Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

AS PHYSICS

Paper 1

Wednesday 14 May 2025 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
- a protractor.

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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- 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	
7	
TOTAL	

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

Do not write outside the box

0 1 Hydrogen has three naturally occurring isotopes. One of these isotopes is hydrogen-3 $\left({}^{3}_{1}\mathrm{H}\right)$.

0 1 . 1 Calculate the specific charge of a nucleus of hydrogen-3.

[2 marks]

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

0 1 . 2 The specific charge of the hydrogen-3 nucleus is less than the specific charges of the nuclei of the other two isotopes.

Suggest why.

[2 marks]

Do not write outside the box

Kaons (K) and pions (π) are produced when a beam of antiprotons is incident on a sample of hydrogen gas.

One reaction that occurs is

$$p + \bar{p} \rightarrow K^- + \pi^+ + K^0$$

0 1 . 3 Deduce, with reference to appropriate conservation laws, the quark structure of the K^0 produced in this reaction.

[3 marks]

quark structure = _____

0 1 . 4 One possible decay of a π^+ particle is

$$\pi^+ \rightarrow \mathbf{A} + \mathbf{B}$$

where **A** is a charged lepton.

Suggest, with reference to appropriate conservation laws, the name of **A** and the name of **B**.

[2 marks]

name of **A** _____

name of **B** _____

9

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0 2 An optical fibre consists of a glass core surrounded by cladding.

Monochromatic light enters the glass core of the optical fibre from air.

0 2 . 1 What happens to the frequency of the light as it enters the glass core?

Tick (✓) **one** box.

[1 mark]

It decreases. ☐

It is unchanged. ☐

It increases. ☐

The refractive index of the glass core is 1.51

0 2 . 2 The critical angle at the core–cladding boundary is $80.7°$

Calculate the refractive index of the cladding.

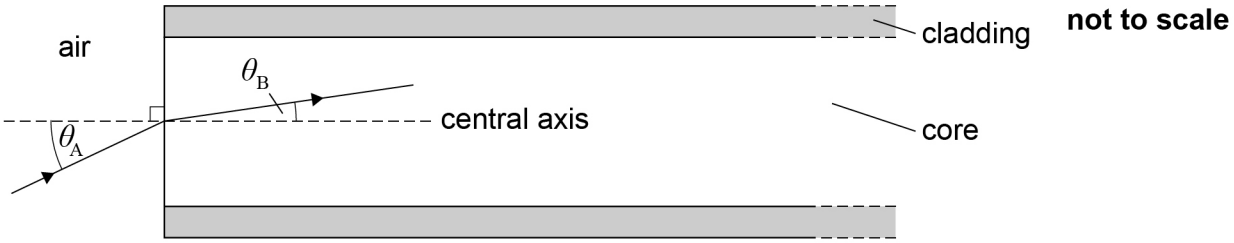
[2 marks]

refractive index of cladding = _____

Do not write outside the box

Figure 1 shows a ray of light that is incident on the centre of the core.
At the air–core boundary, the angle of incidence of this ray is θ_A and the angle of refraction is θ_B.

Figure 1



not to scale

When θ_B is greater than $9.3°$, the ray will **not** be transmitted through the optical fibre.

0 2 . 3 Calculate the maximum value of θ_A for the ray to be transmitted through the optical fibre.

[2 marks]

maximum value of θ_A = _____ °

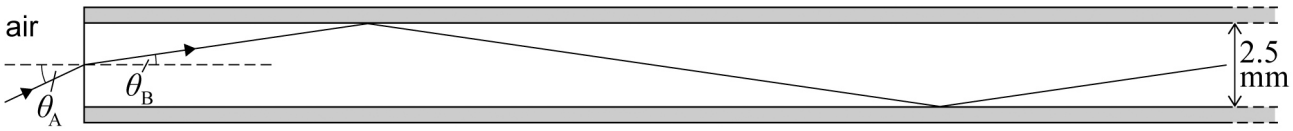
Question 2 continues on the next page

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0 2 . 4 **Figure 2** shows the path of a ray of light that enters at the centre of the straight optical fibre at a smaller value of θ_A. Only the first two total internal reflections are shown.

Figure 2

not to scale



The core has a diameter of 2.5 mm.

θ_B is now $9.0°$

3.1×10^4 total internal reflections occur before the light leaves the optical fibre.

Calculate the time for the light to travel through the optical fibre.

refractive index of glass core = 1.51

[3 marks]

time = _____ s

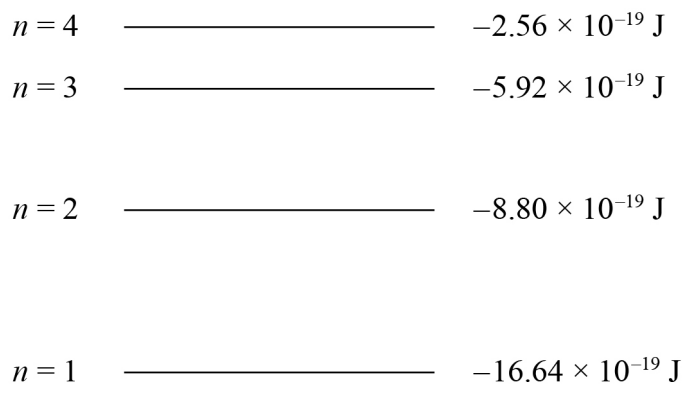
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0 3 A fluorescent tube contains a low-pressure gas consisting of mercury atoms.

Figure 3 shows the four lowest energy levels of a mercury atom.

Figure 3



A mercury atom inside the fluorescent tube is in its ground state $n = 1$

An electron is travelling inside the tube. The electron has a kinetic energy of 13.10×10^{-19} J when it collides with the mercury atom.

As a result of the collision, the mercury atom is excited to its $n = 3$ energy level. Immediately after the collision, the electron is moving with a speed that is smaller than before the collision.
Assume that the kinetic energy of the mercury atom does not change.

0 3 . 1 Calculate the de Broglie wavelength of this electron immediately after the collision.

[4 marks]

de Broglie wavelength = _____ m

Question 3 continues on the next page

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The excited mercury atoms inside the fluorescent tube can emit photons of ultraviolet light, each of energy 7.83×10^{-19} J.

0 3 . 2 Calculate, in nm, the wavelength of a photon with this energy.

[2 marks]

wavelength = _____ nm

0 3 . 3 The fluorescent tube has an input power of 18 W.

82% of the input power is converted into ultraviolet photons, each of energy 7.83×10^{-19} J.

Calculate the number of these photons emitted in one second.

[2 marks]

number of photons = _____

Do not write outside the box

0 3 . 4 Explain how the coating of the fluorescent tube emits white light.

In your answer you should:

- describe the processes that take place in the coating
- suggest why there are many more visible photons than ultraviolet photons emitted by the tube.

[4 marks]

12

Turn over for the next question

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0 4 . 1 State the principle of moments.

[2 marks]

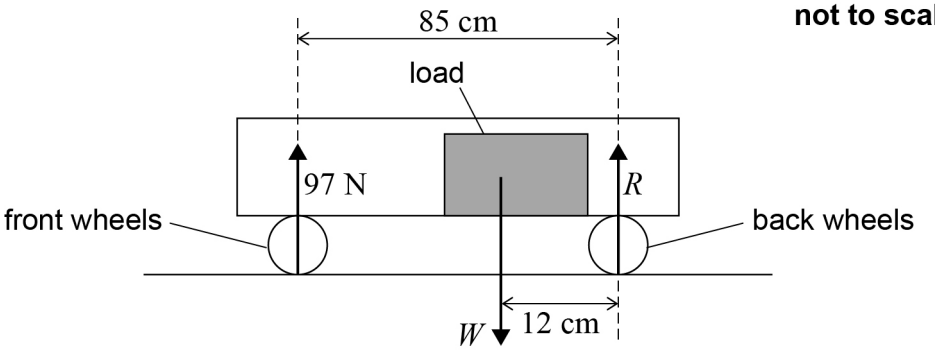
Question 4 continues on the next page

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0 4 . 2 **Figure 4** shows a trolley at rest on a horizontal surface. A load is fixed to the base of the trolley.

Figure 4

not to scale



Assume that the forces in **Figure 4** are coplanar.

The distance between the centre of the front wheels and the centre of the back wheels is 85 cm.

The total reaction force at the front wheels is 97 N and the total reaction force at the back wheels is R.

The trolley and load have a total weight W.

The perpendicular distance between the lines of action of the forces W and R is 12 cm.

Calculate R.

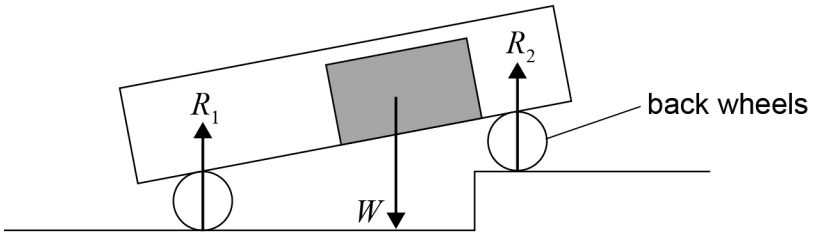
[3 marks]

$R =$ _____ N

Do not write outside the box

Figure 5 shows the trolley after its back wheels have been lifted onto a step.
The trolley is stationary.

Figure 5



0 4 . 3 When the back wheels are on the step, the moment of W about the centre of the back wheels is less than that in **Figure 4**.

Explain why.

[1 mark]

0 4 . 4 Deduce how the magnitude of R_1 in **Figure 5** compares with the value of $97\ \text{N}$ in **Figure 4**.

[3 marks]

9

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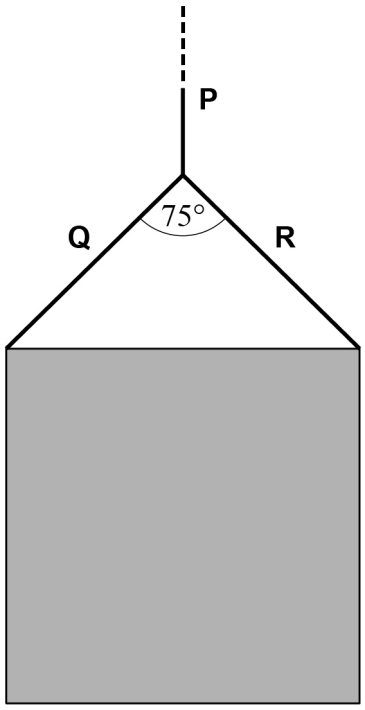
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0 5 **Figure 6** shows a stationary lift suspended using three steel cables **P**, **Q** and **R**.
The centre of mass of the lift is vertically below cable **P**.

Figure 6



The mass of the lift is $850\ \text{kg}$.
The angle between **Q** and **R** is $75°$
Q and **R** each have an unstretched length of $2.0\ \text{m}$.
The cross-sectional area of each cable is $1.4 \times 10^{-4}\ \text{m}^2$.
The Young modulus of the steel is $2.1 \times 10^{11}\ \text{Pa}$.

0 5 . 1 Determine the extension of **Q**.

[4 marks]

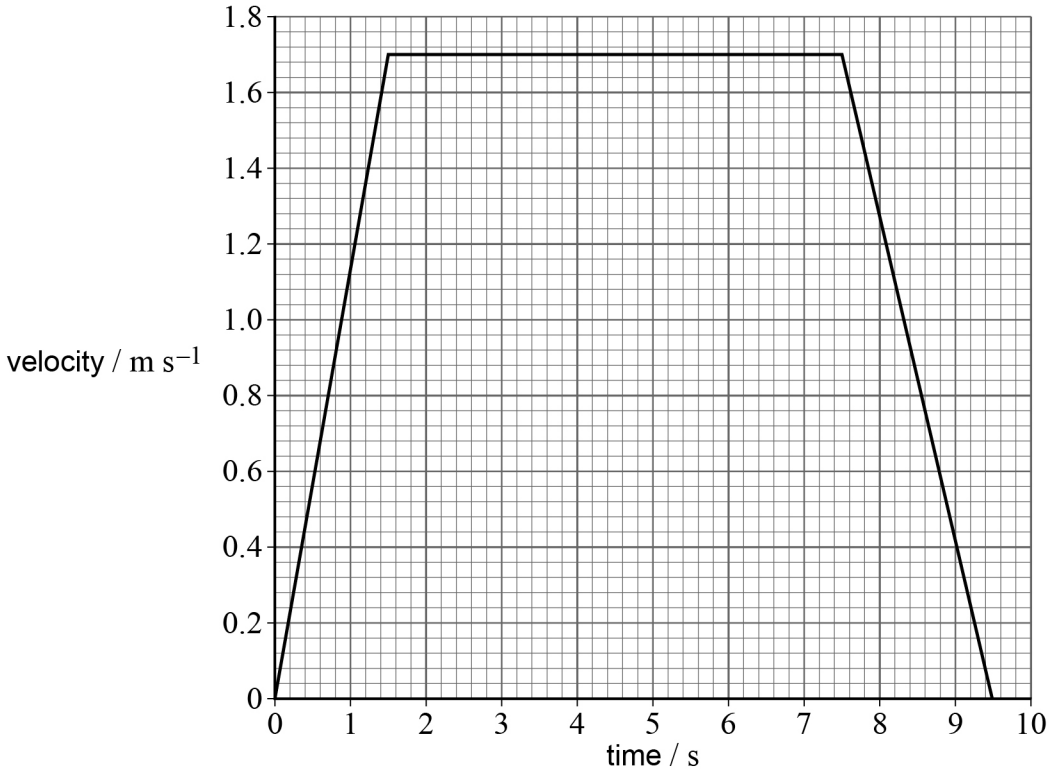
extension = _____ m

Question 5 continues on the next page

Do not write outside the box

Figure 7 is a velocity–time graph for the lift as it travels upwards from ground level.

Figure 7



0 5 . 2 Determine the gravitational potential energy gained by the lift during the first 1.5 s of the motion.

[3 marks]

gravitational potential energy = _____ J

Do not write outside the box

0 5 . 3 **Q** and **R** are connected to **P** as shown in **Figure 6**.

Determine the tension in **P** during the last 2.0 s of the motion.

[3 marks]

tension = _____ N

Question 5 continues on the next page

Do not write outside the box

After 4.0 s of the motion, the lift is moving at a constant velocity and has travelled 5.5 m from ground level. An object becomes detached from the underside of the lift.

0 5 . 4 Determine the velocity of the object when it reaches ground level.

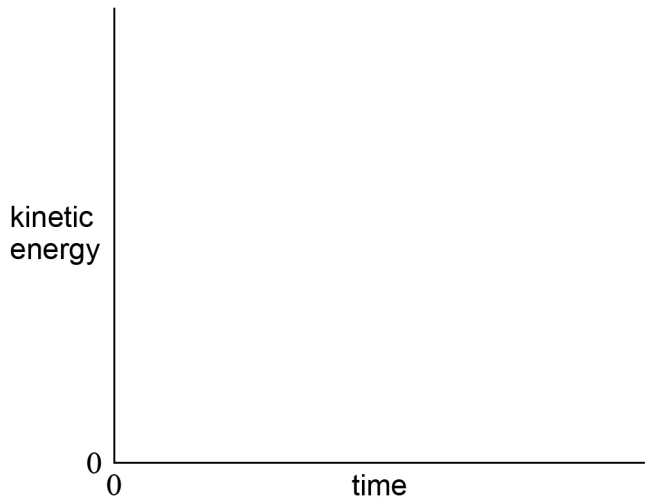
[3 marks]

velocity = _____ m s^{-1}

0 5 . 5 Sketch on **Figure 8** the variation with time of the kinetic energy of the object from when it becomes detached until it hits the ground.
No calculations are required.

[2 marks]

Figure 8



15

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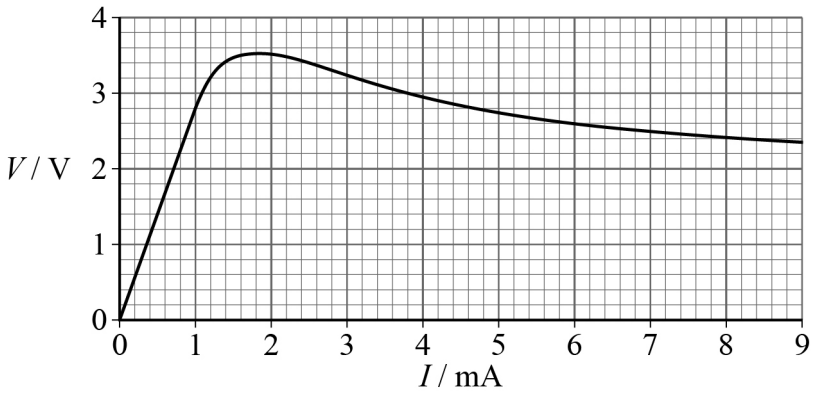
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0 6 **Figure 9** shows the variation of potential difference V with current I for a thermistor **T**.

Figure 9



0 6 . 1 Discuss, for the range 0 to 9 mA, the characteristic of **T** shown by **Figure 9**.

In your answer you should:

- describe how to produce a characteristic experimentally
- describe, in terms of resistance, the behaviour of **T**
- explain, with reference to temperature, the behaviour of **T**.

[6 marks]

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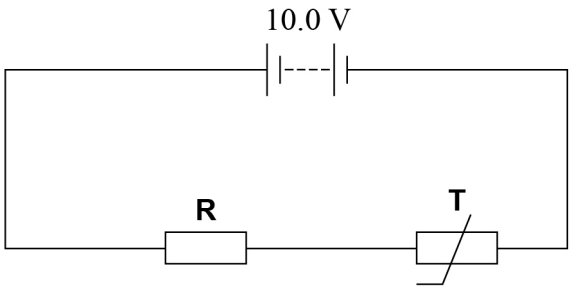
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0 6 . 2 **Figure 10** shows thermistor **T** in series with a fixed resistor **R** and a battery.

The variation of V with I shown in **Figure 9** applies to **T** in this circuit.

Figure 10



The battery has an emf of $10.0\ \text{V}$ and negligible internal resistance.

The current in **T** is $1.0\ \text{mA}$.

Determine the resistance of **R**.

[3 marks]

resistance = _____ Ω

9

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0 7 . 1 State what is meant by the threshold frequency of radiation in the photoelectric effect.

[2 marks]

When magnesium is illuminated with monochromatic electromagnetic radiation, photoelectrons are emitted.
For this radiation, the maximum kinetic energy of the photoelectrons is 5.47×10^{-19} J and the stopping potential is V_s.

0 7 . 2 Calculate V_s.

[1 mark]

$V_s =$ _____ V

0 7 . 3 The radiation incident on the magnesium has a frequency of 1710 THz.

Calculate the work function of the magnesium.

[2 marks]

work function = _____ J

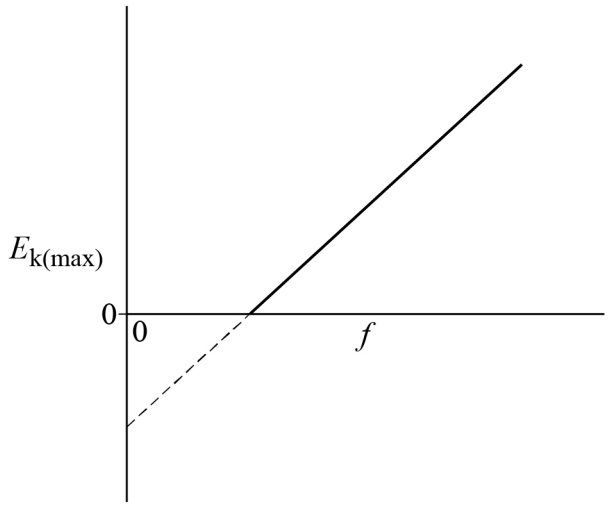
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0 7 . 4 The frequency f of the electromagnetic radiation is varied.

Figure 11 shows the variation of $E_{k(max)}$ with f for magnesium.

Figure 11



Metal **X** and metal **Y** are illuminated by radiation with the same range of frequencies as used for the magnesium.

Sketch, on **Figure 11**, graphs to show how $E_{k(max)}$ varies with f for **X** and for **Y**.
Label your graphs **X** and **Y**.
Go on to explain your reasoning.

work function of **X** > work function of magnesium > work function of **Y**

[3 marks]

8

END OF QUESTIONS

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