NAME ______________________________ CLASS 2T ________

Catholic Junior College

JC2 Preliminary Examinations

Higher 2

PHYSICS

9749/01

Paper 1 Multiple Choice Questions

12 September 2024

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this 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.

MARK SCHEME

DATA

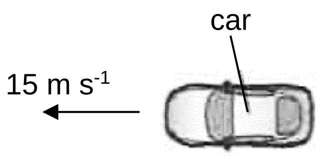
speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified 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} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

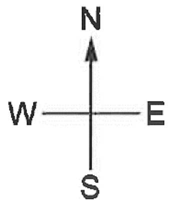
FORMULAE

uniformly accelerated motion	$s = u t + \frac{1}{2} a t^2$ $v^2 = u^2 + 2as$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

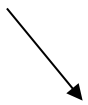
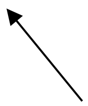
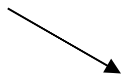
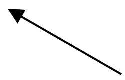
1 A car is travelling west with a speed of 15 m s^{-1}.



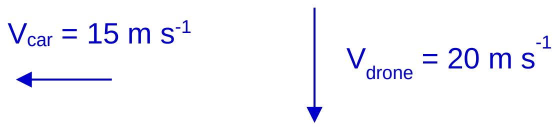


A drone moving south flies over the car with a speed of 20 m s^{-1}.

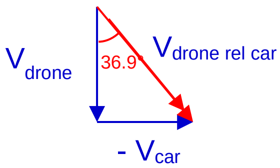
At this instant, which arrow represents the velocity of the drone relative to the car?

A	B	C	D
			

L2 **Answer: A**

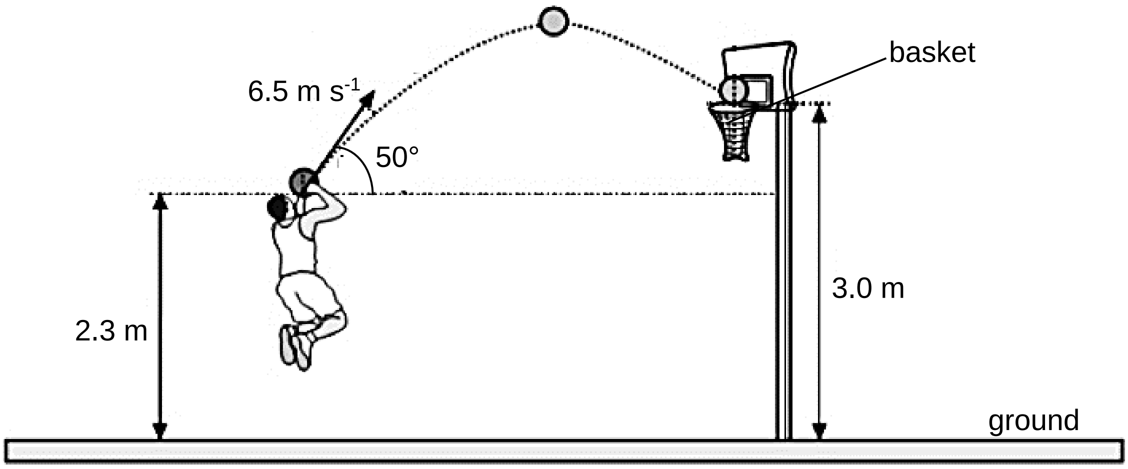


$V_{drone\ rel\ car} = V_{drone} - V_{car} = V_{drone} + (-V_{car})$



Answers B and D are in the wrong direction.
Answer A is closer to 36.9° east-of-south compared to Answer C.

2 A basketball player throws a ball with an initial velocity of 6.5 m s^{-1} at an angle of 50° to the horizontal. The ball is 2.3 m above the ground when released and passes through the basket on its way down.



What is the time taken for the ball to reach the top of the basket which is 3.0 m above the ground?

A	0.17 s	**B**	0.36 s	**C**	0.54 s	**D**	0.85 s

L2 **Answer: D**

Take upwards as positive direction.

$$s_y = u_y t + \frac{1}{2} a_y t^2$$

$$(3.0 - 2.3) = (6.5\sin 50°)t + \frac{1}{2}(-9.81)t^2$$

$$0.7 = 4.97929t - 4.905t^2$$

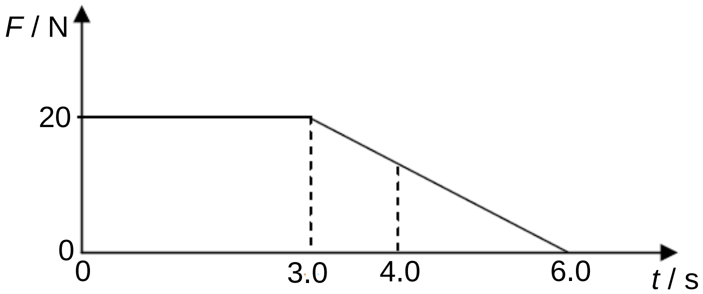
$$4.905t^2 - 4.97929t + 0.7 = 0$$

$$t = 0.16858s(reject) \quad or \quad 0.84657s$$

$$= 0.85s \ (2 \text{ s.f.})$$

Accept the answer where the ball reaches displacement of 0.7 m the **2nd** time.

3 An object of mass 20 kg moves along a straight line on a smooth horizontal surface. A force *F* acts on the object in its direction of motion. A graph of *F* against time *t* is shown below.



If the velocity of the object at *t* = 4.0 s is 4.0 m s^{-1}, what is its velocity at *t* = 6.0 s?

A	3.0 m s^{-1}	**B**	3.3 m s^{-1}	**C**	4.7 m s^{-1}	**D**	5.0 m s^{-1}

L2 **Answer: C**

Area underneath the F – t graph gives the **change in** momentum of the object.

Between 4.0 s to 6.0 s, area = $\frac{1}{2}(6-4)\left(\frac{2}{3}(20)\right) = 13.333\ Ns$

Let positive direction be the direction of the object's motion.
Since F acts in the direction of motion, it acts in the positive direction, and the change in momentum is also of positive direction, i.e. Δp = +13.333 Ns.

Final momentum - Initial momentum = +13.333

$$m(v_f - v_i) = +13.333$$

$$(20)\left(v_f - (+4.0)\right) = +13.333$$

$$v_f = \boldsymbol{+4.7\ m\ s^{-1}}$$

4	Water is ejected at a speed of 0.5 m s^{-1} onto a wall from the nozzle of a hose with a diameter of 0.01 m. The density of water is 1000 kg m^{-3}. If the water does not rebound, what is the force exerted by the water on the wall?

	A	5.0×10^{-3} N	**B**	2.0×10^{-2} N	**C**	2.5×10^{-2} N	**D**	7.9×10^{-2} N

L2 **Answer: B**

Force on water by wall
= Momentum **change** per unit time for the **water**
= (mass per unit time) x (change in velocity of water)
= (density x volume per unit time) x (change in velocity of water)
= (density x cross-sectional area x speed) x (final velocity – initial velocity of water)
= $(1000)(\pi(0.005)^2)(0.5) \times (0 - 0.5)$
= - 0.0196 N
= $- 2.0 \times 10^{-2}$ N (2 s.f.)

By Newton's third law,
Force on water by wall = - Force on wall by water

5	A particle moving with kinetic energy *K* undergoes a head-on perfectly inelastic collision with an identical particle that is initially at rest. What is the total kinetic energy of both particles, in terms of *K*, after the collision?

	A	0.25 *K*	**B**	0.5 *K*	**C**	*K*	**D**	2*K*

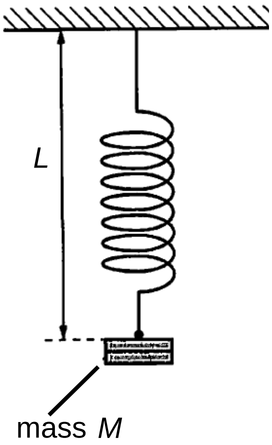
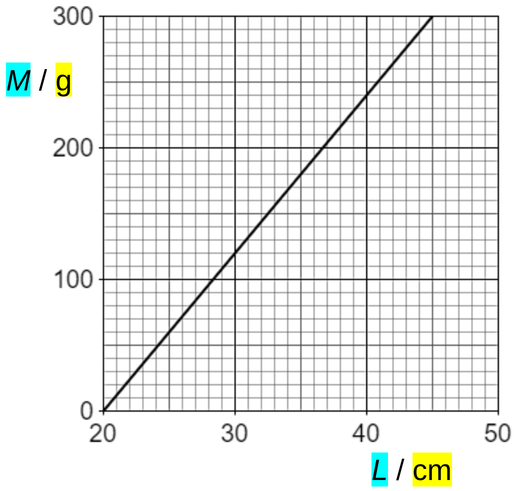
L2 **Answer: B**

Let m be the mass of each particle and u be the initial speed of the first particle.
$K = \frac{1}{2} m u^2$

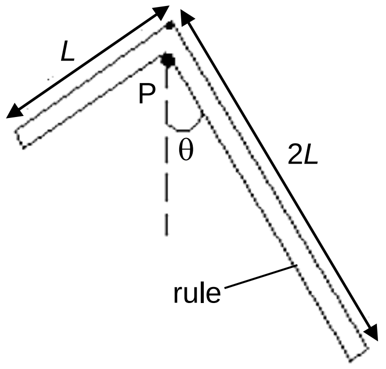
In a perfectly inelastic collision, the two particles **stick together and move with a common velocity V after the collision**.

By principle of conservation of momentum,
$mu + 0 = (m + m) V$
$mu = (2m) V$
$V = \frac{1}{2} u$

Thus total KE of both particles after the collision
$= \frac{1}{2} (2m) V^2$
$= m (\frac{1}{2} u)^2$
$= \frac{1}{2} (\frac{1}{2} m u^2) = \frac{1}{2} K$ = **0.5 K**

6	One end of a spring is fixed to a support. A mass is attached to the other end of the spring as illustrated below. The variation of mass *M* with length *L* is shown in the graph below.   What is the energy stored in the spring when it is extended to a length of 35 cm?						
	A	0.00750 J	**B**	0.0315 J	**C**	0.132 J	**D**	0.309 J
L2	**Answer: C** Energy stored in the spring = Work done by the mass on the spring = (Area bounded by the graph and horizontal axis) x (acceleration due to gravity) $= \frac{1}{2}\left(\frac{35-20}{100}\right)\left(\frac{180}{1000}\right)(9.81)$ = 0.132 J							

7	A uniform cube of volume 0.729 m^3 is floating in water. The density of water is 1000 kg m^{-3}. A load of 400 N is then placed onto the cube. The cube remains afloat. What is the change in the depth of the cube submerged in the water after the load is added?							
	A	0.0503 m	**B**	0.0559 m	**C**	0.494 m	**D**	0.900 m
L2	**Answer: A** Let the change in depth be *d*, Cross-sectional area of the cube $=\left(\sqrt[3]{0.729}\right)^2$ = 0.81 m^2 By the principle of flotation, Weight of **added load** = **Additional** weight of the water displaced due to the load's weight 400 = (0.81*d*) (1000) (9.81) *d* = 0.0503 m							

8	A right-angle rule hangs at rest from a peg P as shown below. The rule is uniform in density and cross-sectional area. One arm is of length *L* while the other arm is of length 2*L*.  What is the angle θ at which the rule will hang in equilibrium?						
	A	8°	**B**	14°	**C**	42°	**D** 76°

L3 **Answer: B**

Let *m* be the mass of the arm of length *L*.
Since rule is of uniform density and uniform cross-sectional area, the other arm of length 2*L* will have mass 2*m*.

Take P as the pivot,

Total anticlockwise moments = Total clockwise moments

$$(mg)\left[\frac{L}{2}(cos\theta)\right] = (2mg)\left[\frac{2L}{2}(sin\theta)\right]$$

$$[(cos\theta)] = (2)[2(sin\theta)]$$

$$tan\theta = \frac{1}{4}$$

$$\theta = 14^{o}$$

9	A car of mass 1200 kg travels along a horizontal road at a speed of 10 m s^{-1}. At the time it just begins to accelerate at 0.20 m s^{-2}, the total resistive force acting on the car is 160 N. What is the total output power developed by the car as it just begins its acceleration?							
	A	800 W	**B**	1600 W	**C**	2400 W	**D**	4000 W

L2 **Answer: D**

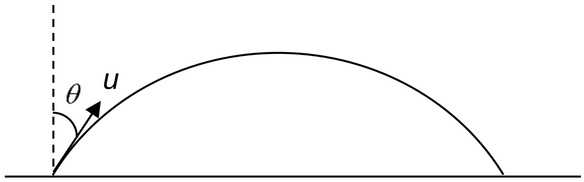
Apply Newton's second law,

$$F_D - F_R = ma$$
$$F_D - 160 = (1200)(0.20)$$
$$F_D = 400\ N$$

Output power = $F_D\ x\ v = 400\ x\ 10 = \mathbf{4000\ W}$

$F_D\ is\ the\ driving\ force$
$F_R\ is\ the\ total\ resistive\ force$

10 The diagram shows a projectile being launched at an angle θ to the vertical.



Ignoring air resistance, what fraction of its initial kinetic energy does the projectile have at the top of its trajectory?

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

L2 **Answer: D**

Initial kinetic energy = $\frac{1}{2}mu^2$
At the top of its trajectory, its velocity is $u\sin\theta$,
Therefore, its kinetic energy is $\frac{1}{2}m(u\sin\theta)^2$

Fraction = $\frac{kinetic\ energy\ at\ maximum\ height}{initial\ kinetic\ energy} = \sin^2\theta$

11 An object of mass m moves in a circular path of radius r at a constant angular speed ω.

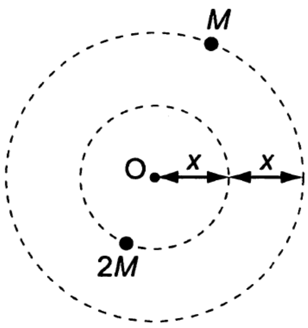
What is the work done by the centripetal force on the object?

A	zero	**B**	$r^2\omega^2$	**C**	$mr\omega^2$	**D**	$mr^2\omega^2$

L1 **Answer: A**

Centripetal force is always perpendicular to the instantaneous velocity, hence produces zero work done.

12 Two stars of mass M and $2M$, a distance $3x$ apart, rotate in circles about their common centre of mass O.



What is the angular speed of the star of mass $2M$?

A	$\frac{1}{3}\sqrt{\frac{GM}{x^3}}$	**B**	$\frac{1}{3}\sqrt{\frac{2GM}{x^3}}$	**C**	$\frac{1}{2}\sqrt{\frac{GM}{x^3}}$	**D**	$\sqrt{\frac{GM}{x^3}}$

L2 **Answer: A**

For each star's circular motion, the gravitational force exerted by the other star provides the centripetal force required.

Considering star of mass 2M,

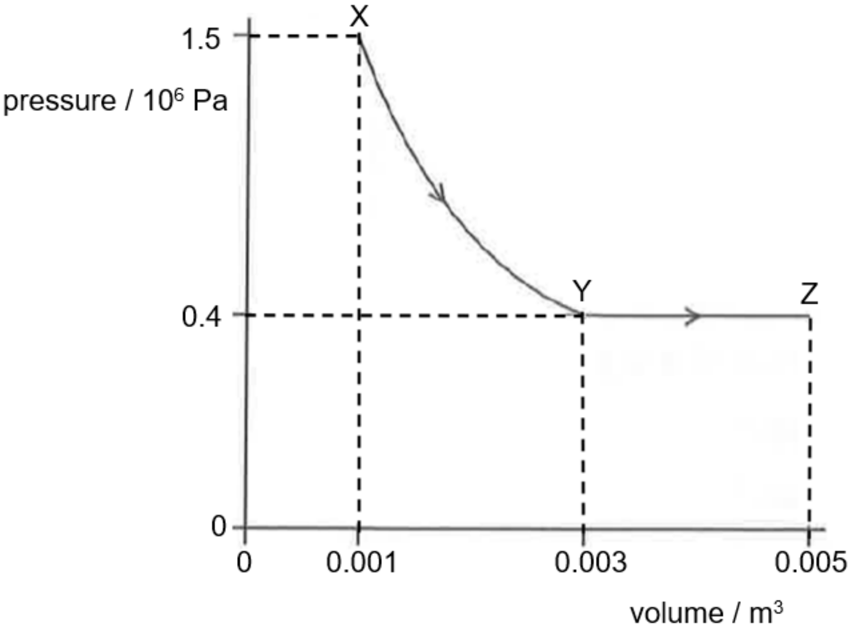
$F_G = F_c$

$$\frac{GM(2M)}{(3x)^2} = (2M)x\omega^2$$

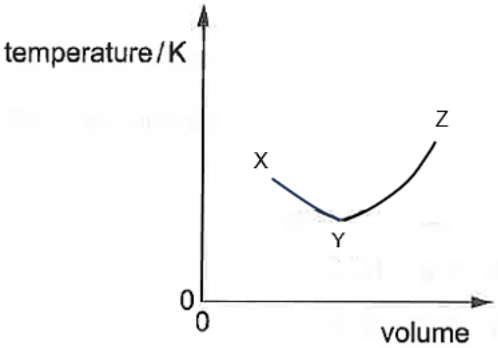
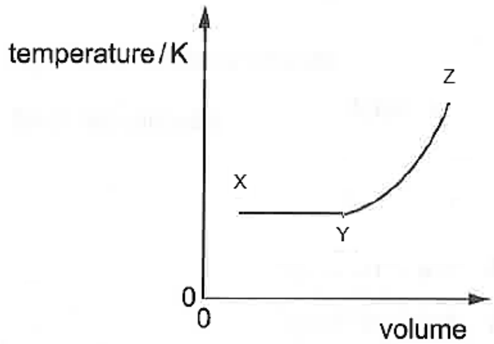
$$\omega^2 = \frac{GM}{9x^3}$$

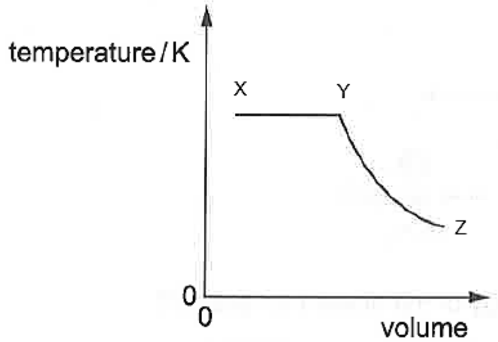
$$\omega = \sqrt{\frac{GM}{9x^3}} = \frac{1}{3}\sqrt{\frac{GM}{x^3}}$$

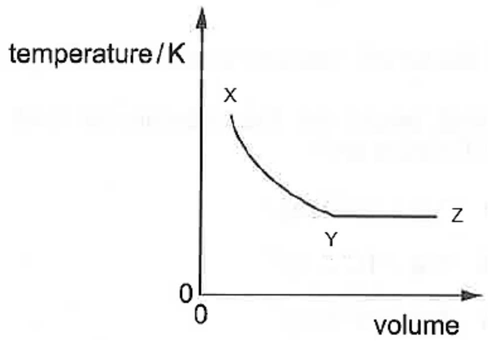
13 A fixed mass of ideal gas undergoes changes of pressure and volume starting at X, as shown.



Which graph shows how temperature (measured in kelvin) changes with volume?

	A	B
		
	C	**D**





L2 **Answer: A**

Apply pV = nRT

At X,
(1.5 x 10^6 x 0.001) = nRT
$T = \frac{1.5 \, x \, 10^3}{nR}$

At Y,
(0.4 x 10^6 x 0.003) = nRT
$T = \frac{1.2 \, x \, 10^3}{nR}$

At Z,
(0.4 x 10^6 x 0.005) = nRT
$T = \frac{2.0 \, x \, 10^3}{nR}$

temperature $T_Z > T_X > T_Y$

14 The mass of an argon atom is 10 times that of a helium atom.

At the same room temperature, what is the ratio of the mean translational kinetic energy of an argon atom to that of a helium atom?

A	0.01	**B**	0.1	**C**	1	**D**	10

L1 **Answer: C**

The **mean translational kinetic energy is proportional to the thermodynamic temperature**.

At the **same room temperature**, **both** argon atom and hydrogen atom have the **same mean translational kinetic energy.**

15 A man of mass 60 kg stands on an oscillating platform. The platform oscillates with a frequency of 0.50 Hz and an amplitude of 0.20 m.

What is the minimum normal contact force exerted by the platform on the man?

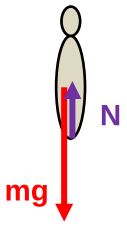
A	zero	**B**	120 N	**C**	470 N	**D**	590 N

L2 **Answer: C**

Let N be the Normal Contact Force.

The **minimum N** occurs at the **HIGHEST point** of the motion (i.e. UPPER amplitude position):

Draw a free body diagram of the man at the HIGHEST point:



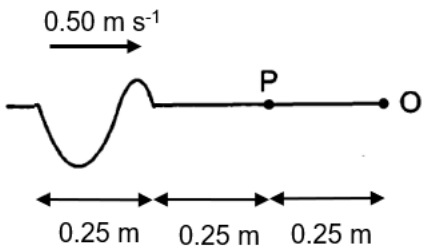
mg downwards, greater magnitude than N upwards.

Also, at Highest point, a is maximum.

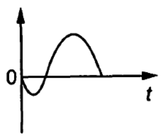
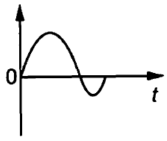
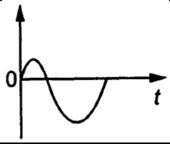
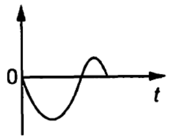
By Newton's 2nd law of motion: $mg - N = ma_{max}$ —(1)
From SHM equation: $a_{max} = \omega^2 x_o$ ---(2)

Sub (2) into (1):
$mg - N = m\omega^2 x_o$
$N = mg - m\omega^2 x_o = (60)(9.81) - (60)(2\pi(0.50))^2(0.20) = 470.1647 = 470\ N$

16 A wave pulse of length 0.25 m is shown at time $t = 0$. It moves along a string, fixed at point O, at 0.50 m s^{-1}.



Which graph best represents the displacement of point P with time for the period $t = 1.5$ s to 2.0 s?

A		**B**		**C**		**D**	

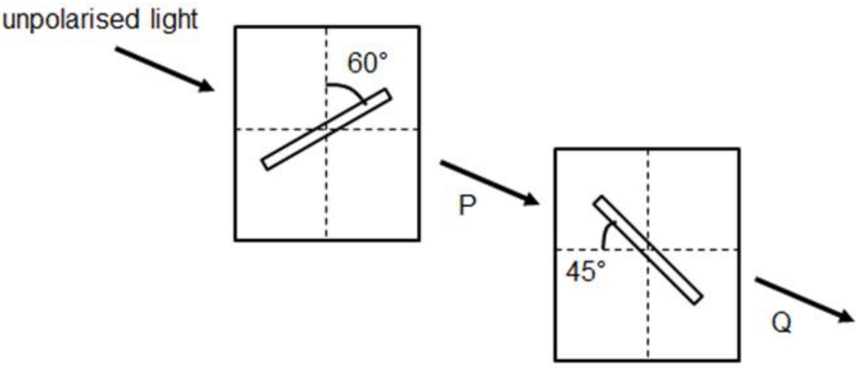
L3 **Answer: A**

At time t = 1.0 s, the pulse will be between P and O, and start to be reflected.

At time t = 1.5 s, the entire pulse would have reflected, and will be between P and O but the wave will be represented as:

From time t = 1.5 s to 2.0 s, the reflected wave will pass through point P with the above wave representation. So point P will be displaced downwards slightly first, then upwards.

17	A narrow, parallel beam of unpolarised light is passed through two optical polarisers. The first polariser's transmission axis is oriented at 60° to the vertical, while the second polariser's transmission axis is oriented at 45° to the horizontal. The light at P has amplitude *A*.



What is the amplitude of the light at Q?

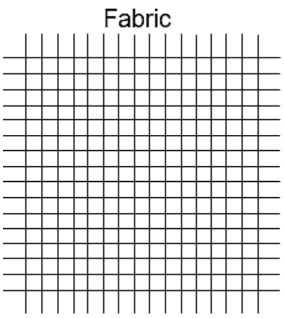
A	$A\cos 15°$	**B**	$A\cos 45°$	**C**	$A\cos 60°$	**D**	$A\cos 75°$

L2 **Answer: D**

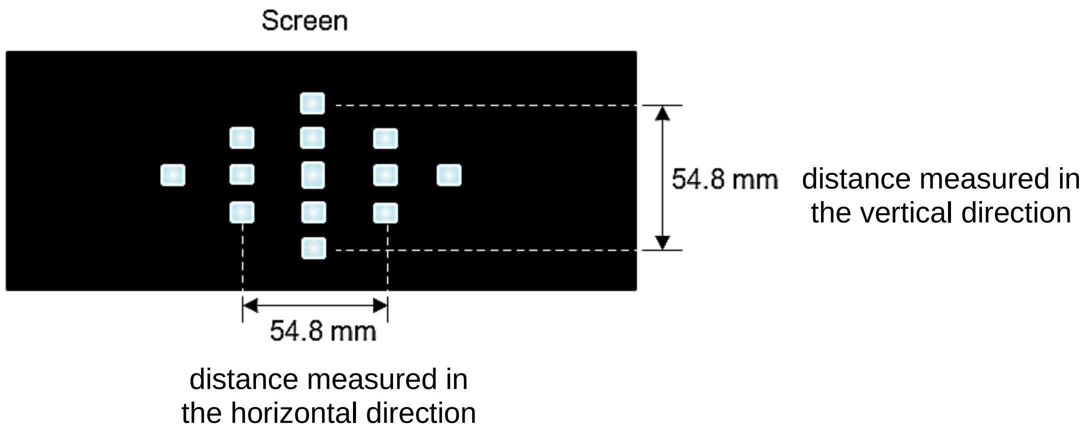
Angle between the polarized light at P and transmission axis of the 2nd polarizer
= 180 – (60 + 45)
= 75°

Amplitude of the light after passing through Q
= $\boldsymbol{A}$ **cos 75°**

18 A fabric consists of closely-spaced horizontal and vertical threads as shown.



When a monochromatic light of wavelength 685 nm is incident normally on the fabric, a diffraction pattern is observed on a screen placed at a distance of 2.00 m away, as shown below.



The separation between the horizontal threads is determined by the vertical fringe separation.

What is the separation between the horizontal threads of the fabric?

A	2.50×10^{-5} m	**B**	5.00×10^{-5} m	**C**	1.00×10^{-4} m	**D**	9.48×10^{-4} m

L3 **Answer: C**

Separation between the **horizontal threads** is determined by the **vertical fringe separation.**

Diffraction grating equation
$d \sin \theta = n\lambda$
Where
$\boldsymbol{\theta = \tan^{-1} [(0.0548/2) / 2.00] = 0.7849^{o}}$
n = 2
$\lambda = 685 \times 10^{-9}$
Thus,
d = <u>1.00×10^{-4} m</u>

<u>Extension Question:</u> For comparison, the spacing of the **vertical threads** is determined by the **horizontal fringe separation**:
$d \sin \theta = n\lambda$
Where
$\theta = \tan^{-1} [(0.0548/2) / 2.00] = 0.7849^{o}$
n = 1
$\lambda = 685 \times 10^{-9}$
Thus,
$d = 5.00 \times 10^{-5}$ m

19 The two headlights of a car are located 0.77 m apart. The headlights emit light of wavelength 550 nm.

The aperture of a human eye is about 1.8 mm in diameter.

What is the maximum distance away from the two headlights whereby these can still be resolved by the human eye?

A	23 m	**B**	41 m	**C**	270 m	**D**	2500 m

L2 **Answer: D**

By Rayleigh criterion,

$$\theta_{min} \approx \frac{\lambda}{b} = \frac{550\ x\ 10^{-9}}{1.8\ x\ 10^{-3}} = 3.05556\ x\ 10^{-4} rad$$

Approximating using "s = rθ",

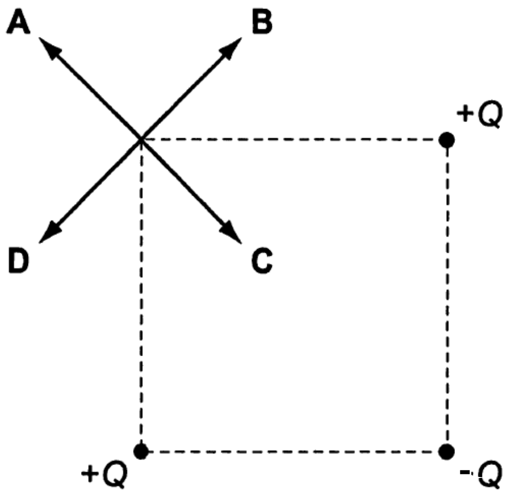
$$D \approx L_{max}\theta_{min}$$

$$0.77 \approx L_{max}(3.05556\ x\ 10^{-4})$$

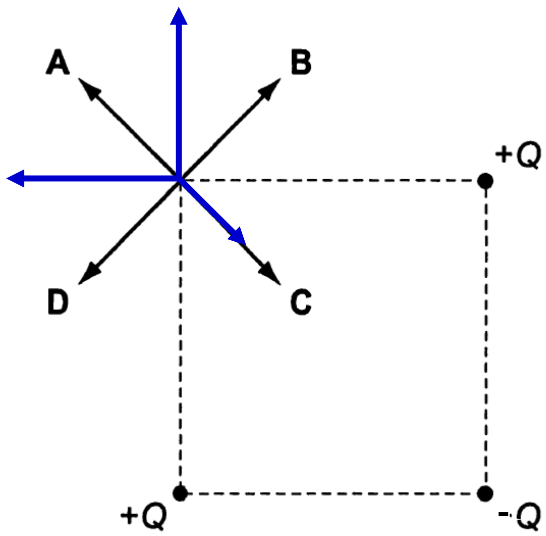
$$L_{max} \approx 2519.996\ =\ \mathbf{2500\ m}\ \ (round\ DOWN, since\ question\ asks\ for\ Max. L)$$

20 Two point charges of charge +*Q* and a third point charge of charge -*Q* are placed at three corners of a square.

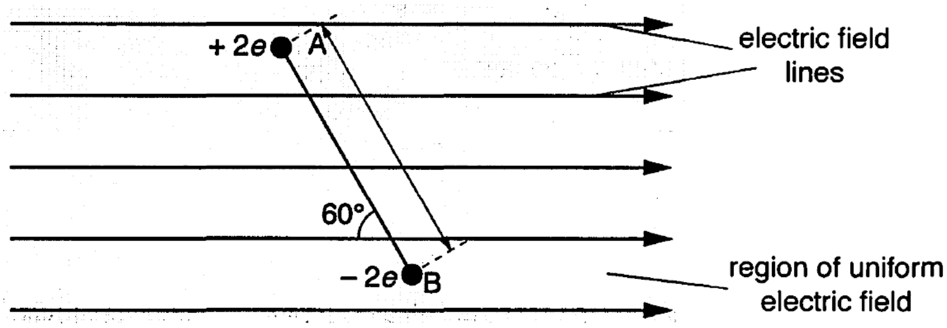
What is the direction of the resultant electric field at the fourth corner?



L2 **Answer: A**



21 Two ions A and B are linked to form a molecule and are situated in a uniform electric field as shown below.



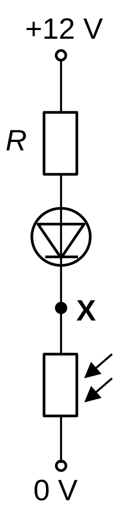
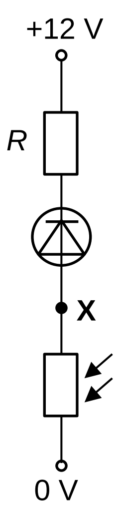
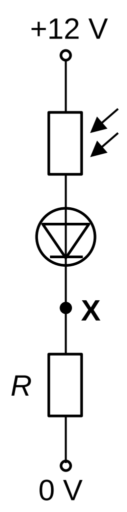
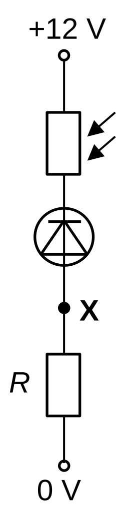
What is the direction of the force on B due to the electric field, and, what is the direction of the electrostatic force on B due to A?

	direction of the force on B due to the electric field	direction of the electrostatic force on B due to A
A	→	↘
B	←	↖
C	↗	↘
D	↙	↖

L1 **Answer: B**

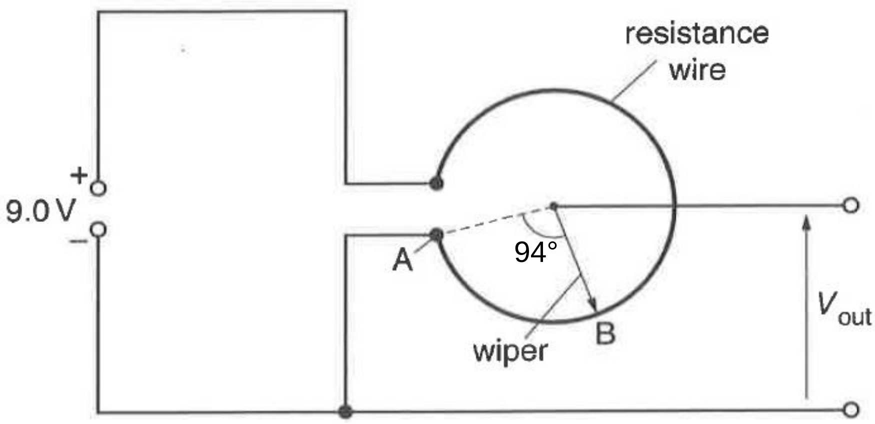
22 In bright light, a light-dependent resistor (LDR) has a resistance of *R*. It is connected in series with an ideal diode and a fixed resistor of resistance *R*. An ideal diode has zero resistance in the forward direction and infinite resistance in the reverse direction.

In which arrangement will the potential at **X** increase when the circuit is moved to a darker environment?

A	B	C	D
			

L2	**Answer: A** Diodes in **options B and D** are in **reverse biased** connection (**like an open circuit where the diode is**). ➔ **No current flows → zero p.d. across the resistance → potential at X = 0 V in both bright and dark conditions**, i.e. **no change in potential at X** for options B and D. ➔ Eliminate options B and D. Diodes in **options A and C** are in **forward biased** connection (**like zero resistance where the diode is**). ➔ **Current flows → non-zero p.d. across the resistance**. Since **LDR's resistance increases when moved into the dark**, by Potential Divider Principle, the **p.d. across the LDR will increase**. **Hence in option A potential at X will increase, while in option C potential at X will decrease.**

23 A rotary potentiometer consists of a length of uniform resistance wire connected to the terminals of the power supply.



A wiper (variable terminal) can rotate and make contact with any part of the resistance wire.

The connection wires to the power supply and the wire have zero resistance.

The power supply has e.m.f. 9.0 V and zero internal resistance.

The resistance wire has length 5.9 cm and is arranged in part of a circle of radius 1.0 cm.

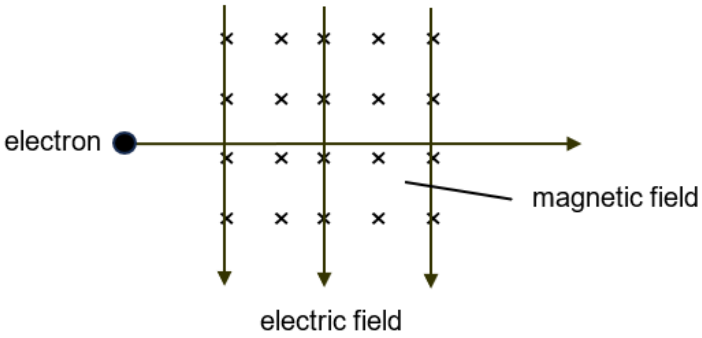
The wiper is rotated to point B through an angle of 94° from point A.

What is the output voltage V_{out} when the wiper is at point B?

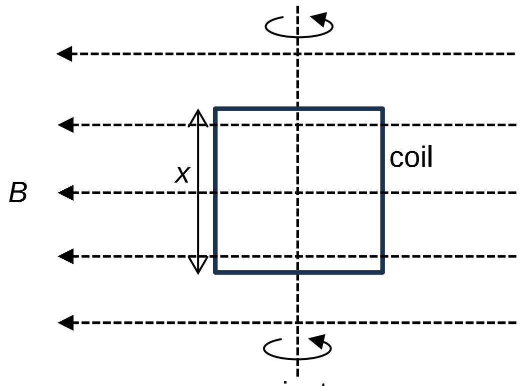
A	2.35 V	**B**	2.50 V	**C**	2.67 V	**D**	2.78 V

L3	**Answer: B** Circumference of circle = 2π(1.0) = 6.2832 cm Angle subtended by the resistance wire = (5.9 / 6.2832) x 360° = 338.04° By potential divider principle, V_{out} = (94° / 338.04°) x 9.0 V = **2.50 V** OR

	Length of wire AB = (94° / 360°) x 2π(1.0) = 1.6406 cm V_{out} = (1.6406 / 5.9) x 9.0 V = 2.2716 = **2.50 V**

24	A beam of electrons enters a region in which there are magnetic and electric fields directed at right angles to each other and to the beam direction as shown below. The electron beam passes straight through without deflection.  A second beam of electrons travelling at half the speed of the first beam of electrons is then directed along the same line. How is this second beam deviated?	
	A	Upwards in the plane of paper
	B	Downwards in the plane of paper
	C	Out of the plane of the paper
	D	Into the plane of the paper
L2	**Answer: A** The electric force acting on the electrons is directed upwards in the plane of the paper. Electric force = qE, which is independent of speed. By Fleming's left hand rule, the magnetic force acting on the electrons is directed downwards in the plane of the paper. Magnetic force **= *Bqv*** , which is proportional to speed. When the speed of the second beam of electrons is half its original speed, the magnetic force decreases (halved) while the electric force remains unchanged. Thus, the second beam of electrons deviates upwards in the plane of the paper.	

25	A 20-turns square coil of side of length x = 8.0 mm is pivoted at its centre and placed in a uniform magnetic field of flux density B = 0.010 T such that two sides of the coil are parallel to the field and two sides of the coil are perpendicular to the field as shown below. The coil rotates about the pivot with a frequency of 25 Hz.						



What is the maximum e.m.f. induced by the coil?

A	1.3×10^{-5} V	**B**	3.2×10^{-4} V	**C**	2.0×10^{-3} V	**D**	1.2 V

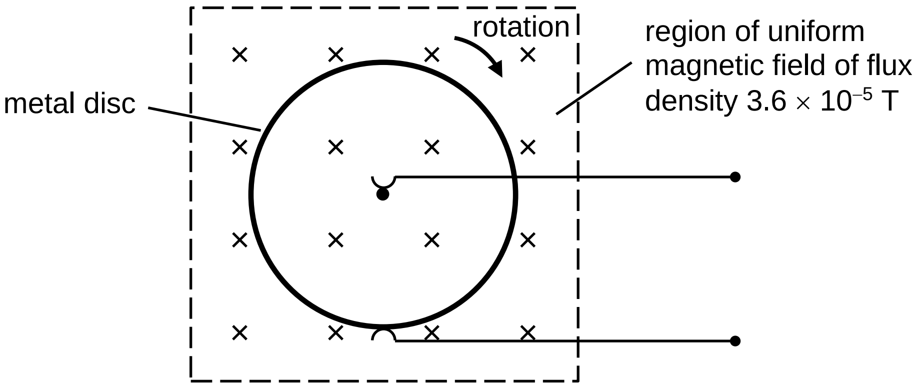
L2 **Answer: C**

Maximum e.m.f. induced $E_0 = NBA\omega = NBA(2\pi f)$

$$= (20)(0.010)(8.0\times10^{-3})^2[2\pi(25)]$$

$$\mathbf{= 2.0 \times 10^{-3}\ V}$$

26 The diagram below shows a metal disc of area A situated in a uniform magnetic field of flux density 3.6×10^{-5} T. The plane of the metal disc is perpendicular to the magnetic field which is directed into the plane of the diagram. The metal disc is rotated about an axis through its centre at 1500 revolutions per minute. An e.m.f. of 3.7×10^{-7} V is induced between the centre of the metal disc and its rim.



What is the area A of the metal disc?

A	2.2×10^{-8} m^2	**B**	4.1×10^{-4} m^2	**C**	3.5×10^{-2} m^2	**D**	5.2×10^{4} m^2

L2 **Answer: B**

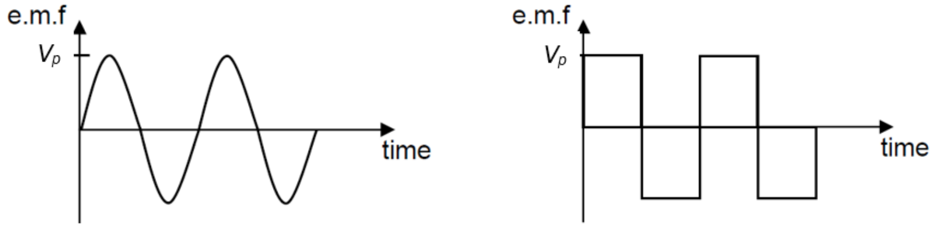
By Faraday's law of electromagnetic induction,

$$E = \left|-\frac{d\Phi}{dt}\right| = \frac{BA}{T} = BAf$$

$$3.7\times10^{-7} = \left(3.6\times10^{-5}\right)A\left(\frac{1500}{60}\right)$$

A = **4.1×10^{-4} m^2**

27 A voltage supply connected to a signal generator can either produce an alternating voltage with a sinusoidal waveform or a square waveform with the same peak value of e.m.f. V_p as illustrated below. The voltage supply is connected across a load resistor.



What is the ratio $\dfrac{\text{mean power dissipated in the load resistor by the square waveform}}{\text{mean power dissipated in the load resistor by the sinusoidal waveform}}$?

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

L2 **Answer: C**

$$\langle P\rangle = \frac{v_{rms}{}^2}{R}$$

For sinusoidal waveform,

$$\langle P\rangle = \frac{\left(\frac{v_p}{\sqrt{2}}\right)^2}{R} = \boldsymbol{\frac{v_p{}^2}{2R}}$$

For square waveform, using graphical method,

$$v_{rms} = v_p$$

$$\langle P\rangle = \boldsymbol{\frac{v_p{}^2}{R}}$$

Ratio = 2

28 To observe diffraction rings by a carbon film, a beam of electrons is accelerated from rest across a potential difference of V so that the de Broglie wavelength of the electrons is 1.0 x 10^{-10} m.

What is the value of V ?

A	90 V	**B**	150 V	**C**	270 V	**D**	330 V

L2 **Answer: B**

de Broglie wavelength,
$p = \frac{h}{\lambda}$ ------ (1)

By conservation of energy,
Loss in electric potential energy = Gain in kinetic energy

$qV = \frac{1}{2}mv^2 = \frac{p^2}{2m}$ ------ (2)

Sub (1) into (2),

$$qV = \frac{h^2}{2m\lambda^2}$$

$$V = \frac{h^2}{2qm\lambda^2} = \frac{(6.63\ x\ 10^{-34})^2}{2(1.60\ x\ 10^{-19})(9.11\ x\ 10^{-31})(1.0\ x\ 10^{-10})^2}$$

$V = 150\ V$ (2 s.f.)

29 A nuclear fusion reaction is as follows:

$$^{7}_{3}\text{Li} + {}^{1}_{1}\text{H} \rightarrow 2\,^{4}_{2}\text{He}$$

The masses of the nuclei are as follow:

$^{7}_{3}$Li : 7.018u

$^{1}_{1}$H : 1.008u

$^{4}_{2}$He : 4.004u

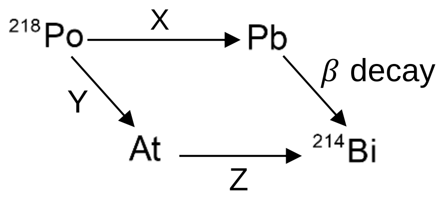
What is the amount of energy released in this reaction?

A	9.0×10^{-21} J	**B**	2.7×10^{-12} J	**C**	6.0×10^{-10} J	**D**	1.6×10^{15} J

L2 **Answer: B**

Energy released per fusion reaction
= (mass of reactants – mass of products) (c^2)
= [(7.018 + 1.008) – 2(4.004)]$(1.66\ x\ 10^{-27})\ (3.00\ x\ 10^{8})^2$
= $\mathbf{2.6892\ x\ 10^{-12} J}$
= $\mathbf{2.7\ x\ 10^{-12}\ J}$

30 ^{218}Po decays to ^{214}Bi via two pathways as shown in the figure below.



What are the possible radioactive decay modes X, Y and Z?

	X	Y	Z
A	γ decay	α decay	β decay
B	α decay	β decay	α decay
C	β decay	α decay	γ decay
D	α decay	α decay	β decay

L2 **Answer: B**

Decay mode X must be an α decay because Pb undergoes a β decay to ^{214}Bi which only changes the atomic number and not the mass number.

	To decay from ^{218}Po to Pb to ^{214}Bi there must be a decrease in the mass number by 4, from 218 to 214. α particle is ^4_2He which can account for this decrease in mass number. Options A and C are out. Option D is out because if decay mode Y is an α decay, the daughter nuclide would be Pb and not At.

END OF PAPER