Lecture 10

Doppler effect
and
Shock waves

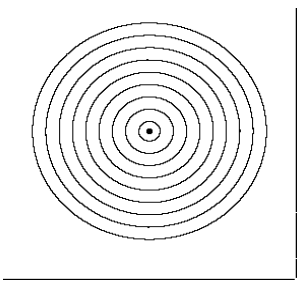
Pre-reading: §16.8–16.9

Please take a clicker and an evaluation form

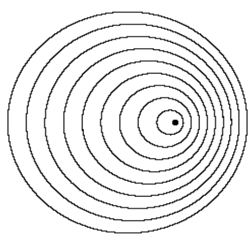
Doppler Effect

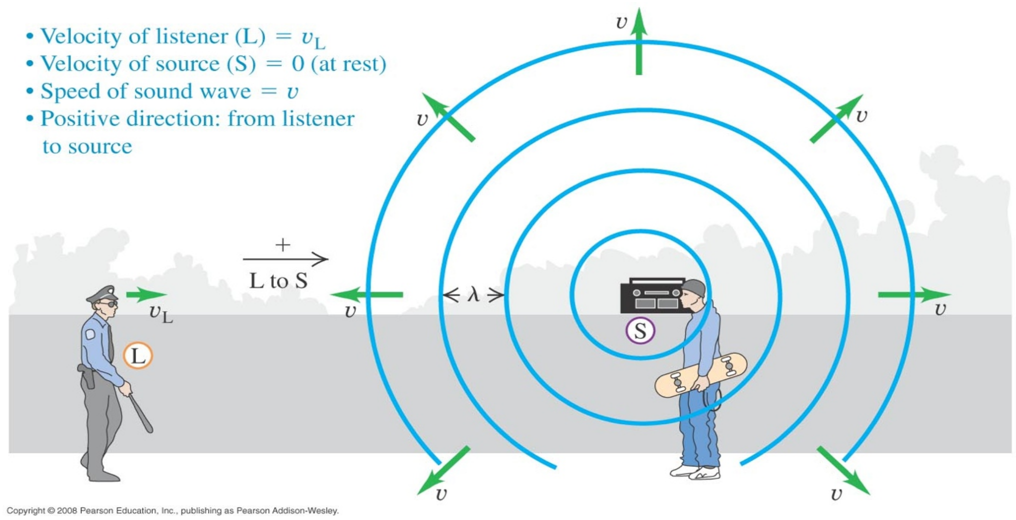
- Change in perceived frequency due to relative motion of a source (S) and listener (L)

Stationary Source



Moving Source





Doppler Effect

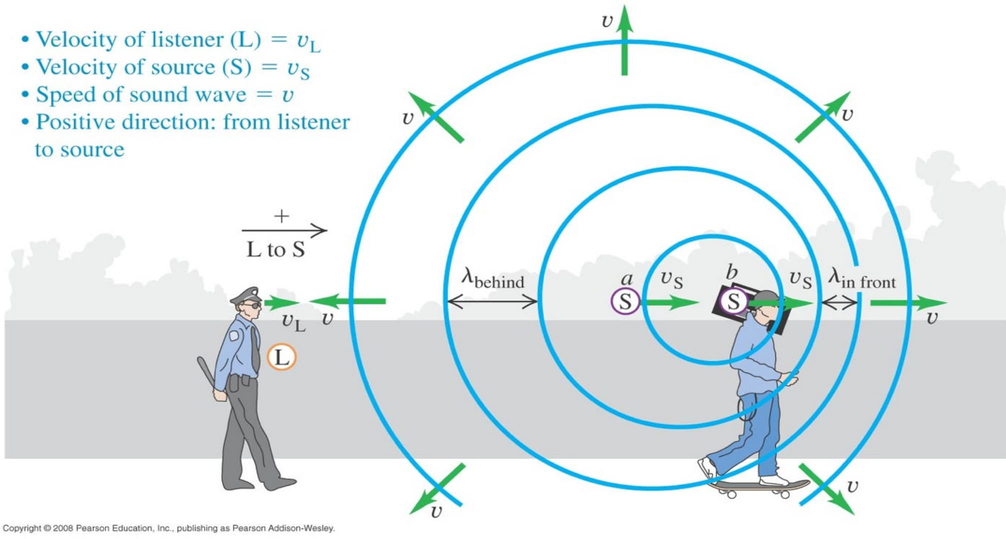
- Change in perceived frequency due to relative motion of a source (S) and listener (L)
- Case 1: Source at rest, Listener moving

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

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



Doppler Effect

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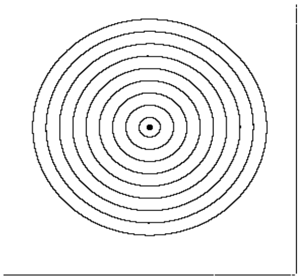
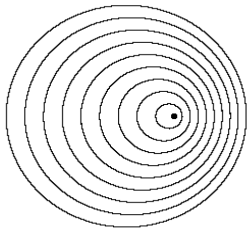


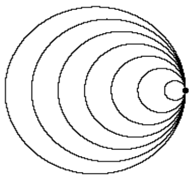
Moving Source



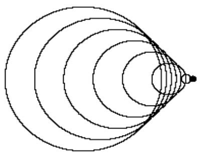
Shock Waves

What if speed of source is equal to or greater than the speed of sound?

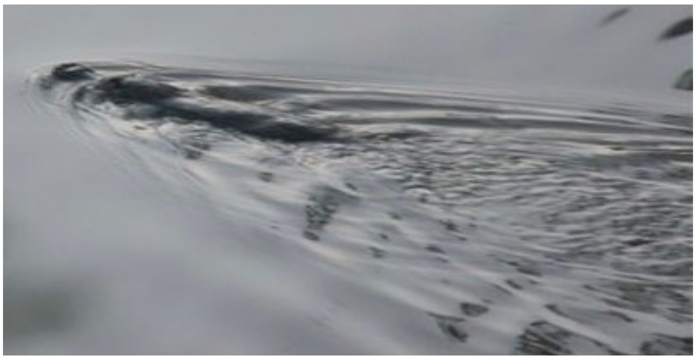
$v_S = v_{sound}$



$v_S > v_{sound}$



This is exactly analogous to the bow wave produced by a swimmer moving faster than the speed of the waves on water.



Bow wave produced by a platypus swimming

Shock Waves

F/A-18 “Hornet”

Shock Waves

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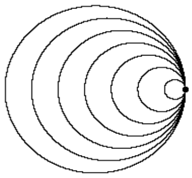
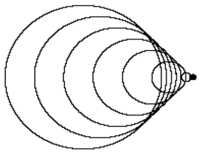
$v_S = v_{sound}$ $v_S > v_{sound}$





Shock Waves

The waves 'pile up' at surface

When that surface hits your ears, you hear very loud sound: **sonic boom**

- If $v_S > v_{(sound)}$, the surface has the shape of a cone with an opening angle α where

$$\sin\alpha = \frac{v}{v_S}$$

v_S/v is called the **Mach number**