AJC H1 Paper 2 Prelims Solutions

1 **(a)** kelvin, ampere, candela, mole
(any 2)

(b) **(i)**

$$K = \frac{T^2 M}{R^3}$$

$$\text{base units of } K = \frac{(\text{base units of } T^2)(\text{base units of } M)}{(\text{base units of } R^3)} = \frac{\text{s}^2\ \text{kg}}{\text{m}^3}$$

$$= \text{s}^2\ \text{kg m}^{-3}$$

(ii) K = [(86400)^2 x 6 x 10^{24}] / (4.23 x 10^7)^3 = 5.918 x 10^{11} s^2 kg m^{-3}

$$\frac{\Delta K}{K} = 2\frac{\Delta T}{T} + \frac{\Delta M}{M} + 3\frac{\Delta R}{R}$$

$$= 2(0.5\%) + (2\%) + 3(1\%) = 6\%$$

$$\Delta K = 6\% \text{ x } 5.918 \text{ x } 10^{11} = 0.4 \text{ x } 10^{11}\ \text{s}^2\ \text{kg m}^{-3}$$

K = (5.9 ± 0.4) × 10^{11} s^2 kg m^{-3}

2 **(a)** A ball moving in opposite direction (after collision)

(b) **(i)** change in momentum = m(v_f – v_i) = 1.2 (– 0.8 – 4.0)
= – 5.76 N s

(ii) force = Δp / Δt *or mΔv / Δt*
= 5.76 / 0.08 or 1.2 x 4.8 / 0.08
= 72 N

(c) By conservation of momentum, $\Delta p_B + \Delta p_S = 0$
$\Delta p_B = -\Delta p_S$
– 5.76= – 3.6 x v
v = 1.6 m s^{-1}

(d) Either speed of approach = 4.0 m s^{-1} and
speed of separation = 1.6 – (–0.8) = 2.4 m s^{-1}
not equal and so inelastic
OR
kinetic energy of system before = 9.6 J and
kinetic energy of system after collision = 4.99 J
kinetic energy after is less / not conserved, so inelastic

3 **(a)** **(i)** Equilibrium is a state of a system in which it experiences no resultant force and
no resultant torque about any axis.

(ii) The **centre of gravity** of an object is the point at which the whole weight of the object may be considered to act.

(iii) **Moment** of a force is the turning effect of the force. It is equal to the product of the force and the perpendicular distance of the line of action of the force from the pivot.

(iv) The **torque of a couple** is the turning effect of the couple**.** It is equal to the product of one of the forces and the perpendicular distance between the forces.

(b) (i) 90^o

(ii) $130 = F \times 0.45$

$F = 290$ N

4 (a) (i) Electric current is a flow of charged particles, which may be positively or negatively charged

(ii) Resistance of a conductor is defined as the ratio of the potential difference across it to the current flowing through it.

(b) (i)

$$I = \frac{2.0 \times 10^{20} \times 1.60 \times 10^{-19}}{6.0} = 5.33 \text{ A}$$

(ii)

$$R = \frac{12.0}{5.33} = 2.25\ \Omega$$

(c) (i) Consider current in 2.0 Ω resistor across voltmeter V_2,

$I = V_2 / R = 4.0 / 2.0 = 2.0$ A

Since this branch is in series with the ammeter A, the current through A is also 2.0 A.

(ii) Since V_2 and V_4 reads 4.0 V and 2.0 V respectively,

potential difference across V_3 and r = 9.0 – (4.0 + 2.0) = 3.0 V

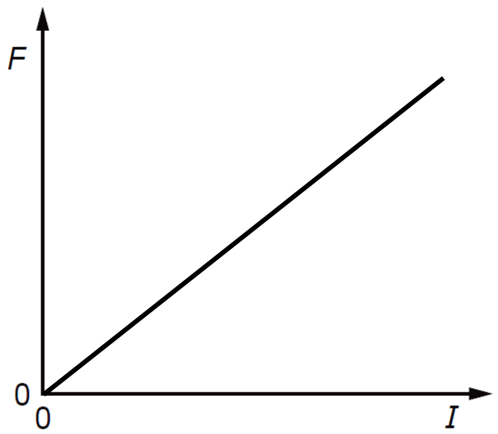
$$V_3 = 2.0 \times \left(\frac{1}{\frac{1}{2} + \frac{1}{3} + \frac{1}{4}} \right) = 1.846 \text{ V}$$

Potential difference across r = 3.0 –1.846 = 1.154 V

r = 1.154 / 2 = 0.58 Ω

5 (a) A magnetic field is a region of space where a magnetic pole, a current-carrying conductor or a moving charged particle will experience a force.

(b) (i)



straight line with positive gradient through origin

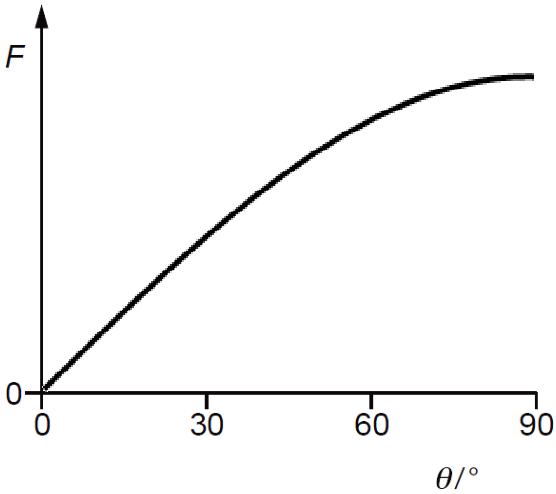
$F = BIL \sin\theta$

$= kI$,

where $k = BL \sin\theta$

= constant

(ii)



maximum force shown at θ = 90°
zero force shown at θ = 0°
reasonable curve with F about ½ max at 30°

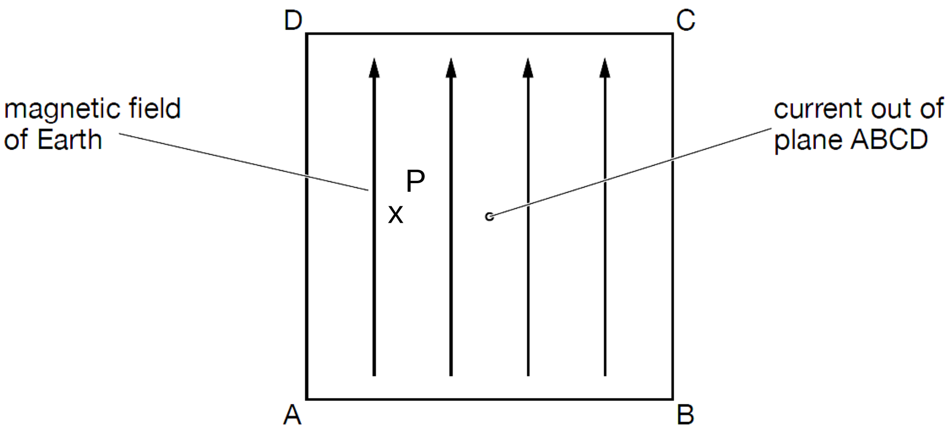
F = *BIL* sin θ
= *k'* sin θ,
where *k'* = *BIL*
= constant

(c) (i) The electron experiences a force due to the magnetic field. The force is normal to the magnetic field and direction of the electron's velocity.

(ii) Using Fleming's left hand rule, electron moves towards QR

(iii) After a while, a build-up of charge at sides QR and PS will exert an electric force on the electrons that balance the magnetic force.

(d) (i)



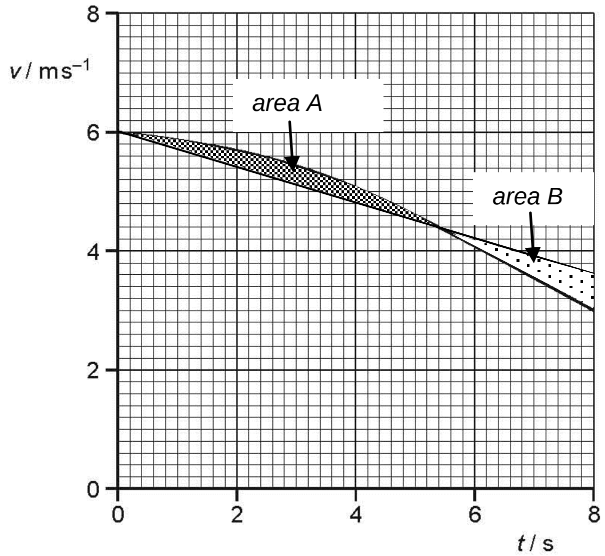
(ii)

$$B = \mu_0 \frac{I}{2\pi r} = \left(4\pi \times 10^{-7}\right)\left(\frac{1.7}{2\pi \times 1.9 \times 10^{-2}}\right)$$

$$= 1.8 \times 10^{-5} \text{ T}$$

(iii) For the same *B*, $I \propto r$.
New current = (2.8 / 1.9) x 1.7
= 2.5 A

6 **(a)** **(i)**



Draw a straight line such at area A = area B.
Distance = area under the line
$= \frac{1}{2} \times (6.0 + 3.6) \times 8.0$
$= 38$ m (allow $\pm$ 1 m)

(ii) **1.** $E_K = \frac{1}{2}mv^2$
$\Delta E_K = \frac{1}{2} \times 92 \times (6^2 - 3^2)$
$= 1240$ J

2. $E_P = mgh$
$\Delta E_P = 92 \times 9.81 \times 1.3$
$= 1170$ J

(iii) **1.** $E = Pt$
$E = 75 \times 8$
$= 600$ J

2. Useful work done + Loss in KE = Gain in EPE + Work done against frictional forces
600 + 1240 = 1170 + Work done against frictional forces
Work done against frictional forces = 670 J

3. W.D = Fd
force = 670/38 = 18 N
allow e.c.f. for distance obtained in (a)(i)

4. frictional forces include air resistance
air resistance decreases with decrease of speed

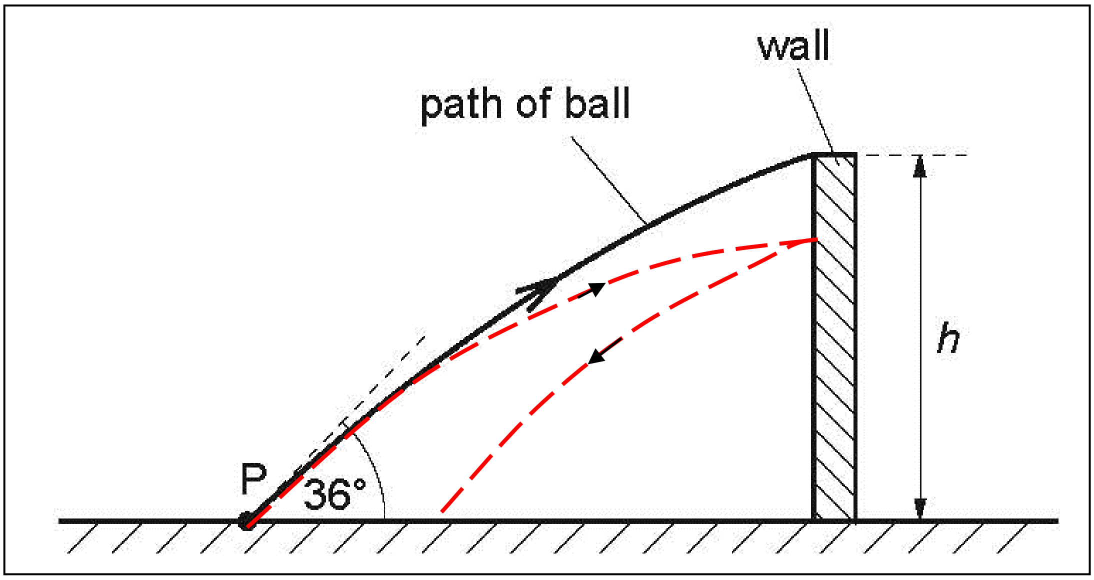
(b) **(i)** **1.** $V_H = 12.4 \cos 36° = 10.0$ m s^{-1}
distance = 10.0×0.17
$= 1.7$ m

2. $V_V = 12.4 \sin 36° = 7.29$ m s^{-1}

$h = 7.29 \times 0.17 - \frac{1}{2} \times 9.81 \times 0.17^2$
$= 1.1$ m

3. Distance is the actual path travelled but displacement is the straight line distance from start to finish point, in that direction.

(ii) smooth curve with ball hitting wall below original
smooth curve showing rebound to ground with correct reflection at wall



(iii) Let maximum energy = $\frac{1}{2}mu^2 = K$
using $v = u - gt$,
at max height , $v = 0$, $t = u/g$
at time = t/2, $v = u - g(t/2) = u - g(u/g)(\frac{1}{2}) = u/2$
kinetic energy of ball = $\frac{1}{2}m(u/2)^2 = (\frac{1}{4})K$
potential energy of ball = $K - \frac{1}{4}K = \frac{3}{4}K$
ratio = $\frac{3}{4}K / \frac{1}{4}K = 3$

7 (a) The *principle of superposition* states that when two waves meet at a point, the resultant displacement is equal to the vector sum of the individual displacements.

(b) (i) 1 cycle represented by 2 cm.
period = 2 x 0.2 ms = 4.0×10^{-4} s
frequency = 1/period
= $1/(4.0 \times 10^{-4}) = 2500$ Hz

(ii) 1. P & Q same distance from speaker OR in phase OR zero path diff.
hence constructive interference/superposition
(do not allow arguments based on: nodes and antinodes/standing waves OR "microphones closer to loudspeaker")

2. as P is moved, path difference increases/changes
minima when P moves odd number of ½ λs & maxima if P moves

whole number of λs
OR minima when waves meet out of phase & maxima when waves meet in phase
OR minima when path difference is odd number of ½ λs & maxima when path difference is whole number of λs

(iii) First minimum corresponds to ½ λ path difference
Wavelength, $\lambda = 2 \times 6.8 = 13.6$ cm = 0.136 m
$v = f\lambda$
$\Rightarrow v = 2500 \times 0.136 = 340 \text{ m s}^{-1}$

(c) **(i)** Incident wave superpose with the reflected wave at closed end stationary wave formed if tube length equivalent to
λ / 4, 3λ / 4, etc.

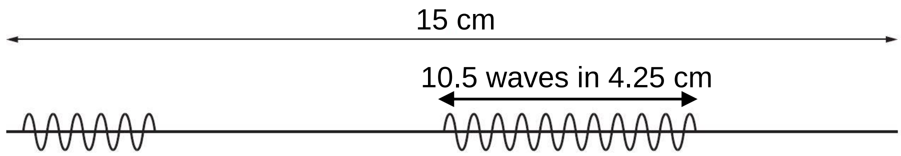
1. **A.** no motion (as node) / zero amplitude

B. vibration backwards and forwards / maximum amplitude along length

2.
$$\frac{3\lambda}{4} = L$$
$$L = 0.75 \times 0.375$$
$$= 0.281\,\text{m}$$

(d) **(i)** frequency, $f = (3.00 \times 10^{8})/(589 \times 10^{-9}) = 5.09 \times 10^{14}$ Hz

(ii)



10.5 waves in 4.25 cm → 15 cm will have $\frac{10.5}{4.25} \times 15 \approx 37$ waves
Accept 32 to 42 waves in *t*

$T = 1/f = 1.96 \times 10^{-15}$ s, so $t \approx 7 \times 10^{-14}$ s

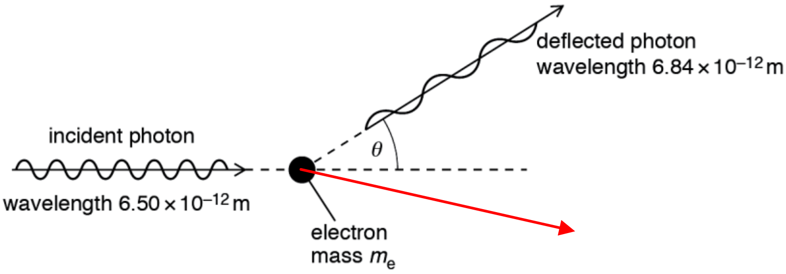
(iii) from two different sources/not a constant phase difference

(iv) *Any of the below*:
any coherence between one set of pulses/waves and another set cannot last
phase difference between the pulses/waves changes with time
position of fringes formed on screen varies

so any pattern only lasts for a very short time

8 **(a)** a photon is a quantum of electromagnetic energy
which is dependent only on the frequency of the radiation (or mention E=hf)

(b) **(i)** arrow below axis and pointing to right



(ii) **1.** change in energy of photon = $\frac{hc}{\lambda_f} - \frac{hc}{\lambda_i}$

$= (6.63\times10^{-34}\times3.0\times10^{8})\left(\frac{1}{6.84\times10^{-12}} - \frac{1}{6.50\times10^{-12}}\right)$

$= -1.52\times10^{-15}$ J (accept +ve value)

2. gain in energy of electron = loss in energy of photon

$½\, m\, v^2 = 1.52\times10^{-15}$

$v = 5.78\times10^{7}\ \mathrm{m\,s^{-1}}$

(c) momentum is a vector quantity
either must consider momentum in two directions
or direction changes so cannot just consider magnitude

(d) **(i)** $6.84\times10^{-12} - 6.50\times10^{-12} = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times3.0\times10^{8}}(1-\cos\theta)$

$\theta = 30.7°$

(ii) photon loses energy to the deflected electron
deflected photon has less energy, longer wavelength (so Δλ always positive)

(e) **(i)** It is the wavelength associated with a particle that is moving, and is related to its momentum p by h/p.

(ii) kinetic energy $E_K = ½\, mv^2 = 1.60 \times 10^{-19} \times 4700$
$= 7.52 \times 10^{-16}$ J

From $p = mv$ and $E_K = ½\, mv^2$, hence $p = \sqrt{2mE_K}$

$= \sqrt{2 \times 9.11 \times 10^{-31} \times 7.52 \times 10^{-16}}$
$= 3.7 \times 10^{-23}$ N s

λ = h/p
$= (6.63 \times 10^{-34}) / (3.7 \times 10^{-23})$
$= 1.8 \times 10^{-11}$ m

(iii) The wavelength of these electrons is about the separation of atoms.

These electrons can be passed through a crystal in electron diffraction, where the interference pattern can be studied to understand the crystal structure.