

BPhO Round 0

17th October 2025

**This question paper, any notes, copies of your answers, formula booklets
must not be taken out of the exam room.**

The questions must not be discussed online until after 1st November 2025

Instructions

Time: 1 hour.

Marks: This paper contains **25** multiple-choice questions, worth **1 mark each**.

There is no negative marking for incorrect answers. You can attempt the questions in any order.

Equipment: (1) Use an **HB or B** pencil. (2) An eraser (3) Plain paper for working. (4) You are allowed any standard exam board data/formula sheet.

No calculators are allowed.

Working: You are encouraged to write your working on paper. However, only your final answer will be marked.

Solutions:

- Answers are to be written on the **Answer Sheet**.
- You should write your **Name, Time** and **Date of sitting** clearly on the answer sheet.
- Fill in the answer bubbles as instructed. Mark **one** answer for each question only.

This paper is about problem solving and the skills needed. It is designed to be a challenge even for the top A Level physics students in the country. If you find the questions hard, they are. Do not be put off. Good luck.

Physical Constants

Throughout this paper, the following letters are used for important constants:

- c is the speed of light in free space
- e is the elementary charge
- g is Earth's gravitational field strength
- h is Planck's constant

Mathematical Formulae

$$\text{Volume of a sphere} = \frac{4}{3}\pi r^3$$

$$e^x \approx 1 + x + \dots \quad \text{for } x \ll 1$$

$$(1+x)^n \approx 1 + nx \quad \text{for } x \ll 1$$

$$\frac{1}{(1+x)^n} \approx 1 - nx \quad \text{for } x \ll 1$$

$$\tan \theta \approx \sin \theta \approx \theta \quad \text{for } \theta \ll 1$$

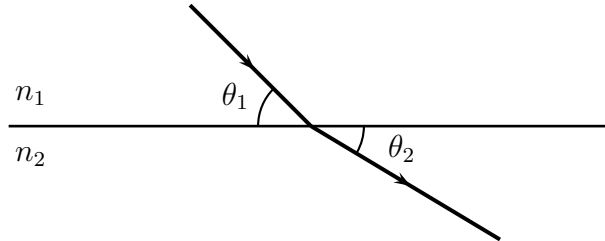
$$\cos \theta \approx 1 - \frac{\theta^2}{2} \quad \text{for } \theta \ll 1$$

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1. A uniform elastic wire of length L and cross-section A is subject to a tensile stress σ , which results in a tensile strain ε . Find the work done on the wire.

- A** $LA\sigma\varepsilon$
 B $\frac{\sigma A}{\varepsilon L}$
 C $\frac{\sigma L}{2\varepsilon A}$
 D $\frac{\varepsilon A}{\sigma L}$
 E $\frac{1}{2}LA\sigma\varepsilon$

2. The diagram below shows the refraction of a light ray travelling from a medium with refractive index n_1 into a medium with refractive index n_2 . Which equation relates the angles θ_1 and θ_2 ?



- A** $n_1 \sin \theta_1 = n_2 \sin \theta_2$
 B $n_1 \sin \theta_2 = n_2 \sin \theta_1$
 C $n_1 \cos \theta_1 = n_2 \cos \theta_2$
 D $n_1 \cos \theta_2 = n_2 \cos \theta_1$
 E $n_1 \sin \theta_1 = n_2 \cos \theta_2$

3. Which of these is **not** a unit of impulse?

- A** Ns
 B $\text{Ws}^2 \text{m}^{-1}$
 C Pa m^3
 D kg m s^{-1}
 E CV s m^{-1}

4. Uranium-238 ($^{238}_{92}\text{U}$) decays to lead-206 ($^{206}_{82}\text{Pb}$) via a series of alpha and beta minus decays only. How many beta minus decays occur in total?

- A** 4
 B 6
 C 8
 D 10
 E 12

5. Two coherent waves of equal amplitude and wavelength 1.8 m, originating from the same source, arrive at the same detector with a path difference of 7.5 m.

Which of these options describes the type of interference that occurs at the detector?

- A** fully destructive
 B mostly destructive
 C mostly constructive
 D fully constructive
 E not enough information

6. A resistor shop sells individual resistors (the stock is unlimited). The price for each resistor is as follows:

$2\ \Omega$ for £3, $3\ \Omega$ for £1, $6\ \Omega$ for £3, $8\ \Omega$ for £4, $12\ \Omega$ for £2.

What is the least you would need to spend to make a combination of resistors equivalent to exactly $4\ \Omega$?

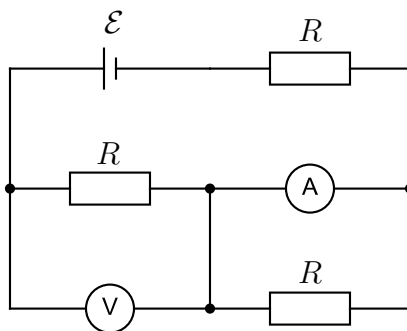
- A** £3 **B** £4 **C** £5 **D** £6 **E** £7

7. Two particles A & B travel along a straight line at a constant speed with velocities as shown in the diagram. Their initial separation is 18 m. How far does particle A travel before colliding with B?



- A** 18 m **B** 27 m **C** 36 m **D** 45 m **E** 54 m

8. A cell of emf $\mathcal{E}$ (and negligible internal resistance), is connected to an ideal voltmeter, an ideal ammeter and three resistors R as shown below. What are the readings on the voltmeter and ammeter respectively?



- A** $\frac{\mathcal{E}}{3}, \frac{\mathcal{E}}{3R}$ **B** $\frac{\mathcal{E}}{3}, \frac{\mathcal{E}}{2R}$ **C** $\frac{\mathcal{E}}{3}, \frac{\mathcal{E}}{R}$ **D** $\frac{\mathcal{E}}{2}, \frac{\mathcal{E}}{3R}$ **E** $\frac{\mathcal{E}}{2}, \frac{\mathcal{E}}{2R}$

9. Two uniform metal wires of the same length are made from the same material. Separately, the wires are subject to the same force on both ends, and the first harmonic frequency of each is measured.

The frequencies are in the ratio 2 : 1. What is the ratio of their electrical resistances?

[Hint: The speed of a transverse wave on a string is $v = \sqrt{T/\mu}$.]

- A** 4 : 1 **B** 3 : 1 **C** $\sqrt{3} : 1$ **D** 2 : 1 **E** $\sqrt{2} : 1$

10. Estimate the number of atoms which make up the Earth.

- A** 10^{50} **B** 10^{55} **C** 10^{60} **D** 10^{65} **E** 10^{70}

11. The first ten energy levels of an atom are labelled $n = 1, 2, \dots, 10$. Assuming all transitions are possible, find the maximum number of unique photon energies corresponding to transitions between $n = 10$ and $n = 1$.

- A** 45 **B** 55 **C** 90 **D** 100 **E** 110

12. A body, initially at rest, explodes into two fragments of masses m and am where $a > 1$. The total kinetic energy after the explosion is E . Find the kinetic energy of the larger mass.

- A** $\frac{E}{1+a}$ **B** $\frac{aE}{1+a^2}$ **C** $\frac{a^2E}{1+a^2}$ **D** $\frac{a^3E}{1+a^3}$ **E** $\frac{E}{a}$

13. The pressure p exerted on two closely spaced parallel plates due to quantum effects is dependent only upon Planck's constant h , the speed of light c and the plate separation r .

Find the proportionality relation between p and r .

- A** $p \propto \frac{1}{r}$ **B** $p \propto \frac{1}{r^2}$ **C** $p \propto \frac{1}{r^3}$ **D** $p \propto \frac{1}{r^4}$ **E** $p \propto \frac{1}{r^5}$

14. A thin uniform circular biscuit of radius b is balanced horizontally on the thin circular rim of a teacup, which has radius $3b/2$, positioned as far as possible from the cup's centre. It is then slowly pushed inwards towards the centre of the teacup. What is the maximum distance it can be pushed before it falls?

- A** $\frac{\sqrt{3}-1}{2}b$ **B** $\frac{5-\sqrt{3}}{5}b$ **C** $\frac{\sqrt{5}-2}{3}b$ **D** $\frac{3-\sqrt{5}}{2}b$ **E** $\frac{\sqrt{3}-1}{3}b$

15. An insulated cup contains 500 g of water at 20°C . Identical ice cubes, each of mass 25 g and at 0°C , are added to the cup. What is the maximum number of cubes that can be added so that, at equilibrium, the mixture is entirely liquid?

Specific heat capacity of water = $4 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$

Specific latent heat of fusion of ice = $3 \times 10^5 \text{ J kg}^{-1}$

- A** 4 **B** 5 **C** 6 **D** 7 **E** 8

16. A ray of light is incident on a glass cube of side length a and refractive index $\sqrt{2}$. The angle of incidence is 30° . Find the time taken for the light to travel to the opposite face.

- A** $\sqrt{\frac{8}{7}} \frac{a}{c}$ **B** $\frac{4}{\sqrt{7}} \frac{a}{c}$ **C** $\frac{\sqrt{2}}{3} \frac{a}{c}$ **D** $\frac{4}{\sqrt{3}} \frac{a}{c}$ **E** $\frac{4}{\sqrt{2}} \frac{a}{c}$

17. An uncharged, isolated parallel plate capacitor has capacitance C . Monochromatic light of frequency f is incident on one of the metal plates, which has threshold frequency f_0 . Emitted photoelectrons are then captured by the other plate. Once the capacitor charge has reached a steady value, how many electrons have been transferred between the plates? (h is Planck's constant and e is the magnitude of the electron charge.)

- A $\frac{Ch(f + f_0)}{e}$ B $\frac{Cf_0(f + f_0)}{e^2}$ C $\frac{Ch(f - f_0)}{e}$ D $\frac{Cf(f + f_0)}{e^2}$ E $\frac{Ch(f - f_0)}{e^2}$

18. Two particles are projected from ground level at the same speed v , but at two different angles to the horizontal: $(\frac{\pi}{4} + \alpha)$ and $(\frac{\pi}{4} - \alpha)$, where α itself is a small angle in radians.

Find the difference between the horizontal ranges of the two particles.

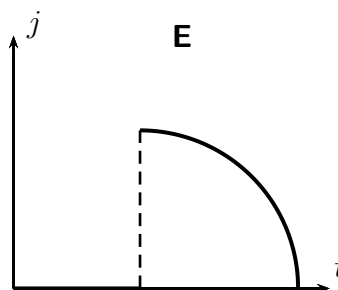
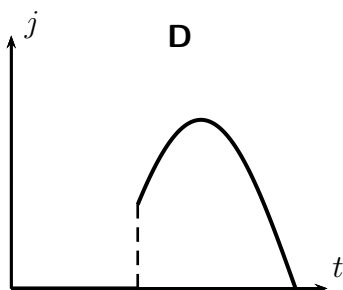
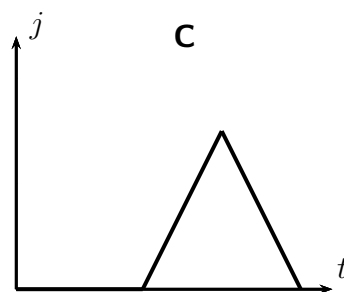
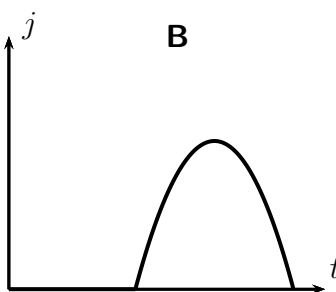
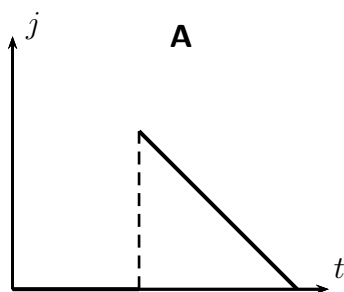
- A 0 B $\frac{\alpha v^2}{g}$ C $\frac{2\alpha v^2}{g}$ D $\frac{\alpha v^2}{2g}$ E $\frac{4\alpha v^2}{g}$

19. The half-life of a radioactive substance is T . What is the time taken for one third of the substance to decay?

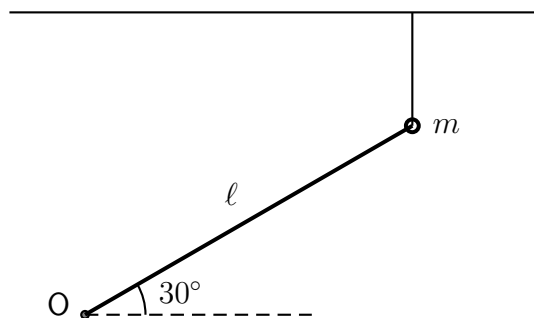
- A $\frac{2}{3}T$ B $\sqrt{\frac{2}{3}}T$ C $T \log_2\left(\frac{3}{2}\right)$ D $T \log_2(3)$ E $T^{\frac{2}{3}}$

20. Jerk is defined as the rate of change of acceleration with respect to time, $j = \frac{da}{dt}$.

A bungee jumper attached to a slack rope falls from a height. Once the rope is taut, it acts as an ideal spring which subsequently brings the jumper to instantaneous rest. Which of the following graphs shows the magnitude of the jerk j as a function of time t , up to this moment?



21. A light inextensible string is attached to one end of a rigid rod of negligible weight and of length ℓ , with its other end freely hinged at O. The other end of the string is attached to the ceiling, so that the string is vertical, and the rod makes an angle of 30° to the horizontal. A small smooth ring of mass m is released from rest at the upper end of the rod and slides downwards along it.



Given that the tension in the string T at time t (while the ring is in motion) is $T = mg(1 - kt^2)$, select the correct expression for k .

A $\frac{g}{4\ell}$

B $\frac{g}{2\ell}$

C $\frac{g}{\ell}$

D $\frac{g}{\sqrt{2}\ell}$

E $\frac{\sqrt{3}g}{2\ell}$

22. A conical pendulum consists of a bob attached to a light inextensible string of length ℓ , with the upper end fixed. The bob moves in a horizontal circle so that the string makes an angle of 30° to the vertical. By what factor must the angular frequency be increased for this angle to double to 60° ?

A $\sqrt{\sqrt{3}}$

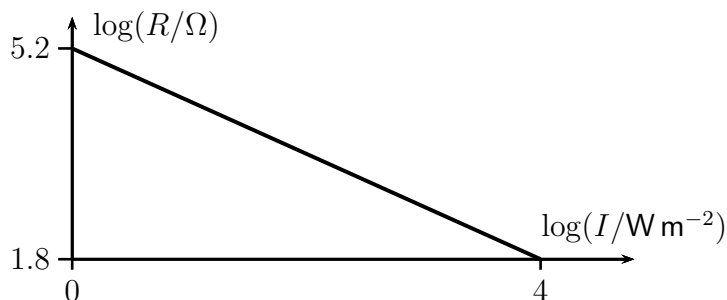
B $\sqrt{2}$

C $\sqrt{3}$

D 2

E 3

23. The resistance R of a light-dependent resistor (LDR) depends on the light intensity I . A logarithmic plot relating these variables is shown below.



A point light source placed a distance d from the LDR illuminates it, and its resistance is measured to be R_0 . Which of the following is a good approximation for the LDR resistance when the distance to the light source is halved?

A $0.1R_0$

B $0.3R_0$

C $0.5R_0$

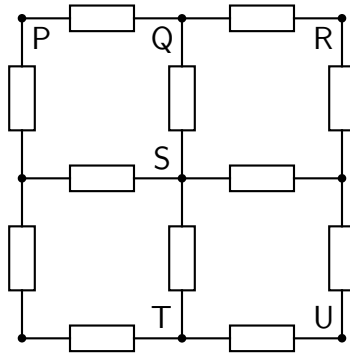
D $0.7R_0$

E $0.9R_0$

24. A uniform ladder of mass m rests against a wall in static equilibrium at an angle of 45° to the vertical. The base of the ladder is pushed a small distance a towards the wall. Which of these options gives the best approximation for the change in gravitational potential energy of the ladder?

- A** $\frac{1}{2}mga$
 B $\frac{1}{\sqrt{2}}mga$
 C mga
 D $\sqrt{2}mga$
 E $2mga$

25. Consider the arrangement of 12 identical resistors below. The equivalent resistance is measured between the following pairs of points: PR, PS, PU, QS, QT. Which measurement gives the median (middle value) resistance?



- A** PR
 B PS
 C PU
 D QS
 E QT

END