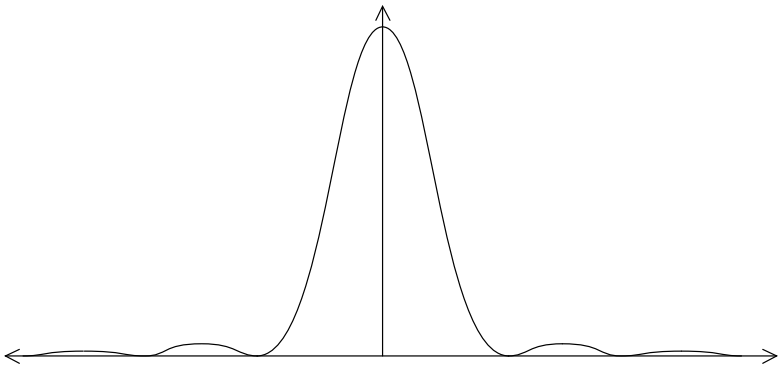
Option A — Sight and wave phenomena

A1. (a) the near point is the closest position of an object from the eye that can be clearly focussed / objects placed closer than the near point cannot be focussed by the eye / *OWTTE*;
the far point is the furthest position of an object from the eye that can be clearly focussed / *OWTTE*;
accommodation is the ability of the eye to focus on objects placed anywhere between the near point and the far point / *OWTTE*; ***[3]***
*Award **[1 max]** if near and far points are defined in terms of distance.*

(b) the (ciliary) muscles (of the eye) alter the shape of the eye lens;
thereby altering its focal length; ***[2]***

A2. (a) (i)



general correct shape touching axis and symmetric about $\theta = 0$ (at least one secondary maxima on each side); *(judge by eye)*
central maximum wider than secondary maxima;
secondary maxima at most one third intensity of central maximum; ***[3]***

(ii) $\frac{d}{2} = \frac{D\lambda}{b}$;

$d = \frac{2.0 \times 1.2 \times 5.2 \times 10^{-7}}{4.0 \times 10^{-5}} = 3.12 \times 10^{-2}\ \text{m}$;

$\approx 3\,\text{cm}$ ***[2]***

(b) *Award **[2 max]** for a sensible argument.*
e.g. light from each point forms a diffraction pattern after being focussed by the eyepiece of the telescope;
if the diffraction patterns are not sufficiently well separated then the points will not be resolved as separate sources;

*Award **[1 max]** for the conclusion.*
e.g. if the points cannot be resolved as separate sources the planet cannot be seen as a disc; ***[3]***

A3. (a) no energy propagated in a standing wave;
the amplitude of a standing wave is not constant;
points along a standing wave are either in phase or out of phase with each other / *OWTTE*; ***[1 max]***

(b) (i) antinode at open end node at closed end; ***[1]***

(ii) antinode at open end and node at closed end and one more node along pipe; ***[1]***
(judge by eye)

(c) for $\lambda_1 = 4L$ and for $\lambda_2 = \frac{4L}{3}$;

$f_1 = \frac{c}{4L}$ and $f_2 = \frac{3c}{4L}$;

$\frac{f_1}{f_2} = \frac{1}{3}$; ***[3]***

(d) there must always be a node at the closed end and an antinode at the open end / there must always be an integer number of $\frac{\lambda}{4}$; ***[1]***

Option A — Sight and wave phenomena

A1. (a) ability to focus light / see clearly images;
of objects that are at different distances from the eye; ***[2]***

(b) (ciliary) muscles;
change shape of lens / change focal length of lens;
thicker lens / more curvature, focus for objects nearer the eye; ***[3]***

(c) extra red colour/longer wavelengths gives impression of warmth;
additional blue colour/shorter wavelengths gives impression of cold; ***[2]***

A2. (a) (i) ***either***

observer sees image of blood cell;
moving at twice speed of blood cell;

or

Doppler shift "observed" by blood cell;
superposed on shift when cell acts as moving source; ***[2]***
*Award **[1]** if mentioned that Doppler effect occurs twice.*

(ii) need component of velocity of cell along direction of ultrasound beam; ***[1]***

(b) $740 = \frac{2 \times 4.5 \times 10^6 \times v \times \cos 40}{1.5 \times 10^3}$;
$v = 0.16\ \text{m s}^{-1}$; ***[2]***
*Award **[1]** if the speed of light is used.*

A3. (a) light with (electric field vector) vibrating in one direction only;
in plane normal to direction of energy transfer; ***[2]***

(b) model made of perspex/polythene *etc.*;
light passed through crossed polaroids;
with model between the polaroids;
when stressed, ***either*** colours seen if white light used
or light & dark regions seen if monochromatic light used;
colour/shade depends on degree of stressing;
stress causes rotation of plane of polarization in perspex; ***[6]***

Option A — Sight and wave phenomena

A1. (a) (i) used in bright light/day-time;
there are three types of cone cells sensitive to different colours;
few are connected to the same nerve implying greater detail of the image formed;
used for photopic vision; ***[1 max]***

(ii) used in dim light/night-time;
insensitive to colour;
different rod cells are connected to the same nerve implying loss of detail in the image formed;
used for scotopic vision; ***[1 max]***

(b) *cone cells*: their distribution increases as the principal axis is approached (reaching a maximum at the fovea) / maximum in centre, fewer away from principal axis;

rod cells: few, near the principal axis, most on the edges of the retina / minimum in centre, more away from principal axis; ***[2]***

(c) since the light is dim rod cells will be used;
and these are mostly on the edge of the retina/they are far from the principal axis; ***[2]***

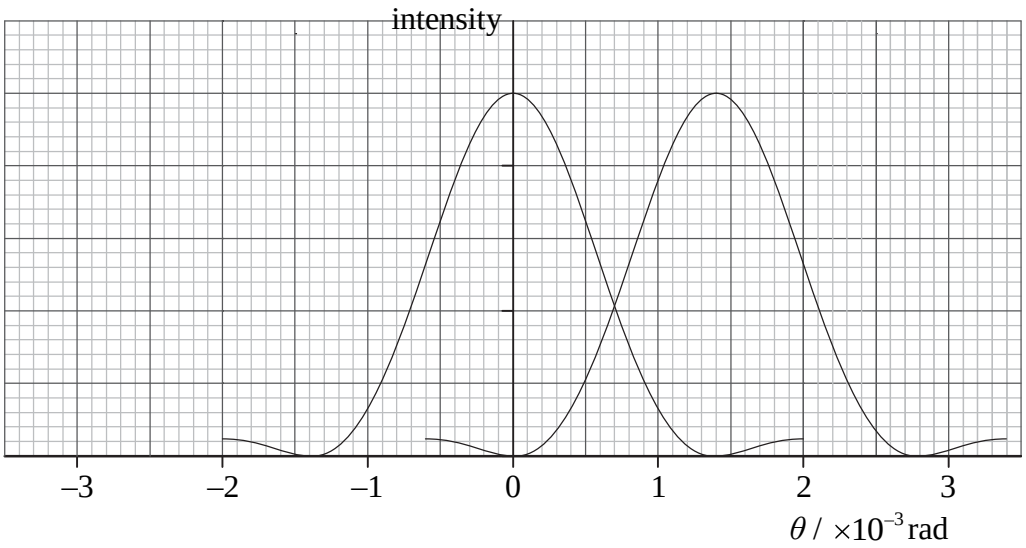
A2. (a) (comparison with the SHM displacement formula shows that) the amplitude is A and this depends on x; ***[1]***

(b) frequency is $\frac{500\pi}{2\pi}$;
$f = 250\,\text{Hz}$; ***[2]***

(c) at $x = 2.0\,\text{m}$, the amplitude is always equal to $A = 12\sin\pi = 0$ as required for a node; ***[1]***

A3. (a) (i) angle of first minimum is 0.0014 rad;
thus $\lambda = b\theta = 0.0014 \times 4.0 \times 10^{-4} = 5.6 \times 10^{-7}$ m; ***[2]***

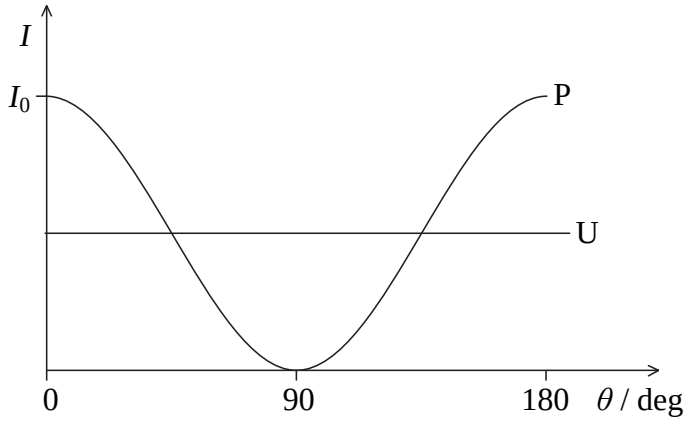
(ii)



as shown above; ***[1]***
Accept if second pattern is drawn to the left of the other.

(b) wavelength is $\left(\frac{3.0 \times 10^{8}}{43 \times 10^{9}}\right) = 7.0 \times 10^{-3}$ m;
telescope can resolve an angular separation of
$\theta = \left(1.22\frac{\lambda}{b} = 1.22\frac{7.0 \times 10^{-3}}{36 \times 10^{3}} =\right) 2.4 \times 10^{-7}$;
and so $L = D\theta = 2.4 \times 10^{-7} \times 4.7 \times 10^{23} = 1.1 \times 10^{17}$ m; ***[3]***

A4.



(a) horizontal line; *(labelled U)*
through half the incident intensity; ***[2]***

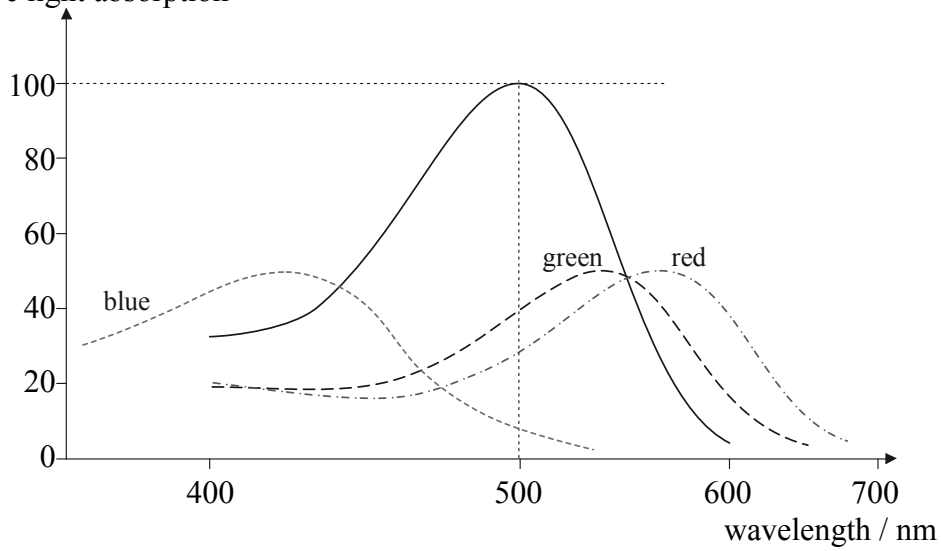
(b) curve starting at I_0; *(labelled P)*
with minima and maxima as shown; ***[2]***

Option A — Sight and wave phenomena

A1. (a) rods; ***[1]***

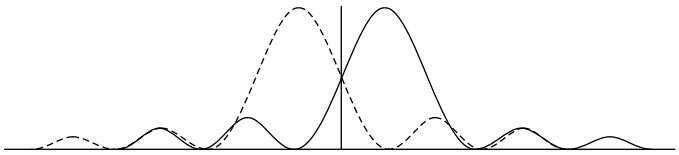
(b) (i) similar shaped curve with different position of maximum;
lower maximum; ***[2]***

(ii) blue, red or green as appropriate to the sketch; ***[1]***



(c) three types of cones/cells involved in part (b)/photopic vision;
each has different frequency response;
normally a shortage/defect of one type / *OWTTE*; ***[3]***

A2. (a) shape of diffraction pattern acceptable;
central maximum of one pattern falls on first minimum of other;
relative heights of central and first maxima realistic for both patterns; ***[3]***



(b) $\theta = \frac{1.22\lambda}{d} = \frac{1.22 \times 400 \times 10^{-9}}{0.003} (= 1.63 \times 10^{-4} \text{ rad})$;

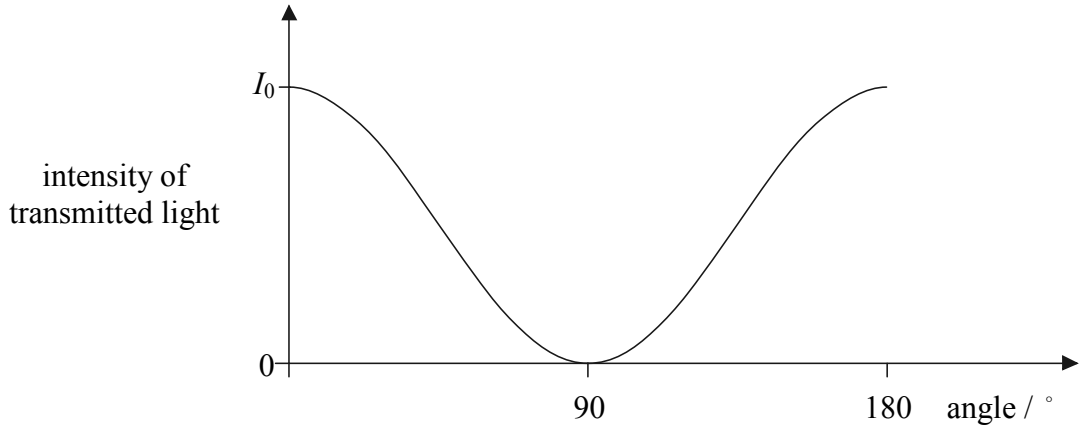
$\text{woman} \rightarrow \text{car distance} = \left(\frac{\text{head lamp separation}}{\tan\theta} \right) = \frac{1.2}{1.63 \times 10^{-4}}$;

$= 7.4 \text{ km}$; ***[3]***

A3. (a) light where the direction of the (electric) field is always/predominantly in the same plane; ***[1]***

(b) (i) $I = \left(I_0 \cos^2 60^\circ\right) = \frac{I_0}{4}$; ***[1]***

(ii)



general $\cos^2$ shape;
max at $\theta = 0$ and curve touches horizontal axis at $\theta = 90^\circ$; ***[2]***

(c) light is (partially) <u>horizontally</u> polarized by reflection;
sunglasses have a transmission axis at 90° to the plane of reflected light;
intensity of reflected light is reduced; ***[3]***
Award full marks for a clearly labelled diagram.