July '04 intake
AS trial

Mr Seo CL P2

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

1 (a) The density ρ and the pressure p of a gas are related by the expression

$$c = \sqrt{\frac{\gamma p}{\rho}}$$

where c and γ are constants.

(i) Show that the base units of pressure p are $kgm^{-1}s^{-2}$.

$p = h\rho g$

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \quad \text{— B1}$$

→ accept symbols with explanation

$$= \frac{kgms^{-2}}{m^2} \quad \text{— B1}$$

$$= kgm^{-1}s^{-2} \quad \text{— A0}$$

(ii) Given that the constant γ has no unit, determine the unit of c.

$$c = \left(\frac{kgm^{-1}s^{-2}}{kgm^{-3}}\right)^{1/2} \quad \text{— B1}$$

$$= (m^2s^{-2})^{1/2}$$

$$= ms^{-1} \quad \text{— A1}$$

[4]

(b) A student set up an electrical circuit in order to determine the resistance of a wire and hence the resistivity of the metal of the wire.
The following readings were obtained for the experiment.

Reading of voltmeter = 1.50 ± 0.01 V
Reading of ammeter = 0.86 ± 0.01 A
Length of wire = 54.6 ± 0.2 cm
Diameter of wire = 0.62 ± 0.02 mm

Calculate, with its actual uncertainty, the value of

(i) the resistance of the wire.

$$R = \frac{V}{I}$$

$$R = \frac{1.50}{0.86} \quad \text{— A1}$$

$$= 1.744\ \Omega$$

$$\Delta R = \pm\left(\frac{\Delta V}{V} + \frac{\Delta I}{I}\right)R \quad \text{— C1}$$

$$\pm\left(\frac{0.01}{1.50} + \frac{0.01}{0.86}\right)1.744$$

$$= \pm 0.03\ \Omega$$

Resistance = 1.74 ± 0.03 Ω — A1

5

(ii) the resistivity of the material of the wire. Express your answers to an appropriate number of significant figures.

$$\rho = \frac{RA}{l} \quad \Omega M$$

$$\Delta\rho = \left[\frac{\Delta R}{R} + \frac{2\Delta d}{d} + \frac{\Delta l}{l}\right] \times \rho \quad \text{C1}$$

$$= 1.74 \times \frac{\left[\pi\left(\frac{0.62\times10^{-3}}{2}\right)^2\right]}{54.6\times10^{-2}} \quad \text{— C1}$$

$$= \left[\frac{0.03}{1.74} + \frac{2\times0.02}{0.62} + \frac{0.2}{54.6}\right] \times 9.622\times10^{-7}$$

$$= 9.622\times10^{-7}\,\Omega M$$

$$= 0.8\times10^{-7}\,\Omega M$$

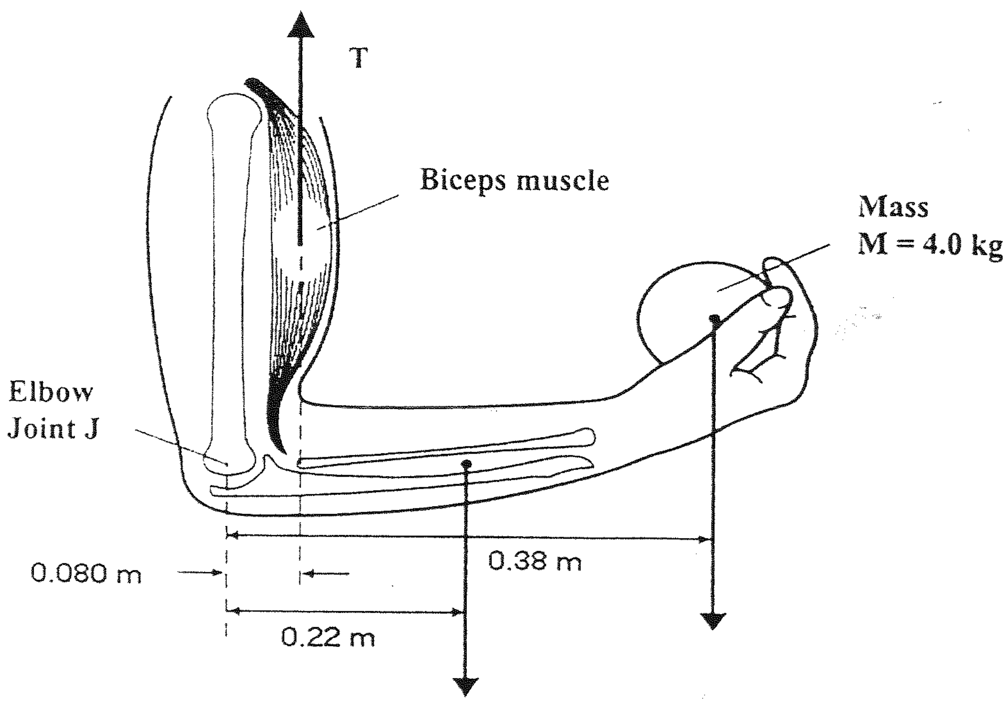
Resistivity = $(9.6 \pm 0.9)\times10^{-7}$ Ωm — A1

[6]

2. (a) State the two conditions necessary for a body to be in equilibrium.

1. The sum of the clockwise moments about any pivot must be equal the sum of the anticlockwise moments about that pivot — B1
   or sum of the moment about any point is zero.
2. There is no resultant force acting on the body — B1

[2]

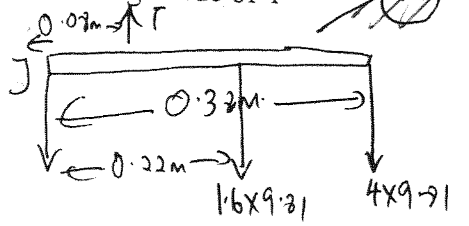


[Turn Over

9

(b) Figure above shows the forearm extended horizontally and holding an object of mass M = 4.0 kg. The forearm pivots about the elbow joint J and the mass of the forearm m = 1.6 kg which acts effectively at a distant 0.22 m from the elbow joint. The forearm and object supported by an upwards force T provided by the biceps muscle and which acts 80 mm from the joint. Calculate

(i) the magnitude of T



C1 Taking moment about J. — B1 C1

$[(1.6\times9.81)\times0.22]+[4\times9.81\times0.38] = T\times0.08$

T = 229 N — A1

T = ...229......N

[3]

(ii) the force acting at the elbow(pivot) joint J

In equilibrium.

Total upwards force = total downwards force — C1

~~162 = F + 14~~ –

$229 = F + (1.6\times9.81) + (4\times9.81)$

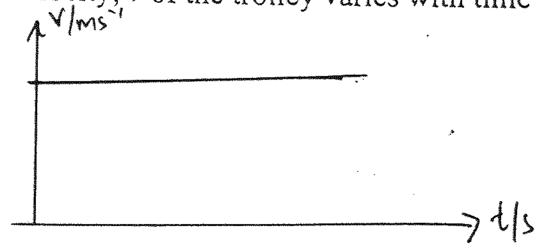
F = 174 N — A1 Force = ...174......N

~~[3]~~ (2)

3. A trolley filled with sand moves on a horizontal surface of negligible friction. At time t = 0, sand starts to drop vertically at a constant rate from a hole at the base of the trolley.

(a) Sketch graphs to show

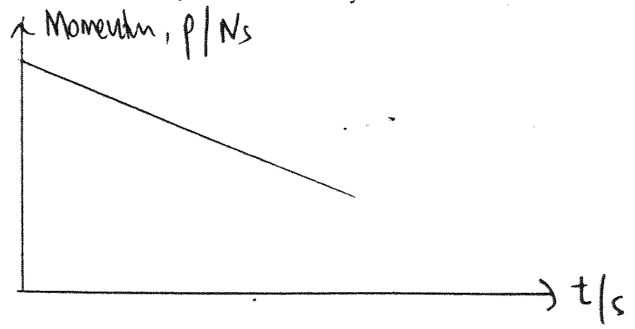
(i) how the velocity, v of the trolley varies with time



Axis-Label – B1

Straight line – B1

(ii) how the momentum, p of the trolley varies with time.



Axis label – B1

Line – B1

[4]

5

(b) A trolley P of mass 2.0 kg moves with a velocity of 1.10 ms^{-1} collides elastically with another trolley Q of mass 4.0 kg moving in the opposite direction with a speed of 0.50 ms^{-1}.
Calculate

(i) the speeds and directions of motion of the trolleys after collisions.

conservation of momentum

$2.0V_1 + 4.0V_2 = (2.0 \times 1.10) - (4.0 \times 0.50)$

$V_1 + 2.0V_2 = 0.1$ — ① — C1

relative speed of separation = relative speed of approach.

$V_1 - V_2 = -1(U_1 - U_2)$

$V_1 - V_2 = -1[1.10 - (-0.50)]$

$V_1 - V_2 = -1.60$ — ② — B1

① − ②. $3V_2 = 1.70$

$V_2 = 0.567\ ms^{-1}$

$V_1 = -1.03\ ms^{-1}$ — ~~A2~~ A1 both.

(ii) the impulses on each trolley during the collision.

Impulses = Change of momentum — ~~B1~~ C1

$= m(v - u)$

$= 4.0(V_2 - U_2)$

$= 4.0[0.567 - (-0.50)]$

$= 4.27$ Ns — A1

[5]

[Turn Over

4

4. A catapult consists of two rubber bands with unstretched length 0.25 m. Each rubber band is stretched by 0.15 m by a tension of 60 N. A stone of mass 0.050 kg is projected vertically upwards from the catapult after each rubber band has been stretched to a total length of 0.30 m.

(a) Calculate the energy stored in the stretched catapult.

$K = \frac{F}{x}$

$K = \frac{60}{0.15}$

$= 400 \text{ N m}^{-1}$ — C1

2 rubber = $\cancel{1200}$ 800 N m^{-1}

Or $E = 2 \times \left(\frac{1}{2} \times 400 \times 0.05^2\right)$

$E = \frac{1}{2} k x^2$

$= \frac{1}{2}(\cancel{1200}\ 800)(0.30 - 0.25)^2$

$E = \cancel{1.50}$ J — A1

$= 1.0$ J.

(b) Find the maximum height reached by the stone. Neglect air resistance.

Loss in Ep.e = gain in Gp.e.

$mgh = \cancel{1.50}\ 1.00$ — C1 e.c.f.

$h = \frac{\cancel{1.50}\ 1.00}{(0.05 \times 9.81)}$

$h = \cancel{3.06}$ m — A1

2.04 m

[4]

10

5 (a) Define the following terms associated with waves.

(i) amplitude,

max displacement from equilibrium position — B1

(ii) frequency,

number of complete ~~oscillation~~ cycles vibration per unit time — B1

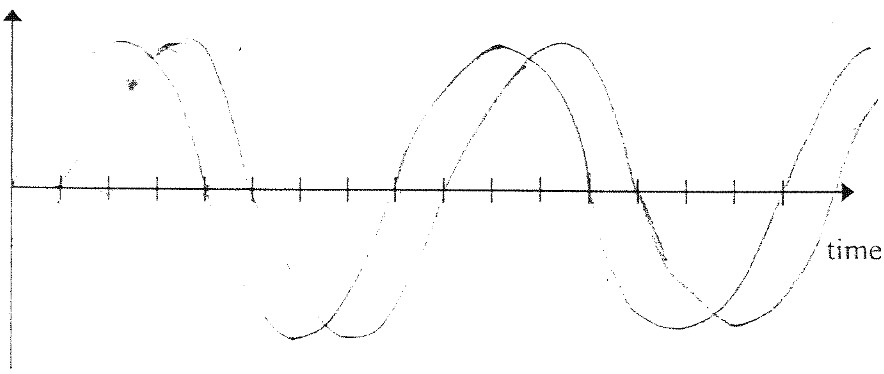
X per seconds.

(iii) wavelength.

distance between 2 consecutive points which are in phase — B2 [4]

(b) On the graph below draw two waves with same amplitude and frequency but with a phase difference of π/4 rad between them. [3]

displacement



$\frac{x}{\lambda} = \frac{\phi}{2\pi}$

~~$\frac{1}{16} = \frac{\pi/4}{2\pi}$~~

$\frac{x}{8} = \frac{\pi/4}{2\pi}$

$x = 1$ unit

M1 → same amp.

M2 – same period

M3 – correct $\Delta\phi = \frac{\pi}{4}$

(c) Monochromatic light of wavelength 6.0×10^{-7}m is incident normally on a plane diffraction grating with 500 lines per mm. Find the total number of directions in which a bright line is produced.

$d\sin\theta = m\lambda$ — B1

$\frac{1}{500\times10^{3}}\sin 90 = m(6.0\times10^{-7})$ — ~~A1~~ C1

$m = 3$ — ~~C1~~

$\frac{m\lambda}{d} \leq 1$

Total bright lines $= (3\times2)+1$

$m \leq \frac{d}{\lambda} = \frac{1}{500\times10^{3}} \times \frac{1}{6\times10^{-7}}$ $= 7$ — A1

$= 3.333$

total number = ...7........[3]

8

6 (a) (i) Define resistance.

Ratio of p.d. to current in a conductor (B2)

$R = V/I$ explain symbols ....[2]

(ii) Write down an equation that relates resistance and resistivity. Identify all the symbols used in the equation. [2]

$R = \frac{\rho l}{A}$, R = resistance, ρ = resistivity, l = length, A = cross-sectional area

formula - (B1)

Symbol - (B1)

(b) Calculate the resistance per metre of a copper wire of diameter 0.050 mm and resistivity 1.7×10^{-8} Ωm

$$\frac{R}{l} = \frac{1.7\times10^{-8}}{\pi\left(\frac{0.050\times10^{-3}}{2}\right)^2} = \left(\frac{l}{A}\right)$$ - ~~A1~~ (C1)

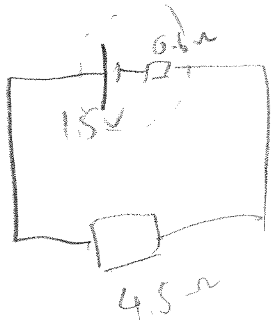
$= \cancel{27.2}\ \Omega m^{-1}$ - ~~C1~~ (A1)

$8.66\ \Omega m^{-1}$

resistance per metre = ...[2]

(c) A battery has e.m.f 1.5 V and internal resistance 0.6 Ω.

(i) Calculate the output power when the battery is connected to an external 4.5 Ω resistor.



$P = I^2R$

$= \frac{E^2}{(R+r)^2} R$ - ~~A1~~ (C1)

$= \frac{1.5^2}{(4.5+0.6)^2}(4.5)$ - ~~C1~~ (A1)

$= 0.39\ W$

output power = 0.39 ......W [2]

$1.5 = I(4.5) + I(0.6)$

(ii) Calculate the efficiency of power that is delivered.

$$\text{Eff} = \frac{I^2R}{I^2(R+r)}$$ — ~~A1~~ C1

$$= \frac{R}{R+r}$$

$$= \frac{4.5}{4.5+0.6}$$

$$= 88.\cancel{3}2\%$$ — ~~C1~~ A1

$P_i = EI$

$= 1.5 \times \left(\frac{1.5}{4.5+0.6}\right)$

$= 0.44$

or 0.88

efficiency = 88.~~3~~2 % [2]

7 (a) State ~~what~~ is meant by electric field strength? Electric

→ force per unit positive charge — B2

$E = \frac{F}{q}$ explain symbol [2]

(b) A charged particle is launched perpendicularly into an electric field. Explain why it follows a parabolic path.

→ horizontal velocity remains constant but — B1

→ vertical velocity increases (up or down) — B1

∴ ⇒ parabolic [2]

(c) An electron of charge e = 1.6x 10^{-19} C is situated in a uniform electric field of 150000 Vm^{-1}. Find

(i) the force that acts on the electron,

$F = Eq$ — C1

$= 150000\,(1.6 \times 10^{-19})$

$= 2.4 \times 10^{-14}\,N$ — A1

force = 2.4×10^{-14} N [2]

(ii) its acceleration,

$$a = \frac{F}{m} = \frac{2.4\times10^{-14}}{9.11\times10^{-31}}$$ — ~~A1~~ C1

$$= 2.63\times10^{16}\ ms^{-2}$$ — ~~C1~~ A1

acceleration = 2.63×10^{16} ms^{-1} [2]

(iii) the time it takes to travel 30 mm from rest.

$$s = \frac{1}{2}at^2$$

$$30\times10^{-3} = \frac{1}{2}(2.63\times10^{16})t^2$$ — ~~A1~~ C1

$$t = 1.51\times10^{-9}\ s$$ — ~~C1~~ A1

time = 1.51×10^{-9} s [2]