TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME	( )
CIVICS GROUP	

H2 PHYSICS 9749/01

Paper 1 Multiple Choice **20 September 2024**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

You do not need to submit this Booklet at the end of the examination.

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

There are **thirty** questions on this paper. Answer **all** questions.
For each question there are four possible answers **A**, **B**, **C**, **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the Multiple Choice Answer Sheet.

Read the instructions on the Multiple Choice Answer Sheet.

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.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\left(1/\left(36\pi\right)\right) \times 10^{-9}$ 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}

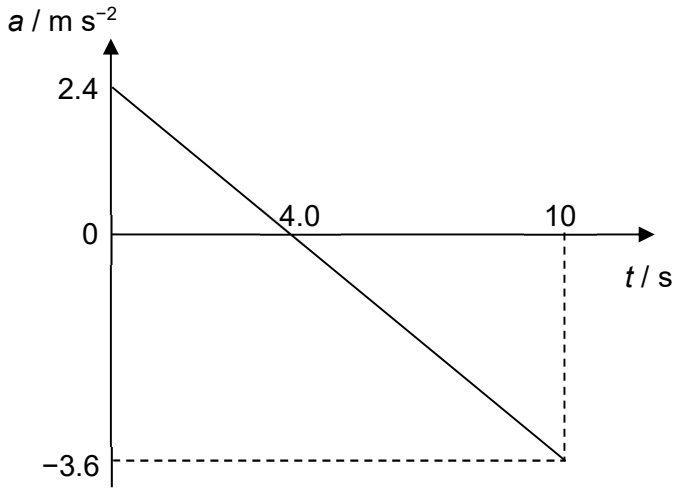
Formulae

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	=	$-\frac{GM}{r}$
temperature	T /K	=	T /°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	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{x_o^{\,2} - x^2}$
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	=	$x_o \sin \omega t$
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 What is a reasonable estimate for the volume of a pen?

A 0.10 cm^3 **B** 1.0 cm^3 **C** 10 cm^3 **D** 100 cm^3

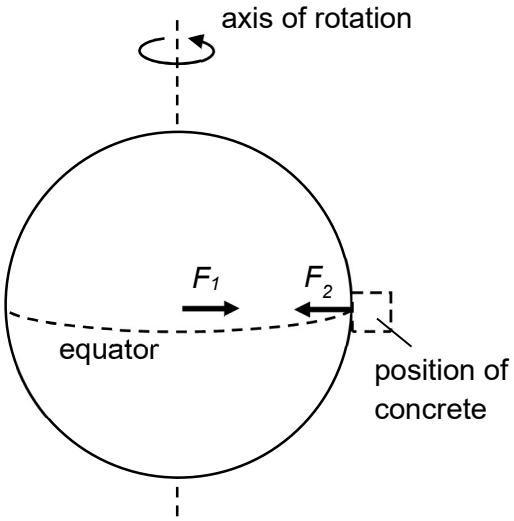
2 The diagram shows the variation with time t of the acceleration a of a body travelling in a straight line.



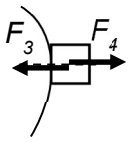
What is the change in velocity between t = 0 and t = 10 s?

A zero **B** −0.60 m s^{-1} **C** −6.0 m s^{-1} **D** −15.6 m s^{-1}

3 A large block of concrete is placed on the ground at the equator where it is rotating with the Earth. The forces acting on the Earth and on the concrete are shown.



forces acting on the Earth

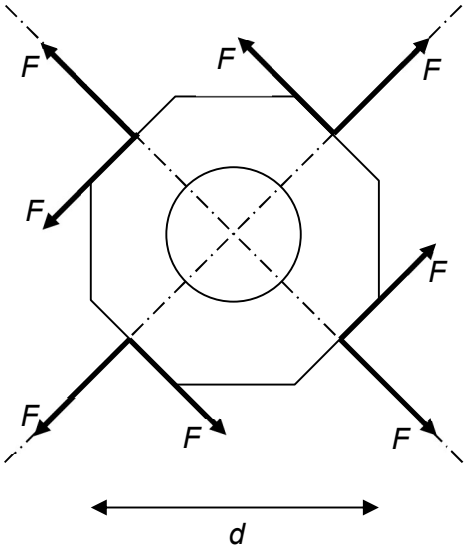


forces acting on the concrete

Which pairs of forces demonstrate Newton's 2nd Law & Newton's 3rd Law?

	Newton's 2nd Law	Newton's 3rd Law
A	F_3 and F_4	F_2 and F_4
B	F_3 and F_4	F_1 and F_2
C	F_1 and F_3	F_2 and F_4
D	F_1 and F_3	F_1 and F_2

4 An octagonal shaped nut, of width *d*, is subjected to eight forces *F* as shown below. All forces are equal in magnitude.

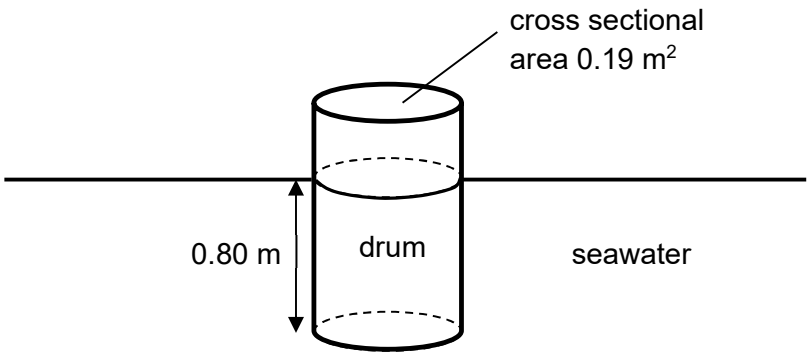


What is the net torque caused by all the forces?

A *Fd** **B** 2*Fd** **C** 3*Fd** **D** 4*Fd*

5 An oil-drum floats in equilibrium in seawater as shown.

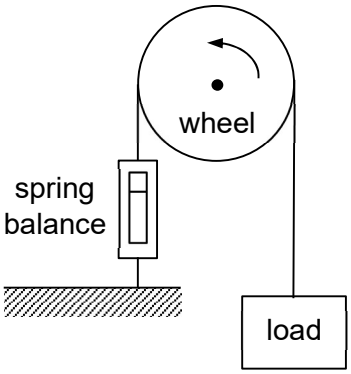
The drum has a cross-sectional area of 0.19 m^2. The length of the drum submerged under water is 0.80 m. The density of seawater is 1.1×10^3 kg m^{-3}.



What is the mass of the drum and its content?

A 167 kg **B** 251 kg **C** 1640 kg **D** 1770 kg

6 The diagram shows a wheel of circumference 0.30 m which is driven by an electric motor. A rope is fastened at one end of the spring balance. The rope passes over the wheel and supports a freely hanging load of 100 N. When the wheel makes 50 revolutions per second, the balance reading is constant at 20 N.

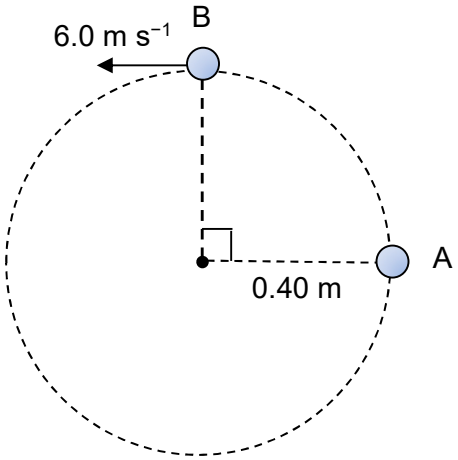


The efficiency of the motor is 20%.

What is the electrical power supplied to the motor?

A 240 W **B** 360 W **C** 6000 W **D** 9000 W

7 A body moves in a uniform circular motion from A to B as shown in the diagram. The radius of the circle is 0.40 m and the speed of the body is 6.0 m s^{-1}.



What is its angular velocity and angular displacement?

	angular velocity / rad s^{-1}	angular displacement / rad
A	2.4	0.63
B	2.4	1.6
C	15	0.63
D	15	1.6

8 On the surface of the Earth, the gravitational force on an object is W.

What is the gravitational force on the object when it is at a height of $2R$ above the surface of the Earth, where R is the radius of the Earth?

A $\frac{W}{2}$ **B** $\frac{W}{3}$ **C** $\frac{W}{4}$ **D** $\frac{W}{9}$

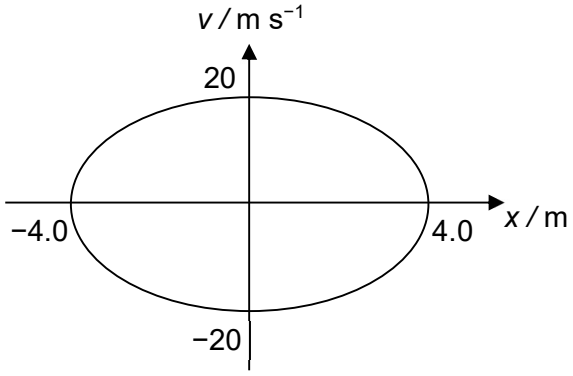
9 A communications satellite which takes 24 hours to orbit the Earth is replaced by a new satellite which has twice the mass of the old one.

The new satellite also has an orbit time of 24 hours.

What is the value of $\frac{\text{radius of orbit of new satellite}}{\text{radius of orbit of old satellite}}$?

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

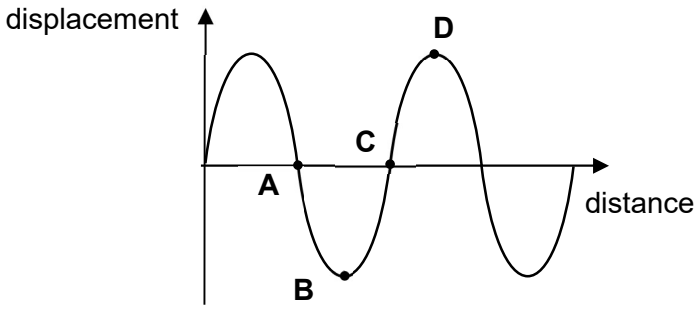
10 The diagram shows the variation with displacement x of the velocity v of a body undergoing simple harmonic motion.



What is the time for the body to take to reduce its speed from maximum to zero?

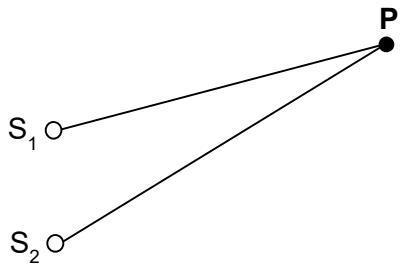
A 0.20 s **B** 0.31 s **C** 1.3 s **D** 4.0 s

11 A sound wave travelling towards the right through air causes the air molecules to be displaced from their original 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, at which point is the pressure minimum?

12 S_1 and S_2 are two wave generators producing waves of intensity $0.36I$ and $0.25I$ respectively at **P**. A resultant intensity minima occurs at **P** as shown in the diagram below.



What is the resultant intensity at point **P** in terms of I?

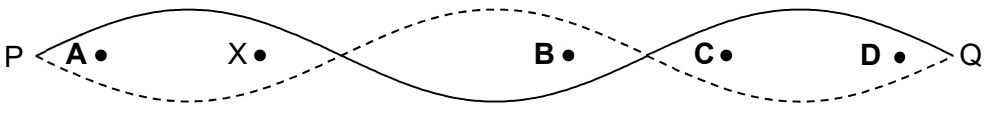
A zero

B $0.010I$

C $0.11I$

D $0.31I$

13 A standing wave is set up on a stretched string PQ as shown in the diagram below.



At which point will the oscillation have π radian phase difference with that at X?

14 An ideal gas is placed in a sealed rigid container and heated uniformly.

Which of the following remains constant?

A average speed of the gas molecules

B average distance between the gas molecules

C average force acting on the gas molecules by the cylinder wall

D average number of molecules hitting the cylinder wall per second

15 Which statement about internal energy is correct?

A Two systems with the same internal energy will have the same temperature.

B When the internal energy of a system is increased, its temperature always rises.

C The internal energy of a system is the sum of the kinetic energies of the molecules.

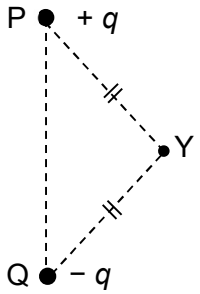
D The internal energy of a system can be increased without the transfer of heat.

16 A hot liquid initially cools at a rate of 1.5 K per minute until it reaches its freezing point. The temperature then remains constant for 30 min as all of the liquid solidifies.

What is the ratio of the specific heat capacity of the liquid to its specific latent heat of fusion?

A $\frac{1}{45}$ **B** $\frac{1}{20}$ **C** 20 **D** 45

17 Two oppositely charged particles are fixed in positions P and Q as shown. Y is equidistant from P and Q.

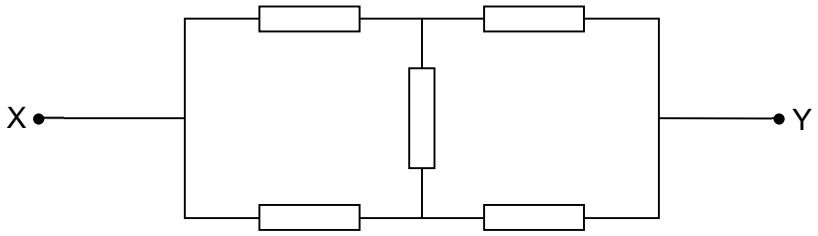


Which one of the following options describes the resultant electric field strength at point Y?

A downwards **B** upwards

C towards the left **D** zero

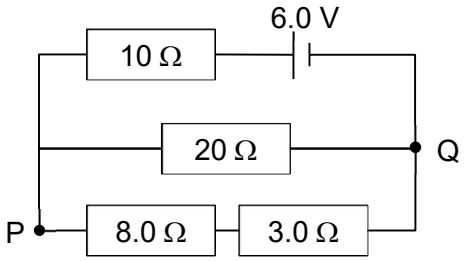
18 Five similar resistors each of resistance R are connected as shown below.



What is the effective resistance across points X and Y?

A $\frac{2R}{5}$ **B** R **C** 2R **D** $\frac{5R}{2}$

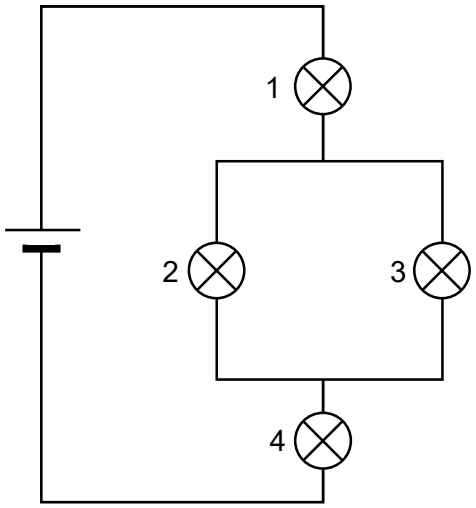
19 A battery with e.m.f. 6.0 V and negligible internal resistance is connected to several resistors as shown below.



What is the potential difference between P and Q?

A 1.6 V **B** 2.3 V **C** 2.5 V **D** 4.0 V

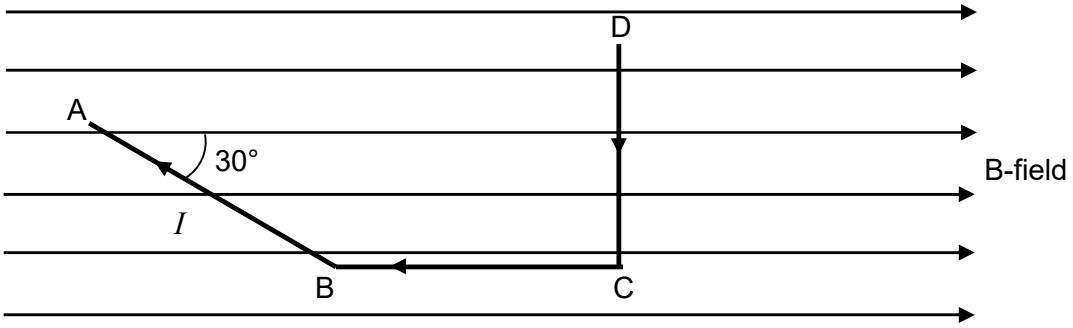
20 An ideal cell and four identical bulbs are connected as shown.



Bulb 3 is removed. Which of the following describes the changes in the brightness of bulbs 1, 2 and 4?

	Bulb 1	Bulb 2	Bulb 4
A	dimmer	brighter	dimmer
B	dimmer	brighter	brighter
C	brighter	dimmer	dimmer
D	brighter	dimmer	brighter

21 The figure below shows a wire ABCD placed in a uniform magnetic field of flux density 0.50 T. The current, I, flowing through the wire is 1.0 A. The lengths of AB, BC and CD are 20 cm each.



What is the net force on the wire ABCD?

A 0.050 N out of the plane of the paper

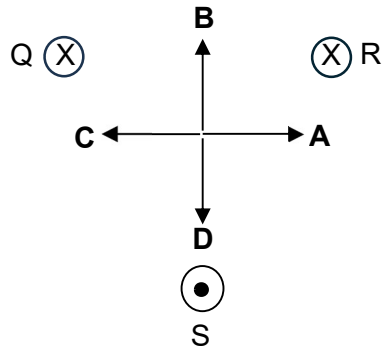
B 0.050 N into the plane of the paper

C 0.15 N out of the plane of the paper

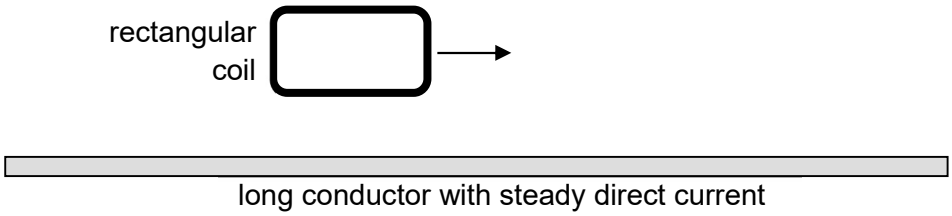
D 0.15 N into the plane of the paper

22 Three wires, Q, R and S, are arranged in an equilateral triangle as shown. The currents in wires Q and R are directed into the plane of the paper, while the current in wire S is directed out of the plane of the paper.

The direction of the magnetic field at the centre of the equilateral triangle is



23 A rectangular coil moves in a direction parallel to a long straight current-carrying conductor as shown below.



The conductor carries a steady direct current. Which of the following statements is true?

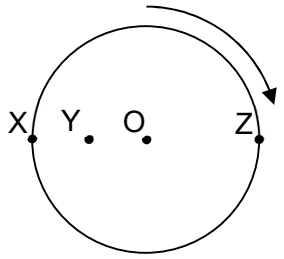
A There is no induced current in the coil.

B The induced current flows clockwise in the coil.

C The magnitude of the induced current in the coil is proportional to $\frac{1}{\sqrt{2}}$.

D The magnitude of the induced current in the coil varies with the speed at which the coil is moving.

24 An aluminium disc is rotated about its centre O at a constant angular speed. It is placed in a uniform magnetic field perpendicular to its surface. X and Z are on the circumference, and Y is midway between O and X. The magnitude of the e.m.f. between any two points, for instance "X" and "Y", is denoted as E_{XY}.



Which of the following options is correct?

A $E_{XY} < E_{YO}$

B $E_{XY} = E_{YO}$

C $E_{XY} < E_{YZ}$

D $E_{XY} = E_{YZ}$

25 An electric kettle has the following label:

power	: 2100 to 2500 W
voltage	: 220 to 240 V
frequency	: 50 to 60 Hz

Which of the following is a probable expression that describes the current flowing through the kettle when it is operational?

A I = 10.4 sin (300t)

B I = 14.1 sin (300t)

C I = 10.4 sin (375t)

D I = 14.1 sin (375t)

26 When a sinusoidal alternating current of peak value I_0 passes through a resistor of resistance R, the mean power dissipated in the resistor is P.

When another sinusoidal alternating current passes through the same resistor of resistance R, the mean power dissipated in the resistor is 4P.

What is the root-mean-square value of this current?

A $\frac{I_0}{\sqrt{2}}$ **B** I_0 **C** $\sqrt{2}I_0$ **D** $2I_0$

27 In a photoelectric effect experiment, the maximum kinetic energy of an emitted photoelectron from the metal surface is 9.0×10^{-20} J.

What is the minimum de Broglie wavelength of this electron?

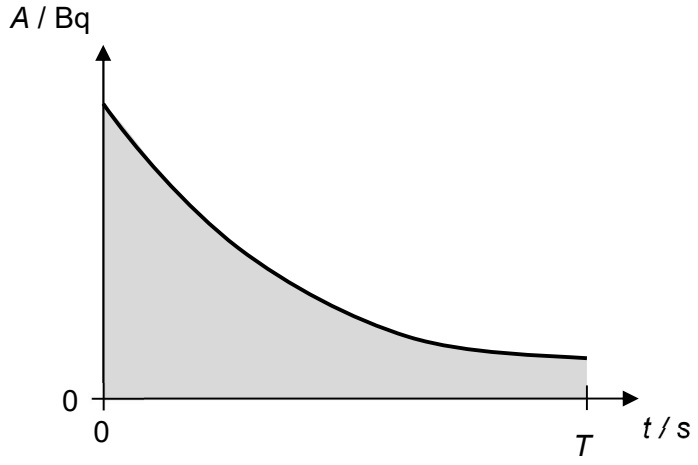
A 3.6×10^{-10} m **B** 7.2×10^{-10} m **C** 8.1×10^{-9} m **D** 1.6×10^{-9} m

28 An electron is travelling in the *x* axis with a speed equal to 60% of the speed of light. The precision of measuring its speed is 0.50%.

What is the uncertainty in measuring the position of the electron along the *x* axis?

A 8×10^{-12} m **B** 8×10^{-11} m **C** 8×10^{-10} m **D** 8×10^{-9} m

29 The graph shows the variation with time *t* of the activity *A* of a pure sample of a radioactive nuclide. The total energy released due to radioactive decay of the sample in time *T* is *E*. The area of the shaded portion is *S*.



What does the quantity $\frac{E}{S}$ represent?

A The number of decays which occur in time *T*

B The average power due to radioactive decay

C The average energy produced in time *T*

D The energy released for each radioactive decay

30 A detector placed close to a radioactive source measures an activity of 320 Bq. The background activity at this location is 20 Bq. The radioactive nuclide has a half-life of 12 hours.

What activity is measured after 9 hours?

A 178 Bq **B** 198 Bq **C** 225 Bq **D** 245 Bq

Blank page

Tampines Meridian Junior College

2024 JC2 H2 Physics Preliminary Examination Paper 1

Suggested Solution

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

Q1 Ans: C

Estimated length = 14.0 cm
Estimated diameter = 1.0 cm
Assuming the cross sectional area is a circle, volume $= \pi \left(\frac{1.0}{2} \right)^2 14.0$

$= 11\ cm^3$

Q2 Ans: C

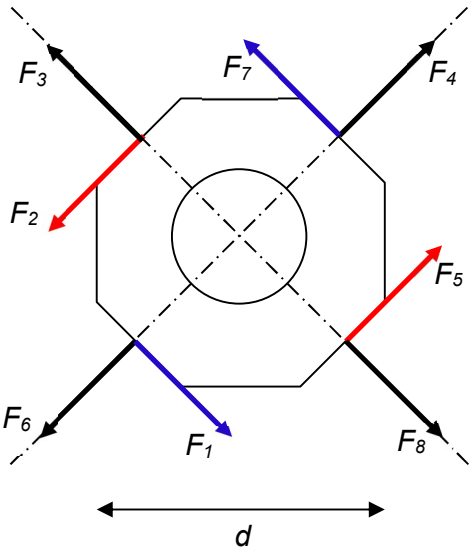
Explanation
change in velocity = total area under graph
total area under graph = ½ × 4.0 × 2.4 + (−½ × 6.0 × 3.6) = −6.0 m s^{-1}

Q3 Ans: A

Newton's 2nd Law: The forces need to act on the same body (to produce a resultant force).
Hence, only the pair F_3 and F_4 satisfy this condition.

Newton's 3rd Law: The forces need to act on different bodies.
Hence, only the pair F_2 and F_4 satisfy this condition.

Q4 Ans: B



Torque of a couple = *Fd* (one set (blue arrows); another set (red arrows)

Hence, total torque = *Fd* + *Fd* = 2*Fd*
*The other forces pass through the cg; hence no torque is generated.

Q5 Ans: A

The effect of atmospheric pressure cancels out at the top and bottom of the drum.

At equilibrium,

$$\text{weight of drum \& content} = \text{weight of water displaced}$$

$$= V\rho g$$

$$= 0.80 \times 0.19 \times 1.1 \times 10^3 \times 9.81$$

$$= 1640 \text{ N}$$

$$\text{mass of drum \& content} = \frac{1640}{9.81} = 167 \text{ kg}$$

Q6 Ans: C

Output power of the motor = (100 - 20)(0.30)(50) = 1200 W

Electrical power supplied to the motor = $\frac{1200}{0.2} = 6000$ W

Q7 Ans: D

Explanation

angular velocity = $\frac{v}{r} = \frac{6.0}{0.40} = 15$ rad s^{-1}

angular displacement = angle $= \frac{\pi}{2} = 1.6$ rad

Q8 Ans: D

Explanation

gravitational force $F = \frac{GMm}{r^2}$

on the ground, $F = W$ and $r = R$: $W = \frac{GMm}{R^2}$ …… equation 1

at a height $2R$ above the ground, $r = 3R$: $F = \frac{GMm}{(3R)^2}$ …… equation 2

equation 2 divide by equation 1 gives $F = \frac{W}{9}$

Q9 Ans: B

Explanation

for orbiting satellite:

gravitational force provides centripetal force

$$\frac{GMm}{r^2} = mr\left(\frac{2\pi}{T}\right)^2$$

$$T^2 = \frac{4\pi^2}{GM}r^3$$

the radius r of orbit is independent of the mass m of the satellite

so the radius is the same

Q10 Ans: B

Explanation

amplitude $x_0 = 4.0$ m

max speed $v_0 = \omega x_0$

$20 = \omega \times 4.0$

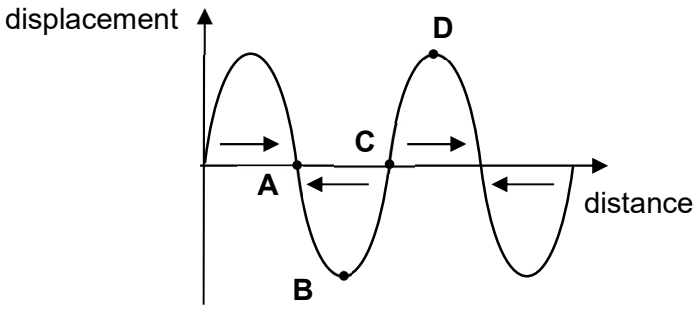
so $\omega = 5.0$

period T = $\frac{2\pi}{\omega} = \frac{2\pi}{5.0} = 1.257$ s

time for speed to reduce from max to zero = $\frac{1}{4}T = \frac{1}{4} \times 1.257 = 0.31$ s

Q11 Ans: C

Since displacement towards the right is taken as positive, we can label the directions of displacement of air molecules as follows:



It can be seen from the figure that at point **C**, it is a region of rarefaction as air molecules on the left side of **C** is displaced to the left and on the right side of **A**, they are displaced to the right. Hence **C** has the minimum pressure.

Q12 Ans: B

$I \propto A^2$

$$\frac{I_1}{I_2} = \frac{A_1^2}{A_2^2} \Rightarrow \sqrt{\frac{0.36}{0.25}} = \frac{A_1}{A_2} \Rightarrow A_1 = 1.2A_2$$

At P (minima), the resultant amplitude, $A_p = 1.2A_2 - A_2 = 0.2\ A_2$

$$\frac{I_P}{I_2} = \frac{A_P^2}{A_2^2} \Rightarrow \frac{I_P}{0.25I} = \frac{0.2A_2^2}{A_2^2} = 0.040 \Rightarrow I_P = 0.010I$$

Or $A_p = 0.6A - 0.5A = 0.1A$
$\Rightarrow I_P = 0.010I$

Q13 Ans: B

Points in alternate segments of a standing wave are in anti-phase (have a phase difference of π).

Q14 Ans: B

Since the container is sealed, volume remains constant. Hence, average distance between the gas molecules does not change.

Q15 Ans: D

From First Law of Thermodynamics, $\Delta U = Q + W$

When Q is zero, internal energy of the system can still increase if there is work done on the system (W is positive).

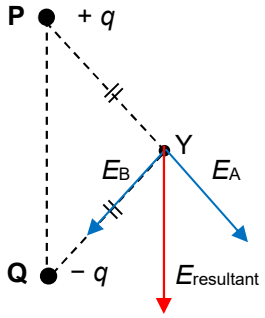
Q16 Ans: A

$P_{cooling} = P_{freezing}$

$\frac{mc\Delta\theta}{t} = \frac{ml_f}{t_f}$

$\frac{c}{l_f} = \frac{1}{1.5 \times 30} = \frac{1}{45}$

Q17 Ans: A



Q18 Ans: B

Note that the middle resistor is redundant as the pd across it is the same, hence no current flow.

Hence $R_E = \left(\frac{1}{R+R} + \frac{1}{R+R}\right)^{-1} = R$

Q19 Ans: C

$R_{\text{eff across PQ}} = \left(\frac{1}{20} + \frac{1}{8+3}\right)^{-1} = 7.10\ \Omega$

$V_{PQ} = \frac{R_{PQ}}{R_{PQ} + R_{10\Omega}} \times 6.0 = \frac{7.10}{7.10 + 10} \times 6.0 = 2.5\ \text{V}$

Q20 Ans: A

With bulb 3 in parallel to bulb 2, the potential difference across bulb 2 is a smaller fraction of the cell's e.m.f as compared to that of bulbs 1 and 4.

With bulb 3 removed, the potential difference across bulb 2 increases while those of bulb 1 and bulb 4 decrease correspondingly. With fixed resistance, power dissipated increases as potential increases, hence bulbs 1 and 4 became dimmer and bulb 2 became brighter.

Q21 Ans: A

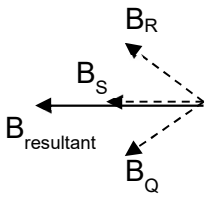
$F_{AB} = (0.50)(1.0)(0.20)\sin(30°) = 0.050$ N into the paper

$F_{BC} = (0.50)(1.0)(0.20)\sin(0°) = 0$ N

$F_{CD} = (0.50)(1.0)(0.20)\sin(90°) = 0.10$ N out of the paper

Net force $= 0.10 - 0.050 = 0.050$ N out of the paper

Q22 Ans: C



Q23 Ans: A

The change of magnetic flux linkage is a constant. Hence, induced emf is zero resulting in zero induced current.

Q24 Ans: D

Electrons either accumulate in the centre or at the rim. In either case, 2 points equidistant from O will have the same potential, and the difference in potential between O and a point gets larger with distance. Therefore, $E_{XY} = E_{YZ}$.

Since points further from O travel faster, the length XY cuts flux faster than YO. Therefore, $E_{XY} > E_{YO}$.

Q25 Ans: D

Using $I_{rms} = \frac{P}{V}$

I_{rms} ranges from 9.55 A to 10.4 A

I_o ranges from 13.5 A to 14.7 A

Hence most probable expression for the current is $I = 14.1 \sin(375t)$

Q26 Ans: C

$$P' = 4P$$

$$= 4\left(\frac{I_o}{\sqrt{2}}\right)^2 R$$

$$\left(I_{rms}'\right)^2 R = 4\left(\frac{I_o}{\sqrt{2}}\right)^2 R$$

$$\left(I_{rms}'\right)^2 = 2I_o^2$$

$$I_{rms}' = \sqrt{2} I_o$$

Q27 Ans: D

$$E_{k\max} = \frac{(p_{\max})^2}{2m}$$

$$\lambda_{\min} = \frac{h}{p_{\max}}$$

$$= \frac{h}{\sqrt{2mE_{k\max}}}$$

$$= \frac{6.63\times10^{-34}}{\sqrt{2\times9.11\times10^{-31}\times9.0\times10^{-20}}}$$

$$= 1.6\times10^{-9} \text{ m}$$

Q28 Ans: C

$$p = mv_x$$

$$\Delta p = m\Delta v_x$$

$$= 9.11\times10^{-31}\times\frac{0.50}{100}\times0.6\times3.00\times10^{8}$$

$$= 8.199\times10^{-25} \text{ kg m s}^{-1}$$

$$\Delta x\cdot\Delta p = h$$

$$\Delta x = \frac{6.63\times10^{-34}}{8.199\times10^{-25}} = 8.09\times10^{-10} \text{ m}$$

Q29 Ans: D

Activity *A* is the number of decays per unit time.
The shaded area S is therefore the total number of decays in time *T*.

The value $\frac{E}{S}$ is the total energy of the decays in time *T* divided by the total number of decays, hence it is the energy released per radioactive decay.

Q30 Ans: B

The corrected count rate initially is
320 – 20 = 300 Bq

The corrected count rate after 9 hours is

$$CCR = 300(\frac{1}{2})^{\frac{9}{12}} = 178 \text{ Bq}$$

The observed count rate after 9 hours is

C = 178 + 20 = 198 Bq