Class 28: (ThT Q)
Why did we do single-slit diffraction after two slit?
Isn’t one simpler than two?
What is the use of understanding diffraction?
Did you complete at least 70% of Chapter 38:1-4?

A. Yes

B. No

1. Why did we do single-slit diffraction after two slit? Isn’t one simpler than two?

2. What is the use on understanding diffraction?

3. Resolution: slits & holes: Rayleigh Criterion, examples: telescopes & eye

Lab 5 is due tonight @ 2200

Sitting in front:
<table>
<thead>
<tr>
<th>#</th>
<th>Date</th>
<th>Read/topic</th>
<th>Quizzes</th>
<th>HW Due</th>
<th>Labs</th>
<th>Exams</th>
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<td>25</td>
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<td>Fri. May 27</td>
<td>37.5–6</td>
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<td>26</td>
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<td>#5 due;#6 begin</td>
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<td>Wed. June 1</td>
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<td>29</td>
<td>24</td>
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<td>31</td>
<td>Fri. June 3</td>
<td>39.1–4</td>
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Today: Physical optics: Diffraction HW (gardner) will be down for about 30 minutes sometime Monday afternoon. If gardner is down when you try to submit homework on Monday, you should wait 1.5 hr. & try again.
The diffraction pattern that appears on a screen when light passes through a narrow vertical slit. The pattern consists of a broad central fringe and a series of less intense and narrower side fringes.
Knife edge test
Poisson’s bright spot

Poisson did not believe Thomas Young’s wave assertions. He said that if they were true then there would be a bright spot behind opaque objects & everyone knew there were no such things. Then someone went & looked.
How does pattern due to a single slit differ from two slits?

1. Do both have bright spot in middle?
2. What does this formula mean:
   \[ a \sin \theta = m\lambda \]
Active figure
Consider diffraction of light through a narrow slit.

If we make the slit narrower, the light will spread out:

A. more.
B. less.

Consider:

\[ a \sin \theta = m \lambda \]
Light from different parts of the slit interfere with each other.
Nearly all of the intensity is in the central maximum.

Minimum @ $a \sin \theta = \lambda$

Fig 38-6, p.1209
24-1. A laser beam passes through a single slit. We observe an interference pattern on a screen [01]___ m away. We find that the distance between the two dark lines (m = ±1) on the two sides of the bright central maximum is 3.0 cm. The wavelength of the laser light is 633 nm. Find the width of the slit. Hint: You will need to divide 3.0 by 2 to use the formula a sinθ = mλ
Demos

• Lasers: with variable slits & hair
• Videos
Consider diffraction of light through a narrow slit. Which color of light will spread out the most?

A. blue  
B. red

Consider:
\[ a \sin \theta = n \lambda \]
Demos

• Light bulb: use fingers to make a single slit.
Fig 38-10, p.1212
The combined effects of two-slit and single-slit interference.

Active Figure
The quest for resolution.

Fig 38-12, p.1214
Minimum at $D \sin \theta = 1.22 \lambda$.

Round holes: ▲ Rayleigh criterion
Animation: Rayleigh
Telescopes

- Keck telescope (14Kft in Hawaii) 10 m
- But Hubble is better though smaller.
- BTW, Acoustic group meetings: 1100 Th in C261 ESC, ME and Physics
Atmosphere limits resolution (0.6 arc sec in past) for ground based telescopes.

Smaller mirror but better resolution.

Atmosphere limits resolution (0.6 arc sec in past) for ground based telescopes.
Human eye: Diffraction limit

\[ \theta_{\text{min}} = 0.02^\circ \]

@\( \geq 7 \text{m lines}\) 2mm apart fall below this level.

Fig 38-14, p.1217
Pluto System

*Hubble Space Telescope* • Advanced Camera for Surveys

NASA, ESA, H. Weaver (JHU/APL), A. Stern (SwRI) and the HST Pluto Companion Search Team

http://antwrp.gsfc.nasa.gov/apod/a051103.html
24-3. A hobby telescope uses a concave mirror with a diameter of [03] cm.

Find the distance between two points on the moon that can be resolved by this telescope. Use 550 nm for the wavelength of visible light.
What should we do more of?

A. Video demos and Mechanical Universe
B. HW problems
C. Conceptual problems and quizzes
D. Demos
E. Everything is about right
What should we do less of?

A. Video demos and Mechanical Universe
B. HW problems
C. Conceptual problems and quizzes
D. Demos
E. Everything is about right
24-2. The diameter of a laser beam is due entirely to the diameter of the hole through which it passes as it exits the instrument. However, at large distances, the diameter of the beam increases due to diffraction at that hole. Suppose that for a particular laser, the diameter of the beam is \([02]\) cm at a distance of 11.5 m. The wavelength of the laser light is 633 nm. Find the diameter of the hole through which the beam exits the instrument. Caution: the value of \(\text{min}\) is measured from the center of the diffraction pattern to the first dark ring.
24-4. In this problem, we will find the ultimate resolving power of a microscope.

First of all, in order to obtain a large magnification, we want an objective lens with a very short focal length. Second, in order to obtain maximum resolution, we also want that lens to have as large a diameter as possible. These two requirements are conflicting, since a lens with a short focal length must have a small diameter. It is not practical for a lens to have a diameter much larger than the radius of curvature of its surfaces. Otherwise, the lens starts looking like a sphere. So, let us assume that the objective lens has a diameter $D$ equal to the radius of curvature of the two surfaces, like the lens in the figure to the right.
(a) If the lens is made of glass with index of refraction [04], find the focal length \( f \) in terms of the diameter \( D \) of the lens.

(b) The distance between the sample to be observed and the objective lens is approximately equal to the focal length \( f \). Find the distance between two points on the sample which can be barely resolved by the lens. Use the result from part (a) to eliminate \( f \) from the expression. You should find that \( D \) is also eliminated from the expression and that the answer is given entirely in terms of the wavelength of the light. You may use the small angle approximation, \( \sin \theta \approx \tan \theta \approx \theta \).
24-5. A diffraction grating contains 15,000 lines/inch. We pass a laser beam through the grating. The wavelength of the laser is 633 nm. On a screen [05] m away, we observe spots of light.

(a) How far from the central maximum (\(m = 0\)) is the first-order maximum (\(m = 1\)) observed?

(b) How far from the central maximum (\(m = 0\)) is the second-order maximum (\(m = 2\)) observed? DO NOT use the “small-angle approximation,” \(y_{\text{bright}} = (L/d)m\). The angles are too large for \(\sin \theta \approx \tan \theta \approx \theta\) to be a very good approximation.
\[ \Delta y \sin \theta \]

Viewing screen

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\[ E_R \]

\[ \beta = 0 \]
\[ \beta = 2\pi \]