MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations
Higher 2

H2 Physics 9749/01

Paper 1 Multiple Choice **20 September 2018**

1 hour

Additional Materials: Optical Mark Sheet (OMS)

		Class	Reg No
Candidate Name:			

READ THESE INSTRUCTIONS FIRST

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

In the Index Number section, shade your index number using the first two spaces (e.g. index number 5 should be entered as "05"). Ignore the remaining numbers and letters.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Data

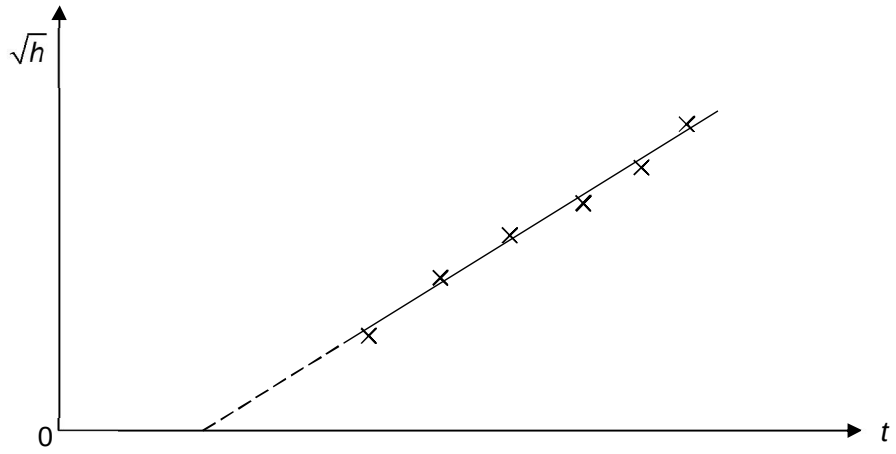
speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\left(1/\left(36\pi\right)\right) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

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

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

1 A student measures the time *t* for a ball to fall from rest through a vertical distance *h*. The student plots his results and best-fit line in the graph shown.



Which of the following statement is true?

A The result is accurate as the line is close to the data points

B The result is not accurate as the line does not pass through the origin

C Data is precise as there are equal number of data points on both sides of the line

D Data is precise as the data points do not deviate from the line

Ans: (B)
At time = 0, the height fallen should be zero since the ball is still at the starting point.

2 The experimental measurement of the heat capacity of a solid as a function of temperature *T* is found to fit the following expression

$$C = \alpha T^3 + \beta T$$

What are the possible base units of α and β?

units of α units of β

A	kg m^2 s^{-1} K^{-4}	kg m^2 s^{-1} K^{-1}
B	kg^2 m s^{-2} K^{-3}	kg^2 m s^{-2} K^{-2}
C	kg m^2 s^{-2} K^{-4}	kg m^2 s^{-2} K^{-2}
D	kg^2 m s^{-2} K^{-3}	kg^2 m s^{-2} K^{-1}

Ans: (C)

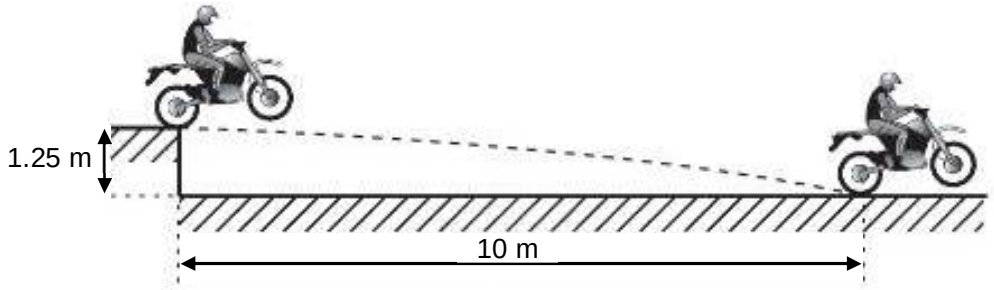
$C = \alpha T^3 + \beta T$

J K^{-1} $= [\alpha](K^3) = [\beta](K)$

Using $E = \frac{1}{2}mv^2$ J = kg m^2 s^{-2}

kg m^2 s^{-2} K^{-1} $= [\alpha](K^3) = [\beta](K)$

3 A motorcycle stunt-rider moving horizontally takes off from a point 1.25 m above the ground, landing 10 m away as shown in the diagram.



What was the speed at take-off?

A 5 m s^{-1} **B** 10 m s^{-1} **C** 15 m s^{-1} **D** 20 m s^{-1}

Ans: D

↓ $s_y = u_y t + ½ a_y t^2 \Rightarrow 1.25 = 0 + ½ (9.81) t^2 \Rightarrow t = 0.50$ s

→ $s_x = u_x t \Rightarrow 10 = u_x (0.50) \Rightarrow u_x = 20$ m s^{-1}

4 A body of mass 3.0 kg is thrown with a velocity of 20 m s^{-1} at an angle of 60° above horizontal. It reaches the maximum height after 1.8 s. Air resistance is negligible.

What is the rate of change of momentum of the body at the maximum height?

A zero **B** 17 kg m s^{-2} **C** 29 kg m s^{-2} **D** 33 kg m s^{-2}

Ans: C

rate of change of momentum = net force = weight = 3.0 × 9.81 = 29 N

OR use $(mv_y - mu_y)/t = (0 - 3.0 \times 20 \sin 60°) / 1.8 = -29$ kg m s^{-2}

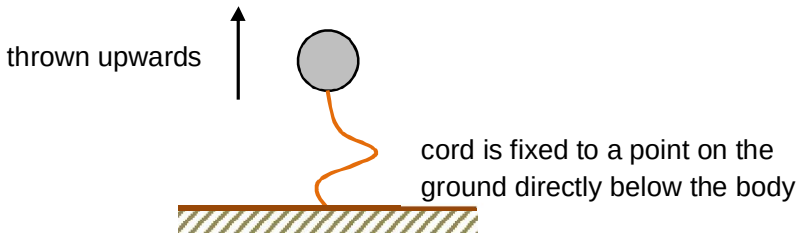
5 A body P of mass 2.0 kg and moving with velocity +3.0 m s^{-1} makes a head-on inelastic collision with a stationary body Q of mass 4.0 kg.

Which of the following could be the velocities of P and Q after the collision?

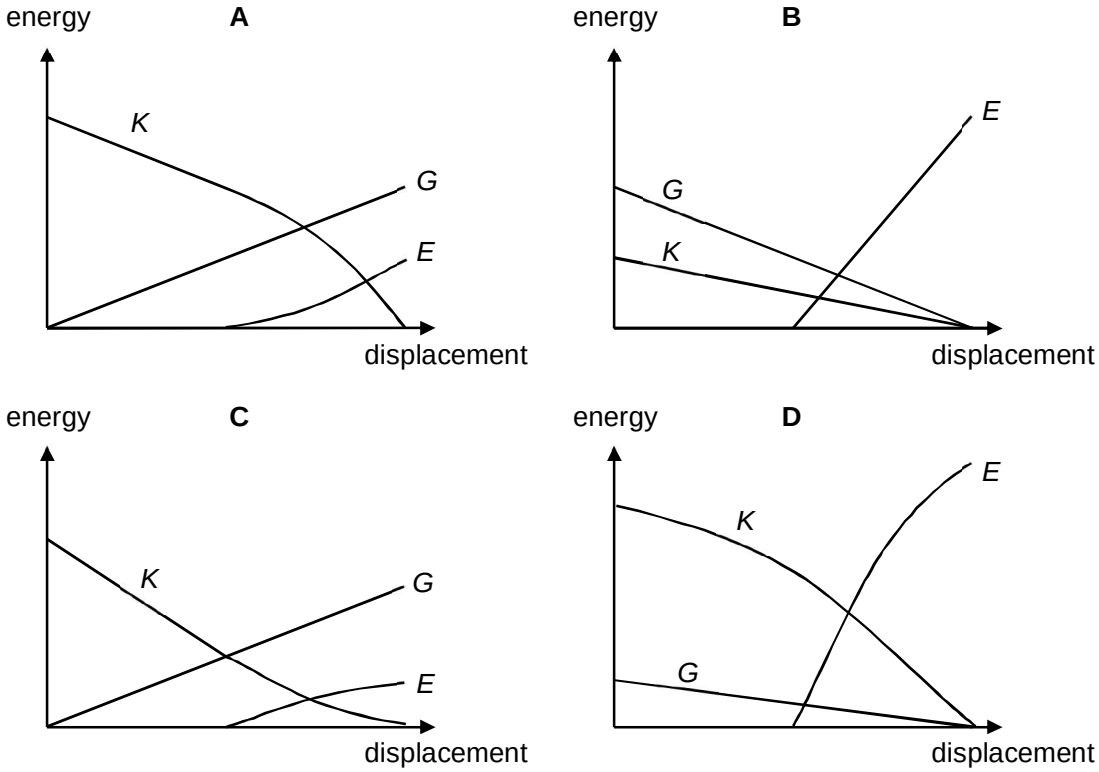
	velocity of P after collision	velocity of Q after collision
A	+0.5 m s^{-1}	+0.5 m s^{-1}
B	+0.0 m s^{-1}	+3.0 m s^{-1}
C	–1.0 m s^{-1}	+2.0 m s^{-1}
D	–0.6 m s^{-1}	+1.8 m s^{-1}

Ans: D
Initial momentum = 2.0 × 3.0 = +6.0 Ns
Final momentum = 2.0(–0.6) + 4.0(1.8) = –1.2 + 7.2 = +6.0 Ns
only D has momentum conserved but KE not conserved (or has lesser relative speed of separation than relative speed of approach)
Both momentum and KE are conserved for C (elastic collision)

6 The diagram shows a body attached to an elastic cord being thrown vertically upwards. Initially the cord is unstretched but after a while it becomes stretched. The cord obeys Hooke's law and air resistance is ignored.

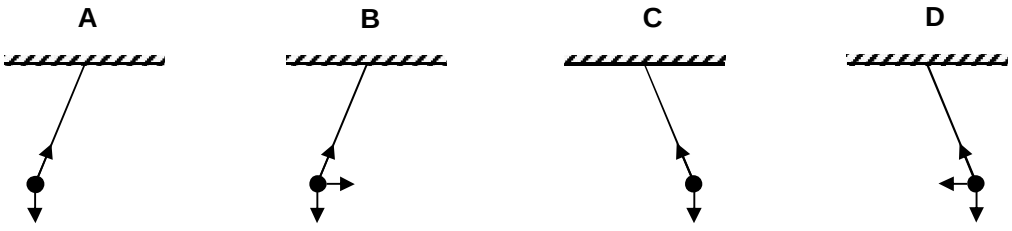


Which of the following shows the variation with displacement of the kinetic energy *K*, gravitational potential energy *G* and elastic potential energy *E*?



Ans: A
GPE increases linearly with displacement
EPE starts later, increases with extension squared (parabolic upwards)
KE decreases linearly with displacement at first (vs GPE), then decreases at greater and greater rate due to increasing EPE

7 A passenger is sitting in a railway carriage facing in the direction in which the train is travelling. A pendulum hangs down in front of him from the carriage roof. The train travels along a circular arc bending to the left. Which one of the following diagrams shows the position of the pendulum as seen by the passenger, and the directions of the forces acting on it?



Ans: C

8 In two widely-separated planetary systems whose suns have masses S_1 and S_2, planet P_1 of mass M_1 (orbiting sun S_1) and planet P_2 of mass M_2 (orbiting sun S_2) are observed to have circular orbits of equal radii. If P_1 completes an orbit in half the time taken by P_2, it may be deduced that

A $S_1 = S_2$ and $M_1 = 0.25\ M_2$

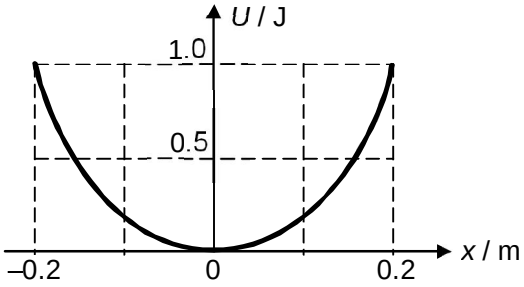
B $S_1 = 4S_2$ only

C $S_1 = 4S_2$ and $M_1 = M_2$

D $S_1 = 0.25\ S_2$ only

Ans: (B)

9 A particle of mass 4.0 kg moves in simple harmonic motion. Its potential energy U varies with position x as shown in the figure below.



What is the period of oscillation of the mass?

A $\frac{2}{25}$ s **B** $\frac{2\pi\sqrt{2}}{5}$ s **C** $\frac{8\pi}{25}$ s **D** $\frac{4\pi}{5}$ s

Ans B
Total energy of system is constant.
Max PE = 1.0 J = Max KE = ½ m v_{max}^2

$$v_{max} = \frac{1}{\sqrt{2}}$$

$$v_{max} = \omega x_o = \frac{2\pi}{T} x_o$$

$$T = \left(\frac{2\pi}{v_{max}}\right) x_o$$

$$= 2\pi\left(\sqrt{2}\right)(0.2)$$

$$= \frac{2\pi\sqrt{2}}{5}$$

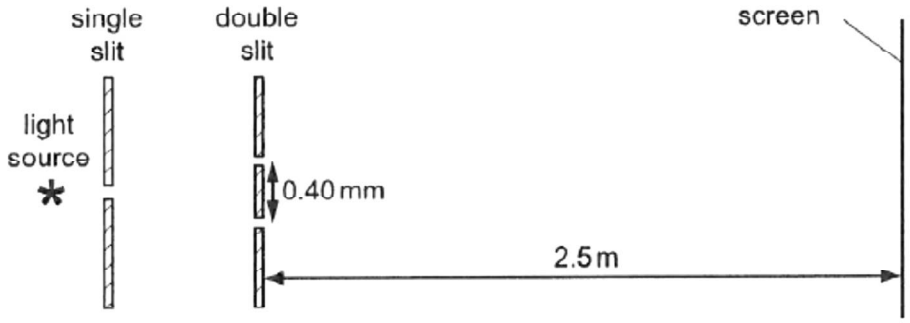
10 A toy car moving along a horizontal plane in simple harmonic motion starts from the amplitude at time t = 0 s. If the amplitude of its motion is 5.0 cm and frequency is 2.0 Hz, the magnitude of the acceleration of the toy car at 1.7 s is

A 0.25 m s^{-2} **B** 0.51 m s^{-2} **C** 6.4 m s^{-2} **D** 7.4 m s^{-2}

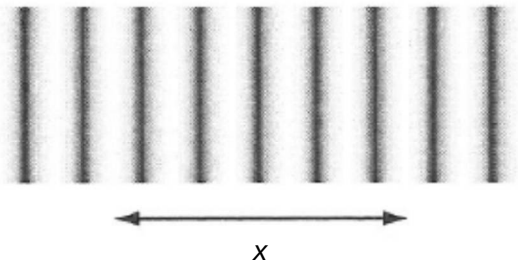
Ans C

$x = x_o \cos(\omega t)$
$= 5.0\cos(2\pi(2)\times 1.7)$
$= -4.05$ cm
$a = |\omega^2 x|$
$= (4\pi)^2 (4.05\times 10^{-2})$
$= 6.4$ m s^{-2}

11 A two source interference experiment is set up as shown.



The source emits light of wavelength 600 nm. The interference pattern on the screen is shown below.



What is the distance *x*?

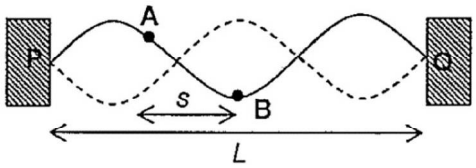
A 3.8 x 10^{-4} m **B** 1.9 x 10^{-3} m **C** 3.8 x 10^{-3} m **D** 1.9 x 10^{-2} m

Ans D

$\Delta x = \frac{\lambda D}{a} = \frac{600\times 10^{-9}(2.5)}{0.40\times 10^{-3}} = 3.75\times 10^{-3}$ m

$x = 5\Delta x = 5(3.75\times 10^{-3}) = 1.9\times 10^{-2}$ m

12 A guitar string of length *L* is stretched between two fixed points **P** and **Q** and made to vibrate transversely as shown.



Two particles **A** and **B** on the string are separated by a distance *s*. The maximum kinetic energies of **A** and **B** are K_A and K_B respectively.

Which of the following gives the correct phase difference and maximum kinetic energies of the particles?

	Phase difference	Maximum kinetic energy
A	$\left(\frac{3s}{2L}\right) \times 360°$	$K_A < K_B$
B	$\left(\frac{3s}{2L}\right) \times 360°$	same
C	180°	$K_A < K_B$
D	180°	same

Ans: C
Since particles A and B are at two sides of a node of a stationary wave, they are anti-phase. Hence phase difference is 180°
Maximum KE is proportional to amplitude. Since amplitude of A < amplitude of B,
$K_A < K_B$

13 Diagram 1 shows a ripple tank experiment in which plane waves are diffracted through a narrow slit in a metal sheet.

Diagram 2 shows the same tank with a slit of greater width.

In each case, the pattern of the waves incident on the slit and the emergent pattern are shown.

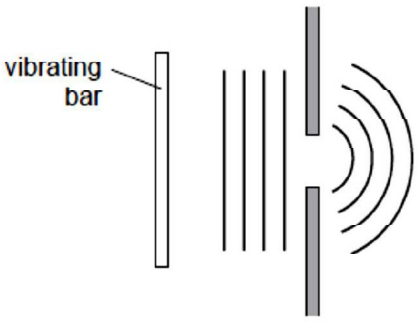


diagram 1

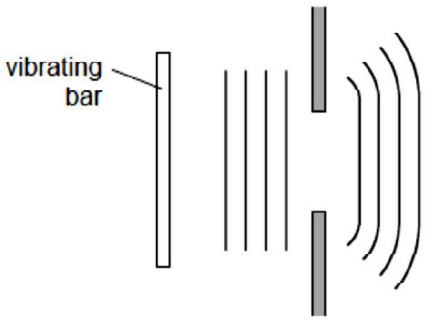


diagram 2

Which action would cause the waves in diagram 1 to produce an emergent pattern closer to that shown in diagram 2?

A Increasing the frequency of vibration of the bar.

B Increasing the speed of the waves by making the water in the tank deeper.

C Reducing the amplitude of vibration of the bar.

D Reducing the length of the vibrating bar.

Ans: A

14 An ideal gas in a container of fixed volume 1.0 m^3 has a pressure of 3.0 x 10^5 Pa at a temperature of 200 K. The gas is heated until the temperature reaches 400 K. Some gas is released from the container during the heating to keep the pressure constant.

What volume does the gas released from the container occupy, if it is at atmospheric pressure of 1.0 x 10^5 Pa and at a room temperature of 300 K?

A 0.500 m^3 **B** 2.00 m^3 **C** 2.25 m^3 **D** 4.50 m^3

Ans C

$$n_1 = \frac{p_1V_1}{RT_1} = \frac{3.0\times10^5(1)}{8.31(200)} = 180.5 \text{ mol}$$

$$n_2 = \frac{p_2V_2}{RT_2} = \frac{3.0\times10^5(1)}{8.31(400)} = 90.25 \text{ mol}$$

$$n_{released} = n_1 - n_2 = 90.25 \text{ mol}$$

$$V_{released} = \frac{n_{released}RT}{p} = \frac{90.25(8.31)(300)}{1.0\times10^5} = 2.25 \text{ m}^3$$

15 When a volatile liquid evaporates it cools down.

What is the reason for this cooling?

A All the molecules slow down.

B Fast molecules leave the surface so the mean speed of those left behind is reduced.

C Molecular collisions result in loss of kinetic energy of the molecules.

D The molecules collide with one another less frequently.

Ans B

16 The molecules of an ideal gas at thermodynamic temperature *T* have a root-mean-square speed *c*.

The gas is heated to temperature 2*T*.

What is the new root-mean-square speed of the molecules?

A $\sqrt{2}c$ **B** $2\sqrt{2}c$ **C** $2c$ **D** $4c$

Ans A

$$\frac{1}{2}m(c)^2 = \frac{3}{2}kT$$
$$c \propto \sqrt{T}$$
$$\frac{c_{new}}{c} = \sqrt{\frac{2T}{T}}$$
$$c_{new} = \sqrt{2}c$$

17 Which one of the following statements about the electric potential at a point is correct?

A The potential is given by the rate of change of electric field strength with distance.

B The potential is equal to the work done per unit positive charge in moving a small point charge from infinity to that point.

C Two points in an electric field are at the same potential when a small positive charge placed along the line joining them remains stationary.

D An alternative unit for electric potential is V m^{-1}.

Ans: B

18 The electric potentials V are measured at distance x from P along a line PQ.

The results are:

V / V	13	15	18	21	23
x / m	0.020	0.030	0.040	0.050	0.060

The electric field at x = 0.040 m is approximately

A 300 V m^{-1} towards Q

B 300 V m^{-1} towards P

C 450 V m^{-1} towards Q

D 450 V m^{-1} towards P

Ans: B

19 A piece of wire of original length *L*, has a resistance of *R*. It is then melted and made into a new wire of length 1.7 *L*.

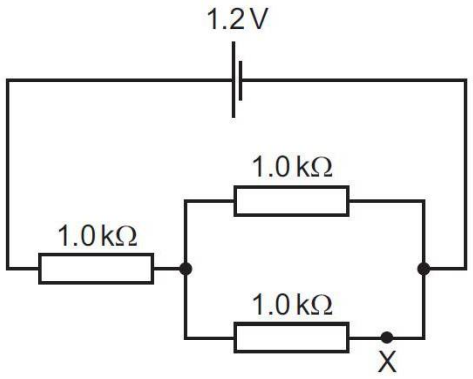
What is the resistance of the new wire?

A 0.59 *R* **B** *R* **C** 1.7 *R* **D** 2.9 *R*

Ans: D
Since volume remains constant,

$$A_{old}L_{old} = A_{new}L_{new}$$
$$A_{new} = \frac{L}{1.7L}A_{old} = 0.59A_{old}$$
$$R_{new} = \rho\frac{L_{new}}{A_{new}} = \rho\frac{1.7L}{0.59A_{old}} = \frac{1.7}{0.59}R = 2.9R$$

20 In the circuit below, 3 identical resistors of resistance 1.0 kΩ are connected to a cell of 1.2 V with negligible internal resistance as shown.



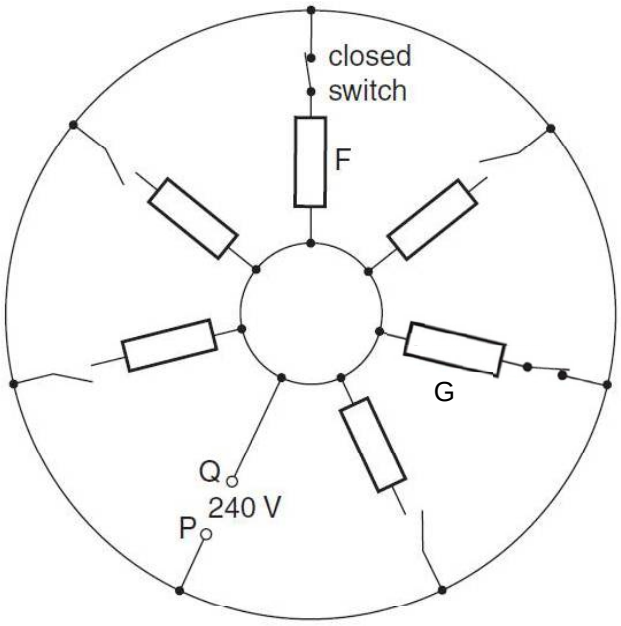
How many electrons pass through point X in a minute?

A 2.5×10^{15} **B** 1.5×10^{17} **C** 2.5×10^{18} **D** 1.5×10^{20}

Ans: B

$$V_{parallel} = \frac{0.5}{1.5}(1.2) = 0.4 \text{ V}$$
$$I = \frac{0.4}{1000} = 0.0004 \text{ A}$$
$$\frac{N_e}{t} = \frac{0.0004}{1.6\times10^{-19}} = 2.5\times10^{15}$$
$$N_e = 2.5\times10^{15}\times60 = 1.5\times10^{17}$$

21 Electrical sockets in a house are connected to a circuit called a ring main. The circuit is connected between P and Q to the 240 V power supply as shown.



Two devices, F and G, are currently switched on. They have resistances of 1200 Ω and 1700 Ω respectively.

What is the current supplied by the power supply and total power dissipated by both devices?

	current / A	total power dissipated / W
A	0.083	20
B	0.083	82
C	0.34	20
D	0.34	82

Ans: D

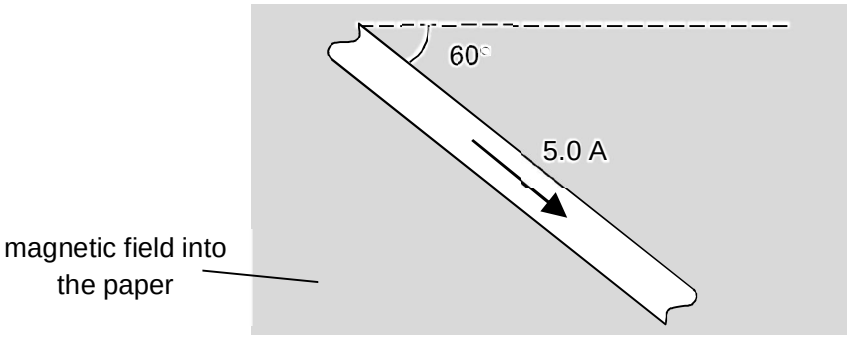
F and G are connected in parallel to the power supply.

$$R_{effective} = \left(\frac{1}{1200} + \frac{1}{1700}\right)^{-1} = 703\ \Omega$$

$$I = \frac{240}{703} = 0.34\ \text{A}$$

$$P_{total} = \frac{240^2}{1200} + \frac{240^2}{1700} = 82\ \text{W}$$

22 A wire of length 3.0 cm is placed in the plane of the paper, along a line 60° clockwise from the *x*-axis. A magnetic field of flux density 0.040 T acts into the paper. The wire carries a current of 5.0 A.



What is the magnitude of the force which the field exerts on the wire?

A 0.0060 N **B** 0.0030 N **C** 0.0052 N **D** 0.0104 N

Ans: (A)
F = BIL = (0.040)(5.0)(0.030) = 0.0060 N
The angle does not play a part.

23 An electron is moving along the axis of a solenoid carrying a current.

Which of the following is a correct statement about the electromagnetic force acting on the electron?

A No force acts on the electron.

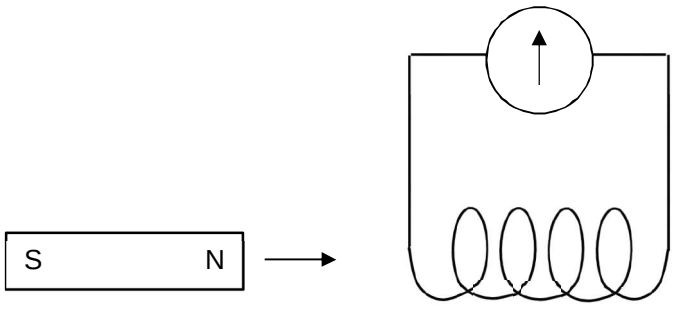
B The force acts in the direction of motion.

C The force acts opposite to the direction of motion.

D The force causes the electron to move along a helical path.

Ans: (A)
Magnetic field is along the axis. Since velocity of electron is parallel to magnetic field, no electromagnetic force acts on the electron.

24 The North pole of a bar magnet is pushed into the end of a coil of wire. The maximum movement of the meter needle is 10 units to the left.



The South pole of the magnet is then pushed into the other end of the coil at half the speed.

What is the maximum movement of the meter needle?

A less than 10 units to the left

B less than 10 units to the right

C more than 10 units to the left

D more than 10 units to the right

Ans: A

Applying Lenz's law, a North will be induced on the left side of the coil when the North pole is pushed into the left end; A South pole will be induced on the right side when South is pushed into the right end. Polarity of the induced B-field in the coil is the same for both cases.

Since speed is halved, rate of change of magnetic flux linkage in the coil is less and a lower (e.m.f. and hence) current is induced.

25 The secondary coil of an ideal transformer delivers an r.m.s. current of 1.5 A to a load resistor of resistance 10 Ω. The r.m.s. current in the primary coil is 5 A.

What is the r.m.s. potential difference across the primary coil?

A 4.5 V **B** 6.4 V **C** 15 V **D** 50 V

Ans: A

$P = I^2R = 1.5^2 \times 10 = 22.5$ W

$V_s = \frac{P}{I_s} = \frac{22.5}{5} = 4.5$ V

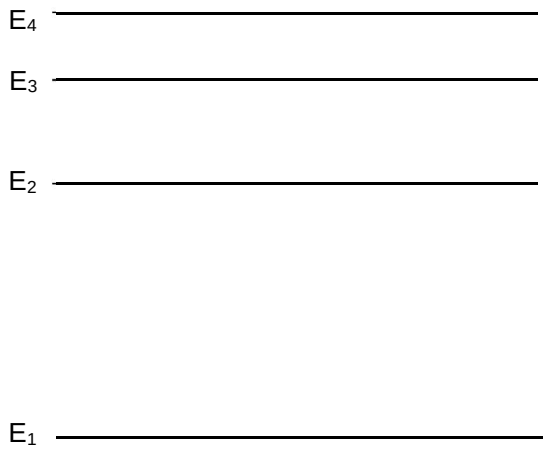
alt: $V_s = RI = 10 \times 1.5 = 15$ V

$\frac{V_p}{V_s} = \frac{I_s}{I_p}$

$V_p = \frac{1.5}{5} \times 15$

$= 4.5$ V

26 The diagram represents in simplified form some of the energy levels of the hydrogen atom.



The transition of an electron from E_3 to E_2 is associated with the emission of red light.

Which transition could be associated with the emission of blue light?

A E_4 to E_1 **B** E_1 to E_4

C E_4 to E_2 **D** E_2 to E_4

Ans: C

$\lambda_{red} \approx 700$ nm, $\lambda_{blue} \approx 400$ nm, $E = \frac{hc}{\lambda}$ hence the energy transition for blue light should be about 1.75 x that of red light.
Transition is from a higher energy level to lower energy level for emission of light.

27 An electron has a kinetic energy of 1.0 MeV. If its momentum is measured with an uncertainty of 1.0%, what is the uncertainty in its position?

A 7.7×10^{-10} m **B** 1.2×10^{-10} m **C** 2.9×10^{-12} m **D** 4.1×10^{-19} m

Ans: (B)

$$E = \frac{p^2}{2m}$$

$$p = \sqrt{2mE} = \sqrt{2\left(9.11\times10^{-31}\right)\left(1.0\times10^{6}\times1.6\times10^{-19}\right)}$$

$$= 5.399\times10^{-22} \text{ kg m s}^{-1}$$

$$\Delta x \cdot \Delta p \gtrsim h$$

$$\Delta x \gtrsim \frac{h}{\Delta p} = \frac{6.63\times10^{-34}}{0.01\times 5.399\times10^{-22}} = 1.2\times10^{-10} \text{ m}$$

28 When the number of protons and the number of neutrons in a nuclide are both "magic numbers", it is more stable than expected. Such nuclides are termed "doubly magic".

The first few "magic numbers" are 2, 8, 20, 28, 50, 82, and 126.

How many of the following five nuclides are "doubly magic"?

$^{28}_{8}O$	$^{40}_{20}Ca$	$^{56}_{26}Fe$	$^{50}_{28}Ni$	$^{126}_{50}Sn$

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

Ans: (B)

$^{28}_{8}O$: 8 protons, 20 neutrons (doubly magic)

$^{40}_{20}Ca$: 20 protons, 20 neutrons (doubly magic)

$^{56}_{26}Fe$: 26 protons, 30 neutrons (not)

$^{50}_{28}Ni$: 28 protons, 22 neutrons (not)

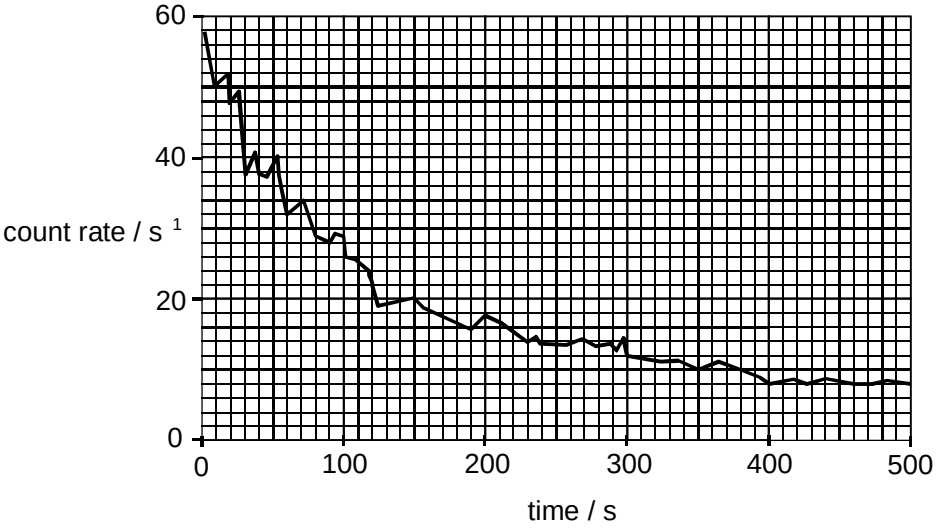
$^{126}_{50}Sn$: 50 protons, 76 neutrons (not)

29 Radon-222, $^{222}_{86}Rn$ decays to Lead-210, $^{210}_{82}Pb$ via a series of three alpha and two beta decays through a series of intermediate nuclides. Which of the following cannot be one of the intermediate nuclides produced?

A $^{214}_{82}Pb$ **B** $^{214}_{83}Bi$ **C** $^{218}_{84}Po$ **D** $^{216}_{85}At$

Ans: D
Alpha decays cause nucleon number to decrease by 4 each time.
Beta decays do not affect nucleon number.
Possible nuclides can only have nucleon numbers of 218, 214, 210.
(Sufficient to only consider nucleon number in this case.)

30 An experiment is carried out in which the count rate is measured at a fixed distance from a sample of a certain radioactive material. The figure below shows the variation of count rate with time.



What is the approximate half-life of the material?

A 60 s **B** 80 s **C** 100 s **D** 120 s

Ans: A
Considering background count rate to be 8 counts s^{-1},
Half life is when count rate decreases from 58 (=50+8) to 33 (=25+8).
Best option is 60 s.