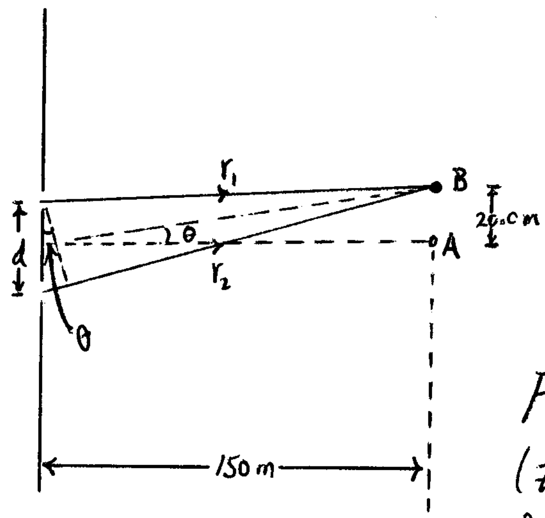
37-9)



$r_1 - r_2 = d\sin\theta$, $\lambda = 3.0\,m$

$\theta = \arctan\left(\frac{2}{15}\right) \simeq 7.6°$

Note: θ is too large to use Eqns. 37.5 or 37.6.

Fortunately, we know that the primary (zeroth-order, m=0) minimum occurs at $\theta = 7.6°$. Therefore, $\theta = \theta_{dark}$ in this case:

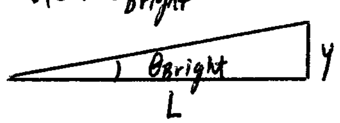
$$\Rightarrow d\sin\theta_{dark} = \frac{\lambda}{2} \Rightarrow \boxed{d = 11.35\,m}$$

37-11)a) $f = 30\ MHz$; $c = 3\times10^{8}\ m/s$

$$c = \lambda f \Rightarrow \boxed{\lambda = 10\,m}$$

37-11)b) $d\sin\theta_{Bright} = m\lambda$; 1st order max, $m=1$

given: $d = 40\,m$



$$\theta_{Bright} = \arctan\left(\frac{y}{L}\right)$$

We solve for y in the following fashion:

$$\sin\theta_{Bright} = \frac{m\lambda}{d} = \frac{\lambda}{d} \Rightarrow \theta_{Bright} = \arcsin\left(\frac{\lambda}{d}\right) = \arctan\left(\frac{y}{L}\right)$$

$$\Rightarrow y = L\tan\left[\arcsin\left(\frac{\lambda}{d}\right)\right] = (2000\,m)\tan\left[\arcsin\left(\frac{1}{4}\right)\right] \simeq \boxed{516.4\,m}$$

37-11)c) The central maximum is the same for both signals in this case and is located on the center of the runway. If the ratio of the frequencies were two small integers then select maxima from the two signals could overlap.

37-15)a) $\theta = \arctan\left(\frac{y}{L}\right) = \arctan\left(\frac{1.8}{140}\right) \simeq 0.737°$

$\delta = d\sin\theta = (1.5\times10^{-4}\text{m})\sin(0.737°) \simeq \boxed{1.93\ \mu m}$

37-15)b) $\frac{1.93\ \mu m}{643\ nm} = 3.0 \Rightarrow \boxed{3.0\ \lambda}$

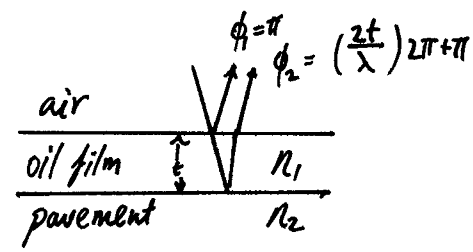
37-15)c) 3rd order maximum!

37-16)a) $I = 0.64\, I_{max} = I_{max}\cos^2\left(\frac{\phi}{2}\right)$

$\Rightarrow \boxed{\phi = 1.6 \text{ radians}}$

37-16)b) $\phi = 1.6 \text{ radians} = \frac{2\pi\delta}{\lambda}$; δ = path difference

$\lambda = 486.1$ nm $\Rightarrow \boxed{\delta \simeq 123.78\text{nm}}$



37-32) With respect to the incident wave, the wave that reflects from the top surface of the oil has a phase change of: $\phi_1 = \pi$

Also w/respect to the incident wave, the wave that reflects from the pavement at the bottom surface of the oil has a phase change due to the add'l path length & a phase change of π on reflection (since $n_2 > n_1$):

$\phi_2 = \left(\frac{2t}{\lambda}\right)2\pi + \pi$

For constructive interference, the net phase change is:

$\phi = \left(\frac{2tn_1}{\lambda_{red}}\right)2\pi + \pi - \pi = m_1 2\pi$, where $m_1 = 1, 2, 3, \ldots \Rightarrow t = \frac{\lambda_{red}\, m_1}{2n_1}$

For destructive interference:

$\phi = \left(\frac{2tn_1}{\lambda_{Blue}}\right)2\pi + \pi - \pi = (2m_2+1)\pi$, where $m_2 = 0, 1, 2, \ldots \Rightarrow t = \frac{1}{2}\left(\frac{\lambda_{Blue}}{n_1}\right)(m_2+\frac{1}{2})$

Combining the two eqns. for thickness gives $\Rightarrow \frac{m_2+\frac{1}{2}}{m_1} = \frac{\lambda_{red}}{\lambda_{Blue}} = \frac{640\text{nm}}{512\text{nm}} = 1.25 \Rightarrow m_1 = m_2 = 2$

Clearly, plugging in $m_1 = m_2 = 2$ gives $\boxed{t = \lambda_{BLUE}}$

38-2) $\sin\theta_{dark} = \pm \frac{\lambda}{a} \Rightarrow a\sin\theta_{dark} = \pm\lambda$

$a = 0.55\,mm$; $L = 2.06\,m$; $2|y| = 4.10\,mm \Rightarrow y = 2.05\,mm$

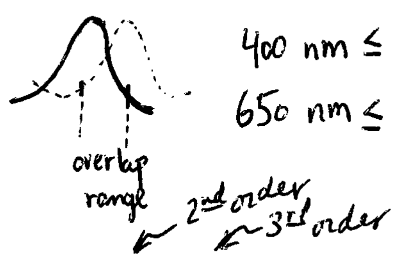
$\theta_{dark} = \arctan\left(\frac{y}{L}\right) \simeq 9.95 \times 10^{-4}\,rad \Rightarrow \boxed{a\sin\theta_{dark} = \lambda \simeq 547\,nm}$ ⇐ this is w/in the range of the wave-length of green light!

38-22) a) $D = 0.3\,m$; $L = 8.86 \times 10^{10}\,m$; $\lambda = 5.90 \times 10^{-7}\,m$

limiting angle of resolution for the telescope is: $\boxed{\theta_{min} = 1.22\left(\frac{\lambda}{d}\right) \simeq 2.40 \times 10^{-6}\,rad}$

38-22) b) $\boxed{d \simeq L\theta_{min} = 2.13 \times 10^{5}\,m}$, roughly 5% of the mean radius of Mars!

38-28) overlapping spectra:



$400\,nm \le \lambda_{violet} \le 450\,nm$

$650\,nm \le \lambda_{red} \le 700\,nm$

$d\sin\theta = m\lambda \qquad m = 0, \pm1, \pm2, \pm3, \ldots$

$\theta = \arctan\frac{y}{L} = \arcsin\left(\frac{m\lambda}{d}\right) \Rightarrow y = L\tan\left\{\arcsin\left(\frac{m\lambda}{d}\right)\right\}$

2nd order red: $y_{red} = L\tan\left\{\arcsin\left(\frac{2\lambda_{red}}{d}\right)\right\}$

3rd order violet: $y_{violet} = L\tan\left\{\arcsin\left(\frac{3\lambda_{violet}}{d}\right)\right\}$

$$\Rightarrow \frac{y_{violet}}{y_{red}} = \frac{\tan\left\{\arcsin\left(\frac{3\lambda_{violet}}{d}\right)\right\}}{\tan\left\{\arcsin\left(\frac{2\lambda_{red}}{d}\right)\right\}}$$

If the 2nd order red & 3rd order violet completely overlap, then both are completely in phase & $y_{violet} = y_{red}$, so this gives: $3\lambda_{violet} = 2\lambda_{red}$

for $\lambda_{red} = 650\,nm \Rightarrow \frac{2}{3}\lambda_{red} = \lambda_{violet} = 433\,nm$

Note that even if the violet light is 180° out of phase w/the red light, we still satisfy the minimum overlap requirement: $3\lambda_{violet} + \frac{\lambda_{violet}}{2} = 2\lambda_{red}$ for $\lambda_{red} = 700\,nm$ & $\lambda_{violet} = 400\,nm$ this equality is valid!