**Chapter 4.9**

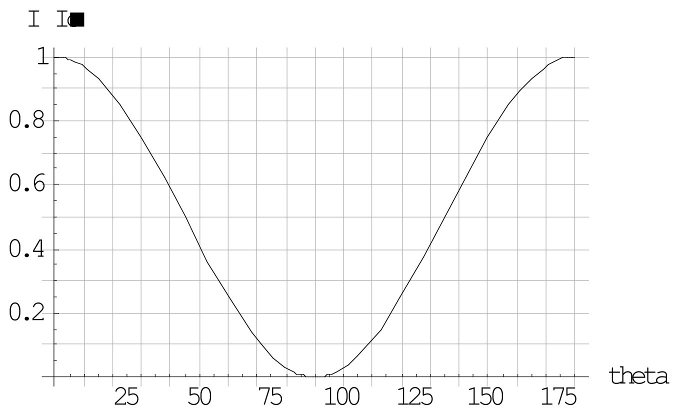
Q1 (a) Polarized light is light in which the electric field oscillates on just one plane. (b) Light can be polarized by (i) reflection from a dielectric surface, (ii) passage through a polarizing medium such as Polaroid glass.

Q2 Polarization means that the displacement must be on the same plane. In the case of a transverse wave this is possible. In a longitudinal wave the displacement is parallel to the direction of energy transfer and therefore it belongs to an infinity of planes containing the direction of energy transfer. Hence polarization is impossible.

Q3 (a) The light is not polarized. In the case of unpolarized light incident on an analyzer, the intensity of the transmitted light would be half the incident intensity and so constant as required in the question. (b) Since there is an orientation (call it X) of the analyzer that makes the transmitted intensity zero, it follows that the incident light was polarized in a direction at right angles to the direction X. (c) Since the intensity never becomes zero the light was not polarized. Since the intensity varies however, it follows that the incident light has unequal components in various directions so it is partially polarized.

Q4 (a) This relates the transmitted intensity $I$ to the incident intensity $I_0$ when polarized light is incident and then transmitted through an analyzer. The relation is $I = I_0 \cos^2\theta$ where $\theta$ is the angle between the transmission axis and the direction of the incident electric field. (b) $\frac{I}{I_0} = \cos^2\theta = \cos^2 25^\circ = 0.82$.

Q5




Q6 Following the argument in the textbook the transmitted intensity will be half the incident intensity.

Q7 The intensity transmitted through the first polarizer will be half the incident intensity i.e. $I = \frac{I_0}{2}$. After transmission through the second polarizer the intensity will be $I' = \frac{I_0}{2}\cos^2 60^\circ = \frac{I_0}{8}$.

Q8 The first polarizer reduces the intensity by half and so the rest must reduce it by $\frac{1}{50}$. Each polarizer will reduce the intensity by $\cos^2 10^\circ = 0.9698$. Hence with *N* of them the reduction will be $0.9698^N$, i.e. $0.9698^N = \frac{1}{50} \Rightarrow N = \frac{\log 0.020}{\log 0.9698} \approx 128$ so we need 128 additional polarizers.

Q9 It does not have to be polarized. With unpolarized or polarized light, the transmitted light is polarized in the direction of the axis of the polarizer. Since the second axis is at right angles to the first no light gets transmitted in either case.

Q10 We just need $\frac{1}{2} = \cos^2\theta \Rightarrow \theta = 45^\circ$.

Q11 $I' = \frac{I_0}{2}\cos^2 50^\circ = 0.21 I_0$.

Q12 (a) The light transmitted through the first polarizer will be polarized in a given direction. The second polarizer's axis is at right angles to this direction so the electric field has zero component along the axis of the second polarizer. Hence no light gets transmitted. (b) Light will be transmitted since now there will be a component of the electric field along the second polarizer's axis. (c) The situation is now identical to (a) and so no light goes through.

Q13 (a) Light that has reflected off a dielectric surface with an angle of incidence equal to the Brewster angle will be completely polarized parallel to the surface. (b) From $\tan\phi = n \Rightarrow \phi = 54.5^\circ$. (c) The reflected and refracted ray will make a right angle in this case. Therefore the angle of refraction is $90^\circ - 54.5^\circ = 35.6^\circ$.

Q14 (a) $\tan\phi = n \Rightarrow \phi = 53.1^\circ$. (b) $n\sin\phi = 1\times\cos\phi \Rightarrow \tan\phi = \frac{1}{n} \Rightarrow \phi = 36.9^\circ$

Q15 Light from the fish is insignificant compared to the glare of the light that is reflected from the surface of the lake and so the fish is not seen. With Polaroid glasses, most of the reflected light is blocked because it is horizontally polarized and the glasses have a vertical transmission axis. Hence the light from the fish can now make an impact in the observer's eye.

Q16 This is the same as in Q15.

Q17 You should rotate the glass until the least amount of light goes through. The transmission axis is then vertical with the glass in this position.

Q18 (a) Optical activity is the ability of certain media to rotate the plane of polarization of light propagating in the medium. (b) An optically active substance is a substance showing optical activity.

Q19 The concentration of the solution and the distance travelled by light in the solution.

Q20 You will need two polarizers, a sugar solution whose concentration will be varied and a source of light. The solution will be placed in between the two polarizers whose axes will be initially at right angles to each other. With the solution in between the polarizers, light will be transmitted and so the second polarizer will have to rotated until no light gets transmitted. The angle by which the polarizer is rotated is equal to the angle by which the solution rotated the plane of polarization. The experiment is then repeated for light travelling the same distance through the solution but with a different concentration. This will give the dependence of the angle of rotation to the concentration of the solution. In a different experiment, the concentration of the solution will be kept constant but the distance travelled by light will be varied so as to get the dependence of the anfl4e of rotation to the distance travelled.

Q21 Apart from its use in Polaroid sunglasses polarization is used in liquid crystal displays and in stress analysis.

Q22 See textbook, page 277.