Physics 161
Lecture 27
A little bit of Wave optics

December 11, 2018
Final exam

Wednesday 19th December at 12:00 in LSH-AUD

The exam will last 3 hours and there will be 30 questions.

There will be 15 questions on the final third of the course (lecture 19 onwards). The rest of the questions may be drawn from any part of the course.

You may bring three sheets of handwritten notes. Each sheet can be no larger than 8.5 x 11 inches (letter paper).

If you have a final exam conflict, email me ASAP.
Final exam preparation

There will also be some **Optics problems** during the Tuesday 11th December lecture.

There will be a **help session day** on **Tuesday 18th December**

The help session day will be in Serin 232 (lab room). At the moment the schedule is:

- 10:00am to 11:30 am - Sridharan
- 11:30am to 1:00pm - Javed
- 1:00pm to 2:30 pm - Admasu
- 2:30pm to 4:00 pm - Kloet
Lecture 27: learning objectives

Review from lecture 26
- Mirrors and lenses.
- 3 typical rays that help locate the image.

This lecture 27
You will be able to explain coherent and incoherent light.

You will be able to apply the conditions for constructive and destructive interference to Young’s double-slit experiment.
iClicker question: toddler

If a toddler crawls towards a mirror at a rate of 0.25 m/s, then at what speed will the toddler and the toddler's image approach each other?

a) 0.125 m/s.
b) 0.25 m/s.
c) 0.5 m/s.
d) 1.0 m/s.
iClicker question: mirrors

A colored block is positioned 4 cm from a vertical mirror and 5 cm from a horizontal mirror, as shown in the diagram. How many blocks will an observer see?

a) 1.
b) 2.
c) 3.
d) 4.
d) 5.
Electromagnetic spectrum

In this lecture we are no longer applying the ray approximation!
Interference, $B_1 + B_2$

Combining the two waves in parts (a) and (b) results in a wave with twice the amplitude.

Combining the waves in (a) and (b) results in complete cancellation.
How observe interference of electromagnetic waves

Interference is hard to observe in light, because it has such a small wavelength. It helps if:

- The waves have **identical wavelengths**.
- The sources are **coherent**.

**Coherent waves:**
Waves have same $\lambda$ and maintain a constant phase with respect to each other.

Waves that are not coherent are **incoherent**.
Young’s double slit experiment

$s_1$ and $s_2$ are coherent
Young’s double slit experiment

$s_1$ and $s_2$ are coherent

- When the path lengths are equal, the waves are in phase and undergo constructive interference at $P$.
- When the path lengths differ by a wavelength, the waves are in phase and undergo constructive interference at $Q$.
- When the path lengths differ by half a wavelength, the waves are 180° out of phase and undergo destructive interference at $R$. 
Geometry of Young’s double slit

$s_1$ and $s_2$ are coherent

The path difference between the two rays is $r_2 - r_1 = d \sin \theta$. 
bright if path difference = \( m \lambda \)

**Path difference, \( \delta \):**
Difference in distance travelled by light waves passing through each slit.

\[
\delta = r_2 - r_1 = d \sin \theta
\]

**Constructive interference = bright**

IF \[ \delta = d \sin \theta_{\text{bright}} = m\lambda \]

\[
y_{\text{bright}} = m \frac{\lambda L}{d}
\]

**Destructive interference = dark**

\[
d \sin \theta_{\text{dark}} = \left( m + \frac{1}{2} \right) \lambda
\]

\[
y_{\text{dark}} = \left( m + \frac{1}{2} \right) \frac{\lambda L}{d}
\]

The path difference between the two rays is \( r_2 - r_1 = d \sin \theta \).
A Young’s double-slit experiment is performed with three different colours of light: red, green and blue. Rank the colours by the distance between adjacent bright fringes, from smallest to largest.

a) Red, green and blue.
b) Green, red and blue.
c) Blue, green and red.
Problem: measure wavelength

Screen at 1.20 m from double-slit. Slit distance is 0.030 mm.

The m=2 bright fringe appears at 4.50 cm from the m=0 bright fringe.

a) Find the wavelength
iClicker question:

Under what angle does one see the m=2 bright fringe?

a) 1 degrees
b) 2 degrees
c) 3 degrees
d) 4 degrees
e) 5 degrees
Problem: hiding diamond

A thief hides a diamond by placing it on the bottom of a 2.58 m deep pool. He places a circular raft on the surface of the water above and centered over the diamond.

a) Find the minimum diameter of the raft in order to hide the diamond.
Problem: converging lens

A converging lens has a focal length of 26.0 cm.

Find the location of image and nature of the image (real/virtual/upright/inverted/no image) and magnification for the following object distances:

a) 26.0 cm
b) 13.0 cm
c) 221 cm
Problem: Two converging lenses

Two converging lenses, each of focal length 14.8 cm, are placed 39.8 cm apart. An object is placed 30.0 cm in front of the first lens.

a) Where is the location of the image?

b) What is the magnification?
iClicker question:

The first and second lens are separated by 39.8 cm. If the image from the first lens is at \( q_1 = 29.2 \) cm, what is the location of the object for the second lens?

a) \( P_2 = 29.2 \) cm  
b) \( P_2 = 39.8 \) cm  
c) \( P_2 = 39.8 - 29.2 \) cm  
d) \( P_2 = -29.2 \) cm  
e) \( P_2 = -39.8 \) cm
Problem: parallel-parallel

A converging lens is placed 26.0 cm to the right of a diverging lens of focal length 7.0 cm.
A beam of parallel light enters the diverging lens from the left, and the beam is again parallel when it emerges from the converging lens.

a) Find the focal length of the converging lens.
Problem: 22.43, critical geometry

The light beam in the Figure strikes the second surface at the critical angle (42.0°). Determine the angle of incidence at surface 1.
Problem:
2-slit Diffraction

Light passing through narrow slits \textit{diffraacts}.