Class	Index Number	Name
21S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2022
Preliminary Examination

PHYSICS, Higher 2 **9749/03**

Paper 3 Longer Structured Questions **15th September 20222**
hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
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.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

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

For Examiner's Use	
Section A	
1	**/ 9**
2	**/ 8**
3	**/ 11**
4	**/ 8**
5	**/ 6**
6	**/ 7**
7	**/ 11**
Section B	
8	**/ 20**
9	**/ 20**
Total	**/ 80**

This document consists of **24** printed pages including this page.

Data
speed of light in free space $c = 3.00 \times 10^{8}$ m s^{-1}

permeability of free space	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
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
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-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	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/^{o}\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$v = \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$
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	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{1/2}}$

Answer **all** the questions in the space provided.

1 **(a)** **(i)** State the principle of moments.

....

....

....[1]

(ii) Fig. 1.1 shows an arrangement used to demonstrate the principle of moments.

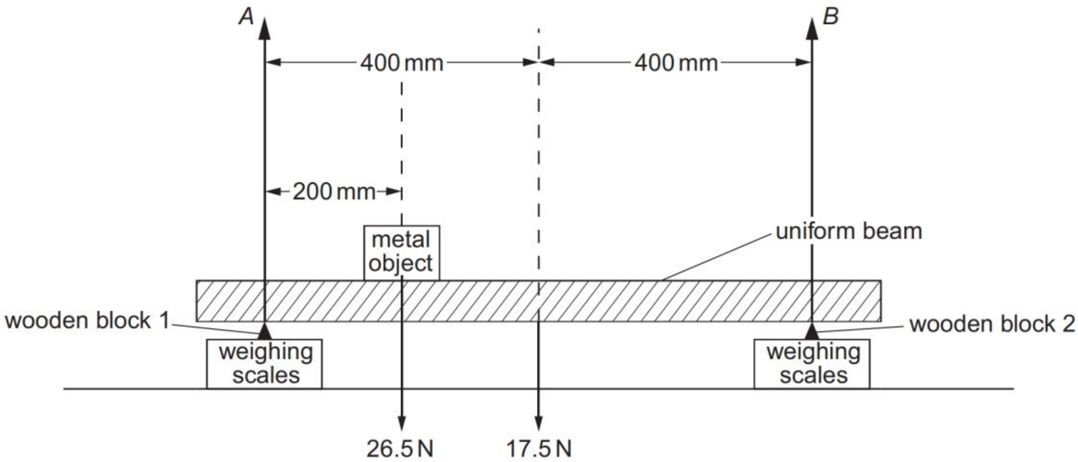


Fig. 1.1

A uniform beam is supported on the edges of two triangular shaped wooden blocks placed on two weighing scales. The weight of the beam is 17.5 N and the distance between the wooden blocks is 800 mm. A metal object of weight 26.5 N is placed 200 mm from one of the blocks. The blocks exert upward forces *A* and *B* on the beam.

Calculate the force *B*.

B = ... N [2]

(iii) State the magnitude of the sum of the two forces *A* and *B* and explain your answer.

....

....

....[2]

(iv) Describe what happens to the forces *A* and *B* as the metal object is gradually moved to the centre of the beam.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(b) Fig. 1.2 shows a girl supported by two elastic ropes. She is in equilibrium. Her weight is 392 N.

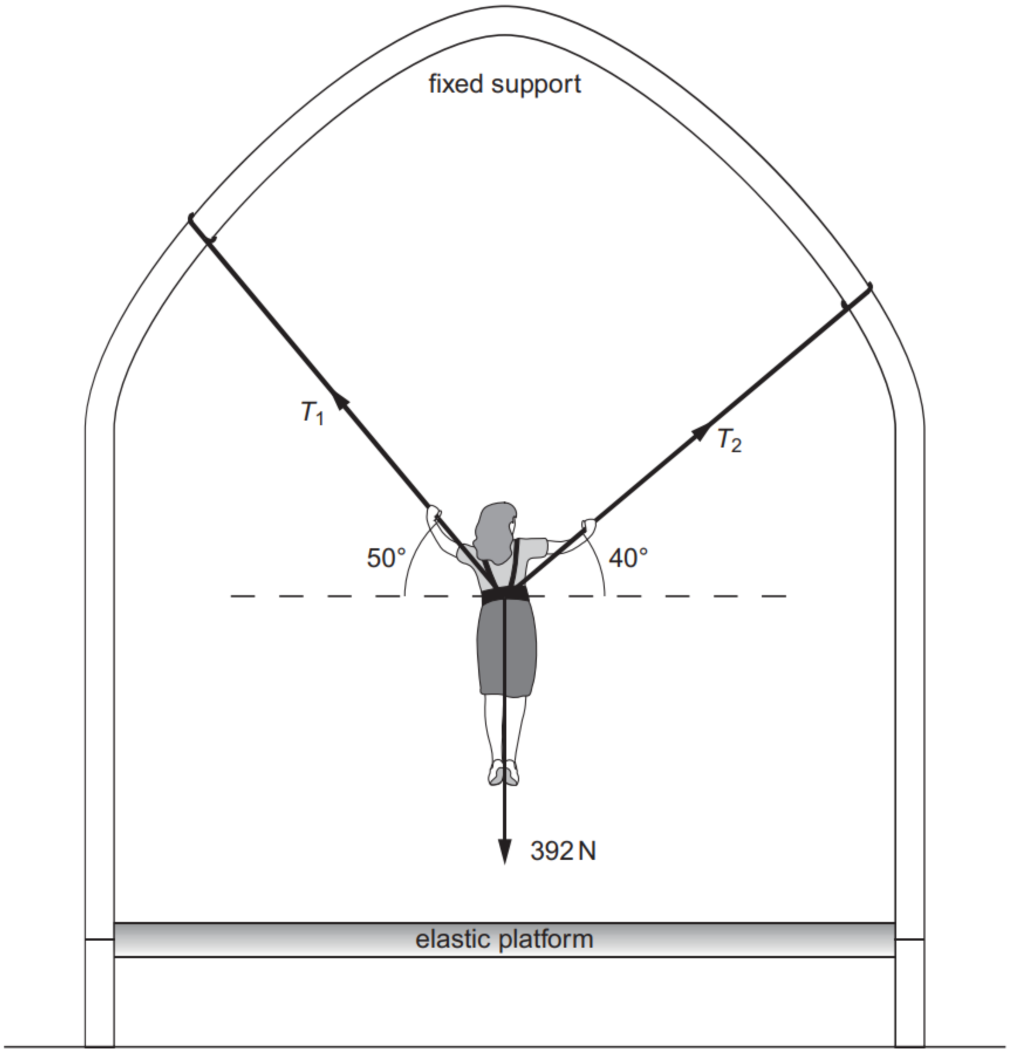


Fig. 1.2

Determine the tensions T_1 and T_2 in the two ropes.

tension T_1 = ……….…. N

tension T_2 = ……….…. N [2]

2 **(a)** One mole of hydrogen at a temperature of 420 K is mixed with one mole of oxygen at 320 K. After a short period of time the mixture is in *thermal equilibrium*.

(i) Explain what is meant by *thermal equilibrium*.

………………………………………………………………………………………[1]

(ii) The kinetic theory of gases leads to the derivation of the equation

$$pV = \frac{1}{3}Nm < c^2 >.$$

Using the formula above and the ideal gas equation, derive an expression for the mean kinetic energy of an ideal gas molecule in terms of the Boltzmann constant, *k*, and the temperature *T*.

[2]

(iii) Hence determine the average kinetic energy of a hydrogen molecule *before* the two gases are mixed.

kinetic energy = …………………………....J [1]

(b) **(i)** Two different gases at the same temperature have molecules with different mean square speeds. Explain why this is so.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) Explain why in the earth's atmosphere, there is hardly any hydrogen, compared to oxygen molecules.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

3 **(a)** A mass undergoes simple harmonic motion. For a displacement x that is measured from its equilibrium position, the acceleration a of the mass m is given by the expression

$$a = -\frac{16}{m}x$$

(i) Explain how the expression leads to the conclusion that the mass is performing simple harmonic motion.

....

....

....

....

....[3]

(ii) Fig. 3.1 shows the variation of the potential energy of the mass with time.

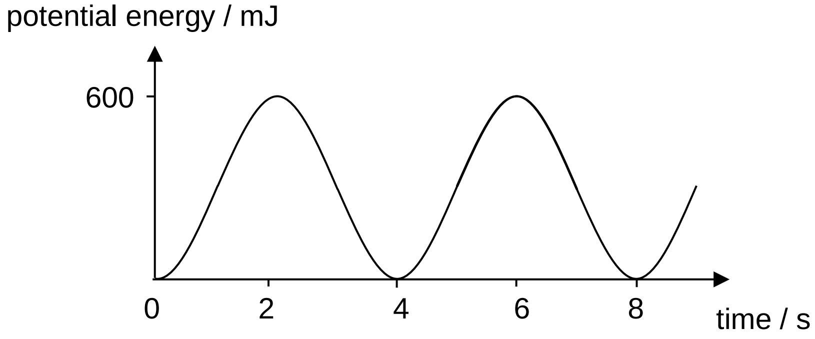


Fig. 3.1

Calculate

1. the frequency for the oscillations of the mass,

frequency = ... Hz [1]

2. the mass,

mass
= .... kg [2]

3. the amplitude of the oscillations.

amplitude = ... m [2]

4. Mark a point on Fig. 3.1 between 0 and 4 s and mark it as Z when the mass is exactly mid-way between the equilibrium position and amplitude position. [1]

(b) On Fig. 3.2, sketch a labelled graph of the variation of the velocity with time of the mass for 2 periods.

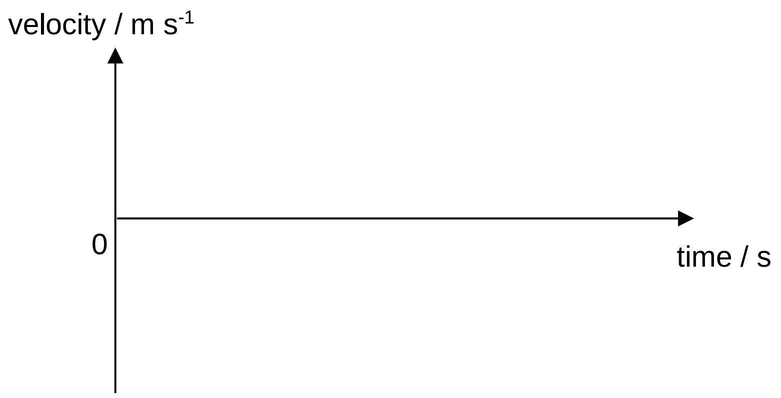


Fig. 3.2

[2]

4 **(a)** A fire alarm on a wall produces a loud sound during a fire drill in SAJC. The speed and frequency of the sound waves are 330 m s^{-1} and 5000 Hz respectively.

(i) Determine the phase difference between any two air molecules which are 3.3 cm apart in the direction of propagation.

phase difference = …………..rad [2]

Hence state whether they are oscillating *in phase* or *in anti-phase*.

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

(ii) The surface area of a human eardrum is approximately 5.5×10^{-5} m^2. Calculate the energy received at a person's eardrum given he is at 24 m away from the alarm for 15 s and the average sound intensity at the eardrum is 3.0 $\times 10^{-2}$ W m^{-2}.

energy = ……………………………J [2]

(iii) State the assumption that you have made.

……………………………………………………………………………………………

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

(b) Distinguish between a *polarised* wave and an *unpolarised* wave.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

5 **(a)** A d.c. supply is connected across a variable resistor. The resistance of the variable resistor is changed. Fig. 5.1 shows the variation of the power P dissipated in the resistance R of the variable resistor.

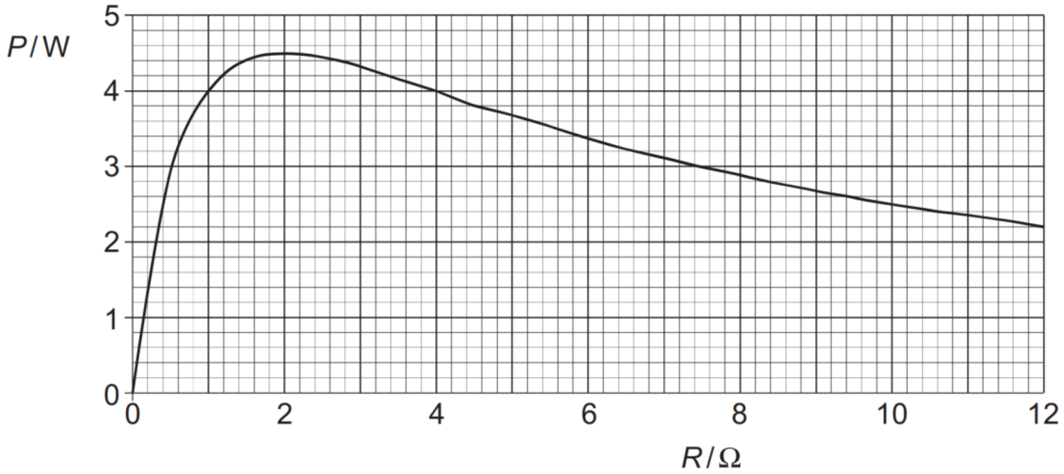


Fig. 5.1

(i) Use Fig. 5.1 to determine the potential difference across the variable resistor when it dissipates maximum power.

potential difference = ………………. V [2]

(ii) Explain why your answer in **(i)** is not equal to the e.m.f. of the supply.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(b) Fig. 5.2 shows a circuit. The battery has negligible internal resistance.

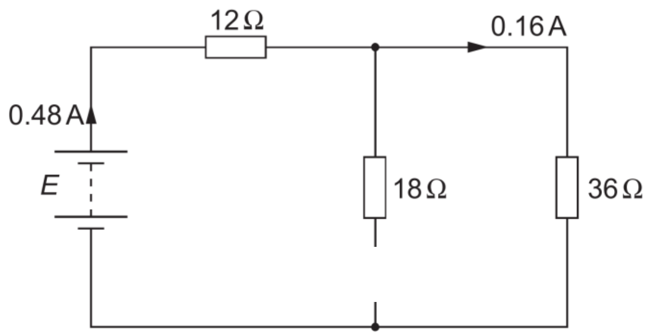


Fig. 5.2

(i) Determine the number of electrons passing through the battery in a time of 150 s.

number = ……………….. [1]

(ii) Determine the e.m.f. E of the battery.

e.m.f. = ……………….. V [2]

6 **(a)** State Faraday's law of electromagnetic induction.

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

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

(b) The diameter of the cross-section of a long solenoid with 15 turns is 3.2 cm, as shown in Fig. 6.1

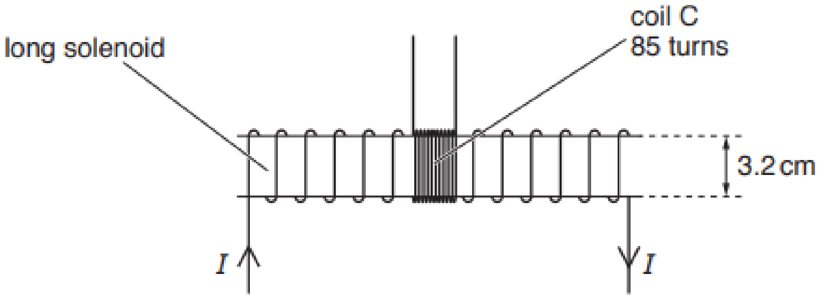


Fig. 6.1

A coil **C**, with 85 turns of wire, is wound tightly around the centre region of the solenoid. The magnetic flux density B, in tesla, at the centre of the solenoid is given by the expression

$$B = \pi \times 10^{-3} \times I$$

where I is the current in the solenoid in ampere.

(i) Calculate, for a current I of 2.8 A in the solenoid, the magnetic flux linkage of the coil **C**.

magnetic flux linkage = …………………. Wb [1]

(ii) The current I in the solenoid in **(b)(i)** is reversed in 0.30 s. Calculate the mean e.m.f. induced in coil **C**.

e.m.f. induced = …………………. V [2]

(iii) The current I in the solenoid in **(b)(i)** is now varied with time t as shown in Fig. 6.2.

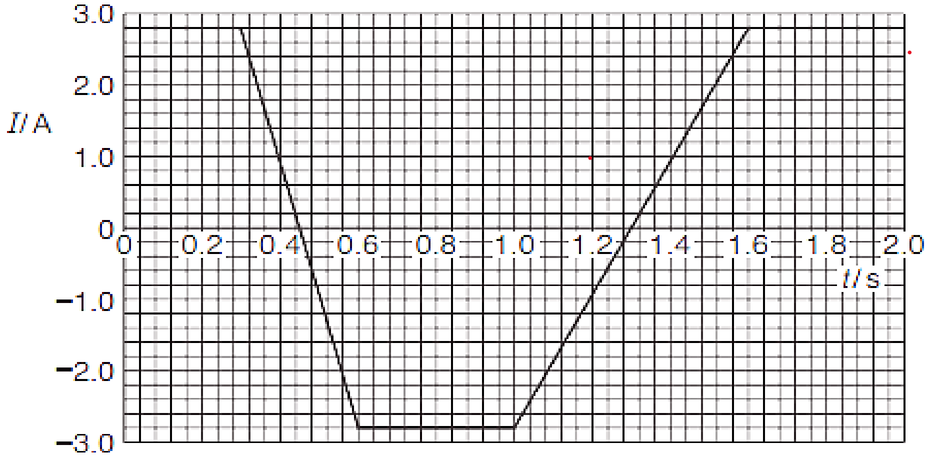


Fig. 6.2

Use your answer to **(b)(ii)** to show, on Fig. 6.3, the variation with time t of the e.m.f. E induced in coil **C**. [3]

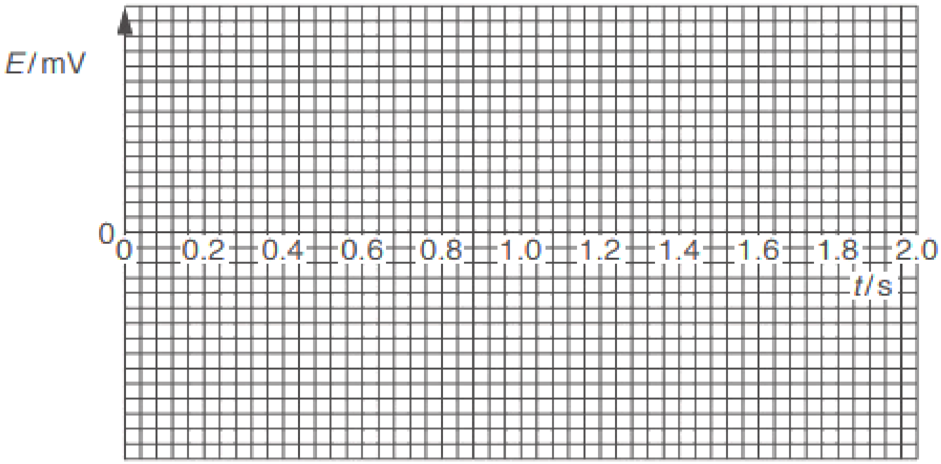


Fig. 6.3

7 **(a)** The β-decay of nuclei of tungsten-185 is spontaneous and random.

State what is meant by

(i) *spontaneous* decay,

……………………………………………………………………………………………

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

(ii) *random* decay.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(b) A nuclear reaction between two helium nuclei produces a second isotope of helium, two protons and 13.8 MeV of energy. The reaction is represented by the following equation.

$$^{3}_{2}He + ^{3}_{2}He \rightarrow ^{\cdots}_{\cdots}He + 2\ ^{\cdots}_{\cdots}p + 13.8\ MeV$$

(i) Complete the nuclear equation. [1]

(ii) Radiation is produced in this nuclear reaction.
State

1. a possible type of radiation that may be produced,

……………………………………………………………………………… [1]

2. why the energy of this radiation is less than the 13.8 MeV given in the equation.

………………………………………………………………………………

………………………………………………………………………………[1]

(iii) Calculate the minimum number of these reactions needed per second to produce a power of 60 W.

number = ……………………….s^{-1} [2]

(c) Using the data below, calculate in MeV, the energy released in the following reaction.

$$^{2}_{1}\text{H} + {}^{3}_{1}H \rightarrow {}^{4}_{2}\text{He} + {}^{1}_{0}n$$

The binding energy per nucleon of

- deuterium $^{2}_{1}\text{H}$ is 1.11 MeV
- tritium $^{3}_{1}H$ is 2.66 MeV
- helium $^{4}_{2}\text{He}$ is 7.20 MeV

energy released = ……………..……….MeV [3]

Section B

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

8 Fig. 8.1 shows an M777 howitzer secured to the ground firing a projectile at an angle of 50° to the horizontal. The projectile exits the muzzle at a speed of 800 m s^{-1}.

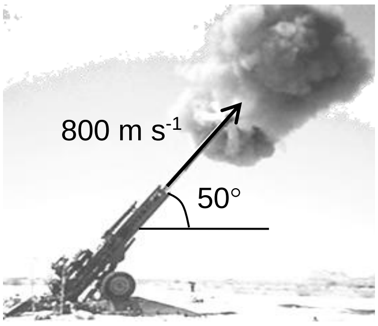


Fig. 8.1

(a) **(i)** Calculate the vertical component of the projectile's initial velocity.

vertical component = ……………………… m s^{-1} [1]

(ii) Neglecting air resistance and the height of the howitzer, determine the horizontal range of this projectile.

range = ……………………… km [3]

(iii) It can be proven that launching the projectile at 40° will achieve the same horizontal range. Suggest one advantage of launching the projectile at this smaller angle.

……………………………………………………..……………………………………

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

(b) The howitzer is set up to destroy an enemy tank by aiming its projectile to land at the expected position of the moving tank.

The enemy tank, initially stationary, is 3.0 km away from the landing point of the howitzer's projectile as shown in Fig. 8.2.

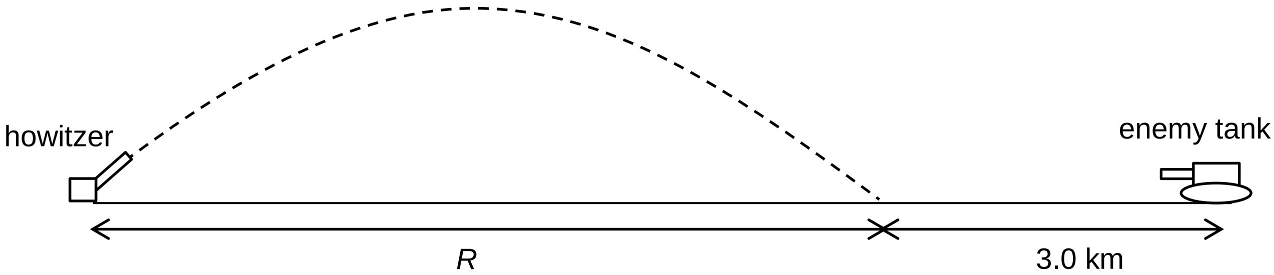


Fig. 8.2

The tank has a maximum speed of 60 km h^{-1} and a maximum acceleration of 1.0 m s^{-2}.

(i) Calculate the minimum time required for the tank to reach the landing point of the howitzer's projectile.

time = …………………. s [4]

(ii) Determine the time the howitzer should start firing after the tank starts moving so that the projectile will hit the tank.

time = …………………. s [1]

(c) In reality, the projectile experiences a large magnitude of air resistance.

(i) In Fig. 8.3(a) and 8.3(b), draw and label the forces acting on the projectile as it is moving up and as it is moving down. [2]

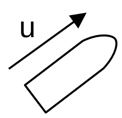


Fig. 8.3(a) Projectile moving up

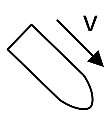
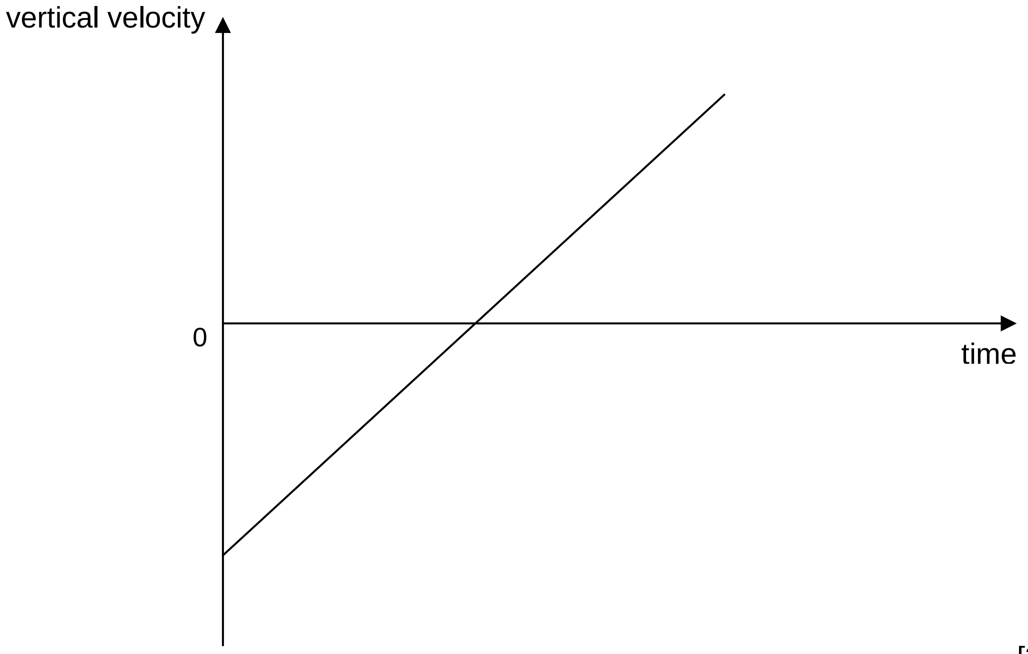


Fig. 8.3(b) Projectile moving down

(ii) Fig 8.4 shows the variation with time of the vertical velocity of the projectile when the air resistance is negligible from the time it is fired to when it reaches the ground.

On Fig. 8.4, draw a line to show the variation with time of the vertical velocity of the projectile when air resistance is not negligible.



[3]

Fig. 8.4

(iii) Label a point **P** on your line when the projectile's vertical acceleration is equal to the acceleration of free fall. [1]

(d) **(i)** State the *principle of conservation of linear momentum.*

………………………………………………..………………………………………

………………………………………………..………………………………………

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

(ii) If the howitzer and the projectile are considered as a system, explain whether the principle of conservation of momentum could be applied to this system during the firing process.

………………………………………………..………………………………………

………………………………………………..………………………………………

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

9 **(a)** Two parallel metal plates in a vacuum are separated by a distance of 15 mm, as shown in Fig. 9.1.

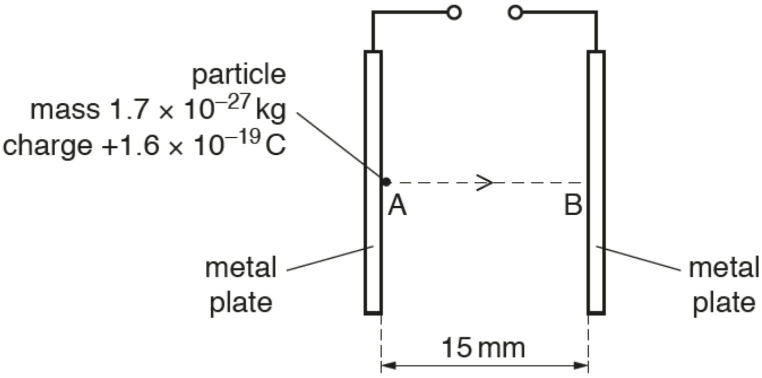


Fig 9.1

A uniform electric field is produced between the plates by applying a potential difference between them.

A particle of mass 1.7×10^{-27} kg and charge $+1.6 \times 10^{-19}$ C is initially at rest at point A on one plate. The particle is moved by the electric field to point B on the other plate. The particle reaches point B with kinetic energy 2.4×10^{-16} J.

(i) Define electric field strength.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) **1.** State whether A or B is at higher potential.

higher potential at ………………. [1]

2. Determine the work done by the electric field to move the particle from A to B.

work done = ……………………….. J [1]

3. Use your answer in **(a)(ii)2.** to determine the force on the particle.

force = ……………………… N [2]

4. Determine the potential difference between the plates.

potential difference = ………………………. V [3]

(iii) On Fig. 9.2, sketch a graph to show the variation of the kinetic energy of the particle with the distance *x* from point A along the line AB.

Numerical values for the kinetic energy are not required. [1]

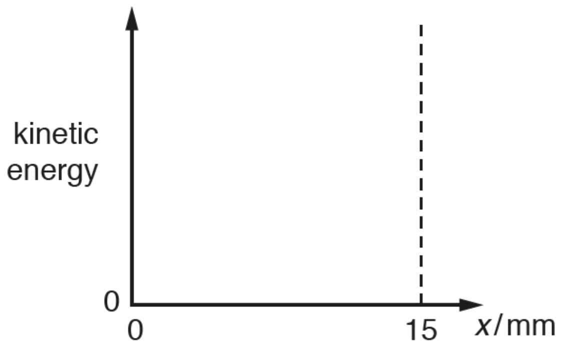


Fig. 9.2

(iv) An electron is placed at A and projected along the direction AB with a kinetic energy less than 2.4×10^{-16} J. Describe the motion of the electron.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(b) A uniform magnetic field normal to the page is produced in the region PQRS. At point X, a gamma-ray photon interaction causes two particles to be formed. The paths of these particles are shown in Fig

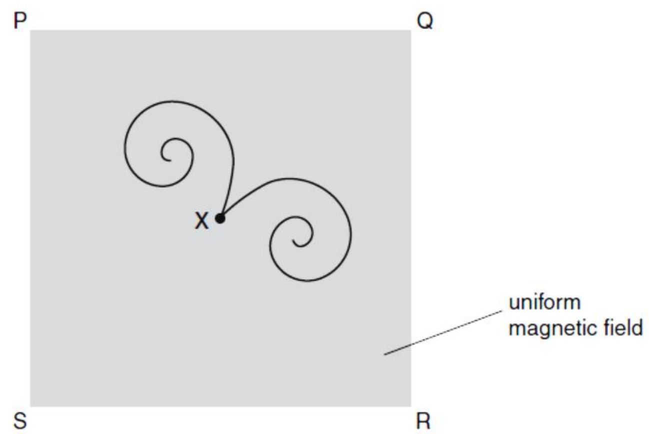


Fig. 9.3

(i) State the condition for a charged particle to experience a force in a magnetic field.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) Suggest with a reason, why each of the paths is a spiral, rather than the arc of a circle.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(iii) State and explain what can be deduced from the paths about

1. the charges on the two particles

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………[2]

2. the initial speeds of the two particles.

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…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

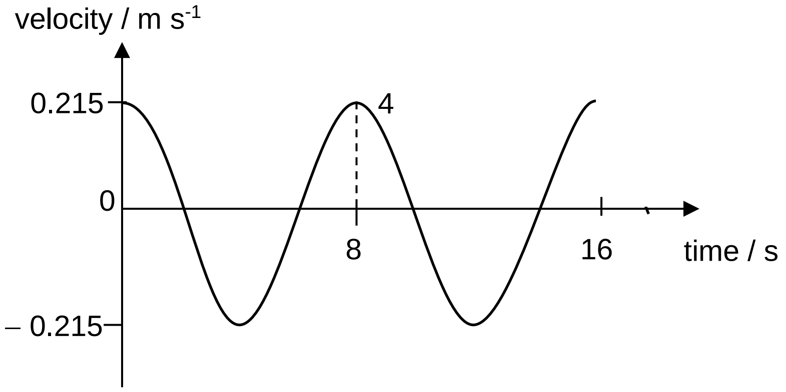
…………………………………………………………………………………[2]

[End of Paper]

JC2 Prelim (H2 Physics) Paper 3 Solution & Post Mortem

1 (a)(i)	For a body to be in rotational equilibrium, the sum of all the anticlockwise moments ***about any point*** must be equal to the sum of all the clockwise moments about that **same point.**	[1]
(a)(ii)	{Given: wt of beam = 17.5 N; wt of object = 26.5 N} Taking moments about wooden block 1, B x 800 = 26.5 x 200 + 17.5 x 400 B = 15.4 N	[1] [1]
(a)(iii)	Sum of forces A & B = 44 N Since the beam is in (translational) equilibrium, the total force acting downward (26.5 + 17.5 N) is equal to the total force acting upward (ie A + B).	[1] [1]
(a)(iv)	Any 2 1. A becomes less and B becomes greater 2. The sum of A and B is constant (= 44 N) 3. Same amount of increase and decrease for A and B. 4. At centre A = B	[2]
(b)	Vertically: $T_1\sin 50^0 + T_2\sin 40^0 = 392$ N $0.7660T_1 + 0.6428T_2 = 392$ -------- (1) Horizontally: $T_1\cos 50^0 = T_2\cos 40^0$ $0.6428T_1 = 0.7660T_2$ $T_1 = 1.192T_2$ -------------(2) Sub (2) in (1): $0.7660(1.192T_2) + 0.6428T_2 = 392$ $1.556T_2 = 392$ $T_2 = 251.9$ N = 252 N Sub in (2): $T_1 = 1.192(251.9)$ = 300.3 N = 300 N Alternatively, may use the vector triangle.	[1] [1]

2(a)(i)	Both gases are at the same temperature or No net flow/transfer of heat between the 2 gases	[1]
(ii)	Since $pV = \frac{1}{3}Nm < c^2 >$, ½ $Nm<c^2>$ = (3/2) pV Since pV = NkT, { ideal gas eqn} ½ $Nm<c^2>$ = (3/2) NkT mean KE of a molecule = ½ $m<c^2>$ {NOT: ½ mv^2} = (3/2) kT	[1] [1]
(iii)	{Given: Before mixing, T of hydrogen = 420 K} mean KE of a molecule = ½ $m<c^2>$ = (3/2)kT = (3/2)(1.38 x 10^{-23}) (420) = 8.69 x 10^{-21} J	[1]
(b)(i)	Gases at *same temp* would have same (mean) KE, or same ½ $m<c^2>$ {since ½ $m<c^2>$ = (3/2)kT }. Since the mass of a molecule/molecular mass for the 2 gases is different, the mean square speed must be different (so that ½ $m<c^2>$ of the 2 can be the same.)	[1] [1]
(b)(ii)	{Deduce that both the hydrogen and oxygen molecules are at the same temp & hence the 2 gases have the same ½ $m<c^2>$.} Since a hydrogen **molecule** has a smaller mass than an oxygen **molecule**, rms speed of H_2 > rms speed for O_2 .(Accept "mean square speed") Thus, when compared with O_2, molecules of H_2 have a **higher probability/proportion of molecules** of exceeding **the escape speed** of Earth. {Hence more H_2 than O_2 molecules are expected to leave earth's atmosphere.}	[1] [1]
3 (a)(i)	{Given: $a = -\frac{16}{m}x$ }	

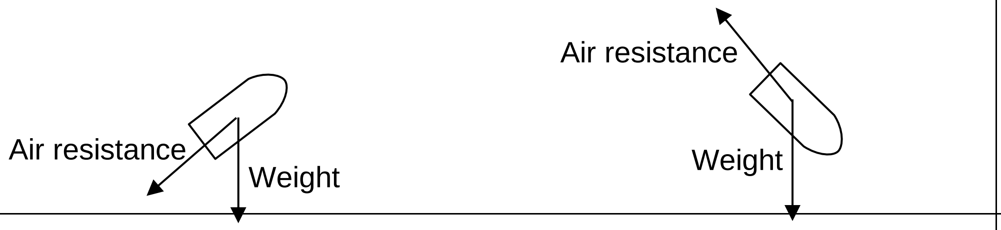
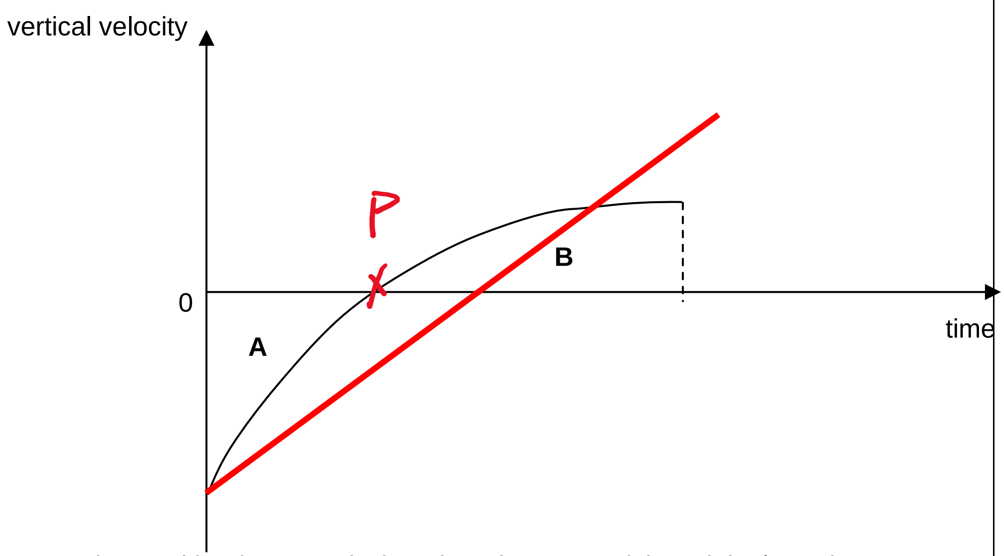
	Since 16/m is a constant, acceleration $\propto$ to its displacement from its equilibrium position. Furthermore acceleration is always directed towards that position as indicated by the negative sign. Thus the block is performing shm as it satisfies the 2 defining conditions of shm.	[1] [1] [1]
(a)(ii) 1	From graph, deduce period of shm T = 8 s { NOT: 4 s} $f = \frac{1}{T} = \frac{1}{8} = 0.125$ Hz	[1]
(a)(ii) 2	Comparing $a = -\omega^2 x$ with $a = -\frac{16}{m}x$, $\Rightarrow \quad 4\pi^2 f^2 = \frac{16}{m}$ $\rightarrow m$ = 25.9 kg	[1] [1-ecf]
(a)(ii)3	Max. p.e. $= \frac{1}{2}m\omega^2 x_o^2 = 0.600$ J (fr graph) (deduce $m\omega^2 = 16$) $\rightarrow \quad x_o = 0.274$ m	[1] [1]
(a)(ii) 4	Z lies **between 0 and 1 s** (at 0.67 s) or **between 3 and 4 s** (at 3.3 s)	[1]
(b)	 $v_{max} = \omega x_0 = 2\pi$(0.125 fr (ii)) x (0.274 fr (ii)) = 0.215 m s^{-1}	[1, shape: cosine or - cosine graph] [1, magnitude of v_{max} and period, allow ecf]
4(a)(i)	From $v = f\lambda$, $\lambda = \frac{330}{5000} = 0.066\, m$ Phase difference, $\phi = \frac{x}{\lambda} \times 2\pi = \frac{0.033}{0.066} \times 2\pi \;\; = \pi$ rad $\Rightarrow$ molecules are in anti-phase.	[1] [1] [1 ecf]

(a)(ii)	Energy received $= Power_{received}\ x\ time$ $= (I_{received} \times A_{ear})\ t$ $= (3.0 \times 10^{-2}) \times (5.5 \times 10^{-5}) \times 15$ $= 2.48 \times 10^{-5}$ J	[1] [1]
(a)(iii)	(The plane of) the eardrum is perpendicular to direction of the waves	[1]
(b)	The wave particles **oscillate/vibrate** (not: move, travel) in **one direction** **in a plane normal to the direction of energy transfer** The oscillations of an unpolarized wave can be in any direction (ie not restricted to only one direction).	[1] [1]

5 (a)(i)	$P = \frac{V^2}{R}$ (where P_{max} = 4.5 W, R = 2 Ω) $4.5 = \frac{V^2}{2.0}$ V= 3.0 V Alternatively, $P = I^2R$ $4.5 = I^2 (2.0)$ I = 1.5 A V = IR = (1.5)(2.0) = 3.0 V)	[1] [1]
(a)(ii)	The supply has internal resistance. Hence the answer in (i) + p.d. across the internal resistance = e.m.f	[1]
(b)(i)	Q = It Ne = It $N(1.6 \times 10^{-19}) = (0.48\ A)(150\ s)$ $N = 4.5 \times 10^{20}$	[1]
(b)(ii)	Given 18 Ω and 36 Ω in parallel: $\frac{1}{18} + \frac{1}{36} = \frac{1}{R_{ll}}$ $R_{ll} = 12\ \Omega$ Total resistance of circuit = $12\Omega + 12\Omega = 24\ \Omega$ E = IR = (0.48)(24) = 11.52 V (OR $V_{12} = 0.48 \times 12 = 5.76$ V $V_{18} = 0.32 \times 18 = 5.76$ V (or $V_{36} = 0.16 \times 36 = 5.76$ V) [1] $E = V_{12} + V_{18} = 11.52$ V [1])	[1] [1]
6(a)	Induced e.m.f. in a coil is proportional to the rate of change of magnetic flux (linkage) of the coil.	[1]
(b)(i)	Flux linkage = NBA (radius of coil = 1.6×10^{-2} m) $= 85 \times (\pi \times 10^{-3} \times 2.8) \times (\pi \times (1.6 \times 10^{-2})^2)$ $= 6.00 \times 10^{-4}$ Wb	[1]
(b)(ii)	Flux linkage change = $(6.00 \times 10^{-4}) - (-6.00 \times 10^{-4})$ Wb $= 2 \times 6.00 \times 10^{-4}$ Wb $= 12.00 \times 10^{-4}$ Wb	[1-ecf]

	Mean emf = d(flux linkage)/t where t = 0.30 s = (12.00 x 10^{-4} Wb) ÷ (0.30 s) = 0.004 V = 4 mV	[1-ecf]
(b) (iii)	**0 V** from t = 0 to 0.3 s, t = 0.6 to 1.0 s and t > 1.6 s (because when current is const & B = constant, thus flux linkage is const; hence induced emf = zero, in accordance to Faraday's Law. This must be drawn CLEARLY in the graph) From t = 0.3 to 0.6 s, the current changes as shown in (b) (ii). Hence induced emf = **4 mV** (Let a positive sign be given to this emf) From t = 1.0 to 1.6 s: the current changes by the same amount as betw 0.3 to 0.6 s, but the time taken is doubled. Hence the magnitude of the induced emf is **half** that in (b)(ii), ie 2 mV. Since the change in current is from low to high current- opposite to that betw 0.3 to 0.6 s, the induced emf here is opposite in sign to that between 0.3 to 0.6 s, ie – 2 mV**.**	[1] [1] [1]
7(a) (i)	The process cannot be controlled (or affected) by external factors – factors outside (external to) the nucleus, like pressure, temperature. {at least one factor cited}	[1]
(a)(ii)	It is impossible to know when the next disintegration/decay will occur. The **probability of decay per unit time** of a nucleus is constant. {This answer, "cannot predict which particular nucleus will decay next" is not acceptable.}	[1] [1]
(b)(i)	${}^{3}_{2}He + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + 2\,{}^{1}_{1}p$ + 13.8 MeV	[1]
(b)(ii)1.	gamma ray/radiation/photon {Accept: γ-ray, Symbol γ must be clear. It should not look like 'Y'}	[1]
2.	13.8 MeV is the (total) energy released, which = **sum** of the **ke of the products** (${}^{4}_{2}He$ & the 2 protons) **and the energy of the radiation**.	[1]
(b) (iii)	{Let $\frac{N}{t}$ be the required minimum number of reactions per second. Since each reaction produces 13.8 MeV, where 1 MeV = 10^6 x 1.6 x 10^{-19} J} $\frac{N}{t}$ x 13.8 x (10^6 x 1.6 x 10^{-19} J) = 60 W $\rightarrow \frac{N}{t}$ = 2.72 x 10^{13} s^{-1}	 [1] [1]
(c)	Energy released = Tot Binding energy of Products – Tot BE of reactants = (4x 7.20) + 0 (for ${}^{1}_{0}n$) – (2 x 1.11) – (3 x 2.66) = 18.6 MeV	 [2] [1]

	Section B	
8(a)(i)	800 sin 50° = 613 m s^{-1} = 6.13 x 10^2 m s^{-1}	[1]
(a)(ii)	$s_y = u_y t + ½ a t^2$ 0 = 800 sin 50° (t) + ½ (-9.81) (t^2) t = 125 s {total time of flight} Range = $s_x = u_x$ t =(800 cos 50°)x (125) = (514 m s^{-1}) x (125 s) = 64.2 x 10^3 m = 64.2 km [ecf allowed]	[1] [1] [1]
(a)(iii)	**Time of flight is shorter** { & so the enemy tank has less time to react. {Range = ucosθ x Time of flight}; NOT because the initial vert velocity is smaller}	[1]
(b)(i)	To find horiz displacement when accelerating at 1 m s^{-2} to its max speed of 60 km km h^{-1} (ie to 16.7 m s^{-1}): $v^2 = u^2 + 2as$ $(60000 / 3600)^2$ = 0 + 2(1)(s) s_x = 138.89 m To find time required to reach max speed from rest at max acc of 1 m s^{-2}: s = $ut_1 + ½ at_1^2$ 138.89 = 0 + ½ (1)$(t_1)^2$ t_1 = 16.67 s To find time taken to travel remaining distance at max speed: (Initial dist apart = 3000 m) $S_x = ut_2$ 3000 – 138.89 = (60000 / 3600)(t_2) t_2 = 171.67 s Thus minimum time required = $t_1 + t_2$ = 171.67 + 16.67 = 188.3 s **Alternatively,** To find time required to reach maximum speed, v = u + at_1 60000 / 3600 = 0 + (1)(t_1) t_1 = 16.67 s To find the distance travelled while accelerating to max speed, s = ut + ½ at^2 = 0 + ½ (1)$(16.67)^2$ = 138.89 m To find the time taken to travel remaining distance at top speed: (Initial separation = 3 km) s = ut_2 3000 – 138.89 = (60000 / 3600)(t_2)	[1] [1] [1] [1] [1] [1] [1] [1]

	$t_2 = 171.67$ s Minimum time required = $t_1 + t_2 = 171.67 + 16.67 = 188.3$ s	
(b)(ii)	time required = (bi) – Time of flight in (aii) = 188.3 – 125 = 63.3 s	[1-ecf]
(c)(i)		[2]
(c)(ii)	 Correct shape with x-intercept before the x-intercept of the original graph Initial speed > final speed **Equal area before and after reach max height** (A = B)	[1] [1] [1]
(c)(iii)	P is the instant **when air resistance = 0**, hence, at where vertical velocity = 0 [Refer to the diagram in (c)(ii)]	[1]
(d)(i)	For a system of interacting bodies, the <u>total momentum</u> of the bodies (i.e. momentum of the system) <u>remains constant</u>, provided <u>no net force acts on the system</u>.	[1] [1]
(d)(ii)	It cannot be applied as there is an (horizontal) external force acting on the system. The external force can be: the ground exerting a contact force/friction on the howitzer, or weight of projectile, or air resistance on projectile.	[1] [1]
9(a)(i)	Electric field strength is the **force per unit** **<u>positive</u> charge**.	[1] [1]
(ii)1.	A (since the positive charge accelerates from A towards B)	[1]
2.	{ Given: initial speed = 0; KE at plate B = 2.4×10^{-16} J } Work done by field = KE gain by charge = 2.4×10^{-16} J.	[1]

3.	W = Fs { since F = const} F = W/s { distance betw plates, s = 15 mm = 0.015 m} $F = 2.4 \times 10^{-16} / 15 \times 10^{-3} = 1.6 \times 10^{-14}$ N or alternative method: KE = $1/2mv^2$ $v^2 = u^2 + 2as$ F = ma	[1-ecf] [1-ecf]
4.	$V = E/d = Fd / Q$ or $V = W / Q$ or $E = V / d$ and $E = F / Q$ *Pd* $V = (1.6 \times 10^{-14} \times 15 \times 10^{-3}) / 1.6 \times 10^{-19}$ or $2.4 \times 10^{-16} / 1.6 \times 10^{-19}$ = 1500 V	[1-ecf] [1-ecf] [1-ecf]
(iii)	straight line with positive gradient starting at origin and ending at x =15 mm.	[1]
(iv)	It will decelerate/slow down and stop before reaching B and accelerate/move to A after a momentary stop	[1] [1]
(b)(i)	Charge must be moving (ie not stationary), with a velocity that is not parallel to the magnetic field.	[1] [1]
(ii)	The speed is decreasing (due to collision with the particles of the medium). This causes the radius to decrease.	[1] [1]
(iii)1.	Since the spirals are in opposite directions, the charges must be oppositely charged.	[1] [1]
2.	Equal **initial** radius, so equal initial speeds.	[1] [1]

End of solutions