<u>Grade 11 Notes May 25-29, 2020</u>

Hope you are well and enjoyed the beautiful weather this past weekend. Hopefully, you are keeping up with all your school work.

This week we are going to continue our investigation of sound energy looking at

1. **The Decibel Scale**
2. **The Doppler Effect**

Remember there is assignment due this week on Wednesday. I will be sending out a new assignment Thursday this week. Questions email me.

Have a good week.

Miss Takken

Impolite as they were, the other bears could never help staring at Larry's enormous deer gut.

1. The Decibel Scale

Last week we learned about intensity which is measured in W/m^2. Intensity levels go from about 1×10^{-12} W/m^2 (which is called the threshold of hearing) to 1 W/m^2. This is a very large range and isn't easily comprehended. So another, logarithmic, scale was create to make it more understandable. This is the Decibel Scale. We are going to learn how to put intensity into decibels and decibels back into intensity.

Commercial	Industrial	Residential	dB Level
Threshold For Hearing			0
Good Recording Studio		Breathing	10
		Rustling Leaves	15
		Whisper, Mosquito	20
Library		Living / Dining Room	30
Refrigerator Hum		Kitchen / Bathroom	40
Quiet Office	Power Lawn Mower	Home Office	50
		Birds at 10'	55
Conversational Speech			60
Piano Practice		Electric Shaver	60
Business Office		Piano Practice	65
Noisy Restaurant	Inplant Office	Street Traffic	70
Chamber Music		Barking Dog	75
Classroom		Alarm Clock	75
		Television / Dishwasher	75
Airplane at 1 mile	Manual Machines	Vacuum Cleaner	80
Reception / Lobby Area	Handsaw	Garbage Disposal	85
Motor Bus		Telephone Dial Tone	85
Applause in Auditorium		Lawn Mower	85
OSHA Required Hearing Protection in Factory			85
Teleconference Room		Train at 100'	90
Subway	Farm Tractor	Teenage Stereo	90
Sustained Exposure May Cause Hearing Loss			90
Music Practice Room	Electric Drill	Walkman at 5/10	94
French Horn	Average Factory Noise	Blender	100
Orchestra	Diesel Truck	Motorcycle	105
Computer Room	Printing Press	Train	105
Bass Drum	Heavy Truck	Power Saw	110
Dog Kennel	Power Mower	Baby Crying	110
Symphony Orchestra	Punch Press	Squeeky Toy to Ear	110
Pain Begins			120
Disco	Sandblasting	Shot Gun	120
Cymbal Crash	Pneumatic Clipper	Air Raid Siren	130
Dragcar Racing	Military Jet	Shotgun	140
Rock Concert	Aircraft Carrier Deck	Jet Takeoff	140
Chest Wall Begins to Vibrate			150
Ear Drum Breaks Instantly			160
Death of Hearing Tissue			180
Loudest Possible Sound			194

First let's discuss the logarithmic scale. In logarithms the number represents the exponent of the power of 10.

i.e. $x = 10^y$ $\therefore y = \log_{10}x$

Locate the log button on your calculator and try to find the log of 1. log1 = 0. If you get zero you did it right. This is because $10^0 = 1$. Now try log100. You should get 2 because $10^2 = 100$.

The other thing to know is that the decibel scale of sound is always related to the threshold of hearing **1×10^{-12} W/m²** which is the lowest sound possible to hear. Think quiet. This is 0 dB! We call the threshold of hearing **I_o** in symbol form.

The formula to calculate intensity into decibels is given by

$\beta = 10\log(I/I_o)$ where β is the value of the decibels in dB, **I** is the intensity we are trying to convert in W/m^2 and **I_o** is the threshold of hearing.

Example: Find the decibel level of 3.16×10^{-4} W/m^2.

$\beta = 10\log(I/I_o)$	
$\beta = 10\log(3.16\times10^{-4}/1\times10^{-12})$	do brackets first
$\beta = 10\log(3.16\times10^{8})$	log the value in the bracket
$\beta = 10\times8.499$	multiply by 10
$\beta \sim 85$ dB	

Now if we want to reverse the process we need to rearrange the formula

$\beta = 10 \log(I/I_o)$ to **$I = I_0 \times 10^{(\beta/10)}$**

Example: What is the intensity level of an 76 dB sound?

$I = I_0 \times 10^{(\beta/10)}$

$I = (1\times10^{-12})(\ 10^{(76/10)})$ **do bracket first**

$I = (1\times10^{-12})(\ 10^{7.6})$ **add exponents**

$I = 1\times10^{-4.4}$ **use the 10^x button on your calculator (by the log button) to find the exponent. Then multiply by 1.**

$I = 3.98\times10^{-5}\ W/m^2$

Now you try pg 458 # 3 and pg 476 # 57, 58

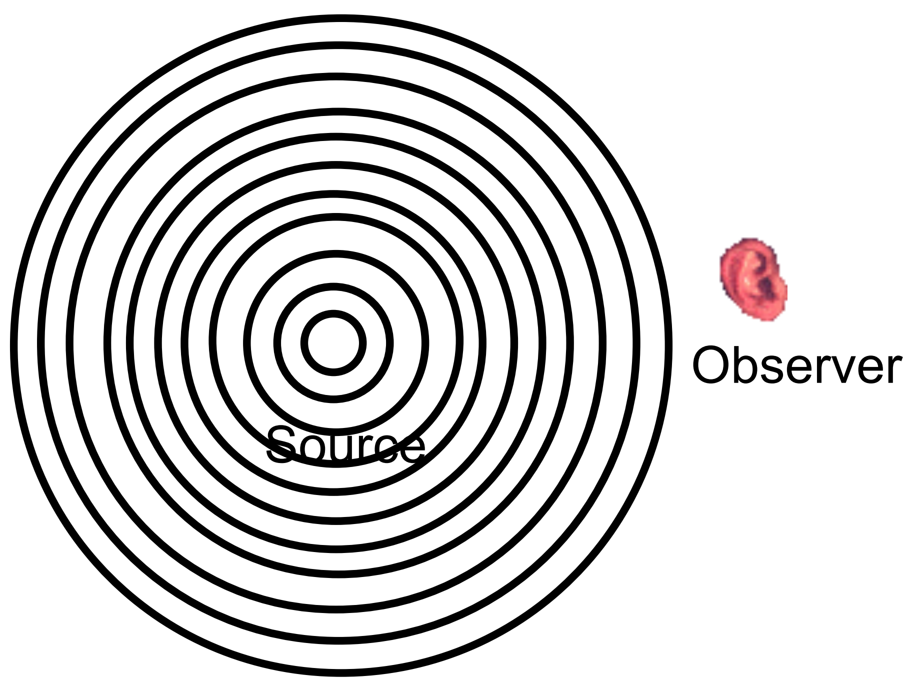
2. The Doppler Effect

The doppler effect is the "apparent" change in the frequency of a sound (or any energy type) due to the movement of the source relative to the observer.
(The frequency does not actually change at the source only the observer's perception of the frequency changes).

This effect only occurs for speeds less than Mach 1.

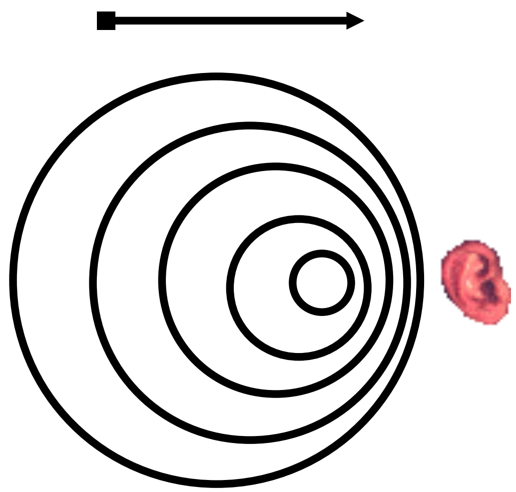
This effect explains why the noise made by the siren of an ambulance seems to change frequency as it passes us by.

Case 1: Stationary Source



The sound waves move out symmetrically. The observed frequency and wavelength are constant. The sound frequency does not change.

Case 2: Moving Source (Approaching)



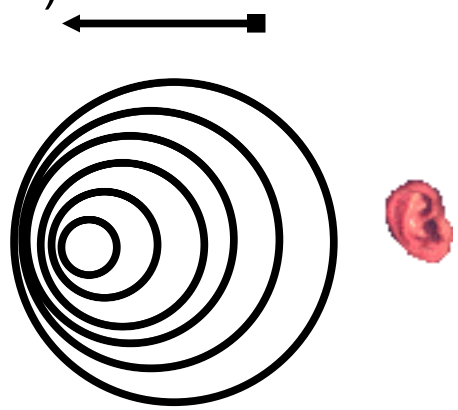
As the object (source of sound) approaches the sound waves seem to have a higher frequency. (f increases, λ decreases)

So here you can see how the Doppler Effect works. Look carefully at the disturbances arriving at your ear. Because the source is moving towards your ear, the spacing between the disturbances is smaller than if the source was not moving. This smaller spacing means the disturbances will arrive at your ear more often than they would if the speaker was not moving at all. Arriving more often means you'll hear a higher frequency. And this is a "rule of thumb" about the Doppler Effect:

A listener will hear a higher frequency when the source of sound is moving towards them.

Case 2: Moving Source (Departing)

Sound waves seem to have a lower frequency as it departs. (f decreases, λ increases)



So here you can see how the Doppler Effect works. Look carefully at the disturbances arriving at your ear. Because the source is moving away from your ear, the spacing between the disturbances is larger than if the source was not moving. The larger spacing means the disturbances will arrive at your ear a bit less often than they would if the source was not moving at all. Arriving less often means you'll hear a lower frequency. And this is a "rule of thumb" about the Doppler Effect:

> **A listener will hear a lower frequency when the source of sound is moving away from them.**

The formula for the Doppler Effect is

$$f_2 = \frac{v_s f_1}{v_s \pm v_0}$$

where f_2 is the apparent frequency of the sound in Hz, f_1 is the actual frequency in Hz, v_s is the speed of sound in air ($v_s = 332+0.6T$) in m/s and v_o is the speed of the object in m/s.

This is actually two equations in one. The ± gives us two answers. Use the + when the object is departing and the - when the object is approaching.

Example: Miss Takken is approaching a student at a speed of 100 km/h while sounding her horn (late lab again!). Calculate the apparent frequency of the horn heard by the student if the sound frequency is 500 Hz. Assume the speed of sound is 344 m/s on this particular day.

First change the 100 km/h to m/s by dividing by 3.6. $v_o = 100/3.6 = 27.8$ m/s

$$f_2 = \frac{v_s f_1}{v_s \pm v_0}$$

$$f_2 = \frac{344(500)}{344-27.8}$$

Use the - as the object is approaching

$f_2 = 172000/316.2$

$f_2 \sim 544$ Hz

So the student will hear 544 Hz even though it really is 500 Hz.

Now you try pg 463 # 1 and pg 476 # 64-71