

- (1) A single slit of width  $W=1.1 \times 10^{-5}$  m passes monochromatic light and it is observed that the first dark fringe is at an angle of  $2.75^\circ$  above the center of the central maximum. What is the wavelength of the light?
- (2) What diameter of circular lens would be required to just resolve two light sources of wavelength 500 nm which are separated by a distance of 0.5 m and are at a distance of 10 km from the lens?
- (3) Light of 530 nm passes through a diffraction grating and produces the third order maximum at an angle of  $12^\circ$ . How many lines per meter does the grating have?
- (4) Suppose light of 600 nm passes through the grating which has  $5 \times 10^5$  lines/m. What is the largest order of diffraction maxima which will be observed?
- (5) Suppose you shine a light of intensity  $I_0$  on the polarizer-analyzer combination shown. At what angle will the intensity reduce by a factor of  $\frac{1}{2}$ ?



(1) A single slit of width  $W=1.1 \times 10^{-5}$  m passes monochromatic light and it is observed that the first dark fringe is at an angle of  $2.75^\circ$  above the center of the central maximum. What is the wavelength of the light?

The condition for destructive interference for single slit diffraction is:

$W \sin(\theta) = \pm m\lambda$ . For the first minimum,  $m=+1$ . We thus have:

$$\lambda = W \sin(\theta) = 1.1 \times 10^{-5} \times \sin(2.75) = 5.28 \times 10^{-7} \text{ m} = 528 \text{ nm}$$

(2) What diameter of circular lens would be required to just resolve two light sources of wavelength 500 nm which are separated by a distance of 0.5 m and are at a distance of 10 km from the lens?

$$\theta_{\min} = 1.22 \frac{\lambda}{D} \Rightarrow D = \frac{1.22 \lambda}{\theta}$$

The required separation is  $s = r\theta \Rightarrow \theta = \frac{0.5}{10 \times 10^3} = 5 \times 10^{-5} \text{ rad}$

We thus have:

$$D = \frac{1.22 (500 \times 10^{-9})}{5 \times 10^{-5}} = 0.0122 \text{ m} = 1.22 \text{ cm}$$

(3) Light of 530 nm passes through a diffraction grating and produces the third order maximum at an angle of  $12^\circ$ . How many lines per meter does the grating have?

For a diffraction grating, the distribution of bright spots is given by:

$\sin(\theta_m) = \frac{m\lambda}{d}$ . In this case,  $m=+3$ , and we want to find  $d$ , and from there find the

number of lines per meter. Thus:

$$d = \frac{3(530 \times 10^{-9})}{\sin(12)} = 7.65 \times 10^{-6} \text{ m}$$

The number of lines per meter is related to  $d$  by:

$$N = \frac{1}{d} = \frac{1}{7.65 \times 10^{-6}} = 1.3 \times 10^5 / \text{m}$$

Notice that  $N$  is used here (instead of  $n$ ) to prevent confusion with the index of refraction.

(4) Suppose light of 600 nm passes through the grating which has  $5 \times 10^5$  lines/m. What is the largest order of diffraction maxima which will be observed?

The condition for the angular distribution of bright spots is given by:  $\sin(\theta_m) = \frac{m\lambda}{d}$ . In

terms of the number of lines per unit length, this reads:  $\sin(\theta_m) = Nm\lambda$ . We thus need to find the largest  $m$  which will allow this to be satisfied. The largest that the sin can be is 1. Thus:

$$m_{\max} = \frac{\sin(\theta_{\max})}{N\lambda} = \frac{1}{5 \times 10^5 (600 \times 10^{-9})} = \frac{1}{0.3} = 3.33$$

The largest order observed here would thus be that for  $m=3$ .

(5) Suppose you shine a light of intensity  $I_0$  on the polarizer-analyzer combination shown. At what angle will the intensity reduce by a factor of  $\frac{1}{2}$ ?

The intensity is given by the Law of Malus:  $I = I_0 \cos^2(\theta)$  .



We want then in this situation :

$$\frac{I}{I_0} = \frac{1}{2} = \cos^2(\theta) \Rightarrow \cos(\theta) = \sqrt{\frac{1}{2}} \Rightarrow \theta = 45^\circ .$$