## Bell Ringer

- Microwaves have a frequency of $300 \times 10^{\wedge} 6 \mathrm{~Hz}$. If the speed of light is $3 \times 10^{\wedge} 8 \mathrm{~m} / \mathrm{s}$, what is the wavelength of a microwave?
- X-rays have a wavelength of $1 \times 10^{\wedge}-9$ 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!

## Refraction

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




Like shooting a fish in a barrel?


## $n_{1} \sin \left(\theta_{1}\right)=n_{2} \sin \left(\theta_{2}\right)$

## Snell's Law

## n is the index of refraction



| $\left(f=5.09 \times 10^{14} \mathrm{~Hz}\right.$ |  |
| ---: | ---: |
| or |  |
| $\left.\lambda=5.9 \times 10^{-7} \mathrm{~m}\right)$ |  |
| 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?



$$
n_{1} \sin \left(\theta_{1}\right)=n_{2} \sin \left(\theta_{2}\right)
$$

$$
1 * \sin (35)=n_{2} \sin (15)
$$

$$
n_{2}=2.216
$$

# Diffraction 

The tendency of waves to bend around corners and fill spaces.



## Double Slit Diffraction

 the slits!!!

[^0]

Longitudinal Waves


Rarefaction

## Sound - Doppler Effect $<\sqrt{2} \operatorname{syy} y$ <br> 

- https://www.youtube.com/watch? v=Q3oItpVagfs



## Sound Waves

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 mediumWe'll use $340 \mathrm{~m} / \mathrm{s}$ in air for all problems unless they say otherwise

$$
v=\lambda f
$$

| Substance | Temp ( $\left.{ }^{\circ} \mathrm{C}\right)$ | Speed (m/s) |
| :--- | :---: | :---: |
| Gases |  |  |
| Carbon Dioxide | 0 | 259 |
| Oxygen | 0 | 316 |
| Air | 0 | 331 |
| Air | 20 | 343 |
| Helium | 0 | 965 |
|  |  |  |
| Liquids | 20 | 1004 |
| Chloroform | 20 | 1162 |
| Ethanol | 20 | 1450 |
| Mercury | 20 | 1482 |
| Water |  |  |
|  |  |  |
| Solids | - | 1960 |
| Lead | - | 5010 |
| Copper | - | 5640 |
| Glass | - | 5960 |
| Steel |  |  |

## 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?

## D

$$
v=2 D / t
$$

$$
D=340 * 5 / 2
$$

$340=2 D / 5$

$$
D=850 m
$$

## Range of Human Hearing

We can hear frequencies between

## 20 hz and $20,000 \mathrm{hz}$

How is energy carried in a sound wave?
The AMPLITUDE or the volume
INFRA SOUND
ULTRA SOUND
over $20,000 \mathrm{~Hz}$ below 20 Hz
nil



Propagation of
sound

$$
\underset{A}{A}
$$

## Decibels

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



## 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.
- https://www.youtube.com/watch ? $\mathrm{v}=\mathrm{Oc} 27 \mathrm{GxSD}$ bI
- https://www.youtube.com/watch ? v=nFzu6CNtqec


## 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?


## The Doppler Effect

 The apparent change in frequency due to the movement of objects
## Doppler simulation

Stationary Source
Moving Source

## Change in Frequency

What is happening to the wavelength?


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

## Doppler Equation



Use:

+ if the objects are getting farther apart
- if the objects are getting closer together


## Practice

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


## Practice

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


$$
\begin{array}{l|l|l}
f_{\text {obs }}=f_{\text {source }} * \frac{v_{\text {sound }}}{v_{\text {sound }} \pm v_{\text {source }}} & \begin{array}{l}
\frac{20,000}{12,000}=\frac{340}{340-v}
\end{array} \begin{array}{l}
\frac{12,000}{20,000} * 340=340-v \\
20,000=12,000 * \frac{340}{340-v}
\end{array} & \begin{array}{l}
12,000 \\
20,000
\end{array}=\frac{340-v}{340}
\end{array} \begin{array}{r}
\left(\frac{12,000}{20,000} * 340\right)-340=-v \\
v=136 \mathrm{~m} / \mathrm{s}
\end{array}
$$

## Super Sonic

## When an object is traveling faster than sound:



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? <br> - https://www.youtube.com/watch?v=gA8x-CfqgYA

- What happens to the observed frequency when the source travels at the speed of sound?

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


[^0]:    https://www.youtube.com/watch?v=Iuv6hY 6zsdo

