TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME	( )
CIVICS GROUP	

H1 PHYSICS 8867/02

Paper 2: Structured Questions **11 September 2024**
2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

For Examiner's Use		Percentage
Subtotal P1	/30	/ 33
Paper 2		
1	/ 10	
2	/ 15	
3	/ 10	
4	/ 10	
5	/ 15	
6	/ 20	
7	/ 20	
Deductions		
Subtotal P2	/ 80	/ 67
Grand total		/ 100

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group in the spaces at the top of the page.
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 staples, 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 **one** question only.

The number of marks is given in brackets [ ] at the end of each question or part question.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
elementary charge	e	=	1.60×10^{-19} C
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
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-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	=	$u^2 + 2as$
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** questions in this section in the spaces provided.

1 Fig.1.1 shows an elongated block with a square cross sectional area of a particular conducting material.

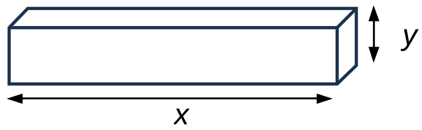

Fig. 1.1

The rate of thermal energy transfer with respect to time, q, through the block is given by

$$q = py^2\left(\frac{T}{x}\right)$$

where p is the conductivity of the material;
y is the length of the square cross-sectional area of the material;
T is the temperature difference between the two ends of the material;
and x is the length of the block.

Fig. 1.2 shows the data obtained in a particular experiment.

quantity	value	percentage uncertainty
T	323 K	± 0.50%
x	1.00 m	± 1.0%
p	237 W m^{-1} K^{-1}	± 2.0%
y	0.200 cm	± 3.0%

Fig. 1.2

(a) Determine the SI base units of p.

SI base units of p = ………………… [2]

(b) Using the values given in Fig. 1.2,

(i) determine the value of q, to three significant figures.

q = ………………… W [2]

(ii) determine the percentage uncertainty of q.

percentage uncertainty of q = …………………% [2]

(c) Use your answer in **(b)** to determine the actual uncertainty in the value of q.

Hence give a statement of q, with its uncertainty, to an appropriate number of significant figures.

q = …………………± …………………W [2]

(d) The accepted value of q is 0.29 W.

State and explain whether your value in **(c)** is accurate.

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

2 A compressible ball of mass 0.50 kg is released from rest at time t = 0 s and falls freely. It hits the ground after falling downwards for 2.0 s. Take the sign convention of up as positive.

(a) **(i)** State the acceleration of the ball during the fall.

acceleration = ………………… m s^{-2} [1]

(ii) Show that the velocity of the ball just before it hits the ground is −20 m s^{-1}.

[1]

(iii) Calculate the magnitude of the impulse on the ball from t = 0 s to t = 2.0 s.

magnitude of impulse = ………………… N s [2]

When the ball hits the ground, it stays on the ground for 3.0 s (from t = 2.0 s to 5.0 s) before rebounding. Fig. 2.1 shows how the resultant force F_R on the ball varies with time t.

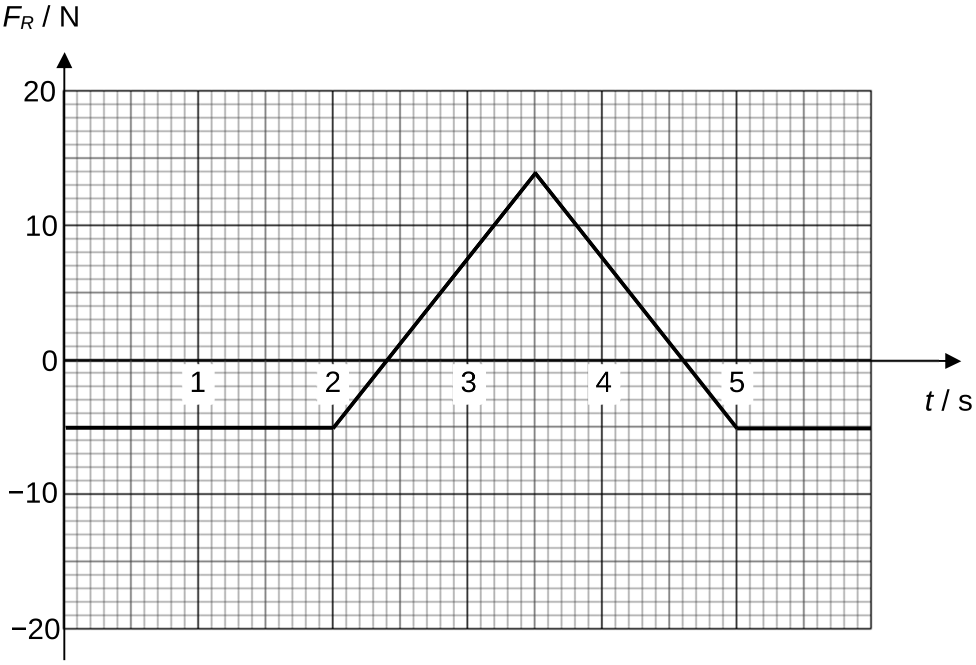

Fig. 2.1

(b) **(i)** Explain why at t = 2.4 s the ball reaches its maximum speed.

……………………………………………………………………………………..

…………………………………………………………………………………… [1]

(ii) Use Fig. 2.1 to show that the maximum speed at t = 2.4 s is 22 m s^{-1}.

[2]

(iii) Determine the maximum acceleration of the ball.

maximum acceleration = ………………… m s^{-2} [2]

Fig. 2.2 shows the variation with time t of velocity v of the ball from t = 2.0 s to 6.0 s.

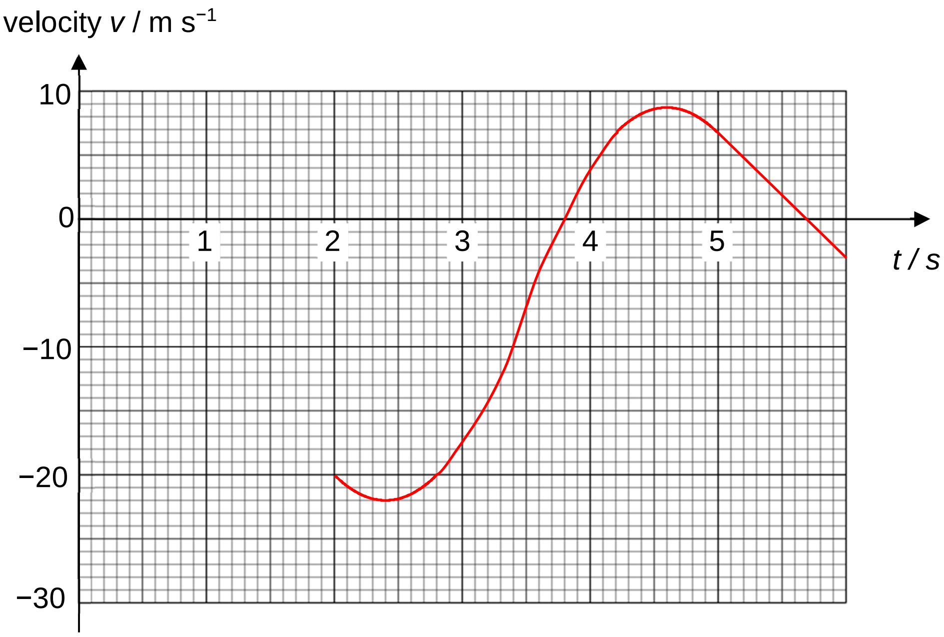

Fig. 2.2

(c) **(i)** On Fig. 2.2, complete the sketch by drawing the graph from t = 0 s to 2.0 s.

[1]

(ii) Describe how the speed of the ball changes from t = 2.0 s (when the ball first hits the ground) to t = 3.8 s.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………… [2]

(iii) Mark and label the point X where the ball reaches its maximum height after the bounce.

[1]

(iv) State and explain whether the collision is elastic.

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………… [2]

3 **(a)** A small metal sphere has a mass of 1.0×10^{-4} kg and charge +2.0 nC. It is placed between two parallel, oppositely-charged horizontal plates and directly above an insulated spring as shown in Fig. 3.1. The electric field strength is 1.5×10^{5} V m^{-1}.

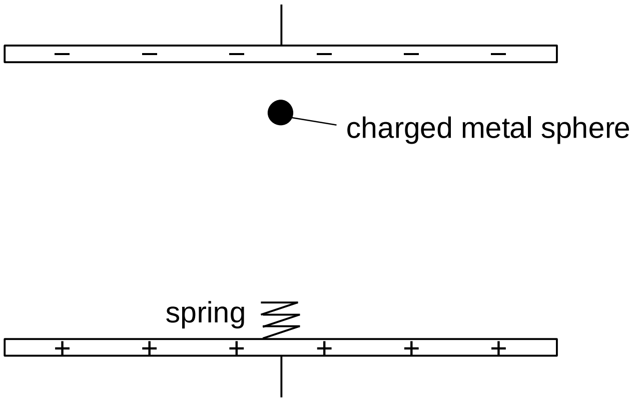

Fig. 3.1

(i) Determine the magnitude and direction of the electric force on the sphere.

magnitude of electric force = ………………… N

direction = …………………… [3]

The sphere is released from rest at a height of 0.50 m above the spring.

Air resistance is negligible.

(ii) Describe the changes in the energies of the sphere as it falls before hitting the spring.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………… [2]

(iii) The sphere hits the spring and causes a maximum compression of 0.015 m.

Determine the spring constant.

spring constant = ……………… N m^{-1} [3]

(b) The sphere is now removed from the electric field and projected at an angle of 30° to the horizontal as shown in Fig. 3.2. Air resistance is negligible.

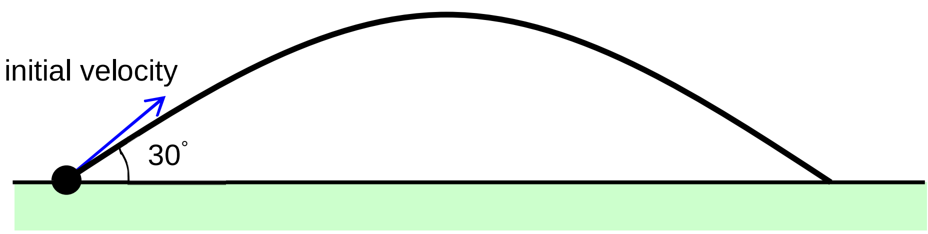

Fig. 3.2

Fig. 3.3 shows the variation with time of the total energy E_T and gravitational potential energy E_P of the sphere.

On Fig. 3.3, sketch the corresponding kinetic energy graph and label it E_K.

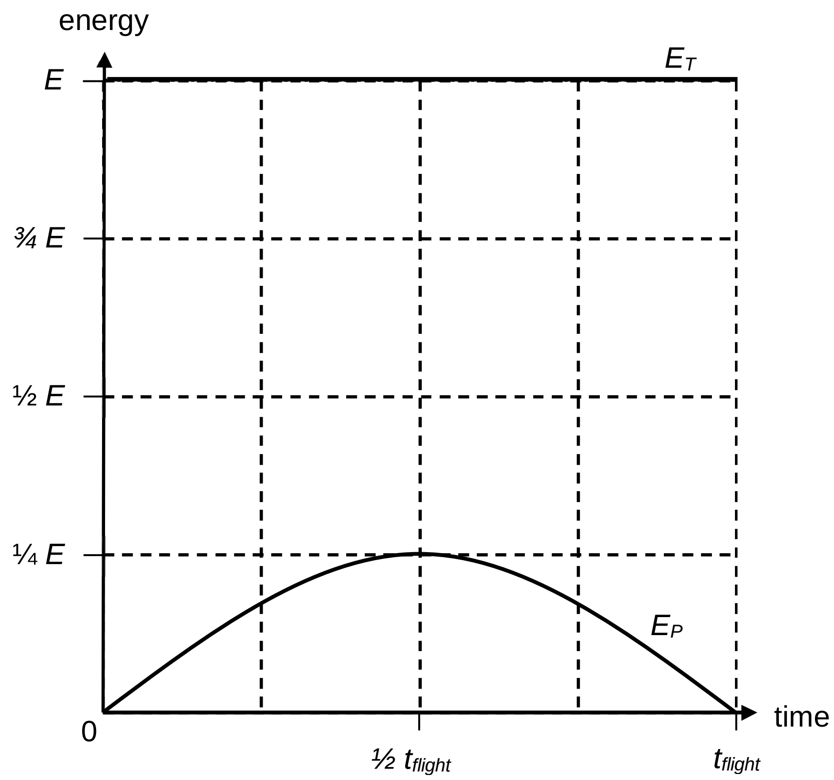

Fig. 3.3

[2]

4 Stars like our sun radiate energy into space due to nuclear fusion. One nuclear fusion reaction that takes place in stars is given below.

$$^{3}_{2}\mathrm{He} + ^{3}_{2}\mathrm{He} \rightarrow ^{4}_{2}\mathrm{He} + x\,^{1}_{1}\mathrm{H} + \gamma$$

(a) State the value of *x* for the nuclear fusion reaction.

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

(b) The masses of the nuclides involved in the nuclear fusion reaction above are provided in Fig. 4.1.

nuclide	mass / u
$^{3}_{2}\mathrm{He}$	3.0149322
$^{4}_{2}\mathrm{He}$	4.0015061
$^{1}_{1}\mathrm{H}$	1.0072765

Fig. 4.1

Calculate the energy released in the nuclear fusion reaction.

energy released = …………………………… J [2]

(c) Certain massive stars fuse hydrogen and helium into heavier elements such as carbon and oxygen. The stars then continue to fuse these elements into even heavier elements such as neon, magnesium, silicon and so on. Eventually, iron is produced and that is where the fusion chain will stop.

With reference to the binding energy per nucleon of iron, explain why the fusion chain in these massive stars does not progress past iron.

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

(d) A certain star of radius *R* and mass *M* was observed to rotate about its axis with an angular velocity ω as shown in Fig. 4.2.

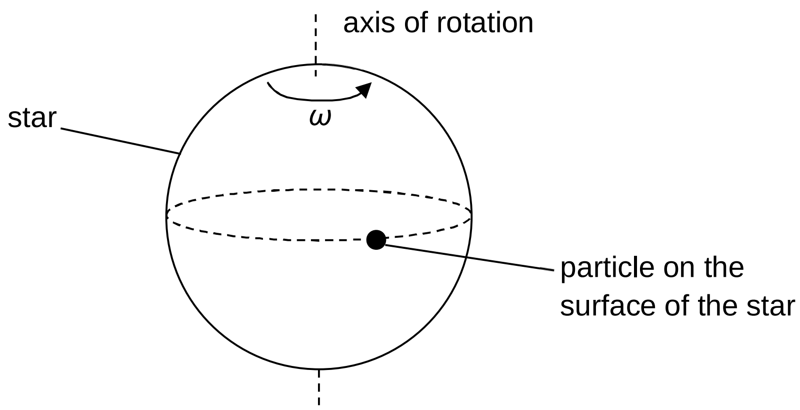

Fig. 4.2

(i) A particle on the surface of the star at its equator rotates together with the star. If the star's angular velocity was too high, the particle would not be able to remain on the surface.

Show that for the particle to remain on the surface of the star,

$$\omega^2 \leq \frac{GM}{R^3}$$

Explain your working.

[2]

(ii) The star was measured to have a mass of 2.0×10^{30} kg and rotates about its axis at the rate of one revolution every 27 days.

Calculate the maximum radius of the star.

radius =………………………………..m [3]

5 **(a)** In the study of Physics, when an object is subjected to force(s), the object may move in different paths e.g. linear, parabolic, circular, or helical path.

(i) State Newton's second law of motion.

……………………………………………………………………………………..

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……………………………………………………………………………………..

…………………………………………………………………………………… [2]

(ii) Fig. 5.1 shows a positively charged particle moving in a helical path within a magnetic field.

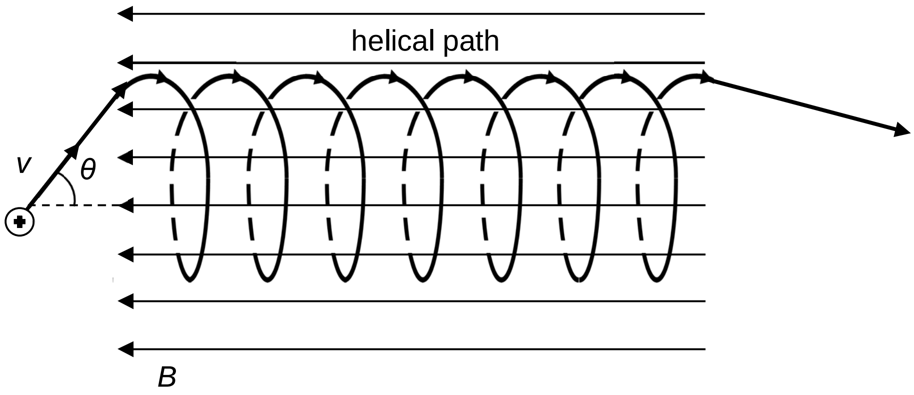

Fig. 5.1

Explain how the charge particle moves in a helical path.

……………………………………………………………………………………..

……………………………………………………………………………………..

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…………………………………………………………………………………… [2]

(b) In a football academy, students are shown Fig. 5.2, the parabolic path of a ball in a gravitational field.

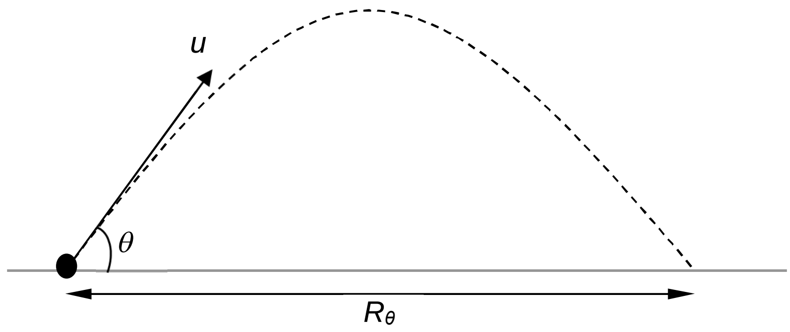


Fig. 5.2

Students are taught that, in the absence of air resistance, when a ball is kicked with an initial velocity of u at an angle θ to the horizontal, it would land at a horizontal range R_θ at the same ground level by the equation:

$$R_\theta = \frac{u^2 \sin 2\theta}{g}$$

where R_θ is the horizontal distance the ball landed when being kicked at angle θ.

A set of data is collated in Fig. 5.3 to plot the graphs in Fig. 5.4 of R_θ against u^2.

u / m s^{-1}	u^2 / m^2 s^{-2}	R_{15} / m	R_{20} / m	R_{25} / m
13.0	169	8.61	11.1	13.2
14.0	196	10.0	12.8	15.3
15.0	225	11.5	14.7	
16.0	256	13.0	16.8	20.0
17.0	289	14.7	18.9	
18.0	324	16.5	21.2	25.3

Fig. 5.3

(i) Complete Fig. 5.3 by calculating the unknown R_{25} values. [1]

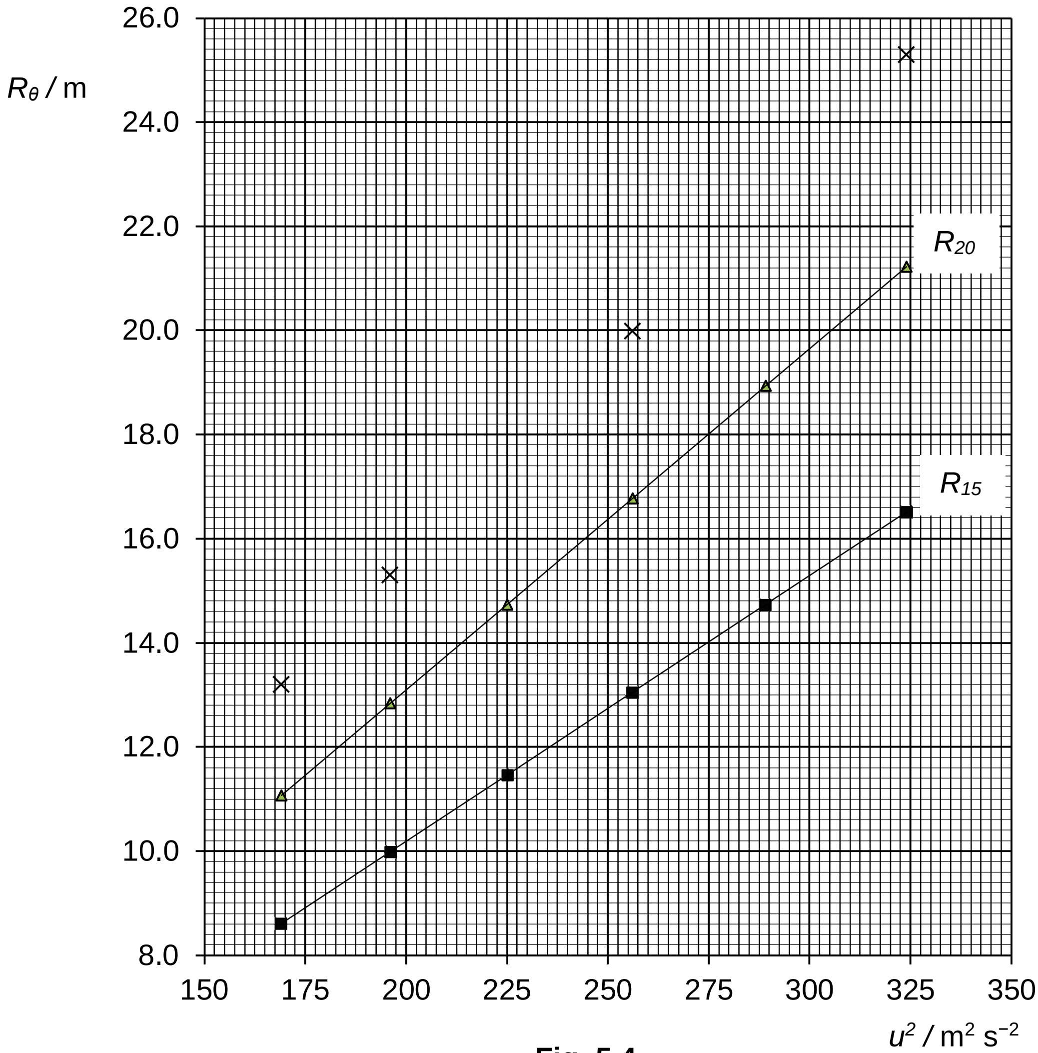


Fig. 5.4

(ii) Use values from Fig. 5.3 to complete the graph in Fig. 5.4 and add a line of best fit for the ball being kicked at an angle of 25° to the horizontal. Label the line R_{25}.

[2]

(iii) Use your line of best fit to estimate the value of R_{25} when the ball is kicked at a velocity of 15.5 m s^{-1}.

R_{25} = ………………… m [2]

(iv) The mass of the ball is 430 g. The kicker's foot is in contact with the stationary ball for 8.0 ms before the ball leaves the kicker's foot at the speed of 15.5 m s^{-1}.

Determine the average force applied.

average force = ………………… N [3]

(v) A student kicks a ball such that it has an initial horizontal speed of 15.5 m s^{-1} from the top of a cliff of height 15 m as shown in Fig. 5.5.

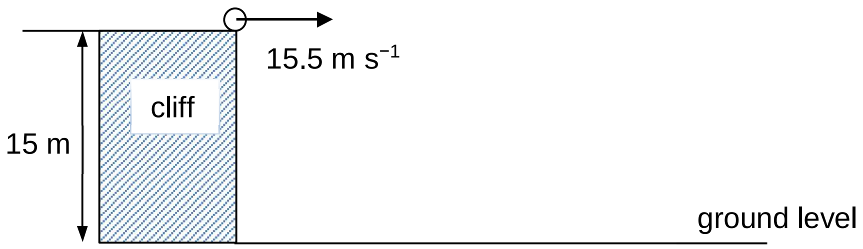


Fig. 5.5

Calculate the speed of the ball just before it touches the ground level.

speed = ………………… m s^{-1} [3]

Section B

Answer **one** question from this Section in the spaces provided.

6 **(a)** A Negative Temperature Coefficient (NTC) thermistor of resistance R_t, together with a fixed resistor of resistance R of 2000 Ω and a cell of E = 10.0 V is connected in a circuit as shown below in Fig. 6.1.

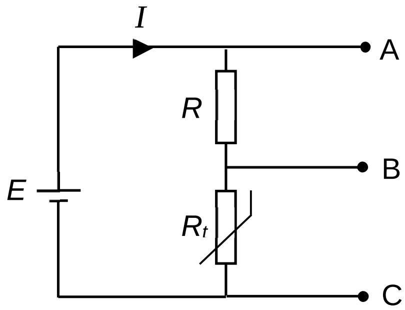


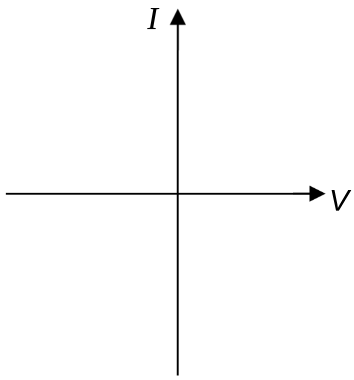
Fig. 6.1

(i) Define the resistance of a resistor.

…………………………………………………………………………………………..

……………………………………………………………………………………… [1]

(ii) Sketch the I-V characteristics of the NTC thermistor.



[1]

(iii) The resistance of the NTC thermistor decreases when temperature increases. Explain why.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

……………………………………………………………………………………… [2]

(iv) At θ = 25 ºC, R_t is 3000 Ω.

Calculate the potential difference V_R across the fixed resistor R.

V_R = ………………… V [2]

(v) The circuit in Fig. 6.1 can be used in a fire alarm which will be triggered to turn on when the voltage connected to it is sufficiently high.

Explain whether the fire alarm should be connected across AB or BC so that fire alarm will be triggered in the case of a fire.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………… [2]

(vi) The thermistor in the circuit in Fig. 6.1 is now replaced by a filament lamp.

State and explain how the voltage across AB changes when the temperature increases.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………… [2]

(b) A cell is labelled “9.0 V, 0.450 A h”. This may be assumed to mean that the cell has an e.m.f. of 9.0 V, and will supply a current of 0.450 A for one hour before running out of energy.

It is found that a steady current of 0.450 A flows when an 18 Ω resistor is connected across the cell terminals as shown in Fig. 6.2. You can assume that the ammeter in the circuit is ideal.

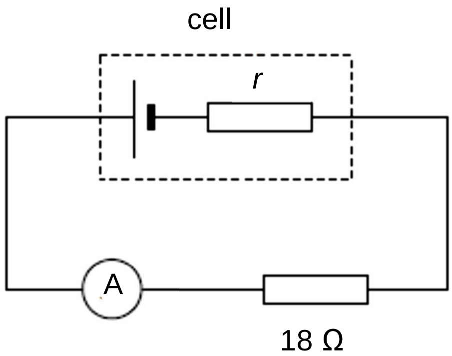


Fig. 6.2

(i) Calculate the cell’s internal resistance, *r*.

r = ………………………… Ω [2]

(ii) Calculate the total charge, *Q* that will flow if the resistor is left connected until the cell has run out of energy.

Q = ………………………… C [2]

(iii) Calculate the total energy generated by the cell before it runs out.

total energy = ………………………… J [2]

(iv) Calculate the rate of heat generated in the 18 Ω resistor.

rate of heat generated = ………………………… W [2]

(v) Suppose that a resistor of higher resistance had been used instead of the 18 Ω resistor, so that the current was 0.225 A, calculate the resistance of this new resistor.

resistance of new resistor = ………………………… Ω [2]

7 **(a)** A particle with mass m, charge $-q$ and speed v is entering perpendicularly into three different uniform fields pointing **into the plane of the paper**.

For each field, state the property of the particle that the field acts on and describe the motion of the particle in the field. You may sketch diagrams to illustrate your answer.

(i) gravitational field

…………………………………………………………………………………………

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

(ii) electric field

…………………………………………………………………………………………

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

(iii) magnetic field

…………………………………………………………………………………………

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

(b) A long straight wire AB carrying current I_1 is placed horizontally as shown in Fig. 7.1. Directly above the wire is conductor YZ that can slide freely along two vertical rods that are frictionless.

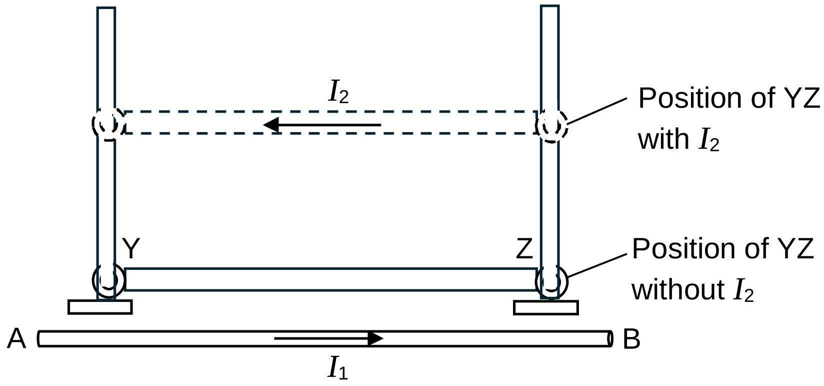


Fig. 7.1

When a current I_2 is passed through the conductor in the direction from Z to Y, the conductor is seen to slide upwards before coming to a rest at a certain height above its original position.

(i) Explain why the conductor YZ slides upwards initially when the current I_2 is passed through it.

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………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………… [2]

(ii) Explain why the conductor comes to a rest when it reaches a certain height above its original position.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………… [2]

(c) Fig. 7.2 shows a plan view of a cyclotron, which is a device used to accelerate charged particles to high speeds. Protons are emitted between two semicircular discs called dees.

A uniform magnetic field is applied within the dees to cause the protons to move in a circular path. In between the dees there is a rapidly changing electric field applied that attracts the proton to the opposite dee.

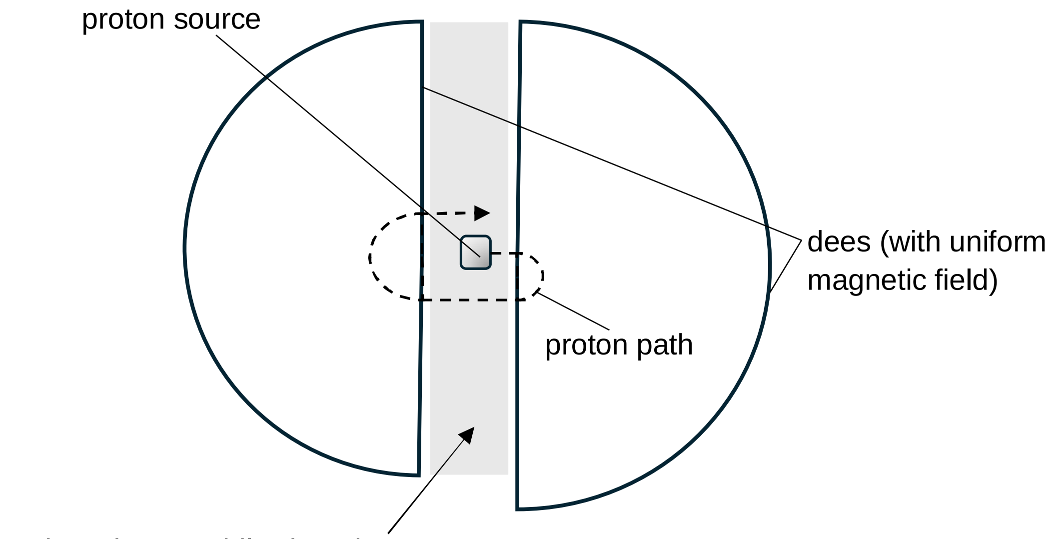

Fig. 7.2

(i) State the direction of the magnetic field in the dees.

…………………………………………………………………………………… [1]

(ii) Show that the time taken for a proton to enter and leave the semicircular dee is given by the expression:

$$t_D = \frac{\pi m}{Bq}$$

where m is the proton mass m, B is the magnetic flux density acting on the proton and q is the charge of the proton.

[3]

(iii) State the effects of the magnetic field and electric field separately on the speed of the proton.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

(iv) State the expression for the time interval between the change in direction of the electric field.

…………………………………………………………………………………… [1]

(v) The proton source in Fig. 6.1 is now replaced by another source that emits particles that have the same mass as a proton but are oppositely charged.

State and explain the effect, if any, on the path and the value of t_D in **(b)** when **it first enters** the magnetic field compared to that of a proton.

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…………………………………………………………………………………… [3]

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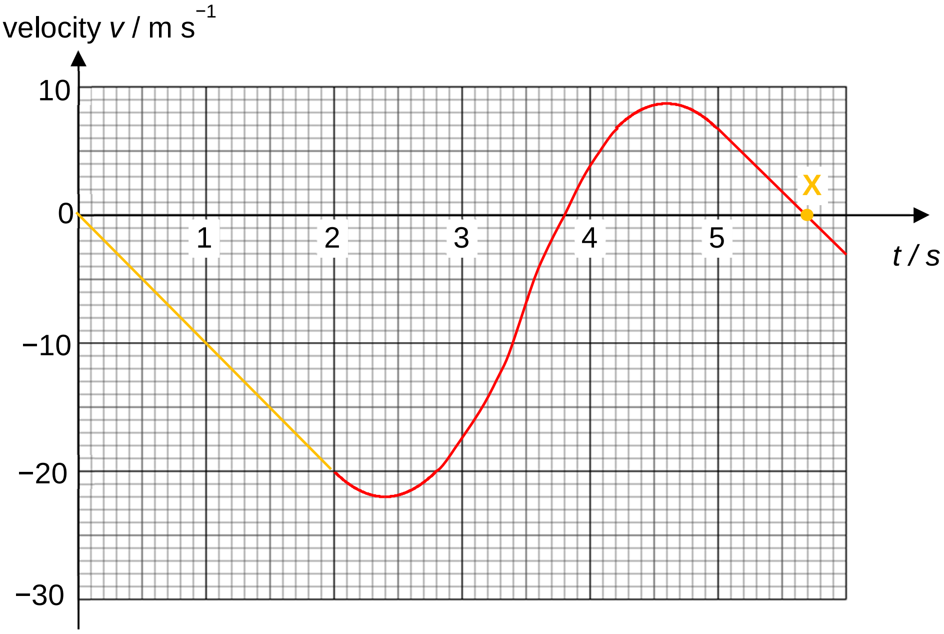
Tampines Meridian Junior College

2024 JC2 H1 Physics Preliminary Exam Paper 2 – Suggested Solution

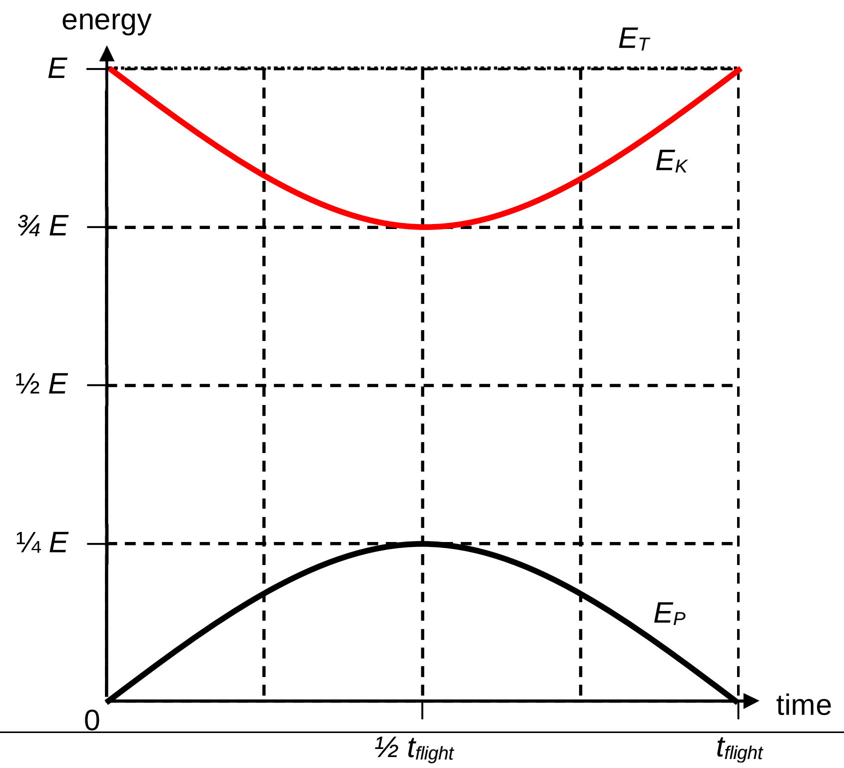
1	**(a)**		$W = J\ s^{-1} = kg\ m^2\ s^{-3}$ SI base units of $p = \dfrac{kg\ m^2\ s^{-3}}{m\ K}$ $= kg\ m\ s^{-3}\ K^{-1}$	C1 A1
	(b)	**(i)**	$q = py^2\left(\dfrac{T}{x}\right)$ $= (237)(0.0020)^2(\dfrac{323}{1.0})$ $= 0.306$	C1 A1
		(ii)	$\dfrac{\Delta q}{q} x100\% = \left(\dfrac{\Delta p}{p} + 2\dfrac{\Delta y}{y} + \dfrac{\Delta T}{T} + \dfrac{\Delta x}{x}\right) x100\%$ $= 2.0 + (2x3.0) + 0.5 + 1.0$ $= 9.5\%$	C1 A1
	(c)		$\Delta q = \dfrac{9.5}{100}(0.306)$ $= 0.03$ q = 0.31 ± 0.03 (with correct s.f. and d.p)	B1 A1
	(d)		Since accepted value of q = 0.29 W lies within the range of q values from **(c)**, answer in (c) is accurate.	M1 A1

2	**(a)**	**(i)**	−9.81 m s^{-2}	A1
		(ii)	$v = u + at$ = 0 + (−9.81) (2.0)	M1
			= −19.6 = −20 m s^{-1} (2 s.f.)	A0
		(iii)	impulse = change in momentum = $mv − mu$ = 0.50 × (−20) − 0 or impulse = force × time = (0.50)(−9.81) × 2.0	C1
			= −10 N s, magnitude = 10 N s	A1
	(b)	**(i)**	at 2.4 s, the net force is zero (and acceleration is zero)	A1
		(ii)	change in momentum = area under graph (= −10 − ½ (0.4)(5) = −11)	C1
			$mv − mu$ = −11 ⇒ 0.50v − 0 = −11 ⇒ v = (−)22	M1
			max speed = 22 m s^{-1}	A0
		(iii)	max acceleration = F/m = 14/0.50 = 28 m s^{-2}	M1 A1

	(c)	 **Fig. 2.2**		
		(i)	straight line from (0, 0) to (2, −20)	B1
		(ii)	The speed increases to maximum (at t = 2.4 s, at decreasing rate)	B1
			then decreases to zero (at increasing rate till t = 3.5 s, then decreasing)	B1
		(iii)	X at horizontal-intercept at t = 5.7 s	B1
		(iv)	speed before collision (20 m/s) > speed after collision (6.8 m/s	M1
			so not elastic	A1

3	**(a)**	**(i)**	F = q E = $(2.0 \times 10^{-9})(1.5 \times 10^{5})$ F = 3.0×10^{-4} N direction: upwards	M1 A1 B1
		(ii)	Loss in gravitational potential energy Gain in kinetic energy and electric potential energy (or work done against electric field).	B1 B1
		(iii)	Loss in gravitational potential energy $= m\,g\,(h + x)$ Gain in elastic potential energy and electric potential energy $= ½\,k\,x^2 + F_E\,(h + x)$ By conservation of energy, $m\,g\,(h + x) = ½\,k\,x^2 + F_E\,(h + x)$ $(1.0 \times 10^{-4})(9.81)(0.515) = ½\,k\,(0.015)^2 + (3.0 \times 10^{-4})(0.515)$ $k = 3.12$ N m^{-1}	C1 C1 A1

	(b)	Correct shape [B1] Symmetrical and correct energy values at the t = 0, ½ t_{flight} and t_{flight} [B1]	



4	**(a)**	x = 2	A1
	(b)	mass difference = 2 x 3.0149322 u – 4.0015061 u – 2 x 1.0072765 u = 0.0138053 u energy released = 0.0138053 x 1.66 x 10^{-27} x (3 x 10^{8})^2 = 2.062 x 10^{-12} J = 2.06 x 10^{-12} J (3 s.f.)	C1 A1
	(c)	Iron has the <u>highest binding energy per nucleon</u> of any element Hence, the <u>fusion of iron</u> into heavier elements <u>requires the input of energy</u>, which makes it unlikely to occur spontaneously.	B1 B1
	(di)	Gravitational force provides for centripetal force or Gravitational force must be greater than the required centripetal force $\frac{GMm}{R^2} \geq mR\omega^2$ $\omega^2 \leq \frac{GM}{R^3}$	 C1 M1 A0

	(dii)	$R^3 \leq \dfrac{GM}{\omega^2}$ $\omega = \dfrac{2\pi}{27 \times 24 \times 3600} = 2.693 \times 10^{-6}$ rad s^{-1} $R \leq \sqrt[3]{\dfrac{6.67 \times 10^{-11} \times 2.0 \times 10^{30}}{\left(2.693 \times 10^{-6}\right)^2}}$ $R \leq 2.64 \times 10^{10}$ m	C1 M1 A1

5	**(a)**	**(i)**	Newton's 2nd law of motion states that the rate of change of momentum of a body is directly proportional to the resultant force acting on it, [B1] the change takes place in the direction of resultant force. [B1]
		(ii)	<u>Horizontal component of velocity</u> (parallel to B field), $v_x = v \cos \theta$ *Effect of velocity:* Component of velocity unaffected by the magnetic field hence particle will continue in motion parallel to the magnetic field (no net force horizontally) [B1] <u>Vertical component of velocity</u> (perpendicular to B field), $v_y = v \sin \theta$ *Effect of velocity:* Component of velocity perpendicular to field results in a circular path in the plane normal to the axis (magnetic force provides for centripetal force) [B1] Combined effect of both components of velocity results in a helical path. [A0]
	(b)	**(i)** [B1] Correct values shown in red.	

u / m s^{-1}	u^2 / m^2 s^{-2}	R_{15} / m	R_{20} / m	R_{25} / m
13.0	169	8.61	11.1	13.2
14.0	196	10.0	12.8	15.3
15.0	225	11.5	14.7	17.6
16.0	256	13.0	16.8	20.0
17.0	289	14.7	18.9	22.6
18.0	324	16.5	21.2	25.3

Fig. 5.3

(ii)

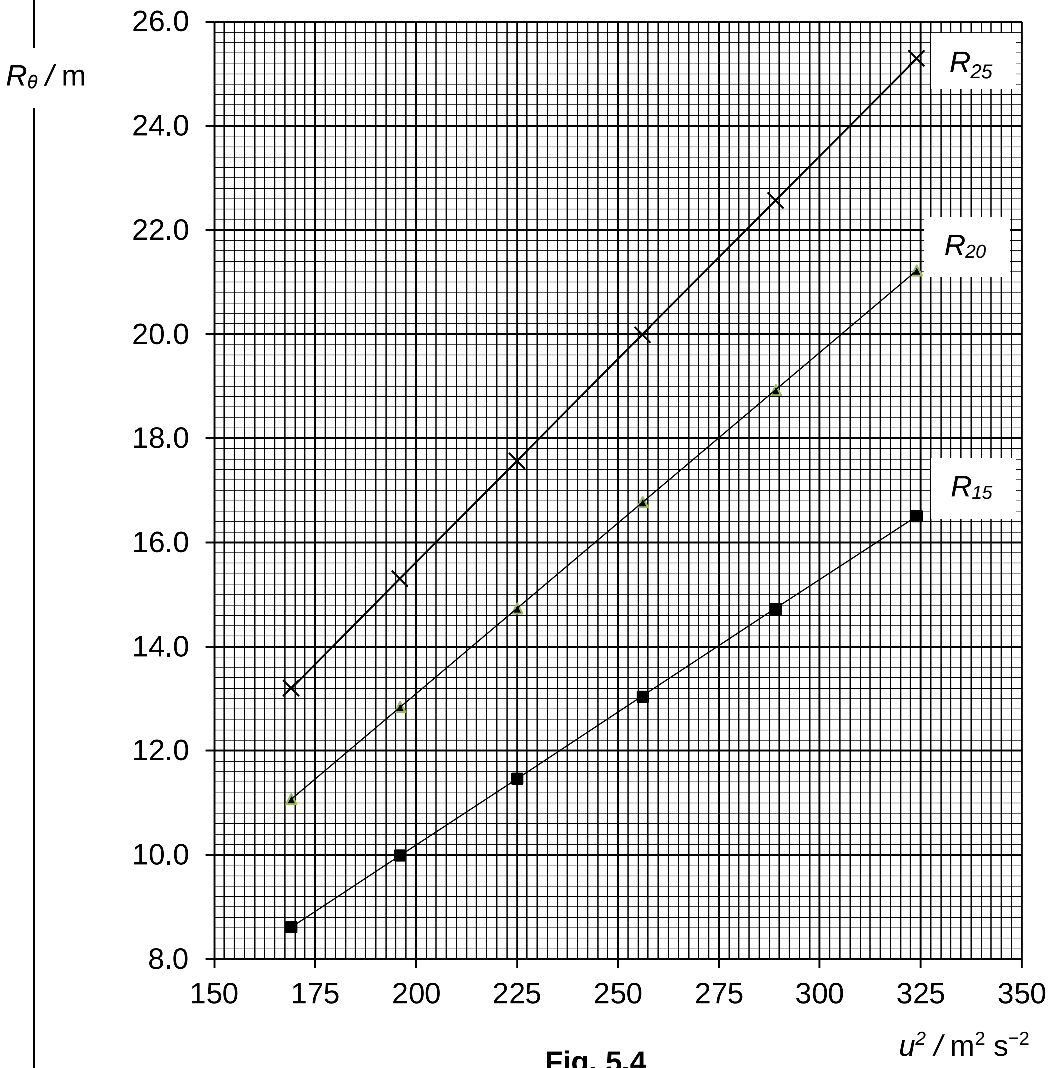


Fig. 5.4

[B1] correct plotting of two points.

[B1] correct best fit line drawn; with label R_{25}.

(iii) Correct read off at $u^2 = (15.5)^2 = 240$ m^2 s^{-2}

$R_{25} = 18.8$ m [accept, from 18.7 m to 18.9 m]

[B1]: Correct read off

[B1]: Answer within acceptable range

(iv)

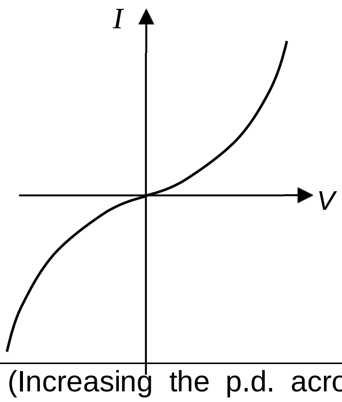
$$F \Delta t = m \Delta v \quad \text{[C1]}$$

$$F \times 0.0080 = \frac{430}{1000} \times (15.5 - 0) \quad \text{[C1]}$$

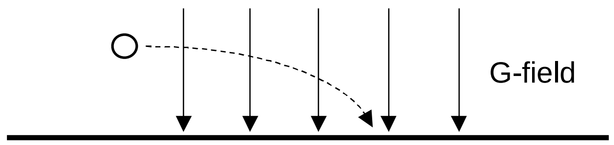
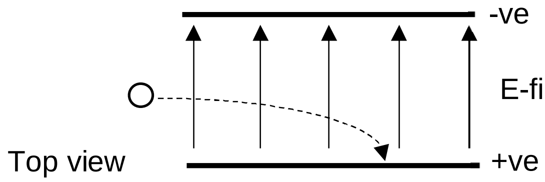
$$F = 833 \text{ N} \quad \text{[A1]}$$

Allow $F = ma$ to solve.

		(v)	*vertically* : $s_y = u_y t + \frac{1}{2} a_y t^2$ $15 = 0 + \frac{1}{2}(9.81)t^2$ $t = 1.75\ \text{s}$ [C1] $v_y = u_y + a_y t$ $v_y = 0 + 9.81(1.75) = 17.17\ \text{m s}^{-1}$ [C1] *Hence* : $v = \sqrt{v_y^2 + v_x^2}$ $= \sqrt{17.17^2 + 15.5^2}$ $= 23.1\ \text{m s}^{-1}$ [A1]

6	**(a)**	**(i)**	The resistance of the fixed resistor is defined as the ratio of the potential difference across the resistor to the current passing through it.	B1
		(ii)	 B1 for correct shape	
		(iii)	(Increasing the p.d. across the thermistor results in an increase in current, which in turn causes the temperature to rise.) The temperature rise causes an increase in the number of mobile charge carriers. The effect of increase in number density of charge carriers outweighs the effect of increase in collisions between the free electrons and the lattice ions. Hence, resistance decreases (i.e. the ratio of $\frac{V}{I}$ decreases).	B1 B1

		(iv)	$V_{out} = \left(\dfrac{R}{R_t + R}\right)\varepsilon$ $= \left(\dfrac{2000}{3000+2000}\right)10$ $= 4.0\text{ V}$	C1 A1
		(v)	When the temperature of the room increases, resistance of thermistor decreases. By potential divider principle, voltage across BC (of the thermistor) decreases and the voltage across AB increases. Hence the fire alarm should be connected to AB.	M1 A1
		(vi)	When temperature increases, the resistance of the filament lamp increases. By potential divider principle, the voltage across AB decreases.	M1 A1
	(b)	**(i)**	$E = I(R + r)$ $9.0 = 0.450(18 + r)$ $r = 2.0\ \Omega$	M1 A1
		(ii)	$Q = It$ $= 0.45 \times 3600$ $= 1.6 \times 10^3\text{ C}$	M1 A1
		(iii)	$E_{total} = IVt$ $= 0.45 \times 9.0 \times 3600$ $= 14.6 \times 10^3\text{ J}$	M1 A1
		(iv)	$P = I^2R$ $= (0.45)^2 \times 18.0$ $= 3.65\text{ W}$	M1 A1
		(v)	New effective resistance $= \dfrac{V}{I} = \dfrac{9.0}{0.225} = 40.0\ \Omega$ Replacement resistance = 40.0 – 2.0 = 38.0 Ω	M1 A1

7	(a)	(i)	The effect of a G-field on the particle is dependent on its mass *m*. [B1] It will travel in parabolic motion, deflecting into the plane of the paper. [B1] 
		(ii)	The effect of an E-field on the particle is dependent on its charge. [B1] It will travel in parabolic motion, deflecting out of the plane of the paper. [B1] 
		(iii)	The effect of a B-field on the particle is dependent on its charge and velocity. [B1] It will travel in a circular motion along the plane of the paper. [B1]
			
	(b)	(i)	AB produces a magnetic field at YZ acting out of the paper. By Fleming's Left Hand Rule, YZ experiences an upward force. [B1] The magnetic force is larger than the weight of YZ, hence causing YZ to move upwards. [B1]
		(ii)	As YZ travels further away from AB, the upward magnetic force decreases as the magnetic field due to AB weakens. [B1] YZ comes to rest when the upwards magnetic force due to AB is equal to the weight of YZ. [B1]
	(c)	(i)	Magnetic field lines are directed out of the paper. [A1]

		(ii)	Magnetic force provides for centripetal force $Bqv = m\omega^2 r$ [M1] where ω is the angular velocity of the proton. $m\omega^2 r = Bq\omega r$ $\omega = \dfrac{Bq}{m}$ $\because \omega = \dfrac{2\pi}{T}$ [M1] where T is the period of the motion. $T = \dfrac{2\pi m}{Bq}$ [M1] $t_D = \dfrac{1}{2}T = \dfrac{\pi m}{Bq}$ [A0] Alternative working: Magnetic force provides for centripetal force $Bqv = m\dfrac{v^2}{r}$ [M1] $r = \dfrac{mv}{Bq}$ [M1] $t_D = \dfrac{\pi r}{v}$ [M1] $= \dfrac{\pi m}{Bq}$ [A0]
		(iii)	The magnetic field does not change the speed of the proton. [B1] The electric field causes the speed to increase. [B1]
		(iv)	t_D or $\dfrac{\pi m}{Bq}$ [A1]
		(v)	Since the charge of the new particle is negative: This particle will make an anticlockwise direction motion within the dees. [B1] Since the mass-to-charge ratio (m/q) of the new particle is the same: This particle will make the same radius within the dees [B1] Since m/q of this new particle is the same: Based on the equation of **(b)** the t_D value will remain same since B remains the same. [B1]