Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

PHYSICS **9749/01**
Paper 1 Multiple Choice 15 September 2023
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 index number on the Answer Sheet provided.

There are **thirty** questions in this section. 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 Question Paper.
The use of an approved scientific calculator is expected, where appropriate.

DATA AND FORMULAE

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

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\,\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_o \sin \omega t$
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	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{½}}$

1 The derived unit for which of the following quantities can be expressed in four different SI base units?

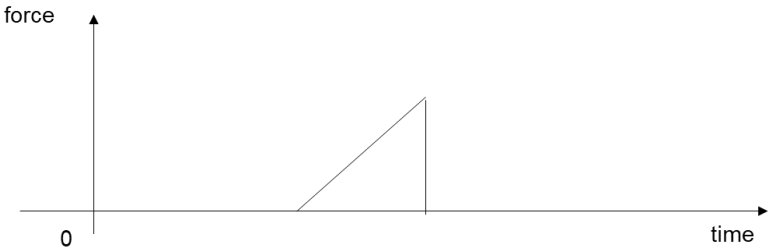
A electromotive force

B momentum

C magnetic flux density

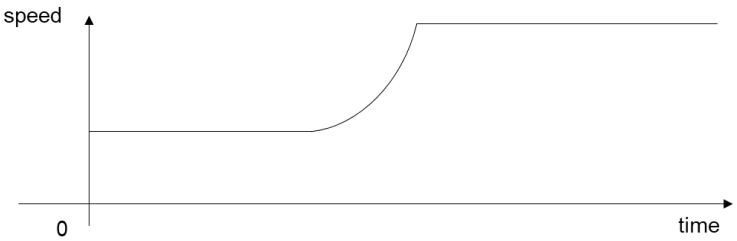
D power

2 A block initially moving on a smooth surface at constant speed, experiences a force that varies with time as shown.

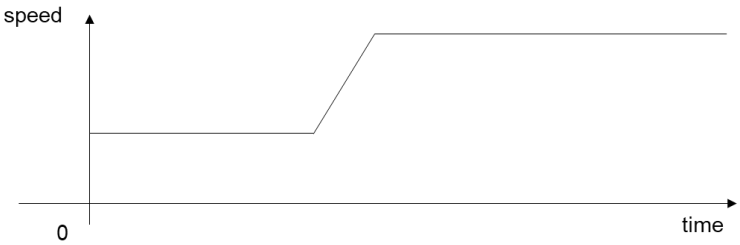


Which graph represents the variation with time of the speed of the block?

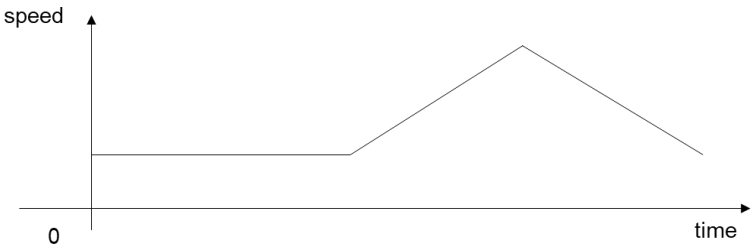
A



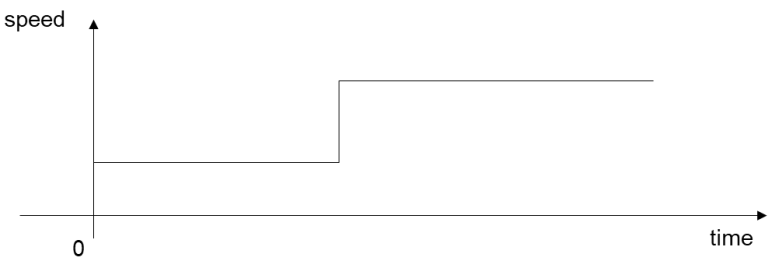
B



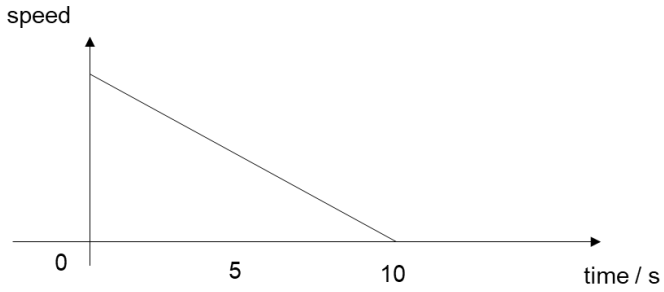
C



D



3 A drone descends from a height for 10 s. The variation with time of the vertical speed of the drone is shown.



What is the ratio $\frac{\text{distance travelled between 0 s to 10 s}}{\text{distance travelled between 0 s to 5 s}}$?

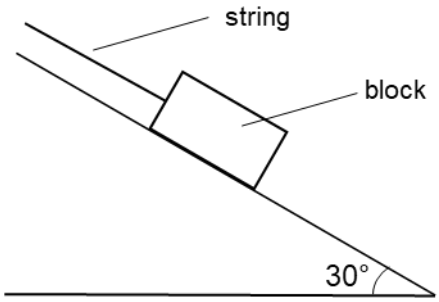
A 1.2 **B** 1.3 **C** 1.5 **D** 1.8

4 A 3.0 kg block is moving on a smooth surface with a speed of 2.0 m s^{-1}. A constant force of 1.5 N is exerted on the block over 2.0 s in a fixed direction.

Which of the following cannot be the magnitude of its final speed?

A 0.5 m s^{-1} **B** 1.0 m s^{-1} **C** 2.0 m s^{-1} **D** 3.0 m s^{-1}

5 A 5.0 kg block is placed on a rough slope inclined at an angle of 30° to the horizontal with a string attached to it as shown below.



The tension in the string is 2.0 N and the frictional force exerted by the slope is 3.0 N.

What is the magnitude of the acceleration of the block?

A 3.9 m s^{-2} **B** 5.1 m s^{-2} **C** 5.9 m s^{-2} **D** 7.5 m s^{-2}

6 Diagram 1 shows two forces *F* acting on a circular disc of radius *r.* The disc is pivoted at a fixed point O which is the center of the disc. The forces give rise to a net moment *M*.

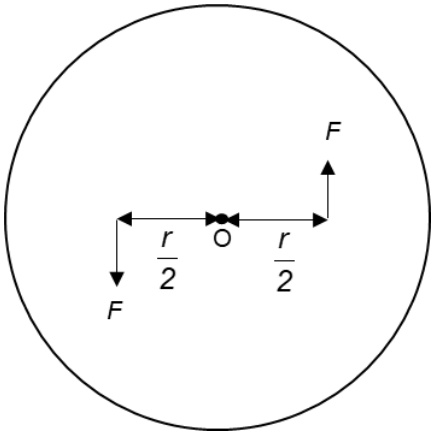


Diagram 1

In diagram 2, the lines of action of forces are moved to new points.

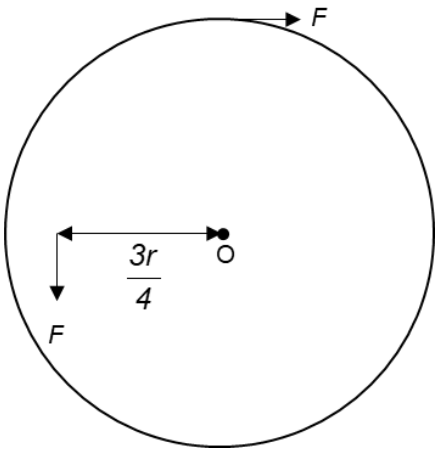
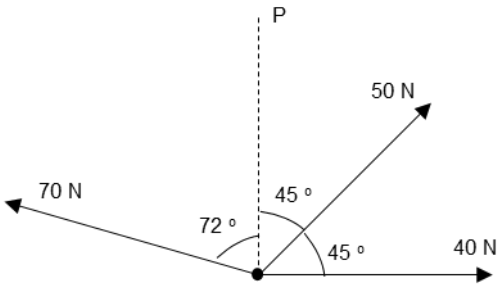


Diagram 2

What is the net moment now?

	magnitude	direction
A	$\frac{M}{4}$	anti-clockwise
B	$\frac{M}{4}$	clockwise
C	$\frac{4}{3}M$	anti-clockwise
D	$\frac{4}{3}M$	clockwise

7 Three forces act on a body in various directions shown below.



An additional force will be required for the system to be at equilibrium.

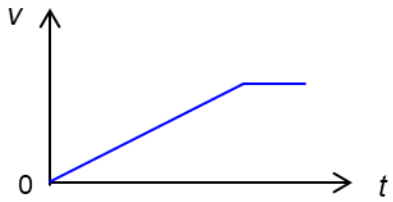
What is the magnitude and direction of the additional force measured from line P?

	force	direction
A	57.7 N	9 °
B	57.7 N	189 °
C	153 N	68 °
D	153 N	248 °

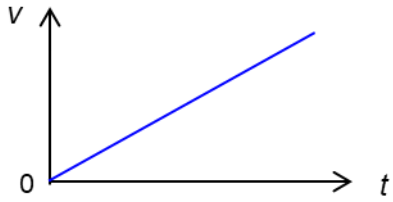
8 A motor with a constant output power pulls a wooden block vertically upwards from rest.

Which of the following graphs best represents the variation with time *t* of the speed *v* of the block?

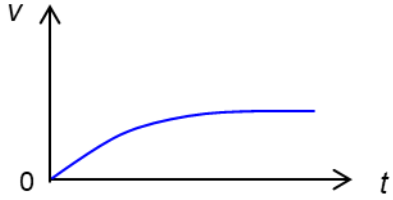
A



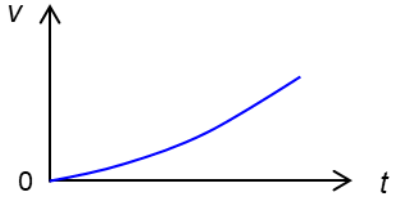
B



C



D



[Turn over

9 Three identical slotted masses are placed at 2*R*, 4*R* and 6*R* respectively from the centre of a horizontal rough disc of radius 10*R*.

The disc rotates about its centre O.

Which statement is correct?

A All three slotted masses experience the same centripetal force.

B The slotted mass at 6*R* is most likely to move out of its circular path.

C The slotted mass at 2*R* completes the least number of revolutions per unit time.

D The slotted mass at 6*R* has three times the amount of kinetic energy as the slotted mass at 2*R*.

10 A binary star consists of two stars A and B. The two stars may be considered to be isolated in space. The centre of the two stars are separated by a constant distance *d*.

Star A, of mass M_A has a smaller mass than star B of mass M_B, such that $\frac{M_A}{M_B} = 0.2$.

The stars are in circular orbits about each other such that the centre of their orbits is at a fixed point with orbital period *T*.

Which row is correct?

	orbital radius of star A	magnitude of gravitational force on star B
A	$\frac{5}{6}d$	$\frac{10\pi^2 dM_A}{3T^2}$
B	$\frac{5}{6}d$	$\frac{10\pi^2 dM_B}{3T^2}$
C	d	$\frac{10\pi^2 dM_A}{3T^2}$
D	d	$\frac{10\pi^2 dM_B}{3T^2}$

11 The mean distance of the planet Saturn from the Sun is 9.5 times that of the mean distance of the Earth from the Sun.

How long does it take Saturn to orbit the Sun?

A 4.5 years

B 29 years

C 90 years

D 860 years

12 A small ice cube of mass 30 g is heated. It changes from the solid state 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 internal energy of the molecules remains the same.

B The kinetic energy of the molecules remains the same.

C There is positive work done on the system as the ice melts.

D The amount of energy the ice absorbs is not equal to the specific latent heat of fusion.

13 Planet Z has a mass 6.4×10^{23} kg and a diameter of 6.8×10^{3} km.

Assuming helium-4 to be an ideal gas, what is the minimum temperature of the helium-4 gas for it to be able to escape from the surface of Planet Z?

A 2.0×10^{3} K

B 2.1×10^{3} K

C 4.0×10^{3} K

D 4.1×10^{3} K

14 An ideal gas is held in a constant volume container fitted with a valve through which gas can escape.

Starting at 150 K, the temperature of the gas is raised by 900 K while its pressure in the container is raised from P to $2P$. This results in a fraction of the original number of gas molecules escaping through the valve.

What is the pressure in the container after the gas is cooled back to its starting temperature?

A 0.29 P **B** 0.33 P **C** 0.50 P **D** P

15 A wooden block is floating on a body of highly viscous liquid. When the block is displaced vertically downwards by a small displacement and released, it is observed to oscillate a few complete cycles before coming to a complete rest.

What degree of damping does the block experienced when it is oscillating?

A Critical damping.

B Heavy damping.

C Light damping.

D No damping.

16 An external oscillator is attached to the top of a vertical spring mass system.

Which statement about the forced oscillation is always true?

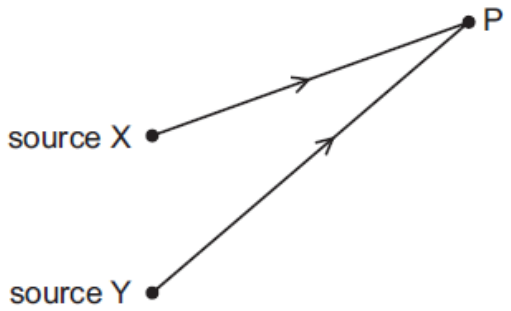
A The amplitude of the spring mass system will increase as the frequency of the oscillator increases.

B The amplitude of the spring mass system will not be affected by the amplitude of the oscillator.

C The spring mass system will always oscillate at its natural frequency.

D The spring mass system will always oscillate at the frequency of the oscillator.

17 Two identical water waves travel from two sources X and Y to meet at point P. The frequency of the waves is 0.40 Hz and the sources are in phase.



Waves from source X take 3.0 s to arrive at P, while waves from source Y take 3.5 s to arrive at P.

What is the phase difference, in radians, between the two waves at P?

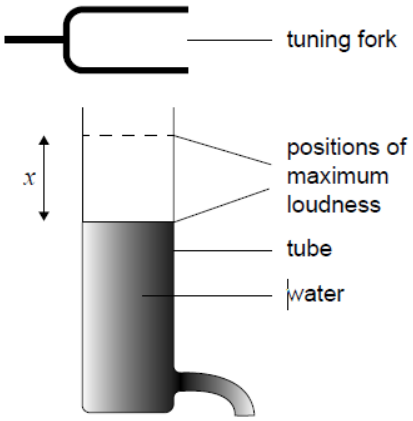
A $\frac{\pi}{5}$ **B** $\frac{2\pi}{5}$ **C** $\frac{5\pi}{2}$ **D** 5π

18 A narrow beam of monochromatic light falls on a diffraction grating at normal incidence. The second order diffracted beam occurs at an angle of 31° to the normal.

What is the total number of intensity maxima from the grating that can be observed?

A 3 **B** 4 **C** 7 **D** 9

19 Water flows out from a vertical tube that was initially full. A vibrating tuning fork is held near the top of the tube.

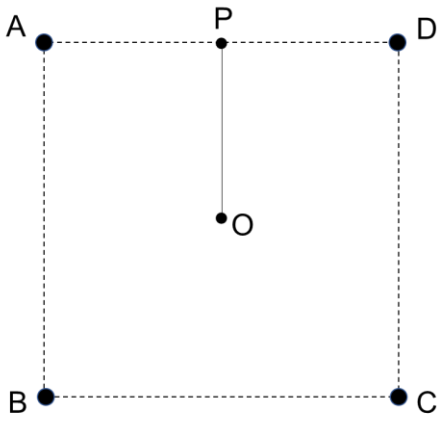


The distance between the two consecutive positions when the sound is at maximum loudness is x.

What is the wavelength of the sound emitted by the tuning fork?

A $\frac{x}{2}$ **B** x **C** $\frac{3x}{2}$ **D** $2x$

20 Four point charges are at the corners of a square ABCD. The point charges A and B are negatively charged and the point charges C and D are positively charged. The magnitude of the charges are the same. A proton is brought from point P to point O in a straight line by an external force without any change in speed.

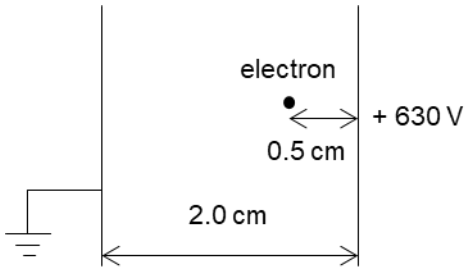


Which row about the change in electric potential energy of the system and the work done by the external force is correct?

	change in electric potential energy	work done by the external force
A	increase	positive
B	increase	negative
C	decrease	negative
D	no change	zero

[Turn over

21 A pair of parallel plates placed 2.0 cm apart is shown below. One of the plates is charged positively and the other is earthed. An electron is placed at a distance 0.5 cm away from the positive plate as shown in the diagram.



What is the force on the electron by the electric field?

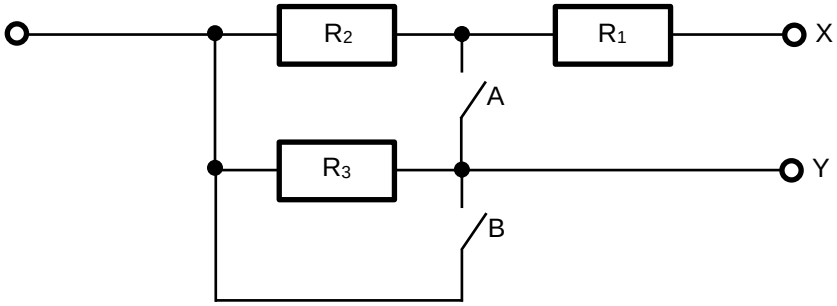
A 2.0×10^{-18} N

B 7.6×10^{-17} N

C 1.0×10^{-16} N

D 5.0×10^{-15} N

22 A circuit consists of three resistors R_1, R_2 and R_3, and two switches A and B, as shown in the figure.



The resistance between the terminals X and Y is measured for different settings of the switches A and B.

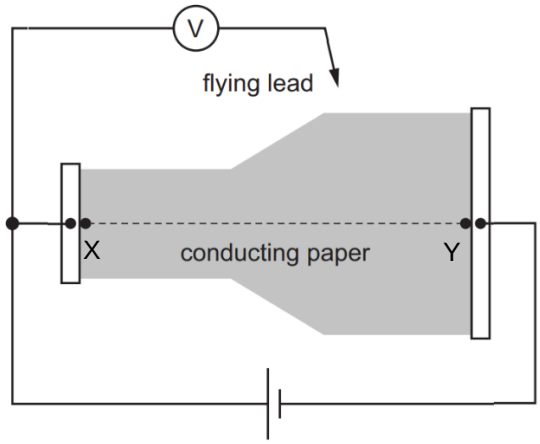
The results are shown in the table.

switch A	switch B	resistance between X and Y / kΩ
open	open	24
open	closed	20
closed	open	12
closed	closed	12

What is the ratio of the $\frac{\text{resistance of } R_1}{\text{resistance of } R_3}$?

A 0.33 **B** 0.50 **C** 1.0 **D** 3.0

23 A sheet of conducting paper of uniform thickness is cut to the shape shown and a battery is connected to each end by aluminium strips. A high resistance voltmeter is also connected as shown.

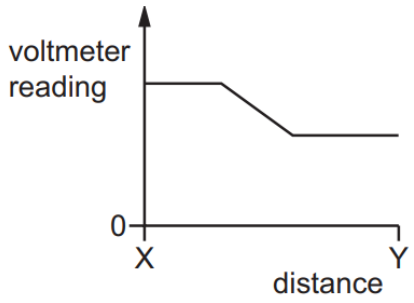


The flying lead of the voltmeter is placed in contact with the conducting surface at X and the reading is noted. This is repeated for a large number of points along the line XY, ending at point Y.

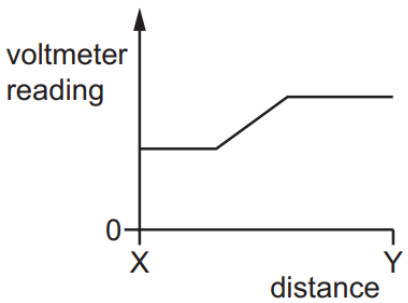
The readings are plotted on a graph of voltmeter reading against distance from X.

Which diagram shows the correct shape of the graph?

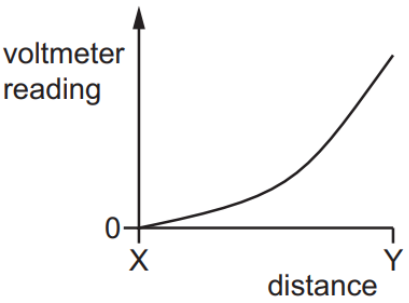
A



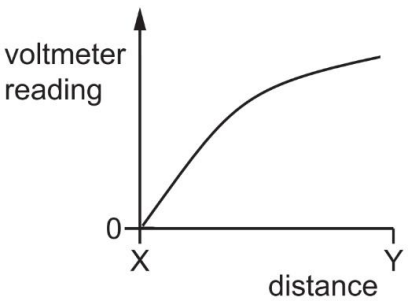
B



C

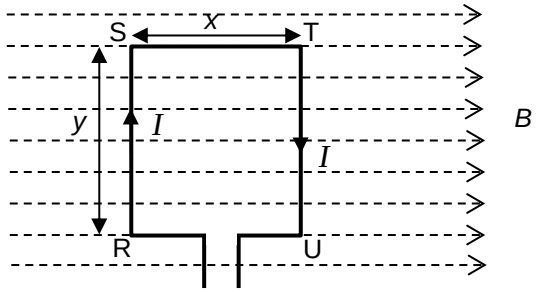


D



[Turn over

24 A rectangular wire loop RSTU with sides of length *x* and *y* carries a current I. A magnetic field of flux density *B* lies in the plane of the coil as shown.



Which statement is correct?

A The force on side ST is BIx.

B The moment on the loop is $BIxy$.

C There is a net force perpendicular to the magnetic field.

D There is no force acting on the wire loop.

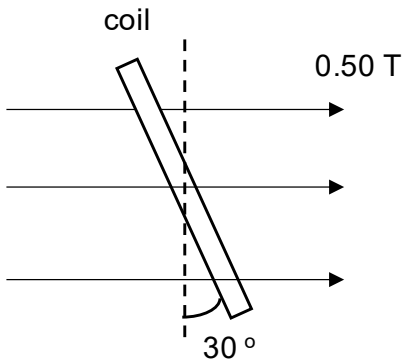
25 When an alternating current, $I = I_0 \cos \omega t$, passes through a resistor, the mean power dissipated in the resistor is *P*.

The peak value of the alternating current is then reduced by half and the current is passed through a diode.

What is the mean power dissipated in the resistor in terms of *P*?

A $\frac{P}{8}$ **B** $\frac{P}{4}$ **C** $\frac{P}{2}$ **D** P

26 A uniform magnetic field of flux density 0.50 T passes through a coil of area 20 cm^2. The coil has 15 turns and is tilted an at angle of 30 ^{o} as shown.



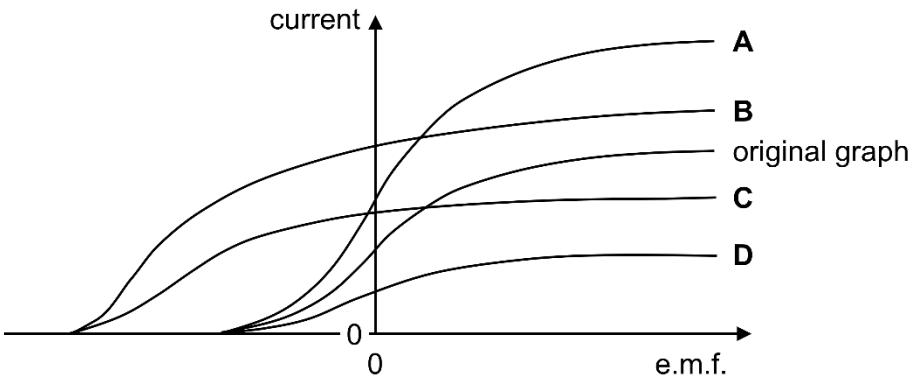
What is the magnetic flux linkage of the coil?

A 1.3×10^{-4} Wb **B** 7.5×10^{-3} Wb **C** 1.3×10^{-2} Wb **D** 1.3 Wb

27 A photoelectric cell is connected to a variable d.c. power supply and a sensitive ammeter.

It is illuminated with ultraviolet radiation and photoelectrons are emitted. The variation with the electromotive force (e.m.f.) supplied of the current is obtained.

Which graph will be obtained if the experiment is repeated with a higher intensity of the ultraviolet radiation of the same frequency?



28 X-rays are produced when electrons are accelerated from rest by a potential difference and collide with a metal target.

The minimum wavelength of X-rays produced is λ_0.

What is the minimum wavelength of X-rays produced if the momentum of the electrons when they collide with the metal target is doubled?

A $\frac{\lambda_0}{4}$ **B** $\frac{\lambda_0}{2}$ **C** $2\lambda_0$ **D** $4\lambda_0$

29 In the Rutherford α - particle scattering experiment, α - particles are directed at a thin gold foil.

Which is a direct deduction from the results of the experiment?

A The α - particles are negatively charged.

B The α - particles are positively charged.

C The atom consists of a large amount of empty space.

D The proton number of the gold nucleus is 79.

30 Consider the following nuclear fission reaction.

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{92}_{36}\mathrm{Kr} + {}^{141}_{56}\mathrm{Ba} + 3\,{}^{1}_{0}\mathrm{n}$$

The binding energy per nucleon for the particles are as shown.

Particle	Binding energy per nucleon / MeV
U	7.59
Kr	8.70
Ba	8.33

What is the amount of energy released by the reaction?

A 81.4 MeV **B** 110 MeV **C** 191 MeV **D** 199 MeV

End of Paper