Accredited

OCR

AS Level Physics A
H156/01 Breadth in physics
Sample Question Paper

Date – Morning/Afternoon
Version 2.0

Time allowed: 1 hour 30 minutes

You must have:
• the Data, Formulae and Relationships Booklet

You may use:
• a scientific or graphical calculator

SPECIMEN

First name									
Last name									
Centre number						**Candidate number**				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **28** pages.

SECTION A

You should spend a maximum of 25 minutes on this section.

Answer **all** the questions.

1 The table below shows the measurements recorded by a student for a solid metal sphere. The absolute uncertainties in the mass of the sphere and in its radius are also shown.

mass	100 ± 6 g
radius	1.60 ± 0.08 cm

What is the percentage uncertainty in the density of the sphere?

A 1%

B 11%

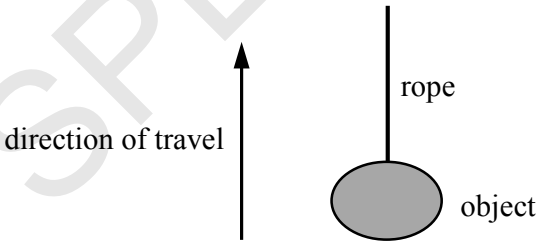
C 16%

D 21%

Your answer ☐

[1]

2 An object of mass 7.0 kg is pulled vertically upwards by a rope. The acceleration of the object is 2.0 m s^{-2}.



What is the tension in the rope?

A 14 N

B 55 N

C 69 N

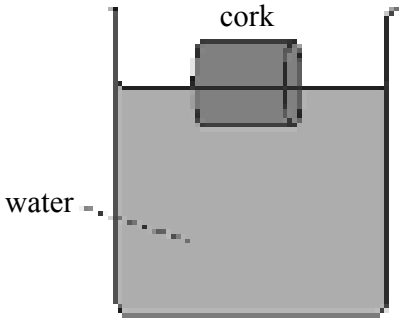
D 83 N

Your answer ☐

[1]

SPECIMEN

3 A bottle cork floats on water. It is partially submerged in the water.



Which of the following statements is/are true?

1 The net force acting on the cork is equal to the weight of the water displaced.

2 The weight of the cork is equal to the upthrust on the cork.

3 The upthrust on the cork is equal to the mass of the water displaced.

A 1, 2 and 3

B Only 2 and 3

C Only 3

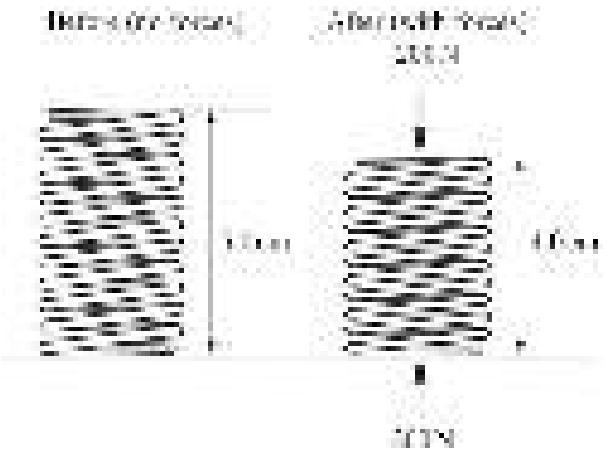
D Only 2

Your answer ☐

[1]

SPECIMEN

4 A compression spring is being tested in an engineering laboratory. The diagram shows the spring before and after the forces are applied to its opposite ends.



The initial length of the spring is 5.0 cm and during the application of the forces its length is 4.0 cm.

What is the force constant of this spring?

A 4.0×10^3 N m^{-1}

B 5.0×10^3 N m^{-1}

C 2.0×10^4 N m^{-1}

D 4.0×10^4 N m^{-1}

Your answer ☐

[1]

5 A balloon is travelling vertically downwards at a constant acceleration. The upthrust on the balloon is U, its weight is W and it experiences air resistance F.

Which statement is correct?

A $F + W > U$

B $W + U > F$

C $F > W + U$

D $W > U + F$

Your answer ☐

[1]

SPECIMEN

6 A brick of mass m has sides of lengths a, b and c, where $a < b < c$. The brick is placed on a horizontal table such that the pressure it exerts on the table is a maximum.

What is the maximum pressure p acting on the table?

A $p = \frac{mg}{ab}$

B $p = \frac{mg}{ac}$

C $p = \frac{mg}{bc}$

D $p = \frac{mg}{abc}$

Your answer ☐

[1]

7 Two balls **X** and **Y** are dropped from a very tall building. Both balls reach terminal velocity before hitting the ground. The balls have the same diameter. The mass of **X** is greater than the mass of **Y**.

Which statement is correct?

A The balls hit the ground at the same time.

B The terminal velocity of **Y** is greater than that of **X**.

C The initial acceleration of both balls is the same.

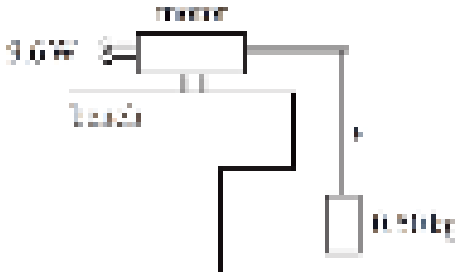
D The balls have the same kinetic energy just before hitting the ground.

Your answer ☐

[1]

SPECIMEN

8 A small electric motor is 20% efficient. Its input power is 9.6 W when it is lifting a mass of 0.50 kg at a steady speed v.



What is the value of v?

A 0.39 m s^{-1}

B 2.0 m s^{-1}

C 2.8 m s^{-1}

D 3.8 m s^{-1}

Your answer ☐

[1]

9 A car accelerates uniformly from rest along a level road.
The effects of air resistance on the car are negligible.
The car travels 12 m in the second second of its journey.

How far does it travel in the fourth second?

A 28 m

B 35 m

C 48 m

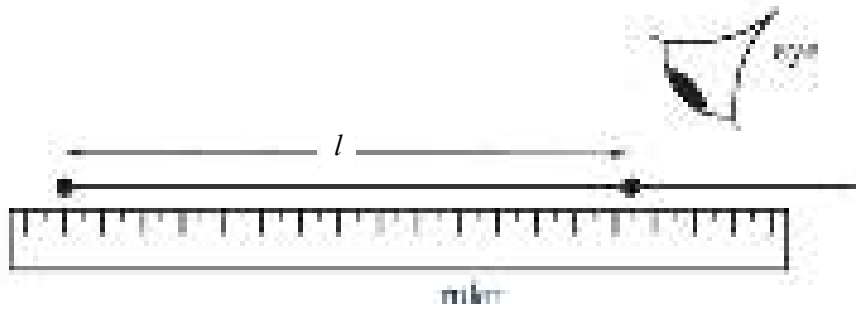
D 64 m

Your answer ☐

[1]

SPECIMEN

10 A metre rule is being used to measure the length l of a section of wire. The end of the ruler is displaced from the start of the wire.



What is the nature of the errors associated with the length measurement?

A There are random errors but no systematic errors.

B There are systematic errors but no random errors.

C There are both systematic and random errors.

D There is no overall error because the random and systematic errors cancel out.

Your answer ☐

[1]

11 Which of the following statements is/are true about photons?

1 The speed of a photon changes at the boundary between air and glass.

2 Photons are electrically neutral.

3 The energy of a photon depends only on its wavelength.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

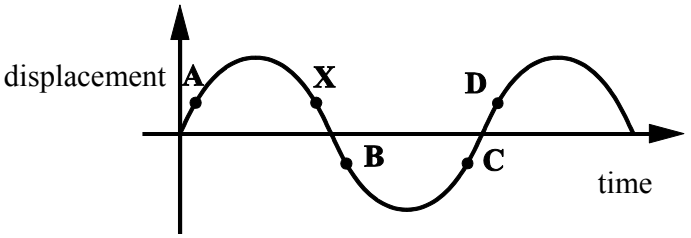
D Only 1 is correct

Your answer ☐

[1]

SPECIMEN

12 The diagram below shows the displacement-time graph of a particle as a progressive wave travels through a medium.

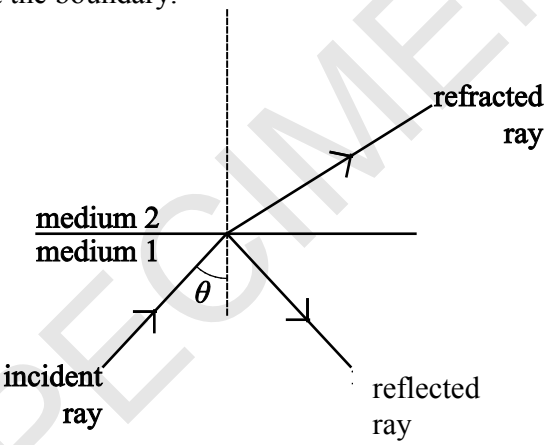


Which point **A**, **B**, **C**, or **D** has a phase difference of 180° with reference to point **X**?

Your answer ☐

[1]

13 A ray of monochromatic light is incident at a boundary between medium 1 and medium 2. The ray is both refracted and reflected at the boundary.



Which of the following statements is/are true?

1 The refracted light and incident light have the same wavelength.

2 The speed of light in medium 2 is greater than the speed of light in medium 1.

3 The angle θ is the critical angle.

A 1, 2 and 3

B Only 1 and 2

C Only 1

D Only 2

Your answer ☐

[1]

SPECIMEN

14 A resistor is connected across a power supply.

Which statement is correct about the conduction electrons in this resistor?

A They travel at the speed of light between collisions with ions.

B They make random collisions with vibrating electrons.

C They travel at their mean drift velocity between collisions.

D They drift towards the positive end of the power supply.

Your answer ☐

[1]

15 A filament lamp is described as being 120 V, 60 W. The lamp is connected to a supply so that it lights normally.

Which statement is correct?

A The charge passing through the filament in one second is 2.0 coulomb.

B The lamp transfers 60 joule for each coulomb passing through the filament.

C The lamp transfers 120 joule in 2.0 second.

D The supply provides 60 joule to the lamp when the current is 2.0 ampere.

Your answer ☐

[1]

16 A battery of e.m.f. of 8.0 V and internal resistance 2.5 Ω is connected to an external resistor. The current in the resistor is 350 mA.

What is the power dissipated in the external resistor?

A 1.9 W

B 2.5 W

C 2.8 W

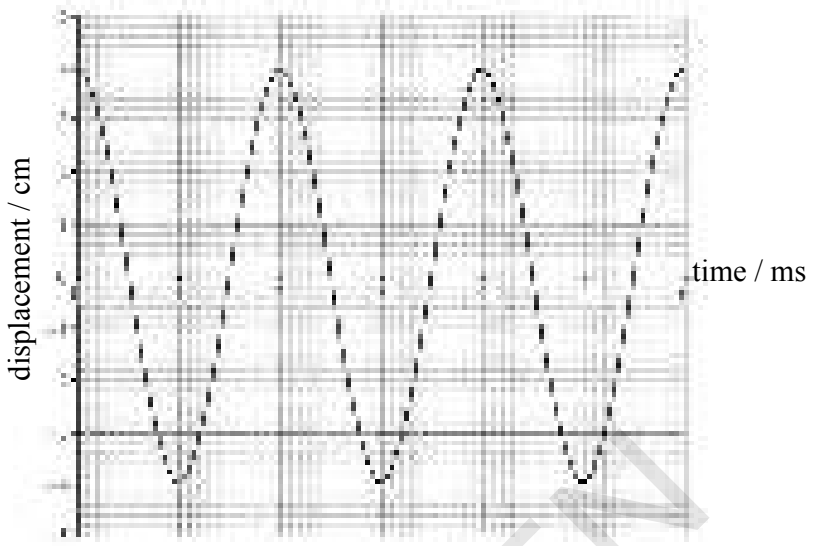
D 3.1 W

Your answer ☐

[1]

SPECIMEN

17 The diagram below shows the displacement-time graph of an air particle as a sound wave passes.



The speed of the sound wave is 340 m s^{-1}.

What is the wavelength of the sound wave?

A 0.68 m

B 1.7 m

C 170 m

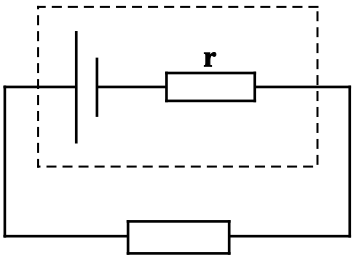
D 680 m

Your answer ☐

[1]

SPECIMEN

18 The diagram below shows a cell with an internal resistance connected to an external resistor.



Which of the following will increase the terminal p.d?

1 Increasing the e.m.f. of the cell.

2 Increasing the value of the external resistance.

3 Increasing the value of the internal resistance.

A 1, 2 and 3

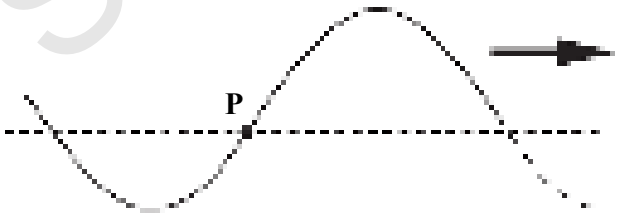
B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

19 The figure shows part of a transverse progressive wave which is travelling to the right along a string.
The horizontal dotted line shows the position of the string when there is no wave present.
In which direction is the string at the point **P** moving at the instant shown?



A upwards

B downwards

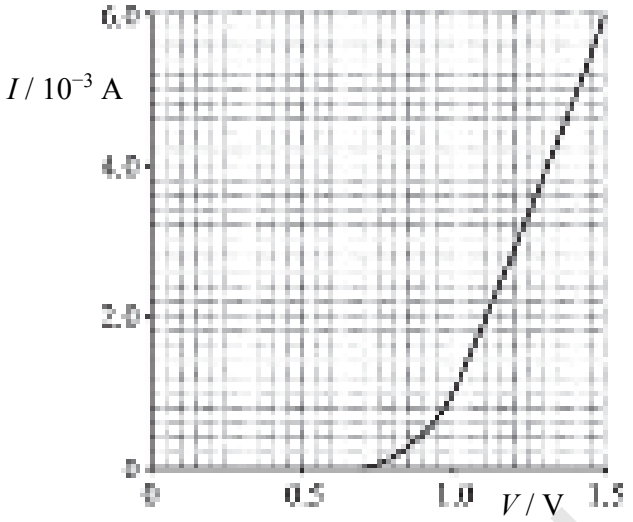
C to the right

D it is at rest

Your answer ☐ **[1]**

SPECIMEN

20 The graph shows the *I*-*V* characteristic of a semiconductor diode.



Which statement about the resistance of the diode can be deduced from the characteristic?

A It is zero between 0 V and 0.70 V.

B It is constant between 1.0 V and 1.5 V.

C It is 0.4 Ω at 1.2 V.

D It decreases between 0.70 V and 1.0 V.

Your answer ☐

[1]

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Section B begins on page 14

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SECTION B

Answer **all** the questions

21 **(a)** State what is meant by a *vector quantity* and give one example.

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…… **[1]**

(b) **Fig. 21.1** shows a toy locomotive on a circular track of radius 0.60 m.

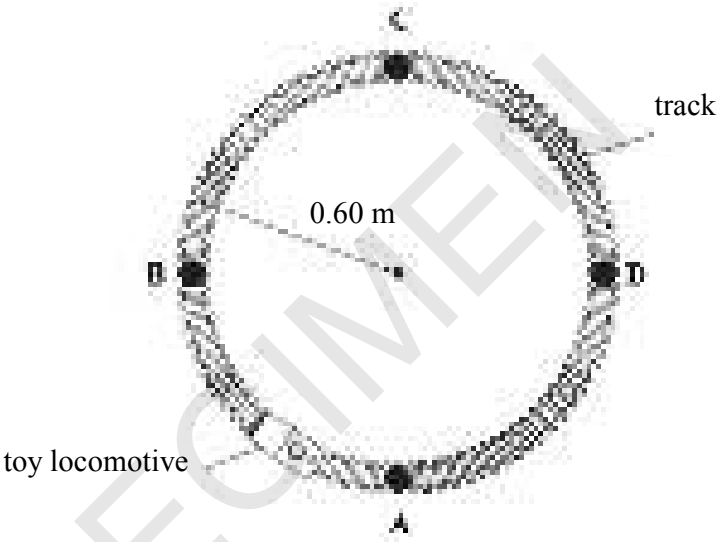


Fig. 21.1

At time $t = 0$, the locomotive is at point **A**. The locomotive travels at a constant speed round the track. It takes 20 s to travel completely round the track.

(i) Calculate the speed of the locomotive.

speed = …… m s^{-1} **[2]**

SPECIMEN

(ii) **Fig. 21.2** shows the variation of the magnitude of the displacement *s* of the locomotive from **A** with time *t*.

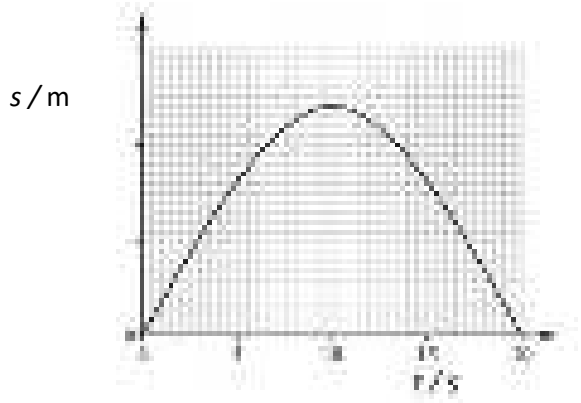


Fig. 21.2

Explain the graph shown in **Fig. 21.2**

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…….. **[2]**

(c) An object is placed on a smooth horizontal surface. Two horizontal forces act on this object. **Fig. 21.3** shows the magnitudes and the directions of these two forces.

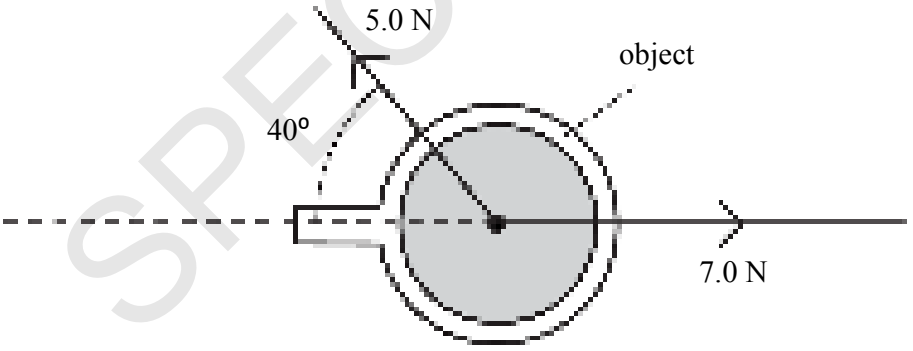


Fig. 21.3

The mass of the object is 320 g.

Calculate the magnitude of the acceleration of the object.

acceleration = ……. m s^{-2} **[3]**

SPECIMEN

22 (a) **Fig. 22.1** shows a graph of velocity v against time t for a skydiver falling vertically through the air.

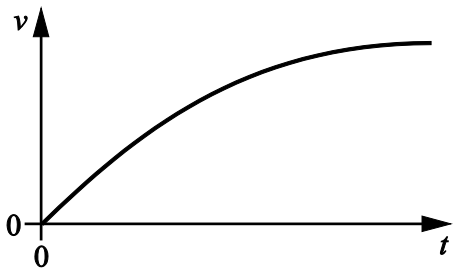


Fig. 22.1

State how you can use **Fig. 22.1** to determine the acceleration of the skydiver and describe how the acceleration varies with time.

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…….. **[2]**

(b) **Fig. 22.2** shows an arrangement used to investigate how the kinetic energy of a toy car varies with its distance d from the top of the ramp.

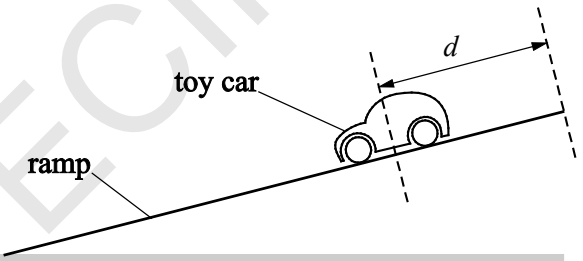


Fig. 22.2

Design a laboratory experiment to determine the kinetic energy of the car at one particular distance d from the top of the ramp.
In your description pay particular attention to

- how the apparatus is used
- what measurements are taken
- how the data is analysed.

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SPECIMEN

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…… **[3]**

(c) The toy car in **(b)** is released from rest from the top of the ramp. The two graphs in **Fig. 22.3** show the variation of the gravitational potential energy E_p of the toy car and its kinetic energy E_k with distance d from the top of the ramp.

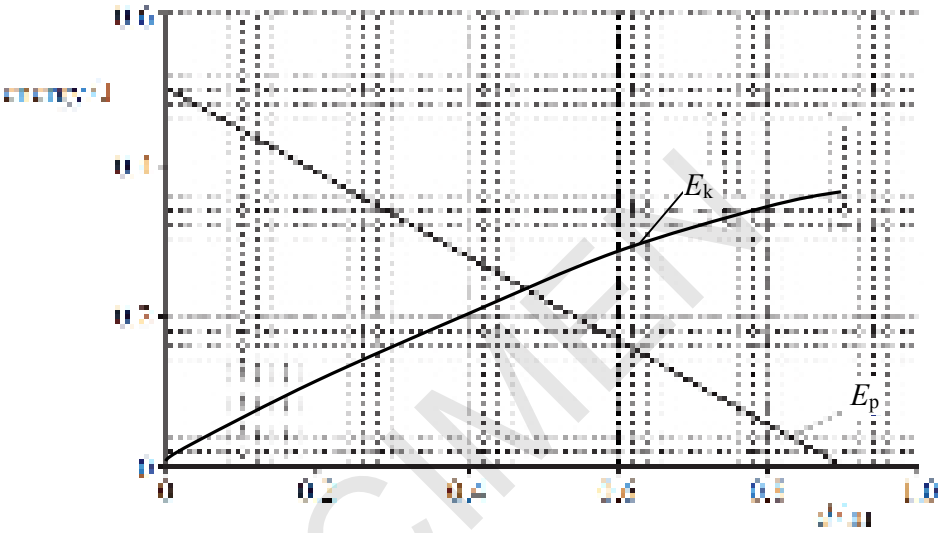


Fig. 22.3

The car travels a distance of 90 cm along the length of the ramp.

(i) The variation of E_p with d is linear.
State why the E_k against d graph is **not** linear.

……

…… **[1]**

(ii) Use **Fig. 22.3** to determine the average resistive force acting on the toy car.

force = ……N **[2]**

SPECIMEN

23 The extension of a metal wire is x when the tension in the wire is F. The table in **Fig. 23.1** shows the results from an experiment, including the stress and the strain values.

F / N	x / 10^{-3} m	stress / 10^7 Pa	strain / 10^{-3}
1.9	0.4	1.73	0.20
4.0	0.8	3.50	0.40
5.9	1.2	5.21	0.60
8.0		7.00	0.80
9.0	1.8	7.95	0.90

Fig. 23.1

(a) Complete the table by determining the extension when the tension is 8.0 N. **[1]**

(b) **Fig. 23.2** shows a graph of stress against strain for the metal.

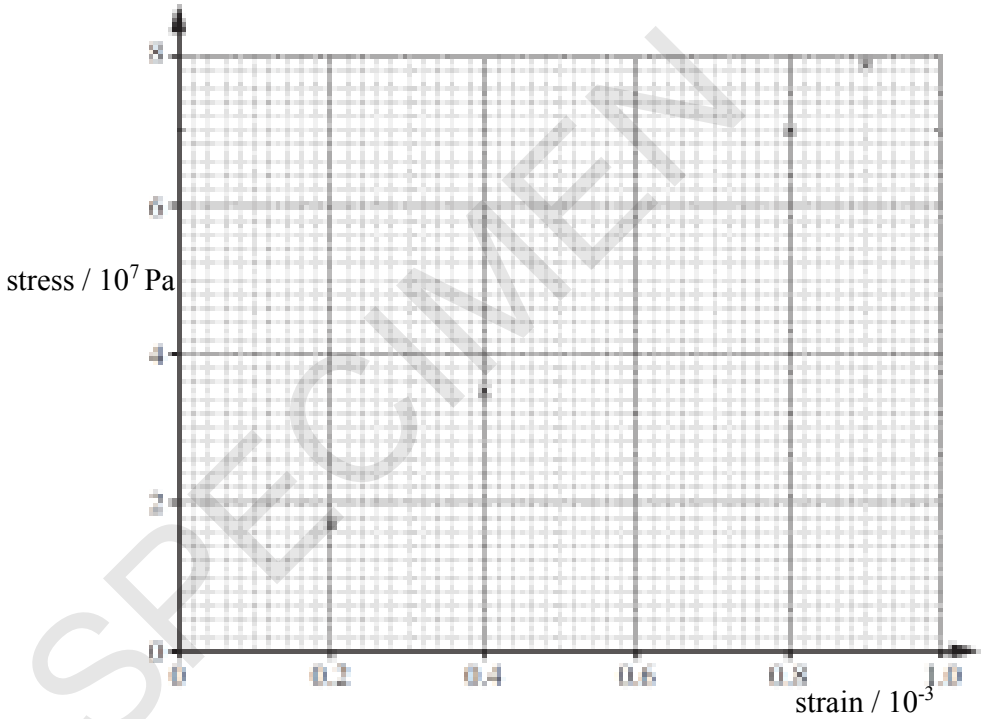


Fig. 23.2

(i) On **Fig. 23.2**, plot the data point corresponding to the tension of 5.9 N and draw the line of best fit through all the data points.

[1]

(ii) Use **Fig. 23.2** to determine the Young modulus of the metal.

Young modulus = …….Pa **[2]**

SPECIMEN

(c) The micrometer screw gauge used to determine the diameter of the wire had a zero error. The diameter recorded by a student was larger than it should have been.

Discuss how the actual value of the Young modulus would differ from the value calculated in **(b)(ii)**.

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…… **[3]**

SPECIMEN

24 **(a)** A battery of negligible internal resistance is connected across two resistors of resistance values R and $2R$ as shown in **Fig. 24.1**.

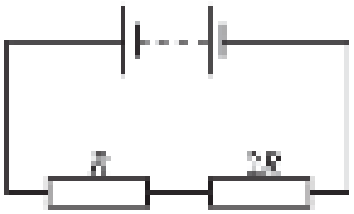


Fig. 24.1

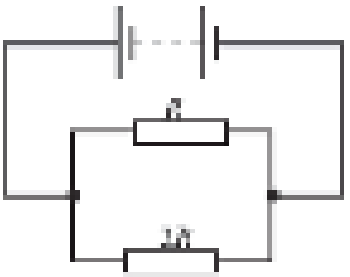


Fig. 24.2

The same battery is now connected to the same resistors as shown in **Fig. 24.2**.

Calculate the ratio

$$\frac{\text{current from battery in circuit of Fig. 24.1}}{\text{current from battery in circuit of Fig. 24.2}}.$$

ratio = ……. **[3]**

(b) A student conducts an experiment using two identical filament lamps and a variable power supply of negligible internal resistance. The lamps are connected in series to the supply. The current in the circuit is 0.030 A and the lamps are dimly lit.

The e.m.f. of the power supply is then doubled and the experiment repeated.
The student expected the current to double, but the current only increased to 0.040 A. The lamps are brightly lit.

Use your knowledge of physics to explain these observations.

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…….....…… **[3]**

SPECIMEN

(c) A researcher connects the circuit as shown in **Fig. 24.3** to determine the resistivity of a new metal designed from waste metals.

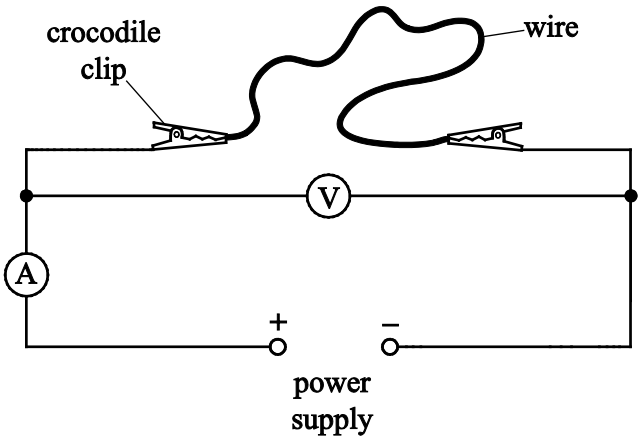


Fig. 24.3

The wire has length 0.75 m and cross-sectional area 1.3×10^{-7} m^2. The ammeter reading is 0.026 A and the voltmeter reading is 1.80 V.

(i) Calculate the resistivity of the metal.

resistivity = ...Ω m **[2]**

(ii) The resistivity of the metal in **(c)(i)** is larger than the value predicted by the researcher.

Explain **one** possible limitation of the experiment.

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…… **[2]**

SPECIMEN

25 **(a)** State what is meant by *coherent waves*.

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……. **[1]**

(b) Two transverse waves **P** and **Q** can pass through a point **X**. **Fig.25.1** shows the displacement-time graphs of a particle at point **X** for each wave independently.

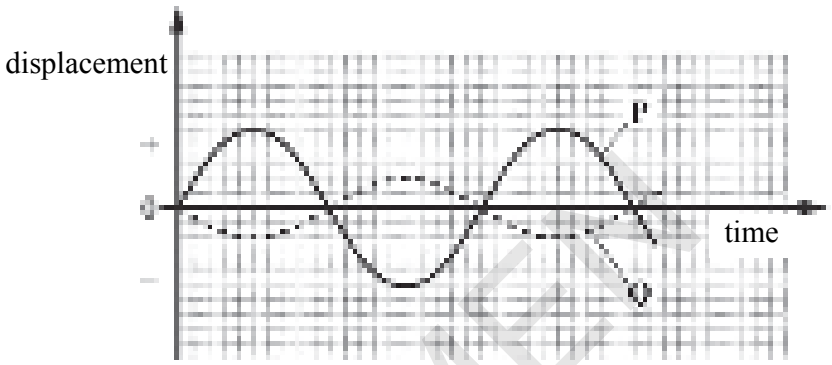


Fig. 25.1

State, with a reason, the motion of the particle at point **X** when both waves are present.

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……. **[2]**

(c) A laser **A** is placed close to two slits as shown in **Fig. 25.2**.

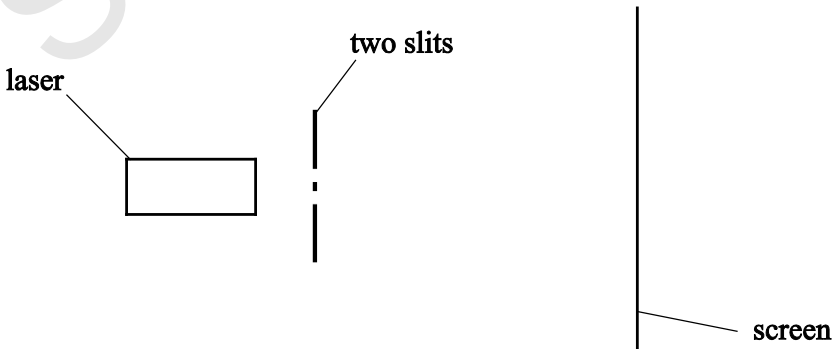


Fig. 25.2

The laser emits monochromatic light. Bright and dark fringes are observed on a screen.

SPECIMEN

(i) Explain why bright and dark fringes are observed on the screen.

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……..

…… **[3]**

(ii) The laser **A** is replaced with another laser **B**. Laser **B** emits light of a different colour with a much greater intensity.

The fringe patterns observed on the screen with these two lasers are shown in **Fig. 25.3**.



Fig. 25.3 (drawn to scale)

According to a student, laser **B** produces a more spread out fringe pattern because the intensity of its light is much greater than that of laser **A**.

This suggestion is incorrect. Give the correct explanation.

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…… **[1]**

(iii) State the effect on the pattern of light seen on the screen when one of the slits is blocked.

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…… **[1]**

SPECIMEN

26 **(a)** Filament lamps are being replaced by LED lamps in many large organisations. LEDs are low-powered devices.

(i) Apart from cost, state one major advantage this can have on the environment.

……

…… **[1]**

(ii) A light-emitting diode emits photons of a specific wavelength. The intensity of the light emitted from the LED is doubled.
Explain the effect this has on the energy of a photon.

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…… **[2]**

(b) **Fig. 26.1** shows part of the apparatus for an experiment in which electrons pass through a thin slice of graphite (carbon atoms) and emerge to produce concentric rings on a fluorescent screen.

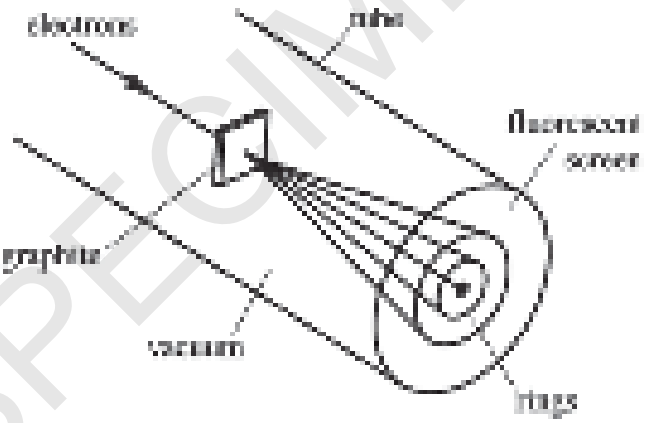


Fig. 26.1

(i) Explain how this experiment demonstrates the wave-nature of electrons.

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…… **[3]**

SPECIMEN

(ii) The beam of electrons in the apparatus shown in **Fig. 26.1** is produced by accelerating electrons through a potential difference of 1200 V.

Show that the de Broglie wavelength of the electrons is 3.5×10^{-11} m.

[2]

(iii) When de Broglie first put forward his idea it was new to the scientific community. Describe one way in which they could validate his ideas.

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[1]

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…day June 20XX–Morning/Afternoon

AS Level Physics A

H156/01 Breadth in physics

SAMPLE MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 70

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This document consists of 16 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

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5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

   - if there is nothing written at all in the answer space

   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')

   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or e-mail.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

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10. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

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11. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

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CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Additional Guidance.

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SECTION A

Question	Answer	Marks	Guidance
1	D	1	
2	D	1	
3	D	1	
4	C	1	
5	D	1	
6	A	1	
7	C	1	
8	A	1	
9	A	1	
10	C	1	
11	A	1	
12	C	1	
13	D	1	
14	D	1	
15	C	1	
16	B	1	
17	A	1	
18	B	1	
19	B	1	
20	D	1	
	Total	**20**	

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SECTION B

Question			Answer	Marks	Guidance
21	(a)		A quantity that has both direction and magnitude. Correct example given, e.g. velocity.	B1	**Note**: The B1 mark is for a correct statement and a correct example.
	(b)	(i)	speed = $\frac{2 \times \pi \times 0.60}{20}$ speed = 0.19 (m s^{-1})	C1 A1	
		(ii)	Displacement is the direct distance of the locomotive from **A**, so the graph is symmetrical about t = 10 s. At t = 20 s it returns back to **A or** at t = 10 s it is 1.2 m from **A or** at t = 10 s, it is at **C**.	B1 B1	
	(c)		resultant force = $(7.0^2 + 5.0^2 - 2 \times 7.0 \times 5.0 \times \cos 40)^{1/2}$ resultant force = 4.51 (N) acceleration = 4.51/0.320 = 14 (m s^{-2})	C1 C1 A1	**Allow**: resultant force = $[(7.0 - 5.0\times\cos 40)^2 + (5.0\times\sin 40)^2]^{1/2}$ **Allow** full marks for a correct scale drawing to determine the resultant force; resultant force = 4.5 $\pm$ 0.1 N **Allow** full marks for resolving into horizontal and vertical components and combining correctly.
			Total	8	

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Question			Answer	Marks	Guidance
22	(a)		Gradient of graph is equal to acceleration. The acceleration decreases as time increases.	B1 B1	
	(b)		Correct use of light-gate and timer **or** light-gate and data-logger **or** video technique to determine time interval. Speed determined by dividing length of car **or** interrupt card by time taken (to pass through light gate). Mass of car determined using scales and KE = ½ × mass × speed^2.	B1 B1 B1	
	(c)	(i)	There is friction. GPE is transferred to KE and heat **or** thermal (energy).	B1	
		(ii)	work done = (0.50 – 0.36) (J) **or** work done = 0.14 (J) $F \times 0.90 = 0.14$, therefore resistive force = 0.16 (N)	C1 A1	
			Total	**8**	

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Question			Answer	Marks	Guidance
23	(a)		1.6 ($\times 10^{-3}$ m).	B1	
	(b)	(i)	Data point plotted to within $\pm$ ½ small square and correct line of best fit though all the data points.	B1	
		(ii)	Gradient of line determined. E = gradient = $(8.8 \pm 0.1) \times 10^{10}$ (Pa).	M1 A1	**Allow** 1 mark for $(8.8 \pm 0.1) \times 10^{n}$ Pa; where $n \neq 10$
	(c)		The actual cross-sectional area will be smaller. The actual stress values on the graph will be larger (because stress $\propto$ area^{-1}) The gradient of the graph will be larger; hence the Young modulus of the metal must be larger than the student's value.	B1 B1 B1	
			Total	7	

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Question			Answer	Marks	Guidance
24	(a)		Fig. 4.1: total resistance = 3*R* Fig. 4.2: total resistance = 2*R*/3 ratio = $\frac{V}{3R} \div \frac{V}{2R/3}$ = 0.22	C1 C1 A1	 **Allow**: 2/9
	(b)		Any **three** from: • Total resistance of the lamps increases by a factor of 1.5. • Resistance of each lamp increases with current. • Resistance increases because of increased temperature. • Lamps are non-ohmic components.	B1×3	
	(c)	(i)	resistance = 1.80/0.026 (= 69.2 Ω) resistivity $= \frac{69.2 \times 1.3 \times 10^{-7}}{0.75}$ = 1.2 × 10^{-5} (Ω m)	C1 A1	
		(ii)	Contact resistance due to croc clips hence the resistance in the circuit must be greater. **or** Heating of wire hence the resistance of the wire increases. **or** (Finite) resistance of ammeter hence the total resistance of circuit increases. **or** Actual length between croc-clips is shorter or < 0.75 m; hence resistance of wire is greater.	B1 B1	**Allow**: Correct zero error on meters (e.g voltmeter reading is 'higher' or ammeter reading is 'lower') hence the (determined) resistance is greater.
			Total	10	

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Question			Answer	Marks	Guidance
25	(a)		There is a constant phase difference between the waves.	B1	
	(b)		The net amplitude is non-zero. Destructive interference occurs.	B1 B1	
	(c)	(i)	Bright fringes are due to constructive interference and the dark fringes are due to destructive interference. Path difference is $n\lambda$ **or** phase difference is 0° at positions of bright fringes. Path difference is $(n + ½)\lambda$ **or** phase difference is 180° at positions of dark fringes.	B1 B1 B1	
		(ii)	**A** emits shorter wavelength of light. Since $x = \frac{\lambda D}{a} \propto \lambda$, the separation between the adjacent fringes is smaller.	B1	
		(iii)	There is no interference of light from the two slits **or** the bands disappear **or** there is only diffraction from a single slit.	B1	
			Total	8	

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Question			Answer	Marks	Guidance
26	(a)	(i)	Less energy used from power stations, which in turn produce less carbon dioxide emissions and hence less environmental damage **or** Infrequent need for disposal of LED lamps has less impact on landfill sites or use of natural resources.	**B1**	
		(ii)	The energy of a photon depends on the wavelength **or** frequency. Energy does not depend on intensity therefore energy of the photon is the same.	**B1** **B1**	
	(b)	(i)	Electrons behave **or** travel as waves. The rings demonstrate that the electrons are diffracted by individual carbon atoms / spacing between carbon atoms. The (de Broglie) wavelength of the electrons is comparable to the 'size' of the carbon atoms or the spacing between carbon atoms.	**B1** **B1** **B1**	
		(ii)	$v^2 = \frac{1.6\times10^{-19}\times1200}{0.5\times9.11\times10^{-31}}$ or $v = 2.053..\times10^7$ (m s^{-1}) $\lambda = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times2.053\times10^7}$ wavelength = 3.5×10^{-11} (m)	**C1** **C1**	Correct use of $\frac{1}{2}mv^2 = eV$
		(iii)	Results published to allow peer review Procedure shared with other scientists to allow replication	**B1**	
			Total	**9**	

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Summary of updates

Date	Version	Change
January 2019	2.0	Addition to the rubric clarifying the general rule that working should be shown for any calculation questions

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