Physics 17
Spring Quarter 1983
June 6, 1983
George Williams

FINAL EXAMINATION

6

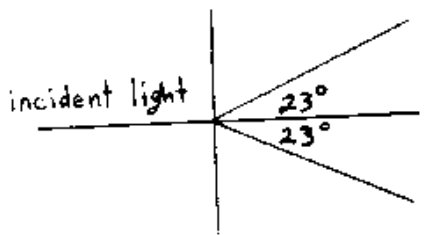
Name: _____

Discussion Instructor (CIRCLE ONE): Abbott Galler Giddings Leaver Saffer Stone

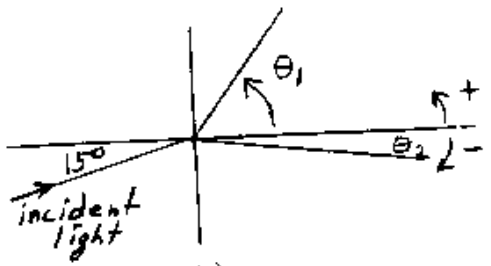
Discussion Section #_____

All numbers to 3 significant figures!

Red light from a laser (λ = 650 nm) is incident normally (angle of incidence = 0) on a diffraction grating. The first maximum on either side of the center spot occurs at an angle of 23°, as in Fig. (a). Now the angle of incidence is changed to 15°. Calculate θ_1 and θ_2 in Fig. (b), the direction of the first maxima on each side of center. θ_2 might be positive or negative, so use the sign convention given and measure the angles from the normal. (This problem involves rederiving the grating equation for angles of incidence other than 0°.)



(a)

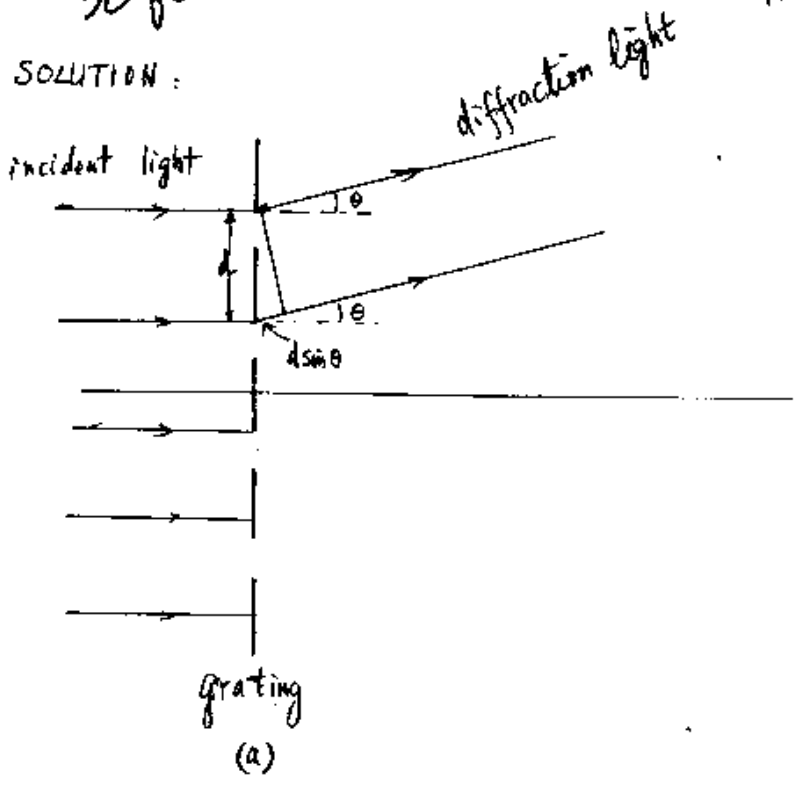


(b)

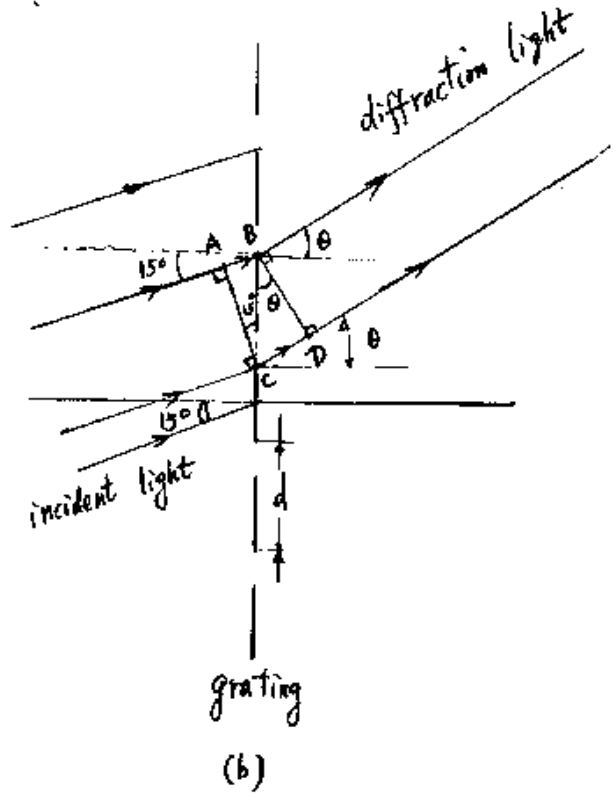
Solution For Problem * 6 For physics 173 FINAL 1983. Spring

30 possible Grader, zhu Ave. 10 . $\bar{\sigma} = 8$. N325

SOLUTION:



(a)



(b)

In the first case, light is incident normally on the grating, then we have (Text. P.756. (41-17))

$$d\sin\theta_m = m\lambda \quad \text{(for maximum diffraction)} \qquad (1)$$

where $m = 0, \pm 1, \pm 2, \ldots$

From the data given in the problem, $\lambda = 650\ nm$. $\theta_1 = 23°$.

We get $$d = \frac{1\cdot\lambda}{\sin 23°} = \frac{\lambda}{\sin 23°} = 1.66\ \mu m \qquad (2)$$ 10

In the second case, the angle of incidence is, $\varphi = 15°$. A principal maximum in Fig. (b) will occur when the path difference between rays from adjacent slits ($=\Delta$) is given by

$$\Delta = m\lambda \qquad m = 0, \pm 1, \pm 2, \ldots \qquad (3)$$

But now $$\Delta = \overline{CD} - \overline{AB} \quad \text{(as shown in Fig. (b))} \qquad (4)$$

$$\overline{CD} = d\sin\theta_m \qquad \overline{AB} = d\sin 15° \qquad (5)$$

(cont.)

From (3), (4) and (5), we have

$$\Delta = \overline{CD} - \overline{AB} = \boxed{d\sin\theta_m - d\sin 15^\circ = m\lambda} \qquad (6)$$

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$m = 0, \pm 1, \pm 2, \ldots$

From (2) and (6), we have

$$\frac{\lambda}{\sin 23^\circ}\left(\sin\theta_m - \sin 15^\circ\right) = m\lambda$$

i.e. $\sin\theta_m = m\sin 23^\circ + \sin 15^\circ$

When $m = 1$, $\sin\theta_1 = \sin 23^\circ + \sin 15^\circ = 6.50 \times 10^{-1}$

$\therefore \boxed{\theta_1 = 40.5^\circ}$

When $m = -1$, $\sin\theta_2 = -\sin 23^\circ + \sin 15^\circ = -1.32 \times 10^{-1}$

$\boxed{\therefore \theta_2 = -7.58^\circ}$