RAFFLES INSTITUTION
2020 Preliminary Examination

PHYSICS **9749/01**
Higher 2

25 September 2020
Paper 1 Multiple Choice Questions **1 hour**

Additional Materials: OMR Form

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your index number, name and class on the OMR Form in the spaces provided. Shade the appropriate boxes.

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 OMR Form.

Read the instructions on the OMR Form very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an appropriate scientific calculator is expected, where necessary.

This document consists of **16** printed pages.

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} J K^{-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	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	$T / ^\circ\text{C} + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t = \pm\omega\sqrt{x_0^2 - x^2}$
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	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 The Planck length is hypothesised to be the smallest possible length at which current physical laws still apply.

It is related to the following fundamental constants: reduced Planck constant $\hbar = h/2\pi$, the gravitational constant G and the speed of light c.

Which expression could be correct for the Planck length?

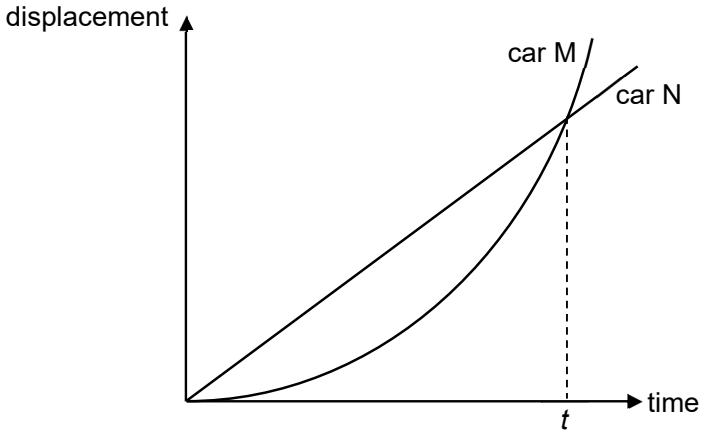
A $\frac{\hbar G}{c^3}$ **B** $\left(\frac{\hbar G}{c^3}\right)^{1/2}$ **C** $\left(\frac{\hbar G}{c^3}\right)^{1/3}$ **D** $\left(\frac{\hbar G}{c^2}\right)^{1/3}$

2 A physical quantity P is described by the relation $P^2 = a^{1/2}b^2c^{-3}d^4$.

If the percentage errors in the measurements of a, b, c and d are 4%, 2%, 6% and 5% respectively, what is the percentage error in P?

A 4% **B** 8% **C** 22% **D** 44%

3 The diagram shows the variation with time of the displacement of two cars M and N.



Which statement is **incorrect**?

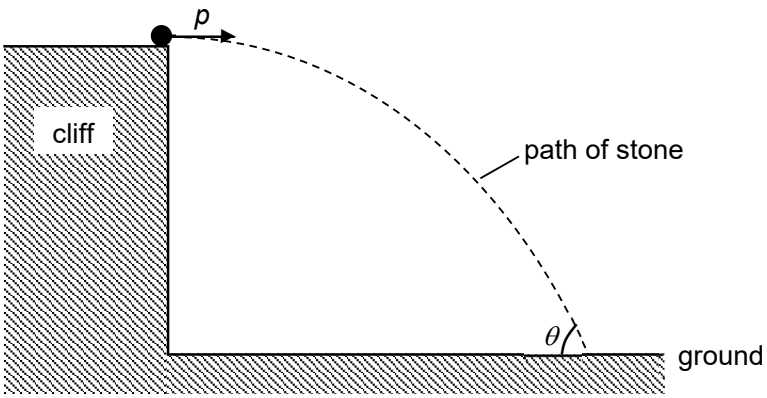
A Car M overtakes car N at time t.

B Throughout the motion, both cars are accelerating.

C At time t, the average velocities of both cars are equal.

D At time t, the rate of change of displacement of car N is less than that of car M.

4 A stone is thrown horizontally from the top of a cliff with an initial momentum p and hits the ground at an angle θ to the horizontal. The path of the stone from the cliff to the ground is as shown in the diagram.



Ignoring the effects of air resistance, which of the following expressions gives the change in the momentum of the stone from the point of launch to the point it hits the ground?

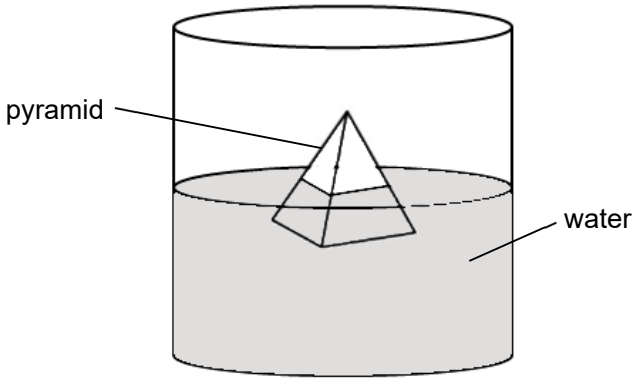
A p **B** $2p$ **C** $p \sin \theta$ **D** $p \tan \theta$

5 In a factory, identical boxes are placed onto the start of a conveyor belt at an average rate of 2.5 kg s^{-1} and removed at the end of the belt at the same rate.

In order to keep the belt moving at a constant speed of 0.80 m s^{-1}, what is the horizontal force that must be applied to the belt?

A 0 N **B** 1.0 N **C** 1.6 N **D** 2.0 N

6 The diagram shows a pyramid partially submerged and floating in water.



Which statement is **incorrect**?

A The depth of submersion depends on the orientation with which the pyramid is floating.

B The total upthrust remains the same when a liquid of higher density is added to the water.

C The pressure difference between the surface of the water and the lowest point of the pyramid remains the same when it is made to float inverted.

D If another object of the same density as the pyramid is placed in the water, the ratio of the volume of the object to the volume of the water it displaces is the same as that for the pyramid.

7 A rock of mass 0.80 kg is projected horizontally with a speed of 1.2 m s^{-1} from the top of a hill. The rock falls through a vertical distance of 10 m before hitting the ground with a speed of 4.0 m s^{-1}.

What is the energy lost by the rock to the surroundings during its fall?

A 5.7 J **B** 39 J **C** 73 J **D** 79 J

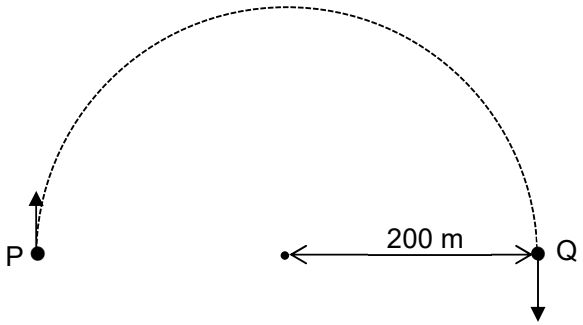
8 A toy car of mass 70 kg is moving at a constant velocity of 20 m s^{-1} up a track that is inclined at an angle of 30° to the horizontal.

A constant resistive force of 120 N acts on the toy car throughout its motion.

What is the power supplied by the motor of the toy car?

A 2400 W **B** 4500 W **C** 9300 W **D** 16000 W

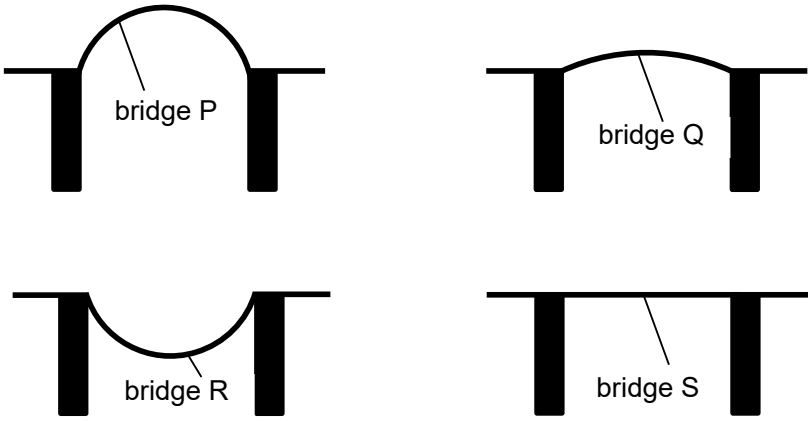
9 A car moves from points P to Q along a horizontal semicircular path with constant speed. The radius of the path is 200 m and the time taken to complete the trip is 30 s.



Which row shows the magnitudes of the linear speed and average velocity of the car?

	linear speed / m s^{-1}	average velocity / m s^{-1}
A	21	13
B	21	21
C	42	13
D	42	21

10 A car moves over bridges of different curvatures at a constant speed.



Which of the following shows the magnitudes of the forces the car exerts on the bridges in increasing order?

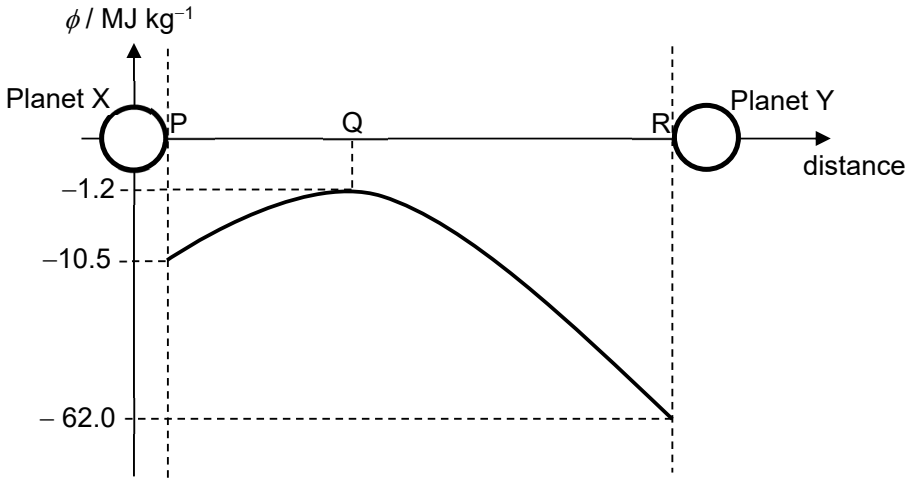
A PQRS **B** PQSR **C** QPSR **D** SPQR

11 A satellite orbits around the Earth with a linear speed of v. The gravitational potential of that orbit is -25 MJ kg^{-1}. The thrusters of the satellite are then fired and it now moves to a new orbit where the gravitational potential is -16 MJ kg^{-1}.

What is the linear speed of the satellite in the new orbit?

A $\frac{4}{5}v$ **B** $\frac{16}{25}v$ **C** $\frac{5}{4}v$ **D** $\frac{25}{16}v$

12 Points P and R are points on the surfaces of Planets X and Y respectively. The graph shows how the gravitational potential ϕ along the line PR varies with distance from the centre of Planet X. At point Q the gravitational potential is maximum. Both planets are approximately the same size.



An object of mass 5.0 kg is projected from the surface of Planet X towards Planet Y along the line PQR.

Which statement is correct?

A Planet X is heavier than Planet Y.

B The object comes to rest at point Q.

C The minimum kinetic energy that the object must be projected with for it to reach Planet Y is 258 MJ.

D The minimum kinetic energy that the object has just before it hits the surface of Planet Y is 304 MJ.

13 When a gas is compressed at constant temperature, the pressure exerted by the gas on the walls of the container increases.

This is because

A the average speed of the gas molecules increases.

B the average distance between the gas molecules decreases.

C the frequency of collisions between the gas molecules increases.

D the frequency of collisions of the gas molecules with the walls increases.

14 An ideal gas expands isothermally by absorbing heat *Q*. It then returns to its original volume adiabatically.

The net change in internal energy of the gas as a result of the two processes is

A zero. **B** smaller than *Q*. **C** equal to *Q*. **D** larger than *Q*.

15 The maximum speed of a particle in simple harmonic motion is v_0.

What is the average speed of this particle in one period?

A zero **B** $\frac{v_0}{2}$ **C** $\frac{v_0}{2\pi}$ **D** $\frac{2v_0}{\pi}$

16 During forced oscillation, the body vibrates at

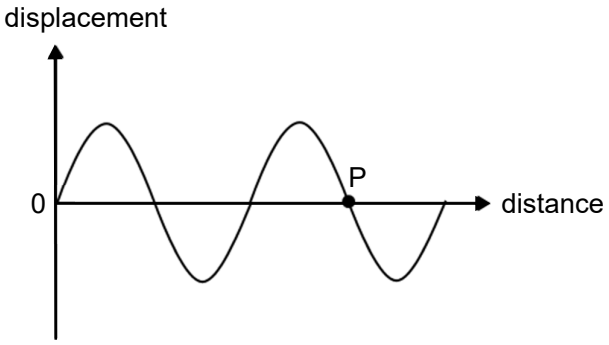
A its natural frequency.

B an unpredictable frequency.

C the same frequency as that of the external periodic force.

D any frequency between the natural frequency and the frequency of the external periodic force.

17 A sound wave travels through air. The graph shows the variation with distance along the sound wave of the displacement of the air molecules at a certain time.



Taking the displacement towards the right as positive, which statement about the wave at P is correct?

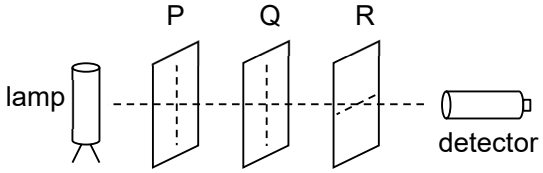
A P is a point of compression.

B The air particle at P is moving towards the right.

C The air particle at P has minimum kinetic energy.

D The air particle at P is experiencing maximum acceleration.

18 Three polaroid sheets P, Q and R are placed along a straight line between a lamp and a detector.



Initially, the directions of polarisation of P and Q are parallel but normal to the direction of polarisation of R.

What happens to the intensity I recorded by the detector when Q is rotated slowly through an angle of 90° until its direction of polarisation is parallel to that of R?

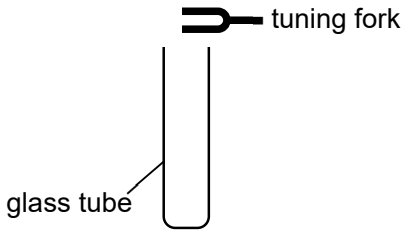
A I remains unchanged.

B I increases throughout.

C I increases and then decreases.

D I decreases and then increases.

19 A vibrating tuning fork is held near the mouth of a glass tube as shown.



Which of the following deductions is **incorrect** if resonance of the air column is observed?

A There is a pressure antinode at the closed end of the tube.

B The observed loudness is greater than just with the fork alone.

C The air molecules in the tube are vibrating at different amplitudes.

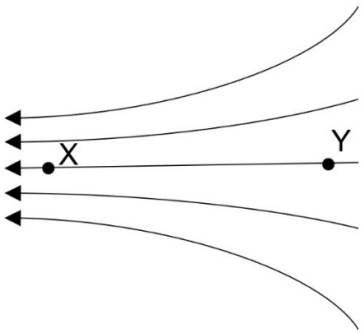
D The fundamental frequency of the air column in the tube must be equal to the frequency of the tuning fork.

20 An optical instrument is used to observe an object illuminated with monochromatic light.

Which of the following changes to the frequency of the light and the width of the aperture of the instrument will increase the resolving power of the instrument?

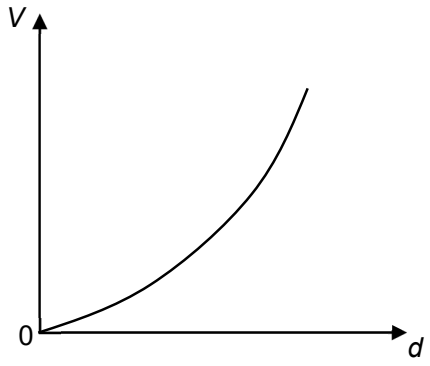
	frequency	aperture diameter
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

21 The diagram shows two points X and Y in an electric field.

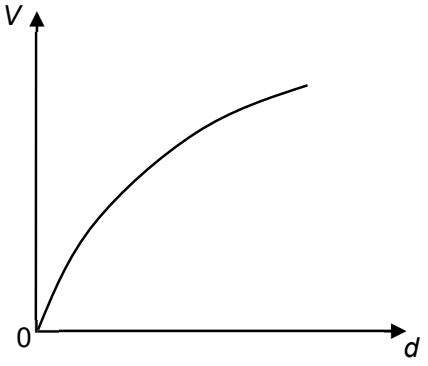


Which graph shows a possible variation with distance *d* from X to Y of the electric potential *V*?

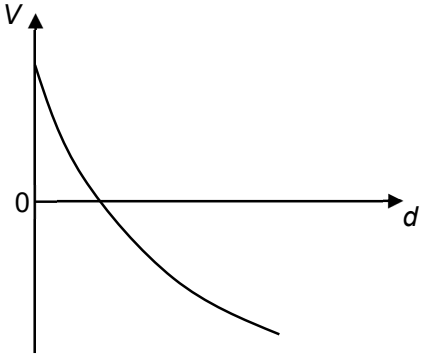
A



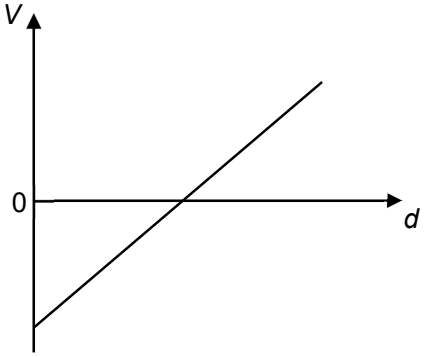
B



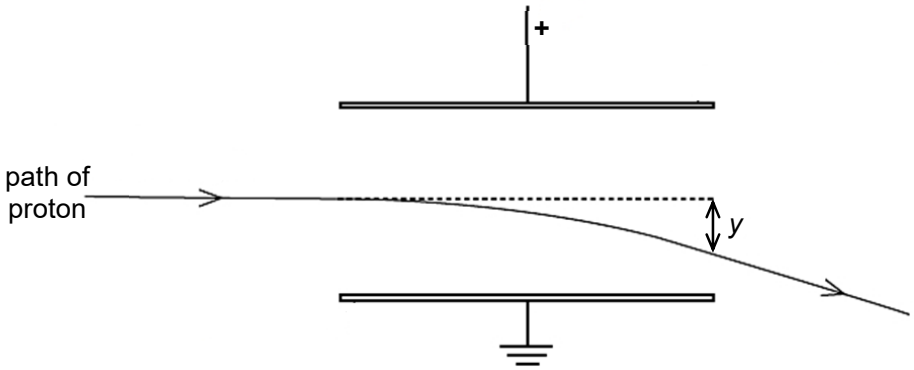
C



D



22 A proton with kinetic energy K is directed horizontally between two charged horizontal plates and exits with a vertical displacement y.

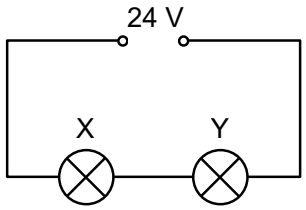


An alpha particle (i.e. a $^{4}_{2}$He nucleus) with kinetic energy $4K$ is now directed horizontally between the plates.

What is the alpha particle's vertical displacement as it exits the plates?
(Ignore the effects of gravity.)

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

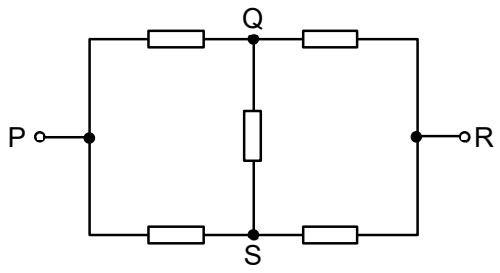
23 Two filament lamps X and Y are connected in series with a 24 V power supply. Lamps X and Y dissipate power of 1 W and 3 W respectively.



What is the potential difference across lamp X?

A 6 V **B** 8 V **C** 16 V **D** 18 V

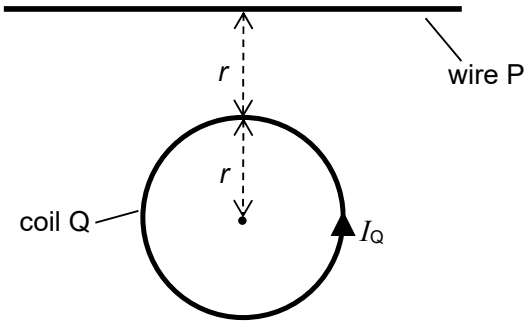
24 A current flows from P to R through a network of resistors such that the potential differences (p.d.) across PQ, QR and PS are 3 V, 5 V and 6 V respectively.



Which row is correct?

	p.d. across SR	p.d. across QS
A	2 V	3 V
B	3 V	2 V
C	8 V	3 V
D	10 V	2 V

25 A coil Q of a single turn and radius r, carries an anti-clockwise current I_Q and lies flat on the table. A long straight wire P carrying current I_P is placed on the same table such that its perpendicular distance from the centre of coil Q is 2r.



Which of the following will cause the resultant magnetic field at the centre of coil Q to be zero?

A I_P to the right, $I_P = 2\pi I_Q$

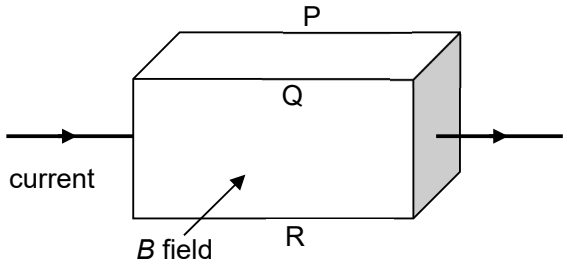
B I_P to the left, $I_P = 2\pi I_Q$

C I_P to the right, $I_Q = 2\pi I_P$

D I_P to the left, $I_Q = 2\pi I_P$

26 A metallic block has a steady current passing through it from the left surface to the right surface. A horizontal magnetic field *B* is directed perpendicularly into the front surface towards the back surface.

Edges P, Q and R are labelled as shown.



Across which two edges will a potential difference be set up, and which edge will be at a higher potential?

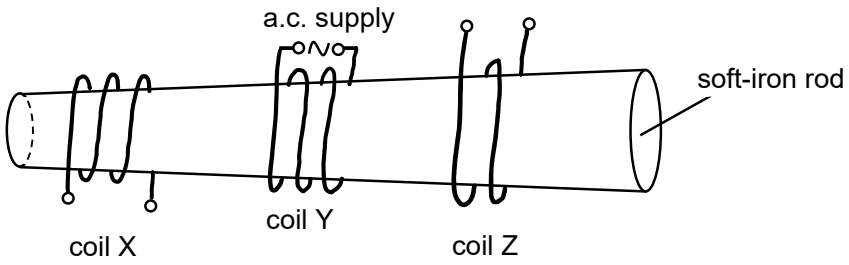
A Across P and Q with P at a higher potential.

B Across P and Q with Q at a higher potential.

C Across Q and R with Q at a higher potential.

D Across Q and R with R at a higher potential.

27 A soft-iron rod of variable cross-section has three coils tightly wound round it at the positions shown. Coil X and coil Y has 3 turns each while coil Z has 2 turns. Coil Y is connected to an alternating current supply.



Which statement is correct?

A The magnitude of the e.m.f. induced in coil X is equal to that induced in coil Z.

B The magnitude of the e.m.f. induced in coil X is larger than that induced in coil Z.

C The magnitude of the e.m.f. induced in coil X is smaller than that induced in coil Z.

D There is no e.m.f. induced in coil X and coil Z as they are not closed loops.

28 Transmission cables of total resistance R are used to transfer electrical energy from an a.c. generator in a power station to a factory located several kilometers away.

The power and voltage outputs of the generator are P and V respectively. The potential difference across the transmission cables is V_c.

What is the power input to the factory?

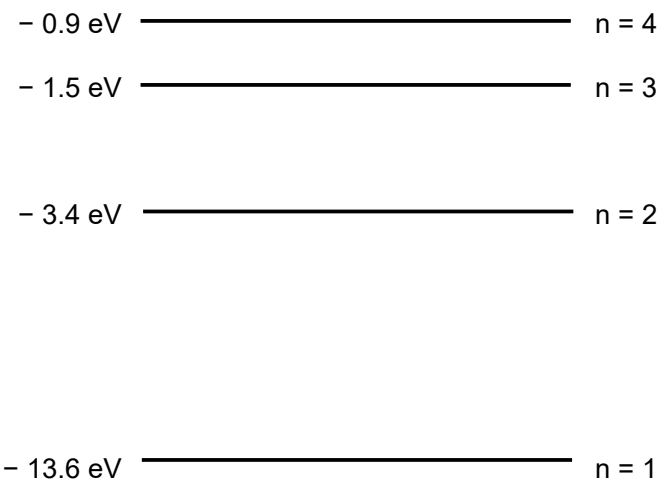
A $P + \left(\frac{P}{V}\right)^2 R$

B $P + \left(\frac{P}{V_C}\right)^2 R$

C $P - \left(\frac{P}{V}\right)^2 R$

D $P - \left(\frac{P}{V_C}\right)^2 R$

29 The diagram shows the first four energy levels of a hydrogen atom.



Which statement is correct?

A An electron transition from n = 4 to n = 2 produces visible light.

B An electron of energy 12.0 eV will not be able to excite a hydrogen atom in the ground state.

C A hydrogen atom in the $-1.5\ \text{eV}$ state can emit a photon of energy 0.6 eV in order to arrive at the $-0.9\ \text{eV}$ state.

D An electron transition from n = 4 to n = 1 produces a photon of a longer wavelength than a transition from n = 4 to n = 2.

30 A virus of mass $(7.0 \pm 0.7) \times 10^{-18}$ kg is moving with a speed of (2.5 ± 0.1) μm s^{-1}.

What is the minimum uncertainty in the measurement of the position of the virus?

A 10×10^{-9} m **B** 3×10^{-10} m **C** 7×10^{-27} m **D** 5×10^{-33} m

End of Paper 1