## **Bell Ringer**

- Microwaves have a frequency of 300 x 10<sup>6</sup> Hz. If the speed of light is 3x10<sup>8</sup> m/s, what is the wavelength of a microwave?
- X-rays have a wavelength of 1 x 10<sup>^</sup>-9 meters. What is their frequency?

## What happens to waves?

- Reflection
- Refraction
- Diffraction

## Law of Reflection

The angle of the reflected wave will always equal the angle of the incident (approaching) wave.



#### **One-way mirrors**

https://www.youtube.com/watch?v=4kKL320pewI

## Practice – Using law of Reflection

How far back from the mirror does Jimmy need to move in order for him to see his entire reflection?



He'll NEVER be able to see his whole self..... Unless he buys a bigger mirror!



# When a wave bends (slows down) because of a change in medium.









https://www.youtube.com/watch?v=Pd-MpXCMcIs

## Snell's Law



#### $n_1\sin(\theta_1) = n_2\sin(\theta_2)$

#### n is the index of refraction

$(f = 5.09 \times 10^{14} \text{ Hz})$		
or		
$\lambda = 5.9 \times 10^{-7} \text{ m})$		
Air	1.00	
Canada Balsam	1.53	
Corn oil	1.47	
Diamond	2.42	
Ethyl alcohol	1.36	
Glass, crown	1.52	
Glass, flint	1.66	
Glycerol	1.47	
Lucite	1.50	
Quartz, fused	1.46	
Sodium chloride	1.54	
Water	1.33	
Zircon	1.92	

#### Practice

Jane is shooting a Laser at Jimmy who is attempting to swim away in the ocean. What does the index of refraction of the water need to be so that she can slow roast Jimmy?













## **Double Slit Diffraction**





## Sound - Doppler Effect





#### https://www.youtube.com/watch?v=Q30ItpVa9fs



# Sound is a compression (longitudinal) wave produced by any vibrating object!

Acoustic Longitudinal Wave



#### Speed of Sound

All sound frequencies travel at the same speed in the same medium

We'll use 340 m/s in air for all problems unless they say otherwise

$$v = \lambda f$$

Because the speed of sound is a constant, you can always find either the frequency or wavelength of a sound wave as long as you know the other

Substance	Temp (°C)	Speed (m/s)
Gases		
Carbon Dioxide	0	259
Oxygen	0	316
Air	0	331
Air	20	343
Helium	0	965
Liquids		
Chloroform	20	1004
Ethanol	20	1162
Mercury	20	1450
Water	20	1482
Solids		
Lead	-	1960
Copper	-	5010
Glass	-	5640
Steel	-	5960

#### Practice

Jimmy is stepping on the tails of stray cats to find out how far away a nearby cliff is. If the howls of the stray cats take 5 seconds to return, how far away is the cliff?



## **Range of Human Hearing** We can hear frequencies between 20 hz and 20, 000 hz How is energy carried in a sound wave? The AMPLITUDE or the volume **ULTRA SOUND INFRA SOUND** over 20,000 Hz 20 Hz to 20,000 Hz below 20 Hz





#### Decibels

# This is how we measure the loudness of a sound and their intensities

To compare decibel levels 140 **Painful Acoustic Trauma** Shotgun blast and sound intensities we use 130 Jet engine 100 feet away 120 a logarithmic base ten scale Rock concert 110 Extremely Loud Car horn, snowblower 100 Blow druer, subway, helicopter, chainsaw 90 Motorcycle, lawn mower, convertible ride on highway 80 Very Loud Factory, noisy restaurant, vacuum, screaming child 70 Loud Car, alarm clock, city traffic For example if you are From 30 you 60 Conversation, dishwasher comparing the loudness of a had to add 10 50 erate Moderate rainfall 3 times to whisper to a conversation, 40 Faint Refrigerator get to 60 start by comparing their 30 Whisper, library So the sound is decibel levels. 20 Watch ticking 1,000 louder dB levels



#### Resonance

- Some materials vibrate with greater amplitudes at different frequencies.
- E.g. where in a swinging person's path would you want to push them to get them to go higher?
- Certain frequencies will transfer energy at just the right time to create series of constructive interference.
- <u>https://www.youtube.com/watch</u> <u>?v=Oc27GxSD\_bI</u>
- <u>https://www.youtube.com/watch</u>
  <u>?v=nFzu6CNtqec</u>



## **Bell Ringer**

- 1. How many times louder is 100 decibels than 30?
- 2. You see lightning in the distance and instantly start counting the time before you hear the thunder, which ends up being 7 seconds. How far away was the lightning strike?



https://www.youtube.com/watch?v=wrzWAox8NCM

#### **Change in Frequency**

What is happening to the wavelength?

Higher Frequency

Shorter

Lower Frequency

Longer **A** 

What does that mean about the frequency? <u>https://www.youtube.com/watch?v=8WgSQlRymwE</u> <u>Shorter  $\lambda$  means a **higher frequency** and <u>Longer  $\lambda$  means **lower frequency**!!</u> What happens as you move faster? <u>https://www.youtube.com/watch?v=dC4Lp7k4zrI</u></u>

#### **Doppler Equation**



#### Practice

Jane is running down the street screaming at Jimmy. What frequency does Jimmy hear if Jane's scream is 12,000 hz and she is running towards him at 23 m/s?



#### Practice

How fast would Jane need to be running for the sound to <u>be outside of Jimmy's range of hearing?</u>

Qr -





Sonic Boom

#### When an object is traveling faster than sound:

https://www.youtu be.com/watch?v=6 B4IVcCuIZE When the train blew its whistle, you could hear it before it reached you. Could you hear a fighter jet before it reaches you?

# Do you think you'd hear a sonic boom in the cockpit?

- https://www.youtube.com/watch?v=gA8x-CfqgYA
- What happens to the observed frequency when the source travels at the speed of sound?

$$f_{obs} = f_{source} * \frac{v_{sound}}{v_{sound} \pm v_{source}}$$