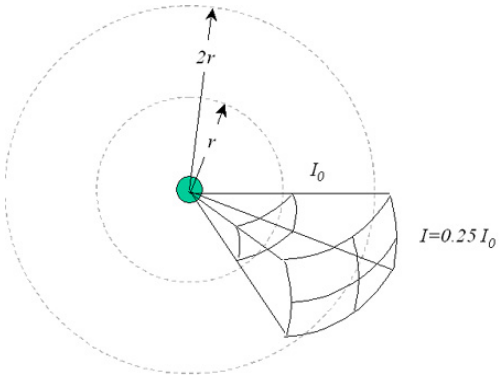
Sound Intensity

When sound is emitted, its energy spreads out in all directions. As it gets further form the source, the energy becomes more spread out. This is why the sound is not as loud. Sound intensity a measure of the amount of sound energy per second per square meter at a given point.



sound intensity --> $J/s/m^2$
$=W/m^2$

Sound intensity is different from loudness (or volume) because loudness is subjective. A sound can be very intense, but impossible to hear.

Sound Intensity Scale

Sound intensities vary quite a bit. For example, the sound intensity of a person whispering 2 m away is about 10^{-10} W/m^2. A slightly louder sound, say a normal conversation between 2 people, is 1000 times more intense (10^{-6} W/m^2). A loud rock concert can reach up to 1 W/m^2 (10 billion times more intense than the whisper.)

When numbers rise so rapidly, a linear scale does not work very well. We use a logarithmic scale. In this case, we use the concept that a change in 1 bel or 1 B represents a change in intensity of 10 times. Note that 1 B = 10 dB. We often call this the decibel system.

For example, an increase in 50 dB (or 5 B) represents a sound that is 10^5 times more intense. (100 000x).

Try these: 1) A sound has an intensity of 60 dB. What is its intensity in dB if it is 1000 times less intense? 10^3 30 dB

2) How many times more intense is a 75 dB sound than a 15 dB sound?

$\Delta B = 75\ dB - 15\ dB$

$= 60\ dB$

$= 6\ B$

$\Delta I = 10^6$

$= 1\,000\,000\ x$

3) What dB increase represents a sound that is 5000 times more intense.

$5000 = 10^x$

$\log 5000 = x \log 10$ ($\log 10 = 1$)

$x = 3.69$ or 36.9 dB

4) How much less intense is a 43 dB sound than a 88 dB sound?

$\Delta\beta = 88 - 43$

$= 45$ dB

$= 4.5$ B

$\Delta I = 10^{4.5}$

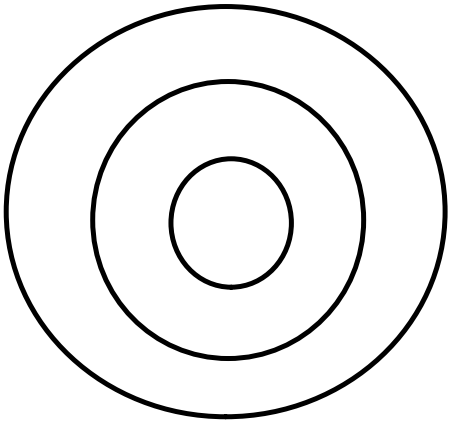
$= 31\,000\ x$

dB Supplementary Questions

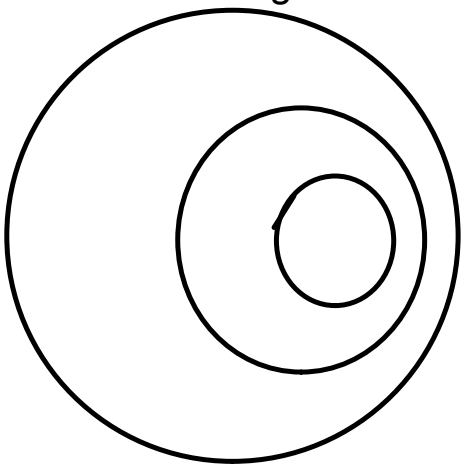
1. Determine the change in dB if a sound is 340 000 times less intense.
2. How much more intense is a 67 dB sound than a 0 dB sound?
3. You are at a rock concert, and find yourself too close to the speaker. The sound intensity where you are is 120 dB. You move 10 times further away from the speaker. What is the new dB level where you are now standing? (This is a tricky question. Refer to the diagram on page 4 for a hint.)

The Doppler Effect

When a stationary object emits sound, the wave spreads out evenly in all directions.
(The circles in the diagram below represent a wave front: the location of a common point in a wave, say its crest, at a given time.)



Now lets consider a moving source...

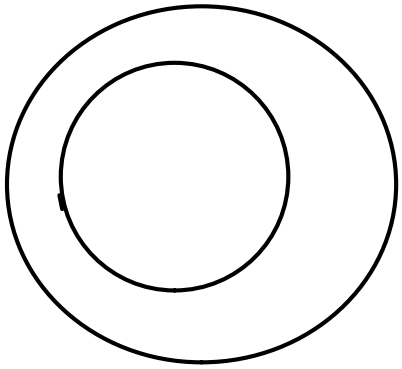


Notice that the wavelengths appear to be smaller in the direction that the source is moving and larger in the direction that the source is moving away from.

Approaching... ___ is getting smaller, so f is getting _____

Receding... ___ is getting larger, so f is getting _____

Doppler Effect Equation



Example

A siren has a frequency of 1200 Hz. What frequency is heard by child on the side of the road if the siren is approaching at 90 $\frac{km}{h}$? (Assume an air temperature of 20°C.)

$$f = f_0\left(\frac{V}{V \pm V_s}\right)$$

$\frac{8}{-25}$

1

After you have done the hit-list questions in the textbook, try this one...

As an ambulance drives by you, its frequency appeared to change by 10%.
a) Did the frequency go up or down?
b) Determine the speed of the ambulance.

$T = 20^{\circ}C$