NAME ______________________________ **CLASS** 2T

Catholic Junior College

JC2 Preliminary Examinations

Higher 2

PHYSICS 9749/1

Paper 1: Multiple Choice Questions **16 September 2022**

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

Suggested Solutions

This document consists of **24** printed pages and **zero** blank page.

[Turn over

PHYSICS 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}
			$\approx (1/(36\pi)) \times 10^{-9}$ 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}

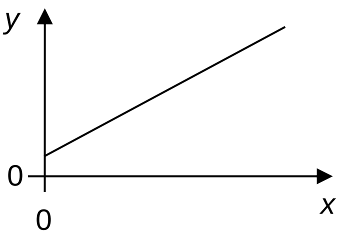
PHYSICS FORMULAE:

uniformly accelerated motion	s	=	$u t + \frac{1}{2} a t^2$
	v^2	=	$u^2 + 2 a s$
work done on / by a gas	W	=	$p \Delta V$
hydrostatic pressure	P	=	$\rho g h$
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
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	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

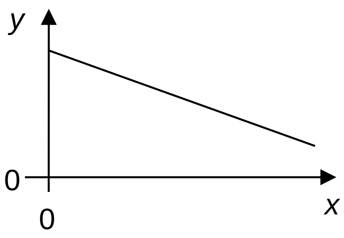
1 In an experiment, the perpendicular distance of a point from a long straight conductor carrying a constant current is measured and the perpendicular distance is used to calculate the magnetic flux density due to the long straight current-carrying conductor at that point. The experiment is repeated for a few points.

Which graph shows how the percentage uncertainty in the magnetic flux density of the long straight current-carrying conductor, *y*, varies with the percentage uncertainty in the perpendicular distance from the conductor, *x*?

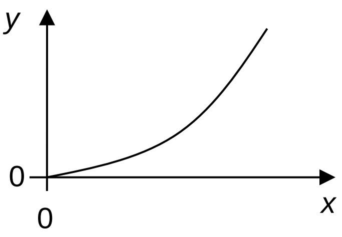
A



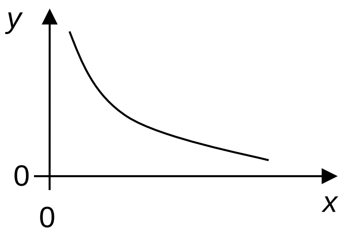
B



C



D



Answer: A

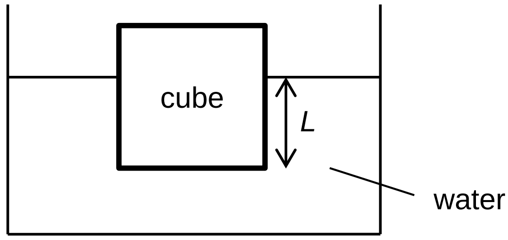
The magnetic flux density due to a long straight current-carrying conductor is

$$B = \frac{\mu_0 I}{2\pi r}$$

Therefore, the percentage uncertainty of the calculated magnetic flux density is

$$\frac{\Delta B}{B} = \frac{\Delta r}{r} + \frac{\Delta I}{I}$$

Therefore, the graph of $\frac{\Delta B}{B}$ against $\frac{\Delta r}{r}$ is a straight line graph with positive gradient and y-intercept $\frac{\Delta I}{I}$

2	A cube of side 5.0 cm is floating on a tank of water as shown in the figure below. The density of the cube is 450 kg m^{-3} and the density of water is 1000 kg m^{-3}.  What is the submerged depth *L* of the cube?						
	A	2.3 cm	**B**	2.8 cm	**C**	4.0 cm	**D** 4.5 cm

Answer: A

By the principle of floatation,
Weight of object = Weight of fluid displaced

$V_c \rho_c g = V_w \rho_w g$

$V_c \rho_c = AL\rho_w,$

$L = \frac{V_c \rho_c}{A\rho_w} = \frac{0.050^3 \times 450}{0.050^2 \times 1000} = 0.023$ m

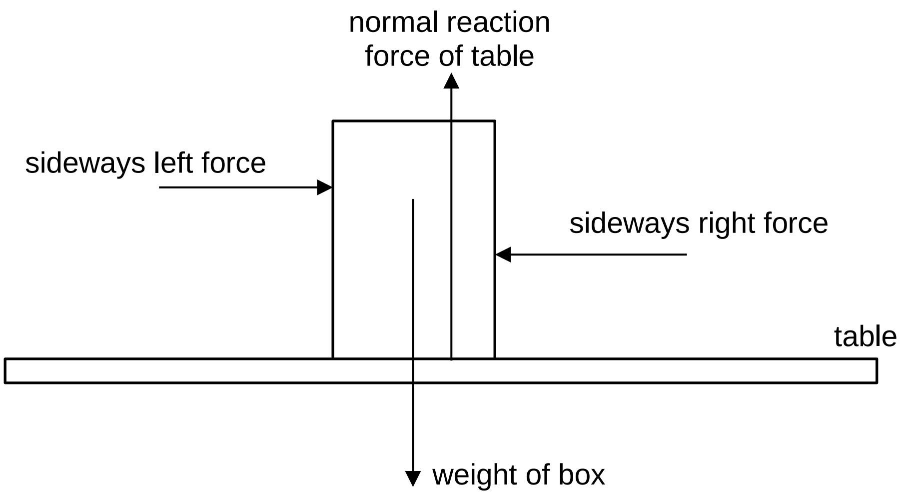
3	Water is ejected from the nozzle of a hose at a speed of 2.0 m s^{-1}. The density of water is 1000 kg m^{-3} and the diameter of the nozzle is 0.50 cm. What is the force exerted on the nozzle by the ejected water?						
	A	0.039 N	**B**	0.079 N	**C**	0.31 N	**D** 7.9 N

Answer: B

Force **on water** = mass per unit time x change in velocity
= (volume per unit time x density) x change in velocity
= $(V/t)(\rho)\Delta v$
= $(\pi r^2)(v)(\rho)(v)$
= $\pi(0.0025^2)(2.0)(1000)(2.0) = 0.079$ N

Magnitude of force **on nozzle** by water = Magnitude of force **on water** by nozzle = 0.079 N
(Newton's 3rd law of motion)

4	A box resting on a table has two vertical and two horizontal forces acting on it as shown in the diagram below. The box is in equilibrium.



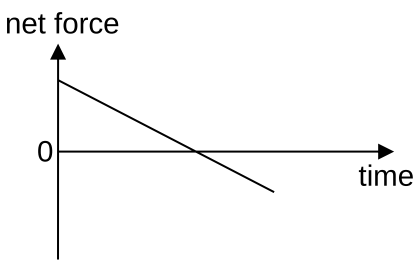
Which statement about the forces is **not** correct?

A	The sideways left force is equal and opposite to the sideways right force on the box.
B	The resultant of all the four forces is zero.
C	The torque provided by the vertical forces is equal to the torque provided by the horizontal forces.
D	The normal reactional force from the table is equal and opposite to the weight of the box.

Answer: C

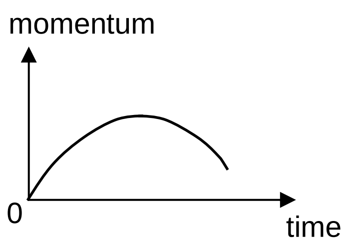
The torque provided by the vertical forces <u>is not only</u> equal to the torque provided by the horizontal forces <u>but also in opposite directions</u>

5	A vehicle starts from rest and a net force acts on it. The figure below shows how the net force varies with time.

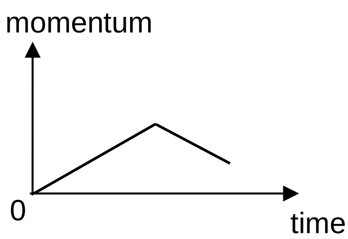


Which graph shows how the momentum of the vehicle varies with time?

A

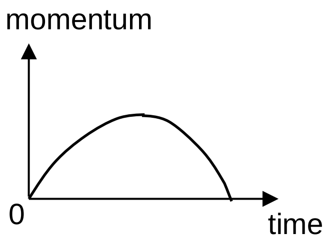
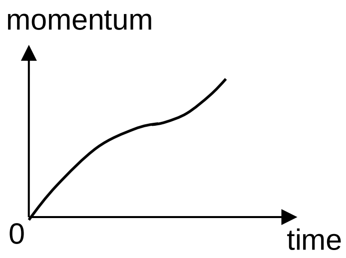


B



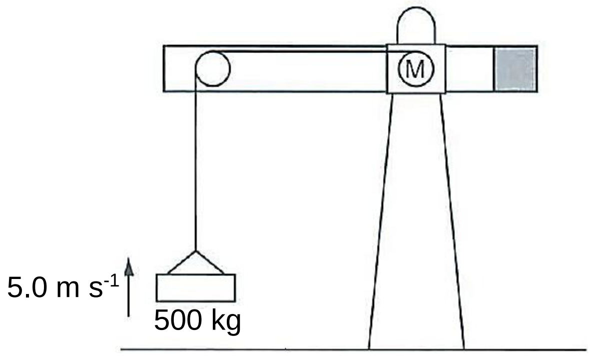
C

D

Answer: A

F = dp/dt = gradient of p-t graph
As force increases linearly, gradient of p-t graph increases. As forcce decreases linearly, gradient of p-t graph decreases B is incorrect
When F is negative, the momentum will decrease. D is incorrect
Area under F-t graph is the change in momentum. Hence the increase in momentum in part 1 is greater than that decrease in part 2 B is incorrect

6	The motor M in a crane is used to lift a load of 500 kg vertically upwards at a constant speed of 5.0 m s^{-1}. During the lifting of the load, energy is supplied to motor M at a constant rate of 3.0×10^4 J s^{-1}.  Which of the following statement is **not** correct?	
	A	The efficiency of motor M is 82%.
	B	The kinetic energy of the load is 6.3 kJ.
	C	The work done on the load by gravity is positive during the lifting of the load.
	D	The rate of gravitational potential energy gained by the load is about 2.5×10^4 W.

Answer: C

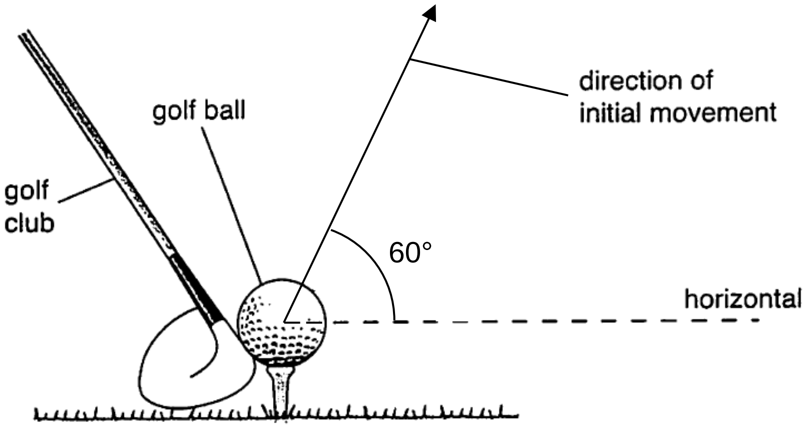
Rate of gravitational potential energy gained,
$= Fv = mgv = 500 \times 9.81 \times 5.0 = 24525 = 2.5 \times 10^4$W (D is correct)

Efficiency of the motor $= \frac{\text{Power output}}{\text{Power input}} \times 100\% = \frac{24525}{3.0\times10^4} \times 100\% = 82\%$ (A is correct)

The kinetic energy of the load,
$\frac{1}{2}mv^2 = \frac{1}{2} \times 500 \times 5.0^2 = 6.3$ kJ (B is correct)

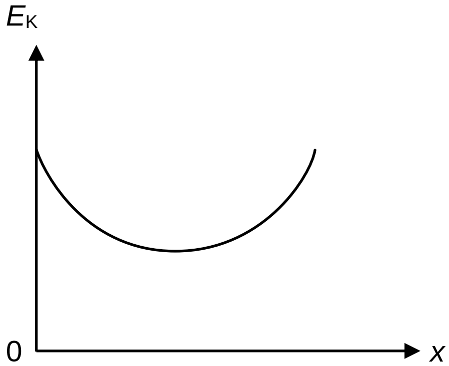
The gravitational force acts downwards on the load while the load's displacement is upwards. As such, the work done by gravity (gravitational force) is negative during the lifting of the load. (C is incorrect)

7 A golf ball, on level ground, is hit and starts to move at an angle of 60° to the horizontal.

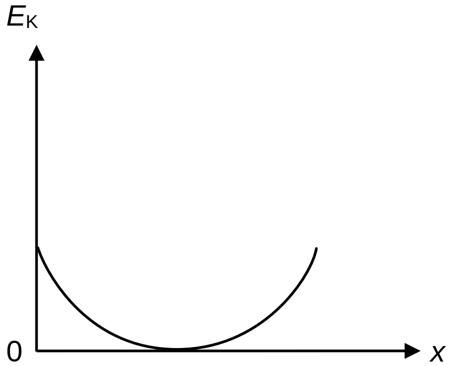


Which graph best represents the variation with horizontal distance x of the kinetic energy E_K of the golf ball? Ignore any effects of air resistance.

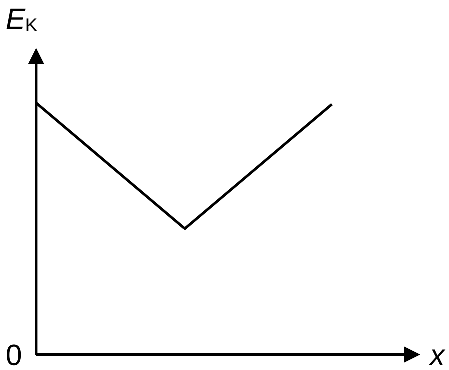
A



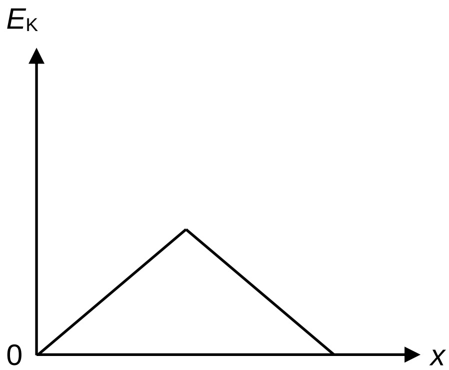
B



C



D



Answer: A

The kinetic energy of the golf ball at the highest point is non-zero. Hence option B is wrong.

The golf ball has the lowest kinetic energy at the highest point. Hence option D is wrong.

The vertical displacement s_y of the golf ball is of the parabolic equation $s_y = u_y t + \frac{1}{2} a_y t^2$ where u_y is the initial vertical velocity, a_y the vertical acceleration of the golf ball and t the time taken for the flight of golf ball. Since $s_x = u_x t$,

$t = \frac{s_x}{u_x} = \frac{x}{u_x}$ where s_x is the horizontal displacement, u_x the initial horizontal velocity of golf ball.

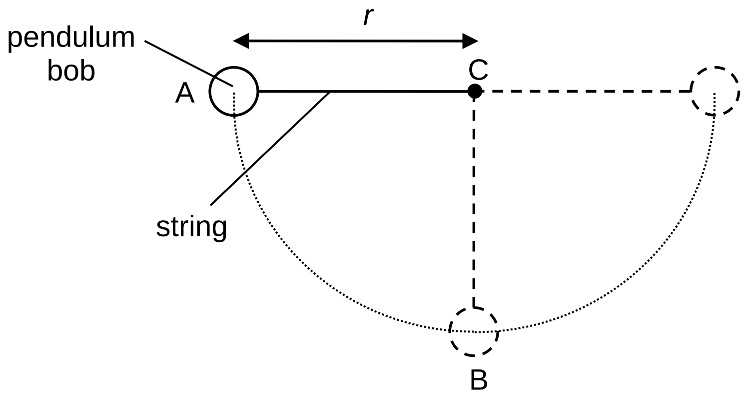
Therefore $s_y = u_y\left(\frac{x}{u_x}\right) - \frac{1}{2}g\left(\frac{x}{u_x}\right)^2 = -\left(\frac{g}{2u_x^{\,2}}\right)x^2 + \left(\frac{u_y}{u_x}\right)x$.

Since gravitational potential energy of golf ball of mass m is given as mgs_y, the graph for gravitational potential energy of the golf ball will be a negative parabolic curve.
By principle of conservation of energy, KE = TE – GPE, the graph for the kinetic energy of the golf ball will be a positive parabolic curve.

8	A body of mass m moves in a horizontal circle of radius r at constant angular speed ω. What is the work done on the body by the centripetal force in one revolution?						
	A	zero	**B**	$mr^2\omega^2$	**C**	$2mr^3\omega$	**D**	$4mr^2\omega^3$

Answer: A

Since the centripetal force always acts perpendicularly to the displacement moved by the body, there is zero work done on the body by the centripetal force.

9	A pendulum bob of mass 0.100 kg is supported by a string and swung along a circular path of radius r about the fixed point C. The bob is momentarily at rest at point A, with the string horizontal and just taut.  What is the tension in the string when the bob is at point B which is vertically below point C?							
	A	0.981 N	**B**	1.96 N	**C**	2.94 N	**D**	3.92 N

Answer: C

Given that at point A the string is horizontal & just taut → T = 0 at point A

Since Weight acts vertically, it cannot provide for the centripetal force at point A.

<u>So at point A, centripetal force = 0 → speed at point A must be zero.</u>

By principle of conservation of energy,
Gain in KE from A to B = Loss in GPE from A to B

$$\left(\frac{1}{2}mv^2\right)_{\text{point B}} - 0 = mgr$$

At point B, $v^2 = 2gr$ ---- (1)

At point B, the resultant force will be towards the centre of the vertical circle is

$$T - mg = \frac{mv^2}{r}$$

$$T = \frac{mv^2}{r} + mg \quad \text{----(2)}$$

Sub (1) into (2):

$$T = \frac{m(2rg)}{r} + mg = 3mg = 3(0.100)(9.81) = 2.943 = 2.94 \text{ N}$$

10	At a point on the surface of a uniform sphere of diameter *d*, the gravitational field strength due to the sphere is *X*. What would be the gravitational field strength on the surface of a uniform sphere of the same density but of diameter 3*d*?						
	A	2*X*	**B**	3*X*	**C**	5*X*	**D**	8*X*

Answer: B

$M = \textbf{density x volume} = \rho\left(\frac{4}{3}\pi R^3\right)$ where *M* is the mass, *ρ* the density and *R* the radius of sphere.

Gravitational field strength at the <u>surface</u>, $g = \frac{GM}{R^2} = \frac{G4\pi R^3\rho}{3R^2} = \frac{G4\pi R\rho}{3} = \frac{G4\pi d\rho}{6}$ where *d* is the diameter of sphere.

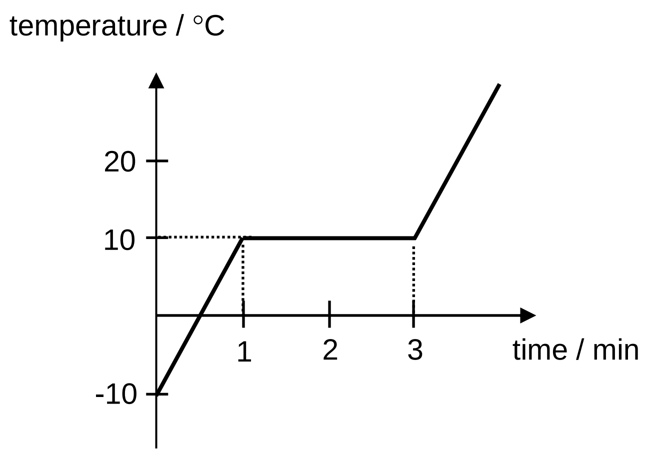
Since *g* is directly proportional to *d*, the gravitational field strength due to the sphere of diameter 3*d* will be 3*X*.

11	Which of the following statement about a geostationary satellite around Earth is true?	
	A	Its linear speed is equal to the speed of a point on the Earth's equator.
	B	It experiences zero net force as it orbits around Earth.
	C	It moves from East to West.
	D	It must remain directly above the equator.

Answer: D

Option A is wrong as the satellite's linear speed is proportional to the distance away from the centre of the earth ($v = r\omega$). Hence the speed of the satellite can never be the same as the speed on the equator.
Option B is wrong as the satellite is experiencing centripetal acceleration, and thus net force as it orbits around Earth.
Option C is wrong as it moves from West to East.
Option D is correct as the geostationary satellite must be at a fixed distance directly above the Earth's equator.

12	A student heats a 500 g solid sample at an initial temperature of -10°C. The rate of heat absorbed by the sample is constant at 200 W. The graph below shows how the temperature of the sample varies with time.



What is the specific latent heat of fusion of the solid sample?

A	12 kJ kg^{-1}	**B**	18 kJ kg^{-1}	**C**	36 kJ kg^{-1}	**D**	48 kJ kg^{-1}

Answer: D

Energy supplied $E = Pt$ where P is the power supplied in time t.
By conservation of energy, $E = Pt = mL$ where m is the mass and L the specific latent heat of solid.

$$200(2 \times 60) = 0.500L$$

L = 48000 J kg^{-1}
= 48 kJ kg^{-1}

13	The density of argon gas at a pressure of 1.00×10^5 Pa is 1.60 kg m^{-3}. What is the root-mean-square speed of the argon molecules?

A	216 m s^{-1}	**B**	250 m s^{-1}	**C**	306 m s^{-1}	**D**	433 m s^{-1}

Answer: D

$pV = \frac{1}{3}Nm\langle c^2 \rangle$ where p is the pressure, V the volume, N the number of molecules, m the mass and $\langle c^2 \rangle$ the mean square speed of molecules.

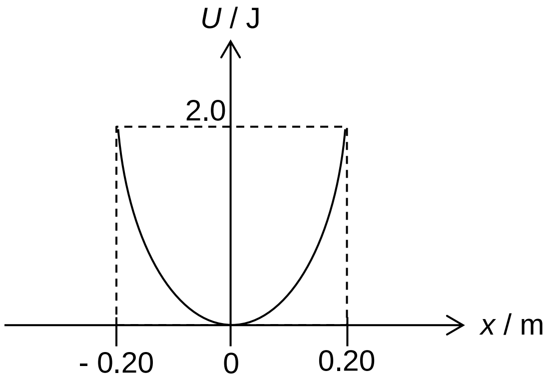
Therefore, $p = \frac{1}{3}\rho\langle c^2 \rangle$ where ρ is the density of molecules.

$$\langle c^2 \rangle = \frac{3p}{\rho}$$

$$\sqrt{\langle c^2 \rangle} = \sqrt{\frac{3p}{\rho}} = \sqrt{\frac{3(1.00 \times 10^5)}{1.60}} \quad = 433 \text{ m s}^{-1}$$

14 A particle of mass 5.0 kg is moving in simple harmonic motion.

The variation of the potential energy *U* with the displacement from the equilibrium position *x* is as shown in the figure below.



What is the period of oscillation of the particle?

A	0.89 s	**B**	1.4 s	**C**	2.2 s	**D**	2.8 s

Answer: B

For SHM,

$$Max\ U = \frac{1}{2}m\omega^2 x_0^2$$
$$= \frac{1}{2}m\left(\frac{2\pi}{T}\right)^2 x_0^2$$

$$T = \sqrt{\frac{1}{2U}m(2\pi)^2 x_0^2}$$
$$= \sqrt{\frac{2m}{U}}\pi x_0$$
$$= \sqrt{\frac{2(5.0)}{2.0}}\pi(0.20)$$
$$= \frac{\pi}{\sqrt{5}} = 1.4\ s$$

15 A sound wave propagates from left to right through a gas.

Fig. 15(a) shows the positions of some gas molecules at a particular instant of time.
Fig. 15(b) shows the variation with time *t* of the displacement *s* of one of these particles.

The distance between particles P and Q is 0.26 m.

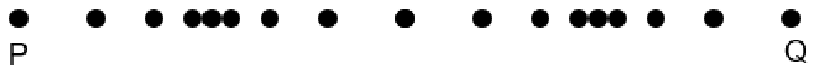


Fig. 15(a)

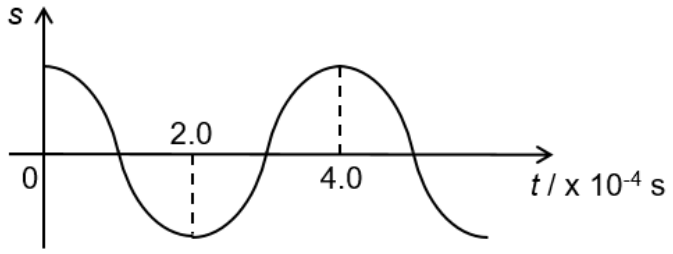


Fig. 15(b)

What is the speed of sound in this gas?

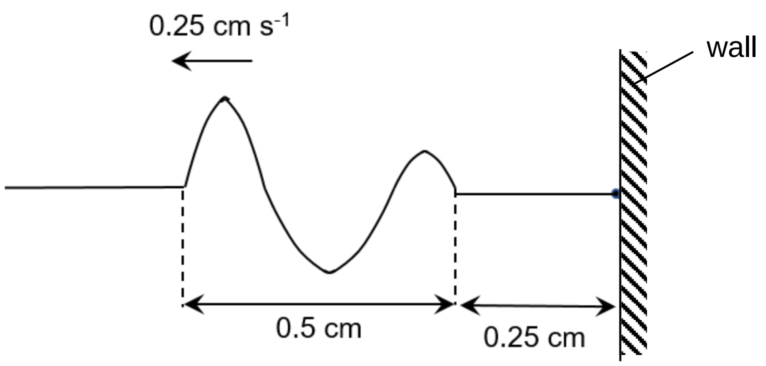
A	300 m s^{-1}	**B**	330 m s^{-1}	**C**	380 m s^{-1}	**D**	660 m s^{-1}

Answer: B

$$v = f\lambda$$
$$= \left(\frac{1}{T}\right)\lambda$$
$$= \left(\frac{1}{4.0 \times 10^{-4}}\right)\left(\frac{0.26}{2}\right)$$
$$= 325 = 330\ m\ s^{-1}$$

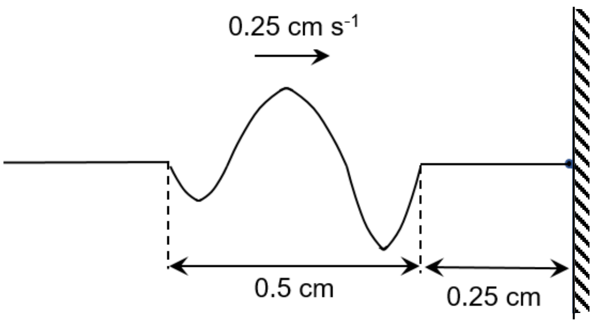
16 A rope is rigidly fixed to a wall. A wave pulse of length 0.5 cm moves at a constant speed of 0.25 cm s^{-1} along the rope towards the wall and is reflected back.

The figure below shows the waveform at time t = 4 s.

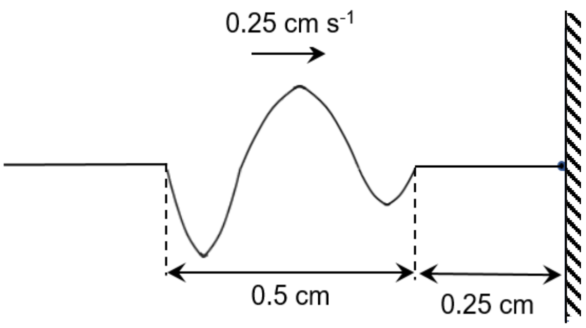


Which of the following correctly shows the waveform at t = 0 s?

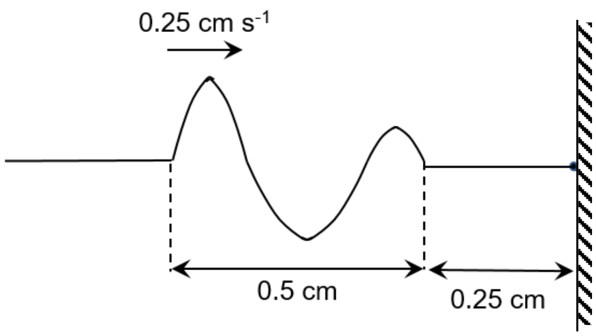
A



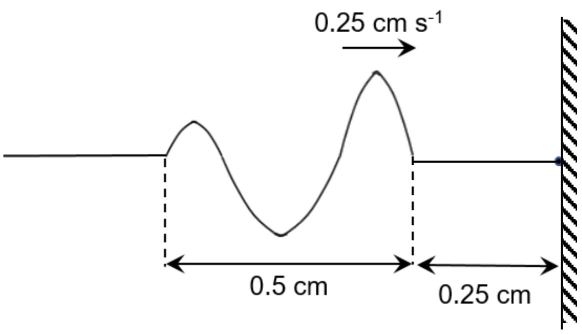
B



C



D



Answer: A

<u>Checking position of the wave pulse:</u>

0.5 cm / 0.25 cm s^{-1} = 2 s
In 2 s, the wave pulse moves a distance equal to one wavelength.

From options A, B, C, D, which shows the wave pulse at t = 0 s, it means that at t = 2 s, half of the wave pulse would have been reflected, and at t = 4 s, it would have been at the position shown.

<u>Determining the shape of the incident waveform:</u>

Since the wave pulse is **reflected at a fixed end**, the reflected pulse will have a **180^{o} change in phase**. Hence answer is A.

17 Light is polarised when it passes through a sheet of material known as polaroid.

Two sources producing coherent light waves are placed at an equal distance away from an observation screen. Each source was covered with a polaroid.

Initially, both polaroids had their transmission axes in the same direction. The intensity of the central maximum fringe formed from the interference of the two light waves was measured to be I.

One of the polaroids is rotated by 60°.

What is the new intensity of the central maximum fringe?

A	$\frac{1}{2}I$	**B**	$\frac{9}{16}I$	**C**	$\frac{3}{2}I$	**D**	$\frac{9}{4}I$

Answer: B

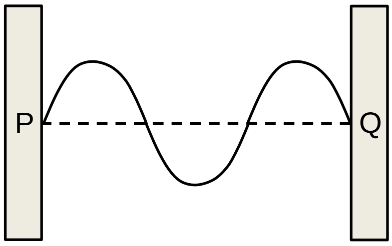
Initially, the intensity of the central maximum fringe is I.

$$\begin{aligned} I &= k(A_1 + A_2)^2 \\ &= k(2A)^2 \\ &= 4kA^2 \end{aligned}$$

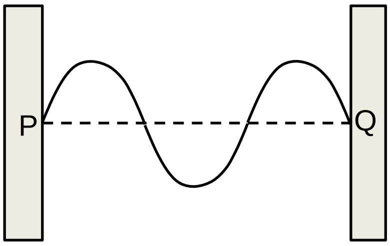
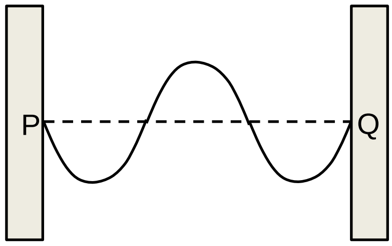
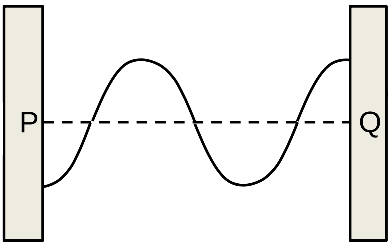
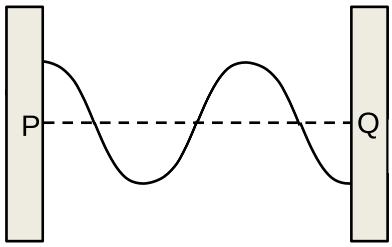
After the rotation of the polaroid,

$$\begin{aligned} I_{new} &= k(A_1 + A_2)^2 \\ &= k(A + A\cos 60)^2 \\ &= k\left(\frac{3A}{2}\right)^2 \\ &= \frac{9}{4}kA^2 \\ &= \frac{9}{16}(4kA^2) \\ &= \frac{9}{16}I \end{aligned}$$

18	The diagram shows a stationary wave of frequency 50 Hz formed between two points P and Q at a time t = 0.



Which of the diagrams correctly shows a possible position of the string at a time t = 0.010 s?

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

Answer: B

f = 50 Hz ➔ T = 1/50= 0.020 s. t = 0.010 s = ½ T

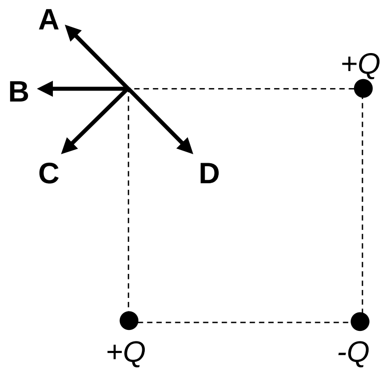
19	In a spectrometer experiment, light of wavelength 400 nm is incident normally on a diffraction grating having 400 lines per millimeters. What is the angle of diffraction of the third order diffracted beam?						
A	13.9°	**B**	18.7°	**C**	28.7°	**D**	56.1°

Answer: C

$d\sin\theta = n\lambda$

$\sin\theta = n\lambda/d$ $\quad\quad\quad 1/d = 400 \times 10^3$

$\sin\theta = 3(400\text{ nm})(400 \times 10^3) \rightarrow \theta = 28.7°$

20	Three point charges, each of magnitude Q, are placed at the three corners of a square as shown in the diagram. What is the direction of the resultant electric field at the fourth corner? 

Answer: A

Due to symmetry, the net electric field at the fourth corner must be along the diagonal of the square in direction A or D.

Let E_1 and E_2 be the electric field strength due to each of the charge of $+Q$.
Resultant of E_1 and E_2 is

$$E_{net\ of+Q} = \frac{Q}{4\pi\varepsilon_0 r^2}\sqrt{2}$$

Let E_3 be the electric field strength due to charge of $-Q$.

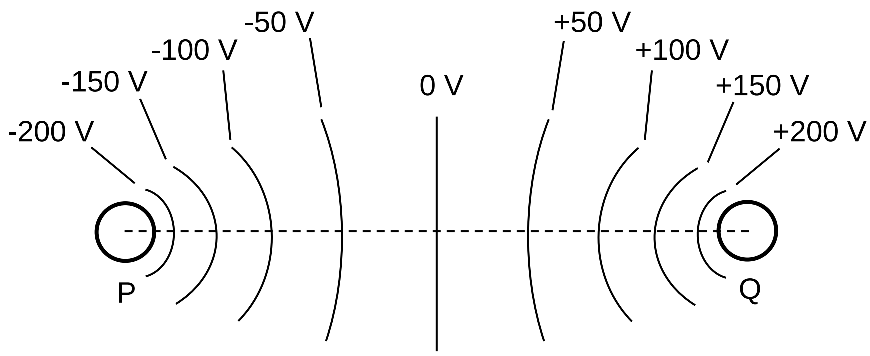
$$E_3 = \frac{Q}{4\pi\varepsilon_0 (r\sqrt{2})^2} = \frac{Q}{8\pi\varepsilon_0 r^2}$$

Therefore the net electric field strength due to all 3 charges is

$E_{net\ of+Q} - E_3 = \frac{Q\sqrt{2}}{4\pi\varepsilon_0 r^2} - \frac{Q}{8\pi\varepsilon_0 r^2} = \frac{Q}{8\pi\varepsilon_0 r^2}\left(2\sqrt{2}-1\right)$ **which is in the direction A**

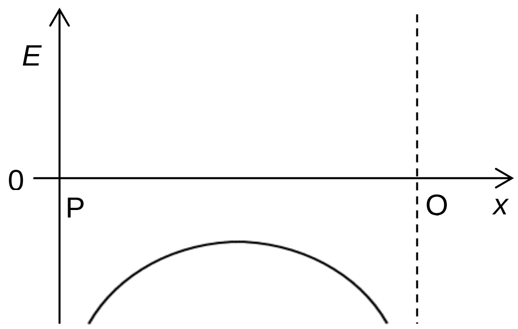
21 A charged object is placed at point P and another charged object is placed at point Q.

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

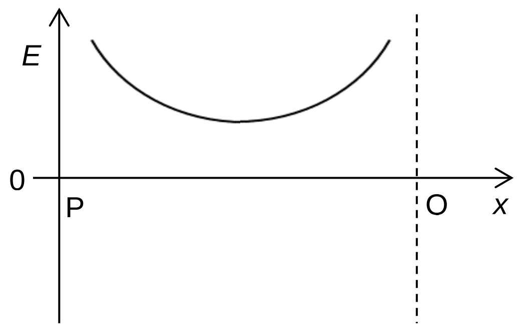


Taking vectors to the right as positive, which graph shows the variation with distance *x* along the line PQ of the electric field strength *E*?

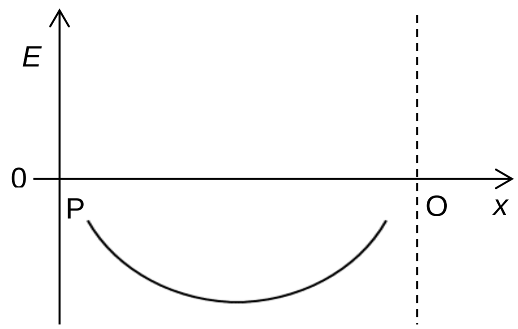
A



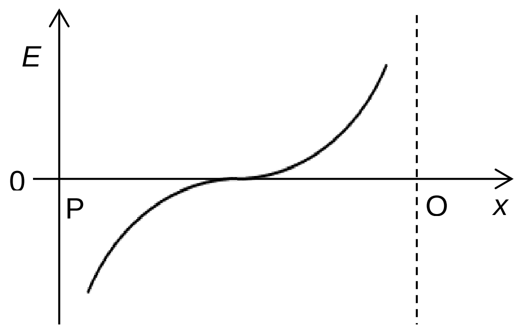
B



C



D



Answer: A

$$E = -\frac{dV}{dx}$$

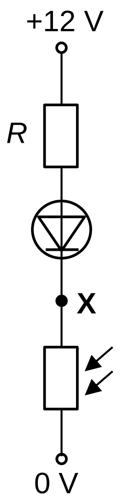
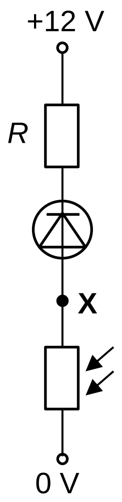
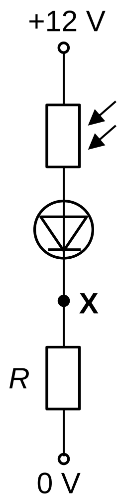
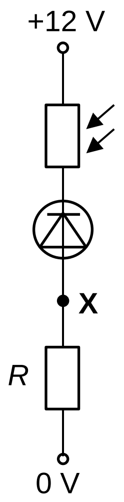
Since the **electric potential V decreases all the way from Q to P**, and the **potential gradient is non-zero everywhere along PQ**,
the electric field along line PQ is **non-zero** everywhere along PQ (hence answer **cannot be D**) and,

the direction of the electric field at every point along PQ is **leftwards**, which by the sign convention is the negative direction, hence ***E* is negative everywhere along PQ** (hence **answer can only be A or C)**.

Also, **where the potential gradient is greater, *E* is greater in magnitude.** As shown in the equipotential map, **nearer P and nearer Q where the equipotential lines get closer, i.e. Δx decreases while ΔV unchanged, magnitude of E should be greater.** Hence **answer must be A.**

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
			

Answer: A

Diodes in options B and D are in reverse biased connection (like an open circuit where the diode is).

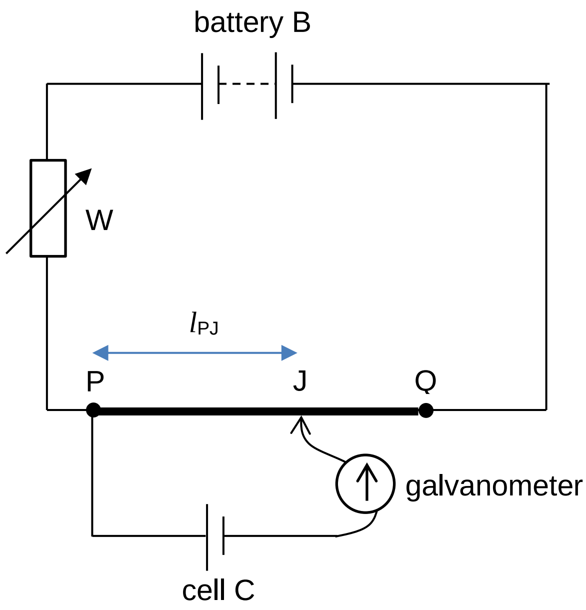
- ➔ No current flows → zero p.d. across the resistance → potential at X = 0 V in both bright and dark conditions, i.e. no change in potential at X for options B and D.
- ➔ Eliminate options B and D.

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 battery B, a variable resistor W and a uniform resistance wire PQ are connected in series. A cell C and a galvanometer are connected to the wire PQ with a contact J as shown.  The contact J is moved along wire PQ until the galvanometer reads zero. The distance of J from P, l_{PJ} is then measured. Which of the following changes will increase the measured distance l_{PJ}?	
	A	Removing W from the circuit.
	B	Adjusting W to a higher resistance.
	C	Connecting a resistor parallel to the galvanometer.
	D	Replacing wire PQ with another wire of similar length and resistivity but smaller diameter.

Answer: B

Regardless, the p.d. across PJ (V_{PJ}) remains unchanged and equal to the e.m.f. of cell C.

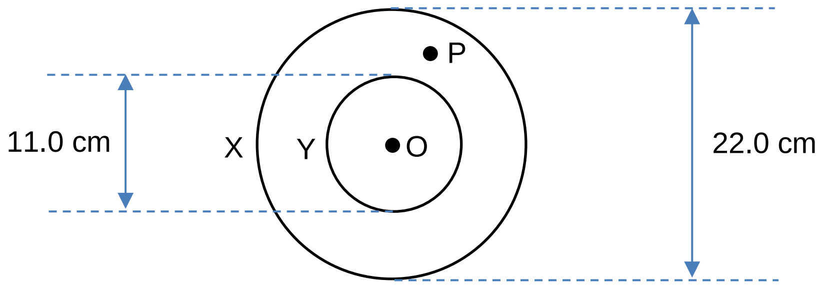
Option A: Removing W increases the p.d. across PQ, hence increases the p.d. per unit length of PQ. Thus for the same V_{PJ}, balance length will decrease.

Option B: Adjusting W to a higher resistance decreases the p.d. across PQ, hence decreases the p.d. per unit length of PQ. Thus for the same V_{PJ}, balance length will increase.

Option C: No effect on the balance length.

Option D: If the wire has a smaller cross-sectional area, its resistance increases. With W unchanged in resistance, the p.d. across PQ increases, hence increases the p.d. per unit length of PQ. Thus for the same V_{PJ}, balance length will decrease.

24	X and Y are two coaxial flat circular coils lying on a table. Coil X has 120 turns and a diameter of 22.0 cm. Coil Y has 80 turns and a diameter of 11.0 cm. O and P are two points on the table, and O is at the centre of the two coils.



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

A current of 1.2 A is now passed through coil Y, which increases the magnitude of the magnetic flux density at P.

What is the final magnitude of the resultant magnetic flux density at O?

A	0.14 mT	**B**	0.27 mT	**C**	0.96 mT	**D**	1.9 mT

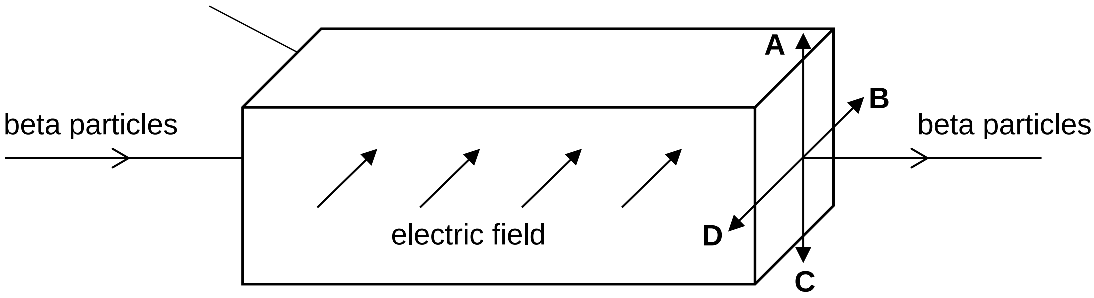
Answer: B

Since the magnitude of flux density at P increases, it implies that the currents in X and Y flow in opposite directions.
Thus the flux densities due to X and Y are in opposite directions at O.

Recall that for a flat circular coil, at its CENTRE, B is given by $\frac{\mu_o NI}{2r}$.

B due to X at O = $\frac{\mu_o NI}{2r} = \frac{(4\pi \times 10^{-7})(120)(1.2)}{2(0.220 \div 2)}$ = 8.22526 x 10^{-4} T
B due to Y at O = $\frac{\mu_o NI}{2r} = \frac{(4\pi \times 10^{-7})(80)(1.2)}{2(0.110 \div 2)}$ = 1.09670 x 10^{-3} T

Magnitude of Resultant B at O = (1.09670 x 10^{-3}) – (8.22526 x 10^{-4}) = 2.7418 x 10^{-4} T = 0.27 mT

25	A beam of beta particles enters a velocity selector. An electric field is applied in a horizontal direction, perpendicular to the beam of beta particles, as shown in the diagram below. A magnetic field is applied perpendicular to the beam such that beta particles of a particular speed leave the selector undeflected. In which direction is the magnetic field? 

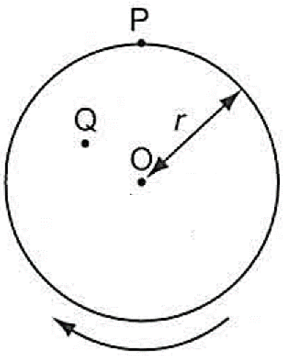
Answer: A

Beta particles are negatively charged.

Electric force acts out of the page, opposite to the electric field.

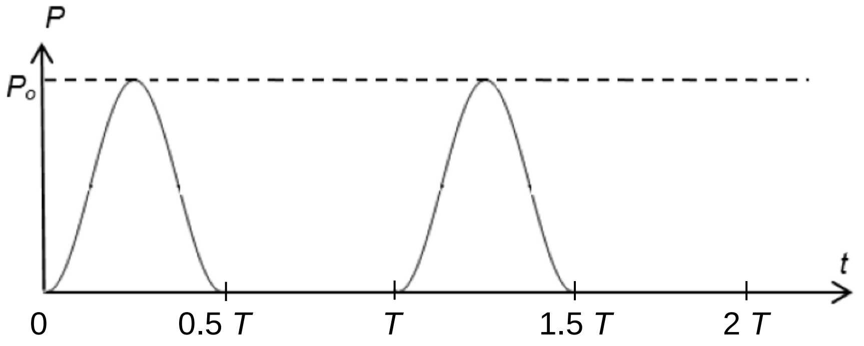
To remain undeflected, he magnetic force must be equal in magnitude and opposite direction to the electric force, so it must act into the page.

By FLHR, magnetic field acts upwards.

26	A copper disc of radius r rotates about its centre O at a constant speed. It is placed in a uniform magnetic field perpendicular to its surface. P is a point on the rim of the disc, while Q is a point at distance $\frac{r}{2}$ from O.  A steady electromotive force (e.m.f.) E is generated between points O and P. What is the e.m.f. generated between points P and Q?						
	A	zero	**B**	¼ E	**C**	½ E	**D** ¾ E

Answer: D

Between O and P, $e.m.f. = B(\pi r^2)f = E$
Between O and Q, $e.m.f. = B(\pi(r/2)^2)f = ¼ E$
Between P and Q, $E – ¼ E = ¾ E$

27	A half-wave rectified sinusoidal alternating current flows through a light bulb. The graph shows the variation of the power dissipated in the light bulb with time t, where T is the period of the current.  What is the average power consumption of the light bulb?

	A	0.25 P_o	**B**	0.40 P_o	**C**	0.50 P_o	**D**	0.70 P_o

Answer: A

Distribute area under graph across the entire period

For full sinusoidal a.c., the average power consumption is 0.50 P_o.

But this is half-wave rectified sinusoidal a.c. the average power consumption is 0.5 (0.50 P_o) = 0.25 P_o

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 0.10 nm. What is the value of V?

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

Answer: B

de Broglie wavelength, $\lambda = \frac{h}{p}$

$$p = \frac{h}{\lambda}$$

KE = $\frac{1}{2}mv^2 = \frac{p^2}{2m} = \frac{\left(\frac{h}{\lambda}\right)^2}{2m} = \frac{h^2}{2m\lambda^2}$

Loss in EPE = Gain in KE

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

$$(1.60\ x\ 10^{-19})V = \frac{(6.63\ x\ 10^{-34})^2}{2(9.11\ x\ 10^{-31})(0.10\ x\ 10^{-9})^2}$$

$$V = 150.79 = 150\ V\ (2\ sig.fig.)$$

29	At time t, a sample of a radioactive substance contains N atoms of a particular nuclide. At time $(t + \Delta t)$, where Δt is a short period of time, the number of atoms of the nuclide is $(N - \Delta N)$. Which expression is equal to the decay constant of the nuclide?						
	A	$\frac{N\Delta N}{\Delta t}$	**B**	$\frac{\Delta N}{N\Delta t}$	**C**	$\frac{\Delta N}{\Delta t}$	**D** $\frac{\Delta N}{N}$

Answer: B

$Activity\ A = \lambda N$

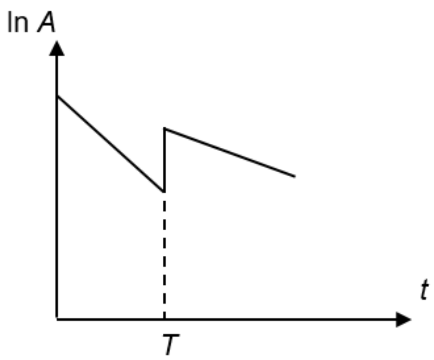
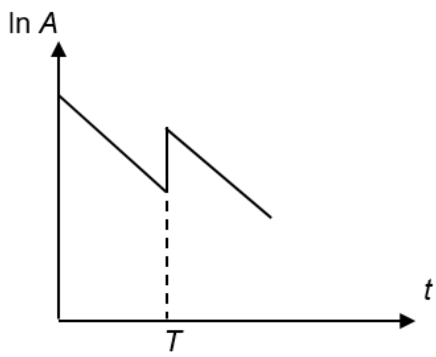
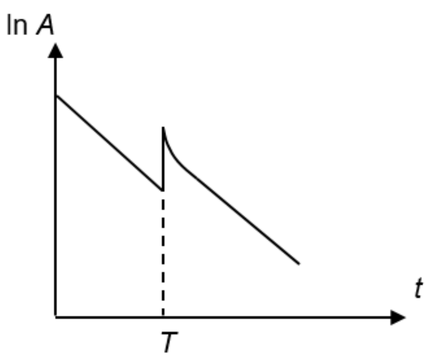
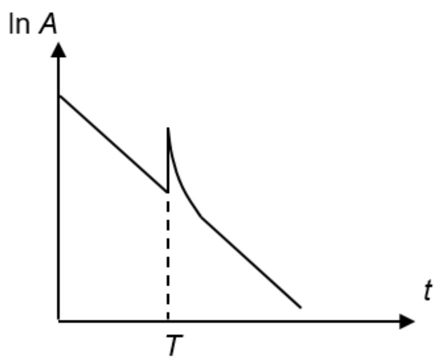
For a short time interval,

$Activity\ A = \frac{\Delta N}{\Delta t}$

Hence

$\frac{\Delta N}{\Delta t} = \lambda N$

$\lambda = \frac{\Delta N}{N\Delta t}$

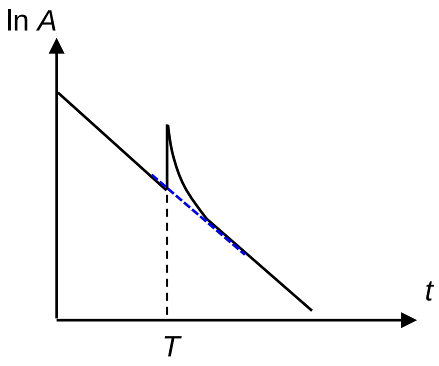
30	At time t = 0, some radioactive gas is injected into a sealed vessel. At time T, a different radioactive gas with a half-life very much shorter than the first is injected into the same vessel. Which one of the following graphs best represents how activity A varies with t?	
	A	**B**
		
	C	**D**
		

Answer: D

$A = A_0 e^{-\lambda t}$

$\ln A = \ln A_0 - \lambda t$

The curved part comes about because of two difference decay constants. Since the added gas has a much shorter half-life, the gradient of the graph should eventually return to the original gradient, and "continue" from where the original "left off".



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