Recitation W2

TA info

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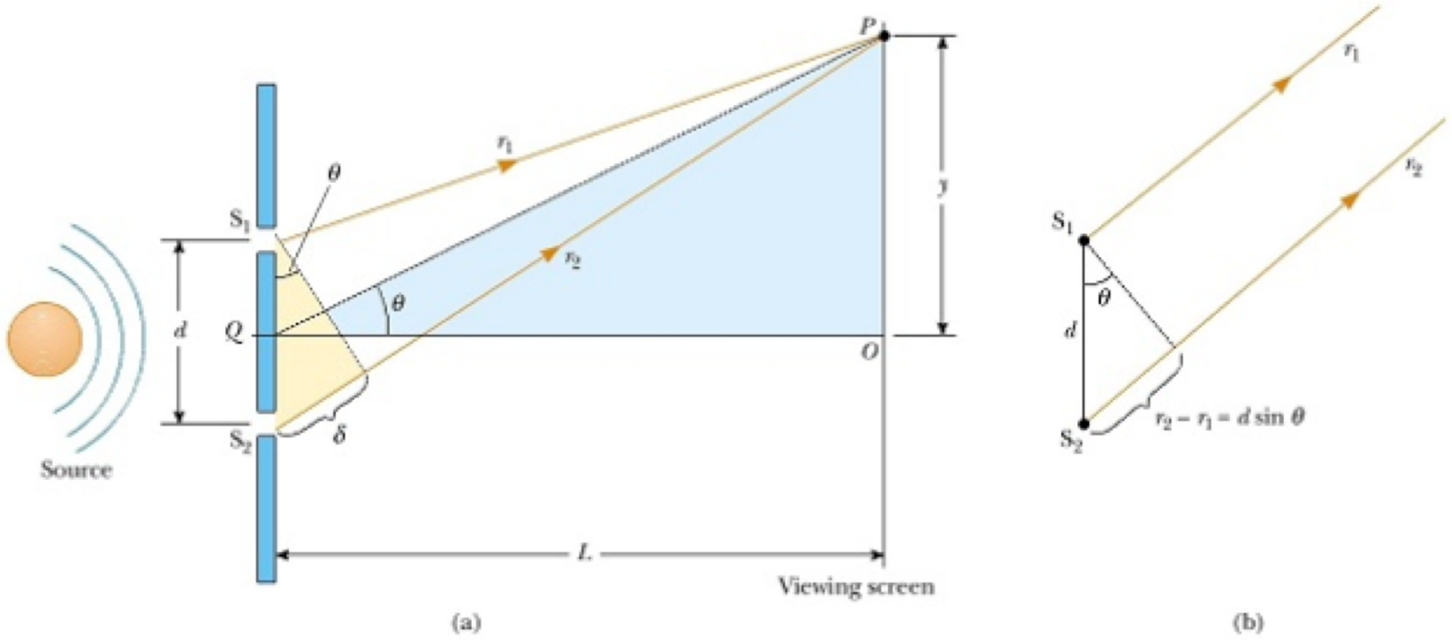
Class info

- Attendance, no make-up session
- Total 9 sessions (w2- w10)
- 8/9 attendance is required to pass the course
- You can attend any other session within a week

Topic

- Single & double-slit interference
- Diffraction grating

Double-slit



$$\Delta r\ (PLD) = d\ sin\theta$$
$$tan\theta = \frac{y}{L}$$

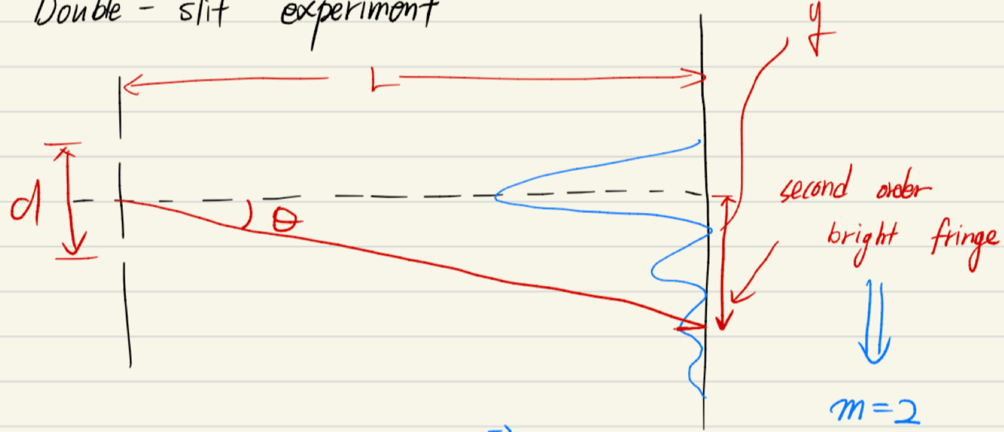
- Bright fringes: $d\ sin\theta = m\lambda$ m = 0, 1, 2, 3, …
- Dark fringes: $d\ sin\theta = (m + \frac{1}{2})\lambda$

- In Young's double-slit experiment, the second-order bright fringe is located at $6.98cm$ from the center of the screen. The screen is placed 2m away from the slit. The slit separation is $3.8 \times 10^{-5}m$. What is the wavelength of the light?

- At most, how many bright fringes can be formed on either side of the central bright fringe when light of wavelength 625 nm falls on a double slit whose slit separation is $3.76\times10^{-6}m$.

①

Double - slit experiment



$y = 6.98\,cm = 6.98\times10^{-2}\,m$

$L = 2\,m$

$d = 3.8\times10^{-5}\,m$

Bright fringe $\Rightarrow$ $d\sin\theta = m\lambda$

To find θ $\Rightarrow$ $\tan\theta = \frac{y}{L}$

$$\theta = \tan^{-1}\left(\frac{6.98\times10^{-2}\,m}{2\,m}\right) = 2^\circ$$

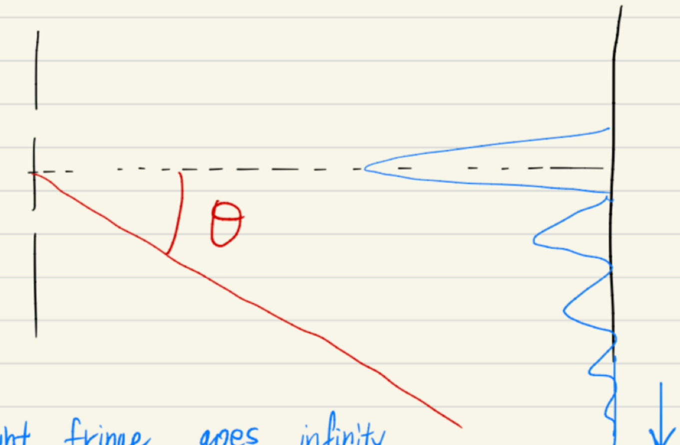
$$\therefore\ \lambda = \frac{d\sin\theta}{m}$$

$$\Rightarrow\ \underline{\lambda} = \frac{(3.8\times10^{-5}\,m)\sin(2^\circ)}{2} = 663\times10^{-9}\,m = \underline{663\,nm}$$

② Double-slit, bright fringes

$\lambda = 625\,nm = 625 \times 10^{-9}\,m$

$d = 3.76 \times 10^{-6}\,m$



If bright fringe goes infinity

$\theta_{max} \rightarrow 90°$

$d \sin\theta_{max} \geq m\lambda$

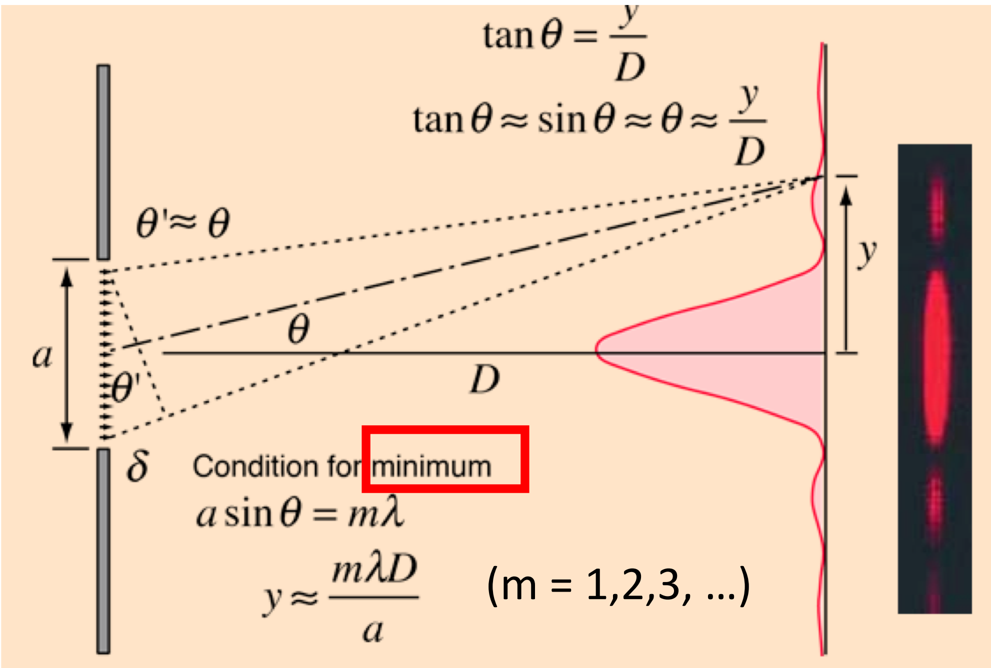
$\Rightarrow d \sin(90°) \geq m\lambda$

$\frac{d}{\lambda} \geq m$

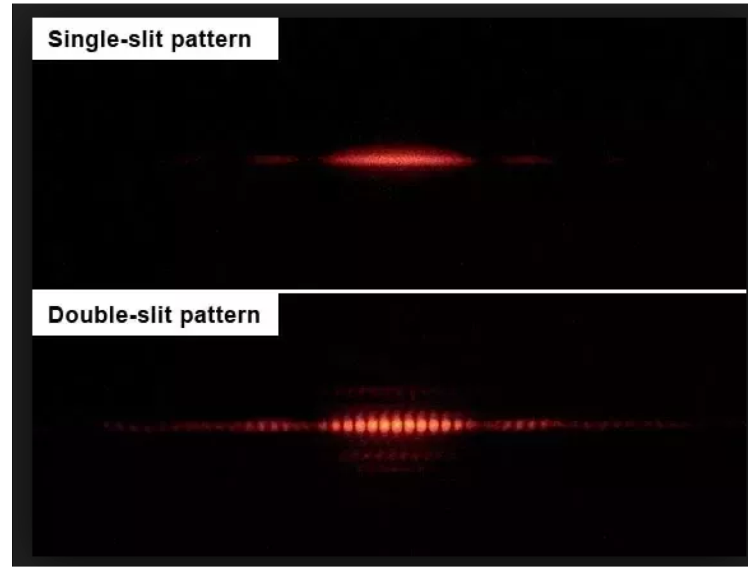
$6.016 \geq m$

$\therefore m = 6$

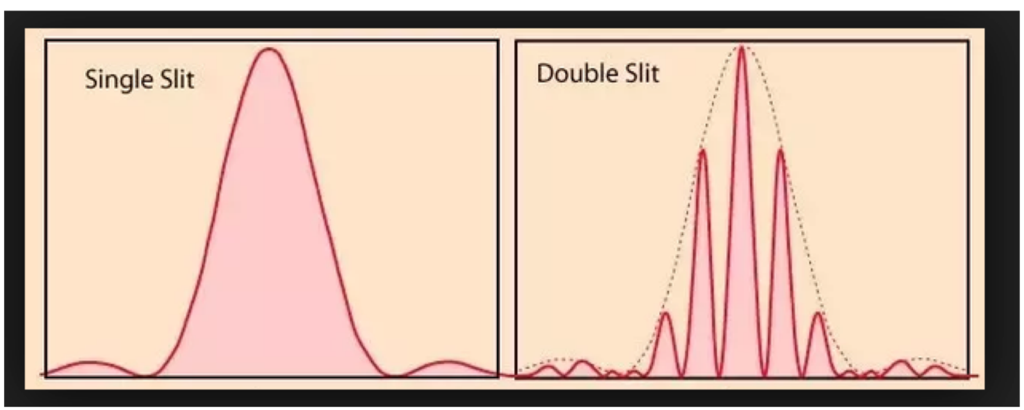
Single-slit



$\tan\theta = \frac{y}{D}$
$\tan\theta \approx \sin\theta \approx \theta \approx \frac{y}{D}$
$\theta' \approx \theta$
a
θ
θ'
D
y
δ
Condition for minimum
$a\sin\theta = m\lambda$
$y \approx \frac{m\lambda D}{a}$
(m = 1,2,3, …)

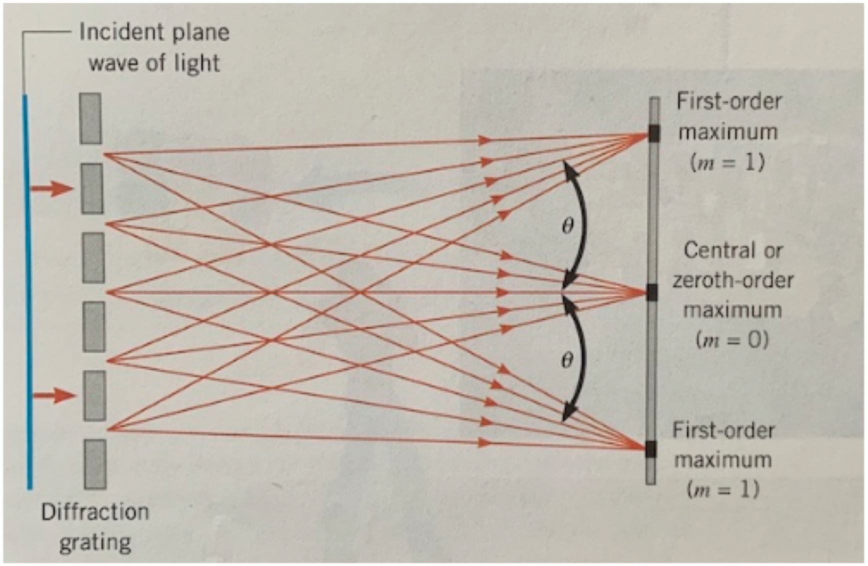


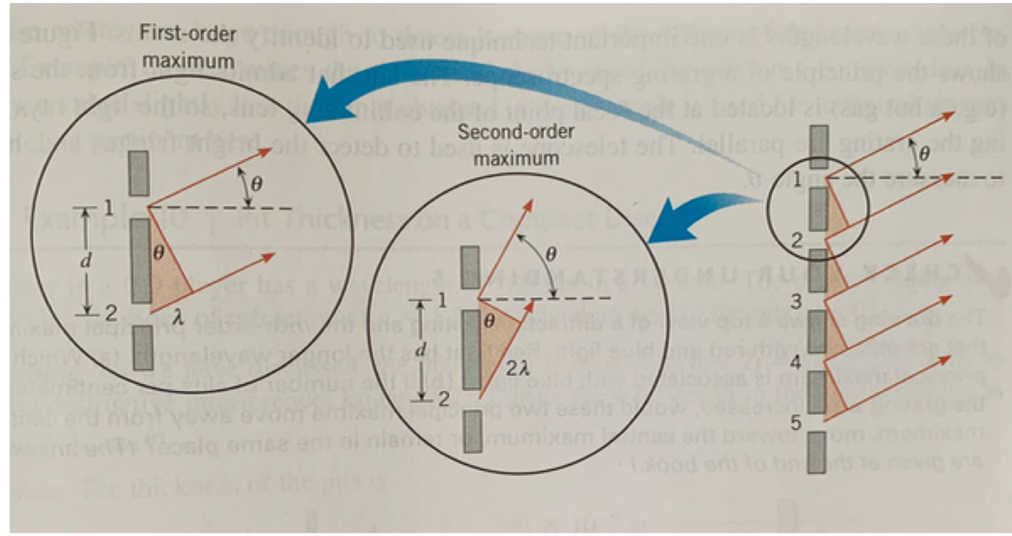
Single-slit pattern
Double-slit pattern



Single Slit
Double Slit

Diffraction grating





- Maxima of a diffraction grating: $sin\theta = m\frac{\lambda}{d}$ m= 0, 1, 2, 3, …

- A mixture of violet light ($\lambda = 410\ nm$ in vacuum) and red light ($\lambda = 660\ nm$) falls on a grating that contains 1.0×10^4 lines/cm. For each wavelength, find the angle θ that locates the first-order maxima.

③ $\lambda_{violet} = 410\ nm$

$\lambda_{red} = 660\ nm$

grating → 1.0×10^4 lines/cm

$$d = \frac{1}{1.0\times10^4}\ cm = \frac{10^{-2}}{1.0\times10^4}\ m$$

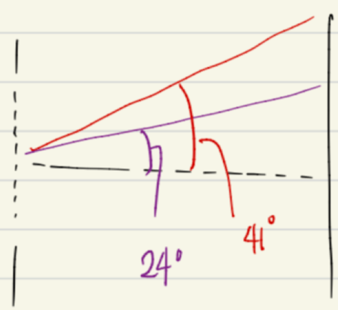
$$= 1.0 \times 10^{-6}\ m$$

first-order maxima → $m=1$

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

$$\theta_{red} = \sin^{-1}\left(\frac{\lambda_{red}}{d}\right) = 41^\circ$$

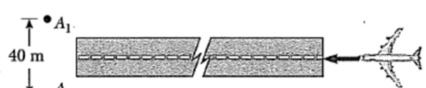
$$\theta_{violet} = \sin^{-1}\left(\frac{\lambda_{violet}}{d}\right) = 24^\circ$$



Questions?

1. We have studied diffraction from a single slit, where light is sent through a thin opening. A similar phenomena occurs when light bends around a thin object, like a human hair. Here the width of the hair plays the role of the width of the single slit. Measurements found that when a beam of light of wavelength 632.8 nm was shone on a single strand of hair, the first dark fringes on either side of the central bright spot were 5.22 cm apart. If the screen is 1.25 meters away, how thick was this strand of hair?

3. Young's double-slit experiment underlies the *instrument landing system* used to guide aircraft to safe landings when the visibility is poor. Although real systems are more complicated than the example described here, they operate on the same principles. A pilot is trying to align her plane with a runway as suggest in the figure. Two radio antennas A_1 and A_2, separated by 40.0 m, are positioned adjacent to the runway. The antennas broadcast single frequency, 30.0 MHz, coherent radio waves. **(a) Find the wavelength of the waves.**



The pilot "locks onto" the strong signal radiated along an interference maximum and steers the plane to keep the received signal strong. If she detects the central maximum, the plane will have the right heading to land when it reaches the runway. (b) Suppose instead that the plane is flying along the first side maximum, one maxima from the central. **How far to the side of the runway centerline is the plane when it is 2.00 km from the antennas?**

(c) It is possible to tell the pilot she is on the wrong maximum by sending out two signals from each antenna and equipping the aircraft with a two-channel receiver. The ratio of the two frequencies must not be the ratio of small integers (such as 3/4). **Explain how this two-frequency system would work, and why it would not necessarily work if the frequencies were related by an integer ratio.**

4. Below is an image of the fringe pattern produced by two identical slits and light of wavelength, $\lambda = 600$ nm. The pattern is produced on a screen 1.0 meters from the slits. Using the provided scale, determine the separation between the slits and the width of one individual slit. Explain your reasoning.