Ch 12. Sound

I. Characteristics of Sound

Speed of sound

Depends on Propagating material

Temperature

Same for all frequencies, and $v=\lambda f$

In air, at 20ºC, v~340 m/s

Pitch

Frequency

Audible range: 20Hz - 20,000Hz

Ultrasonic: $f > 20{,}000$ Hz, Sonar

NOT

Supersonic (speed > sound speed)

Infrasonic: $f < 20$ Hz

Earthquake

Sound Intensity (Loudness)

$$\text{Intensity I} = \frac{\text{energy/time}}{\text{area}} = \frac{\text{power}}{\text{area}}, \text{ in watts/meter}^2 \, (W / m^2)$$

Intensity level: β (in dB)=10 *log* (I/I_0)

I_0=1.0x10^{-12} W/m^2, β=0, Threshold of hearing

I=1W/m^2, β=120 dB, Threshold of pain

10 dB increase in intensity ~ doubling in loudness

Log Exercise

$\log a = \log_{10} a$

if $\log a = x$, *then* $a = 10^x$

$\log a^b = b \log a$

$\log a + \log b = \log ab$

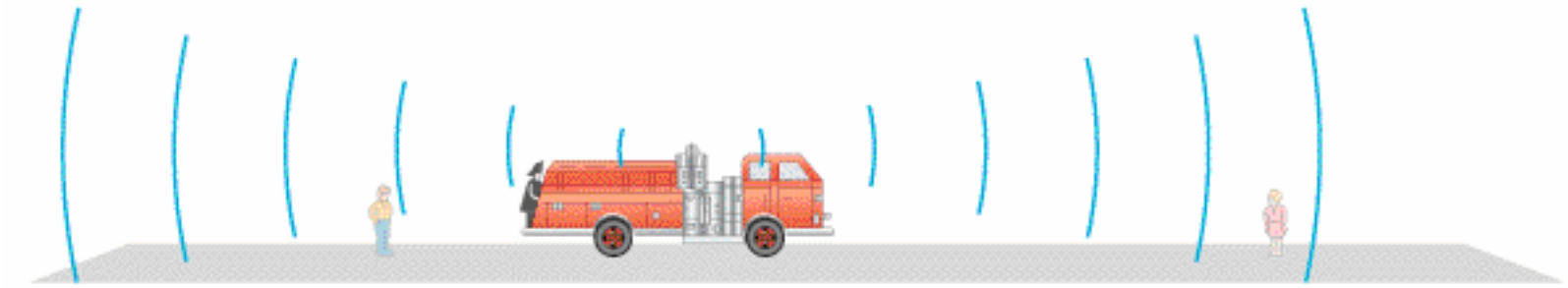
$\log a - \log b = \log (a/b)$

$\log 1 = 0$

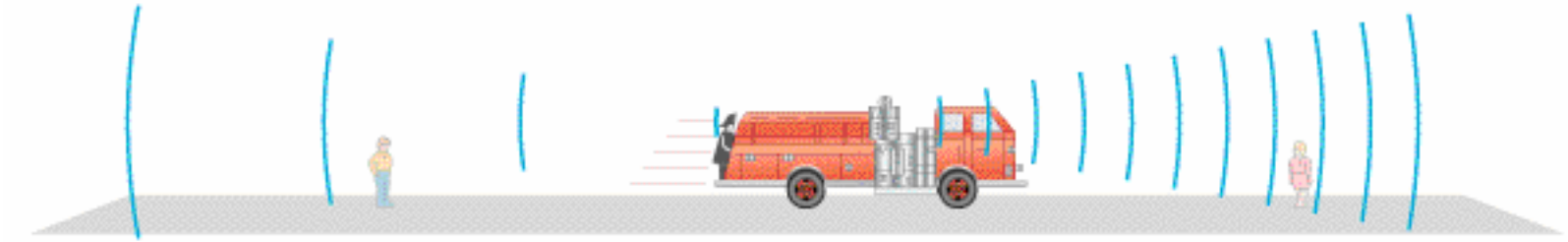
$\log 10 = 1$

$\log 100 = \log 10^2 = 2 \log 10 = 2$

II. Doppler Effect

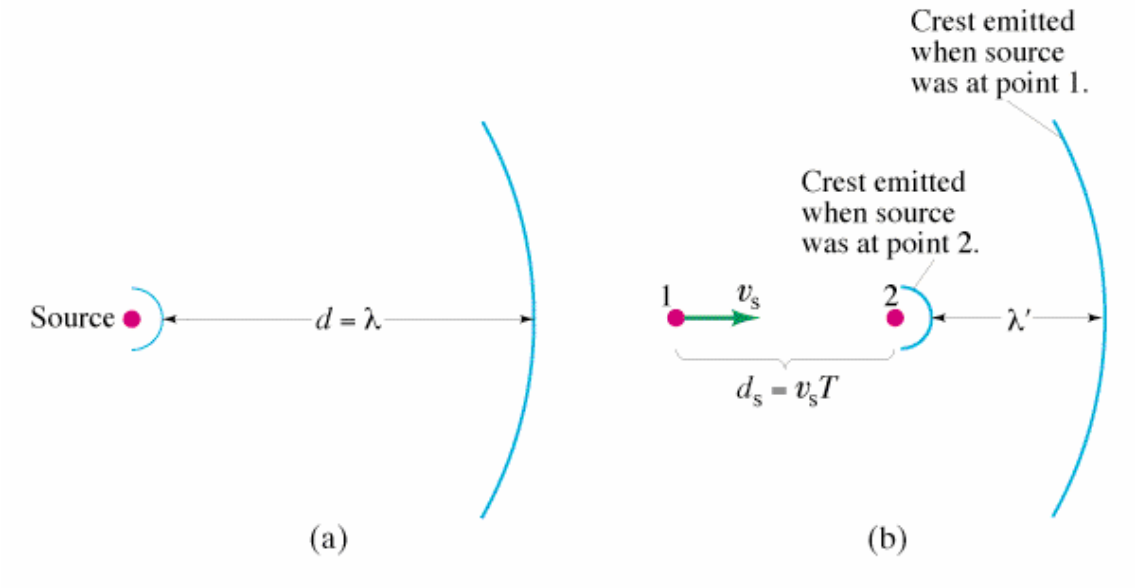


(a) At rest



(b) Firetruck moving

Source moving towards stationary observer



New $\lambda' = \lambda - v_s T$

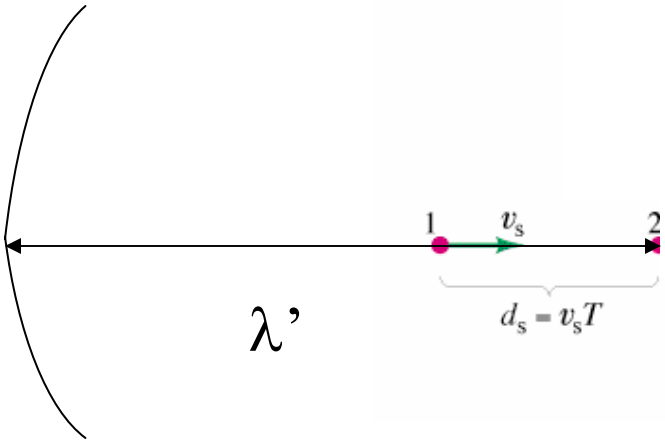
$= \lambda - v_s \lambda / v$

$= \lambda(1 - v_s / v)$

$f' = v / \lambda'$

$$f' = \frac{v}{\lambda(1-\frac{v_s}{v})} = \frac{f}{1-\frac{v_s}{v}} > f$$

Source moving away from stationary observer



New λ' $= \lambda + v_s T$

$= \lambda + v_s \lambda / v$

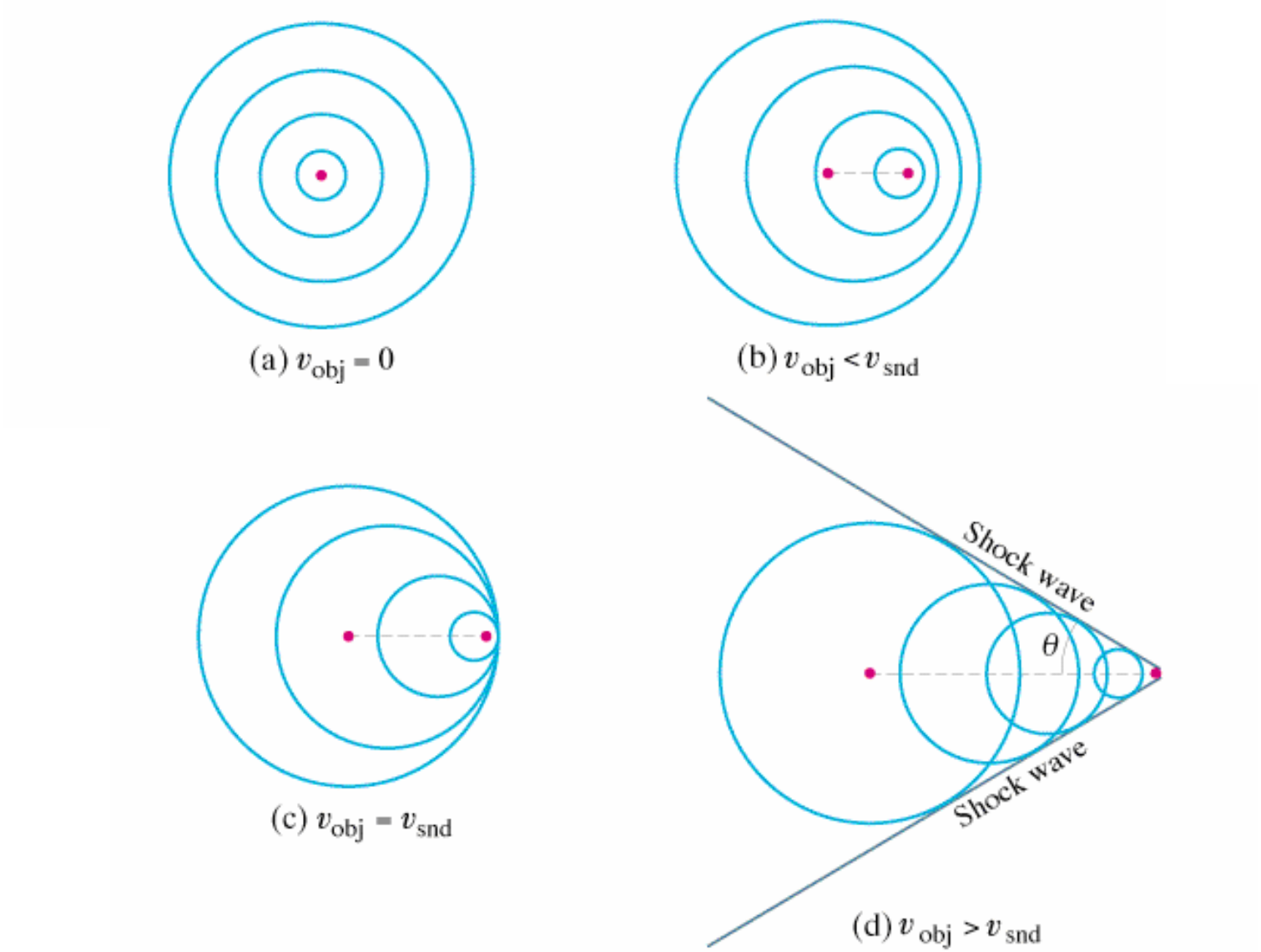
$= \lambda(1 + v_s / v)$

$f' = v / \lambda'$

$$f' = \frac{v}{\lambda(1+\frac{v_s}{v})} = \frac{f}{1+\frac{v_s}{v}} < f$$

Applications: Doppler radar, speed of blood flow, red shift of distant galaxies

III. Sonic Boom



Seeing a Sonic Boom

Credit: Ensign John Gay, USS Constellation, US Navy