1. Two radio antennas separated by 300 m, as shown in Figure, simultaneously transmit identical signals of the same wavelength. A radio in a car traveling due north receives the signals.

(a) What is the difference of the optical paths from the two radio antennas? (0.5/5)

(b) If the car is at the position of the third maximum, what is the wavelength of the signals? (0.5/5)

(c) If you naively use the formula \( y_{bright} = m\lambda L/d \), what is the wavelength of the signals that you will get? The answers between (b) and (c) should be quite different. This is because \( y_{bright} = m\lambda L/d \) is only correct when \( d,yL \), which is not fulfilled in this problem. (0.5/5)

(d) How much farther must the car travel to encounter the next minimum in reception? (0.5/5)

Solution:
Problem 7.

(a) path difference \( \delta \):
\[
\delta \approx d \sin \theta = d \sin(\arctan(400/1000)) = d \sin(21.8^\circ) = 300 \sin(21.8^\circ) = 111.42 \text{ (m)}. 
\]

(b) \( \delta = 3\lambda \). Therefore, \( \lambda = 111.42/3 = 37.14 \text{ (m)}. \)

(c) \( y_{bright} = 3\lambda L/d \Rightarrow \lambda = 40 \text{ m}. \)

This is quite different from 37.14.

(d) \( d \sin \theta = (3 + 0.5)\lambda = 129.99 \). Therefore, \( \theta = \arcsin(129.99/300) = 25.68^\circ. \)

Therefore, \( y = L \tan \theta = 480.76. \)

\( \Delta y = 480.76 - 400 = 80.76 \text{ (m)}. \)
2. Three polarizing plates whose planes are parallel are centered on a common axis. The directions of the transmission axes relative to the common vertical direction are shown in the figure. An unpolarized beam of light is incident from the left onto the first disk with intensity $I_i = 10$ units (arbitrary). Given $\theta_1 = 20^\circ$, $\theta_2 = 50^\circ$, and $\theta_3 = 75^\circ$,

(a) Calculate the transmitted intensity after the first polarizing plate. (0.5/5)
(b) Calculate the transmitted intensity after the second polarizing plate. (0.5/5)
(c) Calculate the transmitted intensity after the third polarizing plate. (0.5/5)

Solution:
Problem 59.

(a) The intensity of unpolarized light through a polarizer becomes half. Therefore, $10/2 = 5$.
(b) $5 \cos^2(\theta_2 - \theta_1) = 5 \cos^2(30^\circ) = 3.75$.
(c) $3.75 \cos^2(\theta_3 - \theta_2) = 3.75 \cos^2(25^\circ) = 3.08$.

3. A thin film of glass ($n = 1.50$) floats on a liquid of $n = 1.35$ and is illuminated by light of $\lambda = 580$ nm incident from air above it.

(a) Find the minimum thickness of the glass, other than zero, that will produce destructive interference in the reflected light. (0.5/5)
(b) Find the minimum thickness of the glass, other than zero, that will produce constructive interference in the reflected light. (0.5/5)

Solution:

From the air ($n = 1$) to the glass ($n = 1.5$), there is one phase reversal after reflection because $1.5 > 1$.
From the glass ($n = 1.5$) to the liquid ($n = 1.35$), there is no phase reversal after reflection because $1.35 < 1.5$.

$\Rightarrow$ There is one phase reversal.

(a) $2t = m\lambda/1.5$.
Choose $m = 1$ to get the minimal $t$ (thickness). $\Rightarrow t = \lambda/3 = 193.33$ (nm).
(b) $2t = (m + 1/2)\lambda/1.5$.
Choose $m = 0$ to get the minimal $t$. $\Rightarrow t = \lambda/6 = 96.67$ (nm).