SPECIMEN MATERIAL

A-level
PHYSICS
(7408/1)

Paper 1

Specimen 2014 Morning Time allowed: 2 hours

Materials
For this paper you must have:
- a pencil
- a ruler
- a calculator
- a data and formulae booklet.

Instructions
- Answer **all** questions.
- Show all your working.

Information
- The maximum mark for this paper is 85.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number Candidate number

Surname

Forename(s)

Candidate signature

Section A

Answer **all** questions in this section.

0 1 A common type of smoke detector contains a very small amount of americium-241, $^{241}_{95}\mathrm{Am}$

0 1 . 1 Determine the number of each type of nucleon in one americium-241 nucleus.

[2 marks]

type of nucleon ______________________ number ________________

type of nucleon ______________________ number ________________

0 1 . 2 Americium-241 is produced in nuclear reactors through the decay of plutonium, $^{241}_{94}\mathrm{Pu}$

State the decay process responsible for the production of americium-241. Explain your answer.

[2 marks]

____

____

____

0 1 . 3 An americium-241 nucleus decays into nuclide X by emitting an alpha particle.

Write an equation for the decay of the nucleus and determine the proton number and nucleon number of X.

[3 marks]

nucleon number ____________________

proton number ____________________

0 1 . 4 The alpha radiation produced by americium-241 causes the ionisation of nitrogen and oxygen molecules in the smoke detector.

State what is meant by ionisation.

[1 mark]

____

____

____

0 1 . 5 A friend who has not studied physics suggests that a smoke detector containing radioactive material should not be sold.

Use your knowledge of physics to explain why a smoke detector containing americium-241 does not provide any risk to the user.

[2 marks]

____

____

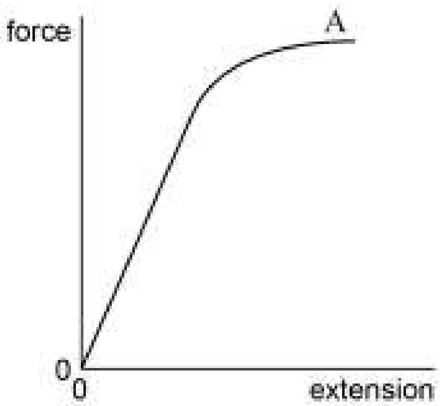
____

____

____

0 2 A student adds a series of masses to a vertical metal wire of circular cross-section and measures the extension of the wire produced. **Figure 1** is a force–extension graph of the data.

Figure 1



0 2 . 1 Mark on **Figure 1** the point P, the limit beyond which Hooke's law is no longer obeyed.

[1 mark]

0 2 . 2 Outline how the student can use these results and other measurements to determine the Young modulus of the wire.

[3 marks]

____

____

____

____

____

____

____

____

____

0 2 . 3 When the wire has been extended to A, the masses are removed one by one and the extension re-measured.

Draw on **Figure 1** the shape of the graph that the student will obtain.

[1 mark]

0 2 . 4 Explain why the graph has the shape you have drawn.

[2 marks]

____

____

____

____

0 2 . 5 The metal wire is used to make a cable of diameter 6.0 mm. The Young modulus of metal of the cable is 2.0×10^{11} Pa.

Calculate the force necessary to produce a strain of 0.20% in the cable.

[3 marks]

force = ________________ kN

0 2 . 6 The cable is used in a crane to lift a mass of 600 kg.

Determine the maximum acceleration with which the mass can be lifted if the strain in the cable is not to exceed 0.20%.

[3 marks]

acceleration = ______________________ $m\ s^{-2}$

0 2 . 7 An engineer redesigns the crane to lift a 1200 kg load at the same maximum acceleration.

Discuss the changes that could be made to the cable of the crane to achieve this, without exceeding 0.20% strain.

[3 marks]

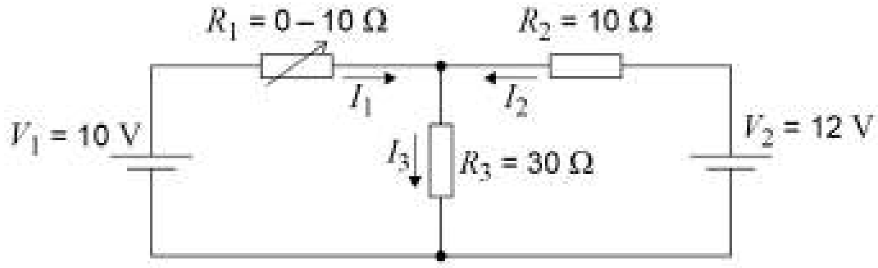
Turn to page 8 for the next question

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

0 3 The cells in the circuit shown in **Figure 2** have zero internal resistance. Currents are in the directions shown by the arrows.

Figure 2



R_1 is a variable resistor with a resistance that varies between 0 and 10 Ω.

0 3 . 1 Write down the relationship between currents I_1, I_2 and I_3.

[1 mark]

____

0 3 . 2 R_1 is adjusted until it has a value of 0 Ω.

State the potential difference across R_3.

[1 mark]

potential difference = ____________________ V

0 3 . 3 Determine the current I_2.

[2 marks]

current = ____________________ A

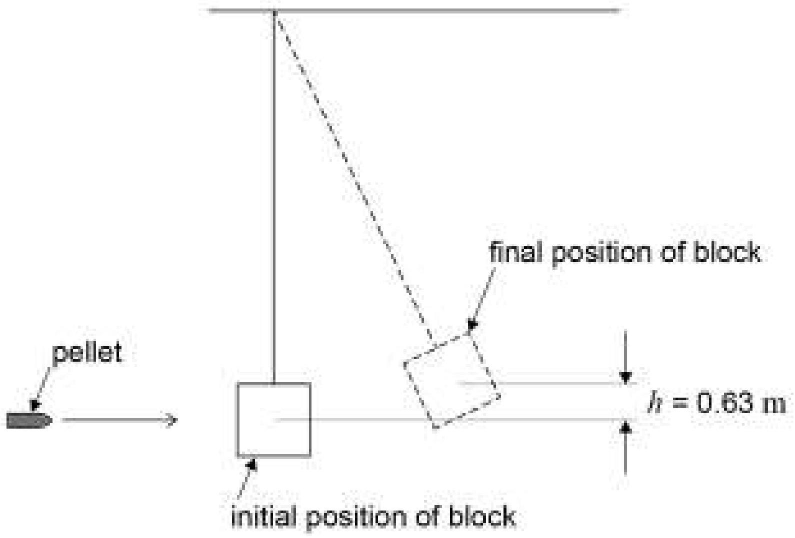
0 3 . 4 State and explain what happens to the potential difference across R_2 as the resistance of R_1 is gradually increased from zero.

[3 marks]

Turn over for the next question

0 4 The speed of an air rifle pellet is measured by firing it into a wooden block suspended from a rigid support.
The wooden block can swing freely at the end of a light inextensible string as shown in **Figure 3**.

Figure 3



A pellet of mass 8.80 g strikes a stationary wooden block and is completely embedded in it. The centre of mass of the block rises by 0.63 m. The wooden block has a mass of 450 g.

0 4 . 1 Determine the speed of the pellet when it strikes the wooden block.

[4 marks]

speed = ____________________ $m\ s^{-1}$

0 4 . 2 The wooden block is replaced by a steel block of the same mass.
The experiment is repeated with the steel block and an identical pellet. The pellet rebounds after striking the block.

Discuss how the height the steel block reaches compares with the height of 0.63 m reached by the wooden block. In your answer compare the energy and momentum changes that occur in the two experiments.

[4 marks]

0 4 . 3 Discuss which experiment is likely to give the more accurate value for the velocity of the pellet.

[2 marks]

0 5 . 1 Describe the structure of a step-index optical fibre outlining the purpose of the core and the cladding.

[3 marks]

0 5 . 2 A signal is to be transmitted along an optical fibre of length 1200 m. The signal consists of a square pulse of white light and this is transmitted along the centre of a fibre. The maximum and minimum wavelengths of the light are shown in **Table 1**.

Table 1

Colour	Refractive index of fibre	Wavelength / nm
Blue	1.467	425
Red	1.459	660

Explain how the difference in refractive index results in a change in the pulse of white light by the time it leaves the fibre.

[2 marks]

0 5 . 3 Discuss **two** changes that could be made to reduce the effect described in part 5.2.

[2 marks]

0 6 Read through the following passage and answer the questions that follow it.

Measuring the speed of sound in air

After the wave nature of sound had been identified, many attempts were made to measure its speed in air. The earliest known attempt was made by the French scientist Gassendi in the 17th century. The procedure involved timing the interval between seeing the flash of a gun and hearing the bang from some distance away. Gassendi assumed that, compared with the speed of sound, the speed of light is infinite. The value he obtained for the speed of sound was 480 $\mathrm{m\,s^{-1}}$. He also realised that the speed of sound does not depend on frequency.
A much better value of 350 $\mathrm{m\,s^{-1}}$ was obtained by the Italian physicists Borelli and Viviani using the same procedure. In 1740 another Italian, Bianconi, showed that sound travels faster when the temperature of the air is greater.
In 1738 a value of 332 $\mathrm{m\,s^{-1}}$ was obtained by scientists in Paris. This is remarkably close to the currently accepted value considering the measuring equipment available to the scientists at that time. Since 1986 the accepted value has been 331.29 $\mathrm{m\,s^{-1}}$ at 0 $^{\circ}\mathrm{C}$.

0 6 . 1 Suggest an experiment that will demonstrate the wave nature of sound (line 1).

[1 mark]

____

____

____

0 6 . 2 Using Gassendi's value for the speed of sound (line 6), calculate the time between seeing the flash of a gun and hearing its bang over a distance of 2.5 km.

[1 mark]

time = ____________________ s

0 6 . 3 Explain why it was necessary to assume that 'compared with the speed of sound, the speed of light is infinite' (line 5).

[1 mark]

____

____

____

0 6 . 4 Explain **one** observation that could have led Gassendi to conclude that 'the speed of sound does not depend on frequency' (line 7).

[2 marks]

____

____

____

____

____

____

Question 6 continues on the next page

0 6 . 5 Explain how the value obtained by Borelli and Viviani was 'much better' than that obtained by Gassendi (line 8).

[1 mark]

____

____

0 6 . 6 The speed of sound c in dry air is given by

$$c = k\sqrt{(\theta + 273.15)}$$

where θ is the temperature in $^{\circ}\mathrm{C}$, and k is a constant.

Calculate a value for k using data from the passage.

[2 marks]

$k =$ ____________________ $\mathrm{m\ s^{-1}\ K^{-1/2}}$

0 6 . 7 State the steps taken by the scientific community for the value of a quantity to be 'accepted' (line 13).

[2 marks]

____

____

____

____

END OF SECTION A

Section B

Each of Questions **7** to **31** is followed by four responses, **A**, **B**, **C**, and **D**. For each question select the best response.

Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD   WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

0 7 The nucleus of $^{9}_{4}$Be captures a proton and emits an α particle. What is the product nucleus?

[1 mark]

A $^{10}_{6}$C

B $^{7}_{3}$Li

C $^{6}_{3}$Li

D $^{6}_{2}$He

0 8 When comparing X-rays with UV radiation, which statement is correct?

[1 mark]

A X-rays have a lower frequency.

B X-rays travel faster in a vacuum.

C X-rays do not show diffraction and interference effects.

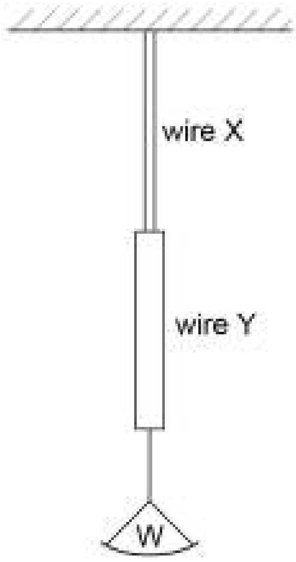
D Using the same element, photoelectrons emitted using X-rays have the greater maximum kinetic energy.

0 9 Monochromatic radiation from a source of light (source A) is shone on to a metallic surface and electrons are emitted from the surface. When a second source (source B) is used no electrons are emitted from the metallic surface. Which property of the radiation from source A must be greater than that from source B?

[1 mark]

A amplitude ⬭
B frequency ⬭
C intensity ⬭
D wavelength ⬭

1 0 Two vertical copper wires X and Y of equal length are joined as shown. Y has a greater diameter than X. A weight W is hung from the lower end of Y.



Which of the following is correct?

[1 mark]

A The strain in X is the same as that in Y. ⬭

B The stress in Y is greater than that in X. ⬭

C The tension in Y is the same as that in X. ⬭

D The elastic energy stored in X is less than that stored in Y. ⬭

1 1 An electron has a kinetic energy E and a de Broglie wavelength λ. The kinetic energy is increased to $4E$. What is the new de Broglie wavelength?

[1 mark]

A $\frac{\lambda}{4}$ ☐

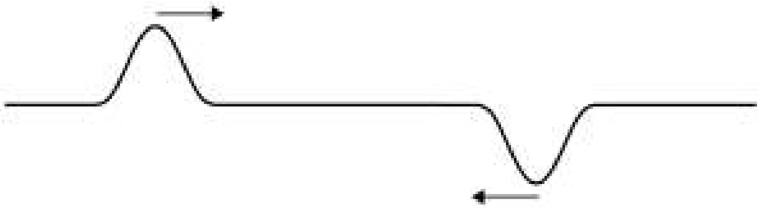
B $\frac{\lambda}{2}$ ☐

C λ ☐

D 4λ ☐

Turn over for the next question

1 2 The diagram shows two pulses on a string travelling towards each other.



Which of the following diagrams shows the shape of the string when the pulses have passed through each other?

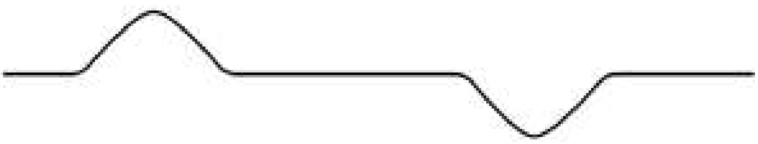
[1 mark]

A ○

B ○

C ○

D ○



1 3 Monochromatic light may be characterised by its speed, frequency and wavelength. Which of the following quantities change when monochromatic light passes from air into glass?

[1 mark]

A Speed only.

B Speed and wavelength only.

C Speed and frequency only.

D Wavelength and frequency only.

1 4 In a photoelectric experiment, light is incident on the metal surface of a photocell. Increasing the intensity of the illumination at the surface leads to an increase in the

[1 mark]

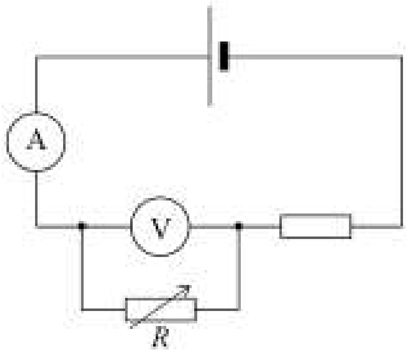
A work function

B minimum frequency at which electrons are emitted

C current through the photocell

D speed of the electrons

1 5 In the circuit shown in the diagram the cell has negligible internal resistance.

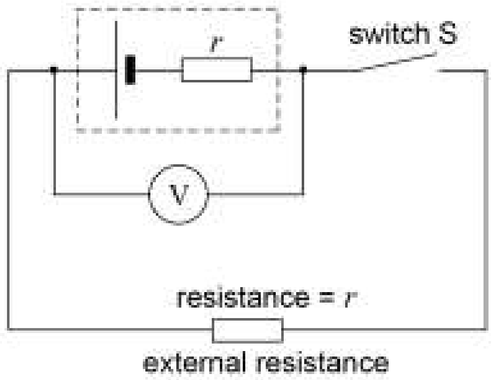


What happens to the reading of both meters when the resistance of R is decreased?

[1 mark]

	Reading of ammeter	Reading of voltmeter	
A	increases	increases	
B	increases	decreases	
C	decreases	increases	
D	unchanged	decreases	

1 6 In the circuit shown, V is a voltmeter with a very high resistance. The internal resistance of the cell, *r*, is equal to the external resistance in the circuit.



Which of the following is not equal to the emf of the cell?

[1 mark]

A the reading of the voltmeter when the Switch S is open

B the chemical energy changed to electrical energy when unit charge passes through the cell

C twice the reading of the voltmeter when the switch S is closed

D the electrical energy produced when unit current passes through the cell

1 7 Monochromatic light of wavelength 490 nm falls normally on a diffraction grating that has 6 x 10^5 lines per metre. Which one of the following is correct?

[1 mark]

A The first order is observed at angle of diffraction of 17°.

B The second order is observed at angle of diffraction of 34°.

C The third and higher orders are not produced.

D A grating with more lines per metre could produce more orders.

1 8 An electron collides with a neutral atom and ionizes it. Which of the following describes the particles present after the collision?

[1 mark]

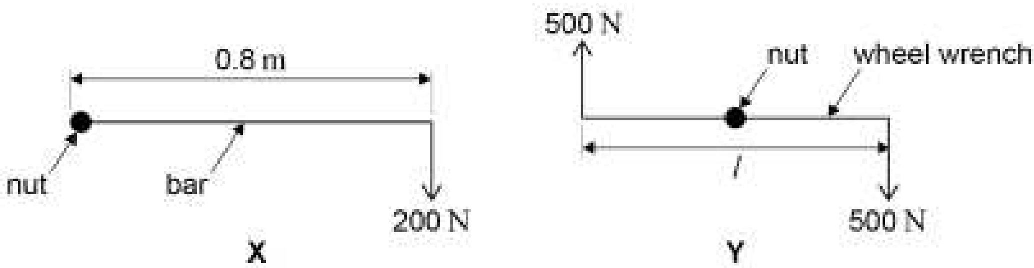
A An electron and an excited atom.
B An excited atom containing an excess electron.
C Two electrons and a positive ion.
D Two electrons and a neutral atom in the ground state.

1 9 Two forces of 6 N and 10 N act at a point. Which of the following could **not** be the magnitude of the result?

[1 mark]

A 16 N
B 8 N
C 5 N
D 3 N

2 0 A car wheel nut can be loosened by applying a force of 200 N on the end of a bar of length 0.8 m as in **X**. A car mechanic is capable of applying forces of 500 N simultaneously in opposite directions on the ends of a wheel wrench as in **Y**.



What is the minimum length l of the wrench which would be needed for him to loosen the nut?

[1 mark]

A 0.16 m
B 0.32 m
C 0.48 m
D 0.64 m

2 1 A ballbearing **X** of mass $2m$ is projected vertically upwards with speed u. A ballbearing **Y** of mass m is projected at 30° to the horizontal with speed $2u$ at the same time. Air resistance is negligible. Which of the following statements is correct?

[1 mark]

A The horizontal component of **Y**'s velocity is u.

B The maximum height reached by **Y** is half that reached by **X**

C **X** and **Y** reach the ground at the same time.

D **X** reaches the ground first.

2 2 What is the relationship between the distance y travelled by an object falling freely from rest and the time x the object has been falling?

[1 mark]

A y is proportional to x^2

B y is proportional to $\sqrt{x}$

C y is proportional to $\frac{1}{x}$

D y is proportional to $\frac{1}{x^2}$

2 3 A car exerts a driving force of 500 N when travelling at a constant speed of 72 km h^{-1} on a level track. What is the work done in 5 minutes?

[1 mark]

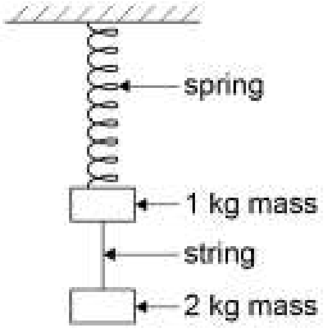
A 3.0×10^6 J

B 2.0×10^6 J

C 2.0×10^5 J

D 1.1×10^5 J

2 4 Two masses hang at rest from a spring, as shown in the diagram. The string separating the masses is burned through.



Which of the following gives the accelerations of the two masses as the string breaks?

acceleration of free fall = g

[1 mark]

	acceleration of 1 kg mass upwards in m s^{-2}	acceleration of 2 kg mass downwards in m s^{-2}	
A	3 g	1 g	⬭
B	2 g	2 g	⬭
C	2 g	1 g	⬭
D	1 g	1 g	⬭

2 5 An object falls freely from rest. After falling a distance d its velocity is v. What is its velocity after it has fallen a distance $2d$?

[1 mark]

A 2 v ⬭

B 4 v ⬭

C 2 v^2 ⬭

D $\sqrt{2}\ v$ ⬭

2 6 An electric motor of input power 100 W raises a mass of 10 kg vertically at a steady speed of 0.5 $\mathrm{m\ s^{-1}}$. What is the efficiency of the system?

[1 mark]

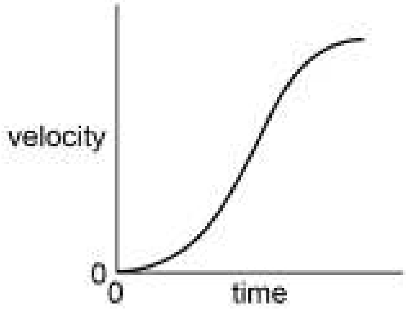
A 5% ☐

B 12% ☐

C 50% ☐

D 100% ☐

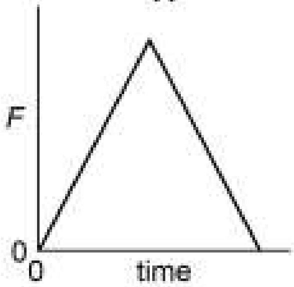
2 7 The velocity of a vehicle varies with time as shown by the following graph.



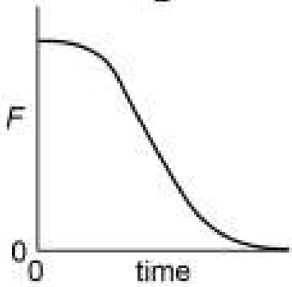
Which graph below represents how the resultant force F on the car varies during the same time?

[1 mark]

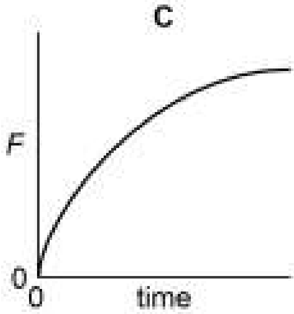
A



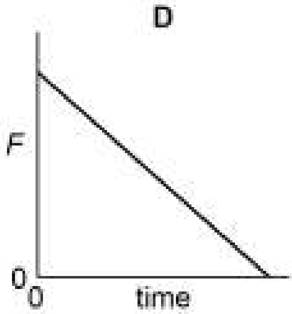
B



C



D



A ☐

B ☐

C ☐

D ☐

2 8 Which one of the following provides direct experimental evidence that light is a transverse wave motion rather than a longitudinal wave motion?

[1 mark]

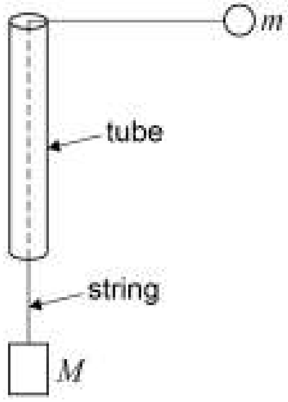
A Two light waves that are coherent can be made to interfere.

B Light can be diffracted.

C Light can be polarised.

D The intensity of light from a point source falls off inversely as the square of the distance from the source.

2 9 A string passes through a smooth thin tube. Masses m and M are attached to the ends of the string. The tube is moved so that the mass m travels in a horizontal circle of constant radius r and at constant speed v.



Which of the following expressions is equal to M ?

[1 mark]

A $\frac{mv^2}{2r}$

B mv^2rg

C $\frac{mv^2}{rg}$

D $\frac{mv^2g}{r}$

3 0 The frequency of a body moving with simple harmonic motion is doubled. If the amplitude remains the same which of the following is also doubled?

[1 mark]

A The time period.

B The total energy.

C The maximum velocity.

D The maximum acceleration.

3 1 A particle oscillates with undamped simple harmonic motion.

The acceleration of the particle

[1 mark]

A is always in the opposite direction to its velocity.

B decreases as the potential energy increases.

C is proportional to the frequency.

D is least when the speed is greatest.

END OF QUESTIONS

There are no questions printed on this page.