Solutions to hw 9

1) First minimum in single-slit diffraction requires $\lambda = a \sin\theta$ where a is the slit width. Here $\sin\theta = \frac{1}{2}\frac{\Delta y}{L}$ where Δy is the distance between minima on either side of the central maximum and L is the distance to the screen.

my numbers: $a = 0.55\ mm$, $L = 2.06\ m$, $\Delta y = 3.30\ mm \Rightarrow \lambda = 441\ nm$

2) $\Delta\theta = 1.22\frac{\lambda}{D} = \frac{s}{vt}$ where D is pupil diameter, s = separation between taillights, and vt = distance to car.

my numbers: $\lambda = 650\ nm$, $D = 5\ mm$, $v = 21\ m/s$, $t = 9\ min \Rightarrow s = 1.8\ m$

3) $\Delta\theta = 1.22\frac{\lambda}{D}$, $\Delta\theta \le 0.1^\circ$, $\lambda = 4.8\ mm \Rightarrow D \ge 3.36\ m$

4) If light is normally incident on a grating, bright spots are produced when $d\sin\theta = m\lambda$ where d is the distance between rulings.

my numbers: $d = \frac{1}{800}\ mm = 1.25\ \mu m$, $\lambda_1 = 470\ nm$, $\lambda_2 = 700\ nm$

m	$\lambda_1 = 470\ nm$	$\lambda_2 = 700\ nm$
1	$\theta_1 = 22.1^\circ$	$\theta_1 = 34.1^\circ$
2	$\theta_2 = 48.8^\circ$	none
3	none	none

Spectra for different orders do not overlap.

5) $\frac{\lambda}{\Delta\lambda} = Nm \Rightarrow$ need $N \ge \frac{\lambda}{m\Delta\lambda}$

my numbers: $\lambda_1 = 531.18\ nm$, $\lambda_2 = 532.06\ nm \Rightarrow \Delta\lambda = 0.88\ nm$

a) $m = 1 \Rightarrow N \ge 604$

b) $Nd = 1.32\ cm$, $N = 604 \Rightarrow d = 21.9\ \mu m$

Bragg reflection : $2d\sin\theta = m\lambda \Rightarrow d = \frac{m\lambda}{2\sin\theta}$

$\lambda = 0.129\text{ nm},\ \theta = 8.15^\circ,\ m=1 \Rightarrow d = 0.455\text{ nm}$

The transmission fraction for each polarizing disk is $\cos^2\theta$ where θ is the angle of the electric field relative to the polarization axis of the disk. Combining three sequentially then gives

$$I_f = I_i \cos^2\theta_1 \cos^2(\theta_2-\theta_1)\cos^2(\theta_3-\theta_2)$$

a) $I_i = 12,\ \theta_1 = 17^\circ,\ \theta_2 = 42^\circ,\ \theta_3 = 60^\circ \Rightarrow I_f = 8.15$

b) $I_i = 12,\ \theta_1 = 0^\circ,\ \theta_2 = 30^\circ,\ \theta_3 = 60^\circ \Rightarrow I_f = 6.75$

The first polarizing sheet transmits half the incident unpolarized light. Two additional sheets and angles θ and 2θ with respect to the first transmit fraction $\cos^2\theta\cos^2(2\theta-\theta)$. Hence, the net transmission fraction is

$$f = \frac{1}{2}\cos^4\theta$$

my numbers : $\theta = 22^\circ \Rightarrow f = 0.37$