1 **(a)** $mg = kx$

$k = \frac{mg}{x} = \frac{\mathbf{0.140(9.81)}}{\mathbf{(10.8-8)10^{-2}}} = 49.05$ **M1**

force constant = **<u>49</u>** N m^{-1} OR **<u>49.1</u>** N m^{-1} **A1** [2]

<u>CAUTION</u>

- *Ensure right conversion from cm to m.*
- *Ensure extension is used, and not final length.*

<u>ANALYSIS</u>

When the steel block is suspended from the lower end of the spring, the spring is extended by 10.8 - 8 = 2.8 cm. At this instant, the system is in equilibrium and that implies no resultant force acting on the spring. So, the upward tension balances the weight.

(b) **(i)** The extended length is 2.8 cm.

Total uncertainty in the measurement of extension = $2(\pm 1) = \pm 2$ mm

% k = % m + % x =**1%** + $\frac{\mathbf{2}}{\mathbf{28}}$ **x 100%** = 8.142 % **M1**

Percentage uncertainty = **<u>8.14</u>** % OR **<u>8.1</u>** % **A1** [2]

<u>CAUTION</u>

- *Ensure that you use extended length when calculating the percentage uncertainty for x.*
- *Read question carefully and ensure that the total uncertainty is ± 2mm since 2 measurements must be taken when calculating extension.*

<u>ANALYSIS</u>

Extension = 2.8 cm = 28 mm. Since total uncertainty = 2 mm, percentage uncertainty = $\frac{2}{28}$ x 100% .

(ii) $k = 49.05 \pm 8.14\% = 49.05 \pm 3.99$

force constant = $\underline{(\mathbf{49 \pm 4})}$ N m^{-1} **A1** [1]

<u>ANALYSIS</u>

$8.14\% = \frac{x}{49.05}$ x 100%

$x = 3.99 = 4\,(1\ s.f.)$

(c) **(i)** $U = k(\Delta x) = \mathbf{49.05(0.5 \times 10^{-2})} = 0.24525 \approx 0.25$ N (shown) **A1**

OR **OR**

$T + U = W$

$U = W - T = \mathbf{(0.140)(9.81) - (49.05)\left(\frac{2.3}{100}\right)} = 0.24525$ N ≈ 0.25 N (shown) **(A1)** [1]

		(ii)	$W = mg = \rho V g = (0.14)(9.81)$ $V_{block} = \frac{0.14}{7750} = \mathbf{1.80645 \times 10^{-5}}$ $U = (\rho V g)_{fluid}$	C1	
			$\mathbf{0.25 = \rho(1.80645 \times 10^{-5})(9.81)}$, so $\rho = 1410.7$ kg m^{-3}	M1	
			OR	OR	
			$\mathbf{0.24525 = \rho(1.80645 \times 10^{-5})(9.81)}$, so $\rho = 1383$ kg m^{-3}	(M1)	
			density = **<u>1410</u>** kg m^{-3} OR **<u>1380</u>** kg m^{-3}	A1	[3]
2	(a)	(i)	$\boldsymbol{v = r\omega = r\left[\frac{2\pi}{T}\right]}$	C1	
			$T = \frac{2\pi r}{v} = \frac{\mathbf{2\pi(1.75 \times 10^{7})}}{\mathbf{200}} = 549850 = 6.364 \text{ days} \simeq 6.36 \text{ days (shown)}$	A1	[1]

CAUTION

Some students used $\frac{GMm}{r^2} = mr\left(\frac{2\pi}{T}\right)^2$*, but this approach was incorrect because Pluto and Charon are not isolated objects in space.*

ANALYSIS

Pluto and Charon are binary stars. They rotate about their common axis.

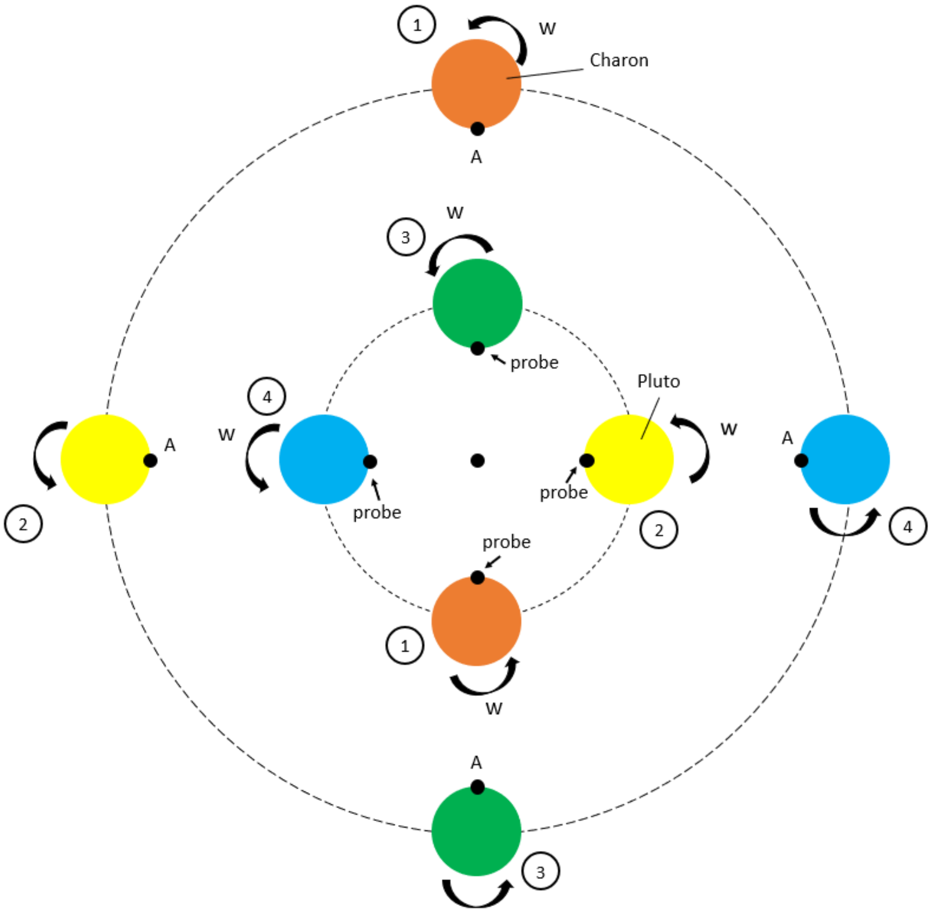
(ii) 1. **Charon is observed to be stationary / at a fixed location** relative to Pluto. **B1**

CAUTION

Do not write "space probe is always in between Pluto and Charon" as the question asked about what will be observed by the space probe, not the position of the space probe.

2. **same side / face / part of Charon will be observed all the time.** **B1** [2]

ANALYSIS



- *Pluto and Charon are gravitationally-locked together, each keep the same face towards each other.*
- *Let's take a look at their respective faces at different time interval: From the diagram above, start analyzing from position 1 for Pluto and Charon. You should observe that probe on Pluto is facing Charon. At subsequent positions (i.e. 2, 3, and 4), probe on Pluto is also facing the same side of Charon since both are rotating in the same direction.*

(b) $g = \dfrac{GM}{r^2} = \dfrac{(6.67 \times 10^{-11})(1.31 \times 10^{22})}{(1.20 \times 10^{6})^2} = 0.606784$ **M1**

$g_p =$ **<u>0.607</u>** N kg^{-1} **A1** [2]

<u>CAUTION</u>

Do not put 2 s.f. as the final answer. Raw data given were in 3 s.f.. Final answer must be in 3 s.f. too.

(c) **(i)** loss in **gravitational potential energy is converted to** gain in **kinetic energy.** **B1**

$\dfrac{GMm_{pluto}}{r} = \dfrac{1}{2}Mv^2$ OR $-\dfrac{GMm_{pluto}}{r} + \dfrac{1}{2}Mv^2 = 0$, so $v = \sqrt{\dfrac{2Gm_{pluto}}{r}}$ **B1**

Since $g_p = \dfrac{Gm_{pluto}}{r^2}$, **M1**

$v = \sqrt{\dfrac{2gr^2}{r}} = \sqrt{2g_p r}$ **(shown)** **A0** [3]

(ii) $v = \sqrt{2g_p r} = \sqrt{2(0.606784)(1.20 \times 10^{6})} = 1206.76$

speed = **<u>1210</u>** m s^{-1} **A1** [1]

<u>CAUTION</u>

Do not put 2 s.f. as the final answer. Raw data given were in 3 s.f.. Final answer must be in 3 s.f. too.

3	**(a)**	**one/single plane/direction of oscillation/vibration** of wave **normal/perpendicular to the direction of energy propagation/transfer** of the wave.	**B1** **B1** [2]
	(b)	$\text{period } T = \dfrac{1}{\text{frequency } f}$	**B1**
		$\text{speed } v = \dfrac{\text{distance}}{\text{time}} = \dfrac{\text{one wavelength } \lambda}{\text{one period } T}$ OR equivalent word explanation	**M1**
		$\therefore v = f\lambda$	**A0** [2]
		ANALYSIS *From the definition of wavelength λ, in one cycle of the source the wave energy moves a distance λ. The time taken for one cycle is the period T. Since speed v is the distance moved per unit time and frequency f = 1/ T, v = λ / T = f λ.*	
	(c) (i)	$\text{wavelength } \lambda = \dfrac{v}{f} = \dfrac{3.0 \times 10^8}{1200000} = 250 \text{ m}$	**B1**
		$\text{Path difference} = \dfrac{13000 - 12000}{250}\lambda = 4\lambda$	**M1**
		OR Since **path difference is in the multiple integer of a wavelength**, the 2 waves will meet in phase at point P.	**OR** **(M1)**
		So, **maxima/maximum signal** is observed OR **constructive interference** occurs.	**A1** **OR** **(A1)** [3]
	(ii)	**fluctuate/varying/alternating between maxima/maximum and minima/minimum** at equal time interval.	**B1** [1]

(iii) **place a vertical polariser between** transmitter **A and** point **P** and **place a horizontal polariser between** transmitter **B and** point **P** — **M1** **A1** [2]

OR similar idea which mentioned that radio waves are polarised perpendicularly to each other using polaroid.

CAUTION

There is no need to explain why you do such changes as the question only ask for "suggest a change" and not "suggest and explain".

ANALYSIS

- *For two transverse waves (i.e. radio waves in this case) to interfere, they must be both unpolarised, or both polarised in the same plane.*
- *To prevent interference between the radio waves, we need both transmitters A and B to produce waves which are polarised and perpendicular to each other.*
- *By placing a vertical polariser at transmitter A, only vertically polarised waves will be produced.*
- *By placing a horizontal polariser at transmitter A, only horizontally polarised waves will be produced.*

(d) **intensity** $\boldsymbol{I \propto \frac{1}{r^2}}$ — **C1**

$$\frac{I_A}{I_B} = \frac{r_B^{\,2}}{r_A^{\,2}} = \frac{13^2}{12^2} = \frac{169}{144} = 1.1736$$ — **M1**

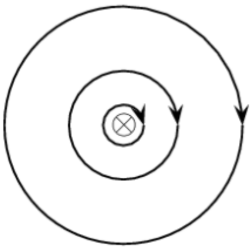
ratio = **1.2** OR **1.17** OR $\frac{169}{144}$ — **A1** [3]

ANALYSIS

Intensity of a point source $= \frac{power\ P}{area\ A} = \frac{P}{4\pi r^2} \propto \frac{1}{r^2}$. *Since power is constant,*

$$\frac{\text{intensity of radio wave from transmitter A}}{\text{intensity of radio wave from transmitter B}} = \frac{\frac{1}{r_A^{\,2}}}{\frac{1}{r_B^{\,2}}} = \frac{\frac{1}{12^2}}{\frac{1}{13^2}} = \frac{13^2}{12^2} = 1.2$$

4 (a)



concentric circles with increasing radius. **B1**
correct arrow direction. **B1** [2]

(b)

$$B = \frac{\mu_o I}{2\pi d} = \frac{\left(4\pi \text{ x } 10^{-7}\right)(8.5)}{2\pi(0.19)} = 8.9473 \text{ x } 10^{-6}$$ **M1**

B = **8.9 x 10^{-6}** T OR **8.95 x 10^{-6}** T **A1** [2]

(c) (i)

$$\tan 12^0 = \frac{B_X}{B_H}$$

$$B_H = \frac{B_X}{\tan 12^0} = \frac{8.9473 \text{ x } 10^{-6}}{\tan 12^0} = 4.2094 \text{ x } 10^{-5} \text{ T}$$ **M1**

B_H = **4.2 x 10^{-5}** T OR **4.21 x 10^{-5}** T **A1** [2]

(ii)

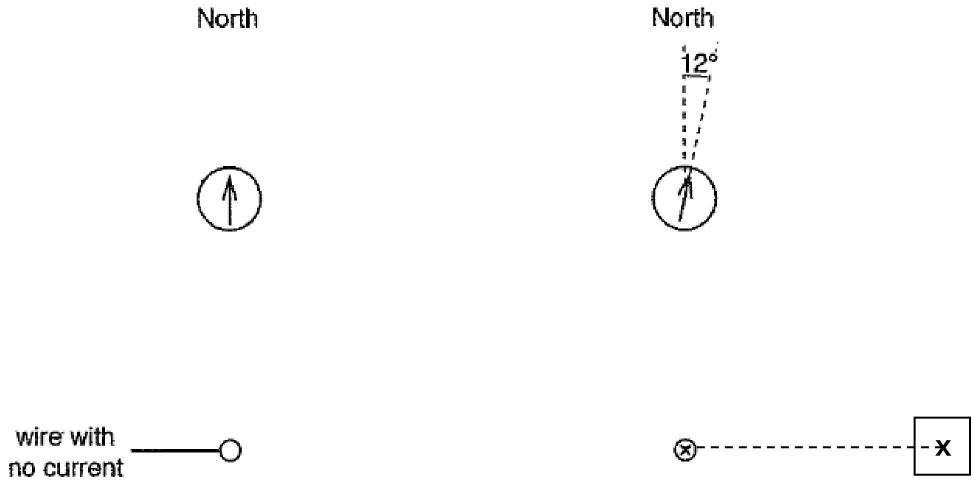


Fig.4.3a Fig.4.3b

M1

Magnetic flux density due to wire is pointing South, **opposes/cancels** the **magnetic flux density due to the Earth** which is pointing North. A1 [2]

ANALYSIS

- *Earth's magnetic flux density B is pointing North. For perfect cancellation of B (i.e. net zero resultant B), B due to the wire must be pointing South.*
- *Using right-hand grip rule, place your thumb into the page at the wire in Fig. 4.3b.*
- *You will figure out that B due to the wire is pointing South at the right side of the wire.*

$$4.2x10^{-5} = \frac{4\pi x10^{-7}(8.5)}{2\pi d}, d = 4.0cm$$

Specifically, the exact location is 4.0 cm to the right side of the wire.

5 (a) (i) $A = \pi(0.09 \times 10^{-3})^2 = 2.545 \times 10^{-8}$ — **C1**

$R = \frac{\rho \ell}{A} = \frac{(1.7 \times 10^{-8})(96)}{\pi(0.09 \times 10^{-3})^2} = 64.125$ — **M1**

resistance = **64** Ω OR **64.1** Ω — **A1** [3]

(ii) Since volume is constant, **resistance increases because cross sectional area becomes smaller and length becomes longer**. — **B1** [1]

ANALYSIS

Volume of a wire remains constant all the time. When wire is stretched, its length increases. So, cross sectional area decreases. According to $R = \frac{\rho \ell}{A}$, *resistance increases.*

(iii) $R = \frac{64}{16} = 4.0\ \Omega$

Resistance = **4.0** Ω OR **4.00** Ω — **A1** [1]

ANALYSIS

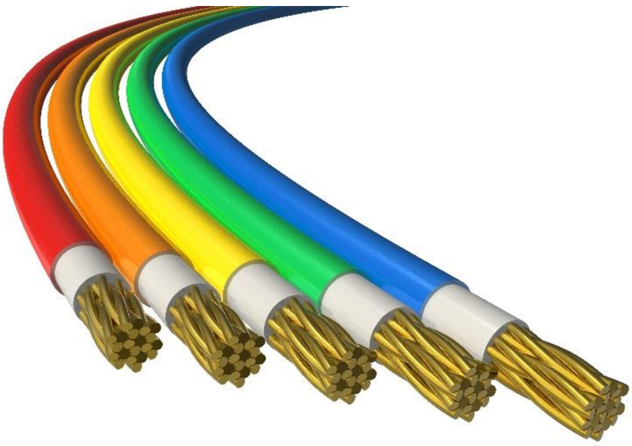


Figure above shows 5 cables, and each cable has multiple strands arranged in parallel connections.

$$\frac{1}{R_{eff}} = \frac{1}{64} + \frac{1}{64} + \frac{1}{64} + \ldots\ldots = \frac{16}{64},\ so\ R_{eff} = \frac{64}{16} = 4.0\ \Omega$$

(b) (i) $P = I^2R = 2.5^2(4) = 25$ W — **M1**

power = **25** W OR **25.0** W — **A1** [2]

(ii) $I = nAve$

$\frac{2.5}{16} = (8.5 \times 10^{28})(\pi \times (0.09 \times 10^{-3})^2)v(1.6 \times 10^{-19})$ — **M1**

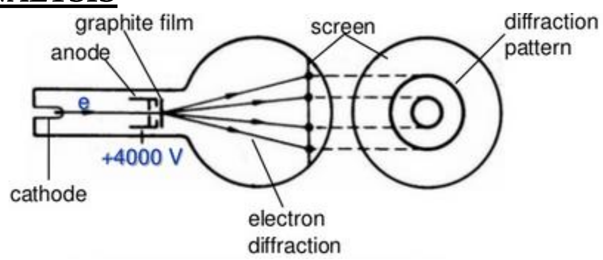
$v = 4.5142948 \times 10^{-4}$ m s^{-1}

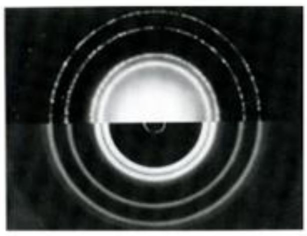
drift velocity = **4.5 x 10^{-4}** m s^{-1} OR **4.51 x 10^{-4}** m s^{-1} — **A1** [2]

6 (a) **electrons** behave like waves and **undergo** two-dimensional **diffraction** when its **wavelength is in the similar order of the atomic spacing** (i.e. 10^{-10} m). **B1** [1]

(b) when p.d. increases, **speed / velocity** of electron **increases.** **B1**
when speed increases, **wavelength** of electron **decreases,** and **angle of diffraction** becomes **smaller.** **M1**
Therefore, **diameter of concentric rings decreases** **A1**
OR **OR**
rings become closer / smaller. **(A1)** [3]

ANALYSIS





(a) *(b)*

- *The diffraction pattern for a thin metal foil shows a set of* <u>*concentric rings with increasing radius.*</u> *Each ring is produced by diffraction from one set of layers in the grains in the foil. The same set of layers may produce several orders of rings, depending on the wavelength and the spacing between layers.*

- *What happens to the radius of diffraction rings if p.d. V suddenly increases?*

  ✓ *When p.d. is applied between the cathode and the anode, electrons would be accelerated. By conservation of energy, lost of electrical potential energy is converted to gain of kinetic energy of the electrons according to* $eV = \frac{1}{2}mv^2$.

  ✓ *When p.d. V increases, the speed v of electrons increases as well, causing the wavelength* λ *of the electrons to decrease according to* $\lambda = \frac{h}{p} = \frac{h}{mv}$.

  ✓ *When wavelength* λ *decreases, the angle of diffraction decreases according to* $d\sin\theta = n\lambda$ *when electrons pass through the graphite film as shown in figure (a).*

(c)

$$eV = \frac{1}{2}mv^2 \quad ---(1)$$ **C1**

$$\lambda = \frac{h}{mv} \quad ---(2)$$ **C1**

$$(1)\rightarrow(2): \lambda = \frac{h}{\sqrt{2meV}} = \frac{\mathbf{6.63 \times 10^{-34}}}{\sqrt{\mathbf{2(9.11 \times 10^{-31})(1.6 \times 10^{-19})(1200)}}} = 3.544 \times 10^{-11} \text{ m}$$ **M1**

wavelength = <u>**3.5 x 10^{-11}**</u> m OR <u>**3.54 x 10^{-11}**</u> m **A1** [4]

7 **(a)** **(i)**

$$\frac{D_H}{D_V} = 40$$

$$D_H = 40[8500 - 1500] = 280000$$

distance = **2.8 x 10⁵** m OR **2.80 x 10⁵** m — A1 [1]

(ii) **1.** improve **aerodynamic/streamlined shape** of the aircraft, therefore reduces drag**.** — B1

2. **increase length** / **size /area of wing span**, therefore increases lift force. — B1 [2]

CAUTION

Answer such as "small mass" is not acceptable because glide ratio is ratio of lift to drag, independent of its mass.

(iii)

$$\text{glide ratio} = \frac{\text{lift}}{\text{drag force}} = \frac{mg}{\text{drag}} = 40$$

$$\text{drag force} = \frac{mg}{40} = \frac{\mathbf{230(9.81)}}{\mathbf{40}} = 564.075 \text{ N}$$ — M1

drag force = **564** N OR **560** N — A1 [2]

(b) **(i)** amount of **energy** stored in the photovoltaic cell **per unit mass / per kilogram** of batteries. — A1 [1]

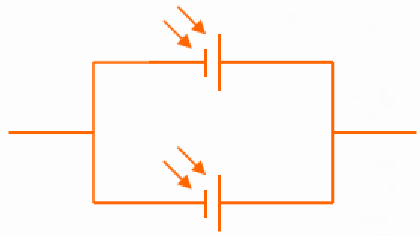
(ii) total energy = 4 x 41 kWh = 4 x 41 x 1000 x 3600 = 5.904 x 10^8 J
OR
total energy = 633 x 0.260 x 3600 x 1000 = 5.92488 x 10^8 J
energy = **5.9 x 10^8** J OR **5.90 x 10^8** J OR **5.92 x 10^8** J — A1 [1]

(iii) work done = energy = Fd
5.904 x 10^8 = 564.075 d, so d = 1.047 x 10^6 m — M1
OR — OR
5.92488 x 10^8 = 564.075 d, so d = 1.050 x 10^6 m — (M1)
distance = **1.05 x 10^6** m OR **1.0 x 10^6** m OR **1.1 x 10^6** m — A1 [2]

(c) **High intensity of sunlight received at higher altitude.** — A1
OR — OR
Intensity of sunlight depends on the altitude. — (A1) [1]

(d) aircraft can **continue its flight during the night time by using the excess energy collected during the day time** *OR similar idea.* — A1 [1]

(e) **1.**



2.

(f) **(i)** they are **directly proportional** since the graph is a straight line that passing origin. — **A1** [1]

(ii) **intensity** of collected sunlight.
OR
power collected **per unit area** of photovoltaic cells. — **A1** **OR** **(A1)** [1]

(iii) Intensity = gradient = $\frac{73-0}{300-0}$ x $10^3 = 243.33$

$I_c =$ **<u>243</u>** W m^{-2} — **A1** [1]

(g) **(i)**

Angle of latitude θ /°	M = 1 / cos θ	I_i / kWm^{-2}
0	1.000	0.947
10	1.015	0.944
20	1.064	0.933
30	1.155	0.913
40	1.305	0.883
50	**1.556**	**0.836**
60	2.000	0.765
70	2.924	0.647
80	5.759	0.420

A1 [1]

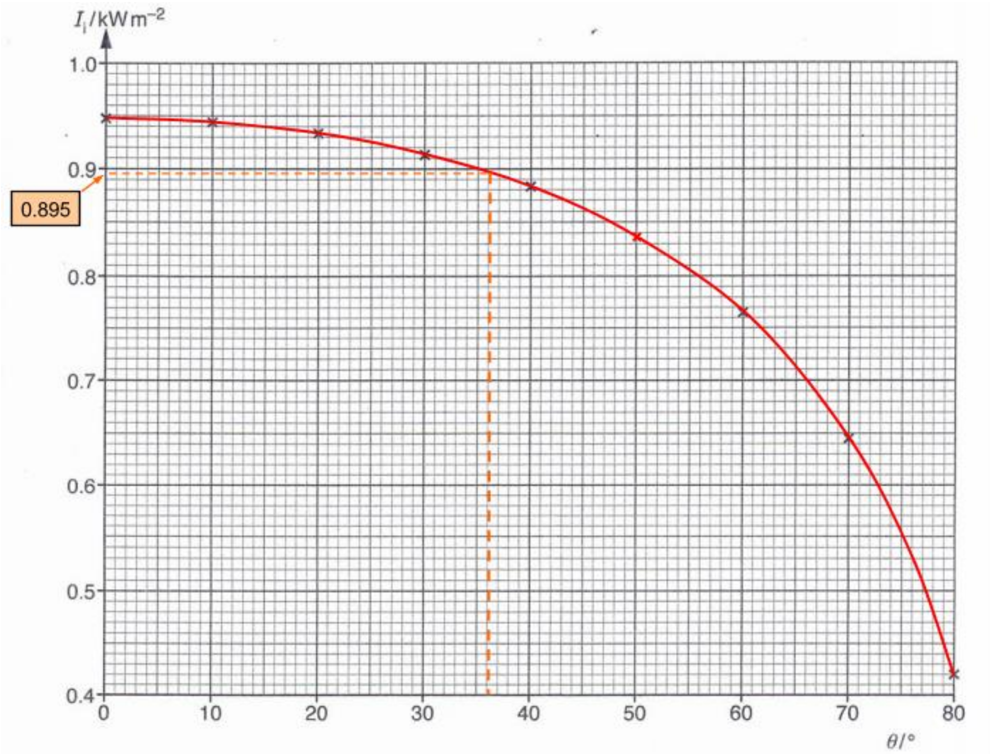
<u>ANALYSIS</u>

From the question, $I = 1.353 \text{ x } 0.700^k$ *and* $k = M^{0.678}$.

At $50^0, M = \frac{1}{\cos\theta} = \frac{1}{\cos 50^0} = 1.556$, *so* $k = 1.556^{0.678} = 1.34952987$

Therefore, $I = 1.353 \text{ x } 0.700^k = 1.353 \text{ x } 0.700^{1.34952987} = 0.836$.

(ii), (iii)



correct point plotted for $\theta = 50^0$ on Fig. 7.4. A1 [1]
best-fit line drawn A1 [1]

(iv) incident intensity = **0.895** kW m^{-2} OR **0.90** kW m^{-2} A1 [1]

(v)

$$\text{efficiency} = \frac{P_{out}}{P_{in}} \times 100\% = \frac{I_{out}}{I_{in}} \times 100\% = \frac{243}{895} \times 100\% = 27.2\%$$

efficiency = **27.2**% OR **27**% A1 [1]

(h) 1. **sunlight is not always available due to different angle of latitude/thunderstorm/poor weather during the flight.** B1
OR **OR**
At high angle of latitude/cloudy/thunderstorm/poor weather, intensity of sunlight is too low and therefore unable to collect much sunlight to power up the flight at night time. **(B1)**

2. **efficiency of solar-powered aircraft is low and requires large number of photovoltaic cells.** Large amount of photovoltaic cells increase the weight of the aircraft, lowering its flight speed, range and duration. **B1** [2]

Nov 2017	Suggested Marking Scheme & Solutions	Syllabus	Marks
Paper 2	Singapore – Cambridge H2 A Level Physics	9749	80

WISH YOU SUCCESS IN A LEVEL 😊

FOR TEACHER REFERENCE

QUESTION NUMBER	TOTAL MARKS
QUESTION 1	9
QUESTION 2	10
QUESTION 3	13
QUESTION 4	8
QUESTION 5	9
QUESTION 6	8
QUESTION 7	23
TOTAL MARKS	80