Lecture 9

Interference, Beats
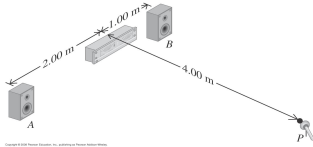and the
Doppler Effect

Pre-reading: §16.6–16.7

Wave Interference

- Two or more traveling waves passing through same space at same time (identical frequencies)
- Use principle of superposition
- Consider the <u>difference</u> in path length to the sources
- **Constructive** interference (double amplitude):
  - path length difference is $0, \lambda, 2\lambda, 3\lambda, ...$
- **Destructive** interference (zero amplitude):
  - path length difference is $\lambda/2, 3\lambda/2, 5\lambda/2, ...$
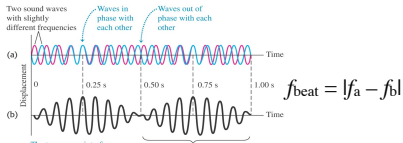

Example 16.13

- Speakers A and B emit identical sinusoids
- Speed of sound is 350 m/s
- What is frequency of waves if there is
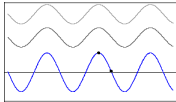 - constructive interference at P ?
  - destructive interference at P ?

Beats

- Two (or more) traveling waves passing through same space at same time (different frequencies)
- You hear both frequencies (f_a and f_b)
- ALSO hear amplitude grow and fall at the beat frequency
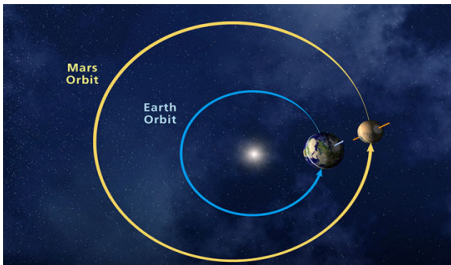

$$f_{beat} = |f_a - f_b|$$

§16.7

Example

- One tuning fork vibrates at 440 Hz
- A second tuning fork vibrates with unknown frequency
- With both forks sounded, you hear a tone with an amplitude that changes with frequency of 3 Hz
- What is the frequency of the second tuning fork?

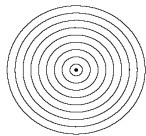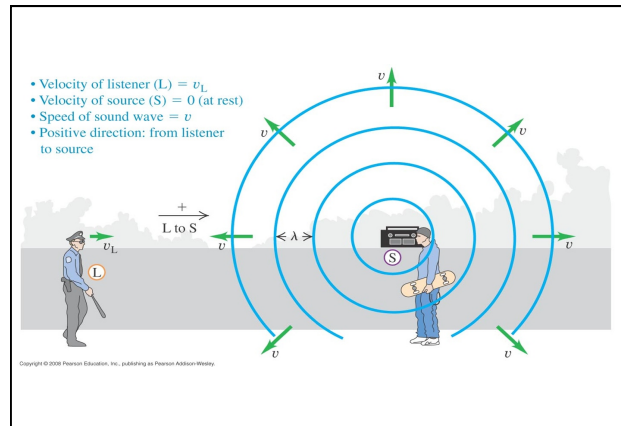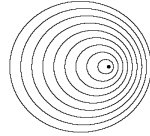

Example: Orbital rendezvous

Doppler Effect

- Change in perceived frequency due to relative motion of a source (S) and listener (L)

Stationary Source   Moving Source

- Velocity of listener (L) = v_L
- Velocity of source (S) = 0 (at rest)
- Speed of sound wave = v
- Positive direction: from listener to source

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Doppler Effect

- Change in perceived frequency due to relative motion of a source (S) and listener (L)

- Case 1: Source at rest, Listener moving
  $$f_L = (1 + v_L/v) \times f_S$$

- Case 2: Source and Listener moving
  $$f_L = \frac{v + v_L}{v + v_S} f_S$$

- Pay attention to sign of v_L, v_S ! *(positive from L to S)*

- For light waves
  $$f_L = \sqrt{(c-v)/(c+v)} \times f_S \qquad c = 3.0 \times 10^8 \text{ ms}^{-1}$$

- Velocity of listener (L) = v_L
- Velocity of source (S) = v_S
- Speed of sound wave = v
- Positive direction: from listener to source

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Doppler Effect

- Change in perceived frequency due to relative motion of a source (S) and listener (L)

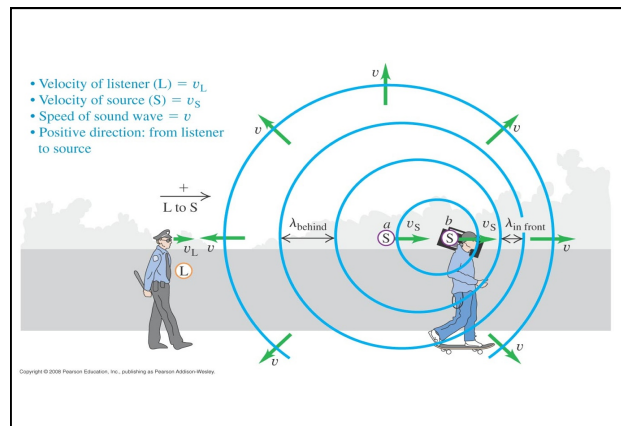- Case 1: Source at rest, Listener moving
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- For light waves
  $$f_L = \sqrt{(c-v)/(c+v)} \times f_S \qquad c = 3.0 \times 10^8 \text{ ms}^{-1}$$

Next lecture

Doppler effect
and
Shock waves

Read §16.8–16.9