OCR
Oxford Cambridge and RSA

AS Level Physics B (Advancing Physics)

H157/01 Foundations of physics

Tuesday 24 May 2016 – Morning

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet (sent with general stationery)

You may use:
- a scientific calculator
- a ruler (cm/mm)

First name									
Last name									
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

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

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PLEASE DO NOT WRITE ON THIS PAGE

SECTION A

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

Answer **all** the questions.

Write your answer to each question in the box provided.

1 Which one of these ratios does **not** have units?

A $\frac{\text{acceleration}}{\text{gravitational field strength}}$

B $\frac{\text{Planck constant}}{\text{momentum}}$

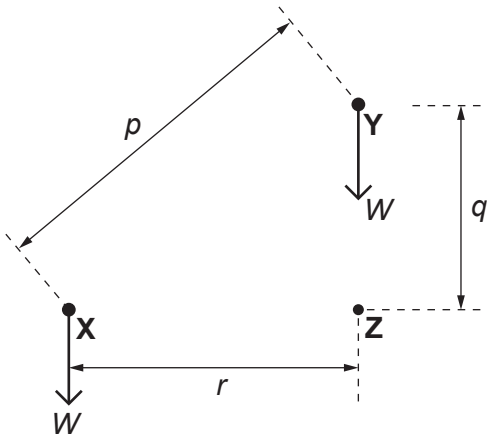
C $\frac{\text{resistance}}{\text{conductance}}$

D $\frac{\text{Young modulus}}{\text{strain}}$

Your answer ☐

[1]

2 A crane is used to lift a load directly from point **X** to point **Y**.



The weight of the load is *W*.
p, q and *r* are distances between points **X**, **Y** and **Z** as shown in the diagram.

What is the work done against the weight?

A Wp

B Wq

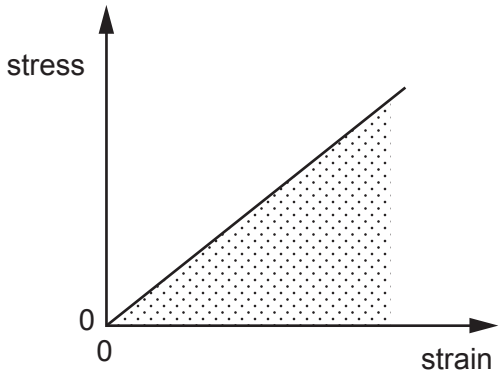
C Wr

D $W(q + r)$

Your answer ☐

[1]

3 The graph shows the variation in stress with strain for a sample of a material.



Which of the following statements is **not** correct?

A The material shows elastic deformation.

B The area under the graph represents the energy stored in the stretched material.

C The gradient gives the Young modulus of the material.

D The graph would show the same gradient for a longer specimen of the same material.

Your answer ☐

[1]

4 Which word used to describe materials does **not** apply to ceramics?

A hard

B stiff

C strong

D tough

Your answer ☐

[1]

5 Here is a list of combinations of base units of the SI system.

Which combination is equivalent to the unit pascal, Pa?

A $kg\,m^{-1}\,s^{-2}$

B $kg\,m\,s^{-2}$

C $kg\,m\,s^{-1}$

D $kg\,m^{2}\,s^{-2}$

Your answer ☐

[1]

6 Waves from an object 0.5 m away pass through a lens of focal length 0.2 m.

Which of the following give the curvature of the waves entering the lens and leaving the lens?

	Curvature entering lens / D	**Curvature leaving lens / D**
A	–2.0	+5.0
B	+2.0	+5.0
C	–2.0	+3.0
D	+2.0	+7.0

Your answer ☐

[1]

7 The display of a laptop screen is viewed through a polarising filter by a student. The intensity of the light changes when the filter is rotated.

Which property of light is demonstrated in this experiment?

A It has wavelength of about 5×10^{-7} m.

B It travels at the speed of light.

C It is a transverse wave.

D It is a longitudinal wave.

Your answer ☐

[1]

8 In which region of the electromagnetic spectrum is radiation of wavelength 50 μm?

A visible

B infra-red

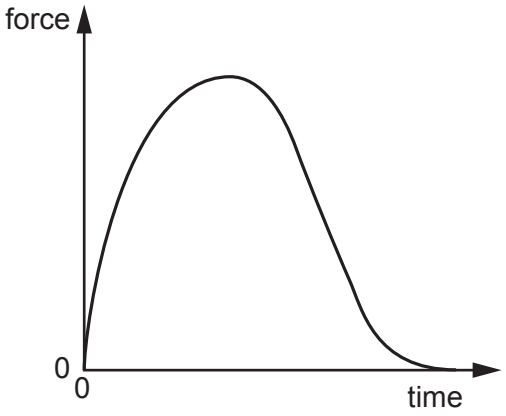
C microwave

D radio

Your answer ☐

[1]

9 The graph shows the resultant force on a football as it is kicked.



Which of the following graphs relating to this kick would have the same shape as the graph above?

A acceleration of the ball against time

B kinetic energy of the ball against time

C momentum of the ball against time

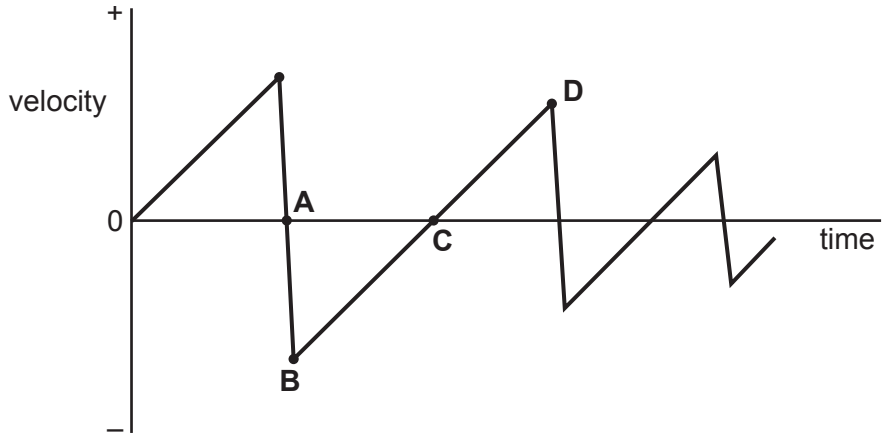
D velocity of the ball against time

Your answer ☐

[1]

10 A golf ball is dropped from rest onto a hard floor.
The graph shows how the velocity of the ball varies with time as it bounces, from the time of release.

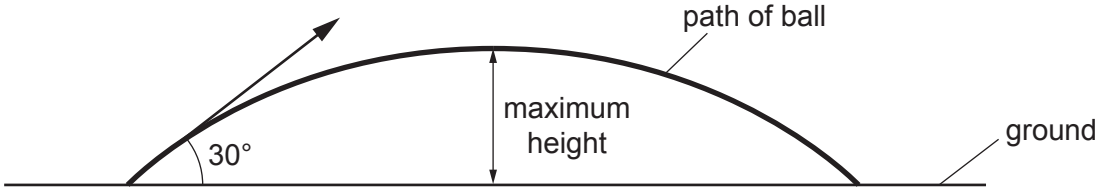
At which point does the ball reach its maximum height after the first bounce?



Your answer

[1]

11 A ball is thrown at an angle of 30° to the horizontal. The initial kinetic energy of the ball is *K*.
Air resistance has negligible effect on the motion of the ball.



What is the kinetic energy of the ball at the maximum height?

A 0

B 0.25 *K*

C 0.75 *K*

D 0.87 *K*

Your answer

[1]

12 Ball **P** has mass m. Ball **Q** has mass $2m$. Both balls have the same kinetic energy, which is greater than zero.

What is the ratio $\frac{\text{momentum of } \mathbf{P}}{\text{momentum of } \mathbf{Q}}$?

A $\frac{1}{2}$

B $\frac{1}{\sqrt{2}}$

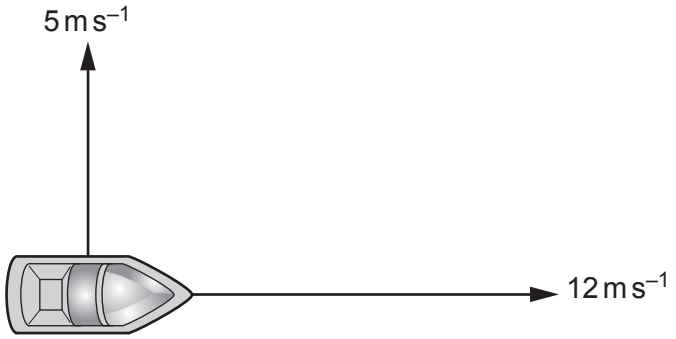
C $\sqrt{2}$

D 2

Your answer ☐

[1]

13 A boat is travelling eastwards across the sea with a velocity of $12\,m\,s^{-1}$. A wind from the south pushes the boat northwards at a velocity of $5\,m\,s^{-1}$.



What is the magnitude of the resultant velocity of the boat as it travels across the sea?

A $7\,m\,s^{-1}$

B $13\,m\,s^{-1}$

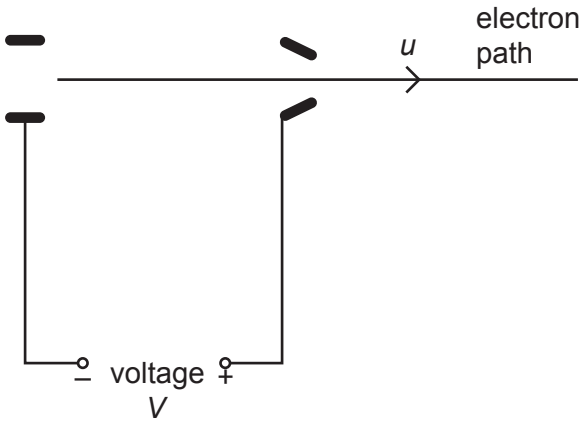
C $17\,m\,s^{-1}$

D $169\,m\,s^{-1}$

Your answer ☐

[1]

14 An electron gun is used to accelerate electrons from rest through a voltage V. The electrons emerge with a speed u.



The voltage in the gun is halved to $\frac{V}{2}$. At what speed do the electrons emerge?

A $\frac{u}{4}$

B $\frac{u}{2}$

C $\frac{u}{\sqrt{2}}$

D $u\sqrt{2}$

Your answer

[1]

15 The solar constant is the average power per square metre that the Sun provides at the surface of the Earth. The solar constant at the solar array on the International Space Station (ISS) is $1360\,\text{W}\,\text{m}^{-2}$. One section of the solar array has an area of $406\,\text{m}^2$.

Assuming that all of the solar energy is converted into electrical energy aboard the ISS, how much electricity is produced by one section of the solar array in one hour?

A 150 J

B 12 kJ

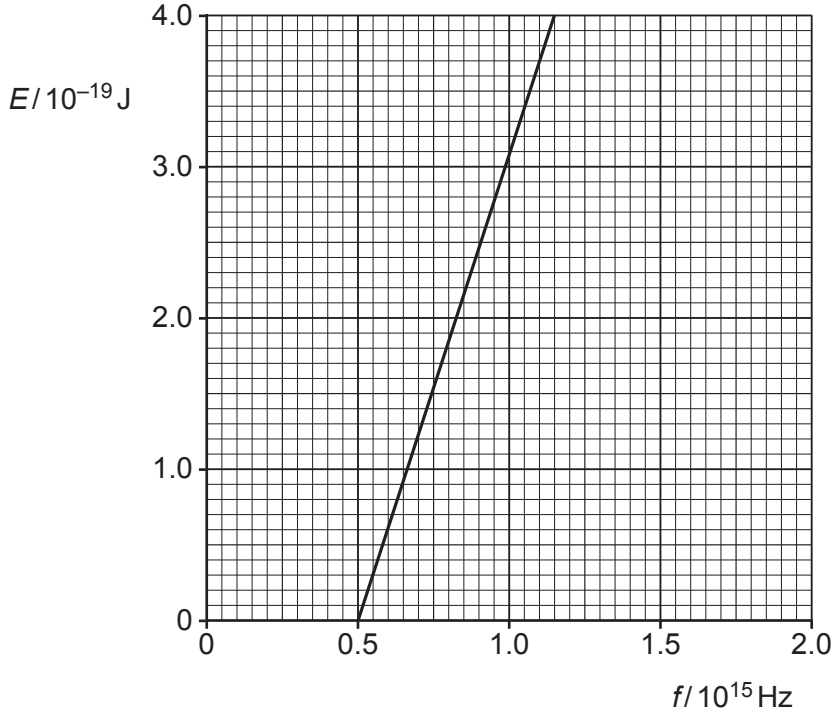
C 0.6 MJ

D 2.0 GJ

Your answer

[1]

16 The graph below shows how the maximum kinetic energy E of electrons released from the surface of a potassium plate varies with frequency f of electromagnetic radiation incident on the plate.



To **two significant figures**, what is the value of the Planck constant that can be calculated from this graph?

A 6.2×10^{-34} J s

B 6.6×10^{-34} J s

C 6.2×10^{4} J s

D 1.6×10^{33} J s

Your answer ☐

[1]

17 A digital voltmeter of very high resistance is connected across the terminals of a source of e.m.f. The voltmeter reads 12 V.

When an analogue voltmeter with a resistance of 1000 Ω is connected across the terminals of the same source of e.m.f, it reads 8 V.

What are the correct values for the e.m.f $\mathcal{E}$ and internal resistance r of the source?

A $\mathcal{E} = 8\,V$ $r = 500\,\Omega$

B $\mathcal{E} = 8\,V$ $r = 1000\,\Omega$

C $\mathcal{E} = 12\,V$ $r = 500\,\Omega$

D $\mathcal{E} = 12\,V$ $r = 1000\,\Omega$

Your answer ☐

[1]

18 The rear window of a car is heated by passing an electric current through a grid of wires that are fixed to the glass. The grid is made up of five wires connected in parallel.

Each wire is a thin rectangular strip of steel 80 cm long, 3.0 mm wide and 50 μm thick with resistivity 470 nΩ m.

What is the total resistance of the wires in the grid?

A 0.50 Ω

B 2.5 Ω

C 13 Ω

D 50 Ω

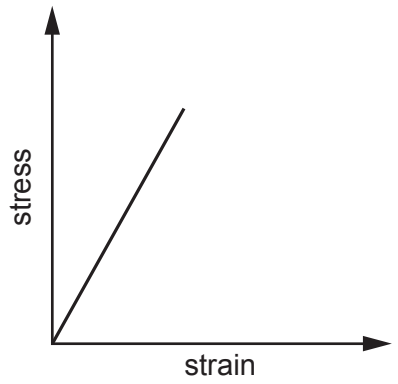
Your answer ☐

[1]

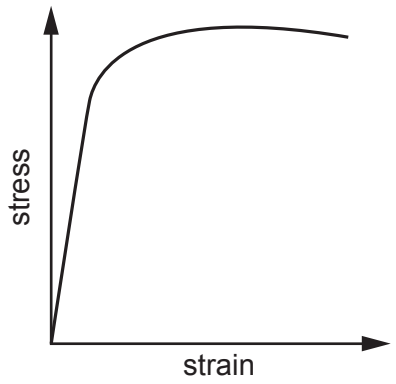
19 The graphs below show the stress against strain relationships for four different materials, **A**, **B**, **C** and **D**. Each graph has the same scales.

Which of the graphs shows a ductile material with the highest Young modulus?

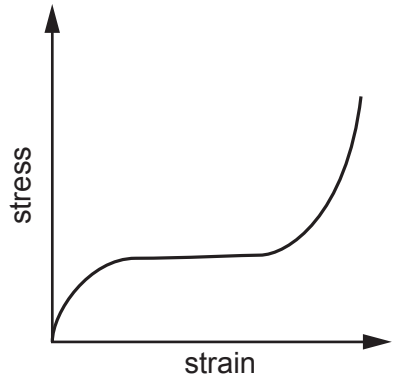
A



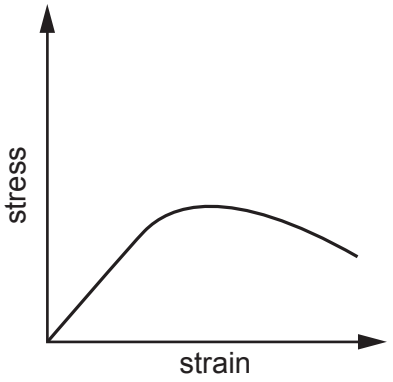
B



C



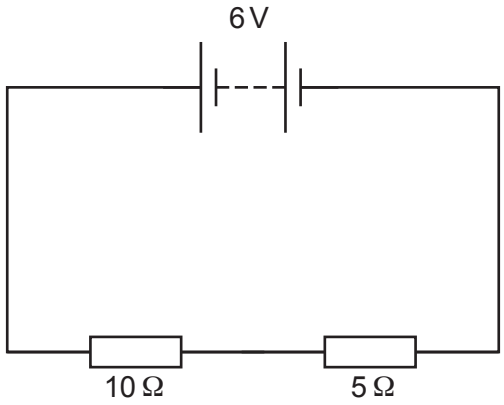
D



Your answer ☐

[1]

20 In the diagram below, the battery of e.m.f 6 V has negligible internal resistance.



What is the power dissipated in the 10 Ω resistor in the circuit shown?

A 0.4 W

B 0.9 W

C 1.6 W

D 3.6 W

Your answer

[1]

SECTION B

Answer **all** the questions.

21 Write down an estimated magnitude for the following everyday quantities:

(a) weight of a fist-sized apple

.....N **[1]**

(b) electric current to run a 230 V kettle

..... A **[1]**

(c) volume of water to fill a bath

.....m^3 **[1]**

22 A microwave transmitter and a receiver operate with polarised waves.

(a) Explain the term *polarised*.

.....

..... **[1]**

(b) The transmitter **T** faces the receiver **R** as shown in Fig. 22.

The signal received is a maximum.

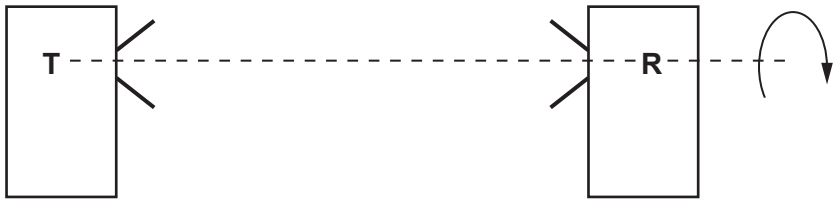


Fig. 22

State what happens to the intensity of the signal received as the receiver is rotated by 180° about the axis **TR**.

.....

..... **[1]**

23 Fig. 23 shows the graph of an analogue signal varying in time, together with the digitised sampled signal.

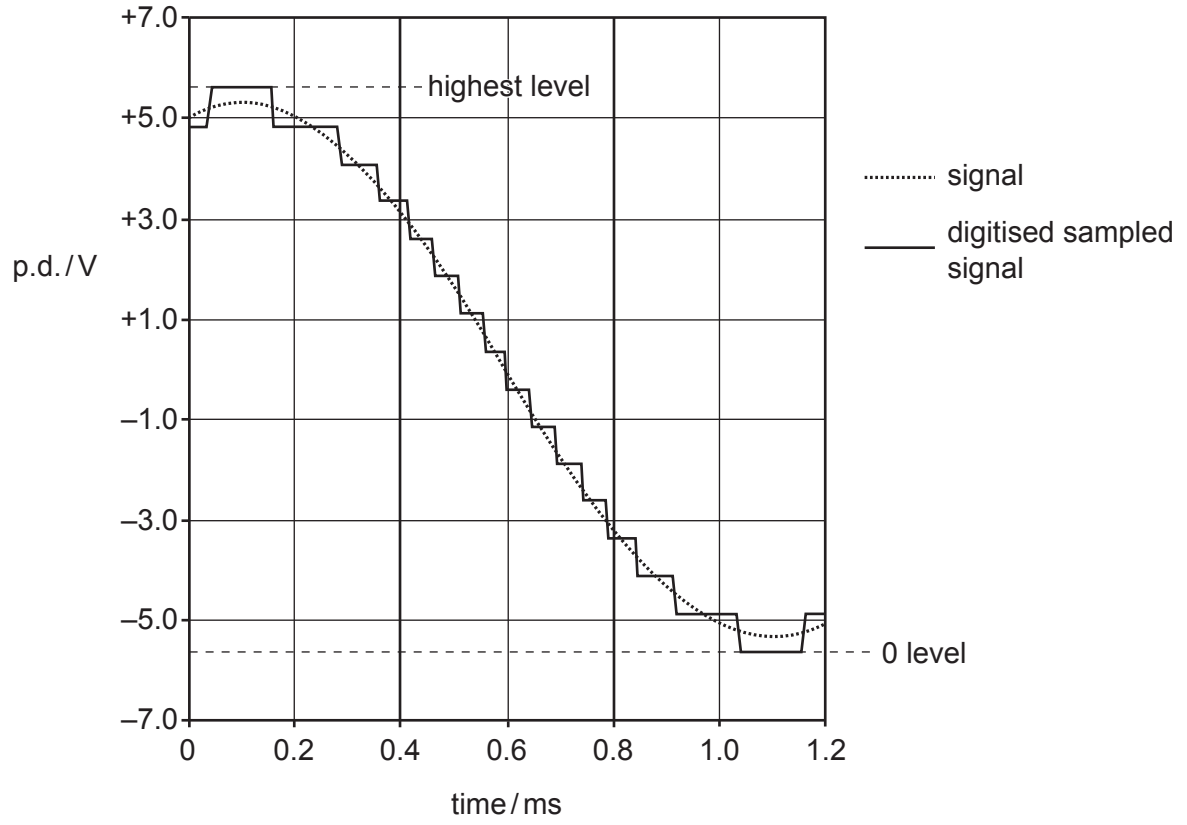


Fig. 23

(a) Determine the number of bits per sample that have been used to digitise the signal.

Explain your reasoning.

number of bits per sample = ... **[2]**

(b) Estimate the frequency of the analogue signal shown in Fig. 23.

Make your method clear.

frequency = ... Hz **[1]**

24 A lit candle is placed between two parallel metal plates. It burns with a vertical orange flame. The orange colour is due to carbon C^+ ions. When the 5 kV power supply is switched on, the plates become charged and the flame bends towards the negatively charged plate as shown in Fig. 24. The current rises from zero to 28 μA between the plates.

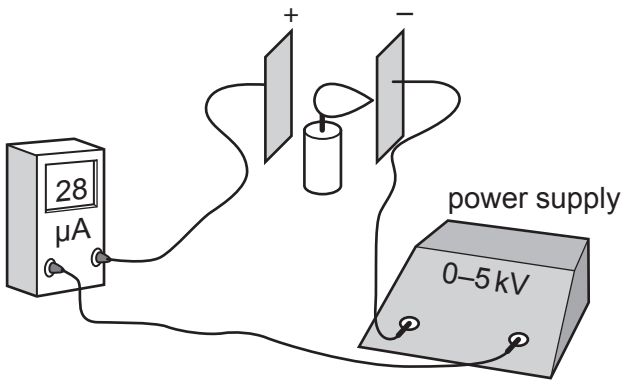


Fig. 24

(a) Explain why there is a current when the power supply is switched on.

.....

.....

..... **[2]**

(b) The charge on a carbon C^+ ion is $+1.6 \times 10^{-19}$ C.

Calculate how many carbon C^+ ions arrive per second at the negative plate when the current is 28 μA.

number of C^+ ions per second = ...s^{-1} **[2]**

25 Fig. 25.1 shows a wrecking ball of weight 4600 N, hanging at rest.
It hangs vertically with the support chain under tension T_1.
It is then deflected through angle θ by the horizontal force H, as shown in Fig. 25.2.
The new tension in the support chain is T_2.

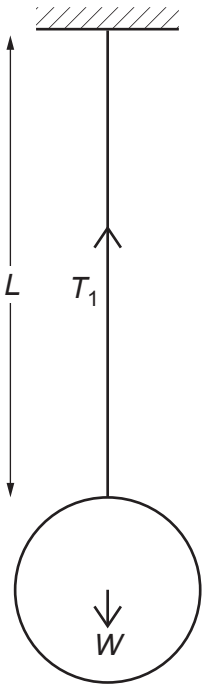


Fig. 25.1

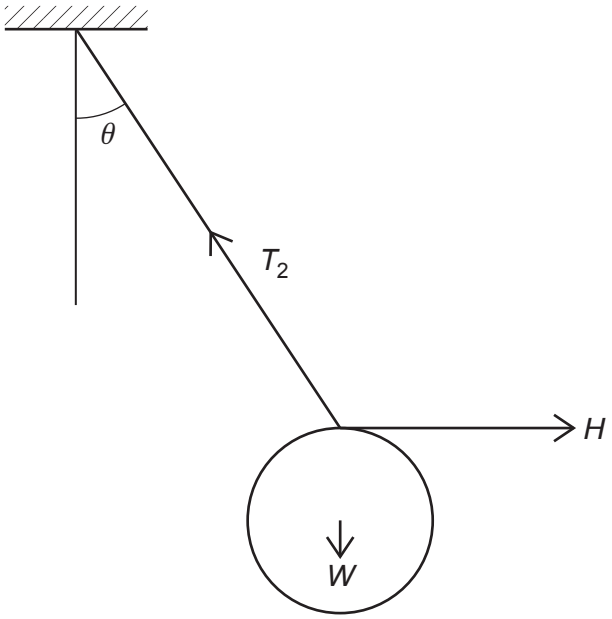


Fig. 25.2

(a) Explain why the magnitude of T_1 is 4600 N.

..... **[1]**

(b) Calculate the magnitude of T_2 when $\theta = 35°$.

T_2 = ... N **[2]**

(c) Calculate the magnitude of H when $\theta = 35°$.

H = ... N **[1]**

26 Fig. 26 shows the head-on collision between a lorry and a truck.
The lorry has mass 8000 kg and initial velocity $30\,m\,s^{-1}$.
The truck has mass 1500 kg and initial velocity $-4.0\,m\,s^{-1}$.

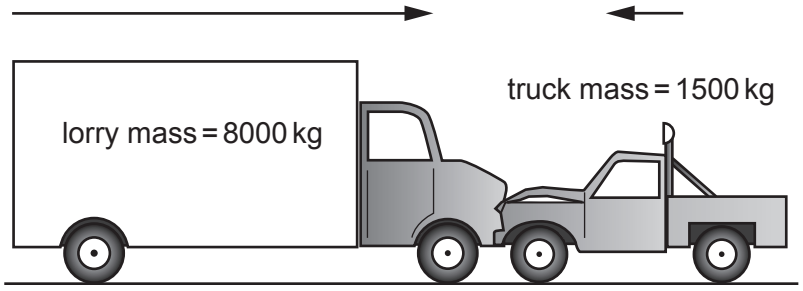


Fig. 26

(a) Show that the combined velocity of the lorry and truck just after the collision is greater than $24\,m\,s^{-1}$.

[2]

(b) Calculate the mean force acting between the lorry and truck during the collision which lasts 20 ms.

mean force = ... N **[2]**

SECTION C

Answer **all** the questions.

27 Fig. 27 shows a scanning tunnelling microscope (STM) scan of iron atoms formed into a double ring on a copper surface. The outer ring has a diameter of 3.8 nm and consists of 48 iron atoms.

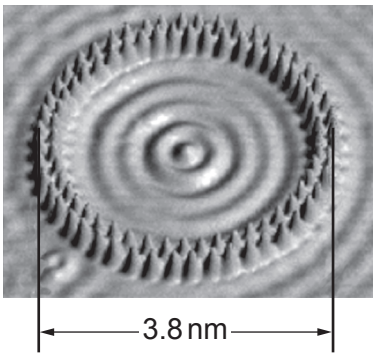


Fig. 27

(a) Use the data from the STM to calculate the diameter of an iron atom.

diameter = ... m **[2]**

(b) **(i)** Describe evidence from Fig. 27 that indicates that free electrons trapped inside the ring of iron atoms have a wavelength.

.....

..... **[1]**

(ii) Using **Fig. 27**, make appropriate measurements to show that the wavelength of these free electrons is about 0.7 nm.

[2]

(iii) Calculate the momentum of each electron.

$h = 6.6 \times 10^{-34}$ J s

momentum = ...kg m s^{-1} **[1]**

(iv) Calculate the kinetic energy of each electron.

kinetic energy = ... J **[2]**

28 Fig. 28.1 shows two I-V graphs **A** and **B**, for a diode and a resistor of fixed resistance.

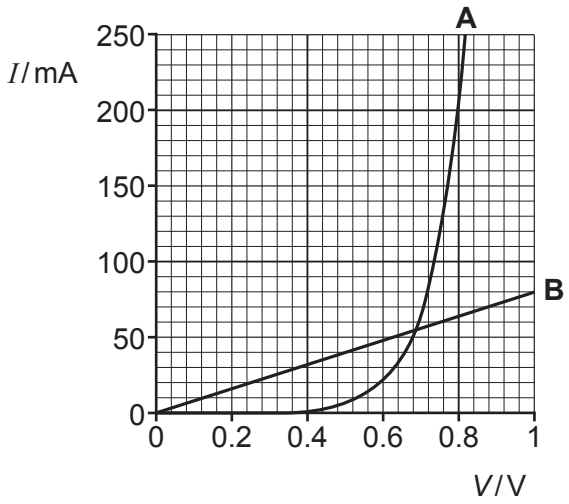


Fig. 28.1

(a) (i) State which of the two graphs relates to the diode.
Explain your decision.

.....

..... **[1]**

(ii) Calculate the resistance of the fixed resistor.

resistance = ... Ω **[1]**

(b) (i) Suggest why the diode should **not** be connected directly across a 1.5 V supply in its conducting direction.

.....

..... **[1]**

(ii) The diode and resistor are connected in series across a 1.5 V supply. The diode is connected in its conducting direction.
Use **Fig. 28.1** to predict the current drawn from the supply.
Make your method clear.

current = ... mA **[2]**

(c) A sensitive ammeter has a full scale deflection of 100 μA and a resistance of 1000 Ω. The meter remains undamaged for voltages across it of up to 0.6 V.

To protect the meter against accidental misconnection, two diodes are connected in parallel across the meter as shown in Fig. 28.2. The diodes have the same I-V graph as the diode shown in Fig. 28.1.

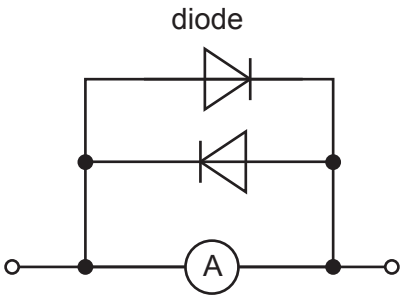


Fig. 28.2

Suggest how the diodes protect the meter from accidental current overload, and why they have little effect during normal operation. You may wish to make numerical calculations with your reasoning.

.....

.....

.....

.....

.....

..... **[4]**

29 This question is about an experiment to find the terminal velocity of a large paper cake case, as shown in Fig. 29.1, falling in air.

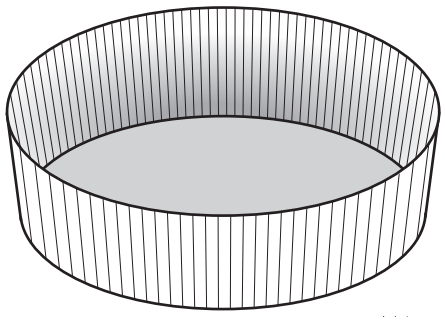


Fig. 29.1

(a) The paper case is dropped from rest and falls a vertical distance of 1.85 m.
13 students use ± 0.1 s stop clocks to time the fall. Fig. 29.2 shows a dot plot of the data obtained.

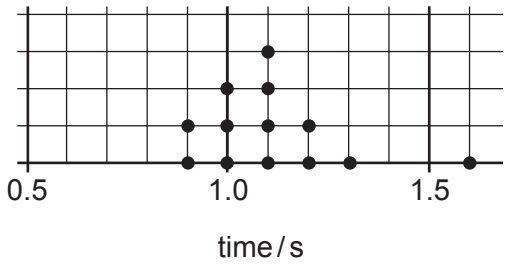


Fig. 29.2

(i) The single 1.6 s reading was treated as an outlier.

Calculate the mean time of drop for the remaining data and estimate the uncertainty.

mean time of drop = ... ± ..... s **[2]**

(ii) Explain why the 1.6 s reading was treated as an outlier.

.....

..... **[1]**

(iii) The vertical distance is measured as 1.85 ± 0.02 m due to the uncertainty in the release position.

Calculate your best estimate for the terminal velocity of the paper case and the uncertainty, using the data.

Make your method clear and justify how you estimated the uncertainty.

terminal velocity = ... ± ..... $m\,s^{-1}$ **[3]**

(iv) Suggest **one** systematic error that exists in this method of finding the terminal velocity, and how it affects the estimate.

.....

.....

.....

..... **[2]**

Question 29 continues on page 26

(b) An improved method for finding the terminal velocity for the same falling paper case gives the data table and distance fallen against time graph shown in Fig. 29.3.

time / s	distance fallen / s	
0	0.43	
0.1	0.43	
0.2	0.43	
0.3	0.43	
0.4	0.44	
0.5	0.49	
0.6	0.60	
0.7	0.72	
0.8	0.94	
0.9	1.17	
1.0	1.38	
1.1	1.61	
1.2	1.84	
1.3	2.08	
1.4	2.28	
1.5	2.28	
1.6	2.28	

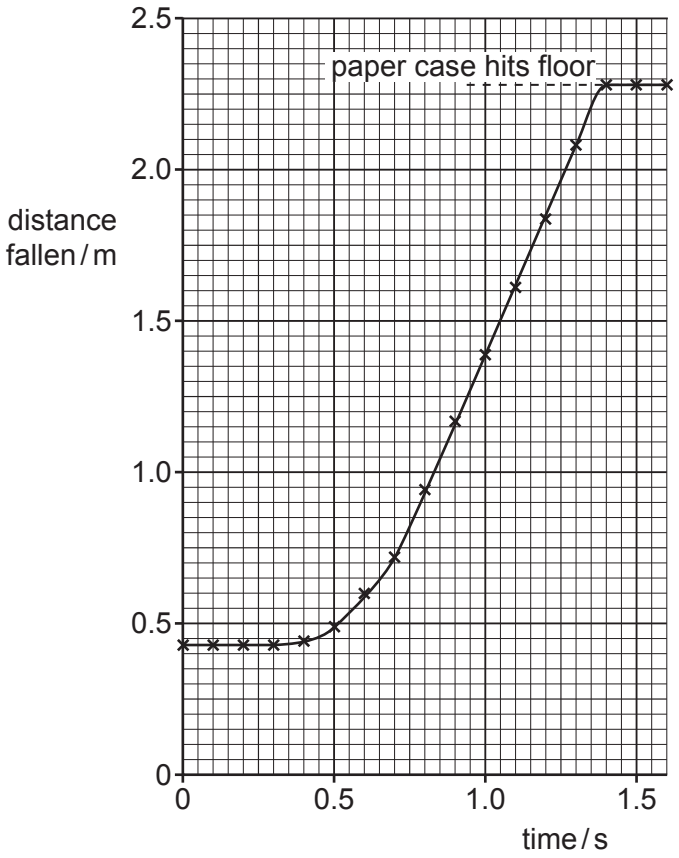


Fig. 29.3

(i) Use the data from the table or the graph to make a new estimate for the terminal velocity. The table has a blank column for you to use, if required.
Make your method clear.

terminal velocity = ... $m\,s^{-1}$ **[2]**

(ii) Describe an experiment that could give the data in Fig. 29.3 and justify **one** way in which this method is better than that in **(a)**.

[3]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).