Name: ________________________________ (   )   PDG : _______ / 17

ANDERSON JUNIOR COLLEGE

2018 JC2 Preliminary Examination

PHYSICS Higher 1 — 8867/01

Paper 1 Multiple Choice — **Tuesday 18 September 2018**

1 hour

Additional Materials: Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

Write your name, class index number and PDG on the Answer Sheet in the spaces provided.
Shade and write your NRIC/FIN.

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

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

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$

1 Which estimate is realistic?

A The power of a toaster is 500 kW.

B The kinetic energy of a bus travelling on a highway is 500 kJ.

C The temperature of a hot oven is 500 K.

D The volume of an Olympic size swimming pool is 500 m^3.

2 A particle has an initial velocity of 25 m s^{-1} in the OX direction, as shown in Fig. 1.
At a later time its velocity is 25 m s^{-1} at an angle of 60° measured anticlockwise from OX, as shown in Fig. 2.

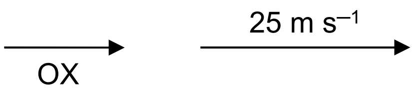


Fig. 1

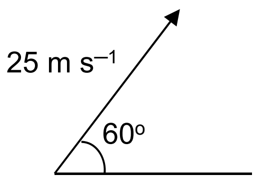


Fig. 2

What is the change of velocity of the particle?

A zero.

B 167 m s^{-1} at an angle of 30° measured anticlockwise from OX.

C 25 m s^{-1} at an angle of 120° measured anticlockwise from OX.

D 167m s^{-1} at an angle of 210° measured anticlockwise from OX.

3 Which experimental technique reduces the systematic error of the quantity being investigated?

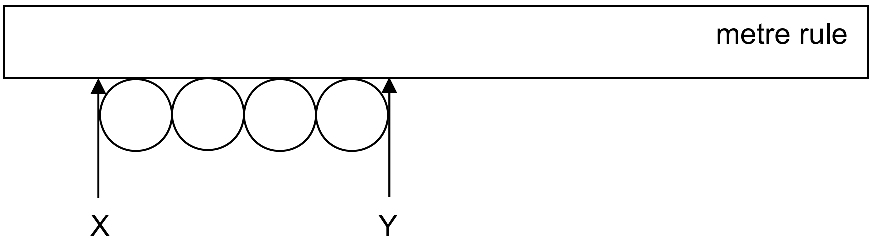
A Measuring the diameter of a wire repeatedly and calculating its average.

B Adjusting the ammeter to remove its zero error before measuring a current.

C Reading off the mass of an object directly from an electronic balance.

D Timing a large number of oscillations to find period.

4 A student attempts to measure and obtain the radius of a steel ball by using a metre rule to measure four similar balls in a row.



The student estimates the position on the scale to be as follows:
X = (1.00 ± 0.05) cm
Y = (5.00 ± 0.05) cm

What is the radius of a steel ball together with its associated uncertainty?

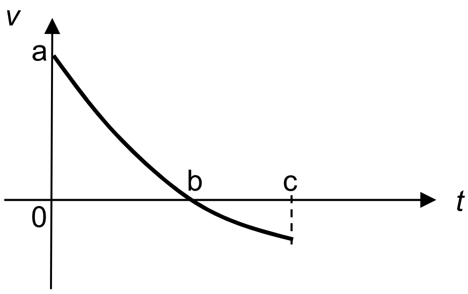
A (0.50 ± 0.01) cm

B (0.50 ± 0.05) cm

C (0.5 ± 0.1) cm

D (1.0 ± 0.1) cm

5 The graph below shows the variation of time t with velocity v of a ball.



Which statement about the motion of the ball is correct?

A The displacement at b is zero.

B The acceleration of the ball is increasing.

C The position at b is furthest from its starting position.

D The position at c is below its initial starting position.

6 A cannon at the top of a 30 m high hill fires a shell at an angle of 30° upwards from the horizontal with a speed of 50 m s^{-1}.
Taking air resistance to be negligible, what is the angle to the vertical at which the shell lands on level ground?

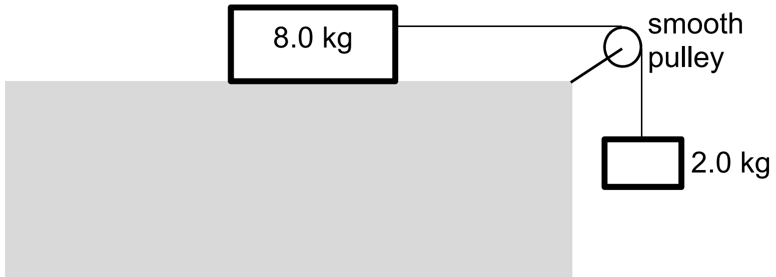
A 39° **B** 42° **C** 48° **D** 51°

7 A model helicopter of mass 5.0 kg rises with constant acceleration from rest to a height of 60 m in 10 s.

What is the upward force exerted on the model by the air?

A 6.0 N **B** 49 N **C** 52 N **D** 55 N

8 A mass of 8.0 kg, resting on a horizontal plane, is connected to a hanging mass of 2.0 kg. There is a frictional force of 5.0 N acting between the 8.0 kg mass and the plane.



What is the acceleration of the 8.0 kg mass?

A 1.5 m s^{-2} **B** 1.8 m s^{-2} **C** 2.0 m s^{-2} **D** 2.5 m s^{-2}

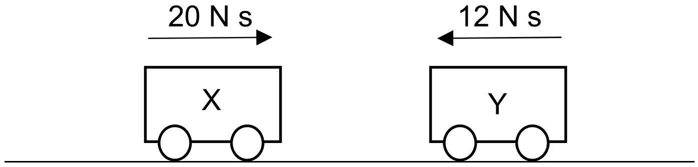
9 Two objects, moving along a frictionless surface, collide elastically.

The total kinetic energy and total momentum of the system before and during the collision are compared.

Which row best describes the system during the collision?

	total kinetic energy	total momentum
A	less	less
B	less	same
C	same	less
D	same	same

10 The given diagram shows the momentum of two trolleys, X and Y just before they collide. The collision reverses the direction of motion of both trolleys. Just after the collision, the momentum of Y is 12 Ns.



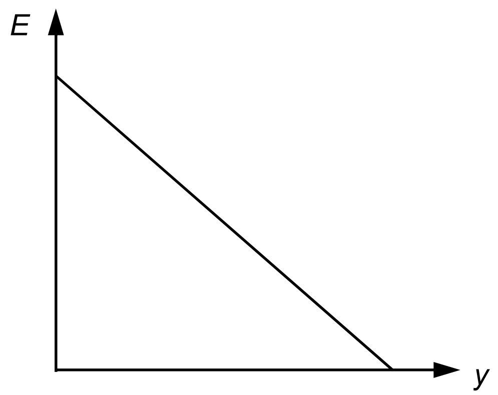
What is the magnitude of the corresponding momentum of X?

A 4 N s **B** **8** N s **C** 10 N s **D** 20 N s

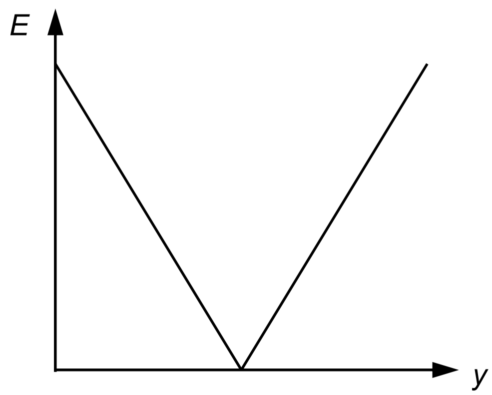
11 A man throws a ball vertically upwards. The ball reaches a maximum height, and then falls back into the man's hand. Air resistance may be assumed to be negligible.

Which graph shows how the kinetic energy *E* of the ball varies with the vertical displacement *y*?

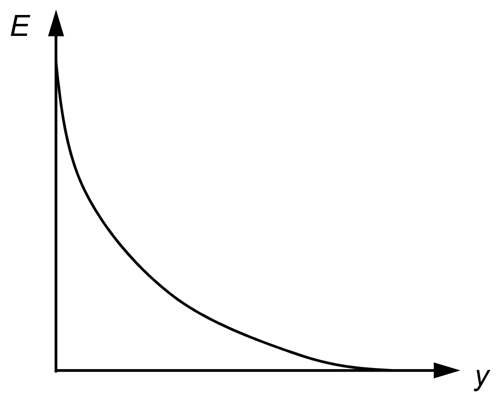
A



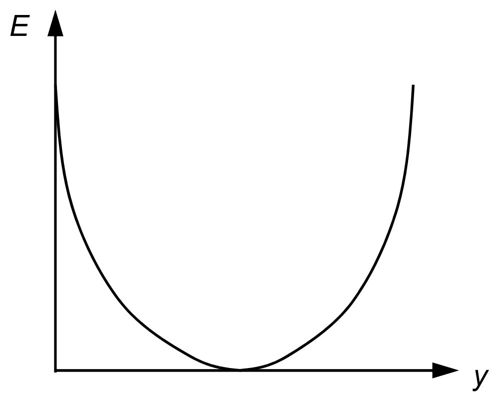
B



C

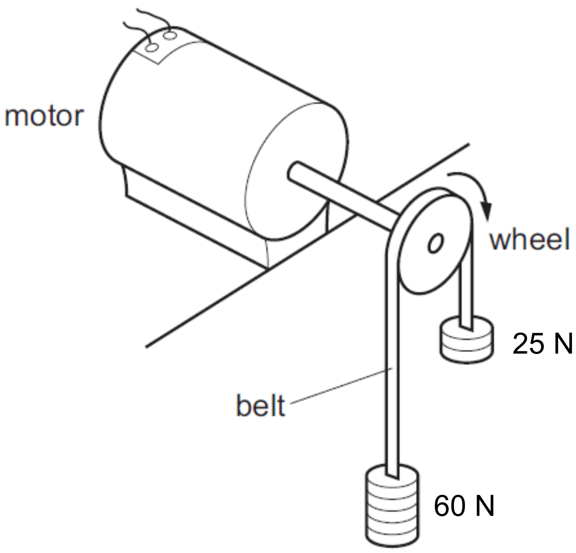


D



12 The diagram shows an arrangement used to find the output power of an electric motor.

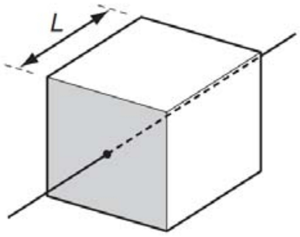
The wheel attached to the motor's axle has a diameter of 35 cm and the belt which passes over it is stationary when the weights have the values shown.



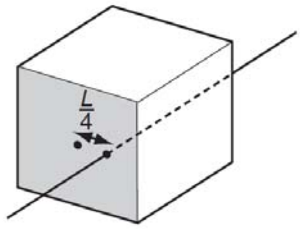
When the wheel is making 20 revolutions per second, what is the output power of the motor?

A 250 W **B** 770 W **C** 1300 W **D** 1900 W

13 The diagram shows a solid cube with weight W and sides of length L. It is supported by a frictionless spindle that passes through the centres of two opposite vertical faces. One of these faces is shaded.



The spindle is now removed and replaced at a distance $\frac{L}{4}$ to the right of its original position.



When viewing the shaded face, what is the torque of the couple that will now be needed to stop the cube from toppling?

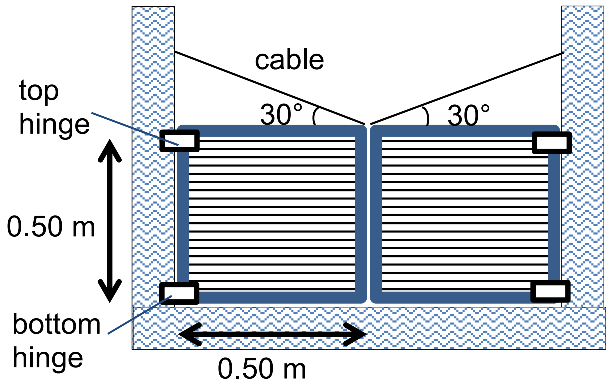
A $\frac{WL}{2}$ anticlockwise

B $\frac{WL}{2}$ clockwise

C $\frac{WL}{4}$ anticlockwise

D $\frac{WL}{4}$ clockwise

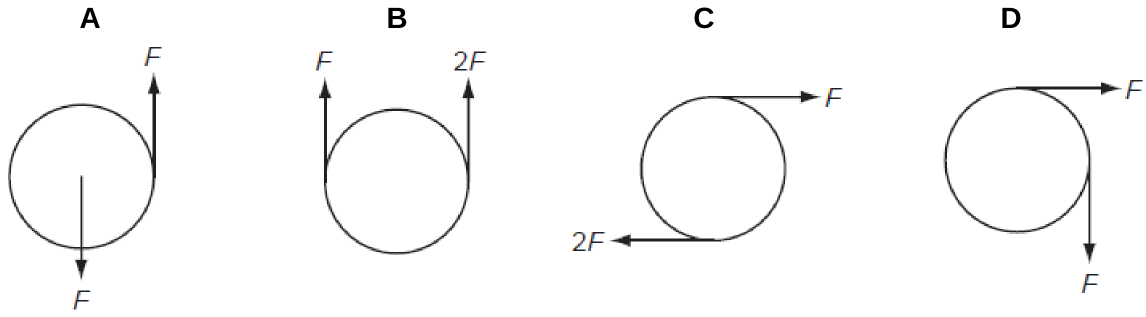
14 A window is made up of 2 uniform panes. Each pane is 0.50 m wide and 0.50 m high, with hinges attached at the top and bottom as seen in the figure. A cable makes an angle of 30° with the top of the pane and has a tension of 150 N. The mass of one pane is 20 kg.



What is the magnitude and direction of the horizontal force exerted by the top hinge on the left pane?

A 107 N to the left **B** 107 N to the right **C** 130 N to the left **D** 130 N to the right

15 Which pair of forces acts as a couple on the circular object?



16 A particle placed in a uniform field experiences a force in the opposite direction to the field.

Which field is the particle in, and which property of the particle is the field acting on?

	field	property of particle on which the field acts
A	electric	charge
B	electric	current
C	gravitational	mass
D	gravitational	weight

17 An electric scooter of mass 10 kg moves at a constant speed over a humpback bridge of radius of curvature 3.0 m.
What is maximum speed of the electric scooter such that it does not lose contact with the bridge?

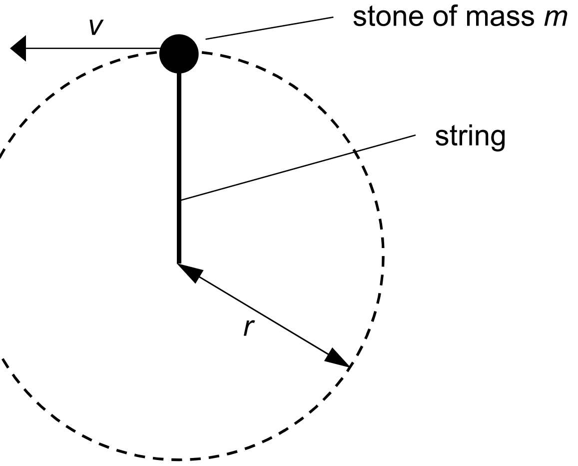
A 1.8 m s^{-1}

B 3.3 m s^{-1}

C 5.4 m s^{-1}

D 5.7 m s^{-1}

18 A stone of mass *m* is attached to a string. The stone is made to rotate in a vertical circle of radius *r*, as shown.



At the point where the stone is vertically above the centre of the circle, the speed of the stone is *v*. Which of the following expressions gives the tension in the string?

A $mg - \frac{mv^2}{r}$

B $\frac{mv^2}{r}$

C $\frac{mv^2}{r} - mg$

D $\frac{mv^2}{r} + mg$

19 Which statement about a geostationary satellite is true?

A It can remain vertically above any chosen fixed point on the Earth.

B Its linear speed is equal to the speed of a point on the Earth's equator.

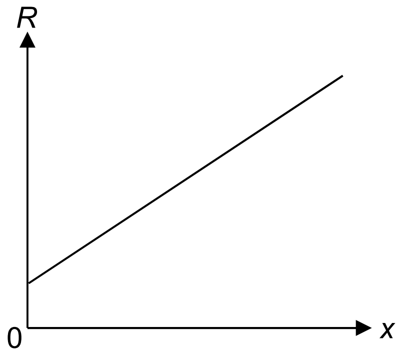
C It is always travelling from east to west.

D It has the same angular velocity as the Earth's rotation on its axis.

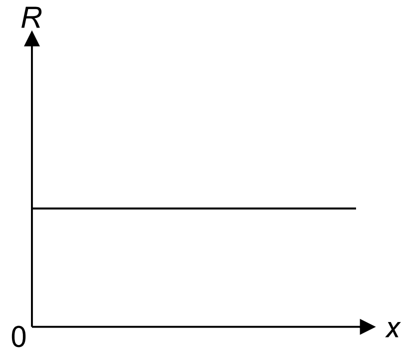
20 When a metal wire is stretched, it becomes longer.

Which graph best represents the variation with extension x of the resistance R of the wire?

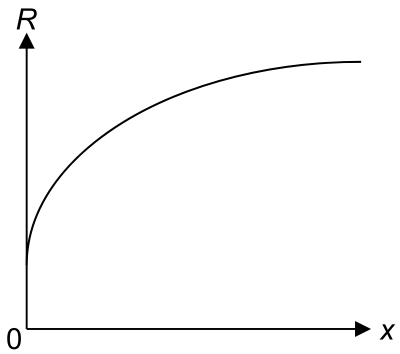
A



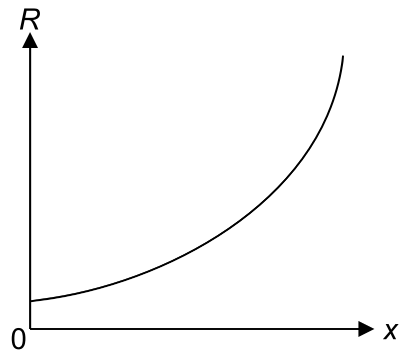
B



C



D



21 Which statement best describes the electric potential difference between two points in a wire that carries a current?

A the ratio of the power dissipated between the points to the charge moved

B the ratio of the power dissipated between the points to the current

C the ratio of the energy dissipated between the points to the current

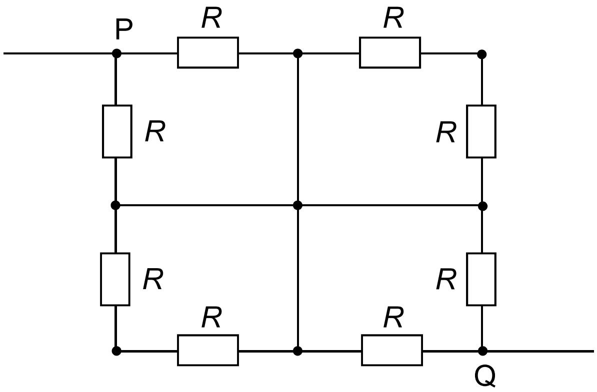
D the force required to move a unit positive charge between the points

22 The current in an electrical component is reduced uniformly from 80 mA to 20 mA over a period of 8.0 s.

What is the amount of charge that flows through the electrical component during this time?

A 240 mC **B** 400 mC **C** 480 mC **D** 640 mC

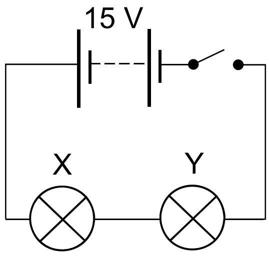
23 Eight identical resistors, each of resistance *R*, are connected in a network as shown below.



What is the effective resistance between the terminals P and Q?

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

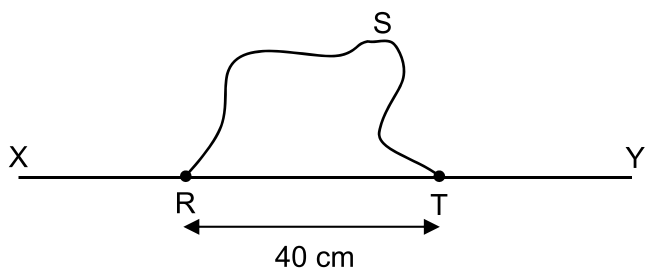
24 Two bulbs are connected in series to a 15 V power supply. Bulb X is rated 10 V, 20 W and Bulb Y is rated 5 V, 2 W.



Which of the following best describes the power output of the bulbs when the switch is closed?

	Power output of Bulb X	Power output of Bulb Y
A	20 W	2 W
B	greater than 20 W	smaller than 2 W
C	smaller than 20 W	greater than 2 W
D	smaller than 20 W	smaller than 2 W

25 A wire RST is connected to another wire XY as shown.



Each wire is 120 cm long with a resistance per unit length of 8.0 $\Omega\,m^{-1}$.

What is the total resistance between X and Y?

A 2.4 Ω

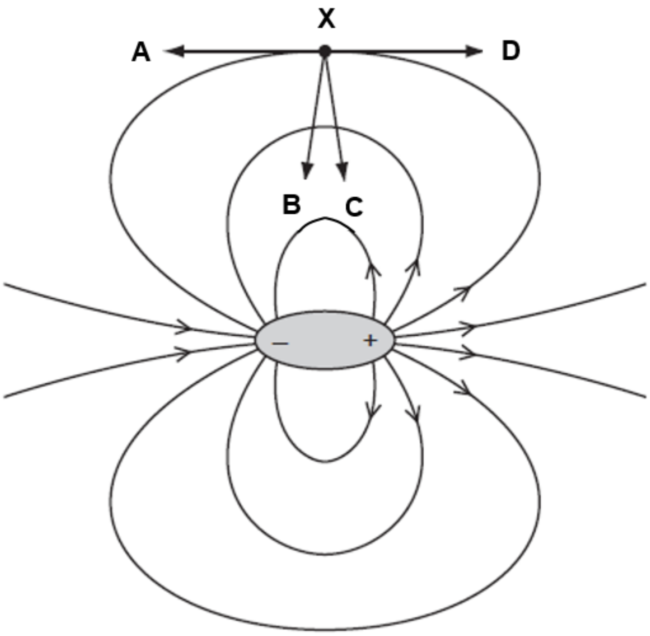
B 4.8 Ω

C 8.8 Ω

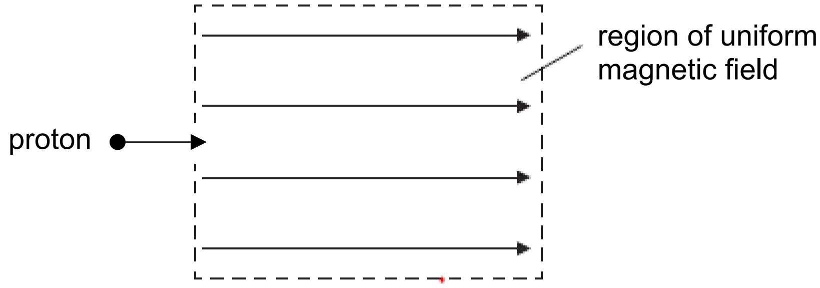
D 9.6 Ω

26 An electric dipole is a pair of one negative charge and one positive charge of equal magnitude. The electric field of an electric dipole is shown below.

Which direction does the force act on an electron when placed at point X?

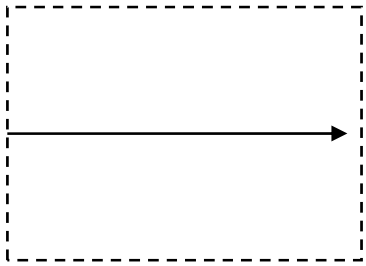


27 A proton enters a region of uniform magnetic field. The direction of the particle's velocity is parallel to the direction of the magnetic field as shown in the diagram below.

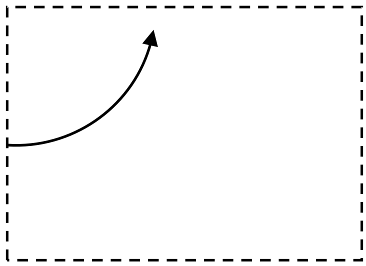


Which diagram shows the path of the proton while in the region of magnetic field?

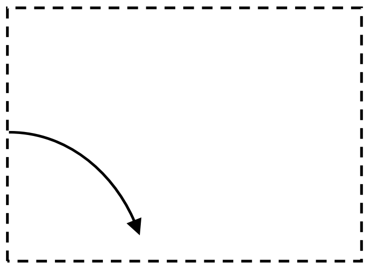
A



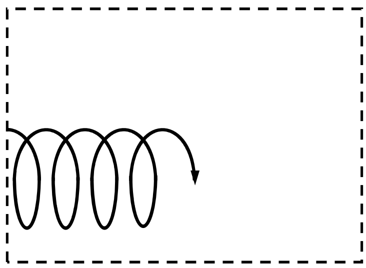
B



C



D



28 A particle has a charge of 3*e*. The particle remains at rest midway between a pair of horizontal, parallel plates with an electric field strength of 44 kN C^{-1}.

What is the mass of the particle?

A 2.11×10^{-14} kg

B 2.15×10^{-15} kg

C 1.09×10^{-23} kg

D 1.11×10^{-24} kg

29 Which equation shows a radioactive decay that emits an alpha particle?

A $^{14}_{7}N + ^{1}_{1}p \rightarrow ^{11}_{6}C + X$

B $^{220}_{86}Rn \rightarrow ^{216}_{84}Po + X$

C $^{137}_{55}Cs \rightarrow ^{137}_{56}Ba + X$

D $^{60}_{28}Ni \rightarrow ^{60}_{28}Ni + X$

30 Which statement concerning nuclear properties is true?

A The greater the binding energy of a nucleus, the more stable it is.

B If the total rest mass of the products of a reaction is greater than the total rest mass of the reactants, this reaction is impossible.

C The half-life of a radioactive isotope can be changed by allowing the isotope to react chemically to produce a new compound.

D When a stationary nucleus decays by emitting an α radiation, the daughter nucleus will move off in opposite direction to the α radiation.

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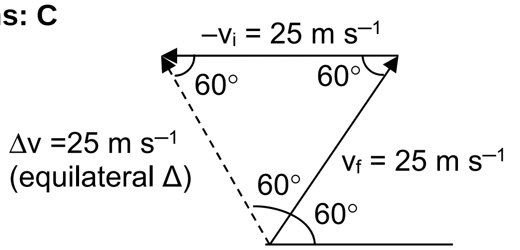
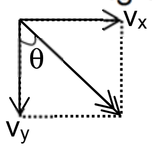
2018 AJC JC2 H1 Physics Prelim Solutions
Paper 1 (30 marks)

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

No	Answer & Solution
1	**Ans: C** A: Typical power of a toaster is around 1 kW. B: KE of a 10000 kg bus travelling at 80 km h^{-1} (22.2 m s^{-1}) = 0.5 × 10000 × 22.2^2 = 2400 kJ C: The approximate temperature of a hot oven is about 200 – 230 °C = 473 to 503 K D: The approximate volume of the swimming pool = 50 × 25 × 1.6 = 2000 m^3
2	**Ans: C**  Chang in velocity, $\Delta v = v_f - v_i$
3	**Ans: B** Option A and D reduce random error. Option C does not reduce any error.
4	**Ans: A** Y-X = 4.0 cm, Δ(Y-X) = 0.1 cm r = 1/8 (Y-X) = 0.50 cm Δr = 1/8 Δ (Y-X) = 0.01 cm (1 s.f.) r = 0.50 ± 0.01 cm
5	**Ans: C** Option A is false. Displacement at b is area under graph from t = 0 to t = b, which is non zero. Option B is false. Gradient gives the acceleration of ball and it is decreasing. Option C is true. Area under graph from t = 0 to t = b is larger than area under graph from t = b to t = c. Option D is false. Area under graph from t = 0 to t = b is larger than area under graph from t = b to t = c.
6	**Ans: D** $v_x = u_x$ $v_y^2 = u_y^2 - 2gs$ $= (50\sin30°)^2 + 2(-9.81)(-30)$ $v_y = -34.8$ m s^{-1}

The negative sign shows tthat the ball is moving downwards.

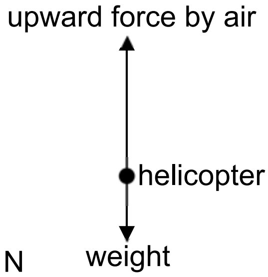
$\theta = \tan^{-1} (v_x / v_y) = (50\cos30° / 34.8)$
$= 51.2°$



7 **Ans: D**

Taking upward direction as positive, $s_y = 0 + \frac{1}{2}a_y t^2$

$$a_y = \frac{2s_y}{t^2} = \frac{2\times60}{10^2} = 1.2 \text{ m s}^{-2}$$



Upward force – weight = ma

Upward force = ma + weight = m (a + g) = 5.0 (1.2 + 9.81) = 55.05 N

8 **Ans: A**

Consider the 2 masses as a system

Weight of 2 kg mass – friction between 8 kg mass and plane = (mass of 2 masses) × a

$$a = \frac{2.0(9.81) - 5.0}{8.0 + 2.0} = 1.46 \text{ m s}^{-2}$$

9 **Ans: B**

During collision, kinetic energy of the system is not conserved (regardless of type of collision)
Total momentum of the system is conserved for all stages of collision (regardless of type of collision)

10 **Ans: A**

Taking the direction to the right as positive, 20 + (–12) = 12 + ($-P_X$)
P_X = 4 N s

11 **Ans: A**

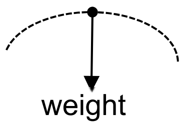
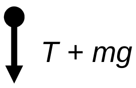
By Conservation of Energy, loss in KE = Gain in GPE.
➔ $\Delta E = \Delta mgh = mg\Delta h$
Hence E varies linearly with height, i.e. a straight line.
Since y is vertical displacement, at maximum height (largest y value) E = 0.
Hence the answer is A.

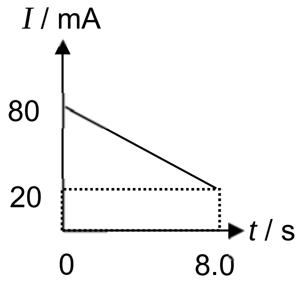
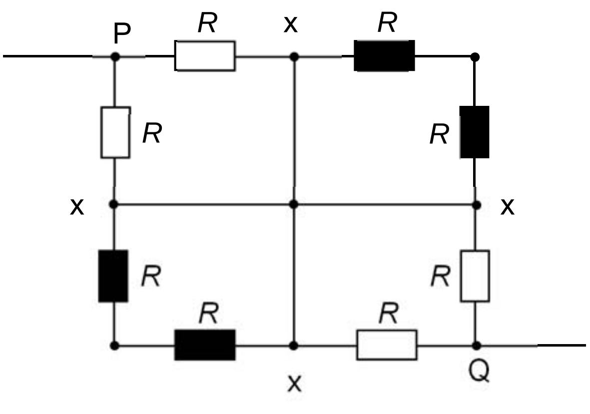
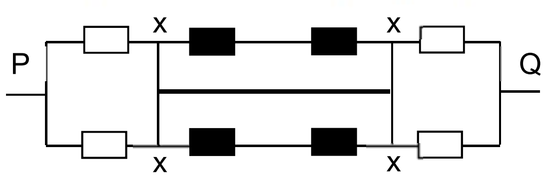
12 **Ans: B**

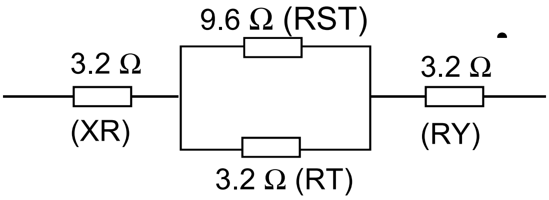
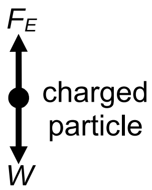
When the motor is not spinning, the 60 N mass will move downwards as there is a net downward force of 35 N.
Since the belt remains stationary when the motor is spinning,
$P_{output} = F_{net}$ × (distance moved per unit time) = $F_{net} \times (20\pi d)$
$= 35 \times (20 \times \pi \times 0.35) = 770$ W

13 **Ans: D**

At the new spindle position, the weight of the cube causes a anticlockwise torque of $\frac{WL}{4}$. Hence the torque of the couple required to prevent the cube from toppling must be $\frac{WL}{4}$ clockwise.

14	**Ans: B** Assume that the horizontal force at the top hinge is to the right, Taking moment about bottom hinge, (T sin θ)(d)+(T cos θ)(d) = (R_x)(d)+(W)(0.5d) (150 sin 30°)(0.5) + (150 cos 30°)(0.5) = Rx(0.5) + (20)(9.81)(0.5)(0.5) R_x = 107 N to the right. (since the answer is positive)
15	**Ans: A** Couple consists of a pair of parallel force, of equal magnitude but opposite direction.
16	**Ans: A** The particle is negatively charged. The electric force is in the opposite direction of the E field. Note: • Choice B is wrong because the property of particle on which electric field acts is charge and not current. • For gravitational field, the property of particle on which the field acts is mass and the direction of gravitational force is same as the direction of the gravitational field. (so choice C and D are not appropriate for this question)
17	**Ans : C** For max speed such that the scooter does not lose contact with bridge, weight of scooter provides centripetal force. mg = mv^2/r v = √(gr) = √(3 × 9.81) = 5.4 m s^{-1} 
18	**Ans : C** Applying the principle of circular motion at the highest point,  $T + mg = \frac{mv^2}{r}$ $T = \frac{mv^2}{r} - mg$
19	**Ans : D** Option A is not correct. The satellite can remain vertically above any chosen fixed point <u>along the equator</u> only. Option B is not correct because the angular speed of the satellite is equal to the angular speed of a point on the Earth's equator. Option C is not correct as the satellite follows Earth's rotation i.e. West to East.
20	**Ans: D** $R = \frac{\rho L}{A}$ $R = \frac{\rho L}{\left(\frac{V}{L}\right)} = \frac{\rho L^2}{V} = \frac{\rho\left(L_0 + x\right)^2}{V}$ Note: For constant volume, *R* against *x* graph is quadratic.

21	**Ans: B** From $P = VI$, we have $V = \dfrac{P}{I}$.
22	**Ans: B**  charge flow = area under graph = ½ × (80 + 20) × 8.0 = 400 mC <u>Alternative</u> ave < I > = $\dfrac{80+20}{2}$ = 50 mA Q = < I > t = 50 × 8.0 = 400 mC
23	**Ans: C**  The above circuit can be redrawn as:  No current passes through the resistors in black as all current will pass through the bold wire (zero resistance) Resistance across PQ = *R*/2 + *R*/2 = *R*
24	**Ans: C** Resistance of 20 W bulb = $10^2/20$ = 5 Ω Resistance of 2 W bulb = $5^2/2$ = 12.5 Ω P.d. across 20 W bulb = 5/(5+12.5) × 15 = 4.3 V (smaller than its 10 V rating) P.d. across 2 W bulb = 12.5/(5+12.5) × 15 = 10.7 V (larger than its 5 V rating) Hence P_X < 20 W and P_Y > 2W

25	**Ans: C** The 2 wires XY and RST can be represented by the following network of resistors.  $R_{total} = 3.2 + \left(\frac{9.6 \times 3.2}{9.6 + 3.2}\right) + 3.2 = 8.8\ \Omega$
26	**Ans : D** The direction of electric field line at a point indicates the direction of electric force on a positive test charge placed at the point. Since an electron is a negative charge, it will experience an electric force in the direction opposite to that of the electric field.
27	**Ans : A** There is no magnetic force on the moving charge whose velocity is parallel to the direction of B-field.
28	**Ans : B**  Since the charged particle is at equilibrium, $F_E = W$ $qE = mg$ $m = \frac{qE}{g} = \frac{(3 \times 1.6 \times 10^{-19})(44 \times 10^{3})}{9.81} = 2.15 \times 10^{-15}$ kg
29	**Ans: B** An alpha particle is a helium nucleus. $^{220}_{86}\text{Rn} \rightarrow {}^{216}_{84}\text{Po} + {}^{4}_{2}\text{He}$ Option A is <u>NOT</u> a radioactive decay, since radioactive decay is spontaneous.
30	**Ans: D** A – The stability of the nucleus depends on the binding energy per nucleon, not the binding energy. B – The reaction can still occur provided energy is given to the reactants. C – The half-life of a radioactive isotope is a constant for a given radioactive isotope. D is correct because of the principle of conservation of momentum.

Name: ____________________________ (   )   PDG: ______/ 17

ANDERSON JUNIOR COLLEGE

2018 JC2 Preliminary Examination

PHYSICS Higher 1 — 8867/02

Paper 2 Structured Questions — **Tuesday 11 September 2018**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and PDG in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Paper 1 (30 m)	
Paper 2 (80 m)	
Section A	
1	
2	
3	
4	
5	
6	
Section B	
7	
8	
Deductions	
Paper 2 Total	
Overall (100 %) / Grade	/

This document consists of **23** printed pages and **1** blank page.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$

Section A

Answer **all** the questions in this section.

1 Ball A falls vertically in air from rest. The variation with time t of the distance d moved by the ball is shown in Fig. 1.1.

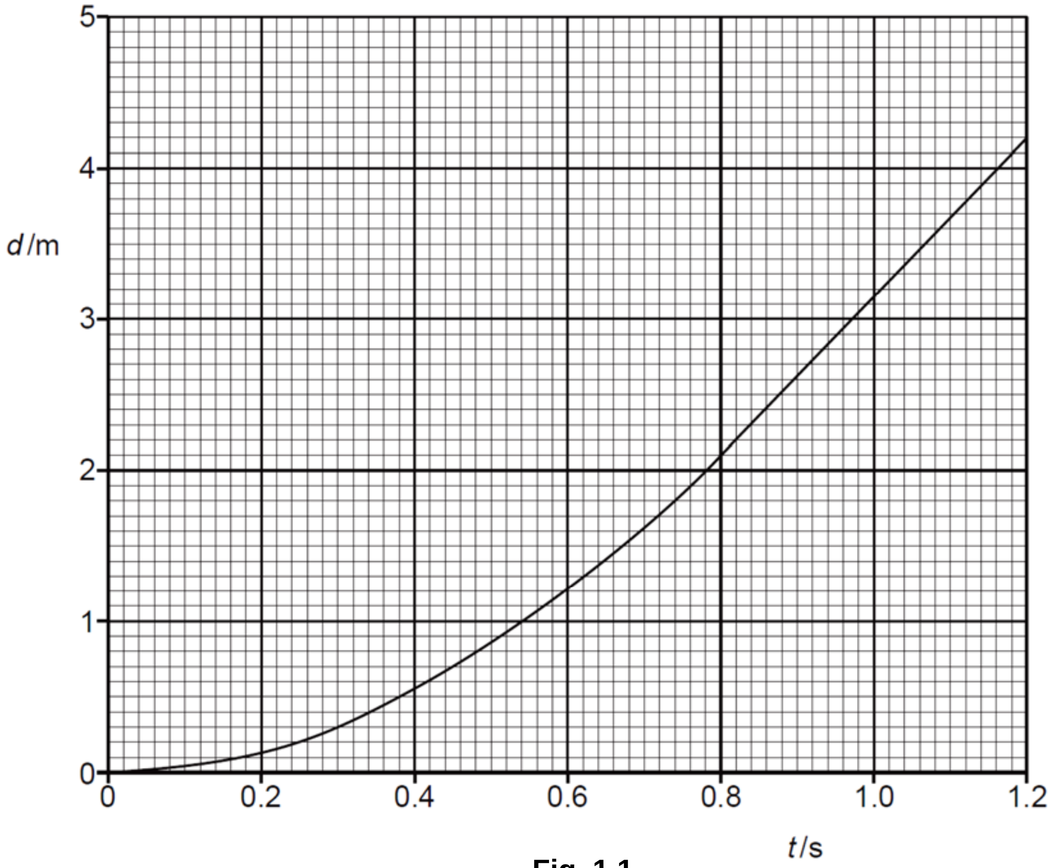


Fig. 1.1

(a) By reference to Fig. 1.1, explain how it can be deduced that air resistance is not negligible.

…………………………………………………………………………………………………..

…………………………………………………………………………………………........ [2]

(b) Use Fig. 1.1 to determine the speed of the ball at a time of 0.40 s after it has been released.

speed = …………………………….m s^{-1} [2]

(c) Ball A is replaced by ball B which experiences negligible air resistance.

On Fig. 1.1, sketch a graph to show the variation with time t of the distance d moved by ball B after falling from rest. Label this graph P. [2]

[Total: 6]

2 One end of a spring is fixed to a support. A mass is attached to the other end of the spring. The arrangement is shown in Fig. 2.1.

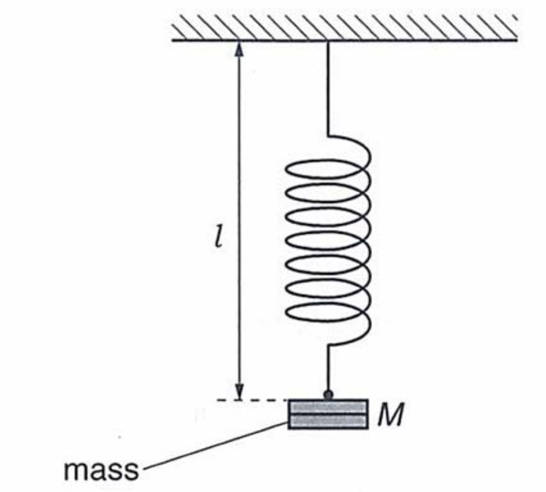


Fig. 2.1

The arrangement is used to determine the length l of the spring when mass M is attached to the spring. The procedure is repeated for different values of M.
The variation of mass M with length l is shown in Fig. 2.2.

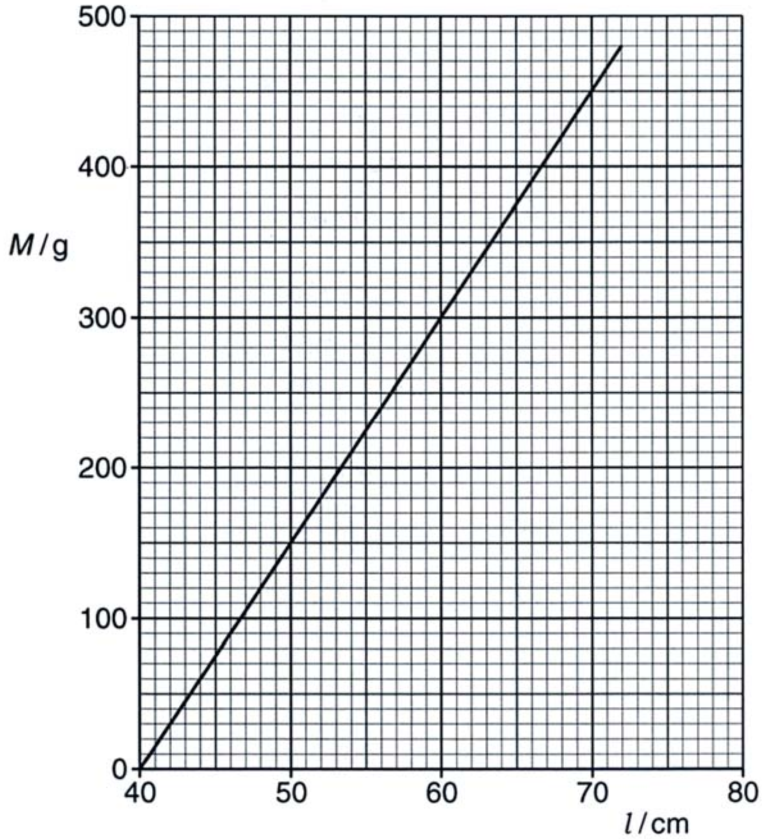


Fig. 2.2

A mass of 450 g is attached to the spring and is held at rest with length l of 40.0 cm. The mass is then released and the spring extends.

(a) State the energy changes in the mass-spring system as the mass falls to its lowest position from its point of release. Numerical values are not required.

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……………………………………………………………………………………………..........[2]

(b) Calculate the maximum kinetic energy of the mass as the spring extends.

maximum kinetic energy = …………………………….J [4]

[Total: 6]

3 A circular disc of radius 11.8 cm is spinning about its centre O in a vertical plane at a rate of 100 revolutions per minute. A plasticine of mass 3.8 g is stuck to the edge of the disc at point P and the line OP is 45 ° from the vertical at the instant, as shown in Fig. 3.1.

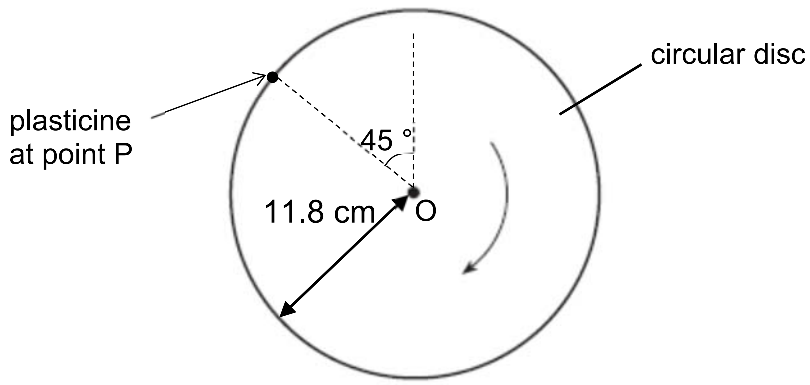

Fig. 3.1

(a) Show that the centripetal force acting on the plasticine is 0.049 N.

[3]

(b) On Fig. 3.2, the weight of the plasticine at P has been drawn. At this instant, the magnitude of the contact force by the disc on the plasticine is equal to the weight of the plasticine. Draw an arrow on Fig. 3.2 to show the contact force by the disc on the plasticine at P. Label this arrow C. [1]

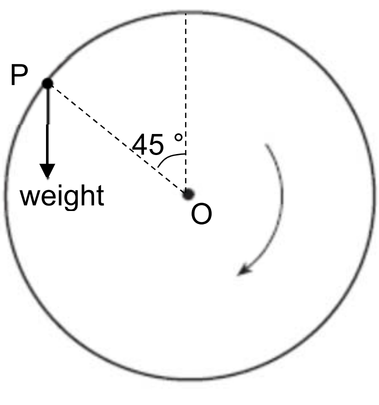

Fig. 3.2

(c) The angular velocity of the disc is increased gradually.

The maximum value of the contact force between the disc and plasticine is 0.23 N.

(i) Explain why the plasticine is most likely to first lose contact with the disc at the lowest point of the revolution.

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…………………………………………………………………………………………… [3]

(ii) Hence, determine the angular velocity when the plasticine first loses contact with the disc.

angular velocity = ………………………….. rad s^{-1} [2]

[Total: 9]

4 **(a)** Fig. 4.1 shows the variation with voltage V of the current I across a filament lamp rated 6.0 V, 1.5 W.

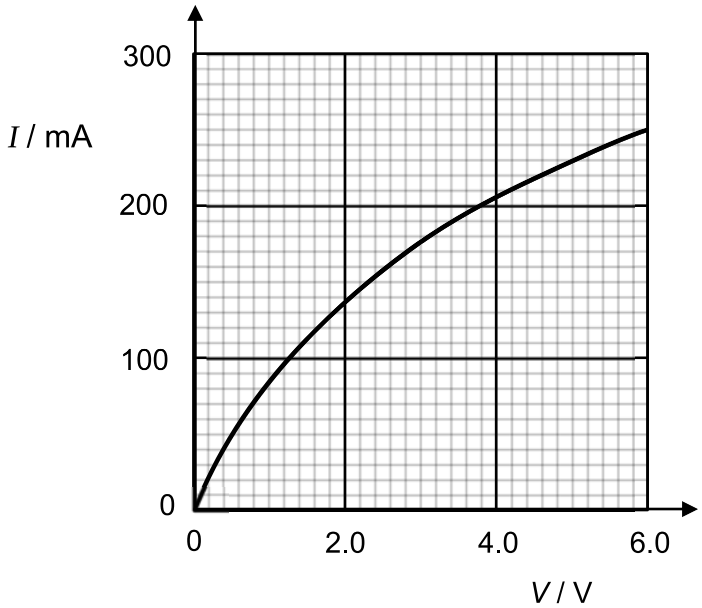

Fig. 4.1

(i) Explain how Fig. 4.1 shows that the resistance of the lamp increases as V increases.

....

.... [1]

(ii) In microscopic terms, explain why the resistance of the filament lamp increases as V increases.

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....

....

.... [3]

(b) A student designs a circuit for a night light using the filament lamp in **(a)** and a light-dependent resistor (LDR), as shown in Fig. 4.2.

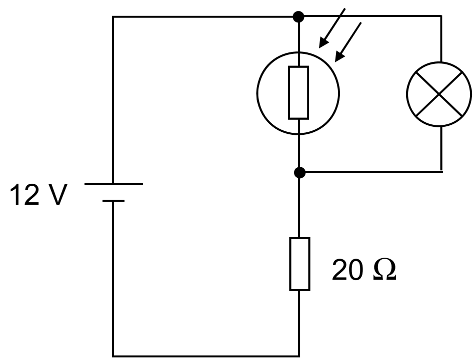

Fig. 4.2

The LDR has a resistance of 10 Ω in daylight and increases to 1000 Ω in the dark.

(i) Explain why the lamp will not operate at its rated power in daylight.

……………………………………………………………………………………..................

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……………………………………………………………………………………..................

……………………………………………………………………………………….... [2]

(ii) Calculate the resistance of the LDR in order for the lamp to operate at its rated power of 1.5 W.

resistance = …………………. Ω [3]

[Total: 9]

5 **(a)** Define the *tesla*.

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.... [3]

(b) Describe an experimental procedure to determine the magnetic flux density of a solenoid at midway along its axis using a current balance.

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.... [4]

(c) A uniform, straight wire of mass 25 g and length 120 cm, is suspended by two threads, one at each end. The wire is in a region of uniform magnetic flux density of 5.5 mT, directed vertically downwards. When a current of 10 A passes through the wire, the wire deflects and comes to an equilibrium position at an angle θ to the vertical, as shown in Fig. 5.1.

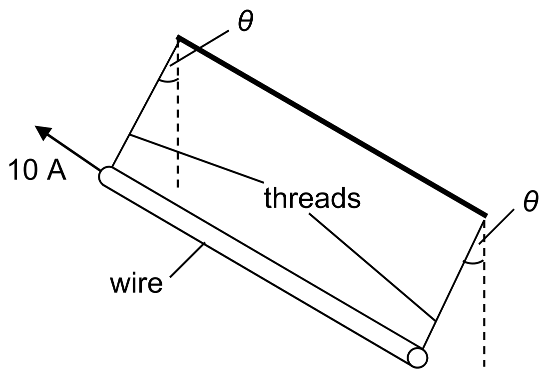

Fig. 5.1

(i) Determine the angle θ.

θ = ………….…………….. ° [3]

(ii) State two ways in which the wire can be made to deflect to the other side of the vertical.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………. [2]

[Total: 12]

6 Dangers associated with exposure to radiation have been recognized for many years. As a result of these hazards, measures have been adopted to reduce exposure to radiation to as low a level as possible. One such measure is to shield individuals from radioactive sources using radiation absorbing materials.

Experiments have been carried out to investigate the effectiveness of materials as absorbers of γ-ray photons. One possible experiment is illustrated in Fig. 6.1.

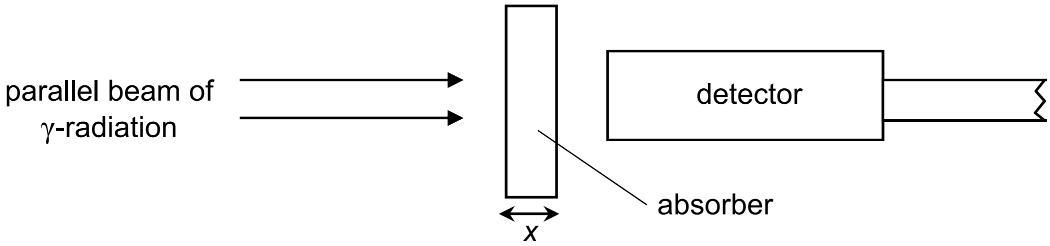

Fig. 6.1

The count-rate C_X of γ-ray photons is measured for various thickness x of the absorber. C_0 is the count-rate measured when no absorber is used.

Fig. 6.2 shows the variation with thickness x of the ratio C_X/C_0 for lead absorbers.

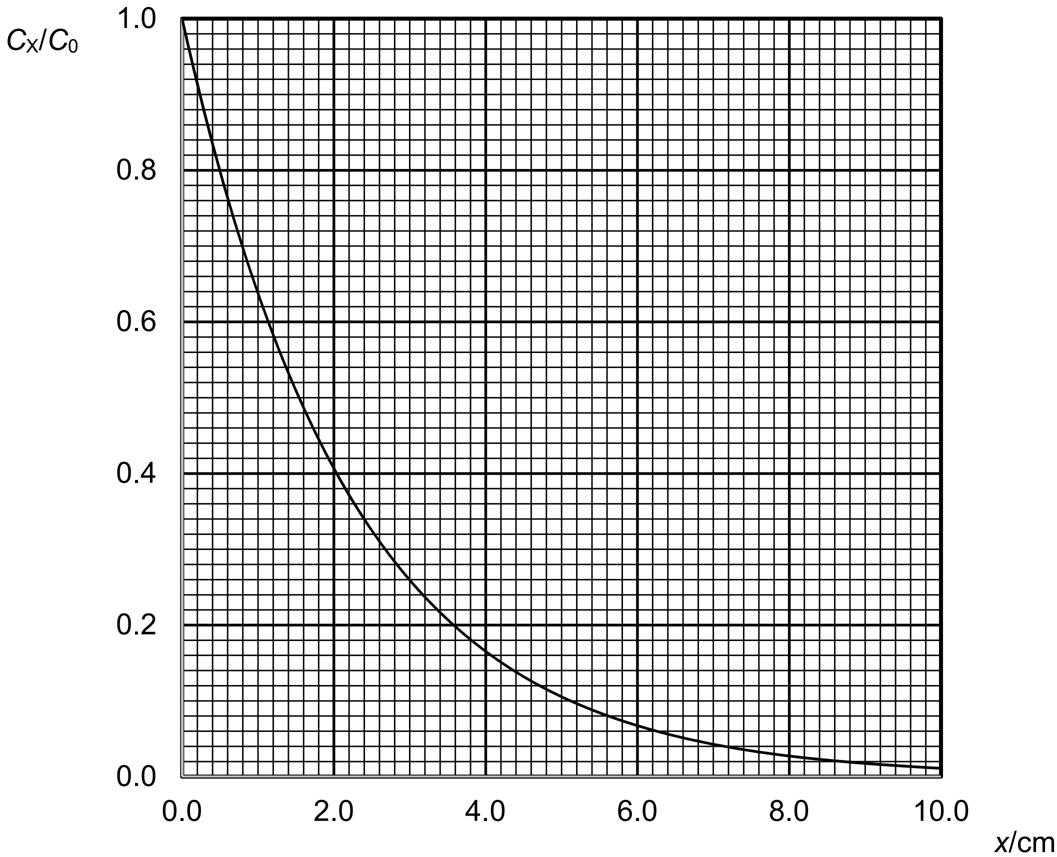

Fig. 6.2

(a) **(i)** State what is meant by γ-radiation.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(ii) Suggest why it is necessary to have a parallel beam of γ-radiation in this experiment.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

(iii) Use Fig. 6.2 to explain why complete shielding is not possible.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

(b) Data from Fig. 6.2 are used to obtain values of ln (C_X/C_0). These are used to plot the graph of Fig. 6.3.

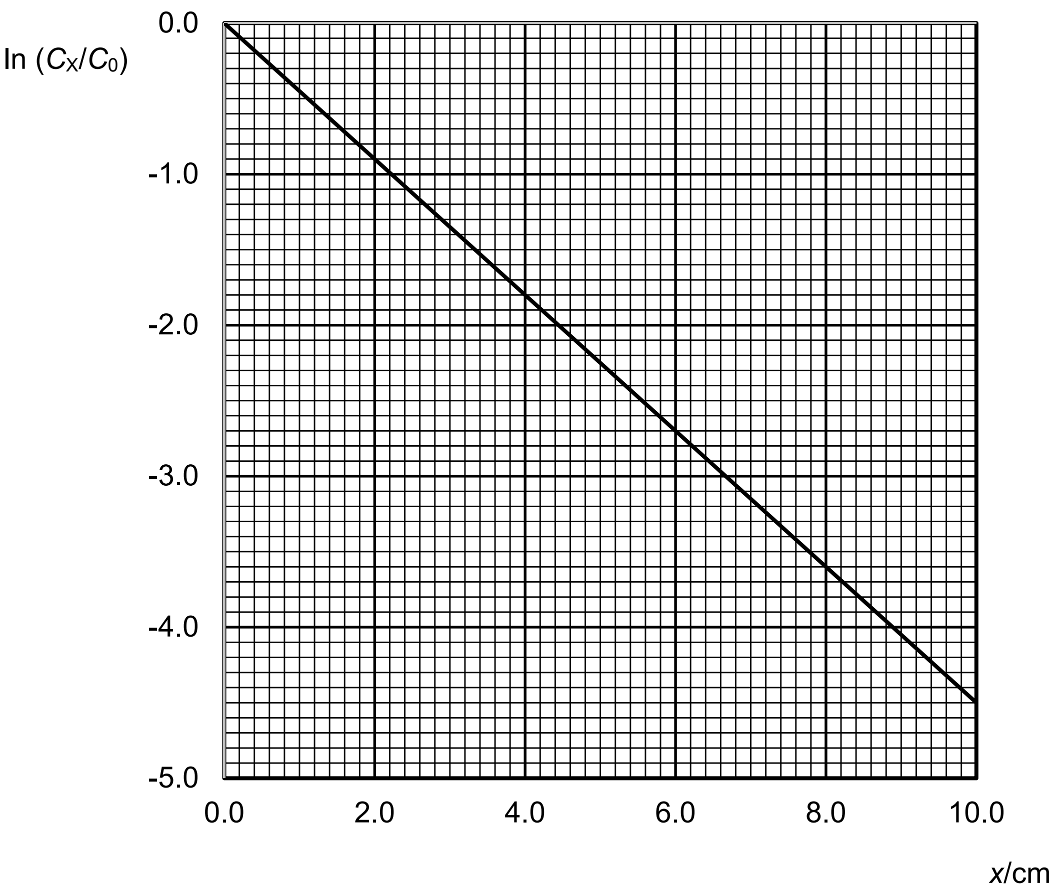

Fig. 6.3

(i) It is proposed that the count-rate C_X changes with the thickness x of the absorber according to an expression of the form

$$C_X = C_0\, e^{-\mu x},$$

where μ is a constant.

Explain why the graph of Fig. 6.3 supports this proposal.

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…………………………………………………………………………….……………... [3]

(ii) The constant μ is known as the linear absorption coefficient. Use Fig. 6.3 to calculate a value of μ for lead.

μ = …………………………….cm^{-1} [2]

(c) The linear absorption coefficient μ has been found to depend on photon energy and on the absorbing material itself. For γ-ray photons of one energy, μ is different for different materials.

In order to assess absorption of γ-ray photons in matter such that the material of the absorber does not have to be specified, a quantity known as the mass absorption coefficient μ_m is calculated. μ_m is given by the expression

$$\mu_m = \frac{\mu}{\rho},$$

where ρ is the density of the absorbing material.

Values of μ for 2.75 MeV photons and of ρ for different materials are given in Fig. 6.4.

material	μ / cm^{-1}	ρ / g cm^{-3}	μ_m / ……..
aluminium	0.095	2.70	0.035
tin	0.267	7.28	0.037
lead	……………..	11.3	……………

Fig. 6.4

On Fig. 6.4,

(i) give an appropriate unit for μ_m. [1]

(ii) use your answer to **(b)(ii)** to complete the table of values for lead. [1]

(d) Concrete is a common building material which is sometimes used for shielding. The density of concrete is 2.4×10^3 kg m^{-3}.

(i) Use the information given in Fig. 6.4 to calculate an average value for μ_m.

average value for μ_m = ……………………………..[1]

(ii) Hence, show that the linear absorption coefficient μ for 2.75 MeV photons in concrete is approximately 0.09 cm^{-1}.

[2]

(iii) Calculate the approximate thickness of concrete which would provide the same level of shielding, for 2.75 MeV photons, as a thickness of 4.0 cm of lead.

thickness = …………………………….cm [2]

(iv) Suggest why concrete may be used, in preference to lead, where radioactive sources of high activity are to be shielded.

1. ……………………………………………………………………………………..................

……………………………………………………………………………………..................

2. ……………………………………………………………………………………..................

……………………………………………………………………………………... [2]

[Total: 18]

Section B

Answer **one** question in this section.

7 A car of mass 950 kg is travelling at constant speed of 90 km h^{-1} along a horizontal straight road.

(a) **(i)** Explain why continuous power is required to be supplied to the car to maintain constant speed.

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…………………………………………………………………………………………… [2]

(ii) Explain why a higher power is required when travelling at a constant speed of 90 km h^{-1} than at a constant speed of 70 km h^{-1}.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) For the car to maintain the constant speed of 90 km h^{-1} along the horizontal straight road, an effective power of 22 kW is required.

(i) Determine the total resistive force on the car at this speed.

total resistive force = ……………………………… N [3]

(ii) Petrol used in the car engine provides 3.4×10^7 joules of energy per litre of fuel. From the manufacturer, the rate of fuel consumption when travelling at 90 km h^{-1} is given as 8.4 litres per 100 km travelled.

1. Show that the power supplied to the car by burning the petrol is 71.4 kW.

[1]

2. Hence, determine the efficiency of the car at this speed.

efficiency = …………………………... [2]

(iii) The car makes a turn round a horizontal curve, maintaining the speed of 90 km h^{-1}. State, with a reason, whether there is any change in the effective power required to travel round the curve as compared with that on the horizontal straight road.

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……………………………………………………………………………………………

……………………………………………………………………………………... [2]

(c) The car now travels up a slope where the road is inclined with a gradient of 1 metre rise for every 20 metres along the road.

(i) Explain why the power delivered by the engine must be increased in order for the car to travel at the same constant speed of 90 km h^{-1}.

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……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………... [2]

(ii) Determine the percentage increase required in power output of the car to maintain the same constant speed of 90 km h^{-1}.

percentage increase = ……..…………………….... % [3]

(d) A student commented that cars should be driven by electric motors rather than petrol or diesel engines so that pollution would be reduced. Comment on this statement.

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……………………………………………………………………………………………..

……………………………………………………………………………………........[3]

[Total: 20]

8 **(a)** State what is meant by *nuclear binding energy*.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………………… [2]

(b) The variation with nucleon number A of the binding energy per nucleon B_E is shown in Fig. 8.1.

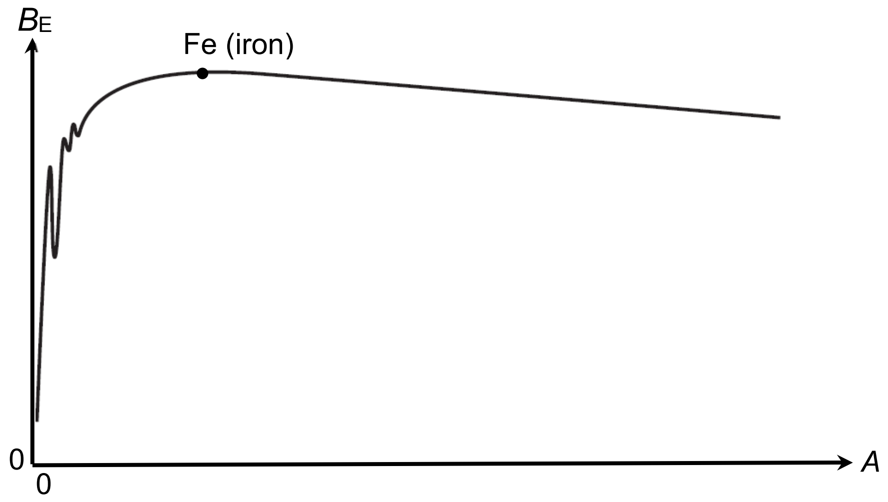

Fig. 8.1

When uranium-235 ($^{235}_{92}U$) absorbs a slow-moving neutron, one possible nuclear reaction is

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{95}_{42}Mo + ^{139}_{57}La + 2\,^{1}_{0}n + 7\,^{0}_{-1}\beta + \text{energy}$$

(i) State the name of this type of nuclear reaction.

……………………………………………………………………………………………………[1]

(ii) On Fig. 8.1, mark the position of

1. the uranium-235 nucleus (label this position U),

2. the molybdenum-95 ($^{95}_{42}Mo$) nucleus (label this position Mo),

3. the lanthanum-139 ($^{139}_{57}La$) nucleus ((label this position La). [2]

(iii) The masses of some particles and nuclei are given in Fig. 8.2.

	mass / u
β-particle	5.49×10^{-4}
neutron	1.00863
uranium-235	235.123
molybdenum-95	94.945
the lanthanum-139	138.955

Fig. 8.2

For this reaction,

1. show that the difference in rest mass is 0.21053 u.

[2]

2. calculate the energy released, in MeV. Give your answer to three significant figures.

energy = ……………………… MeV [2]

(c) A radiation detector is placed near to a radioactive source. The detector does not surround the source. Radiation is emitted in all directions and, as a result, the activity of the source and the measured count rate are different.

Suggest two other reasons why the activity and the measured count rate may be different.

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…………………………………………………………………………………………………

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………………………………………………………………………………………………... [2]

(d) The variation of the measured count rate in **(c)** with time *t* is shown in Fig. 8.3.

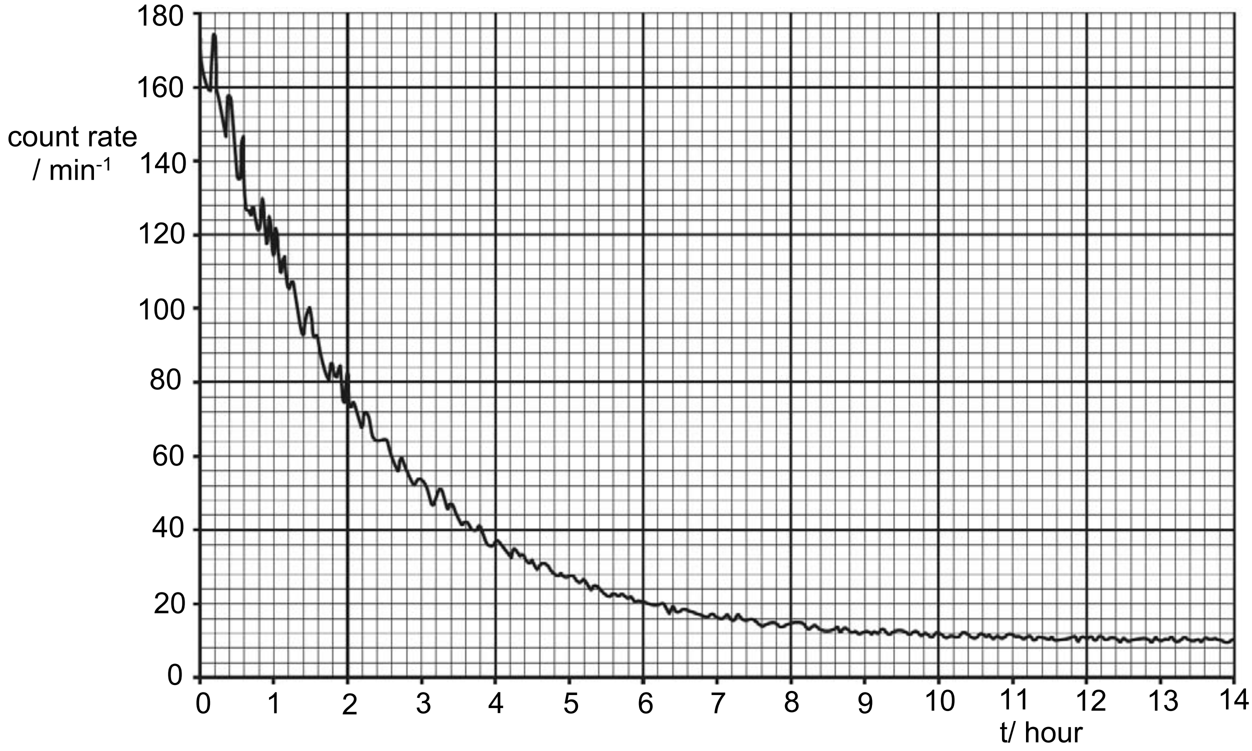

Fig. 8.3

(i) State the feature of Fig. 8.3 that indicates the random nature of radioactive decay.

…………………………………………………………………………………...................

………………………………………………………………………….……………..... [1]

(ii) Use Fig. 8.3 to determine the half-life of the radioactive isotope in the source.

half-life = ………………………. hours [4]

(e) **(i)** Distinguish between α, β and γ radiations in terms of their relative ionising and penetrating abilities.

……

……

……………………………………………………………………………………………………….[2]

(ii) Explain your answers in **(i)** with reference to the masses of the radiation particles.

……

……

……………………………………………………………………………………………………….[2]

[Total: 20]

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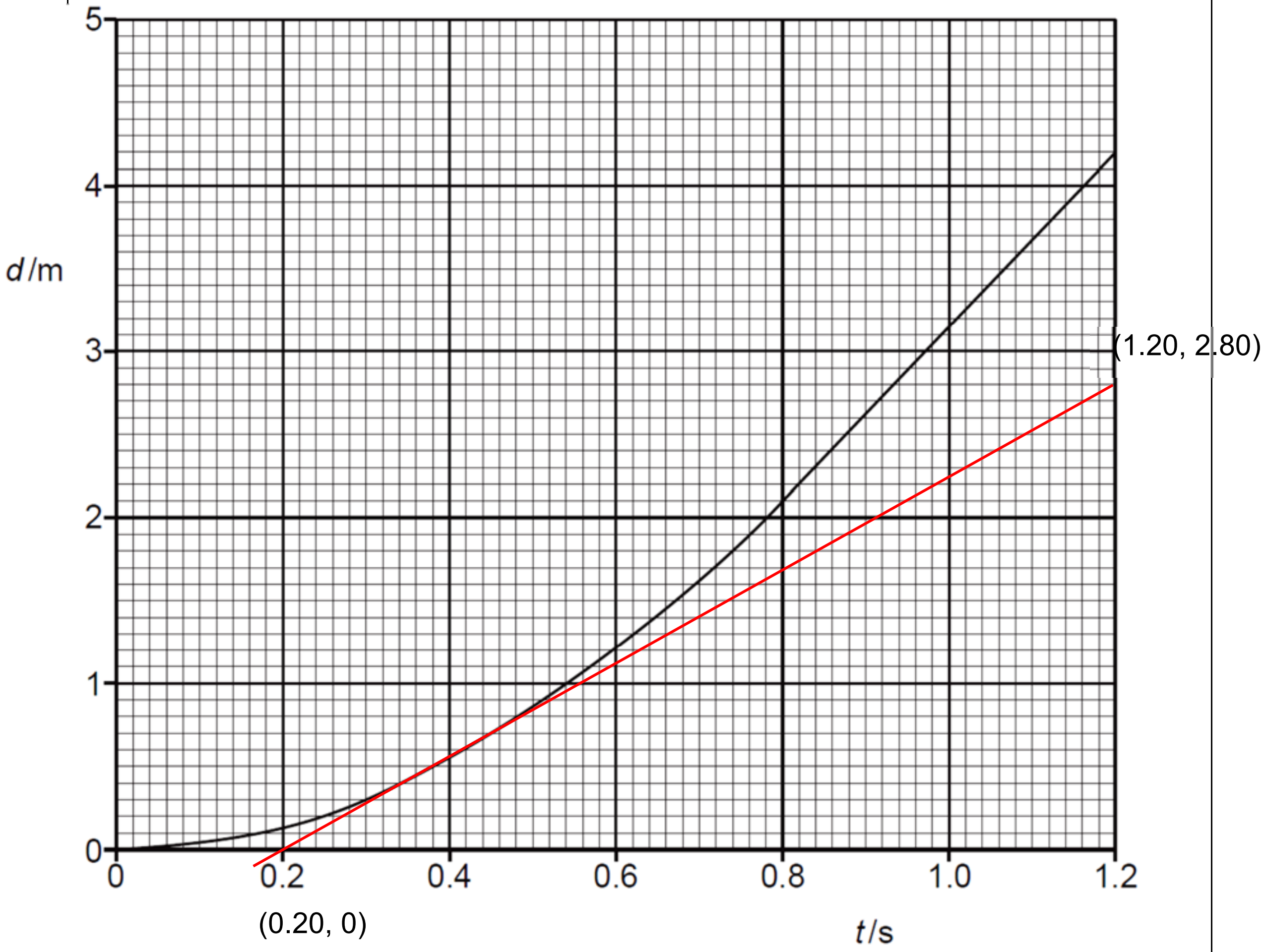
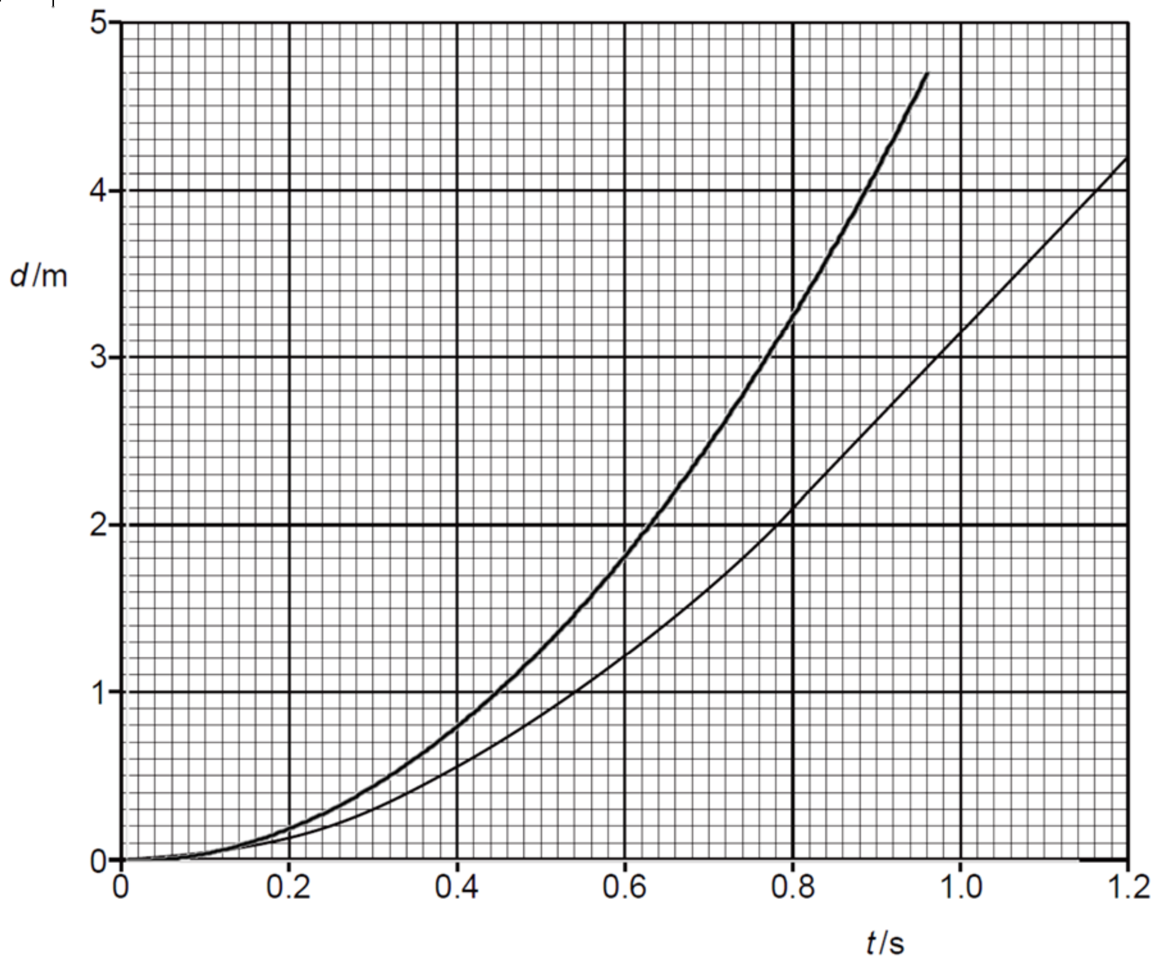
<u>2018 AJC Prelim Physics H1P2 Solutions</u>
Paper 2 (80 marks)

<table>
<tr><td>1a</td><td>The gradient of the graph is the speed or velocity,
And it becomes constant (from approximately 0.8 s onwards)</td><td>B1
B1</td></tr>
<tr><td>1b</td><td>

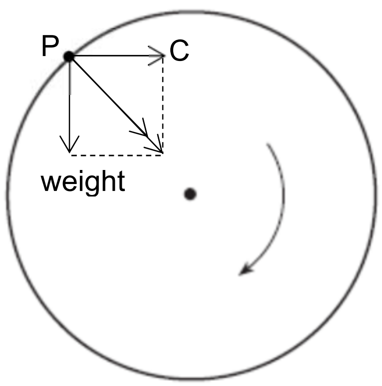


At t = 0.40 s, gradient = (2.80 – 0) / (1.20 – 0.20)
= 2.8
So, speed = 2.8 ms^{-1}

(allowed range is ± 0.1. if answer > ±0.1 but ≤ ±0.2, then award 1 mark)</td><td>M1
A1</td></tr>
</table>

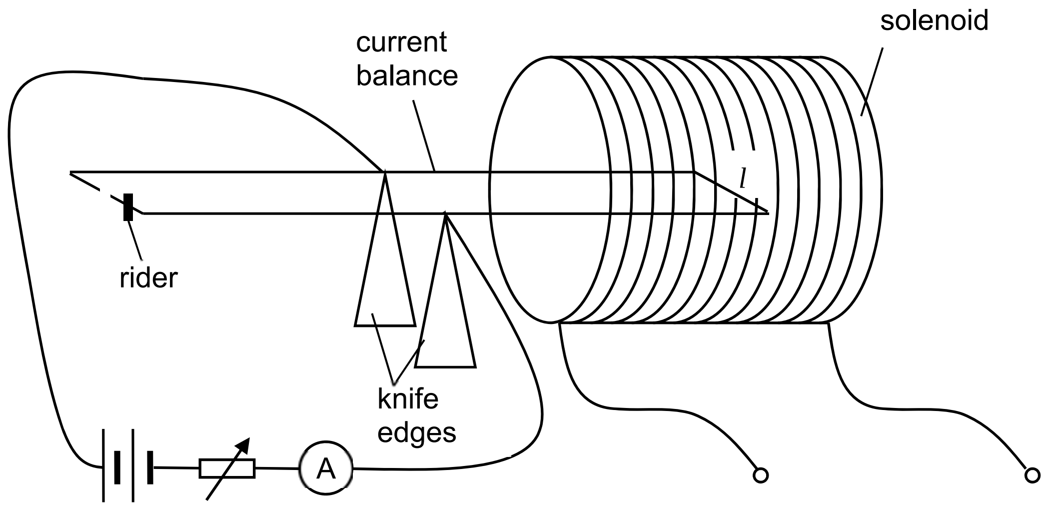
1cii		
	Continuous curve line starting from zero, with increasing gradient Curve line is smooth, always above the given line, never vertical or straight	M1 A1

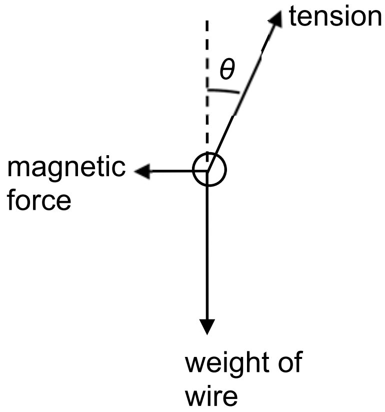
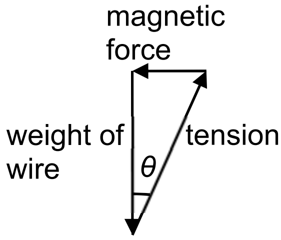
2a	As the mass falls from rest until the equilibrium position (*l* = 70.0 cm), gravitational potential energy is transformed into kinetic energy and elastic potential energy. From the equilibrium position to the lowest point, both gravitational potential energy and kinetic energy are converted into elastic potential energy. Note: Credit 1 mark if it is mentioned that GPE is transformed into EPE.	B1 B1
2b	At maximum KE or speed, resultant force = 0, so mass is at equilibrium position. From Fig. 2.2, for *M* = 450 g, *l* = 70.0 cm, so extension = 70.0 – 40.0 = 30.0 cm At equilibrium position, EPE = area under graph x g = ½(0.30)x(0.450)x9.81 = 0.662175 = 0.662 J Decrease in GPE = mgΔh = 0.450 x 9.81 x 0.300 = 1.324 J Decrease in GPE = increase in KE + increase in EPE Increase in KE = 1.324 – 0.662 = 0.662 J	 C1 C1 C1 A1

3a	$\omega = 2\pi\ (N/t)$ $= 2\pi\ (100/60)$ $= 10.472\ \text{rad s}^{-1}$ $F = mr\omega^2$ $= (3.8 \times 10^{-3})\ (0.118)\ (10.472)$ $= 4.9172$ $= 4.9 \times 10^{-2}\ \text{N}$	 M1 M1 A1
3b	 Arrow C must be equal length to weight and perpendicular to weight.	A1
3ci	Direction of weight and contact force is opposite to each other Contact force is the largest (at the lowest point) Centripetal force is upwards Therefore, plasticine is most likely to first lose contact with the disc at the lowest point of the revolution	M1 M1 M1 A0
3cii	At lowest point, $C_{max} - mg = mr\omega^2$ $0.23 - (3.8 \times 10^{-3})(9.81) = (3.8 \times 10^{-3})(0.118)\ \omega^2$ $\omega = 20.73 = 21\ \text{rad s}^{-1}$	 C1 A1

4ai	As V increases, the ratio of V to I increases.	B1
4aii	As *V* increases, power dissipation increases, which <u>increases</u> the <u>temperature</u> of the filament. The <u>amplitude</u> of vibration of <u>lattice ions/atomic core increases</u>, causing electrons to <u>collide more frequently</u> with the lattice ions/atomic core as they drift along the filament. Hence resistance increases.	B1 B1 B1
4bi	The effective resistance of the LDR and lamp is less than 10 Ω in daylight. Using the potential divider principle, potential difference across the lamp (and LDR) will be less than 6 V (or less than 4 V).	B1 B1
4bii	$R_{\text{lamp}} = \dfrac{V^2}{P_{\text{lamp}}} = \dfrac{6.0^2}{1.5} = 24\ \Omega$ For V across lamp to be 6 V, $R_{\text{effective}}$ of LDR and lamp = 20 Ω	C1

	$\frac{1}{R_{\text{effective}}} = \frac{1}{R_{\text{LDR}}} + \frac{1}{24}$ $\frac{1}{20} = \frac{1}{R_{\text{LDR}}} + \frac{1}{24}$ $R_{\text{LDR}} = 120\ \Omega$	C1 A1

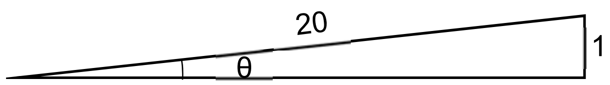
5a	One tesla is the magnetic flux density which causes a force per unit length of <u>one newton per metre</u> on a <u>straight</u> wire carrying a current of <u>one ampere</u> and is at <u>right angles</u> to the direction of the magnetic field.	B1 B1 B1
5b	 [Diagram to show current balance with one end inside the solenoid; circuit of current balance to include power supply and ammeter] Set up a current balance such that it is initially balanced horizontally on the knife edges (without any current or rider) Insert one end into the middle of the solenoid such that when a current ***I*** flows in the circuit, the magnetic force pushes the end of the current balance downwards. OR Diagram shows correct direction of current in the balance & solenoid such that magnetic force is acting downwards. Rider (of known mass) is added to the other side of the frame to restore the current balance to equilibrium position. When the frame is balanced, the magnetic force, ***F***, must be equal to the restoring weights ***W***. The magnetic flux density, ***B***, is then given by $$B = \frac{W}{I\,l}$$ where l is the length of the wire frame within the solenoid and that the distances from the knife edge to either end of the current balance are the same	B1 B1 B1 B1

5ci	Magnetic force on wire = BIL = $5.5 \times 10^{-3} \times 10 \times 1.20$ = 0.0660 N Weight of the wire = mg = $25 \times 10^{-3} \times 9.81$ = 0.24525 N  tan θ = 0.0660 / 0.24525 θ = 15.050 = 15 °	C1 C1 A1
5cii	To reverse the direction of the force - reverse the direction of the current - reverse the direction of the magnetic field	B1 B1

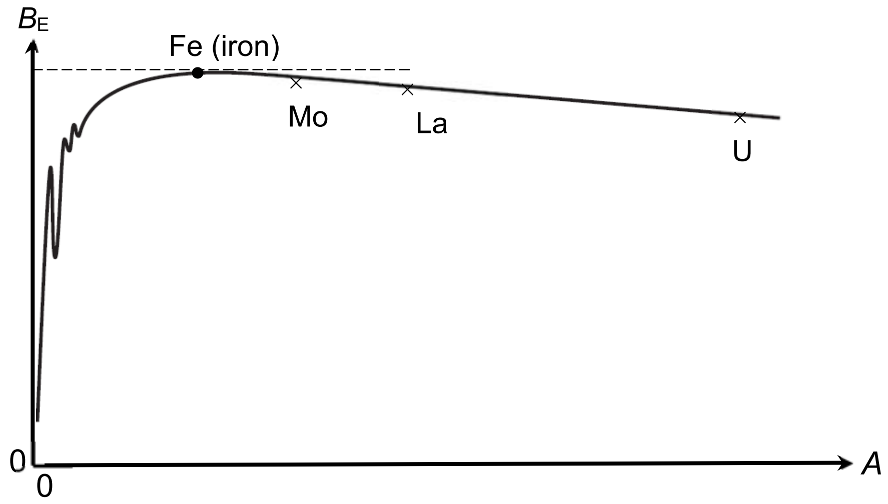
6ai	γ-radiation is <u>high energy</u> electromagnetic radiation emitted from decay of a radioactive nuclei.	B1 B1
6aii	To ensure that all γ-radiation would travel the same distance, *x* through the absorber.	A1
6aiii	The curve only reaches zero at very large values of *x*.	A1
6bi	$C_X / C_0 = e^{-\mu x}$, Taking ln on both sides, ln $(C_X / C_0) = -\mu x$ As Fig. 6.3 is a graph of ln (C_X / C_0) against *x* with a <u>straight line, negative gradient</u>, <u>passing through the origin,</u> it indicates a relationship $C_X / C_0 = e^{-\mu x}$.	B1 B1 B1
6bii	gradient = $-\mu$ gradient = -4.5 / 10 = -0.45 Hence, μ = 0.45 cm^{-1}	M1 A1
6ci	[units of μ_m] = [units of μ] / [units of ρ] = cm^{-1} / g cm^{-3} = g^{-1} cm^2	A1
6cii	For lead, μ = 0.45 cm^{-1} $\mu_m = \mu/\rho$ = 0.45 / 11.3 = 0.0398 = 0.040 cm^{-1}	A1

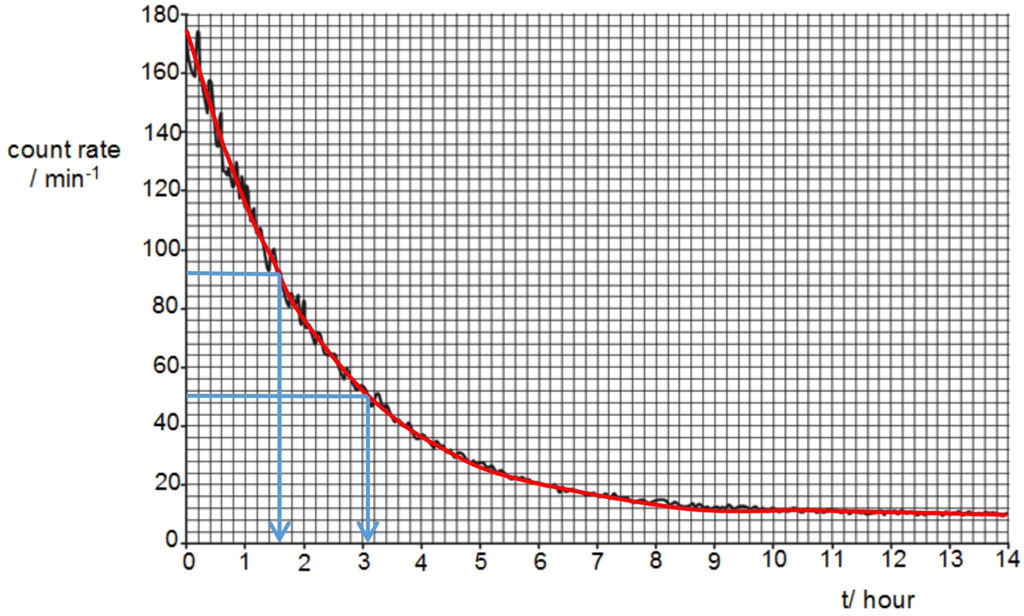
6di	average μ_m = (0.035 + 0.037 + 0.040) /3 = 0.037 g^{-1} cm^2	A1
6dii	For concrete, $\mu = \mu_m \rho$ = 0.037 × 2.4 × 10^3 × 10^3 / 100^3 = 0.0888 = 0.09 cm^{-1}	 M1 M1 A0
6diii	$C_X / C_0 = e^{-\mu x}$, For same shielding effect, value of C_X / C_0 is the same. Hence, value of μx must be the same. $(\mu x)_{concrete} = (\mu x)_{lead}$ (0.09) x = (0.45) (4.0) x = 20 cm OR From Fig. 6.2, when x = 4.0 cm, C_X / C_0 = 0.16 Using $C_X / C_0 = e^{-\mu x}$, ln $(C_X / C_0) = -\mu x$ ln 0.16 = -0.09 x x = 20 cm	 C1 A1 C1 A1
6div	1. Concrete is cheaper OR more available than lead. 2. Concrete is a stronger material than lead OR Concrete is a better choice as a construction material than lead. 3. Lead is toxic as compared to concrete.	B1 B1

7ai	As the car moves, there are <u>drag forces/ air resistance/ resistive forces</u> acting on the car. Power must be continuously supplied to the car as the <u>work done</u> by the drag forces/ air resistance/ resistive forces will remove energy from the car.	B1 B1
7aii	Drag forces/ air resistance/ resistive forces <u>increases</u> with speed of the car At higher constant speed, there is <u>greater work done</u> against drag forces/ air resistance/ resistive forces hence, higher power is required Note: do not give full credit to students who use $P = Fv$ and reasoned that P will increase since v is increased without addressing what happens to F (driving force).	B1 M1 A0
7bi	Since the car is at constant speed, total resistive force = $F_{driving}$ v = 90 × (1000 / 3600) = 25 m s^{-1} Effective power = $F_{driving}$ × v 22 × 10^3 = (total resistive force) × 25 total resistive force = 880 N	B1 C1 A1
7bii	1. Rate of fuel consumption when travelling at 90 km h^{-1} = (8.4 / 100) × 90 = 7.56 litres h^{-1} Total power supplied to the car = energy per litre of fuel × rate of fuel consumption = 3.4 × 10^7 × 7.56 / 3600 = 71.4 kW	 M1 A0

	2. efficiency = effective power/ total power supplied = 22/71.4 = 0.30812 = 0.31	 C1 A1
7biii	When the car makes a horizontal circle, the centripetal (resultant) force acts perpendicular to the direction of motion. Hence, there is no additional work done and the effective power required remains unchanged.	M1 A1
7ci	When travelling up a slope, there is an increase in gravitational potential energy of the car. Hence, more power must be delivered as some of this power is <u>converted</u> into the gain in gravitational potential energy of the car. OR There is a component of the weight force	M1 A1
7cii	distance travelled by the car per second is 25 m (from v calculated in bi) gain in height per second = 25/20 $\times$ 1 = 1.25 m gain in gravitational potential energy per second = 950 $\times$ 9.81 $\times$ 1.25 = 11649 J % increase in power output = 11649 / 22000 $\times$ 100% = 53 % OR  Additional power = W $\times$ v sin θ = mg v sin θ = 950 x 9.81 x 25 x (1/20) = 11649 W % increase in power output = 11649 / 22000 $\times$ 100% = 53 %	 C1 C1 A1 C1 C1 A1
7d	Electric cars produce less pollution at the location at which the car is being used. However, electric cars still require electrical energy which has to be generated. From the production of the electrical energy, there is pollution at the power plant. Any other reasonable comments.	B1 B1 B1

8a	energy required to separate the nucleus into individual protons and neutrons. OR energy released when a nucleus is formed from its constituent particles (protons and neutrons).	B1 B1

8bi	Nuclear fission	B1
8bii	 Positions of all 3 points are marked and labelled correctly (in terms of arrangement) Relative position from Fe (56) of each point is correct	 M1 A1
8biii 1.	Total mass L.H.S = 235.123 u + 1.00863 u = 236.13163 u Total mass R.H.S = 94.945 u + 138.955 u + 2(1.00863 u) + 7(5.49×10^{-4})u = 235.921103 u Change in mass = 236.13163 u – 235.921103 u = 0.210527 u = 0.21053 u	 M1 M1
8biii 2.	$E = (\Delta m)c^2$ $= [0.21053\,(1.66 \times 10^{-27}) \times (3.00 \times 10^{8})^2] \div (1.6 \times 10^{-19})$ $= [3.14532 \times 10^{-11}] \div (1.6 \times 10^{-19})$ = 196582500 = 197 MeV	 C1 A1
8c	Background radiation (in measured count rate) Emission from radioactive daughter nucleus Absorption of some radiation in air before reaching detector Detector may absorb some radiation Any two of the above points.	A1
8di	Curve is not smooth or curve fluctuates or curve is jagged	A1

8dii	 Background radiation = 10 count rate / min^{-1} At t = 0 hr, count rate due to source = 174 – 10 = 164 After 1 half-life, count rate (including background) = 164/2 + 10 = 92 From Fig. 8.3, t = 1.6 After 2 half-lives, count rate (including background) = 164/4 + 10 = 51 From Fig. 8.3, t = 3.1 Half-life = [1.6 + (3.1 – 1.6)] ÷ 2 = 1.55 hour 1 mark if the answer is between 1.7 and 2 hours. 2 marks if the answer is between 1.4 and 1.6 hours.	B1 M1 A2
8ei	α is most ionising and γ the least. γ is the most penetrating and α the least.	B1 B1
8eii	γ is the least massive (as its rest mass is zero) Thus it interacts the least with matter and thus loses the least amount of energy during its travel As a result, it is least ionising and hence most penetrating.	M1 M1 A0