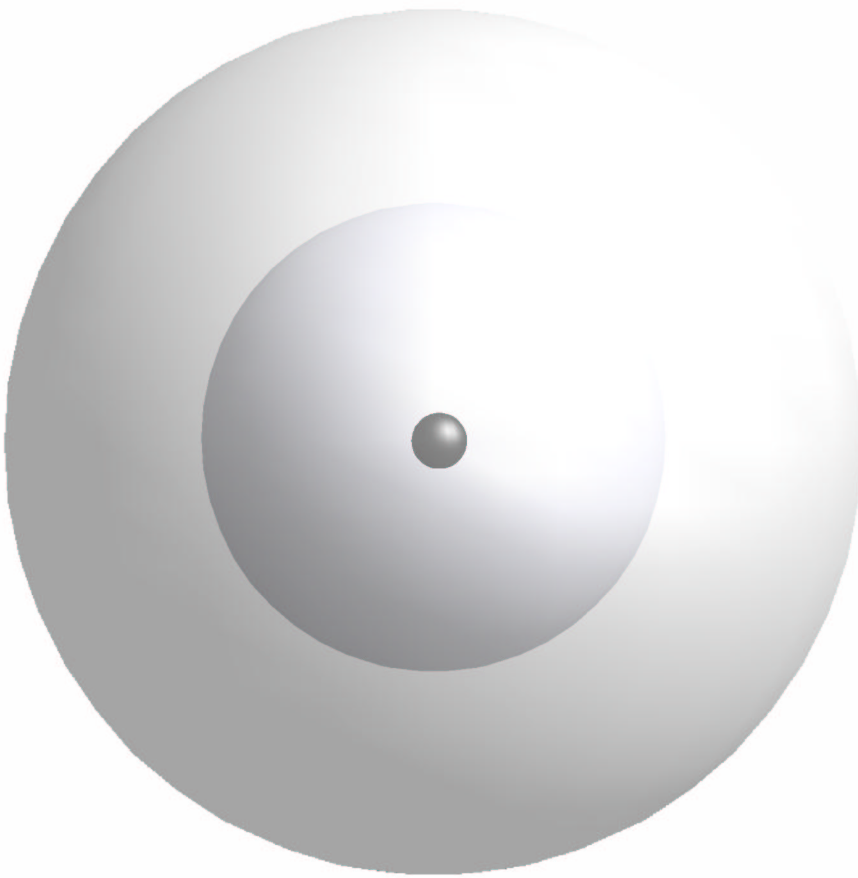
Sound Intensity



The energy transmitted by a sound wave per second is the power of the wave.
(J /s = Watts).

The intensity of the wave is the power of the wave spread over an area. The farther one is from the source, the less intense the wave is.

$$I = \frac{P}{A}$$

Measuring Sound Intensity

Sound is measured in units known as decibels. The decibel is used to compare two sound intensities by taking a ratio of one intensity to another. The intensity level β is defined mathematically as:

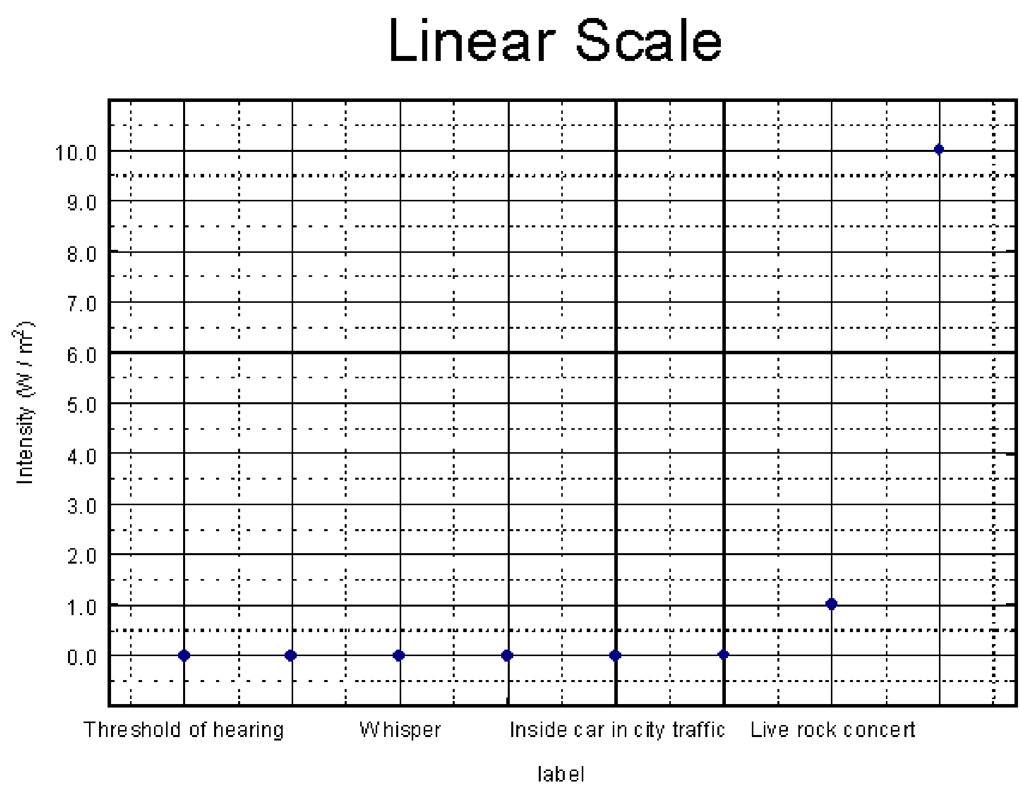
$$\beta = (10\,dB)\log\left(\frac{I}{I_o}\right)$$

where I_o is the threshold of human hearing (smallest amount of sound energy intensity detectable by the human ear) and is 1×10^{-12} W/m^2. The mathematical function log stands for logarithm to the base ten.

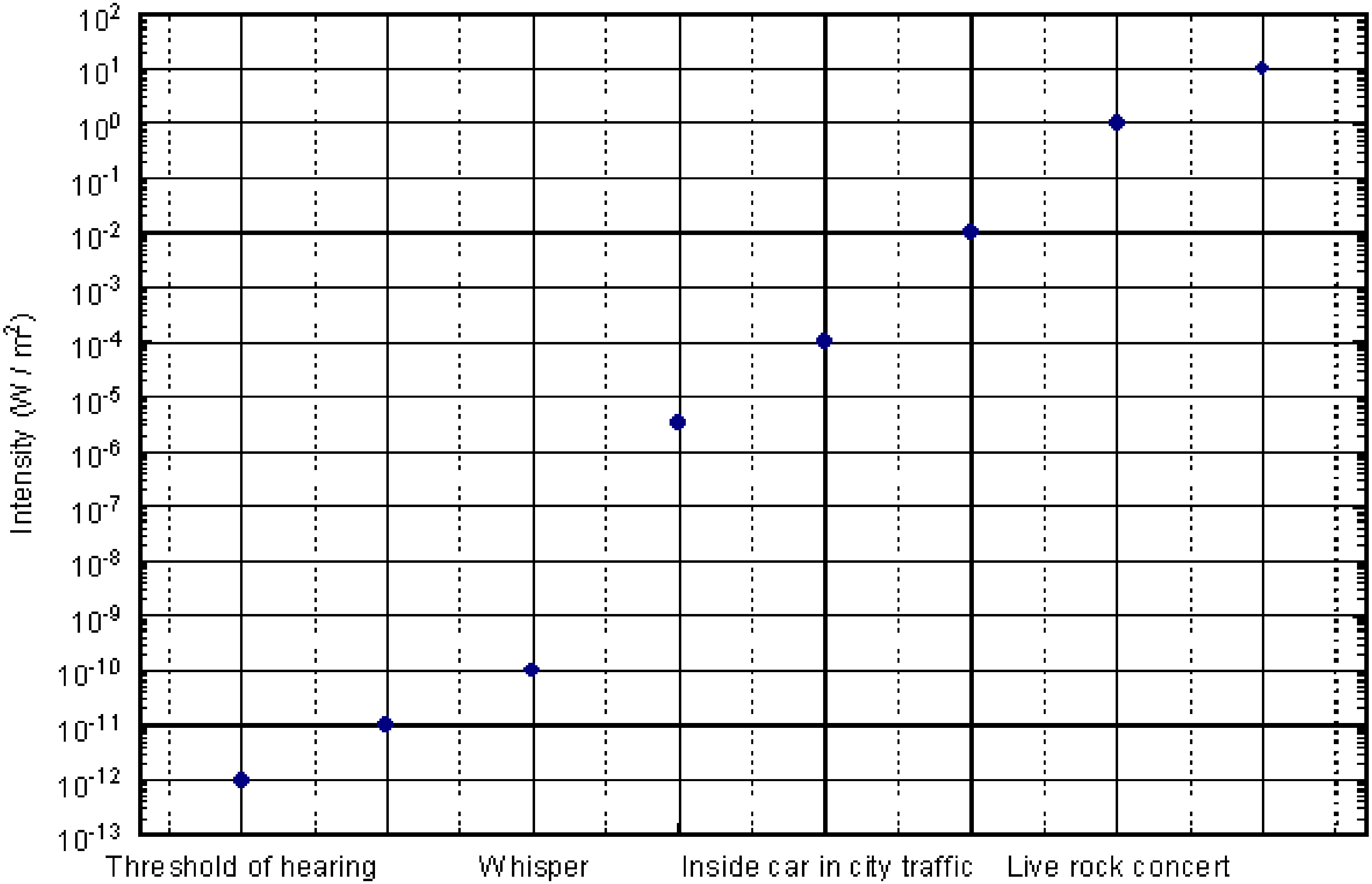
Linear Scales

Some quantities found in nature may span many decades in magnitude. A decade is a power of 10. For instance the range from 1 to 10 is one decade. Another example would be some quantity such as sound intensity which spans from 1×10^{-12} to 1×10^{2}. Let's examine table 16.2 from the book. Linear scales are poor for such a data range.

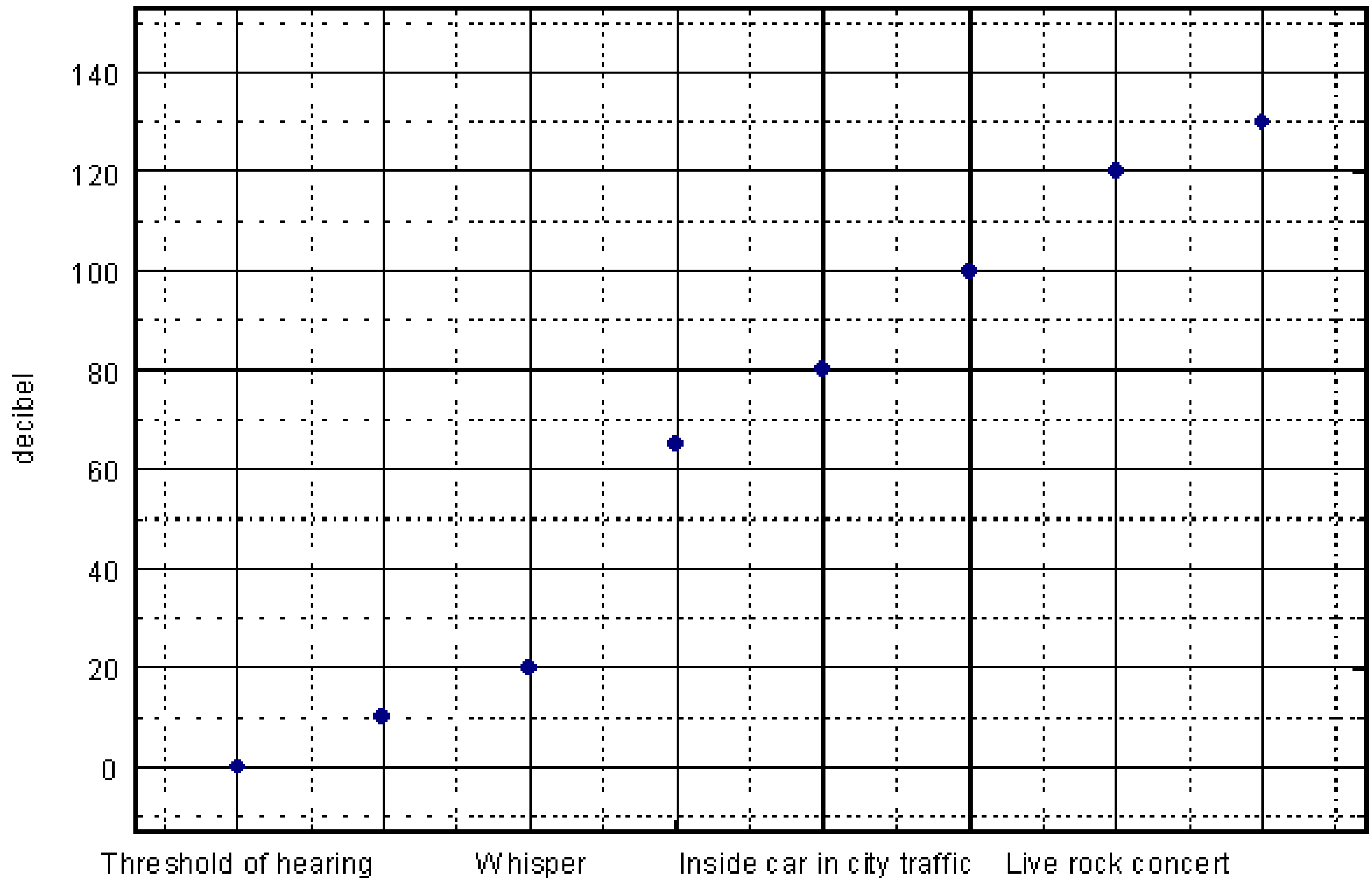
Sound	Decibel	Intensity
Threshold of hearing	0	1.00E-012
Rustling of leaves	10	1.00E-011
Whisper	20	1.00E-010
Normal conversation (1 meter)	65	3.20E-006
Inside car in city traffic	80	1.00E-004
Car without muffler	100	1.00E-002
Live rock concert	120	1.00E+000
Threshold of pain	130	1.00E+001



Log Scale

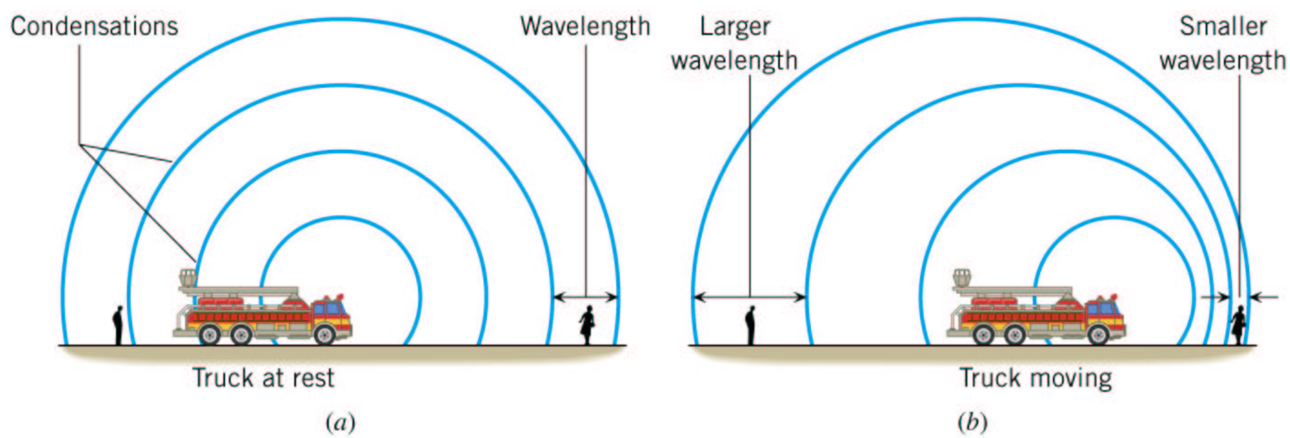

10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
Intensity (W / m^2)
Threshold of hearing
Whisper
Inside car in city traffic
Live rock concert

Decibel Scale



Doppler Effect

The Doppler effect is named after the Austrian Physicist who first described it in 1842. This phenominum occurs when an object emitting a sound is moving relative to the sound detector (either the object is moving, the detector is moving or both are moving).



Cutnell & Johnson
Wiley Publishing
Physics 5th Ed.
Figure 16.29 (W598)
C M Y K

Doppler Effect (2)

This effect occurs because the compressions of the sound carrying medium appear to be spaced closer together if the two objects are moving toward each other and appear to be spaced farther apart if the two objects are moving apart. The wavelength of the sound for each case is shown below.

$$\lambda' = \lambda - v_s T \Rightarrow \text{Source approaching the observer}$$

$$\lambda' = \lambda + v_s T \Rightarrow \text{Source moving from the observer}$$

where v_s is the velocity of the source. It can be shown that with a source moving toward the observer, the frequency of incoming sound wave is given by:

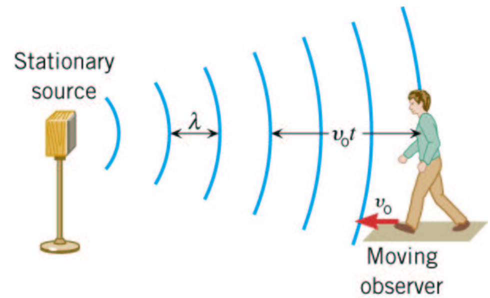
$$f_o = f_s \left(\frac{1}{1 - \frac{v_s}{v}} \right)$$

Doppler Effect (3)

If the observer is moving instead of the source of sound, it can be shown that the frequency of sound heard by the observer is given by:

$$f_o = f_s\left(1 \pm \frac{v_o}{v}\right)$$

where one would use the + sign if the observer is moving toward the stationary source and the - sign if moving away.



Cutnell & Johnson
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Physics 5th Ed.
Figure 16.31 (W600)
C M Y K

Doppler Effect (4)

The most useful equation is one where the observer, the source, or both may be moving relative to each other. This is called the general case since it does not depend on which item is moving. Mathematically this is given by:

$$f_o = f_s\left(\frac{1 \pm \frac{v_o}{v}}{1 \mp \frac{v_s}{v}}\right)$$

Notice, if either v_o or v_s are zero, the equation becomes identical to the last two equations show on the previous slides. This is part of what makes the above equation so general. Also notice if each v_s and v_o are both zero, then $f_o = f_s$!