EC5103

5/22/2021

HW#8

13-15 A slit illuminated with sodium light is placed 60 cm from a straight edge and the diffraction pattern is observed using a photoelectric cell, 120 cm beyond the straight edge. Determine the irradiance at (a) 2 mm inside and (b) 1 mm outside the edge of the geometrical shadow.

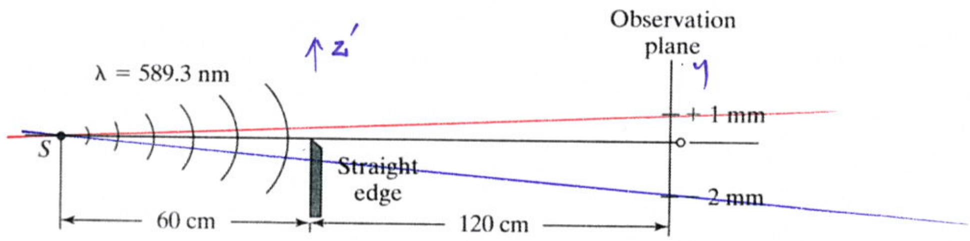
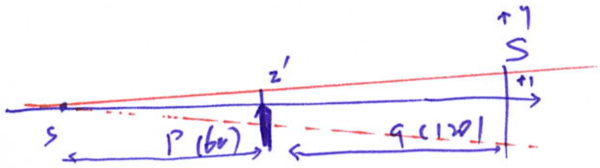


Figure 13-23 Problem 13-15.

Sol.)



From (13-25), $\frac{1}{L} = \frac{1}{p} + \frac{1}{q}$

$= \frac{1}{60} + \frac{1}{120} = \frac{3}{120}$

$\therefore L = 40$ (cm).

From the Fig above.

(i) For $y = +1$ (mm) : red line

$$\frac{z'}{p} = \frac{y}{p+q} \rightarrow z' = \left(\frac{p}{p+q}\right) y.$$

$$= \frac{60}{60+120}(0.1) = 0.33 \text{ (mm)} = 3.3 \times 10^{-4} \text{ (m)}.$$

For Cornu spiral, $v_2 = \infty$

$$v_1 = \sqrt{\frac{2}{\lambda L}}\, z' = \sqrt{\frac{2}{(589.3 \times 10^{-9})(0.4)}}\,(3.3 \times 10^{-4}) = 0.96$$

Here, the z' is under the red line, indicating (-) value for z'-axis.

$\therefore v_1 = -0.96$ & $v_2 = \infty$

From Table 13-1, $C(v_1) \doteq -0.78$, $S(v_1) = -0.44$

$C(v_2) = S(v_2) = 0.5$.

$$\therefore I = I_0 \left\{ [C(v_2) - C(v_1)]^2 + [S(v_2) - S(v_1)]^2 \right\} = I_0 \left\{ [0.5 + 0.78]^2 + [0.5 + 0.44]^2 \right\}$$

$$= I_0 (2.52) = \underline{\underline{1.26 I_u}}.$$

(ii) For $y = -2$ (mm) : red dotted line.

$$z' = \left(\frac{p}{p+q}\right) y = \frac{60}{60+120}(0.2) = 6.67 \times 10^{-4} \text{ (m)}$$

→ Thus, the intensity at (−2 mm) is for $+z'$ to ∞.

For the Cornu spiral, $v_2 = \infty$, $v_1 = \sqrt{\frac{2}{\lambda L}}\, z'$

$$= \sqrt{\frac{2}{(589.3 \times 10^{-9})(0.4)}}\,(6.67 \times 10^{-4})$$

$$= 1.94$$

From Table 13-1,

$C(v_1) \doteq 0.39$; $S(v_1) = 0.37$

$C(v_2 = \infty) = S(v_2 = \infty) = 0.5$

$$\therefore I = I_0 \left\{ [C(v_2) - C(v_1)]^2 + [S(v_2) - S(v_1)]^2 \right\}$$

$$= I_0 \left\{ (0.5 - 0.39)^2 + (0.5 - 0.37)^2 \right\}$$

$$= 0.029\, I_0 = \underline{\underline{0.015\, I_u}}$$

* Important : To read Table 13-1, use a closer v value!
for approximation.