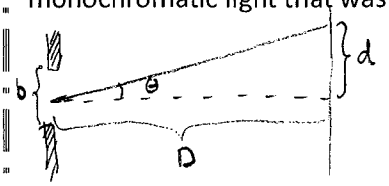
9.2 SINGLE-SLIT DIFFRACTION — PRACTICE QUESTIONS

1. 1 A screen is placed 1.52 m in front of a single-slit that is 0.0000125 m wide. If the distance from the center of the central maximum to the first minimum is 0.0652 m, what is the wavelength of the monochromatic light that was used as a source?



$D = 1,52\ m$
$b = 0,000\,0125\ m$
$d = 0,0652\ m$
$\theta = ?$
$\lambda = ?$

$\tan\theta = \frac{d}{D} \Rightarrow \theta = \tan^{-1}\left(\frac{d}{D}\right)$

$\theta = \tan^{-1}\left(\frac{0,0652\ m}{1,52\ m}\right) \approx 0,0429\ rad$

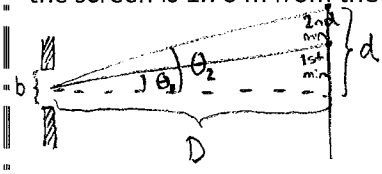
$\theta = \frac{\lambda}{b} \Rightarrow \lambda = \theta \cdot b$

$\lambda = 0,04286...\ rad \cdot 0,0000125\ m \approx$ 536 nm

2 What is the angular width of the central maximum in question 1?

Since $\theta = 0,04286...\ rad$, the angular width of the central maximum is $2\theta \approx 0,0857\ rad$ (or $4,91°$).

3 The angular width of the central maximum is 5.22° when light of wavelength 511 nm falls on a single-slit. What is the distance from the center of the central maximum to the second minimum if the screen is 1.76 m from the slit?



$\theta_1 = 5,22°/2 = 2,61° = 0,045...\ rad$
$\lambda = 511 \cdot 10^{-9}\ m$
$D = 1,76\ m$

$\theta_1 = \frac{\lambda}{b} \Rightarrow b = \frac{\lambda}{\theta_1}$

$b = \frac{511 \cdot 10^{-9}\ m}{0,045...\ rad} = 0,0000112...\ m$

Second min: $\theta_2 = \frac{2\lambda}{b} = \frac{2 \cdot 511 \cdot 10^{-9}\ m}{0,0000112...\ m} = 0,0911...\ rad$

$\tan\theta_2 = \frac{d}{D} \Rightarrow d = \tan\theta_2 \cdot D = \tan(0,0911...) \cdot 1,76\ m \approx$ 0,161 m

4 The central maximum is measured to be 0.0765 m wide when the screen is 1.84 m away from the slit. If the wavelength of the light source is 606 nm, what is the width of the slit?

See picture in question 1.

$d = 0,0765\ m / 2 = 0,03825\ m$
$D = 1,84\ m$
$\lambda = 606 \cdot 10^{-9}\ m$
$\theta = ?$
$b = ?$

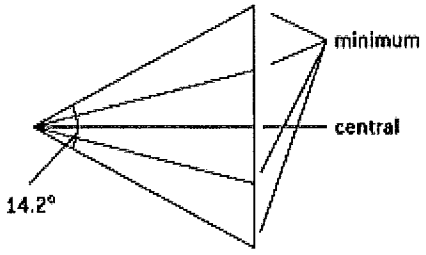
$\tan\theta = \frac{d}{D} \Rightarrow \theta = \tan^{-1}\left(\frac{d}{D}\right)$

$\theta = \tan^{-1}\left(\frac{0,03825\ m}{1,84\ m}\right) = 0,0207...\ rad$

$\theta = \frac{\lambda}{b} \Rightarrow b = \frac{\lambda}{\theta}$

$b = \frac{606 \cdot 10^{-9}\ m}{0,0207...\ rad} \approx 0,0000292\ m = 29,2\ \mu m$

5 Look at the diagram below. The angle from the second minimum on the right to the second minimum on the left is 14.2° when the wavelength of the source is 488 nm as shown below. What is the width of the slit?



$\theta = 14,2°/4 = 3,55° = 0,0619...\ rad$
$\lambda = 488 \cdot 10^{-9}\ m$
$b = ?$

$\theta = \frac{\lambda}{b} \Rightarrow b = \frac{\lambda}{\theta}$

$b = \frac{488 \cdot 10^{-9}\ m}{0,0619...\ rad} = 0,0000078\,76...\ m \approx 7,88\ \mu m$