EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2022
General Certificate of Education Advanced Level
Higher 2

PHYSICS

Paper 1 Multiple Choice

9749/01

August/September 2022

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

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 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 booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **16** printed pages and no blank pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$\left(1/\left(36\pi\right)\right) \times 10^{-9}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ 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,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T\ /\ \text{K} = T\ /\ °\text{C} + 273.15$
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.	$v = v_0 \cos \omega t$ $= \pm\ \omega \sqrt{\left(x_0^2 - x^2\right)}$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 The radius of a helium-4 atom is of the order 10^{-10} m and its nucleus has a radius that is of the order of 10^{-15} m.

If all the empty space in the helium atom is removed and the atom size is reduced to that of the nucleus, what is the approximate density of the matter that is formed?

A 10^{14} kg m^{-3}
B 10^{18} kg m^{-3}
C 10^{22} kg m^{-3}
D 10^{26} kg m^{-3}

2 As part of the 1945 Manhattan project, the United States Army tested the first-of-its-kind nuclear weapon in New Mexico.

The explosion resulted in a radiant, hemispherical blast wave of radius R which could be modelled using

$$R = s\left(\frac{Et^2}{\rho}\right)^{0.2}$$

where E = energy released due to explosion,
t = time elapsed after detonation,
ρ = density of air.

What is the SI unit of the quantity s?

A (dimensionless)
B m$^{0.2}$
C J$^{0.2}$ m$^{-0.2}$ s$^{0.4}$ kg$^{-0.2}$
D J^{-1} m^{2} s^{-2} kg

3 A ball is thrown upwards vertically near Earth's surface.

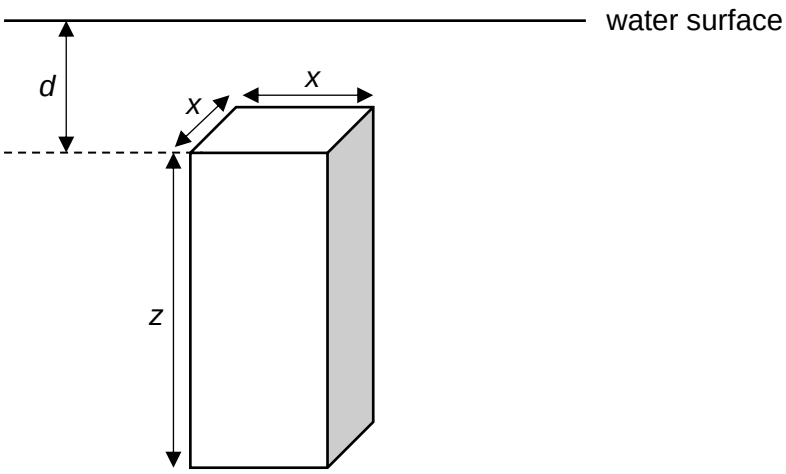
It takes a time of 3.20 s to return to the initial position.

Assume air resistance is negligible.

What is the initial speed with which the ball is thrown?

A 3.07 m s^{-1}
B 7.85 m s^{-1}
C 15.7 m s^{-1}
D 31.4 m s^{-1}

4 A uniform block of dimensions x^2 by z is fully submerged at depth d in a tank of water as shown.



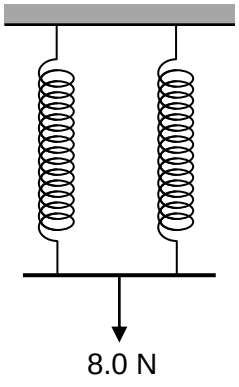
The block is held vertically in the position shown. The density of the block is the same as the density of the water.

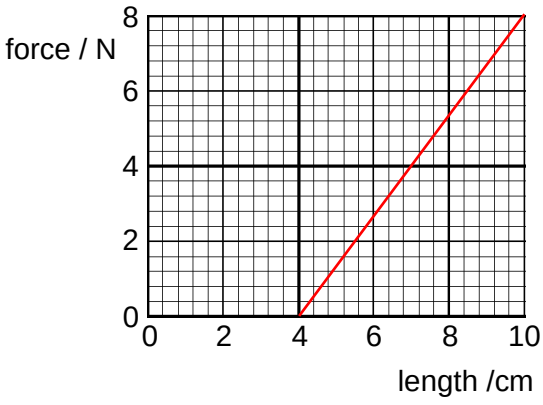
If the block is always held at the same depth d below the surface of the water, which single change would increase the magnitude of the upthrust force on the block?

A decrease the density of the block
B hold the block horizontally
C increase dimension z
D increase the density of the block

5 Two light identical springs are connected in parallel.

A weight of 8.0 N is exerted vertically downwards from the combination as shown.





The graph shows the variation with length of the force applied to **one** of the springs.

What is the elastic potential energy stored in **one** of the springs?

A 0.060 J
B 0.12 J
C 0.14 J
D 0.24 J

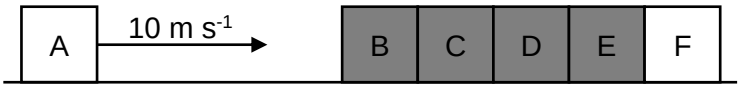
6 Which statement about energy is **not** correct?

A Energy is never lost but it may be transferred between different forms.
B In an inelastic collision, the total energy is constant.
C The efficiency of a system is the ratio of the useful energy output to the total energy input.
D When a machine does work, friction reduces the total energy.

7 In the diagram below, blocks B, C, D, E and F are all in contact with each other and are initially at rest on a smooth horizontal surface.

Block A moves towards block B with a speed of 10 m s^{-1}.

All subsequent collisions are elastic in nature.



The mass of both block A and block F is *m* each. Blocks B, C, D and E have mass of 4*m* each.

Which of the following options concerning blocks A, B, and E after the collisions is true?

	block A	block B	block E
A	at rest	move	move
B	move	move	at rest
C	move	at rest	move
D	move	move	move

8 A uniform ladder of weight *W* rests against a vertical wall, tilted at an angle θ from a rough floor.

The floor exerts normal force N_F on the ladder. The wall exerts normal force N_w on the ladder.

Which of the following equations is correct?

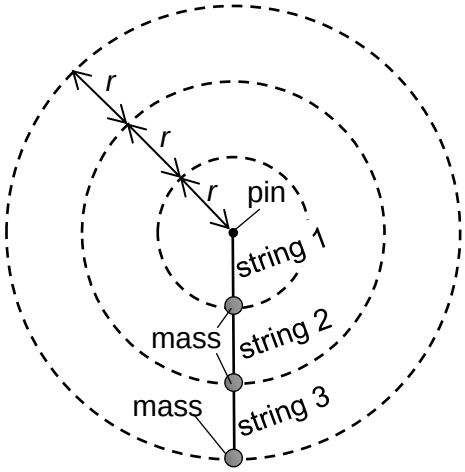
A $N_F = N_W$

B $N_W \tan\theta = N_F - \frac{W}{2}$

C $N_F \tan\theta = N_W - \frac{W}{2}$

D $N_F \tan\theta = N_W + \frac{W}{2}$

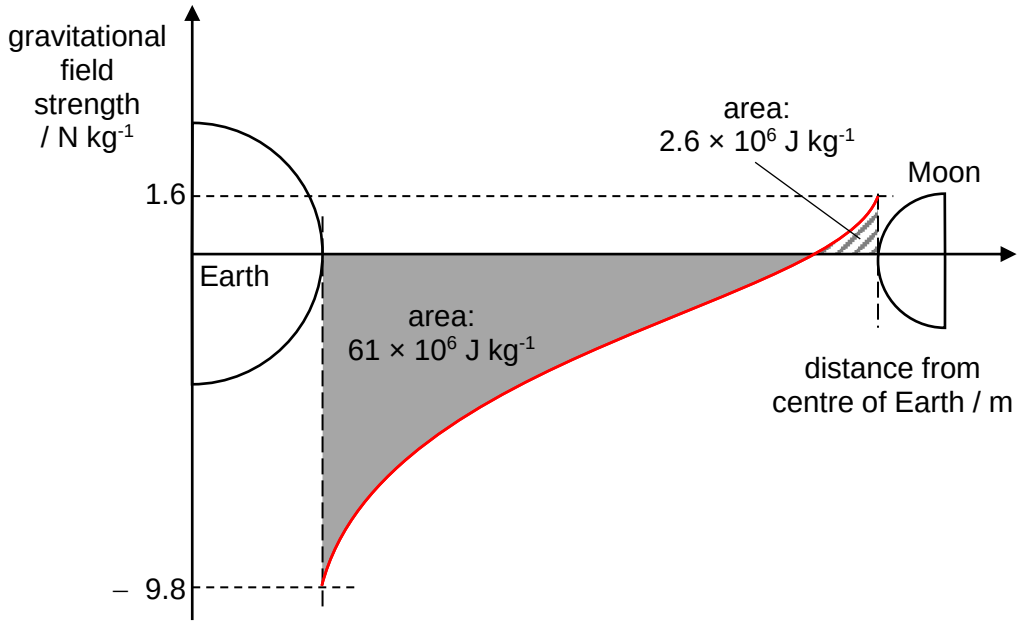
9 Three identical masses are tied using light, inextensible strings of equal lengths r to a pin and made to rotate around the pin by sliding over a smooth horizontal table as shown in the diagram. The strings remain along a straight line as the masses rotate.



What is the ratio of tensions in string 1 : string 2 : string 3?

A 1 : 2 : 3
B 3 : 2 : 1
C 3 : 5 : 6
D 6 : 5 : 3

10 The graph below shows the variation with distance from the centre of Earth, of the gravitational field strength between the surface of the Earth and the Moon. The areas under the graph segments and the value of the gravitational field strength on Earth's and on Moon's surfaces are indicated.



What is the minimum speed a mass on the surface of the Moon must have, in order to be able to reach Earth's surface?

A 186 m s^{-1}
B 902 m s^{-1}
C 2280 m s^{-1}
D 11 000 m s^{-1}

11 A satellite orbits around the Earth in a stable orbit. It is moved to another stable orbit that is further away from the Earth.

Which one of the following quantities increases for the satellite?

A gravitational force
B gravitational potential energy
C angular velocity
D centripetal acceleration

12 The temperature of an ideal gas is raised from 32.1 ºC to 40.5 ºC.

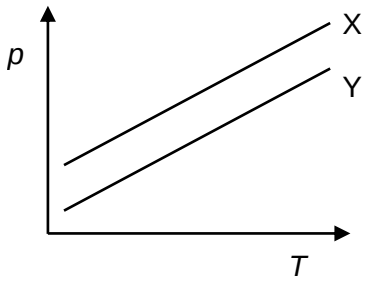
What is the percentage increase in the r.m.s. speed of its gas particles?

A 1.4 %
B 2.8 %
C 12 %
D 13 %

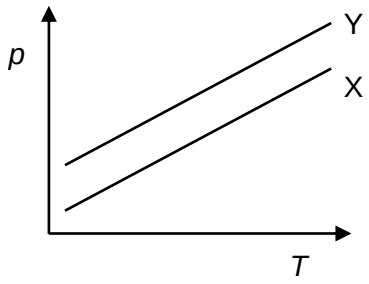
13 Two closed vessels X and Y contain equal masses of an ideal gas. X has a larger volume than Y.

Which of the following best represents the variation with temperature T of the pressure p of the gas in each vessel?

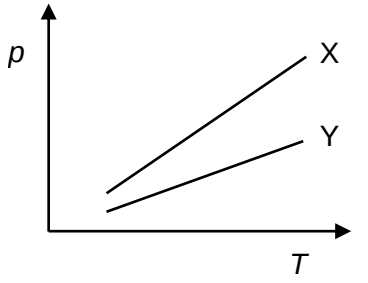
A



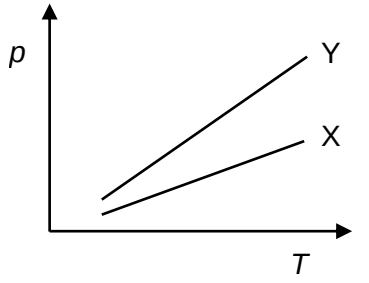
B



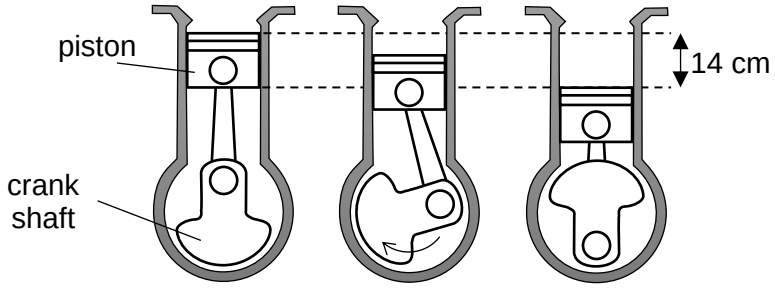
C



D



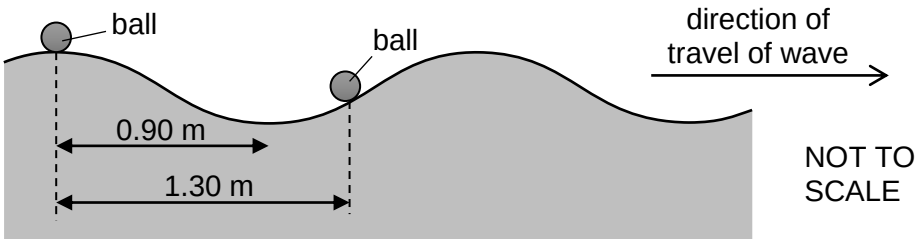
14 A piston undergoes simple harmonic motion vertically when cranked by a rotating crank shaft as shown in the diagram below. A coin rests on top of the initially stationary piston. The rotation of the crank shaft gradually increases in speed.



What is the frequency at which the coin loses contact with piston?

A 1.0 Hz
B 1.3 Hz
C 1.9 Hz
D 26 Hz

15 Two balls float on the surface of the sea. The balls are separated by a distance of 1.30 m. A wave travels on the surface of the sea such that the balls move vertically up and down. The distance between a crest and an adjacent trough of the wave is 0.90 m.



What is the phase difference between the two balls?

A 55°
B 110°
C 160°
D 260°

16 A diffraction grating with 5000 lines per centimetre is illuminated normally by white light.

Which of the following statements is false?

A Within the first-order spectrum, the violet end is closer to the central maxima than the red end.
B The yellow region of the second-order spectrum coincides with the violet end of the third-order spectrum.
C The violet end of the third-order spectrum is visible.
D The violet end of the fourth-order spectrum is not visible.

17 The screen on most modern smartphones uses tiny, regularly-spaced pixels each capable of producing red, green, or blue light to make up an image. At typical viewing distances, the human eye is unable to resolve the individual pixels that make up the image on the screen.

The wavelengths for red, green, and blue are 660 nm, 550 nm, and 470 nm respectively. The diameter of the pupil through which light enters the eye is 4.0 mm. Humans tend to place the mobile phone screens closest to the eye at about 10 cm when lying down.

What is the maximum distance between adjacent pixels?

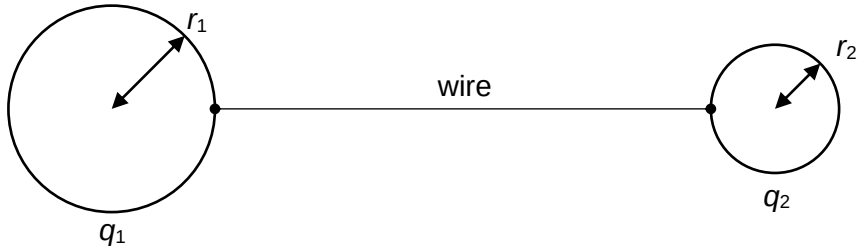
A 1.2×10^{-5} m

B 1.2×10^{-6} m

C 1.7×10^{-5} m

D 1.7×10^{-6} m

18 Two spherical conductors of radii r_1 and r_2 are separated by a distance much greater than the radius of either sphere. The spheres are connected by a conducting wire as shown in the diagram below. The charges on the spheres in equilibrium are q_1 and q_2 respectively.



What is the ratio of the magnitudes of the electric field strengths at the surfaces of the spheres?

A $\left(\frac{r_2}{r_1}\right)^2$

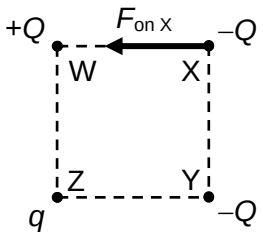
B $\frac{r_2}{r_1}$

C $\frac{q_2 r_2}{q_1 r_1}$

D $\frac{q_1 r_2}{q_2 r_1}$

19 Point charges $+Q$, $-Q$, $-Q$, and q are located at the corners W, X, Y and Z of a square respectively as shown.

The charge at X experiences a net electric force towards W.



What is the magnitude of charge q in terms of Q?

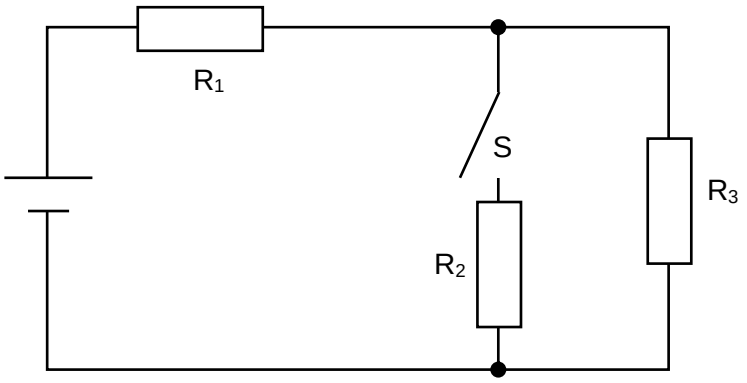
A $+Q$

B $+2Q$

C $+2\sqrt{Q}$

D $+2\sqrt{2}Q$

20 The diagram shows a network of resistors R_1, R_2, and R_3 connected to a battery of negligible internal resistance.

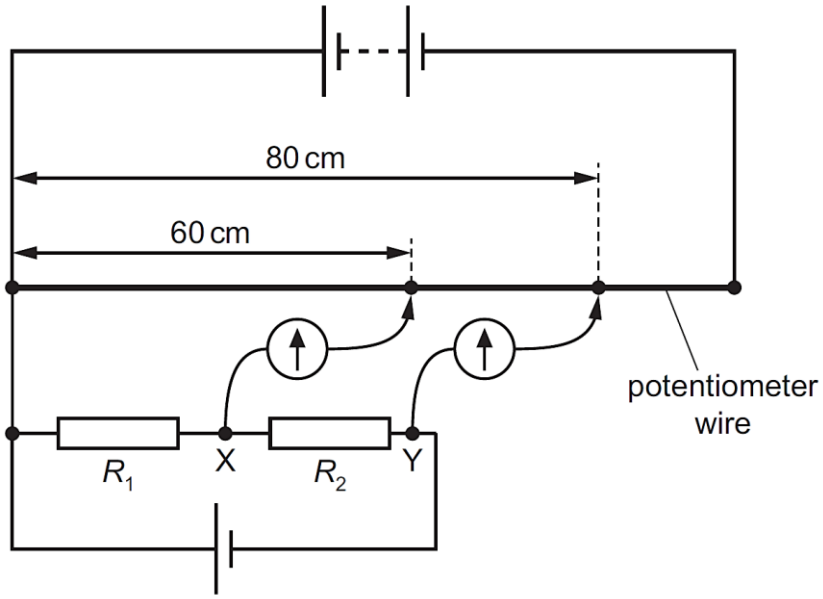


When switch S is closed, the potential difference (p.d.) across R_2 (originally zero) rapidly increases to a steady value.

What happens to the potential difference (p.d.) across each of the other two resistors, and to the power output of the battery?

	p.d. across R_1	p.d. across R_3	battery power output
A	decreases	decreases	decreases
B	decreases	stays the same	decreases
C	increases	decreases	increases
D	increases	stays the same	increases

21 Potential differences across two resistors of resistances R_1 and R_2 are compared using a potentiometer wire (uniform resistance wire) in the electrical circuit shown.



One terminal of a galvanometer is connected to point X. The galvanometer reads zero when its other terminal is connected to a point that is a distance of 60 cm from one end of the potentiometer wire.

One terminal of a second galvanometer is connected to point Y. This galvanometer reads zero when its other terminal is connected to a point that is a distance of 80 cm from the same end of the potentiometer wire.

What is the ratio $\frac{R_2}{R_1}$?

A $\frac{1}{3}$

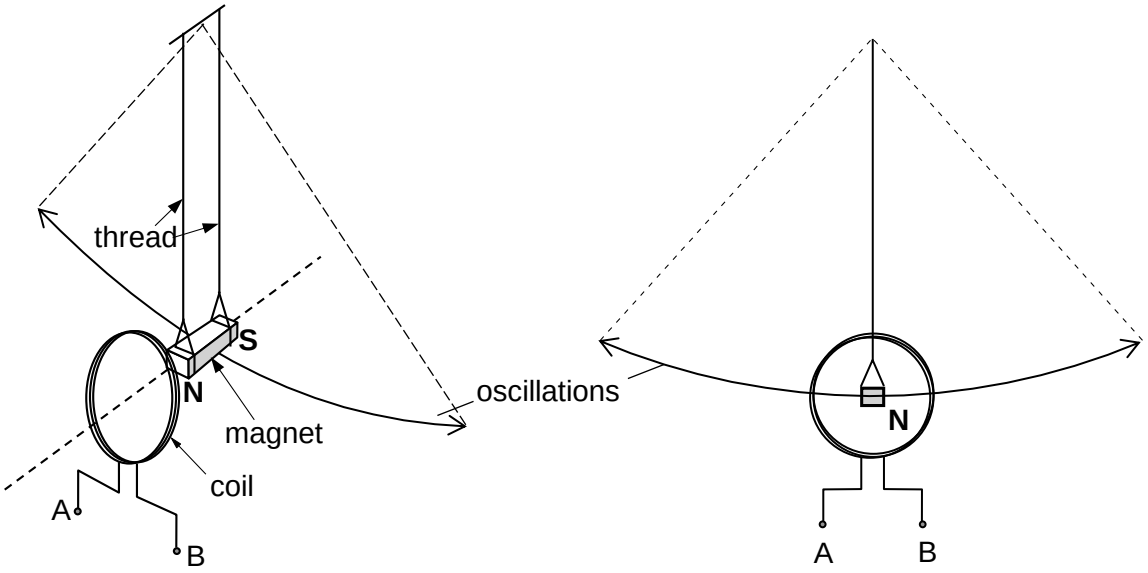
B $\frac{3}{4}$

C $\frac{3}{1}$

D $\frac{4}{3}$

22 A magnet is suspended using threads. It swings like a pendulum as shown in the diagrams below.

The north pole of the magnet passes near a fixed coil at the bottom of its swing. The coil's plane is parallel to the plane of oscillation of the magnet.

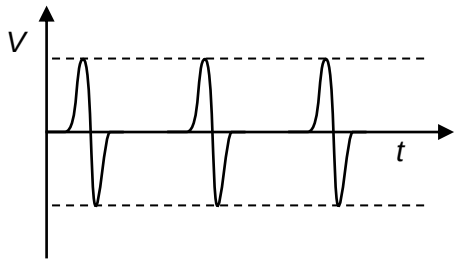


perspective view **side view**

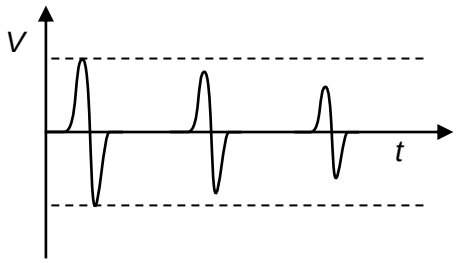
A resistor is connected in parallel across terminals A and B.

Which of the following graphs best shows the variation with time *t* of the potential difference *V* across the resistor?

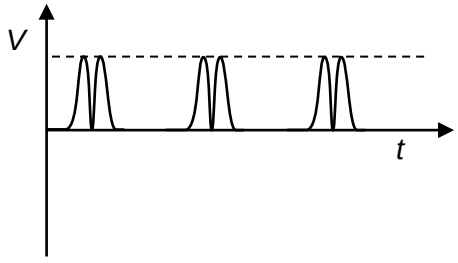
A



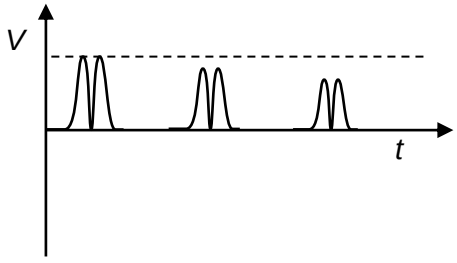
B



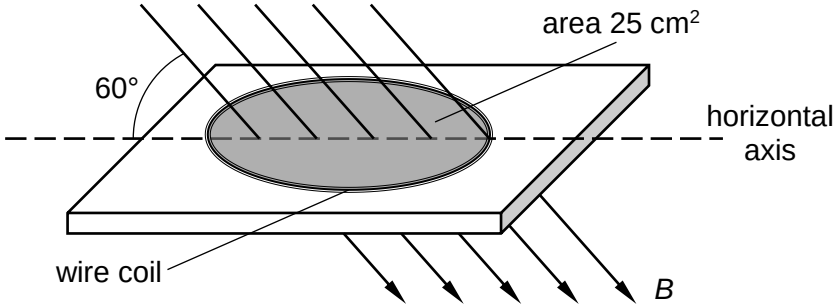
C



D



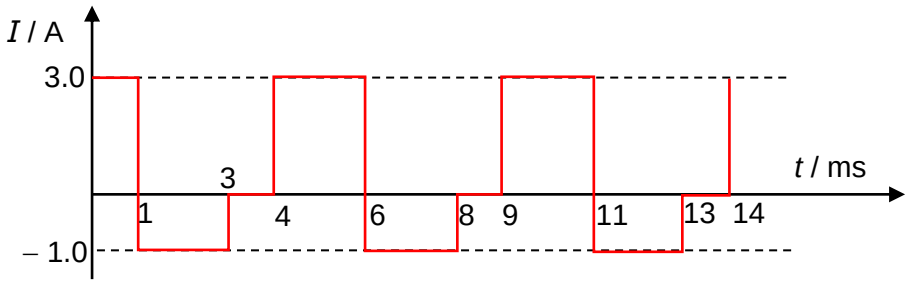
23 A uniform magnetic field of magnetic flux density $B = 2.0 \times 10^{-4}$ T is directed down through a wire coil at an angle of 60° with the horizontal as shown. The coil has 500 turns, a total resistance 5.0 Ω and an area of 25 cm^2.



What is the average charge that flows when the coil is turned π rad about the horizontal axis?

A 0.22 C
B 0.11 C
C 4.3×10^{-5} C
D 8.7×10^{-5} C

24 The diagram below shows the variation with time of an alternating current which flows through a 13 Ω resistor.



What is the average power dissipated by the resistor?

A 52 W
B 36 W
C 2.8 W
D 2.0 W

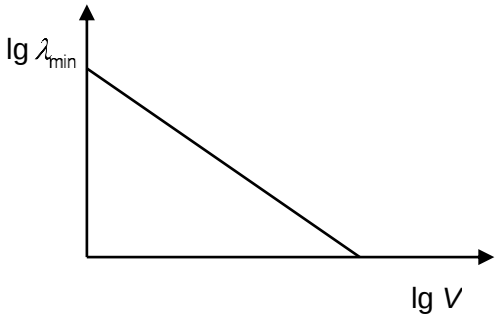
25 Which of the following statements about the photoelectric effect is true?

A Photoelectrons are not emitted as long as intensity of illumination is low.
B Doubling the frequency radiation will double the stopping potential.
C For a particular clean metal surface, there will be a minimum wavelength below which no emission of photoelectrons will occur.
D Increasing the intensity of incident increases the photo-current.

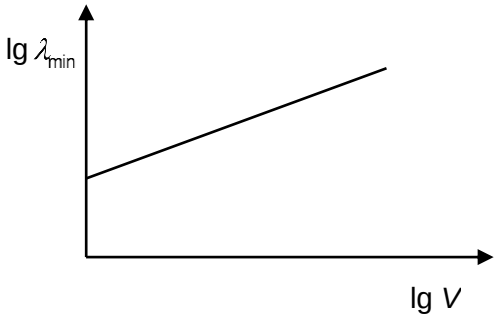
26 Electrons are accelerated from rest by a potential difference V. They bombard a metal target to produce X-rays. On the resulting X-ray spectrum, λ_{min} is the shortest wavelength observed.

Which of the following shows the variation with lg V of lg λ_{min} ?

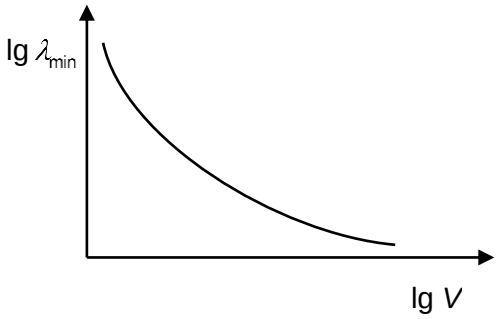
A



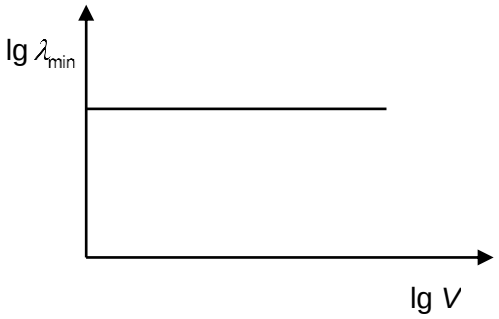
B



C



D



27 An electron moves with a constant velocity of 1.5×10^{6} m s^{-1}. Its momentum is measured to a precision of 0.20%.

What is the uncertainty associated with its position along its direction of travel?

A 2.4×10^{-7} m
B 3.9×10^{-8} m
C 1.2×10^{-10} m
D 1.9×10^{-10} m

28 The half-life of a radioactive substance is 752 s. The background count is found to be 8.3 s^{-1}. A Geiger Muller (GM) counter reads 77.3 s^{-1} when the GM tube is placed near a radioactive sample.

What will be the reading on the GM counter 280 s later?

A 53.3 s^{-1}
B 59.7 s^{-1}
C 61.6 s^{-1}
D 68.0 s^{-1}

29 A stationary nitrogen nucleus reacts with a high speed α-particle to produce a proton and a nucleus of an oxygen isotope as shown in the equation:

$$^{14}_{7}\mathrm{N} + ^{4}_{2}\alpha \rightarrow ^{17}_{8}\mathrm{O} + ^{1}_{1}\mathrm{H}$$

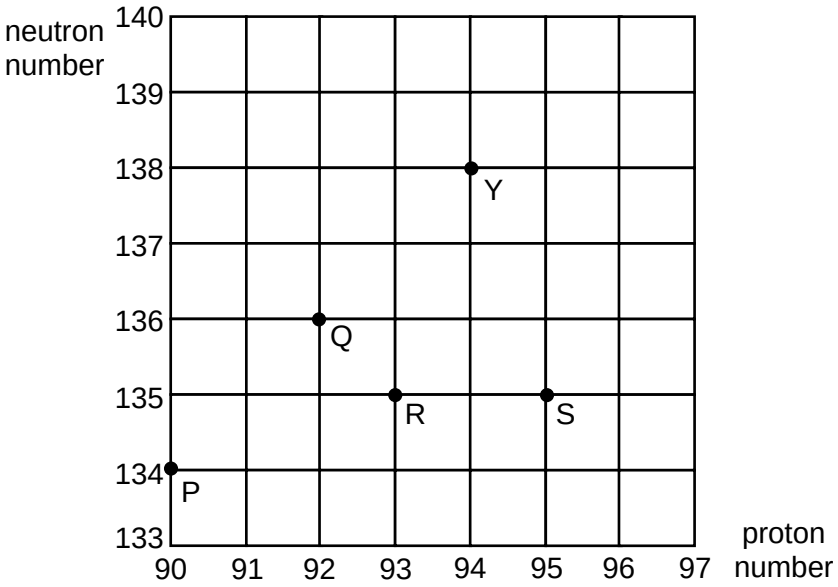
The masses of the nuclides involved are as follows

nuclide	mass / *u*
$^{4}_{2}\alpha$	4.002604
$^{1}_{1}\mathrm{H}$	1.007825
$^{14}_{7}\mathrm{N}$	14.003074
$^{17}_{8}\mathrm{O}$	16.999130

Which is the minimum energy that the α-particle possess in order for the reaction to occur?

A 1.9×10^{-13} eV
B 4.0×10^{-13} eV
C 1.2 eV
D 1.2×10^{6} eV

30 Isotope Y undergoes two successive decays to form another isotope. Each decay can be either alpha-emission or beta-emission. Four other isotopes P, Q, R and S, are shown on the diagram.



Which of the isotopes P, Q, R and S could be the final isotope after the two successive decays of isotope Y?

A P only
B P and R
C Q, R and S
D S only