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NATIONAL JUNIOR COLLEGE
SENIOR HIGH 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

PHYSICS
Paper 1 Multiple Choice

Additional Materials: Multiple Choice Answer Sheet

9749/01

16 September 2021
1 hour

READ THE INSTRUCTION FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

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

Read the instructions 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.

Shading of OAS index number

OAS index number is in a 5-digit format.

The 5 digit forma is as follows: **1st digit** and the **last four digits** of the Reg Number.
e.g. 200**5011** becomes **25011**

This document consists of **19** printed pages and **1** blank page.

Data

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

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 Forces of 3 N and 4 N act at a point. Which one of the following could **not** be the magnitude of their resultant?

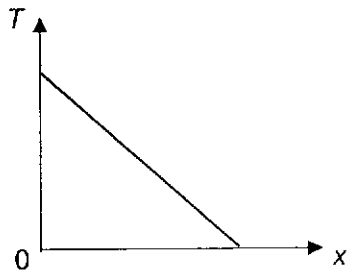
A 1 N **B** 3 N **C** 4 N **D** 8 N

2 Which of the following gives a good estimate of the order of magnitude of the volume of an average human adult?

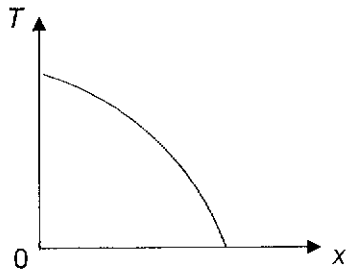
A $10^{-2}\,m^3$ **B** $10^{-1}\,m^3$ **C** $10^{0}\,m^3$ **D** $10^{1}\,m^3$

3 A body moves with a constant acceleration opposite in direction to its initial velocity. Which one of the following graphs represents the variation of its kinetic energy T with the distance travelled x from its initial position?

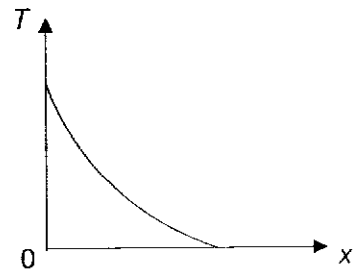
A



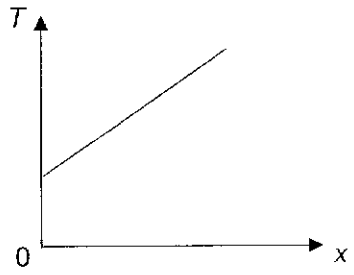
B



C

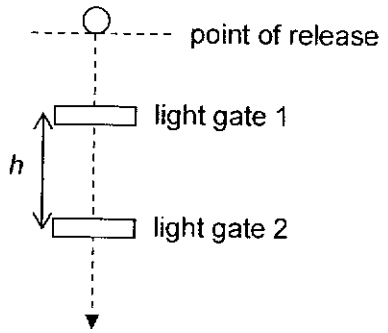


D



4 To determine the acceleration of free fall, a steel ball is dropped above two light gates as shown.

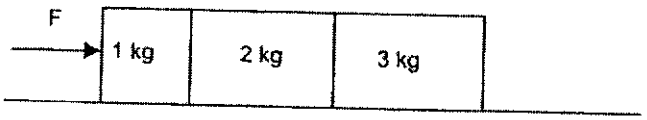
The ball passes light gate 1 and 2 at times t_1 and t_2 after release.



What is the acceleration of free fall?

A $\frac{2h}{t_2 - t_1}$ B $\frac{2h}{(t_2 - t_1)^2}$ C $\frac{2h}{{t_2}^2 - {t_1}^2}$ D $\frac{2h}{\left(\frac{t_2 + t_1}{2}\right)^2}$

5 Three boxes are pushed along a smooth surface by a force F as shown below. What is the force exerted by the 2 kg mass on the 1 kg mass?



A $\frac{1}{3}$F B $\frac{1}{2}$F C $\frac{3}{4}$F D $\frac{5}{6}$F

6 A steel ball of mass m is dropped vertically onto a steel table. The ball is in contact with the table for a very short duration and it rebounds with very little loss in kinetic energy.

Which one of the following statements concerning the average force F exerted on the ball by the table during the collision is correct?

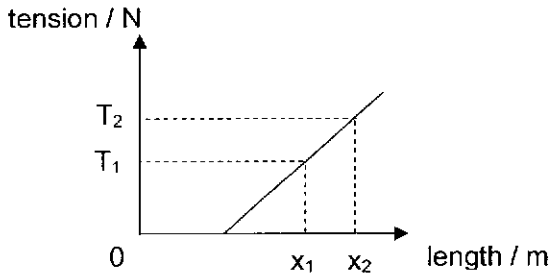
A F is smaller than mg.

B F is greater than mg.

C F is greater than the force that the ball exerted on the table during the collision.

D F is smaller than the force that the ball exerted on the table during the collision.

7 The graph below shows how the length of a wire changes with the tension in the wire.



What is the extra energy stored in the wire when the tension is increased from T_1 to T_2?

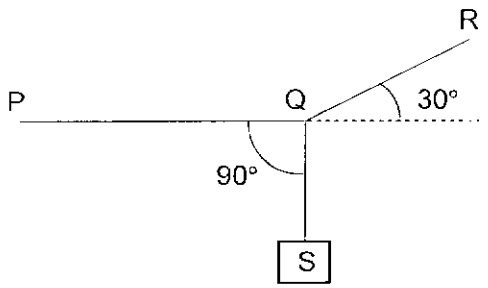
A $\frac{1}{2}(T_2 + T_1)(x_2 - x_1)$

B $\frac{1}{2}(T_2 + T_1)(x_2 + x_1)$

C $\frac{1}{4}(T_2 + T_1)(x_2 - x_1)$

D $\frac{1}{4}(T_2 + T_1)(x_2 + x_1)$

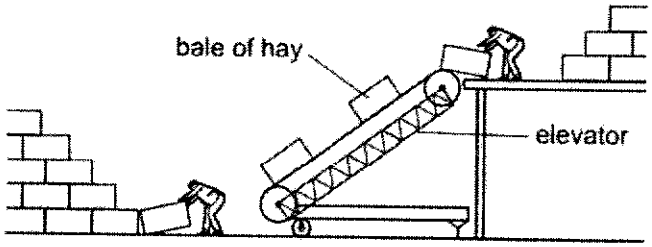
8 In the diagram below, a body S of weight *W* hangs vertically by a thread tied at Q to the string PQR.



If the system is in equilibrium, what is the tension in the section PQ?

A $W\cos 30°$ B $W\cos 60°$ C $W\tan 30°$ D $W\tan 60°$

9 Two farmers use an electrically powered elevator to lift bales of hay. All the bales of hay have the same mass.

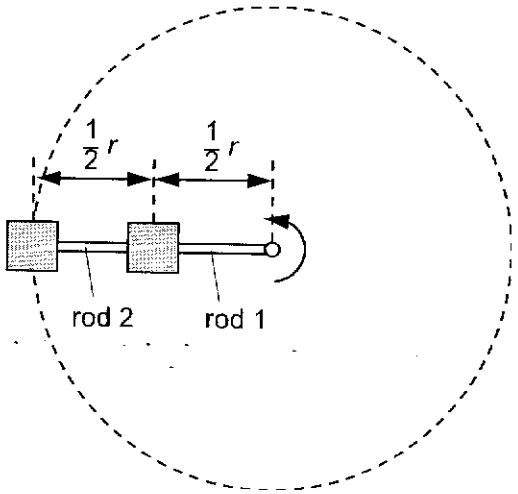


As sunset approaches, they increase the speed of the elevator so that more bales are lifted up in a given time.

How does this affect the work done in lifting each bale and the useful power output of the elevator?

	work done in lifting each bale	useful output power of the elevator
A	increases	decreases
B	increases	increases
C	no change	decreases
D	no change	increases

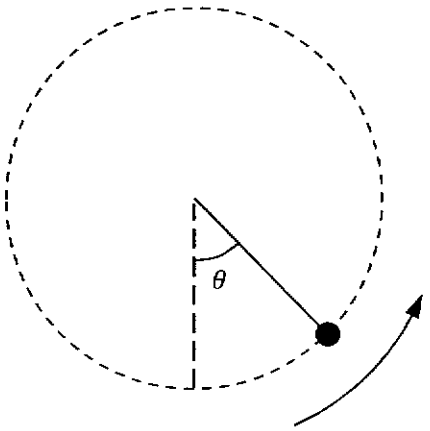
10 Two identical blocks connected by light rigid rods are pivoted at one end to move in a circular path at uniform angular velocity on a smooth horizontal surface, as shown.



What is the ratio of $\frac{\text{tension in rod 1}}{\text{tension in rod 2}}$?

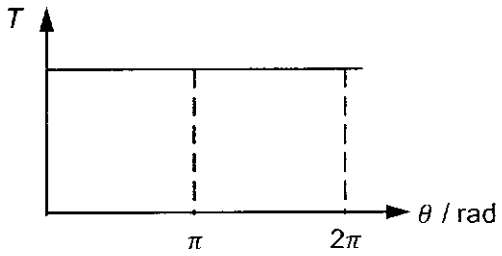
A 0.50 **B** 1.0 **C** 1.5 **D** 2.0

11 An object is fixed to one end of an inextensible light string which rotates in a vertical circle at constant speed.

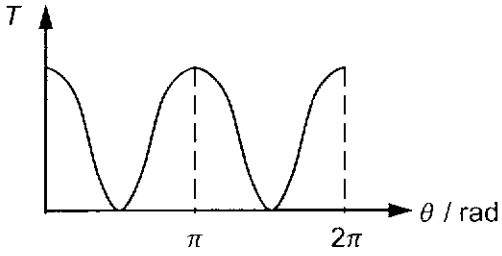


Which graph could represent the variation with angle θ of the tension T in the string?

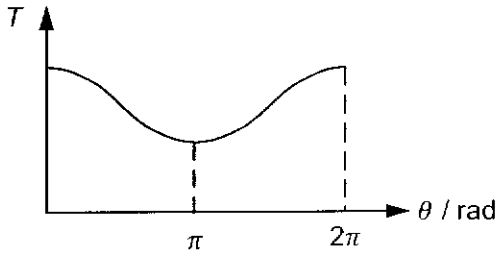
A



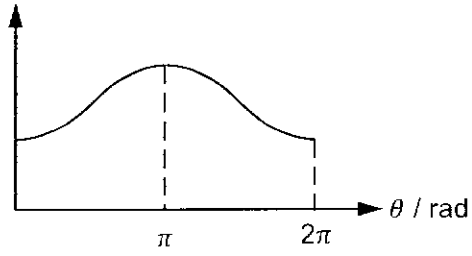
B



C



D



12 Two stationary particles of masses M_1 and M_2 are a distance d apart. A third particle, lying on the line joining the particles, experiences no resultant gravitational force.

What is the distance of this particle from M_1?

A $\left(\frac{M_1}{M_1+M_2}\right)d$

B $\left(\frac{M_2}{M_1+M_2}\right)d$

C $\left(\sqrt{\frac{M_1}{M_1+M_2}}\right)d$

D $\left(\frac{\sqrt{M_1}}{\sqrt{M_1}+\sqrt{M_2}}\right)d$

13 A satellite orbits a planet at a distance $2R$ from its centre. Its gravitational potential energy is –2.1 MJ.

Another identical satellite orbits the planet at a distance $3R$ from its centre.

What is the sum of the kinetic energy and the gravitational potential energy of this second satellite?

A –0.70 MJ **B** –1.4 MJ **C** –2.1 MJ **D** –3.2 MJ

14 A solid X is in thermal equilibrium with a solid Y, which is at the same temperature as a third solid Z. The three bodies are of different materials and masses. Which one of the following statements is certainly correct?

A X and Y have the same heat capacity.

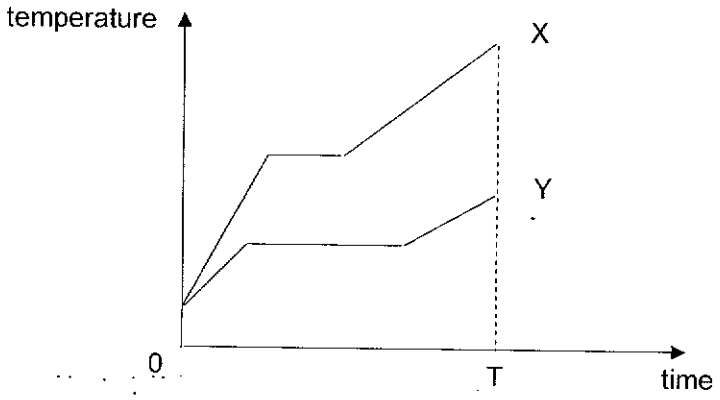
B Y and Z have the same internal energy.

C The atoms of X and Y have the same speed.

D There is no net transfer of energy if Y is placed in thermal contact with Z.

15 Equal masses of two solids X and Y are heated from the same temperature. Energy is supplied by heating at the same constant rate to each solid.

The graph shows how the temperature of each solid varies with time after heating starts.



What can be deduced from the graph?

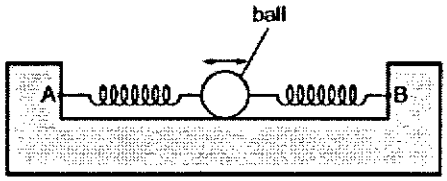
A X has the higher boiling point.

B X has the larger specific latent heat of fusion.

C When X and Y are solids, Y has the larger specific heat capacity.

D At time T, X gained more internal energy than Y.

16 A ball is held between two fixed points A and B by means of two stretched springs, as shown.



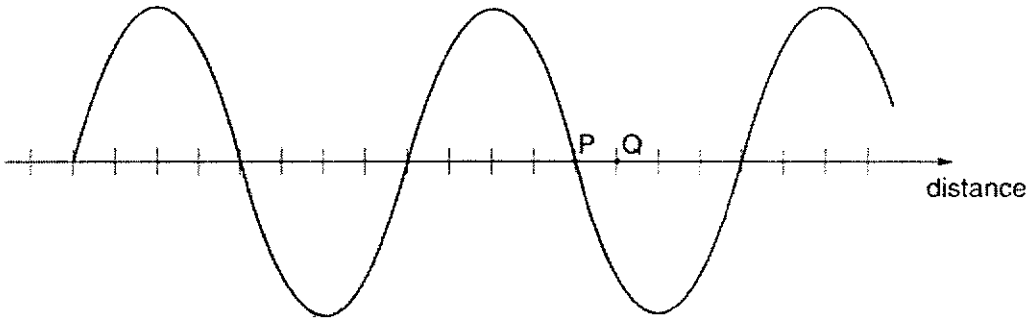
The ball is held at an initial displacement x_0 by a force F. Upon being released, the ball oscillates horizontally with an amplitude A and frequency f.

The springs are changed such that a larger force $2F$ is now required to hold the ball at the same initial displacement x_0.

What are the amplitude and frequency of the oscillations of the ball upon being released, if all the springs do not exceed their limits of proportionality during the oscillations?

	amplitude	frequency
A	$\frac{1}{2}A$	$\sqrt{2}f$
B	A	$\sqrt{2}f$
C	A	$2f$
D	$2A$	$2f$

17 The diagram shows a transverse wave at a particular instant. The wave is travelling to the right. The frequency of the wave is 25 Hz.

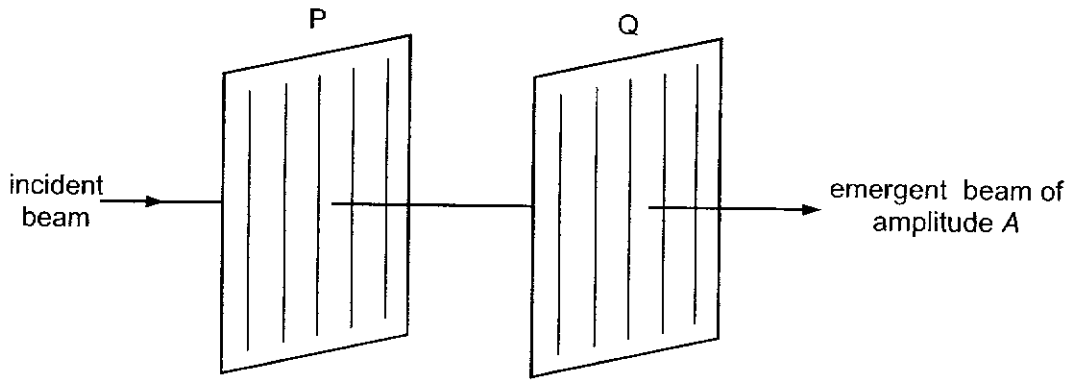


At the instant shown the displacement is zero at the point P.

What is the shortest time to elapse before the displacement is zero at point Q?

A 5 ms **B** 15 ms **C** 25 ms **D** 45 ms

18 When two polarisers P and Q are placed so that their polarising directions are parallel, the amplitude of the emergent beam is *A*.



Q is rotated so that the amplitude of the emergent beam is halved.

Which one of the following represents the angle Q is rotated and the corresponding fractional reduction in the intensity of the emergent beam?

	angle	fractional reduction in intensity
A	60°	0.50
B	75°	0.75
C	120°	0.50
D	240°	0.75

19 Jupiter's moon Europa is an ideal candidate in the solar system to harbour life. It is at an average distance of 6.3×10^8 km from Earth.

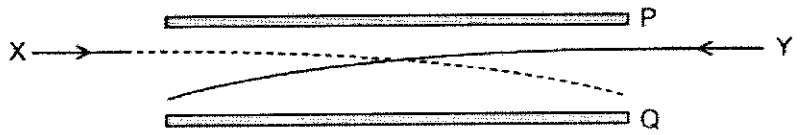
An astronomer builds an optical telescope with a limit of resolution that will allow him to see if there are living creatures on Europa. He estimates that creatures on Europa, should they exist, would have linear dimension of about one metre.

The wavelength of light averages 600 nm.

What is the diameter of the aperture of such a telescope?

A 3.8×10^{-1} m **B** 3.8×10^{2} m **C** 3.8×10^{5} m **D** 3.8×10^{8} m

20 The diagram shows the paths of two charged particles, X and Y, during their passage between a pair of oppositely charged metal plates, P and Q.

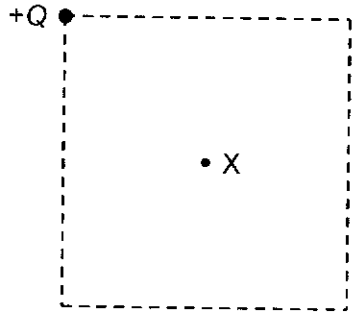


The plates are charged such that the electric field between them is directed from P to Q.

Which charges on X and Y will produce the observed paths?

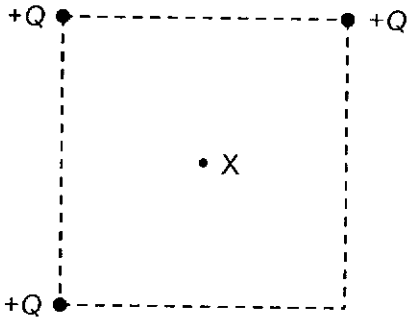
	X	Y
A	positive	positive
B	positive	negative
C	negative	positive
D	negative	negative

21 A point charge +*Q* is placed at the top-left hand corner of a square as shown.



At the centre X of the square, the electric field strength is *E* and the electric potential is *V*.

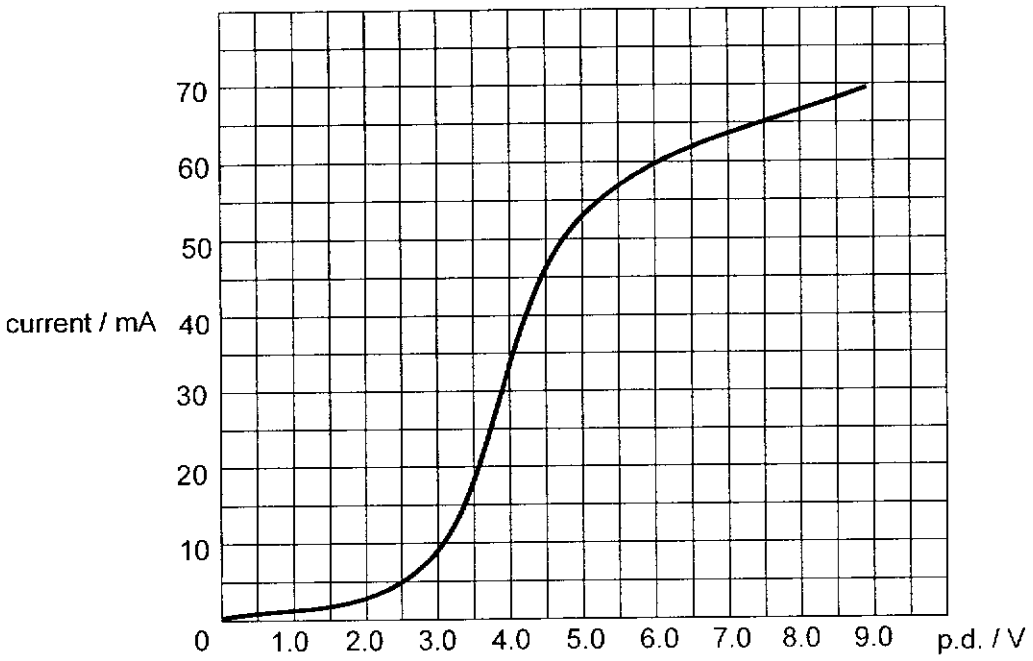
Two additional point charges of the same magnitude +*Q* are placed at the top-right and bottom-left corners of the square as shown.



What are the electric field strength and the electric potential at the centre X of the square?

	electric field strength	electric potential
A	*E*	1.5*V*
B	*E*	3*V*
C	2*E*	3*V*
D	3*E*	3*V*

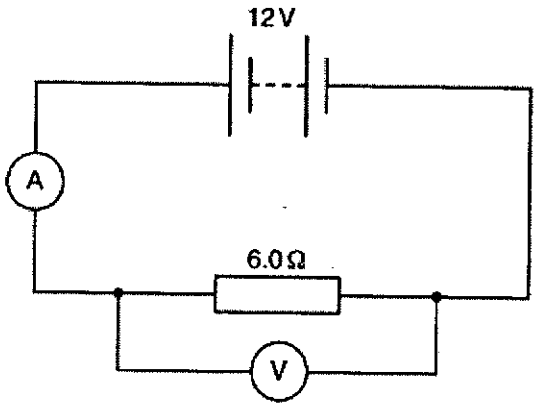
22 A graph of current against potential difference for a component is given below.



What is the potential difference across the component when its resistance is at its lowest?

A 1.5 V **B** 4.0 V **C** 5.0 V **D** 7.0 V

23 In the circuit shown, the battery is ideal but the ammeter and voltmeter are **not** ideal.

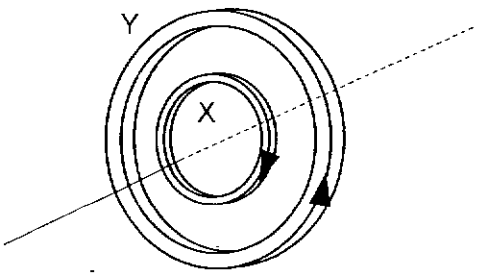


The ammeter reads 1.9 A while the voltmeter reads 11 V.

What are the resistances of the ammeter and voltmeter?

	resistance of ammeter / Ω	resistance of voltmeter / Ω
A	0.32	170
B	0.32	8.3
C	0.53	170
D	0.53	8.3

24 Two flat circular coils, X and Y, each with 50 turns, are arranged as shown in the diagram.

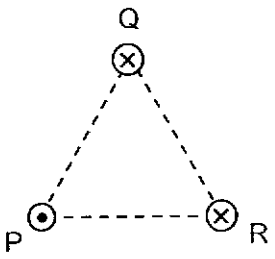


X has radius 0.050 m and carries a current of 2.0 A. Y has radius 0.10 m and carries a current 4.0 A in the opposite direction to X.

What is the magnitude of the total magnetic flux density at the centre of the coils?

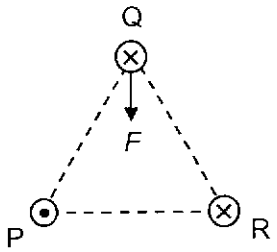
A zero **B** $2000\mu_0$ **C** $3000\mu_0$ **D** $4000\mu_0$

25 Three long vertical wires pass through the corners of an equilateral triangle PQR. They carry equal currents into or out of the paper in the directions shown in the diagram.

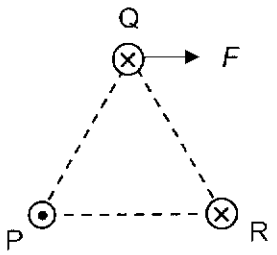


Which diagram shows the resultant force *F* on the wire at Q?

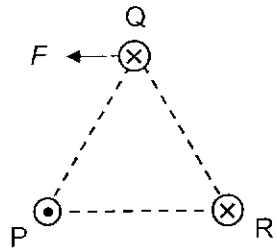
A



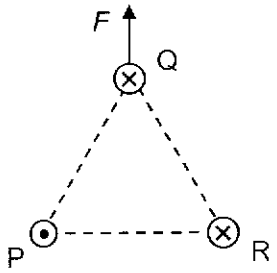
B



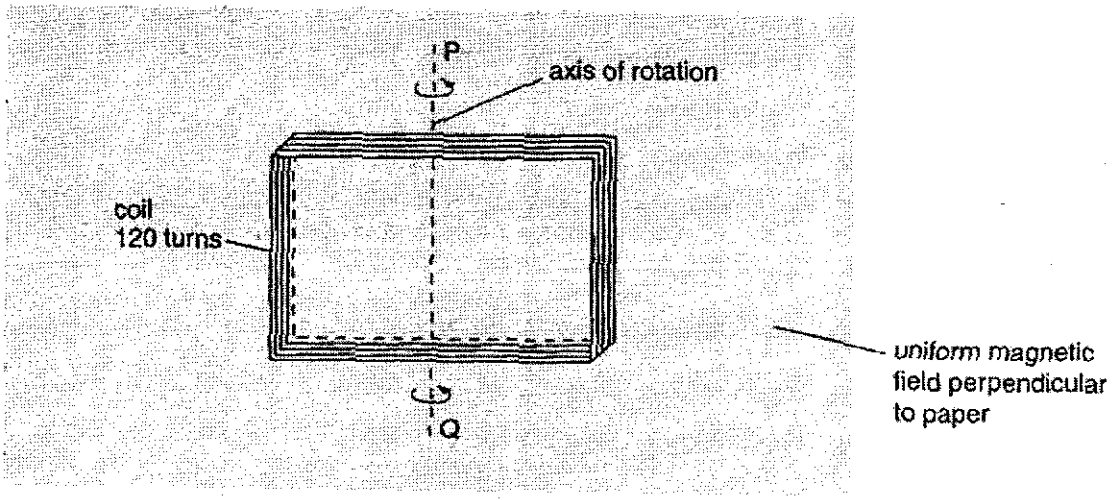
C



D



26 The coil in a generator is situated in a uniform magnetic field, as shown.



The coil of area A is rotated about the axis PQ with an angular speed ω.

Which of the following changes to A and ω increases the electromotive force (e.m.f.) in the coil?

	A	ω
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

27 A circuit with a sinusoidal alternating power supply is rectified with a diode as shown.

before rectification **after rectification**

The mean power of the circuit before rectification is P.

What is the peak and mean power of the circuit after rectification?

	peak power	mean power
A	$0.5P$	$0.5P$
B	P	$0.5P$
C	$2P$	$0.5P$
D	$2P$	P

28 Two beams, P and Q, of light of the same wavelength fall upon the same metal surface causing photoemission of electrons. The photoelectric current produced by P is nine times that produced by Q.

Which of the following gives the ratio

$$\frac{\text{wave amplitude of beam P}}{\text{wave amplitude of beam Q}} ?$$

A 0.11 **B** 0.33 **C** 3.0 **D** 9.0

29 Electron diffraction from a crystal occurs when the wavelength of the electrons is comparable to the atomic spacing of the atoms in the crystal. Atomic spacing is about 10^{-10} m.

Free electrons are accelerated from rest by a potential difference V in a vacuum before being incident onto the crystal.

What would be a suitable value for V?

A 1 mV **B** 1 V **C** 1 kV **D** 1 MV

30 The deviation of α-particles by thin metal foils through angles that range from 0° to 180° can be explained by

A scattering from free electrons.

B scattering from bound electrons.

C scattering from small but heavy regions of positive charge.

D diffraction from the crystal lattice

- END OF PAPER -

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H

NATIONAL JUNIOR COLLEGE
SENIOR HIGH 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS **9749/01**
Paper 1 Multiple Choice
Additional Materials: Multiple Choice Answer Sheet

16 September 2021
1 hour

READ THE INSTRUCTION FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

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

Read the instructions 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.

Shading of OAS index number

OAS index number is in a 5-digit format.

The 5 digit forma is as follows: **1st digit** and the **last four digits** of the Reg Number.
e.g. 200**5011** becomes **25011**

This document consists of **19** printed pages and 1 blank page.

Data

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

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

Answer Key

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

1	Forces of 3 N and 4 N act at a point. Which one of the following could **not** be the magnitude of their resultant?						
	A	1 N	B	3 N	C	4 N	D	8 N

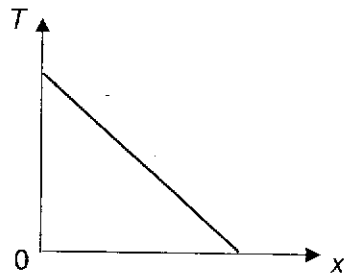
Ans: D
(max force is 3 + 4 = 7 N, min force is 4 – 3 = 1 N)

2	Which of the following gives a good estimate of the order of magnitude of the volume of an average human adult?						
	A	$10^{-2}\ m^3$	B	$10^{-1}\ m^3$	C	$10^{0}\ m^3$	D	$10^{1}\ m^3$

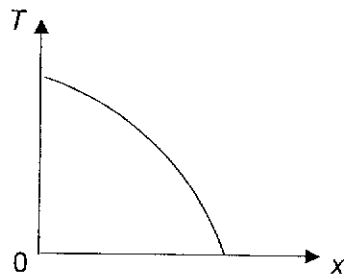
Ans: B
Human adult : $1.60 \times 0.20 \times 0.40 = 1 \times 10^{-1} \approx 10^{-1}\ m^3$

3 A body moves with a constant acceleration opposite in direction to its initial velocity. Which one of the following graphs represents the variation of its kinetic energy T with the distance travelled x from its initial position?

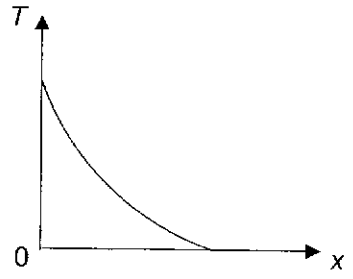
A



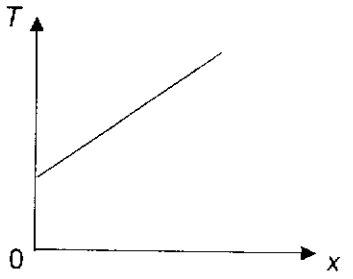
B



C



D



Ans: A

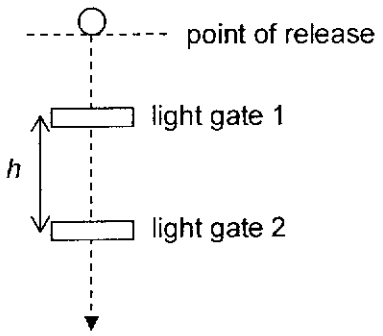
$v^2 = u^2 + 2as = u^2 - 2ax$ (negative sign to indicate direction of acceleration opposite of displacement)

$\frac{1}{2}mv^2 = \frac{1}{2}mu^2 - max$

So graph kinetic energy against x is straight line with negative gradient (also can be deduced using conservation of energy)

4 To determine the acceleration of free fall, a steel ball is dropped above two light gates as shown.

The ball passes light gate 1 and 2 at times t_1 and t_2 after release.



What is the acceleration of free fall?

A	$\frac{2h}{t_2 - t_1}$	**B**	$\frac{2h}{(t_2 - t_1)^2}$	**C**	$\frac{2h}{t_2^{\,2} - t_1^{\,2}}$	**D**	$\frac{2h}{\left(\frac{t_2 + t_1}{2}\right)^2}$

Ans: C

Let distance to light gate 1 from point of release be x

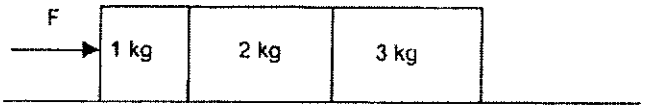
$x = ut + \frac{1}{2}at^2 = \frac{1}{2}gt_1^{\,2}$

$x + h = \frac{1}{2}gt_2^{\,2}$

$h = \frac{1}{2}gt_2^{\,2} - \frac{1}{2}gt_1^{\,2}$

$g = \frac{2h}{t_2^{\,2} - t_1^{\,2}}$

5 Three boxes are pushed along a smooth surface by a force F as shown below. What is the force exerted by the 2 kg mass on the 1 kg mass?



A	$\frac{1}{3}$ F	**B**	$\frac{1}{2}$ F	**C**	$\frac{3}{4}$ F	**D**	$\frac{5}{6}$ F

Ans: D

acceleration of boxes = F/6. Net force on 1 kg box = 1 x F/6 = F/6.

Net force on 1 kg box = F – contact force by 2kg = F/6

Contact force by 2kg = 5/6 F

6 A steel ball of mass m is dropped vertically onto a steel table. The ball is in contact with the table for a very short duration and it rebounds with very little loss in kinetic energy.

Which one of the following statements concerning the average force F exerted on the ball by the table during the collision is correct?

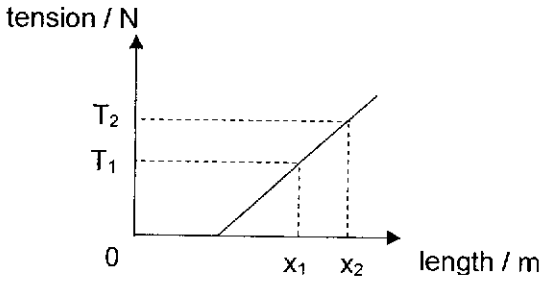
A	F is smaller than mg.
B	F is greater than mg.
C	F is greater than the force that the ball exerted on the table during the collision.
D	F is smaller than the force that the ball exerted on the table during the collision.

Ans: B

Upwards contact force on the ball must be larger than weight otherwise you can't get a net force upwards to cause the ball to rebound

Options C and D are wrong because the force exerted by the ball on the table is always equal to F using Newton's 3rd law.

7 The graph below shows how the length of a wire changes with the tension in the wire.



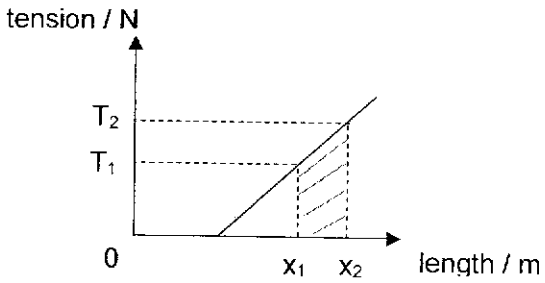
What is the extra energy stored in the wire when the tension is increased from T_1 to T_2?

A	$\frac{1}{2}(T_2 + T_1)(x_2 - x_1)$
B	$\frac{1}{2}(T_2 + T_1)(x_2 + x_1)$
C	$\frac{1}{4}(T_2 + T_1)(x_2 - x_1)$
D	$\frac{1}{4}(T_2 + T_1)(x_2 + x_1)$

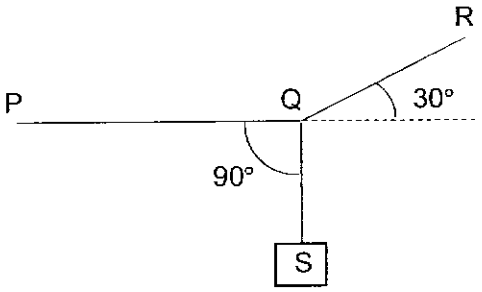
Ans: A

Extra energy stored is the shaded trapezium.

Area of dotted trapezium is $\frac{1}{2}(T_2 + T_1)(x_2 - x_1)$



8 In the diagram below, a body S of weight W hangs vertically by a thread tied at Q to the string PQR.



If the system is in equilibrium, what is the tension in the section PQ?

A	$W\cos 30°$	**B**	$W\cos 60°$	**C**	$W\tan 30°$	**D**	$W\tan 60°$

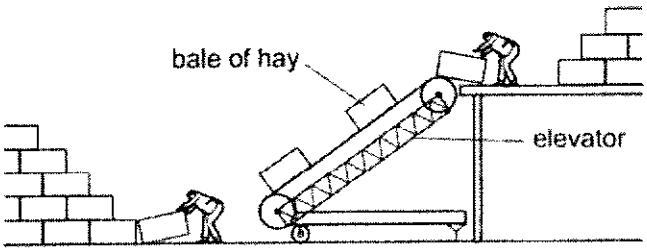
Ans: D

Vertical component of tension = W

Hence tension in QR = $W/\sin 30°$

Tension in PQ = horizontal component of tension in QR = $\frac{W}{\sin 30°} \times \cos 30° = W\cot 30° = W\tan 60°$

9 Two farmers use an electrically powered elevator to lift bales of hay. All the bales of hay have the same mass.



As sunset approaches, they increase the speed of the elevator so that more bales are lifted up in a given time.

How does this affect the work done in lifting each bale and the useful power output of the elevator?

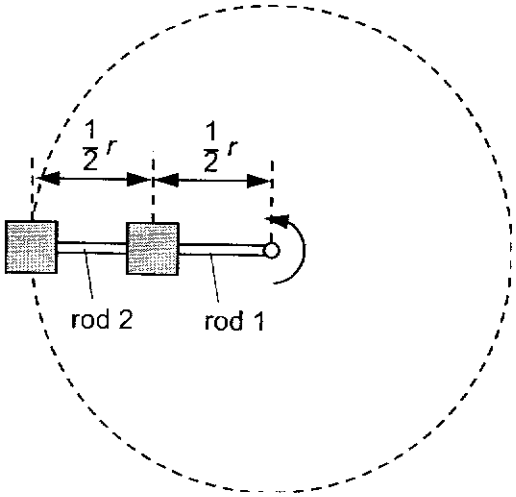
		work done in lifting each bale	useful output power of the elevator	
	A	increases	decreases	
	B	increases	increases	
	C	no change	decreases	
	D	no change	increases	

Ans: D

each bale: same increase in gravitational potential energy

more bale lifted therefore higher useful output power

10 Two identical blocks connected by light rigid rods are pivoted at one end to move in a circular path at uniform angular velocity on a smooth horizontal surface, as shown.



What is the ratio of $\frac{\text{tension in rod 1}}{\text{tension in rod 2}}$?

A	0.50	B	1.0	C	1.5	D	2.0

Answer: C

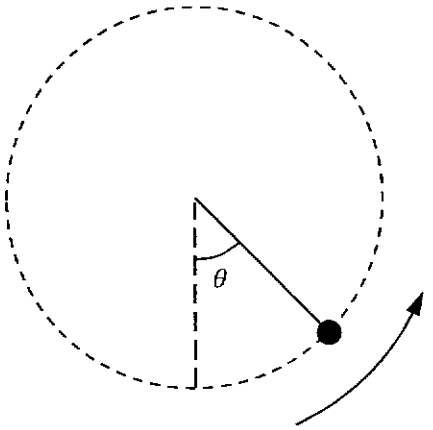
$F_2 = mr\omega^2$ ..... (1)

$F_1 - F_2 = m\left(\frac{1}{2}r\right)\omega^2$ ..... (2)

(1) + (2): $F_1 = \frac{3}{2}mr\omega^2$

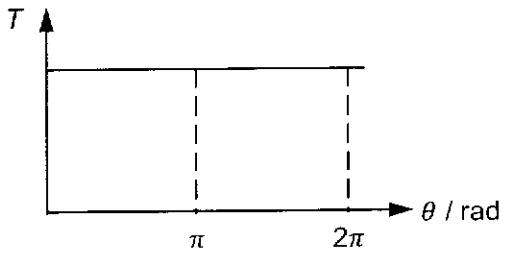
so, ratio $= \frac{\frac{3}{2}mr\omega^2}{mr\omega^2} = 1.5$

11 An object is fixed to one end of an inextensible light string which rotates in a vertical circle at constant speed.

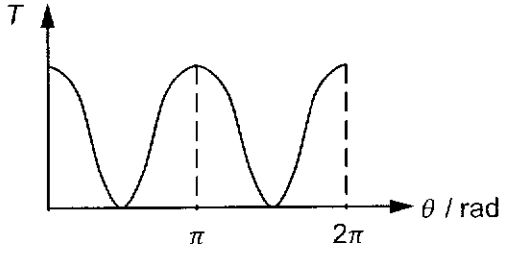


Which graph could represent the variation with angle θ of the tension T in the string?

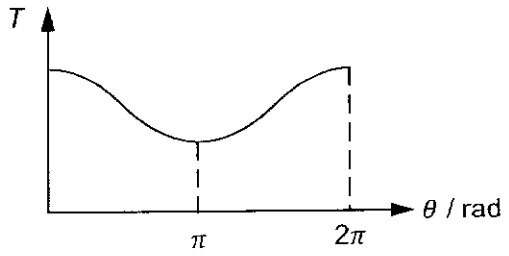
A



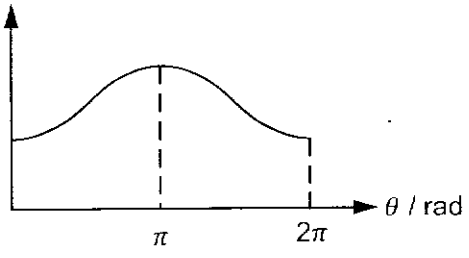
B



C



D



Answer: C

Resultant of force by string and weight of object provides centripetal force

At $\theta = 0$, $\quad T_0 - mg = \frac{mv^2}{r} \Rightarrow T_0 = \frac{mv^2}{r} + mg$

At $\theta = \pi$, $\quad T_\pi + mg = \frac{mv^2}{r} \Rightarrow T_\pi = \frac{mv^2}{r} - mg$

So, tension in string is the least at top of the circle.

12	Two stationary particles of masses M_1 and M_2 are a distance d apart. A third particle, lying on the line joining the particles, experiences no resultant gravitational force. What is the distance of this particle from M_1?				
	A	$\left(\frac{M_1}{M_1+M_2}\right)d$	B	$\left(\frac{M_2}{M_1+M_2}\right)d$	
	C	$\left(\sqrt{\frac{M_1}{M_1+M_2}}\right)d$	D	$\left(\frac{\sqrt{M_1}}{\sqrt{M_1}+\sqrt{M_2}}\right)d$	

Answer: D

$$\frac{GM_1m}{x^2} = \frac{GM_2m}{(d-x)^2}$$
$$\frac{\sqrt{M_1}}{x} = \frac{\sqrt{M_2}}{d-x}$$
$$d - x = \frac{\sqrt{M_2}}{\sqrt{M_1}}x$$
$$\left(1 + \frac{\sqrt{M_2}}{\sqrt{M_1}}\right)x = d$$
$$x = \frac{\sqrt{M_1}}{\sqrt{M_1}+\sqrt{M_2}}d$$

13	A satellite orbits a planet at a distance $2R$ from its centre. Its gravitational potential energy is –2.1 MJ. Another identical satellite orbits the planet at a distance $3R$ from its centre. What is the sum of the kinetic energy and the gravitational potential energy of this second satellite?						
	A	–0.70 MJ	B	–1.4 MJ	C	–2.1 MJ	D	–3.2 MJ

Answer: A

gravitational potential energy $U = -\frac{GMm}{r} \Rightarrow U \propto \frac{1}{r}$

$$\frac{U'}{U} = \frac{r}{r'} \Rightarrow \frac{U'}{-2.1} = \frac{2R}{3R} \Rightarrow U' = -1.4 \text{ MJ}$$

Centripetal force provided by gravitational force

$$\frac{mv^2}{r} = \frac{GMm}{r^2} \Rightarrow \text{k.e.} = \frac{1}{2}mv^2 = \frac{1}{2}\frac{GMm}{r} = -\frac{1}{2} \times \text{g.p.e}$$

k.e. of second satellite $= -\frac{1}{2} \times (-1.4) = 0.7$ MJ

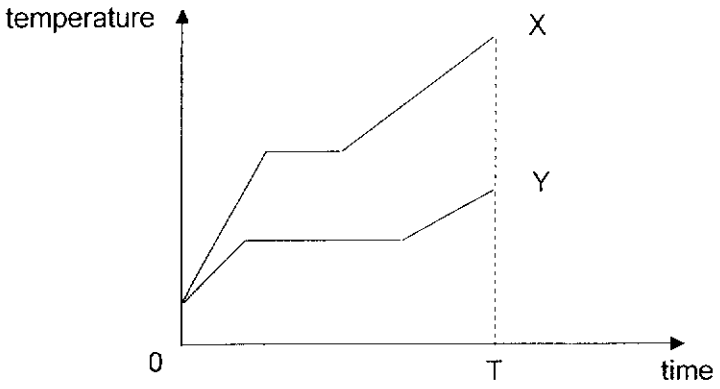
14	A solid X is in thermal equilibrium with a solid Y, which is at the same temperature as a third solid Z. The three bodies are of different materials and masses. Which one of the following statements is certainly correct?	
	A	X and Y have the same heat capacity.
	B	Y and Z have the same internal energy.
	C	The atoms of X and Y have the same speed.
	D	There is no net transfer of energy if Y is placed in thermal contact with Z.

Ans: D

All the bodies have the same temperature and hence have the mean kinetic energy. This does not mean they have the same internal energy which also depends on the mass of the body or number of atoms in the body. (A and B are not definitely true)

The atoms have the same root mean square speed, not the same speed so C is also not true.

D is correct as all bodies are in thermal equilibrium.

15	Equal masses of two solids X and Y are heated from the same temperature. Energy is supplied by heating at the same constant rate to each solid. The graph shows how the temperature of each solid varies with time after heating starts.  What can be deduced from the graph?	
	A	X has the higher boiling point.
	B	X has the larger specific latent heat of fusion.
	C	When X and Y are solids, Y has the larger specific heat capacity.
	D	At time T, X gained more internal energy than Y.

Ans: C

X has higher melting point, not boiling point – A is wrong

Y takes a longer time to melt, hence more heat needs to be supplied to Y to melt. Since the masses of X and Y are the same, Y has the larger specific latent heat of fusion. B is wrong

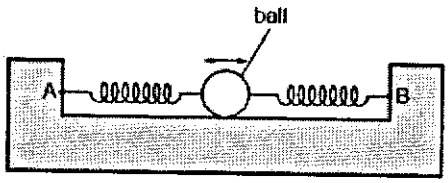
Since the heating rate is constant and equal for both masses, the heat supplied is proportional to the time elapsed in heating. Hence, the inverse of the gradient corresponds to the specific heat capacity. (gradient = $\frac{\text{change in temperature}}{\text{change in time}}$,

inverse of gradient = $\frac{\text{change in time}}{\text{change in temperature}} \propto \frac{\text{heat supplied}}{\text{change in temperature}}$)

Hence the smaller the gradient, the larger the heat capacity. C is correct

There is not enough information to determine D.

16 A ball is held between two fixed points A and B by means of two stretched springs, as shown.



The ball is held at an initial displacement x_0 by a force F. Upon being released, the ball oscillates horizontally with an amplitude A and frequency f.

The springs are changed such that a larger force $2F$ is now required to hold the ball at the same initial displacement x_0.

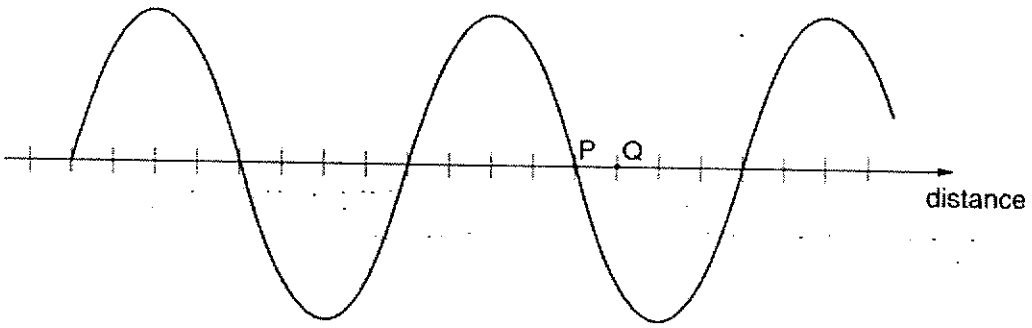
What are the amplitude and frequency of the oscillations of the ball upon being released, if all the springs do not exceed their limits of proportionality during the oscillations?

	amplitude	frequency	
A	$\frac{1}{2}A$	$\sqrt{2}f$	
B	A	$\sqrt{2}f$	
C	A	$2f$	
D	$2A$	$2f$	

Ans: B

Initial displacement is equal to amplitude of oscillations.
Twice the force at same initial displacement means twice the maximum acceleration.
Since $a = -\omega^2 x = -4\pi^2 f^2 x$, for same initial displacement, new frequency = $\sqrt{2}f$

17 The diagram shows a transverse wave at a particular instant. The wave is travelling to the right. The frequency of the wave is 25 Hz.



At the instant shown the displacement is zero at the point P.

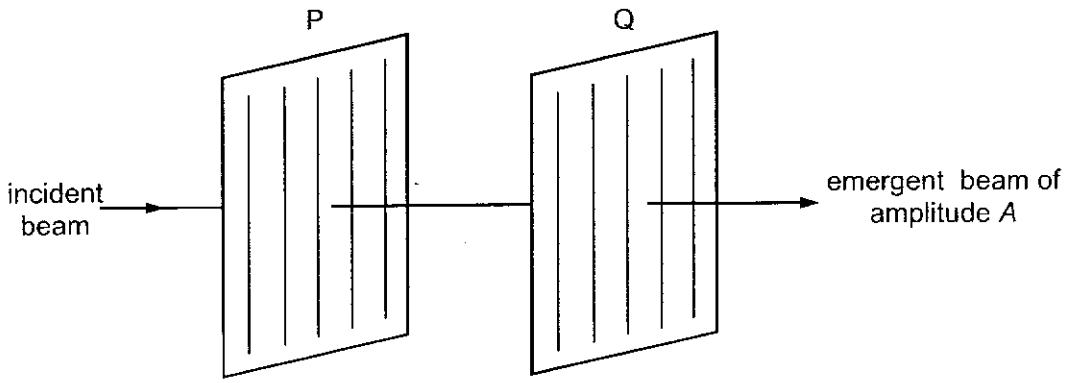
What is the shortest time to elapse before the displacement is zero at point Q?

A	5 ms	B	15 ms	C	25 ms	D	45 ms

Answer: A

period = 1/25 = 40 ms
wavelength is 8 parts
since wave travels to right at constant speed, time taken to traverse 1 part = 5 ms
so, zero at P at the instant shown will be at Q in 5 ms

18 When two polarisers P and Q are placed so that their polarising directions are parallel, the amplitude of the emergent beam is *A*.



Q is rotated so that the amplitude of the emergent beam is halved.

Which one of the following represents the angle Q is rotated and the corresponding fractional reduction in the intensity of the emergent beam?

	angle	fractional reduction in intensity	
A	60°	0.50	
B	75°	0.75	
C	120°	0.50	
D	240°	0.75	

Answer: D

fractional reduction in intensity $= \frac{kA^2 - k\left(\frac{A}{2}\right)^2}{kA^2} = 0.75$

from Malus's law, $I = I_0 \cos^2\theta \Rightarrow k\left(\frac{A}{2}\right)^2 = kA^2\cos^2\theta \Rightarrow \cos\theta = \pm\frac{1}{2} \Rightarrow \theta = 60°, 120°, 240°, 300°$

19 Jupiter's moon Europa is an ideal candidate in the solar system to harbour life. It is at an average distance of 6.3×10^8 km from Earth.

An astronomer builds an optical telescope with a limit of resolution that will allow him to see if there are living creatures on Europa. He estimates that creatures on Europa, should they exist, would have linear dimension of about one metre.

The wavelength of light averages 600 nm.

What is the diameter of the aperture of such a telescope?

A	3.8×10^{-1} m	**B**	3.8×10^{2} m	**C**	3.8×10^{5} m	**D**	3.8×10^{8} m

Answer: C

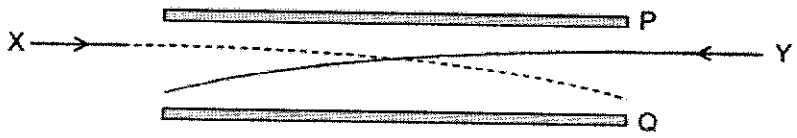
limit of resolution $\theta = \frac{\lambda}{b}$ (Rayleigh Criterion)

geometry gives $\theta = \frac{s}{r} = \frac{1}{6.3\times10^{11}}$

so, $b = \frac{\lambda}{\theta} = 600 \times 10^{-9} \times 6.3 \times 10^{11} = 3.8 \times 10^5$ m

[Turn over

20 The diagram shows the paths of two charged particles, X and Y, during their passage between a pair of oppositely charged metal plates, P and Q.



The plates are charged such that the electric field between them is directed from P to Q.

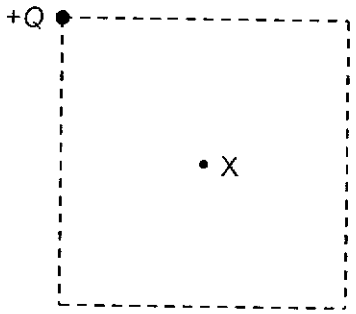
Which charges on X and Y will produce the observed paths?

	X	Y	
A	positive	positive	
B	positive	negative	
C	negative	positive	
D	negative	negative	

Ans: A

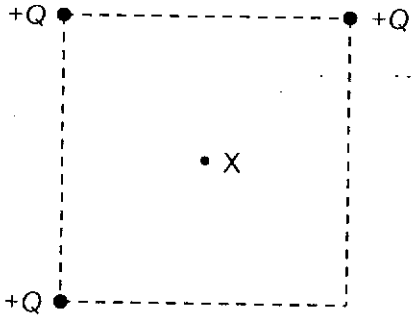
downward force in downward field (force and field same direction) hence positive

21 A point charge +*Q* is placed at the top-left hand corner of a square as shown.



At the centre X of the square, the electric field strength is *E* and the electric potential is *V*.

Two additional point charges of the same magnitude +*Q* are placed at the top-right and bottom-left corners of the square as shown.



What are the electric field strength and the electric potential at the centre X of the square?

	electric field strength	electric potential	
A	*E*	1.5*V*	
B	*E*	3*V*	
C	2*E*	3*V*	

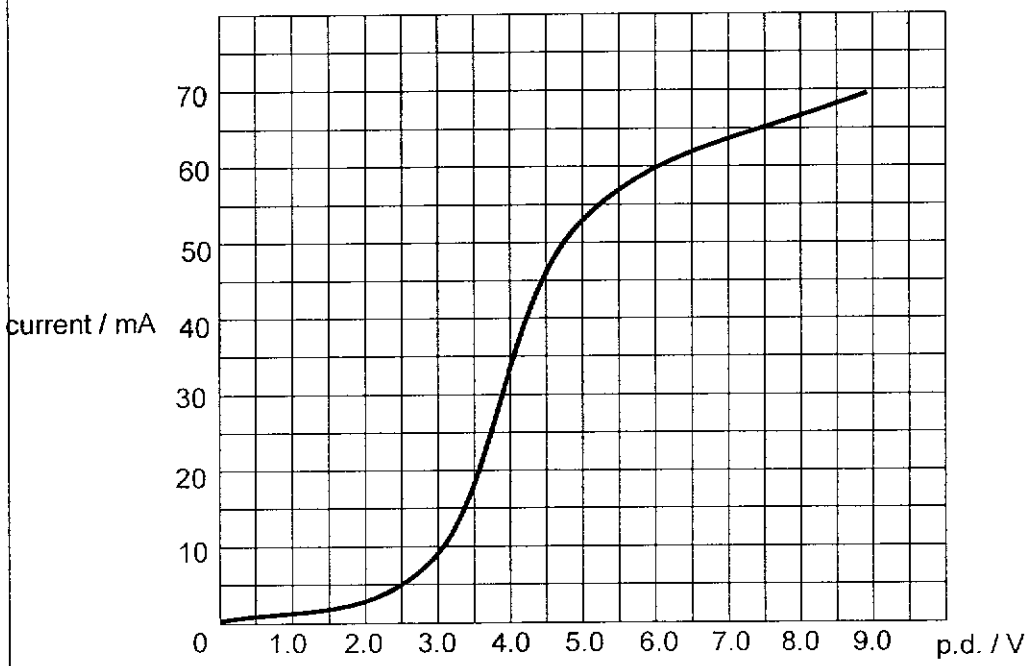
[Turn over

	D	3*E*	3*V*	

Ans: B

The field strength due to the top right corner and bottom left corner cancels out.
Hence the resultant field strength is *E*.
electric potential = 3*V* (electric potential adds up and all charges at same distance from X)

22 A graph of current against potential difference for a component is given below.



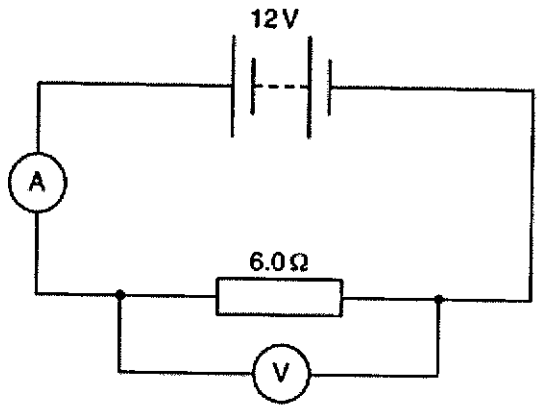
What is the potential difference across the component when its resistance is at its lowest?

A	1.5 V	**B**	4.0 V	**C**	5.0 V	**D**	7.0 V

Ans: C

Lowest resistance occurs at the point where the ratio V/I is the lowest.
This is when the gradient of the line joining the point and the origin is the highest. (gradient is given by $\frac{I}{V}$ so a high value gives lowest $\frac{V}{I}$
This occurs at 5.0 V

23 In the circuit shown, the battery is ideal but the ammeter and voltmeter are **not** ideal.



The ammeter reads 1.9 A while the voltmeter reads 11 V.

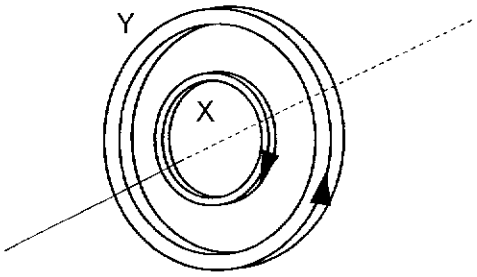
What are the resistances of the ammeter and voltmeter?

		resistance of ammeter / Ω	resistance of voltmeter / Ω	
	A	0.32	170	
	B	0.32	8.3	
	C	0.53	170	
	D	0.53	8.3	

Ans: C

pd across ammeter = 1.0 V
resistance of ammeter = 1.0 V ÷ 1.90 A = 0.526 Ω
current across resistor = 11.0 V ÷ 6.0 Ω = 1.8333 A
current across voltmeter = 1.90 − 1.8333 = 0.0667 A
resistance of voltmeter = 11.0 V ÷ 0.0667 A = 165 Ω
alternatively, effective resistance of voltmeter and resistor = 11 × resistance of ammeter

24 Two flat circular coils, X and Y, each with 50 turns, are arranged as shown in the diagram.



X has radius 0.050 m and carries a current of 2.0 A. Y has radius 0.10 m and carries a current 4.0 A in the opposite direction to X.

What is the magnitude of the total magnetic flux density at the centre of the coils?

A	zero	**B**	$2000\mu_0$	**C**	$3000\mu_0$	**D**	$4000\mu_0$

Ans: A

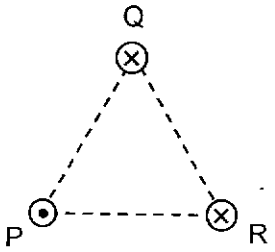
$B = \frac{\mu_0 NI}{r}$

$B_X = \frac{\mu_0 50 \times 2.0}{0.050} = 2000\mu_0$

$B_Y = \frac{\mu_0 50 \times 4.0}{0.10} = 2000\mu_0$

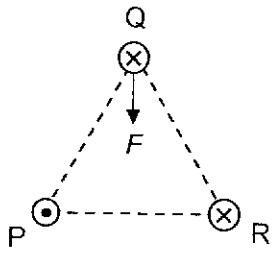
Total B = $B_X - B_Y = 0$

25 Three long vertical wires pass through the corners of an equilateral triangle PQR. They carry equal currents into or out of the paper in the directions shown in the diagram.

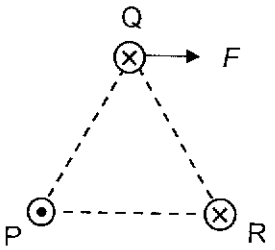


Which diagram shows the resultant force *F* on the wire at Q?

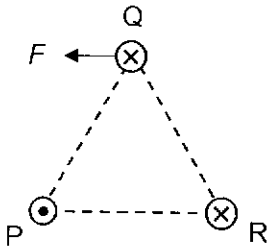
A



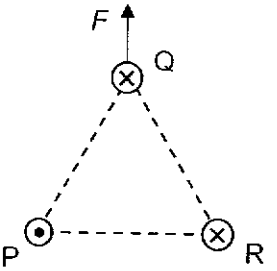
B



C



D

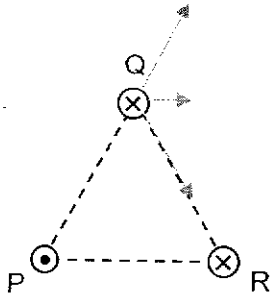


Ans: B

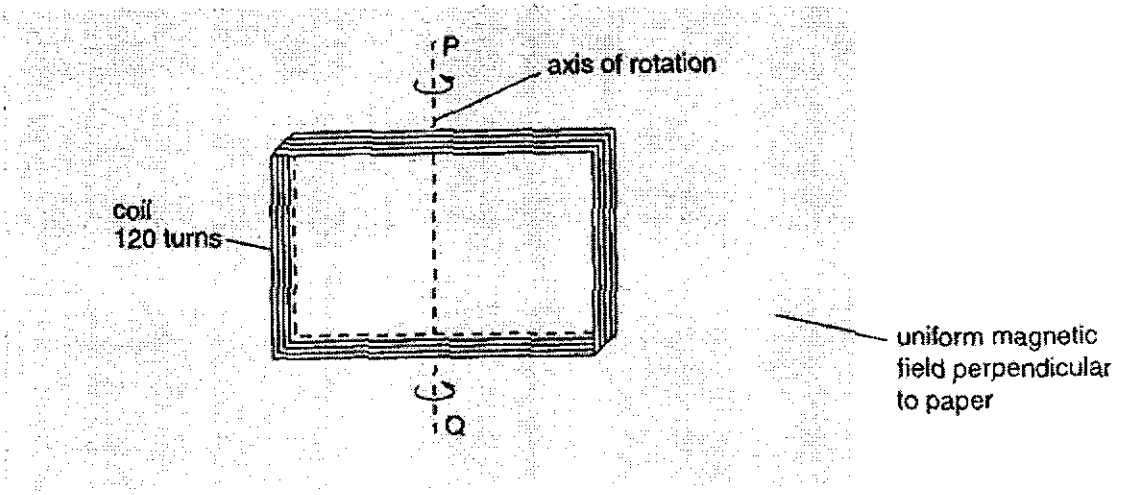
Force due to P is in direction PQ.
Force due to R is in direction QR.

Since currents are the same, the magnitude of the forces are equal.

Resultant force is to the right.



26 The coil in a generator is situated in a uniform magnetic field, as shown.



The coil of area A is rotated about the axis PQ with an angular speed ω.

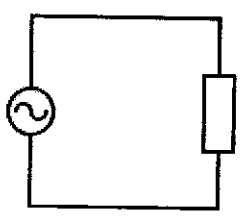
Which of the following changes to A and ω increases the electromotive force (e.m.f.) in the coil?

		A	ω	
	A	increase	increase	
	B	increase	decrease	
	C	decrease	increase	
	D	decrease	decrease	

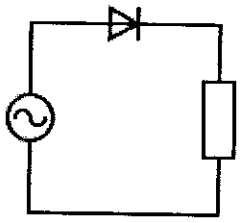
Ans: A

increasing A increases maximum magnitude flux linkage
which increases rate of change of magnetic flux linkage
increasing ω increases rate of change of magnitude flux linkage

27 A circuit with a sinusoidal alternating power supply is rectified with a diode as shown.



before rectification



after rectification

The mean power of the circuit before rectification is P.

What is the peak and mean power of the circuit after rectification?

	peak power	mean power	
A	$0.5P$	$0.5P$	
B	P	$0.5P$	
C	$2P$	$0.5P$	
D	$2P$	P	

Ans: C

Half-wave rectification does not change peak power but halves mean power.

Peak power = twice mean power for sinusoidal alternating power supply
= $2P$

28 Two beams, P and Q, of light of the same wavelength fall upon the same metal surface causing photoemission of electrons. The photoelectric current produced by P is nine times that produced by Q.

Which of the following gives the ratio

$$\frac{\text{wave amplitude of beam P}}{\text{wave amplitude of beam Q}} ?$$

A	0.11	**B**	0.33	**C**	3.0	**D**	9.0

Answer: C

photocurrent $\propto$ intensity

intensity $\propto$ (amplitude)^2

$$\frac{\text{intensity of beam P}}{\text{intensity of beam Q}} = \frac{k \times (\text{wave amplitude of beam P})^2}{k \times (\text{wave amplitude of beam Q})^2} = \frac{9}{1}$$

$$\frac{\text{wave amplitude of beam P}}{\text{wave amplitude of beam Q}} = \sqrt{\frac{9}{1}} = 3$$

29	Electron diffraction from a crystal occurs when the wavelength of the electrons is comparable to the atomic spacing of the atoms in the crystal. Atomic spacing is about 10^{-10} m. Free electrons are accelerated from rest by a potential difference V in a vacuum before being incident onto the crystal. What would be a suitable value for V?						
	A	1 mV	**B**	1 V	**C**	1 kV	**D**	1 MV

Answer: C

$\lambda = \frac{h}{p}$, $E_K = \frac{p^2}{2m} \Rightarrow p = \sqrt{2mE_K}$, $E_K = eV$

so, $\lambda = \frac{h}{\sqrt{2meV}} \Rightarrow V = \frac{1}{2me}\left(\frac{h}{\lambda}\right)^2 = \frac{1}{2\times 9.11\times 10^{-31}\times 1.6\times 10^{-19}}\left(\frac{6.63\times 10^{-34}}{10^{-10}}\right)^2 = 150\ \text{V}$

30	The deviation of α-particles by thin metal foils through angles that range from 0° to 180° can be explained by	
	A	scattering from free electrons.
	B	scattering from bound electrons.
	C	scattering from small but heavy regions of positive charge.
	D	diffraction from the crystal lattice

Ans: C

- END OF PAPER -