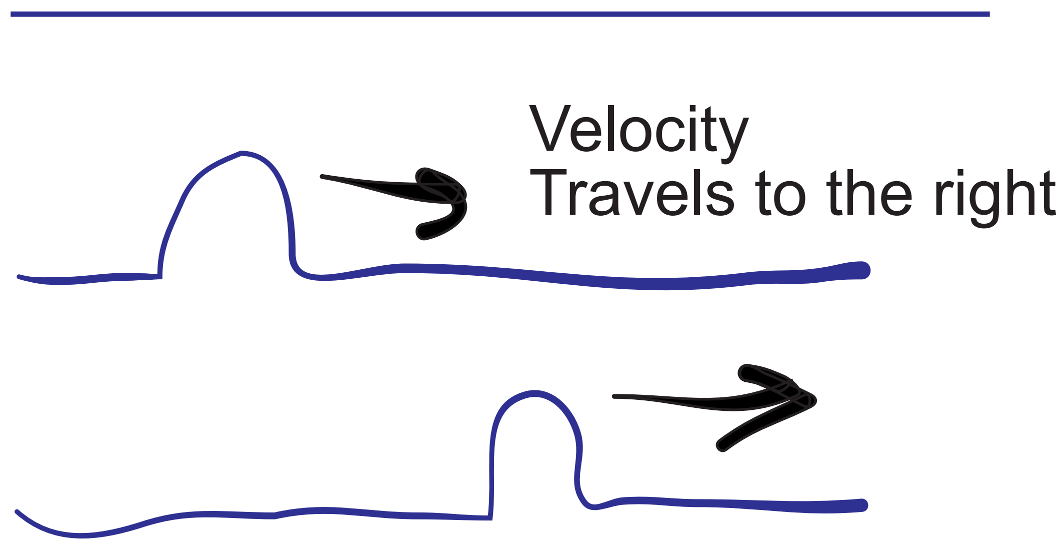
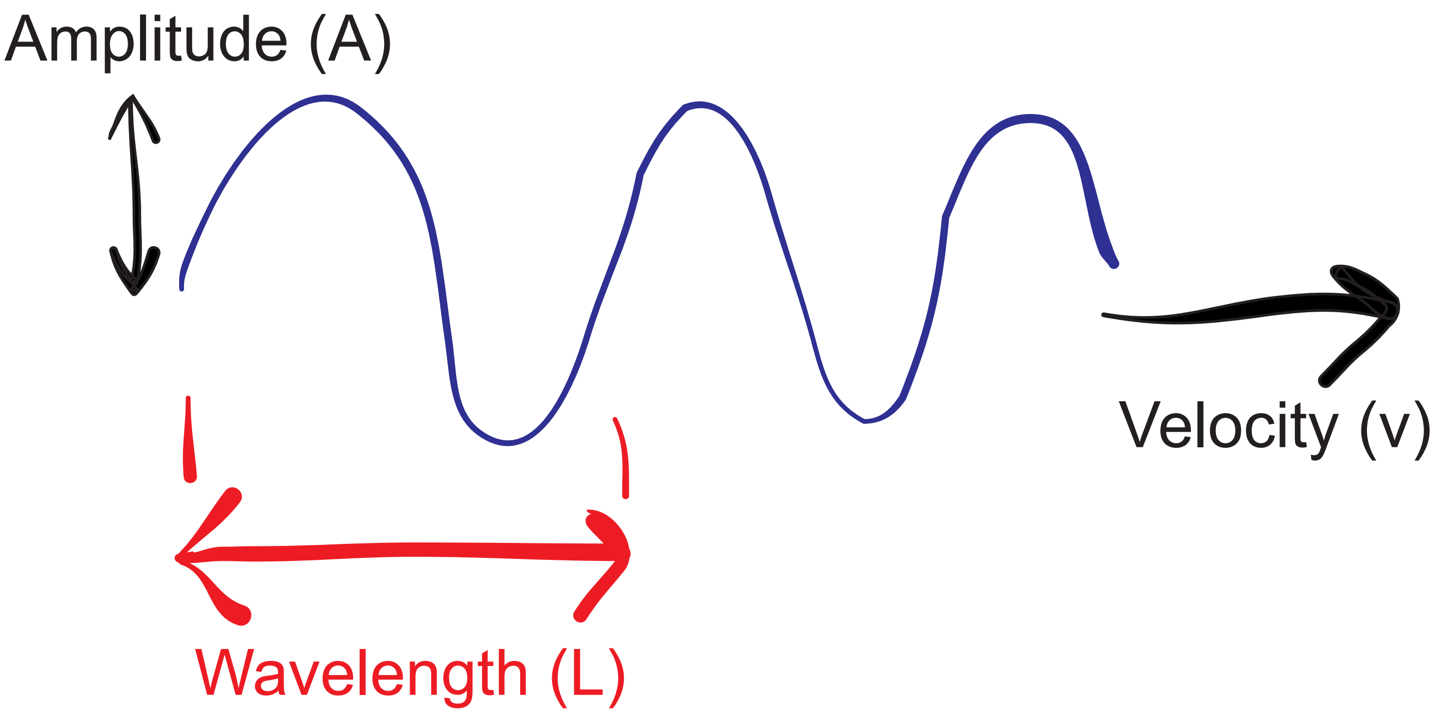
Travelling Waves

Pulse on a string



Can have a wave travelling down
the string
OR
can have a standing wave

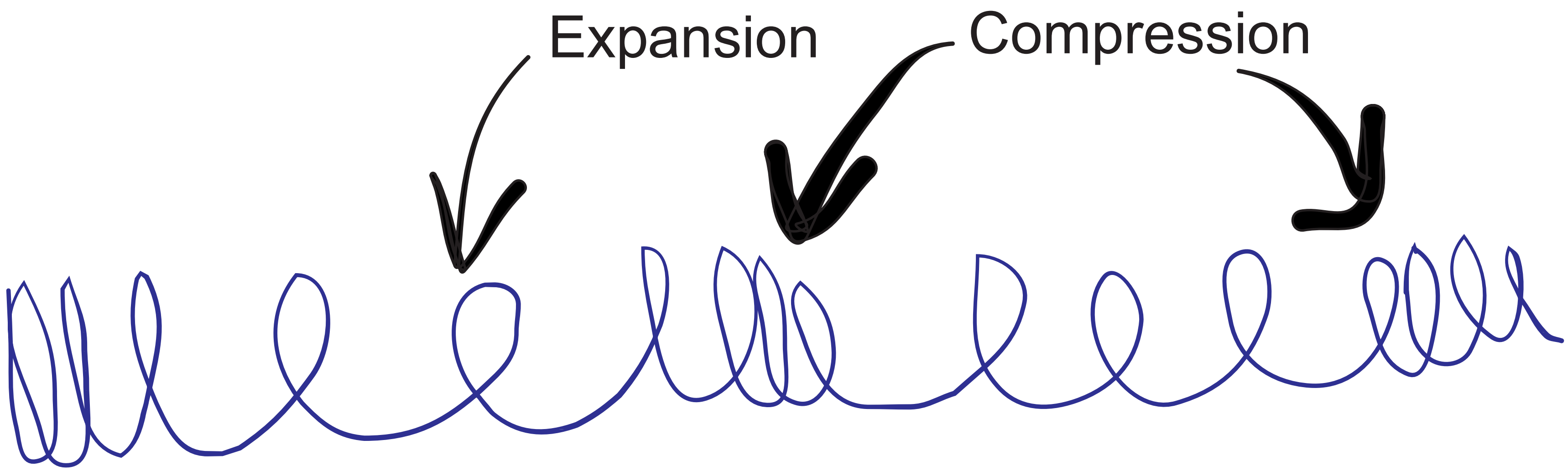
Transverse Oscillations

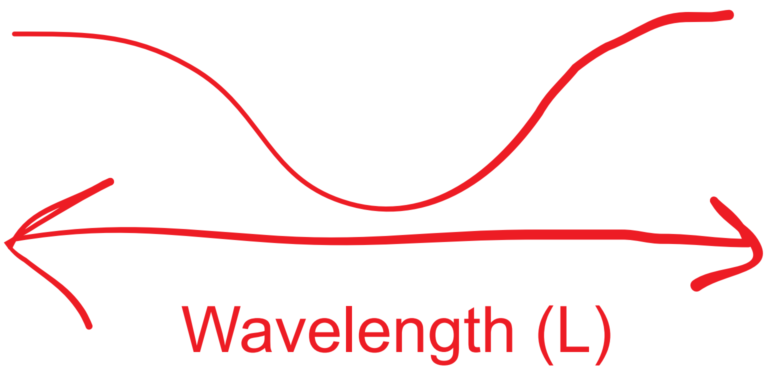


String moves up and down
forming a wave that travels along the string.

Similar to waves in the ocean

Longitudinal Oscillation





Sound is an example of this type of wave

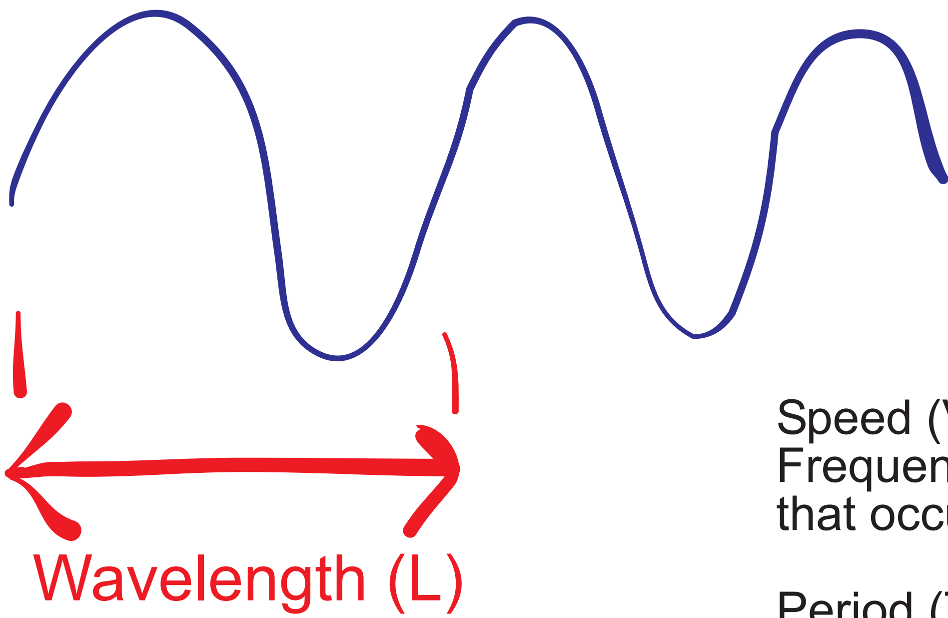
Regions of low pressure and high pressure

Pressure is a force exerted over an area.

Pressure = Force divided by Area

Strong force on a large area has same pressure as weak force on a small area

Speed of a wave

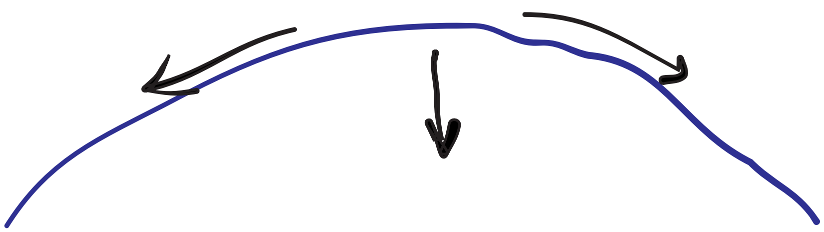


Speed (V)
Frequency (f) The number of oscillations that occur in a second

Period (T) The time it takes for one oscillation to occur

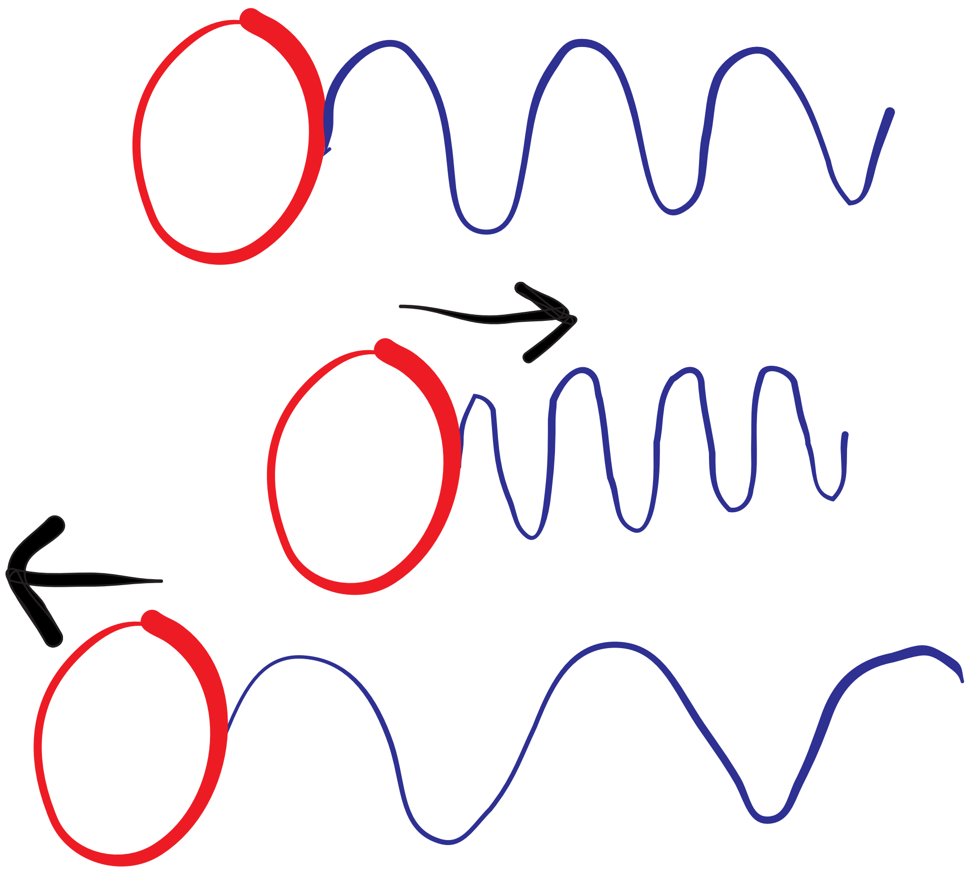
Speed of travelling wave = Frequency x Wavelength

$V = L \times f$



Why does string move up and down?
Restoring force from tension in the string

Doppler Effect
Change in Train Whistle



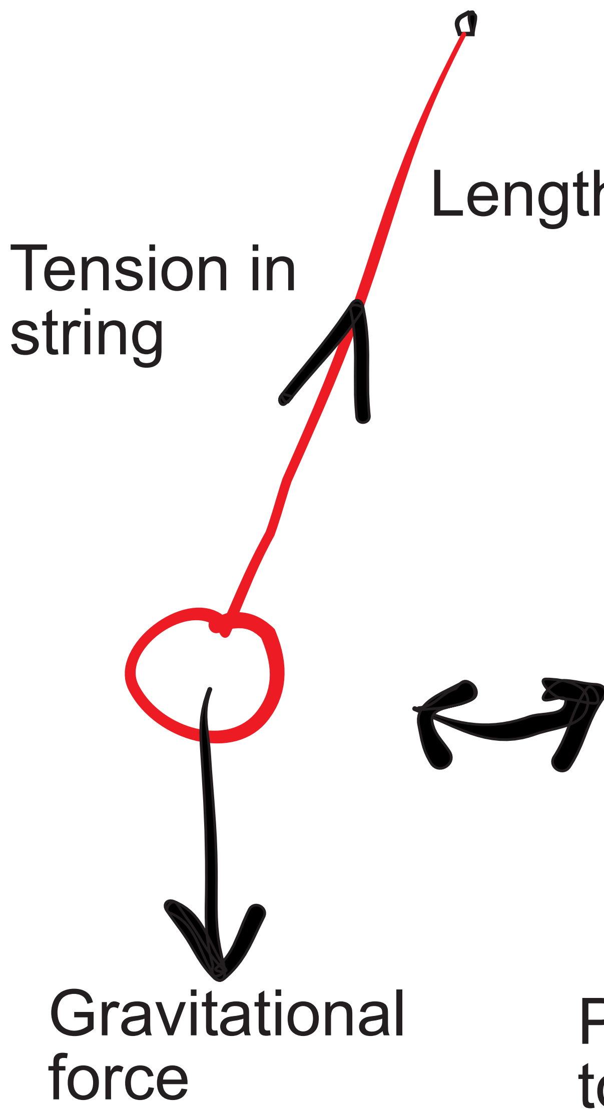
Train not moving
Wavelength L, frequency f

Train moving to right, towards you
Wavelength smaller, frequency higher

Train moving to left, away from you
Wavelength larger, frequency lower

Speed of sound constant
Waves get compressed or expanded

Pendulum



String pulls the mass to the right

The mass keeps moving, past the bottom and off to the right

The string then pulls the mass to the left

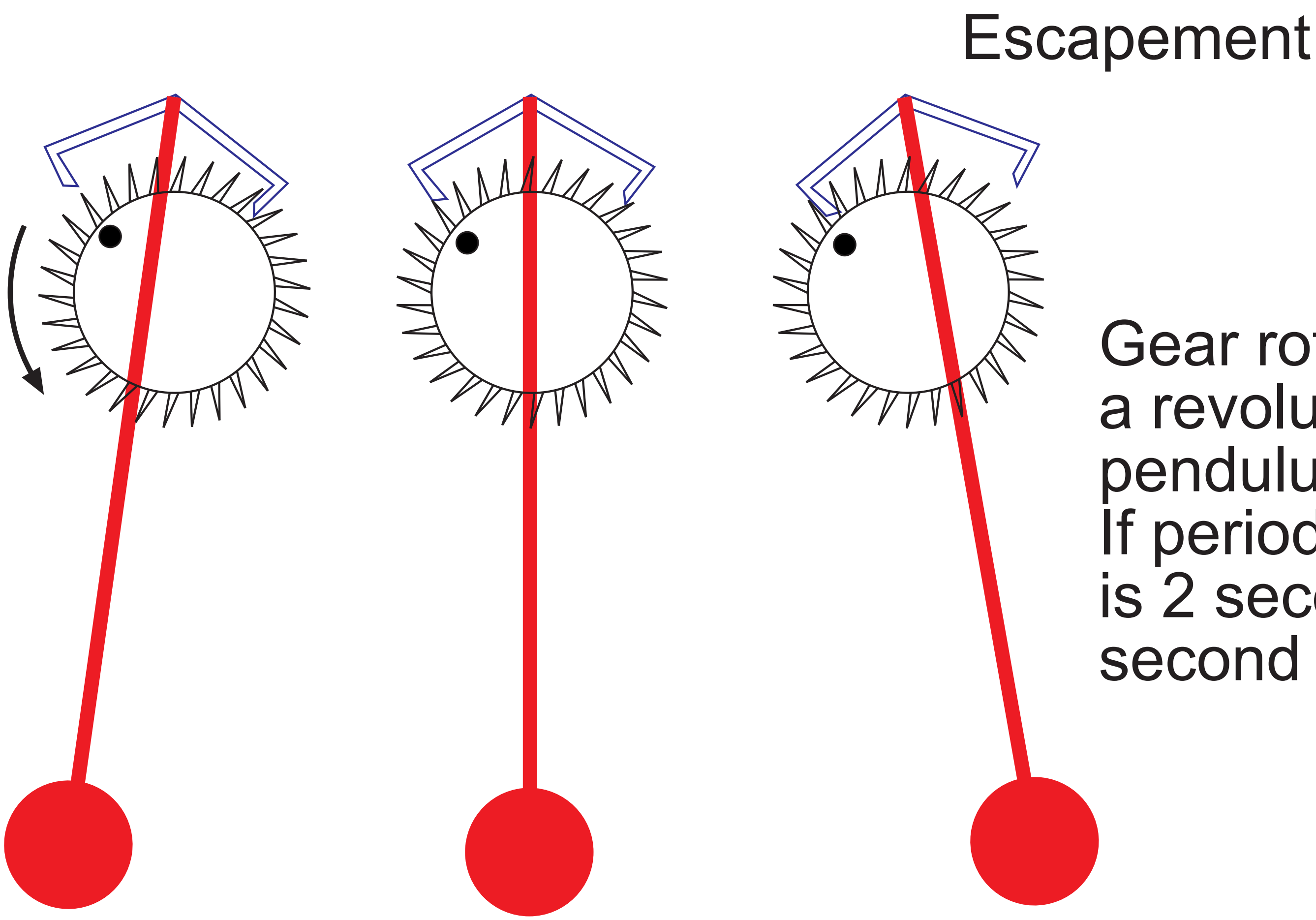
The mass goes back and forth

Restoring force (always tries to bring the mass to equilibrium)

Simple Harmonic Oscillator

Period of pendulum (Time to go back and forth) only depends on length of the string
Long string, long period, low frequency

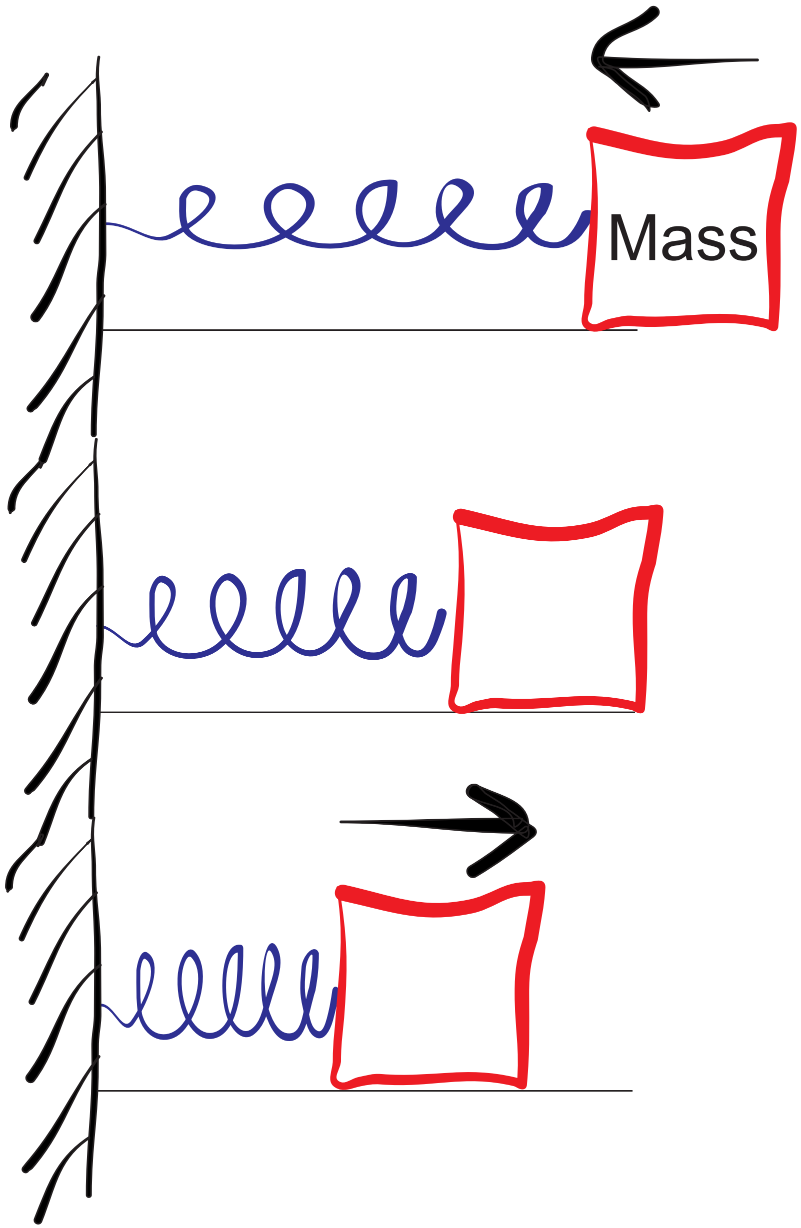
Pendulum Clock



Gear rotates 1/30 of
a revolution for each
pendulum period.
If period of pendulum
is 2 seconds, can attach
second hand to the gear.

Harmonic Oscillator Part 2

Mass on a spring



Start with spring stretched
Spring pulls mass to the left
Spring gets squeezed and
pushes the mass to the right

Spring applies a restoring
force to the mass (tries to
place the mass so the string is
unstretched and relaxed.

frequency depends on mass
and the stiffness of the spring

Bigger mass, lower frequency
Stiffer spring, higher frequency

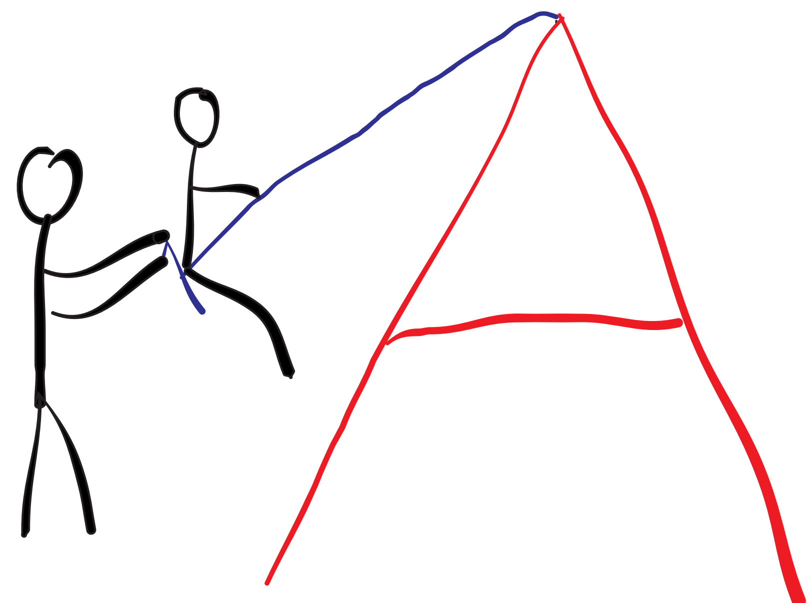
Resonance

Oscillators have a natural frequency at which
they prefer to oscillate

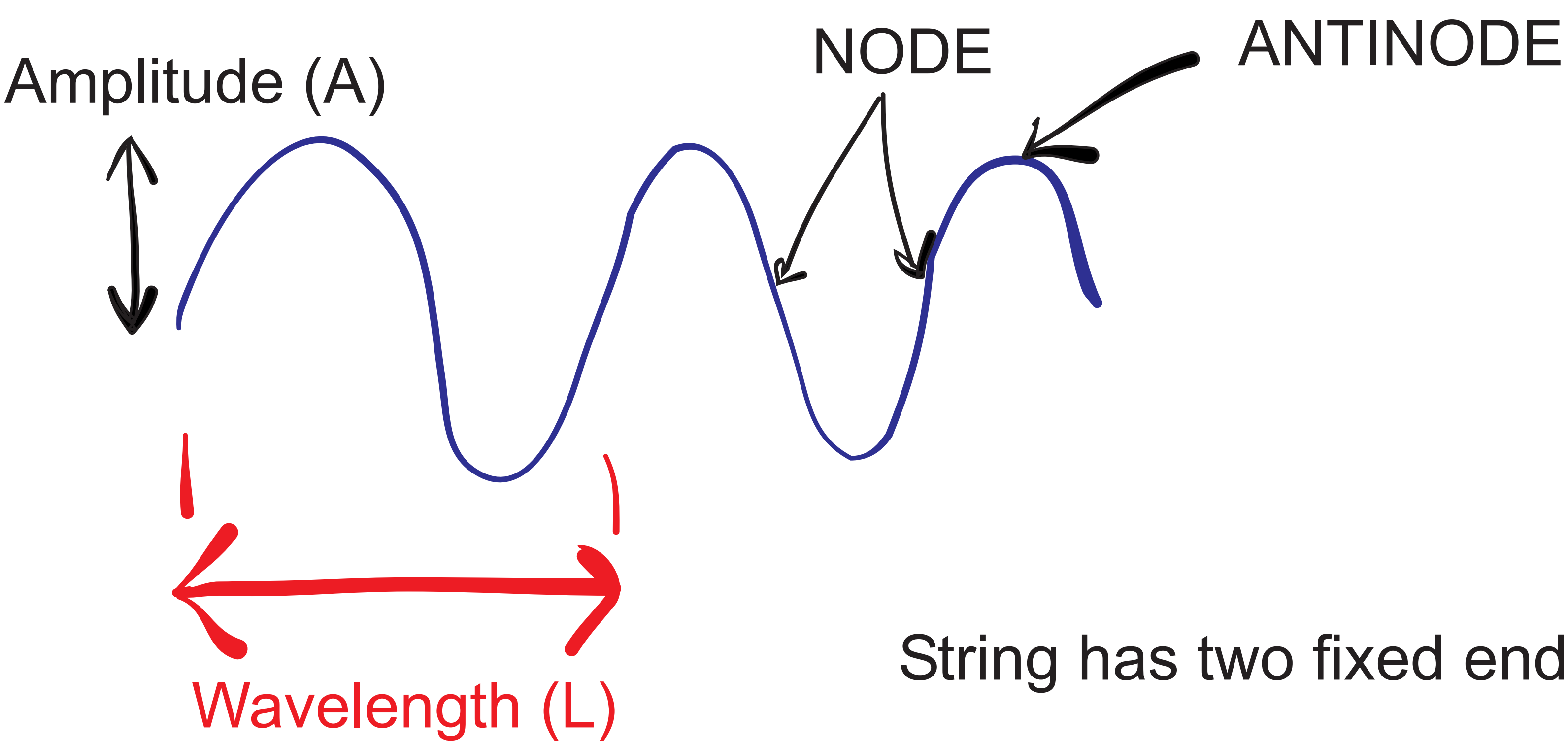
This is the resonant frequency of the oscillator

If energy is applied to the oscillator at the same frequency,
the amplitude of the oscillations will increase.

Example: Pushing a child on a swing

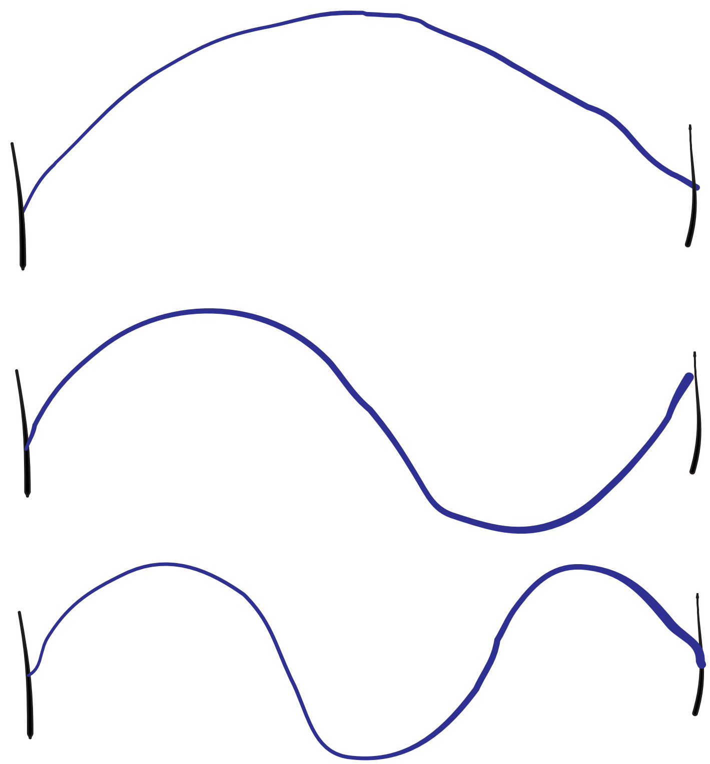


Standing Waves



String has two fixed ends

Standing Waves on a string fastened at both ends (Violin)



half wavelength

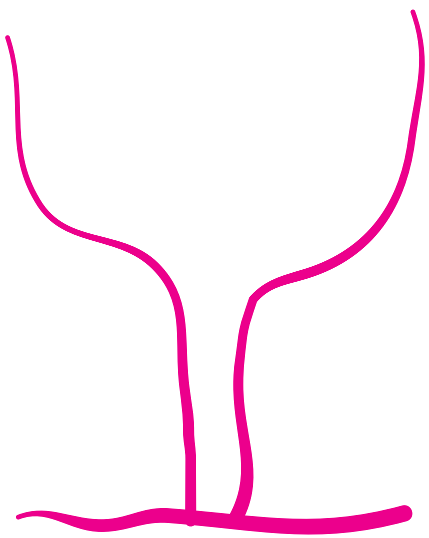
one wavelength

one and a half wavelengths

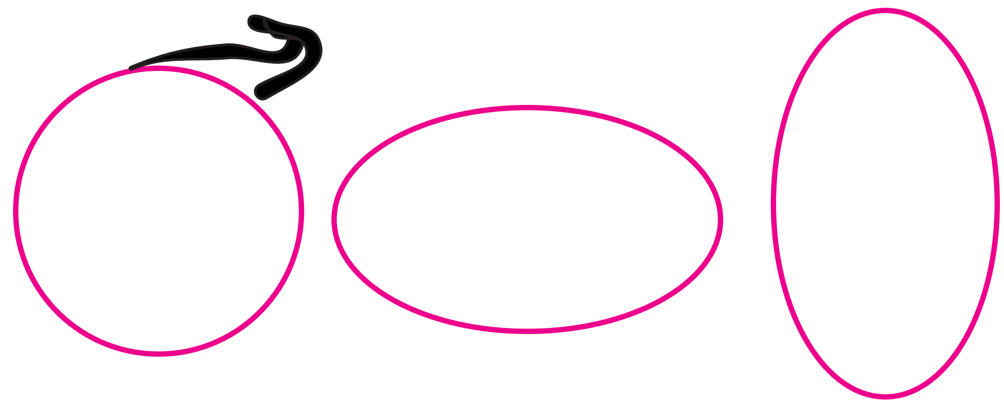
String at ends can not move up or down
(remains stationary)

Speed constant, wavelength different
so frequency different (harmonics)

Sound from Wine Glass



Rub finger along rim of glass
get friction
stick / slip causes rim of wine glass
to move

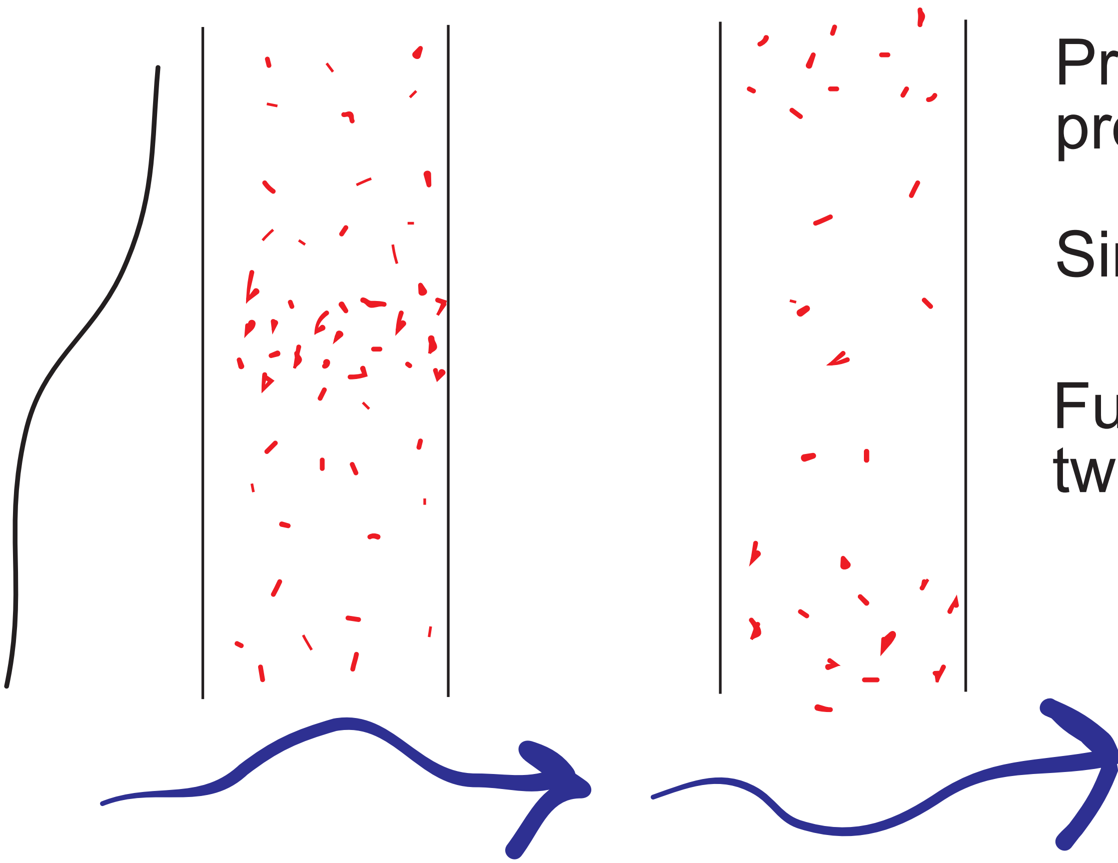


Size and shape of the glass
determine the natural frequency
Rubbing finger adds energy
and makes sound louder
Similar to bow on a violin

Bowl of wine glass
moves in and out
like a water balloon
This moves air back and forth,
producing a pressure wave
SOUND

Sound from a Tube (Organ Pipe)

Standing Wave



Pressure differences in tube provide a restoring force

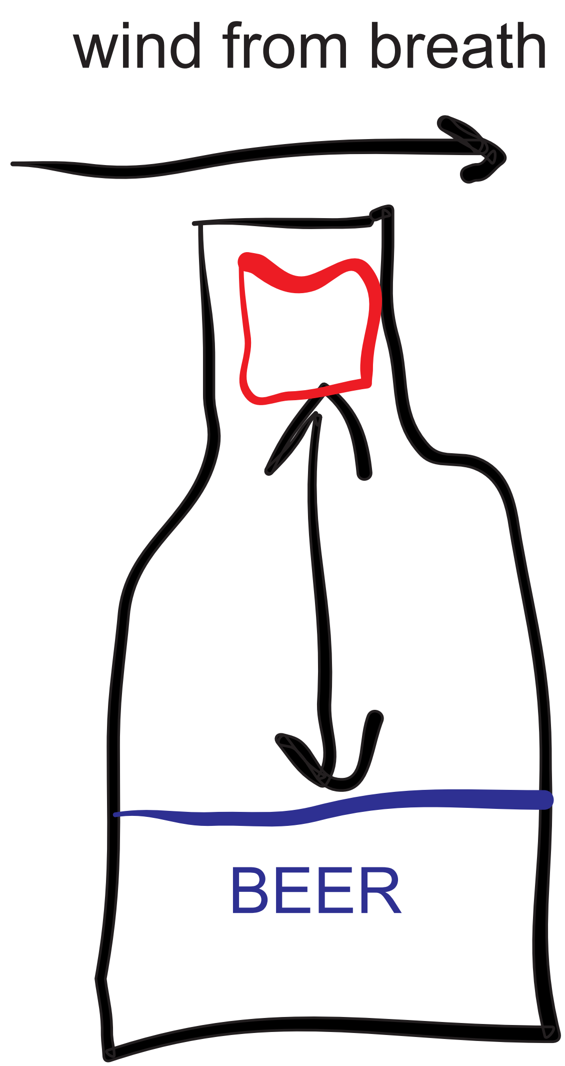
Simple harmonic oscillator

Fundamental wavelength is twice length of tube

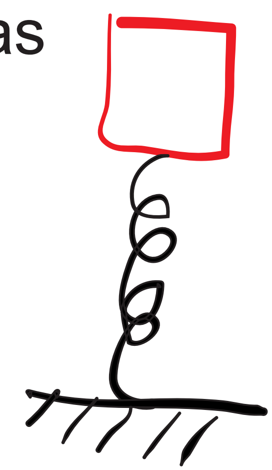
Air moves in and out at the ends

Blow air across bottom of tube
Adds energy to resonator, coupling complicated

Sound from a Beer Bottle

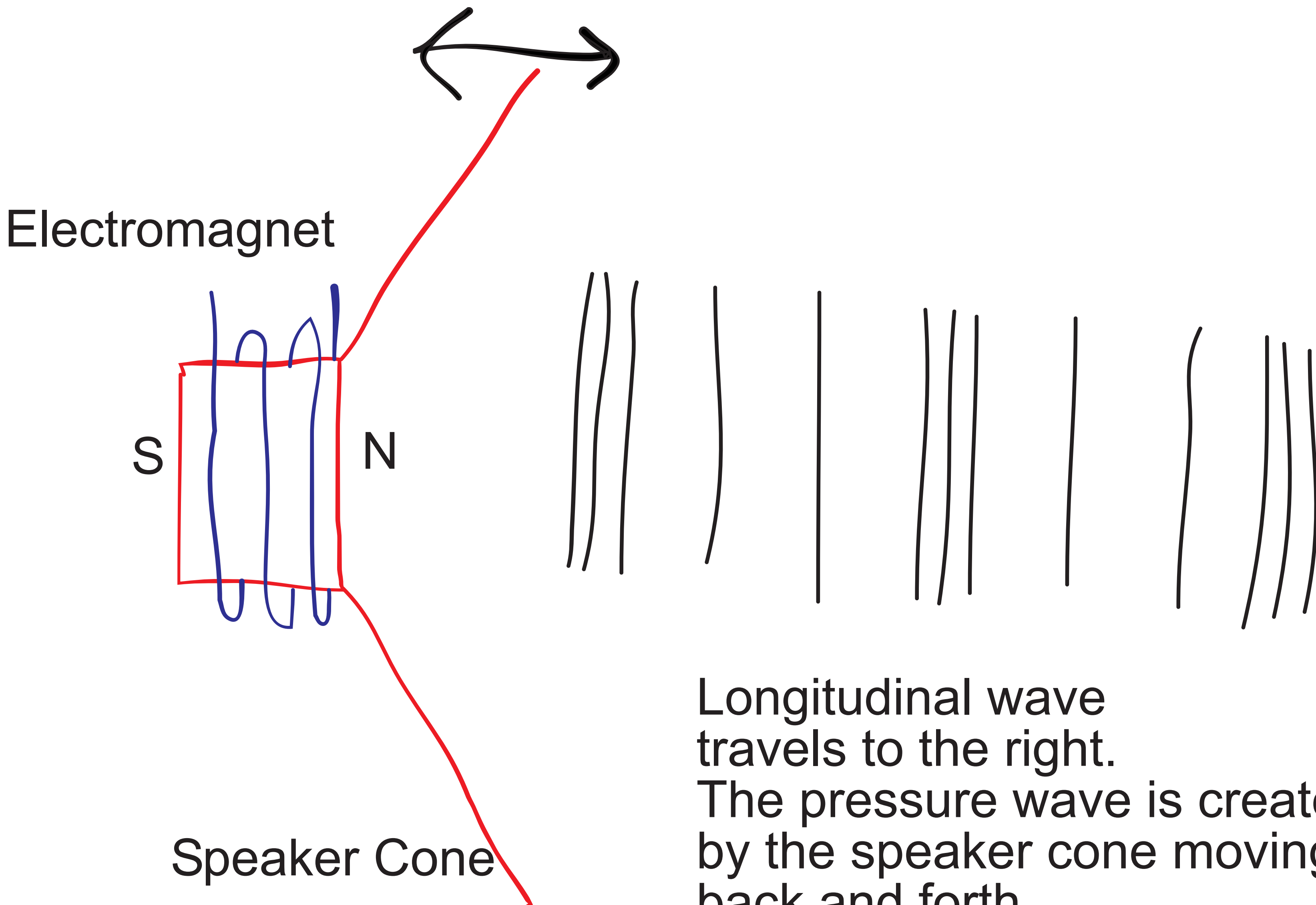


Behaves like a mass on a spring.
Air in bottle is the mass.
Air in the large part of the bottle provides the restoring force as it expands and contracts



Adding liquid to the bottle decreases the size of the air compartment, changes restoring force and therefore the frequency.

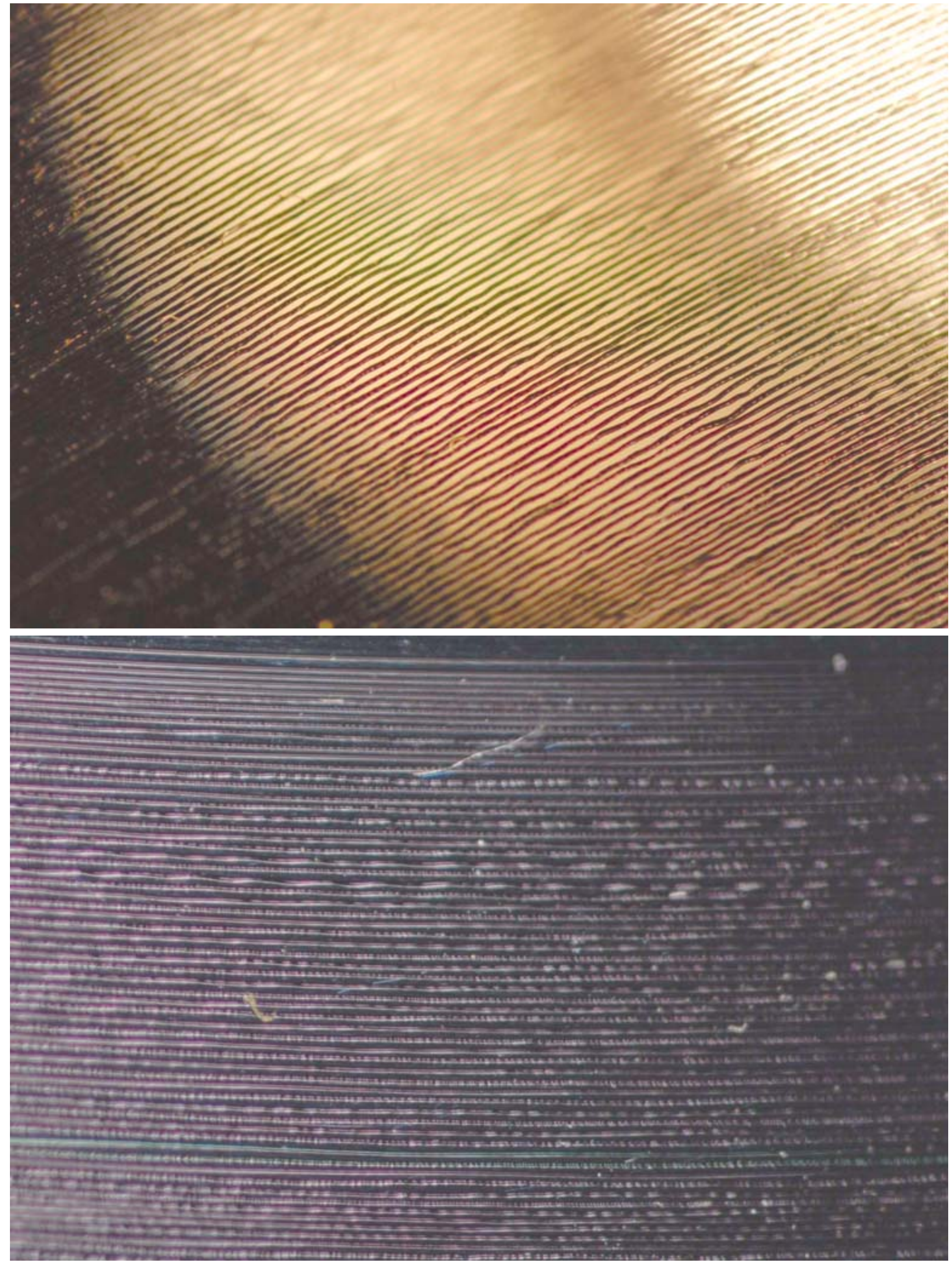
Loud Speaker



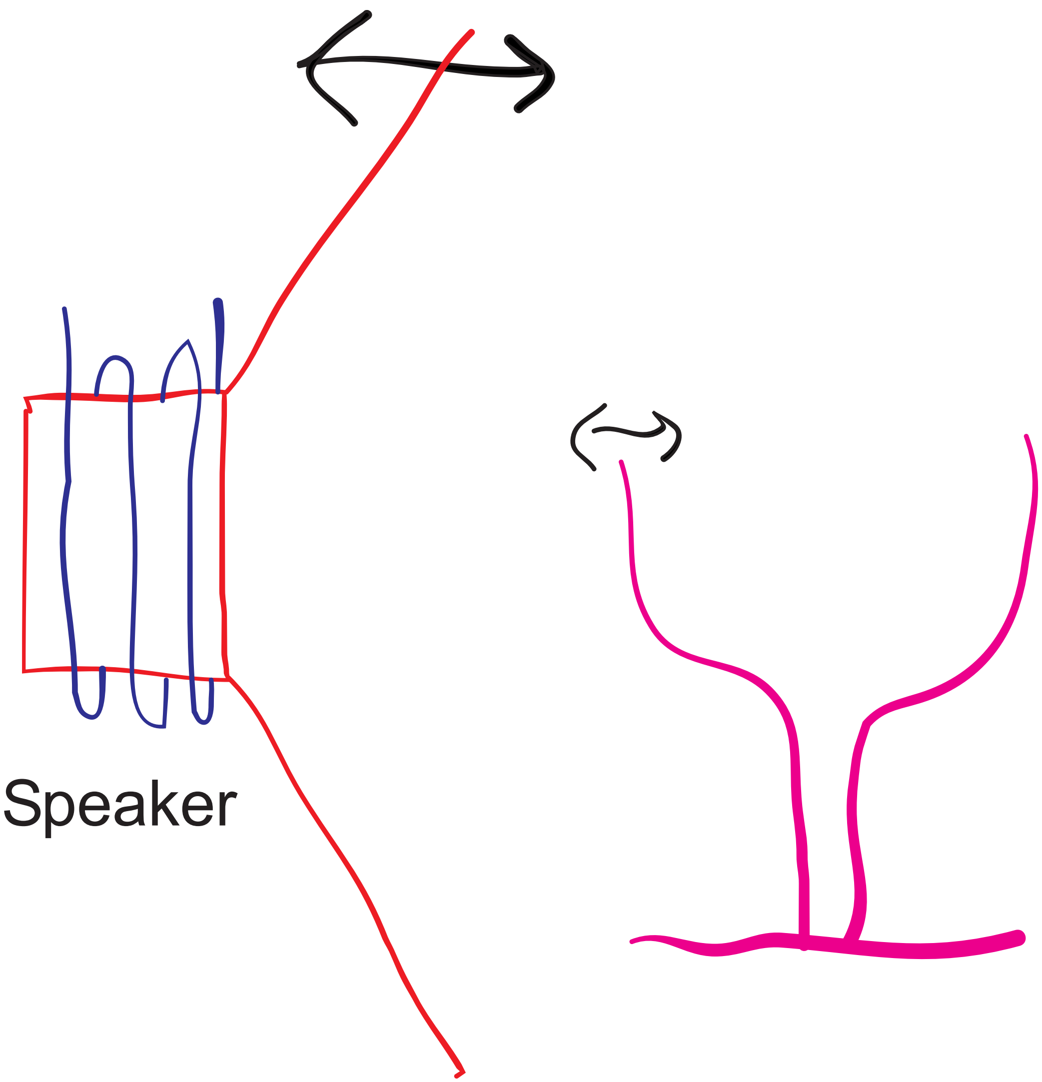
Longitudinal wave travels to the right.
The pressure wave is created by the speaker cone moving back and forth.

78 rpm

33 rpm



Breaking the Glass with Sound



Wine glass oscillates
in and out like balloon
until it breaks

Resonance