Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

PHYSICS **9749/01**
Paper 1 Multiple Choice 14 September 2022
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	=	$\mu_0 n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{½}}$

[Turn over

1 Which estimate is **not** realistic?

A The power of a computer laptop is 50 W.

B The kinetic energy of a car is 100 MJ.

C The mass of a sheet of A4 paper is 5 g.

D The heating element of an iron has a temperature of 500 K.

2 A cannon ball is launched at an angle θ above the horizontal with an initial kinetic energy E. Assume air resistance is negligible.

What is the kinetic energy of the cannon ball at the top of its trajectory?

A $E\cos\theta$ **B** $E\sin^2\theta$ **C** $E\cos^2\theta$ **D** E

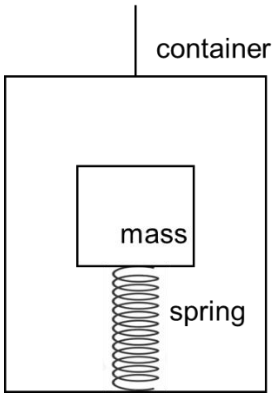
3 In the presence of air resistance, a cyclist and his bicycle of total mass 80.0 kg is able to coast down a smooth slope at a constant speed of 1.4 m s^{-1} as shown below.

The air resistance is directly proportional to the cyclist's speed.

What is the additional force that the cyclist must apply in order to descend the same slope at a steady speed of 5.5 m s^{-1}?

A 200 N **B** 340 N **C** 2200 N **D** 3800 N

4 A light spring of natural length 10.0 cm is attached to the floor of a container. A mass is placed on top of the spring.

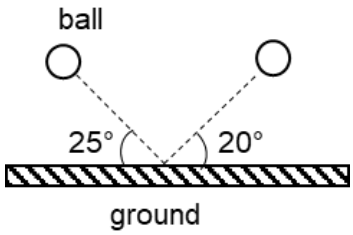


When the container is lifted upwards at a constant speed, the length of the spring is 7.5 cm. The container then moves upwards with a constant deceleration of 2.0 m s^{-2}.

What is the new length of the spring?

A 7.0 cm **B** 8.0 cm **C** 12.0 cm **D** 13.0 cm

5 A ball of mass 140 g is moving towards the ground at an angle of 25°. It hits the ground at 20 m s^{-1} and bounces off with a speed of 15 m s^{-1} at an angle of 20°.



What is the magnitude of the impulse exerted on the ball?

A 1.9 N s **B** 2.0 N s **C** 4.9 N s **D** 32 N s

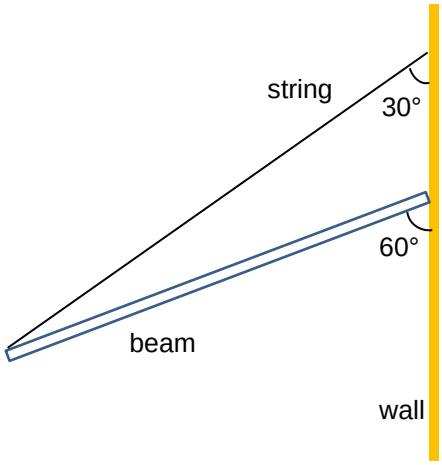
6 Three blocks X, Y and Z of masses *m*, 2*m* and 3*m* respectively, are accelerated along a smooth horizontal surface by a force *F* applied to block X as shown in the diagram below.

What is the force exerted on Y by X?

A $\frac{1}{6}F$ **B** $\frac{1}{2}F$ **C** $\frac{5}{6}F$ **D** F

[Turn over

7 A uniform beam of 10 kg is resting against a rough wall at an angle of 60° to it as shown in the figure below. It is attached to an inextensible string which is fixed to the wall at an angle of 30° to the vertical.

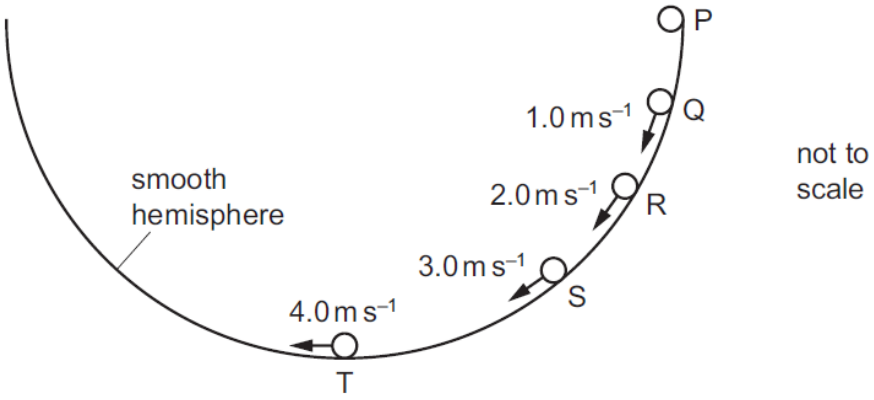


What is the tension *T* in the string?

A 85 N **B** 110 N **C** 130 N **D** 170 N

8 A small mass is placed at point P on the inner surface of a smooth hemisphere as shown in the diagram below. It has an initial gravitational potential energy *E* and is released from rest at point P. The mass has a speed of 4.0 m s^{-1} when it reaches the lowest point at T. Take the gravitational potential energy at T to be 0.

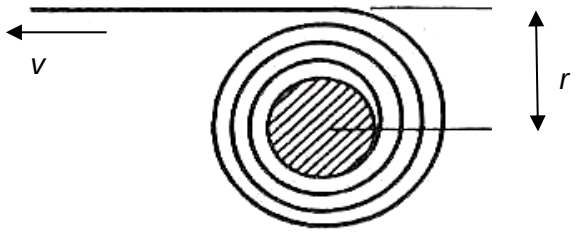
The diagram shows the speeds of the mass at points Q, R and S as it slides down.



Assuming air resistance is negligible, at which point does the mass possess 75% of its initial gravitational potential energy?

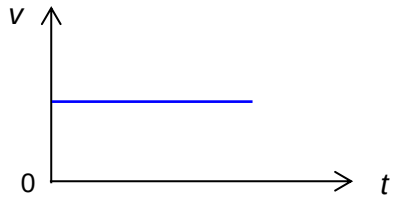
A Q **B** R **C** S **D** None of the points

9 A tape unwinds with speed v from a roll rotating about a fixed axis with constant angular velocity. The radius of the roll r is decreasing at a steady rate.

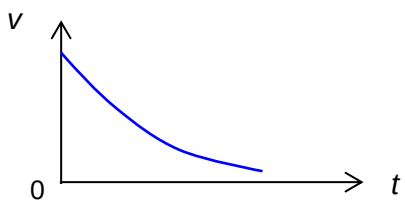


Which of the following graphs best represents the variation with time t of the speed v of the tape?

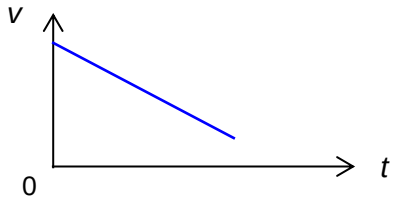
A



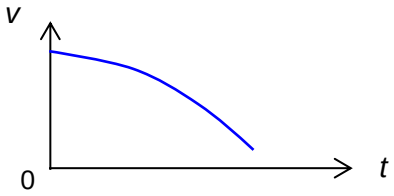
B



C



D



10 A satellite of mass 150 kg is launched into a geostationary orbit around the Earth. The Earth has a radius of 6.4×10^3 km and a mass of 6.0×10^{24} kg.

Which statement is correct?

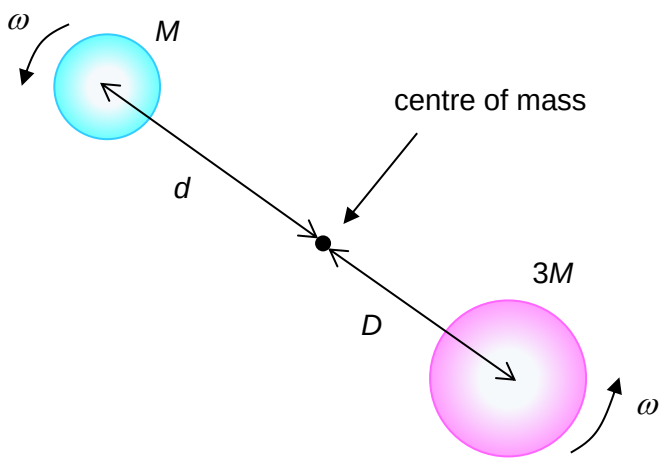
A The satellite need not be above the equator.

B The satellite is launched in the westerly direction.

C The height of the orbit from the surface of the Earth is 4.23×10^7 m.

D All geostationary satellites must have the same orbital radius and linear speed.

11 A binary star is a system of two stars that orbit around each other with angular velocity ω about their centre of mass. The stars have masses M and $3M$ respectively and the distances of stars from their centre of mass are d and D respectively.



Not to scale

Which expression gives the total kinetic energy of the two stars?

A $\frac{3GM^2}{8D}$ **B** $\frac{GM^2}{2D}$ **C** $\frac{3GM^2}{2D}$ **D** $\frac{2GM^2}{D}$

12 A 50 g piece of wood placed next to a 100 g steel bar is at the same temperature as the steel bar. The steel bar is in thermal equilibrium with a 5.0 g piece of paper placed some distance away from it. A student who touched the three objects remarked that the steel bar feels colder to touch than the other two objects.

Which statement is always correct?

A The piece of wood and steel bar have the same amount of internal energy.

B There is no exchange of thermal energy between the piece of wood and the paper.

C The steel bar is at a lower temperature than the other two objects.

D There is no net exchange of thermal energy between the paper and the steel bar.

13 A large tank contains water at a uniform temperature to a depth of 20 m. The tank is open to the atmosphere and atmospheric pressure is equivalent to that of 10 m of water. An air bubble is released from the bottom of the tank and rises to the surface. The air bubbles behave like an ideal gas.

Assuming surface tension effects to be negligible, what happens to the volume of the air bubble?

A Doubles when it reaches the surface

B Triples when it reaches the surface

C Halves when it reaches the surface

D Remains constant

14 Five gas molecules have the following velocities:

velocity / m s^{-1}	250	300	400	100	500

What is the root mean square speed?

A 150 m s^{-1} **B** 270 m s^{-1} **C** 340 m s^{-1} **D** 750 m s^{-1}

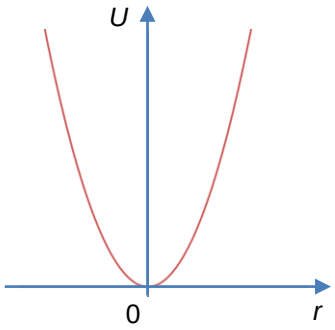
15 An object placed on a horizontal platform is vibrating vertically in simple harmonic motion with a frequency of 2.0 Hz.

What is the maximum amplitude of oscillation which will allow the object to remain in contact with the platform throughout the motion?

A 2.5 cm **B** 5.1 cm **C** 6.2 cm **D** 7.2 cm

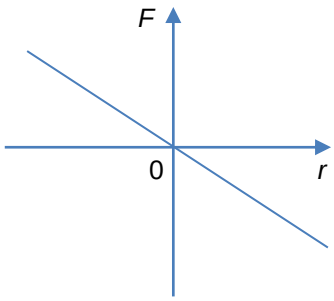
[Turn over

16 The potential energy U of a particle in simple harmonic motion is directly proportional to the square of its displacement r from the origin.

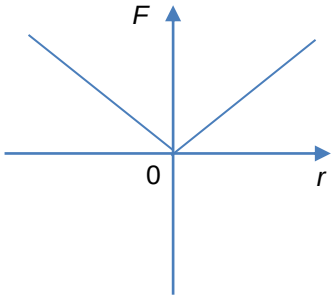


Which of the following graphs best represents the variation with displacement r of the net force F acting on the particle?

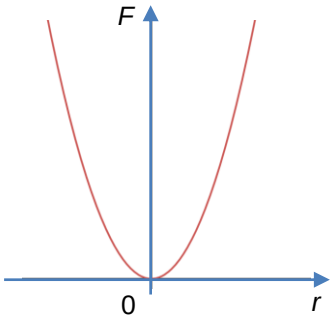
A



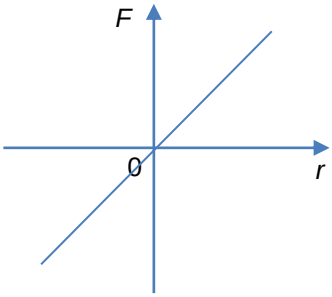
B



C



D



17 A transmitting aerial emits vertically polarised radio waves. A receiving aerial is positioned at an angle θ from the horizontal and is in the plane perpendicular to the direction of plane-polarised waves. The amplitude of the wave received is A.

Which of the following is the total power of the transmitting aerial directly proportional to?

A $A^2 \cos^2 \theta$ **B** $\dfrac{A^2}{\cos^2 \theta}$ **C** $A^2 \sin^2 \theta$ **D** $\dfrac{A^2}{\sin^2 \theta}$

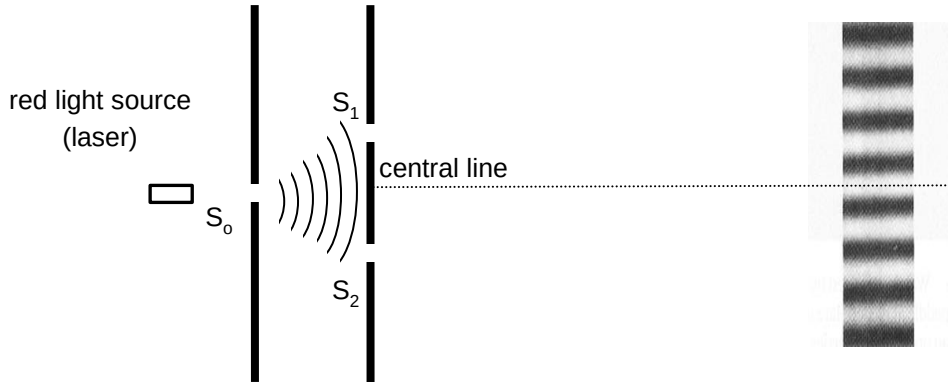
18 A vertical tube is completely filled with water. A small sound source of constant frequency is held slightly above the open upper end. Water runs out from the lower end and a number of resonance positions are detected. The first of these occurs when the water surface is 15 cm below the top of the tube and the next occurs at 49 cm. The speed of sound in air as 330 m s^{-1}.

What is the frequency of the source?

A 390 Hz **B** 490 Hz **C** 500 Hz **D** 550 Hz

19 In a Young's double slit experiment, a red light from a laser is incident on the source slit S_o and passes through the double slits S_1 and S_2, producing red bright fringes as shown the figure below.

Subsequently, a transparent thin glass block is placed in front of S_1.



Which observation is correct?

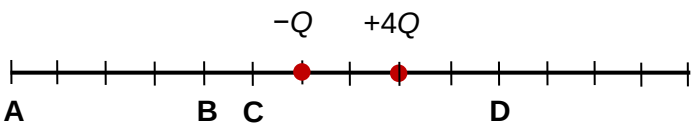
A The fringe separation will decrease.

B The fringe separation will be non-uniform.

C The contrast between bright and dark fringes will increase.

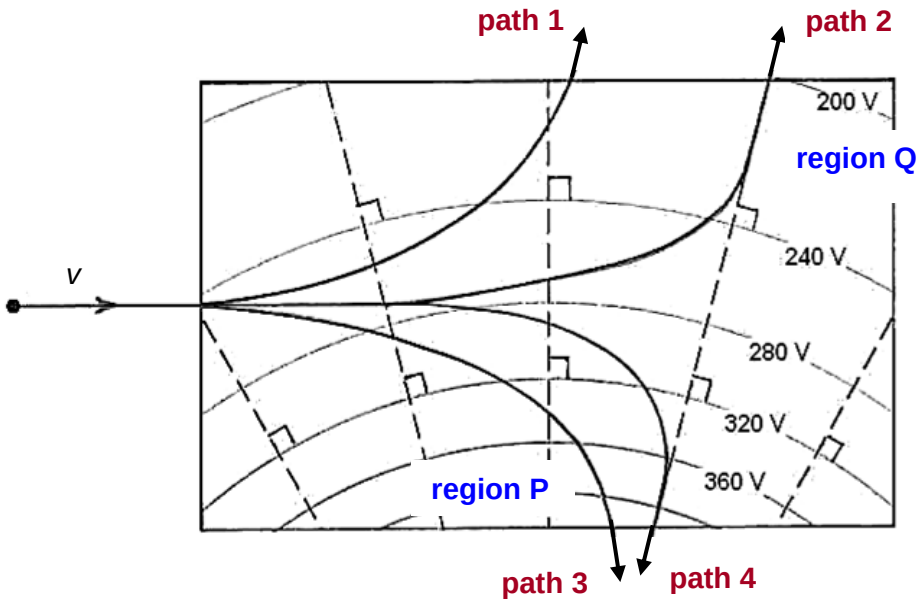
D The central maximum will be shifted upwards.

20 Two point charges $-Q$ and $+4Q$ are situated as shown below. The gridlines are evenly spaced.



At which point could the resultant electric field due to these charges be zero?

21 A charged particle enters a region of non-uniform electric field with speed *v* as shown in the figure below.



Which row is correct?

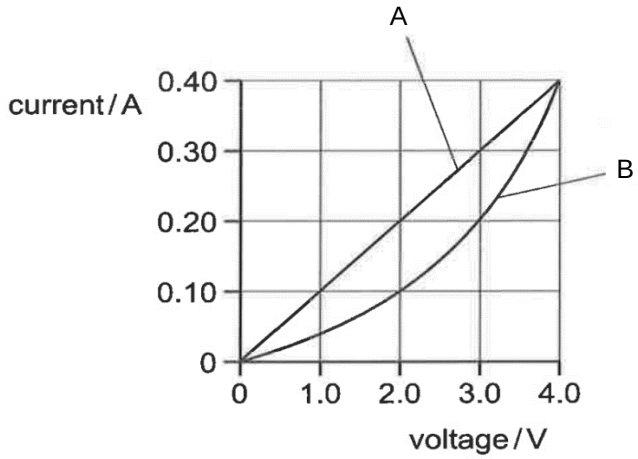
	possible path of charged particle	region with maximum electric field strength
A	1 or 3	P
B	2 or 4	Q
C	1 or 3	Q
D	2 or 4	P

22 Aluminium and copper rods are each designed to have the same length and the same resistance. The resistivity of copper is half that of aluminium, but its density is three times that of aluminium.

What is the ratio of the mass of the aluminium rod to the mass of the copper rod?

A 0.17 **B** 0.33 **C** 0.67 **D** 1.5

23 The current-voltage characteristics of two electrical components A and B are shown below.



Which statement is correct?

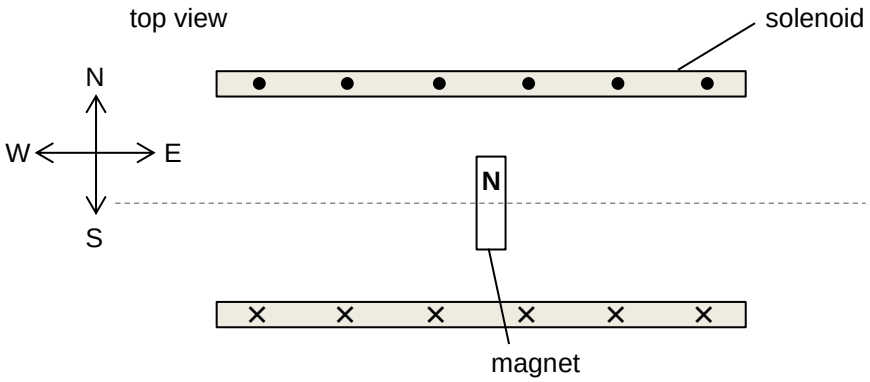
A For a current of 0.20 A, the resistance of B is 50% more than the resistance of A.

B For a current of 0.20 A, the power dissipated in B is double that of the power dissipated in A.

C When A and B are connected in parallel with an e.m.f. of 3.0 V placed across it, the total current is 0.3 A.

D When A and B are connected in series with an e.m.f. of 5.0 V placed across it, the potential difference across B is 2.0 V.

24 A light magnet is suspended inside a solenoid as shown in the figure below. The Earth's magnetic flux density is 2.0×10^{-5} T and the solenoid has 20 turns and a length of 15 cm. When a current is passed through the solenoid, it is found that the magnet rotates through an angle of 68° from its original direction.

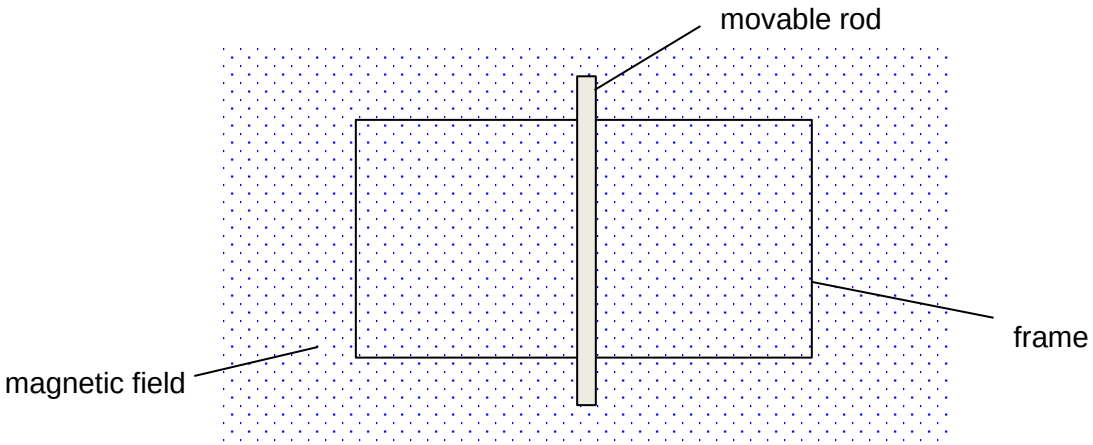


What is the value of the current flowing through the solenoid?

A 0.048 A **B** 0.11 A **C** 0.30 A **D** 2.0 A

[Turn over

25 A movable metal rod is placed in the middle of a rectangular metal frame as shown. A uniform magnetic field directed out of the plane of the paper acts perpendicular to the frame.



Which of the following actions could lead to a clockwise current flowing through the frame?

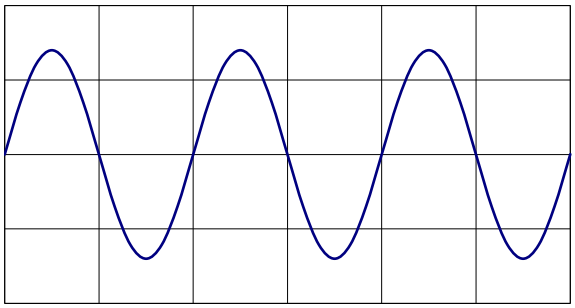
A Decreasing the magnitude of the magnetic flux density of the field.

B Increasing the magnitude of the magnetic flux density of the field.

C Sliding the rod to the left while maintaining contact with the frame.

D Sliding the rod to the right while maintaining contact with the frame.

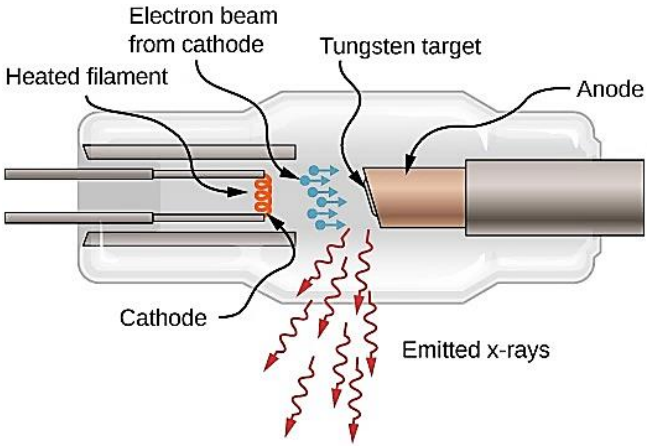
26 An alternating p.d. is applied across the Y-plates of a cathode-ray-oscilloscope (CRO) and produces the trace shown below. The peak voltage of the alternating p.d. is 2.8 V and its frequency is 50 Hz.



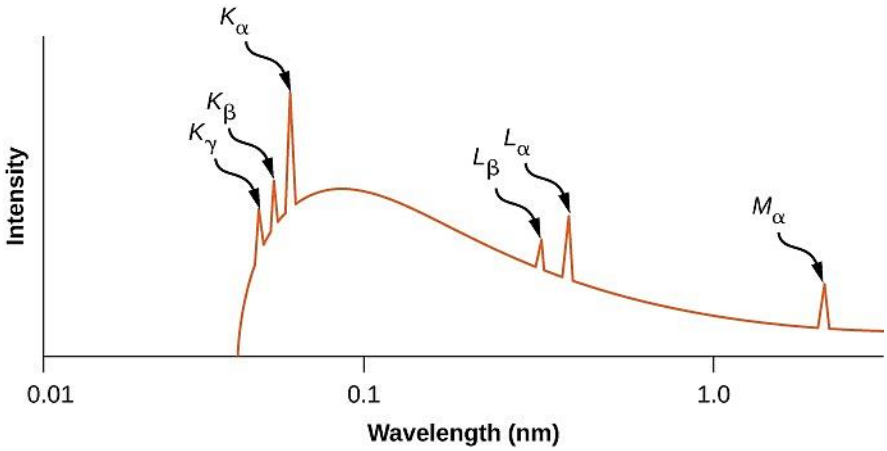
What are the time-base and Y-gain settings of the CRO?

	time-base / ms div^{-1}	Y-gain / V div^{-1}
A	10	1.0
B	20	1.0
C	10	2.0
D	20	2.0

27 X-rays are produced when high speed electrons collide with a tungsten target as shown in the diagram below.



The graph below illustrates variation of wavelength with intensity of X-rays.



Which statement is **not** correct?

A The cut-off wavelength corresponds to the least energetic photon released.

B A continuous spectrum with a minimum wavelength is caused by the braking radiation.

C X-ray photons are produced when the electrons in the outer shells transit to the inner shells.

D The sharp characteristic peaks at well-defined wavelengths are caused by transitions of electrons between energy levels in the tungsten.

28 Which statement about the Heisenberg position-momentum uncertainty principle on a particle is **not** correct?

A The exact values of momentum p and position x cannot be achieved simultaneously.

B The uncertainty of momentum Δp is in the same direction as the uncertainty of position Δx.

C The product of uncertainties of momentum Δp and position Δx will always be greater than the Planck constant.

D The uncertainties of momentum Δp and position Δx can be minimised concurrently with the same experimental equipment.

[Turn over

29 The nuclear fission reaction of Uranium-235 may be represented by the following equation

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + 3{}^{1}_{0}\text{n} + \text{energy}$$

The rest masses of the nuclei are

nuclide	rest mass
$^{235}_{92}$U	235.04393 *u*
$^{141}_{56}$Ba	140.91440 *u*
$^{92}_{36}$Kr	91.92617 *u*
$^{1}_{0}$n	1.00866 *u*

What is the energy released when one nuclide of $^{235}_{92}$U undergoes fission?

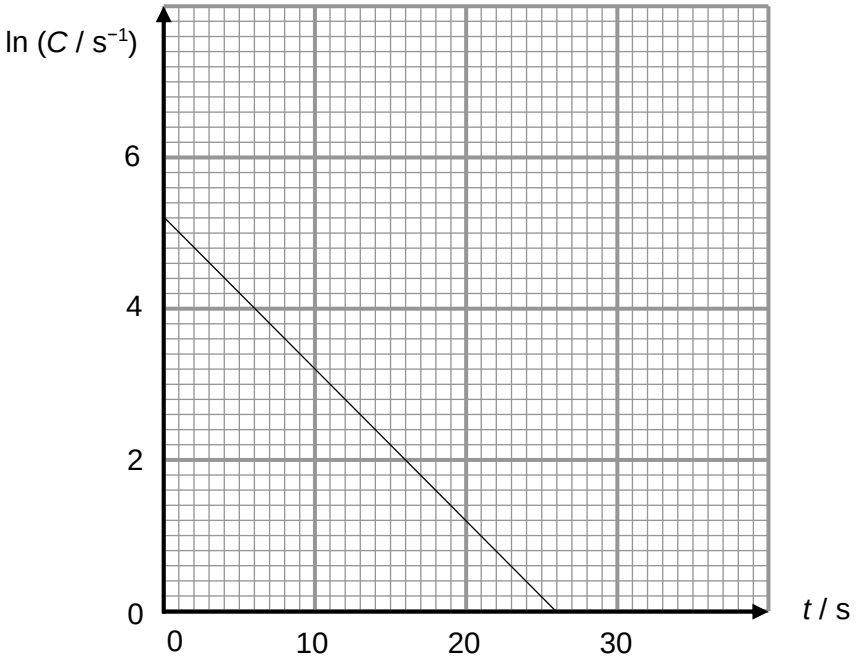
A 3.09×10^{-28} J

B 9.26×10^{-20} J

C 2.78×10^{-11} J

D 3.29×10^{-10} J

30 The graph below shows the variation with time *t* of the natural logarithm of the count rate ln *C* of a radioactive source measured by a Geiger–Müller counter.



What is the half-life of the radioactive source?

A 0.2 s **B** 3.5 s **C** 13 s **D** 26 s

End of Paper