	Physics 220: Worksheet 25	Name: ________________

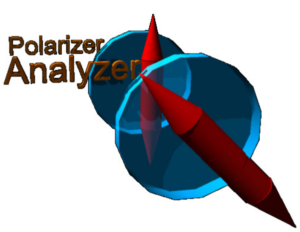
(1) A single slit of width $W=1.1\text{x}10^{-5}$ m passes monochromatic light and it is observed that the first dark fringe is at an angle of 2.75^{0} above the center of the central maximum. What is the wavelength of the light?

(2) What diameter of circular lens would be required to just resolve two light source 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^{0}. Now many lines per meter does the grating have?

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

(5) Suppose you shine a light of intensity I_o on the polarizer-analyzer combination shown. At what angle will the intensity reduce by a factor of ½?



(1) A single slit of width W=1.1x10^{-5} m passes monochromatic light and it is observed that the first dark fringe is at an angle of 2.75^{0} above the center of the central maximum. What is the wavelength of the light?

The condition for destructive interference for single slit diffraction is:

$$W\sin(\theta_m) = \pm m\lambda$$

For the first minimum, m=+1. We thus have:

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

(2) What diameter of circular lens would be required to just resolve two light source 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?

$$\Theta_{min} = 1.22\tfrac{\lambda}{D} \Rightarrow D = \tfrac{1.22\lambda}{\Theta}$$

The required separation is $s = r\Theta \Rightarrow \Theta = \frac{0.5}{10\times10^3} = 5\times10^{-5}\,\text{"rad"}$

We thus have:

$$D = \frac{1.22\left(500\times10^{-9}\right)}{5\times10^{-5}} = 0.0122\text{m} = 1.22\text{cm}$$

(3) Light of 530 nm passes through a diffraction grating and produces the third order maximum at an angle of 12^{0}. Now 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:

$$d = \frac{3\left(530\times10^{-9}\right)}{\sin(12)} = 7.65\times10^{-6}\text{m}$$

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

$$N = \tfrac{1}{d} = \frac{1}{7.65\times10^{-6}} = 1.3\times10^{5}\,/\,\text{m}$$

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 5x10^{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:

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

The largest order observed here would thus be that for m=3.
(5) Suppose you shine a light of intensity I_o on the polarizer-analyzer combination shown. At what angle will the intensity reduce by a factor of ½?

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

We want then in this situation :

$\frac{I}{I_0} = \frac{1}{2} = \cos^2(\theta) \Rightarrow \cos(\theta) = \sqrt{\frac{1}{2}} \Rightarrow \theta = 45^0$