Please write clearly in block capitals.

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

Surname ______________________________

Forename(s) ______________________________

Candidate signature ______________________________

AS
PHYSICS

Paper 1

Tuesday 14 May 2019 Morning Time allowed: 1 hour 30 minutes

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

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 scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

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

Do not write outside the box

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

0 1 . 1 Deuterium is an isotope of hydrogen. Its nucleus contains one proton and one neutron.

Calculate the specific charge of the deuterium nucleus.

[2 marks]

specific charge = ____________________ $\mathrm{C\ kg^{-1}}$

Do not write outside the box

0 1 . 2 The proton and neutron in the deuterium nucleus are held together by the strong nuclear force.

Which is an exchange particle of the strong nuclear force?
Tick (✓) **one** box.

[1 mark]

muon ☐

photon ☐

pion ☐

W^+ boson ☐

0 1 . 3 The deuterium nucleus is stable.

Describe how the variation of the strong nuclear force with distance contributes to the stability of the deuterium nucleus.

[3 marks]

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Question 1 continues on the next page

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0 1 . 4 Tritium is an isotope of hydrogen. Its nucleus contains one proton and two neutrons. Tritium undergoes radioactive decay.

Three modes of radioactive decay are

- alpha decay
- beta minus (β^-) decay
- electron capture.

Deduce which of these modes could produce the nucleus of another element when the tritium nucleus decays.

[3 marks]

9

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0 2 A battery of emf $7.4\ \mathrm{V}$ and negligible internal resistance is used to power a heating element inside a glove. The heating element has a resistance of $3.7\ \Omega$.

0 2 . 1 The designers state that the battery can produce a current of $2.0\ \mathrm{A}$ in the heating element for 240 minutes.

Calculate the energy dissipated in the heating element in this time.

[3 marks]

energy dissipated = ____________________ J

0 2 . 2 The length of the heating element needed is about $0.85\ \mathrm{m}$.
The designer considers using a carbon fibre tape for the heating element.
Table 1 gives information for the carbon fibre tape.

Table 1

Cross-sectional area / m^2	**Resistivity / $\Omega\ \mathrm{m}$**
4.9×10^{-6}	2.0×10^{-5}

Deduce whether the carbon fibre tape is suitable for making the heating element for the glove.

[2 marks]

Question 2 continues on the next page

0 2 . 3 A light emitting diode (LED) is used to indicate that the switch in the glove is closed, as shown in **Figure 1**. Resistor R limits the current in the LED.

Figure 1

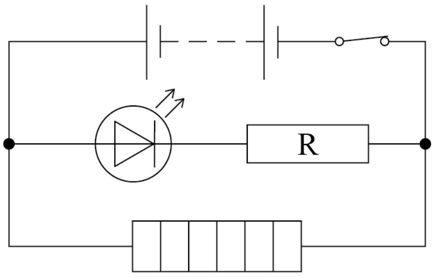
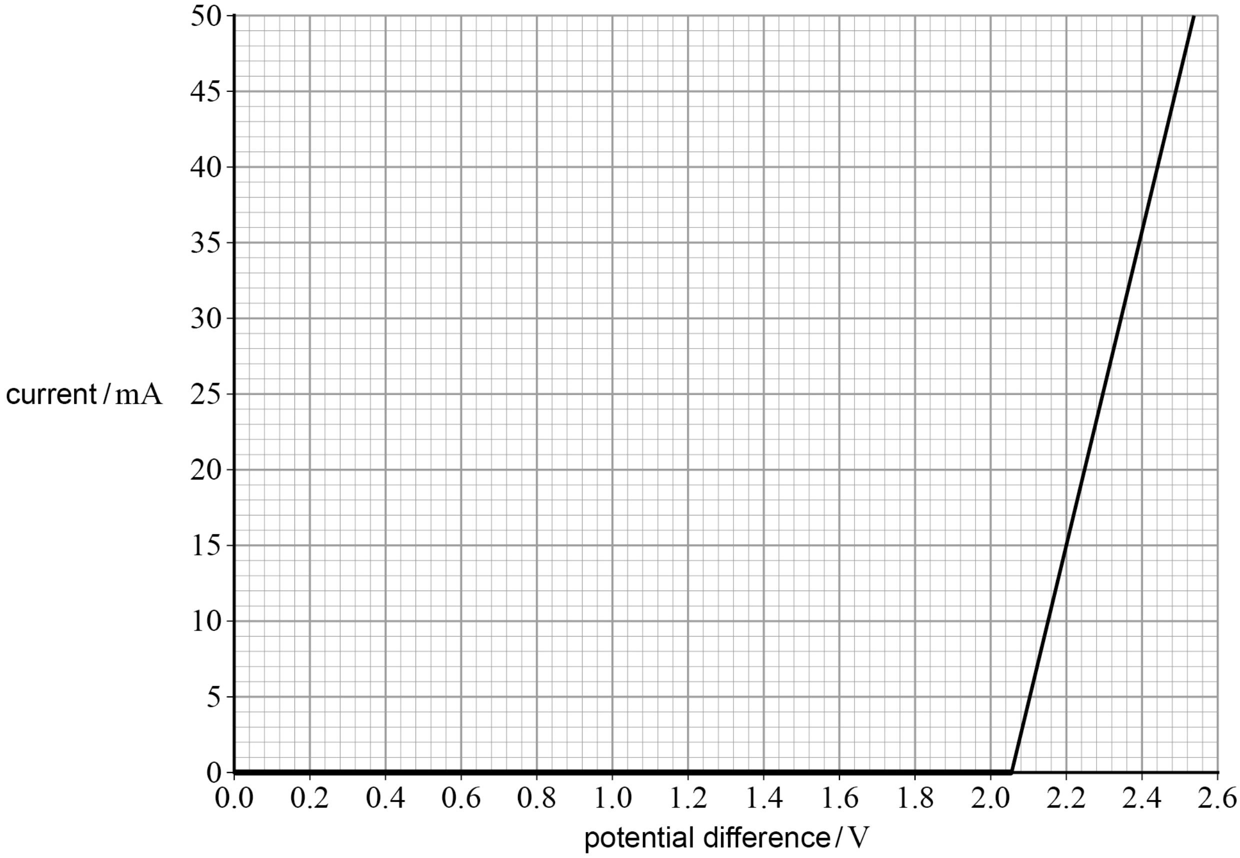


Figure 2 shows part of the characteristic graph for the LED.

Figure 2



The circuit is designed so that the potential difference across the LED is 2.2 V when the switch is closed.

Calculate the resistance of R.

[4 marks]

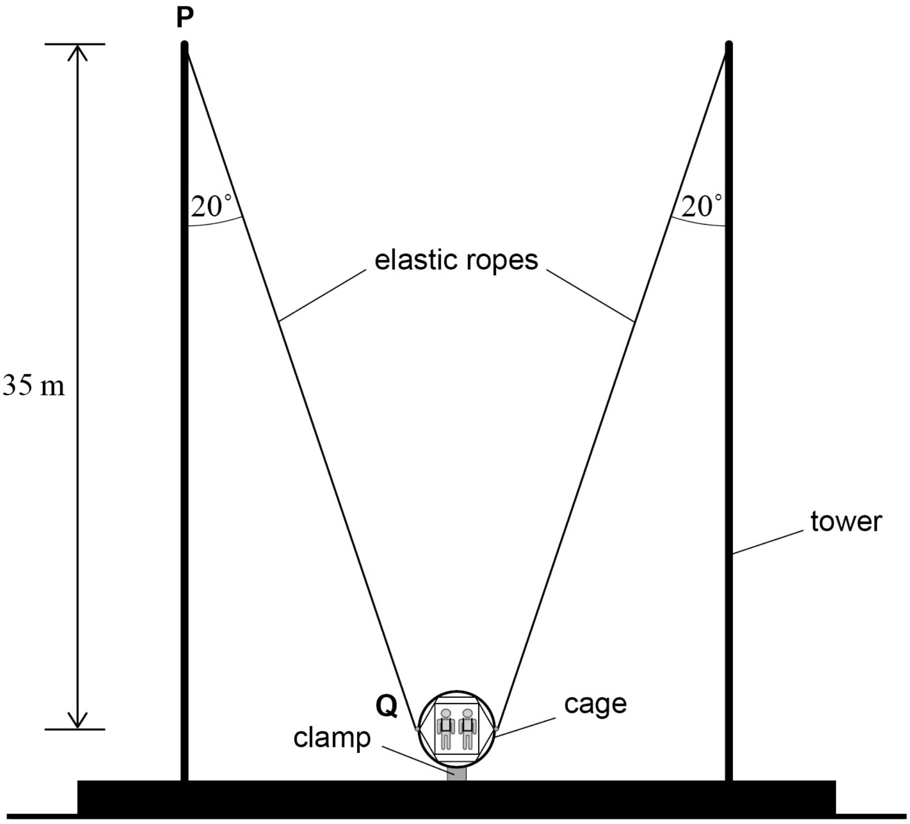
resistance = ______________________ Ω

9

Turn over for the next question

0 3 **Figure 3** shows a fairground ride called a ‘reverse bungee’.

Figure 3



Two identical stretched elastic ropes are fixed to a cage with passengers inside. The loaded cage is held in place by a clamp. When the clamp is released the elastic ropes accelerate the loaded cage vertically into the air.

P is the point where the rope attaches to the top of the vertical tower.
Q is the point where the rope attaches to the cage. **Q** is level with the centre of mass of the loaded cage.

Before release, the tension T in each elastic rope is 3.7×10^4 N and each rope makes an angle of $20°$ with the vertical tower.

The total mass M of the loaded cage is 1.2×10^3 kg and the mass of the elastic ropes is negligible.

0 3 . 1 Show that the downward force F exerted by the clamp on the loaded cage is about 6×10^4 N.

[4 marks]

0 3 . 2 Calculate the initial acceleration of the loaded cage when the clamp is released.

[2 marks]

acceleration = ____________________ $\mathrm{m\ s^{-2}}$

Question 3 continues on the next page

Turn over ►

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0 3 . 3 The unstretched length of each elastic rope is $24\ \mathrm{m}$. The ropes obey Hooke's Law for all extensions used in the ride.
The **vertical** distance between points **P** and **Q** on **Figure 3** is $35\ \mathrm{m}$.

Show that the total elastic potential energy stored in both ropes before the loaded cage is released is about $5 \times 10^5\ \mathrm{J}$.

[4 marks]

0 3 . 4 The designers of the ride claim that the loaded cage will reach a height of $50\ \mathrm{m}$ above **Q**.

Deduce whether this claim is justified.

[3 marks]

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0 3 . 5 The designers also claim that the loaded cage reaches a maximum speed of at least $90\ \mathrm{km\ h^{-1}}$.

Calculate, in J, the kinetic energy of the loaded cage when it travels at $90\ \mathrm{km\ h^{-1}}$.

[3 marks]

kinetic energy = ____________________ J

0 3 . 6 Deduce without further calculation whether the maximum speed claim is justified.

[1 mark]

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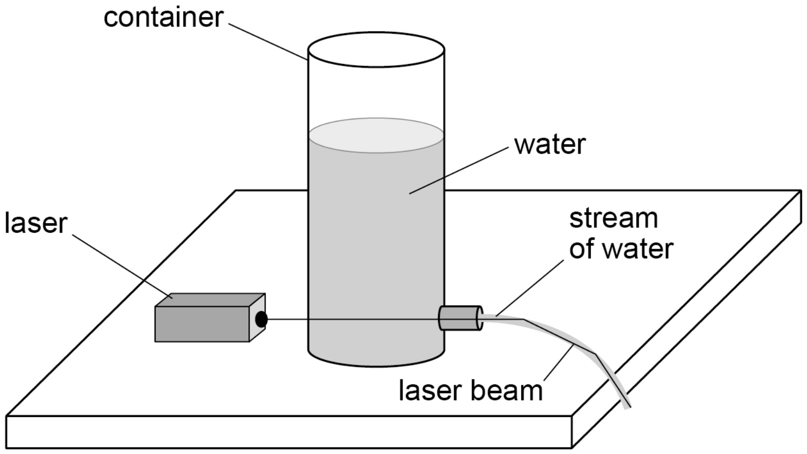
17

0 4 In 1870 John Tyndall sent a beam of light along a stream of water.
Figure 4 shows a modern version of Tyndall's experiment using a laser beam.
Water has a refractive index of 1.33

Figure 4



0 4 . 1 Explain why the laser beam stays inside the stream of water.

[2 marks]

Do not write outside the box

0 4 . 2 Calculate the speed of the laser light in the water.
Give your answer to an appropriate number of significant figures.

[3 marks]

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

0 4 . 3 Calculate the critical angle for the water–air boundary.

[1 mark]

critical angle = ______________________ degrees

Question 4 continues on the next page

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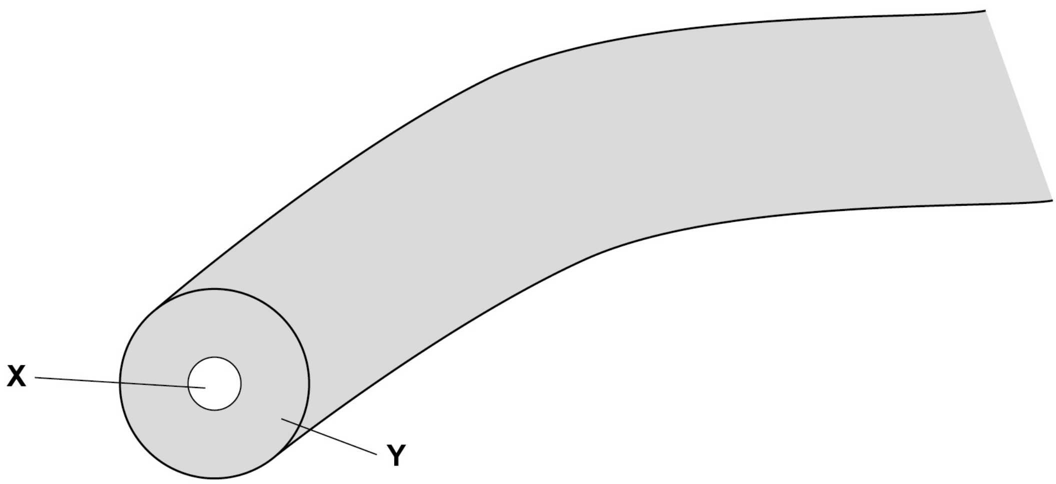
0 4 . 4 Tyndall's experiment led to the development of optical fibres.
Figure 5 shows a step-index optical fibre.

Figure 5



Discuss the properties of a step-index optical fibre.

Your answer should include:

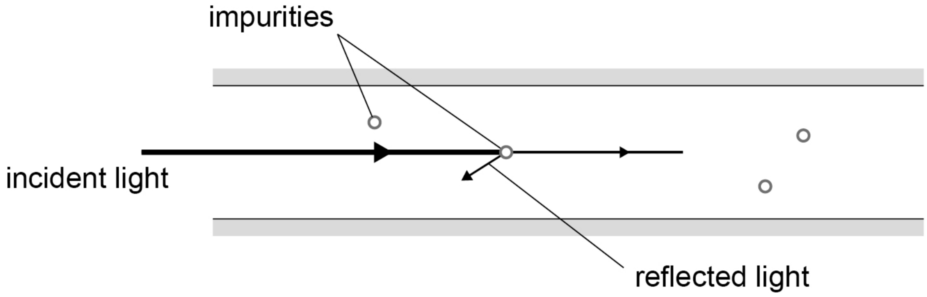
- the names of part **X** and part **Y**
- a description of the functions of **X** and **Y**
- a discussion of the problems caused by material dispersion and modal dispersion and how these problems can be overcome.

[6 marks]

Question 4 continues on the next page

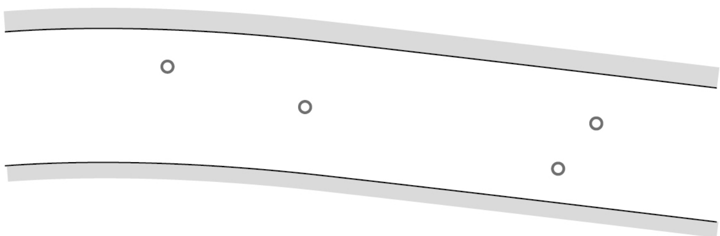
0 4 . 5 Scientists use optical fibres to monitor earthquakes. Light travelling through an optical fibre can be reflected by impurities in the fibre, as shown in **Figure 6**.

Figure 6



Earthquakes bend the optical fibre slightly, as shown in **Figure 7**. This changes the amount of reflected light.

Figure 7



Suggest why the amount of reflected light changes as the fibre bends.
You may draw on **Figure 7** as part of your answer.

[2 marks]

0 4 . 6 The waves caused by earthquakes can be longitudinal or transverse.

Describe the difference between longitudinal waves and transverse waves.

[2 marks]

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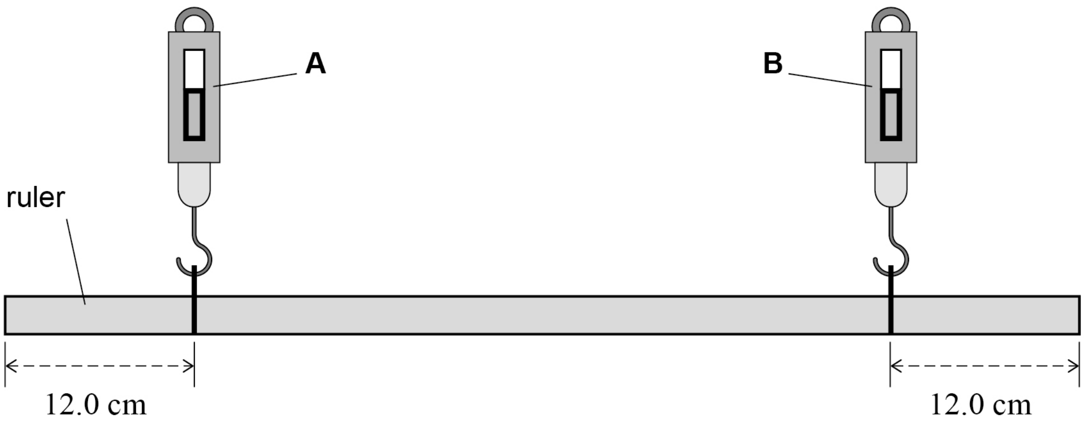
16

Turn over for the next question

0 5 A student investigates moments by suspending a $100\ \mathrm{cm}$ ruler from two force meters, **A** and **B**. **A** and **B** are attached to the ruler $12.0\ \mathrm{cm}$ from each end. Their supports are adjusted to make **A** and **B** vertical and the ruler horizontal.

Figure 8 is a simplified diagram of the experiment.

Figure 8



0 5 . 1 The ruler is uniform and weighs $1.12\ \mathrm{N}$.

Determine the reading on **A**.

[1 mark]

reading = ______________________ N

0 5 . 2 The student suggests that the forces exerted on the ruler by **A** and **B** act as a couple.

Discuss whether his suggestion is correct.

[2 marks]

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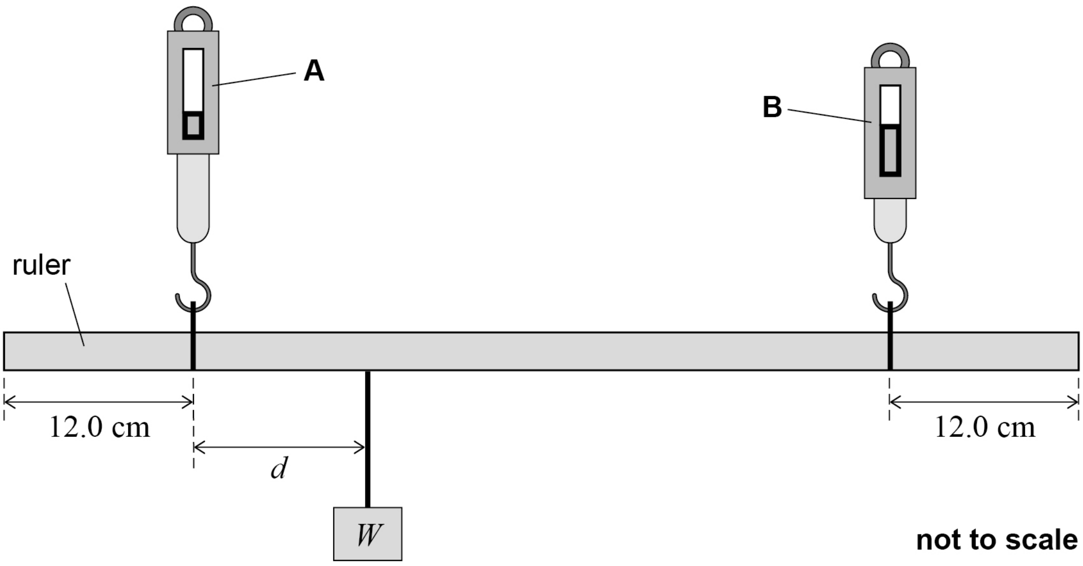
0 5 . 3 The student hangs a mass of weight W on the ruler between **A** and **B**, as shown in **Figure 9**.
He adjusts the supports so that **A** and **B** are again vertical and the ruler is horizontal.
The mass hangs at a distance d from **A**.

Figure 9



not to scale

The reading on **A** is $0.82\ \text{N}$ and the reading on **B** is $0.62\ \text{N}$.

Determine
- W
- d.

[4 marks]

$W =$ ____________________ N

$d =$ ____________________ m

Question 5 continues on the next page

Turn over ►

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0 5 . 4 A second student sets up the same apparatus as shown in **Figure 9**.
She suspends the mass in the same position on the ruler as in question **05.3**.
She moves the supports to make **A** and **B** vertical but does not make the ruler horizontal.

Discuss whether the readings on **A** and **B** taken by this student are different to those in question **05.3**.

[2 marks]

9

0 6 Scientists at CERN have produced atoms of antihydrogen.
An atom of antihydrogen contains the antiparticle of the proton and the antiparticle of the electron.

0 6 . 1 State what is meant by an antiparticle.

[2 marks]

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0 6 . 2 Complete **Table 2** with the names of the antiparticles in an atom of antihydrogen.

[2 marks]

Table 2

Name of particle	Name of antiparticle
proton	
electron	

Question 6 continues on the next page

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0 6 . 3 The particles in antihydrogen can be made by pair production.

Calculate the total minimum energy, in J, needed to produce the particles in one atom of antihydrogen.

[3 marks]

energy = ______________________ J

Do not write outside the box

0 6 . 4 Line emission spectra of hydrogen and antihydrogen have been compared.

Explain in terms of energy changes how line emission spectra are produced.

[3 marks]

10

END OF QUESTIONS

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