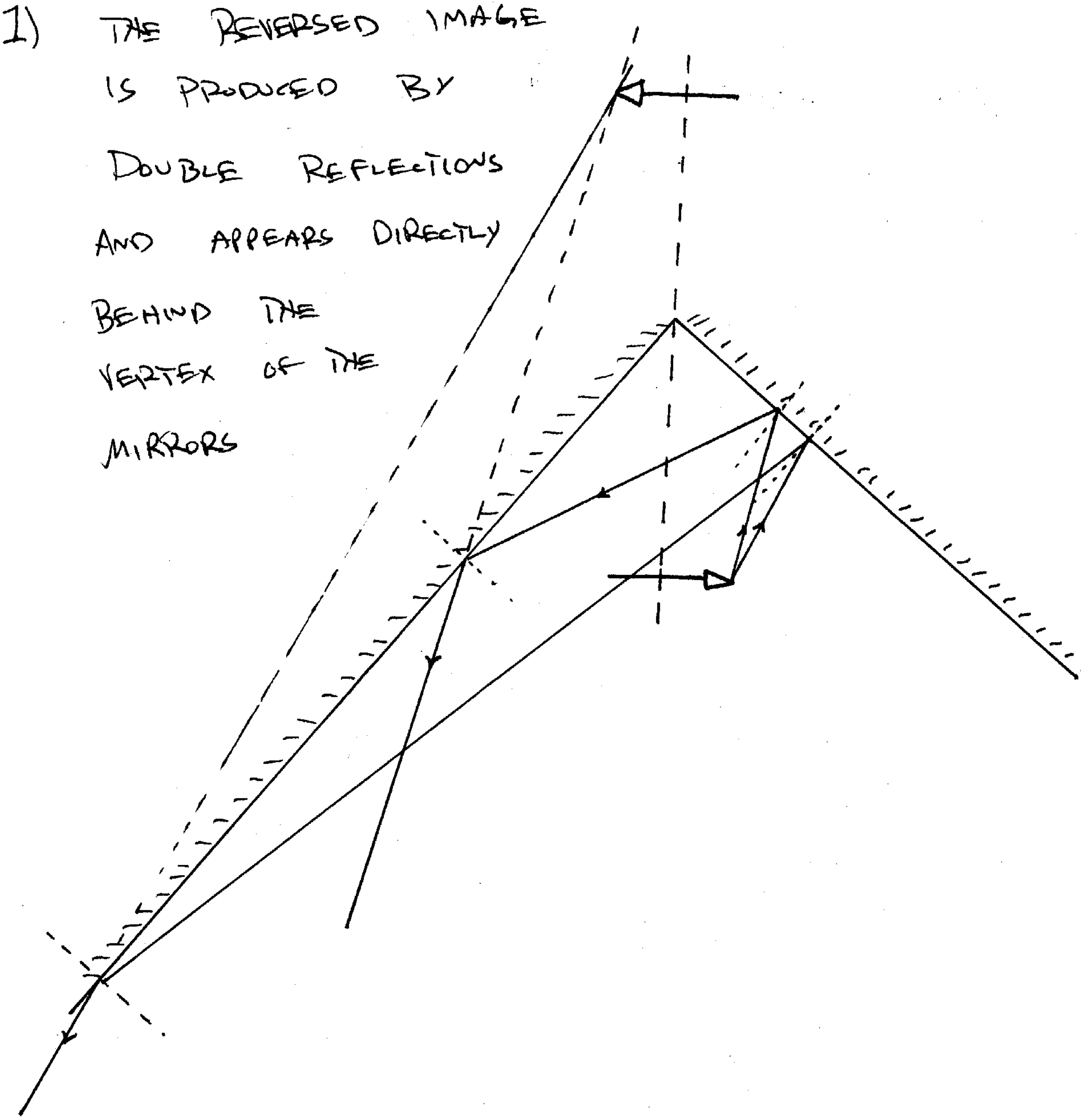
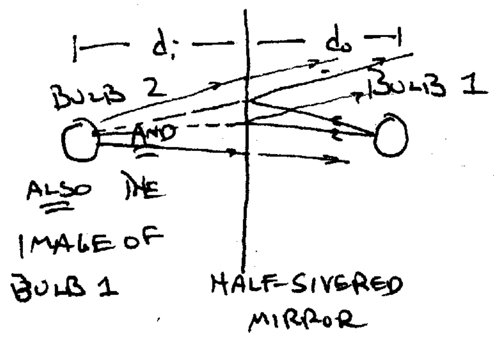
PHYS 195 WEEK 13 SOLUTIONS

(1) THE REVERSED IMAGE IS PRODUCED BY DOUBLE REFLECTIONS AND APPEARS DIRECTLY BEHIND THE VERTEX OF THE MIRRORS



(2.) AS THERE WERE TWO 2 "MISSING LIGHT BULB" DEMOS I'LL GIVE AN EXPLANATION FOR EACH. FIRST, THE LIGHT BULB IN THE BLACK BOX. THIS MYSTERY ~~WAS~~ CONCERNED ~~B~~WHY THE BULB'S IMAGE ~~GLOW~~ WAS LIT WHEN NO POWER WENT TO THE BULB.

THERE WERE TWO BULBS:



$d_i = d_o$

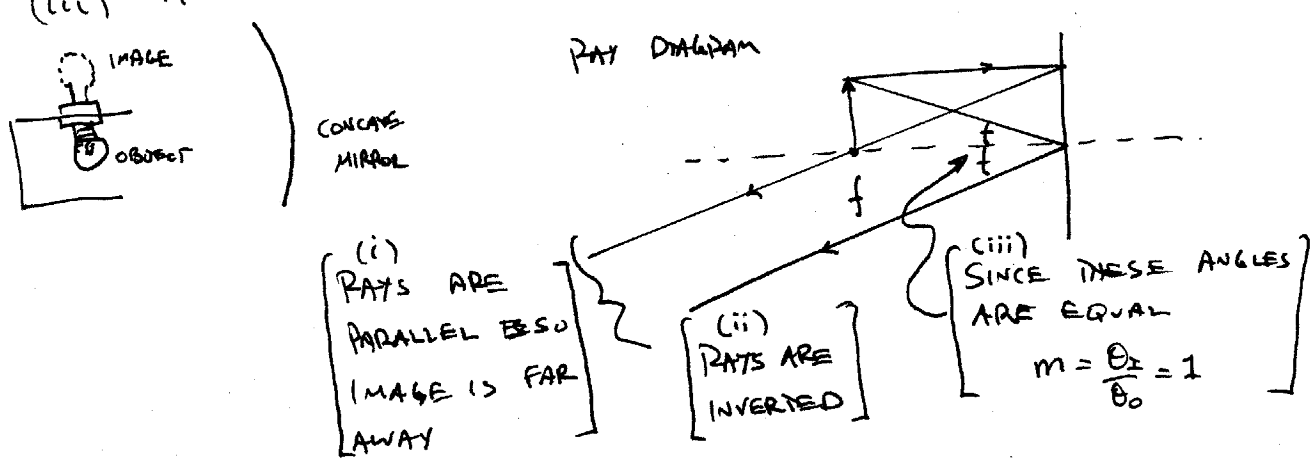
WHEN BULB 2 WAS ILLUMINATED, LIGHT ESCAPED THE BOX AND IT APPEARED THAT THE IMAGE OF BULB 1 'GLOWED'.

FOR THE OTHER MISSING BULB DEMO THERE ARE 3 ASPECTS TO EXPLAIN.

(i) THE IMAGE WAS ONLY VISIBLE 'FAR AWAY' (AT THE DOOR OF G041)

(ii) THE IMAGE WAS INVERTED.

(iii) IT WAS THE CORRECT SIZE.



SINCE $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{d_o}$ AND $d_o = f$

(3.) (a.) · PRINCIPAL RAYS ARE ABSTRACT RAYS THAT WE USE TO QUICKLY LOCATE THE IMAGE OR OBJECT.

· "MANY RAYS" ARE A REALISTIC SAMPLE OF RAYS GENERATED BY DIFFUSE REFLECTION

· MARGINAL RAYS ARE THOSE RAYS THAT PASS THROUGH THE EDGE OF THE LENS.

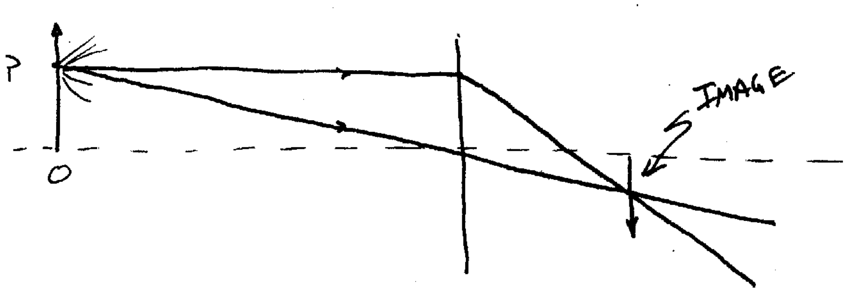
(b.) FEWERS RAYS PASS THROUGH THE LENS SO THE IMAGE DIMS.

(c.) Ooups! THERE IT GOES. THE IMAGE IS NOW VIRTUAL.

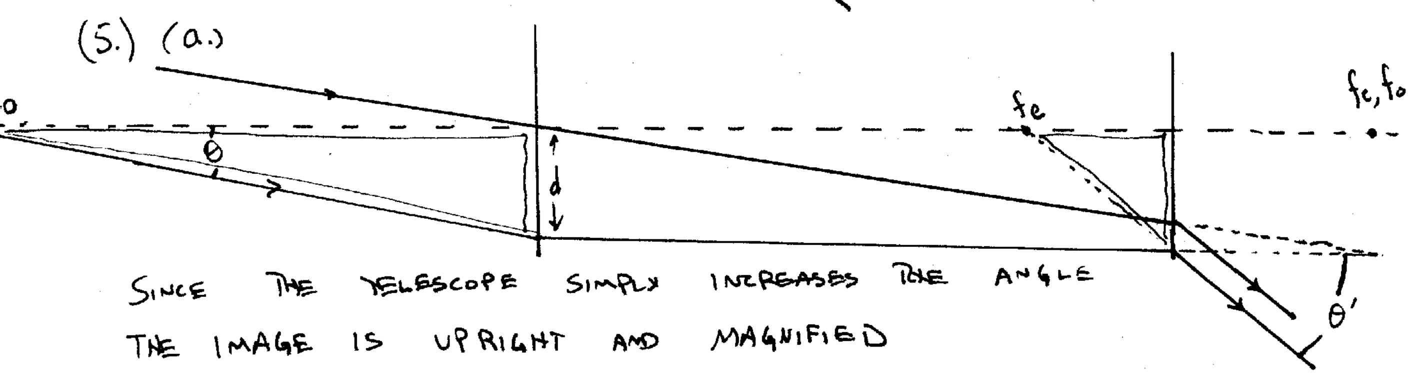
(d.) $d_i = 106$ cm AND SO $M = \frac{h_i}{h_o} = \frac{d_i}{d_o} = 2.65 \simeq 3$

(4.) (a) THE WHOLE OBJECT. AS WE SAW IN 3, THE ONLY EFFECT OF REDUCING THE SIZE OF THE LENS IS TO MAKE THE IMAGE LESS BRIGHT

(b) RAYS COME FROM P IN ALL DIRECTIONS BUT PRINCIPAL RAYS HELP TO LOCATE THE IMAGE OF P QUICKLY.



(5.) (a.)



SINCE THE TELESCOPE SIMPLY INCREASES THE ANGLE THE IMAGE IS UPRIGHT AND MAGNIFIED

(b) WITH THE TWO TRIANGLES SHOWN

$$\theta' \simeq \frac{d}{f_e} \quad \text{AND} \quad \theta \simeq \frac{d}{f_o} \quad \Rightarrow \quad m = \frac{\theta'}{\theta} = \frac{d}{f_e} \cdot \frac{f_o}{d} = \frac{f_o}{f_e}$$

(TAKING SIGNS INTO ACCOUNT, SINCE $f_e < 0$ THEN

$m = -f_o/f_e$)

(c) $m = \dfrac{+30\text{ cm}}{10\text{ cm}} = 3$

(6.) (a.) SO WE'RE LOOKING FOR THE DIFFERENCE IN NUMBER OF WAVELENGTHS IN THE MATERIAL ~~So~~ AND OUTSIDE OF MATERIAL 2 SO

FOR #1'S

$$N_1 - N_2 = \frac{L_1}{\lambda_{n_1}} - \frac{L_2}{\lambda_{n_2}} + \frac{L_1 - L_2}{\lambda} = \frac{L_1 n_1}{\lambda} - \frac{L_2 n_2}{\lambda} + \frac{L_1 - L_2}{\lambda} - \frac{L_1 - L_2}{\lambda}$$

$$= \frac{L_2}{\lambda}(n_2 - n_1) + \frac{L_1 - L_2}{\lambda}(1 - n_1)$$

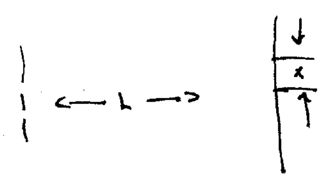
$$\simeq 0.833$$

(b.) INTERMEDIATE CLOSER TO FULLY CONSTRUCTIVE

(7.) FROM $d\sin\theta = m\lambda$, FOR SMALL ANGLES $d\theta \simeq m\lambda$, AND $\theta \simeq \frac{x}{L}$ SO THE SPACING ON THE SCREEN, x, IS

$$x \cong \frac{\lambda L}{d} = \frac{(500\text{ nm})(5.40\text{ m})}{1.2\text{ mm}}$$

$$\simeq 2.25\text{ mm} \simeq 2\text{ mm}$$



(8.) FOR CONSTRUCTIVE INTERFERENCE $2nt = (m+\frac{1}{2})\lambda$. NOW $2nt \simeq 1680$ nm SO FOR $\lambda \cong 305$ nm, $m + \frac{1}{2} = 5.5$ SO THERE ARE 5 FRINGES FOR THIS WAVELENGTH. SIMILARLY, FOR THE OTHER WAVELENGTHS, FOR $\lambda \simeq 373$ nm, $m = 4$, etc. IN A TABLE

m	λ (nm)
5	305
4	373
3	480
2	672

* FOR DESTRUCTIVE INTERFERENCE

$2nt = m\lambda$ SO

m	λ (nm)
5	336
4	420
3	560

(9.) WE HAVE $2\underbrace{n}_{=1 \text{ IN AIR}}t = (m+\frac{1}{2})\lambda$ WHERE m COUNTS THE NUMBER OF BRIGHT BANDS (AS WE SAW IN CLASS). THUS FOR 8 BRIGHT BANDS

$$t = \frac{(8.5)\lambda}{2} = \frac{(8.5)(600\text{ nm})}{2} \simeq 2550 \text{ nm}.$$

IF t IS INCREASED BY 600, ~~THEN~~ LET'S CALL THE THICKNESS t', THEN

$$t' = t + 600 \simeq 3150 \text{ nm}$$

AND SO NOW THE NEW ORDER WILL BE GIVEN BY

$$2t' = (m'+\tfrac{1}{2})\lambda \implies m' = -\frac{1}{2} + \frac{2t'}{\lambda} = \frac{2\left(\frac{8.5\cancel{\lambda}}{2} + \cancel{\lambda}\right)}{\cancel{\lambda}} - \frac{1}{2}$$

$$= 8.5 + 2 - \frac{1}{2} = 10$$

NOW SINCE THE DARK BANDS START WITH $m=0$, THERE WILL BE 11 OF THOSE.

ALTERNATELY STARTING WITH DARK BANDS $2t = m\lambda$ AND

$t = \frac{8\lambda}{2}$ (RECALL DARK BANDS START WITH $m=0$, 0 THICKNESS)

AS ABOVE $t' = t + 600 = t + \lambda \implies m' = \frac{2t'}{\lambda} = \frac{2\left(\frac{8\cancel{\lambda}}{2} + \cancel{\lambda}\right)}{\cancel{\lambda}}$

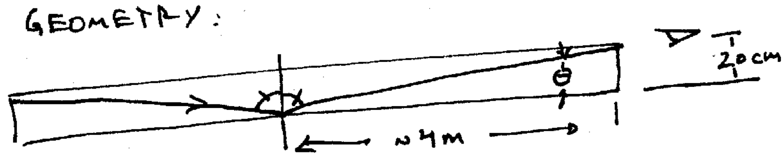
$$= 8 + 2 = 10.$$

SO THERE ARE 11 DARK BANDS.

(ALL THIS ASSUMES THE LAST DARK BAND IS ~~AT~~ AT THE EDGE OF THE GLASS.)

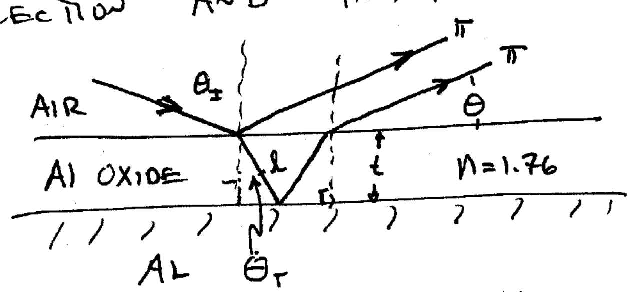
(10.) THIN FILMS WITH ANGLES! (I SIMPLIFIED THIS PROBLEM SLIGHTLY SINCE I DON'T RECALL HOW MANY SPECTRAL BANDS I SAW.) THERE ARE A NUMBER OF ESTIMATED PARAMETERS IN THIS PROBLEM SO YOUR NUMBERS WILL LIKELY DIFFER FROM MINE. THAT'S FINE AS LONG AS THE LOGIC OF THE SOL'N IS CLEAR AND IF THE FINAL THICKNESS AS ROUGHLY SIMILAR.

THE TUBE GEOMETRY:



SO $\theta \simeq \frac{.2}{4}$

THE REFLECTION AND INTERFERENCE



* FOR CONSTRUCTIVE INTERFERENCE ΔPATH MUST BE A WHOLE WAVELENGTH.

* FROM SNELL'S LAW $\sin\theta_I = n \sin\theta_T$ WITH $\theta_I = \frac{\pi}{2} - \theta$.

FROM THE ABOVE GEOMETRY $\sin\theta_T = \frac{t}{\ell}$ SO WE HAVE

$\cos\theta = \frac{n t}{\ell}$. FOR CONSTRUCTIVE INTERFERENCE $2\ell = \lambda$

$$\Rightarrow \cos\theta = \frac{2nt}{\lambda} \quad \text{AND} \quad t = \frac{\lambda \cos\theta}{2n} \simeq \frac{(420\text{ nm})(0.998)}{(2)(1.76)}$$

FOR VIOLET

$\simeq 1$

$\simeq 119 \simeq \underline{100 \text{ nm}}$