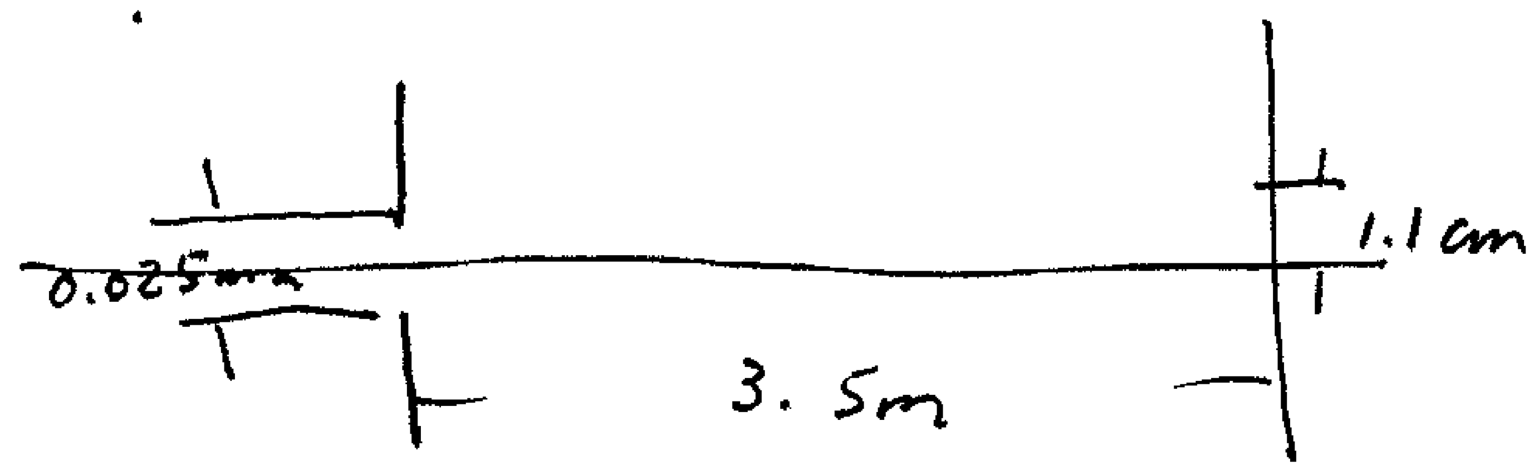
ch. 37 10. 11. 28, 29. 30. 32, 34, 37, 38, 41, 45, 47. 48 51, 52

10.



$\lambda = 538\,nm$

$\tan^{-1} \frac{1.1\,cm}{3.5\,m} = 0.^\circ 18007185$

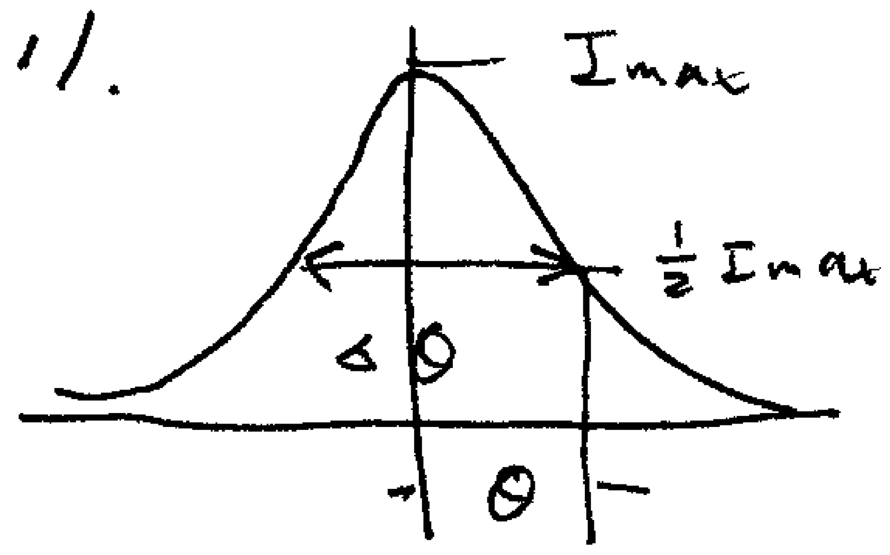
(a)

$\frac{1}{2}\phi = \frac{\pi a}{\lambda}\theta =$

$\phi = 0.45880707$ rad $\rightarrow \alpha = \frac{1}{2}\phi$

$I(\theta) = I_{max}\left(\frac{\sin\alpha}{\alpha}\right)^2 = \underline{0.93177215\ I_{max}}$

11.



(a) $I(\theta) = I_{max}\left(\frac{\sin\alpha}{\alpha}\right)^2 = \frac{1}{2} I_{max}$

$\therefore \sin^2\alpha = \frac{\alpha^2}{2}$

when $\alpha = 1.39$ rad

(b) $\frac{\sin^2\alpha}{\alpha^2} = 0.500837064$ ✓ ($\frac{1}{2}$ max)

(c) $\alpha = \frac{\pi a}{\lambda}\sin\theta$

$\therefore \theta = \sin^{-1}\frac{\alpha\lambda}{\pi a} = \sin^{-1}\left(\frac{1.39\lambda}{\pi a}\right) = \sin^{-1}\left((0.44245071)\frac{\lambda}{a}\right)$

$\Delta\theta = 2\theta = 2\sin^{-1}\left(\frac{0.44245..}{a}\lambda\right)$

(d)

$a = 1\lambda$ $\quad \Delta\theta = 2\sin^{-1}\left(0.44245..\ \frac{\lambda}{\lambda}\right) = \underline{0.91665923\ rad}$

$= \underline{52.^\circ 5207591}$

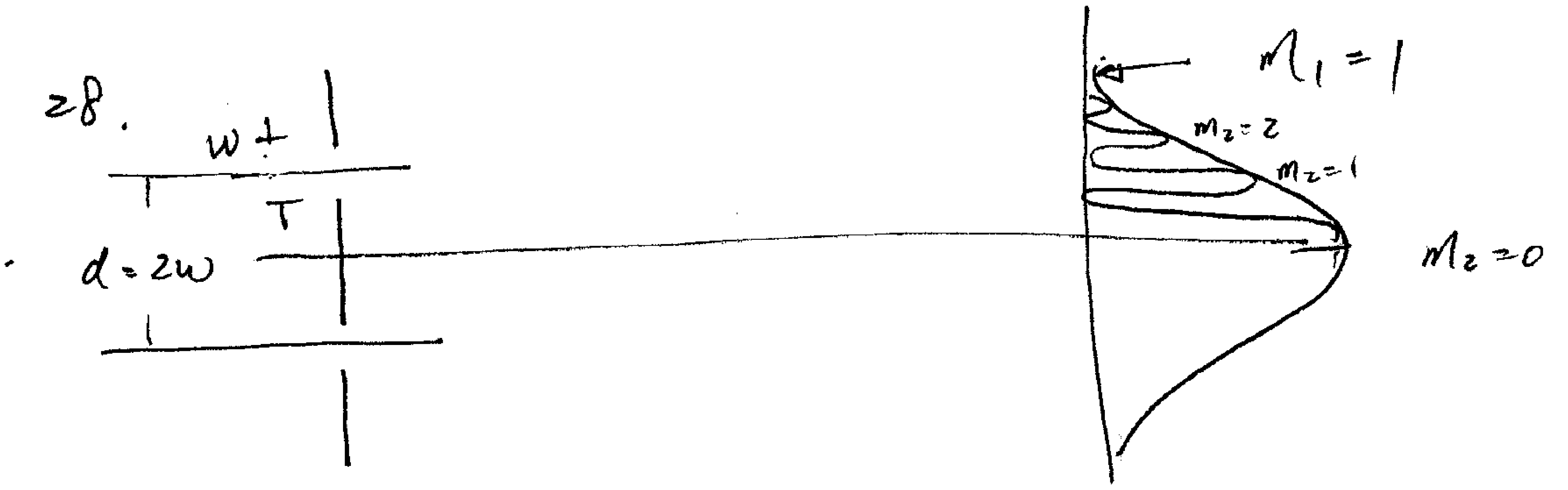
$a = 5\lambda$ $\quad \Delta\theta = \quad$ " $\left(\ ...\ \frac{\lambda}{5\lambda}\right) = \underline{0.08860604\ rad}$

$= \underline{5.^\circ 76752379}$

$a = 10\lambda$ $\quad \Delta\theta = \quad$ " $\left(\ \frac{\lambda}{10\lambda}\right) = \underline{0.08851904 5\ rad}$

$= \underline{5.^\circ 0717 67719}$

28.



Single slit $\quad a \sin\theta = m_1 \lambda$ (dark) — ①

Double slit $\quad d \sin\theta = m_2 \lambda$ (bright) — ②

From the ~~0th~~ order to the first dark region, how many m_2's can we have?

where does first dark occur?

Eq ①. $\quad a \sin\theta = m_1 \lambda$

$$\sin\theta = \frac{\lambda}{a} \quad (m_1 = 1\text{st}) \quad — ①'$$

② ← ①'

$$d\left(\frac{\lambda}{a}\right) = m_2 \lambda$$

$$m_2 = \frac{d}{a} = \frac{2a}{a} = 2$$ → w/ the center the Total is $\underline{\underline{3}}$

29. If the first minimum $(m_1 = 1)$ due to the single slit happens at the same spot that bright happens due to the double slitness then they cancel (In this case $m_2 = 4$)

(a)
$$\begin{cases} a \sin\theta = 1\lambda \rightarrow \sin\theta = \frac{\lambda}{a} & — ① \\ d \sin\theta = 4\lambda & — ② \end{cases}$$

② ← ①

$$d \frac{\lambda}{a} = 4$$

$$\therefore \underline{\underline{d = 4a}}$$

b)
$$\begin{cases} a \sin\theta = m_1 \lambda & — ① \\ 4a \sin\theta = m_2 \lambda & — ② \end{cases}$$

② ← ①

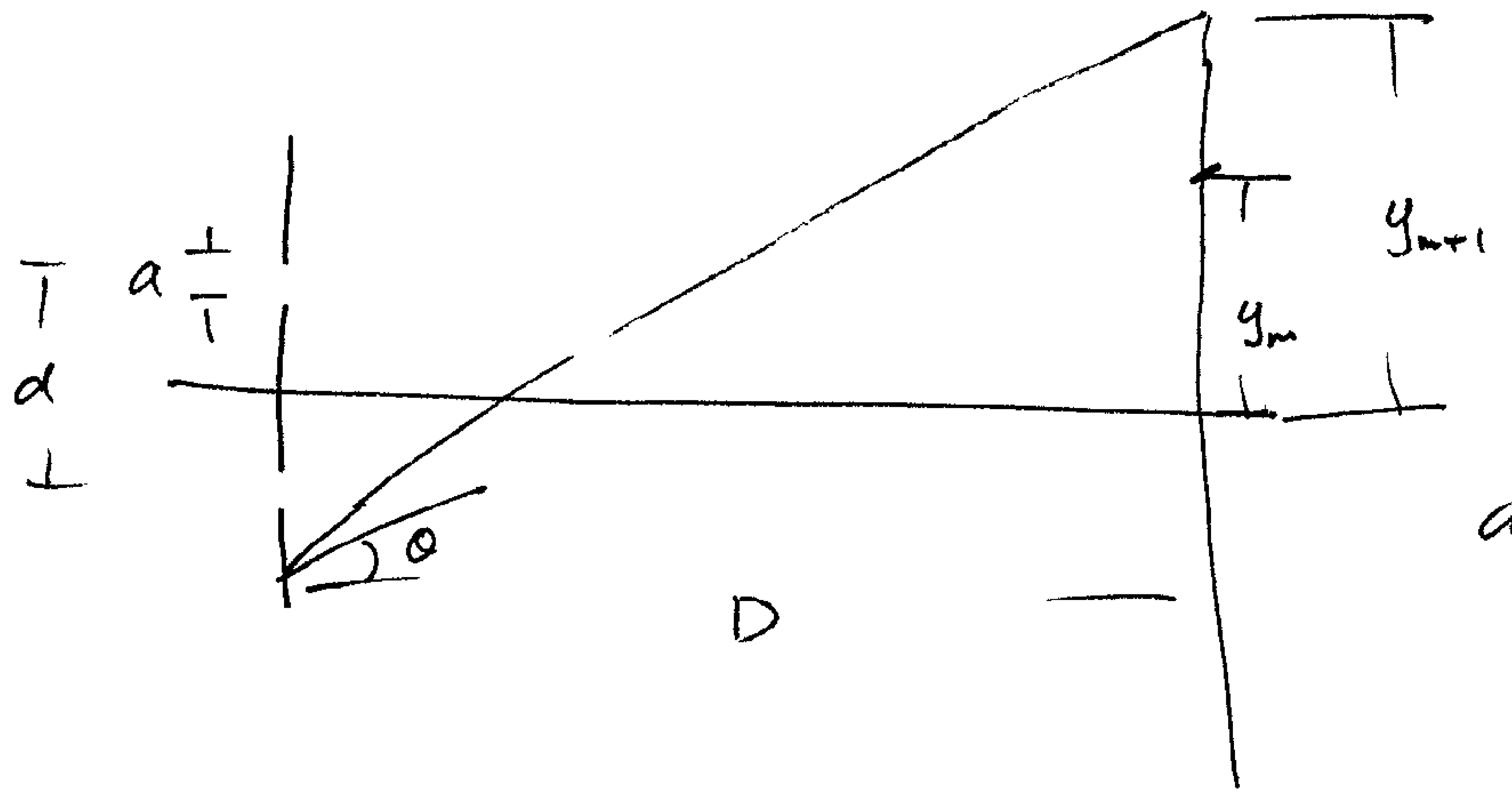
$$4(m_1 \lambda) = m_2 \lambda$$

$$4m_1 = m_2$$

Missing bright spots are when

$\underline{\underline{m_2 = 4, 8, 12, \ldots}}$

30



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

$$\Rightarrow \sin\theta = \frac{m\lambda}{d} \quad -①$$

$$y = D\sin\theta$$

$$\Delta y = \Delta(D\sin\theta) \leftarrow ①$$

$$= \Delta\left(D\frac{m\lambda}{d}\right)$$

$$= \frac{D\lambda}{d}\cdot\Delta m \qquad \text{since the diff. is } (m+1) \,\&\, m \to 1$$

$$= \underline{\underline{\frac{D\lambda}{d}}}$$

32. (a) the first maximum occurs at 5°

$$a\sin\theta = \lambda$$

$$\therefore a = \frac{\lambda}{\sin\theta} = \frac{440nm}{\sin 5°} = \underline{\underline{5.048433828\,\mu m}}$$

(b) 4^{th} is missing $d = 4a = \underline{\underline{20.19373531\,\mu m}}$

(c) $I(\theta) = I_{max}\left(\frac{\sin\alpha}{\alpha}\right)^2$ (this intensity should be the same w/ I with Double slit eqn.)

$$\alpha = \frac{\pi a \sin\theta}{\lambda}$$

$d\sin\theta = m_2\lambda$ when $m_2 = 1$

$$\theta = \sin^{-1}\frac{\lambda}{d} = 1.248512858°$$

$$\alpha = 0.785398163 \ \underline{\underline{rad}}$$

$$= 7\left(\frac{mW}{cm^2}\right)\left(\frac{\sin\alpha}{\alpha}\right)^2 = \underline{\underline{5.673986\ \frac{mW}{cm^2}}}$$

this matches w/ the graph!

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

$$\sin\theta = \frac{m\lambda}{d} = \frac{5\lambda}{d} < 1$$

$$\lambda < \frac{d}{5} = \frac{\frac{1\,mm}{315}}{5} = \underline{634.9206\ nm}$$

any λ shorter than 634.9206 nm

37. $\sin\theta_m = 0.2$ — m^{th}

$\sin\theta_{m+1} = 0.3$ — $(m+1)^{th}$

(a) $d\sin\theta = m\lambda$

$d(0.2) = m\lambda$ —— ①

$d(0.3) = (m+1)\lambda$ —— ②

② − ①

$$\begin{array}{rl} 0.3d = & (m+1)\lambda \\ -)\ 0.2d = & m\lambda \\ \hline 0.1d = & \lambda \end{array}$$

$$d = \frac{\lambda}{0.1} = \frac{600\ nm}{0.1} = \underline{6\ \mu m}$$

(b)
$$\begin{cases} a\sin\theta = m_1\lambda & (m_1 = 1) \text{ — Single slit} \\ d\sin\theta = m_2\lambda & (m_2 = 4) \text{ — Double slit} \end{cases}$$

Solve for a

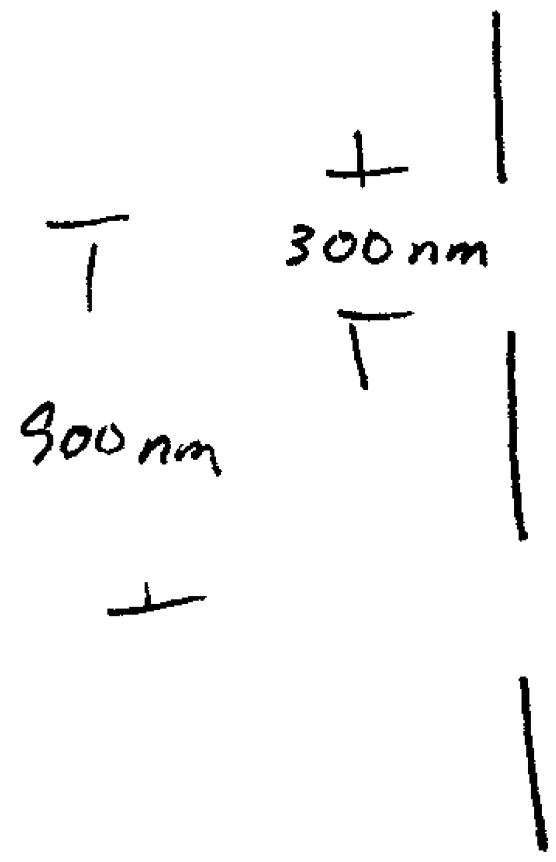
$$a\frac{m_2\lambda}{d} = m_1\lambda \Rightarrow a = \frac{d}{m_2} = \frac{6\mu m}{4} = \underline{1.5\ \mu m}$$

(c) $d\sin\theta = m\lambda$

$$m = \frac{d\ \cancel{\sin\theta}\ 1}{\lambda} = \frac{6\mu m}{600nm} = 10$$

$m = 10^{th}$ at $90°$ but it is not possible → $\underline{m_{max} = 9}$

38



(a) $d \sin\theta = m\lambda$

for θ_{max}, $m = max \rightarrow \sin\theta = 1$

$d = m\lambda$

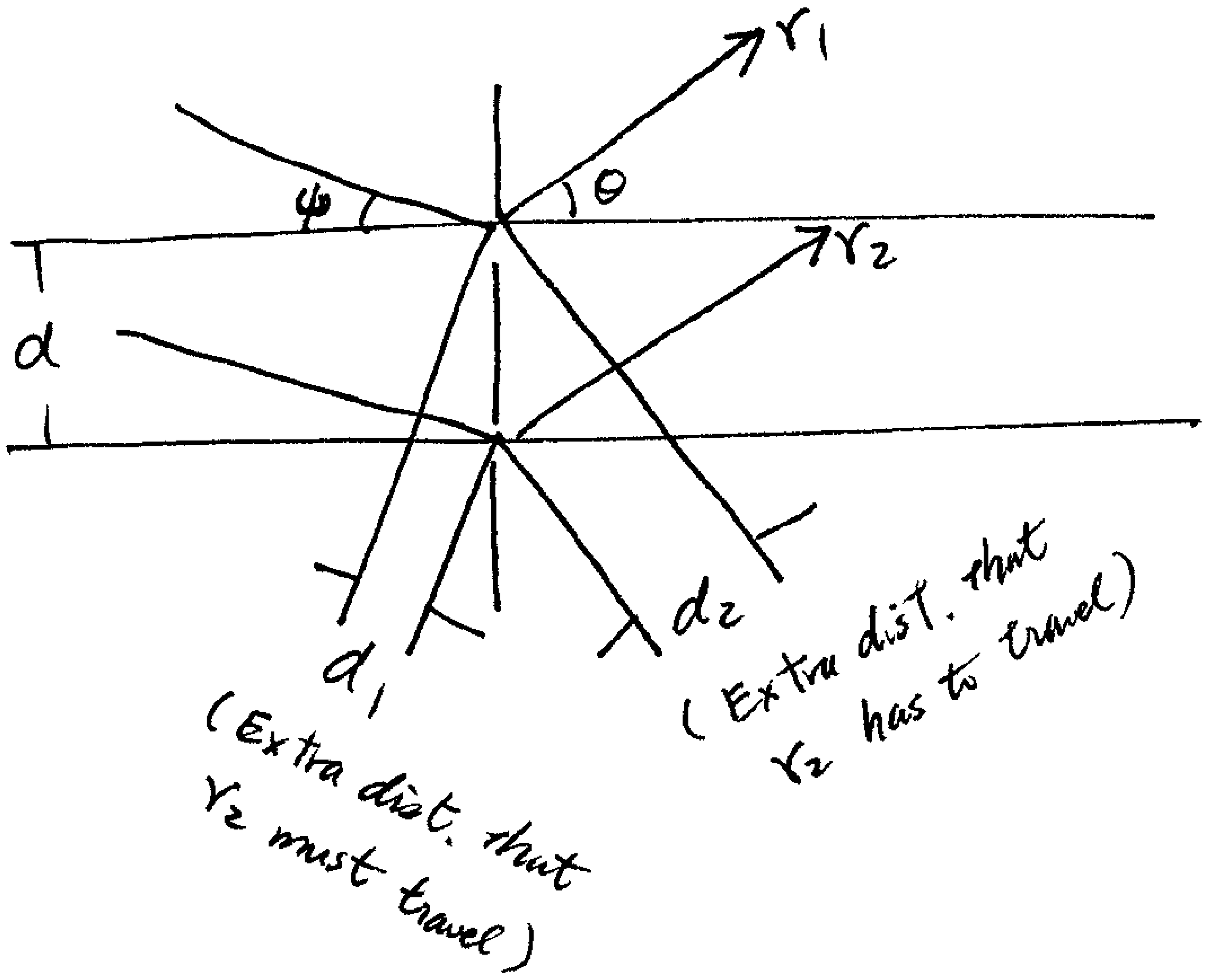
$m = \frac{d}{\lambda} = \frac{900\ nm}{600\ nm} = 1.5$

So, we have, 0^{th}, $\pm 1^{st}$ $\Rightarrow$ $\underline{\underline{3}}$

(b) $\theta_{hw} = \frac{\lambda}{Nd\cos\theta} = \frac{d\sin\theta}{Nd\cos\theta} = \frac{1}{N}\tan\theta$

$= \frac{1}{1000}\tan\theta = \underline{\underline{0.051^\circ}}$

41



so r_2 must travel the total dist of d_1 & d_2. If this total dist. is a multiple of λ, it contruct.

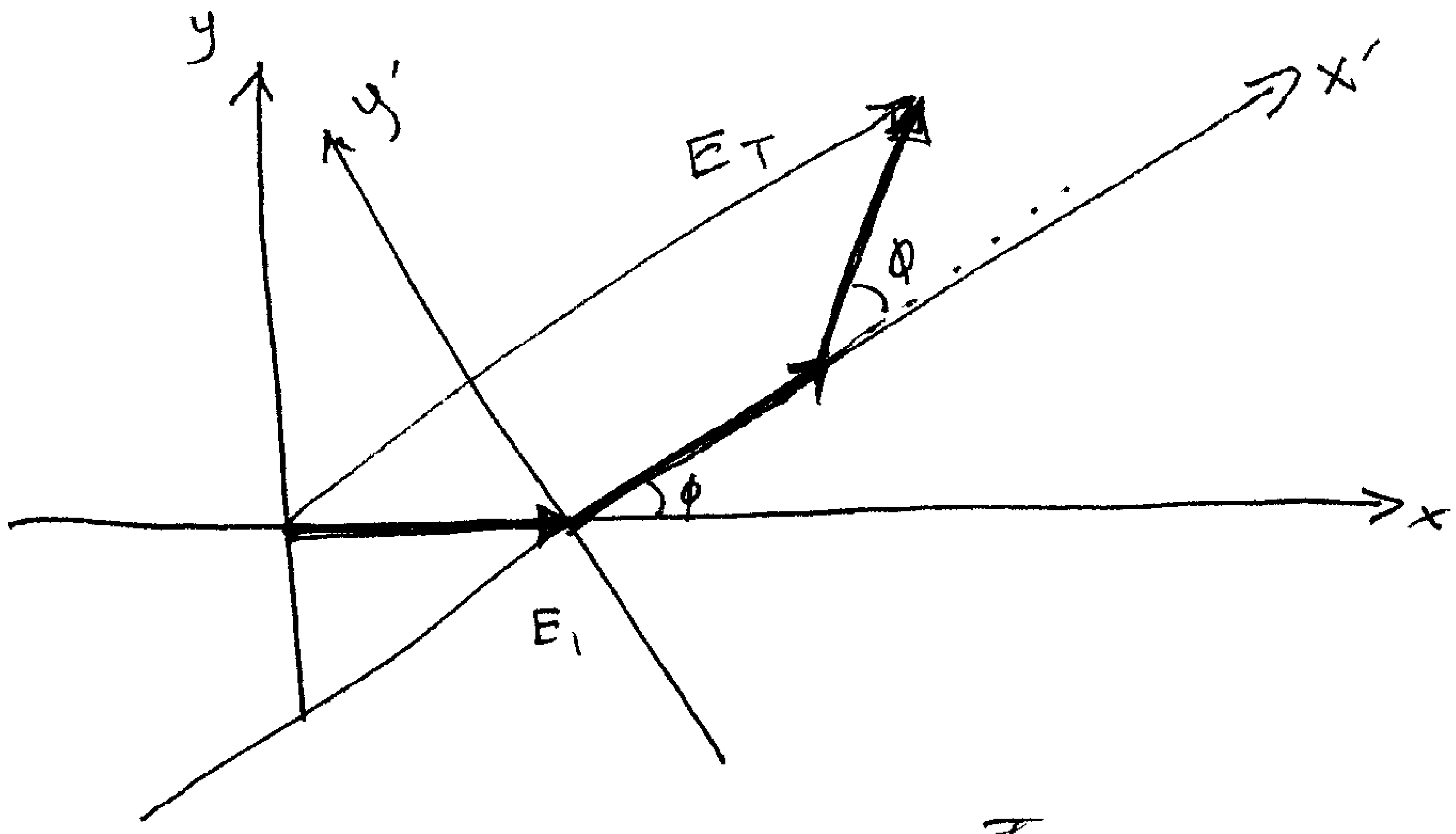
$d_T = d_1 + d_2 = d\sin\phi + d\sin\theta = \underline{\underline{d(\sin\phi + \sin\theta) = m\lambda}}$

$m = 0, 1, 2 \ldots$

45.

$$E_1 = E_0 \sin(\omega t)$$
$$E_2 = E_0 \sin(\omega t + \phi)$$
$$E_3 = E_0 \sin(\omega t + 2\phi)$$

Each has E_0 magnitude & they are off by ϕ each



$$\phi = 2\pi \frac{d \sin\theta}{\lambda}$$

Using $x'-y'$ coordinate system.

$$E_T = E_0 \cos\phi + E_0 + E_0 \cos\phi \qquad (\text{Notice } E_{y'} = 0 \text{ w/ this system})$$
$$= E_0 (1 + 2\cos\phi)$$

$$I_0 \propto (3E_0)^2 = 9E_0^2 \Rightarrow E_0^2 \propto \frac{1}{9} I_0$$

$$I \propto (E_T)^2 = E_0^2 (1 + 2\cos\phi)^2 = E_0^2 (1 + 4\cos\phi + 4\cos^2\phi)$$
$$= \frac{1}{9} I_0 (1 + 4\cos\phi + 4\cos^2\phi)$$

47

$$N m = R = \frac{\lambda_{AVE}}{\Delta\lambda}$$

$$\therefore N = \frac{\lambda_{Ave}}{\cancel{m}\,\Delta\lambda} = \frac{656.3\,nm}{0.18\,nm} = 3650 \text{ rulings}$$

1

48. (a)

$$Nm = R = \frac{\lambda_{Ave}}{\Delta\lambda}$$

$$\Delta\lambda = \frac{\lambda_{Ave}}{Nm} = \frac{500\,nm}{(600/mm \cdot 5\,mm)\cdot 3} = 0.056\,nm$$

(b)

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

$$m_{max} = \frac{d \sin\theta}{\lambda} = 3.3$$

1

$$m_{max} = 3 \rightarrow \text{No higher than } 3$$

51/ $$R = \frac{\lambda_{ave}}{\Delta\lambda} = Nm$$

(a) $$\Delta\lambda = \frac{\lambda_{ave}}{Nm} \quad \text{——— ①}$$

Also $$c = \lambda \nu$$

$$dc = d\lambda \cdot \nu + \lambda \cdot d\nu = 0 \quad (\text{since } c \text{ is const})$$

$$|d\lambda| = \left| -\frac{\lambda\, d\nu}{\nu} \right| \quad \text{—— ②}$$

① ← ②

$$\frac{\lambda d\nu}{\nu} = \frac{\lambda_{ave}}{N \cdot m}$$

$$d\nu = \frac{\nu \cancel{\lambda_{ave}}}{\cancel{\lambda} N m} = \underline{\underline{\frac{c}{\lambda N m}}} \quad \text{——— ①'}$$

(b) $$L = (N-1)\, d \sin\theta$$

$$\therefore t = \underline{\underline{\frac{(N-1)\, d \sin\theta}{c}}}$$ for large N, $$t \sim \underline{\underline{\frac{N d \sin\theta}{c}}} \quad \text{— ③}$$

(c) $$\underset{①'}{d\nu} \cdot \underset{③}{t} = \frac{c}{\lambda N m} \cdot \frac{N d \sin\theta}{c} = \frac{d \sin\theta}{m\lambda} = 1$$

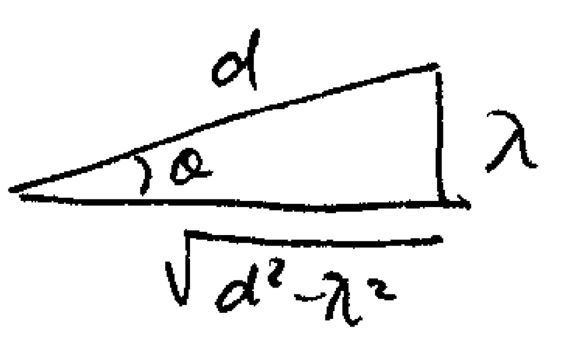
52 $$\Delta\theta_{hw} = \frac{\lambda}{N d \cos\theta}, \qquad R = \frac{\lambda_{ave}}{\Delta\lambda} = Nm$$

(a) $$\Delta\theta_{hw} \cdot R = \frac{\lambda}{N d \cos\theta} \cdot Nm = \frac{m\lambda}{d\cos\theta}$$

$$m\lambda = d \sin\theta \rightarrow$$

$$= \frac{d \sin\theta}{d \cos\theta} = \underline{\underline{\tan\theta}}$$

(b) for $m = 1$ $$d \sin\theta = \lambda$$
$$\sin\theta = \frac{\lambda}{d}$$



$$\rightarrow \tan\theta = \frac{\lambda}{\sqrt{d^2-\lambda^2}} = \frac{600\text{ nm}}{\sqrt{(900\text{nm})^2 - (600\text{ nm})^2}} = \underline{\underline{0.89}}$$