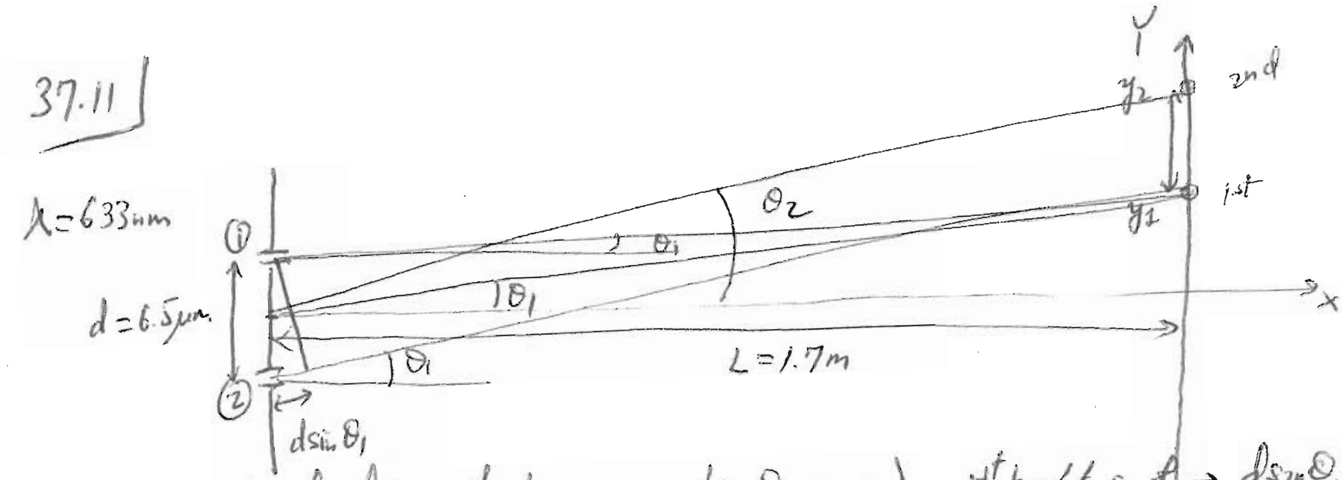
37.11

$\lambda = 633\,nm$



Constructive interference: $d\sin\theta_n = n\lambda$: 1st bright spot → $d\sin\theta_1 = \lambda$
2nd bright spot → $d\sin\theta_2 = 2\lambda$

$y_n = L\tan\theta_n$

a) $y_2 - y_1 \overset{?}{=}$

$$L(\tan\theta_2 - \tan\theta_1)$$

$$= L\left(\tan\left(\sin^{-1}\frac{2\lambda}{d}\right) - \tan\left(\sin^{-1}\frac{\lambda}{d}\right)\right)$$

$$= 1.7\left(\tan\left(\sin^{-1}\frac{2\times 633\times10^{-9}}{6.5\times10^{-6}}\right) - \tan\left(\sin^{-1}\frac{633\times10^{-9}}{6.5\times10^{-6}}\right)\right)$$

$$= 17.17\,cm$$

b) $$y_4 - y_3 = 1.7\left(\tan\left(\sin^{-1}\frac{4\times 633\times10^{-9}}{6.5\times10^{-6}}\right) - \tan\left(\sin^{-1}\frac{3\times 633\times10^{-9}}{6.5\times10^{-6}}\right)\right)$$

$$= 20\,cm$$

37-20

Visible spectrum: $400 - 700$ nm
consecutive orders with overlap b/w visible spectra as dispersed by a grating?

$n_v > n_r$

$\lambda f = \frac{c}{n} \rightarrow n = \frac{c}{\lambda f}$

$d\sin\theta = m\lambda$ overlap.

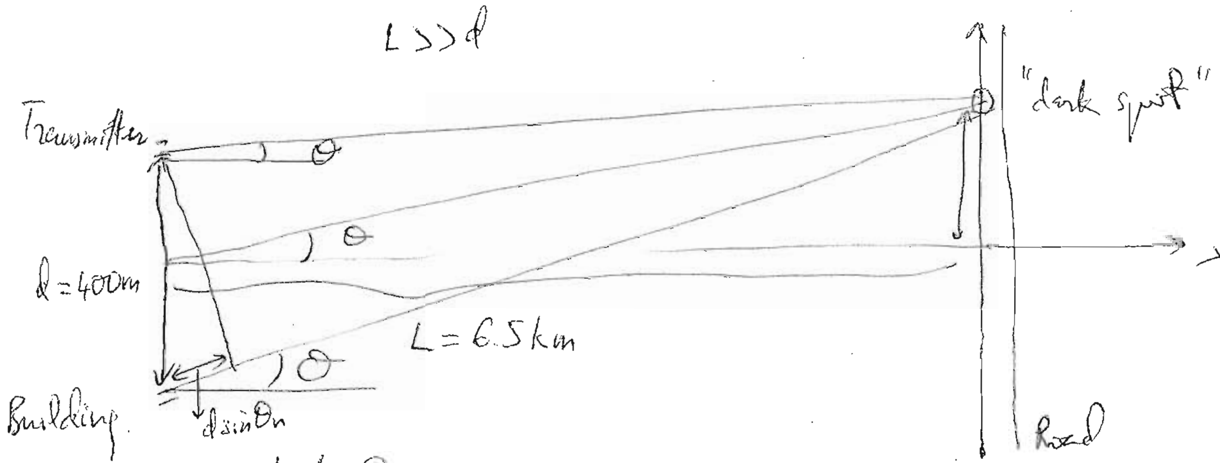
$$\sin\theta_r = \frac{m\lambda_r}{d} > \sin\theta_v = \frac{(m+1)\lambda_v}{d}$$

$$m\lambda_r > (m+1)\lambda_v$$

$$m(\lambda_r - \lambda_v) > \lambda_v \rightarrow m > \frac{\lambda_v}{\lambda_r - \lambda_v}$$

$$m > \frac{4}{7-4} = \frac{4}{3} \rightarrow \boxed{m = 2 \text{ and } m+1 = 3}$$

37.77 "Double-slit" experiment for radio waves instead of light waves



$y_n = L \tan\theta_n$

Dark spot: $d\sin\theta_n = (2n+1)\frac{\lambda}{2}$

$d\sin\theta_{n+1} = (2n+3)\frac{\lambda}{2}$

Driving along this direction at 60 km/h $= v$

How often would the radio signal appear to fade?

We need the separation b/w two "dark spots" along the road: Δy

→ Time b/w fades $\frac{\Delta y}{v}$.

$\Delta y = y_{n+1} - y_n = L\left(\tan\theta_{n+1} - \tan\theta_n\right)$

$= L\left[\tan\left(\sin^{-1}\left(\frac{(2n+3)\lambda}{2d}\right)\right) - \tan\left(\sin^{-1}\left(\frac{(2n+1)\lambda}{2d}\right)\right)\right]$

$\boxed{\text{Small angle approximation : } \tan \sim \sin}$ $(\sin(\sin^{-1}) = \text{neutral})$

$\Delta y = L\Bigg[\underbrace{(2n+3)\frac{\lambda}{2d} - (2n+1)\frac{\lambda}{2d}}_{\frac{\lambda}{d}}\Bigg] = \boxed{\frac{L\lambda}{d}} = \frac{6500 \times \overset{3}{\overline{1.039}}}{400} = 46.9\,m$

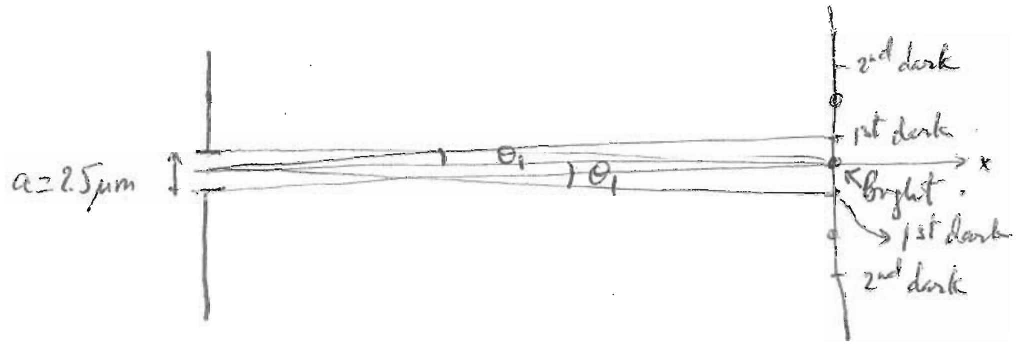
Otherwise Δy depends on the order of interference!

$f = 103.9 \times 10^6\ Hz \rightarrow f\lambda = c \rightarrow \lambda = \frac{c}{f} = \frac{3\times 10^{\cancel{8}}}{1.039\times 10^{\cancel{8}}}\ m$

→ Time b/w fadings $\frac{\Delta y}{v} = \frac{46.9\ m}{60\frac{\cancel{km}}{h}\cdot\frac{1h}{3600s}\cdot\frac{1000m}{1\cancel{km}}} = 2.82\ s$

37.50

$\lambda = 633\,nm$



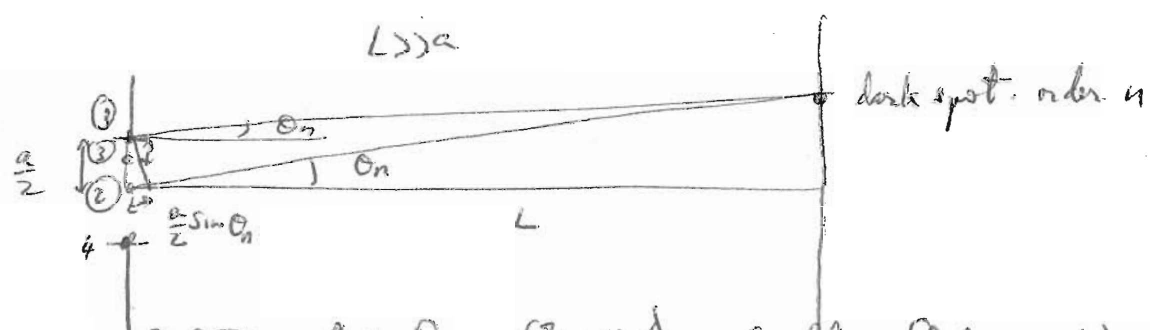
Dark spot in diffraction : $a \sin\theta_n = n\lambda$

$$\theta_1 = \sin^{-1}\frac{\lambda}{a} = \sin^{-1}\frac{633\times10^{-9}\,m}{2.5\times10^{-6}\,m}$$

$$= 14.7°$$

→ Angular width of central bright spot is $2\theta_1 = 29.3°$.

More on diffraction:



① & ② $\frac{a}{2}\sin\theta_n = (2n+1)\frac{\lambda}{2}$ (odd multiple of λ)

① & ③ $\frac{a}{4}\sin\theta_n = (2n+1)\frac{\lambda}{2}$ (~~odd~~

$a \sin\theta_n = 2(2n+1)$ (even multiple of λ)

→ dark spot for one-slit diffraction is $\boxed{a \sin\theta_n = n\lambda}$
n any integer

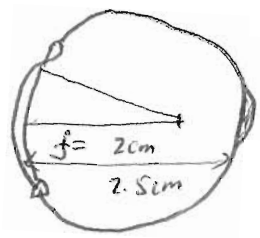
Bright spot: ① & ② $\frac{a}{2}\sin\theta_n = n\lambda \rightarrow a\sin\theta_n = 2n\lambda$

① & ③ $\frac{a}{4}\sin\theta_n = n\lambda \rightarrow a\sin\theta_n = 4n\lambda$

even multiples of λ.

① & ④ $a \sin\theta_n = n\lambda$

36.50



Nearsighted or myopic

Corrective lense (diverging) to open the light beam so it would fall onto the retina → sharp image

Dioptric power is $\frac{1}{f}$

This eye : $\frac{1}{0.02m} = 50$ diopters

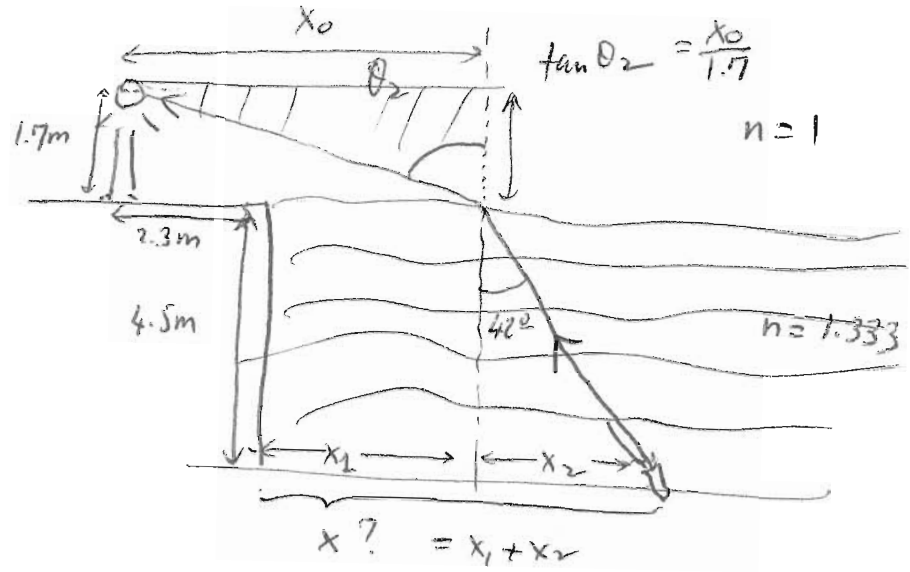
Would need : $\frac{1}{0.025m} = 45.5$ diopters.

↳ can get here with a corrective lense of -4.5 diopters.

→ focal length for corrective lense is $\frac{1}{-4.5} = -22.2$ cm

b/c lense has to be diverging

35.17



$\tan\theta_2 = \frac{x_0}{1.7}$

$$1 \sin\theta_2 = 1.333 \sin 42^\circ \rightarrow \theta_2 = \sin^{-1}(1.333 \sin 42^\circ) = 63.1^\circ.$$

$$x = x_1 + x_2 = (x_0 - 2.3) + 4.5 \tan 42^\circ$$

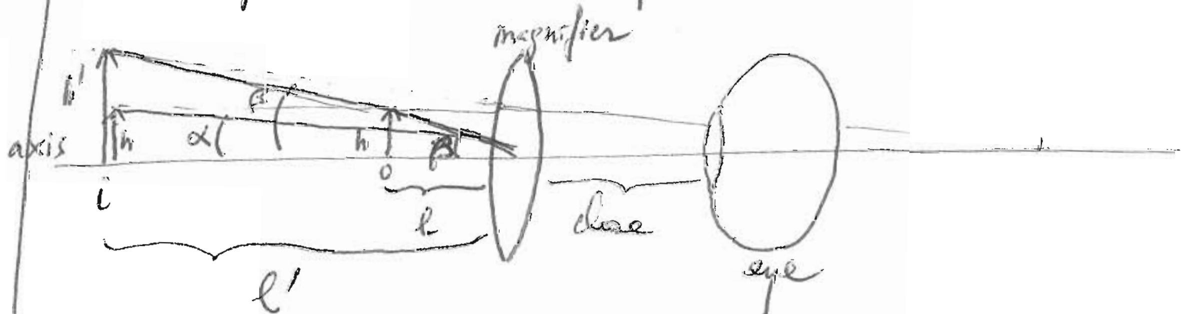
$$= (1.7 \tan 63.1^\circ - 2.3) + 4.5 \tan 42^\circ$$

$$= 1.05\,m + 4.05\,m = 5.1\,m$$

36.53

angular magnification $m = 1 + \frac{25\,cm}{f}$

(image at 25 cm near point) $\rightarrow l' = -25\,cm$



$m = \frac{\beta}{\alpha}$

Lens eq: $\frac{1}{l} + \frac{1}{l'} = \frac{1}{f} \rightarrow \frac{1}{l} = \frac{1}{f} - \frac{1}{l'}$

$\beta \simeq \tan\beta = \frac{h'}{-l'} = \frac{h}{l} = h\frac{1}{l} = h\left(\frac{1}{f} - \frac{1}{l'}\right)$ || $\alpha \simeq \tan\alpha = \frac{h}{-l'}$

small angle approximation

$-l' \rightarrow$ b/c image same side as object.

$$m = \frac{\beta}{\alpha} = \frac{h\left(\frac{1}{f} - \frac{1}{\ell'}\right)}{\frac{h}{-\ell'}} = \left(\frac{\frac{h}{f}}{\frac{h}{-\ell'}} + 1\right) = \left(\frac{-\ell'}{f} + 1\right)$$

$$m = \left(\frac{25\,cm}{f} + 1\right)$$