PHY132H1F Introduction to Physics II
Class 4 – **Outline:**

- Standing Waves in closed-closed, open-open, and closed-open tubes
- Interference in 1-D and 2-D
- Beats
- Ray optics, and the law of reflection

Quick reading quiz..

What is specular reflection?

A. The image of a specimen.
B. A reflection that separates different colors.
C. Reflection by a flat smooth object.
D. When the image is virtual and special.
E. This topic is not covered in Chapter 23, Sections 23.1-4.

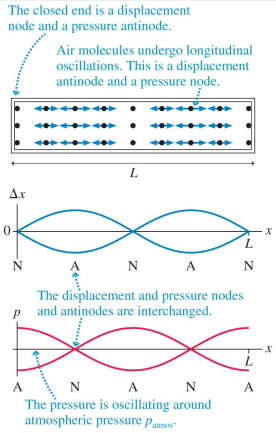
Standing Sound Waves

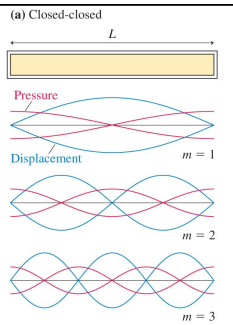
• A long, narrow column of air, such as the air in a tube or pipe, can support a longitudinal standing sound wave.

• A closed end of a column of air must be a displacement node. Thus the boundary conditions — nodes at the ends — are the same as for a standing wave on a string.

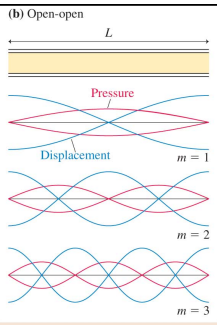
• It is often useful to think of sound as a pressure wave rather than a displacement wave. The pressure oscillates around its equilibrium value.

• The nodes and antinodes of the pressure wave are interchanged with those of the displacement wave.





$$\begin{cases} \lambda_m = \dfrac{2L}{m} \\ f_m = m\dfrac{v}{2L} = mf_1 \end{cases} \qquad m = 1, 2, 3, 4, \ldots \text{ (open-open or closed-closed tube)}$$



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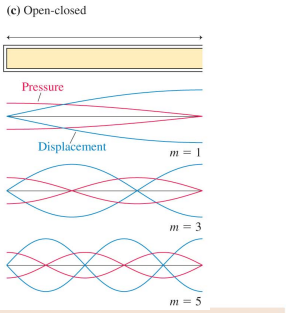
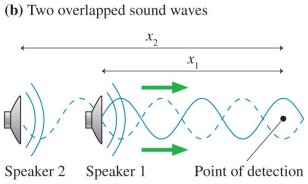
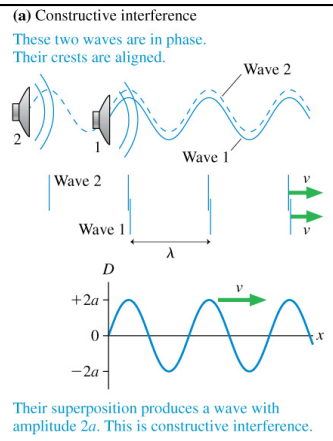


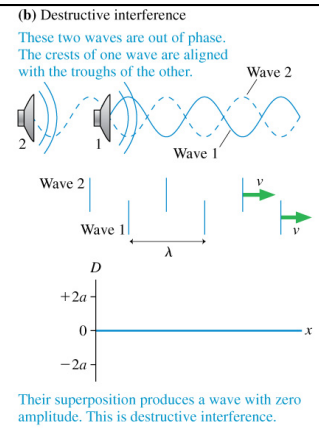
$$\begin{cases} \lambda_m = \dfrac{4L}{m} \\ f_m = m\dfrac{v}{4L} = mf_1 \end{cases} \qquad m = 1, 3, 5, 7, \ldots \text{ (open-closed tube)}$$

Wave Interference

- The pattern resulting from the superposition of two waves is often called interference. Interference can be
- ***constructive***, meaning the disturbances **add** to make a resultant wave of **larger** amplitude, or
- ***destructive***, meaning the disturbances **cancel**, making a resultant wave of **smaller** amplitude.





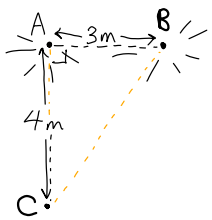


In Class Discussion Question

Two speakers, A and B, are "in phase" and emit a pure note with a wavelength 2 m. The speakers are side-by-side, 3 m apart. Point C is 4 m directly in front of speaker A.

How many wavelengths are between Speaker A and Point C?

A. 0.5
B. 1.0
C. 1.5
D. 2.0
E. 2.5

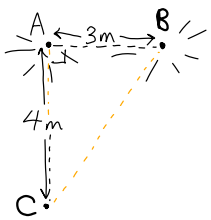


In Class Discussion Question

Two speakers, A and B, are "in phase" and emit a pure note with a wavelength 2 m. The speakers are side-by-side, 3 m apart. Point C is 4 m directly in front of speaker A.

How many wavelengths are between Speaker B and Point C?

A. 0.5
B. 1.0
C. 1.5
D. 2.0
E. 2.5



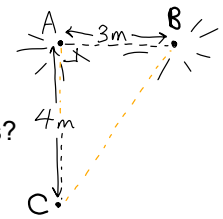
In Class Discussion Question

Two speakers, A and B, are “in phase” and emit a pure note with a wavelength 2 m. The speakers are side-by-side, 3 m apart. Point C is 4 m directly in front of speaker A.

At point C, what is the path difference between the sounds received from speakers A and B, as measured in wavelengths?

A. 0.5 B. 1.0 C. 1.5

D. 2.0 E. 2.5



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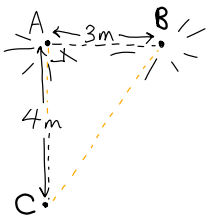
At point C, what is the phase difference between the sounds received from speakers A and B?

A. 0.5π B. π C. 1.5 π

D. 2.0 π E. 2.5 π



In Class Discussion Question

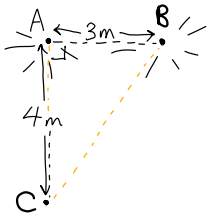
Two speakers, A and B, are “in phase” and emit a pure note with a wavelength 2 m. The speakers are side-by-side, 3 m apart. Point C is 4 m directly in front of speaker A.

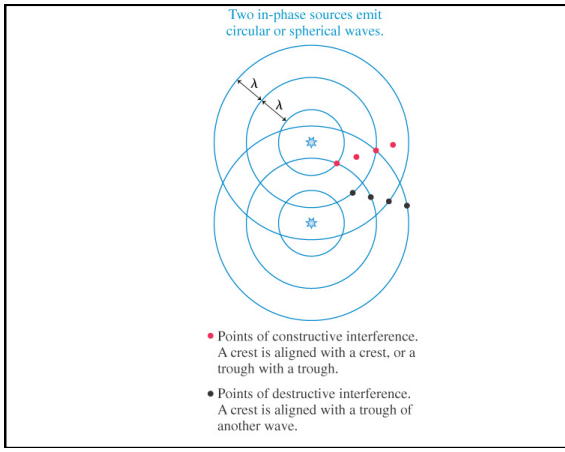
At point C, there will be

A. Perfect constructive interference (A_C=2A)

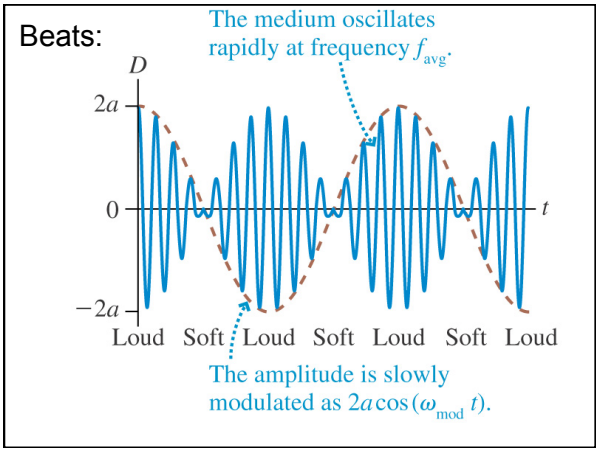
B. Perfect destructive interference (A_C=zero)

C. Intermediate interference ($0 < A_C < 2A$)





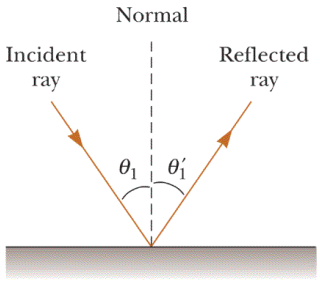
Beats:



Wave Fronts and Rays

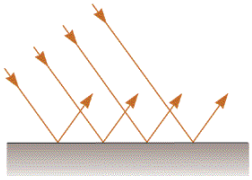
- Wave fronts connect points of equal phase on an extended wave.
- Rays show the propagation direction of waves, and are always perpendicular to wave fronts.
- Rays travel in straight lines
- At a boundary they can *reflect* (bounce off) and *refract* (penetrate) the different medium.
- Ray angles are measured relative to surface normal.

The Law of Reflection



$$\theta_1' = \theta_1$$

Specular vs. Diffuse Reflection

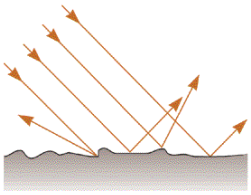


Specular Reflection

•The surface is *flat* at distance scales near or above the wavelength of light

•It looks "shiny", like a mirror.

Specular vs. Diffuse Reflection

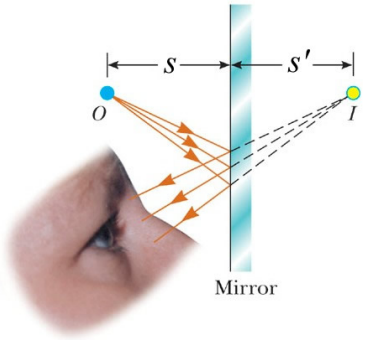


Diffuse Reflection

•The surface is *rough* at distance scales near or above the wavelength of light

•Almost ***all*** surfaces reflect in this way!

How an image is formed



Virtual Image in a flat mirror

- Light rays emerging from an object obey the law of reflection for the specular surface of a mirror
- Our mind imagines that the rays emerge from points beyond the mirror.
- This thing beyond the mirror is called an image. No light rays actually pass through the image, so it is "virtual".
- It is convenient to describe the size and location of the image as if it were an actual thing.

Before Next Class:

• Problem Set 1 is due on masteringphysics tonight!

• First Practical meets on Friday in MP125C! You will be meeting your two T.A.s! Bring questions if you have them!

• Please finish reading Chapter 23. But you can skip section 23.8 (we won't be covering this on the tests or exam)

See you Friday!