scale

Do not write outside the box

5 (b) (i) A ray **A** enters perpendicularly to one face of the prism. It is partially refracted and partially reflected at the interface between the glass and the transparent substance. The angle of refraction is 65.0°. The ray eventually leaves at an angle α to the surface of the transparent substance.

Determine the angle α.

[2 marks]

angle α = ... degree

5 (b) (ii) Determine the angle θ in **Figure 5**.

[2 marks]

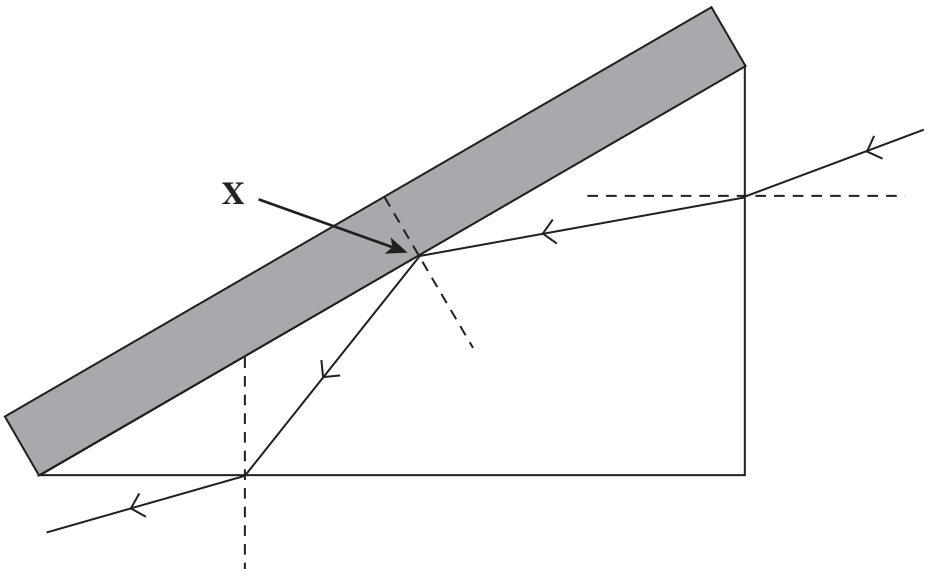
angle θ = ... degree

Question 5 continues on the next page

Do not write outside the box

5 (c) **Figure 6** shows another ray entering the prism.

Figure 6



5 (c) (i) Identify the effect that takes place at **X** in **Figure 6**.

[1 mark]

.....

5 (c) (ii) Explain, with a diagram, how the effect that occurs at **X** is used to transmit information along an optic fibre.

[3 marks]

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10

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

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6 A stationary wave is formed on a stretched string. Discuss the formation of this wave. Your answer should include:

- an explanation of how the stationary wave is formed
- a description of the features of the stationary wave
- a description of the processes that produce these features.

The quality of your written communication will be assessed in your answer.

[6 marks]

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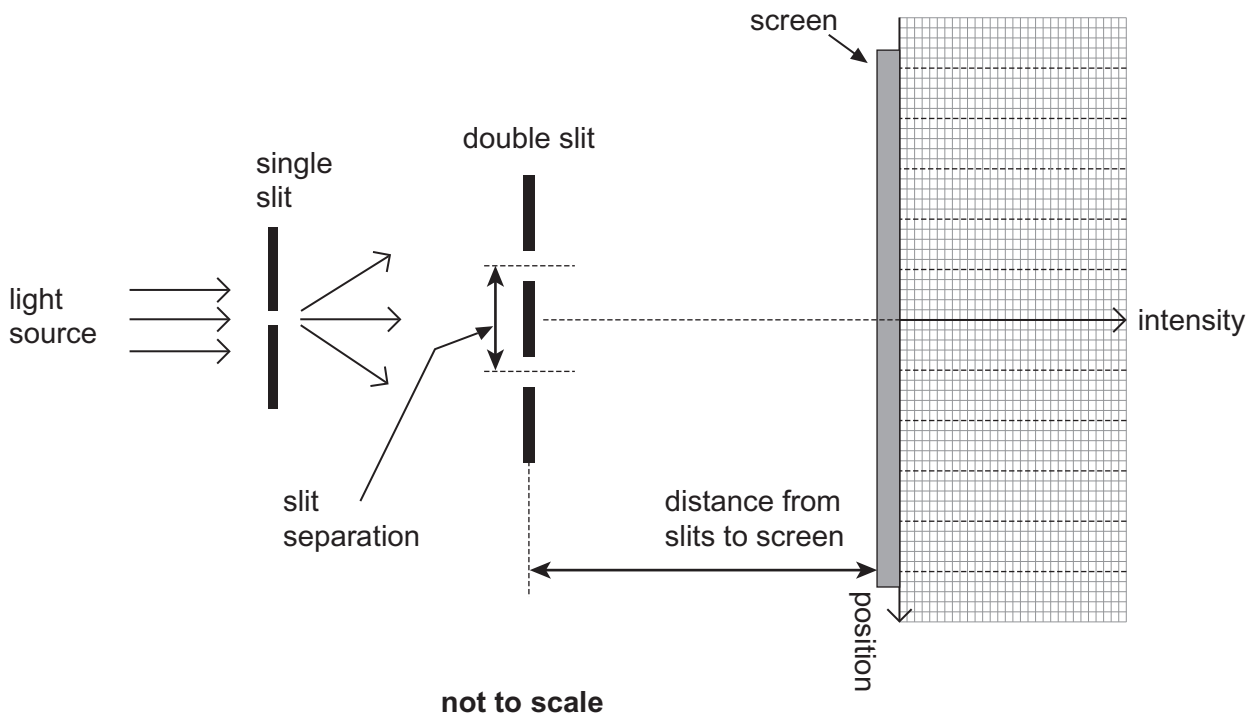
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6

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7 **Figure 7** shows Young's double-slit experiment performed with a tungsten filament lamp as the light source.

Figure 7



not to scale

7 (a) On the axes in **Figure 7**, sketch a graph to show how the intensity varies with position for a **monochromatic** light source.

[2 marks]

7 (b) (i) For an interference pattern to be observed the light has to be emitted by two **coherent sources**.
Explain what is meant by coherent sources.

[1 mark]

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Do not write outside the box

7 (b) (ii) Explain how the use of the single slit in the arrangement in **Figure 7** makes the light from the two slits sufficiently coherent for fringes to be observed.

[1 mark]

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7 (b) (iii) In this experiment light behaves as a wave.
Explain how the bright fringes are formed.

[3 marks]

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7 (c) (i) A scientist carries out the Young double-slit experiment using a laser that emits violet light of wavelength $405\ \text{nm}$. The separation of the slits is $5.00 \times 10^{-5}\ \text{m}$.

Using a metre ruler the scientist measures the separation of two adjacent bright fringes in the central region of the pattern to be $4\ \text{mm}$.

Calculate the distance between the double slits and the screen.

[2 marks]

distance = ... m

Question 7 continues on the next page

Do not write outside the box

7 (c) (ii) Describe the change to the pattern seen on the screen when the violet laser is replaced by a green laser. Assume the brightness of the central maximum is the same for both lasers.

[1 mark]

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7 (c) (iii) The scientist uses the same apparatus to measure the wavelength of visible electromagnetic radiation emitted by another laser.
Describe how he should change the way the apparatus is arranged and used in order to obtain an **accurate** value for the wavelength.

[3 marks]

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13

END OF QUESTIONS

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A-LEVEL

Physics

PHYA2 – Mechanics, Materials and Waves
Mark scheme

2450
June 2015

Version: 1 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

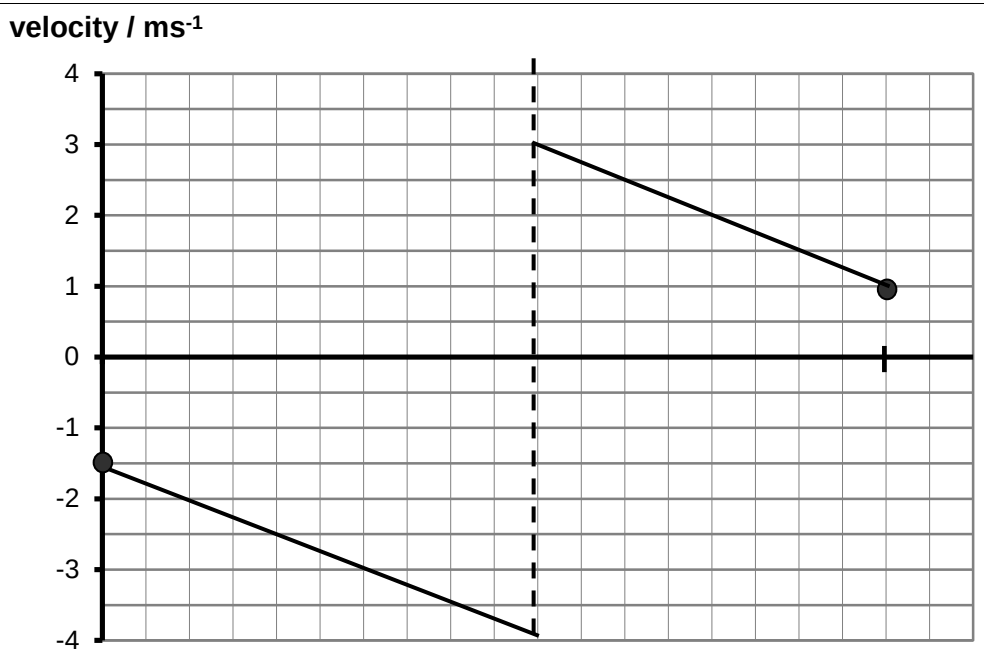
It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr><td>1a</td><td>Velocity and speed correct ✓
Distance and displacement correct ✓
<table><tr><td></td><td>velocity</td><td>speed</td><td>distance</td><td>displacement</td></tr><tr><td>vector</td><td>✓</td><td></td><td></td><td>✓</td></tr><tr><td>scalar</td><td></td><td>✓</td><td>✓</td><td></td></tr></table></td><td></td><td>2</td><td></td></tr>
<tr><td>1bi</td><td>$v^2 = u^2 + 2as$
$v = \sqrt{u^2 + 2as}$ ✓ $v = \sqrt{1.5^2 + 2 \times 9.81 \times 0.65}$ ✓
= (-)3.9 (m s^{-1}) ✓two or more sig fig needed (- 3.87337 m s^{-1})</td><td>1st mark for equation rearranged to make v the subject (note sq' root may be implied by a later calculation)
penalise the use of g = 10 m s^2 only on this question
2nd mark for substituting numbers into any valid equation
3rd mark for answer
Alt' approach is gainKE=lossPE
Missing out u gives zero marks
Answer only gains one mark
[Note it is possible to achieve the correct answer by a wrong calculation]</td><td>3</td><td></td></tr>
</table>

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1bii	 first line descends from X to the dotted line at t_A or up to one division sooner ✓ (allow line to curve) first line is straight and descends from X to v = -4 (m s^{-1}) ✓(allow tolerance one division) second line has same gradient as the first , straight and descends to v = 1(m s^{-1}) ✓ (tolerance ½ division) A steep line may join the two straight lines but its width must be less than 2 divisions		3	

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1c	$s = ut + 1/2at^2$ $t = \sqrt{\frac{2s}{a}}$ OR correct substitution seen into either equation $t = \sqrt{\frac{2\times1.2}{9.81}}$ ✓ = 0.49 (s) ✓ (0.4946 s) $v = s/t$ = 5.0 / 0.49 = 10 (m s^{-1}) ✓ (10.2 m s^{-1}) (allow CE from their time)	working must be shown for the first mark but not the subsequent marks. [Note it is possible to achieve the correct answer by a wrong calculation]	3	

Total			11

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Question	Answers	Additional Comments/Guidance	Mark	ID details
2a	(moment =) Force x perpendicular distance ✓ Between line of action (of force) and pivot/point ✓	both marks need to be clear – avoid bod If the force is named specifically (eg weight) mark the work but give a maximum of 1 mark. Ignore extra material such as law of moments.	2	
2bi	moment = 250 x 0.048 = 12 ✓ (allow 12000 for this mark) **N m** ✓ (stand alone mark if no number is present but only for N mm, N cm and N m)	only allow answers in other units if consistent eg 1200 N cm no working shown can gain full marks if answer and unit are consistent newton should be upper case if a symbol and metre should be in lower case (but only penalise if it is very obviously wrong)	2	
2bii	Y x 0.027 = 12 OR Y = 12/0.027 ✓ (allow use of 12 and 27 for this mark) = 440 (N) ✓ (444.4 N) CE from 2bi	Y = 2b(i)/0.027 treat power of 10 error as an AE note 450 N is wrong 1 sig fig is not acceptable	2	
2biii	*(k = F/ΔL)* = 444.4 / 0.015 ✓ CE from 2b(ii) = 3.0×10^4 (Nm^{-1}) ✓ (29630 Nm^{-1})	k = 2b(ii)/0.015 treat power of 10 error as an AE using 440 gives 2.9×10^4 (Nm^{-1}) 1 sig fig is not acceptable	2	
2biv	W (= ½ F ΔL) = ½ x 444.4 x 0.015 Or W (= ½ k ΔL^2) = ½ × 29630 × 0.015^2 ✓ (give this mark for seeing the digits only ie ignore powers of 10 and allow CE from b(ii) or b(iii) as appropriate = 3.3 (J) ✓ (3.333 J)	W = ½ × b(ii) × 0.015 W = ½ × b(iii) × 0.015^2 treat power of 10 error as an AE If either equation misses out the ½ no marks. Common CE is to use F = 250 N which can be used giving W = 1.9 J	2	
Total			10	

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Question	Answers	Additional Comments/Guidance	Mark	ID details
3ai	($a = (v-u) / t$) = 27.8 (-0) / 4.6 = 6.04 ✓ = 6.0 (ms^{-1}) ✓	no need to see working for the mark 2 sig fig mark stands alone	2	
3aii	($F = ma$) = (360 + 82) x 6.0(4) ✓ (allow CE from 3ai) = 2700 (N) ✓ (2670 N or 2652 N)	F = 442 × a(i) 1 mark may be gained if mass of rider is ignored giving answer 2200N from 2175N	2	
3b	(forward force would have to) increase ✓ air resistance/drag increases (with speed) ✓ driving/forward force must be greater than resistive/drag force✓ (So that) resultant/net force stayed the same / otherwise the resultant/net force would decrease ✓	no mark for wind resistance	4max3	
3c	horizontal force arrows on both wheels towards the right starting where tyre meets road or on the axle labelled driving force or equivalent ✓ A horizontal arrow to the left starting anywhere on the vehicle labelled drag/air resistance ✓	ignore the actual lengths of any arrows ignore any arrows simply labelled 'friction' no mark for wind resistance, resistance or friction force the base of an arrow is where the force is applied	2	
3d	($F = P/v$) = 22 000/ 55✓ Condone 22/55 for this mark = 400 ✓ (N)		2	
Total			11	

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Question	Answers	Additional Comments/Guidance	Mark	ID details
4a	<table><tr><td>breaking stress</td><td>✓</td></tr><tr><td>stiffness constant, *k*</td><td></td></tr><tr><td>tensile strain</td><td></td></tr><tr><td>tensile stress</td><td></td></tr><tr><td>Young modulus</td><td>✓</td></tr></table>		1	
4bi	Elastic limit✓	only one attempt at the answer is allowed	1	
4bii	(E = 300 x 10^6 / 4 x10^{-2} = 7.5 x10^9) 7.5 (Pa) ✓ allow 7.4 to 7.6 (Pa) $\times 10^9$ ✓	first mark is for most significant digits ignoring the power of 10. Eg 7500 gains mark	2	
4c	straight line beginning on existing line at a strain of 0.10 and hitting the strain axis at a lower non-zero value ✓ line that ends on the x -axis with strain between 0.045 and 0.055✓(only allow if first mark is given)	ie accuracy required ± one division	2	
4d	8.99 x 10^{-3} (m^3)✓ condone 1 sig fig	allow 9.00 $\times 10^{-3}$	1	
4e	0.9872 x 8.99 x 10^{-3} or = 8.8749 x 10^{-3} (m^3) ✓ allow CE from 4d ($m = \rho V$)= 2700 x 8.8749 x 10^{-3} = 24 (kg) ✓ (23.962 kg) allow CE from first part ,e.g. if 1.28% was used gives 0.311 kg	V =0.9872 $\times$ (d) m = 2.665 $\times$ (d) 1.28% of vol = 1.15 $\times 10^{-4}$ m^3	2	
Total			9	

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Question	Answers	Additional Comments/Guidance	Mark	ID details
5a	<table><tr><td></td><td>wavelength</td><td>frequency</td><td>speed</td></tr><tr><td>increases</td><td></td><td></td><td></td></tr><tr><td>stays the same</td><td></td><td>✓</td><td></td></tr><tr><td>decreases</td><td>✓</td><td></td><td>✓</td></tr></table> middle column correct ✓ first and third column correct ✓		2	
5bi	$(n_1 \sin\theta_2 = n_2 \sin\theta_2)$ (1.09)sin 65.0 = (1.00)sinθ_2 ✓ (giving θ_2 =81°) α = 9(°) ✓ (8.93°)	no internal CE Allow 9.0°	2	
5bii	1.09sin65 = 1.70sin*x* or sin*x* = 0.58 or *x* = 35.5 (°) ✓ (allow 35° or 36°) 90 - 35.5 = 54.5(°) ✓ (allow 54° or 55°) CE for 90° - their value	[Beware an answer close to the correct value can come from *n* = 1 / sin*C*]	2	
5ci	<u>total</u> internal reflection	TIR does not gain the mark	1	

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5cii	diagram showing core/cladding and light ray TIR at interface at least once with another TIR shown on the diagram or suggested in their explanation✓ light fibre consists of core and cladding with lower refractive index/<u>optical</u> density✓ light (incident) at angle greater than the critical angle (results in TIR)✓	labelling is not required and reflections do not have to be accurate provided they are shown on the correct side of the normal	3	

Total			10

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Question	Answers	Additional Comments/Guidance	Mark	ID details
6	**The student's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The student's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. *Answers may cover some of the following points:* • *(1) A wave and its reflection/waves travelling in opposite directions meet/interact/overlap/cross/pass through etc* • *(2) same wavelength (or frequency)* • *(3) node – point of minimum or no disturbance* • *(4) antinode – is a point of maximum amplitude* • *(5) node - two waves (always) cancel/ destructive interference / 180° phase difference /in antiphase [out of phase is not enough](of the two waves at the node)*[not peak meets trough] • *(6) antinode – reinforcement / constructive interference occurs / (displacements) in phase* • *(7) mention of <u>superposition</u> [not superimpose]of the two waves* • *(8) energy is not transferred (along in a standing wave)* **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary	Point (1) must be stated together ie it should not be necessary to search the whole script to find the two parts namely the directions of the waves and their meeting. Points (3) and (4) may come from a diagram but only if the node and antinode is written in full and the y-axis is labelled amplitude or displacement. If any point made appears to be contradicted elsewhere the point is lost – no bod's	6	

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	correctly. The form and style of writing is appropriate to answer the question. *6 marks: points (1) **AND** (2) **with** 4 other points which must include point (4) or the passage must indicate that the wave is oscillating at an antinode* *5 marks: points (1) **AND** (2) **with** any three other points* **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. *4 marks: (1) **OR** (2) **AND** any three other points* *3 marks: any three points* **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. *2 marks: any two points* *1 marks: any point or a reference is made to both nodes and antinodes*	Although point (1) may not be given as a mark the script can be searched to see if its meaning has been conveyed as a whole before restricting the mark and not allowing 5 or 6 marks.		

Total			6

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Question	Answers	Additional Comments/Guidance	Mark	ID details
7a	Uniform width peaks ✓ (accurate to within ± one division) A collection of peaks of constant amplitude or amplitude decreasing away from central peak ✓	Peaks need to be rounded ie not triangular The minima do not need to be exactly zero. Pattern must look symmetrical by eye Condone errors towards the edge of the pattern Double width centre peak total mark = 0	2	
7bi	Constant/fixed/same phase relationship/difference (and same frequency/wavelength) ✓	In phase is not enough for the mark	1	
7bii	Single slit acts as a point/single source diffracting/spreading light to <u>both slits</u> ✓ OR The path lengths between the single slit and the double slits are constant/the same/fixed ✓		1	
7biii	<u>Superposition</u> of waves from two slits ✓ Diffraction (patterns) from both slits overlap (and interfere constructively) ✓(this mark may come from a diagram) Constructive interference / reinforcement (at bright fringe) peaks meet peaks / troughs meet troughs ✓(any reference to antinode will lose this mark) Waves from each slit meet in phase OR path difference = $n\lambda$ ✓	phrase 'constructive superposition' = 2 marks	4max3	

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7ci	$D = \frac{w\,s}{\lambda} = \frac{0.004 \times 5.0\ 10^{-5}}{405 \times 10^{-9}}$ ✓ **do not penalise any incorrect powers of ten for this mark** = 0.5 (m) ✓ (0.4938 m)	Numbers can be substituted into the equation using any form Note 0.50 m is wrong because of a rounding error. Full marks available for answer only	2	
7cii	fringes further apart or fringe/pattern has a greater width/is wider ✓	Ignore any incorrect reasoning Changes to green is not enough for mark	1	

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7ciii	Increase *D* ✓ Measure across more than 2 maxima✓ Added detail which includes✓ Explaining that when *D* is increased then *w* increases Or repeat the reading with a changed distance *D* or using different numbers of fringes or measuring across different pairs of (adjacent) fringes. Or Explaining how either of the first two points improves/reduces the percentage error.	Several/few implies more than two. No mark for darkened room	3	

Total			13

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2014

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Monday 9 June 2014 9.00 am to 10.15 am

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

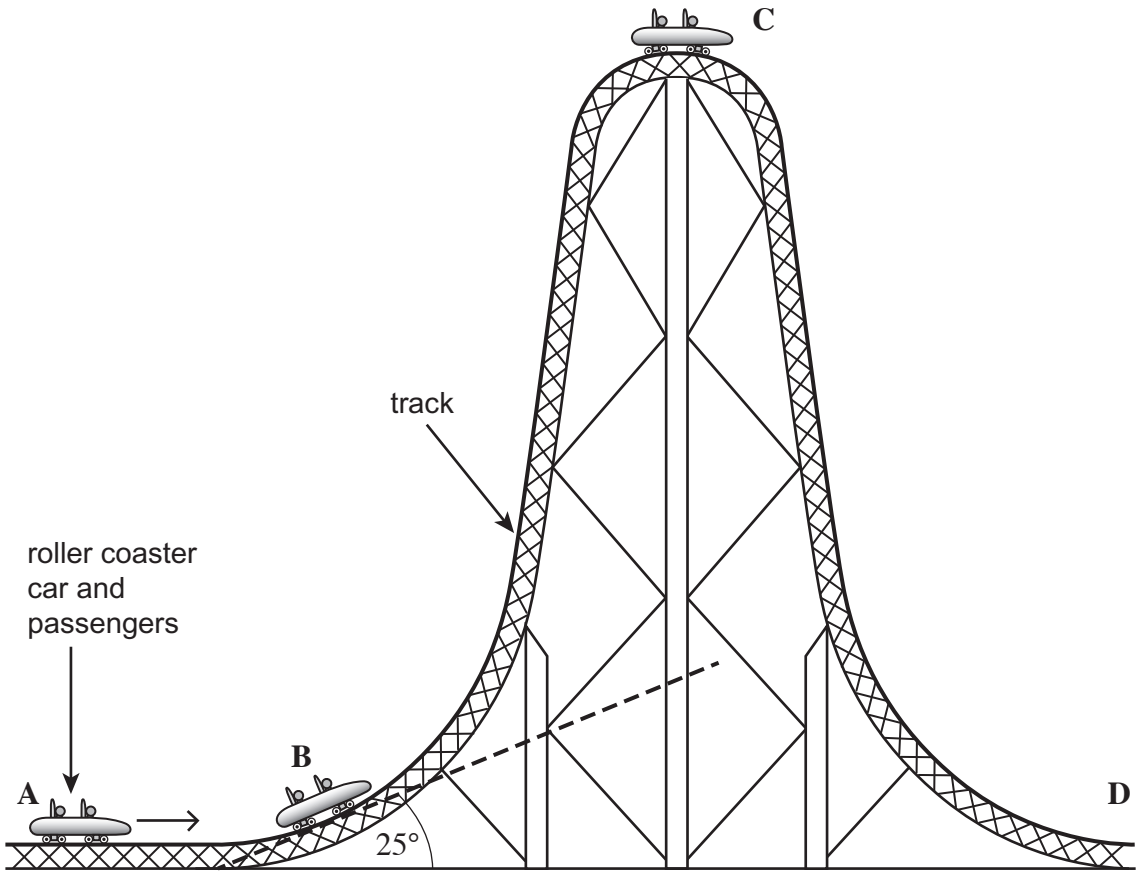
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Do not write outside the box

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

1 **Figure 1** shows a roller coaster car which is accelerated from rest to a speed of $56\,\text{m}\,\text{s}^{-1}$ on a horizontal track, **A**, before ascending the steep part of the track. The roller coaster car then becomes stationary at **C**, the highest point of the track. The total mass of the car and passengers is $8300\,\text{kg}$.

Figure 1



1 (a) The angle of the track at **B** is 25° to the horizontal. Calculate the component of the weight of the car and passengers acting along the slope when the car and passengers are in position **B** as shown in **Figure 1**.

[2 marks]

component of weight ..... N

Do not write outside the box

1 (b) (i) Calculate the kinetic energy of the car including the passengers when travelling at $56\,\text{m}\,\text{s}^{-1}$.

[2 marks]

kinetic energy ..... J

1 (b) (ii) Calculate the maximum height above **A** that would be reached by the car and passengers if all the kinetic energy could be transferred to gravitational potential energy.

[2 marks]

maximum height ..... m

1 (c) The car does not reach the height calculated in part (b).

1 (c) (i) Explain the main reason why the car does not reach this height.

[2 marks]

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1 (c) (ii) The car reaches point **C** which is at a height of $140\,\text{m}$ above **A**. Calculate the speed that the car would reach when it descends from rest at **C** to its original height from the ground at **D** if 87% of its energy at **C** is converted to kinetic energy.

[2 marks]

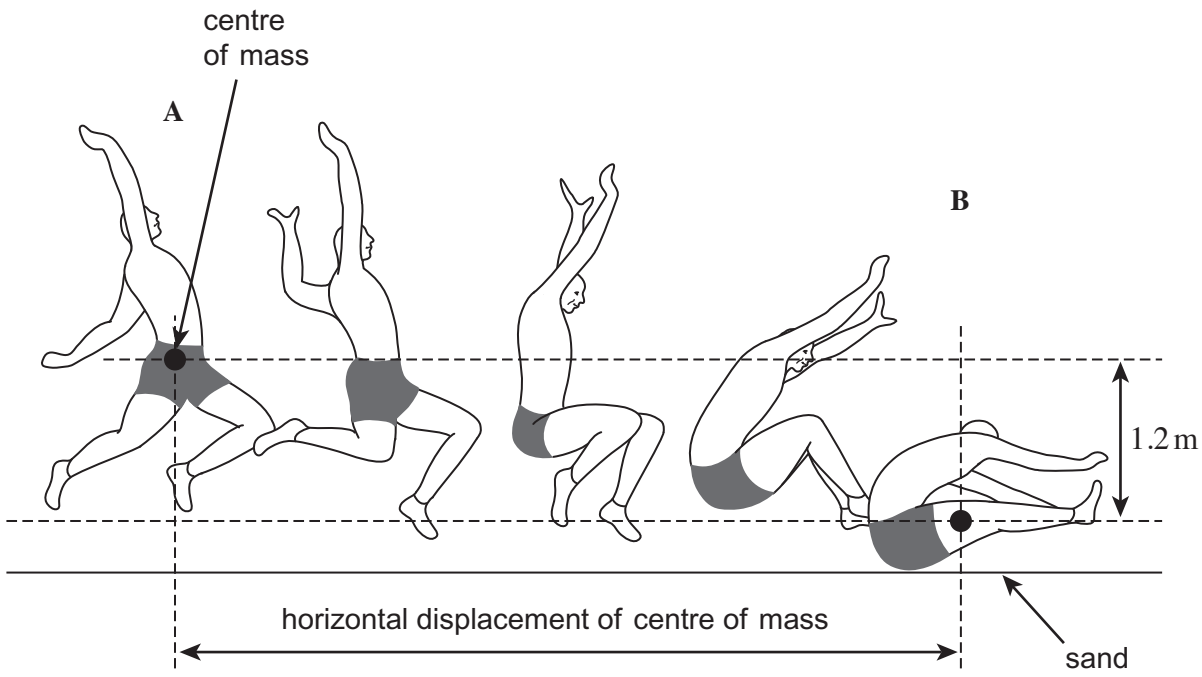
speed ..... $\text{m}\,\text{s}^{-1}$

10

Do not write outside the box

2 The motion of a long jumper during a jump is similar to that of a projectile moving under gravity. **Figure 2** shows the path of an athlete above the ground during a long jump from half-way through the jump at position **A**, to position **B** at which contact is made with sand on the ground. The athlete is travelling horizontally at **A**.

Figure 2



2 (a) During this part of the jump, the centre of mass of the athlete falls 1.2 m.

2 (a) (i) Calculate the time between positions **A** and **B**.

[3 marks]

time ..... s

Do not write outside the box

2 (a) (ii) The athlete is moving horizontally at **A** with a velocity of $8.5\,\mathrm{m\,s^{-1}}$. Assume there is no air resistance. Calculate the horizontal displacement of the centre of mass from **A** to **B**.

[2 marks]

horizontal displacement ..... m

2 (b) (i) The athlete in **Figure 2** slides horizontally through the sand a distance of $0.35\,\mathrm{m}$ before stopping.

Calculate the time taken for the athlete to stop. Assume the horizontal component of the resistive force from the sand is constant.

[2 marks]

time ..... s

2 (b) (ii) The athlete has a mass of $75\,\mathrm{kg}$. Calculate the horizontal component of the resistive force from the sand.

[3 marks]

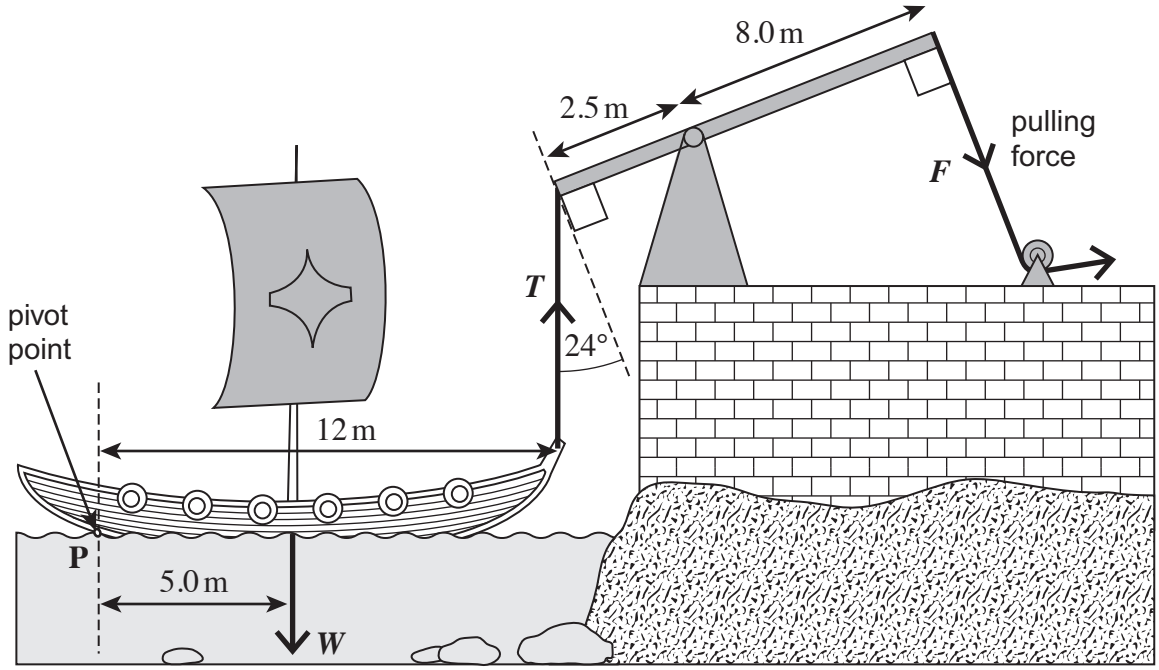
horizontal component of resistive force ..... N

10

Do not write outside the box

3 It is said that Archimedes used huge levers to sink Roman ships invading the city of Syracuse. A possible system is shown in **Figure 3** where a rope is hooked on to the front of the ship and the lever is pulled by several men.

Figure 3



3 (a) (i) Calculate the mass of the ship if its weight was 3.4×10^4 N.

[1 mark]

mass ..... kg

3 (a) (ii) Calculate the moment of the ship's weight about point **P**. State an appropriate unit for your answer.

[2 marks]

moment ..... unit .....

Do not write outside the box

3 (a) (iii) Calculate the minimum vertical force, T, required to start to raise the front of the ship. Assume the ship pivots about point **P**.

[2 marks]

minimum vertical force ..... N

3 (a) (iv) Calculate the minimum force, F, that must be exerted to start to raise the front of the ship.

[3 marks]

force ..... N

8

Turn over for the next question

Do not write outside the box

4 (a) In order to compare the mechanical properties of two different types of metal alloy, an engineer decides to measure the Young modulus for each of them. She has a sample of each alloy in the form of a wire. Each wire is about $1.5\,\mathrm{m}$ in length but they have different diameters.

Describe an experimental method that she could use to obtain the data necessary to accurately determine the Young modulus of these metals. You may wish to illustrate your answer with a diagram.

The quality of your written communication will be assessed in your answer.

[6 marks]

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Do not write outside the box

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4 (b) In this experiment, wire **A** is found to have a higher Young modulus than wire **B** and it fractures before any permanent deformation takes place. Wire **B** stretches well beyond its elastic limit before fracturing.

4 (b) (i) From this evidence, state a mechanical property of the metal that wire **A** is made from.

[1 mark]

.....

4 (b) (ii) On the axes below, sketch possible stress-strain graphs for wires **A** and **B**. Label the axes and label the lines **A** and **B**.

[3 marks]



Question 4 continues on the next page

Do not write outside the box

4 (c) The engineer found that the Young modulus of alloy **A** was 2.80×10^{11} Pa. During the experiment, the 1.5 m wire underwent a 0.24% increase in length.

4 (c) (i) Calculate the stress on the wire for this extension.

[3 marks]

stress ..... Pa

4 (c) (ii) For the same extension as in part (c)(i), calculate the load that must be applied to wire **A**. The diameter of the wire **A** is 1.40 mm.

[3 marks]

load ..... N

16

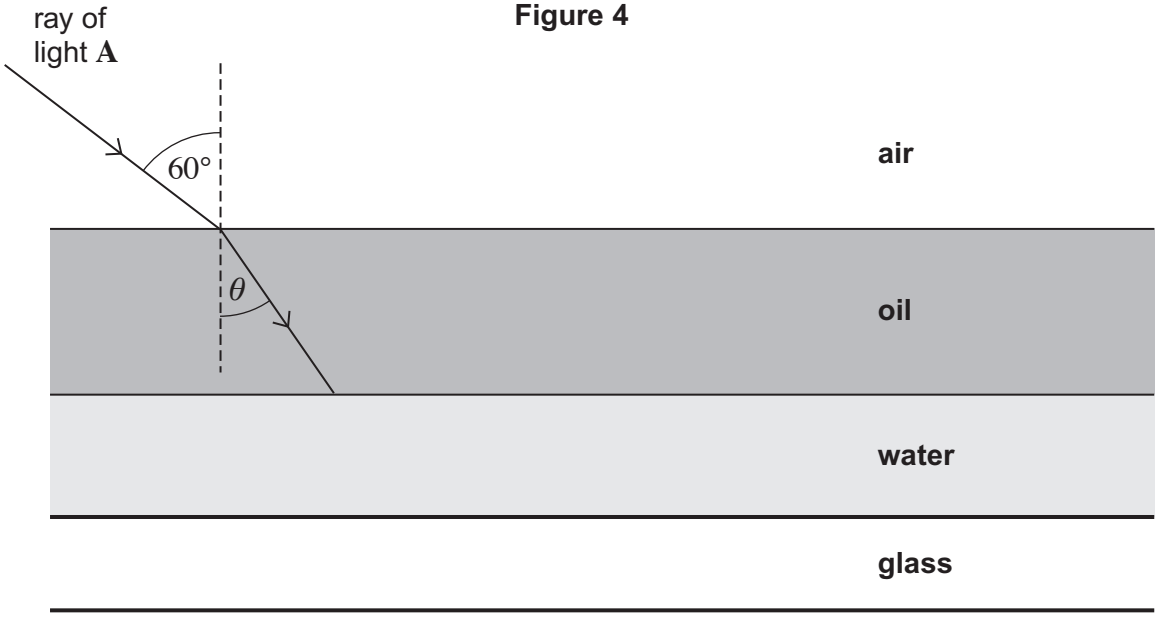
Do not write outside the box

5 **Figure 4** shows a ray of light **A** incident at an angle of 60° to the surface of a layer of oil that is floating on water.

refractive index of oil = 1.47

refractive index of water = 1.33

Figure 4



5 (a) (i) Calculate the angle of refraction θ in **Figure 4**.

[2 marks]

angle ..... degrees

5 (a) (ii) Calculate the critical angle for a ray of light travelling from oil to water.

[2 marks]

angle ..... degrees

5 (a) (iii) On **Figure 4** continue the path of the ray of light **A** immediately after it strikes the boundary between the oil and the water.

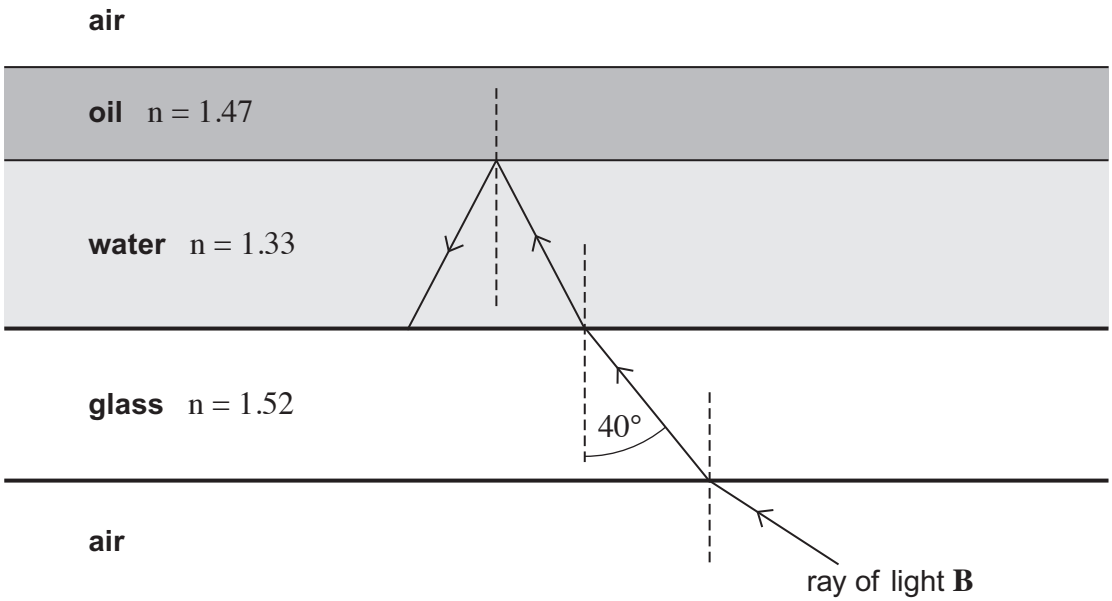
[2 marks]

Turn over ▶

Do not write outside the box

5 (b) In **Figure 5** a student has incorrectly drawn a ray of light **B** entering the glass and then entering the water before totally internally reflecting from the water–oil boundary.

Figure 5



The refractive index of the glass is 1.52 and the critical angle for the glass–water boundary is about 60°.

Give **two** reasons why the ray of light **B** would **not** behave in this way. Explain your answers.

[4 marks]

reason 1 .....

.....

explanation .....

.....

.....

reason 2 .....

.....

explanation .....

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10

Do not write outside the box

6 **Figure 6** shows a spectrometer that uses a diffraction grating to split a beam of light into its constituent wavelengths and enables the angles of the diffracted beams to be measured.

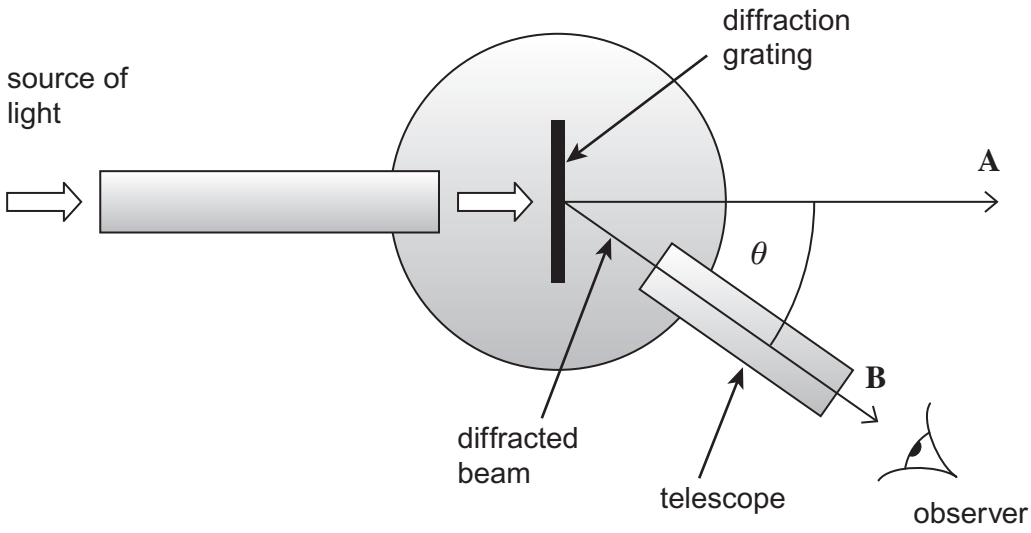
6 (a) Give **one** possible application of the spectrometer and diffraction grating used in this way.

[1 mark]

.....

.....

Figure 6



6 (b) (i) When the spectrometer telescope is rotated from an initial angle of zero degrees, a spectrum is not observed until the angle of diffraction θ is about 50°. State the order of this spectrum.

[1 mark]

.....

6 (b) (ii) White light is directed into the spectrometer. Light emerges at **A** and **B**. State **one** difference between the light emerging at **B** compared to that emerging at **A**.

[1 mark]

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Turn over ▶

Do not write outside the box

6 (c) The angle of diffraction θ at the centre of the observed beam **B** in **Figure 6** is 51.0° and the grating has 1480 lines per mm.

Calculate the wavelength of the light observed at the centre of beam **B**.

[3 marks]

wavelength ..... m

6 (d) Determine by calculation whether any more orders could be observed at the wavelength calculated in part (c).

[2 marks]

8

Do not write outside the box

7 Ultrasound waves are used to produce images of a fetus inside a womb.

7 (a) Explain what is meant by the frequency of a wave.

[1 mark]

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7 (b) Ultrasound is a longitudinal wave. Describe the nature of a longitudinal wave.

[2 marks]

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7 (c) In order to produce an image with sufficient detail, the wavelength of the ultrasound must be $0.50\,\text{mm}$. The speed of the ultrasound in body tissue is $1540\,\text{m s}^{-1}$. Calculate the frequency of the ultrasound at this wavelength.
Give your answer to an appropriate number of significant figures.

[2 marks]

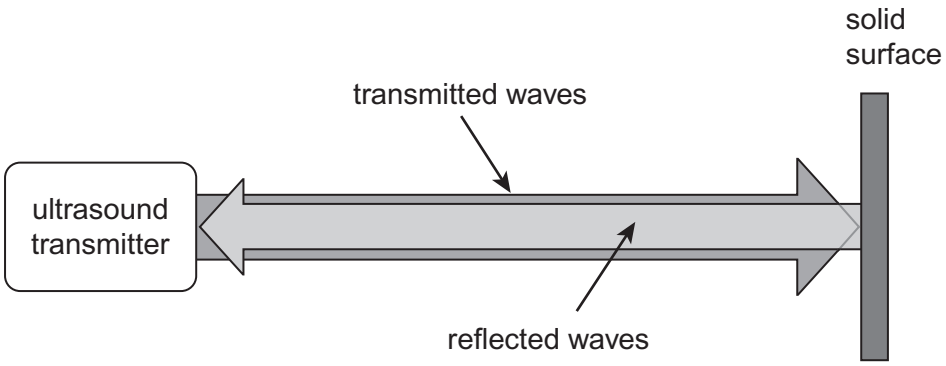
frequency ..... Hz

Question 7 continues on the next page

Do not write outside the box

7 (d) A continuous ultrasound wave of constant frequency is reflected from a solid surface and returns in the direction it came from.

Figure 7



Assuming there is no significant loss in amplitude upon reflection, describe and explain the effect the waves have on the particles in the medium between the transmitter and the solid surface.

[3 marks]

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8

END OF QUESTIONS

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A-LEVEL
PHYSICS A

PHYA2 – mechanics, materials and waves
Mark scheme

2450
June 2014

Version: 1.0 Final

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COMPONENT NAME: Unit 2 – Mechanics, materials and waves

COMPONENT NUMBER: PHYA2

Question	Part	Sub Part	Marking Guidance	Mark		Comments
1	a		8300 x 9.81 OR = 81423 ✓ (8300 x 9.81 sin 25) = 3.4 x 10^4 (N) ✓ (34 411 N) ecf from first line unless g not used msin25 gets zero	2		Penalize use of g=10 here only (35 077 N) Allow 9.8 in any question **Correct answer only, gets both marks for all two mark questions**
1	b	i	(E_k = ½mv^2) = ½ x 8300 x 56^2 ✓ = 1.3 x10^7 (J) ✓ (13 014 400) allow use of 8300 only	2		In general: Penalise transcription errors and rounding errors in answers

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1	b	ii	*mgh* = KE (13 014 400) for *mgh* allow GPE or E_p OR 13 014 400 / 81 423 ✓ h = 160 (m) ✓ (159.8) ecf 1bi	2		Allow use of suvat approach
1	c	i	(work done) by friction \ drag \ air resistance \ resistive forces ✓ (Energy converted) to internal \ thermal energy ✓	2		Allow 'heat'
1	c	ii	0.87 x (8300 x 9.81 x 140 = 9 917 000) OR $v = \sqrt{\left[\frac{2 \times (9\,917\,000)}{8300}\right]}$ ✓ = 49 (= 48.88 ms^{-1}) ✓	2		87% of energy for 140m or 160m only for first mark. Use of 160 (52.26) and/or incorrect or no % (52.4) gets max 1 provided working is shown. **Do not credit suvat approaches here**.
			Total	10		

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2	a	i	Use of $\left(s = \frac{1}{2}gt^2\right)$ OR $t^2 = 2s/g$ ✓ t = $\sqrt{\frac{2 \times 1.2}{9.81}}$ ✓ = 0.49 (0.4946 s) ✓ allow 0.5 do not allow 0.50	3		Some working required for full marks. Correct answer only gets 2
2	a	ii	*(s= vt)* = 8.5 x 0.4946 ✓ ecf ai = 4.2 m ✓ (4.20) ecf from ai	2		
2	b	i	$\left(s = \frac{1}{2}(u+v)\,t\right)$ $t = \frac{2s}{u(+v)}$ or correct sub into equation above ✓ $= \frac{2 \times 0.35}{8.5}$ = 8.2 x 10^{-2} (s) ✓ (0.0824) allow 0.08 but not 0.080 or 0.1	2		Allow alternative correct approaches
2	b ii		*a* = (*v*-*u*) / *t* OR correct substitution OR a= 103 ✓ (= -8.5) / 8.24 x 10^{-2} = 103.2) (*F* = *ma* =) 75 x (103.2) ✓ ecf from bi for incorrect acceleration due to arithmetic error only, not a physics error (e.g. do not allow a = 8.5. Use of g gets zero for the question. = 7700 N ✓ (7741) ecf (see above)	3		Or from loss of KE Some working required for full marks. Correct answer only gets 2
			Total	10		

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3	a	i	$m = W/g)$ (3.4 x 10^4 / 9.81 =) 3500 (3466 kg) ✓	1		Allow use of g=10
3	a	ii	(moment = 34 000 x 5.0) = 1.7 x 10^5 ✓ (Nm) **Nm** ✓ do not allow NM \ nM etc	2		allow in words
3	a	iii	170 000 = T x 12 OR T = 170 000 / 12 ✓ ecf aii = 1.4(167) x 10^4 ✓ (N)	2		
3	a	iv	(Component of T perpendicular to lever) = T cos 24 **OR** 14 167 x 0.9135 **OR** 12942 (N) ✓ ecf aiii allow 2.5cos24 x T (12942) x 2.5 = **F** x 8.0 **OR** F = ((12942) x 2.5) / 8.0 ✓ ecf for incorrect component of T or T on its own F = 4000 (N) ✓ (4044) ecf ecf for incorrect component of T or T on its own allow 4100 for use of 14 200 (4054)	3		Some working required for full marks. Correct answer only gets 2. Failure to find component of T is max 2 (4400 N)
			total	8		

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4	a 5/6	Good/excellent	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. Mentions **5** of the following: • Diagram (not necessarily labelled) showing a workable arrangement of suitable apparatus • measure diameter of wires • use a micrometer (for the diameter)* • apply range of loads or masses • measure original length • measure or calculate extension • (metre) rule (or equivalent) for the original length or extended length or extension* • Calculation of the weight of the mass \ use 'weights' in newtons And **2** of the following: • Measure diameter in several places • At least 7 different loads* • Repeat measurements for the same wire (or measure whilst unloading)	5/6		

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			• Use of a travelling microscope or Searle's apparatus \ pointer touching scale \ set square (for parallax reduction) \ Vernier scale (not Vernier calipers) * • Monitor diameter change during experiment *These points may appear in a clear diagram			
	3/4	Moderate	**Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. Mentions **4** points in total from the following 2 lists: • Diagram (not necessarily labelled) showing a workable arrangement of suitable apparatus • measure diameter of wires (must be stated) • use a micrometer (for the diameter)* • apply range of loads or masses • measure original length • measure or calculate extension • (metre) rule (or equivalent) for the original length or extended length or extension* • Calculation of the weight of the mass \ use 'weights' in newtons Accuracy • Measure diameter in several places • At least 7 different loads* • Repeat measurements for the same wire (or measure whilst unloading) • Use of a travelling microscope or Searle's apparatus \ pointer	3/4		

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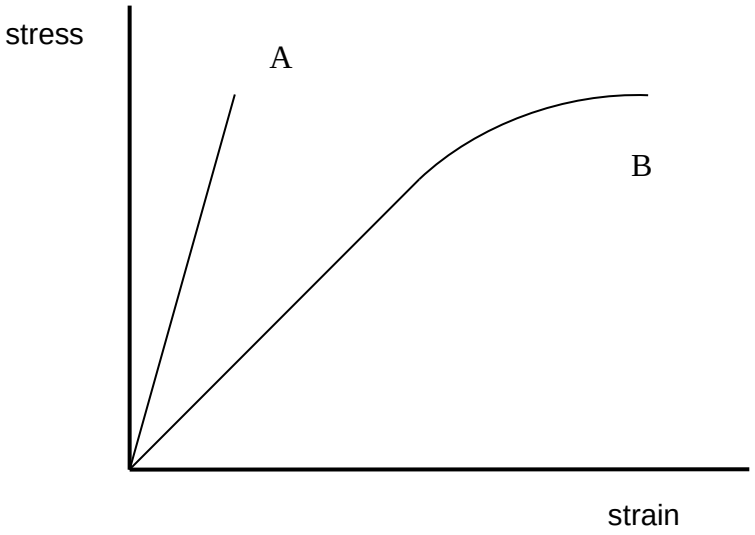
			touching scale \ set square(for parallax reduction) \ Vernier scale (not Vernier calipers)* • Monitor diameter change during experiment *These points may appear in a clear and suitably labelled diagram A **four mark answer** will have good QWC **OR** will exceed the specification above and will have at least one of the 5 points from the Accuracy list.			
	1/2	Limited	**Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. **Two** valid points from the list For two marks, at least **3** points are required	1/2		
			Marking points: • Diagram (not necessarily labelled) showing a workable arrangement of suitable apparatus • measure <u>diameter</u> of wires • use a micrometer (for the diameter)* • apply range of loads or masses • measure original length • measure or calculate extension		**6 marks**	

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			• (metre) rule (or equivalent) for the original length or extended length or extension* • Calculation of the weight of the mass \ use 'weights' in newtons • Measure diameter in several places • At least 7 different loads* • Repeat measurements for the same wire (or measure whilst unloading) • Use of a travelling microscope or Searle's apparatus \ pointer touching scale \ set square(for parallax reduction) \ Vernier scale (not Vernier calipers) * • Monitor diameter change during experiment			

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4	b	i	brittle ✓ allow misspellings allow: britle, brittleness,	1		

4	b	ii	 For stress- strain: Straight line labelled 'A' with greater gradient than other line and starting close to origin✓ allow small curve in correct direction at end of line. Line labelled 'B' with significant curve and decreasing gradient which may then undulate ✓ (**forgive one label to be missing**)	3		Allow full credit if strain plotted against stress correctly Allow reasonable free hand straight line. Tolerance for curve of A: no more than 10% of the total change in strain for their line.

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			Both of the above AND axes labelled, y, 'stress' or symbol or F/A, and x, 'strain or symbol or deltaL / L' ✓ (disallow if incorrect units are included but forgive 'PA' etc) (Assume stress-strain if no labels are give – max 2) For strain – stress: Straight line labelled 'A' with lesser gradient than other line ✓ allow small curve in correct direction at end of line. Line labelled 'B' with significant curve and increasing gradient which may then undulate ✓ (allow one label to be missing) Both of the above AND axes labelled, x, 'stress' or symbol or F/A , and y, 'strain or symbol or deltaL / L' ✓ (disallow if incorrect units are included)			Line B must have a curved portion of 20% or more. It must have an initial straight section A correct force-extension graph gets max 2
4	c	i	(strain = $\Delta L / L$) strain = 0.24/100 (= 0.0024) OR correct calculation of extension (0.0036) ✓ (stress = E x strain) stress = 2.80 (x 10^{11}) x 0.0024 ✓ **ecf from first mark** = 6.7 x10^{8} (Pa) ✓ ecf from first mark	3		Some working required for full marks. Correct answer only gets 2
4	c	ii	($A = \pi(D/2)^2$)	3		Some working required for full

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			$\pi(1.4\ (x10^{-3})\ /2)^2$ OR $= 1.539 \times 10^{-6}\ (m^2)$ ✓ ignore incorrect powers of ten $F = E \times A \times \Delta L / L$ **OR** $= 280\ (x10^{9}) \times 1.539\ (x\ 10^{-6})\ 0.0024$ ecf 4ci (incorrect extension or strain) **OR** A x their stress from 4ci ✓ ecf 4ci for strain and ecf for incorrect area in 4cii but do not accept use of diameter or radius as the area = 1 000 ✓ (1034.46 N)			marks. Correct answer only gets 2 Use of diameter or radius for area gets zero for the question
			total		16	

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5	a	i	sin 60 = 1.47sin θ **OR** sin θ = sin 60 / 1.47 ✓ ($\sin^{-1}$ 0.5891) = 36 (^{o}) ✓ (36.0955^o) (allow 36.2)	2		Allow 36.0
5	a	ii	$\sin\theta_c = 1.33/1.47$ OR $\sin\theta_c = 0.9(048)$ ✓ ($\sin^{-1}$ 0.9048) = 65 (^{o}) ✓ (64.79)	2		Allow 64 for use of 0.9 and 66 for use of 0.91
5	a	iii	Answer consistent with previous answers, e.g. If aii >ai: Ray refracts at the boundary AND goes to the right of the normal ✓ Angle of refraction > angle of incidence ✓ **this mark depends on the first** If aii < ai: TIR ✓ Angle of reflection = angle of incidence ✓ Ignore the path of the ray beyond water/glass boundary	2		Approx. equal angles (continuation of the line must touch 'Figure 4' label)
5	b		For Reason or Explanation: The angle of refraction should be > angle of incidence when entering the water ✓ water has a lower refractive index than glass \ light is faster in water than in glass ✓ TIR could not happen \ there is no critical angle, when ray travels from	4		Allow 'ray doesn't bend towards normal' (at glass/water) Allow optical

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			water to oil✓ TIR only occurs when ray travels from higher to lower refractive index \ water has a lower refractive index than oil ✓			density Boundary in question must be clearly implied

			total		10	

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6	a		One of: (spectral) analysis of light from stars (analyse) composition of stars Chemical analysis Measuring red shift \ rotation of stars ✓ Insufficient answers: 'observe spectra', 'spectroscopy', 'view absorption \emission spectrum', 'compare spectra', 'look at light from stars'.	1		Allow : measuring wavelength or frequency from a named source of light. Allow any other legitimate application that specifies the source of light. E.g. absorbtion\emission spectra in stars, 'observe spectra of materials'
6	b	i	first order beam first order spectrum first order image ✓	1		Allow 'n=1' , '1' 'one', 1st
6	b	ii	The light at A will appear white (and at B there will be a spectrum) OR greater intensity at A ✓	1		
6	c		(d = 1/ (lines per mm x 10^3) = 6.757 x 10^{-7} (m) OR 6.757 x 10^{-4} (mm) ✓	3		Some working required for full marks. Correct

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			($n\lambda = d \sin\theta$) = 6.757 x 10^{-7} x sin 51.0 ✓ ecf **only** for : • incorrect power of ten in otherwise correct calculation of d • use of d =1480, 1.48, 14.8 (etc) • from incorrect order in 6bii = 5.25 x 10^{-7} (m) ✓ ecf **only** for : • incorrect power of ten in otherwise correct d • from incorrect order in 6bii			answer only gets 2 Power of 10 error in d gets max 2. For use of d in mm, answer = 5.25 x 10^{-4} gets max 2 n =2 gets max 2 unless ecf from 6bii use of d=1480 yields wavelength of 1150m

6	d		n = d (sin90) / λ OR n = 6.757 x 10^{-7} / 5.25 x 10^{-7} ✓ ecf both numbers from 6c = 1.29 so <u>no more</u> beams observed ✓ or answer consistent with their working **OR** 2 = d (sinΘ) / λ OR sinΘ = 2 x 5.25 x 10^{-7} / 6.757 x 10^{-7} ✓ ecf both numbers from 6c sinΘ = 1.55 (so not possible to calculate angle) so <u>no more</u> beams ✓	2		Accept 1.28, 1.3 Second line gets both marks Conclusion consistent with working

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			OR $\sin^{-1}$(2 x (their λ / their d)) ✓ (not possible to calculate) so no more beams ✓ ecf			

			total		8	
7	a		number of (complete) waves (passing a point) in 1 second OR number of waves / time (for the waves to pass a point) OR (complete number of) oscillations \ vibrations per second OR 1/T with T defined as time for 1 (complete) oscillation ✓	1		Allow: Cycles Allow: unit time

7	b		For two marks: Oscillation of particles \ medium \ material etc, but not oscillation of wave is parallel to \ in same direction as the direction wave (travels) ✓✓ For one mark: Particles\material\medium move(s) \ disturbance \ displacement Parallel to \ in same direction as the direction wave travels OR (oscillations) parallel to direction of wave travel ✓ The one mark answer with: Mention of compressions and rarefactions	2		Allow Vibration Allow direction of energy transfer \ wave propagation

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			OR (Longitudinal waves) cannot be polarised Gets **two** marks ✓			

7	c		(f = 1540 / 0.50 x10^{-3}) = 3 100 000 (Hz) ✓ (3 080 000) **2sf** ✓	2		

7	d		No more than two points from either list (max 3): <u>Description</u> • Mention of nodes <u>and</u> antinodes • Particles not moving at a node • Maximum displacement at antinode • Particles either side of node in antiphase / between two nodes in phase • Variation of amplitude between nodes <u>Explanation</u> • A stationary wave (forms) • two waves are of <u>equal frequency</u> or wavelength (and amplitude in the same medium) • reflected and transmitted waves \ waves travelling in opposite directions, pass through each other • superpose / interfere occurs • constructive interference at antinodes • destructive interference at nodes	3		Allow 'standing wave'

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			✓✓✓			

			total		8	
			Total on paper		70	

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2013

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Wednesday 5 June 2013 9.00 am to 10.15 am

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

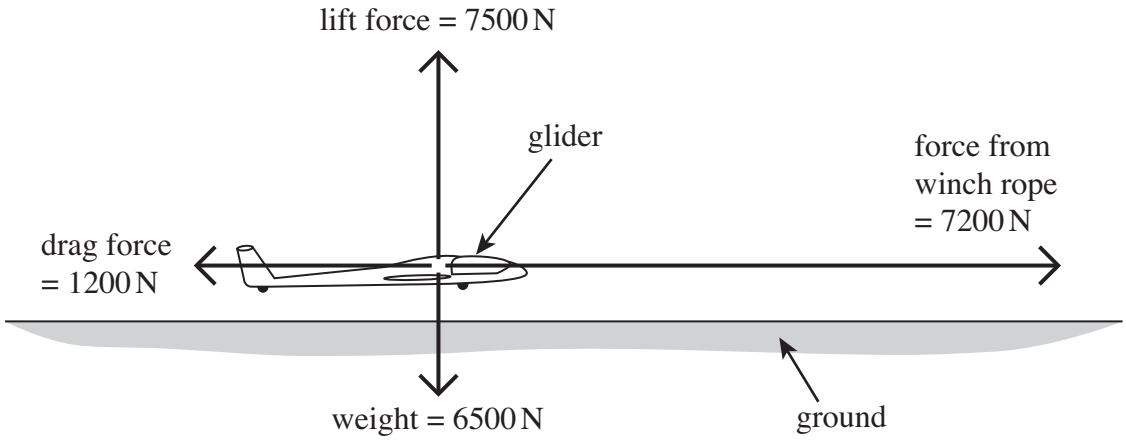
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Answer **all** questions in the spaces provided.

1 Gliders can be launched with a winch situated on the ground. The winch pulls a rope that is attached to the glider. **Figure 1** shows the forces acting on the glider at one instant during the launch.

Figure 1



1 (a) The combined weight of the glider and pilot is 6500 N.

1 (a) (i) Show that the magnitude of the resultant force acting on the glider is about 6100 N.

(2 marks)

1 (a) (ii) Calculate the angle between this resultant force and the horizontal.

angle ..... degrees

(2 marks)

Do not write outside the box

1 (a) (iii) Calculate the resultant acceleration of the glider in **Figure 1**.

resultant acceleration ..... m s^{-2}
(2 marks)

1 (b) The glider climbs a vertical distance of 600 m in 55 s. The average power input to the winch motor during the launch is 320 kW.

1 (b) (i) Calculate the gain in gravitational potential energy (gpe) of the glider.

gain in gpe ..... J
(2 marks)

1 (b) (ii) Calculate the percentage efficiency of the winch system used to launch the glider. Assume the kinetic energy of the glider after the launch is negligible.

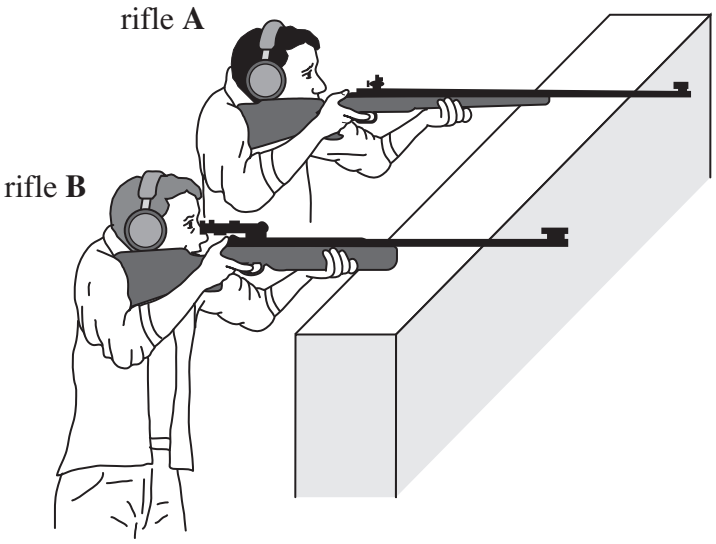
efficiency ..... %
(3 marks)

11

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2 **Figure 2** shows two different rifles being fired horizontally from a height of 1.5 m above ground level.
Assume the air resistance experienced by the bullets is negligible.

Figure 2



2 (a) When rifle **A** is fired, the bullet has a horizontal velocity of 430 m s^{-1} as it leaves the rifle. Assume the ground is level.

2 (a) (i) Calculate the time that the bullet is in the air before it hits the ground.

time ..... s
(2 marks)

2 (a) (ii) Calculate the horizontal distance travelled by the bullet before it hits the ground.

horizontal distance ..... m
(1 mark)

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2 (b) Rifle **B** is fired and the bullet emerges with a smaller horizontal velocity than the bullet from rifle **A**.

Explain why the horizontal distance travelled by bullet **B** will be less than bullet **A**.

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(3 marks)

6

3 A steel ball has a diameter of 2.2×10^{-2} m.

3 (a) Calculate the weight of the steel ball. Give your answer to an appropriate number of significant figures.

density of steel = 8100 kg m^{-3}

weight ..... N

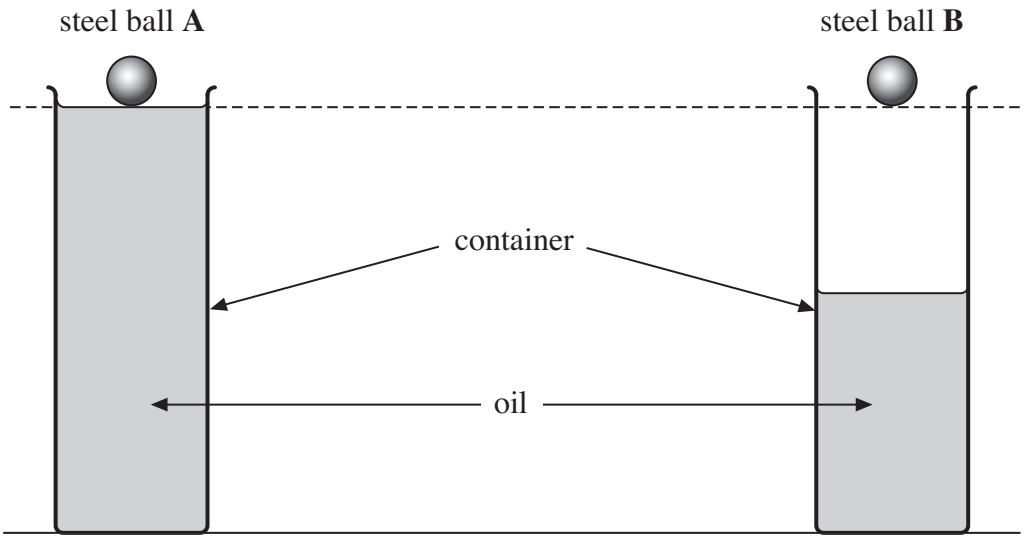
(4 marks)

question 3 continues on the next page

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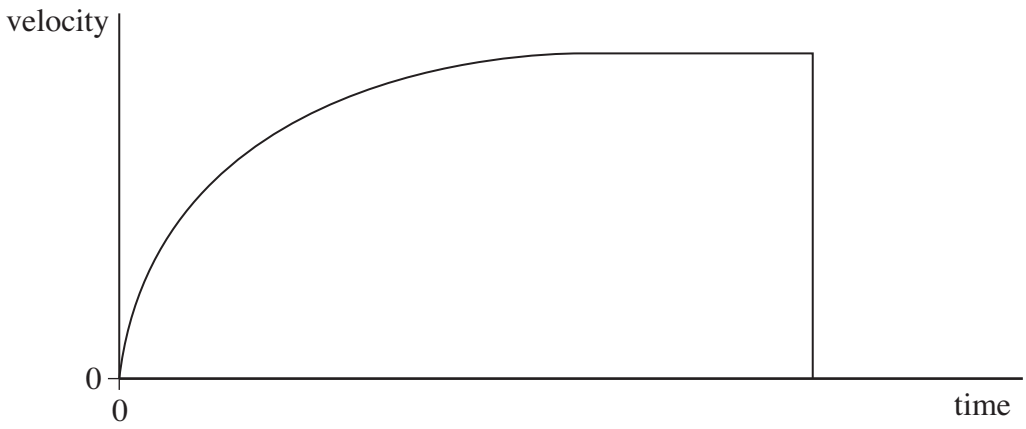
3 (b) **Figure 3** shows two identical steel balls dropped from rest into containers of oil.

Figure 3



3 (b) (i) **Figure 4** shows the velocity-time graph for steel ball **A**.

Figure 4



Explain the shape of the graph in **Figure 4**. Your account should include

- how the velocity and acceleration of the steel ball vary with time
- reference to how Newton's First and Second laws of motion apply in this situation.

The quality of written communication will be assessed in your answer.

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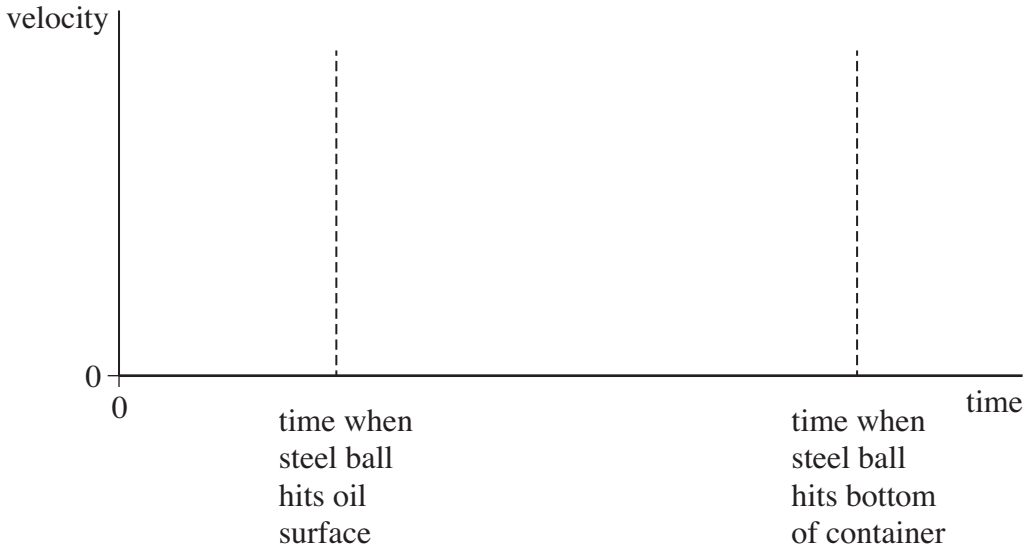
(6 marks)

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3 (b) (ii) On **Figure 5**, sketch the velocity-time graph you would expect to see for steel ball **B**. Assume air resistance is negligible.

Figure 5



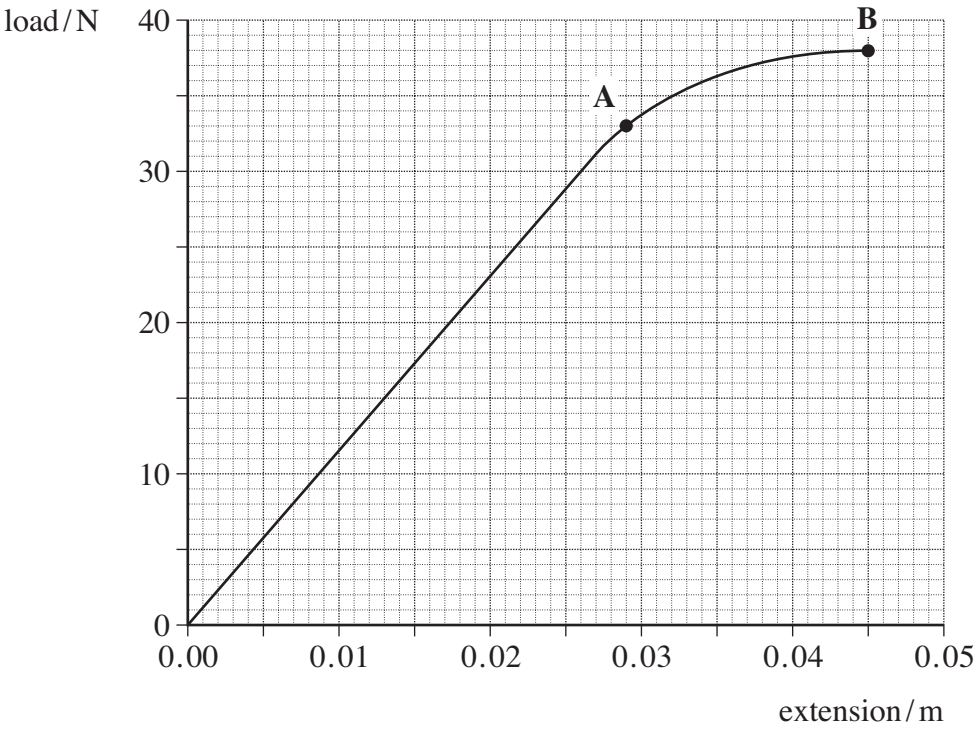
(3 marks)

13

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4 A manufacturer of springs tests the properties of a spring by measuring the load applied each time the extension is increased. The graph of load against extension is shown in **Figure 6**.

Figure 6



4 (a) State Hooke's law.

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(2 marks)

4 (b) Calculate the spring constant, k, for the spring. State an appropriate unit.

spring constant ..... unit .....

(3 marks)

Turn over ▶

Do not write outside the box

4 (c) Use the graph to find the work done in extending the spring up to point **B**.

work done ..... J

(3 marks)

4 (d) Beyond point **A** the spring undergoes *plastic deformation*.

Explain the meaning of the term plastic deformation.

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(1 mark)

4 (e) When the spring reaches an extension of 0.045 m, the load on it is gradually reduced to zero. On the graph in **Figure 6**, sketch how the extension of the spring will vary with load as the load is reduced to zero.

(2 marks)

4 (f) Without further calculation, compare the total work done by the spring when the load is removed with the work that was done by the load in producing the extension of 0.045 m.

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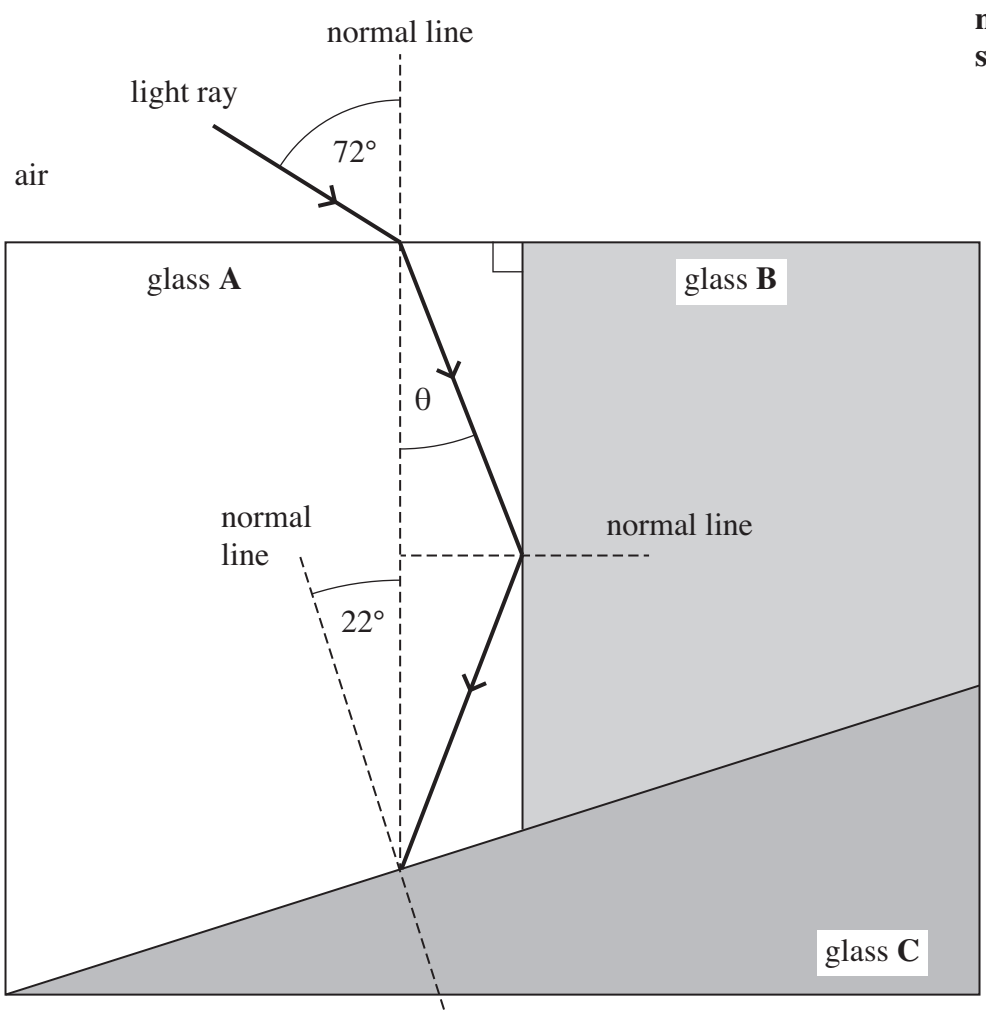
(1 mark)

12

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5 **Figure 7** shows three transparent glass blocks **A**, **B** and **C** joined together. Each glass block has a different refractive index.

Figure 7



5 (a) State the **two** conditions necessary for a light ray to undergo total internal reflection at the boundary between two transparent media.

condition 1 .....

.....

condition 2 .....

.....

(2 marks)

question 5 continues on the next page

Turn over ▶

Do not write outside the box

5 (b) Calculate the speed of light in glass **A**.

refractive index of glass **A** = 1.80

speed of light ..... $m\,s^{-1}$

(2 marks)

5 (c) Show that angle θ is about 30°.

(2 marks)

5 (d) The refractive index of glass **C** is 1.40.

Calculate the critical angle between glass **A** and glass **C**.

critical angle ..... degrees

(2 marks)

5 (e) (i) State and explain what happens to the light ray when it reaches the boundary between glass **A** and glass **C**.

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(2 marks)

5 (e) (ii) On **Figure 7** continue the path of the light ray after it strikes the boundary between glass **A** and glass **C**.

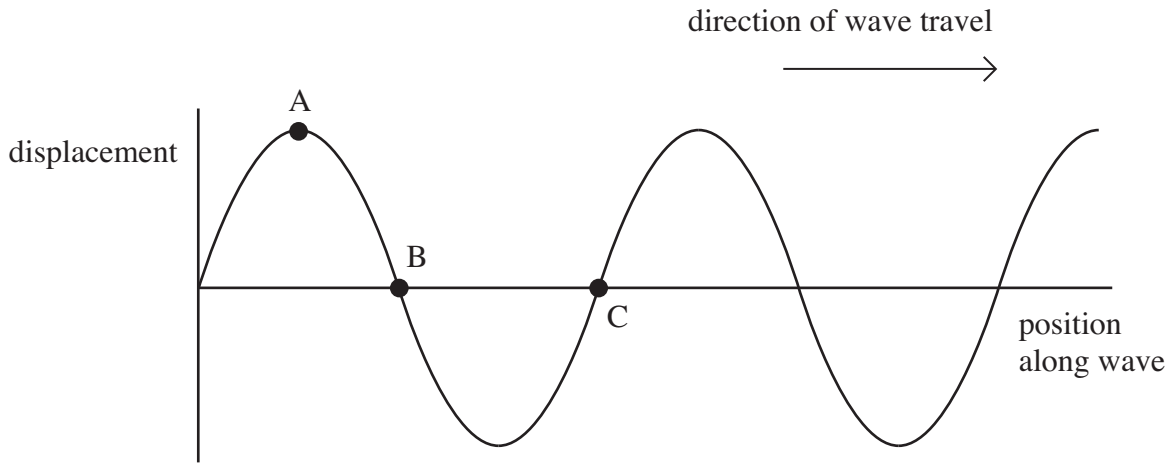
(1 mark)

11

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6 Earthquakes produce transverse and longitudinal seismic waves that travel through rock. **Figure 8** shows the displacement of the particles of rock at a given instant, for different positions along a transverse wave.

Figure 8



6 (a) State the phase difference between

6 (a) (i) points **A** and **B** on the wave .....

6 (a) (ii) points **A** and **C** on the wave. .....

(2 marks)

6 (b) Describe the motion of the rock particle at point **B** during the passage of the next complete cycle.

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(2 marks)

6 (c) A scientist detects a seismic wave that is polarised. State and explain what the scientist can deduce from this information.

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(2 marks)

Turn over ▶

Do not write outside the box

6 (d) The *frequency* of the seismic wave is measured to be 6.0 Hz.

6 (d) (i) Define the frequency of a progressive wave.

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(1 mark)

6 (d) (ii) Calculate the wavelength of the wave if its speed is $4.5 \times 10^3\,m\,s^{-1}$.

wavelength ..... m

(2 marks)

9

7 (a) A laser emits *monochromatic light*.

Explain the meaning of the term monochromatic light.

.....

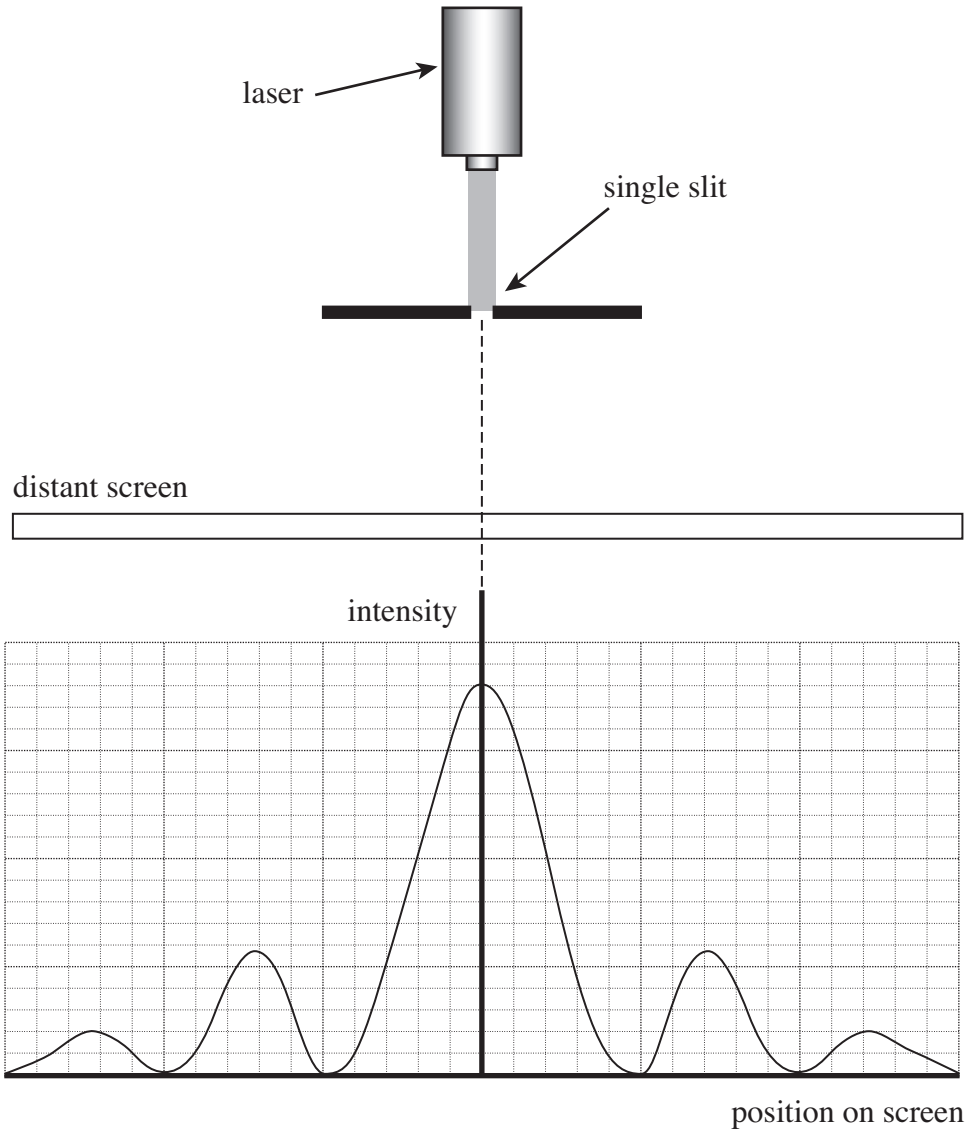
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(1 mark)

Do not write outside the box

7 (b) **Figure 9** shows a laser emitting blue light directed at a single slit, where the slit width is greater than the wavelength of the light. The intensity graph for the diffracted blue light is shown.

Figure 9



The laser is replaced by a laser emitting red light.

7 (b) On the axes shown in **Figure 9**, sketch the intensity graph for a laser emitting red light.
(2 marks)

question 7 continues on the next page

Do not write outside the box

7 (c) State and explain **one** precaution that should be taken when using laser light.

.....

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(2 marks)

7 (d) The red laser light is replaced by a non-laser source emitting white light.

Describe how the appearance of the pattern would change.

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(3 marks)

8

END OF QUESTIONS

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Version 1.0



General Certificate of Education (A-level)
June 2013

Physics A PHYA2

(Specification 2450)

Unit 2: Mechanics, materials and waves

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Question	Part	Sub Part	Marking Guidance	Mark	Comments
1	a	i	1000(N) AND 6000(N) seen **OR** $F = \sqrt{(1000)^2 + (6000)^2}$ ✓ allow incorrect values seen = **6083** (N) (= 6100) ✓ More than 2 sf seen	2	Independent marks Allow full credit for appropriate scale drawing Ignore rounding errors in 3rd sig fig.
1	a	ii	tanΘ = 1000/ 6000 or correct use of sin or cos ✓ Θ = 9.5 (9.46°) ✓ Allow range 9.4 – 10.4	2	Use of cos yields 10.4 Allow use of 6100 Some working required for 2 marks. Max 1 mark for correct calculation of vertical angle (range 79.6 – 80.6) some working must be seen
1	a	iii	($m = W/g$ =) 6500 / 9.81 (= 662.6 kg) ✓ ($a = F/m$ = 6083 / 662.6) = 9.2 (ms^{-2}) ✓ (9.180)	2	Use of weight rather than mass gets zero Correct answer on its own gets 2 marks Penalise use of g=10 in this question part only (max 1)
1	b	i	= 6500 × 600 ✓ (662.6 x 9.81 x 600) = 3 900 000 ✓ (J)	2	Look out for *W* x *g* x *h* which gives 39000000 (gets zero) Correct answer on its own gets 2 marks **Do not allow use of 1/2mv^2 (= 39 000)**

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1	b	ii	(E= Pt =) 320 000 × 55 (= 17 600 k J) **OR** P= 1(b)(i) / 55 (7.09x10^4) ✓ 3.9 / 17.6 OR 70.9 / 320 OR = 0.22(16) ✓ ecf from first line conversion to a percentage (= 22 %) ✓	3	Some valid working required for 3 marks Look out for physics error: Power/time (320/55) then use of inverted efficiency equation yielding correct answer Do not allow percentages >= 100% for third mark
2	a	i	($s = \frac{1}{2}gt^2$) $1.5 = \frac{1}{2}9.81t^2$ OR $t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2\times1.5}{9.81}}$ ✓ (= 0.553) = 0.55 (s) ✓	2	Allow g=10 (0.5477) 0.6 gets 2 marks only if working shown. 0.6 on its own gets 1 mark.
2	a	ii	($s = v\,t$ = 430 × 0.553 = 237.8 =) 240 (m) ✓ ecf a(i)	1	
2	b		their vertical motion is independent of their horizontal motion **OR** downward /vertical acceleration is the same for both **OR** acceleration due to gravity is the same for both **OR** vertical speed/velocity is the same for both ✓ (bullets A and B will be in the air) for the same time ✓ (Horizontal acceleration is zero and thus horizontal) distance is proportional to horizontal speed **OR** *s* = *ut* where *u* is the horizontal velocity ✓	3	Allow 'time is constant' Don't allow 'similar' 'velocity smaller so distance smaller' is not sufficient

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3	a		vol = $\frac{4}{3}\pi 0.011^3$ = (5.5753) 5.6×10^{-6} (m^3)✓ ($m = \rho V$) (= 8100 × 5.575×10^{-6} =) 0.045 (kg) ✓ ecf from first part **candidate's mass x g** (W = 0.045160 × 9.81 = 0.44302 = 0.44 N) ✓ **any 2sf** ✓	4	Allow use of g = 10 0.36kg , 3.5N from use of diameter rather than radius (max 3 from 4)

3	b	i	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. Mentions **all** of the following: • velocity (or speed) increases and then becomes constant (terminal velocity) • acceleration reduces to zero • forces become equal / balanced • weight (allow 'gravity') and drag/friction correctly identified	5-6	

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3	b	i	**For 6 marks: In addition to the above, two of the following:** • drag force increases with speed • (weight /downward force initially) greater than drag/friction etc • resultant force causes acceleration • Resultant force = W – drag • acceleration = gradient • acceleration is maximum (9.81) at the beginning **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. Mentions the **two** following points: • velocity (or speed) increases **OR** velocity (or speed) becomes constant / terminal velocity reached • acceleration decreases **OR** acceleration becomes zero **AND** for 3 marks: mentions **one** more valid point from the 4 above or from the 7 below: for 4 marks: at least two additional points with at least one from the 'Forces' list	3-4	

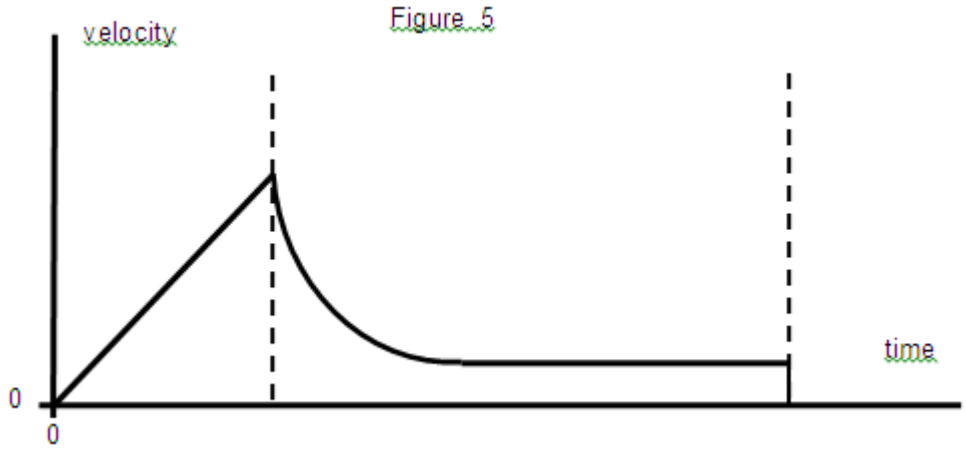
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			• acceleration = gradient • acceleration is maximum (9.81) at the beginning **Forces** • <u>weight</u> greater than drag (before terminal velocity) • there is a resultant force downwards (before terminal velocity) • forces become equal/ balanced / drag = weight • drag force increases with speed. • Resultant force = W – drag **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. **One** valid point from list below For two marks: **Two** valid points **The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.** Mention of the points below may influence the mark given within each category: • velocity increases • velocity becomes constant (terminal velocity) • acceleration is maximum (9.81) at the beginning • acceleration decreases (to zero) • <u>weight</u> greater than drag (before terminal velocity)	1-2	Poor QWC may result in award of the lower mark within a band. **Max 3 for mention of deceleration or increasing acceleration** Several serious misconceptions may reduce a 2 mark answer to 1

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			• there is a resultant force downwards (before terminal velocity) • forces become equal/ balanced / drag = weight • drag force increases with speed. • resultant force = W – drag • acceleration = gradient valid point explaining why rapid decrease in velocity occurs when ball hits bottom of container. E.g. resultant upward force (decelerates the ball)		

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3	b	ii	Figure 5  straight line with positive gradient from origin to first dotted line ✓ descending line (curved or straight but non-vertical) starting from a point on first dotted line (must not have negative velocity at any point) and the line may then become horizontal ✓ <u>curved</u> line descending from first dotted line which is a continuation of the initial line (the gradient must be decreasing initially (a curve) and the line may then become horizontal **AND** extending up to second dotted line (with positive non-zero velocity) **AND** no **incorrect** continuation of line beyond second time line ✓ **OR** straight line with positive gradient from origin to first dotted line ✓ straight line with positive gradient from origin to first dotted line **AND** ascending <u>curved</u> line with positive gradient decreasing, starting from a point on first dotted line (continuation of first line) ✓ extending up to second dotted line **AND** no **incorrect** continuation of line beyond second time line ✓	3	3rd mark: Allow lines that become straight with a constant negative gradient after a curve. Vertical line at the end is not necessary. End of line must be between start of 'e' in 'time' and end of 'w' in 'when'. Allow correct lines beyond the second time line: continuous zero velocity or falling below x axis and rising back to x axis (bouncing) but not reaching a higher speed than descent

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4	a		Force proportional to extension ✓ up to the limit of proportionality (accept elastic limit) ✓ dependent upon award of first mark	2	Symbols must be defined Accept word equation allow '$F=k\Delta L$ (or $F \propto \Delta L$) up to the limit of proportionality' **for the second mark only** allow stress ∝ strain up to the limit of proportionality' **for the second mark only**

4	b		Gradient clearly attempted / use of $k=F/\Delta L$ ✓ correct values used to calculate gradient with appropriate 2sf answer given (1100 or 1200) OR <u>1154 ± 6</u> seen AND <u>load used >= 15</u> ✓ (= 1100 or 1200 (2sf)) **Nm^{-1}** / N/m (newtons per metre) ✓ (not n/m, n/M, N/M)	3	k = 30/0.026 = 1154 or 31/0.027 = 1148 1100 or 1200 with no other working gets 1 out of 2 Do not allow 32/0.0280 or 33/0.0290 (point A) for second mark. 32/0.028 is outside tolerance. 32/0.0277 is just inside.

4	c		any area calculated or link energy with area / use of $1/2F\Delta L$ ✓ 35 whole squares, 16 part gives 43 ± 1.0 **OR** equivalent correct method to find whole area ✓ 0.025 Nm per (1cm) square x candidates number of squares and correctly evaluated OR (= 1.075) = 1.1 (J) (1.05 to 1.10 if not rounded) ✓	3	(or 0.001 Nm for little squares)

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4	d		permanent deformation / permanent extension ✓	1	Allow: 'doesn't return to original length'; correct reference to 'yield' e.g. allow **'extension beyond the yield point'** do not accept: 'does not obey Hooke's law' or 'ceases to obey Hooke's law',

4	e		any line from B to a point on the x axis from 0.005 to 0.020 ✓ straight line from B to x axis (and no further) that reaches x axis for 0.010<=ΔL<= 0.014 ✓	2	

4	f		work done by spring < work done by the load	1	Accept 'less work' or 'it is less' (we assume they are referring to the work done by spring)

5	a		$n_1 > n_2$ ✓ (incident) angle > critical angle (allow θ_c not 'c') **OR** critical angle must be exceeded ✓	2	Allow correct reference to 'optical density' Allow $n_A > n_B$ Do not allow: 'angle **passes** the critical angle'

5	b		($n_s = \frac{c}{c_s}$) ($c_A = \frac{c}{n_A}$ =) $\frac{3.00\times10^8}{1.80}$ ✓ (= 1.667×10^8) = 1.67×10^8 (ms^{-1}) ✓	2	For second mark, don't allow 1.6×10^8 Allow 1.66×10^8 or 1.70×10^8 Allow $1.\dot{6}$ x 10^8

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5	c		$\sin 72 = 1.80 \sin\theta$ ✓ ($\sin\theta = \frac{\sin 72}{1.80} = \frac{0.9510565}{1.8}$ = 0.52836) θ = 31.895 = 31.9 correct answer >= 2sf seen ✓	2	Correct answer on its own gets both marks Do not allow 31 for second mark Allow 31.8 - 32
5	d		$1.80 \sin\theta_c = 1.40$ **OR** $\sin\theta_c = \frac{1.40}{1.80}$ θ_c = 51.058 = 51.1 ° ✓ (accept 51) **OR** = 0.778 ✓	2	Correct answer on its own gets both marks Don't accept 50 by itself
5	e	i	22 + their 5(c) (22+31.9 = 53.9) ✓ 53.9 > (51.1) critical angle ✓ **OR** 5c + 22 **<** their 5d (θ_c) ✓ ecf from (c) and (d) angle less than critical angle ✓	2	If 5c+22 **>** 5d then TIR expected If 5c+22 **<** 5d then REFRACTION expected Allow max 1 for 'TIR because angle > critical angle' only if their 5d >5c +22
5	e	ii	TIR angle correct ✓ ecf from e(i) for refraction answer	1	Tolerance: horizontal line from normal on the right/ horizontal line from top of lower arrow. If 5ei not answered then ecf 5(d). If 5ei and 5d not answered then ecf 5c
6	a	i	$\pi/2$ (radians) or 90 (degrees) ✓	1	No path differences Penalise contradictions No fractions of a cycle

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6	a	ii	$3\pi/2$ (rad) or 270 (degrees) ✓	1	No path differences Penalise contradictions No fractions of a cycle

6	b		(oscillation or motion) perpendicular to direction of wave (travel /velocity/energy transfer) ✓ (oscillates from equilibrium to maximum positive displacement, back to equilibrium, then to max negative displacement) and back to equilibrium /starting position /rest position ✓	2	do not allow 'up and down' for first mark allow 'up and down', or 'down then up', 'side to side', 'rise and fall' in place of oscillates Allow 'rest position', 'starting position' ,'middle', 'centre line' ref to nodes/antinodes not allowed for 2nd mark

6	c		(the wave is) transverse **OR** not longitudinal✓ only transverse can be polarised **OR** longitudinal waves cannot be polarised **OR** oscillations are in one plane ✓	2	accept it is an S wave or secondary wave

6	d	i	number of waves/complete cycles/wavelengths (passing a point/produced) per second ✓	1	or 'unit time' **allow: (number of) oscillations/vibrations/cycles per second** allow $f=1/T$ only if T is correctly defined do not allow references to f=c/λ

6	d	ii	($v = f/\lambda$ $\lambda = v/f$ =) $4.5 \times 10^3 / 6.0$ ✓ = 750 (m) ✓	2	correct answer only gets 2 marks

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7	a		single frequency (or wavelength or photon energy) ✓	1	not single colour accept 'very narrow band of frequencies'

7	b		subsidiary maxima (centre of) peaks further away from centre ✓ subsidiary maxima peaks further away from centre **AND** central maximum twice width of subsidiaries **AND** symmetrical ✓	2	For second mark: One square tolerance horizontally. One whole subsid max seen on either side. Central higher than subsid and subsid same height +/- 2 squares. Minima on the x axis +/- 1 square. Must see 1 whole subsidiary for second mark

7	c		ONE FROM: • don't shine towards a person • avoid (accidental) reflections • wear laser safety goggles • 'laser on' warning light outside room • Stand behind laser • other sensible suggestion ✓ • eye / skin damage could occur ✓	2	allow green goggles for red laser, 'high intensity goggles', etc. not 'goggles', 'sunglasses'

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7	d		3 from 4 ✓✓✓ • central white (fringe) • each/every/all subsidiary maxima are composed of a spectrum (clearly stated or implied) • each/every/all subsidiary maxima are composed of a spectrum (clearly stated or implied) **AND** (subsidiary maxima) have violet (allow blue) nearest central maximum **OR** red furthest from center • Fringe spacing less / maxima are wider / dark fringes are smaller (or not present)	3	allow 'white in middle' For second mark do not allow 'there are colours' or 'there is a spectrum' on their own Allow 'rainbow pattern' instead of spectrum but not 'a rainbow' If they get the first, the second and third are easier to award Allow full credit for annotated sketch

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2013

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Friday 18 January 2013 9.00 am to 10.15 am

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed
- 1 hour 15 minutes.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on a blank page.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

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Do not write outside the box

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

1 The world record for a high dive into deep water is 54 m.

1 (a) Calculate the loss in gravitational potential energy (gpe) of a diver of mass 65 kg falling through 54 m.

loss in gpe = ... J
(2 marks)

1 (b) Calculate the vertical velocity of the diver the instant before he enters the water. Ignore the effects of air resistance.

velocity = ... $m\,s^{-1}$
(2 marks)

1 (c) Calculate the time taken for the diver to fall 54 m. Ignore the effects of air resistance.

time = ... s
(2 marks)

Do not write outside the box

1 (d) Explain, with reference to energy, why the velocity of the diver is independent of his mass if air resistance is insignificant.

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(3 marks)

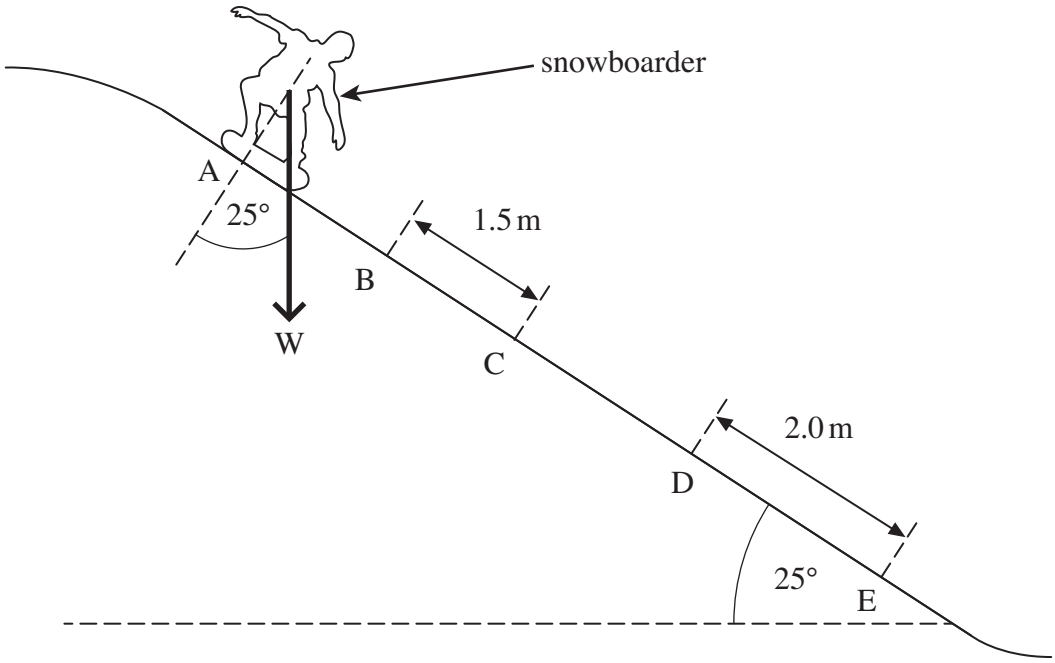
9

Turn over for the next question

Do not write outside the box

2 A snowboarder slides down a slope, as shown in **Figure 1**. Between **B** and **C** her acceleration is uniform.

Figure 1



2 (a) The snowboarder travels 1.5 m from B to C in a time of 0.43 s and her velocity down the slope at C is 5.0 m s^{-1}.

Calculate her velocity down the slope at B.

velocity = ... m s^{-1}

(3 marks)

2 (b) The combined mass of the snowboarder and snowboard is 75 kg and the angle of the slope is 25°.

2 (b) (i) Calculate the component of the weight of the snowboarder and snowboard acting down the slope.

weight component = ... N

(2 marks)

Do not write outside the box

2 (b) (ii) At D the snowboarder has reached a constant velocity. She moves a distance of 2.0 m at constant velocity between D and E.

Calculate the work done against resistive forces as she moves from D to E.

work done = ... J

(1 mark)

2 (c) State and explain what happens to the gravitational potential energy lost between D and E.

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(3 marks)

9

Turn over for the next question

Do not write outside the box

3 (a) State the principle of moments.

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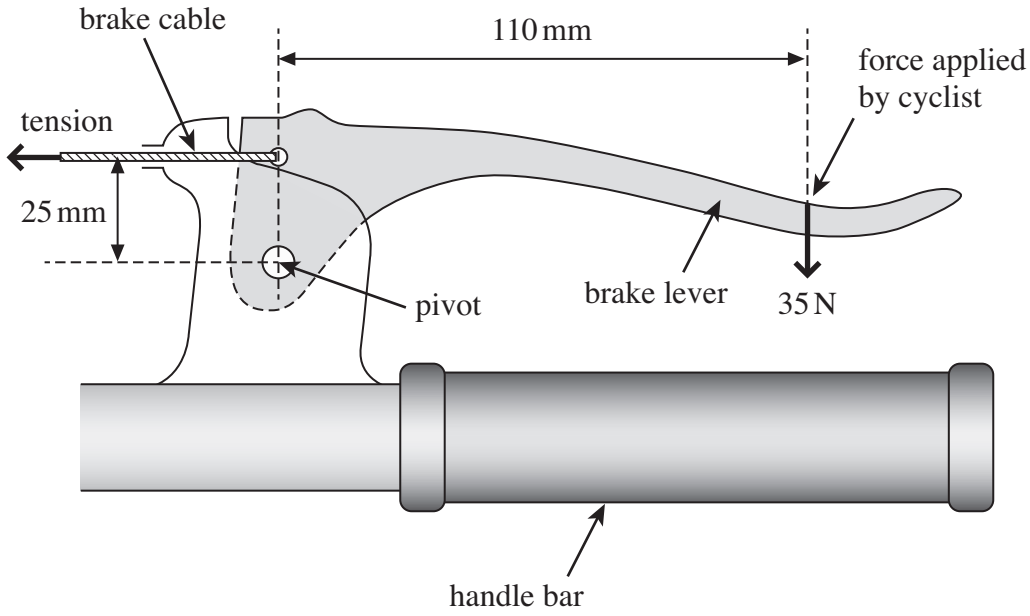
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(3 marks)

3 (b) **Figure 2** shows a bicycle brake lever that has been pulled with a 35 N force to apply the brake.

Figure 2



3 (b) (i) Calculate the moment of the force applied by the cyclist about the pivot. State an appropriate unit.

moment = ... unit .....

(3 marks)

Do not write outside the box

3 (b) (ii) Calculate the tension in the brake cable. Assume the weight of the lever is negligible.

tension = ... N
(3 marks)

3 (c) In order to maintain a constant velocity of 15 m s^{-1} downhill, the cyclist applies the brake. The power developed by the braking force is 2.8 kW.

Calculate the total average frictional force between the brake blocks and the wheel rim.

frictional force = ... N
(2 marks)

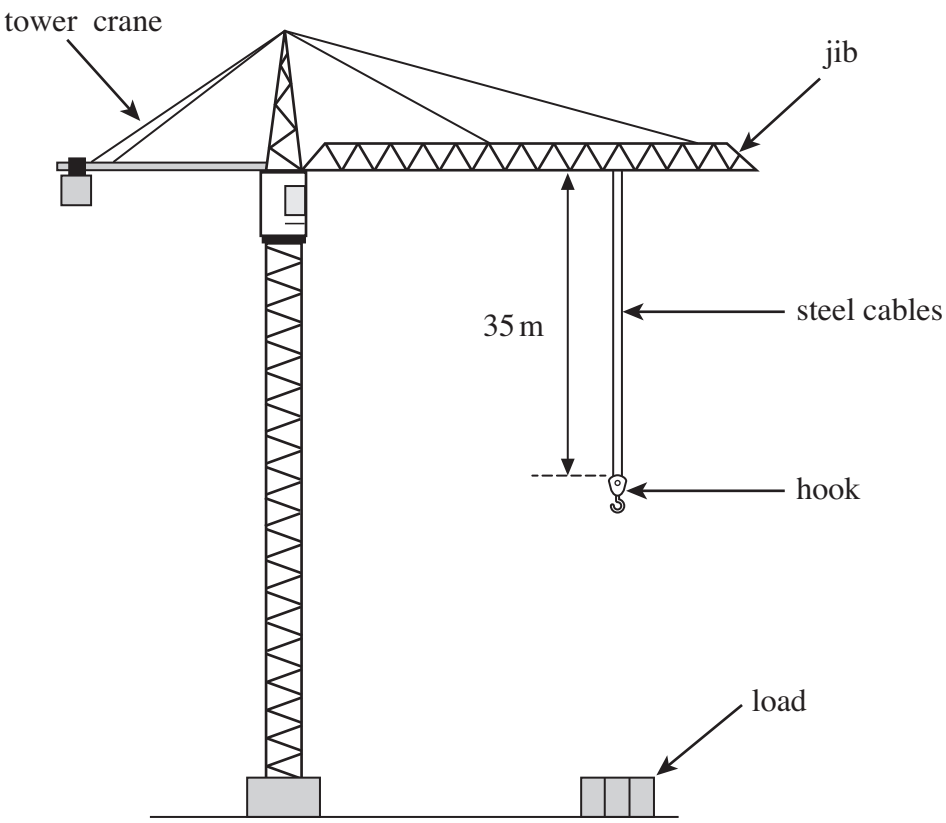
11

Turn over for the next question

Do not write outside the box

4 **Figure 3** shows a tower crane that has two identical steel cables. The length of each steel cable is 35 m from the jib to the hook.

Figure 3



4 (a) Each cable has a mass of 4.8 kg per metre. Calculate the weight of a 35 m length of **one** cable.

weight = ... N

(2 marks)

4 (b) The cables would break if the crane attempted to lift a load of 1.5×10^6 N or more. Calculate the breaking stress of **one** cable.

cross-sectional area of each cable = 6.2×10^{-4} m^2

breaking stress = ... Pa

(2 marks)

Do not write outside the box

4 (c) When the crane supports a load **each** cable experiences a stress of 400 MPa. Each cable obeys Hooke's law. Ignore the weight of the cables.

Young modulus of steel = 2.1×10^{11} Pa

4 (c) (i) Calculate the weight of the load.

weight = ... N
(2 marks)

4 (c) (ii) The unstretched length of each cable is 35 m.

Calculate the extension of each cable when supporting the load.

extension = ... m
(3 marks)

4 (c) (iii) Calculate the combined stiffness constant, k, for the **two** cables.

stiffness constant = ... $N\,m^{-1}$
(2 marks)

4 (c) (iv) Calculate the total energy stored in both stretched cables.

energy stored = ... J
(2 marks)

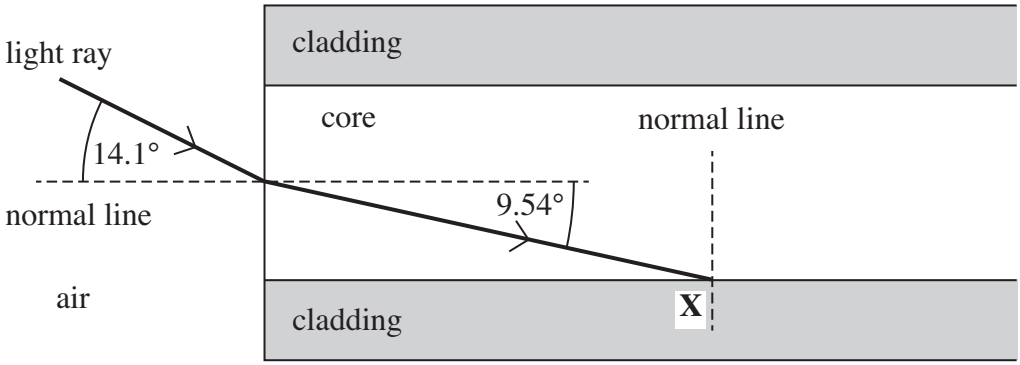
13

Turn over ▶

Do not write outside the box

5 **Figure 4** shows a section of a typical glass step-index optical fibre used for communications.

Figure 4



5 (a) Show that the refractive index of the core is 1.47.

(1 mark)

5 (b) The refracted ray meets the core-cladding boundary at an angle exactly equal to the critical angle.

5 (b) (i) Complete **Figure 4** to show what happens to the ray after it strikes the boundary at **X**.

(2 marks)

5 (b) (ii) Calculate the critical angle.

critical angle = ...degrees

(1 mark)

Do not write outside the box

5 (b) (iii) Calculate the refractive index of the cladding.

refractive index = ...

(2 marks)

5 (c) Give **two** reasons why optical fibres used for communications have a cladding.

reason 1 .....

.....

reason 2 .....

.....

(2 marks)

8

Turn over for the next question

Do not write outside the box

6 Discuss the formation of stationary waves on a string or rope. Your account should include:

- a labelled diagram of a stationary wave
- the conditions necessary for stationary waves to form
- a definition of the terms node and antinode
- an explanation of how nodes and antinodes form.

The quality of written communication will be assessed in your answer.

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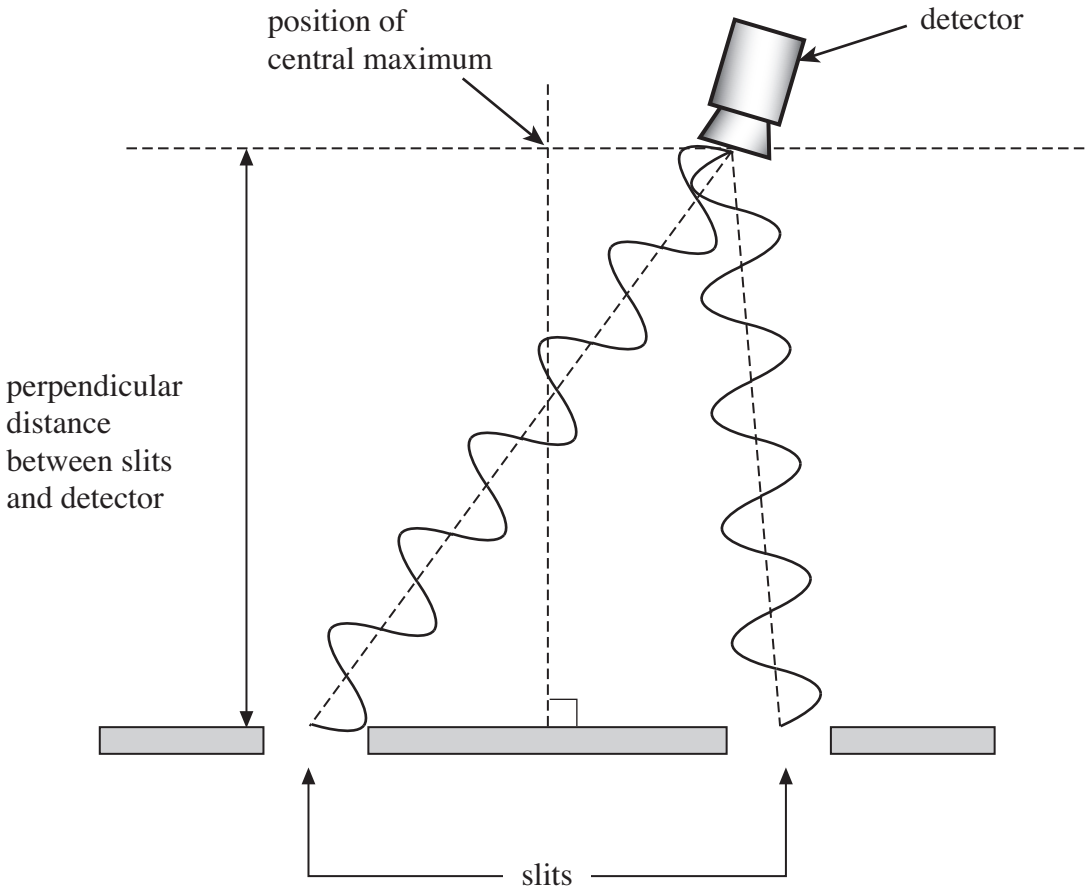
(6 marks)

6

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7 **Figure 5** shows the paths of microwaves from two narrow slits, acting as coherent sources, through a vacuum to a detector.

Figure 5



7 (a) Explain what is meant by *coherent sources*.

.....

.....

.....

.....

(2 marks)

7 (b) (i) The frequency of the microwaves is 9.4 GHz.

Calculate the wavelength of the waves.

wavelength = ... m

(2 marks)

Turn over ▶

Do not write outside the box

7 (b) (ii) Using **Figure 5** and your answer to part **(b)(i)**, calculate the path difference between the two waves arriving at the detector.

path difference = ... m

(1 mark)

7 (c) State and explain whether a maximum or minimum is detected at the position shown in **Figure 5**.

.....

.....

.....

.....

(3 marks)

7 (d) The experiment is now rearranged so that the perpendicular distance from the slits to the detector is 0.42 m. The interference fringe spacing changes to 0.11 m.

Calculate the slit separation. Give your answer to an appropriate number of significant figures.

slit separation = ... m

(3 marks)

7 (e) With the detector at the position of a maximum, the frequency of the microwaves is now doubled. State and explain what would now be detected by the detector in the same position.

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(3 marks)

14

END OF QUESTIONS

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Version 1.0



General Certificate of Education (A-level)
January 2013

Physics A PHYA2

(Specification 2450)

Unit 2: Mechanics, materials and waves

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

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Question				Mark & Comments	
1	a		$(Ep = mg\Delta h)$ = 65 × 9.81× 54 ✓ = 3.44×10^4 = 3.4×10^4 (J) ✓ (34433)	2	max 1 if g =10 used (35100 J) Correct answer gains both marks
1	b		$v = \sqrt{\frac{2Ep}{m}}$ OR $v = \sqrt{\frac{2\times34433}{65}}$ ✓ = 33 (32.55 ms^{-1}) ✓ ecf 1(a) OR correct use of $v^2 = 2\,g\,s$	2	allow 32 (32.3) for the use of 34000 allow 32.6 don't penalise g=10 (32.863)
1	c		$(s = 1/2\ gt^2$ or other kinematics equation) $t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2\times54}{9.81}}$ ✓ = 3.318 = 3.3 (s) ✓ ecf from 1(b) if speed used	2	With use of g= 9.8 or 9.81or 10 and/or various suvat equations, expect range 3.2 to 3.4 s. No penalty for using g= 10 here.
1	d		(all G)PE (lost) is transferred to KE no (GP)E transferred to 'heat' / 'thermal' / internal energy **OR** ✓ (therefore) $mg\Delta h = \frac{1}{2}mv^2$ ✓ mass cancels ✓	3	Must imply that <u>all</u> GPE is transferred to KE. E.g. accept 'loss of GPE is gain in KE' but not: 'loses GPE and gains KE. Accept 'm's crossed out
			total	9	

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2	a		$(s = \frac{1}{2}(u + v)t)$ $u = \frac{2s}{t}$ - *v* **OR** substitution in above equation **OR** $u = \frac{2\times1.5}{0.43}$ - 5.0 ✓ = 6.9767 – 5.0 ✓ = 2.0 ✓ (1.98 ms^{-1})	3	Correct answer with no working gets 2 out of three. Full credit for use of *g*sin25 = acceleration down slope. This yields answer 3.22 ms^{-1} Allow 1sf answer (2).
2	b	i	(*F* = 75 × 9.81 ×) sin25 (^{o})✓ = 310 (311, 310.94) (N) ✓	2	use of g = 10 not penalised here 'sin25' on its own Use of g=10 yields 317 Allow cos65
2	b	ii	$W = Fs$ = 311× 2.0 = 620 (622 J) ✓ ecf (2bi) × 2.0	1	
2	c		Idea that GPE is ultimately transferred to: internal (energy) /'heat'/ 'thermal' (energy in the surroundings) ✓ Correct reference to a named resistive force: friction / drag / air resistance ✓ All GPE becomes 'heat', etc **OR** no (overall) increase in KE **OR** reference to work done against or by a resistive force ✓	3	Allow transfer of GPE to KE and then to 'thermal' etc Do not allow reference to 'sound' on its own Don't accept implication that a resistive force is a form of energy Do not allow references to loss of body heat. Allow: '(GPE) not converted to KE'
			total	**9**	

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3	a		(sum of) clockwise moment(s) = (sum of) anticlockwise moment(s) ✓ **sum of** clockwise moment **s** = **sum of** anticlockwise moment **s** (about any given point) ✓ (for a system in) equilibrium ✓ allow 'balanced'	3	third mark depends upon the first Don't allow references to 'forces' being balanced. Don't allow 'stationary'. Allow 'total', etc instead of sum Ignore definitions of moment
3	b	i	35 × 110 (×10^{-3}) ✓ (= 3.85) = 3.9 (or 3.8) ✓ (3.9) **Nm** / allow (3850, 3900) **Nmm** ✓ don't allow nm, NM	3	allow 4 or 3.90 but not 4.0 unit must match answer
3	b	ii	3.85 = T × 25 (×10^{-3}) ✓ ecf from (bi) T = 3.85 / 25 (×10^{-3}) = 0.150 (×10^{3}) ✓ ecf = 150 (154 N) ✓	3	Correct answer with no working gets 2 out of three. Allow 156 (160) N from rounding error
3	c		($P = Fv$, $F = P/v$) = 2.8(×10^{3}) / 15 ✓ = 190 (186.7 N) ✓	2	
			total	11	

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4	a		$(W = mg)$ = 4.8 × 35 × 9.81✓ =1600 (1648 N) ✓	2	Allow g=10 : 1680 (1700 N) g = 9.8 → 1646 N max 1 for doubling or halving. Max 1 for use of grammes
4	b		(stress = tension / area) = (0.5 ×) 1.5×10^{6} / 6.2×10^{-4} OR = 1.5×10^{6} / (2 ×) 6.2×10^{-4} ✓ = 1.2×10^{9} (1.21 GPa) ✓	2	For first mark, forgive absence of or incorrect doubling/ halving. Forgive incorrect prefix if correct answer seen.
4	c	i	(weight = stress × area) = 400×(10^{6}) × 6.2×10^{-4} (= 248 000 N) ✓ (× 2 =) 5.0×10^{5} (496 000 N) ✓	2	max 1 mark for incorrect power of ten in first marking point max 1 mark for doubling or halving both stress and area Forgive incorrect prefix if correct answer seen. Look out for YM ÷ 400k Pa which gives correct answer but scores zero.
4	c	ii	$\Delta L = \frac{F\ L}{A\ E}$ **OR** correct substitution into a correct equation (forgive incorrect doubling or halving for this mark only) ✓ = $\frac{(\text{Ans } 4\text{ci}/\mathbf{2})\times 35}{6.2\times10^{-4}\times 2.1\times 10^{11}}$ **OR** $\frac{\text{Ans } 4\text{ci} \times 35}{\mathbf{2}\times 6.2\times10^{-4}\times 2.1\times 10^{11}}$ ✓ ecf from 4ci (= $\frac{(4.96\times10^{5}/2)\times 35}{6.2\times10^{-4}\times 2.1\times 10^{11}}$ =) 6.7×10^{-2} (6.667×10^{-2} m) ✓ ecf from 4ci	3	OR alternative method: strain = stress/ *E* then Δ*L* = *L* x strain If answer to 4ci is used, it must be halved, unless area is doubled, for this mark Any incorrect doubling or halving is max 1 mark. Allow 0.07

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4	c	iii	($k = \frac{F}{\Delta L}$) = $\frac{2 \times 248\,000}{6.667 \times 10^{-2}}$ OR correct substitution into $F=k\Delta L$ ✓ ecf ci and cii (answer 4c(i) ÷ answer 4c(ii)) = 7.4(4)×10^{6} ✓ (Nm^{-1})	2	Allow halving extension for force on one cable Correct answer gains both marks
4	c	iv	($E = \frac{1}{2}F\Delta L$ or $E = \frac{1}{2}k\Delta L^2$) = ½ × 496 000 × 6.667×10^{-2} OR $½ \times 7.4(4) \times 10^{6} \times (6.667 \times 10^{-2})^2$ ✓ ecf ci, cii, ciii = $1.6(5) \times 10^{4}$ (J) ✓	2	Correct answer gains both marks Forgive incorrect prefix if correct answer seen. Doubling the force gets zero.
			total	13	

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5	a		$(n =) \frac{\sin 14.1}{\sin 9.54}$ **OR** 0.2436 / 0.1657 working must be seen **AND** (= 1.4699) = 1.47 ✓ given correctly to 3 or more significant figures	1	0.24/0.17 = 1.41 is not acceptable Watch for: 14.1 / 9.54 = 1.478
5	b	i	ray goes along the boundary ✓ (partial) reflection shown ✓ (allow dotted or solid line. This mark can be awarded if TIR is shown)	2	Deviation by no more than 1mm by the end of the diagram. Tolerance: 70° to 85° to normal or labelled e.g. θ and θ, etc
5	b	ii	(90 – 9.54 =) 80.46 or 80.5 ✓ (^{o}) (allow 80°)	1	Don't allow 81 degrees
5	b	iii	$(n = n_c \sin\theta)$ = 1.47 $\sin 80.46^\circ$ ✓ ecf bii =1.45 ✓ (1.4496)	2	allow 80 or 81 degrees here Correct answer gains both marks
5	c		• protect the <u>core</u> (from scratches, stretching or breakage) • prevent 'crossover' of signal / ensure security of data / prevent loss of information/data/signal • increase the critical angle / reduce pulse broadening/(modal)dispersion / rays with a small angle of incidence will be refracted out of the core • increase rate of data transfer max two correct (from separate bullet points) ✓✓	2	comment on 'quality' of signal' is not sufficient don't allow 'leakage' on its own. Don't allow 'loss of light' Allow 'leakage of signal', etc
			total	8	

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6	5/6		**Good / Excellent** **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. Mentions: • (1) waves (meet when) travelling in <u>opposite</u> directions / cross/ wave meets a reflected wave / etc • (2) same wavelength (or frequency) • (3) node – point of minimum or no disturbance • (4) antinode – point of maximum disturbance / maximum displacement/amplitude occurs • (5) node - two waves (always) cancel/ destructive interference / 180° phase difference (between displacements of the two waves at the node) • (6) antinode – reinforcement / constructive interference occurs / (displacements) in phase • (7) mention of <u>superposition</u> of the two waves 5 marks: points (1) **AND** (2) with three points from (3), (4), (5), (6) or (7) for 6 marks: points (1) to (6) must be seen	5/6	can say disturbance, amplitude or displacement labelled diagram can provide supporting evidence but labels: 'node' / 'antinode' by themselves cannot replace points 3 and 4
	3/4		**Modest** **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. Mentions any 3 of the 7 points. 4 marks: (1) **OR** (2) **AND** three others.	3/4	

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	1/2		**Limited** **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. One relevant point **OR** a relevant, labelled diagram 2 marks: two points OR one point and a relevant labelled diagram	1/2	
			total	6	

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7	a		same wavelength/ frequency ✓ constant phase relationship ✓ allow 'constant phase difference' but not 'in phase'	2	
7	b	i	($\lambda = \frac{c}{f}$) $3.00\times10^{8} = 9.4\times (10^{9})\ \lambda$ OR $= \frac{3.00\times10^{8}}{9.4\times(10^{9})}$ ✓ $= 3.2\times10^{-2}$ $(3.19\times10^{-2}$ m) ✓	2	Use of speed of sound gets zero Allow 0.03
7	b	ii	3.2×10^{-2} ✓ (m) ecf from bi	1	Don't allow '1 wavelength', 1λ, etc Do not accept: zero, 2π, 360°
7	c		maximum (at position shown) ✓ constructive interference / reinforcement ✓ **ecf for 'minimum' or for reference to wrong maximum** (the waves meet) 'in step' / peak meets peak / trough meets trough / path difference is (n)λ / in phase ✓	3	allow constructive superposition. 'Addition' is not enough
7	d		$s = \frac{\lambda D}{w}$ $= \frac{0.0319\times0.42}{0.11}$ ✓ ecf 7bi = 0.12 (0.1218 m) ✓ = **any <u>2sf</u>** number ✓	3	Don't allow use of Fig 5 as a scale diagram. Do not penalise *s* and *w* symbols wrong way round in working if answer is correct. Correct answer gains first two marks. Independent sf mark for **any** 2 sf number

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7	e		a maximum ✓ (f × 2 results in) $\lambda/2$ ✓ path difference is an even number of multiples of the new wavelength (2n λ_{new}) ✓ allow 'path difference is $n\lambda$' / any even number of multiples of the new λ quoted e.g. 'path difference is now 2λ'	3	Candidates stating 'minimum' can get second mark only
			total	14	

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2012

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Friday 25 May 2012 1.30 pm to 2.45 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

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Do not write outside the box

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

1 (a) (i) State **two** vector quantities.

vector quantity 1 .....

vector quantity 2 .....

1 (a) (ii) State **two** scalar quantities.

scalar quantity 1 .....

scalar quantity 2 .....

(2 marks)

1 (b) The helicopter shown in **Figure 1a** is moving horizontally through still air. The lift force from the helicopter's blades is labelled **A**.

Figure 1a

not to scale

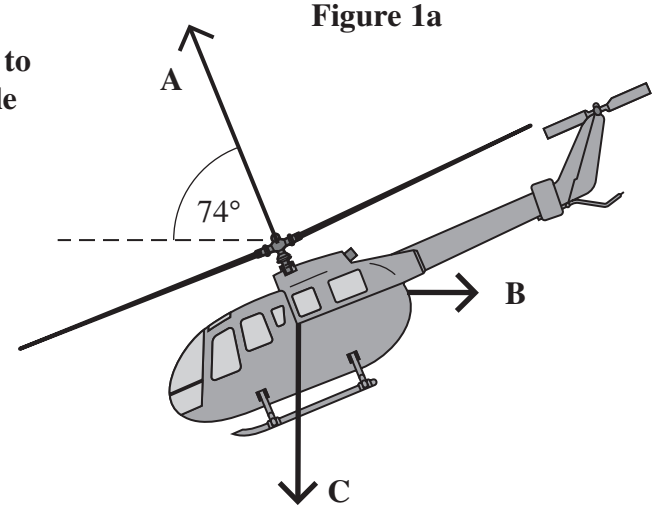


Figure 1b



1 (b) (i) Name the two forces **B** and **C** that also act on the helicopter.

B .....

C .....

(2 marks)

Do not write outside the box

1 (b) (ii) The force vectors are also shown arranged as a triangle in **Figure 1b**.

State and explain how **Figure 1b** shows that the helicopter is moving at a constant velocity.

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(2 marks)

1 (c) The lift force, **A**, is 9.5 kN and acts at an angle of 74° to the horizontal.

Calculate the weight of the helicopter. Give your answer to an appropriate number of significant figures.

answer = ... N

(3 marks)

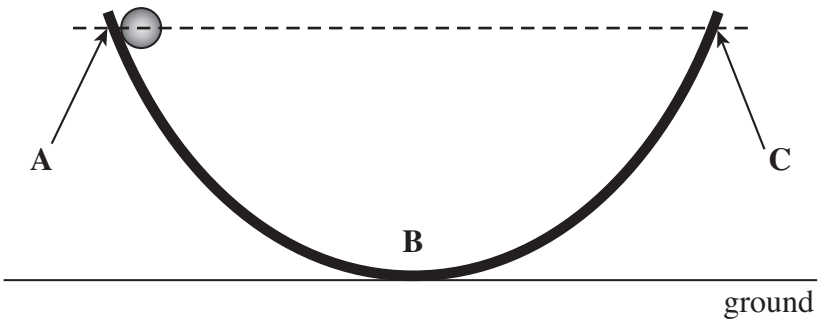
9

Turn over for the next question

Do not write outside the box

2 In the 17th century, when thinking about forces, Galileo imagined a ball moving in the absence of air resistance on a frictionless track as shown in **Figure 2**.

Figure 2



2 (a) Galileo thought that, under these circumstances, the ball would reach position **C** if released from rest at position **A**. Position **C** is the same height above the ground as **A**.

Using ideas about energy, explain why Galileo was correct.

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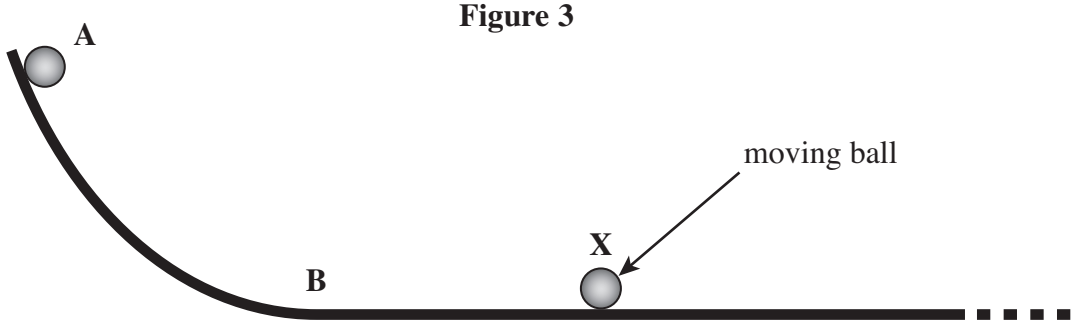
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(3 marks)

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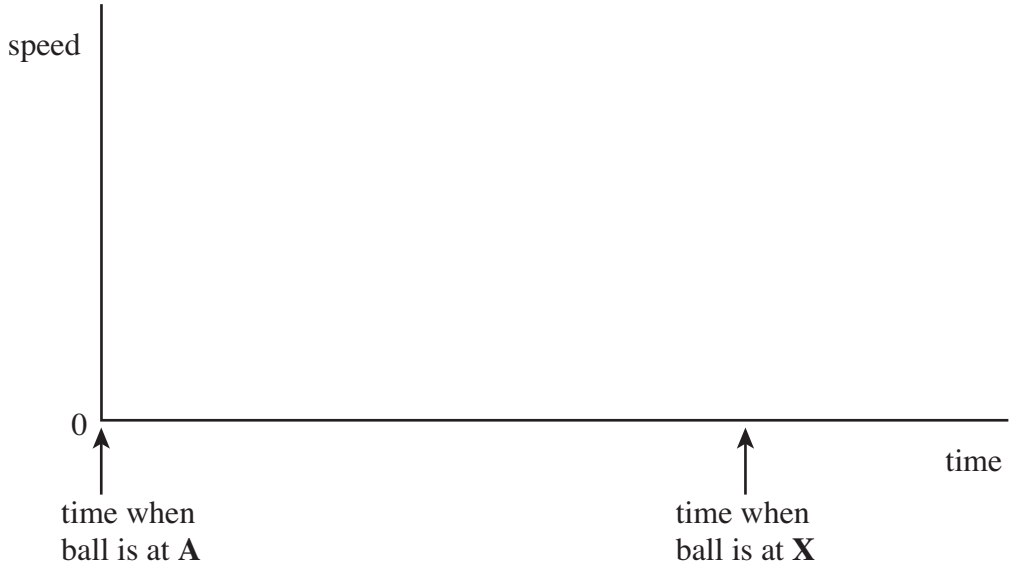
2 (b) Galileo then imagined that the track was changed, as shown in **Figure 3**.

Figure 3



The slope beyond **B** was now horizontal.

On the axes below, sketch a speed – time graph for the ball from its release at **A** until it reaches the position **X** shown in **Figure 3**. Indicate on your graph the time when the ball is at **B**.



(3 marks)

2 (c) Newton later published his three laws of motion.

Explain how Newton's first law of motion is illustrated by the motion of the ball between **B** and **X**.

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(2 marks)

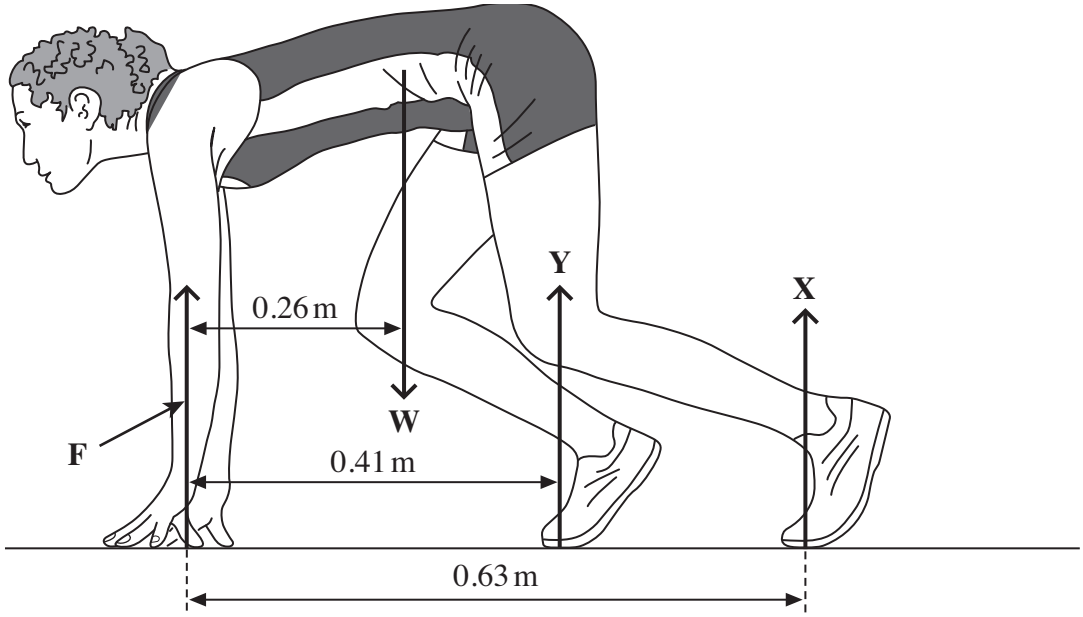
8

Turn over ▶

Do not write outside the box

3 A sprinter is shown before a race, stationary in the 'set' position, as shown in **Figure 4**. Force **F** is the resultant force on the sprinter's finger tips. The reaction force, **Y**, on her forward foot is 180 N and her weight, **W**, is 520 N. **X** is the vertical reaction force on her back foot.

Figure 4



3 (a) (i) Calculate the moment of the sprinter's weight, **W**, about her finger tips.
Give an appropriate unit.

answer = ... unit .....
(2 marks)

3 (a) (ii) By taking moments about her finger tips, calculate the force on her back foot, marked **X**.

answer = ...N
(3 marks)

Do not write outside the box

3 (a) (iii) Calculate the force **F**.

answer = ...N
(1 mark)

3 (b) The sprinter starts running and reaches a horizontal velocity of 9.3 m s^{-1} in a distance of 35 m.

3 (b) (i) Calculate her average acceleration over this distance.

answer = ...m s^{-2}
(2 marks)

3 (b) (ii) Calculate the resultant force necessary to produce this acceleration.

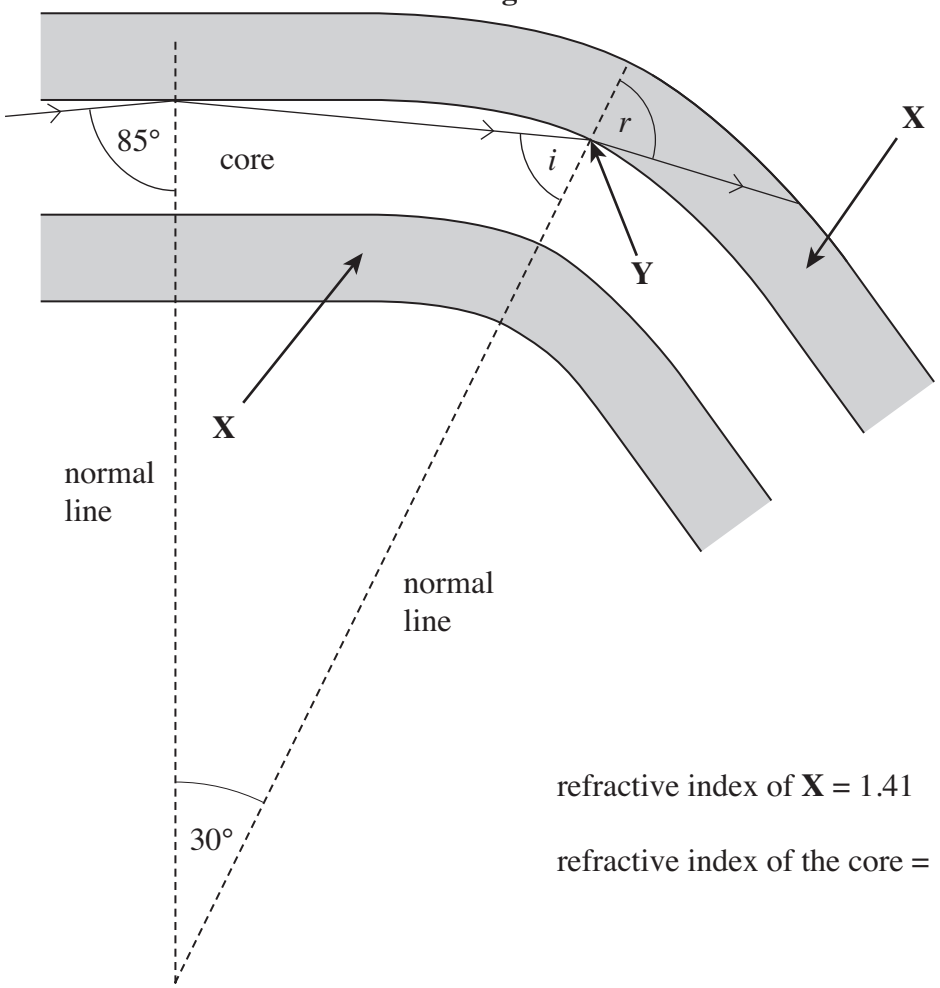
answer = ...N
(2 marks)

10

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4 **Figure 5** shows a cross-section through an optical fibre used for communications.

Figure 5



refractive index of **X** = 1.41

refractive index of the core = 1.46

4 (a) (i) Name the part of the fibre labelled **X**.

.....

(1 mark)

4 (a) (ii) Calculate the critical angle for the boundary between the core and **X**.

answer = ...degrees

(2 marks)

Do not write outside the box

4 (b) (i) The ray leaves the core at **Y**. At this point the fibre has been bent through an angle of 30° as shown in **Figure 5**.

Calculate the value of the angle i.

answer = ...degrees
(1 mark)

4 (b) (ii) Calculate the angle r.

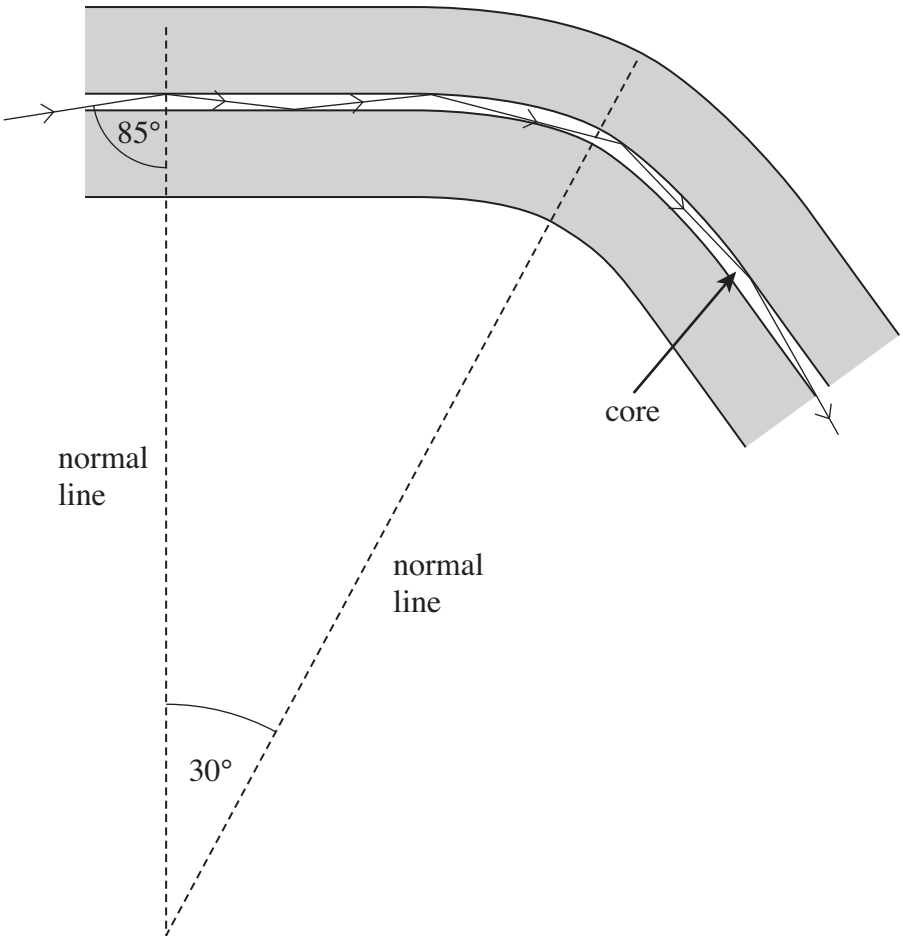
answer = ...degrees
(2 marks)

Question 4 continues on the next page

Do not write outside the box

4 (c) The core of another fibre is made with a smaller diameter than the first, as shown in **Figure 6**. The curvature is the same and the path of a ray of light is shown.

Figure 6



4 (c) State and explain **one** advantage associated with a smaller diameter core.

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(2 marks)

8

Do not write outside the box

5 (a) Describe an experiment to accurately determine the spring constant k of a spring that is thought to reach its limit of proportionality when the load is about 20 N.

Include details of the necessary measurements and calculations and describe how you would reduce uncertainty in your measurements. A space is provided for a labelled diagram should you wish to include one.

The quality of your written communication will be assessed in this question.

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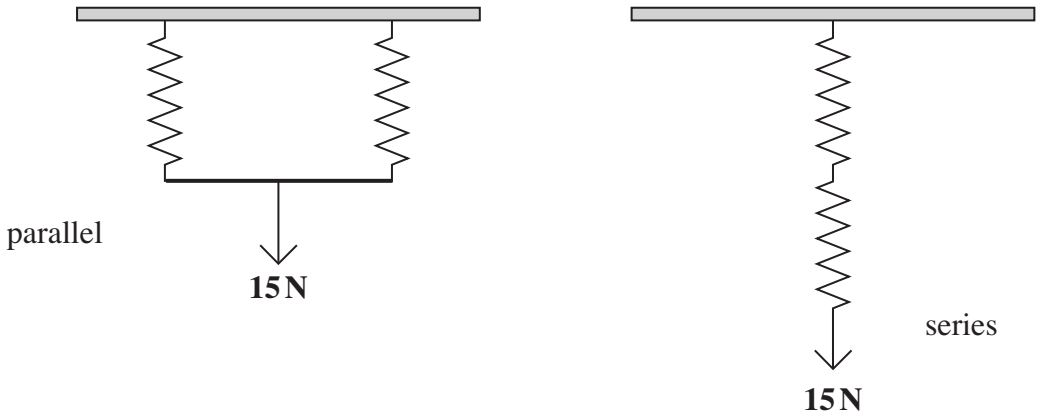
(6 marks)

Turn over ▶

Do not write outside the box

5 (b) Two identical springs, each having a spring constant of $85\,N\,m^{-1}$, are shown arranged in parallel and series in **Figure 7**.

Figure 7



A load of 15 N is attached to each arrangement.

5 (b) (i) Calculate the extension for the parallel arrangement when the load is midway between the lower ends of the springs.

answer = ... m

(2 marks)

5 (b) (ii) Calculate the extension for the series arrangement.

answer = ... m

(2 marks)

5 (b) (iii) Calculate the energy stored in the parallel arrangement.

answer = ... J

(2 marks)

Do not write outside the box

5 (b) (iv) Without further calculation, discuss whether the energy stored in the series arrangement is less, or greater, or the same as in the parallel arrangement.

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(3 marks)

15

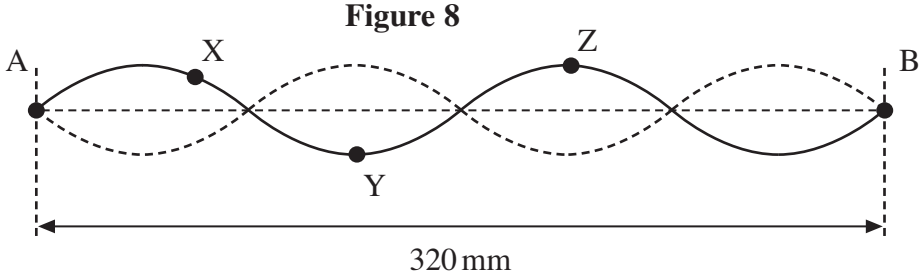
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6 When a note is played on a violin, the sound it produces consists of the fundamental and many overtones.

Figure 8 shows the shape of the string for a stationary wave that corresponds to one of these overtones. The positions of maximum and zero displacement for one overtone are shown. Points **A** and **B** are fixed. Points **X**, **Y** and **Z** are points on the string.

Figure 8



6 (a) (i) Describe the motion of point **X**.

.....

.....

.....

.....

(2 marks)

6 (a) (ii) State the phase relationship between

X and **Y** .....

X and **Z** .....

(2 marks)

6 (b) The frequency of this overtone is 780 Hz.

6 (b) (i) Show that the speed of a progressive wave on this string is about 125 m s^{-1}

(2 marks)

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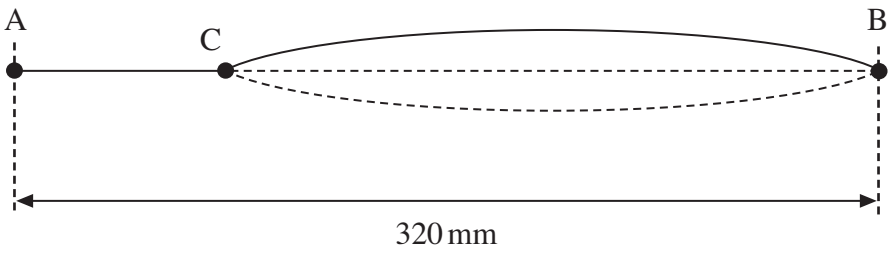
6 (b) (ii) Calculate the time taken for the string at point **Z** to move from maximum displacement back to zero displacement.

answer = ... s

(3 marks)

6 (c) The violinist presses on the string at **C** to shorten the part of the string that vibrates. **Figure 9** shows the string between **C** and **B** vibrating in its fundamental mode. The length of the whole string is 320 mm and the distance between **C** and **B** is 240 mm.

Figure 9



6 (c) (i) State the name given to the point on the wave midway between **C** and **B**.

.....

(1 mark)

6 (c) (ii) Calculate the wavelength of this stationary wave.

answer = ...m

(2 marks)

Do not write outside the box

6 (c) (iii) Calculate the frequency of this fundamental mode. The speed of the progressive wave remains at $125\,m\,s^{-1}$.

13

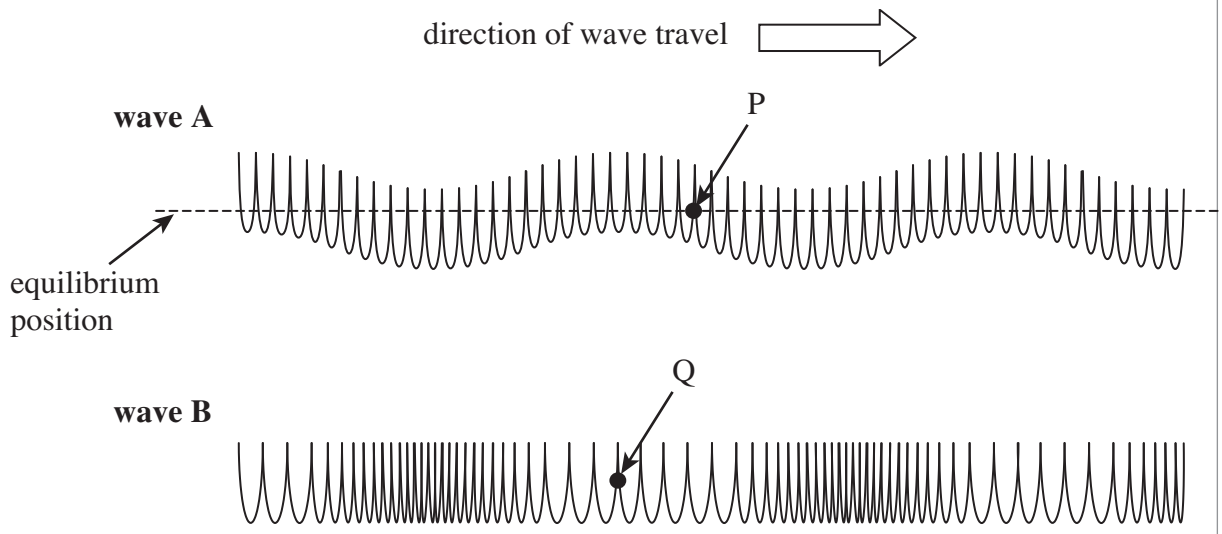
answer = ...Hz

(1 mark)

Do not write outside the box

7 **Figure 10** shows two ways in which a wave can travel along a slinky spring.

Figure 10



7 (a) State and explain which wave is longitudinal.

.....

.....

(2 marks)

7 (b) On **Figure 10**,

7 (b) (i) clearly indicate and label the wavelength of **wave B**

(1 mark)

7 (b) (ii) use arrows to show the direction in which the points **P** and **Q** are about to move as each wave moves to the right.

(2 marks)

7 (c) Electromagnetic waves are similar in nature to **wave A**.

Explain why it is important to correctly align the aerial of a TV in order to receive the strongest signal.

.....

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.....

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(2 marks)

END OF QUESTIONS

7

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Version 1.0



General Certificate of Education (A-level)
June 2012

Physics A PHYA2

(Specification 2450)

Unit 2: Mechanics, materials and waves

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Instructions to Examiners

1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	**5-6**
Modest - Adequate	*see specific mark scheme*	**3-4**
Poor - Limited	*see specific mark scheme*	**1-2**
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.

4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

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GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

1	a	i	two from: velocity, acceleration, force etc ✓	1

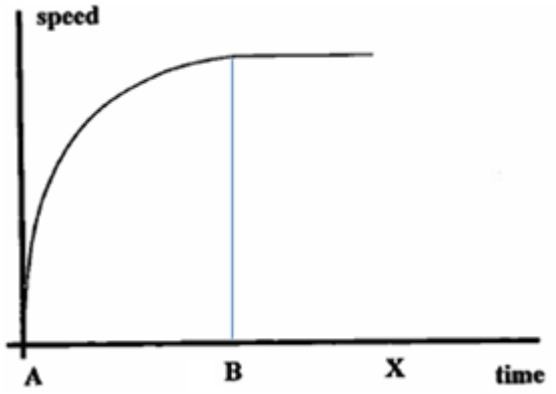
1	a	ii	two from: speed, distance, mass etc ✓	1

1	b	i	B: drag / air resistance ✓ C: weight ✓	2

1	b	ii	closed triangle (of vectors) ✓ so forces are in **equilibrium / resultant force is zero / forces balance** (so moving at constant velocity) ✓	2

1	c		$W = 9500 \sin 74$ ✓ = 9100 ✓ (9132) **2 sf** ✓	3

2	a		*GPE* to *KE* to *GPE* ✓ no energy lost (from system) / no <u>work done</u> against resistive forces ✓ initial *GPE* = final (*GPE)* / initial (*GPE)* = final *GPE* **OR** $h = GPE / mg$ and these are all constant so h is the same ✓	3

2	b		Initial curve with decreasing gradient and reaching constant maximum speed before X and maintaining constant speed up to X ✓ B labelled in correct place ✓ B labelled in correct place **AND** constant speed maintained for remainder of candidates graph and line is straight ✓  	3

2	c		(first law) ball travels in a straight line at a constant speed / constant velocity / (maintains) uniform / no change in motion / zero acceleration ✓ there is no (external) **unbalanced / resultant** force acting on it ✓	2

3	a	i	(moment = 520 x 0.26) = 140 (135.2) ✓ **Nm** ✓	2

3	a	ii	**180 x 0.41** and **0.63 X** seen ✓ 135.2 = 180 x 0.41 + 0.63 X ✓ ecf from 3(a)(i) (X = (135.2 – 73.8) / 0.63) = 97 ✓ (N) (97.46) allow 105 from use of 140Nm ecf from 3(a)(i)	3

3	a	iii	(520 – (180 + 97.46)) = 240 ✓ (242.5 N) ecf (or from correct moments calculation)	1

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3	b	i	($v^2 = u^2 + 2as$) $9.3^2 = 2 \times a \times 35$ OR $9.3^2 = 70a$ OR $a = v^2/2s$ OR $9.3^2/70$ ✓ OR correct alternative approach 1.2 (1.2356) ✓ (m s^{-2})	2

3	b	ii	($m = W/g$) = 520/9.81 (= 53.0) ✓ (kg) $F = ma$ = 53 × 3bi (1.2356) = 65 (N) (65.49) ✓ accept use of 1.2 giving 64(63.6) , allow 53 x 124 = 65.7	2

4	a	i	<u>cladding</u> ✓	1

4	a	ii	sin θ_c = 1.41/1.46 ✓ θ_c = 75.0 (°) (74.96) ✓	2

4	b	i	65 (degrees) ✓	1

4	b	ii	1.46 sin 65 = 1.41 sin r **or** sin r = 0.93845 ✓ ecf bi r = 70 ✓ (degrees) (69.79) ecf bi	2

4	c		Two from: • less light is lost • better quality signal / less distortion • increased probability of TIR • Less change of angle between each reflection • reflects more times (in a given length of fibre) keeping (incident) angle large(r than critical angle) • (angle of incidence is) less likely to fall below the <u>critical angle</u> • less <u>refraction</u> out of the core • improved data transfer / <u>information/ data/ signal</u> carried quicker • less multipath dispersion (smearing / overlap of pulses) ✓✓	2

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5	a		**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. Candidate must suggest: • drawing a graph of F vs ΔL (or *vice versa*) • AND that k is in some way linked to the gradient • AND use of a suitable named instrument to measure or determine extension • AND 1 further means of reducing uncertainty: repeats / minimum 8 different readings / use of vernier scale / check values of mass with balance / parallax elimination with set square, pointer in contact with scale, mirror. For 6 marks: must also give suitable range at least up to 10N but not beyond 20N (accept 'up to 20N' / 'not beyond 20N') AND minimum **8 different readings** OR **parallax** elimination must be included AND **repeats** must be included AND correctly explains how k is obtained from their graph. **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. Candidate must suggest: • to measure / determine extension OR initial and final length • AND to use $F = k\,\Delta L$ or $k = F / \Delta L$ OR drawing a graph of F vs ΔL (or *vice versa*) • AND use of suitable **instrument** to measure extension OR 1 means of reducing **uncertainty**: repeats / use of vernier scale / check values of mass with balance / parallax elimination with set square, pointer in contact with scale,	max 6

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			mirror / minimum 8 different readings / graphical approach For 4 marks, **uncertainty** comment AND **instrument** required **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. Any relevant statement from the marking points above For 2 marks: must mention minimum two points including: • to measure / determine extension OR initial and final length	

5	b	i	(k = 2 × 85 = 170 (N m^{-1})) (ΔL = F / k =) 15 / 170 (or 7.5 / 85) ✓ = 0.088 ✓ (m) (0.0882)	2

5	b	ii	(k = ½ × 85 = 42.5) (ΔL = F / k =) 15/42.5 (or 2 x 15/85) ✓ = 0.35 ✓ (m) (0.3529)	2

5	b	iii	(W = ½ $F\Delta L$ or ½ $k\Delta L^2$) = ½ × 15 × 0.0882 (or 2 x ½ × 7.5 × 0.0882) ✓ ecf 5bi = 0.66 ✓ (J) (0.6615) ecf 5bi	2

5	b	iv	(series) **greater** ✓ ecf for answer 'less' or 'same' where candidates incorrect answers to 5bi and 5bii support this. extension is more (in series) and the **force is the same** (in both situations) ✓ **AND** quotes Energy stored = (½)Fs or ½ $F\Delta L$ OR energy proportional to extension ✓	3

6	a	i	oscillates / vibrates ✓ (allow goes up and down / side to side / etc, <u>repeatedly, continuously,etc</u>) about <u>equilibrium</u> position / perpendicularly to central line ✓	2

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6	a	ii	X and Y: antiphase / 180 (degrees out of phase) / π (radians out of phase) ✓ X and Z: in phase / zero (degrees) / 2π (radians) ✓	2

6	b	i	$v = f\lambda$ = **780 x 0.32 / 2** or **780 x 0.16** **OR 780 x 320 / 2** or **780 x 160** ✓ THIS IS AN INDEPENDENT MARK = 124.8 ✓ (m s^{-1}) correct 4 sig fig answer must be seen	2

6	b	ii	¼ cycle ✓ T = 1 / 780 OR = 1.28×10^{-3} ✓ $0.25 \times 1.28 \times 10^{-3}$ = 3.2×10^{-4} (s) ✓ Allow correct alternative approach using distance of 0.04m ✓ travelled by progressive wave in ¼ cycle divided by speed. 0.04 /125 ✓ = 3.2×10^{-4} (s) ✓	3

6	c	i	antinode ✓	1

6	c	ii	2 x 0.240 ✓ = 0.48 m ✓ '480m' gets 1 mark out of 2	2

6	c	iii	($f = v/\lambda$ = 124.8 or 125 / 0.48) = **260** (Hz) ecf from cii ✓	1

7	a		(wave) **B** ✓ (the parts of the) spring oscillate / move back and forth **in direction of / parallel to** wave travel OR mention of compressions and rarefactions ✓ Second mark can only be scored if first mark is scored	2

7	b	i	(double ended arrow / line / brackets) from between two points in phase ✓	1

7	b	ii	wave A: arrow vertically upwards ✓ wave B: arrow horizontally to the left ✓	2

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7	c		(transmitted radio waves are often) polarised ✓ aerial (rods) must be aligned in the same plane (of polarisation / electric field) of the wave ✓	2

UMS conversion calculator www.aqa.org.uk/umsconversion

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2012

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Friday 20 January 2012 9.00 am to 10.15 am

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on a blank page.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

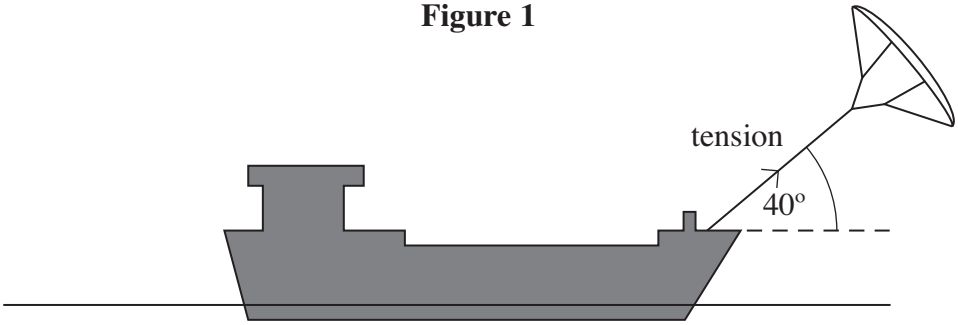
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Answer **all** questions in the spaces provided.

1 Sail systems are being developed to reduce the running costs of cargo ships. The sail and ship's engines work together to power the ship. One of these sails is shown in **Figure 1** pulling at an angle of 40° to the horizontal.

Figure 1



1 (a) The average tension in the cable is 170 kN.
Show that, when the ship travels 1.0 km, the work done by the sail on the ship is 1.3×10^8 J.

(2 marks)

1 (b) With the sail and the engines operating, the ship is travelling at a steady speed of 7.0 m s^{-1}.

1 (b) (i) Calculate the power developed by the sail.

answer = ... W
(2 marks)

Do not write outside the box

1 (b) (ii) Calculate the percentage of the ship's power requirement that is provided by the wind when the ship is travelling at this speed.
The power output of the engines is 2.1 MW.

answer = ... %
(2 marks)

1 (c) The angle of the cable to the horizontal is one of the factors that affects the horizontal force exerted by the sail on the ship. State **two** other factors that would affect this force.

Factor 1 .....

Factor 2 .....
(2 marks)

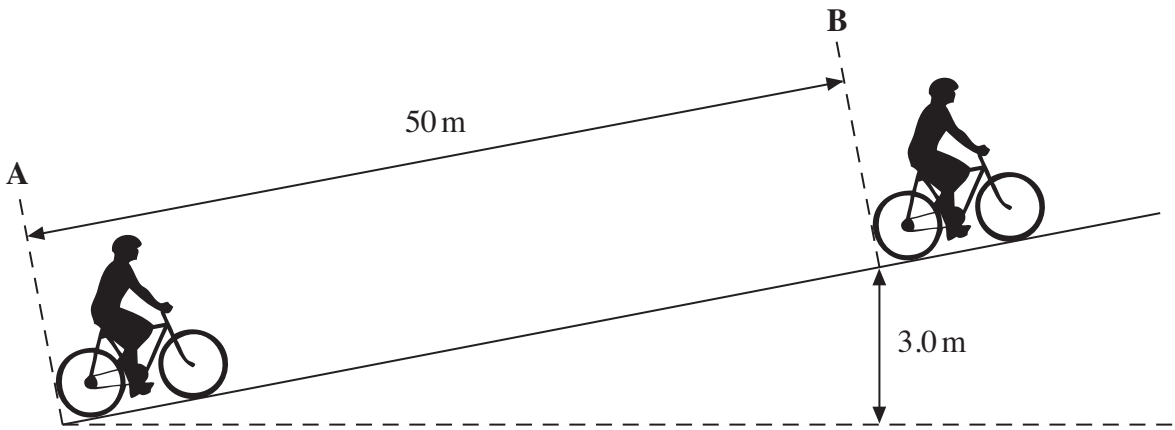
8

Turn over for the next question

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2 An 'E-bike' is a bicycle that is assisted by an electric motor. **Figure 2** shows an E-bike and rider with a total mass of 83 kg moving up an incline.

Figure 2



2 (a) (i) The cyclist begins at rest at **A** and accelerates uniformly to a speed of 6.7 m s^{-1} at **B**. The distance between **A** and **B** is 50 m.
Calculate the time taken for the cyclist to travel this distance.

answer = ... s
(2 marks)

2 (a) (ii) Calculate the kinetic energy of the E-bike and rider when at **B**. Give your answer to an appropriate number of significant figures.

answer = ... J
(2 marks)

Do not write outside the box

2 (a) (iii) Calculate the gravitational potential energy gained by the E-bike and rider between **A** and **B**.

answer = ... J
(2 marks)

2 (b) Between **A** and **B**, the work done by the electric motor is 3700 J, and the work done by the cyclist pedalling is 5300 J.

2 (b) (i) Calculate the wasted energy as the cyclist travels from **A** to **B**.

answer = ... J
(2 marks)

2 (b) (ii) State **two** causes of this wasted energy.

Cause 1 .....

.....

Cause 2 .....

.....
(2 marks)

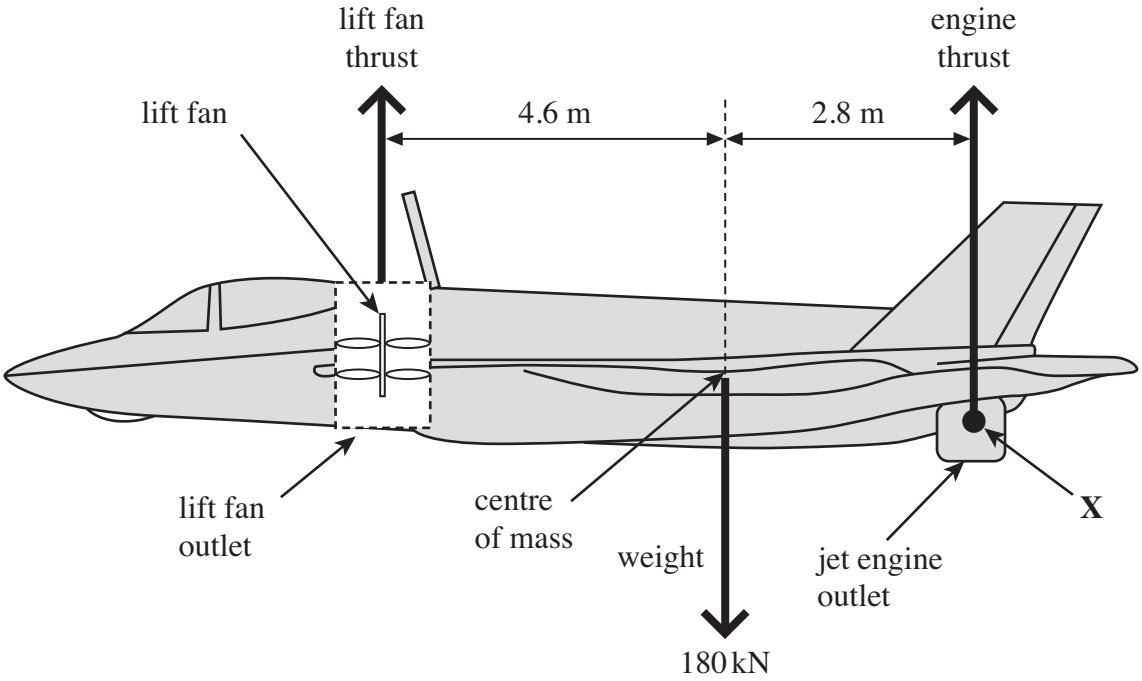
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3 **Figure 3** shows an aircraft designed to take off and land vertically and also to hover without horizontal movement. In order to achieve this, upward lift is produced by directing the jet engine outlet downwards. The engine also drives a vertical lift fan near the front of the aircraft. The weight of the aircraft is 180 kN. The distance between the lift fan and the centre of mass is 4.6 m and the distance between the jet engine outlet and the centre of mass is 2.8 m.

Figure 3



3 (a) (i) Calculate the moment caused by the weight of the aircraft about the point **X**.

answer = ... N m
(2 marks)

3 (a) (ii) By taking moments about **X**, calculate the lift fan thrust if the aircraft is to remain horizontal when hovering.

answer = ... N
(3 marks)

Do not write outside the box

3 (a) (iii) Calculate the engine thrust in **Figure 3**.

answer = ... N
(1 mark)

3 (b) Having taken off vertically, the jet engine outlet is turned so that the engine thrust acts horizontally. The aircraft accelerates horizontally to a maximum velocity. The forward thrust produced by the jet is 155 kN. The weight of the aircraft is 180 kN.

3 (b) (i) When the resultant horizontal force is 155 kN, calculate the horizontal acceleration of the aircraft.

answer = ... $m\,s^{-2}$
(2 marks)

3 (b) (ii) State and explain **one** characteristic of the aircraft that limits its maximum horizontal velocity.

.....

.....

.....

.....
(2 marks)

Question 3 continues on the next page

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3 (b) (iii) On the axes below, sketch the velocity-time graph for the horizontal motion of the aircraft as it accelerates from zero to its maximum horizontal velocity.



(2 marks)

3 (c) State how a velocity-time graph could be used to find the maximum acceleration.

.....

(1 mark)

13

Turn to page 10 for the next question

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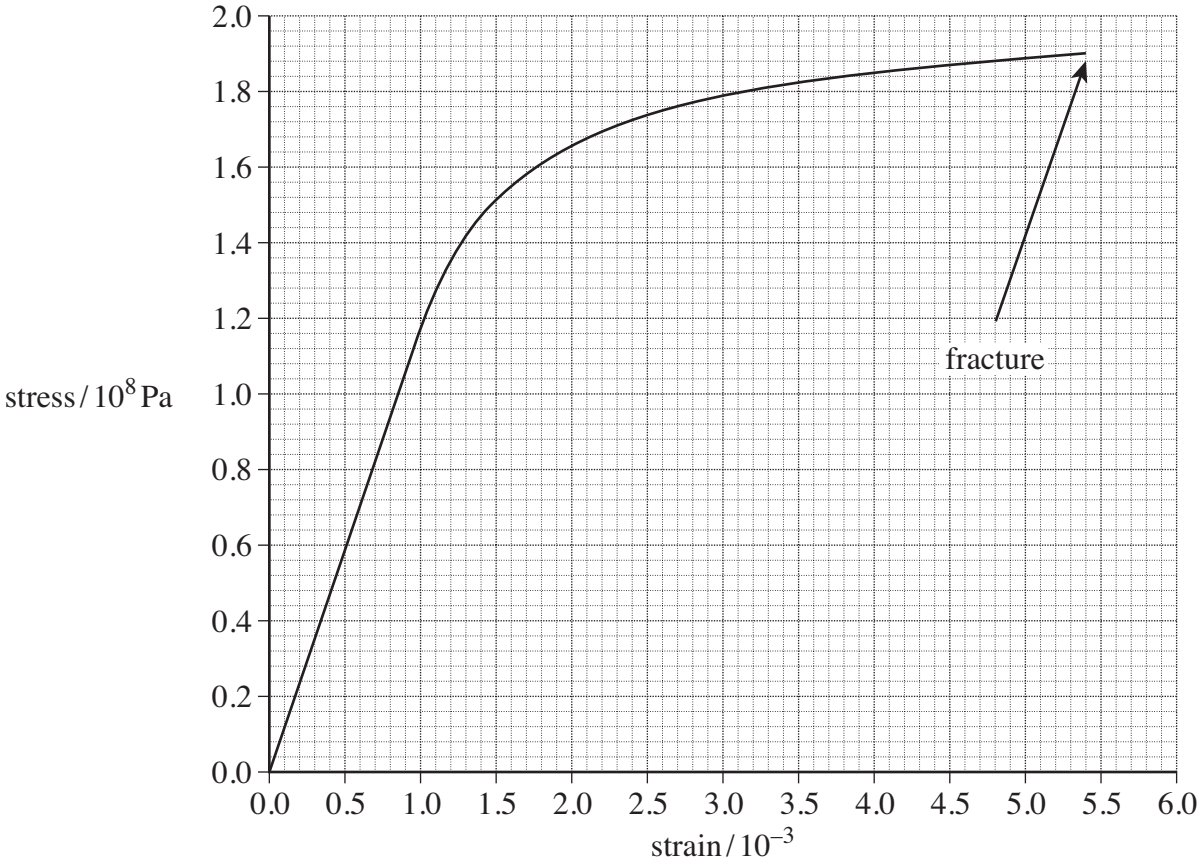
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4 **Figure 4** shows a stress-strain graph for a copper wire.

Figure 4



4 (a) Define tensile strain.

.....

.....

(1 mark)

4 (b) State the breaking stress of this copper wire.

answer = ... Pa

(1 mark)

4 (c) Mark on **Figure 4** a point on the line where you consider plastic deformation may start. Label this point **A**.

(1 mark)

4 (d) Use the graph to calculate the Young modulus of copper. State an appropriate unit for your answer.

answer = ...

(3 marks)

Do not write outside the box

4 (e) The area under the line in a stress-strain graph represents the work done per unit volume to stretch the wire.

4 (e) (i) Use the graph to find the work done per unit volume in stretching the wire to a strain of 3.0×10^{-3}.

answer = ... J m^{-3}

(2 marks)

4 (e) (ii) Calculate the work done to stretch a 0.015 kg sample of this wire to a strain of 3.0×10^{-3}.

The density of copper = 8960 kg m^{-3}.

answer = ... J

(2 marks)

4 (f) A certain material has a Young modulus greater than copper and undergoes brittle fracture at a stress of 176 MPa.

On **Figure 4** draw a line showing the possible variation of stress with strain for this material.

(2 marks)

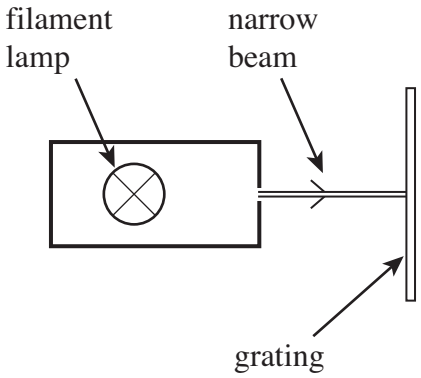
12

Turn over for the next question

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5 (a) In an experiment, a narrow beam of white light from a filament lamp is directed at normal incidence at a diffraction grating. Complete the diagram in **Figure 5** to show the light beams transmitted by the grating, showing the zero-order beam and the first-order beams.

Figure 5



(3 marks)

5 (b) Light from a star is passed through the grating.

Explain how the appearance of the first-order beam can be used to deduce **one** piece of information about the gases that make up the outer layers of the star.

.....

.....

.....

.....

(2 marks)

5 (c) In an experiment, a laser is used with a diffraction grating of known number of lines per mm to measure the wavelength of the laser light.

5 (c) (i) Draw a labelled diagram of a suitable arrangement to carry out this experiment.

(2 marks)

Do not write outside the box

5 (c) (ii) Describe the necessary procedure in order to obtain an accurate and reliable value for the wavelength of the laser light.
Your answer should include details of all the measurements and necessary calculations.
The quality of your written communication will be assessed in your answer.

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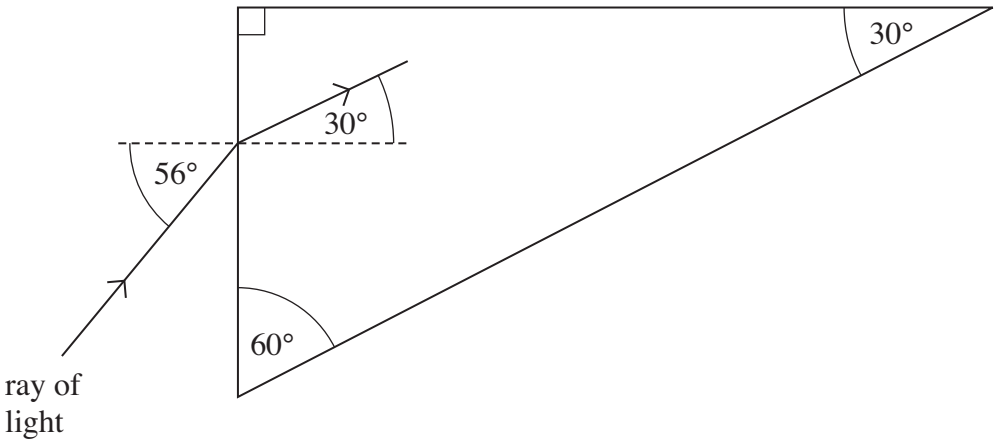
(6 marks)

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6 **Figure 6** shows a glass prism. Light is directed into the prism at an angle of 56°. The path of the ray of light is shown as is it enters the prism.

Figure 6



6 (a) (i) Calculate the refractive index of the glass.

answer = ...

(2 marks)

6 (a) (ii) Calculate the critical angle for the glass-air boundary.

answer = ... degrees

(2 marks)

6 (b) On **Figure 6**, continue the path of the ray of light until it emerges from the prism.

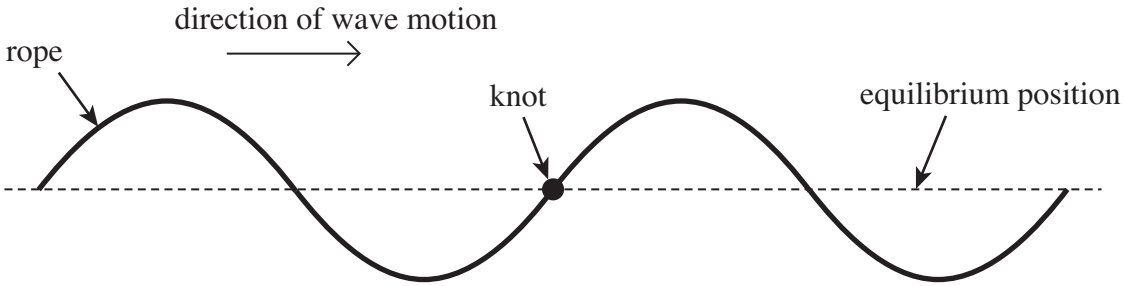
(2 marks)

6

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7 **Figure 7** shows a continuous progressive wave on a rope. There is a knot in the rope.

Figure 7



7 (a) Define the amplitude of a wave.

.....

.....

(2 marks)

7 (b) The wave travels to the right.
Describe how the **vertical** displacement of the knot varies over the next complete cycle.

.....

.....

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.....

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(3 marks)

7 (c) A continuous wave of the same amplitude and frequency moves along the rope from the right and passes through the first wave. The knot becomes motionless.
Explain how this could happen.

.....

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(3 marks)

END OF QUESTIONS

8

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Version 1.0



General Certificate of Education (A-level)
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Physics A PHYA2

(Specification 2450)

Unit 2: Mechanics, materials and waves

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2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	**5-6**
Modest - Adequate	*see specific mark scheme*	**3-4**
Poor - Limited	*see specific mark scheme*	**1-2**
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.

4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

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GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

Question 1		
a	$170 \times 10^3 \times \cos 40$ (**or** 1.3×10^5) ✓ $\times 1000$ ✓ ($= 1.302 \times 10^8$ J)	**2**
b i	$(P = Fv) = 1.3 \times 10^5 \times 7.0$ ✓ $= 9.1 \times 10^5$ ✓ (911.6 kW) ecf wrong force from part a **or** correct alternative approach using $t=s/v$ and $P= E/t$	**2**
b ii	(total power =) 9.1 ($\times 10^5$) + 21 ($\times 10^5$) ✓ ecf from bi powers of 10 must be consistent for this mark (eg not 9.1 + 2.1) (percentage = (9.1/9.1 + 21) × 100) = 30 (%) ✓ ecf for power of 10 error in first mark ecf from bi, but must have attempted to calculate **total power** eg 9.1/21 gains zero	**2**
c	**any two from** (surface) **area** (of the sail) ✓ **wind** speed/strength/power/KE/force (not air resistance) ✓ acceleration or speed of the ship ✓	**max 2**
	Total	**8**

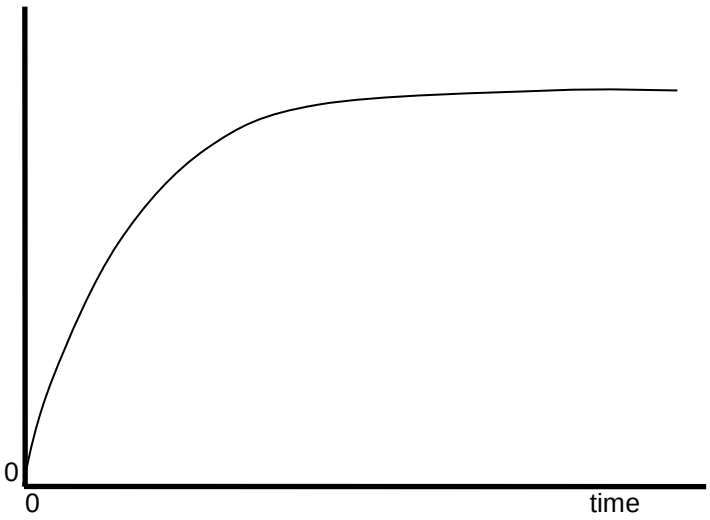
Question 2		
a i	($s = ½(u+v)\,t$) $t = 2s/v$ ✓ (correct rearrangement, either symbols or values) (= 100/6.7) = 15 ✓ (s) (14.925) or alternative correct approach	**2**
a ii	($KE = 1/2mv^2 = ½ \times 83 \times 6.7^2$) = 1900 ✓ (1862.9 J) **2 sf** ✓	**2**
a iii	GPE = 83 × 9.81 × 3.0 ✓ penalise use of 10, allow 9.8 = 2400 (2443 J) ✓ do not allow 2500 (2490) for use of g = 10	**2**
b i	5300 + 3700 (or 9000 seen) **or** – 2443 – 1863 (or (–) 4306 seen) ✓ = 4700 (J) ✓ (4694) ecf from parts aii & aiii	**2**

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b	ii	mention of friction and appropriate location given ✓ mention of **air** resistance (or drag) ✓ do not allow energy losses or friction within the motor do not allow energy losses from the cyclist must give a **cause** not just eg 'heat loss in tyres'	**2**
		Total	**10**

Question 3			
a	i	180000 × 2.8 ✓ = 500000 ✓ (504000 Nm) ecf from first line for incorrect power of 10	**2**
a	ii	7.4 × lift fan thrust ✓ = 180000 × 2.8 (504000 Nm) ✓ ecf from part ai F = 68000 or 68 k (N) ✓ (68108 N) ecf	**3**
a	iii	180k – 68.1k = (111.9 =) 112 k (N) ✓ ecf from part aii **or** by taking moments	**1**
b	i	(*m* = *W*/*g*) = 180 000/9.81 ✓ (= 18349 kg) *a* = *F*/*m* = 155 000/18349 = 8.4 ✓ (8.4475 ms^{-2}) ecf for use of 180 in 1st mark use of weight rather than mass gets zero	**2**
b	ii	**cross-sectional or surface** area/shape/streamlining/aerodynamics/nature of surface/drag coefficient ✓ **correctly linked** to its effect on air resistance/drag ✓ **or maximum** thrust/force power of engine ✓ counterforce increases with speed **or** when drag equals thrust (forces are balanced) ✓	**2**

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b	ii	velocity  line starting at zero and **curving with decreasing gradient** ✓ reaching a constant velocity ✓	**2**
c		steepest/maximum gradient ✓	**1**
		Total	**13**

Question 4		
a	extension divided by its **original** length ✓ do not allow symbols unless defined ✓	**1**
b	1.9×10^{8} (Pa) ✓	**1**
c	point on line **marked 'A'** between a strain of 1.0×10^{-3} and 3.5×10^{-3} ✓	**1**
d	clear evidence of gradient calculation for **straight section** eg 1.18 (1.2) $\times 10^{8}/1.0 \times 10^{-3}$ ✓ = 120 GPa **and stress used ≥ 0.6×10^{8} Pa** ✓ allow range 116 – 120 GPa **Pa or Nm^{-2} or N/m^2** ✓	**3**
e	i	clear attempt to calculate correct area (evidence on graph is sufficient) ✓ (32 whole squares + 12 part/2 = 38 squares) (38 × 10000 =) 380000 ($J\,m^{-3}$) ✓ allow range 375000 to 400000	**2**
e	ii	$V = m/\rho$ **or** 0.015/8960 **or** 1.674×10^{-6} (m^3) ✓ 380 000 × 1.674×10^{-6} = 0.64 (0.6362 J) ✓ ecf from ei	**2**
f		straight line passing through origin (small curvature to the right only above 160 MPa is acceptable) end at 176 MPa ✓ (allow 174 to 178) straight section to the left of the line for copper (steeper gradient) ✓	**2**
		Total	**12**

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Question 5		
a	**max three from** central maximum shown ✓ two equally spaced first order maxima ✓ central and one first order labelled correctly ✓ central white maximum ✓ indication of spectra/colours in at least one first order beam ✓ at least one first order beam labelled with violet (indigo or blue) closest to the centre **or** red furthest ✓	**max 3**
b	**dark/black** lines **or** absorption spectrum **or** Fraunhofer lines ✓ (reveal the) composition (of the star's atmosphere) ✓ accept dark 'bands' accept atoms or elements in the star **or** the peak of intensity ✓ (is related to) the temperature ✓ **or** Doppler (blue or red) shift ✓ (speed of) rotation **or** speed of star (relative to Earth) ✓	**2**
c i	grating and screen shown with both labelled ✓ laser or laser beam labelled ✓	**2**
c ii	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. • correct use of $(n)\lambda = d \sin\theta$ • **and** measure appropriate angle (eg 'to first order beam' is the minimum required) • **and** method to measure angle (eg tan $\theta = x/D$, spectrometer, accept protractor) • **and** at least **one** way of improving accuracy/reliability • for **full** marks: also explain how d is calculated, eg d = 1/ lines per mm ($\times 10^3$)	**max 6**

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	Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. • use of $(n)\lambda = d \sin\theta$ • **and** measure appropriate angle (eg 'to first order beam' is the minimum required) • **and** method of measurement of θ (eg tan $\theta = x/D$, spectrometer, accept protractor) **or** at least **one** way of improving accuracy/reliability **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. • use of $(n)\lambda = d \sin\theta$ • **or** measure appropriate angle (eg 'to first order beam' is the minimum required) • **or** at least **one** way of improving accuracy/reliability **Incorrect, inappropriate of no response: 0 marks** No answer or answer refers to unrelated, incorrect or inappropriate physics. **The explanation expected in a competent answer should include** **Accuracy/reliability points** • measure between more than one order (eg 2 θ) • measure θ for different orders (for average λ **not average angle**) • check or repeat/repeat for different distances (D) • use of spectrometer • use large distance to screen (D) • protractor with 0.5 degree (or less) intervals • graphical method: **plot sin θ against n** (gradient $= \lambda/d$)	
	Total	**13**

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Question 6		
a i	sin 56 = n_{glass} sin 30 ✓ (n_{glass} = sin56/sin30) (= 1.658) = 1.7 ✓	**2**
a ii	sin θ_c = 1/1.658 ✓ ecf from ai θ_c = (37.09 or 37.04) = 37 (degrees) ✓ accept 36 (36.03 degrees) for use of 1.7	**2**
b	TIR from the upper side of the prism ecf from part aii **and** correct angle ✓ refraction out of the long edge of the prism away from the normal ✓	**2**
	Total	**6**

Question 7		
a	the **maximum displacement** (of the wave or medium) ✓ from the equilibrium position ✓ accept 'rest position', 'undisturbed position', 'mean position'	**2**
b	(vertically) **down**wards (¼ cycle to maximum negative displacement) ✓ then **upwards** (¼ cycle to equilibrium position and ¼ cycle to maximum positive displacement) ✓ **down** (¼ cycle) to **equilibrium position/zero** displacement **and** correct reference to either **maximum** positive or negative displacement **or** correct reference to fractions of the cycle ✓ candidate who correctly describes the motion of a knot 180 degrees out of phase with the one shown can gain maximum two marks (ie knot initially moving upwards)	**3**
c	**max 3 from** **stationary wave** formed ✓ by **superposition or interference** (of two progressive waves) ✓ knot is at a **node** ✓ waves (always) cancel **where the knot is** ✓ allow 'standing wave'	**max 3**
	Total	**8**

	UMS conversion calculator www.aqa.org.uk/umsconversion	

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2011

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Monday 6 June 2011 1.30 pm to 2.45 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

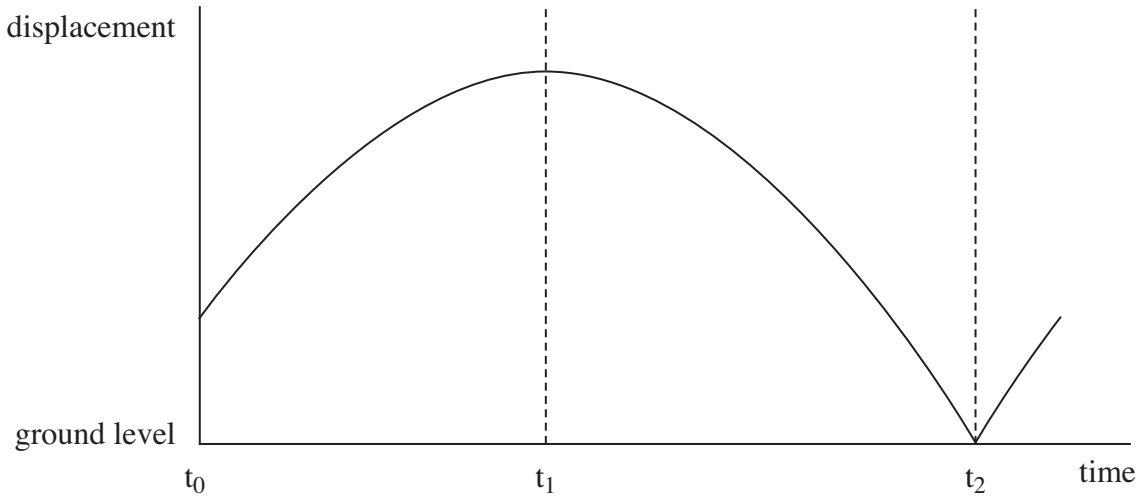
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Answer **all** questions in the spaces provided.

1 A boy throws a ball vertically upwards and lets it fall to the ground. **Figure 1** shows how displacement relative to the ground varies with time for the ball.

Figure 1



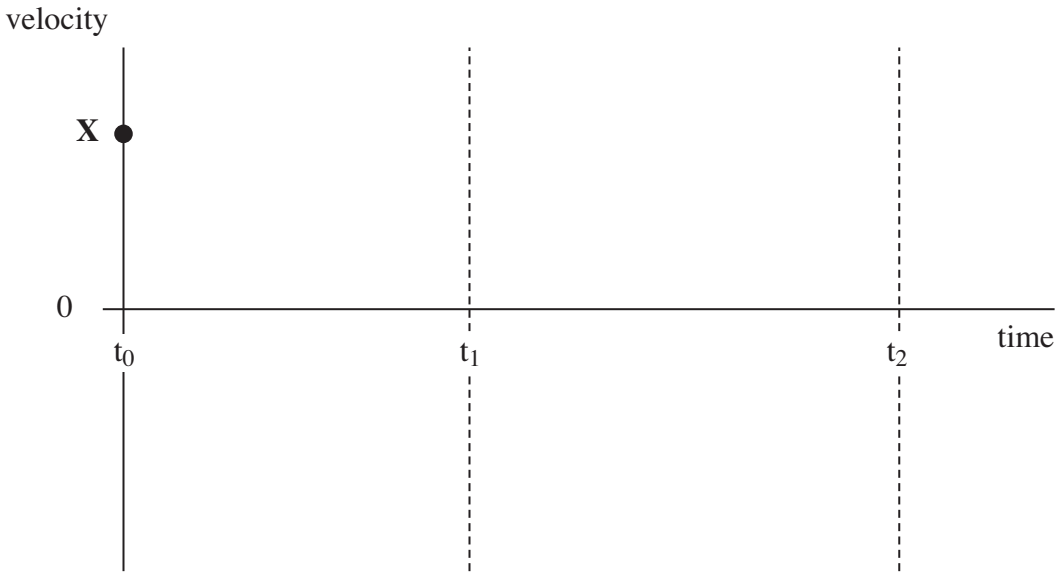
1 (a) (i) State which feature of a displacement-time graph represents the velocity.

.....

(1 mark)

1 (a) (ii) On the axes below, draw the shape of the velocity-time graph for the ball between t_0 and t_2. The starting point is labelled **X**.

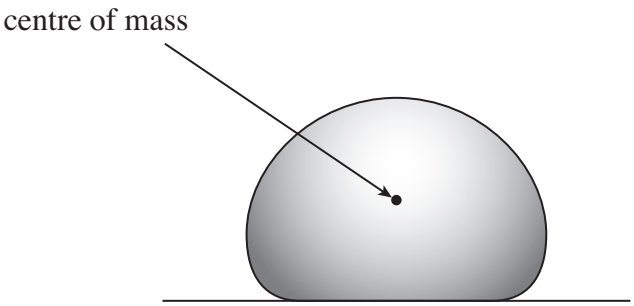
(3 marks)



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1 (b) **Figure 2** shows the ball deforming as it contacts the ground, just at the point where it is stationary for an instant and has reached maximum deformation.

Figure 2



1 (b) (i) Explain how Newton's third law of motion applies to **Figure 2**.

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(2 marks)

1 (b) (ii) Explain why there is a resultant upward force on the ball in **Figure 2**.

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(2 marks)

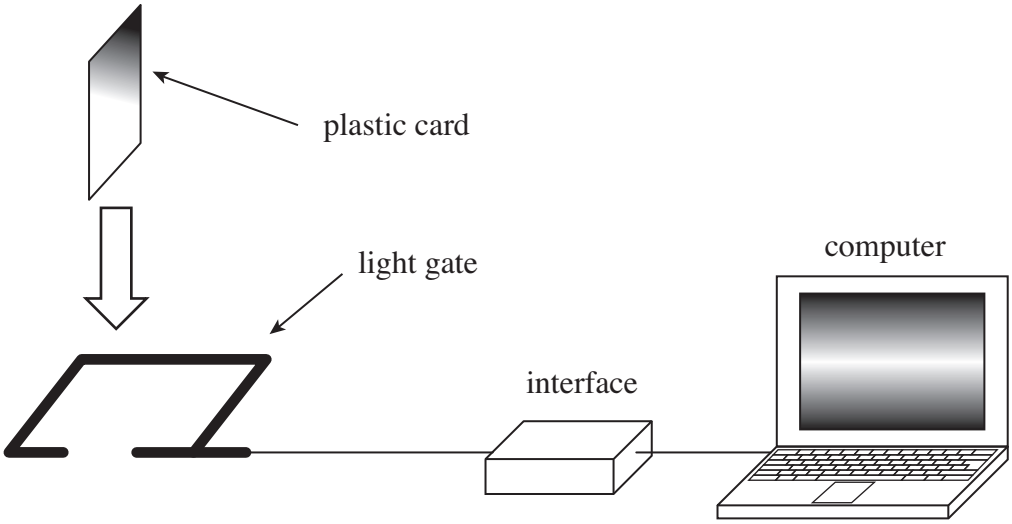
8

Turn over for the next question

Do not write outside the box

2 A student measures the acceleration due to gravity, g, using the apparatus shown in **Figure 3**. A plastic card of known length is released from rest at a height of 0.50 m above a light gate. A computer calculates the velocity of the card at this point, using the time for the card to pass through the light gate.

Figure 3



2 (a) The computer calculated a value of 3.10 ms^{-1} for the velocity of the card as it travelled through the light gate. Calculate a value for the acceleration due to gravity, g, from these data.

answer = ... ms^{-2}

(2 marks)

2 (b) The student doubles the mass of the card and finds a value for g that is similar to the original value. Use the relationship between *weight*, *mass* and g to explain this result.

.....

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(1 mark)

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2 (c) State and explain **one** reason why the card would give more reliable results than a table tennis ball for this experiment.

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(2 marks)

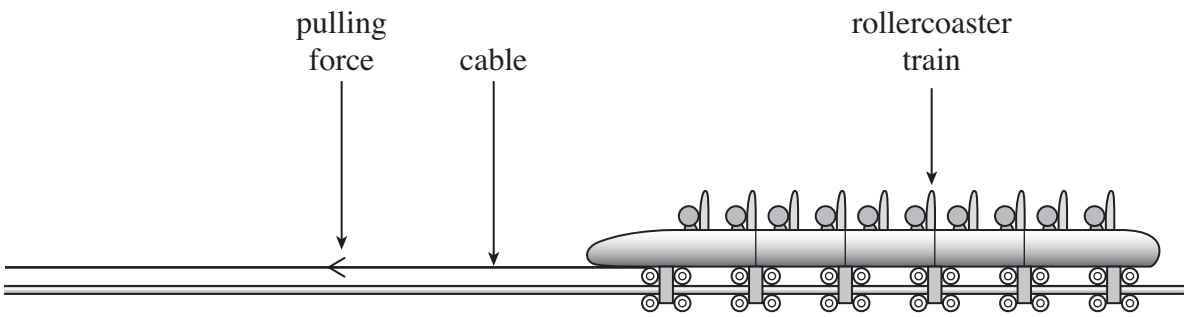
5

Turn over for the next question

Do not write outside the box

3 **Figure 4** shows a rollercoaster train that is being accelerated when it is pulled horizontally by a cable.

Figure 4



3 (a) The train accelerates from rest to a speed of 58 ms^{-1} in 3.5 s. The mass of the fully loaded train is 5800 kg.

3 (a) (i) Calculate the average acceleration of the train.

answer = ... ms^{-2}

(2 marks)

3 (a) (ii) Calculate the average tension in the cable as the train is accelerated, stating an appropriate unit.

answer = ...

(3 marks)

Do not write outside the box

3 (a) (iii) Calculate the distance the train moves while accelerating from rest to $58\,ms^{-1}$.

answer = ... m
(2 marks)

3 (a) (iv) The efficiency of the rollercoaster acceleration system is 20%.
Calculate the average power input to this system during the acceleration.

answer = ... W
(3 marks)

3 (b) After reaching its top speed the driving force is removed and the rollercoaster train begins to ascend a steep track. By considering energy transfers, calculate the height that the train would reach if there were no energy losses due to friction.

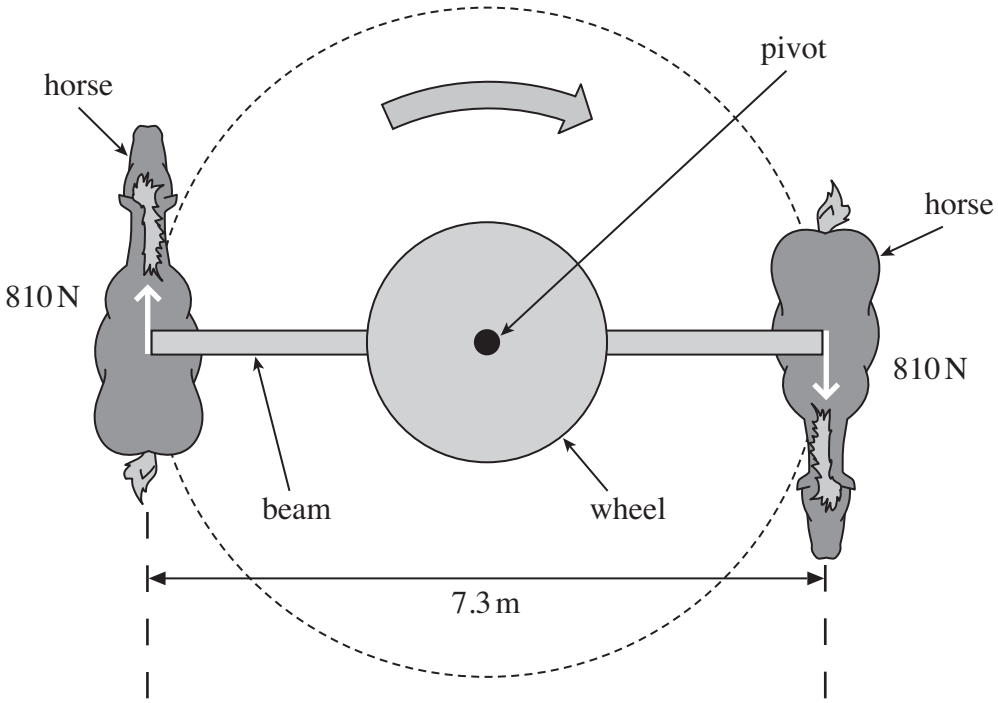
answer = ... m
(3 marks)

13

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4 Horses were once used to power machinery in factories, mines and mills.
Figure 5 shows two horses attached to a beam which turns a wheel. This wheel drives machinery.

Figure 5



4 (a) Each horse exerts a force of 810 N and the length of the beam is 7.3 m.

4 (a) (i) Define the moment of a couple.

.....

.....

.....

(2 marks)

4 (a) (ii) Calculate the moment of the couple exerted by the horses, stating an appropriate unit.

answer = ...

(2 marks)

Do not write outside the box

4 (b) The horses move at a constant speed of $0.91\ ms^{-1}$. Calculate the combined power output of the two horses. Give your answer to an appropriate number of significant figures.

answer = ... W

(3 marks)

4 (c) During the Industrial Revolution in the 19th Century, James Watt became well known for developing and improving steam engines to replace horses. He defined the unit of power called '*horsepower*' by studying a system similar to the one shown in **Figure 5**.

Suggest why Watt decided to use *horsepower* as a unit of power.

.....

.....

.....

(1 mark)

8

Turn over for the next question

Do not write outside the box

5 (a) The speed of light is given by

$$c = f\lambda$$

State how each of these quantities will change, if at all, when light travels from air to glass.

c .....

f .....

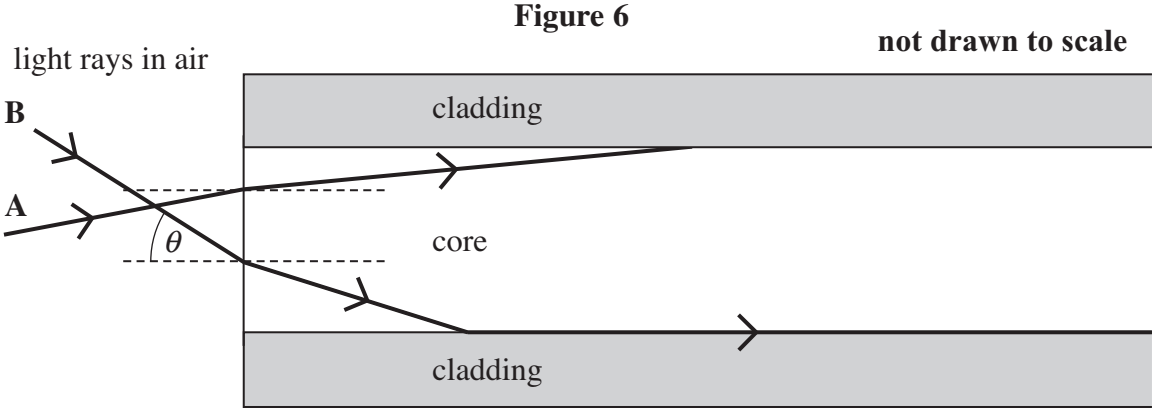
λ .....

(3 marks)

Figure 6 shows a side view of a step index optical fibre.

Figure 6

not drawn to scale



5 (b) Ray **A** enters the end of the fibre and then undergoes total internal reflection. On **Figure 6** complete the path of this ray along the fibre.

(2 marks)

5 (c) (i) The speed of light in the core is 2.04×10^8 ms^{-1}. Show that the refractive index of the core is 1.47.

(2 marks)

5 (c) (ii) Show that the critical angle at the boundary between the core and the cladding is about 80°.

refractive index of the cladding = 1.45

(2 marks)

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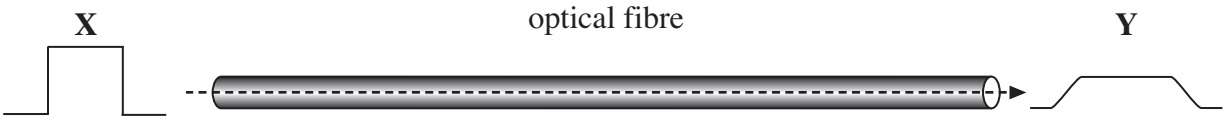
5 (d) Ray **B** enters the end of the fibre and refracts along the core-cladding boundary. Calculate the angle of incidence, θ, of this ray at the point of entry to the fibre.

answer = ... degrees

(3 marks)

5 (e) **Figure 7** shows a pulse of monochromatic light (labelled **X**) that is transmitted a significant distance along the fibre. The shape of the pulse after travelling along the fibre is labelled **Y**. Explain why the pulse at **Y** has a lower amplitude and is longer than it is at **X**.

Figure 7



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(2 marks)

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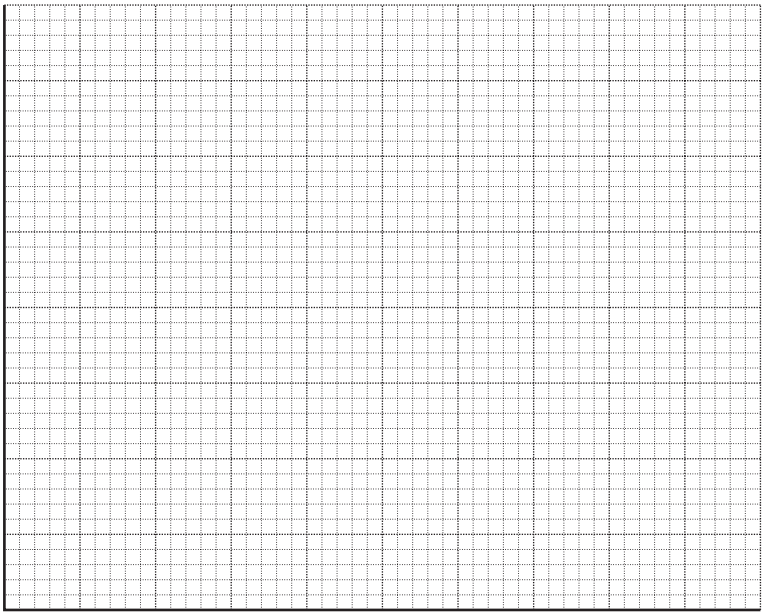
6 The table below shows the results of an experiment where a force was applied to a sample of metal.

6 (a) On the axes below, plot a graph of stress against strain using the data in the table.

(3 marks)

strain / 10^{-3}	0	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
stress / 10^{8} Pa	0	0.90	2.15	3.15	3.35	3.20	3.30	3.50	3.60	3.60	3.50

stress / 10^{8} Pa



strain / 10^{-3}

6 (b) Use your graph to find the Young modulus of the metal.

answer = ... Pa

(2 marks)

Do not write outside the box

6 (c) A 3.0 m length of steel rod is going to be used in the construction of a bridge. The tension in the rod will be 10 kN and the rod must extend by no more than 1.0 mm. Calculate the minimum cross-sectional area required for the rod.

Young modulus of steel = 1.90×10^{11} Pa

answer = ... m^2

(3 marks)

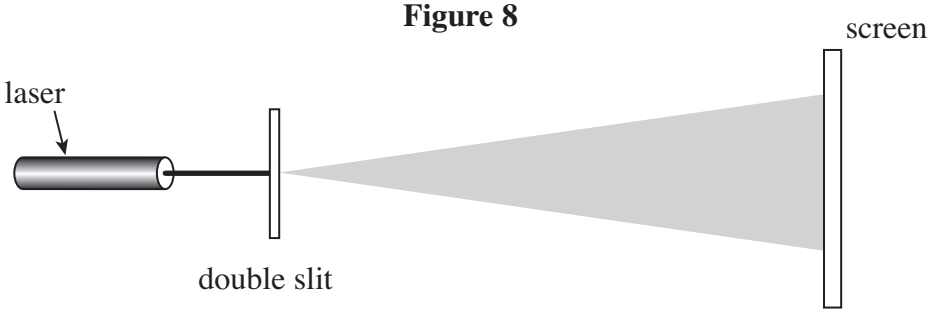
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Turn over for the next question

Do not write outside the box

7 A scientist is going to use a double-slit arrangement to carry out measurements in order to determine the wavelength of light from a laser.

Figure 8



7 (a) The scientist has a double slit of known separation. Describe the measurements that need to be taken and explain how they are used to find the wavelength of the light. Discuss any necessary safety precautions and how you would arrange the apparatus to improve accuracy.

The quality of your written communication will be assessed in this question.

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(6 marks)

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7 (b) In 1802 Thomas Young used candle light to observe the interference pattern from two narrow slits acting as *coherent light sources*.

Explain what is meant by coherent light sources.

.....

.....

.....

(2 marks)

7 (c) Sketch and label on the diagram below the arrangement that Young would have used to obtain his interference pattern.



(2 marks)

7 (d) State **two** differences in the appearance of the pattern obtained with a laser and that produced by a white light source such as a candle.

Difference 1 .....

.....

Difference 2 .....

.....

(2 marks)

7 (e) Explain how the wave theory of light accounts for the areas on the screen where the intensity is a minimum.

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(2 marks)

END OF QUESTIONS

14

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There are no questions printed on this page

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Version 1.0



General Certificate of Education (A-level)
June 2011

Physics A PHYA2

(Specification 2450)

Unit 2: Mechanics, materials and waves

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Instructions to Examiners

1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	**5-6**
Modest - Adequate	*see specific mark scheme*	**3-4**
Poor - Limited	*see specific mark scheme*	**1-2**
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.

4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

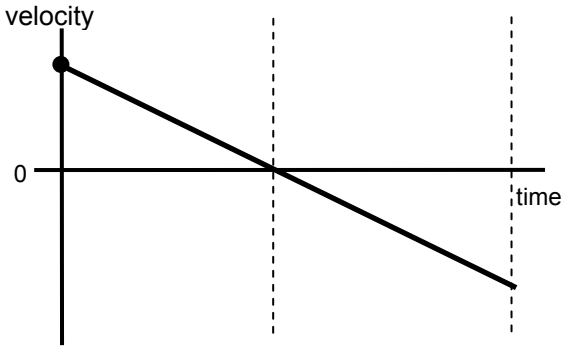
5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

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GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

Question 1		
a i	gradient (allow 'slope'/'**steepness of the line**') ✓	**1**
a ii	 single straight line sloping down from X to t_2 ✓ passes through zero at t_1 ✓ increases to a maximum negative value at t_2 (ignore all lines beyond t_2) **or** allow line from zero at t_1 to a positive velocity at t_2 greater than the initial velocity ✓	**3**
b i	**ball** exerts **force on ground and** ground exerts force (on ball)/reaction ✓ and **these** forces are **equal** and **opposite** ✓	**2**
(b) ii	recognise that the downward force is the weight of the ball (accept gravity) ✓ recognition that the upward/reaction force (on the ball) is greater than the downward force on the ball ✓	**2**
	Total	**8**

Question 2		
a	correct substitution in ($v^2 = u^2 + 2as$) **or** correct rearrangement $g = \frac{v^2}{2s}$ **or** $\frac{3.10^2}{2 \times 0.50}$ ✓ = 9.6 (9.61 m s^{-1}) ✓	**2**
b	$g = W/m$ **or** $W = mg$ (= ma) **and** weight is proportional to mass/doubling the mass doubles the weight/'masses cancel'/the factor of two cancels (so g remains the same) ✓	**1**
c	ball's acceleration will decrease/be less than cards **or** cards acceleration will be unaffected/nearly constant ✓ air resistance affects cards less **or** card is more streamlined **or** card does less work against air resistance ✓ **alternative** timing/(velocity/speed/acceleration) uncertain/(inaccurate /imprecise/less reliable) ✓ indication that full width of ball may not pass through gate/difficulty in determining 'length' of ball passing through gate ✓	**2**
	Total	**5**

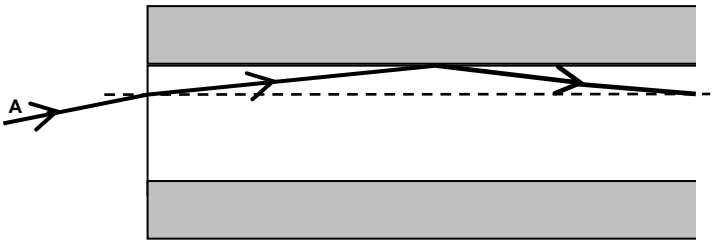
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Question 3		
a i	$\left(\alpha = \frac{v-u}{t}\right) = \frac{58}{3.5}$ ✓ = 17 (m s^{-2}) ✓	**2**
a ii	($F = ma$) = 5800 × 16.57 ecf (a)(i) ✓ = 96000 ✓ allow 98600 or 99000 for use of 17 **N** ✓	**3**
a iii	$\left(s = \frac{1}{2}(u+v)t\right) = \frac{1}{2}$ × 58 × 3.5 ✓ = 100 (101.50, 102, accept 101 m) ✓ **or** use of $v^2 = u^2 + 2as$ (= 101 m. 98.9 for use of 17) **or** $s = ut + \frac{1}{2}at^2$ (= 101.7, use of 17 gives 104) (ecf from (a)(i))	**2**
a iv	($W = Fs$) (a)(ii) × (a)(iii) **or** use of $\frac{1}{2}mv^2$ ✓ (= 13.6 to 14.7) $\left(P = \frac{Fs}{t}\right) = \frac{96106 \times 101.5}{3.5}$ ✓ = 2.8 M (W) ecf (a)(ii), (a)(iii) **or** use of $P = \frac{Fv}{2}$ their answer × 5 ✓ = 14,000,000 = 14 M (W)	**3**
b	$\frac{1}{2}(m)v^2 = (m)g(\Delta)h$ **or** (loss of) KE = (gain in) PE ✓ allow their work done from (iv) used as KE $h = \frac{1}{2}\frac{v^2}{g}$ **or** $h = \frac{1}{2} \times \frac{58^2}{9.81}$ ✓ accept use of kinematics equation = 170 ✓	**3**
	Total	**13**

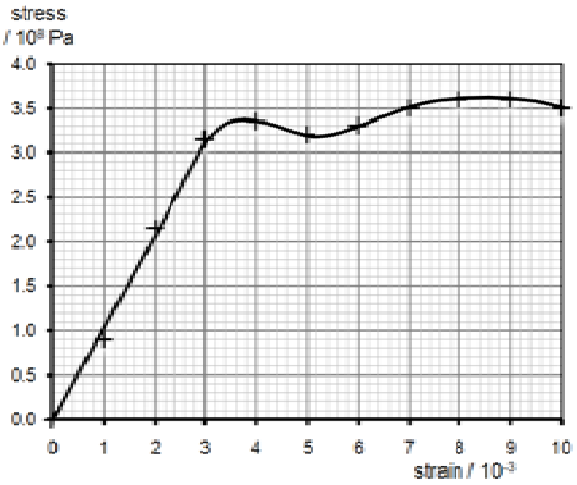
Question 4		
a i	(one) **force** × distance between the **forces** ✓ (one) **force** × **perpendicular** distance between the **lines of action** **or** (one) **force** × **perpendicular** distance between the (two) **forces** ✓	**2**
a ii	(810 × 7.3 =) 5900 ✓ (5913) (or alternative correct method) **Nm** ✓	**2**
b	$P = Fv$ = (2 ×) 810 × 0.91 ✓ (1620 × 0.91) = 1500 ✓ (1474 W) **any number to 2 sf** ✓	**3**

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c	to enable comparison between steam and horses **or** mill owners/engineers etc needed to know which steam engine would be suitable **or** would easily be able to compare the cost/time saved **or** good marketing ploy for steam engines **or** easily understood (by industrialists or the public) **or** other suitable valid reason ✓	**1**
	Total	**8**

Question 5		
a	decrease ✓ constant ✓ decrease ✓	**3**
b	 straight ray (ignore arrow) reflecting to the right ✓ reflected angle = incident angle ✓ (accept correct angle labels if reflected angle is outside tolerance)	**2**
c i	($n = \frac{c}{c_s}$) use of 3 ($\times 10^8$) ✓ = $\frac{300\ (\times 10^8)}{2.04\ (\times 10^8)}$ = 1.47 ✓ (1.4706) (must see 3 sf or more)	**2**
c ii	sin θ_c = $\frac{1.45}{1.47(06)}$ or correct substitution in un-rearranged formula ✓ θ_c = 80.4 ✓ (80.401) (80.3 to 80.54) (≈ 80°) must see 3 sf or more	**2**
d	angle of refraction = 180 – 90 – 80.4 = 9.6° ✓ sinθ = 147(06) sin 9.6 ✓ = 0.25 ecf from first mark θ = 14 (= 14.194°) ✓ ecf from first mark range **13 to 15°** due to use of rounded values	**3**
e	(reduced amplitude) due to absorption/energy loss (within the fibre)/ attenuation/scattering (by the medium)/loss from fibre ✓ (pulse broadening caused by) multi-path (modal) dispersion/different rays/ modes propagating at different angles/non axial rays take longer time to travel same distance along fibre as axial rays ✓	**2**
	Total	**14**

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Question 6		
a	 suitable scale on both axes (eg not going up in 3s) **and** > ½ space used ✓ ≥ 8 points correct (within half a small square) ✓ line is straight up to at least stress = 2.5×10^8 **and** curve is smooth beyond straight section ✓	**3**
b	understanding that E = gradient (= $\Delta y/\Delta x$) ✓ allow y/x if line passes through origin = 1.05×10^{11} (Pa) (allow 0.90 to 1.1) **ecf** from their line in (a) if answer outside this range **and** uses a y value ≥ 2.0 ✓ when values used from table; ● two marks can be scored only if candidates line passes through them ● one mark only can be scored if these points are not on their line	**2**

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c	correct rearrangement of symbols or numbers ignoring incorrect powers of ten, eg $A = \frac{FL}{E\Delta L}$ ✓ correct substitution in any correct form of the equation, eg = $\frac{10(000)\times 3.0}{1.90\ (\times 10^{11})\times 1.0\ (\times 10^{-3})}$ ✓ allow incorrect powers of ten for this mark = 1.6×10^{-4} ✓ (1.5789) (m^2)	**3**
	Total	**8**

Question 7		
a	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate provides a comprehensive and coherent description which includes; fringe spacing/separation *w* **and** distance *D* measured with one **instrument named**, uses $\lambda = \frac{ws}{D}$ to obtain value for λ, measures distance between several maxima and includes a valid point about safety. **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate provides an adequate explanation that lacks some of the essential points. The candidate is expected to include; *w* **or** 'fringes' measured **or** uses $\lambda = \frac{ws}{D}$ to obtain value for λ. They include one accuracy point **or** a valid point about safety. **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate provides a limited explanation with no more than one or two valid points. **Incorrect, inappropriate of no response: 0 marks** No answer or answer refers to unrelated, incorrect or inappropriate physics.	**max 6**

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	The explanation expected in a competent answer should include a coherent selection of the following points. **Measurements** • suitable measuring instrument for *w* • suitable measuring instrument for *D* **Finding the wavelength** • uses $\lambda = \frac{ws}{D}$ to obtain value for λ • explains graphical approach **Accuracy** • several fringe spaces measured • centres of fringes used • five or more fringes/four fringe spaces measured • large value of *D* • *D* greater than or equal to 2 m • dark room • repeat measurements • **vernier** calliper for *w* (not 'calliper', not micrometer) • graphical method varying *D* and measuring *w* • other valid accuracy point **Safety** • avoid shining laser at (or near) a person • **laser** safety goggles • avoid reflections • warning sign or light	
b	(light from both sources has) constant phase **relationship/difference** ✓✓ 'in phase' or 'same wavelength' or 'same frequency' is **one mark**	**2**
c	single slit **then** double slits to the right ✓ single slit and double slits **labelled** ✓	**2**

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<table>
<tr><td>d</td><td>
<table>
<tr><th>if candidate refers to white light Young's fringes with white light;</th><th>or
if candidate refers to the laser;</th></tr>
<tr><td>contain (different) colours or central white fringe</td><td>monochromatic/one colour</td></tr>
<tr><td>less intense</td><td>more intense</td></tr>
<tr><td>maxima wider/minima narrower or max or min closer together for white light compared to a red laser</td><td>maxima narrower/minima wider or max or min further apart for a red laser</td></tr>
<tr><td>fringes/lines/bands etc compared to 'dots'</td><td>'dots' for laser compared to 'bands' etc</td></tr>
</table>
from each row, one only max 2 ✓
</td><td>2</td></tr>
<tr><td>e</td><td>cancellation/waves cancel/destructive interference/destructive superposition ✓

(light from one slit meets light from the other) in antiphase (180 out of phase) or a path difference of ((n+) ½)λ ✓</td><td>2</td></tr>
<tr><td></td><td>Total</td><td>14</td></tr>
</table>

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2011

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Monday 17 January 2011 1.30 pm to 2.45 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on a blank page.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

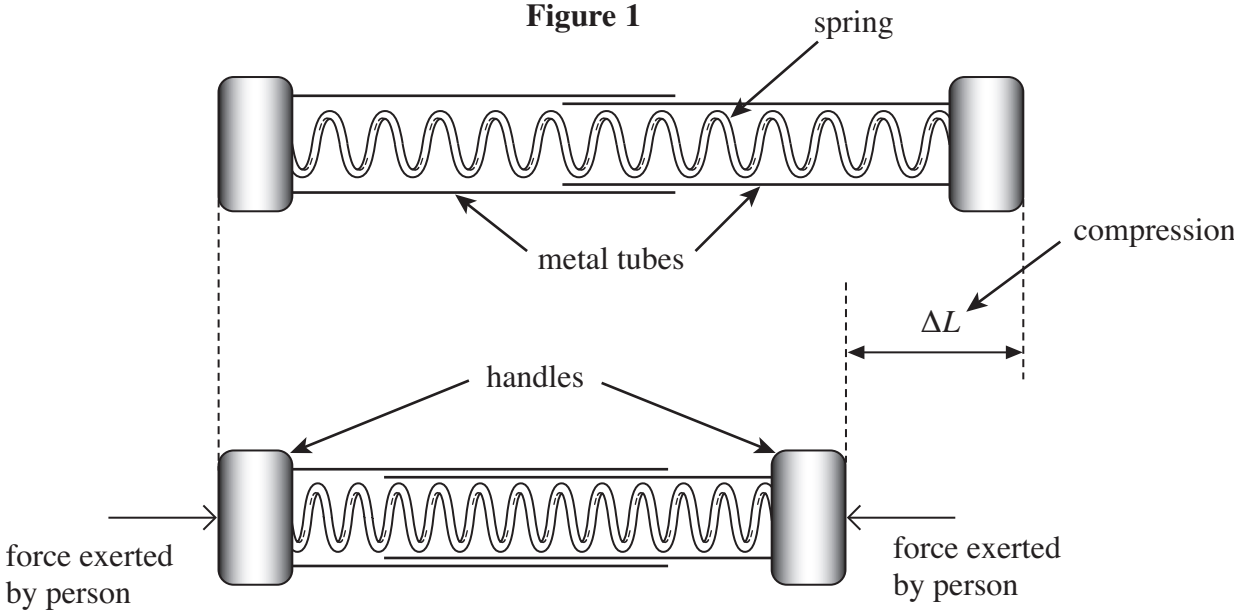
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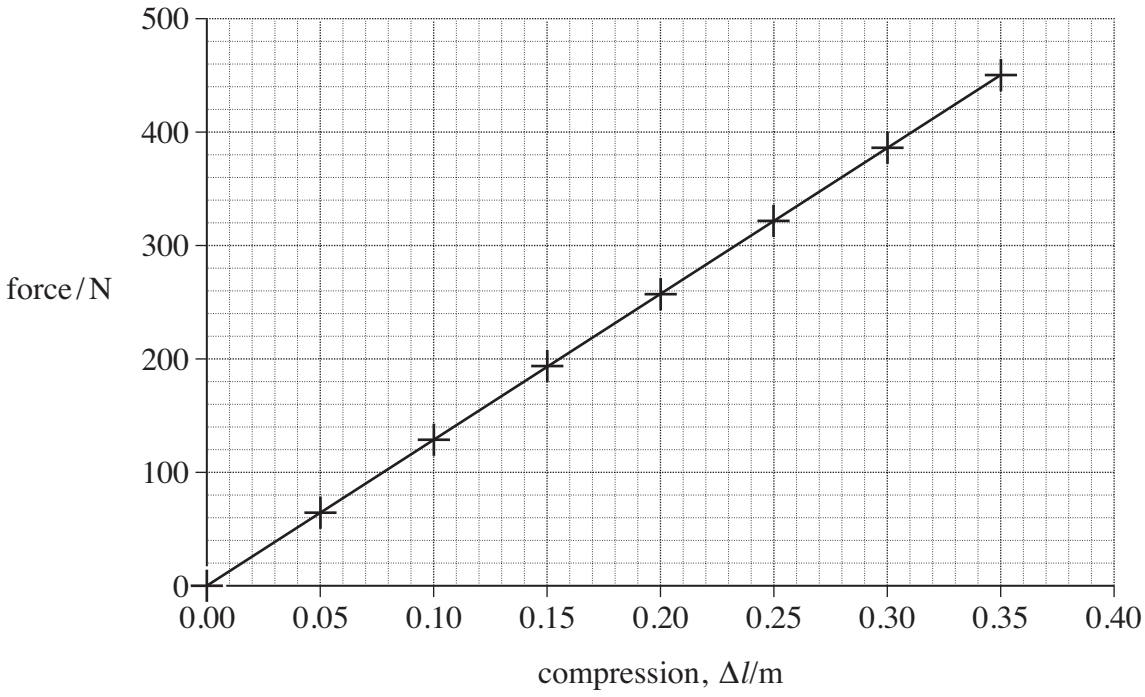
Answer **all** questions in the spaces provided.

1 A type of exercise device is used to provide resistive forces when a person applies compressive forces to its handles. The stiff spring inside the device compresses as shown in **Figure 1.**

Figure 1



1 (a) The force exerted by the spring over a range of compressions was measured. The results are plotted on the grid below.



Do not write outside the box

1 (a) (i) State Hooke's law.

.....

.....

(2 marks)

1 (a) (ii) State which two features of the graph confirm that the spring obeys Hooke's law over the range of values tested.

.....

.....

(2 marks)

1 (a) (iii) Use the graph to calculate the spring constant, stating an appropriate unit.

answer = ...

(3 marks)

1 (b) (i) The formula for the energy stored by the spring is

$$E = \frac{1}{2} F\Delta L$$

Explain how this formula can be derived from a graph of force against extension.

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(3 marks)

Question 1 continues on the next page

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1 (b) (ii) The person causes a compression of 0.28 m in a time of 1.5 s. Use the graph in part (a) to calculate the average power developed.

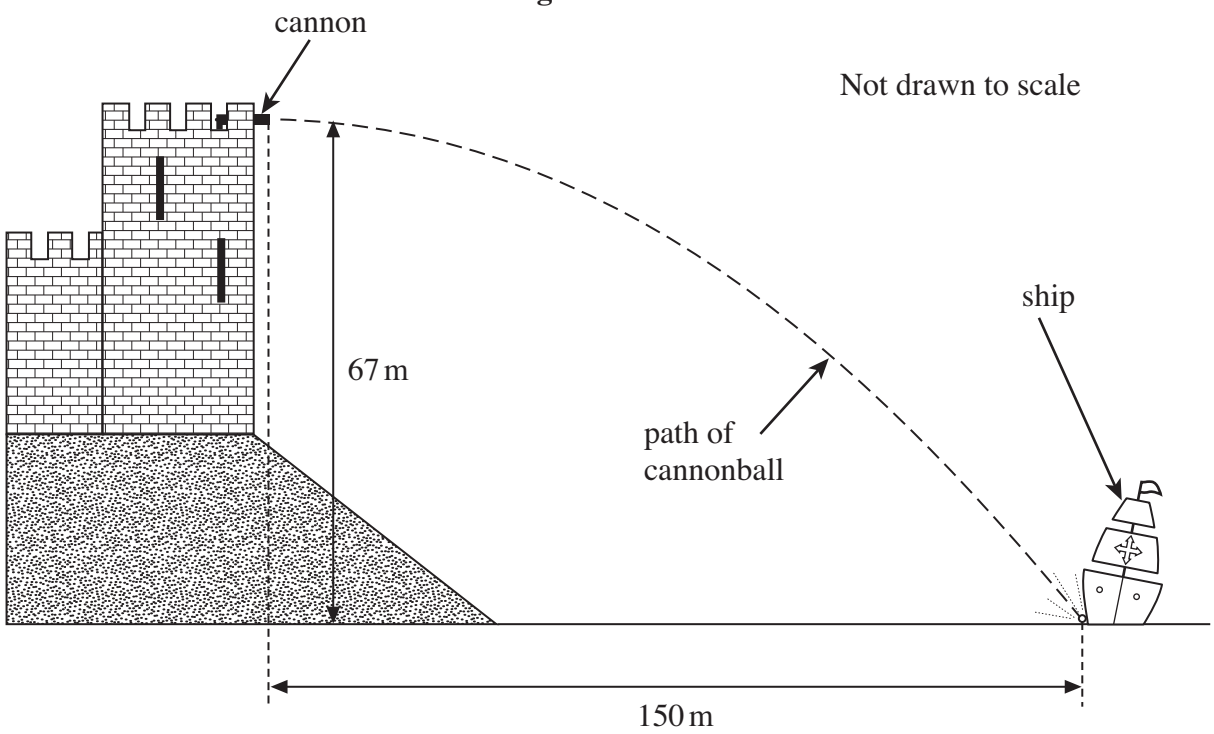
answer = ...W

(3 marks)

13

2 In a castle, overlooking a river, a cannon was once employed to fire at enemy ships. One ship was hit by a cannonball at a horizontal distance of 150 m from the cannon as shown in **Figure 2**. The height of the cannon above the river was 67 m and the cannonball was fired horizontally.

Figure 2



2 (a) (i) Show that the time taken for the cannonball to reach the water surface after being fired from the cannon was 3.7 s. Assume the air resistance was negligible.

(2 marks)

Do not write outside the box

2 (a) (ii) Calculate the velocity at which the cannonball was fired. Give your answer to an appropriate number of significant figures.

answer = ... $m\,s^{-1}$

(2 marks)

2 (a) (iii) Calculate the vertical component of velocity just before the cannonball hit the ship.

answer = ... $m\,s^{-1}$

(2 marks)

2 (a) (iv) By calculation or scale drawing, find the magnitude and direction of the velocity of the cannonball just before it hit the ship.

velocity = ... $m\,s^{-1}$

direction = ...

(4 marks)

2 (b) (i) Calculate the loss in gravitational potential energy of the cannonball.
mass of the cannonball = 22 kg

answer = ... J

(1 mark)

Turn over ▶

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2 (b) (ii) Describe the energy changes that take place from the moment the cannonball leaves the cannon until just before it hits the water. Include the effects of air resistance.

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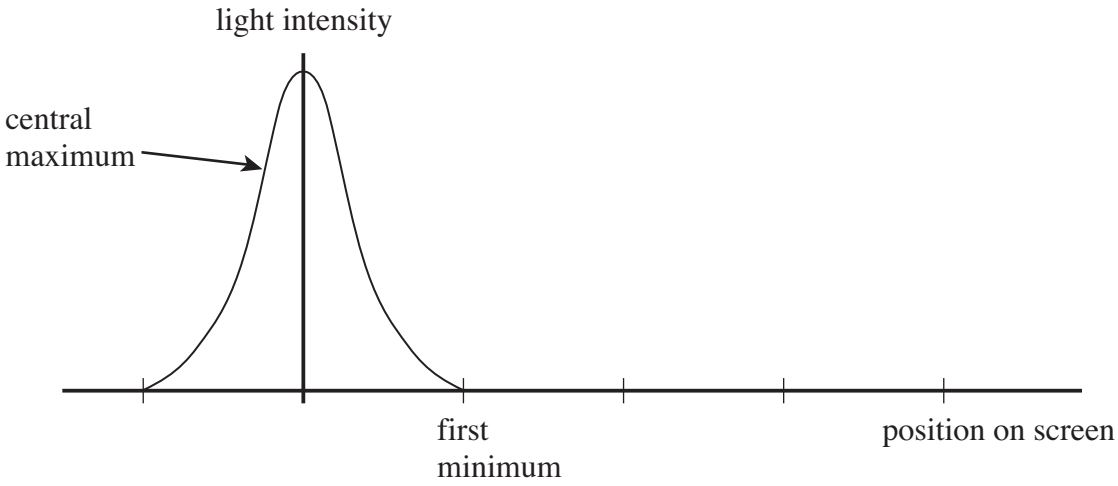
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(2 marks)

13

3 A single slit diffraction pattern is produced on a screen using a laser. The intensity of the central maximum is plotted on the axes in **Figure 3**.

Figure 3



3 (a) On **Figure 3**, sketch how the intensity varies across the screen to the right of the central maximum.

(2 marks)

3 (b) A laser is a source of *monochromatic*, *coherent* light. State what is meant by

monochromatic light .....

.....

coherent light .....

.....

(2 marks)

Do not write outside the box

3 (c) Describe how the pattern would change if light of a longer wavelength was used.

.....

.....

(1 mark)

3 (d) State **two** ways in which the appearance of the fringes would change if the slit was made narrower.

.....

.....

(2 marks)

3 (e) The laser is replaced with a lamp that produces a narrow beam of white light. Sketch and label the appearance of the fringes as you would see them on a screen.

(3 marks)

10

Turn over for the next question

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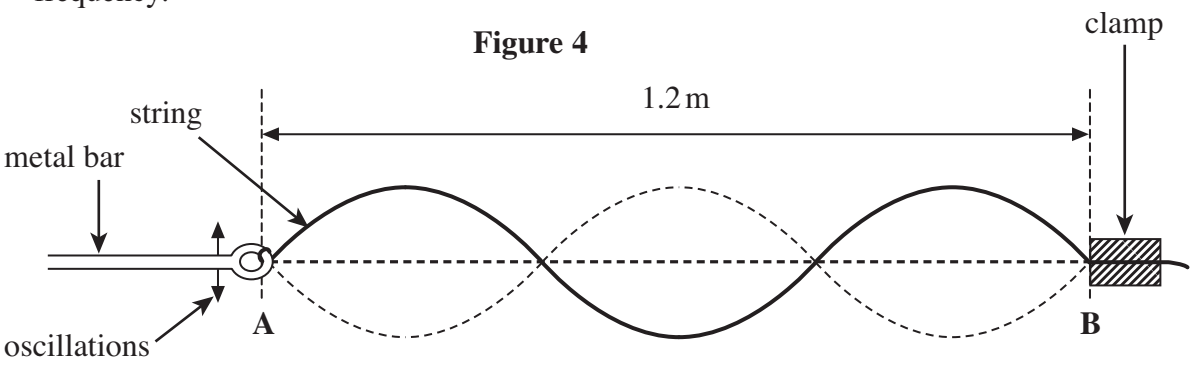
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ANSWER IN THE SPACES PROVIDED

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4 **Figure 4** shows a stationary wave on a string. The string is tied onto a thin metal bar at **A** and fixed at **B**. A vibration generator causes the bar to oscillate at a chosen frequency.

Figure 4



Explain how a stationary wave is formed. Then describe the key features of the stationary wave shown in **Figure 4.**

The quality of your written answer will be assessed in this question.

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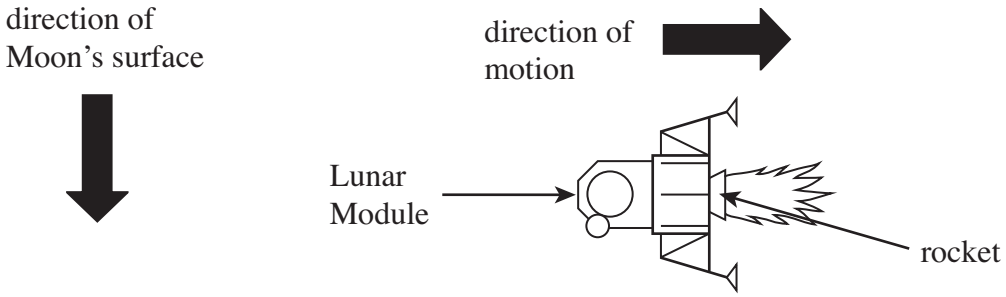
(6 marks)

6

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5 In the 1969 Moon landing, the Lunar Module separated from the Command Module above the surface of the Moon when it was travelling at a horizontal speed of 2040 ms^{-1}. In order to descend to the Moon's surface the Lunar Module needed to reduce its speed using its rocket as shown in **Figure 5**.

Figure 5



5 (a) (i) The average thrust from the rocket was 30 kN and the mass of the Lunar Module was 15100 kg. Calculate the horizontal deceleration of the Lunar Module.

answer = ... $m\,s^{-2}$

(2 marks)

5 (a) (ii) Calculate the time for the Lunar Module to slow to the required horizontal velocity of 150 $m\,s^{-1}$. Assume the mass remained constant.

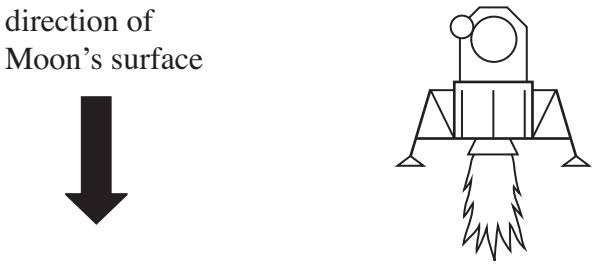
answer = ... s

(2 marks)

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5 (b) The rocket was then used to control the velocity of descent so that the Lunar Module descended vertically with a constant velocity as shown in **Figure 6**. Due to the use of fuel during the previous deceleration, the mass of the Lunar Module had fallen by 53%.

Figure 6



acceleration due to gravity near the Moon's surface = 1.61 m s^{-2}

5 (b) (i) Draw force vectors on **Figure 6** to show the forces acting on the Lunar Module at this time. Label the vectors.

(2 marks)

5 (b) (ii) Calculate the thrust force needed to maintain a constant vertical downwards velocity.

answer = ... N

(2 marks)

5 (c) When the Lunar Module was 1.2 m from the lunar surface, the rocket was switched off. At this point the vertical velocity was 0.80 m s^{-1}. Calculate the vertical velocity at which the Lunar Module reached the lunar surface.

answer = ... m s^{-1}

(2 marks)

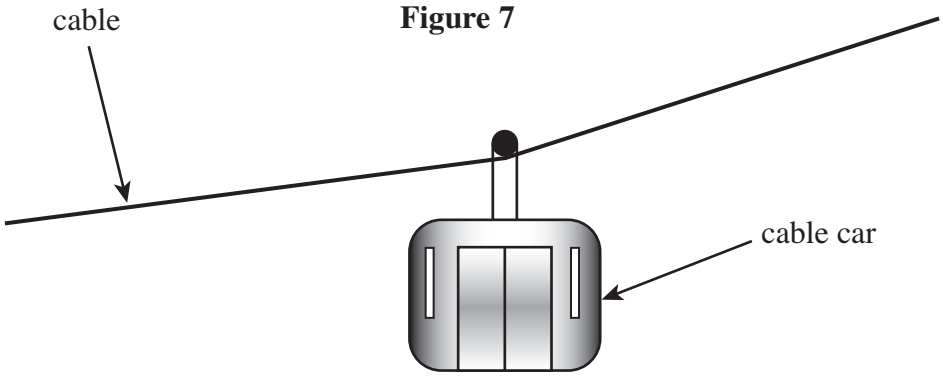
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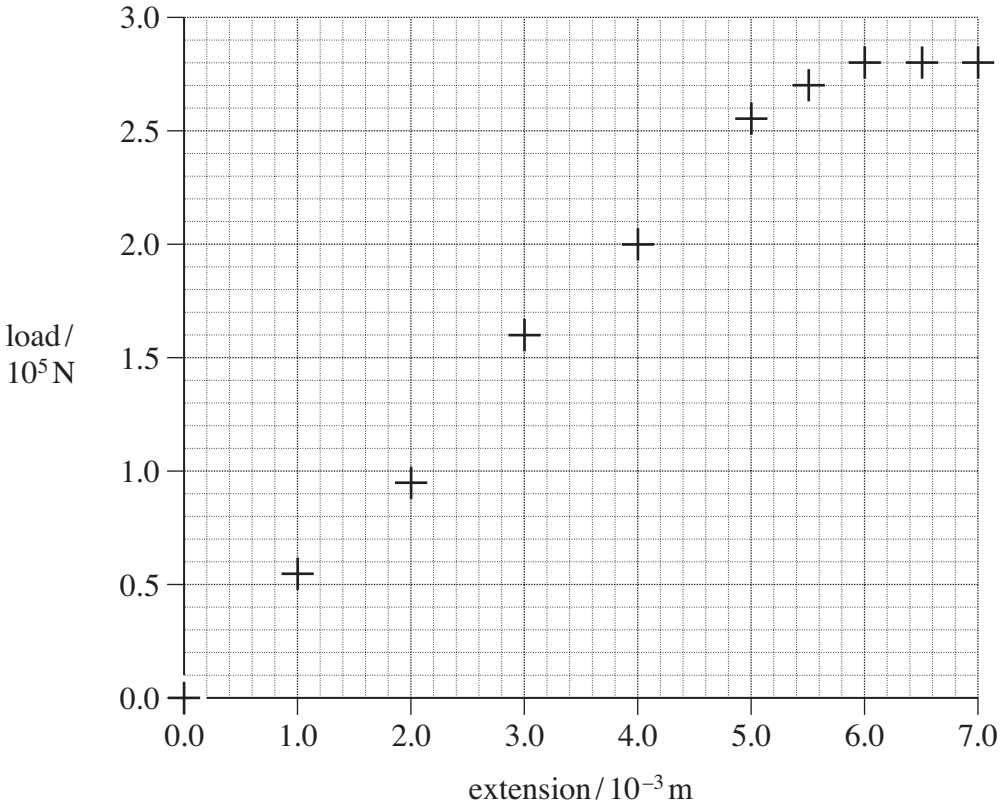
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6 A cable car system is used to transport people up a hill. **Figure 7** shows a stationary cable car suspended from a steel cable of cross-sectional area $2.5 \times 10^{-3}\,m^2$.

Figure 7



6 **(a)** The graph below is for a 10 m length of this steel cable.



6 (a) (i) Draw a line of best fit on the graph. *(2 marks)*

6 (a) (ii) Use the graph to calculate the initial gradient, *k*, for this sample of the cable.

answer = ... Nm^{-1}

(2 marks)

Do not write outside the box

6 (b) The cable breaks when the extension of the sample reaches 7.0 mm. Calculate the breaking stress, stating an appropriate unit.

answer = ...

(3 marks)

6 (c) In a cable car system a 1000 m length of this cable is used. Calculate the extension of this cable when the tension is 150 kN.

answer = ...m

(2 marks)

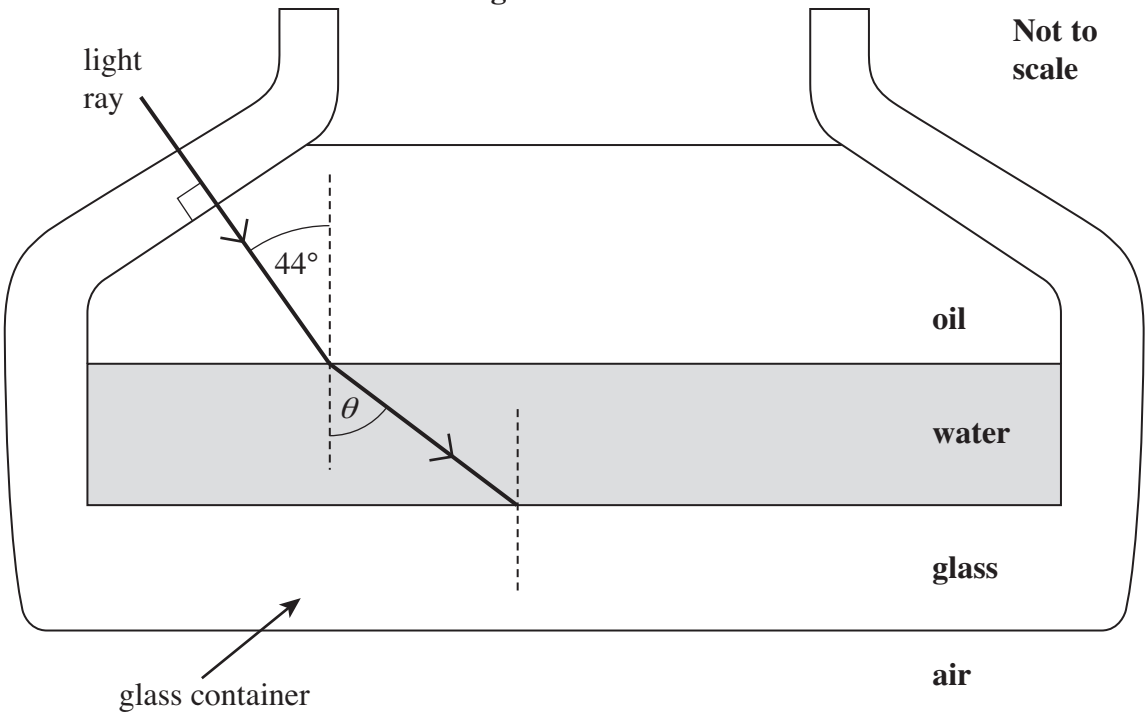
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Turn over for the next question

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7 **Figure 8** shows a layer of oil that is floating on water in a glass container. A ray of light in the oil is incident at an angle of 44° on the water surface and refracts.

Figure 8



The refractive indices of the materials are as follows.

refractive index of oil	= 1.47
refractive index of water	= 1.33
refractive index of the glass	= 1.47

7 (a) Show that the angle of refraction θ in **Figure 8** is about 50°.

(2 marks)

7 (b) The oil and the glass have the same refractive index. On **Figure 8**, draw the path of the light ray after it strikes the boundary between the water and the glass and enters the glass. Show the value of the angle of refraction in the glass.

(2 marks)

Do not write outside the box

7 (c) Explain why the total internal reflection will not occur when the ray travels from water to glass.

.....

.....

.....

(1 mark)

7 (d) Calculate the critical angle for the boundary between the glass and air.

answer = ...degrees

(2 marks)

7 (e) On **Figure 8**, complete the path of the ray after it strikes the boundary between the glass and air.

(2 marks)

9

END OF QUESTIONS

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Version 1.0



General Certificate of Education (A-level)
January 2011

Physics A PHYA2

(Specification 2450)

Unit 2: Mechanics, materials and waves

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Instructions to Examiners

1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	**5 – 6**
Modest - Adequate	*see specific mark scheme*	**3 – 4**
Poor - Limited	*see specific mark scheme*	**1 – 2**
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.

4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

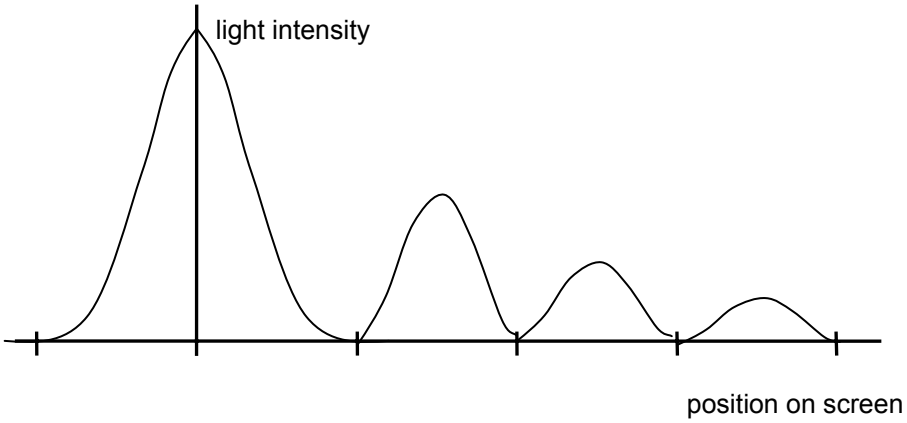
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GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

Question 1		
(a) (i)	$F \propto \Delta L$ ✓ up to limit of proportionality ✓ accept 'elastic limit' F = kΔL with terms defined gets first mark	**2**
(a) (ii)	straight line ✓ through origin ✓	**2**
(a) (iii)	working shown and $F \geq 200$ N ✓ (500/0.385) = **1290** ± 20 ✓ **N m^{-1} or** N/m kg s^{-2} ✓	**3**
(b) (i)	($\Delta W = F\Delta s$) so area (beneath line from origin to ΔL) represents (work done or) energy (to compress/extend) ✓ **work done** (on or by the spring) linked to energy stored ✓ (area of triangle) = $\frac{1}{2} b \times h$ (therefore $E = \frac{1}{2} F\Delta L$) ✓	**3**
(b) (ii)	F = **360** (N) used ✓ $P = \frac{\frac{1}{2} \times (360) \times 0.28}{1.5} = \frac{50.4}{1.5}$ ✓ = **34** (33.6) (W) ✓ ecf from wrong force	**3**
	Total	**13**

Question 2		
(a) (i)	$t = \sqrt{\frac{2s}{g}}$ (evidence for correct rearrangement or substitution) ✓ $= \sqrt{\frac{2 \times 67}{9.81}}$ (correct substitution leading to answer) ✓ (= **3.7** (3.696) (s))	**2**
(a) (ii)	$\left(v = \frac{s}{t} = \frac{150}{3.696}\right)$ = **41** (m s^{-1}) ✓ 2 sf ✓	**2**
(a) (iii)	(v = (u +) gt =) 9.81 × 3.696 ✓ = **36** ✓ (m s^{-1})	**2**
(a) (iv)	$v = \sqrt{40.586^2 + 36.257^2}$ (or correct scale drawing) ✓ = 54 (m s^{-1}) ✓ ecf from (ii) (iii) [for scale drawing allow range 53 → 56] tan$\theta = \frac{36.257}{40.586}$ ✓ or correct alternative (angle from horizontal =) **42** (°) or correct alternative angle **and clear indication of direction** ✓ [for scale drawing allow range 40 → 44 ✓ for scale drawing: quality of construction ✓]	**4**
(b) (i)	(= mgh = 22 × 9.81 × 67) = 14000 (14460) (J) ✓	**1**
(b) (ii)	(G)PE → KE ✓ (KE to) internal/thermal/'heat' (energy) ✓	**2**
	Total	**13**

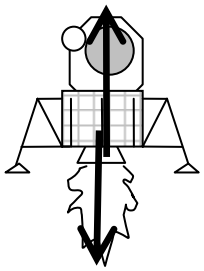
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Question 3		
(a)	3 subsidiary maxima in correct positions ✓ intensity decreasing ✓  	**2**
(b)	a single wavelength ✓ constant phase relationship/difference ✓	**2**
(c)	maxima further apart/central maximum wider/subsidiary maximum wider/maxima are wider ✓	**1**
(d)	wider/increased separation ✓ lower intensity ✓	**2**
(e)	distinct fringes shown with subsidiary maxima ✓ indication that colours are present within each subsidiary maxima ✓ blue/violet on the inner edge **or** red outer for at least one subsidiary maximum ✓ (middle of) central maximum white ✓	**3**
	Total	**10**

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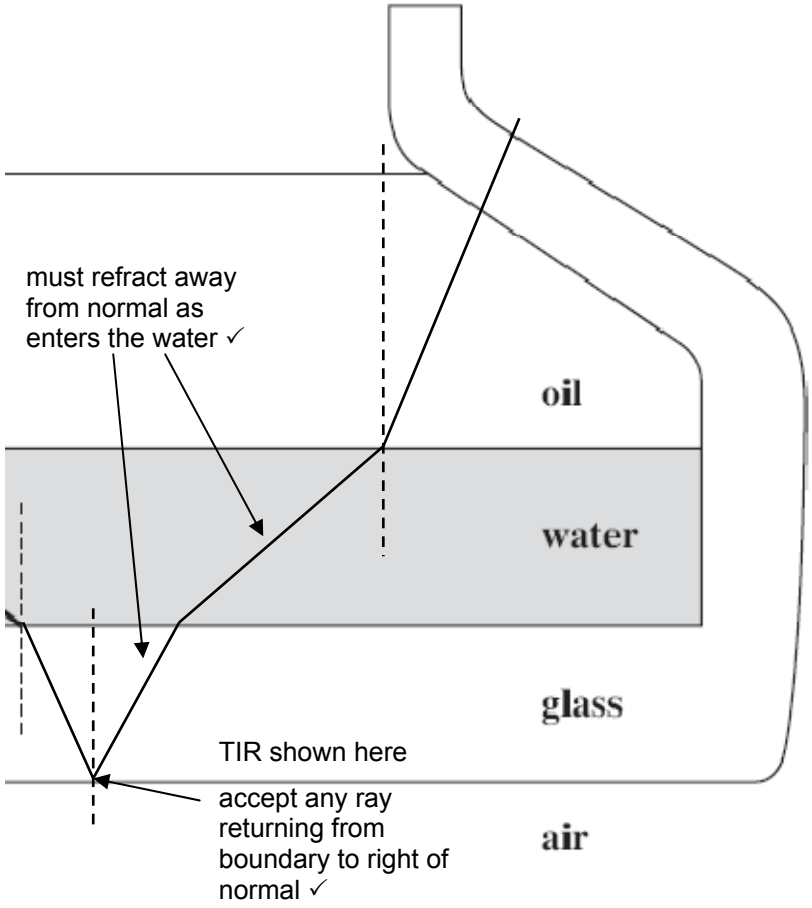
Question 4		
	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of the three levels according to the following criteria. **High Level (good to excellent) 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. Mentions **waves** travelling in **opposite directions or** waves of **same frequency** (and amplitude) **and** superpose **or** interfere **or** add together. **Intermediate Level (modest to adequate) 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. Mentions **waves** travelling in **opposite directions** (accept 'waves reflect/ rebound back or from clamp') **or superposition/addition/interference of waves or** waves of same frequency/wavelength. **Low Level (poor to limited) 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may only be partly appropriate. One correct key feature **or** one relevant remark regarding formation given. **The explanation expected in a competent answer should include a coherent account of the following points concerning the physical principles involved and their consequences in this case.** ● 4 nodes where there is no movement/zero amplitude ● 3 antinodes where amplitude is maximum ● wavelength 0.80 m ● end antinodes in phase/middle and ends in antiphase ● between node and antinode, amplitude of oscillation increases ● waves reflect off the clamp (and the rod) ● waves travelling in opposite directions superpose/add/interfere ● wave have same wavelength and frequency (similar amplitude) ● always cancellation at nodes/always constructive superposition at antinodes ● energy is not transferred along string	**max 6**
	Total	**6**

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Question 5		
(a) (i)	$\left(a = \frac{F}{m}\right) = \frac{(-)30(000)}{15100}$ ✓ = (–) 2.0 (= 1.99 m s^{-2}) ✓	**2**
(a) (ii)	($v = u + at$) $t = \frac{v-u}{a}$ or substitution ✓ = $\left(\frac{150-2040}{-1.99}\right)$ = 950 (s) ✓ ecf from (i)	**2**
(b) (i)	 opposing vertical arrows of roughly equal length **or** labelled weight/mg/gravity/W **and** thrust/reaction/R/F/TF/engine force/rocket force/motor force/motive force/driving force ✓ correctly labelled + arrows vertical + not more than 2 mm apart + roughly central + weight arrow originates within rectangular section and thrust originates within rectangular section or on jet outlet ✓	**2**
(b) (ii)	new mass = 15100 × 0.47 = 7097 (kg) ✓ ($F = mg$ = 7097 × 16(1)) = 11000 (= 11426 N) ✓	**2**
(c)	($v^2 = u^2 + 2as$ $v = \sqrt{0.80^2 + 2 \times 1.61 \times 1.2}$) correct u, a and s clearly identified ✓ = 2.1 (= 2.122 m s^{-1}) ✓	**2**
	Total	**10**

Question 6		
(a) (i)	straight best fit line from 0 → (at least) extension of 4.0 × 10^{-3} m ✓ smooth curve near points after 5.0 × 10^{-3} m ✓	**2**
(a) (ii)	$\left(k = \frac{\Delta F}{\Delta l} = \frac{2.55(\times 10^5)}{5.0\ (\times 10^{-3})}\right)$ their $\frac{\Delta F}{\Delta l}$ (ignore powers of ten) ✓ = 5.1 × 10^7 **and** x axis interval ≥ 3.0 ✓ (5.06 to 5.14 × 10^7 N m^{-1}) ecf from graph allow error in calculation ± 2%	**2**
(b)	load = 2.8 × 10^5 or $\left(stress = \frac{F}{A}\right) = \frac{2.8\ (\times 10^5)}{2.5 \times 10^{-3}}$ ✓ 2.8 only = 1.1 × 10^8 (Pa) 110 (MPa) ✓ (1.12 × 10^8) (M)Pa, pascals, N m^{-2} ✓	**3**
(c)	$\left(\Delta l = \frac{F}{k}\right) = \frac{150000}{5.1 \times 10^7}$ ✓ (= 2.94 × 10^{-3} m for 10 m) gives 0.29(4) (m) ✓ ecf or reads a reasonable extension for 150 kN from the graph ✓ and multiples by 100 (= 0.29) (ecf) ✓	**2**
	Total	**9**

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Question 7		
(a)	$\sin\theta = \frac{1.47 \sin 44}{1.33}$ or 1.33 $\sin\theta$ = 1.47 sin44 or $\sin^{-1}$ 0.768 ✓ θ = 50.15, 50.2, 50.35 (°) ✓ answer seen to > 2 sf	**2**
(b)	refracts towards normal ✓ 44° shown ✓	**2**
(c)	(TIR) only when ray travels from higher *n* to lower *n* **or** (water to glass) is lower *n* to higher *n* ✓ do not allow 'density', allow 'optical density', n or refractive index only	**1**
(d)	$\sin\theta_c = \frac{1}{1.47}$ or 1.47 $\sin\theta_c$ = (1 ×) sin90 ✓ θ_c = 42.86 (= 43.0(°)) ✓	**2**
(e)		**2**
	Total	**9**

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2010

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Wednesday 9 June 2010 9.00 am to 10.15 am

For this paper you must have:
- a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Book* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

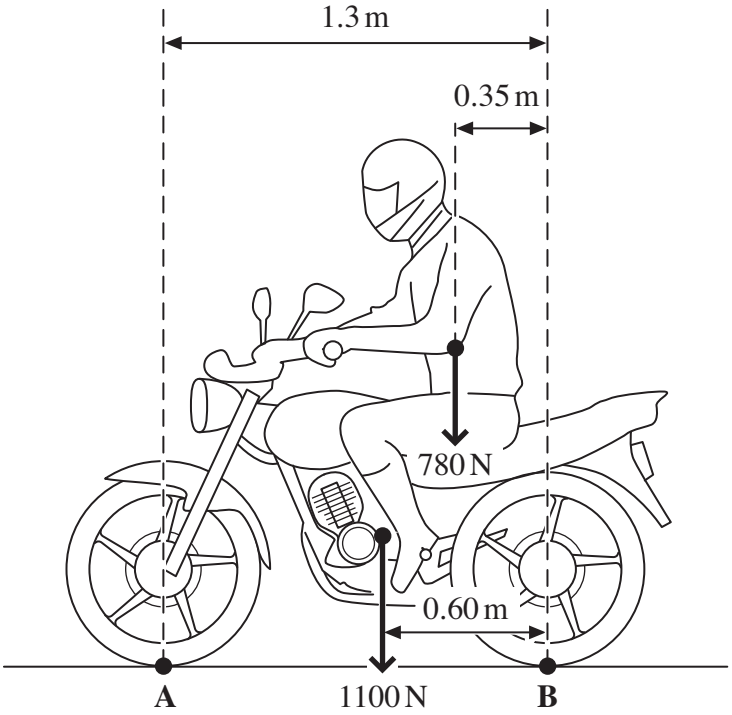
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Answer **all** questions in the spaces provided.

1 **Figure 1** shows a motorcycle and rider. The motorcycle is in contact with the road at **A** and **B**.

Figure 1



The motorcycle has a weight of 1100 N and the rider's weight is 780 N.

1 (a) State the Principle of Moments.

.....

.....

.....

(2 marks)

1 (b) Calculate the moment of the rider's weight about **B**. Give an appropriate unit.

answer = ...

(2 marks)

Do not write outside the box

1 (c) By taking the moments about **B**, calculate the vertical force that the road exerts on the front tyre at **A**. State your answer to an appropriate number of significant figures.

answer = ... N
(4 marks)

1 (d) Calculate the vertical force that the road exerts on the rear tyre at **B**.

answer = ... N
(1 mark)

1 (e) The maximum power of the motorcycle is 7.5 kW and it has a maximum speed of 26 m s^{-1}, when travelling on a level road.

Calculate the total horizontal resistive force for this speed.

answer = ... N
(2 marks)

11

There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED

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2 Galileo used an inclined plane, similar to the one shown in **Figure 2**, to investigate the motion of falling objects.

2 (a) Explain why using an inclined plane rather than free fall would produce data which is valid when investigating the motion of a falling object.

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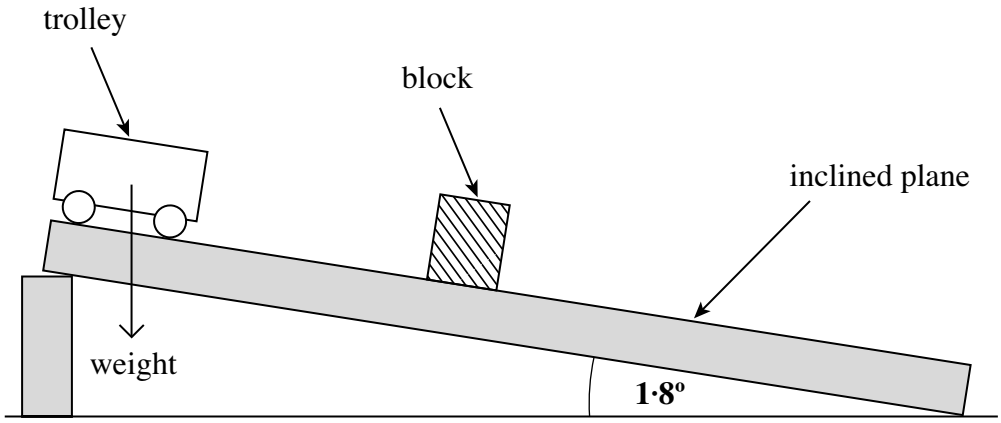
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(2 marks)

2 (b) In a demonstration of Galileo's investigation, the number of swings of a pendulum was used to time a trolley after it was released from rest. A block was positioned to mark the distance that the trolley had travelled after a chosen whole number of swings. See **Figure 2**.

Figure 2



The mass of the trolley in **Figure 2** is 0.20 kg and the slope is at an angle of 1·8° to the horizontal.

2 (b) (i) Show that the component of the weight acting along the slope is about 0.06 N.

(2 marks)

Question 2 continues on the next page

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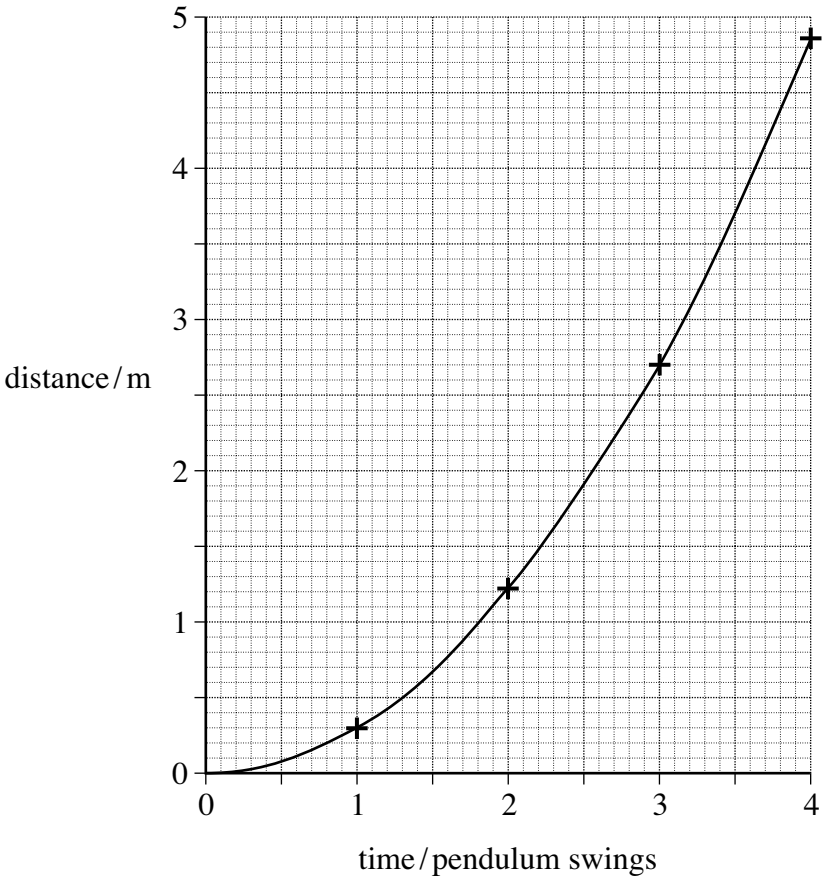
2 (b) (ii) Calculate the initial acceleration down the slope.

answer = ... $m\,s^{-2}$

(2 marks)

2 (c) In this experiment, the following data was obtained. A graph of the data is shown below it.

time / pendulum swings	distance travelled / m
1	0.29
2	1.22
3	2.70
4	4.85



Do not write outside the box

2 (c) From the graph on **page 6**, state what you would conclude about the motion of the trolley?
Give a reason for your answer.

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(2 marks)

2 (d) Each complete pendulum swing had a period of 1.4 s. Use the graph on **page 6** to find the speed of the trolley after it had travelled 3.0 m.

answer = ... $m\,s^{-1}$

(3 marks)

11

Turn over for the next question

Do not write outside the box

3 (a) Define the amplitude of a wave.

.....

.....

(1 mark)

3 (b) (i) Other than electromagnetic radiation, give **one** example of a wave that is transverse.

.....

(1 mark)

3 (b) (ii) State **one** difference between a transverse wave and a longitudinal wave.

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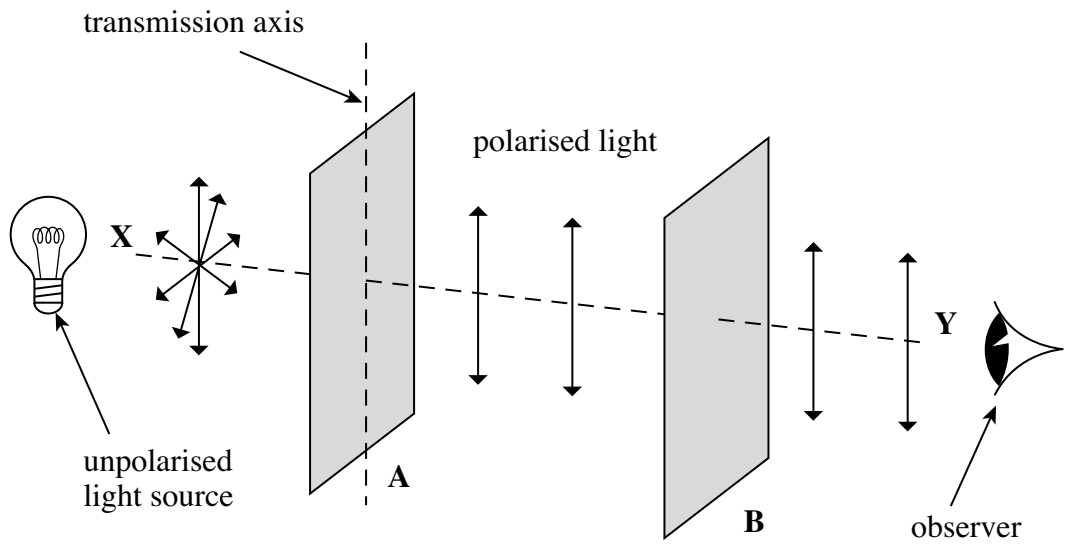
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(1 mark)

3 (c) **Figure 3** shows two identical polarising filters, **A** and **B**, and an unpolarised light source. The arrows indicate the plane in which the electric field of the wave oscillates.

3 (c) (i) If polarised light is reaching the observer, draw the direction of the transmission axis on filter **B** in **Figure 3**.

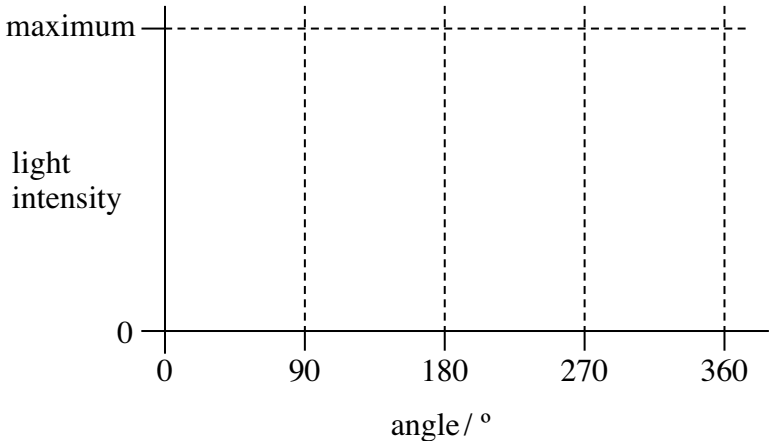
Figure 3



(1 mark)

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3 (c) (ii) The polarising filter **B** is rotated clockwise through 360° about line **XY** from the position shown in **Figure 3**. On the axes below, sketch how the light intensity reaching the observer varies as this is done.



(2 marks)

3 (d) State **one** application, other than in education, of a polarising filter and give a reason for its use.

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(2 marks)

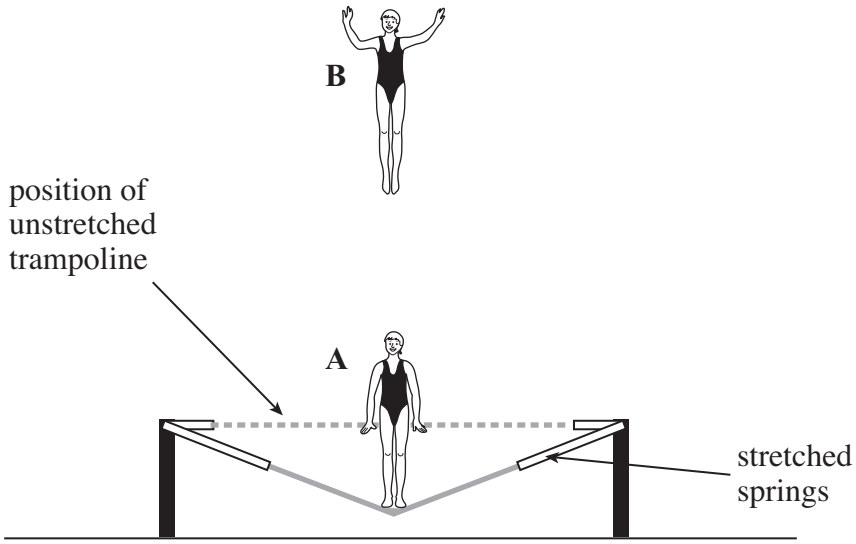
Turn over for the next question

8

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4 **Figure 4** shows a gymnast trampolining.

Figure 4



In travelling from her lowest position at **A** to her highest position at **B**, her centre of mass rises 4.2 m vertically. Her mass is 55 kg.

4 (a) Calculate the increase in her gravitational potential energy when she ascends from position **A** to position **B**.

answer = ... J

(2 marks)

Do not write outside the box

4 (b) The gymnast descends from position **B** and regains contact with the trampoline when it is in its unstretched position. At this position, her centre of mass is 3.2 m below its position at **B**.

4 (b) (i) Calculate her kinetic energy at the instant she touches the unstretched trampoline.

answer = ... J

(1 mark)

4 (b) (ii) Calculate her vertical speed at the same instant.

answer = ... $m\,s^{-1}$

(2 marks)

4 (c) Draw an arrow on **Figure 4** to show the force exerted on the gymnast by the trampoline when she is in position **A**.

(1 mark)

4 (d) As she accelerates upwards again from position **A**, she is in contact with the trampoline for a further 0.26 s. Calculate the average acceleration she would experience while she is in contact with the trampoline, if she is to reach the same height as before.

answer = ... $m\,s^{-2}$

(2 marks)

Question 4 continues on the next page

Do not write outside the box

4 (e) On her next jump the gymnast decides to reach a height above position **B**. Describe and explain, in terms of energy and work, the transformations that occur as she ascends from her lowest position **A** until she reaches her new position above **B**.

The quality of your written communication will be assessed in this question.

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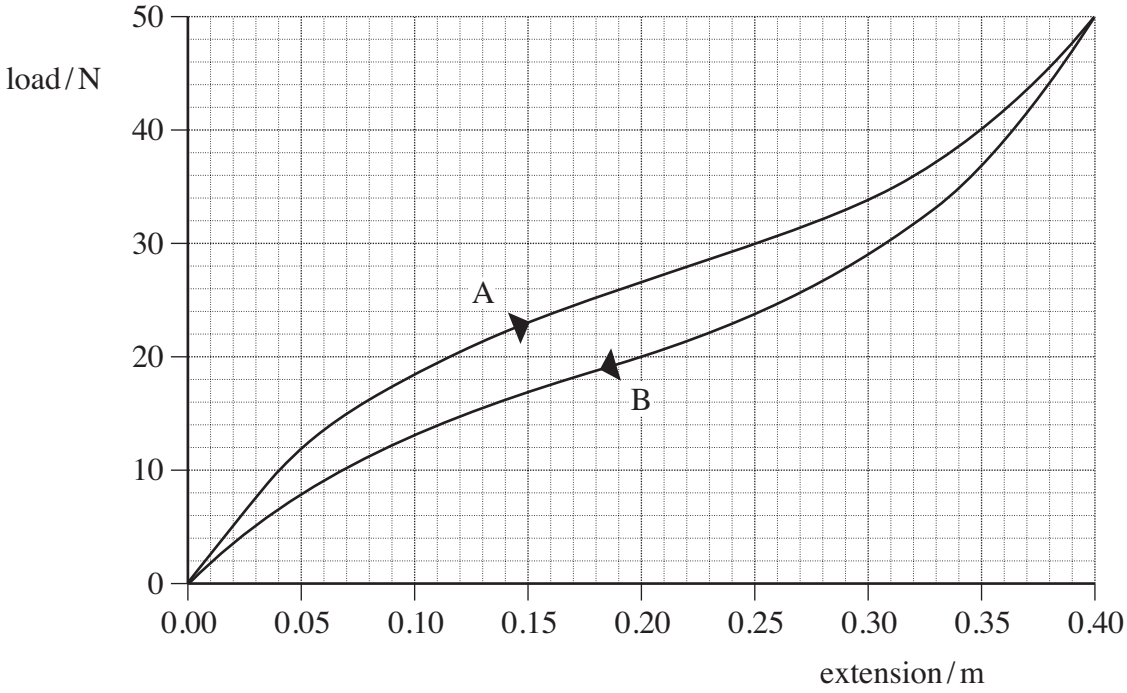
(6 marks)

14

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5 A rubber cord is used to provide mechanical resistance when performing fitness exercises. A scientist decided to test the properties of the cord to find out how effective it was for this purpose. The graph of load against extension is shown in **Figure 5** for a 0.50 m length of the cord.

Figure 5



Curve **A** shows loading and curve **B** shows unloading of the cord.

5 (a) State which feature of this graph confirms that the rubber cord is elastic.

.....

(1 mark)

5 (b) Explaining your method, use the graph (curve **A**) to estimate the work done in producing an extension of 0.30 m.

.....

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answer = ... J

(3 marks)

Question 5 continues on the next page

Do not write outside the box

5 (c) Assuming that line **A** is linear up to an extension of 0.040 m, calculate the Young modulus of the rubber for small strains.

The cross-sectional area of the cord = $5.0 \times 10^{-6}\,m^2$
The unstretched length of the cord = 0.50 m

answer = ... Pa
(3 marks)

5 (d) The scientist compared this cord with a steel spring that reached the same extension for the same maximum load without exceeding its *limit of proportionality*.

5 (d) (i) On **Figure 5**, draw the load-extension line for this spring up to a load of 50 N and label it **C**.

(1 mark)

5 (d) (ii) With reference to the spring, explain what is meant by limit of proportionality.

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(1 mark)

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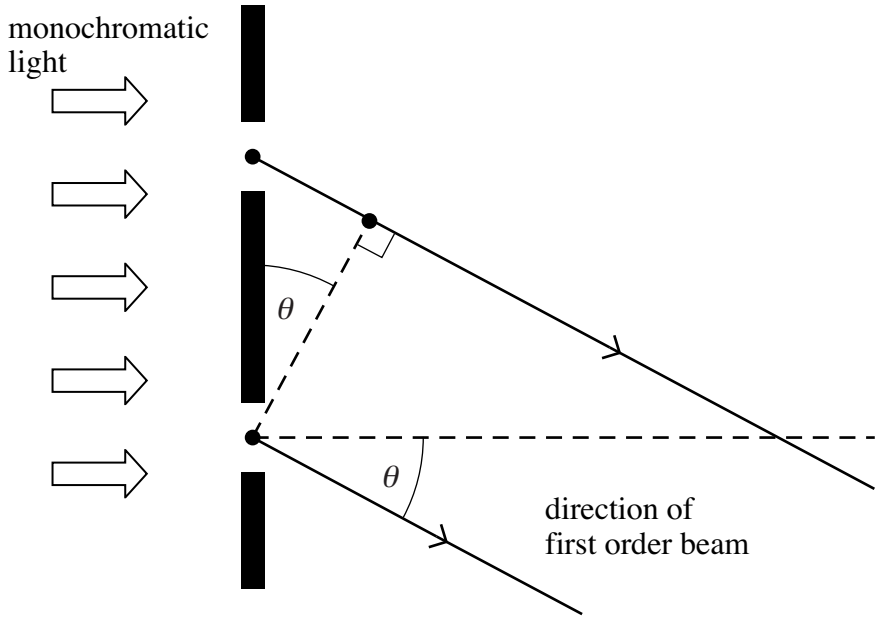
6 For a plane transmission diffraction grating, the diffraction grating equation for the first order beam is:

$$\lambda = d \sin \theta$$

6 (a) **Figure 6** shows two of the slits in the grating. Label **Figure 6** with the distances d and λ.

(2 marks)

Figure 6



6 (b) State and explain what happens to the value of angle θ for the first order beam if the wavelength of the monochromatic light decreases.

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(2 marks)

Question 6 continues on the next page

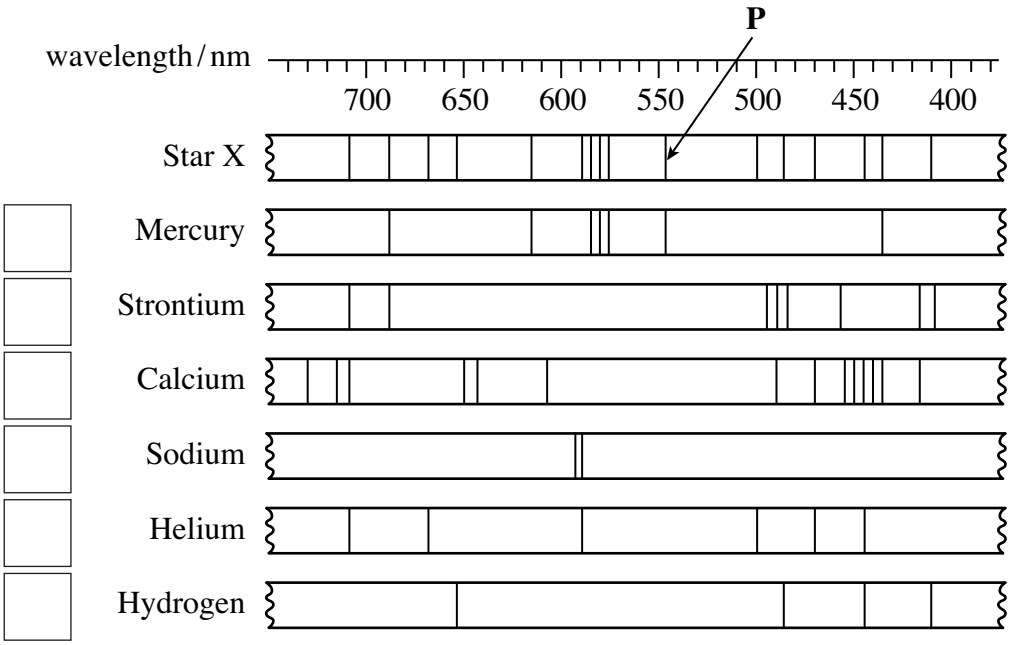
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6 (c) A diffraction grating was used with a spectrometer to obtain the line spectrum of star X shown in **Figure 7**. Below this are some line spectra for six elements that have been obtained in the laboratory.

Place ticks in the boxes next to the **three** elements that are present in the atmosphere of star X.

(2 marks)

Figure 7



6 (d) The diffraction grating used to obtain the spectrum of star X had 300 slits per mm.

6 (d) (i) Calculate the distance between the centres of two adjacent slits on this grating.

answer = ... m

(1 mark)

6 (d) (ii) Calculate the first order angle of diffraction of line **P** in **Figure 7**.

answer = ... degrees

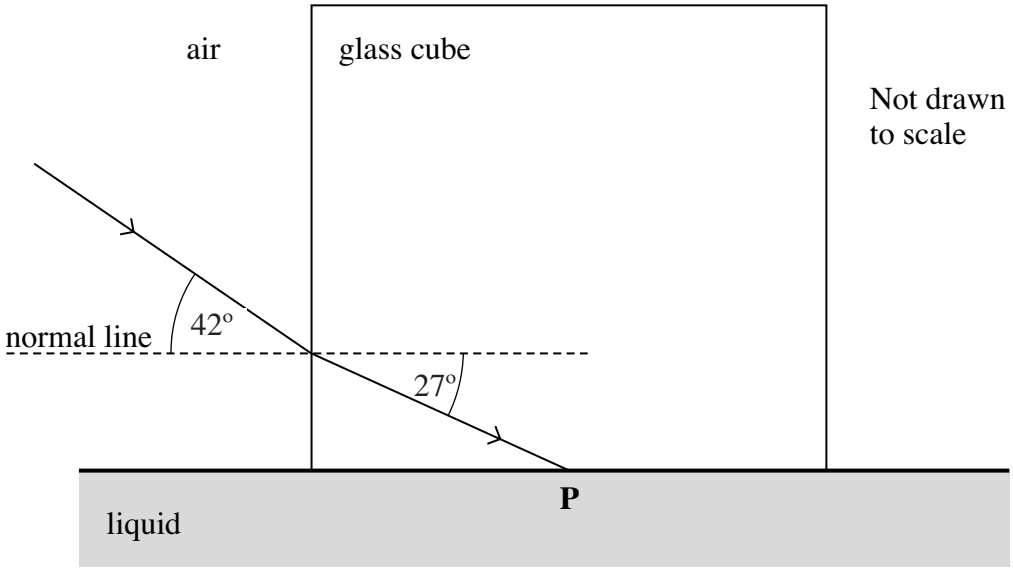
(2 marks)

9

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7 A glass cube is held in contact with a liquid and a light ray is directed at a vertical face of the cube. The angle of incidence at the vertical face is then decreased to 42° as shown in **Figure 8**. At this point the angle of refraction is 27° and the ray is totally internally reflected at **P** for the first time.

Figure 8



7 (a) Complete **Figure 8** to show the path of the ray beyond **P** until it returns to air.

(3 marks)

7 (b) Show that the refractive index of the glass is about 1.5.

(2 marks)

7 (c) Calculate the critical angle for the glass-liquid boundary.

answer = ... degrees

(1 mark)

Question 7 continues on the next page

Do not write outside the box

7 (d) Calculate the refractive index of the liquid.

answer = ...

(2 marks)

END OF QUESTIONS

8

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Version 1.0



General Certificate of Education
June 2010

Physics A PHYA2

Mechanics, Materials and Waves

Unit 2

Final

Mark Scheme

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Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available to download from the AQA Website: www.aqa.org.uk

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Instructions to Examiners

1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	**5-6**
Modest - Adequate	*see specific mark scheme*	**3-4**
Poor - Limited	*see specific mark scheme*	**1-2**
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.

4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

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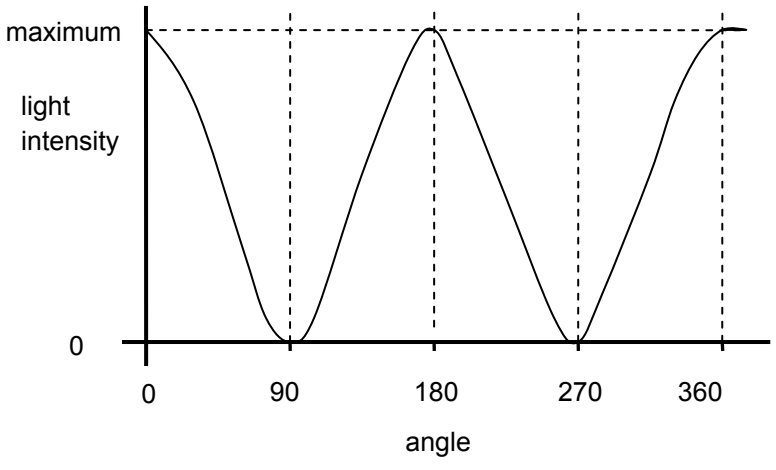
GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

Question 1		
(a)	(sum of) clockwise moment**s** (about a point) =(sum of) anticlockwise moment**s** ✓ (for a system) in equilibrium ✓ accept *balanced* not *stationary*	**2**
(b)	(780 × 0.35 =) 270 (Nm) ✓ (273) **Nm** ✓ or newton metre(s) accept Newton metre(s) (not J, nm or nM, Nms, etc)	**2**
(c)	1 (b) + (1100 x 0.60) ✓ (=) F_A × 1.3 ✓ (F_A = 660 + 273/1.3 gets both marks) (= 933/1.3) = 720 (N) ✓ (717.7 or 715 for use of 930) ecf 1 (b) **2 sf only** ✓ independent mark	**4**
(d)	(780 +1100 – (1(c)) = 1200 ✓ (1162 N) ecf 1 (c)	**1**
(e)	$\left(F = \frac{P}{v}\right) = \frac{7.5\,(\times 10^3)}{26}$ ✓ must be arranged in this form = 290 (N) ✓ (288.46)	**2**
	Total	**11**

Question 2		
(a)	any **two** from freefall is too quick (any indication of slower motion) ✓ (Galileo had) no (accurate) method to **time** freefall (or valid comment regarding timing of freefall or inclined plane) ✓ correct reference to **air** resistance or **drag** (not 'wind') ✓	**max 2**
(b) (i)	0.20 × 9.81 = 1.962 (N) ✓ (1.962 sin 1.8 =) 0.0616 or 0.062 seen ✓ (allow 0.061) (0.0628 for use of g = 10 gets 1 mark)	**2**
(b) (ii)	0.06(16)/0.20 **or** use of *a=F/m* with a clearly identified force but not the weight **or** g sin θ = g sin 1.8° ✓ 0.31 (ms^{-2}) ✓ (0.308) accept 0.3 or 0.30 correct answer only for second mark **or** ($a = 2s/t^2$) = 2 × 0.29/1.4^2 ✓ = 0.31 ✓ or use of other values from table	**2**
(c)	accelerating ✓ (accept increasing speed, etc but not increasing acceleration/quicker motion, etc) greater distance for each additional swing ('per unit time' must be implied) or gradient/ steepness/ slope increasing ✓ (accept curves upwards)	**2**

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(d)	**tangent used**: tangent drawn at 3.0m ± 0.3 on graph ✓ their time from graph × 1.4 ✓ = 1.28 to 1.44 ($m\,s^{-1}$) ✓ **or suvat used**: use of $v = \frac{2s}{t}$ or $v = (u) + at$ with a from 2 (b) (ii) ✓ (t =) 4.4 to 4.5 (s) ✓ (speed =) 1.3 to 1.4 (ms^{-1}) ✓	**3**
	Total	**11**

Question 3			
(a)		**maximum displacement** from equilibrium/mean position/mid-point/etc ✓	**1**
(b)	(i)	any **one** from: surface of water/water waves/in ripple tank ✓ rope ✓ slinky clearly qualified as transverse ✓ secondary ('s') waves ✓	**max 1**
(b)	(ii)	transverse wave: oscillation (of medium) is perpendicular to wave travel or transverse can be polarised or **all** longitudinal require a medium ✓	**1**
(c)	(i)	vertical line on B ± 5° ✓	**1**
(c)	(ii)	 max 0, 180, 360 + min 90, 270 ✓ **and** line reaches same minimum and maximum every time and reasonable shape ✓	**2**

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(d)	appropriate use ✓ reason for Polaroid filter being used ✓ **eg** **Polaroid** glasses/**sun**glasses/ windscreens — to reduce glare camera — reduce glare/enhance image (in a) microscope — to identify minerals/rocks polarimeter — to analyse chemicals/concentration or type of sugar stress analysis — reveals areas of high/low stress/ other relevant detail LCD displays — very low power/other relevant detail 3D glasses — enhance viewing experience, etc	**2**
	Total	**8**

Question 4		
(a)	(ΔEp= $mg\Delta h$) = **55** × 9.8(1) × 4.2 ✓ = 2300 (J) ✓ (2266.1)	**2**
(b) (i)	(E_k = 3.2/4.2 x 2264 or uses suitable kinematics equation) = 1700(J) ✓ (= 1724.8 = 1720) ecf 4 (a)	**1**
(b) (ii)	($E_k = \frac{1}{2}mv^2$ = 1724.8) $v = \sqrt{\frac{2 \times 1724.8}{55}} = \sqrt{62.72}$ ecf (b) (i) or use of $v^2 = 2as$ ✓ = 7.9 m s^{-1} ✓ (= 7.9196)	**2**
(c)	one arrow, vertical, upward pointing, starts on soles of feet ✓	**1**
(d)	(use of $\alpha = \frac{\Delta v}{\Delta t}$ gives) = $\frac{7.920}{0.26}$ ✓ or ecf 4 (b) (ii)/0.26 = 30 ($m s^{-2}$) ✓ (30.46) **or use** $\alpha = \frac{2s}{t^2}$ of or $\alpha = \frac{v^2}{2s}$ ✓ allow incorrect values of *s* here = 29.6 or 31.4 respectively ✓	**2**

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(e)	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. Candidate must state that: • (elastic potential) energy is transformed to **kinetic or** trampoline does work (on gymnast) • (KE) is transformed into (gravitational) **potential** energy • (the gymnast) must 'jump'/bend knees/do work/'use' chemical energy/supply energy (to increase height) For 6 marks, must also state that (the gymnast) must overcome resistive forces (drag/heat loss/reference to energy 'lost' in trampoline, etc) **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. Candidate must state **one** from: • chemical energy (transferred) to elastic, kinetic or gravitational energy • PE (from trampoline) to KE (of gymnast) • KE (gymnast) to (G)PE (gymnast) **and one** of the following: • work is done by the trampoline (on the gymnast) • that work is done on the trampoline (by the gymnast) • work done against resistive forces • (additional) energy input required (to achieve additional height) **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. Candidate must • give **one** relevant energy gain or loss in the system **or** state that energy is input to reach greater height For two marks, a relevant energy transformation must be given **or** one further marking point from next page	**max 6**

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	Further marking points: • (to reach the same height) the gymnast must do work in order to replace the energy wasted as the springs and the trampoline (rubber) unload (contract) • to reach a greater height, the gymnast must do additional work by (bending and) extending her legs (jumping) as the trampoline moves upwards • the additional downward force keeps the trampoline extended for longer, thus increasing the impulse • correct reference to law of energy conservation	
	Total	**14**

Question 5		
(a)	returns to original length/shape/position/state/zero extension/no **permanent** extension ✓	**1**
(b)	(12 to 14 big squares/318 small squares ± 8 area of 1 big square = 10N × 0.05m = 0.50/small = 2 × 0.01 = 0.02) statement of method that refers to **area** ✓ accept triangle if **area** is mentioned 5.0 to 8.0 (J) or clear attempt to calculate correct area ✓ triangle OK here 5.1 (J) for single triangle is max 2 6.0 to 7.0 (J) ✓	**4**
(c)	(E =) $\frac{FL}{A\Delta L}$ ✓ (=) $\frac{10 \times 0.50}{5.0 \times 10^{-6} \times 0.04}$ ✓ also gets first mark incorrect values of F and ΔL get first mark only 2.5×10^7 (Pa) ✓ **or** (stress = F/A =) $10/5 \times 10^{-6}$ (= 2.0×10^6 Pa) ✓ (strain = $\Delta L/L$ =) 0.04/0.5 (= 0.08) ✓ $2 \times 10^6/0.08$ gets both marks E correctly evaluated from incorrect value of stress and incorrect value of strain gets 1 mark only use of 50 (N) and 0.04 (m) giving 1.25×10^8 (Pa) gains 2 marks use of 5(N) and 0.4 (m) is max 2 2.5×10^7 (Pa) ✓	**3**
(d) (i)	straight line through origin finishing at the same point as the rubber ± 1 small division ✓	**1**
(d) (ii)	**point beyond which** graph is no longer linear **or** force no longer proportional to extension **or** Hooke's law limit ✓	**1**
	Total	**10**

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Question 6		
(a)	λ correct ✓ d correct ✓ arrow or line needed, both ends extending beyond central black line	**2**
(b)	angle θ gets smaller ✓ because path difference gets smaller/***d* constant**, (λ smaller) so sin θ smaller ✓ max 1 for correct explanation for λ increasing	**3**
(c)	boxes 1,5,6 ✓✓ two correct 1 mark 4 ticks max 1 5 or 6 ticks gets 0	**2**
(d) (i)	3.3×10^{-6} m ✓ (1/300 = 3.33×10^{-3} **mm**, 3300 **nm**) DNA 1 sf here DNA 1/300 000 as answer accept 3 1/3 x 10^{-6}, 3.33 x 10^{-6} recurring, etc	**1**
(d) (ii)	(sin θ =) $\frac{540 \text{ to } 560 \times (10^{-9})}{((d)(i))}$ ✓ correct wavelength used and seen (**545 to 548 x 10^{-9}**) **and** 9.4 to 9.6 (°) ✓ ecf (d) (i), for correct wavelength only (545 to 548 × 10^{-9})	**2**
	Total	**10**

Question 7		
(a)	reflects at correct angle by eye (use top of '27' and bottom of '42' as a guide) **or 27**° or **63**° correctly marked ✓ refracts away from normal at glass/air ✓ symmetrical by eye or refracted angle (42°) correctly marked and at least one normal line added ✓	**3**
(b)	(n_g) = $\frac{\sin 42}{\sin 27}$ ✓ DNA 42/27 = 1.56 = 1.47 (1.474) 3 sf shown ✓	**2**
(c)	63 (°) ✓ allow 62 to 62.99 **with** reasoning, allow 'slightly less than 63' without reason given	**1**
(d)	$\left(\frac{n_l}{n_g} = \frac{\sin 63}{\sin 90}\right) n_l$ = 1.474 sin (7 (c)) ✓ or use of n = 1.5 = 1.3(1) or 1.34 if n = 1.5 used ✓	**2**
	Total	**8**

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2010

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Monday 18 January 2010 1.30 pm to 2.45 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

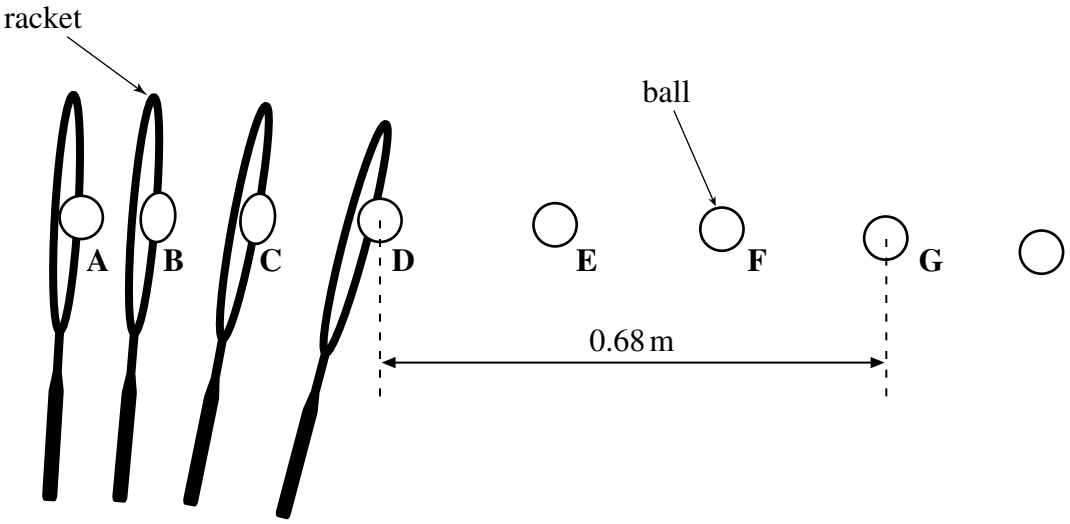
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Areas outside the box will not be scanned for marking

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

1 A digital camera was used to obtain a sequence of images of a tennis ball being struck by a tennis racket. The camera was set to take an image every 5.0 ms. The successive positions of the racket and ball are shown in **Figure 1**.

Figure 1



1 (a) The ball has a horizontal velocity of zero at **A** and reaches a constant horizontal velocity at **D** as it leaves the racket. The ball travels a horizontal distance of 0.68 m between **D** and **G**.

1 (a) (i) Show that the horizontal velocity of the ball between positions **D** and **G** in **Figure 1** is about 45 m s^{-1}.

(3 marks)

Areas outside the box will not be scanned for marking

1 (a) (ii) Calculate the horizontal acceleration of the ball between **A** and **D**.

answer = ... $m\,s^{-2}$

(1 mark)

1 (b) At **D**, the ball was projected horizontally from a height of 2.3 m above level ground.

1 (b) (i) Show that the ball would fall to the ground in about 0.7 s.

(3 marks)

1 (b) (ii) Calculate the horizontal distance that the ball will travel after it leaves the racket before hitting the ground. Assume that only gravity acts on the ball as it falls.

answer = ... m

(2 marks)

1 (b) (iii) Explain why, in practice, the ball will not travel this far before hitting the ground.

.....

.....

.....

(2 marks)

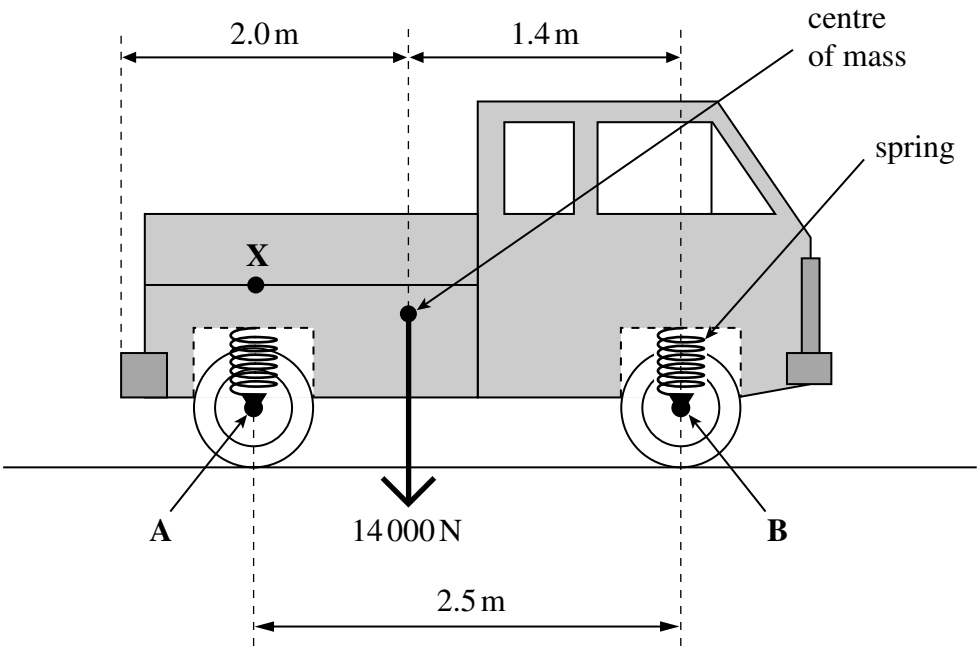
11

Turn over ▶

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2 Heavy duty coil springs are used in vehicle suspensions. The pick-up truck shown in **Figure 2** has a weight of 14 000 N and length of 4.5 m. When carrying no load, the centre of mass is 2.0 m from the rear end. The part of the vehicle shown shaded in grey is supported by four identical springs, one near each wheel.

Figure 2



2 (a) (i) Define the moment of a force about a point.

.....

.....

.....

.....

(2 marks)

2 (a) (ii) State and explain which pair of springs, front or rear, will be compressed the most.

.....

.....

.....

.....

(2 marks)

Areas outside the box will not be scanned for marking

2 (a) (iii) By taking moments about axle **B**, calculate the force exerted on the truck by each rear spring.

answer = ... N

(4 marks)

2 (b) The spring constant for each of these springs is $100\,000\,\text{N}\,\text{m}^{-1}$.

Calculate the distance that each of these rear springs is compressed by this vehicle as shown in **Figure 2**.

answer = ... m

(2 marks)

2 (c) The springs must not be compressed by more than an additional 0.065 m. Calculate the maximum load that could be placed at point **X**, which is directly above the centre of the rear axle **A**, as shown in **Figure 2**.

answer = ... N

(2 marks)

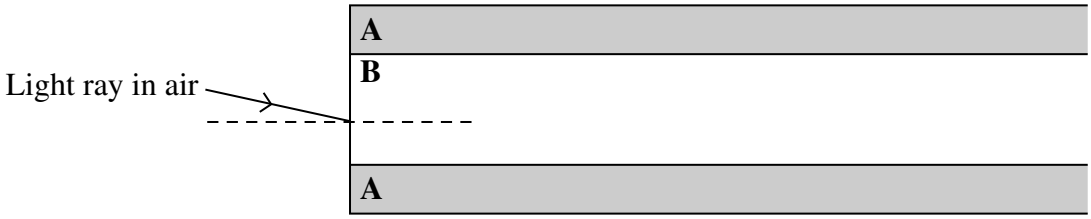
12

Turn over ▶

Areas outside the box will not be scanned for marking

3 **Figure 3** shows a cross-section through a step index optical fibre.

Figure 3



3 (a) (i) Name the parts **A** and **B** of the fibre.

(1 mark)

A	
B	

3 (a) (ii) On **Figure 3**, draw the path of the ray of light through the fibre. Assume the light ray undergoes *total internal reflection* at the boundary between **A** and **B**.

(2 marks)

3 (b) Calculate the critical angle for the boundary between **A** and **B**. Give your answer to an appropriate number of significant figures.

The refractive index of part **A** = 1.46
The refractive index of part **B** = 1.48

answer = ... degrees

(2 marks)

Areas outside the box will not be scanned for marking

3 (c) State and explain **one** reason why part **B** of the optical fibre is made as narrow as possible.

.....

.....

.....

.....

(2 marks)

3 (d) State **one** application of optical fibres and explain how this has benefited society.

Application

.....

.....

Benefit

.....

.....

(2 marks)

9

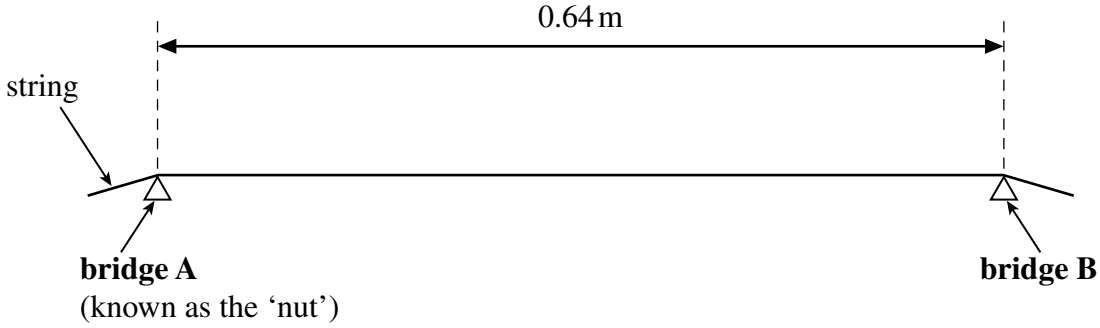
Turn over for the next question

Areas outside the box will not be scanned for marking

4 **Figure 4** shows a side view of a string on a guitar. The string cannot move at either of the two bridges when it is vibrating. When vibrating in its fundamental mode the frequency of the sound produced is 108 Hz.

4 (a) (i) On **Figure 4**, sketch the stationary wave produced when the string is vibrating in its fundamental mode.

Figure 4



(1 mark)

4 (a) (ii) Calculate the wavelength of the fundamental mode of vibration.

answer = ... m

(2 marks)

4 (a) (iii) Calculate the speed of a progressive wave on this string.

answer = ... $m\,s^{-1}$

(2 marks)

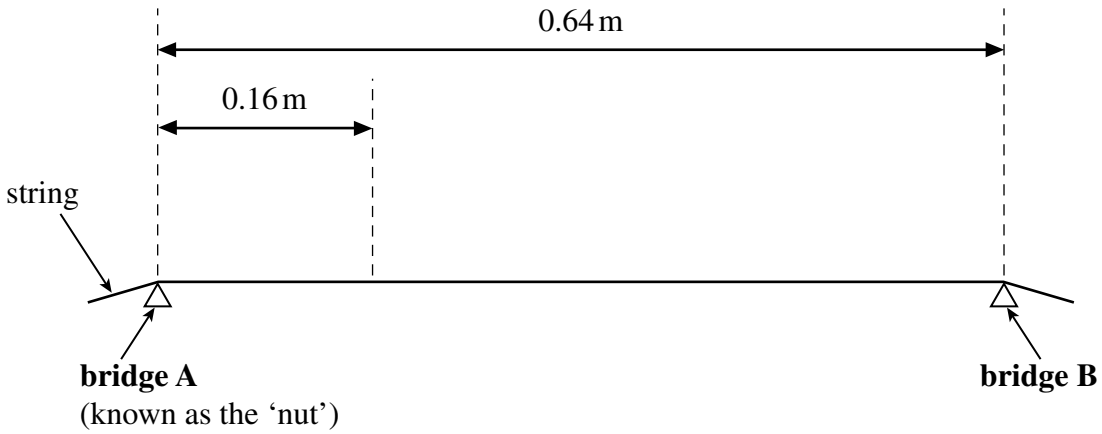
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4 (b) While tuning the guitar, the guitarist produces an overtone that has a node 0.16 m from **bridge A**.

4 (b) (i) On **Figure 5**, sketch the stationary wave produced and label all nodes that are present.

(2 marks)

Figure 5



4 (b) (ii) Calculate the frequency of the overtone.

answer = ... Hz

(1 mark)

4 (c) The guitarist needs to raise the fundamental frequency of vibration of this string. State **one** way in which this can be achieved.

.....

.....

(1 mark)

9

Turn over ▶

Areas outside the box will not be scanned for marking

5 Just over two hundred years ago Thomas Young demonstrated the interference of light by illuminating two closely spaced narrow slits with light from a single light source.

5 (a) What did this suggest to Young about the nature of light?

.....

.....

(1 mark)

5 (b) The demonstration can be carried out more conveniently with a laser. A laser produces *coherent*, *monochromatic* light.

5 (b) (i) State what is meant by monochromatic.

.....

.....

5 (b) (ii) State what is meant by coherent.

.....

.....

(2 marks)

5 (b) (iii) State **one** safety precaution that should be taken while using a laser.

.....

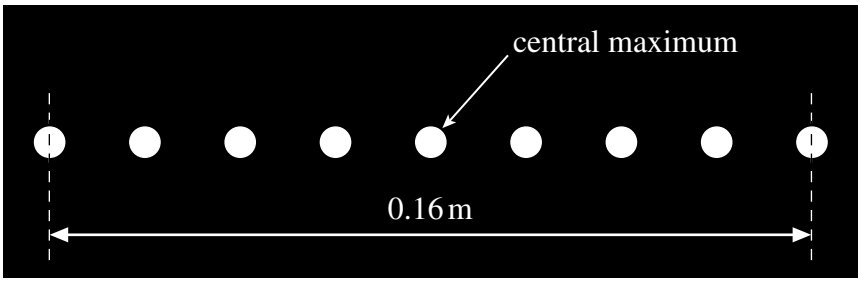
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(1 mark)

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5 (c) **Figure 6** shows the maxima of a two slit interference pattern produced on a screen when a laser was used as a monochromatic light source.

Figure 6



The slit spacing = 0.30 mm.
The distance from the slits to the screen = 10.0 m.

Use **Figure 6** to calculate the wavelength of the light that produced the pattern.

answer = ... m

(3 marks)

5 (d) The laser is replaced by another laser emitting visible light with a shorter wavelength. State and explain how this will affect the spacing of the maxima on the screen.

.....

.....

.....

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(2 marks)

9

Turn over ▶

Areas outside the box will not be scanned for marking

6 (a) Describe how to obtain, accurately by experiment, the data to determine the Young modulus of a metal wire.

A space is provided for a labelled diagram.

The quality of your written answer will be assessed in this question.

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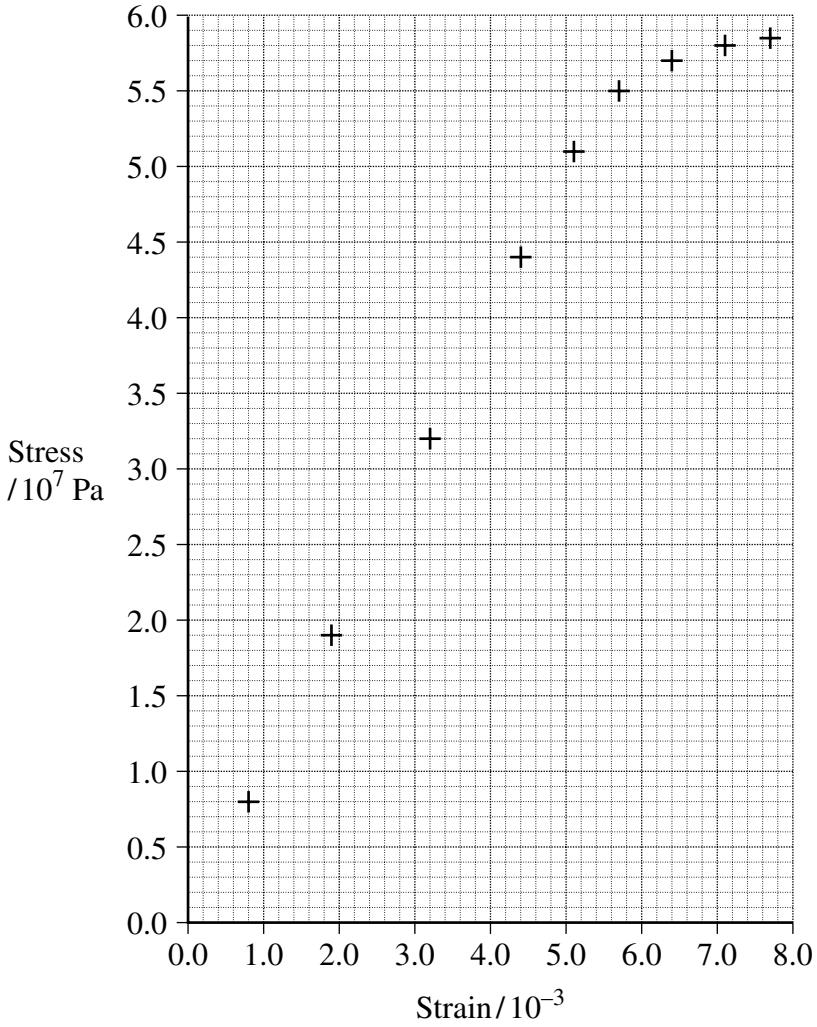
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(6 marks)

Areas outside the box will not be scanned for marking

6 (b) **Figure 7** is a plot of some results from an experiment in which a metal wire was stretched.

Figure 7



6 (b) (i) Draw a best-fit line using the data points.

(1 mark)

Question 6 continues on the next page

Turn over ▶

Areas outside the box will not be scanned for marking

6 (b) (ii) Use your line to find the Young modulus of the metal, stating an appropriate unit.

answer = ...

(4 marks)

6 (c) After reaching a strain of 7.7×10^{-3}, the wire is to be unloaded. On **Figure 7**, sketch the line you would expect to obtain for this.

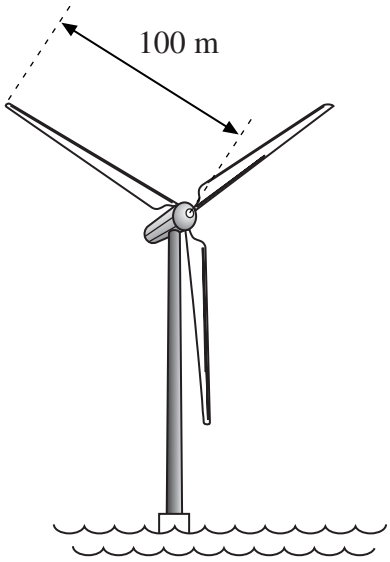
(1 mark)

12

Areas outside the box will not be scanned for marking

7 It has been predicted that in the future large offshore wind turbines may have a power output ten times that of the largest ones currently in use. These turbines could have a blade length of 100 m or more. A turbine such as this is shown in **Figure 8**.

Figure 8



7 (a) At a wind speed of 11 m s^{-1} the volume of air passing through the blades each second is 3.5×10^5 m^3.

7 (a) (i) Show that the mass of air that would pass through the blades each second is about 4×10^5 kg.

The density of air is 1.2 kg m^{-3}

(2 marks)

Question 7 continues on the next page

Turn over ▶

Areas outside the box will not be scanned for marking

7 (a) (ii) Calculate the kinetic energy of the air that would enter the turbine each second.

answer = ... J
(2 marks)

7 (a) (iii) It has been predicted that the turbine would produce an electrical power output of 10 MW in these wind conditions. Calculate the percentage efficiency of the turbine in converting this kinetic energy into electrical energy.

answer = ... %
(2 marks)

7 (b) State **one** advantage and **one** disadvantage of wind power in comparison to fossil fuel.

Advantage .....

.....

Disadvantage .....

.....
(2 marks)

8

END OF QUESTIONS

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Version 1.0: 0310

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 1451

Specification A

PHYA2 Mechanics, Materials and Waves

Mark Scheme

2010 examination - January series

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Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available to download from the AQA Website: www.aqa.org.uk

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Dr Michael Cresswell Director General

Instructions to Examiners

1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	**5-6**
Modest - Adequate	*see specific mark scheme*	**3-4**
Poor - Limited	*see specific mark scheme*	**1-2**
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.

4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

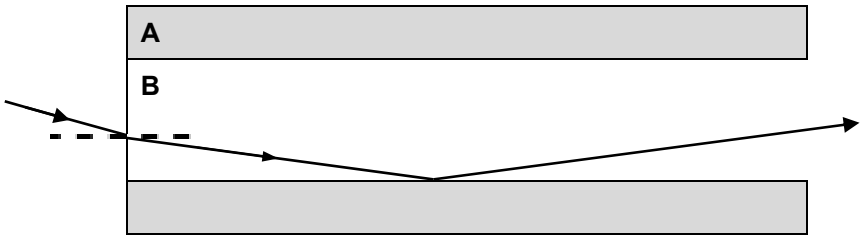
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GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

Question 1		
(a) (i)	$v = \frac{s}{t}$ ✓ t = 0.015 (s) or 15 (ms) ✓ 0.68/0.015 ✓ (= 45)	**3**
(a) (ii)	$\left(a = \frac{\Delta v}{\Delta t} = \frac{45.3}{0.015}\right)$ = 3000 (m s^{-2}) (3022) ✓	**1**
(b) (i)	$s = (ut) = \frac{1}{2}gt^2$ or $t = \sqrt{\frac{2s}{g}}$ ✓ correct substitution seen = $\sqrt{\frac{2 \times 2.3}{9.81}}$ ✓ 0.68 to 0.69 correct answer to more than one dp seen ✓	**3**
(b) (ii)	($s = vt$) = 45(.3) × 0.685 or 0.7 ✓ = 30.6 to 32 ✓ (m)	**2**
(b) (iii)	mention of air resistance or drag ✓ causing **horizontal** deceleration or 'slowing down' ✓	**2**
	Total	**11**

Question 2		
(a) (i)	force × perpendicular distance ✓ between line of action of force and the point ✓	**2**
(a) (ii)	rear ✓ at rear + idea that centre of mass is closer to the rear wheel (than to the front wheel) ✓	**2**
(a) (iii)	14000 × 1.4 = F × 2.5 ✓ F = 7840 (N) ✓ divides their final answer by 2 ✓ = 3900 (N) ✓ (3922)	**4**
(b)	$(F = k\Delta l)\frac{F}{k}$ or (Δl =) $\frac{\text{a(iii)}}{100000}$ ✓ = 0.039 (m) ✓ ecf	**2**
(c)	F = (100000 × 0.065 =) 6500 (N) ✓ F = (2 × 6500) = 13000 (N) ✓	**2**
	Total	**12**

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Question 3		
(a) (i)	A: **cladding** + B: **core** ✓	**1**
(a) (ii)	 refraction towards the normal line ✓ continuous lines + strikes boundary + TIR correct angles by eye + maximum 2 TIRs ✓	**2**
(b)	$\left(sin\theta_c = \frac{n_2}{n_1}\right)$ or = 0.9865 ✓ 80.6 or 80.8 or 81 (°) only ✓	**2**
(c)	to reduce **multipath** or **multimode dispersion** ✓ (which would cause) light travelling at different angles to arrive at different times/pulse broadening/merging of adjacent pulses/'smearing'/ poor resolution/lower transmission rate/lower bandwidth/less distance between regenerators ✓ **or** to prevent light/data/signal loss (from core or fibre) ✓ (which would cause) signal to get weaker/attenuation/crossover/data to be less secure ✓	**2**
(d)	correct application ✓ (endoscope, cytoscope, arthroscope etc, communications etc) linked significant benefit stated eg improve medical diagnosis/improve transmission of data/high speed internet ✓	**2**
	Total	**9**

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Question 4		
(a) (i)	one 'loop' (accept single line only, accept single dashed line) + nodes at each bridge (± length of arrowhead) + antinode at centre ✓	**1**
(a) (ii)	$\lambda_0 = 2L$ or $\lambda = 0.64 \times 2$ ✓ = 1.3 (m) ✓ (1.28)	**2**
(a) (iii)	($c = f\lambda$) = 108 × (a)(ii) ✓ = 138 to 140(.4) ($m\,s^{-1}$) ✓ ecf from (a)(ii)	**2**
(b) (i)	four antinodes ✓ (single or double line) first node on 0.16 m (within width of arrowhead) + middle node between the decimal point and the centre of the 'm' in '0.64 m' + middle 3 nodes labelled 'N', 'n' or 'node' ✓	**2**
(b) (ii)	(4 f_0 =) 430 (Hz) ✓ (432) or use of $f = \frac{v}{\lambda}$ gives 430 to 440 Hz correct answer only, no ecf	**1**
(c)	decrease the length/increase tension/tighten string ✓	**1**
	Total	**9**

Question 5		
(a)	showed that light was a **wave** (rather than a particle)/**wave** nature (of light) ✓	**1**
(b) (i)	single wavelength (or frequency) ✓	**1**
(b) (ii)	(waves/source(s) have) constant phase difference ✓	**1**
(b) (iii)	any sensible precaution, eg do not look into laser/do not point the laser at others/do not let (regular) reflections enter the eye/safety signs/suitable safety goggles ✓	**1**
(c)	(0.16/8) = 0.02(0) ✓ = $\frac{0.020 \times 0.30\ (\times 10^{-3})}{10.0}$ ✓ ecf from calculation of fringe spacing = 6.0 × 10^{-7} m ✓ (= 600 nm) ecf from calculation of fringe spacing	**3**
(d)	maxima closer together ✓ (quotes equation and states that) spacing is proportional to wavelength/ D and s are constant therefore as λ decreases so ω decreases ✓ **or** links smaller wavelength to smaller path difference ✓	**2**
	Total	**9**

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Question 6		
(a) **QWC**	the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication **descriptor**	**mark range**
good - excellent	(i) Uses accurately appropriate grammar, spelling, punctuation and legibility. (ii) Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [may include bullet points and/or formulae or equations] **Physics**: describes a workable account of making most measurements accurately. **For 6 marks**: complete description of the measurements required + **how to find the extension** + instruments needed + at least 2 accuracy points **For 5 marks**: all 4 quantities measured including **varying** load + 2 instruments, 2 accuracy points. (i) Only a few errors. (ii) Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples.	**5 - 6**
modest - adequate	**Physics**: describes a workable account of making all or most of the measurements and has some correct awareness of at least one accurate measurement. **For 4 marks**: all 4 quantities measured including **varying** load + 2 instruments mentioned + 1 accuracy point. **For 3 marks**: 3 quantities (**load**, **extension**, **diameter** or **cross-sectional area**) may only omit original length + 1 instrument + 1 accuracy point. (i) Several significant errors. (ii) Answer lacking structure, arguments not supported by evidence and contains limited information.	**3 - 4**
poor - limited	**Physics**: unable to give a workable account but can describe some of the measurements. **For 2 marks**: load or mass + measure extension + one instrument mentioned. **For 1 mark**: applying a single load/mass + one other quantity or one instrument named or shown.	**1 – 2**
incorrect, inappropriate or no response		**0**

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	Quantities to be measured • describe/show means of applying a **load/force** to a wire • measure **original length** • measure **extension** • measure **diameter** • extension = extension length – original length (needed for six marks) Measuring instruments • use of **rule**/ruler/tape measure • measure diameter with **micrometer** • use of **travelling microscope** to measure extension, or extension of wire measured with **vernier** scale for Searle's apparatus Accuracy • varying load/mass • repeat readings (of length or extension) • diameter measured in several places • Searle's 'control' wire negating effect of temperature change • change in diameter monitored (with micrometer) • original length of wire ≥ 1.0 m Additional creditworthy point • explain how cross-sectional area is found using $A = \pi (D/2)^2$ • showing how Young modulus is found is regarded as neutral	
(b) (i)	good straight line through origin (within one square) up to stress = 5.1×10^7 and line that lies close to data points thereafter ✓	**1**
(b) (ii)	evidence of use of gradient or stress/strain ✓ Δ strain used ≥ 3.2 ($\times 10^{-3}$) for correct gradient calculation ✓ $1.0 \pm 0.05 \times 10^{10}$ ✓ (0.95 to 1.05) allow 1 sf ecf form their line – may gain full marks Pa or $N\,m^{-2}$ or N/m^2 only ✓	**4**
(c)	originates at last point + parallel to their first line + straight + touches *x* axis ✓	**1**
	Total	**12**

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Question 7		
(a) (i)	($m = \rho V$) = 1.2 × 3.5 × 10^5 must be seen ✓ 4.2 × 10^5 (kg) seen ✓	**2**
(a) (ii)	($E_k = \frac{1}{2} mv^2$) = $\frac{1}{2}$ × 4.2 × 10^5 × 11^2 ✓ 2.5 or 2.4 × 10^7 (J) ✓ (25.4 or 24.2 MJ)	**2**
(a) (iii)	$\frac{10 \times 10^6}{2.54 \times 10^7}$ ✓ allow ecf from (a)(ii) 39 to 41.6 (%) ✓ allow ecf from (a)(ii) unless percentage is greater than 100	**2**
(b)	**advantages**, any one: wind has: no fuel cost/causes no air pollution/no CO_2/is renewable ✓ **disadvantages**, any one from: wind: varies/is intermittent/unreliable/causes visual pollution/noise/danger to birds/has a high capital cost/high 'start up' cost/requires changes to National Grid need ✓ allow 'unpredictable'	**2**
	Total	**8**

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