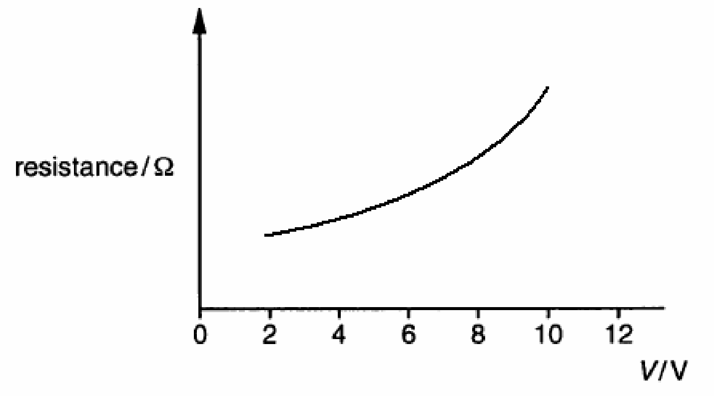
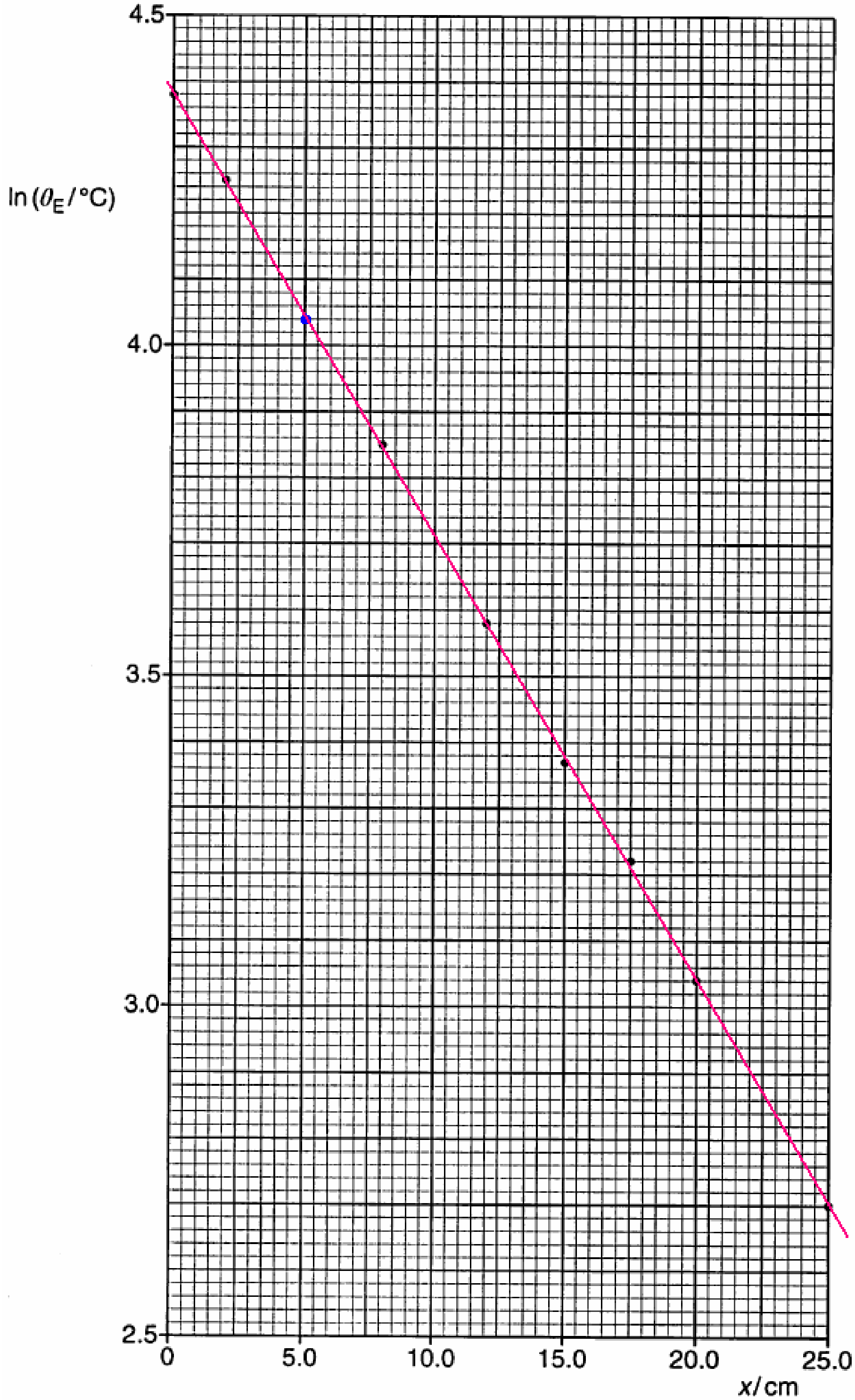
H2 Physics 9646 – 2010 Paper 2 (Worked solutions)

1	(a)		The net force acting on a body is directly proportional to the rate of change of its momentum.
	(b)	(i)	Upon application of brakes, net force = resistive force F Resistive force F = ma = (750)(4.8) = 3600 N
		(ii)	Known: u = 25 ms^{-1} , a = -4.8 ms^{-2}; v = 0 To find: s Use $v^2 = u^2 + 2as$ $0 = 25^2 + 2(-4.8)s$ s = 65.104 = 65.1 m
		(iii)	The frictional force exerted by the road on the car tyres is equal in magnitude to the force exerted by the frictional force exerted by the car tyres on the road. The frictional force exerted by the road on the car tyres acts in the opposite direction to the car's velocity thus slowing the car down, while the frictional force exerted by the car tyres on the road acts in the same direction of the car's velocity. *Examiner's report:* *Candidates focused on a statement of Newton's third law rather than its application to the specific problem. Very few were able to give the correct directions for these forces.*
	(c)	(i)	The deceleration of the car is smaller than 4.8 ms^{-2} as the net decelerating force is now smaller and equals to the difference between the resistive force and the downslope component of the car's weight (W), that is, (3600 – Wsin10°) N.
		(ii)	3600 – Wsin10° = ma 3600 – mgsin10° = ma 3600 – (750)(9.81) sin10° = (750)a a = 3.10 ms^{-2}
2	(a)	(i)	$P = V^2/R$ $24 = 12^2/R$ R = 6 Ω
		(ii)	Energy (W) = Pt = 24 (1800) = 43200 J
		(iii)	W = QV 43200 = Q (12) Q = 3600 C Q = Ne = 3600 N (1.6 x 10^{-19}) = 3600 N = 2.25 x 10^{22}
	(b)	(i)	The resistance of the lamp at any particular value of *V* may be obtained by taking the ratio of that value of *V* to the value of I at that same point. *Note: it is NOT given by the inverse of the gradient of the graph.*

		(ii)	 *Examiner's report:* *Calculation of resistance values are NOT awarded marks.* *Graph should not start from origin.*
		(iii)	The battery may have internal resistance causing the terminal potential difference of the battery to be smaller than 12 V. Also, the lamp and the variable resistor have comparable resistances as seen from 2(a)(i) hence a potential difference close to 0 V is unattainable. [only when the maximum resistance of the variable resistor is much greater than that of the lamp's resistance then a p.d. of close to 0 V across the lamp is achievable.]
3	(a)	(i)	Diffraction is the spreading of waves into the geometrical shadow regions after passing through a slit or around the edge of an obstacle. *Examiner's report:* *Calculation who did not explain that the waves spread after passing through a slit or around the edge of an obstacle were not awarded marks.*
		(ii)	Phase difference: a measure of the difference in states of motion between 2 waves/particles in cyclical motion / a measure of the difference between how far the 2 waves/particles in cyclical motion have proceeded through their cycles. "State" of motion refers to the set of variables (displacement, velocity, acceleration) of the wave/particle at a particular instant in time. Additional info: Phase: a measure of the state of motion of a wave/particle in cyclical motion. "State" of motion refers to the set of variables (displacement, velocity, acceleration) of the wave/particle at a particular instant in time. [A comparison: when we talk about "state" of a gas, we are referring to the set of variables (pressure, Volume, Temperature, no. of moles).]
		(iii)	Coherence means constant phase difference. *Note: 'same phase' is not accepted.*
	(b)	(i)	For observable interference fringes to form, the sources M_1 and M_2 must be coherent. In the region where the 2 waves overlap, they superpose to produce a resultant wave. At points where the 2 waves arrive in phase (0 radians), they undergo constructive interference resulting in maximum intensity at that point. At points where the 2 waves arrive in antiphase (π radians), they undergo complete destructive interference resulting in

			<u>minimum intensity at that point</u>. At other points, where the waves arrive with a phase difference other than 0 radians or π radians, they undergo partial destructive interference. <u>Examiner's report:</u> Candidates must mention the need for the sources to be coherent. Conditions for constructive and destructive interference must be described. Many confused *phase difference* and *path difference*!
		(ii)	1. Maximum intensity will increase, but minimum intensity remain unchanged. Position of fringes remain unchanged. 2. Positions of maxima and minima along AB will be swapped as phase difference changes by π radians at every point. Maximum and minimum intensity remain unchanged. *<u>Examiner's report</u>*: *Many candidates discussed the effects as would be seen with light waves when the question is about microwaves NOT light waves.* *Also, note that dark fringes cannot become darker!*
4	(a)		Magnetic flux through a plane surface is the product of magnetic flux density <u>normal</u> to the surface and the area of the surface.
	(b)		$\Phi = N\varphi = NBA \cos\theta$ $= (500)(5.0\times10^{-2})(2.5\times10^{-2}) \cos 0°$ $= 0.625$ Wb
	(c)	(i)	As the coil rotates, the area of the coil perpendicular to the magnetic field changes. Magnetic flux and hence magnetic flux linkages changes.
		(ii)	Note: question asks for 'average' induced emf, not 'instantaneous' induced emf. Average induced emf, $E = \lvert\Phi_f - \Phi_i\rvert / t$ $= \lvert 0 - 0.625\rvert / (0.25\times10^{-3})$ $= 2.5 \times10^{-3}$ V
		(iii)	According to Faraday's law, the magnitude of the induced emf is directly proportional to the rate of change of flux linkage, that is, $\lvert E\rvert = d\Phi/dt$. Maximum value of induced emf is <u>given by the gradient of the tangent at the point where gradient is the steepest (that is, at t = 0.25ms, 0.75ms, 1.25ms etc.)</u>
5	(a)	(i)	The temperature at which all substances have a minimum internal energy.
		(ii)	The thermodynamic temperature of an ideal gas is directly proportional to the average kinetic energy of molecules of the ideal gas.
	(b)	(i)	$pV = nRT = (m/M_r)RT$ $(1.0\times10^5)(0.064) = (m/0.030)(8.31)(27 + 273.15)$ $m = 0.076977 = 0.0770$ kg
		(ii)	$pV = (m/M_r)RT$ Since p, V, M_r and R are constants, mT = constant $m_1 T_1 = m_2 T_2$

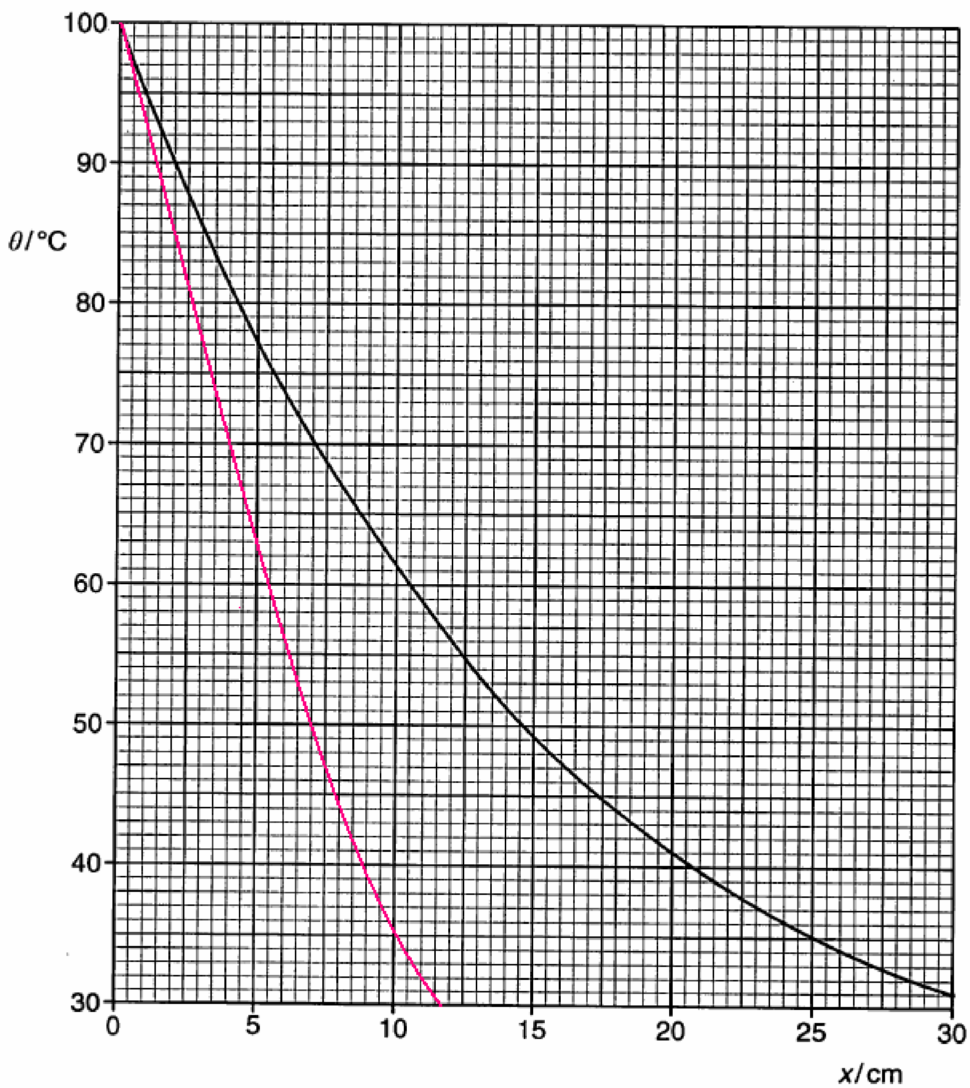
			(0.076977)(27+273.15) = m_2 (180+273.15) m_2 = 0.050987 kg mass that must escape = $m_1 - m_2$ = 0.076977 – 0.050987 = 0.0260 kg
6	(a)		45°C
	(b)	(i)	They are equal.
		(ii)	Precision of graph: Horizontal scale → half the smallest division = 0.25 cm (2 dp) Vertical scale → half the smallest division = 0.5°C (1dp) Using the coordinates (0.00, 100.0) and (17.50, 45.0), Temperature gradient = Gradient of graph = (100.0 – 45.0) / (0.00 – 17.50) = -3.14 °C cm^{-1} (3 s.f.) → since smallest s.f. in the values used for calculation is 3 s.f.
		(iii)	The insulation used in Figure 6.3 prevents heat lost from the rod to the surroundings, thus maintaining higher temperatures.
	(c)		If temperature is inversely proportional to distance x along the rod, then the following relationship should hold: θ = k / x where k is the constant of proportionality. → θx = k → The product θx should be a constant for all values of θ and x. Let's check! From the graph, At (0.00, 100.0), θx = 0 At (17.50, 45.0), θx = 787.5 Obviously, θx is not a constant. Hence the relationship "θ = k / x" does not hold. *<u>Examiner's report:</u>* *Candidates should be advised that where the question involves an instruction to 'show' then full working is expected. The candidates who only gave a descriptive answer were not considered to have answered the question.*
	(d)	(i)	Room temp = 20°C θ_E = 77 – 20 = 57°C ln θ_E = ln (57) = 4.04

		(ii)	1.  2. Take 'ln' on both sides, $\ln \theta_E = \ln \theta_o + (-\mu x) \ln e$ $\ln \theta_E = - \mu x + \ln \theta_o$ If the relationship holds, then plotting a graph of $\ln \theta_E$ against x should give a straight line with gradient equal to $-\mu$ and vertical intercept equal to $\ln \theta_o$ Since a straight line graph in obtained, the equation supports the proposal.

<table>
<tr><td></td><td></td><td></td><td>3. gradient, $-\mu = (4.38 - 2.7) / (0 - 25)$
$\mu = 0.0672\ cm^{-1}$

Vertical intercept, $\ln \theta_o = 4.38$
$\theta_o = 79.8\ ℃$</td></tr>
<tr><td></td><td>(e)</td><td></td><td>$Q = mc\,\Delta\theta$
Rate of heat loss is proportional to the mass, specific heat capacity and temperature difference between the material and the surroundings.

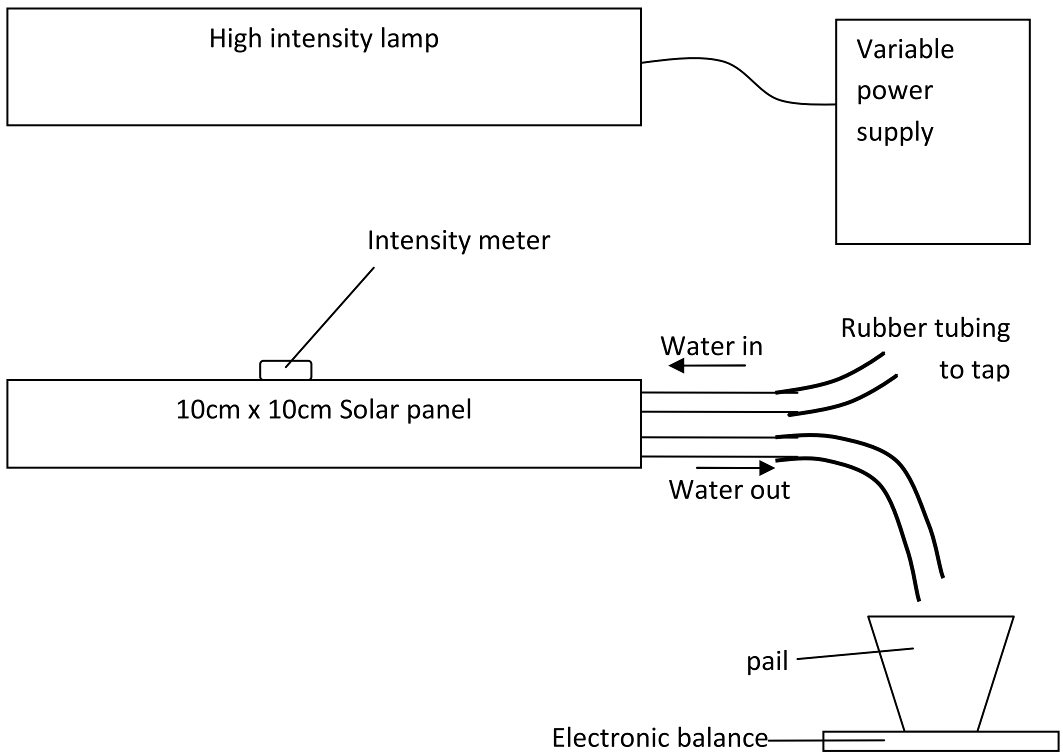
Wood, which has a larger specific heat capacity than metal, requires a much larger amount of heat to cause per unit rise in temperature. Hence its temperature will be overall lower than that of the metal.
Eventually, when the rate of heat entering the section of the rod equals the rate of heat leaving that section of the rod, the temperature remains constant.


</td></tr>
<tr><td>7</td><td></td><td></td><td>Definition of efficiency:
Efficiency = Increase in internal energy of water / energy absorbed by solar panel

Independent variable: energy absorbed by solar panel
Dependent variable: temperature increase of water</td></tr>
</table>

Controlled variables: Area of solar panel exposed to light, mass flow rate of water

Diagram:



Procedure:
1) Set up the apparatus as shown in the diagram.
2) Tare the electronic balance with the pail placed on it.
3) Arrange the lamp vertically above the solar panel so that light from the lamp is incident perpendicularly on the solar panel. Ensure entire solar panel receives the radiation from the lamp.
4) Switch on the lamp.
5) Using the intensity meter, measure and record the intensity of the radiation <u>on the surface</u> of the solar panel at multiple locations and calculate the average intensity I. This is to reduce random error.
6) Use a thermometer to measure the temperature of the water flowing from the tap. Record as θ_i.
7) Connect the rubber tubing from the tap to the pipe supplying water to the solar panel. Switch on the tap to allow water to flow in.
8) Once water is <u>flowing steadily</u> through the pipe, with the rubber tubing connected to the outflow pipe, channel the water into the empty pail. Start the stopwatch at the same instant. Measure and record the mass of water (m) collected in 5 minutes.
9) Measure the final temperature of the water in the pail (θ_f)
10) Calculate the energy absorbed by the solar panel in 5 minutes:

$$E_{supplied} = \text{Power x time} = \text{Intensity x Area of solar panel x time}$$
$$= I \times (0.10\text{ m} \times 0.10\text{ m}) \times (5 \times 60\text{ s})$$

11) Calculate the energy absorbed by the water:

$$E_{water} = \text{m x specific heat capacity of water x } (\theta_f - \theta_i)$$

12) Calculate the efficiency of the solar panel:

$$\text{Efficiency} = E_{water} / E_{supplied}$$

			13) Repeat steps 4 to 12 with a different power supplied to the lamp. 14) Plot a graph of efficiency against $E_{supplied}$.