NAME ______________________ **CLASS** 2T

Catholic Junior College

JC2 Preliminary Examinations

Higher 2

PHYSICS

9749/1

Paper 1: Multiple Choice Questions

September 2023

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name and tutorial group on this cover page.

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write and shade your name, NRIC / FIN number and HT group on the Answer Sheet (OMR sheet), unless this has been done for you.

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 (OMR sheet).

Read the instructions on the Answer Sheet 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.

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
D	C	C	D	A	B	A	B	A	B	D	C	A	A	B	C	D	B	C	B	A	A	B	B	A	D	B	D	A	D

Suggested Solutions

This document consists of **21** printed pages and **1** blank page.

[Turn over

DATA

speed of light in free space c = $3.00 \text{ x } 10^{8}$ m s^{-1}

permeability of free space μ_0 = $4\pi \text{ x } 10^{-7}$ H m^{-1}

permittivity of free space ε_0 = $8.85 \text{ x } 10^{-12}$ F m^{-1}

$(1/(36\pi)) \text{ x } 10^{-9}$ F m^{-1}

elementary charge e = $1.60 \text{ x } 10^{-19}$ C

the Planck constant h = $6.63 \text{ x } 10^{-34}$ J s

unified atomic mass constant u = $1.66 \text{ x } 10^{-27}$ kg

rest mass of electron m_e = $9.11 \text{ x } 10^{-31}$ kg

rest mass of proton m_P = $1.67 \text{ x } 10^{-27}$ kg

molar gas constant R = 8.31 J K^{-1} mol^{-1}

the Avogadro constant N_A = $6.02 \text{ x } 10^{23}$ mol^{-1}

the Boltzmann constant k = $1.38 \text{ x } 10^{-23}$ mol^{-1}

gravitational constant G = $6.67 \text{ x } 10^{-11}$ N m^{2} kg^{-2}

acceleration of free fall g = 9.81 m s^{-2}

FORMULAE

uniformly accelerated motion	$s = u\,t + \frac{1}{2}\,a\,t^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\,\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T / K = T / {^\circ}C + 273.15$
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	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	$x = x_0 \sin \omega t$
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	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 A man of mass 75.2 kg uses a set of weighing scales to measure his mass three times. He obtains the following readings.

	mass / kg
reading 1	80.2
reading 2	80.1
reading 2	80.2

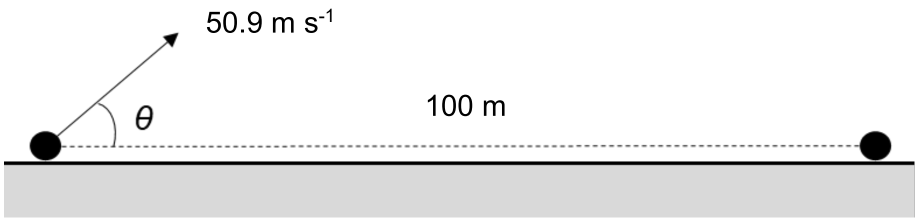
Which statement describes the precision and accuracy of the weighing scales?

A	not precise to ± 0.1 kg and accurate to ± 0.1 kg
B	not precise to ± 0.1 kg and not accurate to ± 0.1 kg
C	precise to ± 0.1 kg and accurate to ± 0.1 kg
D	precise to ± 0.1 kg and not accurate to ± 0.1 kg

Answer: D

Since the weighing scale's reading is bout 5 kg away from the man's true mass, the scale reading is not accurate. However, repeated readings are close to one another with 0.1 kg deviation. Hence the readings are precise.

2 An object is launched with a speed of 50.9 m s^{-1} at an angle θ above the horizontal, as shown.



The ground is level. The object lands on the ground 100 m from its initial launch position.

What is the value of the angle θ?

You may need to make use of the double angle formula: $\sin(2\theta) = 2\sin\theta\cos\theta$

A	2.8°	**B**	5.5°	**C**	11°	**D**	79°

Solution: C

In the horizontal direction:
$50.9\, t \cos\theta = 100$

In the vertical direction (taking upwards as positive):
$0 = 50.9\, t \sin\theta - (0.5)(9.81)t^2 = 50.9 \sin\theta - ½\,(9.81)t$
$50.9 \sin\theta = (0.5)(9.81)t$

$$t = \frac{50.9\sin\theta}{(0.5)(9.81)}$$

Substituting into the previous equation:

$$100=\frac{50.9^2\sin\theta\cos\theta}{(0.5)(9.81)}=\frac{50.9^2(0.5)(\sin 2\theta)}{(0.5)(9.81)}$$

$$2\theta=22^{\circ}$$

$$\theta=11^{\circ}$$

3 Two spheres with different masses are initially moving towards each other with the same speed. The two spheres collide elastically.

Which of the following statements is **true**?

A The two spheres can be at rest at the same time because they were initially moving in opposite directions.

B The two spheres can be at rest at the same time because momentum is always conserved in an elastic collision.

C The two spheres cannot be at rest at the same time at any point in time because the total momentum of the system is not zero.

D The two spheres cannot be at rest at the same time at any point in time because energy is always conserved in an elastic collision.

Solution: C

Since the two spheres do not have the same momentum (since their momentum are unequal in magnitudes), the total momentum of the system is not zero, and hence they cannot be at rest at the same time.

4 A rower is sitting on a boat in the middle of a calm lake.

Which of the following forces forms a Newton's third law pair with the upthrust acting on the boat?

A The weight of the boat alone.

B The weight of the rower alone.

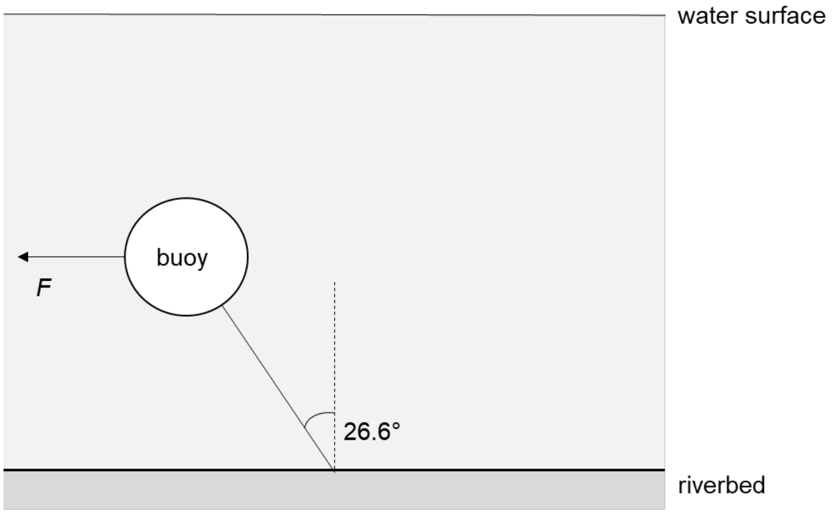
C The combined weight of the boat and the rower.

D The force of the boat on the lake's water to displace some of the lake's water.

Solution: D

The action-reaction pair to the upthrust (which is exerted by the water on the boat) is the downwards force exerted by the boat on the water when it displaced some of the lake's water.

5 A fully submerged buoy is tethered by a rope to a riverbed. The current of the river exerts a constant horizontal force of *F* on the buoy causing the rope to make an angle of 26.6° to the vertical, as shown. The buoy is in equilibrium.



The buoy has a volume of 0.500 m^3 and a density of 390 kg m^{-3}.

The river water has a density of 1000 kg m^{-3}.

What is the force *F* exerted by the river current on the buoy *F*?

A	1500 N	**B**	3830 N	**C**	6000 N	**D**	9810 N

Solution: A

The vertical forces on the buoy are the vertical component of tension, upwards upthrust and the downwards weight.

The net force in the vertical direction is:

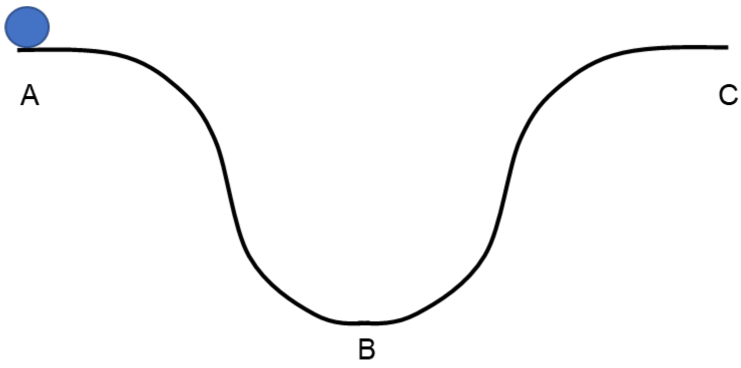
$$F_y = U - W$$
$$= V\rho_w g - mg$$
$$= V\rho_w g - V\rho_b g$$
$$= Vg(\rho_w - \rho_b)$$
$$= (0.500)(9.81)(1000 - 390)$$
$$= 3000\text{N}$$

The tangent of the angle that the rope makes with the vertical can be expressed as the ratio of the magnitude of the resultant horizontal force acting on the buoy to the resultant vertical force:

$$\tan 26.6 = \frac{F_x}{F_y}$$

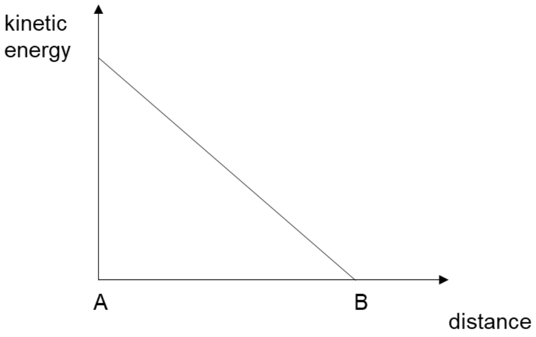
$$0.5 = \frac{F_x}{3000}$$
$$F_x = 1500\text{N}$$

6 An object moves along a frictionless track from A to C, through B, which is the lowest point of the motion.

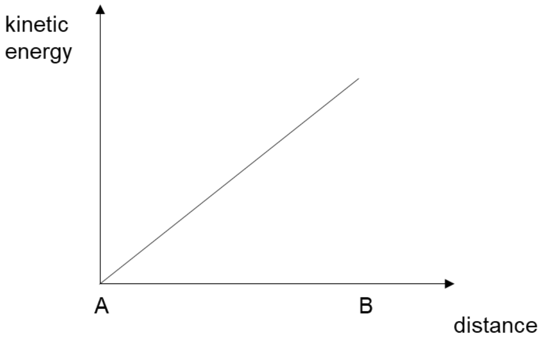


Which graph shows how the kinetic energy of the object varies with the vertical distance from A?

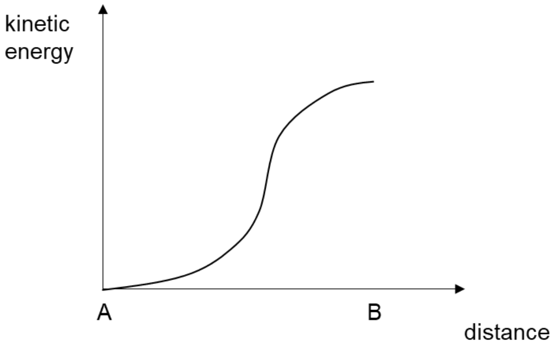
A



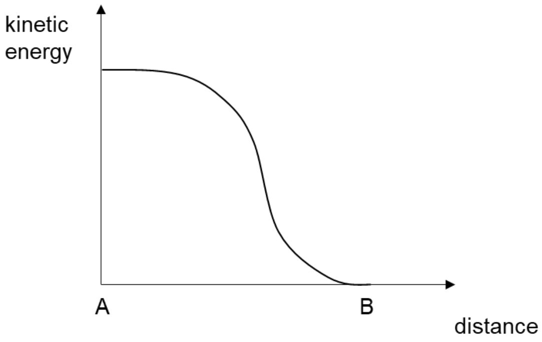
B



C



D

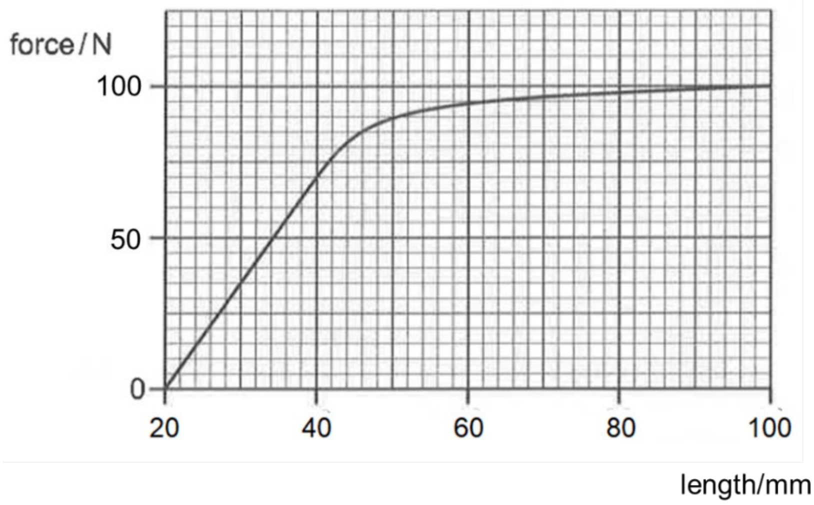


Solution: B

The gravitational potential energy will decrease linearly with the vertical distance from A since the change in GPE = $mg\Delta h$

The kinetic energy will increase at the same linear rate, and therefore, the answer is B.

7 A rubber strip is stretched by a force. The graph of the applied force against its length is shown.



What is the work done in stretching the strip to the first point where it no longer obeys Hooke's Law?

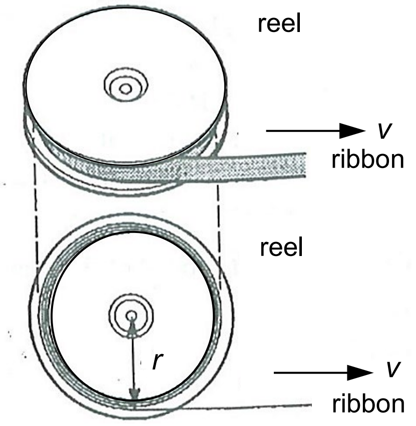
A	0.70 J	**B**	6.3 J	**C**	700 J	**D**	6300 J

Solution: A

The limit of proportionality is when the strip no longer obeys Hooke's Law. This occurs at 40mm of length (20 mm of extension).

Work done
= area under the graph up to 40mm
= ½ (0.0020 m)(70N)
=0.70 J

8 A ribbon, wound around a reel, is pulled and rotates about its centre. The ribbon leaves the reel at a constant *v* and at a variable distance *r* from the centre of the reel as shown.



What is the relationship between the angular velocity of the reel and the variable distance *r* from the centre of the reel?

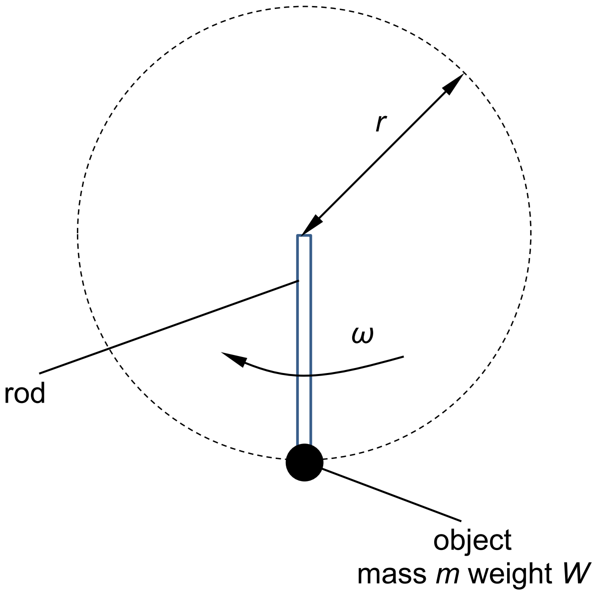
	A	Angular velocity is proportional to $\frac{1}{r^2}$.
	B	Angular velocity is proportional to $\frac{1}{r}$.
	C	Angular velocity is proportional to r.
	D	Angular velocity does not depend on r.

Answer: B

$v = r\omega \quad \Rightarrow \quad \omega = \frac{v}{r}$ where ω is the angular velocity.

Since v is constant, angular velocity ω is proportional to $\frac{1}{r}$.

9 An object of mass m and weight W is fixed to one end of a light rod which rotates in a vertical circle of radius r. The object has an angular velocity when it is vertically below the centre of the circle



What is the tension in the rod acting upwards on the object when the object is vertically below the centre of the circle?

A	$W + mr\omega^2$	**B**	$W - mr\omega^2$	**C**	$mr\omega^2 - W$	**D**	$mr\omega^2$

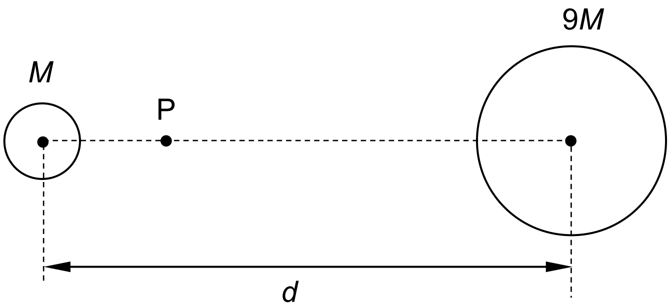
Answer: A

T – tension in the rod

At the bottom of the circular path, $(T - W)$ provides the centripetal force.

$$(T - W) = mr\omega^2 \quad \Rightarrow \quad T = W + mr\omega^2$$

10 Two isolated stars, of mass M and $9M$, are separated in space by a distance d between the centres of the stars.

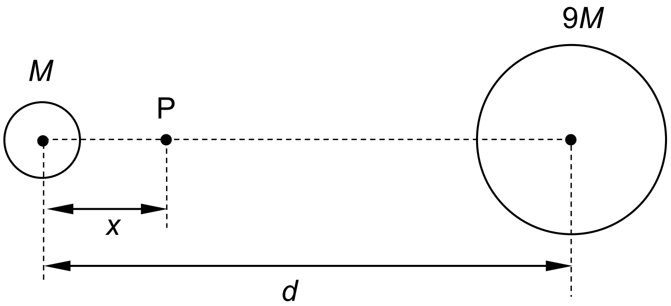


Point P is a point, between the centres of the stars, where the gravitational field strength is zero.

What is the gravitational potential at P?

A	$-\dfrac{10GM^2}{d}$	**B**	$-\dfrac{16GM}{d}$	**C**	$-\dfrac{20GM^2}{d}$	**D**	$-\dfrac{32GM}{d}$

Answer: B



x – distance from the centre of star mass M.

At P, where gravitational field strength is zero,

$$\frac{GM}{x^2}=\frac{G(9M)}{(d-x)^2}$$

$$(d-x)^2=9x^2$$

$$d-x=3x$$

$$x=\frac{1}{4}d$$

Gravitational potential at P = $-\dfrac{GM}{\frac{1}{4}d}-\dfrac{G(9M)}{\frac{3}{4}d}=-\dfrac{GM}{d}\left(4+\dfrac{4}{3}\times 9\right)=-\dfrac{16GM}{d}$

11 The International Space Station (ISS) orbits the Earth with uniform speed, above the Earth's atmosphere, at a constant height 420 km above the Earth's surface.

What statement about the ISS is correct?

A There is no gravitational force on the ISS.

B The resultant force on the ISS is in the direction it is moving.

C The ISS is not accelerating.

D The acceleration of the ISS is less than 9.81 m s^{-2}.

Answer: D

The gravitational force provides the centripetal force for the ISS to move in circular motion and the direction of the centripetal force is towards the centre of the Earth. Option A and B are incorrect.

The acceleration is equal to the magnitude of the gravitational field strength $\left(\frac{GM_{Earth}}{r^2}\right)$.

Since the acceleration on the Earth's surface is 9.81 m s^{-1} and the ISS is above the Earth's surface, its acceleration will be less than 9.81 m s^{-1}. Option D.

12 A weather balloon, initially stationary on the ground, contains an ideal gas with an internal energy of 500 J. The balloon is then launched into the air, reaching a certain altitude Y where the potential energy of the gas has increased by 100 J and its kinetic energy is 250 J.

Assuming the balloon is tied tightly and there is no heat transfer or work done on the ideal gas, what is the internal energy of the gas when the balloon is at that altitude Y?

A 150 J	**B** 350 J	**C** 500 J	**D** 850 J

Answer: C

Given Q = 0 and W = 0, thus ΔU = 0.
No change in internal energy → internal energy remains at the initial value of 500 J.

Recall also that internal energy of an ideal gas is associated with the kinetic energy due to the random motion of the molecules, and independent of the bulk changes in KE and PE of the system as a whole.

13 A sealed container is filled with an ideal gas which is initially at a temperature of 50 °C. The root-mean-square (r.m.s.) speed of the gas molecules at this temperature is measured to be 400 m s^{-1}.

If the temperature of the gas is increased to 100 °C, what is now the r.m.s speed of the gas molecules?

A 430 m s^{-1}	**B** 460 m s^{-1}	**C** 570 m s^{-1}	**D** 800 m s^{-1}

Answer: A

$$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$$

$$c_{rms} \propto \sqrt{T}$$

$$\frac{c_{rms,new}}{400} = \sqrt{\frac{100+273.15}{50+273.15}} = 1.07$$

$$c_{rms,new} = 430\ m\ s^{-1}$$

[Turn over

14 Which of the following is **not** an example of resonance?

A A flag flaps at a larger amplitude when blown by a stronger wind.

B A glass sheet shattering when exposed to certain frequencies of sound.

C A bottle filled with water producing a loud sound when air is blown over its mouth.

D A washing machine strongly vibrating when the drum rotates at a certain speed.

Solution: A

A flag fluttering with a larger amplitude only shows that the amplitude of an oscillation increases when the magnitude of the force increases, and is not specifically an example of resonance.

The rest are examples of objects vibrating strongly at a certain frequency when subjected to a periodic external force of the same frequency.

15 When a spring-mass system is displaced by an initial displacement X and released, it moves in a simple harmonic motion with a maximum momentum of p.

The same spring-mass system is now displaced by an initial displacement of $0.5X$.

What is the new maximum momentum of its motion, in terms of p?

A	$0.25p$	**B**	$0.5p$	**C**	$2p$	**D**	$4p$

Solution: B

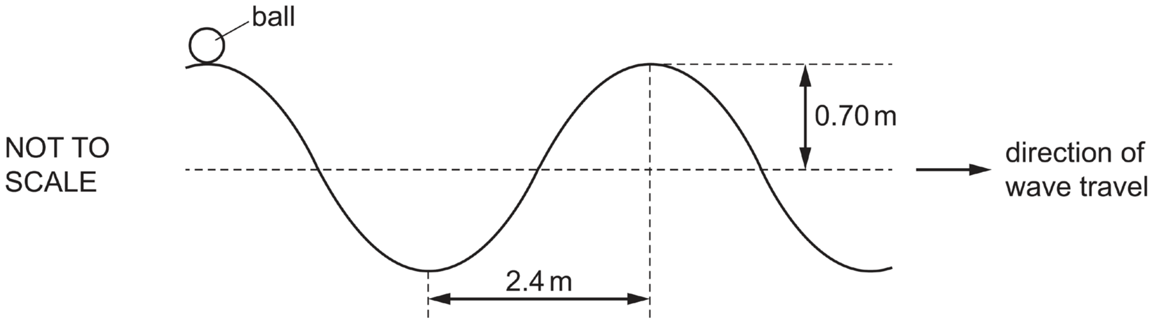
The maximum velocity is given by $v = \omega x_0$ where ω is the angular frequency and x_0 is the amplitude of the oscillation, which, in this case, is the initial displacement X.

Also, since $p = mv$

Then, $p \ \alpha \ v \ \alpha X$

So, when the displacement is halved, the maximum momentum is halved as well.

16 A transverse water wave is moving along the surface of some water. This causes a ball to move vertically without moving horizontally as it floats upon the surface. At one instant, the ball is at the position shown.



The wave has a frequency of 0.20 Hz and an amplitude of 0.70 m. The distance between a trough and an adjacent peak is 2.4 m.

What is the distance travelled by the ball in a time of 20 s?

A	5.6 m	**B**	9.6 m	**C**	11.2 m	**D**	19.2 m

Answer: C

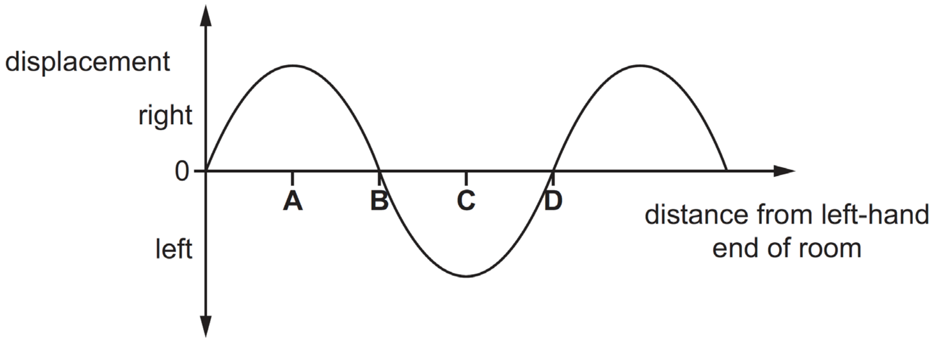
Period of the wave = $\frac{1}{f}$ = 5 s

In 20 s, the ball would have oscillated by $\frac{20}{5}$ = 4 cycles

It would have moved a total distance of 4 x (0.7 x 4) = 11.2 m

Students who found the speed of the wave using fλ, and then take speed x time = dist would end up getting 19.2 m (D).

17 A sound wave travels from left to right across a room. The variation with distance across the room of the displacement of the air molecules at one instant is shown. At which distance will the air pressure be lowest?



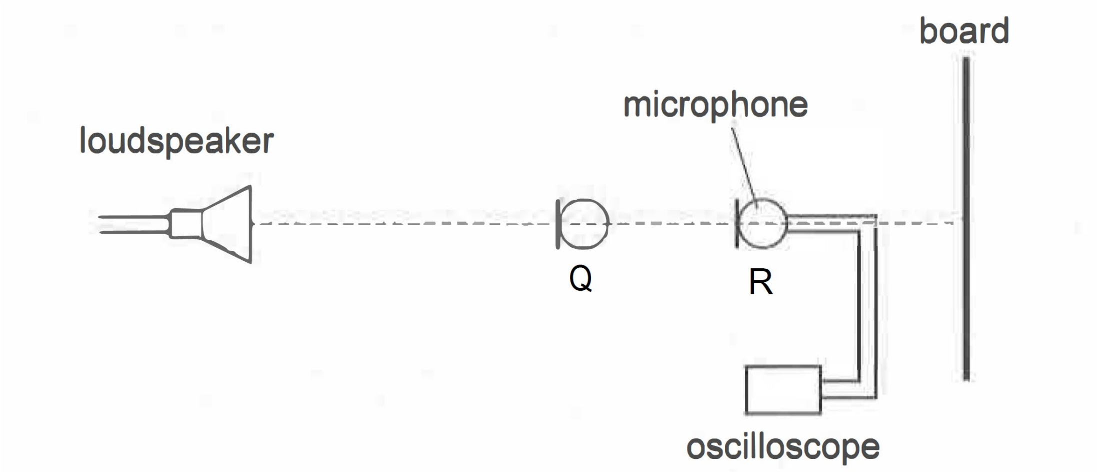
Answer: D

The air molecule at A & the air molecules next to it are being displaced to the right at that instant in time.
Similarly, the air molecule at position C and the air molecules next to it are being displaced to the left at that instant in time.

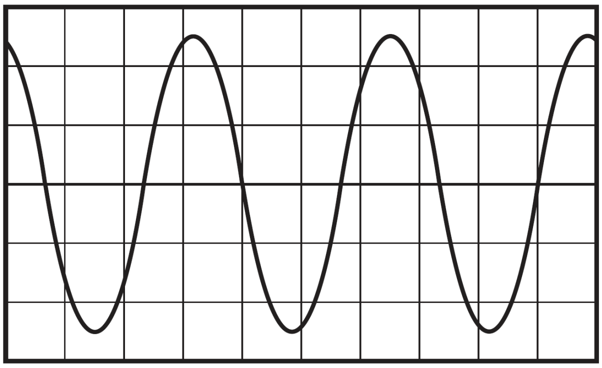
The air molecule at B is not displaced but the air molecules next to it are being displaced towards it and the air pressure will be the highest there.

The air molecule at D is not displaced and the air molecules next to it are being displaced AWAY from it so the air pressure will be the lowest there.

18 Stationary sound waves are investigated using the apparatus shown.



Q and R are adjacent positions of the microphone that give maximum amplitude on the oscilloscope, as shown.



oscilloscope screen when microphone is at R

The distance QR is 6.0 cm and the time base of the oscilloscope is 20 μs div^{-1}. What are the frequency and the wavelength of the sound wave?

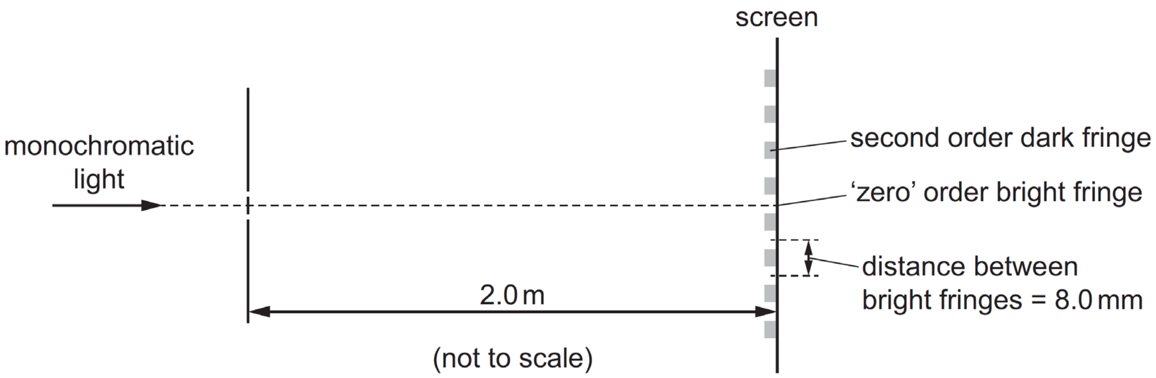
	frequency / kHz	wavelength / cm
A	15	6.0
B	15	12
C	20	6.0
D	20	12

Answer: B

Distance between two antinodes = $\frac{\lambda}{2}$ = 6.0 cm
Wavelength = 6.0 x 2 = 12 cm

1.5 T as seen from the oscilloscope = $5 \times 20 \times 10^{-6}$
$T = \frac{5 \times 20 \times 10^{-6}}{1.5}$
Frequency = $\frac{1}{T} = \frac{1.5}{5 \times 20 \times 10^{-6}}$ = 15 000 Hz = 15 kHz

19 Monochromatic light is incident on a pair of narrow slits a distance of 0.1 mm apart. A series of bright and dark fringes are observed on a screen a distance of 2.0 m away. The distance between adjacent bright fringes is 8.0 mm.



What is the path difference between the light waves from the two slits that meet at the second order dark fringe?

A	2.0×10^{-7} m
B	4.0×10^{-7} m
C	6.0×10^{-7} m
D	8.0×10^{-7} m

Answer: C

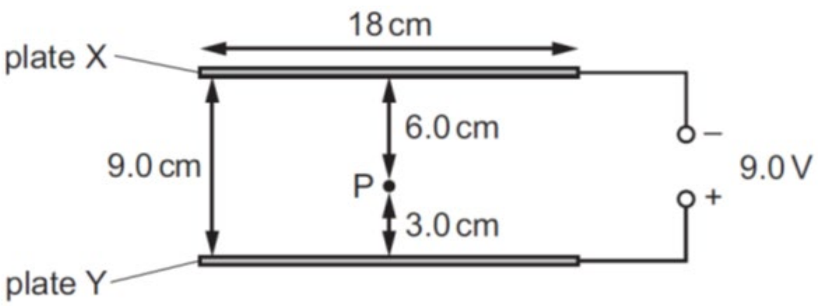
Double slit equation,

$$x = \frac{\lambda D}{a}$$

$$\lambda = \frac{xa}{D} = \frac{8x10^{-3} \text{ x } 0.1x10^{-3}}{2} = 4x10^{-7}$$

At the n = 2 dark fringe, the path difference travelled by the light waves are 1.5 λ
Path difference = 1.5λ = 6 x 10^{-7} m

20 Two parallel circular metal plates X and Y, each of diameter 18 cm, have a separation of 9.0 cm. A potential difference of 9.0 V is applied between them.



Point P is 6.0 cm from the surface of plate X and 3.0 cm from the surface of plate Y.

What is the electric field strength at P?

A	50 N C^{-1}	**B**	100 N C^{-1}	**C**	150 N C^{-1}	**D**	300 N C^{-1}

[Turn over

Answer: B

E = V/d = 9.0 / 0.09 = 100 N C^{-1}

21 The electric field strength due to a point charge at a distance *r* from the charge is *E*.

What is the electric field strength at distance 2*r* from the point charge?

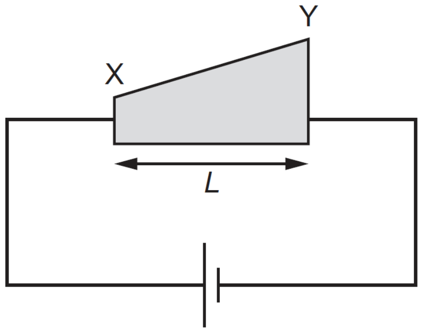
A	$\frac{E}{4}$	**B**	$\frac{E}{2}$	**C**	2*E*	**D**	4*E*

Answer: A

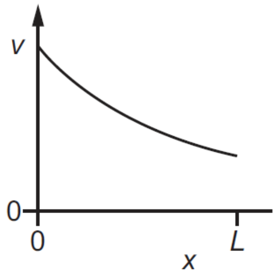
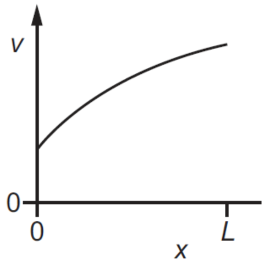
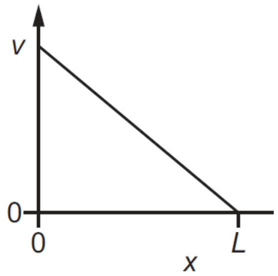
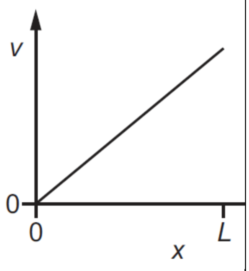
$$E \propto \frac{1}{r^2}, \text{ so } \frac{E}{E'} = \frac{r'^2}{r^2} \rightarrow \frac{E}{E'} = \frac{4r^2}{r^2}$$

Hence $E' = \frac{E}{4}$

22 A wedge-shaped metal conductor of length L, varying width and uniform thickness is connected to a cell, as shown.



Which graph best shows how the average drift velocity v of electrons in the conductor varies with distance *x* from end X?

A	B	C	D
			

Answer: A

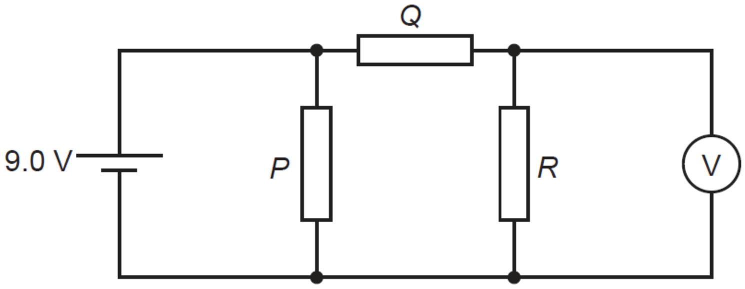
From $I = nAv_dq$

$I = nAv_dq$

$v_d = \frac{I}{nAq}$

The cross-sectional area of the metal conductor increases from X to Y but the current must remain constant. So the drift speed v_d of the electrons must decrease as they move from X to Y, eliminating graphs B and D. Graph C can also be rejected, as this graph implies that the electrons stop at Y.

23 A 9.0 V battery with negligible internal resistance is connected into a circuit, as shown.



The resistance of the voltmeter is equal to the resistance of *R*.

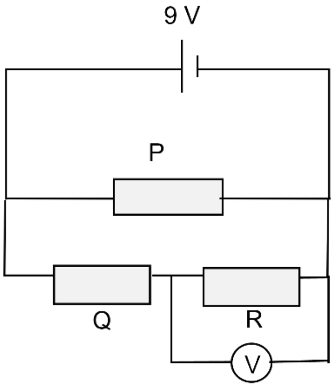
The reading on the voltmeter is 3.0 V.

What is the value of the ratio $\frac{\text{resistance of the voltmeter}}{\text{resistance of Q}}$?

A	$\frac{1}{2}$	**B**	1	**C**	2	**D**	4

Answer: B

Redrawing the circuit,



Resistor Q and R are in series and have a pd of 9 V across them.
Voltmeter and resistor R are in parallel, the potential difference across both is also 3 V.
Potential difference across Resistor Q is 9-3 = 6 V
Resistance of voltmeter cannot be ignored.
Let resistance of voltmeter be R
Effective resistance of voltmeter and resistor R (as they are in parallel and have the same resistance) = $\frac{R}{2}$

By potential divider approach,

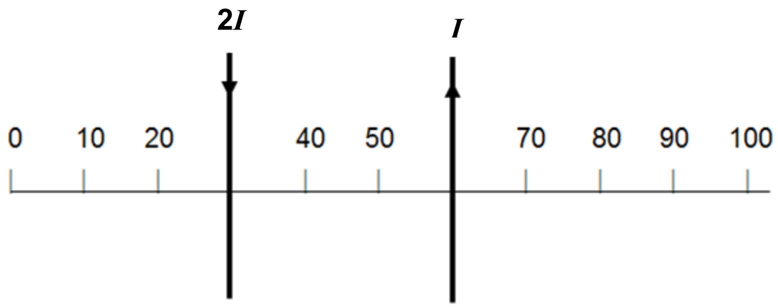
$$\frac{\text{effective resistance of the voltmeter \& resistor } R}{\text{resistor } Q} = \frac{\text{pd across voltmeter \& resistor } R}{\text{pd across resistor } Q}$$

$$\frac{\frac{R}{2}}{Q} = \frac{3}{6}$$

$$\frac{R}{Q} = 1$$

* If students pick A, they have ignored the resistance of the voltmeter.

24 Two parallel, straight conductors, placed at right angles to a ruler, carry currents of $2I$ and I flowing in opposite directions.

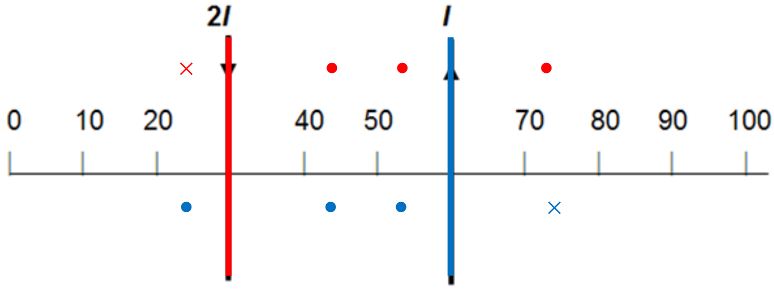


At which point on the ruler is the resultant magnetic field the greatest?

A	20 cm mark
B	40 cm mark
C	50 cm mark
D	70 cm mark

Answer: B

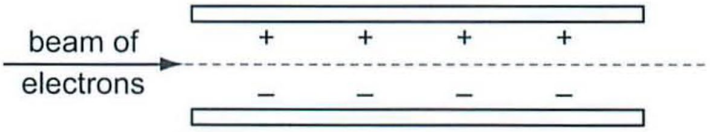
Using the RHGR, the magnetic field due to the individual wires are indicated on the diagram.



$$B_{40cm} = \frac{\mu_0(2I)}{2\pi(0.1)} + \frac{\mu_0(I)}{2\pi(0.2)} = 12.5\frac{\mu_0 I}{\pi}$$

$$B_{50cm} = \frac{\mu_0(2I)}{2\pi(0.2)} + \frac{\mu_0(I)}{2\pi(0.1)} = 10\frac{\mu_0 I}{\pi}$$

25 A beam of electrons, travelling horizontally towards the right, passes between two horizontal charged parallel metal plates.



There is a vertical electric field between the plates. There is no deflection of the beam because of the presence of a uniform magnetic field in the region between the plates.

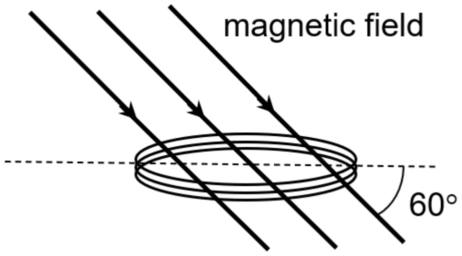
In which direction must this magnetic field be?

A	into the paper
B	out of the paper

C	vertically upwards
D	vertically downwards

Answer: A
The electric force on the electrons due to the electric field is upwards.
Hence the magnetic force must be downwards in order for the beam not to be deflected.
Using FLHR, current is towards the left, field must be into the paper.

26 A magnetic field of uniform flux density 0.045 T is at an angle of 60° below the plane of horizontal coil of wire as shown.



The coil of wire has 4 turns and cross sectional area of 0.30 m^2.

What is the magnitude of the change in magnetic flux linkage of the coil of wire when it is flipped over 180° about a horizontal axis?

A	0 Wb turns	**B**	0.012 Wb turns	**C**	0.035 Wb turns	**D**	0.094 Wb turns

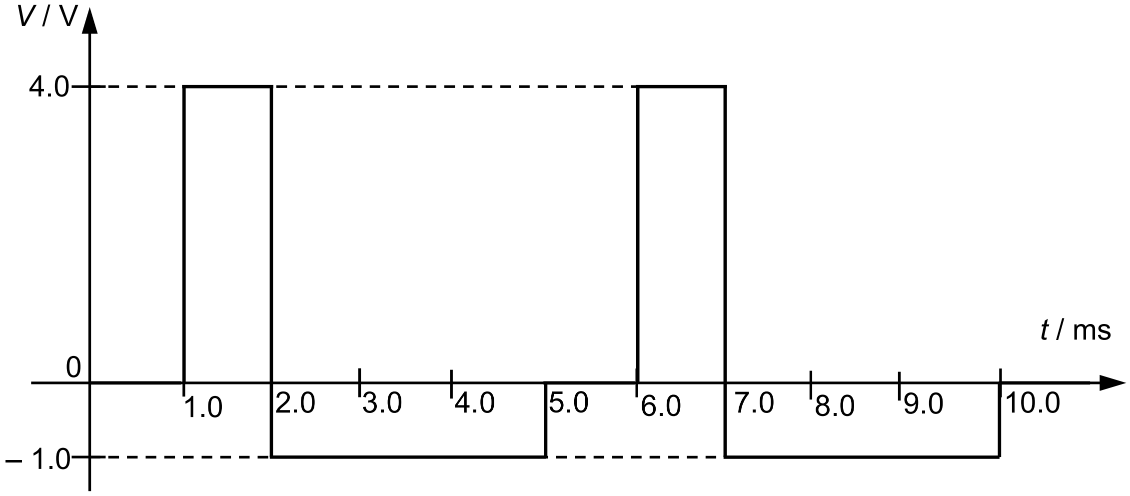
Answer: D

Taking downwards as positive,

$$\Delta\phi = \phi_f - \phi_i$$

= NA (B sin 60 - (-Bsin60))
= 4 x 0.3 x [0.045 sin60 - (-0.045 sin60)]
= 0.094 Wb turns

27 The variation with time *t* of the voltage *V* of an alternating source applied across a 2.5 Ω resistor is shown below.



What is the mean power dissipated in the resistor?

[Turn over

A 0.98 W	**B** 1.5 W	**C** 1.9 W	**D** 2.4 W

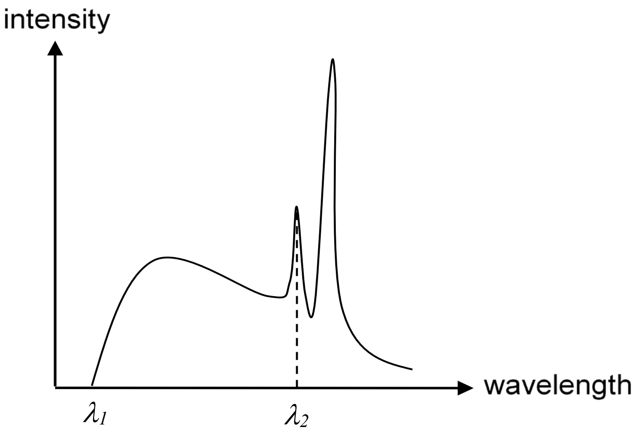
Answer: B

To find r.m.s. value of V, we need to square the graph and find the average value of V^2 then find square root.

$V_{r.m.s.} = \sqrt{\frac{(4^2 \times 1) + (1 \times 3)}{5}} = \sqrt{(3.8)}$

Power dissipated = $V_{r.m.s.}^2 / R = 3.8 / 2.5 = 1.5$ W

28 The graph below shows the variation of X-ray intensity with wavelength emitted from an X-ray tube.



The target metal and the accelerating voltage are varied. Which wavelengths will be affected by the changes?

	Changing the target metal	Changing the accelerating voltage
A	λ_1	λ_1
B	λ_1	λ_2
C	λ_2	λ_2
D	λ_2	λ_1

Answer: D

The minimum wavelength, λ_1, is affected by the potential difference which accelerates the electron and causes it to gain KE. The electron loses all its KE in the form of an X ray photon with minimum wavelength through a single head-on collision with the target atom.

λ_2 is located at one of the peaks. Changing the target metal will affect the characteristic wavelength of the peaks which is *dependent* on the target material. Since each element has a unique set of electron energy levels, the energy differences between these levels are also characteristic of the material.

29	One nuclear reaction that can take place in a nuclear reactor may be represented by the equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{95}_{42}Mo + ^{139}_{57}La + 2^{1}_{0}n + 7^{0}_{-1}e$$

Data for a nucleus and some particles are given in the table.

nucleus or particle	mass / u
$^{139}_{57}La$ nucleus	138.955
$^{1}_{0}n$ particle	1.00863
$^{1}_{1}p$ particle	1.00728
$^{0}_{-1}e$ particle	5.49 x 10^{-4}

What is the binding energy per nucleon of lanthanum-139 ($^{139}_{57}La$)?

A	7.84 Mev	**B**	7.87 MeV	**C**	19.13 MeV	**D**	19.19 MeV

Answer: A

Given the nuclear mass and not atomic mass,

Δm = (82 x 1.00863u) + (57 x 1.00728u) – 138.955u = 1.16762u

Energy = Δmc^2 = (1.16762 x 1.66 x 10^{-27}) x (3.00 x 10^8)^2

$$= 1.74442428 \text{ x } 10^{-10} \text{ J} = \frac{1.74442428 \times 10^{-10}}{1.6 \times 10^{-13}} \text{ MeV} = 1090.265 \text{ MeV}$$

$$\text{Energy per nucleon} = \frac{1090.265}{139} = 7.84 \text{ MeV}$$

30	The half-life of a certain radioactive isotope is 32 hours. What fraction of a sample would remain after 16 hours?

A	0.25	**B**	0.29	**C**	0.5	**D**	0.71

Answer: D

Using $x = x_0 \left(\frac{1}{2}\right)^n$

Since 16 hours is 0.5 half-life,

$$x = x_0 \left(\frac{1}{2}\right)^{0.5} = 0.7071x_0 = 0.71x_0$$

– END OF PAPER 1 –

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