H

NATIONAL JUNIOR COLLEGE

SENIOR HIGH 2 PRELIMINARY EXAMINATION

Higher 2

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

PHYSICS

Paper 1 Multiple Choice

9749/01

18 September 2024
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THE INSTRUCTION FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, subject class and registration number on the Answer Sheet in the spaces provided 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.

Read the instructions on the Answer Sheet very carefully.

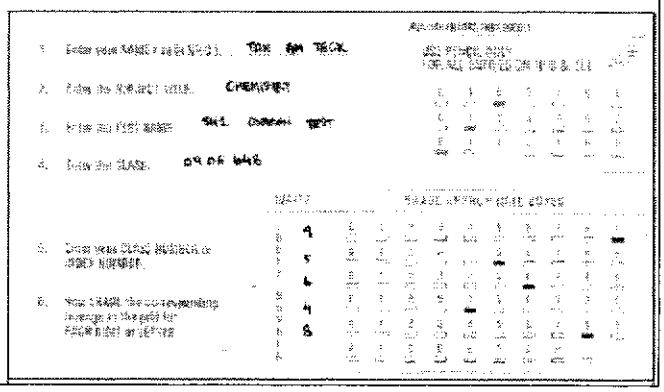
Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

The OAS index number is in a 5-digit format.

The 5-digit format is as follows: **2nd digit** and the **last four digits** of the Reg Number.

e.g. 2005011 becomes **05011**

INSTRUCTIONS ON SHADING OF REGISTRATION NUMBER



This document contains **15** printed pages and **1** blank pages.

[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -Gm/r$
temperature	$T/\mathrm{K} = T/^\circ\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

over

1 What is the number of heartbeats of a person at rest in one hour, to the nearest order of magnitude?

A 10^1 **B** 10^2 **C** 10^3 **D** 10^5

2 Which experimental technique reduces the systematic error of the quantity being investigated?

A measuring the diameter of a wire repeatedly and calculating the average

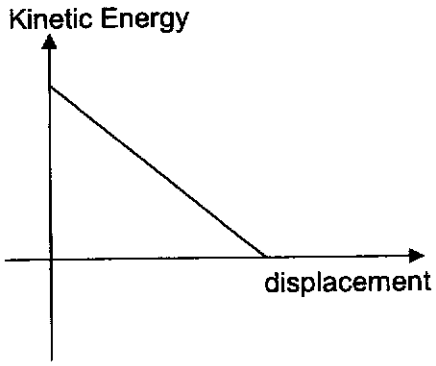
B measuring several internodal distances on a standing wave to find the mean internodal distance

C adjusting an analogue ammeter to remove its zero error before measuring a current

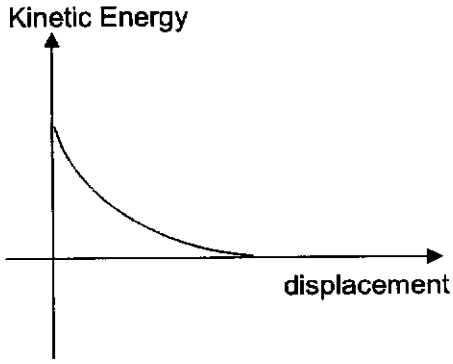
D timing a large number of oscillations to find a period

3 A block is projected at a certain speed up a frictionless slope. Which of the following graphs correctly shows the relationship between the kinetic energy of the block and the displacement of the block along the slope after its point of projection?

A



B



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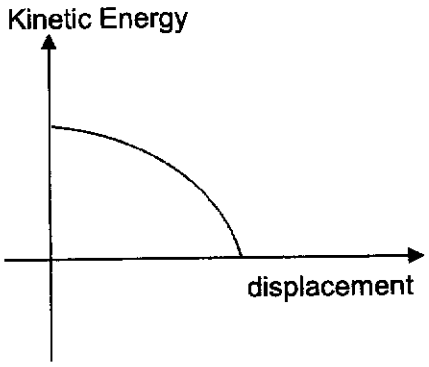
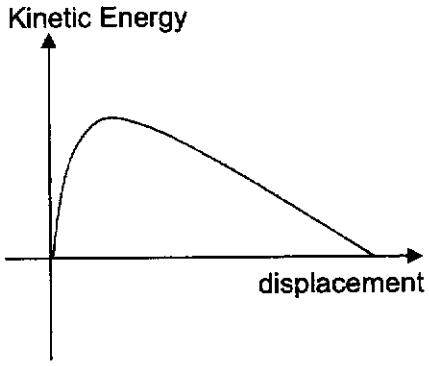


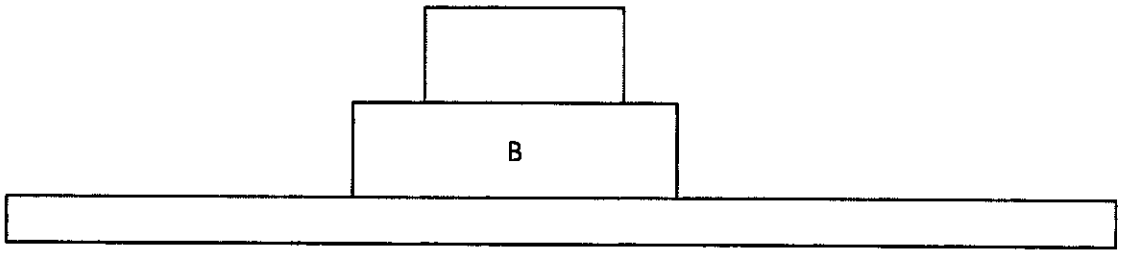
D



4 Drops of water falls from the roof of a building 9.0 m high at regular intervals of time. The first drop reaches the ground at the instant the fourth drop starts its fall. What is the distance between the second and third drops from the roof?

A 1.0 m **B** 3.0 m **C** 4.0 m **D** 5.0 m

5 Two objects are being pulled along a smooth floor by a 70 N force as shown. Object A has a mass of 20 kg and object B has a mass of 6.0 kg. The masses do not slide against each other.



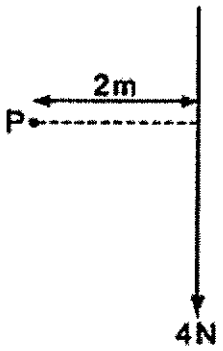
A
B
70 N

Which line of the table correctly states the magnitude and direction of friction on A by B?

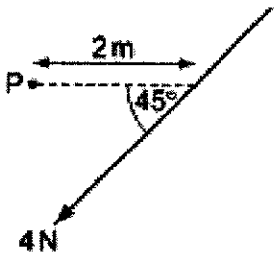
	magnitude	direction
A	16 N	to the left
B	16 N	to the right
C	54 N	to the left
D	54 N	to the right

6 In which diagram is the moment of force about point P greatest?

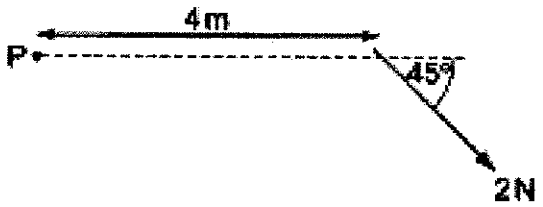
A



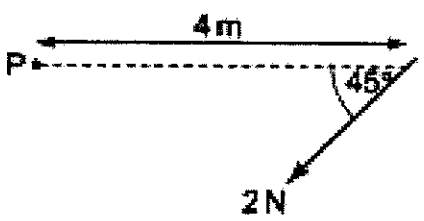
B



C



D

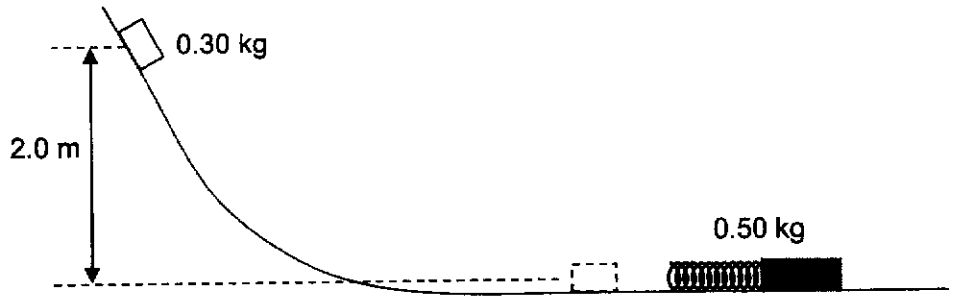


7 Before two moving bodies collide, they have kinetic energy and momentum.

Which row correctly states whether the total kinetic energy and the total momentum are conserved or not after the collision?

	total kinetic energy	total momentum
A	always conserved	always conserved
B	always conserved	may change
C	may change	always conserved
D	may change	may change

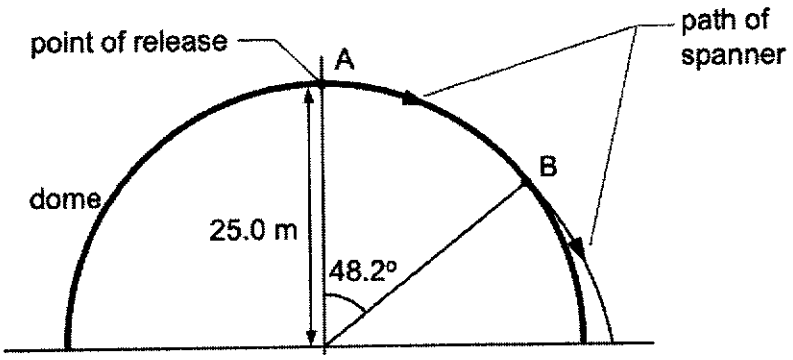
8 A mass of 0.30 kg slides from rest at height 2.0 m down a smooth curved surface which becomes horizontal at zero height. Another mass with a spring attached has a total mass of 0.50 kg and it is at rest on the level part of the surface. During collision, the maximum compression of the spring is 0.20 m.



What is the spring constant?

A 184 N m^{-1} **B** 196 N m^{-1} **C** 253 N m^{-1} **D** 294 N m^{-1}

9 A workman on the roof of a hemispherical sports dome of radius 25.0 m lets go of a spanner very close to the highest point A as shown.



The surface of the roof is very smooth and the spanner starts to slide from rest down the dome. The spanner loses contact with the surface at point B.

What is the centripetal acceleration of the spanner at point B?

A 4.91 m s^{-2} **B** 6.54 m s^{-2} **C** 7.31 m s^{-2} **D** 9.81 m s^{-2}

10 Which of the following statements about geostationary orbits is **false**?

A A geostationary orbit must be directly above the equator.

B All satellites in a geostationary orbit must have the same mass.

C The period of a geostationary orbit must be 24 hours.

D There is only one possible radius for a geostationary orbit.

11 Which of the following is a property of a uniform gravitational field?

A It acts equally in all directions

B Its field strength is the same at all points within it.

C It produces zero force on a stationary test mass placed in it.

D The gravitational potential has the same value at all points within it.

12 Three particles have speeds of $2u$, $10u$ and $11u$. Which one of the following statements is correct?

A The r.m.s. speed exceeds the mean speed by about $1u$.

B The mean speed exceeds the r.m.s. by about $1u$.

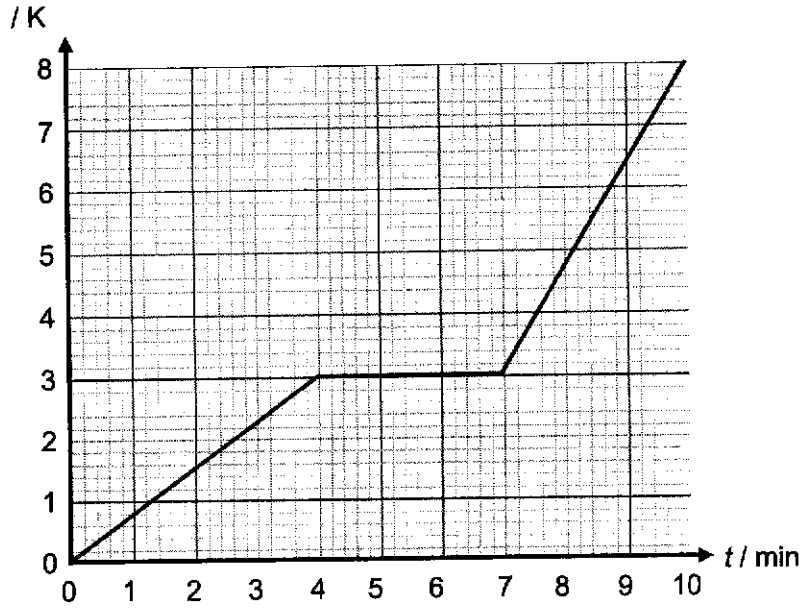
C The r.m.s. speed exceeds the mean speed by more than $2u$.

D The mean speed exceeds the r.m.s. speed by more than $2u$.

13 A gas cylinder is fitted with a safety valve which releases a gas when the pressure inside the cylinder reaches 2.0×10^6 Pa. Given that the maximum mass of this gas the cylinder can hold at 10°C is 15 kg, what would be the maximum mass at 30°C?

A 5.0 kg **B** 14 kg **C** 15 kg **D** 16 kg

14 The graph shows the variation with time t of temperature change $\Delta($ for 1 kg of a substance, initially solid at room temperature. The substance receives heat at a uniform rate of 2000 J min^{-1}.



What can be deduced from this graph?

A The specific heat capacity of the substance is greater when liquid than when solid.

B The specific latent heat of fusion of the substance is 6000 J kg^{-1}.

C The substance melts at a temperature of 3 K.

D After 10 min, the substance is all gaseous.

15 A student is investigating the specifications of a camera shutter. He used a camera to photograph a simple pendulum bob that is moving in front of a horizontal scale. The extreme positions of the bob were at 600 mm and 700 mm marks.

The photograph showed that the bob moved from the 640 mm mark to the 675 mm mark when the shutter was opened. If the period of the pendulum was 2.0 s, what is the time that the shutter has remained opened?

A 0.13 s **B** 0.23 s **C** 0.40 s **D** 0.44 s

16 Two particles P and Q are in a sinusoidal wave of amplitude A. The distance of particle P from its equilibrium is A while the distance of particle Q from its equilibrium is $\frac{1}{3}A$.

What can be the phase angle between the two particles P and Q?

A 19° **B** 45° **C** 60° **D** 71°

17 The intensity of a wave depends on the amplitude. The intensity is also proportional to the square of the frequency.

A wave has frequency 5.0 Hz, amplitude 2.4 cm and intensity I.

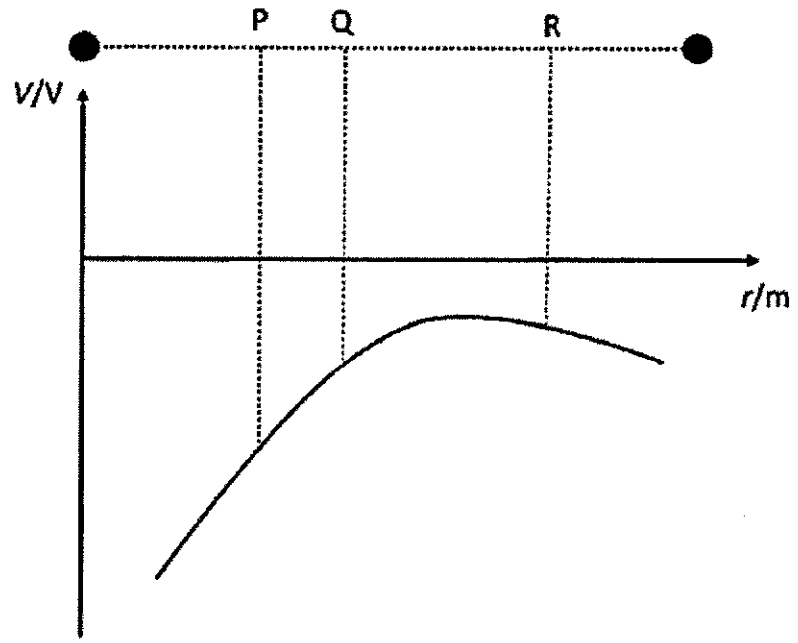
What is the intensity of a similar wave of frequency 15.0 Hz and amplitude 1.2 cm?

A $\frac{4}{9}I$ **B** $\frac{2}{3}I$ **C** $\frac{9}{4}I$ **D** $36\,I$

18 Light of wavelength λ is incident normally on a diffraction grating of slit separation 4λ. What is the angle between the second order maximum and third order maximum?

A 14.5° **B** 18.6° **C** 48.6° **D** 71.4°

19 Two charges are placed in free space. The variation of the electric potential V, with the distance r from the left charge along the line joining the centres of the charges is shown below.



Which of the following statements is true?

A Any charge placed at point P will experience a resultant force towards the left.

B The electric field strength at point Q is larger than the electric field strength at P.

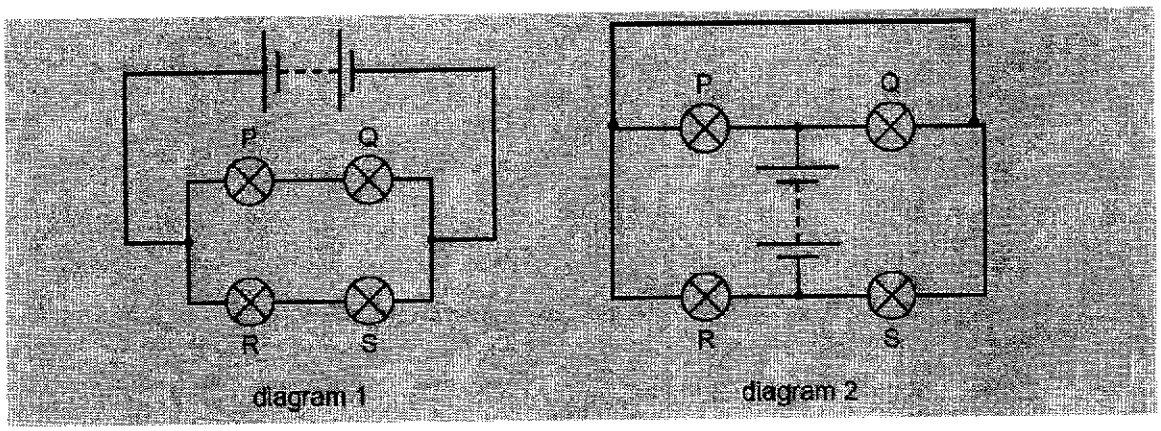
C Net positive work needs to be done by an external agent to move a negative charge from point R to point P.

D A positive charge at P has more electric potential energy as compared to an identical positive charge placed at R.

20 Two parallel plates are connected to a high potential difference of 4.5 kV. The separation of the plates is 1.5 mm. The maximum acceleration of an electron between the plates is

A 1.0×10^{9} m s^{-2} **B** 1.2×10^{12} m s^{-2} **C** 1.6×10^{15} m s^{-2} **D** 5.3×10^{17} m s^{-2}

21 When four identical lamps P, Q, R and S are connected as shown in diagram 1, they have normal brightness.



The four lamps and the battery are then connected as shown in diagram 2. Which statement is correct?

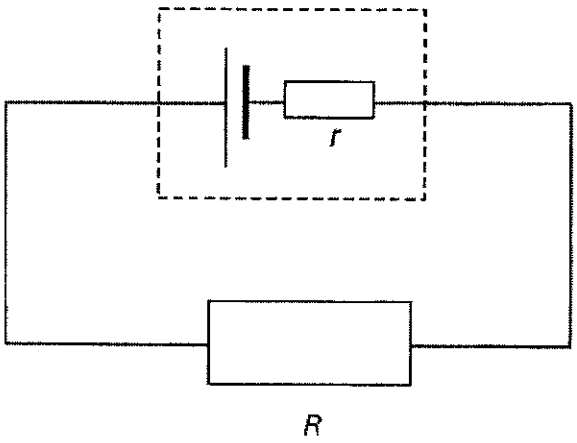
A The lamps P and Q in diagram 2 do not light up.

B The lamps P and Q are brighter while R and S are less bright than normal.

C All lamps have normal brightness.

D All lamps are brighter than normal.

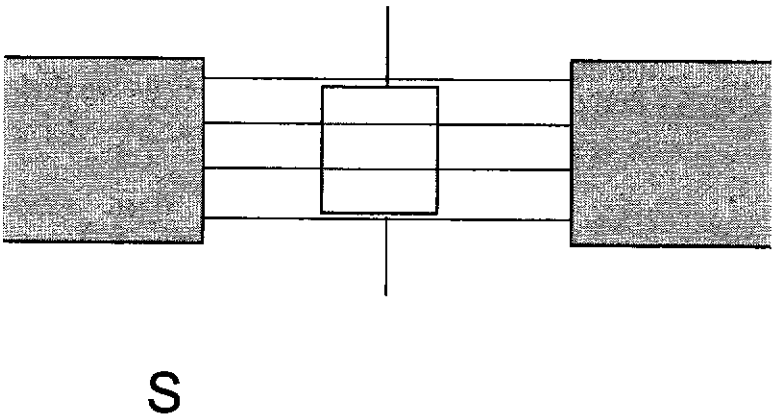
22 A battery with internal resistance *r* is connected to a resistor *R* as shown in the figure below. A constant current passes through *R*. When a charge of 20.0 C passes through the circuit, the heat dissipated in *r* is 10.0 J and the heat dissipated in *R* is 50.0 J.



What is the e.m.f. of the battery and the potential differences across *r* and *R*?

	e.m.f. of the battery	potential difference across r	potential difference across R
A	6.00 V	1.00 V	5.00 V
B	6.00 V	5.00 V	1.00 V
C	3.00 V	2.50 V	0.50 V
D	3.00 V	0.50 V	2.50 V

23 In an electric motor, a rectangular coil WXYZ carrying current has 20 turns and is in a uniform magnetic field of flux density 0.80 T.

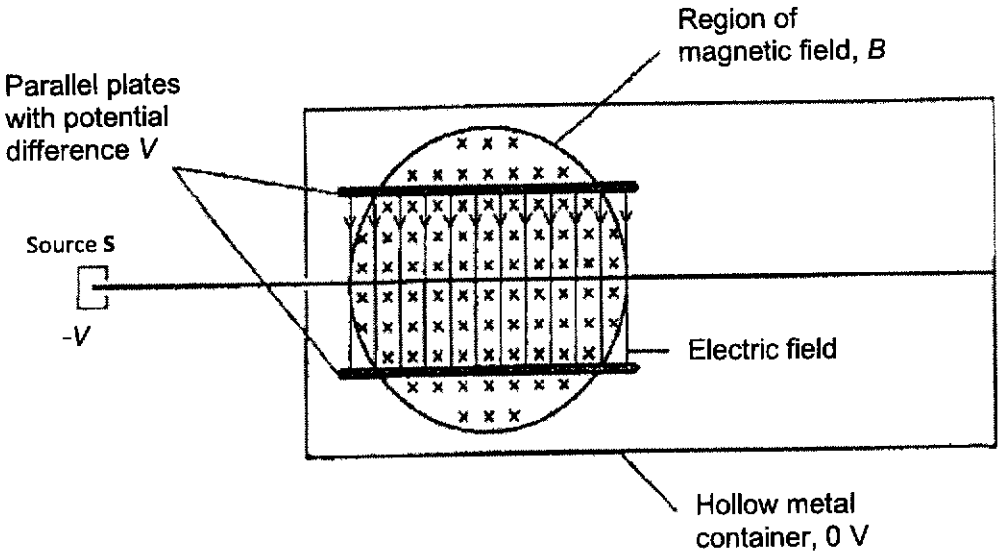


The lengths of sides XY and ZW are 0.17 m and of sides WX and YZ are 0.11 m. The maximum torque provided by the motor is 1.35 N m.

What is the current in the rectangular coil?

A 4.5 A **B** 9.0 A **C** 45 A **D** 90 A

24 A part of a mass spectrometer is shown in the figure below. Negative ions are generated at the source **S** with negligible speed, which is at a potential of $-V$ with respect to the hollow metal container. Inside the container, there are parallel plates separated by distance d and a uniform magnetic field B is applied to the region between the parallel plates.

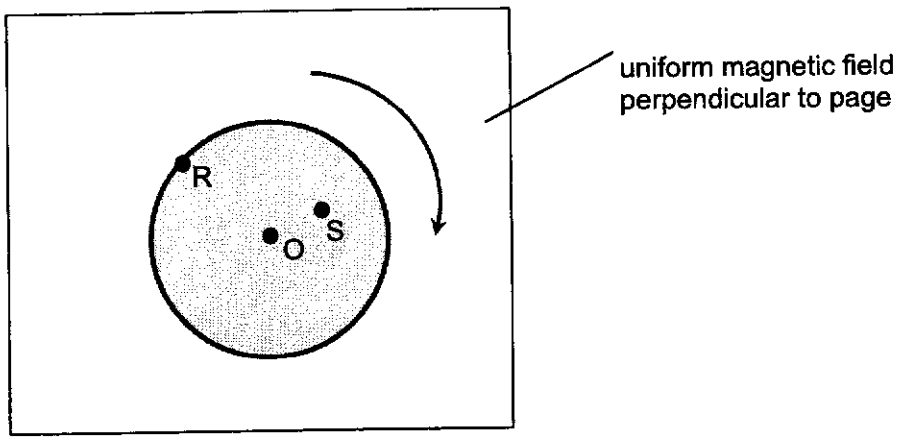


If the potential difference between the parallel plates is V, what is the charge to mass ratio of the ions that can pass through the fields undeviated?

A $\frac{V}{2B^2d^2}$ **B** $\frac{2V}{B^2d^2}$ **C** $\frac{2B^2d^2}{V}$ **D** $\frac{B^2d^2}{2V}$

25 The figure below shows a copper disc rotating at constant angular speed about its centre O in a uniform magnetic field acting perpendicular to the page. Point R is at a distance r from the centre O. The induced e.m.f. between O and R is E.

Point S is at a distance $\frac{r}{2}$ from O.



What is the induced e.m.f. between R and S?

A $E/4$ **B** $E/2$ **C** $3E/4$ **D** E

26 Fig. (a) shows two concentric circular conductors lying in the same plane. The current in the outer loop is clockwise and changes with time as shown in Fig. (b).

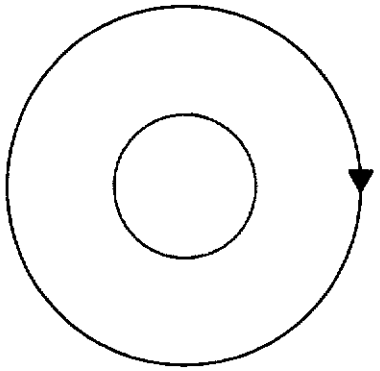


Fig. (a)

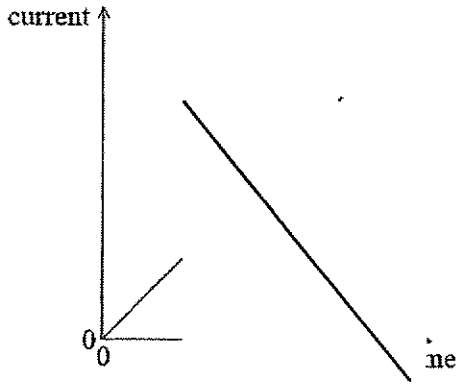


Fig. (b)

inner loop
outer loop
current
time

The induced current in the inner loop is

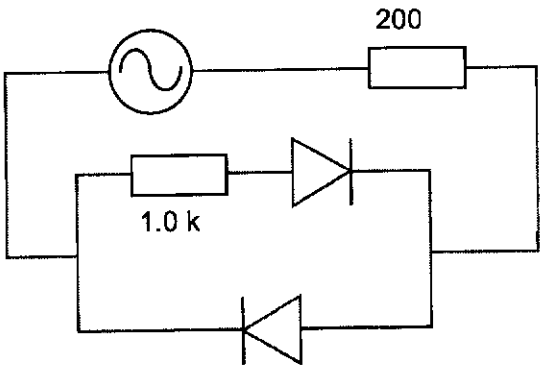
A constant in the clockwise direction.

B increasing linearly with time in the clockwise direction.

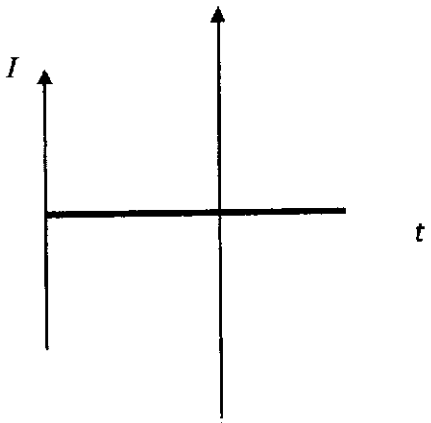
C decreasing linearly with time in the clockwise direction.

D increasing linearly with time in the anticlockwise direction.

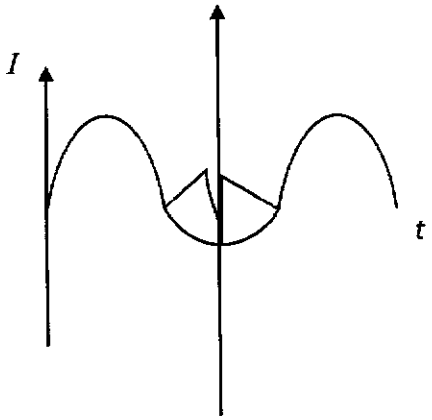
27 Which of the following graphs best represents the variation with time t of the current I through the 200 Ω resistor in the circuit below?



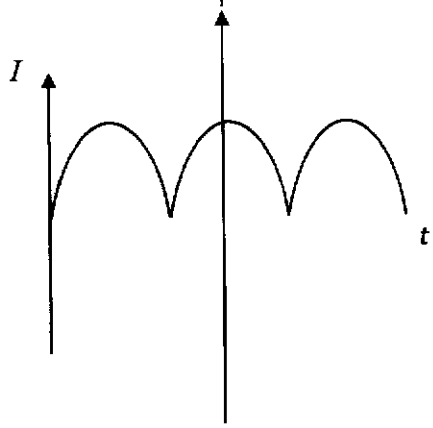
A



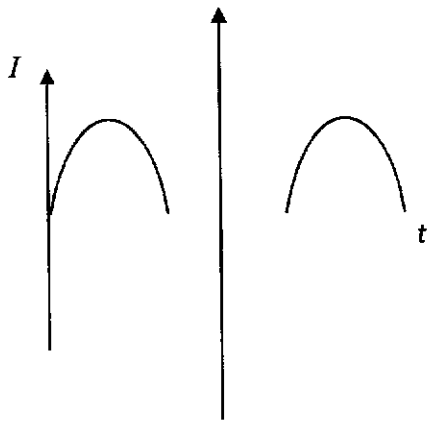
B



C



D



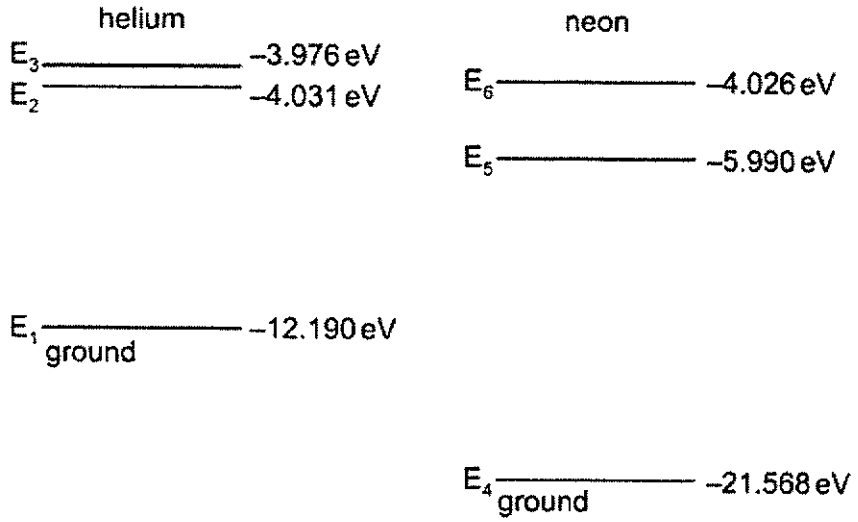
28 Two beams P and Q of light of the same wavelength is incident on the same metal surface causing photoelectrons to be emitted.

The photoelectric current produced by P is four times that produced by Q.

Which of the following gives the ratio $\frac{amplitude\ of\ wave\ P}{amplitude\ of\ wave\ Q}$?

A 0.25 **B** 0.50 **C** 2.0 **D** 4.0

29 The diagram shows some of the energy levels of helium and neon. The elements are the major constituents in a laser that emits red light.



Which transition between the labelled levels gives rise to the emission of the laser light?

A E_3 to E_2 **B** E_6 to E_5 **C** E_2 to E_1 **D** E_5 to E_4

30 Thorium $_{90}^{232}Th$ decays through a series of transformations. The particles emitted in successive transformations are

α β β γ α

The resulting nuclide may be represented by

A $_{82}^{230}Pb$ **B** $_{88}^{226}Ra$ **C** $_{86}^{224}Rn$ **D** $_{88}^{224}Ra$

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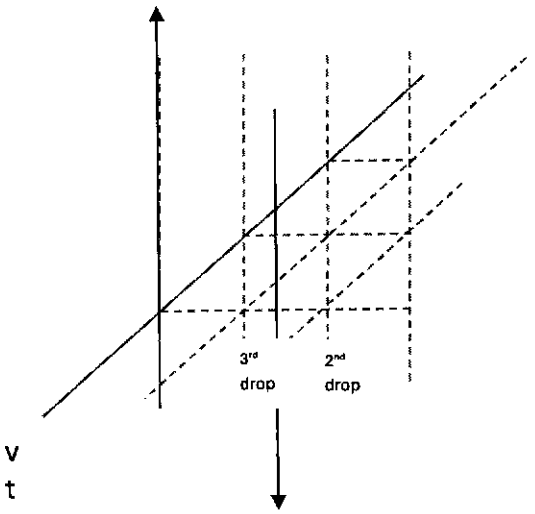
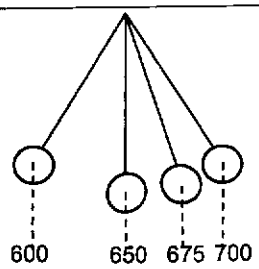
NJC Preliminary Examination 2024
H2 Physics Paper 1

Solutions

1	2	3	4	5	6	7	8	9	10
C	C	A	B	A	A	C	A	B	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	A	B	B	B	D	C	B	C	D
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
C	D	A	A	C	A	B	C	B	D

1	C	1 per second, 3600 per hour
2	C	by definition
3	A	Slope has constant gradient. $v^2 = u^2 + 2as$. So KE is proportional to the displacement with a being negative.
4	B	Let time interval between each drop be t. First drop took 3t to reach the ground and travelled 9 m $9 = 0\ (4t) + ½\ (g)(3t)^2$ $t^2 = \frac{2}{g}$ distance travelled by 2nd drop = $0(2t) + ½\ g\ (t)^2$ distance travelled by 3rd drop = $0\ (3t) + ½\ g\ (2t)^2$ distance between 2nd and 3rd drop = $½\ g\ (2t)^2 - ½\ g\ (t)^2 = 3.0$ m alternative solution:  distance between 1st drop and 4th drop = 9 triangles = 9m distance between 2nd and 3rd drop = 3 triangles = 3m
5	A	$F = 70 = (20+6)\ a$ $a = 2.692\ ms^{-2}$ f on B = 6 a = 16.15 N (to right) N3L, f on A = f on B = 16.15 N = 16 N (2sf) (to left)
6	A	Taking moments. A has the greatest moments.
7	C	Kinetic energy is conserved only for elastic collision, momentum is conserved for both elastic and inelastic

8	A	GPE = KE 0.3 (9.81) (2) = 5.886 = ½ (0.3) v^2 v = 6.2641 m s^{-1} $P_i = P_f$ 0.3 (6.2641) = (0.3 + 0.5) V V = 2.3491 m s^{-1} KE after collision = ½ (0.8) 2.3491^2 = 2.20725 J therefore EPE = 5.886 – 2.20725 = ½ k $(0.20)^2$ k = 184 N m^{-1} (3 s.f.)
9	B	At B, resultant force towards centre of dome $F_{net} = mg \cos 48.2°$ Centripetal acceleration = F_{net} / m = $g \cos 48.2°$ = 6.54 m s^{-2}
10	B	Geostationary orbit is always at the same radius, have the same period and mass does not affect the orbit
11	B	Uniform g field has the same g field strength at all points
12	A	Mean speed = $\frac{(2+10+11)u}{3} = 7.67u$ Mean square speed = $\frac{(4+100+121)u^2}{3} = 75u^2$ Root mean square speed = $u\sqrt{75} = 8.66u$
13	B	$pV = nRT = \frac{m}{M}RT$ At constant pressure and volume, mT = constant. $m_2T_2 = m_1T_1$ ® $m_2 = \frac{m_1T_1}{T_2} = \frac{(273+10)}{(273+30)} \times 15 = 14$ kg
14	B	Q = Pt = mcΔ(P = mc(Δ(/t) P and m is constant, Δ(/t is bigger for liquid than solid, therefore specific heat capacity c is smaller for liquid than solid. (A is wrong) Q = mL 2000 x 3 = 1 x L □ L = 6000 J kg^{-1} (B is correct) The substance melts after an increase in temperature of 3K from room temperature. The melting temperature is not 3K. (C is wrong) Unless the graph becomes horizontal again, we are unable to determine when the substance starts to become gaseous. And only after it stops being horizontal again will it be completely gaseous. (D is wrong)

15	B	 Taking the initial position at 650 mm mark, $x = x_0 \, sin \, sin \, \omega \, t = x_0 \, sin \, sin \left[\left(\frac{2\pi}{T}\right)t\right] \; 25 = 50 \, sin \, sin \left[\left(\frac{2\pi}{2}\right)t\right] \; t = 0.167 \, s$ $x = x_0 \, sin \, sin \, \omega \, t = x_0 \, sin \, sin \left[\left(\frac{2\pi}{T}\right)t\right] \; 10 = 50 \, sin \, sin \left[\left(\frac{2\pi}{2}\right)t\right] \; t = 0.064 \, s$ t_{Total} = 0.167 + 0.064 = 0.231 = 0.23 s
16	D	$y = A \, cos \, cos \, \theta$ $y_P = \pm A = A \, cos \, cos \, \theta_P \Rightarrow \theta_P = 0°, 180°$ $y_Q = \pm\frac{1}{3}A = A \, cos \, cos \, \theta_Q \Rightarrow \theta_Q = 70.5°, 109°$
17	C	Intensity proportional to (amplitude)^2 × (frequency)^2. $\frac{I'}{I} = \left(\frac{1.2}{2.4}\right)^2 \left(\frac{15}{5}\right)^2 = \frac{9}{4}$
18	B	$d \sin\theta = n\lambda$ $4\lambda \sin\theta = 2\lambda$ $\sin\theta_1 = 0.5, \longrightarrow \theta_1 = 30^0$ $\sin\theta_2 = \frac{3\lambda}{4\lambda} \longrightarrow \theta_2 = 48.59^0$ $48.59^0 - 30^0 = 18.59^0 \approx 18.6^0$

19	C	Option A: Depending on the charge of the object, the force could either be left (positive charge) or right (negative charge). Option B: The magnitude of the field strength can be found using E = – dV/dr. The gradient at P is larger than Q, so the field strength is larger at P Option C: The potential at P is lower than R, and thus ΔV is a negative number. The work done is W = q ΔV and this is a positive number since *q* is also negative. So, the work done is positive□□ Option D: The potential energy is given by U = qV, and so, since *V* is more negative at P than at R, the potential energy is lower at P than at R.
20	D	Using F = ma, thus eE = m a a = e(V/d) / m_e = 5.3 X 10^{17} m s^{-2}
21	C	There is no difference between the connections in diagram 1 and diagram 2. Since the lamps are of the same resistance, putting a wire across the points parallel to the lamps P and Q does nothing to change the circuit itself
22	D	Total energy provided by battery is 60J Emf is W/Q = 60/20 = 3.00 V Pd across r = 10/20 = 0.50 V Pd across R = 50/20 = 2.50 V
23	A	The forces acting on XY and ZW have the same magnitude in opposite directions. These two forces form a couple with a torque as follow: $\tau = NBIL \times d = (20)(0.80)(I)(0.17) \times (0.11) = 1.35$ *I* = 4.5 A
24	A	Negative charges gain KE as it loses EPE from Source S to the hollow metal container. qV = ½ mv^2 □ 2V (q/m) = v^2 — (1) Inside the hollow metal container, in order for the ions to pass through un-deviated, $F_B = F_E$ Bqv = qE = q(V/d) Bv = (V/d) v = (V/Bd) — (2) Sub (2) in (1) $(V/Bd)^2$ = 2V (q/m) q/m = V / (2 B^2 d^2)

25	C	Emf of a rotating disc of radius L $= \frac{\text{Change in flux}}{\text{Time}}$ $= \frac{B.\pi L^2}{T}$ $= \frac{B.\pi L^2}{\frac{2\pi}{\omega}}$ $= \frac{1}{2} BL^2\omega$ $\lvert e \rvert = \frac{1}{2} BL^2\ \omega.$ Emf between R and S = ½ $BL^2\ \omega$ - ½ $B(L/2)^2\ \omega$ = ¾ (1/2 $BL^2\ \omega$) According to the question E = ½ $BL^2\ \omega$, therefore, emf between R and S is ¾ E
26	A	Since inner loop experiences decreasing flux linkage, current in the inner wire will flow in the same direction as that in the outer wire to oppose this deceasing flux linkage (Lenz's law). Since the rate of decrease of current with time is constant, the rate of decrease of B and hence flux linkage is constant, hence e.m.f. induced in inner loop is constant and the current in the inner loop is constant.
27	B	Clockwise: current pass through 200 Ω only. anticlockwise: current pass through both resistors.
28	C	Photocurrent is proportional to intensity. Intensity is proportional to (amplitude)^2. $\frac{amplitude\ of\ wave\ P}{amplitude\ of\ wave\ Q} = \sqrt{\frac{intensity\ of\ wave\ P}{intensity\ of\ wave\ Q}} = \sqrt{\frac{photocurrent\ of\ wave\ P}{photocurrent\ of\ wave\ Q}}$ $= \sqrt{\frac{4}{1}} = 2$
29	B	Energy of red wavelength photon $= \frac{hc}{\lambda} \approx \frac{(6.63 \times 10^{-34}) \times (3 \times 10^{8})}{600 \times 10^{-9}} \times \frac{1}{1.6 \times 10^{-19}} = 2.1\ eV$ Only option B's energy difference is the closest to red wavelength
30	D	Nucleon number = 232 – 4 + 0 + 0 + 0 – 4 = 224 Proton number = 90 – 2 + 1 + 1 + 0 – 2 = 88