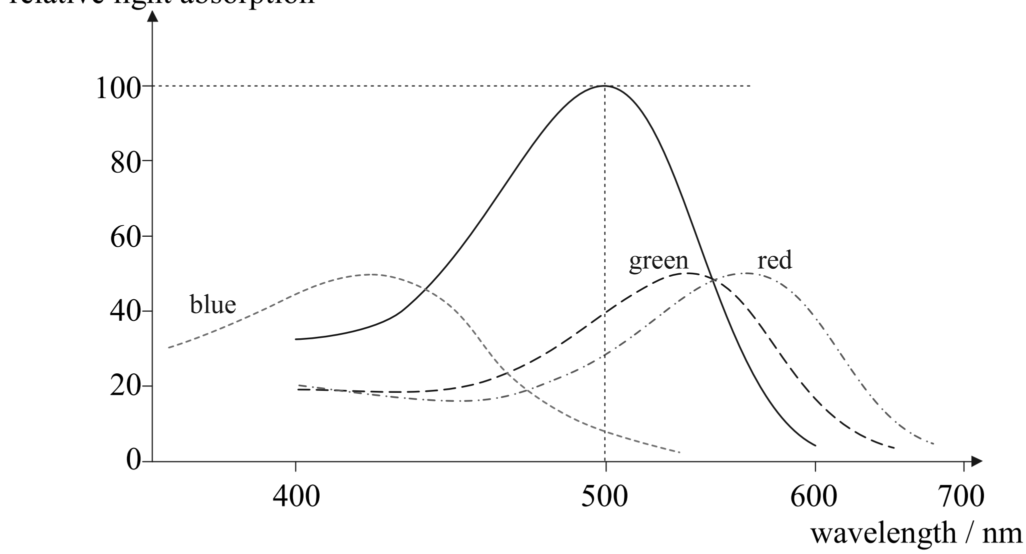
Option A — Sight and wave phenomena

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

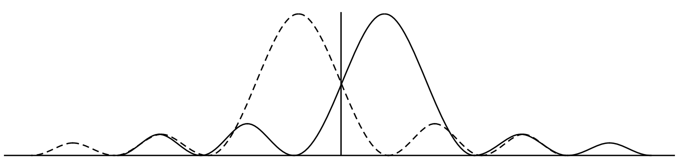
(b) (i) similar shaped curve with different position of maximum;
lower maximum; *[2]*

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



(c) <u>three</u> 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) $\theta = \frac{1.22\lambda}{d} = \frac{1.22 \times 400 \times 10^{-9}}{0.003} (= 1.63 \times 10^{-4} \text{ rad})$;

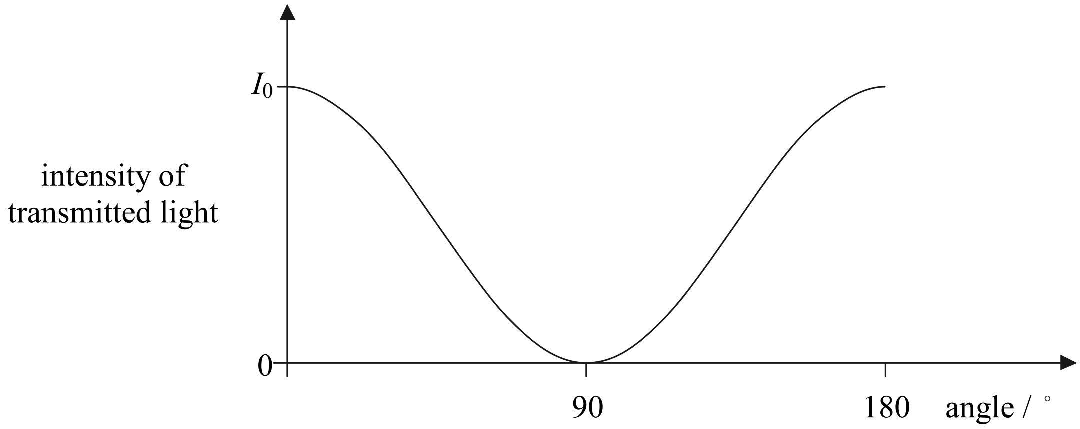
woman $\rightarrow$ car distance $= \left(\frac{\text{head lamp separation}}{\tan\theta}\right) = \frac{1.2}{1.63 \times 10^{-4}}$;

$= 7.4\,\text{km}$; *[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) horizontally 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.

Option B — Quantum physics and nuclear physics

B1. (a) all particles have a wavelength associated with them / *OWTTE*;
given by $\lambda = \frac{h}{p}$, <u>with h and p explained</u>; ***[2]***

(b) kinetic energy of electron $= qV$;
$= 2.00 \times 10^{-16}$ J;
$E_K = \frac{p^2}{2m}$ *or* $v^2 = \frac{2E}{m}$ and $p = mv$ $(v = 2.1 \times 10^7 \text{ m s}^{-1})$
$p = 1.91 \times 10^{-23}$ N s;
$\lambda = \frac{h}{p}$
$= 3.47 \times 10^{-11}$ m; *(allow 2 or 4 significant digits)* ***[4]***

B2. (a) use of diffraction grating/prism and screen/telescope;
observe <u>diffracted</u>/<u>refracted</u> (as appropriate) light / first/second orders; ***[2]***

(b) $E = \frac{hc}{\lambda}$ *or* $E = hf$ and $c = f\lambda$;
correct substitution into relevant formula clear; ***[2]***
to give energy $= 4.09 \times 10^{-19}$ J
*Award **[0]** for answer alone.*

(c) (i)

——————————— -1.35×10^{-19} J
——————————— -2.41×10^{-19} J

——————————— -5.44×10^{-19} J

level shown in "reasonable" position (spacing of lines not important); ***[1]***
To receive the mark answers must quote -1.35×10^{-19} J.

(ii) transition $-1.35 \times 10^{-19} \rightarrow -5.44 \times 10^{-19}$ (and labelled 486 m)
transition $-1.35 \times 10^{-19} \rightarrow -2.41 \times 10^{-19}$ (and labelled 1880 m); ***[1]***

B3. (a) A negative (–) B positive (+); ***[1]***

(b) *Answers will be open ended but look for these main points.*
light consists of photons;
each photon has energy hf;
a certain amount of energy is required to eject an electron from a metal;
if hf is less than this energy, then no electrons will be emitted;
and so no current will be registered by the microammeter; ***[4 max]***

(c) (i) intercept of f axis $= 4.6\times10^{14}$ Hz ; ***[1]***

(ii) intercept on V_s axis;
$= 1.9\,(\pm0.2)\,\text{eV}$;
or
slope of graph $= 4.2\times10^{-15} = \frac{h}{e}$ to give $h = 4.2\times10^{-15}$ eV s ;
$W = hf_0 = 4.6\times10^{14}\times4.2\times10^{-15} = 1.9\,(\pm0.2)\,\text{eV}$; ***[2]***