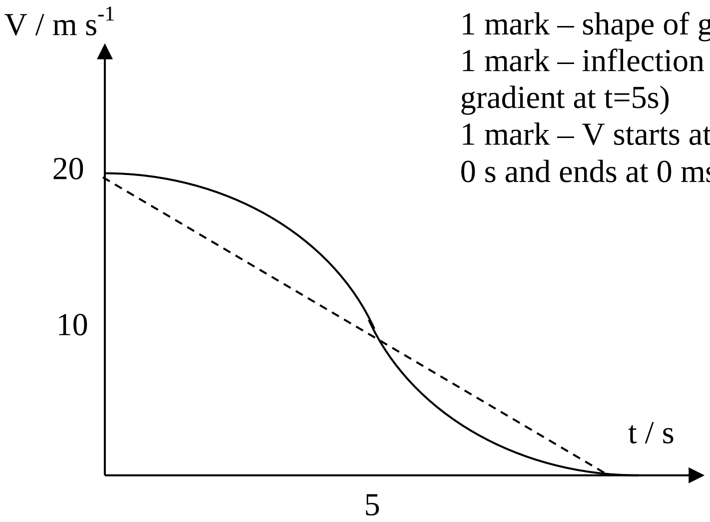
2015 H1 Physics P2 Suggested Solution

1(a) Rate of change of velocity. [1]

(b) [3]

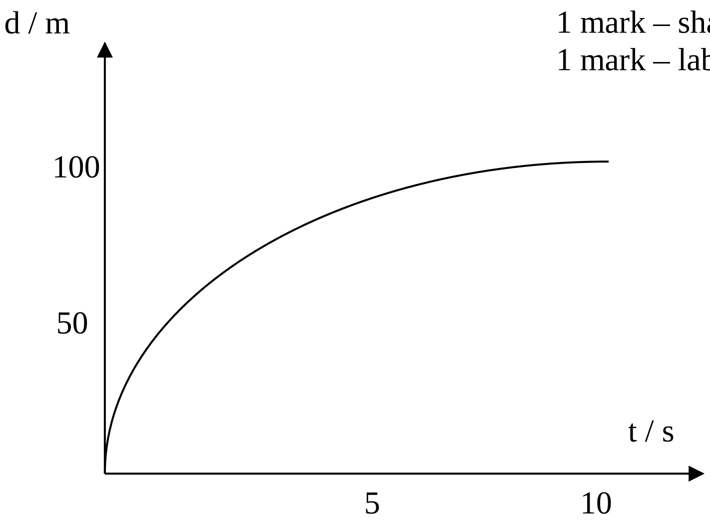



1 mark – shape of graph
1 mark – inflection (steepest gradient at t=5s)
1 mark – V starts at 20ms$^{-1}$ at 0 s and ends at 0 ms$^{-1}$ at 10s

(b)(i) Area under v-t graph gives the displacement. [1]

(ii) Area under graph is given by the dotted triangle (1 mark) [2]
= ½ x 20 x 10 = 100 m (1 mark) (1 mark if only mentioned area under graph)

(iii) [2]




1 mark – shape of graph
1 mark – labeled graph

(c) The <u>sudden application of force</u> is necessary for constant deceleration. Hence discomfort is experienced at the beginning and the end of the deceleration. [2]
If the braking force is as shown in figure 1.1, then the change in velocity at the start and end is minimized (figure 1.2) and therefore, does not cause jerking.

2 (a) **Total linear momentum of a system of interacting bodies** is constant provided that there is **no net external force acting on the system**. [1]

(b) (i) Impulse = area under F – t graph = change in momentum [1]
= 22000 (3) – 0 = 66 000 Ns [1]

(ii) Total KE before collision = ½ (22000)$(3)^2$ + ½ (66000) $(1)^2$ = 132 000 J
Total KE after collision = 0 + ½ (66000) $(2)^2$ = 132 000 J [1]
Since Total KE before and after collision are the same, [1]

OR relative speed of approach = relative speed of separation
= 3 – 1 = 2 – 0 = 2 m $s^{-1}$ [1]
the collision is **elastic** [1]
[1 mark for working on $E_k$ or Relative speed, 1 mark for correct conclusion]

(iii) Difference in energy is stored as **elastic potential energy in the springs.** [1]

3 (a) In the opposite direction of motion [1]

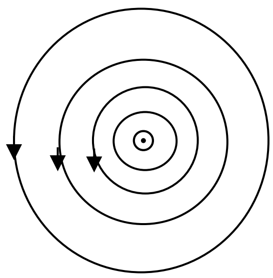
(b) At uniform speed, driving force = drag force $F$

Power supplied = (driving force) $\times v$
$= F \times v$
$= (kv^2)v$
$= (13360)(5)^3$ [1]
= 1.67 MW [1]

(c) Efficiency = 60% = $\frac{\text{output}}{\text{input}} \times 100\% = \frac{1.67\,\text{MW}}{\text{input}} \times 100\%$ [1]
Input = 2.78 x $10^6$ W [1]

4 (a) Magnetic flux density in a magnetic field is the <u>force per unit length</u> acting on a conductor carrying a <u>unit current</u> placed at <u>right angles to the field</u>. [2]

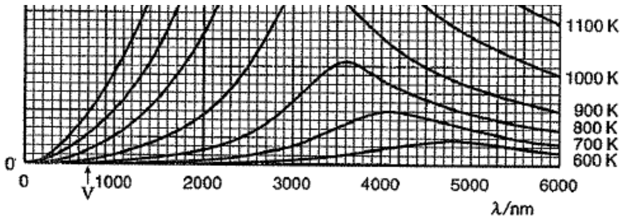
(b) (i) Direction and shape (1)



Non-uniform spacing (closer when nearer the wire) (1)

(ii) $F = BIL$
= (0.40)(3.0)(0.12) substitution (1)
= <u>**0.144 N**</u> answer (1)

5(a)(i) The wavelength of visible light ranges from 400 nm (violet) to 700 nm (red). One possible wavelength in the visible spectrum will be 700 nm (red), indicated with the later V in the figure below. [1]




(ii) Referring to the curve for 1100 K, the intensity of the longer wavelengths at the red end of the visible spectrum (> 600 nm) exceeds those at the violet end of the spectrum (<500 nm). [1]
The longer wavelengths thus dominate, resulting in a reddish glow.

(b)(i) The products of T x λmax for the six sets of data are: [1]
$2.898 \times 10^{-3}$ m K
$2.898 \times 10^{-3}$ m K
$2.888 \times 10^{-3}$ m K
$2.889 \times 10^{-3}$ m K
$2.900 \times 10^{-3}$ m K
$2.893 \times 10^{-3}$ m K

The constant can be obtained by averaging the six sets of values. [1]

The average value is $2.89 \times 10^{-3}$ m K [1]

(ii) T x λmax = $2.89 \times 10^{-3}$
λmax = 2410 nm [1]

(c)(i) log(Itot) = log(c) + nlog(T) [1]

Draw best fit line to find gradient [1]

n = (2.22 – 1.00)/(3.05 – 2.74)
= 1.22/0.31
=3.94 [1]

(ii) Substituting T = 900 K and $I_{tot}$ = 71 W $m^{-2}$ into the equation $I_{tot} = cT^n$ with n =3.94, c = 1.63 x 10-10 [1]

Using the same equation for T = 1200 K, [1]
$I^{tot}$ = ($1.63 \times 10^{-10}$)(1200)3.94
= 220 W $m^{-2}$

Section B

**6(a)** When two or more travelling <u>waves of the same type meet</u> at a point in space, the <u>resultant displacement</u> at that point is the vector <u>sum of the displacements</u> that the waves at that point. [2]

**6(b)(i)** $v = k\sqrt{h}$

Unit of constant = $\dfrac{\text{m s}^{-1}}{\text{m}^{\frac{1}{2}}} = \text{m}^{\frac{1}{2}}\text{s}^{-1}$ [2]

**6(b)(ii)** $v = 3.13\sqrt{0.026} \approx 0.50\ \text{m s}^{-1}$ (shown) [1]

$f = \dfrac{v}{\lambda} = \dfrac{3.13\sqrt{0.026}}{0.025} \approx 20.188 \approx 20\,\text{Hz}$ [1]

**6(b)(iii)** $v = f\lambda$

$3.13\sqrt{0.026} = \dfrac{0.125}{t}$ [1]

$t \approx 0.25\ \text{s}$ [1]

**6(c)(i) 1.** Wavelength $\lambda = \dfrac{0.50}{50} = 0.010\ \text{m}$

Distance between $S_2$ and sensor

$= \sqrt{0.100^2 + 0.240^2} = 0.260\,\text{m}$ [1]

Path difference = 0.260 – 0.240 = 0.020 m = $2\lambda$ [1]

**6(c)(i) 2.** Destructive interference at the location of the sensor. [1]

<u>Minimum / zero amplitude</u> detected.

**6(c)(ii)** As frequency is increased from 50 Hz to 100 Hz, wavelength of waves decreases from 0.010 m to 0.005 m. [1]

For the same <u>path difference 0.020 m</u>, the sensor <u>detects 2 cycles of alternating destructive and constructive interference.</u> [2]

**6(d)(i)** Upon striking the barrier, the plane waves are <u>reflected</u> and will <u>superpose</u> with the <u>incident waves</u>. [1]
The incident and reflected waves have the <u>same wavelength, frequency and amplitude</u>, and thus stationary waves are formed. [1]
Regions of <u>nodes</u> and <u>antinodes</u> formed. Fine sand will settle <u>along the nodal regions</u>, forming equally-spaced ridges. [1]

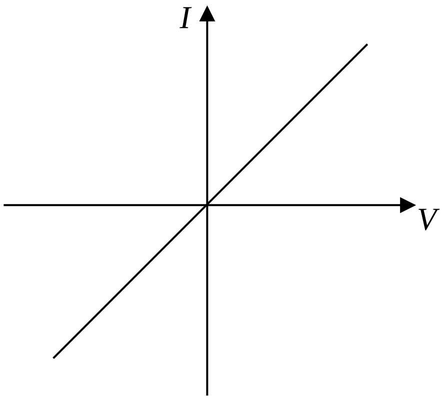
**6(d)(ii)** Wavelength of stationary waves = 2 (0.018) = 0.036 m [1]

$v = 3.13\sqrt{h}$

$12 \times 0.036 = 3.13\sqrt{h}$ [1]

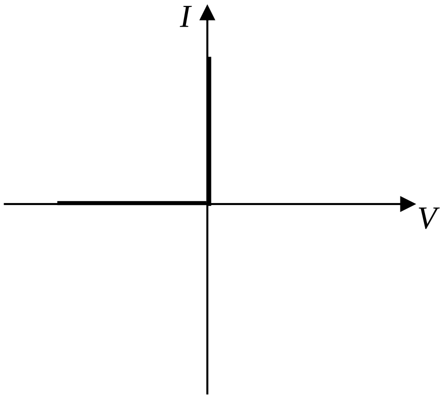
$h \approx 0.019$ m [1]

**7(a)(i)**




[1]

**7(a)(ii)**

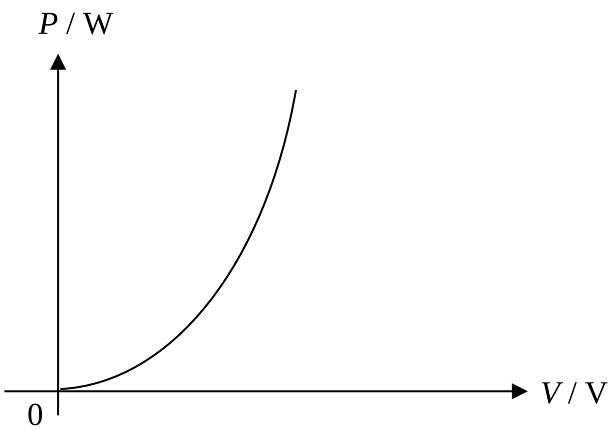



[1]

**7(b)(i)** As current increases, power dissipation increases and this leads to an increase in temperature. [1]
More electron-hole pairs will be formed; there is an increase in the number of mobile charge carries and so the resistivity decreases. [1]

**7(b)(ii)** Resistance of a conductor is the ratio of the potential difference across the conductor to the current flowing through the conductor. Hence, it can be obtained by reading the values of *V* and *I* and taking the ratio. [1]

**7(b)(iii)**




[1] – upwards trend
[1] – for shape

**7(b)(iv)** At low temperature, $V_X = \frac{500}{1000+500}(120)$

$= 40$ V [1]

At high temperature, $V_X = \frac{500}{100+500}(120)$

$= 100$ V [1]

Change in potential at X $= 100 - 40$

$= 60$ V [1]

**7(c)** The p.d. across lamps B and C will decrease due to a decrease in effective resistance. [1]
This causes the p.d. across lamp A to exceed 6 V, hence it will blow (optional). [1]
Hence, lamps A brighter and B dimmer OR A and B will not light up. [1]

**7(d)(i)** $P_X = \left(\frac{12}{3.9+48}\right)^2(48)$

$= 0.2312^2 \times 48$ [1]

$\approx 2.57$ W [1]

**7(d)(ii)** $Q = 0.2312 \times 60$ [1]

$\approx 13.9$ C [1]

**7(d)(ii)** Energy input $= QE = 13.9 \times 12$ [1]

Efficiency of circuit $= \frac{P_X t}{QE} \times 100\%$

$= \frac{2.5661 \times 60}{13.8728 \times 12} \times 100\%$ [1]

$\approx 92.5\ \%$ [1]

8 (ai) Electrons below the surface lose some KE on their way to the surface if and when they collide with the metallic lattice; they do not ALL experience the same loss in KE during such collisions before they are emitted. [1]

(aii) $P = E / t = N \times E_{1photon} / t$

$N/t$ = rate of emission of photons $= P / E_{1photon}$

$= I \times A / E_{1photon} = (0.23)(12\times10^{-4}) / (6.63\times10^{-34} \times 3\times10^{8} / 254 \times 10^{-9})$ [1]

$= 3.52 \times 10^{14}\ s^{-1}$ [1]

(a ii 2) $Q = It$

$N \times Q_{1electron} = I\,t$

$N/t$ = rate of emission of electrons

$= 0.05 \times 3.52 \times 10^{14} = I / Q_{1electron}$

$I = 0.05 \times 3.52 \times 10^{-14} \times (1.6\times10^{-19})$ [1]

$= 2.82 \times10^{-6}$ A [1]

8 (a) (iii) 1. Electron collides with air molecules, hence less electrons reach the anode $\Rightarrow$ smaller maximum photocurrent **OR**

Photons is absorbed by the air, hence less photons will reach the emitter, and so fewer electrons will be emitted $\Rightarrow$ smaller maximum photocurrent

. **OR**

Air contaminates the plate, so workfunction increases and hence fewer photons sufficiently energetic to release electrons . $\Rightarrow$ smaller maximum photocurrent

[ any 2]

2. Point source of radiation moves further away $\Rightarrow$ fewer photons hitting the emitter per unit time $\Rightarrow$ fewer photoelectrons emitted per unit time [1]

$\Rightarrow$ smaller maximum photocurrent [1]

(b) (i) The electron occupies one of a limited number of energy levels.

When the electron drops from a higher level to a lower one, a photon is emitted. [1]

The photon energy/wavelength/frequency depends on the energy difference between the 2 levels. [1]

Each spectral line corresponds to a particular photon energy/wavelength/frequency. [1]

(ii) 1. Energy absorbed by the ground state electron to transit to level 4

$= (5.45 - 0.78) \times 10^{-19} = 4.67 \times 10^{-19}$ J [1]

Kinetic energy of the scattered electron, $K = (5.00 - 4.67) \times 10^{-19}$

$= 0.33 \times 10^{-19}$ J [1]

Momentum of the scattered electron, $p = \sqrt{2mK}$

$= \sqrt{2 \times 9.11 \times 10^{-31} \times 0.33 \times 10^{-19}}$

$= 2.45 \times 10^{-25}$ kg m s$^{-1}$ [1]

Hence, the de-Broglie wavelength $= \frac{h}{p} = \frac{6.63 \times 10^{-34}}{2.45 \times 10^{-25}} = 2.71 \times 10^{-9}$ m [1]

.2. Longest wavelength correspond to smallest $\Delta E$

$\Rightarrow \lambda = \frac{hc}{\Delta E} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{(1.36 - 0.78) \times 10^{-19}}$ [1]

$= 3.43 \times 10^{-6}$ m [1]

3. Arrow pointing downwards from level 4 to level 3. [1]