Lecture 9

Interference, Beats

and the

Doppler Effect

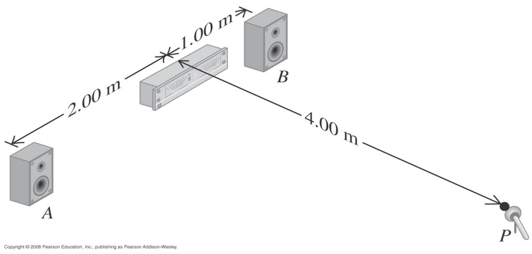
Pre-reading: §16.6–16.7

Wave Interference

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

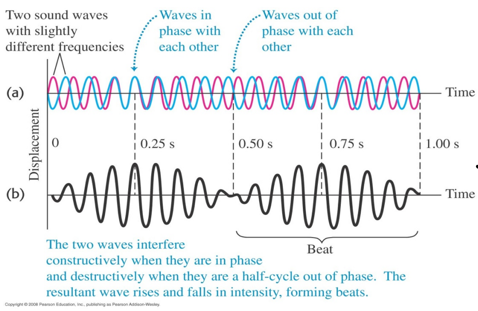
Example 16.13

- 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

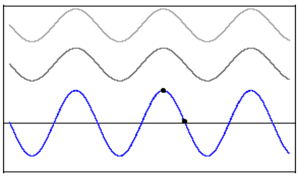


$$f_{beat} = |f_a - f_b|$$

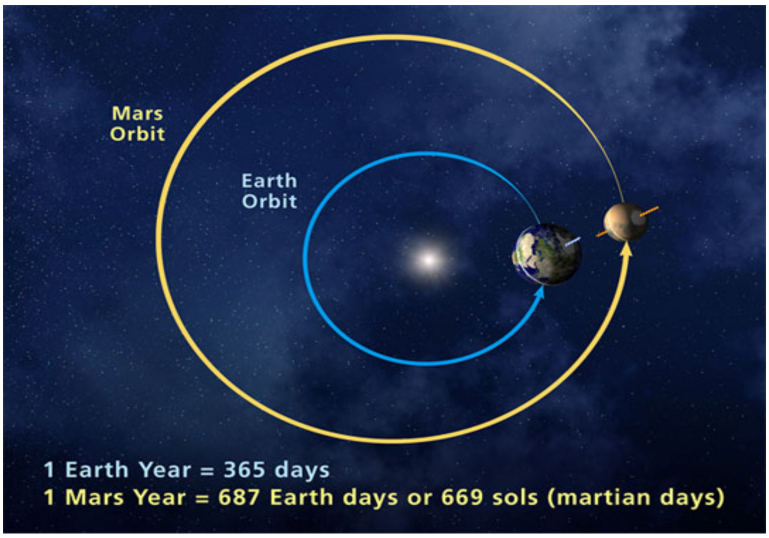
§16.7

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?



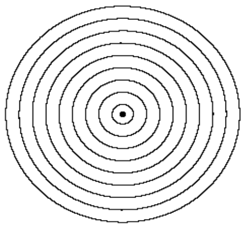
Example: Orbital rendezvous



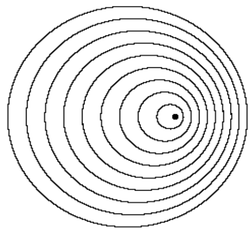
Doppler Effect

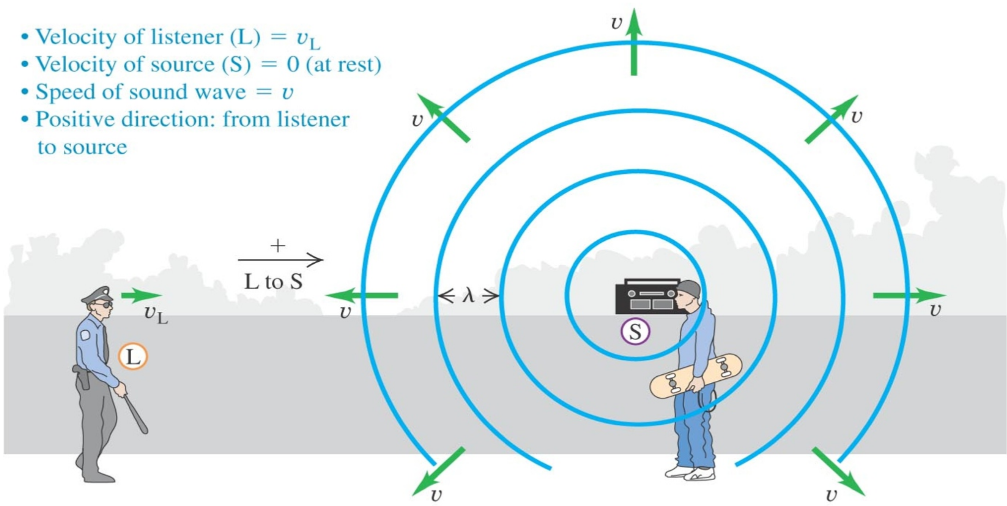
- Change in perceived frequency due to relative motion of a source (S) and listener (L)

Stationary Source



Moving Source





Doppler Effect

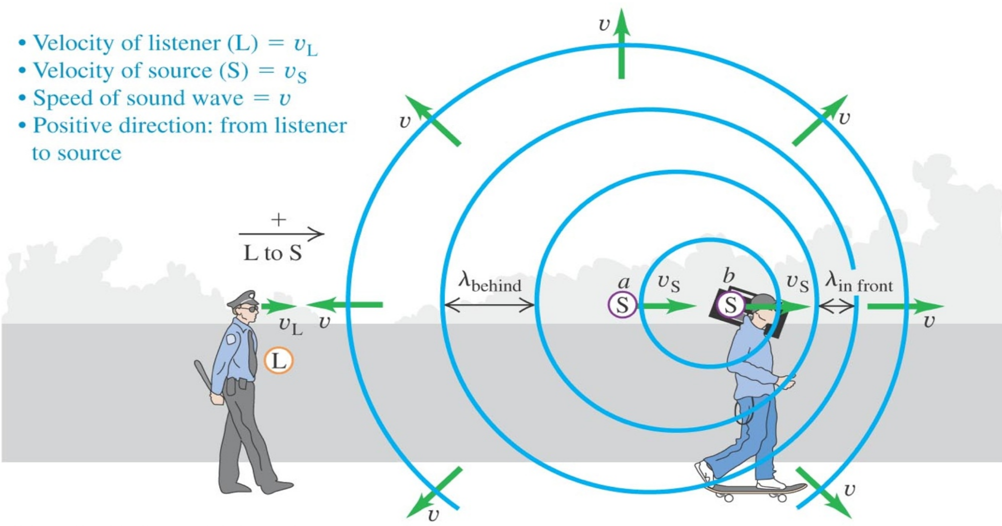
- Change in perceived frequency due to relative motion of a source (S) and listener (L)
- Case 1: Source at rest, Listener moving

  $f_L = (1 + v_L/v) \times f_S$
- 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

  $f_L = \sqrt{[\,(c-v) / (c+v)\,]} \times f_S \qquad c = 3.0 \times 10^8\ \mathrm{ms}^{-1}$



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
  $f_L = \sqrt{[\ (c-v)\ /\ (c+v)\ ]} \times f_S \qquad c = 3.0 \times 10^8\ \mathrm{ms^{-1}}$

Next lecture

Doppler effect

and

Shock waves

Read §16.8–16.9