NAME ______________________ CLASS 2T

Catholic Junior College

JC2 Mid-Year Examinations

Higher 2

PHYSICS

9749/01

Paper 1 Multiple Choice Questions

28 June 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	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\,\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\mathrm{K} = T/{}^\circ\mathrm{C} + 273.15$
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 The period of oscillation T of a simple pendulum of length L is given by

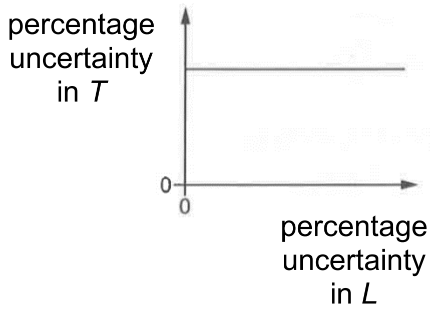
$$T = 2\pi\sqrt{\frac{L}{g}}$$

where g is the acceleration of free fall.

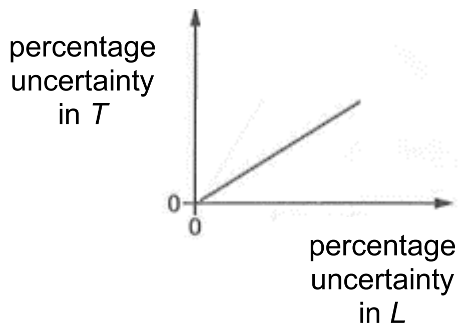
Measurements were taken for different values of L and the corresponding T.

Which graph shows how the percentage uncertainty in T varies with the percentage uncertainty in L?

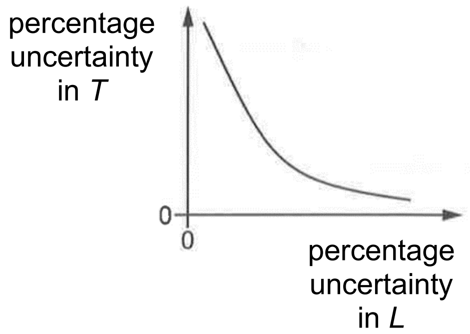
A



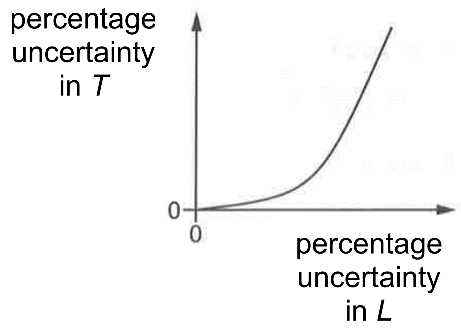
B



C



D



L2 **Answer: B**

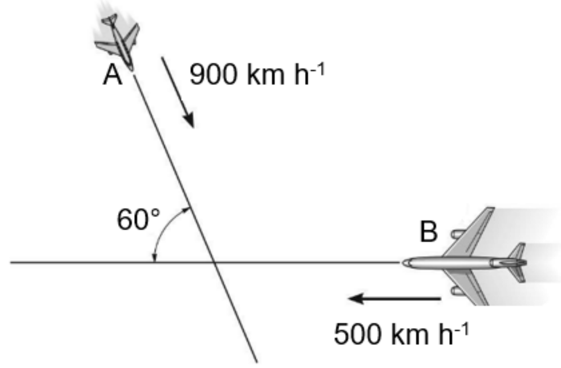
$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta L}{L}$$

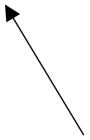
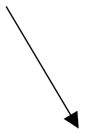
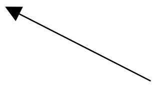
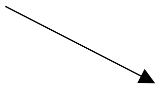
$$\frac{\Delta T}{T} x100\% = \frac{1}{2}\left(\frac{\Delta L}{L} x100\%\right)$$

Thus the graph **is linear with non-zero gradient equal to ½ and passing through (0, 0)**.

2 Planes A and B are cruising at the same altitude. The velocity of A is 900 km h^{-1} and the velocity of B is 500 km h^{-1}. The angle between their line of paths is 60°.

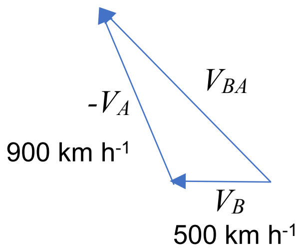


At this instant, which arrow represents the velocity of plane B relative to plane A?

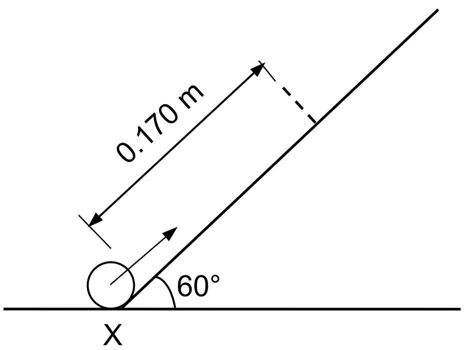
A		**B**		**C**		**D**	

L2 **Answer: A**

relative velocity of plane B with respect to plane A $v_{BA} = v_B - v_A = v_B + (-v_A)$
v_B = velocity of plane B
v_A = velocity of plane A
v_{BA} = velocity of the plane B relative to the plane A



3 In the diagram below, a ball at point X is projected up a smooth slope with an initial velocity. It momentarily comes to a stop after moving a distance of 0.170 m.



What is the time taken for the ball to travel a distance of 0.170 m up the slope?

A	0.100 s	**B**	0.186 s	**C**	0.200 s	**D**	0.263 s

L2 **Answer: C**

Magnitude of acceleration along the slope, a = g sin 60°

Take upslope as positive direction.

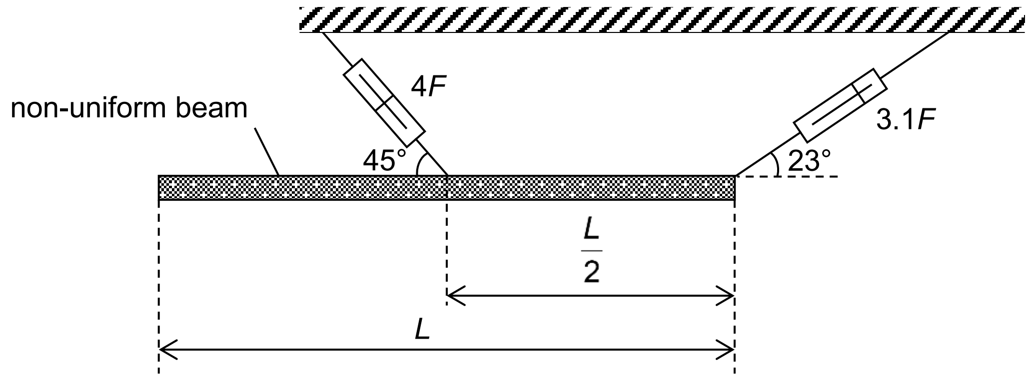
Determine the initial velocity of the ball,

$$v^2 = u^2 + 2as$$
$$0^2 = u^2 + 2(-9.81 \sin 60°)(0.170)$$
$$u = 1.69957\ ms^{-1}$$

Determine the time taken,

$$v = u + at$$
$$0 = 1.69957 + (-9.81 \sin 60°)\,t$$
$$t = 0.200\ s$$

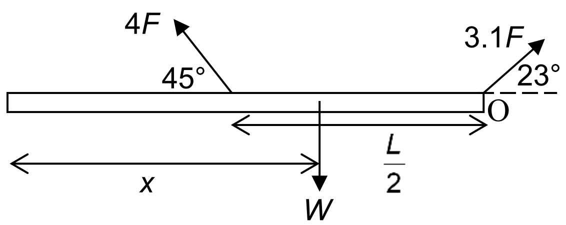
4 A non-uniform beam of length *L* hangs horizontally from two spring balances as shown. The forces recorded by the balances are 4*F* and 3.1*F*. The spring balance that registers 4*F* is at 45° to the horizontal and at the midpoint of the beam. The spring balance that registers 3.1*F* is at 23° to the horizontal and at the right end of the beam.



What is the horizontal distance of the centre of gravity of the beam from the left end of the beam?

A	0.35*L*	**B**	0.38*L*	**C**	0.62*L*	**D**	0.65*L*

L2 **Answer: D**



Let the C.G. be at distance *x* from the **left** end of the beam.

Consider vertical equilibrium of forces,
$W = 3.1F \sin 23° + 4F \sin 45°$

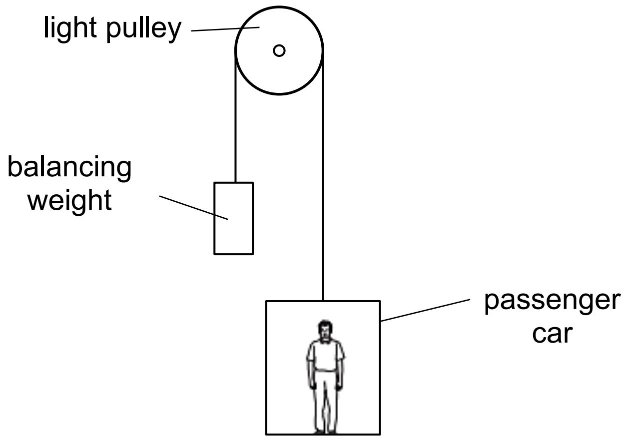
Taking moments about point O,

$$W(L-x)=(4F\sin 45°)\left(\frac{L}{2}\right)$$

$$L-x=\frac{(4\sin 45°)FL}{2W}=\frac{4FL}{2\sqrt{2}\left(3.1\sin 23°F+\frac{4}{\sqrt{2}}F\right)}=0.35L$$

Horizontal distance from left hand end = $L-0.35L=0.65L$

5 An elevator consists of a passenger car of mass 520 kg, supported by a cable that runs over a light, frictionless pulley to a balancing weight of mass 640 kg. The balancing weight falls as the passenger car rises. The passenger has a mass of 80 kg.



What is the magnitude of the acceleration of the passenger car as it rises?

A	0.032 m s^{-2}	**B**	0.32 m s^{-2}	**C**	0.65 m s^{-2}	**D**	0.75 m s^{-2}

L2 **Answer: B**

Let tension in cable be T.
Using Newton's 2nd law of motion for passenger car, $F_{net} = ma$

$T-(520+80)g=(520+80)a$ ------(1)

Using Newton's 2nd law of motion for balancing weight,

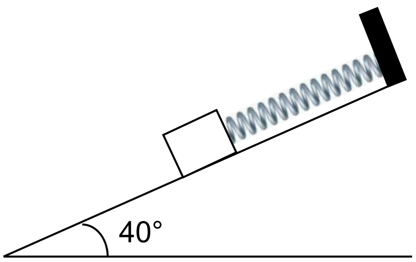
$640g-T=640a$ ---------(2)

(1) + (2):

$T-(520+80)g+640g-T=(640+520+80)a$

$a=0.316$ m s^{-2}

6 A 2.0 kg mass is attached to an unstretched spring fixed to a support and placed on a smooth slope inclined at 40° to the horizontal. The spring constant is 400 N m^{-1}.

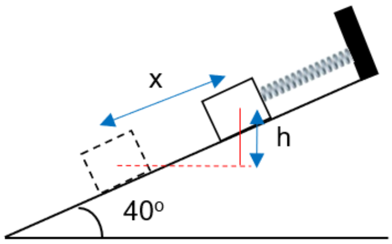


	When the mass is released, it slides down before stopping momentarily. What is the extension of the spring at this instant?

	A	0.032 m	**B**	0.049 m	**C**	0.063 m	**D**	0.075 m

L2 **Answer: C**

Consider the vertical height, h that the mass has moved when it slides down before momentarily coming to a rest. The extension of the spring, x is also the distance moved by the mass parallel to the slope.



Gain in Elastic PE by spring = Loss in Gravitational PE by mass

$$\frac{1}{2}kx^2 = mgh$$

$$\frac{1}{2}kx^2 = mgx\sin 40°$$

$$\frac{1}{2}(400)x = (2.0)(9.81)\sin 40°$$

$$\boldsymbol{x = 0.063\ m}$$

7	The force resisting the motion of a car is proportional to the square of the car's speed. The magnitude of the force at a speed of 20 m s^{-1} is 800 N. What effective power is required from the car's engine to maintain a steady speed of 40 m s^{-1}?

	A	3.2 kW	**B**	16 kW	**C**	64 kW	**D**	128 kW

L2 **Answer: D**

$P_{engine} = F_{engine}\ v$

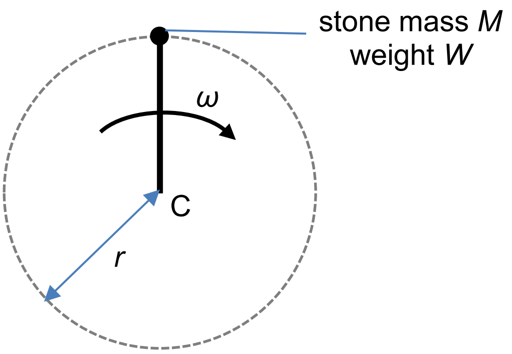
Since car is travelling at constant speed, $F_{engine} = F_{resistive}$. Thus,
$P_{engine} = F_{resistive}\ v$

Given $F_{resistive} \propto v^2$
$F_{resistive} = kv^2$
$(800) = k\ (20)^2$
$k = 2$

$F_{resistive}' = (2)\ (40)^2$
$F_{resistive}' = 3200$ N

$P_{engine}' = F_{resistive}'\ v$
$= (3200)\ (40)$
$= 1.28 \times 10^5$ W = 128 kW

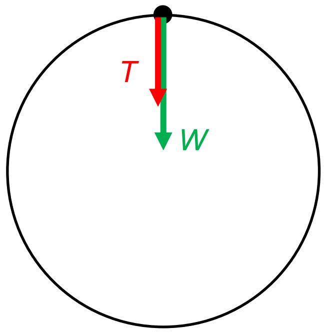
8 A stone of mass M and weight W is attached to a string and is rotating in a vertical circle of radius r. The stone has an angular velocity of ω when it is vertically above the centre C of the circle.



What is the tension in the string when the stone is vertically above the centre of the circle?

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

L2 **Answer: A**



The resultant of tensile force and weight provide for the centripetal force required. Therefore,

$T + W = Mr\omega^2$

$T = Mr\omega^2 - W$

9 A 20 W filament lamp has been operating normally for an hour so that its temperature is constant.

When the first law of thermodynamics is used to quantitatively describe the filament of the lamp after this time, which row correctly describes the application of the first law?

	rate of increase of internal energy / W	rate of heating the filament / W	rate of doing work on the filament / W
A	0	-20	+20
B	0	+20	-20
C	+20	+20	0
D	+20	0	+20

L2 **Answer: A**

Since **temperature** of the filament is **constant, ΔU = 0 → Eliminate A & B**

For temperature to remain constant (ΔU = 0),
rate of energy transferred **to** filament = rate of energy transferred **out** of filament

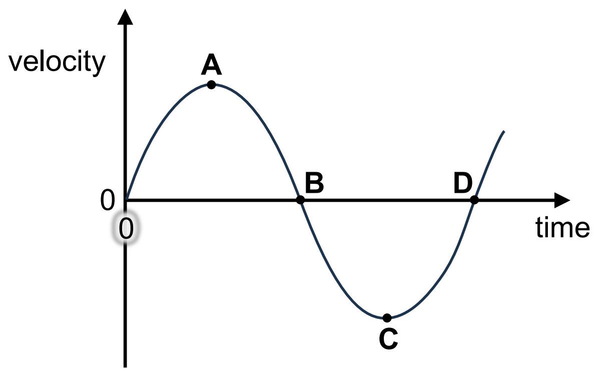
[Turn over

Since **filament is hotter than surrounding temperature**, it **loses heat** to the surroundings. Thus **Q< 0**. **Thermal energy** is being transferred **out** of the filament.

Positive work is being done on the filament by the electric current (recall the p.d. across a component in a circuit as the work done to drive a unit charge through the component). *(Microscopically, collisions of mobile electrons with the metal cations in the filament when current flows causes the electrons to lose KE and the cations to gain internal energy. But the electrons and metal cations are both part of the filament (same system). However, in the First Law of Thermodynamics, W refers to work done by external agent on the system.*
→What causes the electrons to move? → Electric force due to the source of e.m.f. setting up a p.d. and hence electric field across the filament. Thus W represents the work done by the electric force on the electrons in the filament.)
Thus **W > 0.**

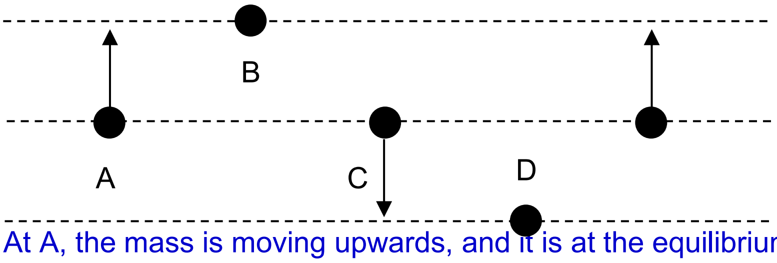
Only option A satisfies ΔU = 0, Q< 0 and W > 0.

10	An ideal gas with a total mass of 1.60 kg exerts a pressure of 1.00×10^5 Pa in a sealed container of volume 0.500 m^3. What is the root-mean-square speed of the gas molecules?						
	A	250 m s^{-1}	**B**	286 m s^{-1}	**C**	300 m s^{-1}	**D**	306 m s^{-1}
L2	**Answer: D** $p = \frac{1}{3}(Nm/V)\langle c^2\rangle$ where Nm is the Total mass of gas, so **Nm = 1.60 kg** $1.00 \times 10^5 = \frac{1}{3}(1.60 / 0.500)\langle c^2\rangle$ $\sqrt{\langle c^2\rangle}$ = **306 m s^{-1}**						

11	The diagram shows a velocity-time graph for a mass oscillating up and down on the end of a vertical spring. Taking velocity vectors upwards to be positive, which point represents the velocity of the mass when at the lowest point of its motion? 
L2	**Answer: D** **At the lowest point,** **Mass is at instantaneous rest, so v = 0. → Either option B or D.**

Acceleration is maximum & upwards in direction, so gradient a = dv/dt must be positive.
→ Answer is D.

Additional notes:



At A, the mass is moving upwards, and it is at the equilibrium position. At B, it is at the highest position. At C, the mass is moving downwards, and it is at the equilibrium position. At D, it is at the lowest position.

12 An object placed on a horizontal platform is oscillating vertically in simple harmonic motion with a frequency of 1.5 Hz.

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

A	0.11 m	**B**	1.0 m	**C**	4.2 m	**D**	9.0 m

L2 **Answer: A**

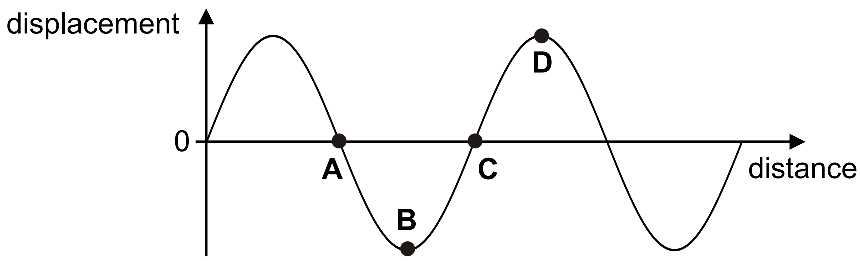
For the object to remain in contact with the platform throughout the motion, its acceleration at the upper amplitude position must not be greater than 9.81 m s^{-1}.
Therefore, the maximum acceleration of the platform will be 9.81 m s^{-2}.

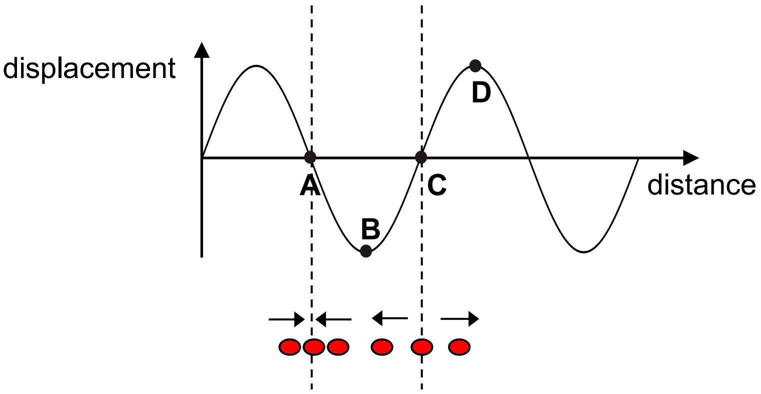
$$a_{max} = \omega^2 x_0$$

$$x_0 = \frac{a_{max}}{\omega^2} = \frac{a_{max}}{(2\pi f)^2} = \frac{9.81}{(2\pi(1.5))^2} = 0.11\ m$$

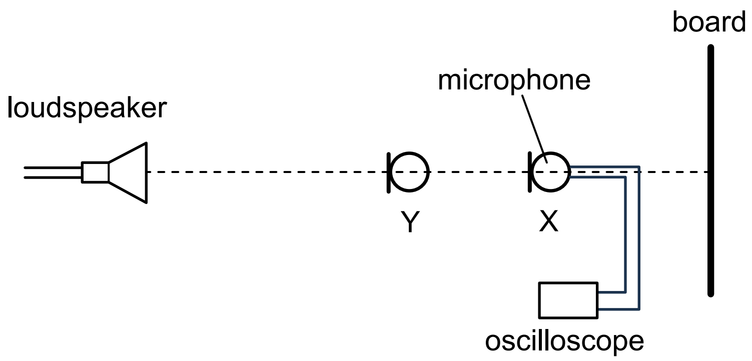
13 A sound wave travelling towards the right through air causes the air molecules to be displaced from their equilibrium positions. The graph below shows the variation with distance of the displacement of air molecules at a particular instant of time.

Taking the displacement towards the right as positive, which is a point of compression?

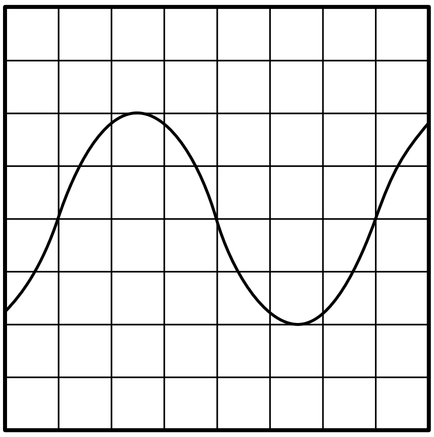


L2	**Answer: A** A is a point of compression, the molecules on the left of A is moving towards A (rightwards) and the molecules on the right of A is moving towards A (leftwards). C is a point of rarefaction, the molecules on the left of C is moving away from C (leftwards) and the molecules on the right of C is moving away from C (rightwards). 

14 Stationary sound waves are investigated using the apparatus shown.



X and Y are adjacent positions of the microphone that give maximum amplitude of the oscilloscope, as shown.



oscilloscope screen when microphone is at X

The distance XY is 4.0 cm and the time base of the oscilloscope is 0.040 ms div^{-1}.

What are the frequency and the wavelength of the sound wave?

	wavelength / cm	frequency / kHz

A	4.0	4.2
B	8.0	4.2
C	4.0	8.3
D	8.0	8.3

L2 **Answer: B**

Sound wave is a longitudinal wave, where there are pressure variations in the wave.

In a Stationary longitudinal wave, maximum pressure variations occur at the displacement nodes; minimum pressure variations occur at the displacement antinodes.

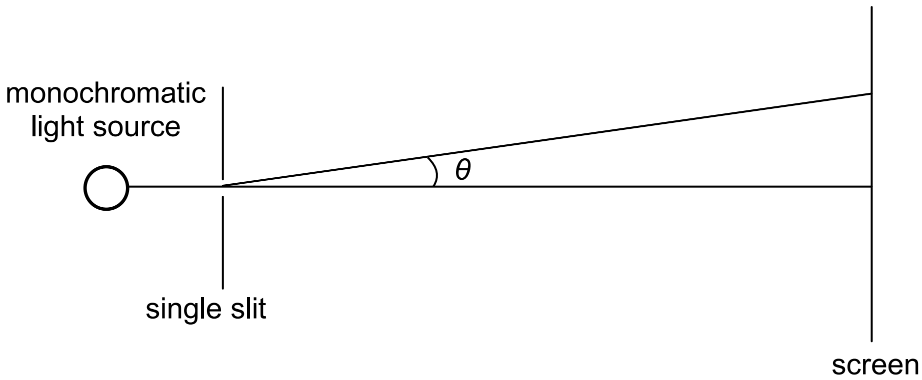
A microphone is a pressure sensor.

Hence at X (and at Y), these correspond to positions of maximum pressure variations (pressure antinode; displacement node).

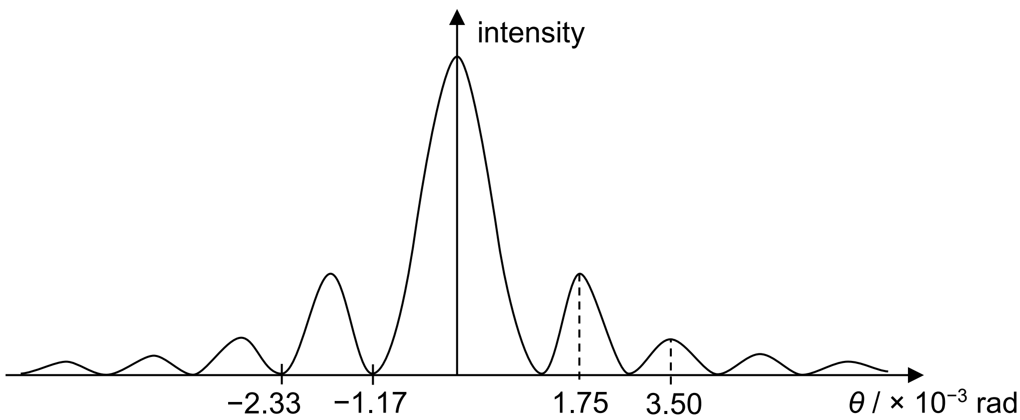
In a Stationary wave,
Distance between adjacent nodes/antinodes = ½ λ
Distance XY = ½ λ
4.0 cm = ½ λ
λ = 2 x 4.0 = 8.0 cm

From the trace on the oscilloscope screen,
One cycle spans 6 divisions → One period = 6 x 0.040 ms = 0.00024 s
frequency **=** 1 / period = 1 / 0.00024 = 4166.7 Hz = **4.2 kHz**

15 A single slit is illuminated by monochromatic light of wavelength 700 nm.



The following graph shows the variation of intensity with angular position θ.



	What is the width of the slit?							
	A	0.3 mm	B	0.4 mm	C	0.5 mm	D	0.6 mm

L2 **Answer: D**

Single-slit diffraction equation:
$b \sin \theta_{min} = m\lambda$ where m is the order of intensity MINIMA (not maximum)

Since first minima (m = 1) occurs at 1.17×10^{-3} rad,
$b \sin (1.17 \times 10^{-3} \text{ rad}) = (1)(700 \times 10^{-9})$
b = **0.6 mm**

OR, using the second minima (m = 2) which occurs at 2.33×10^{-3} rad,
b = **0.6 mm**

**** use radians mode of your calculator***

16	To be able to just resolve a grain of red sand of diameter 100 μm, the maximum distance your eye can be positioned is 20 cm away from the grain. A grain of violet sand has diameter 80 μm. Assuming that the aperture of your eye remains unchanged in diameter, what is the maximum distance your eye can be positioned away from the violet grain of sand in order to just resolve its image?							
	A	28 cm	B	69 cm	C	120 cm	D	180 cm

L2 **Answer: A**

Maximum distance → **Just** resolved → $\boldsymbol{\theta = \theta_{min}}$

Where:
- θ is estimated using "$s = r\theta$", where s is the diameter of the sand grain, and, r is the distance of eye from sand grain in this context; and
- $\theta_{min} \approx \lambda / b$ from Rayleigh's criterion, where b is the aperture diameter of the eye.

Violet light has shorter wavelength than Red light, and thus gives greater resolving power (since θ_{min} smaller).
Estimate the wavelengths of Red light and Violet light:
$\boldsymbol{\lambda_{red} \approx 700}$ **nm** **and** $\boldsymbol{\lambda_{violet} \approx 400}$ **nm**

For the Red grain:
Using "$s = r\theta$" to estimate,
100 μm ≈ (20 cm) θ
$\theta \approx 0.0005$ rad

When the eye JUST resolves the Red grain, $\theta = \theta_{min} \approx 0.0005$ rad
From Rayleigh's criterion,
$\theta_{min} \approx \lambda / b$
0.0005 rad ≈ (700 nm) / b
$b \approx 0.0014$ m (Aperture diameter of the eye)

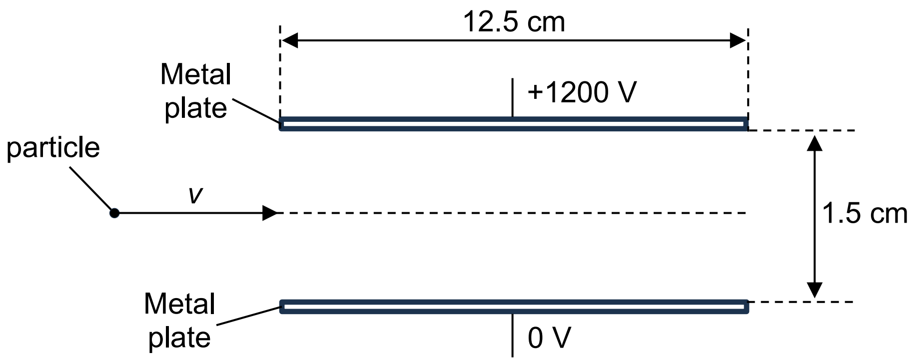
For the Violet grain:
From Rayleigh's criterion,
$\theta_{min} \approx \lambda / b$

$\theta_{min} \approx$ (400 nm) / (0.0014 m) = 2.8571 x 10^{-4} rad

When the eye JUST resolves the Red grain, $\theta = \theta_{min} \approx 2.8571 \times 10^{-4}$ rad

Using "*s = rθ*" to estimate,
80 μm ≈ (maximum distance) (2.8571 x 10^{-4} rad)
maximum distance ≈ 0.28 m = 28 cm

17 Two parallel metal plates each of length 12.5 cm are in a vacuum and separated by a distance of 1.5 cm as shown below.



The potential difference of 1200 V between the plates gives rise to a uniform electric field in the region between the plates.

A particle of charge +4.8 × 10^{-19} C and mass 8.2 × 10^{-27} kg has an initial speed *v*. It is travelling parallel to the metal plates and enters the electric field mid-way between the plates.

What is the minimum speed *v* such that the particle travels beyond the plates without colliding with the lower plates?

A	1.9 × 10^5 m s^{-1}	**B**	2.7 × 10^5 m s^{-1}	**C**	1.6 × 10^6 m s^{-1}	**D**	2.2 × 10^6 m s^{-1}

L3 **Answer: D**

Electric force F_E acts downwards on the particle. Particle's weight mg also acts downwards.
Since mg <<< F_E, neglecting the weight will not affect the final answer significantly.

Hence the Net Force on the particle ≈ F_E

By Newton's second law of motion,

$$F_E = ma$$

$$qE = ma$$

$$q\frac{\Delta V}{d} = ma$$

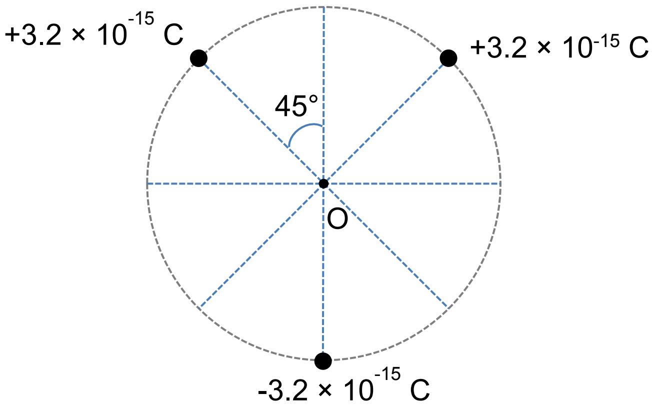
$$a = \frac{q\Delta V}{md} = \frac{4.8\times10^{-19}\ \ 1200}{8.2\times10^{-27}\ \ 1.5\times10^{-2}}$$

$$a = 4.6829\times10^{12}\text{ m s}^{-2}$$

Time taken for charge to move a **vertical** displacement equal to **half**-plate-separation,

	$s_y = u_y t + \frac{1}{2} a_y t^2$ $\frac{1.5\times10^{-2}}{2} = 0 + \frac{1}{2}\ 4.6829\times10^{12}\ t^2$ $t = 5.6596\times10^{-8}$ s Therefore, **minimum** entry speed to clear the plates, $u_x = \frac{s_x}{t} = \frac{12.5\times10^{-2}}{5.6596\times10^{-8}} = 2.2086\times10^{6}$ m s$^{-1} = v$

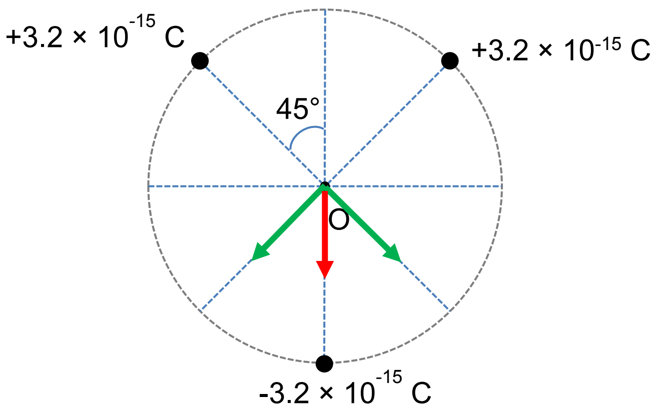
18 Three point charges, equal in magnitude of 3.2 × 10^{-15} C but different signs as shown, are placed evenly on the circumference of a circle with radius 5.0 mm.



What is the electric field strength at O, the centre of the circle?

	A	5.8 × 10^{-3} N C^{-1}	**B**	0.48 N C^{-1}	**C**	1.2 N C^{-1}	**D**	2.8 N C^{-1}

L2 **Answer: D**



The green arrow represents the electric field strength due to the two +3.2 × 10^{-15} C charges respectively and the red arrow represents the electric field strength due to the -3.2 × 10^{-15} C.

The electric field strength due to one +3.2 × 10^{-15} C charge,

$$E = \frac{q}{4\pi\varepsilon_0 r^2} = \frac{3.2\times10^{-15}}{4\pi\ 8.85\times10^{-12}\ \ 0.0050^{\ 2}} = 1.1510\ \text{N C}^{-1}$$

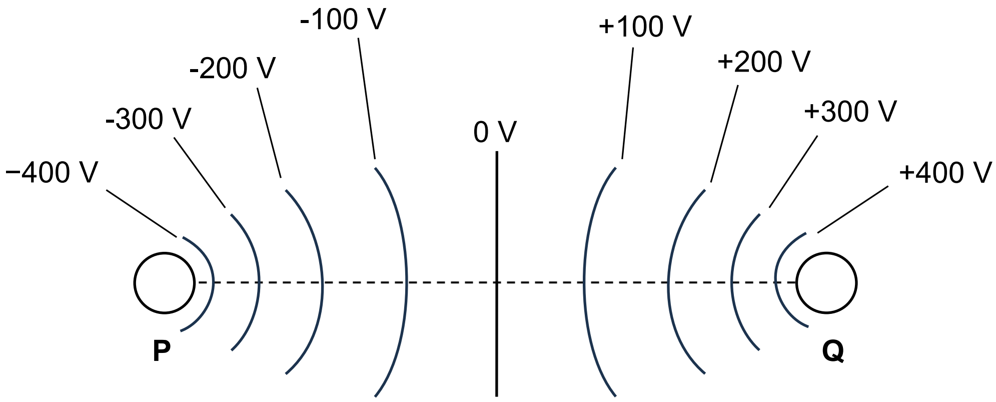
The resultant electric field strength due to two +3.2 × 10^{-15} C charges,

$E_{2+} = 2\ 1.1510\cos 45^\circ = 1.6277$ N C^{-1}

Therefore, the resultant electric field strength due to all three point charges,
$E_{tot} = 1.6277 + 1.1510 = 2.7786$ N C^{-1}

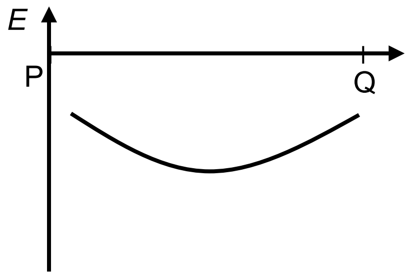
19 An object with a charge is placed at P and a similar object with a charge is placed at Q.

The diagram shows a number of solid lines along which the potential has a constant value.

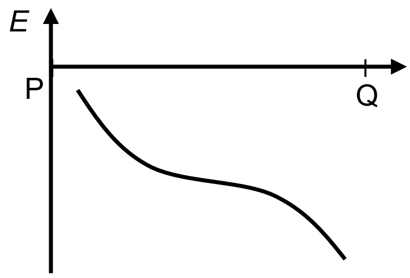


Which graph shows the variation with distance x along the line PQ of the electric field strength E?

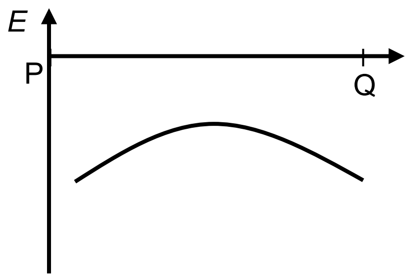
A



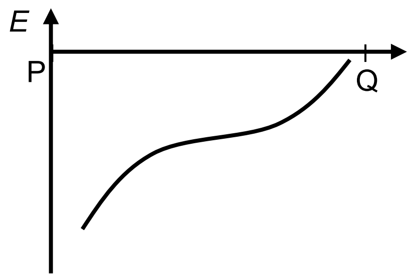
B



C



D



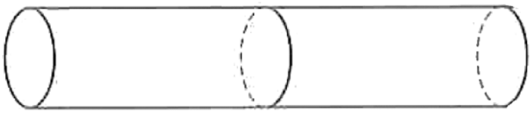
L2 **Answer: C**

As the electric potentials are negative nearer to P and positive nearer to Q, charge P is negative while charge Q is positive.

The **electric field strength at a point is equal to the negative potential gradient at that point**. Therefore,

	• Since neighbouring pairs of equipotential lines have the same differences but increasing separations from P to 0 V and then decreasing separation from O to Q, the **magnitude of *E* decreases from O to P and increases from O to Q.** • The **direction of *E* is in the direction of decreasing potential, hence towards the left.** Sign convention adopted here (as inferred from the given options) is left is taken to be negative on the graph.

20 An aluminium rod and a copper rod of equal length and cross-sectional area are welded together.



The table gives details of the number of free electrons per cubic metre in each material.

	aluminium rod	copper rod
number of free electrons per cubic metre	2.0×10^{29}	8.5×10^{28}

The drift velocity of electrons through the copper rod is 0.52 mm s^{-1}.

What is the drift velocity of electrons through the aluminium rod?

A	0.221 mm s^{-1}
B	0.52 mm s^{-1}
C	1.22 mm s^{-1}
D	2.21 mm s^{-1}

L2 **Answer: A**

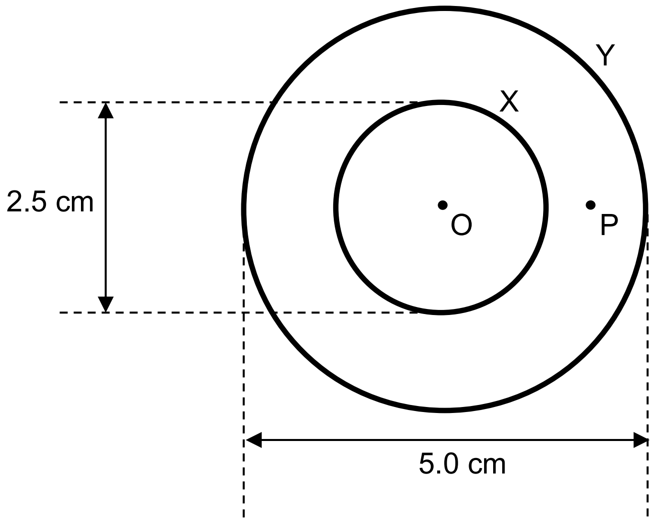
The same current is passing through both rods in series.

Using I = Anqv,

$$A(2.0 \times 10^{29})(e)(v_{Al}) = A(8.5 \times 10^{28})(e)(0.52 \text{ mm s}^{-1})$$

$$v_{Al} = 0.221 \text{ mm s}^{-1}$$

21 X and Y are two flat single circular coils of wire lying on a table, sharing a common centre O. X has a diameter of 2.5 cm and Y has a diameter of 5.0 cm. Point P is a point on the table. The diagram is a view from above the coils.



Initially there is a constant current of 1.2 A in the coil X and no current in coil Y.

A small current 0.50 A is now passed through coil Y, which increases the magnitude of the magnetic flux density at point P.

What is the resultant magnetic flux density at O?

A	2.4×10^{-5} T	**B**	3.6×10^{-5} T	**C**	4.8×10^{-5} T	**D**	7.3×10^{-5} T

L2 **Answer: C**

Point P is outside of coil X while it is inside of coil Y. Since the magnetic flux density increases at P, the **current in X flows opposite to the current in Y** – if coil X has a clockwise current, coil Y will have an anticlockwise current.

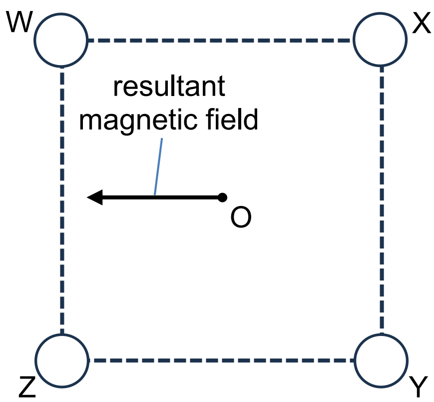
Therefore, **at point O**, it is both inside coil X and coil Y. Therefore, the **magnetic flux density decreases**,

$$B_{tot} = \frac{\mu_0 N_X I_X}{2r_X} - \frac{\mu_0 N_Y I_Y}{2r_Y} \quad \text{where } N_X = N_Y = 1$$

$$B_{tot} = \frac{\mu_0}{2}\left(\frac{I_X}{r_X} - \frac{I_Y}{r_Y}\right) = \frac{4\pi \times 10^{-7}}{2}\left(\frac{1.2}{0.0125} - \frac{0.50}{0.025}\right)$$

$$B_{tot} = 4.7752 \times 10^{-5} \approx 4.8 \times 10^{-5}\,\text{T}$$

22 Parallel conductors WXYZ, carrying equal currents, pass vertically through the four corners of a square. In two conductors, the current is flowing into the page, and in the other two out of the page.



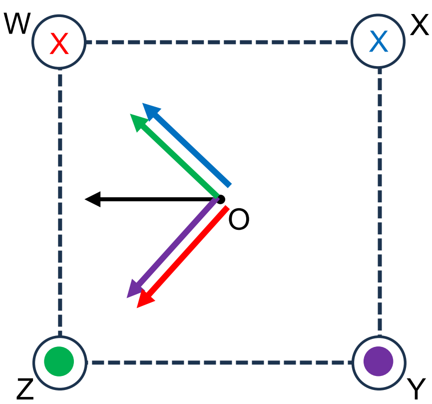
What are the directions of the current in order to produce a resultant magnetic field in the direction shown at O, the centre of the square?

	into the page	out of the page
A	W and X	Y and Z
B	W and Y	X and Z
C	X and Z	W and Y
D	Y and Z	W and X

L2

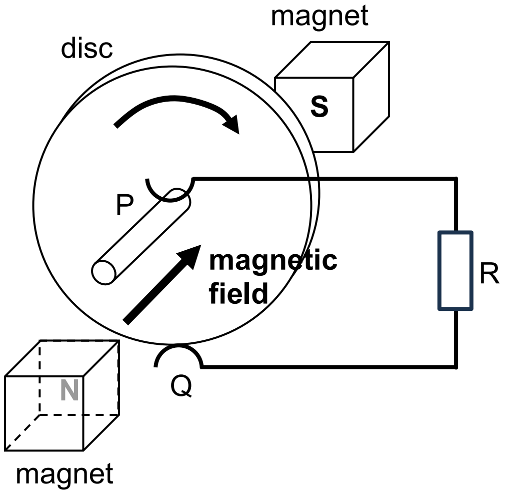
Answer: A

For option A, using Right Hand Grip Rule to determine the direction of the magnetic field due to each conductor,



By finding the resultant field, it will point to the left.

23 An aluminium disc of radius 5.0 cm rotates clockwise about its centre at a constant frequency of 4.0 Hz in a constant magnetic field of 4.0×10^{-3} T, directed perpendicular to the plane of the disc. A resistor R is connected across O and P. A steady electromotive force E is generated between O and P.



What is the magnitude of E and the direction of the current through the disc?

	E / V	current direction through disc
A	1.3×10^{-4}	P to Q
B	1.3×10^{-4}	Q to P
C	3.1×10^{-5}	P to Q
D	3.1×10^{-5}	Q to P

L2

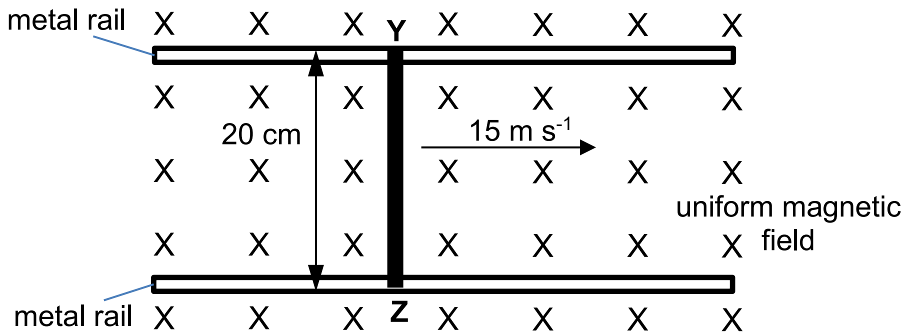
Answer: A

The induced e.m.f. in a disc generator,

$E = B\pi r^2 f = \left(4.0\times10^{-3}\right)\left(\pi\right)\left(0.050^2\right)\left(4.0\right) = 1.2566\times10^{-4} \approx 1.3\times10^{-4}$ V.

The magnetic field points away from us while the line joining PQ through the disc is moving to the left. Thus, the **induced current will flow from P to Q**.

24 A straight wire YZ of length 20 cm is placed at right-angles to a uniform magnetic field 3.2×10^{-3} T as shown in the diagram.



The wire moves 10 cm along a pair of parallel metal rails with a horizontal constant speed of 15 m s^{-1}.

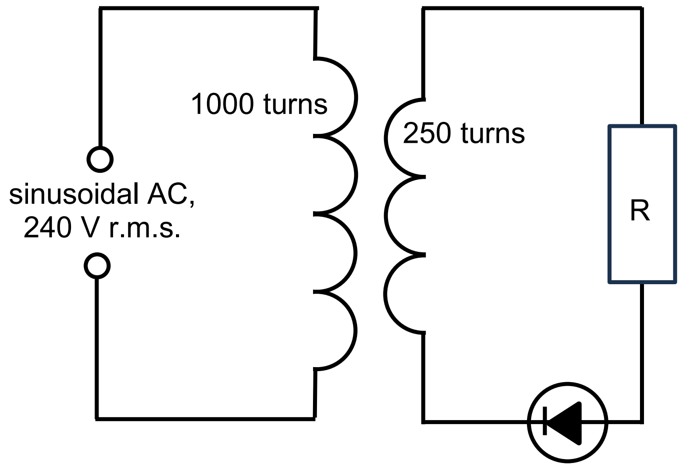
What is the induced e.m.f. across the wire YZ?

A	4.8 mV	B	9.6 mV	C	480 mV	D	960 mV

L1 **Answer: B**

$$E = BLv = 3.2\times10^{-3}\ \ 0.20\ \ 15\ = 9.6\,\text{mV}$$

25 An ideal transformer has 1000 turns of wire on the primary coil and 250 turns on the secondary coil as shown below.



At the primary circuit, the input sinusoidal potential difference is 240 V r.m.s.

At the secondary circuit, a resistor R and a diode are connected in series.

What is the root-mean-square potential difference across the resistor?

A	30 V	B	60 V	C	42 V	D	84 V

L3 **Answer: C**

The peak e.m.f. in the primary coil is,

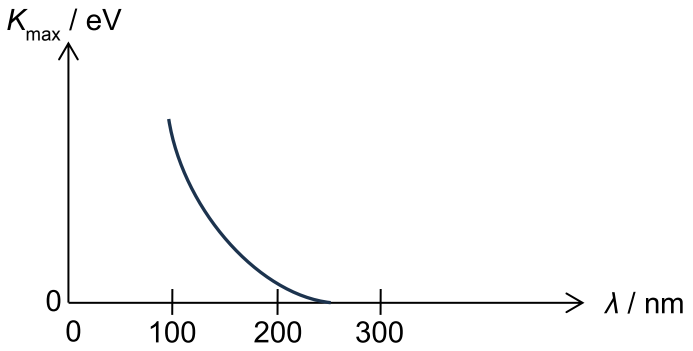
$$V_{0,P} = \sqrt{2}V_{rms} = \sqrt{2}\ \ 240\ = 339.41\,\text{V}$$

After the step-down transformer, the peak output potential difference,

$$V_{0,S} = V_{0,P}\frac{N_S}{N_P} = \ 339.41\ \frac{250}{1000} = 84.853\,\text{V}$$

With a **diode in series with the load**, the potential difference **across the resistor** follows a **half-wave rectified** voltage. Therefore, using a graphical approach, it can be shown that the root-mean-square potential difference across the resistor is given by

$$V_{rms,S} = \frac{V_{0,S}}{2} = \frac{84.853}{2} = 42\ \text{V}$$

26	In a photoelectric experiment, the maximum kinetic energy of the ejected photoelectrons is measured for various wavelengths of incident electromagnetic radiation. A graph of this maximum kinetic energy, K_{max}, as a function of the wavelength λ of the incident electromagnetic radiation falling on the surface of a metal is shown below.  When K_{max} = 0, the graph cuts the horizontal axis at λ = 250 nm. What is the work function energy for this metal?						
	A	4.97 eV	**B**	6.22 eV	**C**	7.96 eV	**D** 24.9 eV
L2	**Answer: A** K_{max} = 0 occurs when λ = 250 nm. By photoelectric equation, $\frac{hc}{\lambda} = \Phi + K_{max}$ Hence, $\Phi = \frac{hc}{\lambda} - K_{max} = \frac{6.63\times10^{-34}(3.0\times10^{8})}{250\times10^{-9}} - 0$ $\Phi = 7.956\times10^{-19}\text{ J} = 4.97\text{ eV}$						

27	An electron has a kinetic energy of 1.3 MeV. If its momentum is measured with an uncertainty of 1.3%, what is the uncertainty in its position?						
	A	8.3×10^{-11} m	**B**	1.1×10^{-12} m	**C**	1.4×10^{-14} m	**D** 3.3×10^{-20} m
L2	**Answer: A**						

	$E=\frac{1}{2}mv^2=\frac{p^2}{2m}$ $p=\sqrt{2mE}=\sqrt{2\left(9.11\times10^{-31}\right)\left(1.3\times10^{6}\times1.60\times10^{-19}\right)}$ $=6.156\times10^{-22}\text{ kg m s}^{-1}$ $\frac{\Delta p}{p}=0.013$ $\Delta p=0.013p$ $\Delta x\cdot\Delta p\gtrsim h$ $\Delta x\gtrsim\frac{h}{\Delta p}=\frac{6.63\times10^{-34}}{0.013\times6.156\times10^{-22}}=8.3\times10^{-11}\text{ m}$ B: wrongly forget to multiply 1.3% C: wrongly divide by 1.3% instead of multiplying D: wrongly forget to multiply *e* for kinetic energy.

28	What is the de Broglie wavelength of a proton moving at 1.32×10^{5} m s^{-1}?						
	A	3.0×10^{-12} m	**B**	5.5×10^{-9} m	**C**	1.8×10^{8} m	**D**	3.3×10^{11} m
L1	**Answer: A** $\lambda=\frac{h}{p}=\frac{h}{mv}\quad(\because p=mv)$ $\lambda=\frac{6.63\times10^{-34}}{\left(1.67\times10^{-27}\right)\left(1.32\times10^{5}\right)}=3.0076\times10^{-12}\text{ m}$						

29	Which equation shows a radioactive decay and emits an alpha particle, *X*?	
	A	${}^{14}_{7}N+{}^{1}_{1}H\rightarrow{}^{11}_{6}C+X$
	B	${}^{220}_{86}Rn\rightarrow{}^{216}_{84}Po+X$
	C	${}^{137}_{55}Cs\rightarrow{}^{137}_{56}Ba+X$
	D	${}^{60}_{28}Ni\rightarrow{}^{60}_{28}Ni+X$
L2	**Answer: B** An **alpha particle is a helium-4 nucleus**. ${}^{220}_{86}Rn\rightarrow{}^{216}_{84}Po+{}^{4}_{2}He$ Note: **Option A is <u>NOT</u> a radioactive decay** since radioactive decay is spontaneous involving one nucleus undergoing spontaneous fission.	

30	A radioactive sample is left overnight in a laboratory. After 12 hours, it is found that 62% of the original sample remains.

	What is the half-life of this sample?						
	A	6.6 hours	**B**	11 hours	**C**	15 hours	**D**	17 hours

L2 **Answer: D**

$$\frac{N}{N_0} = e^{-\frac{\ln 2}{t_{1/2}}t}$$

$$\ln 0.62 = -\frac{\ln 2}{t_{1/2}} \times 12 \quad \Rightarrow \quad t_{1/2} = 17.4 \text{ hours}$$

A: wrongly used 38% of decayed sample as *N*.
B: wrongly key calculator ln(2×12)
C: wrongly use simple inverse proportionality between *N* and *t*.

END OF PAPER 1

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