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H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CLASS | TUTOR'S NAME

CENTRE NUMBER | S | INDEX NUMBER

# PHYSICS

**9749/01**

Paper 1 Multiple Choice

**23 September 2021**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, Centre number and index number in the spaces at the top of this page.

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.

This document consists of **12** printed pages.

## Data

| | |
|---|---|
| speed of light in free space | $c = 3.00 \times 10^{8}$ m s$^{-1}$ |
| permeability of free space | $\mu_0 = 4\pi \times 10^{-7}$ H m$^{-1}$ |
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## Formulae

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| 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 | $p = \rho gh$ |
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| temperature | $T / \text{K} = T / ^\circ\text{C} + 273.15$ |
| pressure of an ideal gas | $p = \frac{1}{3}\frac{Nm}{V} < c^2 >$ |
| mean translational kinetic energy of an ideal 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 | $R = R_1 + R_2 + \ldots$ |
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| electric potential | $V = \frac{Q}{4\pi\varepsilon_0 r}$ |
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| magnetic flux density due to a long straight wire | $B = \frac{\mu_0 I}{2\pi d}$ |
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1 Which of the following is considered as a random error?

**A** Error as a result of using $g = 10\ m\ s^{-2}$, instead of $g = 9.81\ m\ s^{-2}$.

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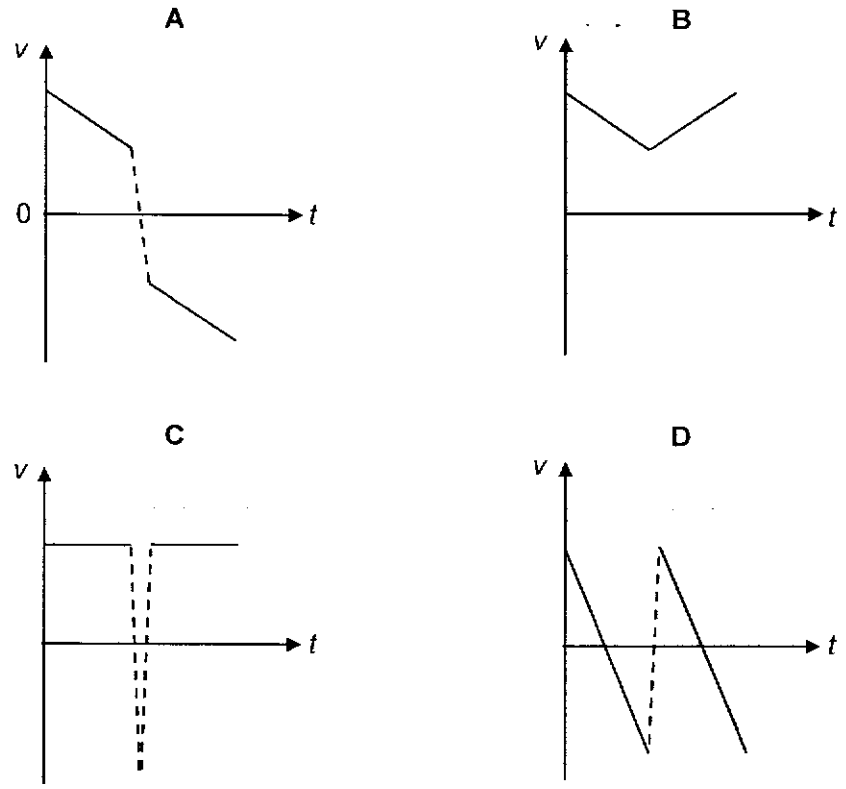
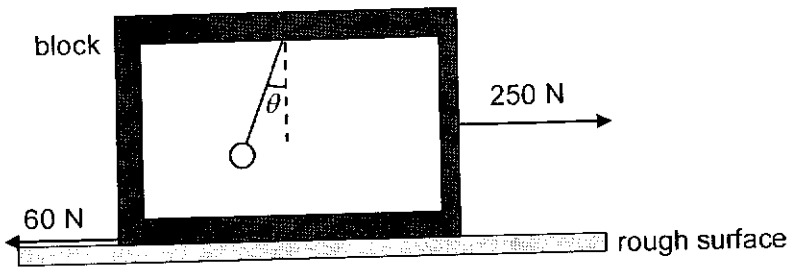



3 An object is projected with velocity 40 m $s^{-1}$ at an angle of 60° to the horizontal. Air resistance is negligible.

What is the speed of the object after 5.0 s?

**A** 14 m $s^{-1}$ **B** 25 m $s^{-1}$ **C** 35 m $s^{-1}$ **D** 45 m $s^{-1}$

4 A block with a pendulum bob hanging lies on a rough surface. The total mass of the block and the pendulum bob is 100 kg. A force of 250 N is applied to the block and the pendulum bob makes an angle $\theta$ to the vertical axis.




What is the magnitude of $\theta$ if a constant frictional force of 60 N is acting on the block?

**A** 11° **B** 14° **C** 76° **D** 79°

5 Which one of the following pair of forces is **not** an example of Newton's third law action and reaction pair?

**A** The thrust on the rocket and expulsion of hot air due to the burning of fuel.

**B** The gravitational force by Earth on man standing on Earth and the gravitational force on Earth by man.

**C** The upthrust on a piece of wood in water and the weight of the wood.

**D** The magnetic force on a magnet by a long wire carrying current and the magnetic force on the wire by the magnet.

6 A cylindrical block of wood has a cross-sectional area $A$ and weight $W$. It is completely immersed in water with its axis vertical. The block experiences pressures $p_t$ *and* $p_b$ at its top and bottom surfaces respectively.

Which of the following expressions is equal to the upthrust on the block?

**A** $(p_b - p_t)A + W$

**B** $(p_b - p_t)$

**C** $(p_b - p_t)A$

**D** $(p_b - p_t)A - W$

7 The engine of a boat supplies a constant power of 110 kW to propel the boat forward. The boat attains a maximum speed of 21.0 m $s^{-1}$.

If the magnitude of the resistive force acting on the boat is proportional to the square of the boat's speed, what is the resultant force acting on the boat when it is moving at the instant when its speed is 15.0 m $s^{-1}$?

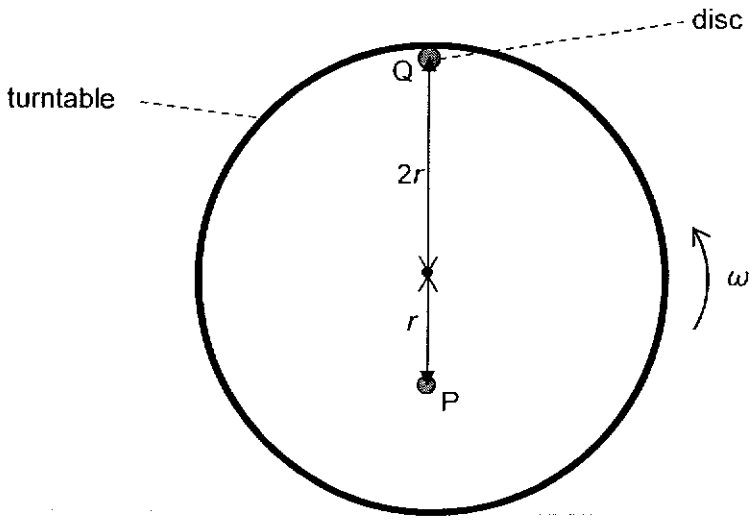
**A** 2.7 kN **B** 3.6 kN **C** 4.7 kN **D** 7.3 kN

8 A crane is used to raise a weight of 200 N at a constant speed through a vertical height of 8.0 m in 4.0 s.

The efficiency of the crane is 20%. What is the electrical power needed to be supplied to the crane?

**A** 80 W **B** 400 W **C** 1600 W **D** 2000 W

9 Two discs P and Q of mass $m$ and $2m$ respectively are placed on a rough, horizontal and level turntable as shown in the diagram. P and Q are at a distance of $r$ and $2r$ from the centre of the turntable respectively. The turntable starts rotating from rest with gradually increasing angular velocity $\omega$.




**Top View**

Given that the maximum frictional force acting on P is half of that on Q, which of the following is correct?

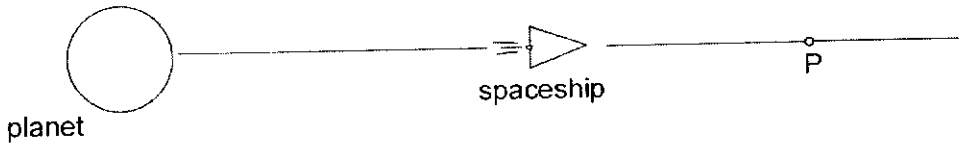
**A** P will slip first.

**B** Q will slip first.

**C** P and Q will slip at the same time.

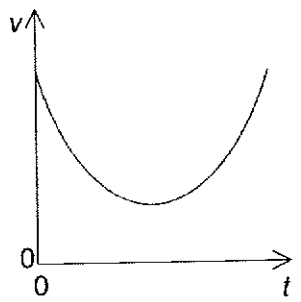
**D** Neither P nor Q will slip.

**10** A powered spaceship is moving directly away from a planet as shown below.

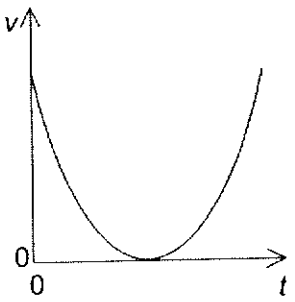



The spaceship passes point P at $t = 0$. At point P, the thrusters of the spaceship are switched off but the spaceship remains under the influence of the planet. Which one of the following graphs best represents the subsequent variation with time $t$ of the velocity $v$ of the spaceship?

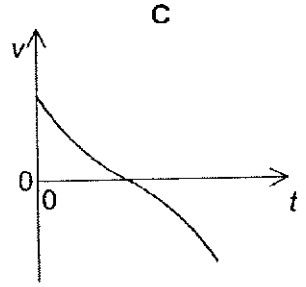
**A**



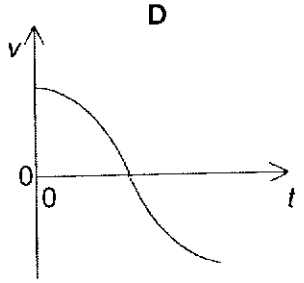

**B**




**C**




**D**




**11** A satellite of mass 200 kg is moved from an orbit where the gravitational potential is $-80$ MJ kg$^{-1}$ to another orbit where the gravitational potential is $-40$ MJ kg$^{-1}$.

What is the increase in its **total** energy?

**A** 0 MJ **B** 2000 MJ **C** 4000 MJ **D** 8000 MJ

**12** A small ice cube of mass 20 g is heated and changes from the solid to the liquid state. During this change in state the temperature of the substance does not change.

Which statement about this change in state is **not** correct?

**A** The amount of energy the ice absorbs is equal to the specific latent heat of fusion.

**B** The average kinetic energy of the molecules remains unchanged.

**C** The average potential energy of the molecules increases.

**D** The total mass of ice and water remains constant throughout.

13 Two identical vessels contain two different gases X and Y with molecular mass $m_x$ and $m_y$ respectively. The thermodynamic temperature of gas X is twice that of gas Y and the root-mean-square speed of the molecules in X is three times that of the molecules in Y. What is the ratio of $\frac{m_X}{m_Y}$?

**A** 2 : 3 **B** 2 : 9 **C** 9 : 2 **D** 3 : 2

14 An ideal monatomic gas has 1000 J of heat added to it and it does 500 J of work; its thermodynamic temperature changes by $\Delta T_1$. When twice the amount of heat is added to it and it does the same amount of work, its temperature changes by $\Delta T_2$. The ratio of $\Delta T_1 / \Delta T_2$ is

**A** 1/5 **B** 1/3 **C** 3/5 **D** 1

15 One end of a spring is fixed to a support. A block of mass 2.0 kg is attached to the other end of the spring, which causes the spring to extend by 5.0 cm.

The block is then pulled down a distance of 2.5 cm and released to perform a simple harmonic motion of period 0.45 s.

What is the amplitude and angular frequency of the motion?

| | amplitude / cm | angular frequency / rad $s^{-1}$ |
|---|---|---|
| **A** | 7.5 | 0.45 |
| **B** | 7.5 | 14 |
| **C** | 2.5 | 0.45 |
| **D** | 2.5 | 14 |

16 Which of the following shows oscillation of decreasing order of damping?

**A** critical damping, light damping, heavy damping.
**B** critical damping, heavy damping, light damping.
**C** heavy damping, critical damping, light damping.
**D** critical damping, heavy damping, free oscillation.

17 A wave has a frequency of 5 Hz. It travels through a medium at a speed of 8 km $s^{-1}$.

What is the phase difference, in radians, between two points 2 km apart?

**A** 0 **B** $\frac{\pi}{4}$ **C** $\frac{\pi}{2}$ **D** $\pi$

18 A strip of wet cardboard is placed inside a microwave oven. The microwave oven is turned on for a short time. When the card is removed, a pattern of dry spots is observed on the cardboard. This is because a standing wave set up inside the oven.

The dry spots are measured and found to occur at 14 mm, 84 mm, 152 mm, 221 mm and 292 mm from one end of the strip.

From this information, what is the frequency of the microwaves?

**A** 2.2 GHz **B** 2.6 GHz **C** 4.3 GHz **D** 5.1 GHz

19 Monochromatic light of wavelength 600 nm diffracts through a single slit of width 0.01 mm.

What is the angular width of the central maximum of the diffraction pattern?

**A** 0.0034° **B** 0.0069° **C** 3.4° **D** 6.9°

20 An ideal cell is connected across a resistor for an unknown period of time.

Which quantities can be used to calculate the energy supplied by the cell?

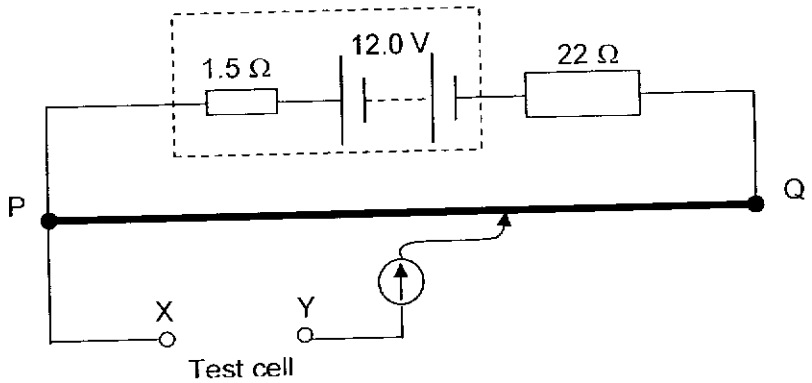
**A** The current in the resistor and the resistance of the resistor.

**B** The current in the resistor and the potential difference across the resistor.

**C** The total charge passing through the resistor and the resistance of the resistor.

**D** The total charge passing through the resistor and the potential difference across the resistor.

21 A student attempts to measure the e.m.f. of a test cell using a potentiometer circuit as shown in the diagram.




The wire PQ has a resistance of 3.0 Ω and the driver cell has an e.m.f. of 12.0 V. He was unable to obtain an observable balance length on PQ when he connected the circuit. The tutor he consulted told him that the test cell has an e.m.f. of a few millivolts. What could he do in order to obtain an observable balance length?

**A** Reversed the polarity of the test cell at XY.

**B** Use a driver cell of e.m.f. 20 V.

**C** Change the resistance of the connected resistor to 1 kΩ.

**D** Change the wire PQ to a wire of resistance 20 Ω .

22 The diagram shows two charged horizontal metal plates X and Z with a potential difference set up between them. A small sphere Y with charge Q is suspended and remain stationary at the midpoint between the plates.


What will happen to sphere Y when its charge increases?

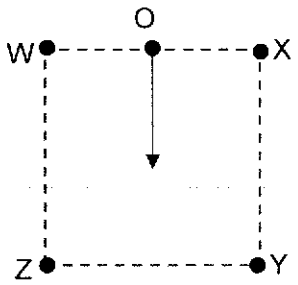
**A** Sphere Y will accelerate downwards and hit plate Z

**B** Sphere Y will move down nearer to plate Z and remain staionary.

**C** Sphere Y will accelerate upwards and hit plate X.

**D** Sphere Y will move up nearer to plate X and remain staionary.

23 Four parallel current carrying conductors are placed vertically at the corners of a square WXYZ. The magnitudes of the current at W and X are $I$ while the magnitudes of the current at Y and Z are $2I$.




O is the mid-point between W and X.
If there is to be a resultant magnetic flux density produced at O in the direction shown, which option gives the largest magnetic flux density?

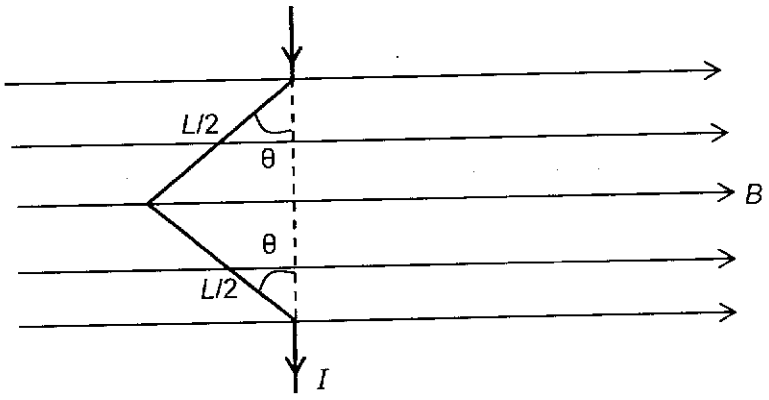
| | current into the plane | current out of the plane |
|---|---|---|
| **A** | W and Z | X and Y |
| **B** | X and Z | W and Y |
| **C** | W and Y | X and Z |
| **D** | X and Y | W and Z |

**24** An electron P, having a speed $v$, travels at right-angles to a uniform magnetic field. P then travels in a circular orbit of period $T$ and orbital radius $r$.

Another electron Q travels at right-angles to the same magnetic field. Q travels in a circular orbit of radius $2r$. What are the period and speed of Q?

| | period | speed |
|---|---|---|
| **A** | $2T$ | $v$ |
| **B** | $0.5T$ | $v$ |
| **C** | $T$ | $2v$ |
| **D** | $T$ | $0.5v$ |

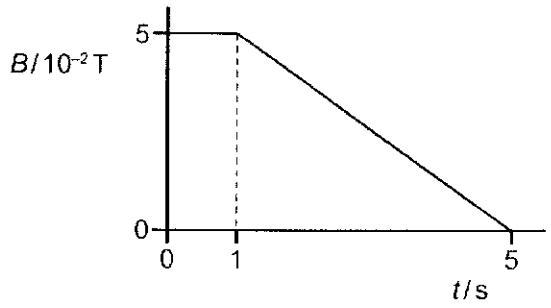
**25** The diagram shows a V-shaped wire in the magnetic field of flux density $B$. The length of the wire in the field is $L$ and the first half of the wire is inclined with an angle $\theta$ normal to the field direction. The current in the wire is $I$.




Which row gives the magnitude and direction of the force acting on the wire?

| | magnitude | direction |
|---|---|---|
| **A** | $BIL\cos\theta$ | into of the page |
| **B** | $BIL\cos\theta$ | out of the page |
| **C** | $BIL\sin\theta$ | into the page |
| **D** | $BIL\sin\theta$ | out of the page |

**26** A 120 turn coil of area $5.0 \times 10^{-4}$ m$^2$ is placed in a magnetic field of strength $5.0 \times 10^{-2}$ T. The magnetic flux density $B$ is then varied as shown.



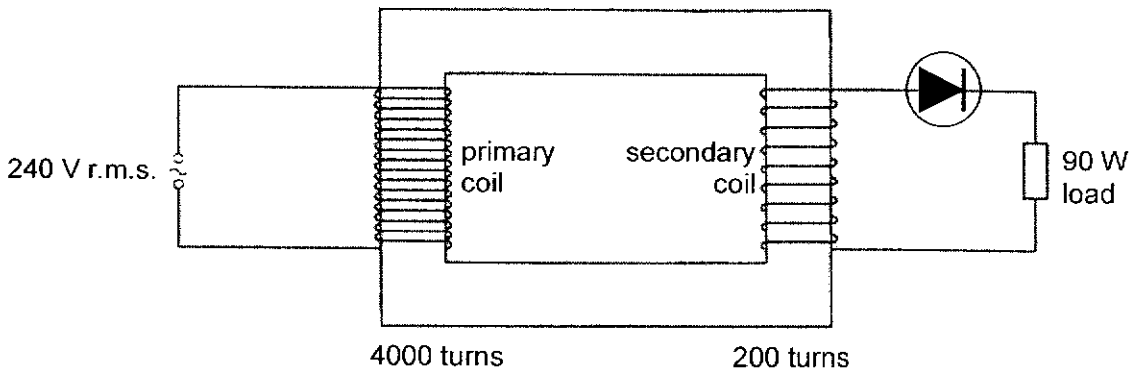

What is the induced electromotive force when $t = 3$ s?

**A** 6.25 μV **B** 600 μV **C** 750 μV **D** 1250 μV

**27** A device that produces a pointer deflection proportional to the heating effect of a current is correctly calibrated for direct current. What will it read when used to measure an alternating current of 12 A r.m.s.?

**A** 0 A **B** 8.5 A **C** 12 A **D** 17 A

**28** The diagram shows an iron-cored transformer assumed to be 100% efficient. The primary coil of the transformer has 4000 turns and is connected to a 240 V r.m.s. supply. The secondary coil has 200 turns and is connected, through an ideal diode, to a resistive load which is dissipating energy at a mean rate of 90 W.




What is the r.m.s. current in the secondary coil.

**A** 0.375 A **B** 0.750 A **C** 7.50 A **D** 10.6 A

29 A metal surface is illuminated with a beam of monochromatic electromagnetic radiation. By the photoelectric effect, photoelectrons may be emitted from the metal surface.

Which statement about the photoelectrons is correct?

**A** No emission of photoelectrons occurs if the radiation is of a very low intensity.

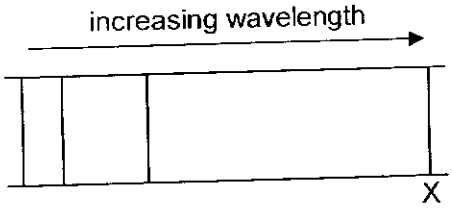
**B** Photoelectrons are emitted only if the wavelength of the radiation is greater than a minimum value.

**C** The maximum speed of the photoelectrons emitted increases when the intensity of the radiation increases at constant frequency.

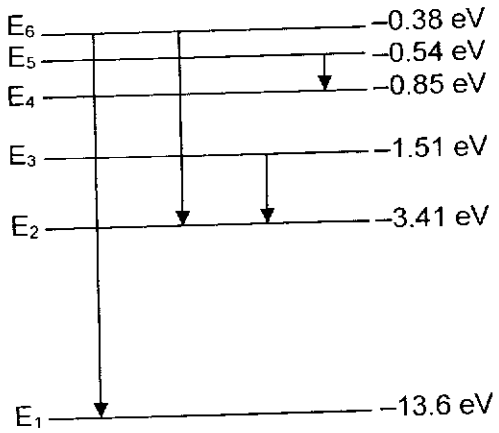
**D** The rate of emission of photoelectrons decreases when the frequency of the radiation increases at constant intensity.

30 The line emission spectrum of a hydrogen discharge tube when viewed through a diffraction grating consists of coloured lines on a dark background. One of the coloured lines is marked X, as shown.

The wavelength scale is linear and increases to the right.




The diagram below represents some of the electron energy levels in a hydrogen atom.




Which transition best corresponds to the emission of line X?

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

**End of Paper**

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| gravitational potential | $\phi = -Gm / r$ |
| temperature | $T / \text{K} = T / ^\circ\text{C} + 273.15$ |
| pressure of an ideal gas | $p = \frac{1}{3}\frac{Nm}{V} < c^2 >$ |
| mean translational kinetic energy of an ideal 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 | $R = R_1 + R_2 + \ldots$ |
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1 Which of the following is considered as a random error?

**A** Error as a result of using $g = 10\ m\ s^{-2}$, instead of $g = 9.81\ m\ s^{-2}$.

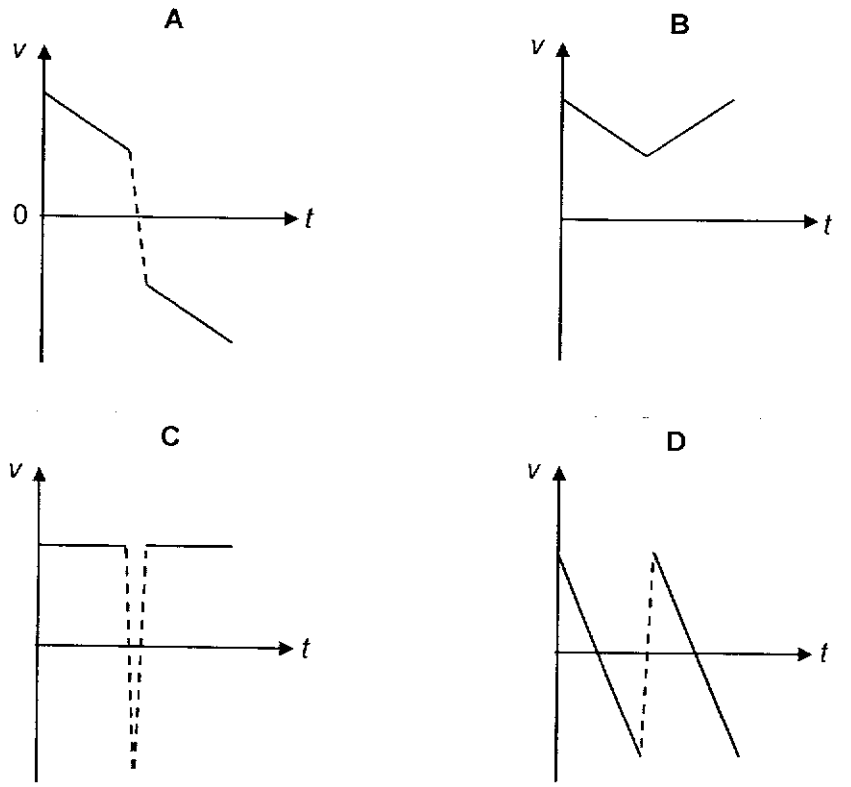
**B** Error in measuring the time duration of a 100 m sprint using a stopwatch.

**C** Error due to a stopwatch running too fast.

**D** Zero error of a measuring instrument.

Ans: B
Options A, C and D will cause values to be consistently biased (either always larger or always smaller) and hence causes systematic errors

2 A tennis ball is thrown vertically upward. It hits the ceiling before it falls down. Assuming the effect of air resistance is negligible, which graph best represents the variation of velocity $v$ with time $t$ before and after hitting the ceiling?




Ans: A
Before hitting and after hitting ceiling, the ball is under free fall, with a constant downward acceleration of $9.81\ m\ s^{-2}$, where straight downward diagonal lines are expected. During the collision with the ceiling, the downward acceleration is greater than $9.81\ m\ s^{-2}$ as the ceiling, in addition to the weight of the ball, exerts a downward foce → hence a more negative gradient.

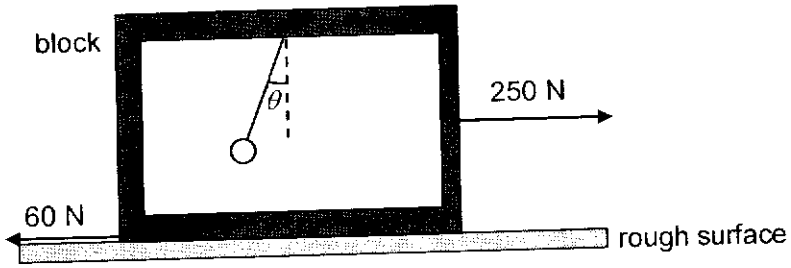
3 An object is projected with velocity $40\ m\ s^{-1}$ at an angle of 60° to the horizontal. Air resistance is negligible.

What is the speed of the object after 5.0 s?

**A** $14\ m\ s^{-1}$ **B** $25\ m\ s^{-1}$ **C** $35\ m\ s^{-1}$ **D** $45\ m\ s^{-1}$

Ans: B
The horizontal velocity is constant at $v_x = u_x = 40 \cos 60° = 20.0$ m s$^{-1}$.
The initial vertical velocity is $u_x = 40 \sin 60° = 34.6$ m s$^{-1}$.
After 5.0 s, $v_y = u_y + a_y t = 34.6 + (-9.81)(5.0) = -14.4$ m s$^{-1}$.
Hence, after 5.0 s, $v = \sqrt{v_x^2 + v_y^2} = 25$ m s$^{-1}$.

4 A block with a pendulum bob hanging lies on a rough surface. The total mass of the block and the pendulum bob is 100 kg. A force of 250 N is applied to the block and the pendulum bob makes an angle θ to the vertical axis.




What is the magnitude of θ if a constant frictional force of 60 N is acting on the block?

**A** 11° **B** 14° **C** 76° **D** 79°

Ans: A
Referring to FBD of whole system,
$\Sigma F = ma$
$250 - 60 = 100a$
$a = 1.9$ m s$^{-2}$
Referring to FBD of bob,
$\Sigma F_x = m_{bob}a$
$T \sin\theta = m_{bob}a$----- (1)
$\Sigma F_y = 0$
$T \cos\theta = m_{bob}g$ ----- (2)
(1)/(2): $\tan\theta = a / g = 1.9 / 9.81$
$\theta = 11°$

5 Which one of the following pair of forces is **not** an example of Newton's third law action and reaction pair?

**A** The thrust on the rocket and expulsion of hot air due to the burning of fuel.

**B** The gravitational force by Earth on man standing on Earth and the gravitational force on Earth by man.

**C** The upthrust on a piece of wood in water and the weight of the wood.

**D** The magnetic force on a magnet by a long wire carrying current and the magnetic force on the wire by the magnet.

Ans: C

6 A cylindrical block of wood has a cross-sectional area $A$ and weight $W$. It is completely immersed in water with its axis vertical. The block experiences pressures $p_t$ *and* $p_b$ at its top and bottom surfaces respectively.

Which of the following expressions is equal to the upthrust on the block?

**A** $(p_b - p_t)A + W$

**B** $(p_b - p_t)$

**C** $(p_b - p_t)A$

**D** $(p_b - p_t)A - W$

Ans: C

7 The engine of a boat supplies a constant power of 110 kW to propel the boat forward. The boat attains a maximum speed of 21.0 m $s^{-1}$.

If the magnitude of the resistive force acting on the boat is proportional to the square of the boat's speed, what is the resultant force acting on the boat when it is moving at the instant when its speed is 15.0 m $s^{-1}$?

**A** 2.7 kN **B** 3.6 kN **C** 4.7 kN **D** 7.3 kN

Ans: C

Drag @ 21.0 m $s^{-1}$: $f_D = \dfrac{110}{21} = 5.24 \text{ kN}$

Drag @ 15.0 m $s^{-1}$: $\dfrac{f_D'}{f_D} = \left(\dfrac{15.0}{21.0}\right)^2 \Rightarrow f_D' = 2.67 \text{ kN}$

Force of engine @ 15.0 m $s^{-1}$: $F_{engine} = \dfrac{110}{15} = 7.33 \text{ kN}$

Hence resultant force = 7.33 – 2.67 = 4.66 kN

8 A crane is used to raise a weight of 200 N at a constant speed through a vertical height of 8.0 m in 4.0 s.

The efficiency of the crane is 20%. What is the electrical power needed to be supplied to the crane?

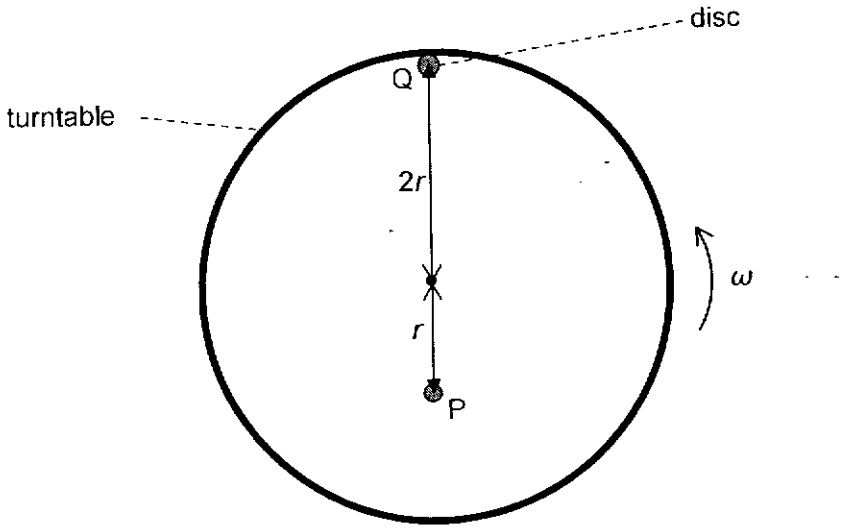
**A** 80 W **B** 400 W **C** 1600 W **D** 2000 W

Ans: D

Power to raise the weight $= \dfrac{200(8.0)}{4.0} = 400 \text{ W}$

Electrical power needed $= \dfrac{400}{0.2} = 2000 \text{ W}$

9 Two discs P and Q of mass $m$ and $2m$ respectively are placed on a rough, horizontal and level turntable as shown in the diagram. P and Q are at a distance of $r$ and $2r$ from the centre of the turntable respectively. The turntable starts rotating from rest with gradually increasing angular velocity $\omega$.




**Top View**

Given that the maximum frictional force acting on P is half of that on Q, which of the following is correct?

**A** P will slip first.

**B** Q will slip first.

**C** P and Q will slip at the same time.

**D** Neither P nor Q will slip.

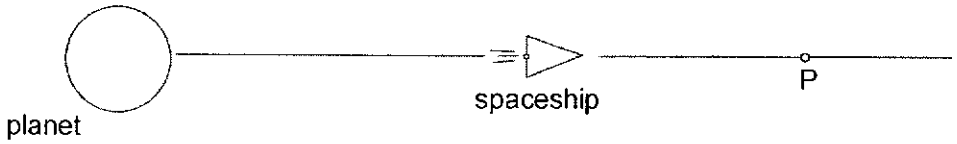
Ans: B
The frictional force provides the centripetal force → $f = MR\omega^2$.
When P is about to slip, $f_{max\ P} = mr\omega_{max\ P}^2$
$\omega_{max\ P}^2 = f_{max\ P} / mr$ ----- eqn (1)

When Q is about to slip, $f_{max\ Q} = (2m)(2r)\omega^2 = 4mr\omega_{max\ Q}^2$
$\omega_{max\ Q}^2 = f_{max\ Q} / 4mr$ ----- eqn (2)

since $f_{max\ Q} = 2\ f_{max\ P}$, from eqn (2)
$\omega_{max\ Q}^2 = 2f_{max\ P} / 4mr = f_{max\ P} / 2mr$ ----- eqn (3)

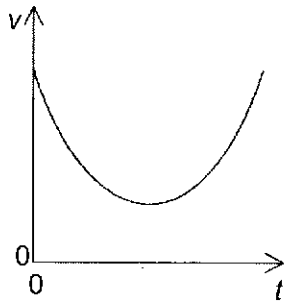
Comparing eqn (1) and (3), $\omega_{max\ Q} < \omega_{max\ P}$. Hence Q will slip first.

**10** A powered spaceship is moving directly away from a planet as shown below.

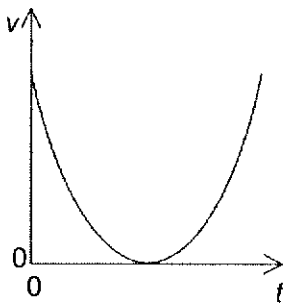



The spaceship passes point P at $t = 0$. At point P, the thrusters of the spaceship are switched off but the spaceship remains under the influence of the planet. Which one of the following graphs best represents the subsequent variation with time $t$ of the velocity $v$ of the spaceship?

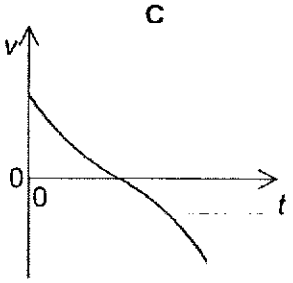
**A**



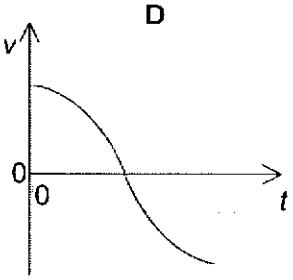

**B**




**C**




**D**




Ans: C
Gradient is equal to acceleration, as well as gravitational field strength. As the spaceship moves away from the planet, gravitational field strength must decrease. After the horizontal intercept where $v = 0$, the spaceship will be travelling toward the planet.

**11** A satellite of mass 200 kg is moved from an orbit where the gravitational potential is $-80$ MJ kg$^{-1}$ to another orbit where the gravitational potential is $-40$ MJ kg$^{-1}$.

What is the increase in its **total** energy?

**A** 0 MJ **B** 2000 MJ **C** 4000 MJ **D** 8000 MJ

Ans: C

$$U = -\frac{GMm}{r}$$

$$TE = -\frac{GMm}{2r} = \frac{U}{2} = \frac{m\phi}{2}$$

$$\Delta TE = 0.5m(\phi_f - \phi_i) = 0.5(200)(-40-(-80)) = 4000 \text{ MJ}$$

12 A small ice cube of mass 20 g is heated and changes from the solid to the liquid state. During this change in state the temperature of the substance does not change.

Which statement about this change in state is **not** correct?

**A** The amount of energy the ice absorbs is equal to the specific latent heat of fusion.

**B** The average kinetic energy of the molecules remains unchanged.

**C** The average potential energy of the molecules increases.

**D** The total mass of ice and water remains constant throughout.

Ans: A

13 Two identical vessels contain two different gases X and Y with molecular mass $m_x$ and $m_y$ respectively. The thermodynamic temperature of gas X is twice that of gas Y and the root-mean-square speed of the molecules in X is three times that of the molecules in Y. What is the ratio of $\frac{m_X}{m_Y}$?

**A** 2 : 3 **B** 2 : 9 **C** 9 : 2 **D** 3 : 2

Ans: B
Using KE = 3/2 kT → $mv_{rms}^2 \propto T$
$m \propto T/v_{rms}^2$

$$\frac{m_X}{m_Y} = \left(\frac{2}{1}\right)\left(\frac{1}{3}\right)^2 = \frac{2}{9}$$

14 An ideal monatomic gas has 1000 J of heat added to it and it does 500 J of work; its thermodynamic temperature changes by $\Delta T_1$. When twice the amount of heat is added to it and it does the same amount of work, its temperature changes by $\Delta T_2$. The ratio of $\Delta T_1 / \Delta T_2$ is

**A** 1/5 **B** 1/3 **C** 3/5 **D** 1

Ans : B

$\Delta U_1 = Q_1 + W_1$
$= 1000 - 500$
$= 500$ J

$\Delta U_2 = Q_2 + W_2$
$= 2000 - 500$
$= 1500$ J

$\Delta U \propto \Delta T$

$$\frac{\Delta U_1}{\Delta U_2} = \frac{T_1}{T_2}$$

$$\frac{T_1}{T_2} = \frac{500}{1500} = \frac{1}{3}$$

**15** One end of a spring is fixed to a support. A block of mass 2.0 kg is attached to the other end of the spring, which causes the spring to extend by 5.0 cm.

The block is then pulled down a distance of 2.5 cm and released to perform a simple harmonic motion of period 0.45 s.

What is the amplitude and angular frequency of the motion?

| | amplitude / cm | angular frequency / rad $s^{-1}$ |
|---|---|---|
| **A** | 7.5 | 0.45 |
| **B** | 7.5 | 14 |
| **C** | 2.5 | 0.45 |
| **D** | 2.5 | 14 |

Ans: D
The displaced amount = amplitude of oscillation = 2.5 cm

$\omega = 2\pi/T$

**16** Which of the following shows oscillation of decreasing order of damping?

**A** critical damping, light damping, heavy damping.
**B** critical damping, heavy damping, light damping.
**C** heavy damping, critical damping, light damping.
**D** critical damping, heavy damping, free oscillation.

Ans: C

**17** A wave has a frequency of 5 Hz. It travels through a medium at a speed of 8 km $s^{-1}$.

What is the phase difference, in radians, between two points 2 km apart?

**A** 0 **B** $\frac{\pi}{4}$ **C** $\frac{\pi}{2}$ **D** $\pi$

Ans: C
Use the formula $\phi = x/\lambda \times 2\pi$ and $v = f\lambda$

**18** A strip of wet cardboard is placed inside a microwave oven. The microwave oven is turned on for a short time. When the card is removed, a pattern of dry spots is observed on the cardboard. This is because a standing wave set up inside the oven.

The dry spots are measured and found to occur at 14 mm, 84 mm, 152 mm, 221 mm and 292 mm from one end of the strip.

From this information, what is the frequency of the microwaves?

**A** 2.2 GHz **B** 2.6 GHz **C** 4.3 GHz **D** 5.1 GHz

Ans: A
A – A = $1/2\lambda$ = 84 – 14 (A- A represent antinode to anti node distance)

**19** Monochromatic light of wavelength 600 nm diffracts through a single slit of width 0.01 mm.

What is the angular width of the central maximum of the diffraction pattern?

**A** 0.0034° **B** 0.0069° **C** 3.4° **D** 6.9°

Ans: D
**Use the formula** $\sin\theta = \lambda/b$
Angular width = $2\theta$

**20** An ideal cell is connected across a resistor for an unknown period of time.

Which quantities can be used to calculate the energy supplied by the cell?

**A** The current in the resistor and the resistance of the resistor.

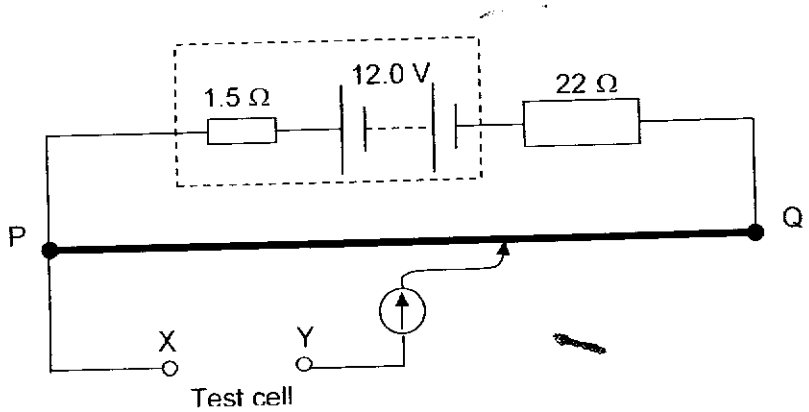
**B** The current in the resistor and the potential difference across the resistor.

**C** The total charge passing through the resistor and the resistance of the resistor.

**D** The total charge passing through the resistor and the potential difference across the resistor.

Ans: D
Use formula : V = E /Q

**21** A student attempts to measure the e.m.f. of a test cell using a potentiometer circuit as shown in the diagram.




The wire PQ has a resistance of 3.0 Ω and the driver cell has an e.m.f. of 12.0 V. He was unable to obtain an observable balance length on PQ when he connected the circuit. The tutor he consulted told him that the test cell has an e.m.f. of a few millivolts. What could he do in order to obtain an observable balance length?

**A** Reversed the polarity of the test cell at XY.

**B** Use a driver cell of e.m.f. 20 V.

**C** Change the resistance of the connected resistor to 1 kΩ.

**D** Change the wire PQ to a wire of resistance 20 Ω .

Ans: C
In the setup, $V_{PQ}$ = 3/ (3+1.5+22)12.0 = 1.31 V.
Hence, if the test cell is in range of mV, Vpq need to be further redueced, thus, increase 22 Ω to 1kΩ.

**22** The diagram shows two charged horizontal metal plates X and Z with a potential difference set up between them. A small sphere Y with charge Q is suspended and remain stationary at the midpoint between the plates.


What will happen to sphere Y when its charge increases?

**A** Sphere Y will accelerate downwards and hit plate Z

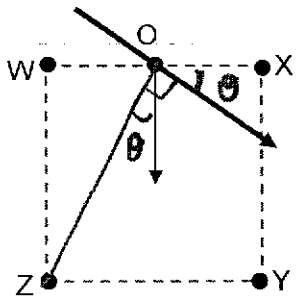
**B** Sphere Y will move down nearer to plate Z and remain staionary.

**C** Sphere Y will accelerate upwards and hit plate X.

**D** Sphere Y will move up nearer to plate X and remain staionary.

Ans: C
Y is stationary as its weight balanced the electric force
mg = qE
when the charge increases, electric force increase and sphere Y will accelerate upwards due to a resultant force.

**23** Four parallel current carrying conductors are placed vertically at the corners of a square WXYZ. The magnitudes of the current at W and X are $I$ while the magnitudes of the current at Y and Z are $2I$.




$\sin\theta = \frac{d/2}{\sqrt{5}d/2} = \frac{1}{\sqrt{5}}$

O is the mid-point between W and X.
If there is to be a resultant magnetic flux density produced at O in the direction shown, which option gives the largest magnetic flux density?

| | current into the plane | current out of the plane |
|---|---|---|
| **A** | W and Z | X and Y |
| **B** | X and Z | W and Y |
| **C** | W and Y | X and Z |
| **D** | X and Y | W and Z |

Ans: A
Let the side of square be d.
B-field due to W = $\mu_o$ I / (2π d/2) = (2 $\mu_o$ I )/(2π d)
B-field due to X = $\mu_o$ I / (2π d/2) = (2 $\mu_o$ I)/(2π d)
B-field due to Z = $\mu_o$ 2I / (2π $\sqrt{5}$ d/2) = (4/$\sqrt{5}$ $\mu_o$ I )/(2π d)
B-field due to X = $\mu_o$ 2I / (2π $\sqrt{5}$ d/2) = (4/$\sqrt{5}$ $\mu_o$ I )/(2π d)
For Z, the B field will tangent to the point O when you draw a circle about Z cutting O. To find the component perpendicular to WX,
B-field component due to Z = (4/$\sqrt{5}\mu_o$ I)/(2π d) sinθ = (4/5 $\mu_o$ I)/(2π d).
Likewise for Y, B-field component due to Z = (4/5 $\mu_o$ I)/(2π d)
The largest magnetic flux density will be W and Z into the plane and X and Y out of the plane.

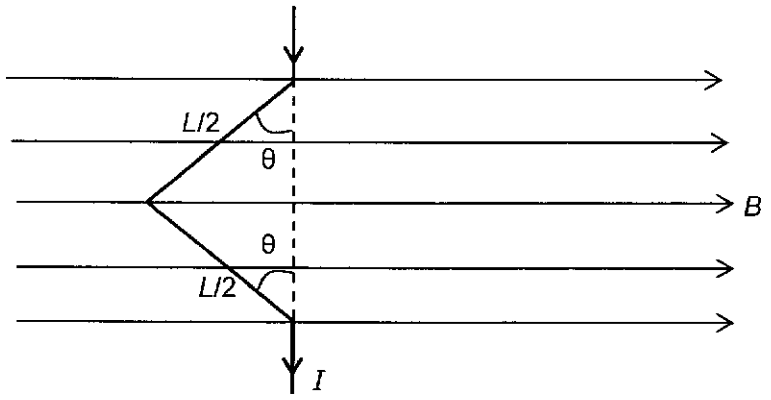
**24** An electron P, having a speed *v*, travels at right-angles to a uniform magnetic field. P then travels in a circular orbit of period *T* and orbital radius *r*.

Another electron Q travels at right-angles to the same magnetic field. Q travels in a circular orbit of radius 2*r*. What are the period and speed of Q?

| | period | speed |
|---|---|---|
| **A** | 2*T* | *v* |
| **B** | 0.5*T* | *v* |
| **C** | *T* | 2*v* |
| **D** | *T* | 0.5*v* |

Ans: C
For the first electron,
F = Bqv = $mv^2/r$ , r = mv / Bq
Since, ω = v/r = Bq/m, T = 2πm/Bq
For the second electron,
Same m, q, B, r' is 2r, v' = 2v, T is constant.

**25** The diagram shows a V-shaped wire in the magnetic field of flux density $B$. The length of the wire in the field is $L$ and the first half of the wire is inclined with an angle $\theta$ normal to the field direction. The current in the wire is $I$.




Which row gives the magnitude and direction of the force acting on the wire?

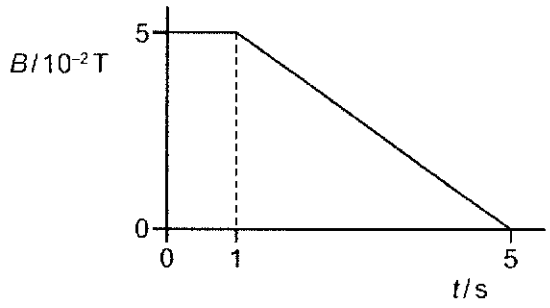
| | magnitude | direction |
|---|---|---|
| **A** | $BIL\cos\theta$ | into of the page |
| **B** | $BIL\cos\theta$ | out of the page |
| **C** | $BIL\sin\theta$ | into the page |
| **D** | $BIL\sin\theta$ | out of the page |

Ans: B

Resolve the wire to be perpendicular to the B-field, F = BI(L/2 cosθ+ L/2 cosθ) = BILcosθ

Using FLHR, direction is out of the page.

**26** A 120 turn coil of area $5.0 \times 10^{-4}$ m$^2$ is placed in a magnetic field of strength $5.0 \times 10^{-2}$ T. The magnetic flux density $B$ is then varied as shown.




What is the induced electromotive force when $t = 3$ s?

**A** 6.25 μV **B** 600 μV **C** 750 μV **D** 1250 μV

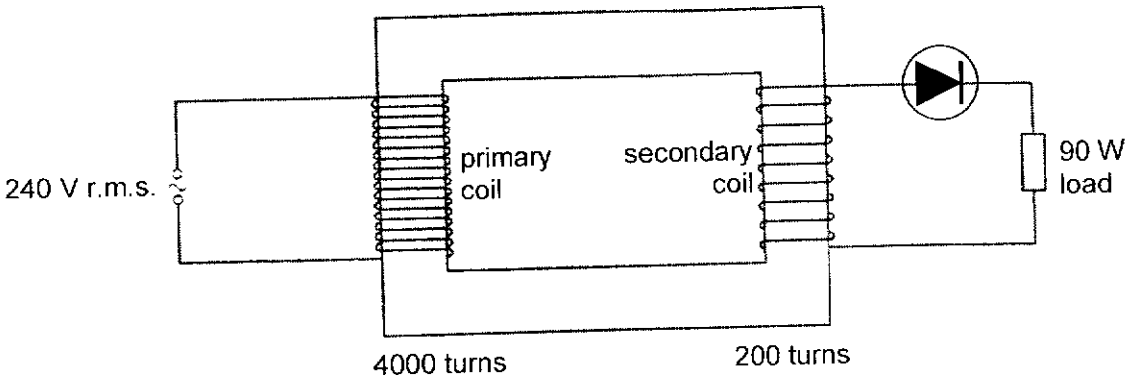
Ans: C

27 A device that produces a pointer deflection proportional to the heating effect of a current is correctly calibrated for direct current. What will it read when used to measure an alternating current of 12 A r.m.s.?

**A** 0 A **B** 8.5 A **C** 12 A **D** 17 A

Ans: C

28 The diagram shows an iron-cored transformer assumed to be 100% efficient. The primary coil of the transformer has 4000 turns and is connected to a 240 V r.m.s. supply. The secondary coil has 200 turns and is connected, through an ideal diode, to a resistive load which is dissipating energy at a mean rate of 90 W.




What is the r.m.s. current in the secondary coil.

**A** 0.375 A **B** 0.750 A **C** 7.50 A **D** 10.6 A

Calculate the Vs : Vs(rms) = 200/4000 x 240 = 12 V

$(12)^2 / R = 180$ W Hence R = 0.80 Ω . The power is 180 W as the diode remove half the power.

$I^2 (0.80) = 90$ W ,

I = 10.6 A
Ans: D

29 A metal surface is illuminated with a beam of monochromatic electromagnetic radiation. By the photoelectric effect, photoelectrons may be emitted from the metal surface.

Which statement about the photoelectrons is correct?

**A** No emission of photoelectrons occurs if the radiation is of a very low intensity.

**B** Photoelectrons are emitted only if the wavelength of the radiation is greater than a minimum value.

**C** The maximum speed of the photoelectrons emitted increases when the intensity of the radiation increases at constant frequency.

**D** The rate of emission of photoelectrons decreases when the frequency of the radiation increases at constant intensity.

Ans: D

Option A is incorrect because photoelectric effect can occur even for very low intensity but sufficiently high frequency radiation (above the threshold frequency $f_0$).

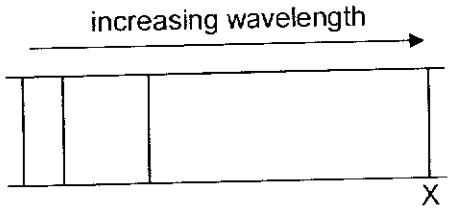
Option B is incorrect because photoelectrons are emitted only if the frequency of radiation is greater than a minimum frequency known as threshold frequency $f_0$; since $\lambda_0 = \frac{c}{f_0}$, the wavelength of the radiation must be smaller than the threshold wavelength, which is instead a maximum value.

Option C is incorrect because the maximum kinetic energy and thus speed of the photoelectrons is independent of intensity but depends on the frequency of radiation and work function of the metal, as given by $hf = \Phi + E_{k,max}$.

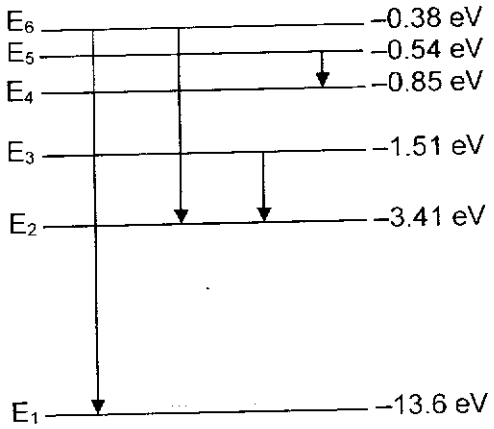
Option D is correct since $I = \frac{N_P}{t}\frac{hf}{A}$, at constant intensity and increased frequency, the rate of photons incident on the metal decreases, the lesser the rate of emission of photoelectrons.

**30** The line emission spectrum of a hydrogen discharge tube when viewed through a diffraction grating consists of coloured lines on a dark background. One of the coloured lines is marked X, as shown.

The wavelength scale is linear and increases to the right.




The diagram below represents some of the electron energy levels in a hydrogen atom.




Which transition best corresponds to the emission of line X?

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

Ans: C
Since the line spectrum consists of coloured lines on dark background, the spectrum must fall within the visible light wavelengths of about 400nm to 700nm (1.8 eV to 3.1 eV). Since $\Delta E = \frac{hc}{\lambda}$, only transitions $E_6$ to $E_2$ and $E_3$ to $E_2$ will emit photons of wavelengths within the visible spectrum. Since the visible emission line X has the longest visible wavelength, it must have the smallest energy difference between the levels, thus $E_3$ to $E_2$. Transition $E_6$ to $E_1$ falls within the UV spectrum whereas transition $E_5$ to $E_4$ falls within the infrared spectrum.

**End of Paper**