TEMASEK JUNIOR COLLEGE

2022 JC2 PRELIMINARY EXAMINATION

Higher 2

CANDIDATE NAME									
CENTRE NUMBER	S					INDEX NUMBER			

PHYSICS **9749/01**

Paper 1 Multiple Choice **15 September 2022**

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 and Civics group on the Answer Sheet in the spaces provided.

There are **thirty** questions in 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.

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.

Do NOT open the booklets until you are told to do so.

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}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ 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	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t = \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots .$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots .$
electric potential	$V = Q/(4\pi\varepsilon_0 r)$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 The drag coefficient C_d is a number with no units. It is used to compare the drag on different cars at different speed. C_d is given by the equation

$$C_d = \frac{2F}{v^n \rho A}$$

where F is the drag force on the car, ρ is the density of the air, A is the cross-sectional area of the car and v is the speed of the car.

What is the value of n ?

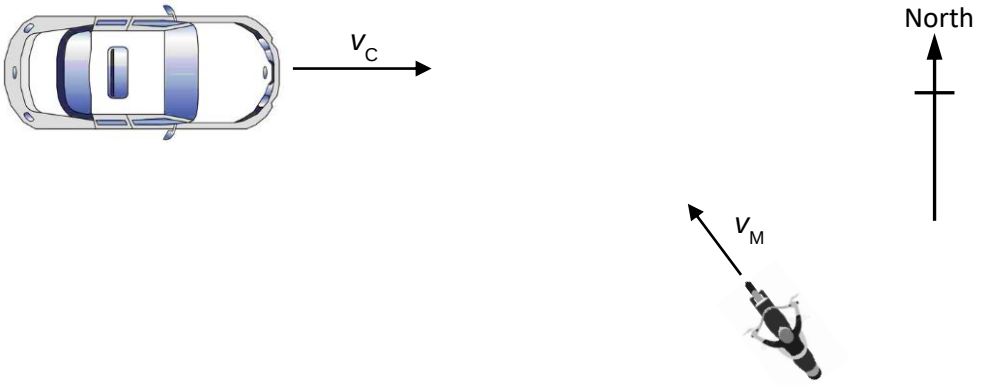
A 1 **B** 2 **C** 3 **D** 4

2 The radius of the Earth is approximately 6.4×10^6 m, and the radius of the moon is approximately 1.7×10^6 m. A student wishes to build a scale model of the Solar System in the classroom, using a football of radius 0.12 m to represent the Earth.

Which object would best represent the Moon?

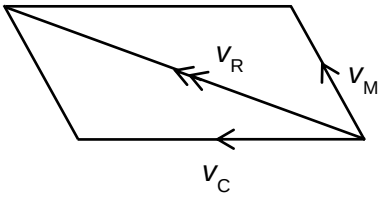
A basketball **B** cherry **C** golf ball **D** tennis ball

3 A passenger in a car travelling due East at speed v_C sees a motorcyclist travelling due North−West at speed v_M.

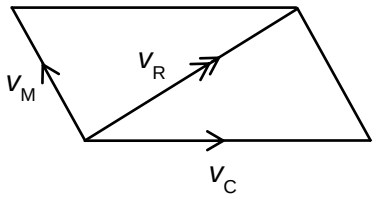


Which diagram shows the velocity v_R of the motorcyclist relative to the passenger in the car?

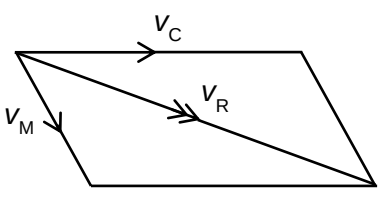
A



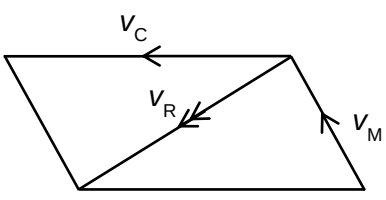
B



C



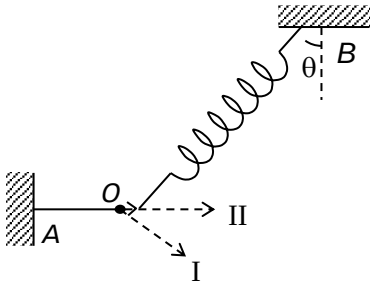
D



4 Two small identical objects P and Q are released from rest from the top of a building 80 m above the ground. Q is released 1.0 s after P. Neglecting air resistance, what is the maximum vertical separation between P and Q in the air?

A 5.0 m **B** 10 m **C** 35 m **D** 45 m

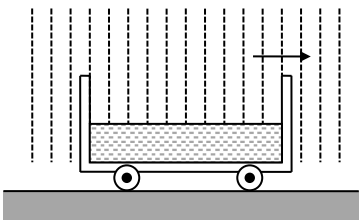
5 A small object at O is kept in static equilibrium by a horizontal thread OA and a light spring OB which makes an angle θ with the vertical as shown below.



If the thread is suddenly cut, what are the direction and magnitude of the acceleration of the object at that instant?

	Direction	Magnitude
A	I	$g \sin\theta$
B	I	$g \tan\theta$
C	II	$g \sin\theta$
D	II	$g \tan\theta$

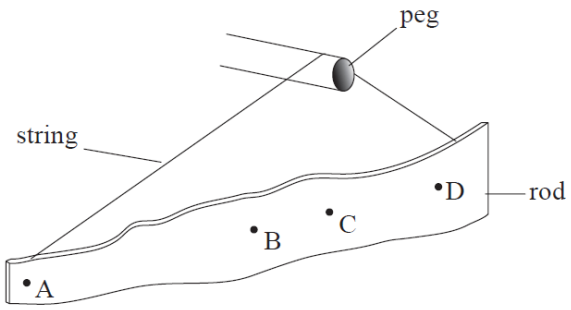
6



The above figure shows an open wagon moving with negligible resistance in vertically falling rain. An appreciable amount of rain falls into the wagon and accumulates there. What are the effects of the accumulating rain on the speed, momentum and kinetic energy of the wagon? (Ignore the effects of the raindrops hitting the front of the wagon.)

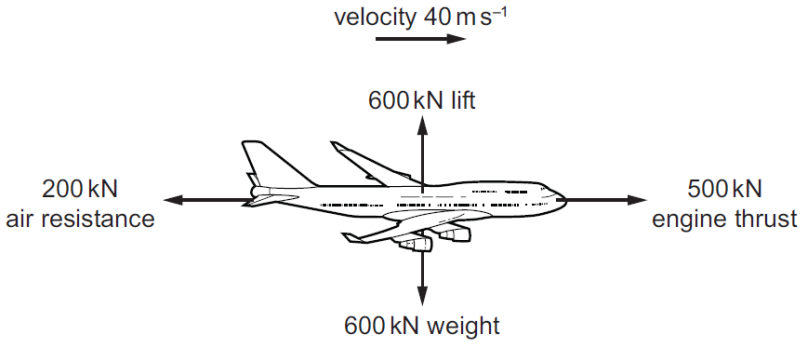
	speed	momentum	Kinetic energy
A	decrease	unchanged	unchanged
B	decrease	unchanged	decrease
C	decrease	decrease	decrease
D	unchanged	unchanged	Unchanged

7 An uneven rod is supported from a peg by means of a string. The friction force between the peg and the string is negligible.



Which of the points best shows the position of the centre of gravity of the rod?

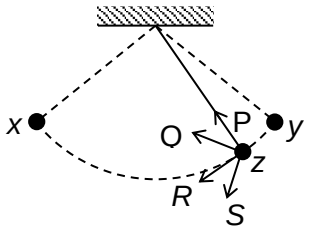
8 The force diagram shows an aircraft accelerating. At the instant shown, the velocity of the aircraft is 40 m s^{-1}.



At what rate is its kinetic energy increasing?

A 2.4 MW **B** 8.0 MW **C** 12 MW **D** 20 MW

9 The figure shows a pendulum bob swinging between positions *x* and *y*.



Which of the arrows *P*, *Q*, *R*, *S* represents the direction of the resultant force acting on the bob when the bob is at position *z*? (Neglect air resistance.)

A *P* **B** *Q* **C** *R* **D** *S*

10 A car is travelling on a road in hilly terrain, as shown in diagram below. The tops and bottoms of the hill have radius of curvature R.

Assuming that the car is moving with a speed v, at which point of the hill and at what speed is the driver of the car most likely to feel weightless?

A at the top of a hill when $v > \sqrt{gR}$

B at the bottom of a hill when $v > \sqrt{gR}$

C at the top of a hill when $v < \sqrt{gR}$

D at the bottom of a hill when $v < \sqrt{gR}$

11 Four planets A, B, C and D have masses and radii as listed in terms of M and R where M and R are the mass and radius of the Earth respectively.

Which planet would have a surface escape speed which is the same as that of the Earth?

	mass of planet	radius of planet
A	$\frac{1}{2}M$	$\frac{1}{\sqrt{2}}R$
B	$\frac{1}{2}M$	R
C	M	$\frac{1}{2}R$
D	$2M$	$2R$

12 An external agent does 50 J of work in moving a mass of 2.0 kg from point A to point B in a gravitational field, and –60 J of work in moving the mass from point B to point C. Finally, the external agent does work of 1000 J in moving the mass from point C to infinity.

What is the gravitational potential at point A?

A –555 J kg^{-1}

B –505 J kg^{-1}

C -495 J kg^{-1}

D -445 J kg^{-1}

13 To cool down the electrical generator of a nuclear power plant, cold water enters the heat exchanger of the generator at 3 °C and leaves at 11 °C. The rate of heat removed by the water is 4.0×10^{11} J per hour. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

What is the rate of water flow?

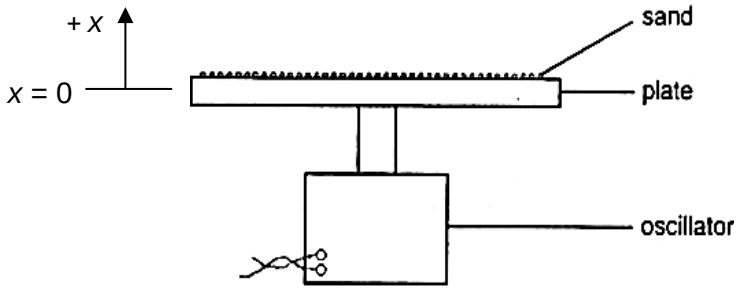
A $\dfrac{4.0 \times 10^{11}}{4200 \times 8 \times 60 \times 60}$ kg s^{-1}

B $\dfrac{4.0 \times 10^{11} \times 60 \times 60}{4200 \times 8}$ kg s^{-1}

C $\dfrac{4.0 \times 10^{11}}{4200 \times 8 \times 60}$ kg s^{-1}

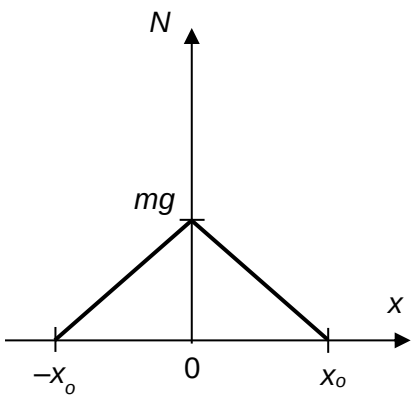
D $\dfrac{4.0 \times 10^{11} \times 60}{4200 \times 8}$ kg s^{-1}

14 Some sand is placed on a flat horizontal plate and the plate is made to oscillate with simple harmonic motion in a vertical *x*-direction, as shown. The amplitude of oscillation x_o of the plate is such that the maximum acceleration is equal to the acceleration of free fall.

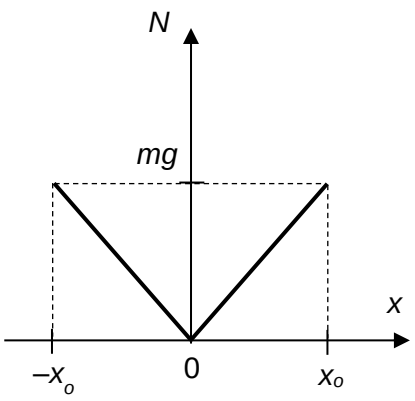


Which of the following graphs correctly describes the variation of the normal contact force *N* that the plate exerts on a grain of sand of mass *m*, with respect to the vertical displacement *x* of the plate?

A

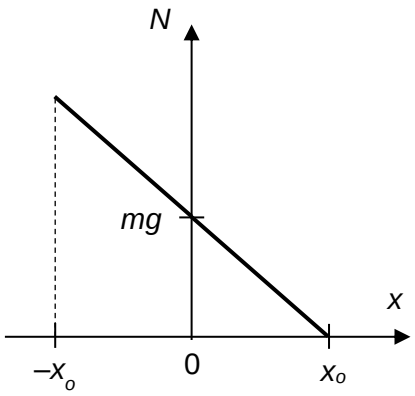


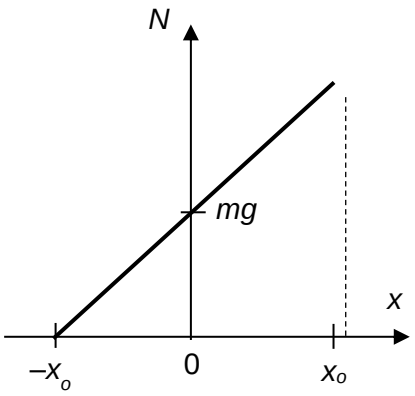
B



C

D





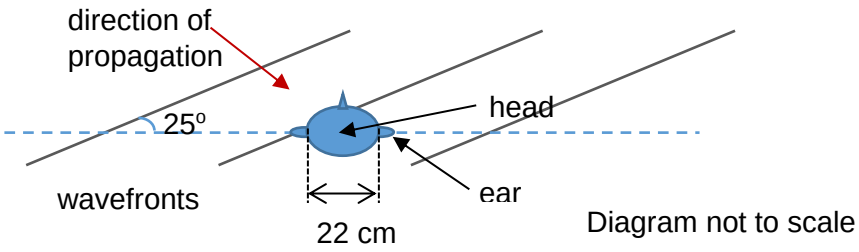
15 A small mass suspended at the end of a helical spring is given a vertical displacement of 3.0 cm from its rest position and then released. The subsequent simple harmonic oscillation produced has a period of 2.0 s.

What is the distance moved by the mass in the first 0.75 s?

A 1.5 cm **B** 2.1 cm **C** 4.5 m **D** 5.1 cm

16 Humans are able to detect the general direction of a sound source because sound waves from the source reaches the left and right ears at slightly different times.

The figure shows the top view of a human head with the two ears 22 cm apart. Sound waves of wavelength 1.7 m from a distant source reach the ears at an angle of 25° to the horizontal.



What is the phase difference between the waves reaching the left and right ear?

A 0.34 rad **B** 0.58 rad **C** 0.74 rad **D** 0.81 rad

17 The diagram shows a wave travelling from left to right at a frequency of 200 Hz. Two particles in the wave labelled X and Y are separated by a distance of 50 m.

Which of the following statement is correct?

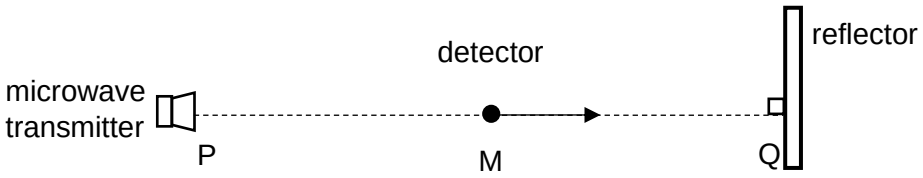
A At X, the air pressure is minimum.

B At Y, it is a position of antinode.

C At X, the air molecule is moving to the right.

D At Y, the air molecule is momentarily at rest.

18 A microwave transmitter emits waves that are incident normally on a reflector. A microwave detector is initially at the point M where it detects a maximum intensity. As it moves along the line PQ towards Q, the detector picks up a series of maximum and minimum intensity signals.

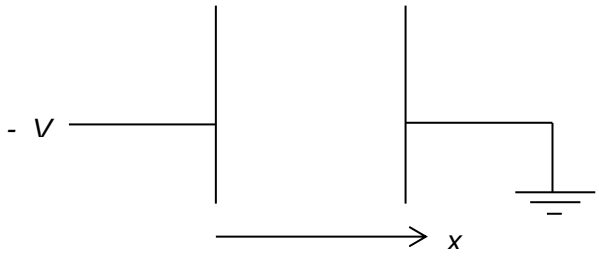


The detector moves with a speed of 2.0 m s^{-1} and the frequency at which maximum intensity signals are picked up is 10 Hz.

What is the distance moved by the detector from its initial position at M to a position where it detects the second minimum intensity signal?

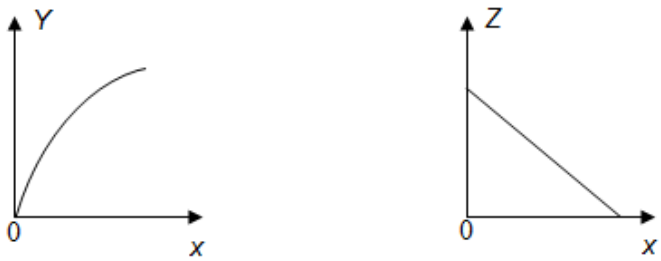
A 0.10 m **B** 0.20 m **C** 0.30 m **D** 0.40 m

19 Two parallel plates are arranged as shown, with the right plate being earthed and the left plate at a negative potential, - *V*.



An electron is released from rest from the surface of the left plate and travels to the right plate.

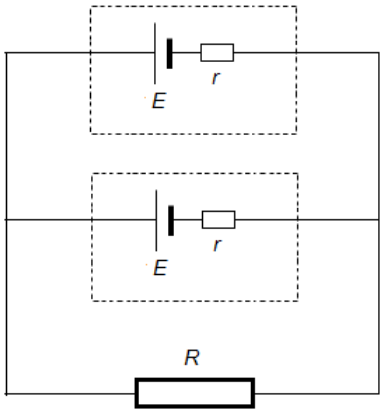
The graphs below shows the variations with displacement *x* of two quantities *Y* and *Z* of the electron as it moves from the left plate to the right plate.



Which one of the following quantity could *Y* and *Z* represent for the electron?

	quantity *Y*	quantity *Z*
A	speed	electric potential energy
B	speed	electric force
C	kinetic energy	electric potential energy
D	kinetic energy	electric force

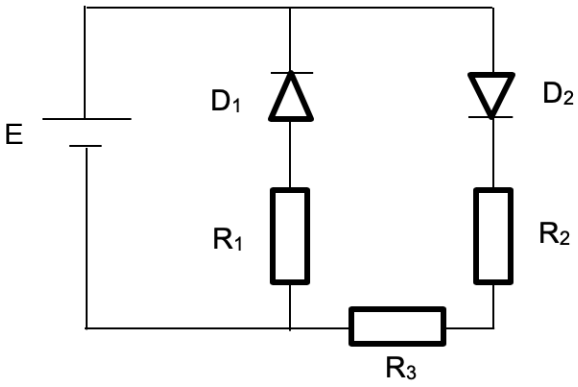
20 Two identical electrical sources are used to operate a lamp of resistance R as shown in the figure below. The internal resistance of each electrical source is r.



What is the fraction of the total power lost in the internal resistance of both sources?

A $\frac{2R-r}{2R}$ **B** $\frac{2R+r}{2R}$ **C** $\frac{r}{2R+r}$ **D** $\frac{2R}{2R+r}$

21 A circuit consisting of diodes D_1 and D_2 and resistors R_1, R_2 and R_3 is shown below.



Which is the correct relative magnitude (from greatest to the smallest) of the potential differences across the components D_1, R_1 and R_2?

	Greatest		Smallest
A	D_1	R_1	R_2
B	D_1	R_2	R_1
C	R_1	R_2	D_1
D	R_2	R_1	D_1

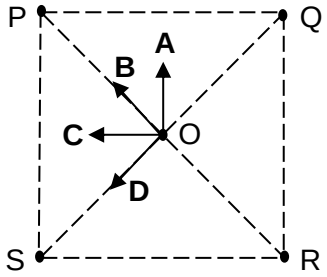
22 A variable resistor dissipates a certain power when a steady current I flows through it. The resistance had to be halved to obtain the same power dissipation in the resistor when a sinusoidal alternating current is used with a diode in series with the resistor in the circuit.

What is the peak value of the alternating current?

A I **B** $1.4\,I$ **C** $2\,I$ **D** $2.8\,I$

23 The figure below shows four long, straight current-carrying wires P, Q, R and S which are perpendicular to the plane of the paper. They pass through the corners of a square. Point O is the point of intersection of the diagonals of the square. The currents in all four wires have the same magnitude. The currents in wires P, Q and R flow into the plane of the paper while that in S flows out of the plane of the paper.

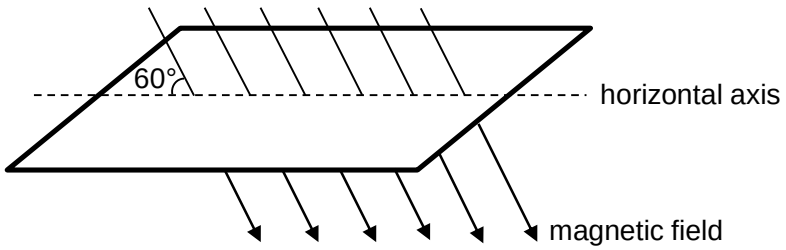
Which arrow shows the direction of the resultant magnetic field at O?



24 Two very long, straight, parallel wires carry equal steady current I in opposite directions. The distance between the wires is *d*. At a certain instant of time, a point charge *q* is at a point equidistant from the two wires, in the plane of the wires. Its instantaneous velocity *v* is perpendicular to this plane. The magnitude of the force due to the magnetic field acting on the charge at this instant is

A 0 N **B** $\frac{\mu_0 Iqv}{2\pi d}$ **C** $\frac{\mu_0 Iqv}{\pi d}$ **D** $\frac{2\mu_0 Iqv}{\pi d}$

25 A magnetic field of flux density 4.0×10^{-4} T passes through a coil of wire of 50 turns and an area of 30 cm^2. The field makes an angle of 60° with the horizontal plane of the coil.



What is the e.m.f. induced in the coil when it is turned over once about its horizontal axis in a time of 0.60 s?

A 5.0×10^{-5} V **B** 8.7×10^{-5} V **C** 1.0×10^{-4} V **D** 1.7×10^{-4} V

26 Fig. 26 (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. 26 (b).

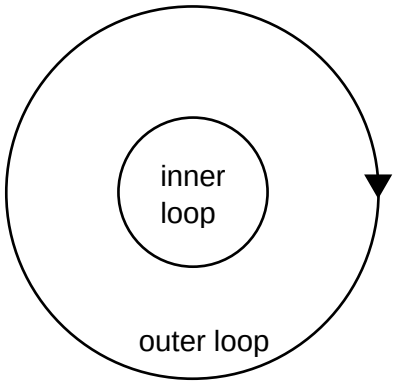


Fig. 26 (a)

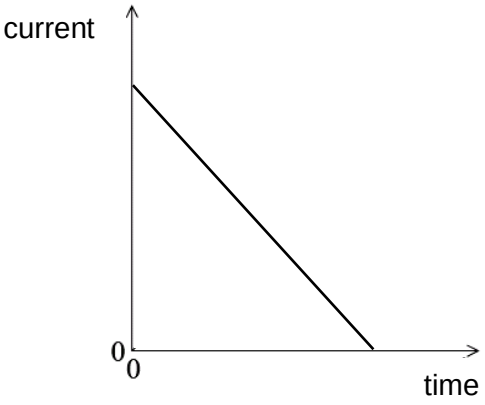


Fig. 26 (b)

The induced current in the inner loop is

A constant in the clockwise direction.
B variable in the clockwise direction.
C constant in the anticlockwise direction.
D variable in the anticlockwise direction.

27 When electrons with velocity *v* travel through a vacuum and are incident on a thin carbon film, they produce a pattern of concentric circles on the fluorescent screen.

What causes the pattern and how would the pattern change when the velocity *v* is decreased?

	cause	change to pattern
A	refraction	diameters of circles decrease
B	refraction	diameters of circles increase
C	diffraction	diameters of circles decrease
D	diffraction	diameters of circles increase

28 Light quanta each of energy 3.5×10^{-19} J fall on the cathode of a photocell. The current through the cell is just reduced to zero by applying a reverse voltage to make the cathode 0.25 V positive with respect to the anode.

The minimum energy required to remove an electron from the cathode is

A 2.9×10^{-19} J
B 3.1×10^{-19} J
C 3.5×10^{-19} J
D 3.9×10^{-19} J

29 Consider the following nuclear reaction:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{121}_{45}Rh + ^{113}_{47}Ag + 2\,^{1}_{0}n$$

Data:

binding energy per nucleon of $^{235}_{92}U$ = 7.59 MeV

binding energy per nucleon of $^{121}_{45}Rh$ = 8.26 MeV

binding energy per nucleon of $^{113}_{47}Ag$ = 8.52 MeV

What is the energy change in this reaction?

A 73.9 MeV of energy is released.

B 73.9 MeV of energy is absorbed.

C 179 MeV of energy is released.

D 179 MeV of energy is absorbed.

30 A radioactive source in the laboratory has a half-life of 10 days. The count rate was measured to be 100 Bq initially. 20 days later, the count rate was found to be 34 Bq.

What is the count rate in the laboratory without the source?

A 9 Bq **B** 12 Bq **C** 17 Bq **D** 22 Bq

End of Paper