Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

PHYSICS **9749/01**
Paper 1 Multiple Choice 13 September 2024
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and index number on the Answer Sheet provided.

There are **thirty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this Question Paper.
The use of an approved scientific calculator is expected, where appropriate.

DATA AND FORMULAE

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\,\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{x_o^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 The maximum theoretical power P of a wind turbine is given by the equation

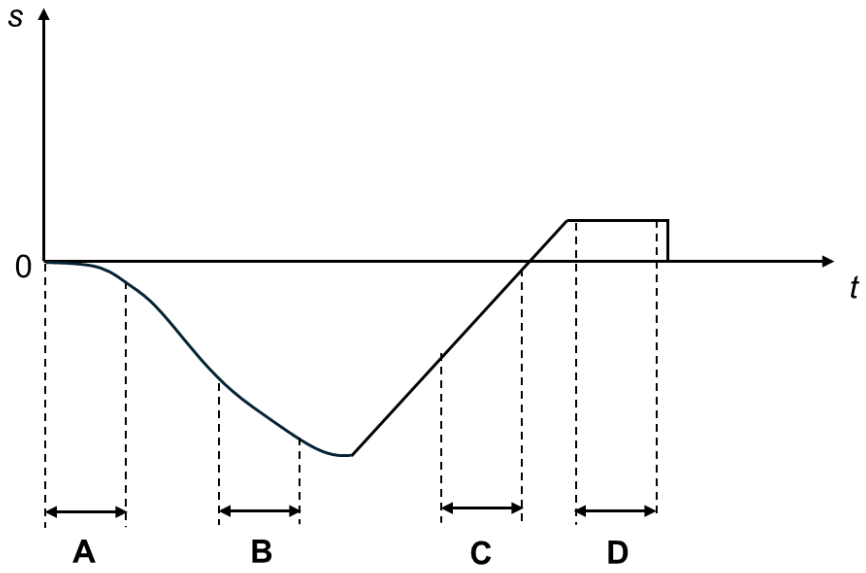
$$P = k \rho A v^n,$$

where ρ is the density of air, A is the area swept by the turbine blades, v is the speed of the air and k is a constant with no units.

What is the value of n?

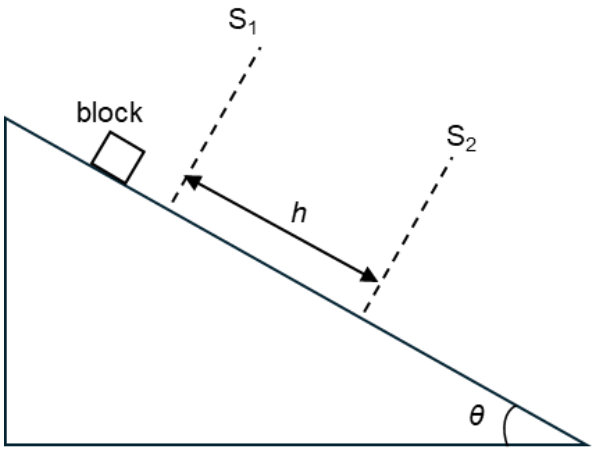
A 1 **B** 2 **C** 3 **D** 4

2 The graph shows the variation with time t of the displacement s of an object moving along a straight path.



Which time interval has the greatest magnitude of acceleration?

3 A block is released from rest down a frictionless inclined plane of angle θ. The block passes two light sensors S_1 and S_2 at time t_1 and t_2 respectively.



What is the acceleration of free fall?

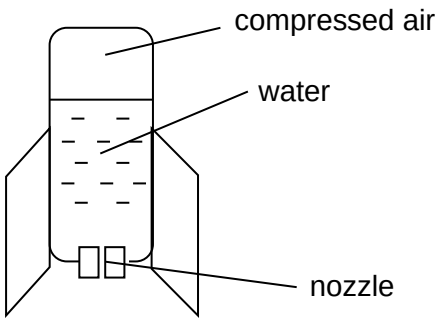
A $\dfrac{2h}{(t_2^2 - t_1^2)}$

B $\dfrac{2h}{(t_2 - t_1)^2}$

C $\dfrac{2h}{(t_2^2 - t_1^2)\cos\theta}$

D $\dfrac{2h}{(t_2^2 - t_1^2)\sin\theta}$

4 A toy rocket consists of a plastic bottle which is partially filled with water as shown in the figure below. The space above the water contains compressed air.



At one instant during the flight of the rocket bottle, water of density 1000 kg m^{-3} is forced out of the nozzle of radius 0.012 m at a speed of 10 m s^{-1} relative to the nozzle.

What is the rate of change of momentum of the water?

A 45 N **B** 120 N **C** 3800 N **D** 7500 N

[Turn over]

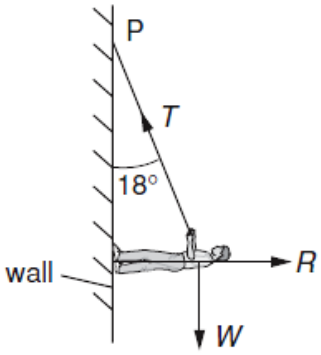
5 Two stationary ice-skaters Charlie and Sam, each of mass 60 kg, are directly facing one another on an ice-skating rink.

Charlie throws a 1.5 kg ball towards Sam with a horizontal speed of 2.5 m s^{-1}. Sam catches the ball and throws it back to Charlie with the same horizontal speed.

What is the speed of Charlie after catching the ball?

A 0 m s^{-1} **B** 0.063 m s^{-1} **C** 0.12 m s^{-1} **D** 0.13 m s^{-1}

6 A climber is supported by a light rope on a vertical wall as shown.

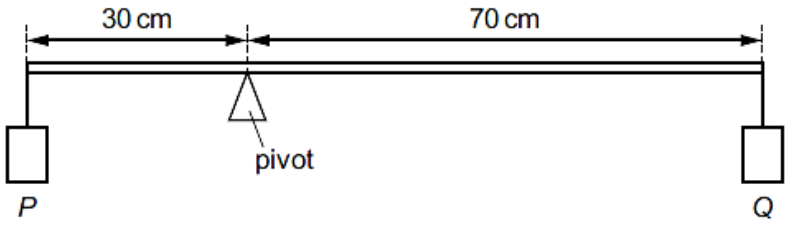


The weight *W* of the climber is 520 N and the reaction force *R* acts at right angles to the wall. The climber is in equilibrium.

Which row shows the value of the tension *T* in the rope and *R*?

	T / N	*R* / N
A	500	150
B	500	480
C	550	170
D	550	520

7 A beam on a pivot supports a load *P* at one end and a load *Q* at the other end.



The weight of the beam is negligible and the beam is maintained in a horizontal position as shown.

Which row gives possible values for *P* and for *Q*?

	P / N	*Q* / N
A	3.0	7.0
B	49	7.0
C	21	9.0
D	27	9.0

8 A motor driving a pump raises 0.20 m^3 of water through a vertical height of 10 m in 5.0 minutes. The efficiency of the motor is 40% and the density of water is 1000 kg m^{-3}.

What is the power generated by the motor?

A 26 W **B** 65 W **C** 160 W **D** 9800 W

9 The hour hand of a large clock is 2.5 m long.

What is the average angular speed of this hand?

A 1.5×10^{-4} rad s^{-1}

B 3.0×10^{-4} rad s^{-1}

C 1.8×10^{-3} rad s^{-1}

D 1.0×10^{-1} rad s^{-1}

10 A sphere moves in a horizontal circle with constant angular speed.

What is its linear speed and its centripetal acceleration when the radius of the horizontal circle is halved and angular speed is doubled?

	linear speed	centripetal acceleration
A	halved	constant
B	halved	doubled
C	constant	constant
D	constant	doubled

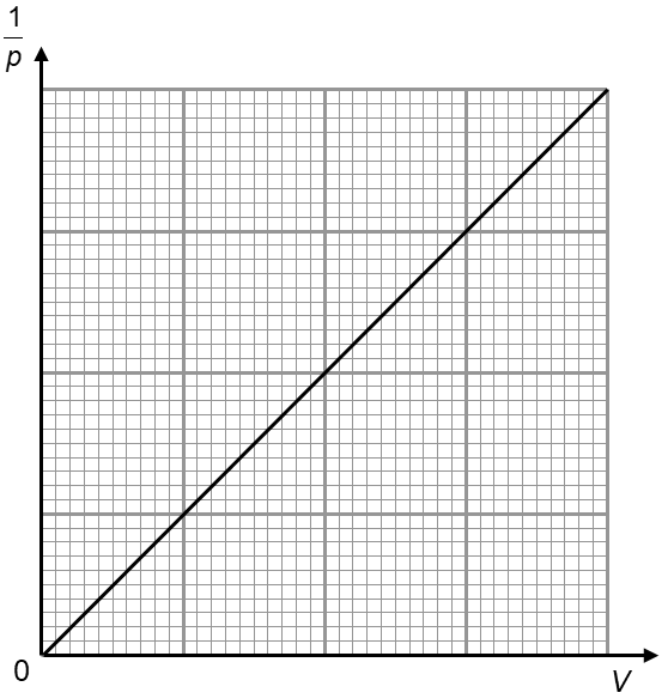
11 The figure below shows a group of three planets. The mass of Planet 2 is about 80 times that of Planet 1 while the mass of Planet 3 is about 350 000 times that of Planet 2. The neutral point in the gravitational field is the point at which the resultant gravitational field due to the three planets is zero.

(not to scale)

Which position is a possible neutral point?

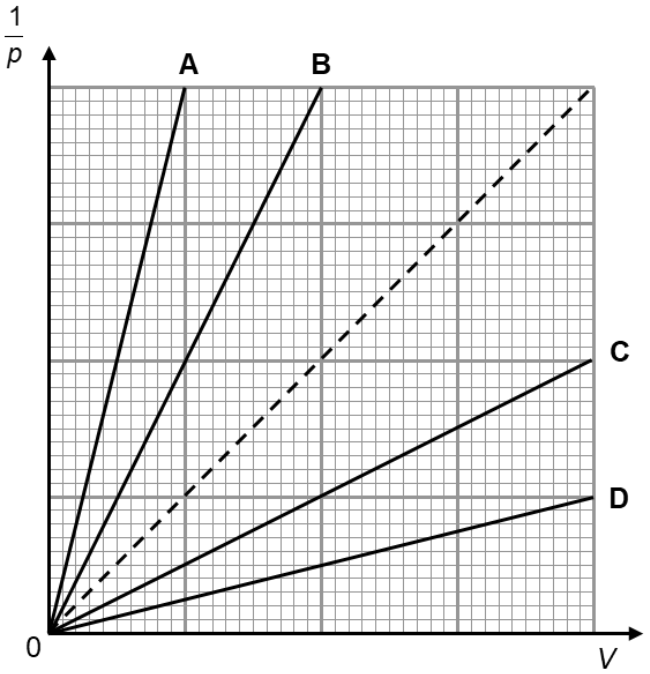
12 A fixed amount of an ideal gas has pressure p and volume V.

The graph shows the variation of $\frac{1}{p}$ with V at a constant temperature.



The amount of gas and the thermodynamic temperature are then both decreased by half.

Which line shows the variation of $\frac{1}{p}$ with V?



[Turn over]

13 Thermal energy is supplied to 2.1 kg of ice at –4.5 °C. All the ice becomes water at 96 °C. There is no heat loss to the surroundings.

Specific heat capacity of water = 4190 J kg^{-1} K^{-1}
Specific latent heat of vaporization of water = 2260 kJ kg^{-1}
Specific heat capacity of ice = 2108 J kg^{-1} K^{-1}
Specific latent heat of fusion of water = 334 kJ kg^{-1}

How much thermal energy is supplied to the ice?

A 721 kJ **B** 865 kJ **C** 1.55 MJ **D** 1.57 MJ

14 Which is **not** an assumption of the kinetic theory of gas?

A The motion of the molecules is random.

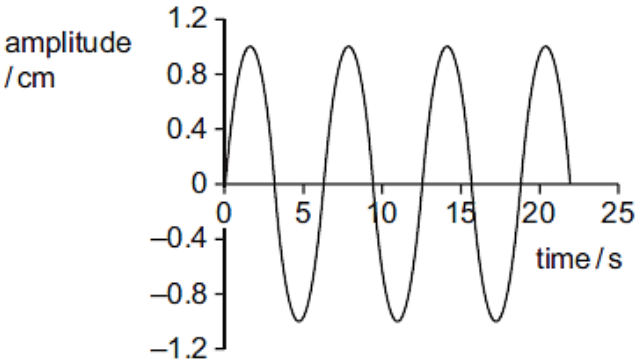
B The molecules move at various speeds.

C The volume of the molecules is comparable with the volume of the container.

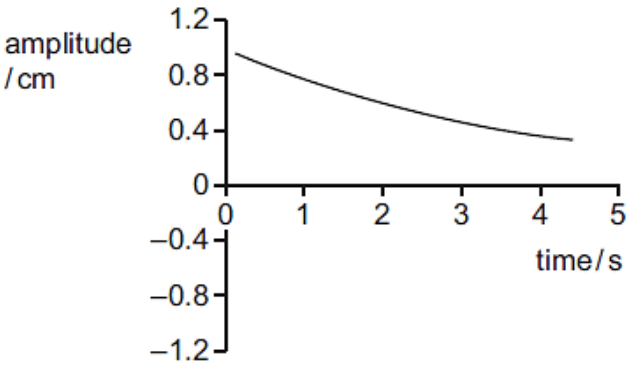
D All collisions of molecules with each other and with the container walls are perfectly elastic.

15 Which graph shows a vibrating system undergoing critical damping?

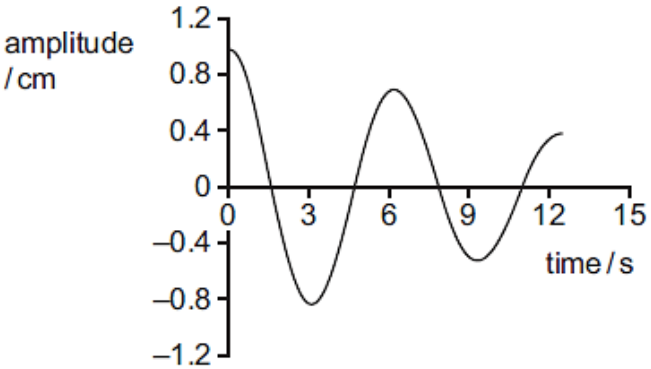
A



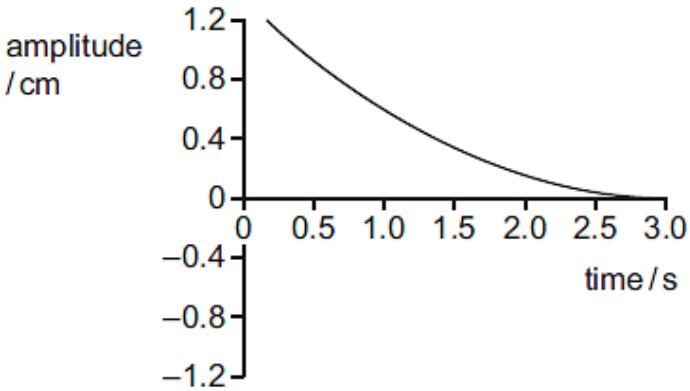
B



C



D



[Turn over]

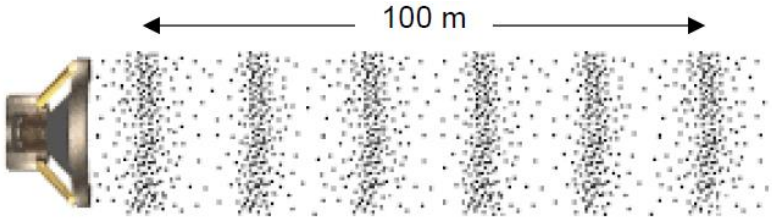
16 A particle undergoes simple harmonic motion with amplitude A_o and period T.

What is the ratio of its kinetic energy to the total energy when its displacement is $\frac{1}{2}A_o$?

A 0.50 **B** 0.75 **C** 0.87 **D** 1.0

17 The diagram illustrates the relative positions of particles in a medium as a sound wave from the speaker on the left propagates through it.

The speed of the wave is 350 m s^{-1}.



What is the frequency of the wave?

A 8.8 Hz **B** 18 Hz **C** 36 Hz **D** 540 Hz

18 The frequency of a water wave is 400 Hz and its speed is 36 m s^{-1}.

What is the phase difference between the motions of two points on the wave that are 0.18 m apart?

A 0.50π **B** 1.0π **C** 2.0π **D** 2.5π

19 The angular resolution of a vertical slit for a pair of objects is 4.0×10^{-2} rad.

What is the new angular resolution if the width of the slit is doubled?

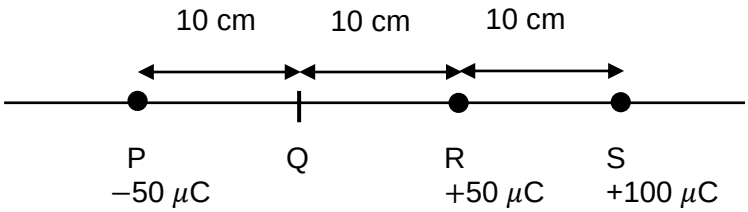
A 1.0×10^{-2} rad

B 2.0×10^{-2} rad

C 8.0×10^{-2} rad

D 16×10^{-2} rad

20 Points P, Q, R and S are spaced 10 cm apart as shown in the diagram below. A $-50\ \mu$C point charge, a $+50\ \mu$C point charge and a $+100\ \mu$C point charge are placed at P, R and S respectively.



What is the electric potential at point Q?

A 0 MV **B** + 4.5 MV **C** + 9.0 MV **D** + 14 MV

21 An electric field pattern is set up in the region around a charged particle.

Which statement is true?

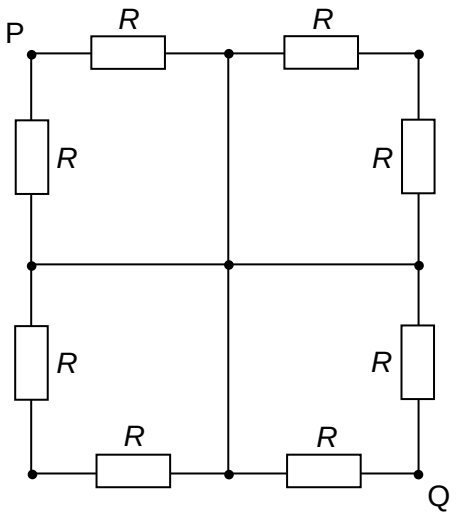
A The electric potential must increase in the direction of the electric field line.

B The electric potential must decrease in the direction of the electric field line.

C The electric field strength must increase in the direction of the electric field line.

D The electric field strength must decrease in the direction of the electric field line.

22 Eight identical resistors, each of resistance *R*, are connected in a network as shown below.

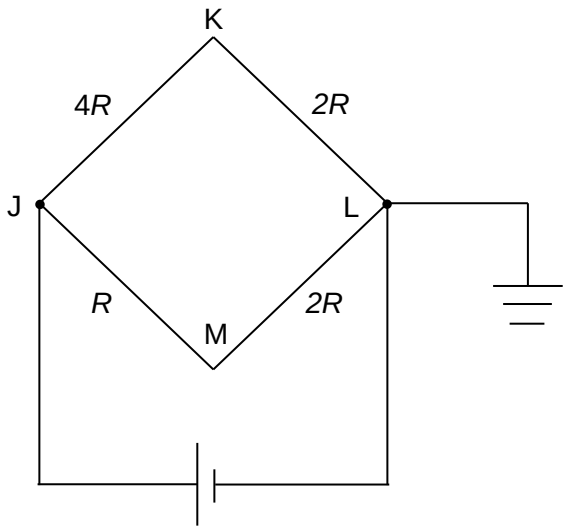


What is the effective resistance between terminals P and Q?

A 0.5*R* **B** *R* **C** 2*R* **D** 4*R*

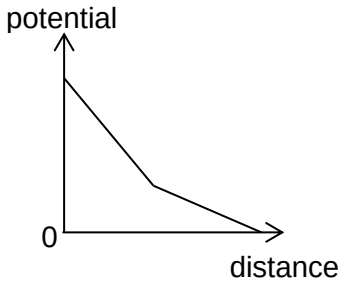
[Turn over]

23 Four wires, JK, KL, JM, and LM (of equal length) are joined as shown in the figure below and a battery is connected between J and L. Point L is earthed. The resistance of each wire, in terms of *R* is indicated in the figure.

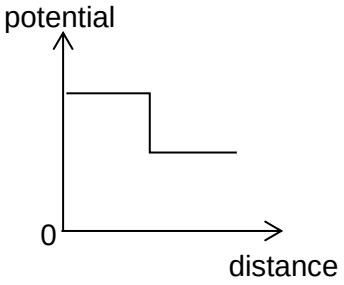


Which graph best shows how the electric potential varies with distance from J along the path JML?

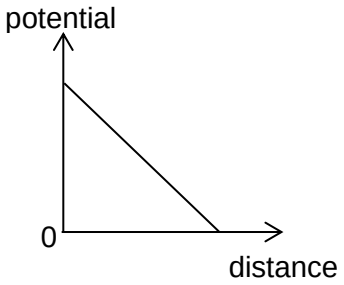
A



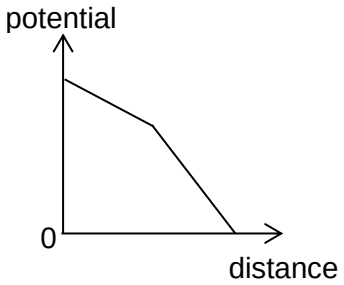
B



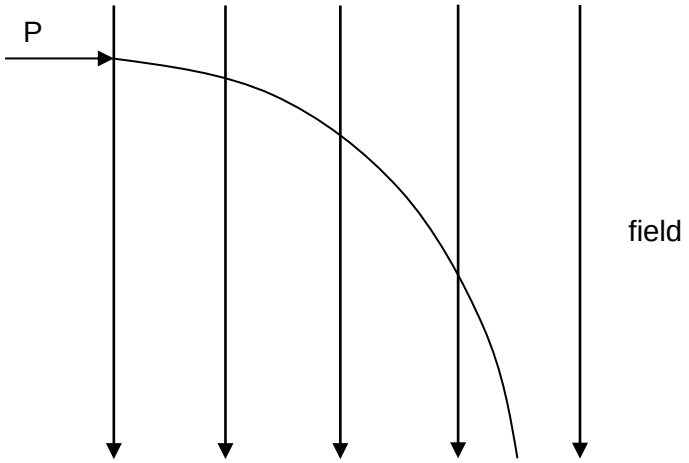
C



D



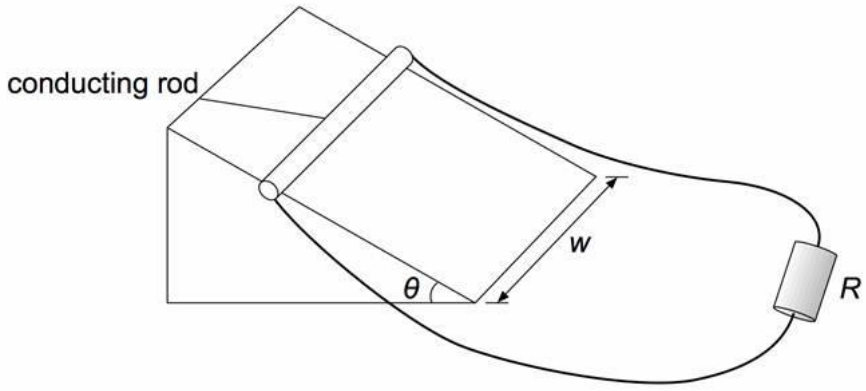
24 A charged particle is projected horizontally at P into a uniform vertical field. The particle follows the path shown below.



Ignoring gravitational effects, what describes the charge of the particle and the nature of the field?

	charge	field
A	negative	electric
B	negative	magnetic
C	positive	electric
D	positive	magnetic

25 The figure below shows a conducting rod of length L and mass m placed on a very long and smooth plane of width w which makes an angle of θ to the horizontal. The rod is connected to a resistor of resistance R through light and flexible wires. The rod is then released from rest at the top of the plane and moves in a uniform magnetic flux density B that is vertically downwards everywhere. The rod attains terminal velocity after some time.

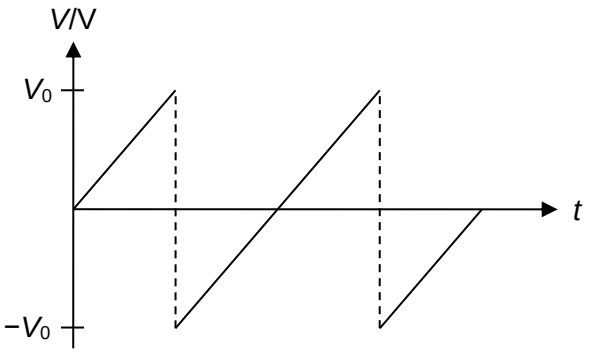


What is the magnitude of the rod's terminal velocity?

A $\dfrac{mgR\tan\theta}{B^2w^2}$ **B** $\dfrac{mgR\tan\theta}{B^2L^2}$ **C** $\dfrac{mgR\tan\theta}{B^2w^2\cos\theta}$ **D** $\dfrac{mgR\tan\theta}{B^2L^2\cos\theta}$

[Turn over]

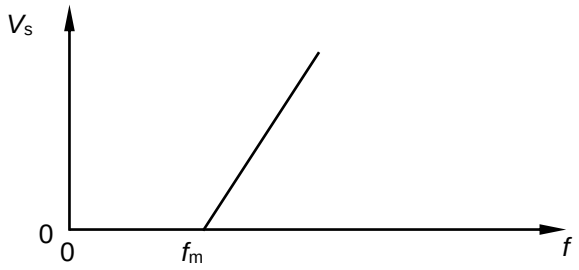
26 An alternating potential with a saw tooth waveform is shown below.



What is the root-mean-square voltage of the waveform?

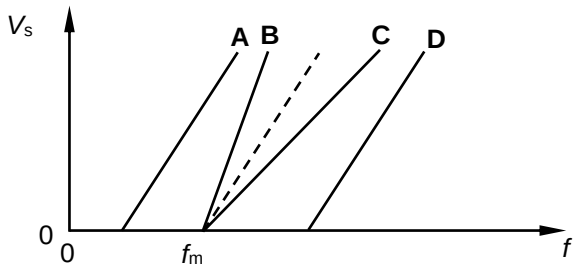
A 0 **B** $\frac{V_0}{\sqrt{3}}$ **C** $\frac{V_0}{\sqrt{2}}$ **D** V_0

27 The graph shows the variation of stopping potential V_s with frequency f for photoelectric electrons emitted from the surface of a metal illuminated with electromagnetic radiation.

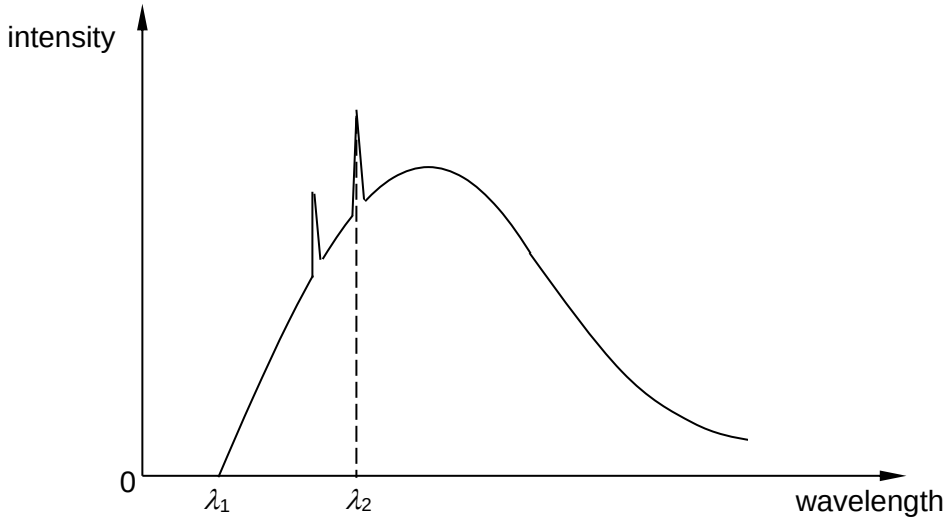


The metal is replaced with one that has a smaller work function.

Which line shows the variation of stopping potential with frequency for the new metal?



28 The diagram below shows a typical X-ray spectrum produced by an X-ray tube.



The operating voltage across the X-ray tube is decreased.

Which of the following gives the corresponding changes in λ_1 and λ_2?

	λ_1	λ_2
A	increase	no change
B	no change	decrease
C	decrease	no change
D	decrease	decrease

29 The Rutherford scattering experiment found that most of the alpha-particles passed through the gold foil with no significant deviation, although a very tiny minority were deflected through large angles, and some were even back-scattered.

The experiment is repeated with a foil made from a heavier isotope of gold.

How would the results be different?

A There would be no significant change.

B A much greater proportion of the alpha-particles would be back-scattered.

C A much greater proportion of the alpha-particles would be deflected through a large angle.

D A greater proportion of the alpha-particles would pass through with no significant deviation.

30 A nucleus of element X absorbs a neutron and undergoes nuclear fission to give a nucleus of element Y and a nucleus of element Z.

Which row gives the correct relation of the binding energy per nucleon of the respective nuclei?

	$\frac{\text{binding energy per nucleon of Y}}{\text{binding energy per nucleon of X}}$	$\frac{\text{total binding energy per nucleon of Y and Z}}{\text{binding energy per nucleon of X}}$
A	greater than 1	greater than 1
B	greater than 1	less than 1
C	less than 1	greater than 1
D	less than 1	less than 1

End of Paper