RAFFLES INSTITUTION
2018 Preliminary Examination

PHYSICS **9749/01**
Higher 2

25 September 2018
Paper 1 Multiple Choice Questions **1 hour**

Additional Materials: OMR Form

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your index number, name and class on the OMR Form in the spaces provided. Shade the appropriate boxes.

There are **thirty** questions on this paper. 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 OMR Form.

Read the instructions on the OMR Form 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 booklet.
The use of an appropriate scientific calculator is expected, where necessary.

This document consists of **17** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	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	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	$T / ^\circ\text{C} + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t = \pm\omega\sqrt{x_0^2 - x^2}$
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	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 The density of a liquid is calculated by measuring its mass and its volume. The measurements taken are as shown.

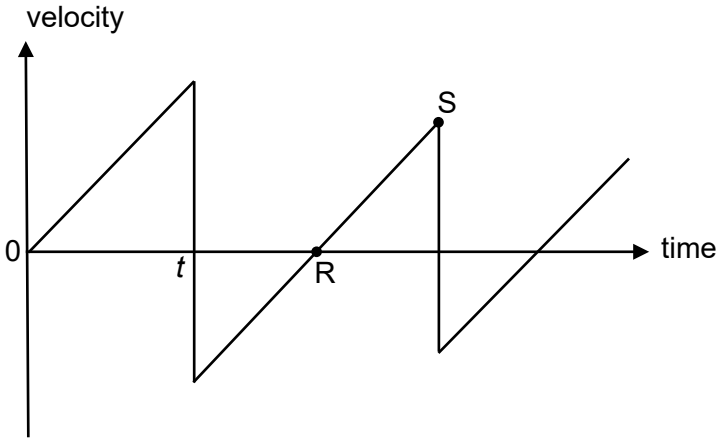
$$\text{mass of beaker} = (20 \pm 1)\ \text{g}$$
$$\text{mass of beaker and liquid} = (70 \pm 1)\ \text{g}$$
$$\text{volume of liquid} = (10.0 \pm 0.6)\ \text{cm}^3$$

The density of the liquid calculated is 5.0 g cm^{-3}.

What is the uncertainty in this value of density?

A 0.1 g cm^{-3} **B** 0.4 g cm^{-3} **C** 0.5 g cm^{-3} **D** 2.6 g cm^{-3}

2 A ball released from rest above a hard, horizontal surface undergoes several bounces. The graph shows the variation with time of the velocity of the bouncing ball.

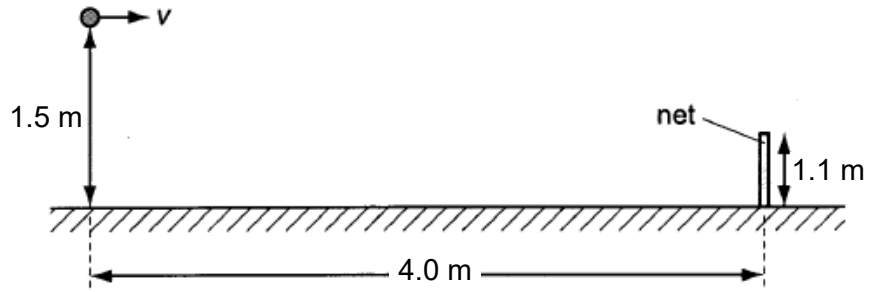


The time taken for the ball to first reach the ground after release is *t*. With each bounce, the ball loses $\frac{7}{16}$ of the kinetic energy it has just before the bounce.

Assuming air resistance is negligible, which of the following gives the time duration, in terms of *t*, between points R and S on the graph?

A 0.44 *t* **B** 0.56 *t* **C** 0.66 *t* **D** 0.75 *t*

3 In a junior tennis match, a player hits an incoming tennis ball such that it leaves his racket horizontally with speed v as shown.



The tennis ball is hit at a height of 1.5 m above the ground and 4.0 m from the net. It just clears the net, which is 1.1 m high. Neglect the effects of air resistance.

What is the value of v?

A 7.2 m s^{-1} **B** 8.4 m s^{-1} **C** 14 m s^{-1} **D** 49 m s^{-1}

4 Mass M is dropped gently onto another mass N that is initially sliding on a smooth horizontal surface at constant velocity. After landing, the two masses move forward as one body as shown.

Which of the following statements regarding the two masses is incorrect?

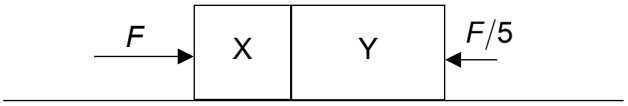
A The total mechanical energy of the two masses is conserved because they move with the same velocity after the collision.

B Mass N slows down during the collision because M exerts a decelerating force on N.

C The total horizontal momentum of the two masses is conserved because the resultant horizontal force acting on them is zero.

D There is heat produced in the collision because the collision is inelastic.

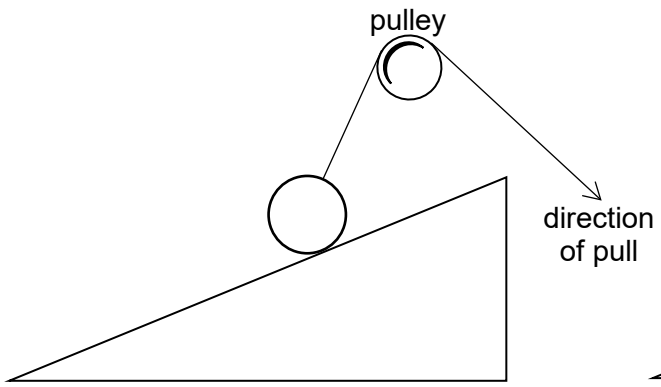
5 Two blocks X and Y, of masses m and $3m$ respectively, are placed in contact on a smooth horizontal surface. Forces F and $F/5$ are applied on either side of the blocks as shown.



What is the magnitude of the force exerted by block X on block Y during their subsequent motion?

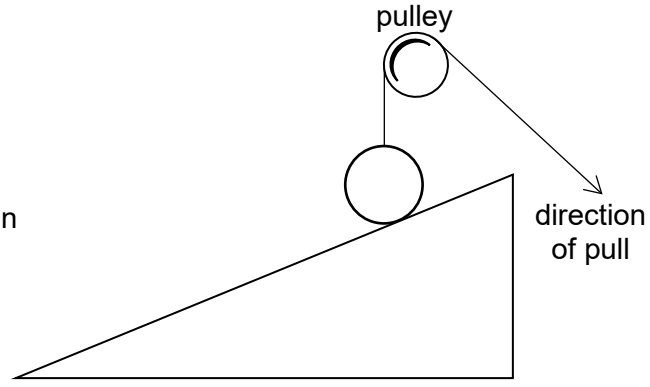
A $\frac{F}{5}$ **B** $\frac{3F}{5}$ **C** $\frac{3F}{4}$ **D** $\frac{4F}{5}$

6 A sphere resting on a smooth inclined plane is tied to a string that loops over a pulley as shown in Fig. (a).



Initial position

Fig. (a)



Final position

Fig. (b)

The string is slowly pulled until the end connected to the sphere becomes vertical as shown in Fig. (b). At this instant, the forces acting on the sphere are

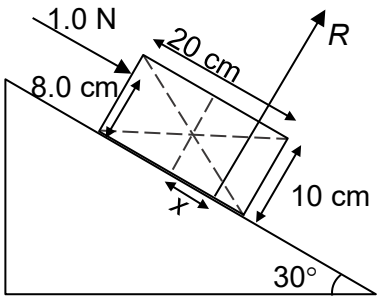
A weight, tension and normal reaction.

B weight and tension.

C weight and normal reaction.

D tension and normal reaction.

7 A uniform rectangular block of dimensions 20 cm by 10 cm and weight 5.0 N is placed on a rough surface inclined at 30° to the horizontal. A force of 1.0 N parallel to the surface is then applied on the block 8.0 cm from its base.



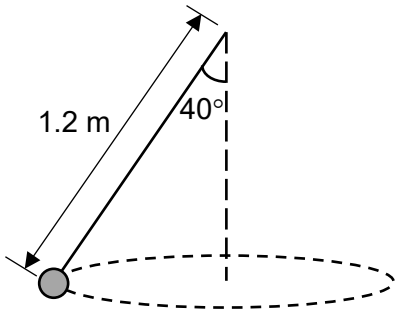
Given that the block remains in equilibrium, what is the distance *x* between the line of action of the normal contact force *R* exerted by the surface on the block and the centre of the block?

A 0.7 cm **B** 1.8 cm **C** 2.9 cm **D** 4.7 cm

8 It takes 4.0 J of work to stretch a spring 10 cm from its unstretched length. Given that the spring obeys Hooke's Law, what is the additional work required to stretch it a further 10 cm?

A 4.0 J **B** 6.0 J **C** 12 J **D** 16 J

9 A simple pendulum of length 1.2 m is swung such that the mass goes round in a uniform circular motion in the horizontal plane. The string makes an angle of 40° with the vertical.



What is the speed of the mass in its circular path?

A 2.5 m s^{-1} **B** 2.8 m s^{-1} **C** 3.0 m s^{-1} **D** 3.3 m s^{-1}

10 A satellite is moved from a circular orbit of radius R_1 around the Earth to a new circular orbit of radius R_2 where $R_2 > R_1$.

What happens to its gravitational potential energy and kinetic energy?

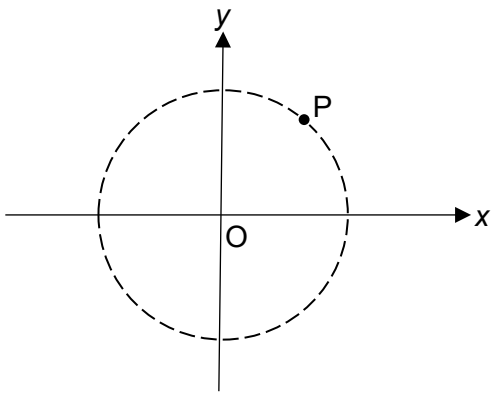
	potential energy	kinetic energy
A	increases	decreases
B	decreases	decreases
C	increases	increases
D	decreases	increases

11 The ratio of the densities and the ratio of the radii of Planet X to Planet Y are $\frac{9}{4}$ and $\frac{3}{1}$ respectively.

What is the ratio $\frac{\text{escape speed from the surface of Planet X}}{\text{escape speed from the surface of Planet Y}}$?

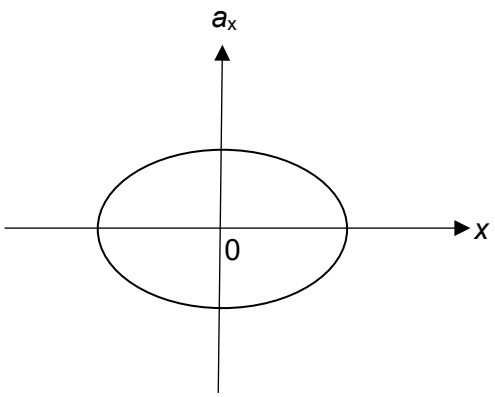
A 0.578 **B** 2.60 **C** 4.50 **D** 13.5

12 A particle P performs uniform circular motion about the origin O in the x-y plane as shown.

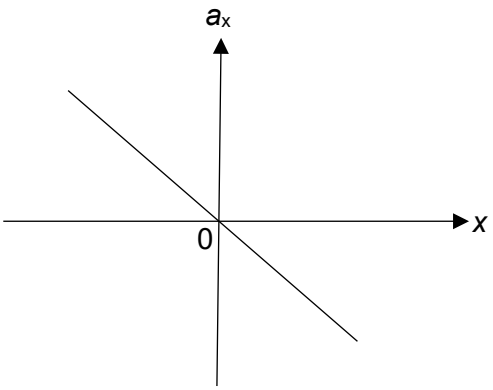


Which of the following graphs shows the relationship between the *x*-component of the acceleration a_x and the displacement in the *x*-direction?

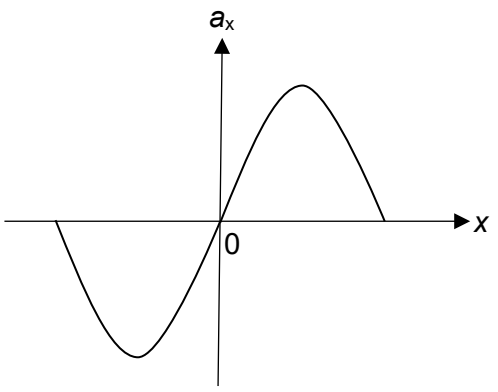
A



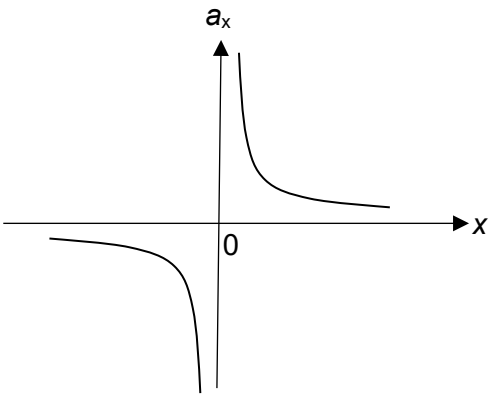
B



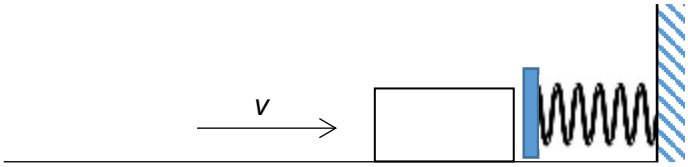
C



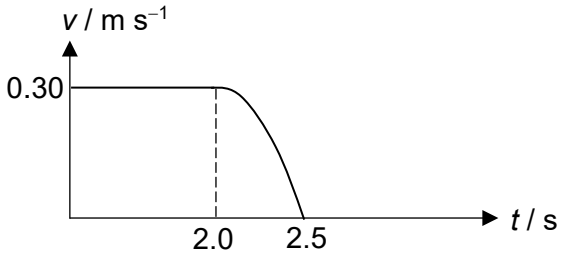
D



13 A block of mass 0.500 kg sliding on a smooth table at 0.30 m s^{-1} collides with a board attached to a spring which obeys Hooke's Law.



The graph shows the variation with time t of the velocity v of the block up to the moment just before it reverses its motion.

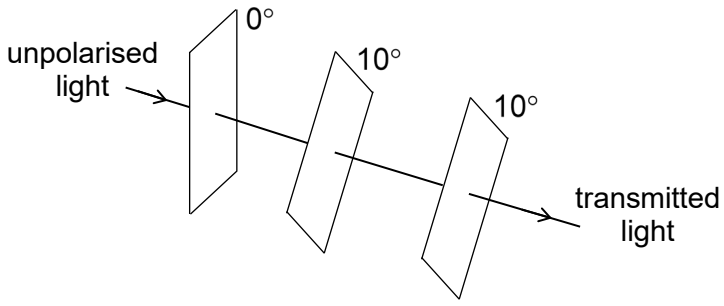


Given that the magnitude of the acceleration of the block is directly proportional to the compression of the spring, what is the maximum compression experienced by the spring?

A 0.024 m **B** 0.075 m **C** 0.095 m **D** 0.94 m

14 A narrow, parallel beam of unpolarised light is directed towards three ideal polarising filters.

The beam meets the first filter with its axis of polarisation vertical. The axis of polarisation of the second filter is at an angle of 10° to the first filter. The third filter has its axis of polarisation parallel to the second filter as shown.

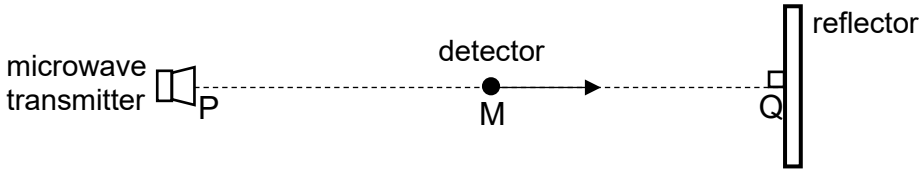


The third filter is now turned.

At what angle must the third filter be with respect to the second filter so that the intensity of the transmitted light is reduced to one-third of the intensity of the unpolarised light?

A 34° **B** 44° **C** 47° **D** 54°

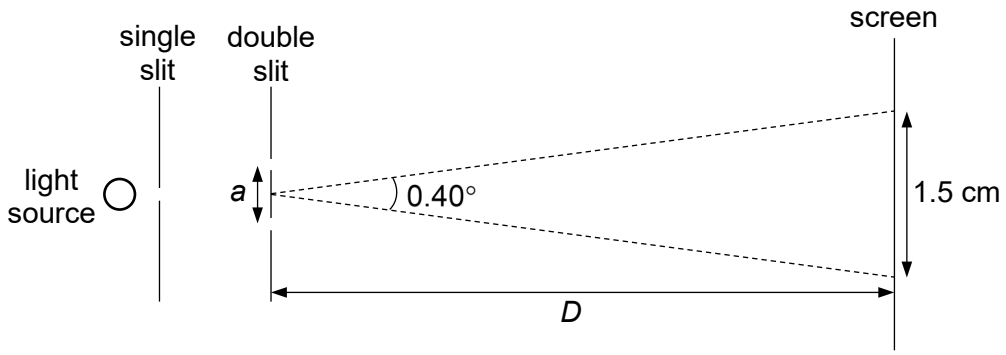
15 A microwave transmitter emits waves that are incident normally on a reflector. A microwave detector is initially at the point M where it detects a maximum intensity. As it moves along the line PQ towards Q, the detector picks up a series of maximum and minimum intensity signals.



If the detector moves with a speed of 2.0 m s^{-1} and the frequency at which maximum intensity signals are picked up is 10 Hz, what is the distance moved by the detector from its initial position at M when it detects the first minimum intensity signal?

A 0.05 m **B** 0.10 m **C** 0.20 m **D** 0.40 m

16 A two-source interference experiment is set-up as shown. The light source emits light of wavelength 600 nm. The distance between the second order bright fringes on the screen is 1.5 cm and their angular separation is $0.40°$.



What are the values of the slit separation *a* and the distance *D* between the double slits and the screen?

	a / mm	*D* / m
A	0.17	1.1
B	0.34	1.1
C	0.17	2.1
D	0.34	2.1

17 The root-mean-square (r.m.s.) speed of the molecules of a fixed mass of an ideal gas at a certain temperature is *c*. If the pressure is increased by 25% while its volume is decreased by 25%, what will be the r.m.s. speed of the molecules?

A 0.88 *c* **B** 0.94 *c* **C** 0.97 *c* **D** *c*

18 A frictionless and well-insulated bicycle pump is used to inflate a basketball. After several compression cycles, the air in the basketball becomes warmer than the surrounding air.

Which one of the following statements best explains this observation?

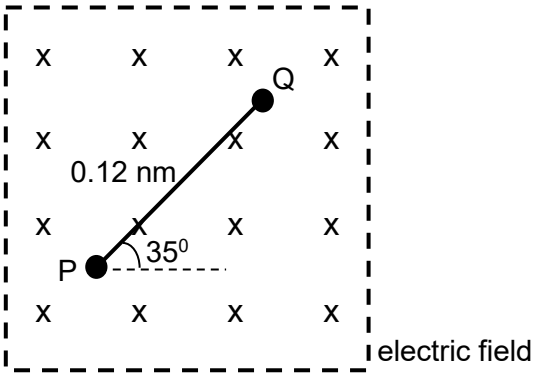
A The air molecules collide with the inner wall of the basketball more frequently.

B Work is done on the air in the basketball and the internal energy remains unchanged.

C The internal energy of air in the basketball increases as work is done on the air and thermal energy is supplied to it.

D Work is done on the air in the basketball and since little thermal energy escapes, the internal energy increases.

19 Two ions P and Q, of charge $+e$ and $-e$ respectively, are linked to form a molecule and placed in a uniform electric field that is directed into the page. The distance between P and Q is 0.12 nm. The electric field strength is 4200 V m^{-1}.



Which of the following gives the resultant force and initial torque on the molecule?

	resultant force / N	torque / Nm
A	1.3×10^{-15}	4.6×10^{-26}
B	1.3×10^{-15}	8.1×10^{-26}
C	0	4.6×10^{-26}
D	0	8.1×10^{-26}

20 An oil-drop of mass m, carrying a charge q, is in the region between two horizontal plates. When the potential difference between the upper and lower plates is V, the oil-drop is stationary. The potential difference is then increased to $2V$.

What is the initial upward acceleration of the oil-drop? Assume negligible upthrust.

A g **B** $2g$ **C** $\frac{2qV}{m} - g$ **D** $\frac{2qV}{m}$

21 A potential difference of 6 V is applied across a resistor for a time interval of 10 s. The current flowing through the resistor is 2 A.

Which of the following statements is incorrect?

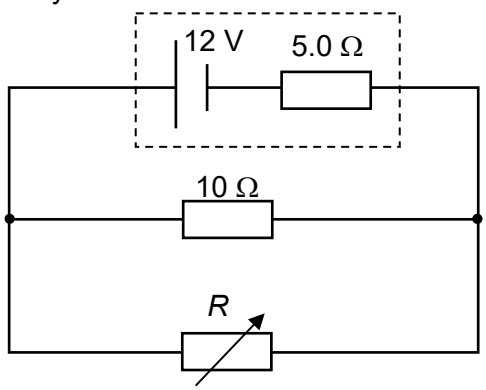
A The resistance of the resistor is 3 Ω.

B The energy dissipated in the resistor is 12 J.

C The charge passing through the resistor is 20 C.

D The potential difference across the resistor is 6 J C^{-1}.

22 A battery of e.m.f. 12 V and internal resistance 5.0 Ω is connected to a fixed resistor of resistance 10 Ω and a variable resistor of resistance R as shown. The battery delivers maximum power to the external resistance when the external resistance is equal to the internal resistance of the battery.



What is the value of R and the power dissipated across the 10 Ω fixed resistor when maximum power is delivered?

	R / Ω	P / W
A	5.0	7.2
B	10	3.6
C	10	14
D	5.0	3.6

23 Fig. (a) shows the top view of two long parallel wires, wire X and wire Y, carrying currents I_X and I_Y respectively in a direction perpendicular to the plane of the paper. The distance between wire X and wire Y is *L*.

Fig. (b) shows the variation of the net magnetic field at distances to the right of wire Y along the line joining wire X and wire Y. At a distance *d* from wire Y, the net magnetic field is zero.

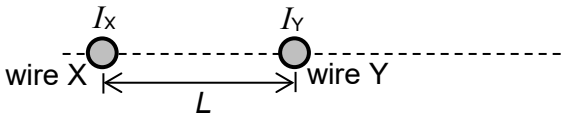


Fig. (a) top view (not to scale)

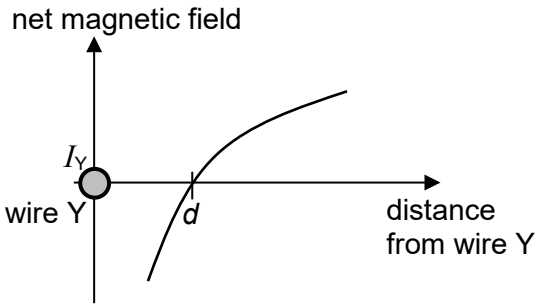


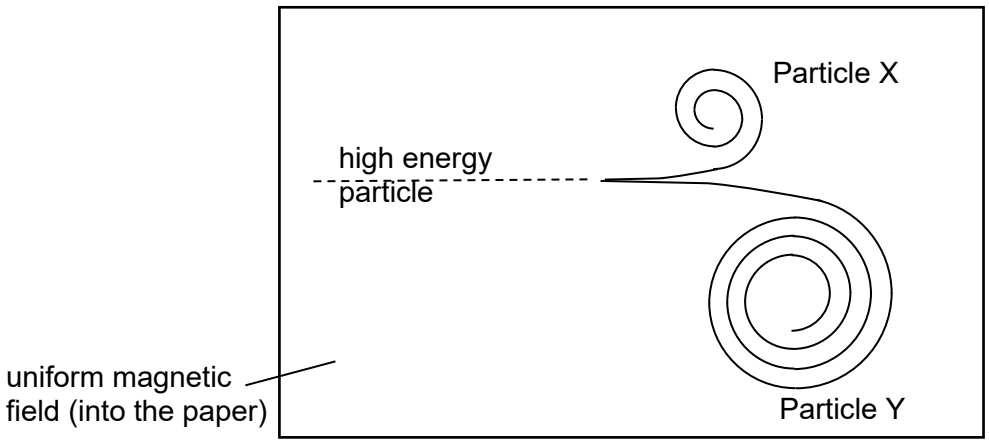
Fig. (b)

Given that the ratio $\frac{I_X}{I_Y}$ is 4.00 and taking the upwards direction to be positive, which of the following gives the relative direction of I_X and I_Y and the value of *L* in terms of *d*?

	relative direction of I_X and I_Y	*L* in terms of *d*
A	I_X and I_Y flow in opposite directions	*d*
B	I_X and I_Y flow in the same direction	*d*
C	I_X and I_Y flow in opposite directions	3*d*
D	I_X and I_Y flow in the same direction	3*d*

24 A high energy particle which carries no charge enters a region of uniform magnetic field directed into the paper. The particle subsequently disintegrates to form two particles X and Y which have the same mass and same magnitude of charge.

The paths of X and Y are shown in the diagram and the initial radius of Y is twice the initial radius of X.



Which of the following statements is correct?

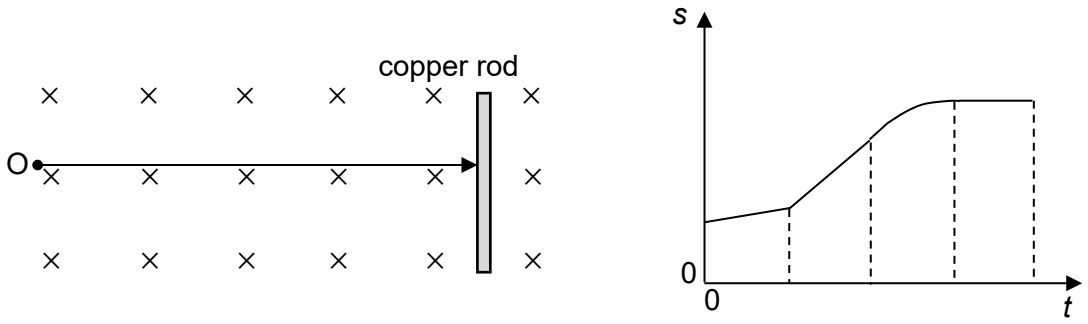
A Particle X is negatively charged, particle Y is positively charged.

B The ratio of the initial kinetic energy of particle X to particle Y is 0.25.

C The speeds of both particles are increasing steadily.

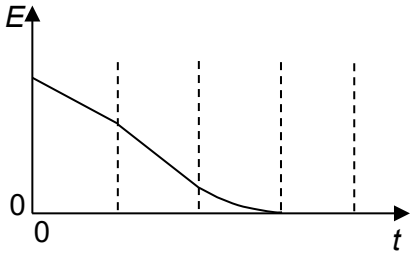
D Particle X has a larger momentum than particle Y.

25 A copper rod is moved at right angles to a uniform magnetic field as shown in the diagram. The graph on the right shows the variation with time t of the displacement s of the copper rod from point O.

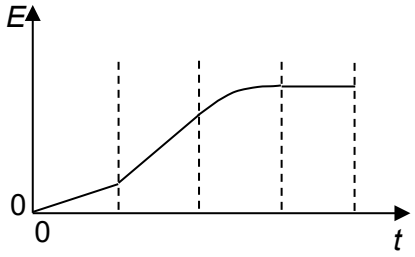


Which graph best shows the variation with time t of the e.m.f. E induced across the rod?

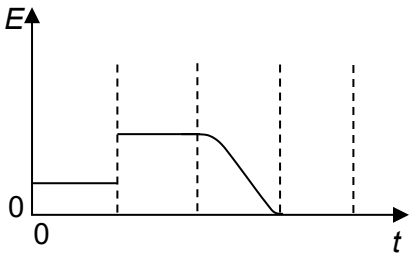
A



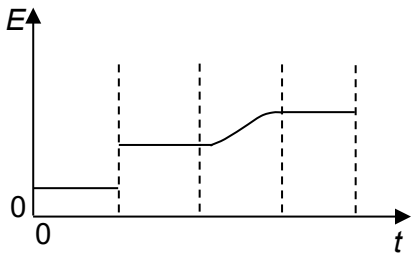
B



C



D



26 A heater is connected to a 110 V sinusoidal alternating current and it dissipates energy at a mean rate of 800 W. The same heater, with its resistance unchanged, is then connected to a 156 V d.c. supply.

At what rate does the heater dissipate energy now?

A 400 W **B** 800 W **C** 1100 W **D** 1600 W

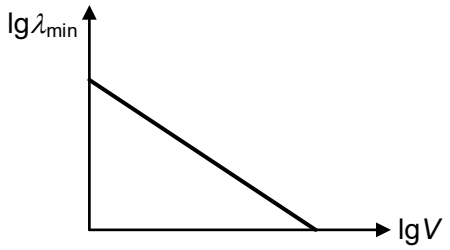
27 Light of wavelength λ strikes a photo-sensitive surface and electrons are ejected with maximum kinetic energy *E*. If the maximum kinetic energy is to be increased to 2*E*, the wavelength must be changed to λ' where

A $\lambda' = \lambda/2$ **B** $\lambda/2 < \lambda' < \lambda$ **C** $\lambda < \lambda' < 2\lambda$ **D** $\lambda' = 2\lambda$

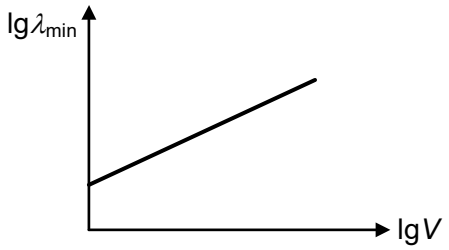
28 Electrons accelerated from rest by a potential difference *V* are directed to hit a metallic target to produce X-rays. It produces continuous as well as characteristic X-rays.

If λ_{min} is the shortest possible wavelength of X-ray in the spectrum, which of the following shows the variation with $\lg V$ of $\lg \lambda_{min}$?

A



B



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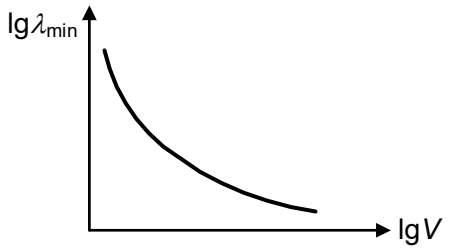

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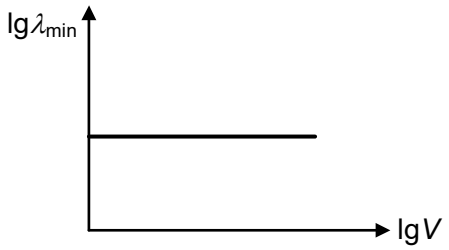

29 1 g of a sample which contains radioactive nuclei is left in the laboratory for 4 days. The radioactive nuclei emit β radiation and have a half-life of 2 days.

What is the mass of the sample at the end of that period?

A $\frac{1}{16}$ g **B** $\frac{1}{8}$ g

C $\frac{1}{4}$ g **D** slightly less than 1 g

30 The following process shows a stationary isotope of boron when capturing a slow moving neutron, splits to become a lithium isotope and an alpha particle.

$$^{10}_{5}\mathrm{B} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{7}_{3}\mathrm{Li} + {}^{4}_{2}\mathrm{He}$$

γ-ray is emitted in the process.

The nuclear binding energies are:

$^{10}_{5}\mathrm{B}$: 64.94 MeV
$^{7}_{3}\mathrm{Li}$: 39.25 MeV
$^{4}_{2}\mathrm{He}$: 28.48 MeV

What is the energy of the γ-ray emitted, given that the total kinetic energy of $^{7}_{3}\mathrm{Li}$ and $^{4}_{2}\mathrm{He}$ is 2.31 MeV?

A 0.48 MeV

B 2.79 MeV

C 25.69 MeV

D 260.73 MeV

End of Paper 1