Candidate's name ………………………………………. CTG ………..…

YISHUN JUNIOR COLLEGE
JC 2 Preliminary Examinations 2014

PHYSICS **8866/2**

HIGHER 1 **Monday 18th August 2014**

8.00 am – 10.00 am

Paper 2 Structured Questions 2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name and CTG in the spaces provided on this cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

Write your answers in the spaces provided on the question paper.
For numerical answers, **all** working should be shown clearly.

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

For Examiner's Use	
Section A	
1	**/5**
2	**/6**
3	**/6**
4	**/5**
5	**/5**
6	**/4**
7	**/9**
Section B	
8	**/20**
9	**/20**
10	**/20**
Penalty	
Paper 2 Total	**/80**
Paper 1 Total	**/30**
Grand Total	**/110**

For Examiner's Use

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
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	=	$\rho g h$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$

For Examiner's Use

Section A

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

1 **(a)** Express *watt*, in terms of the SI base units.

Watt **= J / s**
= N.m / s **[1]**
= kg.m s^{-2}.m / s
= kg m^2 s^{-3} **[1]**

SI Base Units of Watt = ………………….. [2]

(b) Intensity I of a wave propagated in radial directions from a point source, measured at a particular position, is determined by

$$I = \frac{P}{4\,\pi\, r^2}$$

where P = power of the wave propagated from the source and r = distance from the source to that position measured.

Determine the intensity I, with its associated uncertainty, given

P = (120 ± 5) W

r = (165 ± 2) cm

I **= P / 4π r^2**
= 120 / 4π $(1.65)^2$
= 3.50754 **[1]**

$\Delta I / I$ **= Δ *P* / P + 2 (Δ *r* / *r*)**
= (5/120) + 2 (2/165) **[1]**
= 0.065909
ΔI **= 0.23**
≈ 0.3 (round up)

Hence I **= 3.5 ± 0.3** **[1]**

Intensity I = (…………………… ± ……………) W m^{-2} [3]

For Examiner's Use

2 A toy rocket is propelled vertically upwards. The graph of Fig. 2.1 shows the variation with time *t* of the velocity *v* of a toy rocket from the moment the fuel of the rocket is used up.

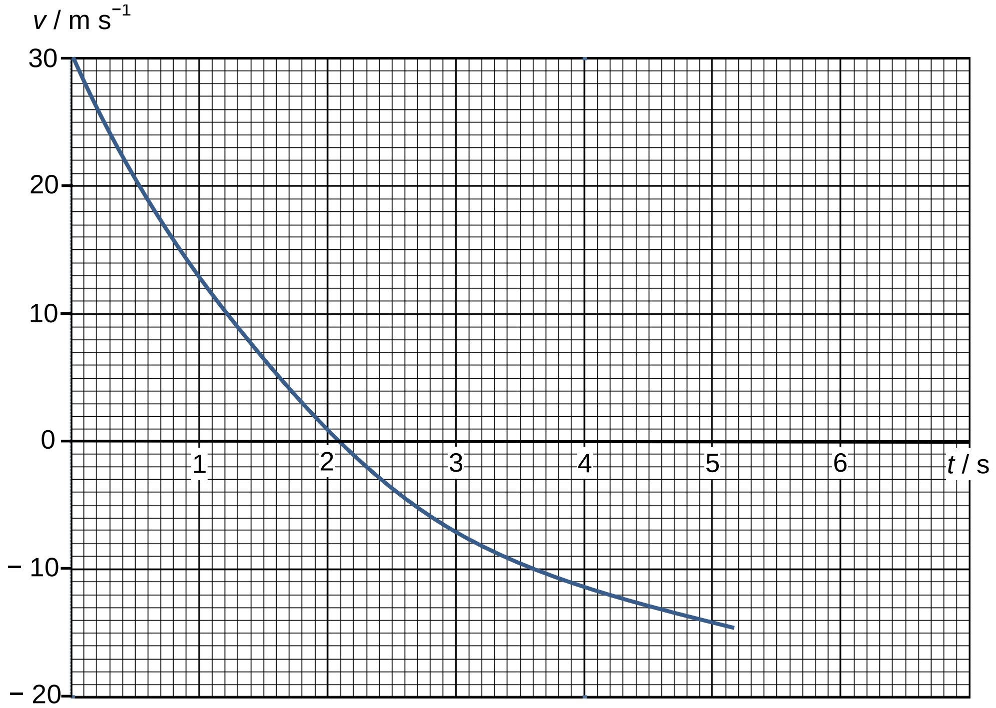


Fig. 2.1

(a) State the time at which the acceleration equals to acceleration of free fall.

time = 2.1 s ……………………. s [1]

(b) Sketch on Fig. 2.2, the acceleration-time graph for the toy rocket for the first 3 seconds of the motion after the fuel is used up. (Find the acceleration of the toy rocket when t = 0) [2]

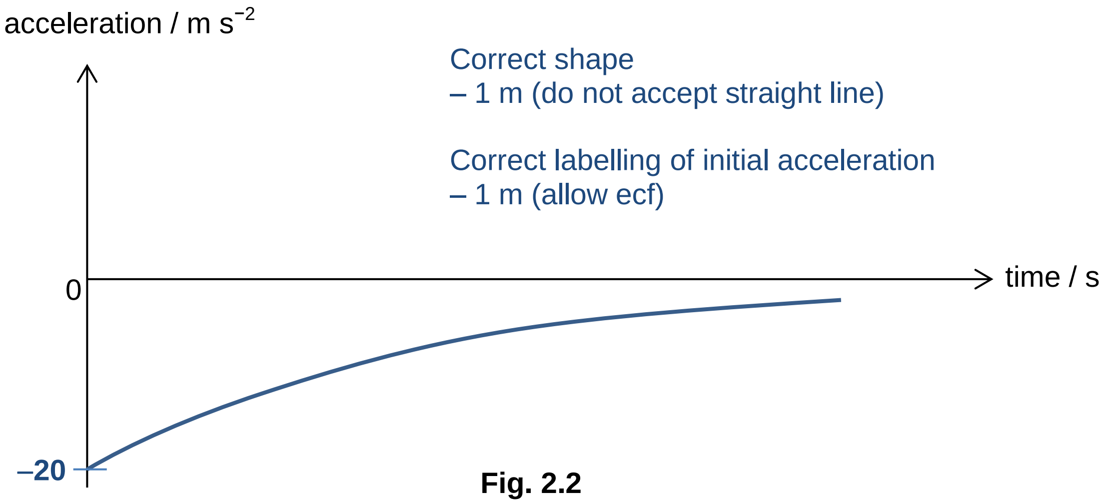


Fig. 2.2

(c) Without further calculations, sketch on Fig. 2.3, the displacement-time graph of the toy rocket for the first 3 seconds of the motion **after** the fuel is used up. (Measure the displacement with respect to the displacement where the fuel has been used up. Label the time when maximum height is reached) [3]

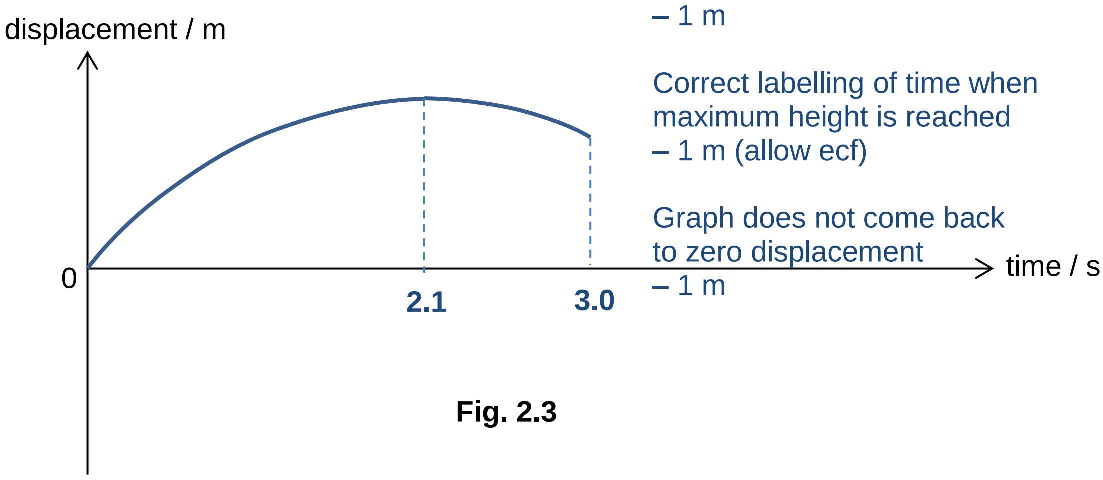


Fig. 2.3

3 **(a)** State the conditions required for a rigid body acted upon by two or more forces to be in equilibrium.

Resultant force on the body must be zero.

Resultant torque on the body about any axis must be zero

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

(b) Fig. 3 shows a heavy rod **OA** of weight 120 N and length 1.0 m is hinged at **O** and held in the position shown by a force *F* acting at right angles to the rod and applied at **A**.

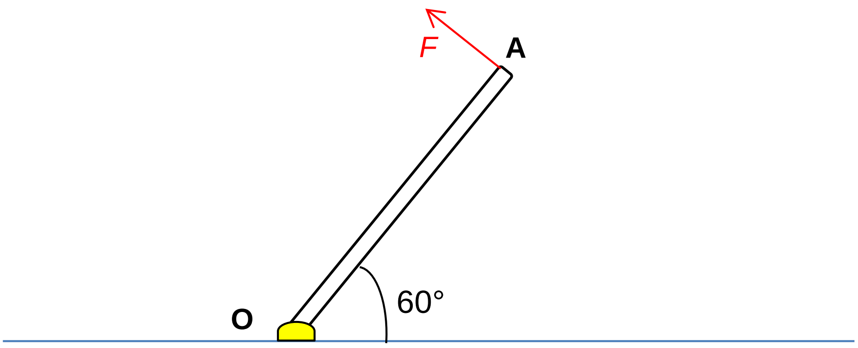


Fig. 3

(i) Indicate and label force *F* on Fig. 3. [1]

(ii) Explain the direction of *F* as indicated in Fig. 3.

The direction of the F has to be 90° upwards with respect to the rod to create anti clockwise moment and to counter act the clockwise moment of the weight of the rod. [1]

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

(iii) Calculate the magnitude of F.

Taking moments about the hinge,

$120 \times 0.5 \cos 60° = F \times 1$ [1]

$F = 30$ N [1]

F = ……………………… N [2]

4 Fig. 4 shows two electrical cables, Cable **A** and Cable **B** used to connect a power supply to a lamp. Each cable has a length of 0.45 m and has a resistance of 0.50 Ω m^{-1}.

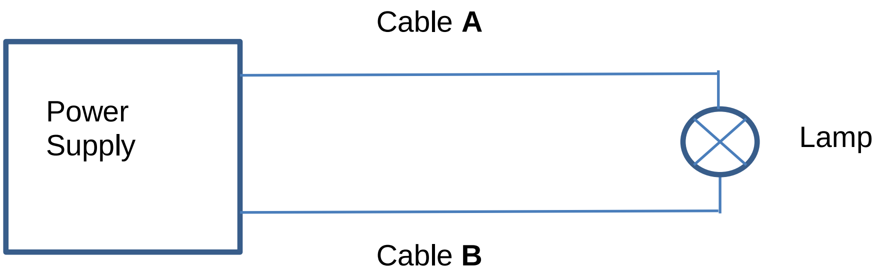


Fig. 4

The lamp is rated at 36 W, 6.0 V. The power supply has an internal resistance of 2.5 Ω and its output is adjusted so that the potential difference across the lamp is 6.0 V.

(a) Calculate the resistance of the lamp when it is operating at 6.0 V.

$R = 6.0^2/36$ [1]
$= 1.0$ Ω [1]

Resistance of lamp = ………… Ω [2]

(b) Calculate the e.m.f of the power supply.

Current through the lamp = 6.0 / 1.0 = 6.0 A [1]
E.m.f of supply = 6.0 x (2.5 + 0.45 + 1.0) [1]
= 24 V [1]

E.m.f of power supply = ………… V [3]

For Examiner's Use

5 **(a)** As shown in Fig. 5.1, two resistors of resistances R_1 and R_2 respectively are connected in parallel. Derive a formula, using principal of conservation of energy, for the total resistance R of this combination of resistors. [2]

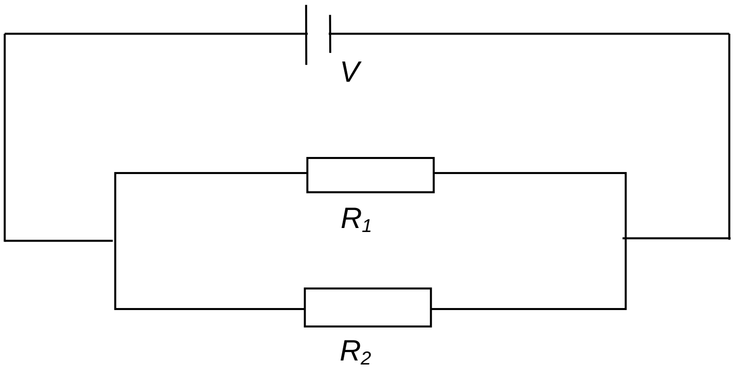


Fig. 5.1

Power generated by the source = Total power dissipated by the resistors

Hence, $VI = VI_1 + VI_2$ [1]

$\therefore$ $I = I_1 + I_2$

Since $I = \frac{V}{R}, I_1 = \frac{V}{R_1}, I_2 = \frac{V}{R_2}$.

Thus, $\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2}$ [1], $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

(b) Fig. 5.2 shows a circuit which contains a component Y in parallel with a thermistor.

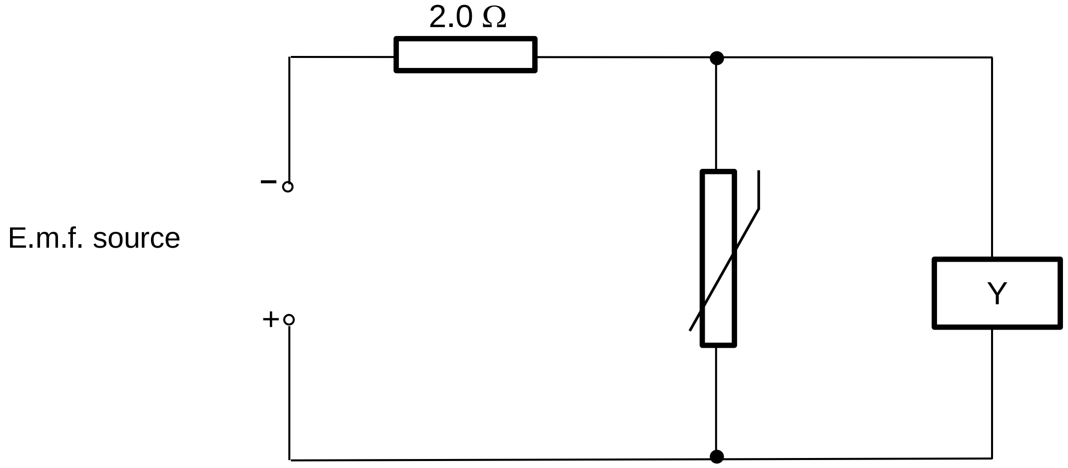


Fig. 5.2

At a particular temperature, the potential difference across Y is 5.00 V while the resistances of component Y and the thermistor are 125 Ω and 50.0 Ω respectively.

For Examiner's Use

Calculate

(i) the total resistance of the circuit.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = 35.714\ \Omega$$

Total R = 2 + 35.714 = 37.7 Ω [1]

Total resistance = ……………………… Ω [1]

(ii) the potential difference across the power supply.

$$5 = \frac{35.714}{35.714 + 2} V_{in} \quad [1]$$

Vin = 5.28 V [1]

Potential difference across power supply = ……………………… V [2]

6 An overhead power line consists of two parallel identical cables, each with a cross sectional area of 0.100 m^2 and separated by a distance of 15.0 m. The current in each cable is 150 A and the magnetic field strength due to each cable is 5.85×10^{-6} T.

(a) Calculate the force per unit length on each cable.

F = BIL = $5.85 \times 10^{-6} \times 150$ [1]
= 8.78×10^{-4} N [1]

Force per unit length = …….........N m^{-1} [2]

(b) A junior electrician claims that he is able to detect current flow in the cables by observing the movement of the cables. Explain why this is not possible.

The amount of force per unit length is too small to move the cable which is heavy.

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

For Examiner's Use

(c) Explain how your answer in (a) will be affected if the separation between the cables decreases.

The amount of force per unit length will increase because the magnetic field strength will increase .

....[1]

7 **(a)** Fig 7.1 shows the variation of the photocurrent I with the potential of the anode with respect to the cathode, V in the photoelectric experiment.

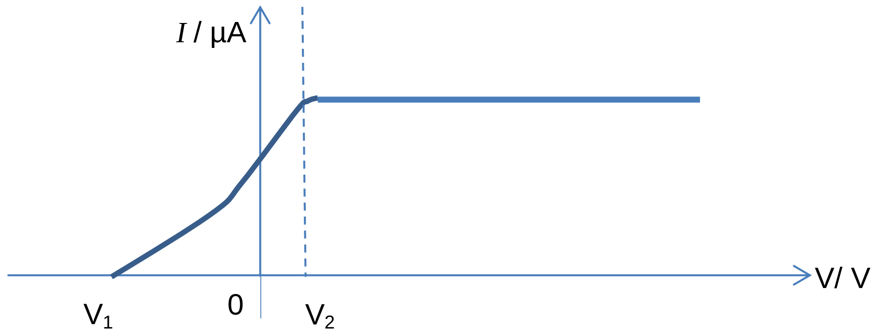


Fig. 7.1

Suggest possible reasons for the following observations as seen from Fig. 7.1.

(i) For values of V between V_1 and 0 V, the photocurrent increases as V becomes less negative.

As V becomes less negative, more electrons with kinetic energy smaller than maximum kinetic energy electron can reach the collector [1]. Hence the photocurrent increases.

....[1]

(ii) For values of V more negative than V_1, no photocurrent is detected.

When V_1 is applied to the collector, even the electrons with maximum kinetic energy will not be able to reach it [1]. Thus making the collector more negative than V_1 will prevent all the electrons from reaching the collector.

....[1]

(iii) For values of V between 0 V and V_2, saturation current was not achieved.

When V became slightly greater than 0 some of the electrons are absorbed back into the surface of the metal due to the attractive forces of the metal ions [1]. Some others may repel each other and move in a direction away from the collector [1]

....[2]

[Turn over

(b) An incident photon is incident on a metallic surface of work function energy of 5.32 eV. However, the photoelectron emitted has zero kinetic energy. Calculate the momentum of the photon.

$\lambda = hc/\ 5.32 \times 1.6 \times 10^{-19}$ [1]

$p = h/\ \lambda = 5.32 \times 1.6 \times 10^{-19} / 3 \times 10^{8} = 2.84 \times 10^{-27}$ N s [1]

Momentum of the photon = …………..N s [2]

(c) An electron in the ground state of an atom with energy levels as shown in Fig. 7.2 is struck by a photon.

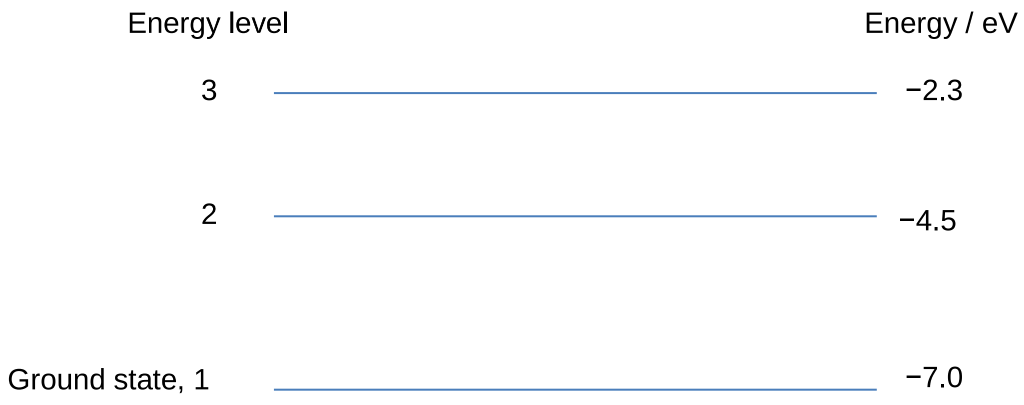


Fig. 7.2

State and explain what happens to the electron when the energy of the photon is

(i) 2.5 eV

The electron will absorb the energy of the photon and move up to level 2.

……………………………………………………………………………………[1]

(ii) 4.5 eV

The electron will not absorb the energy of the photon [1] as it does not correspond to the difference in energy between any energy levels of the atom [1].

……………………………………………………………………………………[2]

For Examiner's Use

For Examiner's Use

Section B

Answer **two** of the questions in this section.

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

A tesla is the magnetic flux density of a field in which a force of 1 N is exerted on a conductor of length 1 m carrying a current of 1 A [1] and placed at right angles to the field [1]

[2]

(b) A student decides to design a simple motor to be used for his toy trolley. He sets up a current carrying square coil of wire as shown in Fig.8.1. The coil **ABCD** has length 5.00 cm and width 5.00 cm. The number of turns in the coil, N is 110. The current passing through the wire is 3.50 A while the magnetic field strength is 1.85 T.

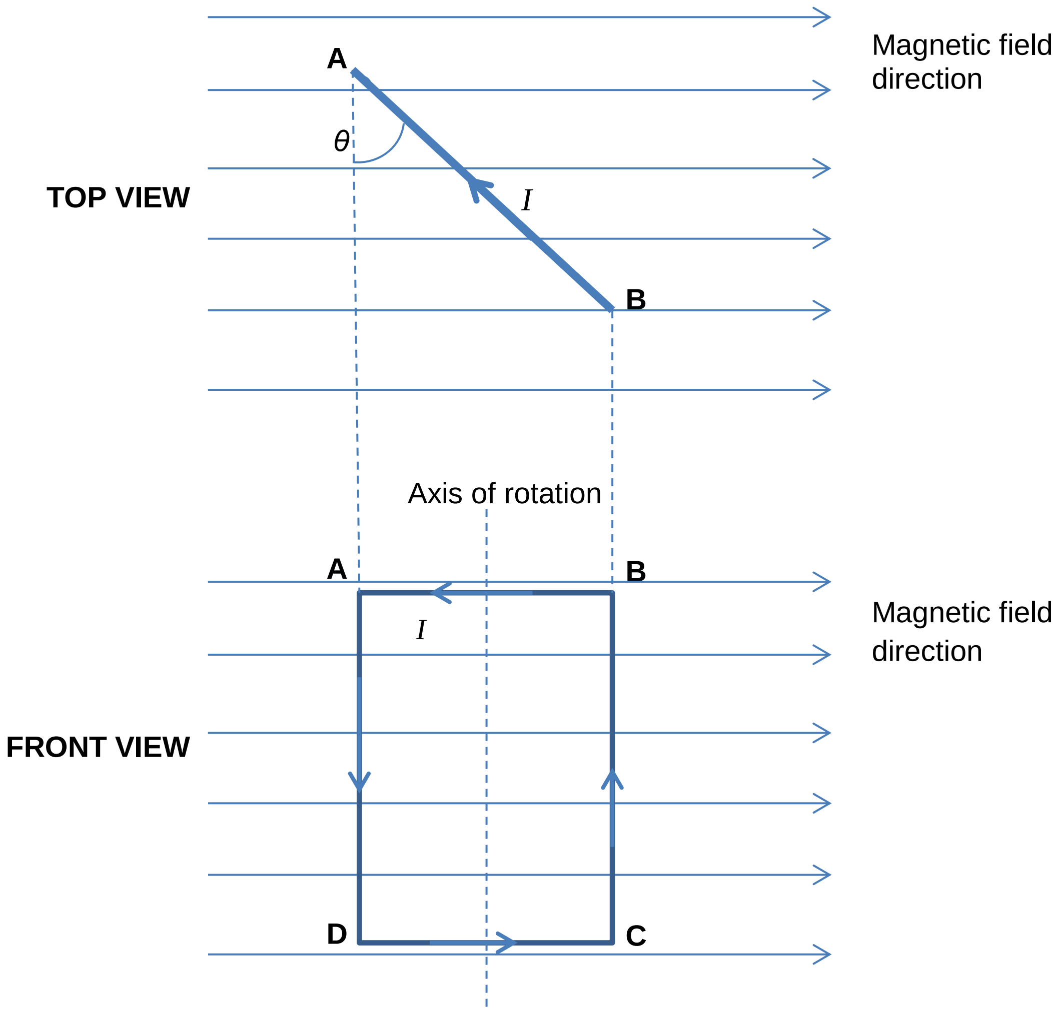


Fig.8.1

[Turn over

(i) Determine the direction and magnitude of the torque exerted on the coil when $\theta = 30^o$.

Torque exerted = 1.85 x 110 x 3.50 x 5.00 x 10^{-2} x (5.00 x 10^{-2} sin 30) [1]
= 0.890 Nm [1] ACW [1]

Torque exerted on coil = ………… N m [2]

Direction when viewed from top = ……………………………[1]

(ii) Later, it was observed that arm **BC** actually experiences a resistive force. This resistive force causes 0.175 Nm of torque in the clockwise direction viewed from the top when θ = 30°. Calculate the new magnetic field strength required in order to ensure the net torque remains the same as **(i)**. (Assume the resistive force remains unchanged)

Required torque due to magnetic force = 0.175 + 0.890 = 1.065 Nm [1]

New magnetic field = 1.065/(110 x 3.50 x 5.00 x 5.00 x 10^{-2} x 10^{-2} xsin30)
= 2.21 T [1]

New magnetic field strength = …………………… T [2]

(c) The student installs the motor in his toy trolley, **A**. Trolley **A** of mass 2.0 kg is then connected to trolley **B** of mass 6.0 kg using a light cable. Both trolleys are accelerating down a slope at an angle of 30° and a constant force *F* is applied on trolley **A** by the motor to reduce the acceleration as shown in Fig. 8.2. Neglect friction and effects of air resistance.

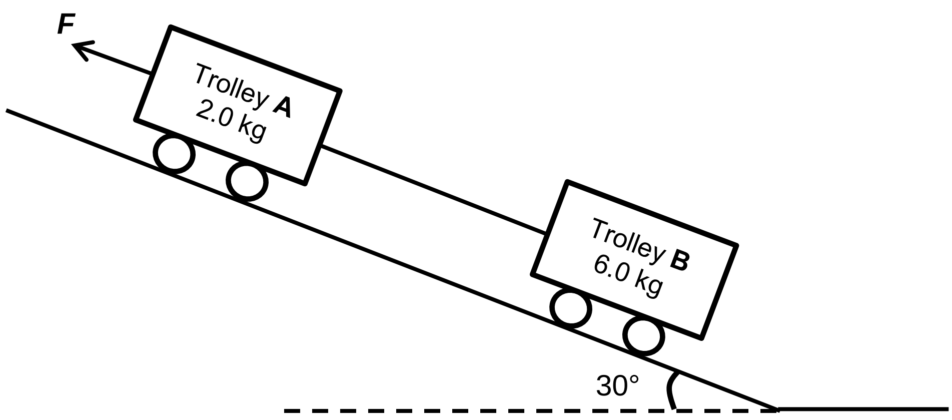


Fig. 8.2

[Turn over

For Examiner's Use

(i) Write an equation which relates the acceleration a_A of trolley **A** with its mass m_A, the tension in the cable T and the pulling force F. [1]

$\Sigma F = ma$

$m_A g \sin 30 + T - F = m_A a_A$ [1]

$a_A = (m_A g \sin 30 + T - F) / m_A$

(ii) Write an equation which relates the acceleration a_B of trolley **B** with its mass m_B and the tension T in the cable. [1]

$\Sigma F = ma$

$m_B g \sin 30 - T = m_B a_B$ [1]

$a_B = (m_B g \sin 30 - T) / m_B$

(iii) Hence, determine the tension in the cable T in terms of F. [2]

Since $a_A = a_B$

$(m_A g \sin 30 + T - F) / m_A = (m_A g \sin 30 - T) / m_B$ [1]

$(2g \sin 30 + T - F) / 2 = (6g \sin 30 - T) / 6$

$T = \frac{3}{4} F$

The cable is now cut. Trolley **B** reaches the bottom of the slope with a speed of 5.0 m s^{-1}. Trolley **B** then collides head-on with trolley **C** of mass 10 kg travelling at a speed of 3.0 m s^{-1} to the left as shown in Fig. 8.3. Trolley **C** then travels to the right after the collision with a speed of 2.0 m s^{-1}.

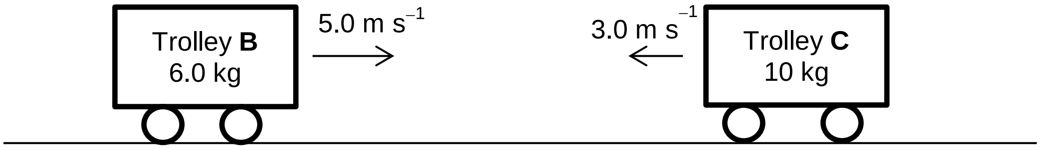


Fig. 8.3

(iv) Determine the velocity of trolley **B** after the collision.

By conservation of momentum,

$M_B u_B + m_C u_C = m_B v_B + m_C v_C$

6.0 (5.0) + 10 (-3.0)= 6.0 (v_B) + 10 (2.0) [1]

v_A = - 3.3 m s^{-1}

speed = 3.3 m s^{-1} [1]

To the left

speed = …………….m s^{-1} [2]

Direction = …………………. [1]

(v) Fig. 8.4 shows the variation of the velocity of trolley **C,** *v* with respect to time, *t*. Sketch the corresponding velocity-time graph for trolley **B**. [2]

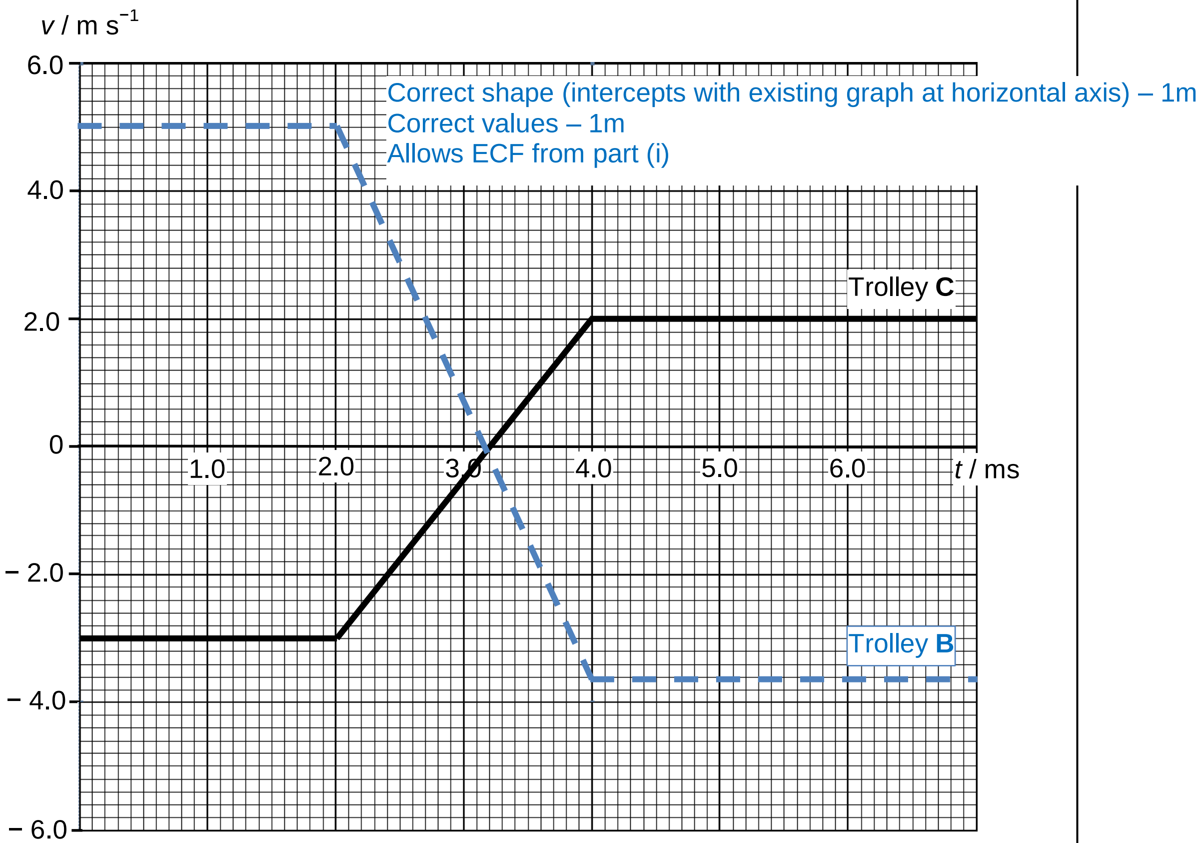


Fig. 8.4

For Examiner's Use

(vi) Explain whether the collision is an elastic collision. Substantiate your conclusion with workings.

KE before

$KE_i = ½ (6)(5)^2 + ½ (10)(3)^2 = 120$ J

KE after

$KE_f = ½ (6)(3.3)^2 + ½ (10)(2)^2 = 53$ J [1]

Conclusion: Since there is loss in kinetic energy during the collision, the collision is inelastic. [1]

....[2]

(vii) Determine the average force experienced by trolley **C** during the collision.

$F = mv – mu / t$

$= 10 (2 + 3) / (2 \times 10^{-3})$ [1]

$= 25000$ N [1]

average force = ... N [2]

9 **(a)** A bungee jumper is attached to an elastic rope which is tied at one end to a pole. At the start of the jump, the man is initially at rest at the edge of a cliff. The man then jumps off from the cliff. Fig. 9.1 shows the graph of the net force, F_{net} acting on the man against the vertical distance, h travelled by man with respect to the point he jumps from. The natural length of the rope is 10 m and the weight of the man is 500 N.

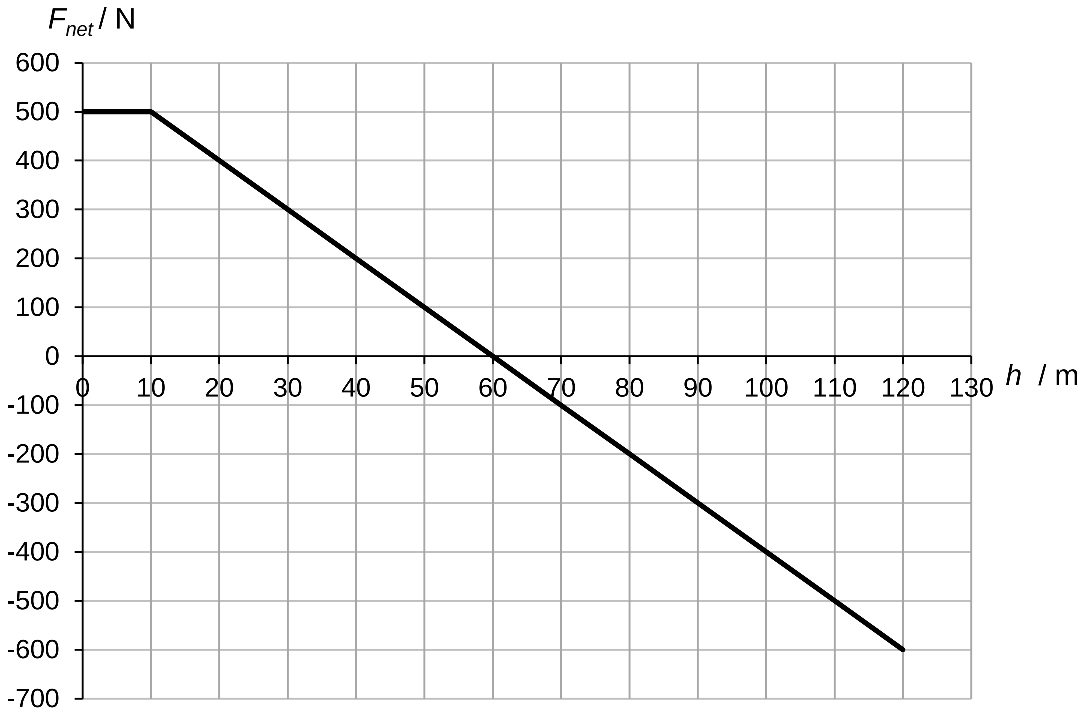
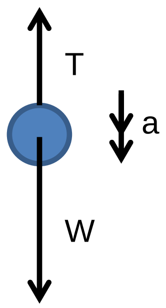


Fig. 9.1

(i) Calculate the spring constant of the elastic rope.



$W - T = F_{net}$

$500 - k\,(60-10) = 0$ [M1]

$k = 10\ \text{N m}^{-1}$ [A1]

Spring constant = ... N m^{-1} [2]

(ii) Calculate the distance, h travelled where he reaches the lowest point.

$K.E_i + G.P.E_i + E.P.E_i = K.E_f + G.P.E_f + E.P.E_f$

$0 + 500\,h + 0 = 0 + 0 + \frac{1}{2}(10)(h - 10)^2$ [M1]

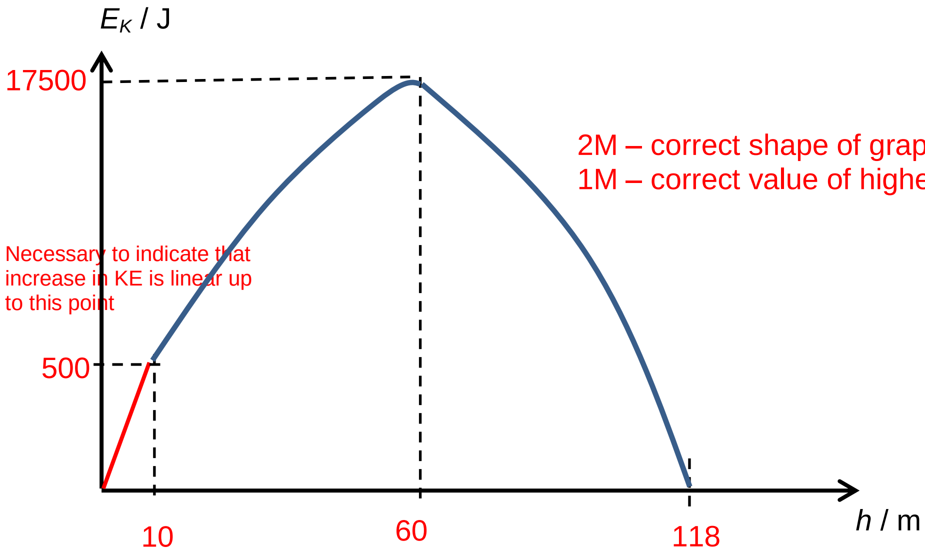
$h^2 - 120\,h + 100 = 0$

$h = 118$ m or $h = 0.839$ m (N.A) [A1]

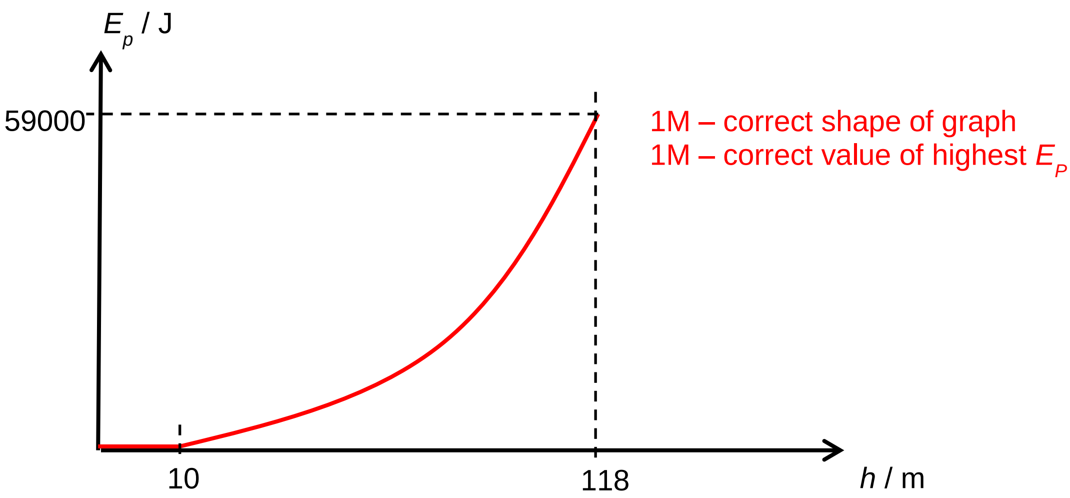
Distance = ... m [2]

For Examiner's Use

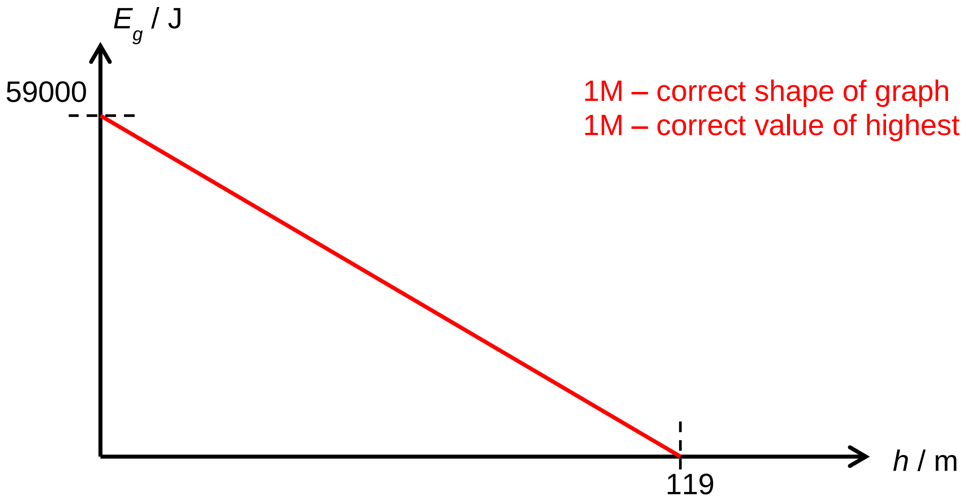
(iii) Sketch a graph of kinetic energy, E_k of the man against the distance, h from the start to the lowest point reached. Label on the graph the value of highest kinetic energy attained and the kinetic energy attained when h = 10 m . Hint: Consider the area of F_{net} – h graph. [3]



(iv) Sketch a graph of elastic potential energy, E_p of the rope against the distance, h from the start to the lowest point reached. Indicate on the graph the greatest E_p attained to two significant figures. [2]



(v) Sketch a graph of gravitational potential energy, E_g of the rope against the distance, h from the start to the lowest point reached, assuming that the E_g is zero at the lowest point. Label on the graph the value of greatest E_g attained to two significant figures.



(b) A box is pulled up along a slope at a constant speed of 3.0 m s^{-1} by a string tied to a motor as shown in Fig. 9.2. The slope exerts a frictional force of 6.0 N on the box and the mass of the box is 1.0 kg. The motor has an efficiency of 80 %.

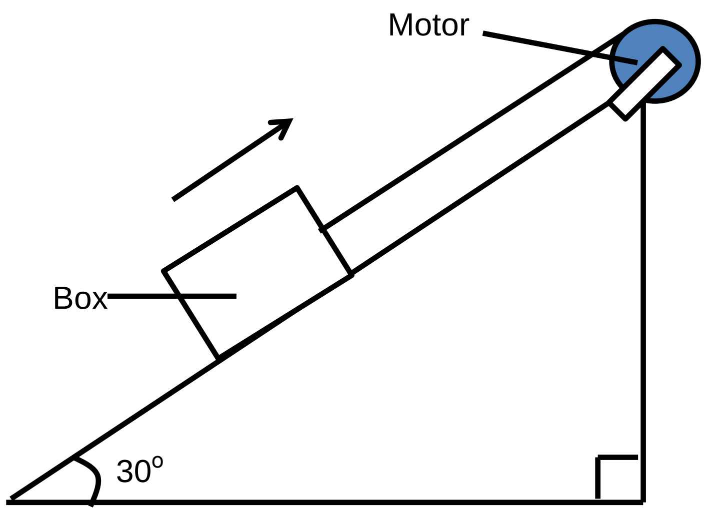


Fig. 9.2

(i) Calculate the tension in the string.

$T - m\,g \sin 30^\circ - Fr = m\,a$

T - (1)(9.81) sin 30° - 6.0 = 1 × 0 [M1]

T = 10.905 = 11 N [A1]

Tension = ……………………… [2]

For Examiner's Use

(ii) Calculate the input power of the motor required to pull up the box.

$P_{output} = T\,v = 10.9 \times 3 = 32.7$ W [M1]

$P_{input} = \dfrac{100}{80} \times P_{output}$

$= \dfrac{100}{80} \times 32.7 = 40.9$ W [A1]

Input power = ………………………. W [2]

(iii) Calculate the total input energy supplied to the motor when the box moved up through a vertical height of 15 m.

$t = \dfrac{15 / \sin 30^{\circ}}{3.0} = 10$ s [M1]

$E_{input} = 10 \times 40.9 = 409$ J [A1]

Input energy = ………………… J [2]

(iv) State the relationship between the power of the motor and the frictional force, such that the speed of the box remains unchanged at 3.0 m s^{-1}.

Power of the motor varies linearly with frictional force [1M].

…………………………………………………………………………………… [1]

(v) State the energy conversion of the box as the box is pulled up along the slope.

The useful energy supplied by the motor is converted to gravitational potential energy [1] and heat energy due friction[1].

…………………………………………………………………………………… [2]

For Examiner's Use

10 **(a)** Define *wavelength, frequency and speed*, as applied to wave motion.

Wavelength: Distance between 2 consecutive particles of the same phase [1];

Frequency: Number of oscillations per unit time made by a point in the wave [1];

Speed: Distance moved by wavefront per unit time [1]

....[3]

(b) Based on the definitions in **(a)**, deduce the equation for the speed of wave is in terms of its wavelength and frequency. [3]

From the definition of speed, for the wave to travel a distance of one wavelength λ, the time taken by the waveform is one period, *T*. [1]

Speed of wave = distance moved / time taken

= λ / *T* [1]

= f λ *(since f = 1 / T)* [1]

(c) At time $t = 0$, the displacement-distance graph of a progressive wave is shown in Fig. 10.1. The wave is progressing to the left at 0.50 m s^{-1}.

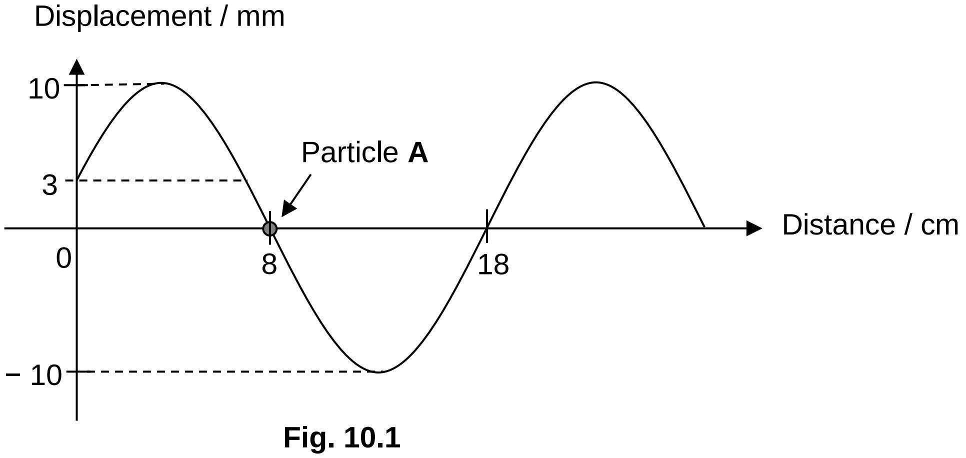


Fig. 10.1

For Examiner's Use

(i) Determine the frequency of the wave.

From the graph, wavelength = 2 (18 – 8)
= 20 cm [1]

Frequency = speed / wavelength
= 50 / 20
= 2.5 Hz [1]

Frequency = ……………………… Hz [2]

(ii) On Fig.10.2, show the variation with time of the displacement of particle **A,** for at least one complete cycle. Label the critical values on the axes. [2]

[1] Correct graph shape
[1] Period of 0.4 s indicated

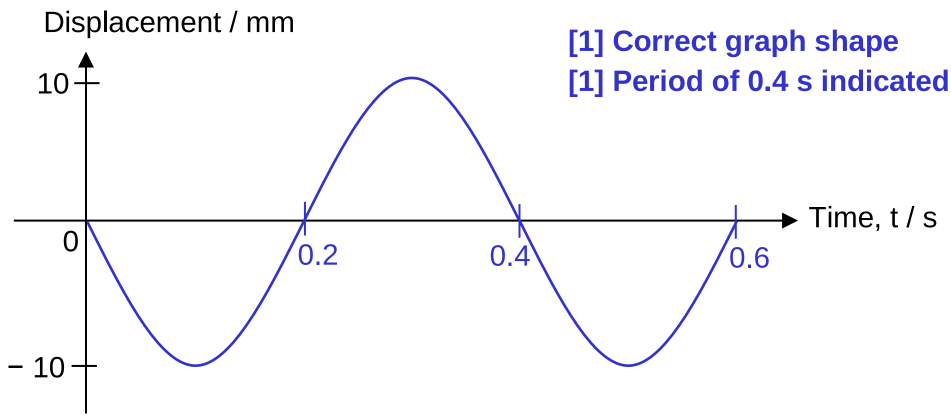


Fig.10.2

For Examiner's Use

(d) A small loudspeaker emitting sound of constant frequency is positioned a short distance above a long glass tube containing water. When water is allowed to run slowly out of the tube, the intensity of the sound heard increases whenever the length *l* (shown in Fig.10.3) takes certain values.

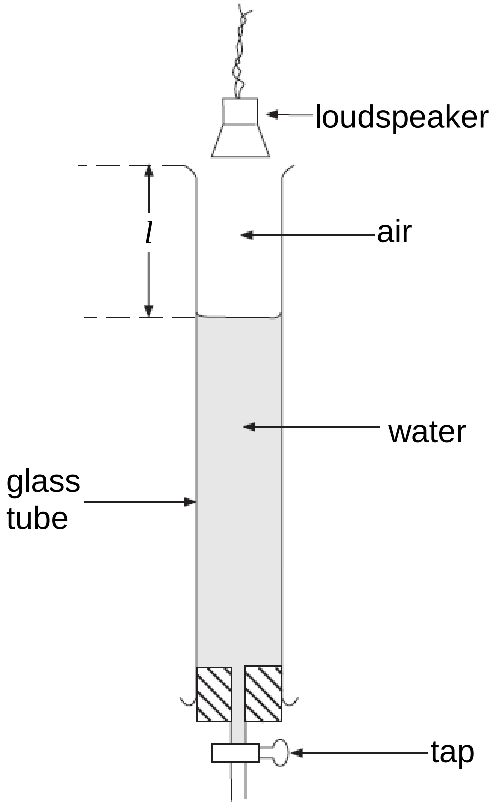


Fig.10.3

(i) Explain these observations by reference to the physical principles involved.

air set into vibration at frequency of loudspeaker [1]

wave reflected from surface (of water) [1]

(interference/superposition between transmitted and reflected waves) or (stationary wave is formed when incident waves and reflected waves meet) [1]

maximum intensity when $l = \frac{1}{4}\lambda$, $3/4\ \lambda$ etc. (Accept if stated path difference between the transmitted and reflected waves is $n\lambda$) [1]

....[4]

[Turn over

For Examiner's Use

(ii) With the loudspeaker emitting sound of frequency 480 Hz, the effect described in **(i)** is first noticed when l = 168 mm. It next occurs when l = 523mm.

Use both values of l to calculate

1. the wavelength of the sound waves in the air column,

$\lambda/2 = 523 - 168$ [1]
$\lambda = 710$ mm [1]

wavelength = ……………………… m [2]

2. the speed of the sound waves.

$v(= f\lambda) = 480 \times 0.71$ [1]
$= 341 \text{ m s}^{-1}$ [1]

speed = ……………………… m s^{-1} [2]

3. At the fundamental frequency, the student commented that the wavelength of the sound is four times the length, l. He thus calculated the speed of sound using this value of wavelength. Explain why the speed of sound calculated in this manner is inaccurate and state whether this calculation is an overestimate or underestimate.

Antinode is slightly above the opening of the glass tube OR did not account for end correction [1]……………………………………………………………………………

……………………………………………………………………………………………

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

…………………………………………………………………………………………[2]

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