BP~627

TEMASEK JUNIOR COLLEGE
2024 JC2 Preliminary Examination
Higher 2

TEMASEK JUNIOR COLLEGE

NAME

CG

PHYSICS

9749/02

Paper 2 Structured Questions

23 August 2024

2 hours

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
s.f	
Total	

READ THESE INSTRUCTIONS FIRST

Write your name 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.

Answer **all** questions

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

Formulae

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

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

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

1 **(a)** State the conditions for a body to be in equilibirum.

1. ....

....

2. ....

.... [2]

(b) An athlete uses a machine in the gym where he hinges at the knee joint to move his lower legs up as shown in Fig. 1.1. There is a constant downward force of 25 N exerted at point A on each feet at constant distance L from point B, as shown in Fig. 1.2. The combined weight of a foot and one lower leg is 30 N acting at L/2 from the knee joint. When the legs are raised, there is a force F at distance L/4 from knee joint and at angle of θ to the leg as shown in Fig 1.2.

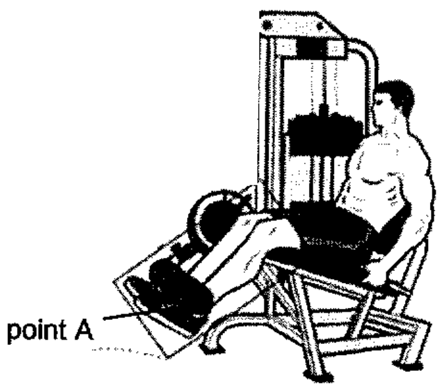


Fig. 1.1

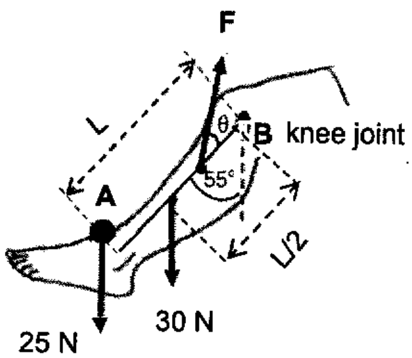


Fig 1.2

It is given that L = 40 cm. At position shown in Fig. 1.2, the lower leg and feet are at equilbrium at angle of 55° to the vertical, and θ = 25°.

(i) By taking moments about point B at the knee joint, calculate the force F exerted on the lower leg in Fig 1.2.

force, F = ... N [2]

(ii) For the lower leg to be in equilibrium, there is a force R at the knee joint.

Draw on Fig.1.2, a labelled arrow to represent the force R. [1]

(iii) At the beginning, the feet are down as shown in Fig. 1.3.

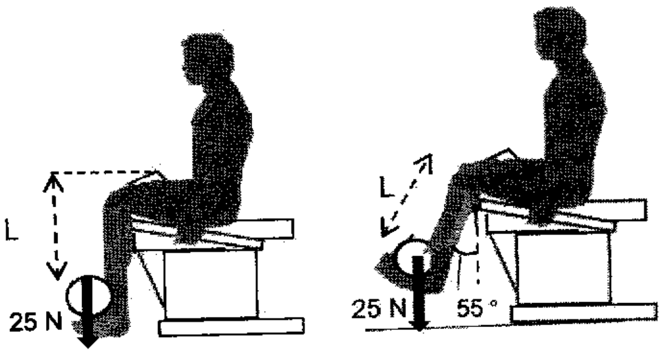


Fig 1.3 **Fig 1.4**

He raises his legs until they are at an angle of 55° to the vertical as shown in Fig. 1.4. Calculate the work done to raise one lower leg to this position at constant speed. Assume that the knee joint is a point that stays in place throughout.

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

[2]

(iv) Hence calculate the power exerted by the athlete in raising one leg to the position shown in Fig 1.4 if the time taken is 5.0 s.

Power exerted = ... W [1]

2 (a) (i) Explain why the gravitational potential at a point in a gravitational field is negative.

....

....

.... [2]

(ii) The gravitational potential at the surface of Earth is -62.6×10^6 J kg^{-1}, and that at the surface of Moon is -28.1×10^6 J kg^{-1}. (The mass of the Earth is 81 times the mass of the Moon).

1. On Fig. 2.1, sketch a graph which shows the variation of gravitational field strength along a line from the surface of Earth to the surface of Moon. [2]

2. Hence sketch, on Fig. 2.2, a graph which shows the variation of gravitational potential along a line from the surface of Earth to the surface of Moon. [2]

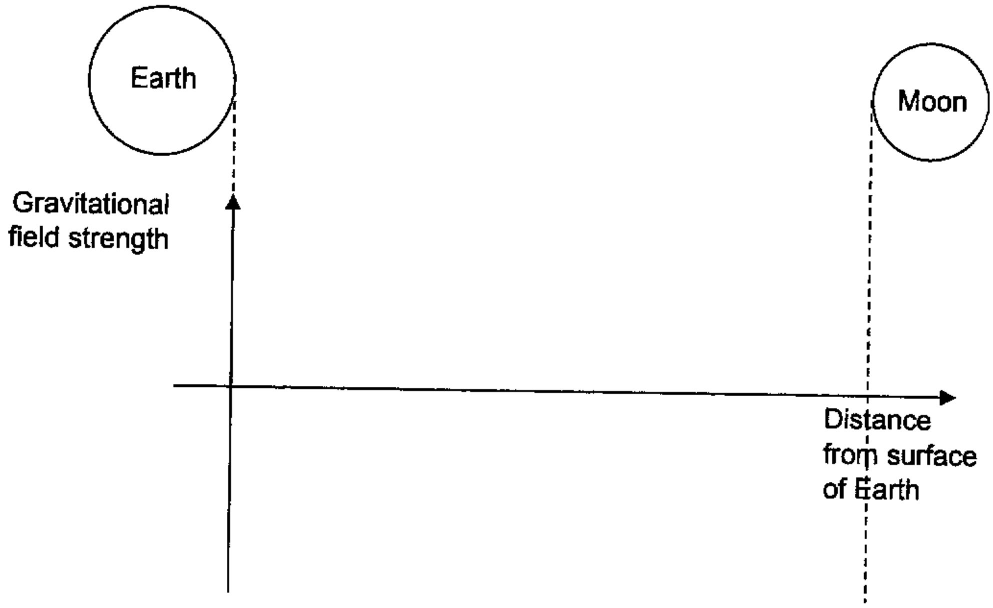


Fig. 2.1

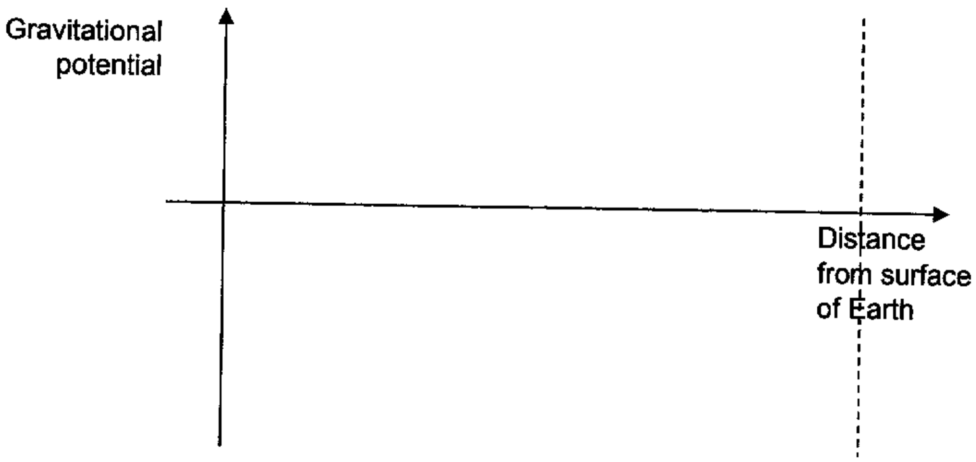


Fig. 2.2

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

(b) An isolated spherical planet has a diameter of 6.8×10^6 m. Its mass of 6.4×10^{23} kg may be assumed to be a point mass at the centre of the planet.

(i) Show that the gravitational field strength at the surface of the planet is 3.7 N kg^{-1}. [1]

(ii) A stone of mass 2.4 kg is raised from the surface of the planet through a vertical height of 1800 m. Use the value of the field strength from **(i)** to determine the change in gravitational potential energy of the stone. Explain your working.

change in gravitational potential energy = ... J [2]

(iii) A rock, initially at rest at infinity, moves towards the planet. At point P, its height above the surface of the planet is 3.5 *D*, where *D* is the diameter of the planet, as shown in Fig. 2.3.

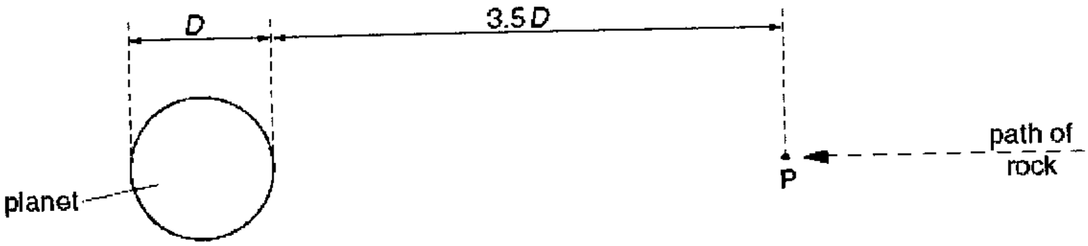


Fig. 2.3

Calculate the speed of the rock at point P. Explain your working.

speed at point P = ... m s^{-1} [3]

3 A horizontal string is stretched between two fixed points A and B. A vibrator is used to oscillate the string and produce an observable stationary wave.
At one instant, the moving string is straight, as shown in Fig. 3.1.

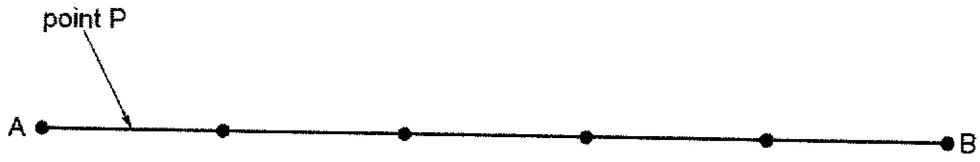


Fig. 3.1

The dots in the diagram represents the positions of the nodes on the string. Point P, which is in the middle of the 2 adjacent dots on the string is moving downwards.
The wave on the string has a speed of 35 m s^{-1} and period of 0.040 s.

(a) Explain how the stationary wave is produced.

....

....

....

.... [2]

(b) On Fig. 3.1, sketch a line to show a possible position of the string a quarter of a cycle later than the position shown on the diagram. [1]

(c) Determine the horizontal distance from A to B.

distance = ... m [2]

(d) A particle on the string has zero displacement at t = 0 s. From time t = 0 to time = 0.060 s, the particle moves through a total distance of 72 mm.

(i) Calculate the amplitude of oscillation of the particle.

amplitude = ... mm [2]

(ii) State a time at which this particle will have maximum speed.

time = ... s [1]

(iii) Calculate the maximum speed of this particle.

maximum speed = ... m s^{-1} [2]

(e)

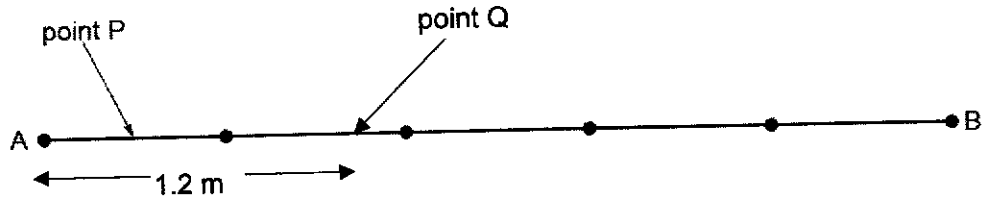


Fig. 3.2

Fig. 3.2 again shows one instant in which the string is straight, and points P and Q are two points on the string as shown. Point P is midway between the two dots while point Q is at a distance of 1.2 m from point A.

Compare the vibrations of the point P with those of point Q, with reference to amplitude, phase and frequency.

....

....

....

.... [2]

4 The *I*-V characteristic of a light-emitting diode (LED) is shown in Fig. 4.1.

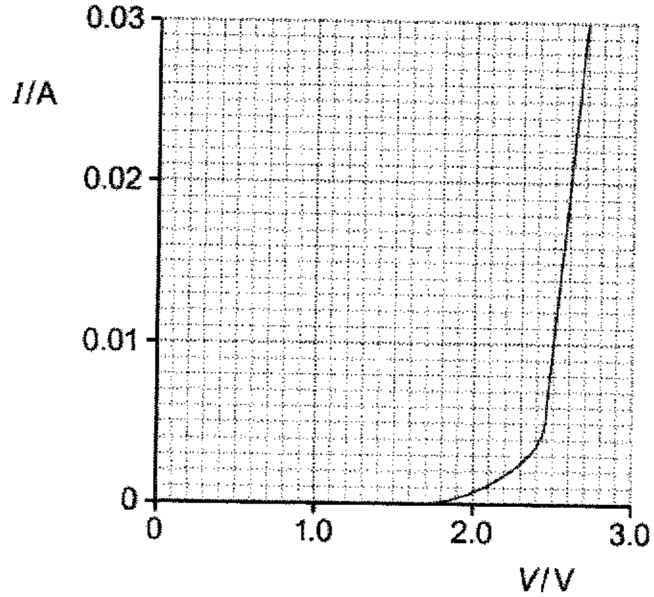


Fig. 4.1

(a) Describe the variation of the resistance of the LED as V increases from zero to 2.7 V.

....

....

....

.... [2]

(b) The LED is connected in a circuit as shown in Fig. 4.2.

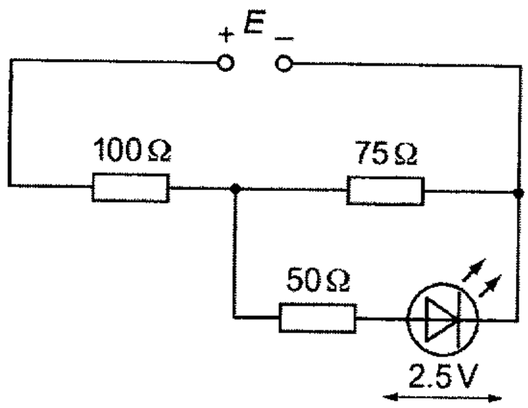


Fig. 4.2

The power supply has electromotive force (e.m.f.) E and negligible internal resistance. The resistance values of the resistors are indicated in the figure.

The potential difference (p.d.) across the LED is 2.5 V.

(i) Use Fig. 4.1 to show that the p.d. across the 50 Ω resistor is 0.50 V

[1]

(ii) Calculate the e.m.f. E of the power supply.

E = ... V [3]

(iii) The LED emits blue light of wavelength 4.7×10^{-7} m.
Estimate the number of blue light photons emitted from the LED per second

number of photons per second = ... s^{-1} [2]

(c) An identical LED is connected in a circuit designed by a student, as shown in Fig. 4.3.

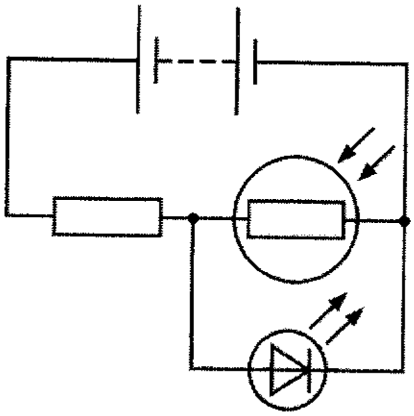


Fig. 4.3

The LED is very close to and facing the light dependent resistor (LDR).
The circuit is taken into a dark room.

The student thought that the LED would switch on. Instead, the LED was found to repeatedly switch on and off.

Explain this behaviour of the LED in the circuit.

DO NOT WRITE IN THIS MARGIN

....

....

....

.... [2]

DO NOT WRITE IN THIS MARGIN

5 (a) Fig. 5.1 shows two horizontal metal plates in a vacuum.

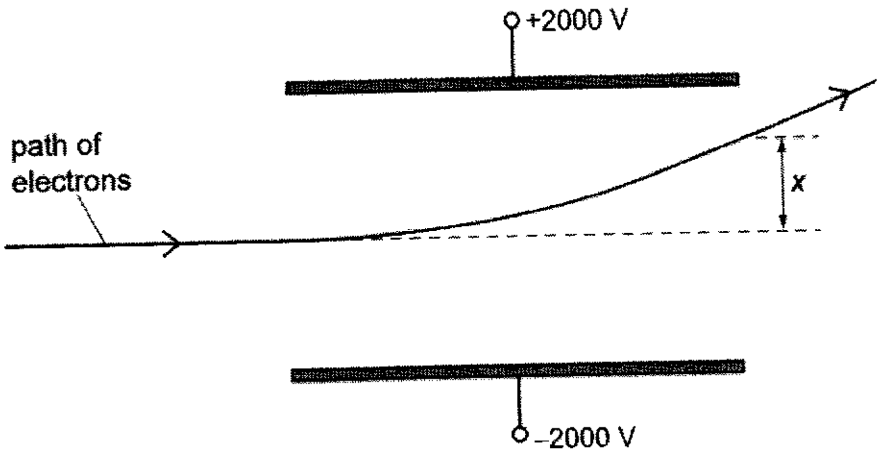


Fig. 5.1

The diagram is not drawn to scale.

Electrons travelling horizontally enter the region of uniform electric field between the charged plates and are deflected vertically.

The distance between the plates is 0.08 m.
The initial speed of the electrons is 6.0×10^7 m s^{-1}.
The vertical deflection of the electrons at the far end of the plates is x.

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

(i) The length of each plate is 0.12 m.
Show that the time t taken by the electron to travel this length is 2.0×10^{-9} s.

[1]

(ii) Calculate the vertical deflection x of the electron.

x = ... m [3]

(b) In a separate experiment, an electron is travelling at 5.0×10^5 m s^{-1} at an angle of 25° to the direction of the magnetic field as shown in Fig. 5.2a.
It forms a helix of radius $r = 0.029$ m as shown in Fig. 5.2b.

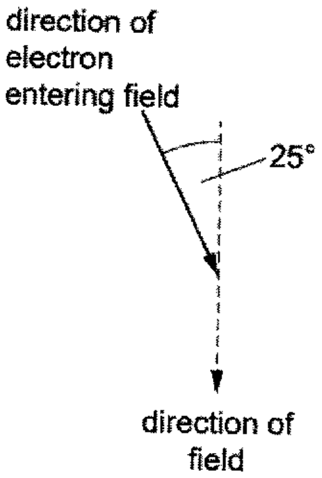


Fig. 5.2a

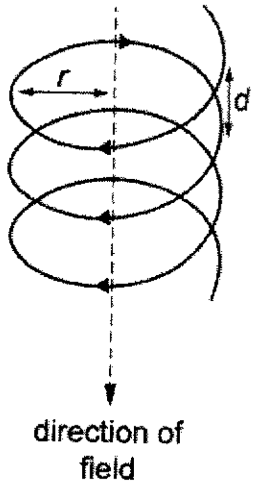


Fig. 5.2b

(i) Explain why the electron follows this path.

....

....

....

.... [2]

(ii) Show that the time taken for the electron to complete each loop of the helix as shown in Fig. 5.2b is 8.6×10^{-7} s.

[1]

(iii) Hence, determine the distance d between adjacent loops in the helix as shown in Fig. 5.2b.

d = ... m [1]

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

6 A small coil is positioned so that its axis lies along the axis of a large bar magnet, as shown in Fig. 6.1.

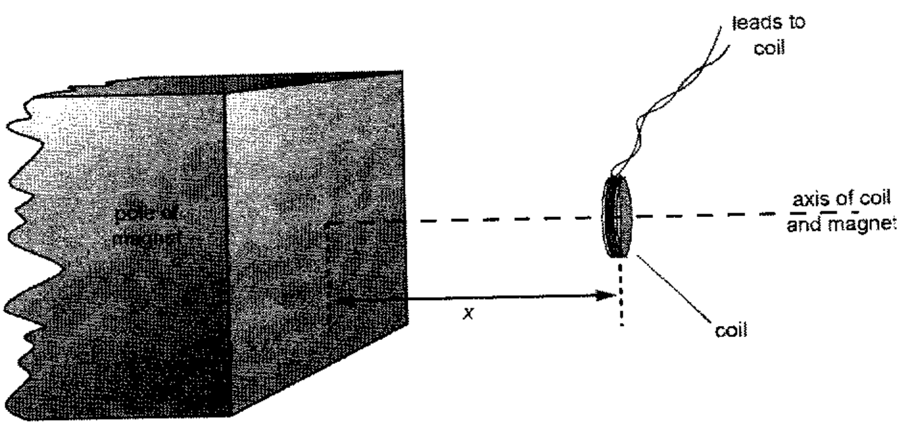


Fig. 6.1

The coil has a cross-sectional area of 0.40 cm² and contains 150 turns of wire.

The average magnetic flux density *B* through the coil varies with distance *x* between the face of the magnet and the plane of the coil as shown in Fig. 6.2.

DO NOT WRITE IN THIS MARGIN

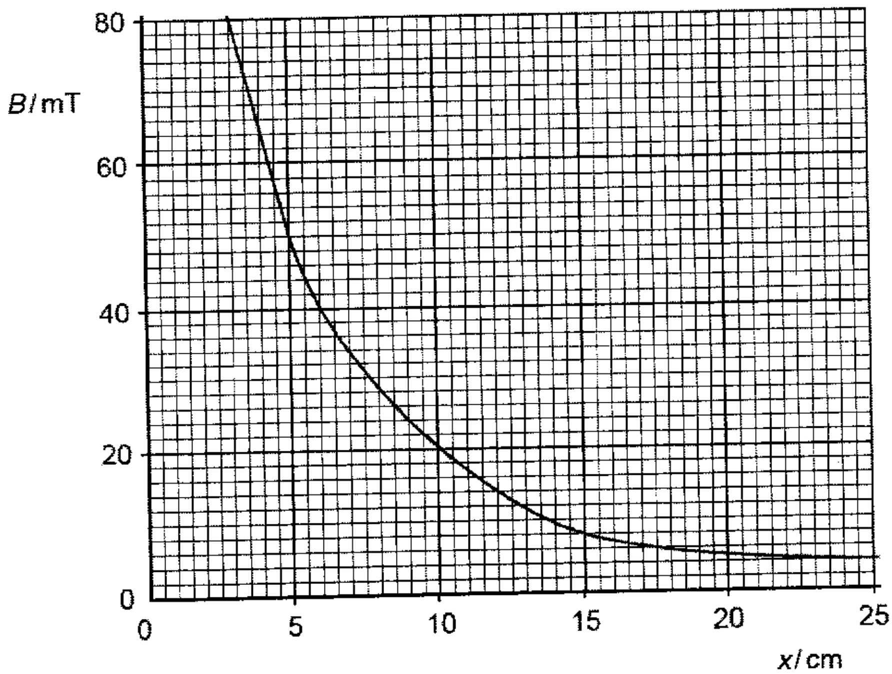


Fig. 6.2

(a) (i) The coil is 5.0 cm from the face of the magnet. Use Fig. 6.2 to determine the magnetic flux density in the coil

magnetic flux density = ... T [1]

(ii) Hence show that the magnetic flux linkage of the coil is 3.0×10^{-4} Wb. [2]

(b) The coil is moved along the axis of the magnet so that the distance x changes from $x = 5.0$ cm to $x = 15.0$ cm in a time of 0.30 s. Calculate

(i) the change in flux linkage of the coil,

change in flux linkage = ... Wb [1]

(ii) the average induced e.m.f. induced in the coil

e.m.f.= .... V [2]

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

(c) State and explain the variation, if any, of the speed of the coil so that the induced e.m.f. remains constant during the movement in **(b)**.

....

....

....

.... [2]

(d) Use Lenz's law to explain why work has to be done to move the coil along the axis shown in Fig 6.1.

....

....

....

.... [2]

7 The Singapore Mass Rapid Transit (SMRT) started its first train services in 1987. It was a massive nationwide project, beginning from the physical construction of the train tracks to the planning of the train arrival frequency. Amongst other professionals, the project involved the close collaboration of civil and structural engineers as well as transport engineers.

The Kawasaki Heavy Industries (KHI) C151 train as shown in Fig. 7.1, is Singapore's first generation of SMRT train fleet and has been in passenger service since 7 November 1987. All of the 396 KHI cars are built from 1986 to 1989 by four manufacturers in the consortium led by Kawasaki Heavy Industries.

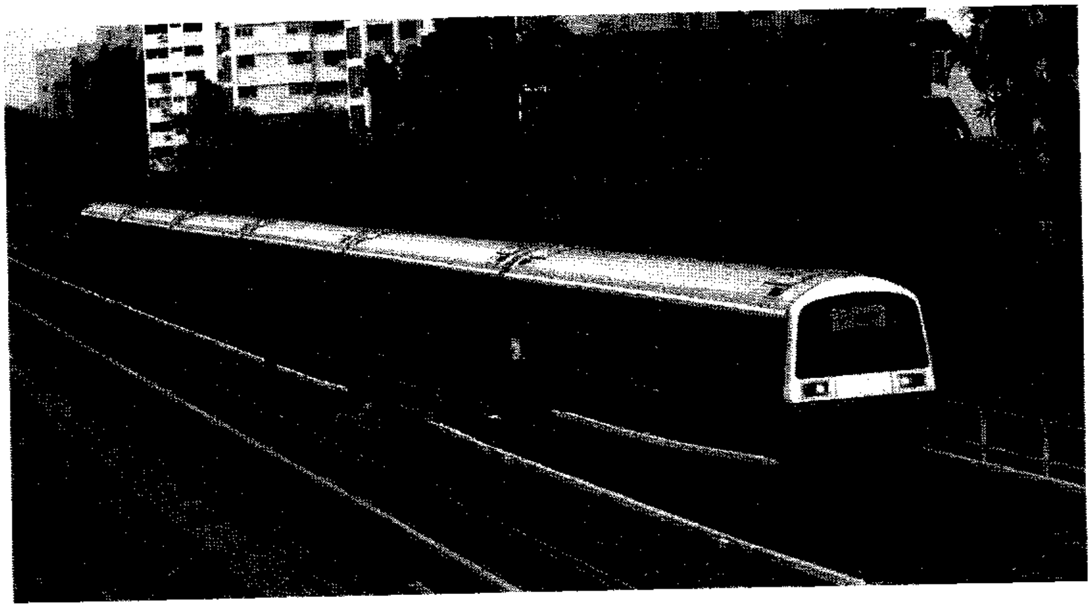


Fig. 7.1

DO NOT WRITE IN THIS MARGIN

Technical Specifications:

Manufacturer:	Kawasaki Heavy Industries, Nippon Sharyo, Tokyu Car Corporation, Kinki Sharyo
Number built:	396 cars (66 trains)
Car body Construction:	Aluminium-alloy construction
Maximum Speed:	90 km h^{-1} (Design)
	80 km h^{-1} (Service)
Train Length:	138 m (for the 6 cars in one train)
Width:	3.2 m
Height:	3.7 m
Train Mass:	286000 kg (fully laden)
Doors:	1.45 m, 8 per car
Seating Capacity:	208 seats

Fig. 7.2 shows a section of an elevated MRT track with a train on it. From the structural aspect, the structure load is being supported as follows:

1. Each car, with passengers in it, has its load supported by the beam below it. Car 2 is thus supported by beam 2.
2. Car 2 and beam 2 are both supported by columns 1 and 2.

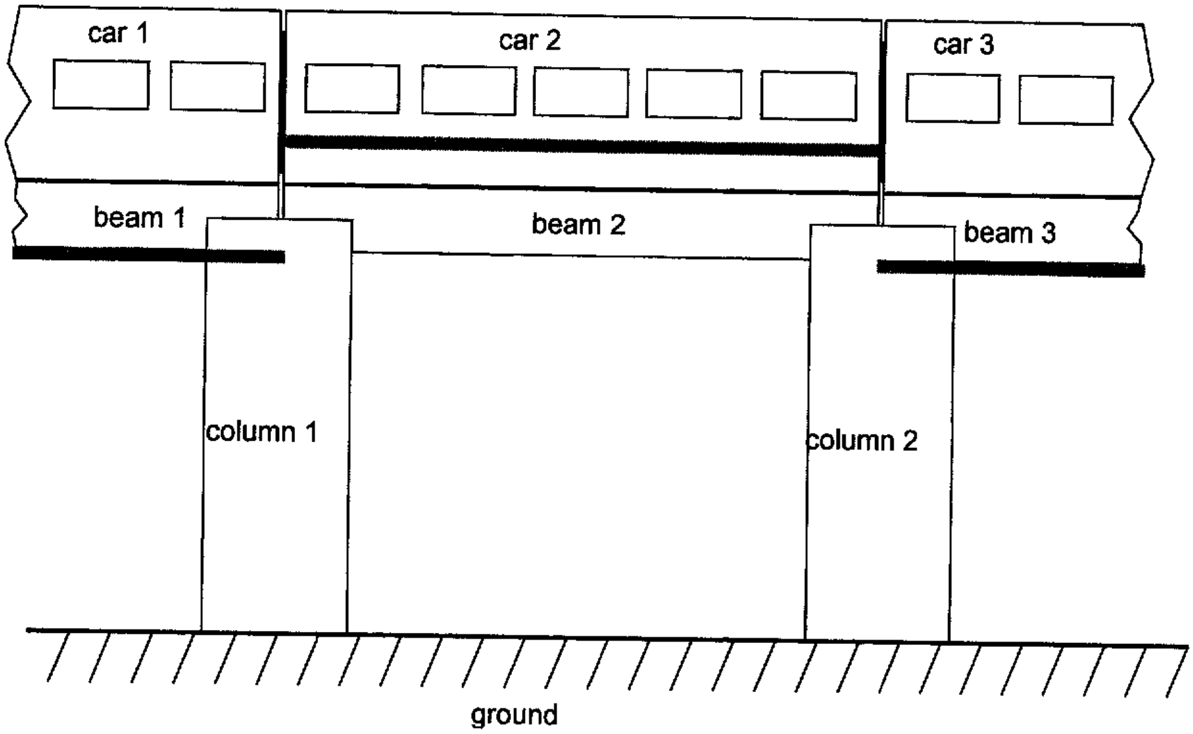


Fig. 7.2

The following set of simplified data is provided.

Weight of 1 empty car = 350 kN

Weight of 1 beam = 380 kN

Weight of 1 column = 100 kN

(a) Explain what is meant by *train arrival frequency*.

.... [1]

(b) An alloy is a combination of metals or of a metal and another element.

Suggest why trains are commonly made of aluminium alloy.

.... [1]

(c) When a train with no passengers in it, and is at the position shown in Fig. 7.2,

(i) State whether the bottom of beam 2 is under compression or tension.

.... [1]

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

(ii) calculate the total normal reaction force acting on beam 2 due to the supporting columns.

normal force = ... N [1]

(iii) Hence, state the total load that the top of column 1 has to take.

total load = ... N [1]

(iv) calculate the total load that the ground directly below each column has to take.

total load = ... N [2]

DO NOT WRITE IN THIS MARGIN

(d) An engineer needs to design the structure such that the ground does not cave in when a fully loaded train passes overhead. In designing the structure loading, a factor of safety is incorporated.

$$\text{Factor of safety} = \frac{\text{maximum stress}}{\text{applied stress}} = \frac{\text{maximum load}}{\text{applied load}}$$

Maximum stress is defined as the maximum force the ground can withstand per unit cross-sectional area.

Applied stress is defined as the applied force the ground withstands F, per unit cross-sectional area A.

Simplified data for the applied force the ground withstands F, and the cross-sectional area A, are given in Fig. 7.3.

F / kN	A / m^2
922	4.3
916	4.4
936	4.5
958	4.6
980	4.7
996	4.8
1020	4.9
1040	5.0

Fig. 7.3

The variation with A of F is as shown in Fig. 7.4.

(i) Complete Fig. 7.4 by drawing the best-fit line (ignore any anomalous data). [1]

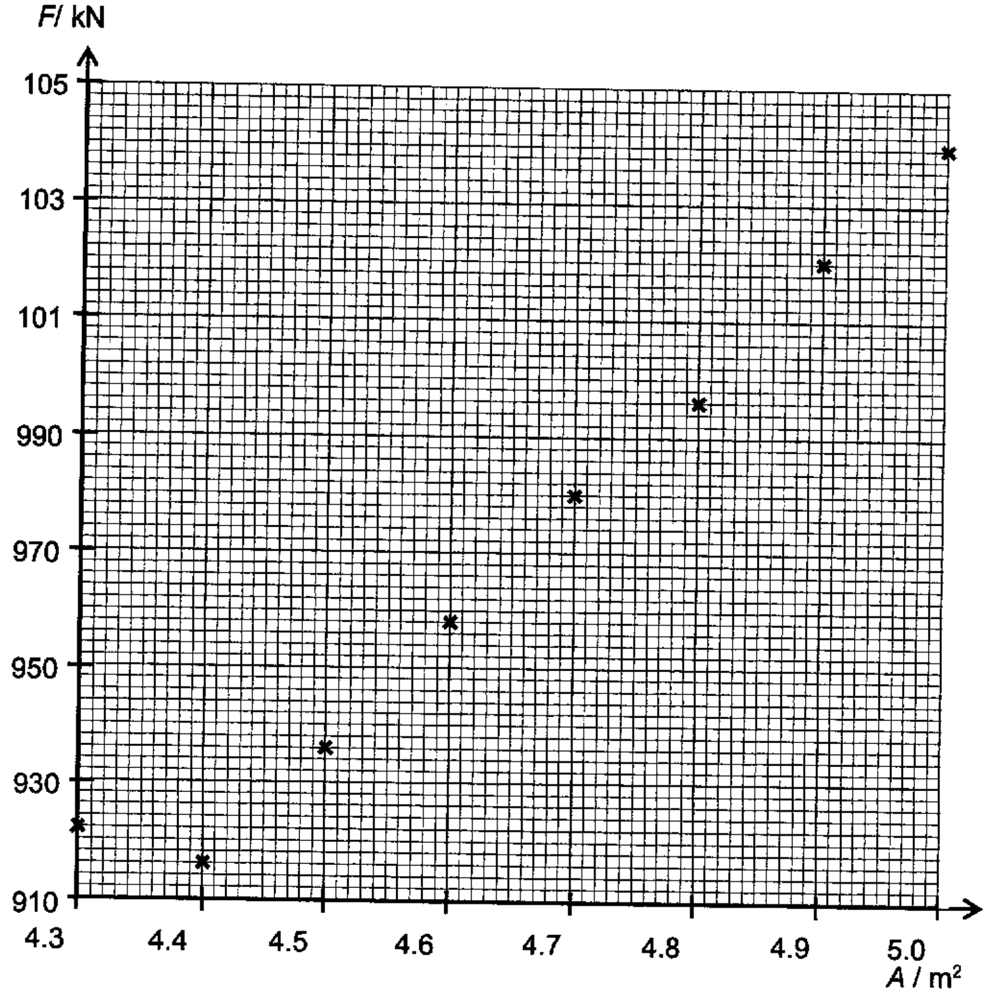


Fig. 7.4

(ii) Use Fig. 7.4 to determine the applied stress that the ground withstands.

applied stress = ... N m^{-2} [2]

(iii) The column structure is considered safe if the factor of safety is greater than 2.9. Assuming that the maximum stress the ground is designed to withstand is 645 kN m^{-2}, determine whether the column structure is safe.

column structure is .... [2]

(e) The simplified dimensions of each column are given in Fig. 7.5.

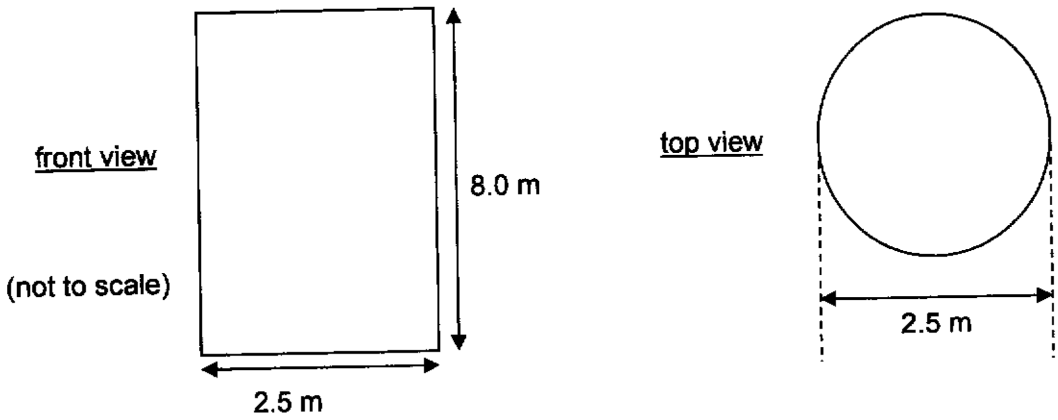


Fig. 7.5

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

(i) Using the value of applied stress from **(d)(ii)**, calculate the applied load that the ground withstands.

applied load = ... N [2]

(ii) Hence using e(i) and c(iv), calculate the total allowable weight of passengers that each car can carry.

allowable weight = ... N [1]

(iii) Assuming the average mass of 1 passenger to be 60 kg and value of g to be 10 m s^{-2}, calculate the allowable number of passengers that a car can carry at any one time.

number of passengers = ... [2]

(f) A transport engineer is employed to design the frequency of the trains arriving at Tuas Crescent MRT Station. In order not to cause the ground to sink, he needs to look into the allowable passengers that each car can take and not overload each car. The following information is available to him:

<u>Peak hours at Tuas Crescent MRT Station</u>

Average number of east-bound passengers per minute = 240

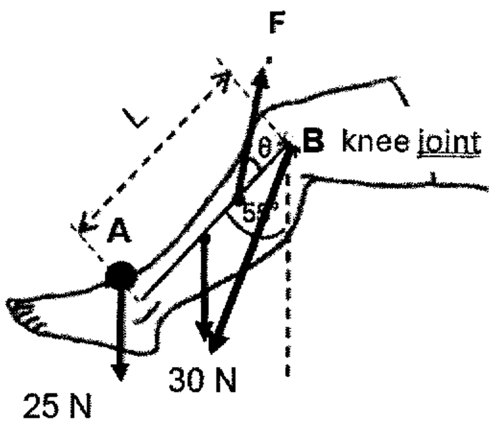
On average, a typical east-bound train of 6 cars is anticipated to be already 75% filled just before it arrives at Tuas Crescent MRT Station.

Assuming that each car takes equal number of passengers and all board the train, determine the maximum time interval between arrival of consecutive east-bound trains at the station during peak hours.

Maximum time interval = ... minutes [3]

Paper- 2

Answers and Marking Scheme

1(a)	1. The resultant force is zero. 2. The resultant moment about any axis is zero.	[B1] [B1]
(bi)	(25 x 0.40 sin 55) + (30 x 0.20 sin 55) = (F sin 25) x 0.10 F = 310 N	[M1] [A1]
(bii)	 Correctly drawn (direction) and labelled	[B1]
(biii)	Work done = increase in GPE one leg Work done =25 (L – L cos 55) + 30(L/2 – L/2 cos 55) 25 (0.4)(1- cos 55) + 30(0.2)(1- cos 55) = 6.8 J	[M1] [A1]
(biv)	Work done = (6.8)/5 = 1.4 W	[B1]

DO NOT WRITE IN THIS MARGIN

2 **(a)** **(i)** Since the direction of the force exerted by the external agent is opposite to the direction of displacement of the mass [B1] when it moves from infinity to a point in the gravitational field [B1], the work done by the external agent is negative. Hence gravitational potential at that point is negative.

(iii)

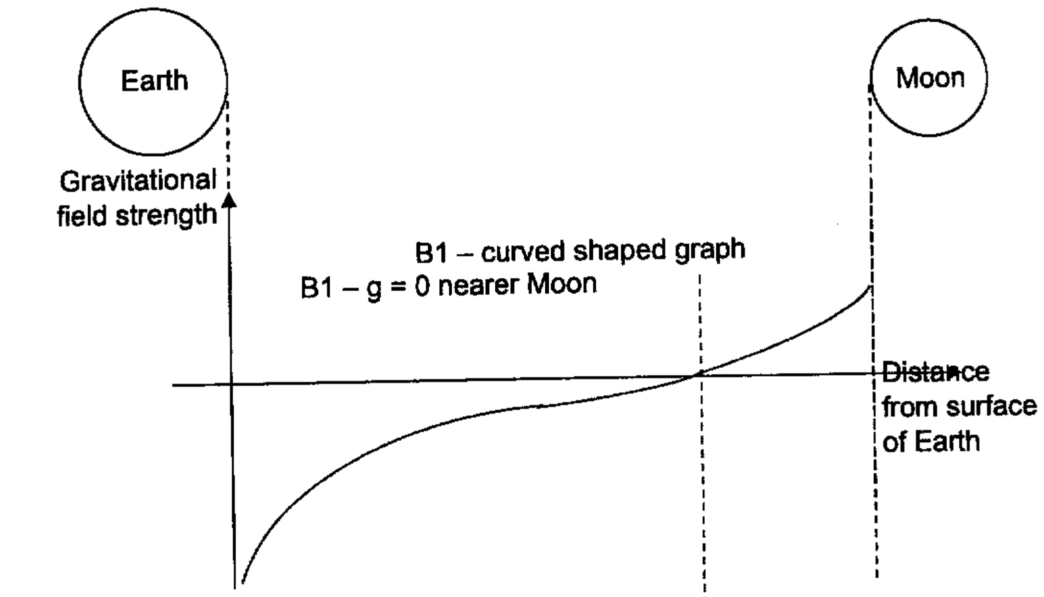


Fig. 2.1

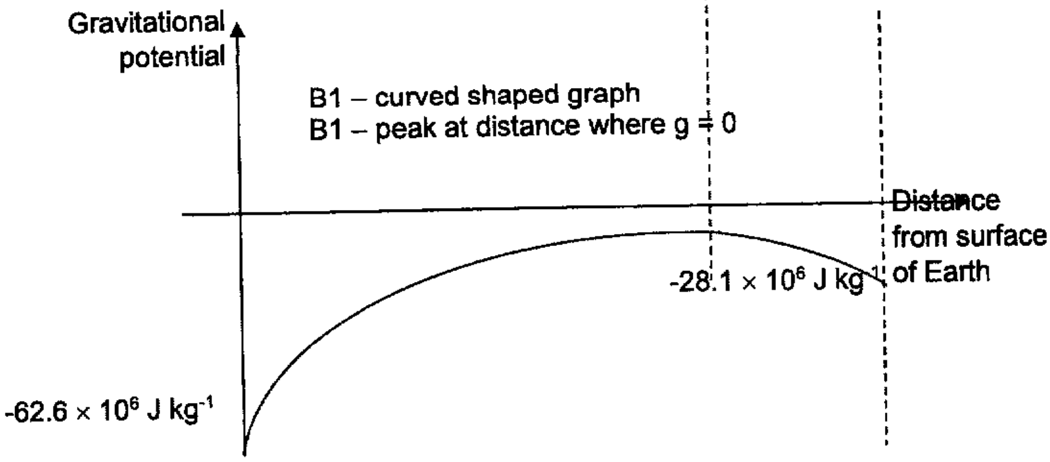


Fig. 2.2

(b)

(iv)

$$g=\frac{GM}{r^2}=\frac{(6.67\times10^{-11})(6.4\times10^{23})}{(3.4\times10^{6})^2}[M1]=3.69\ \text{N kg}^{-1}=3.7\ \text{N kg}^{-1}[A0]$$

(v)

Since the height of 1800 m is much smaller than the radius of the planet, it can be assumed that the stone is moved through 1800 m in a uniform gravitational field. [M1]

Hence $\Delta E_p = mg\Delta h = 2.4(3.7)(1800) = 1.6\times10^4$ J [A1]

(vi)

Assumption: All the loss in gravitational potential energy of the rock is transferred to its kinetic energy.
Total final KE + GPE = Total initial KE + GPE [M1]

$$\frac{1}{2}mv^2 + \left(-\frac{GMm}{8r}\right) = 0 + 0[M1]$$

[

$$\Rightarrow v = \sqrt{\frac{GM}{4r}} = \sqrt{\frac{(6.67\times10^{-11})(6.4\times10^{23})}{4(3.4\times10^6)}} = 1.77\times10^3 \text{ m s}^{-1}[A1]$$

DO NOT WRITE IN THIS MARGIN

3	**(a)**	**Waves** travel along string and gets **reflected at the fixed point** (A/B/end) **Incident and reflected waves**, having the **same frequency, amplitude** and **speed** moving in opposite direction **superpose/interfere**	B1 B1
	(b)	Line of approximate sinusoidal shape with maximum downward displacement at P and zero displacement at each node (dots)	B1
	(c)	$\lambda = v\times T = 35\times0.04 = 1.4$ m $\Rightarrow$ distance AB $= 2.5\lambda = 2.5\times1.4 = 3.5$ m	C1 A1
	(d)(i)	No of cycles or periods $= \frac{0.060}{0.040} = 1.5$ Amplitude of oscillation = $\frac{72}{6} = 12$ mm	C1 A1
	(d)(ii)	0.0 s, 0.020 s, 0.040 s, 0.060 s, ...	A1
	(d)(iii)	$v_{max} = \omega x_o = \frac{2\pi}{T}x_o = \frac{2\pi}{0.040}\times0.012$ = 1.89 m s^{-1}	M1 A1
	(e)	Point P and Q are anti-phase (or 180° out of phase) Amplitude of Q < amplitude of P but their frequency is equal	B1 B1

4	**(a)**	very high/infinite resistance at low voltages (0 to 1.8V) resistance decreases as V increases (to about 90 Ω at 2.7 V)	B1 B1
	(b) (i)	From graph, current = 0.0100 A V = IR = 0.0100 (50) = 0.50 V	M1
	(b) (ii)	$V_{//} = 2.5 + 0.50 = 3.0$ V current through 75 Ω $= \frac{3.0}{75} = 0.040$ A current through 100 Ω $= 0.010 + 0.040 = 0.050$ A Emf $= 3.0 + (0.050)(100) = 8.0$ V	C1 C1 A1

DO NOT WRITE IN THIS MARGIN

	(iii)	$E = Nhf$ $Pt = \frac{Nhc}{\lambda}$ $\frac{N}{t} = \frac{P\lambda}{hc} = \frac{(2.5\times0.0100)(4.7\times10^{-7})}{6.63\times10^{-34}(3.00\times10^{8})}$ $= 5.91\times10^{16}\ \text{s}^{-1}$ $= 5.9\times10^{16}\ \text{s}^{-1}$	C1 A1
	(c)	In darkness, LDR's resistance is very large, thus p.d. across parallel branch is large and this turns the LED on. When the LED is turned on, resistance of LDR decreases and p.d. across parallel branch decreases. This turns the LED off. (this cycle of LED switching on and off is repeated)	B1 B1

5	(a) (i)	$s_x = u_x t$ $0.12 = (6.0\times10^{7})t$ $t = 2.0\times10^{-9}$ s	M1 A0
	(a) (ii)	$s_y = u_y t + \frac{1}{2}a_y t^2$ $x = 0 + \frac{1}{2}\left(\frac{qE}{m}\right)t^2$ $x = 0 + \frac{1}{2}\left(\frac{qV}{md}\right)t^2$ $= \frac{1}{2}\left(\frac{1.60\times10^{-19}(4000)}{9.11\times10^{-31}(0.08)}\right)(2.0\times10^{-9})^2$ $= 0.0176 = 0.018$ m	 C1 C1 A1
	(b) (i)	Component of velocity <u>perpendicular to magnetic field</u> experiences a magnetic force which provides for centripetal force for circular motion. Component of velocity <u>parallel to magnetic field</u> experiences no force, thus electron continues to move in this direction at constant speed. (combined motion is that of a helix)	B1 B1
	b(ii)	$T = \frac{2\pi r}{v_\perp}$ $= \frac{2\pi\times0.029}{5.0\times10^{5}\sin25°}$ $= 8.62\times10^{-7} = 8.6\times10^{-7}$ s (2sf)	M1 A0
	(b) (iii)	$d = v_{//}T$ $= (5.0\times10^{5}\cos25°)(8.62\times10^{-7})$ $= 0.391$ m $= 0.39$ m (2sf)	C1 A1

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

6 (a)(i) 50 ×10^{-3} T — B1

(a)(ii) Flux linkage = $NBA = 150 \times 50 \times 10^{-3} \times 0.40 \times 10^{-4}$ — C1

$= 3.0 \times 10^{-4}$ Wb — A1

(b)(i) Final flux linkage = $150 \times 8.0 \times 10^{-3} \times 0.40 \times 10^{-4} = 4.8 \times 10^{-5}$ Wb

Change in flux linkage = final – initial = $4.8 \times 10^{-5} - 3.0 \times 10^{-4}$

$= -2.52 \times 10^{-4}$ Wb — A1

(b)(ii) Average induced e.m.f. = $\frac{\Delta\phi}{\Delta t} = \frac{2.52 \times 10^{-4}}{0.30}$ — M1

$= 8.4 \times 10^{-4}$ — A1

(c) Flux linkage decreases as the distance *x* increases. — C1

Hence, speed of coil need to increase to keep rate of change of flux (induced e.m.f.) constant — A1

(d) Induced current in the coil produces a magnetic field in the coil./ Induced current is in the field of the magnet. — B1

This field/The current interacts with the magnetic field of the magnet to produce a force , — B1

which opposes the motion of the coil. — B1

Hence, work need to be done to move the magnet along the axis

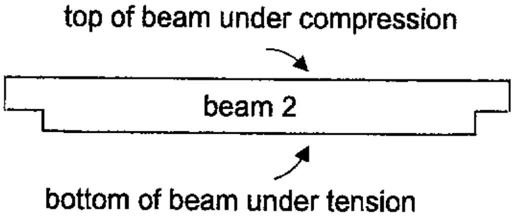
DO NOT WRITE IN THIS MARGIN

7 (a) It is the number of trains arriving at a station per unit time. — A1

(b) Aluminium alloy has high strength-to-weight ratio, thus reduces the amount of friction by reducing the weight of the trains. It has high corrosion resistance. Aluminium's natural passivation process in which a thin aluminium oxide layer forms when the metal is exposed to oxygen, reduces the possibility of further oxidation. — A1

DO NOT WRITE IN THIS MARGIN

(c) (i) top of beam — A1



(ii) Total normal reaction forces = (350 + 380) × 10^{3}

= 7.30 × 10^{5} N — A1

(iii) Total load column 1 has to take = 7.30 × 10^{5} N — A1

(iv) Total load ground has to take = (730 + 100) × 10^{3} — M1

= 8.30 × 10^{5} N — A1

(d) (i) Coordinate (4.3, 922) is treated as anomaly. Best fit line drawn through the rest of the seven points. — A1

(ii) Gradient of line $= \frac{1040 - 916}{5.00 - 4.40}$ — M1

$= 2.07 \times 10^5\ N\ m^{-2}$ A1

(iii) Factor of safety = $\frac{645 \times 10^3}{207 \times 10^3}$

$= 3.12$ M1

Since factor of safety is greater than 2.9, it is safe. A1

(e) **(i)** Applied load = $(207 \times 10^3)\pi(\frac{2.5}{2})^2$ M1

$= 1.0 \times 10^6$ N A1

(ii) Total allowable weight of passengers = $(1016 - 830) \times 10^3$

$= 1.9 \times 10^5$ N A1

(iii) Total allowable number of passengers per car = $(\frac{1.9 \times 10^5}{60 \times 10})$ M1

$= 316$ A1

(f) Number of passengers a car can take when train arrives at station

$= 0.25 \times 316 = 77.5$ (25% of the total allowable) C1

Total number of passengers train can take = 79×6

$= 474$ M1

Longest time interval between train arrivals = $(\frac{474}{240})$

$= 1.98$ minutes A1

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN