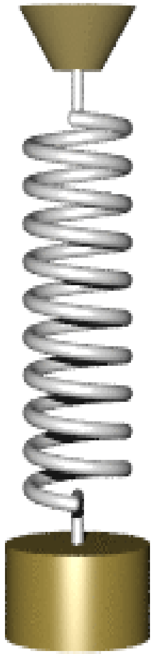
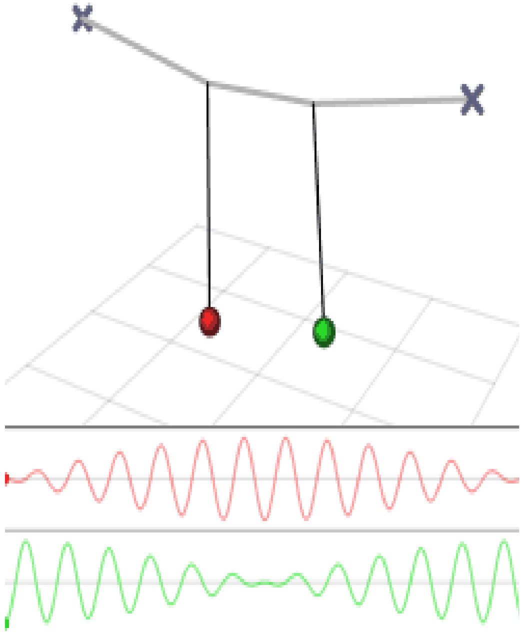
Oscillations presented by David & Madeline Keenahan

Abstract:



Oscillations

Oscillations occur in many situations.
Many demonstrations will show different kinds of pendulum and loaded springs.
We explore
(1) how to change the frequency of oscillation
(2) how the energy of oscillation often transmits as a wave.
(3) damping and resonance, etc
The demonstrations use simple and inexpensive equipment.



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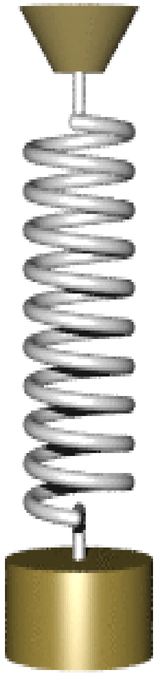
Oscillations



Oscillations are everywhere

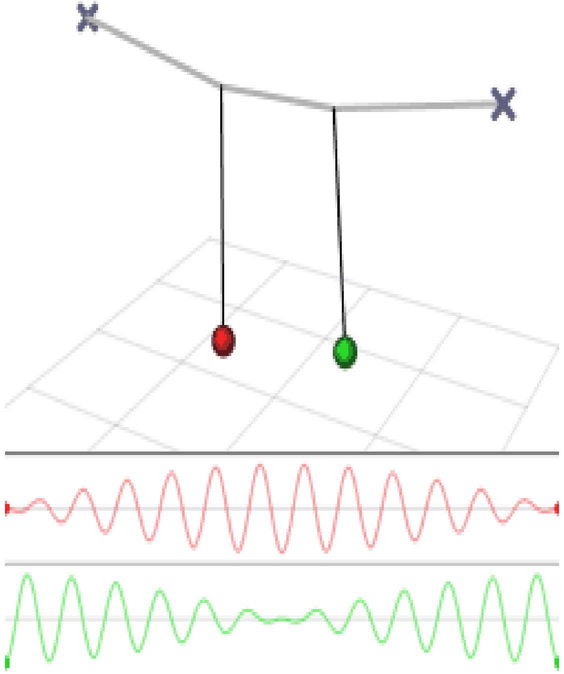
- - pendulums and loaded springs, etc

We explore

(1) how to change the frequency of oscillation

(2) how the energy of oscillation moves as a wave.

(3) damping and resonance, etc



Ideas related to oscillation

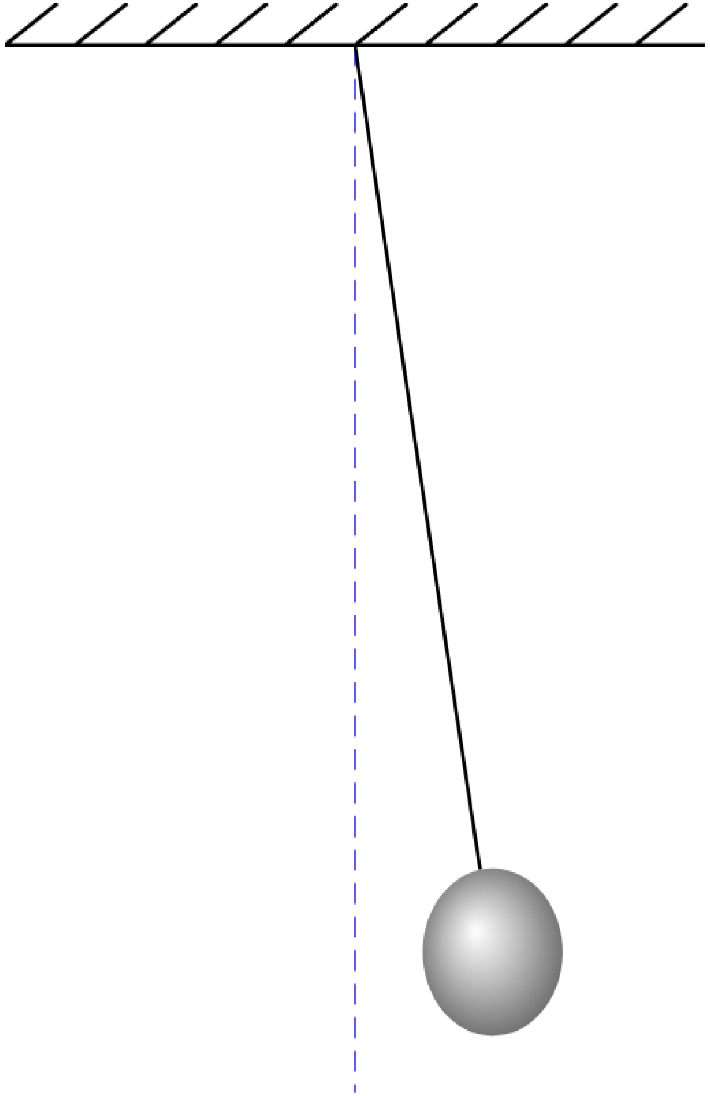
"Oscillate" is a verb that means to move back and forth often around a center point.

Frequency and period

Damping and Resonance

Energy both P.E. and K.E.

Simple Harmonic Motion SHM



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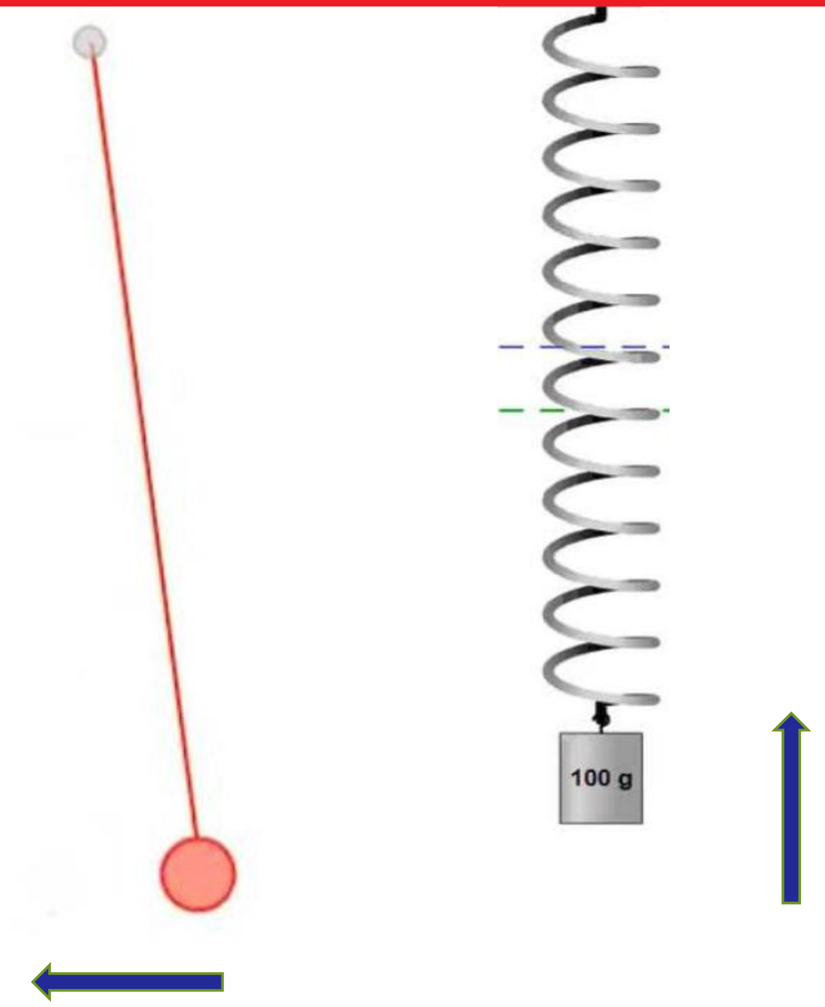
Harmonic oscillators

A simple pendulum and a loaded spring
are both examples of **harmonic oscillators**

When a **harmonic oscillator** is displaced from
its equilibrium position,
it experiences a restoring force *F*
proportional to the displacement *x*:

F = kx

where *k* is a positive constant.



Oscillations - - an introduction

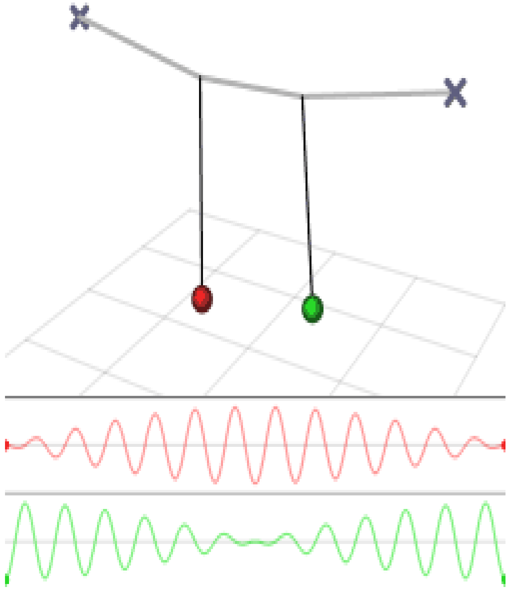
Examples of oscillation include
a swinging pendulum and a loaded spring.

KE at the center point is converted to PE at the edge.

Damping refers to energy dissipated due to heat or friction.

Oscillations tend to decay with time unless there is some net source of energy into the system

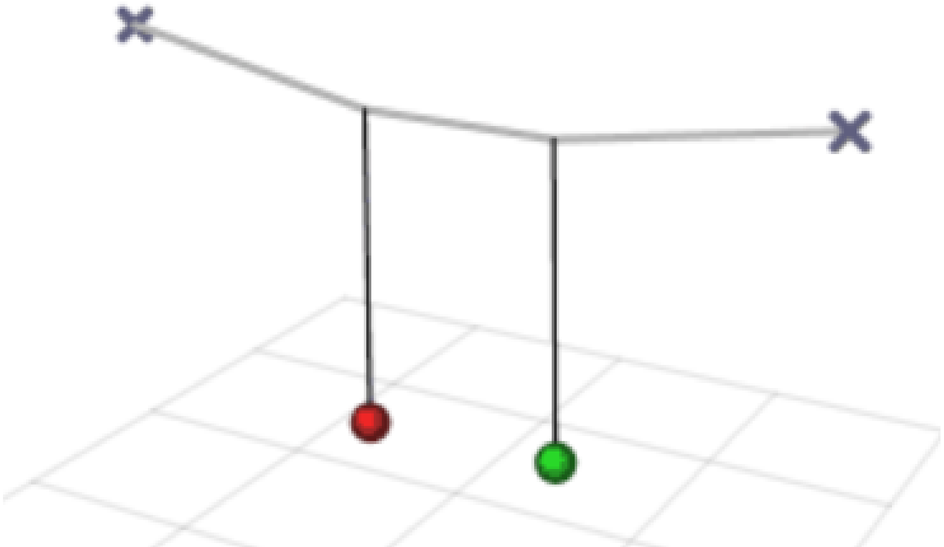
Resonance occurs when the driving frequency is equal to the natural frequency of the system.



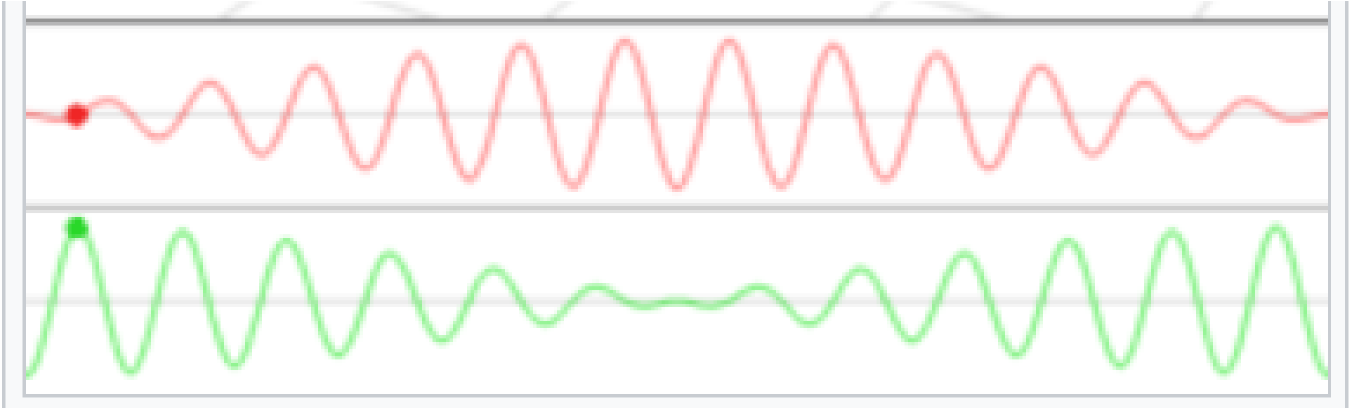
Acknowledgement
https://en.wikipedia.org/wiki/Oscillation

The harmonic oscillator

A pair of coupled oscillators



Two pendulums with the same period
fixed on a string
act as pair of coupled oscillators.
The oscillation alternates between the two.



Hooke’s law

Robert Hooke

Hooke’s law (1678)

The **force exerted by a spring is proportional to its extension (or** compression)

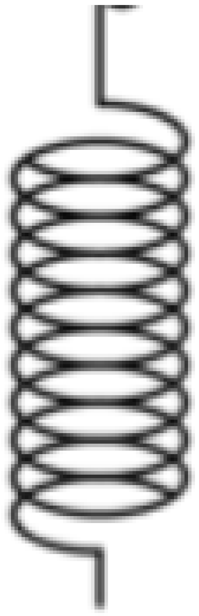
The law implies **F=kX**,

where F is force,

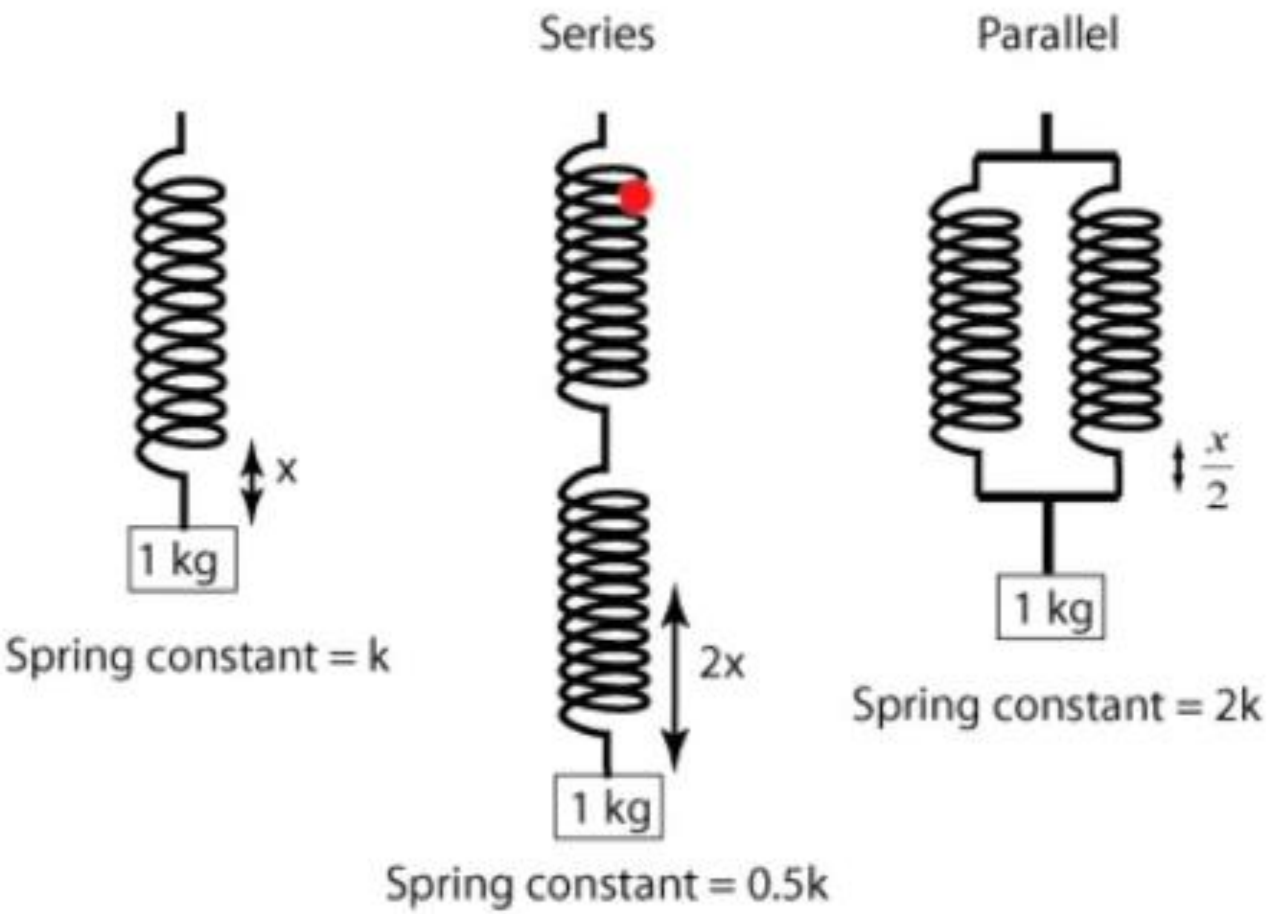
and X is the length of the extension.

k is the **spring constant**.

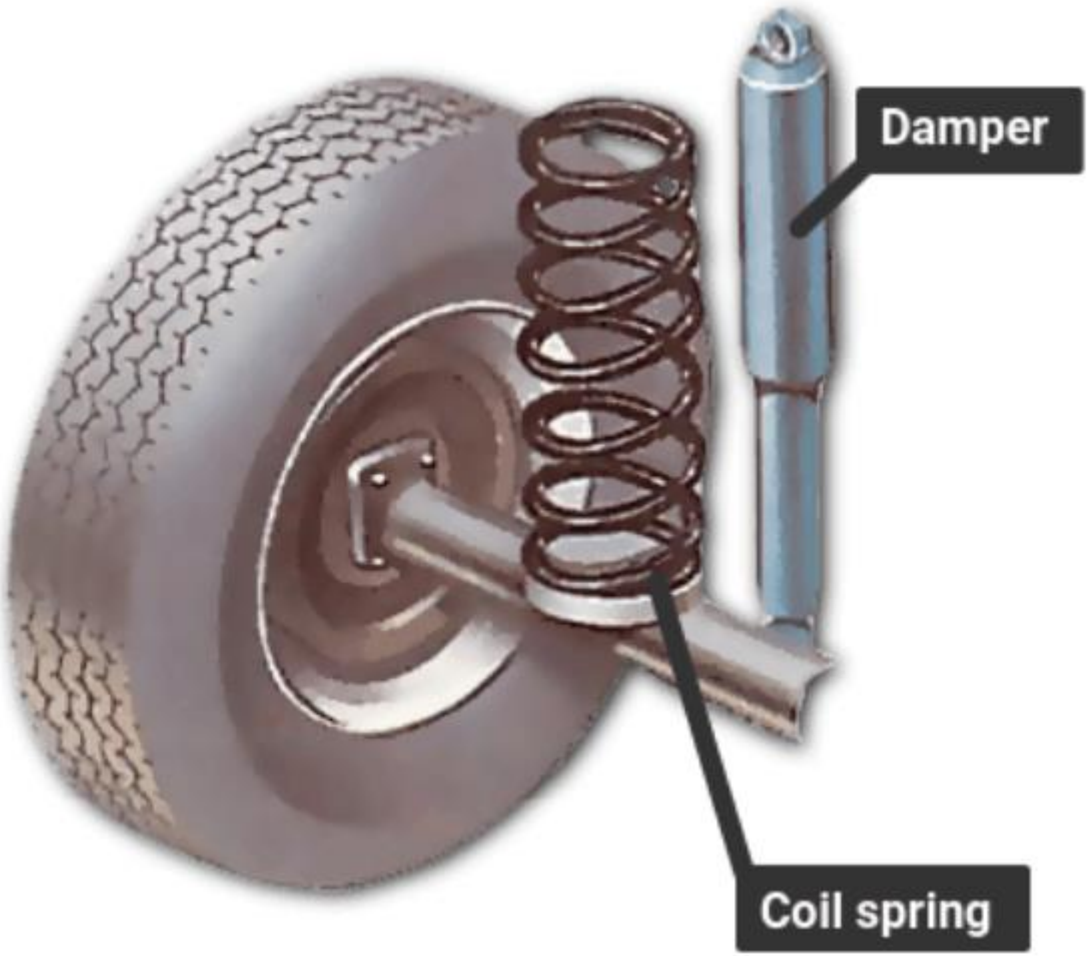
Key word: elastic



Combining springs



Compression springs



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Examples of oscillations

Sound Waves: longitudinal waves --- oscillations in air pressure.

Light Waves electromagnetic waves --oscillating electric and magnetic fields.

Alternating current (AC) oscillations in voltage and current.

Tides --- gravitational pull of moon and sun --- variations in sea levels.

Quartz Crystal in Watches vibrate at a precise frequency in many watches.

Atomic Clocks use the oscillations of atoms (usually caesium) to measure time

Heartbeat: The human heart beats ---- regular oscillations in blood flow.

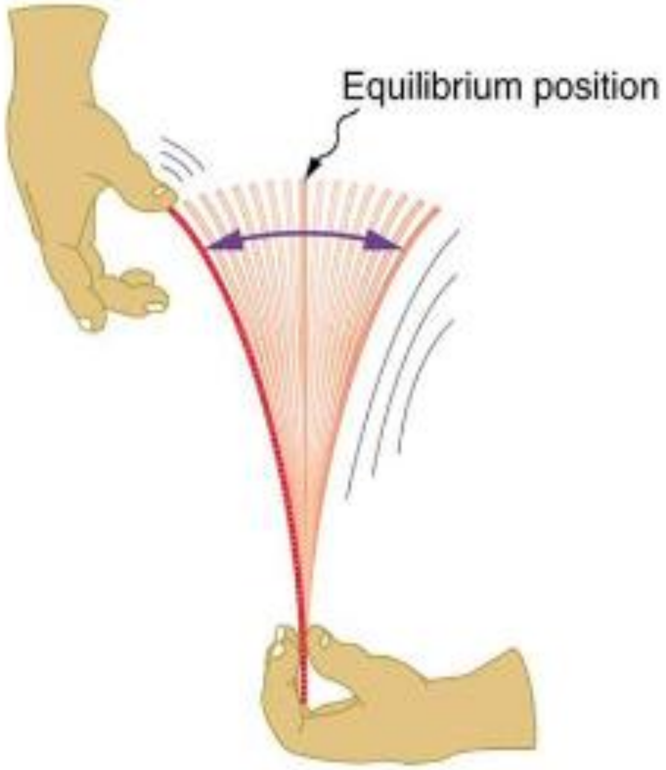
Tuning forks

A tuning fork is an acoustic resonator

(It oscillates with large amplitude at one particular frequency)

Tuning forks produce a pure tone.

Invented in 1711 by British musician John Shore



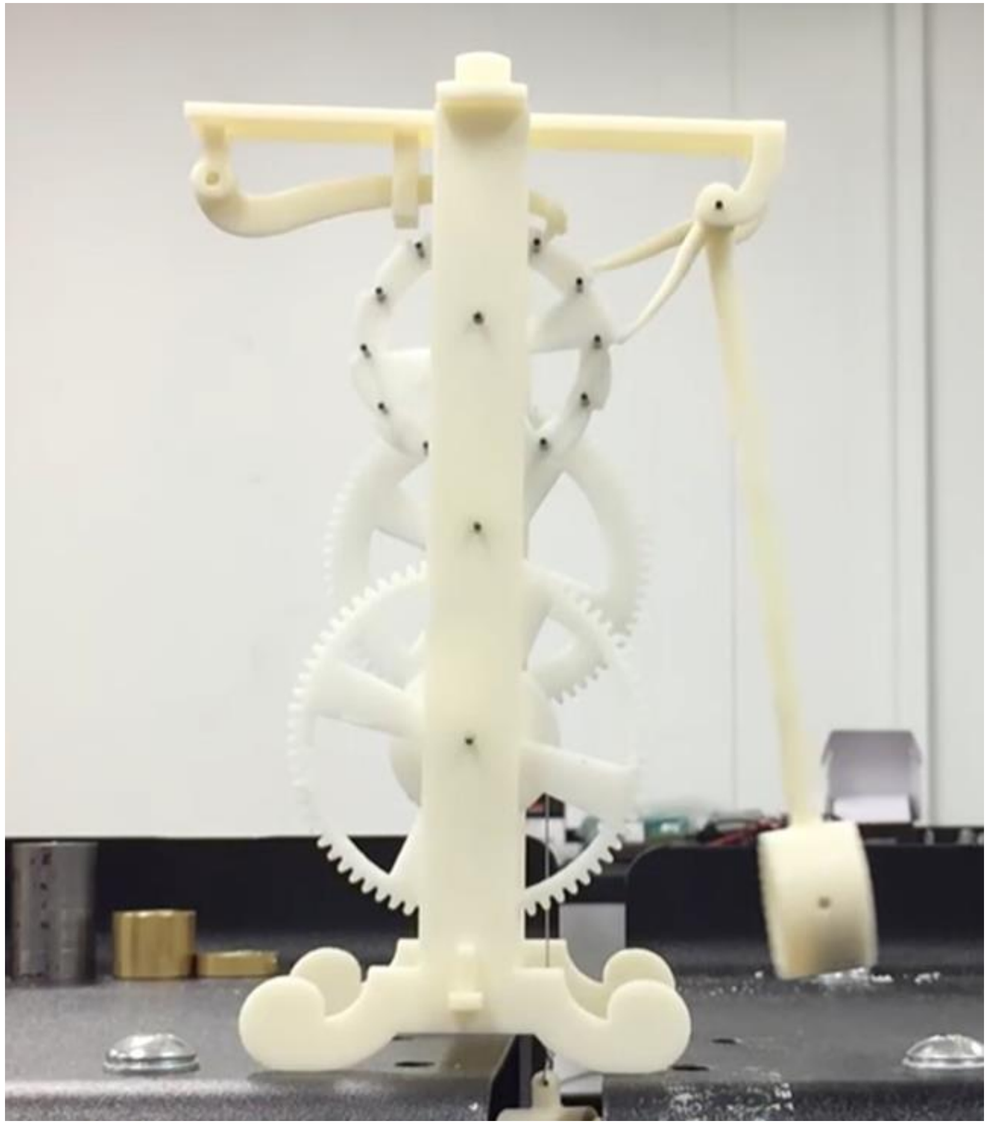
Pendulum clocks

Galileo designed a pendulum clock in 1637 but died before he could make it.

Huygens made a pendulum clock in 1656

A pendulum was the first harmonic oscillator used in timekeeping

Video
https://www.youtube.com/watch?v=8g-rlaZNAjU



Some relevant mathematics

$$F = ma$$

$$F = kx$$

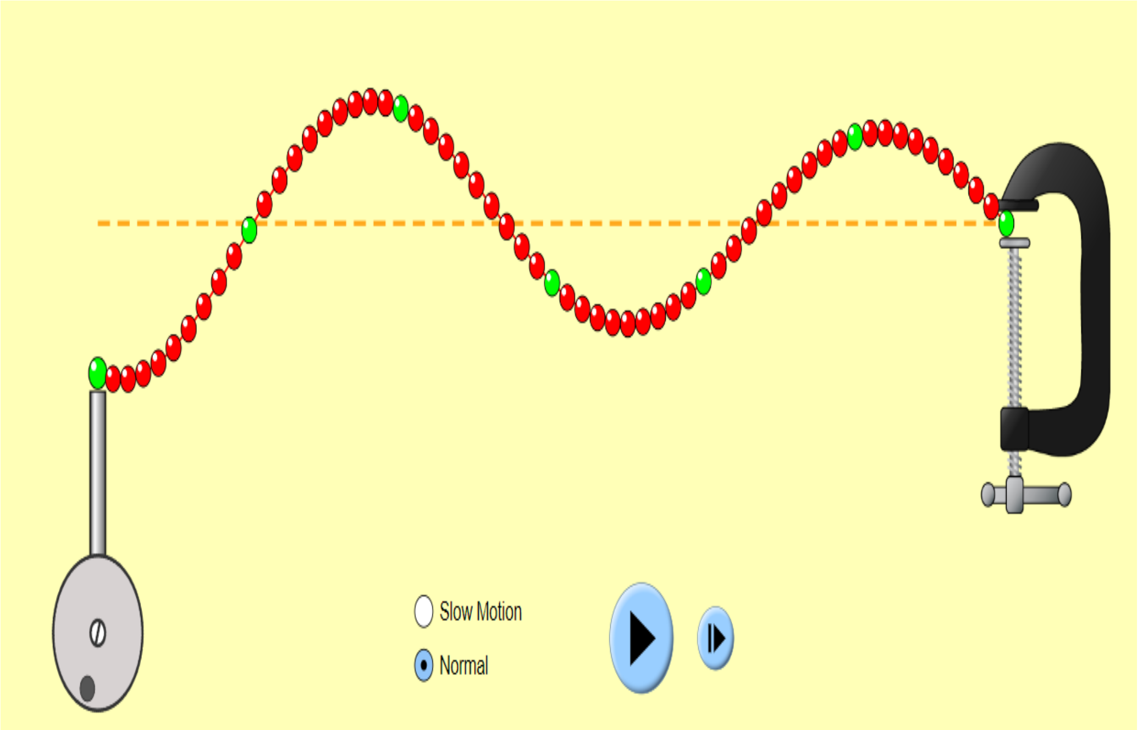
$$ma = kx$$

$$a = \frac{k}{m} x$$

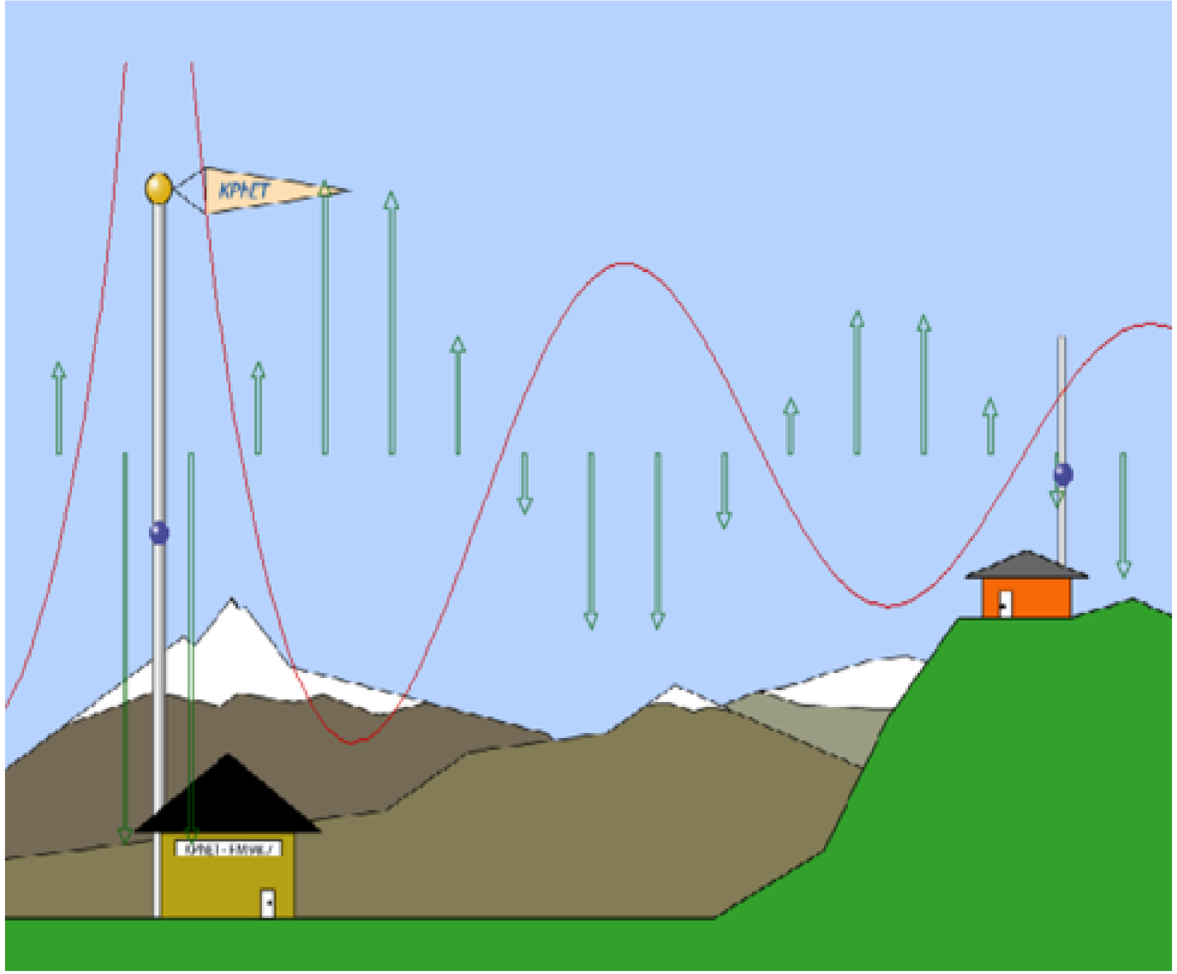
which is of the form $a = \omega^2 x$ *where* $\omega^2 = \frac{k}{m}$

PhET simulations https://phet.colorado.edu/

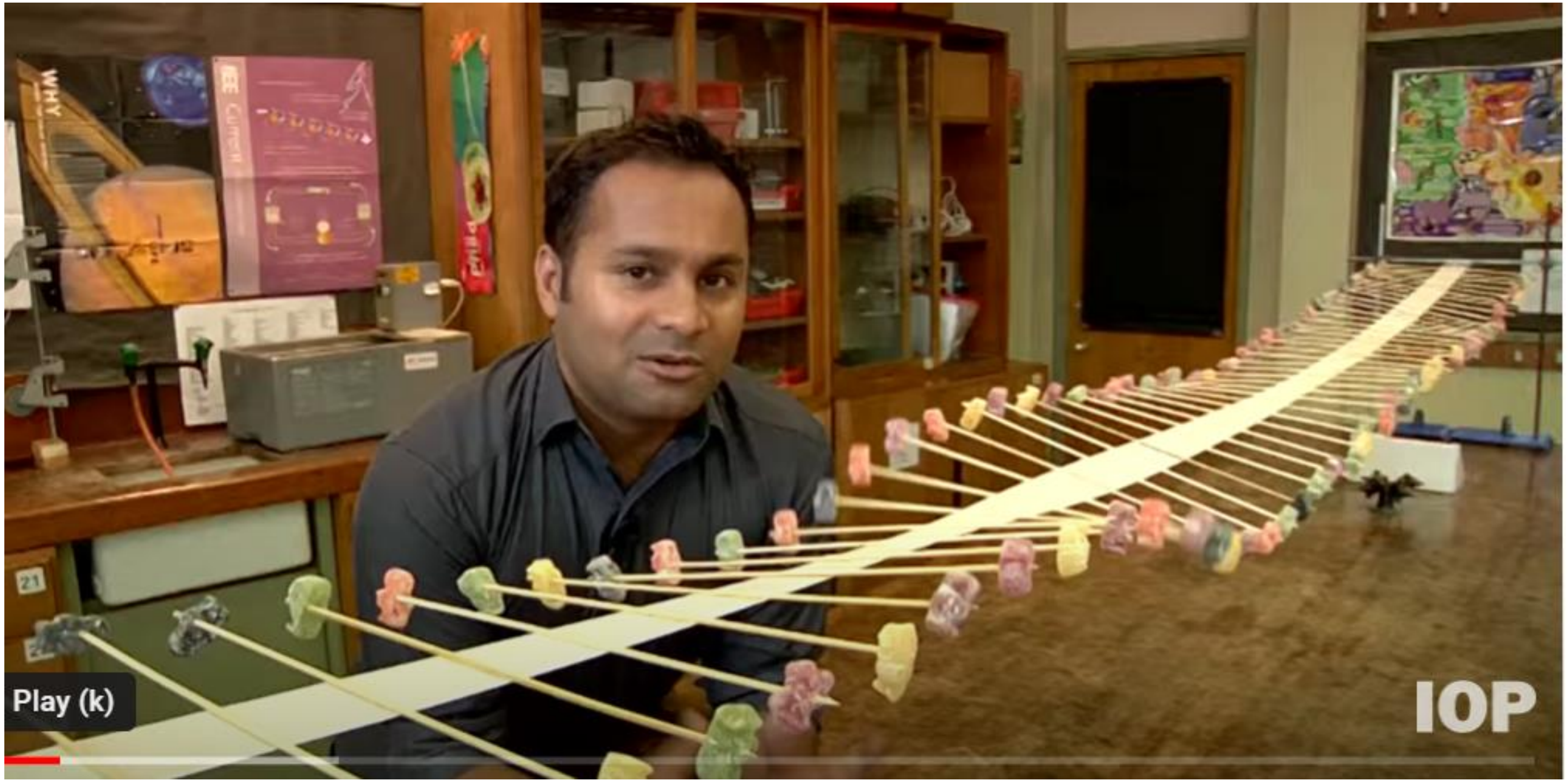
Mechanical waves



electromagnetic waves



The kebab wave machine



https://www.youtube.com/watch?v=2eMT3skCTDg

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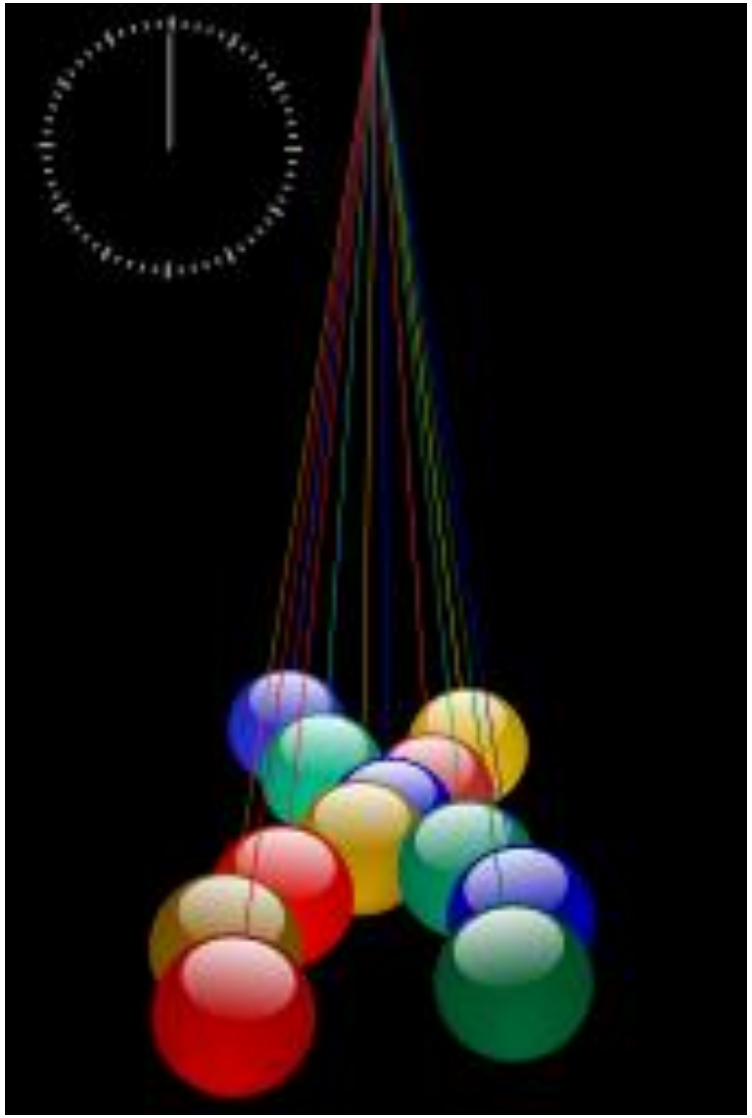
Pendulum wave



https://upload.wikimedia.org/wikipedia/commons/5/5c/Pendulum_wave_animation.svg

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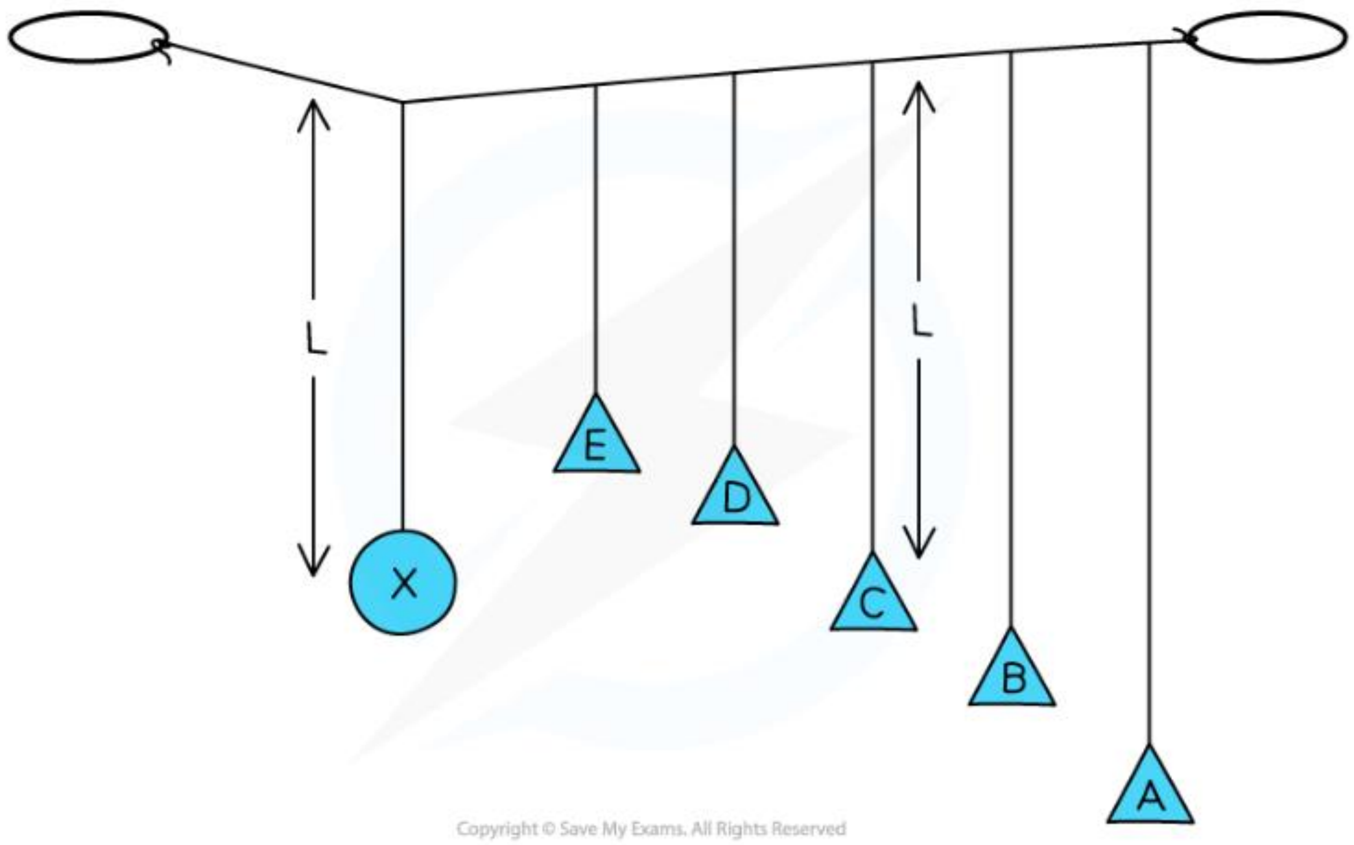
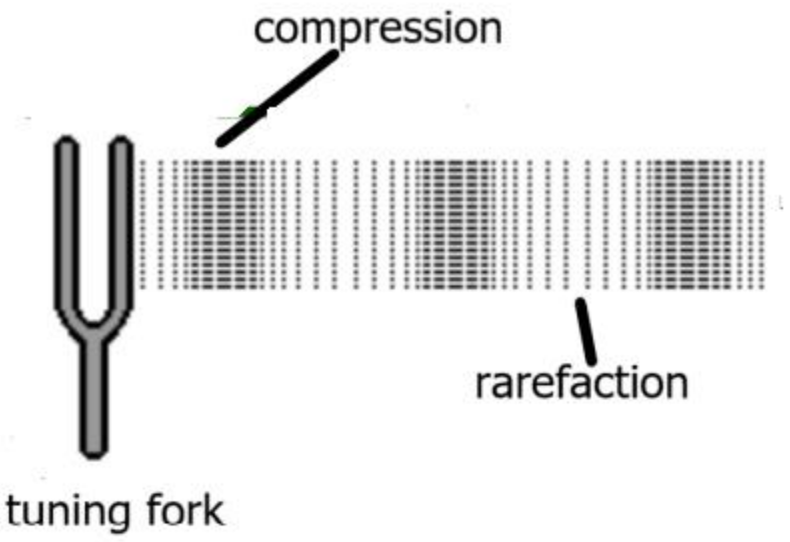
Barton’s pendulum

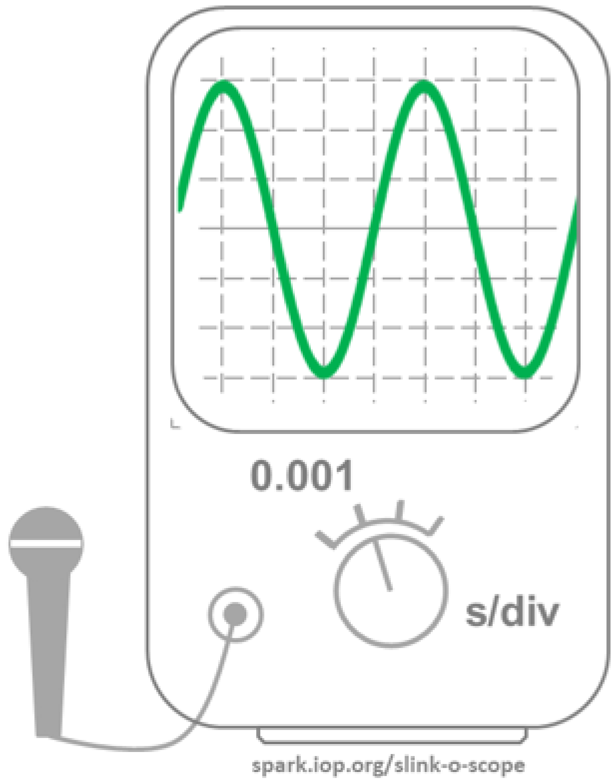


Barton's pendulums helps display resonance

Oscillations of tuning fork

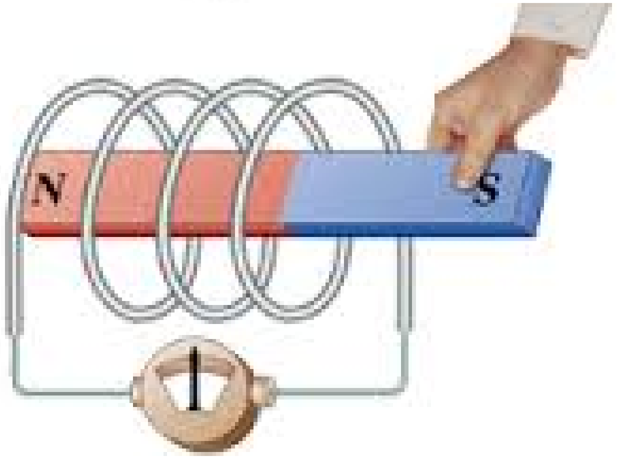


Oscilloscope



Transverse wave

Electromagnetic induction



$$E = \frac{d\Phi}{dt}$$

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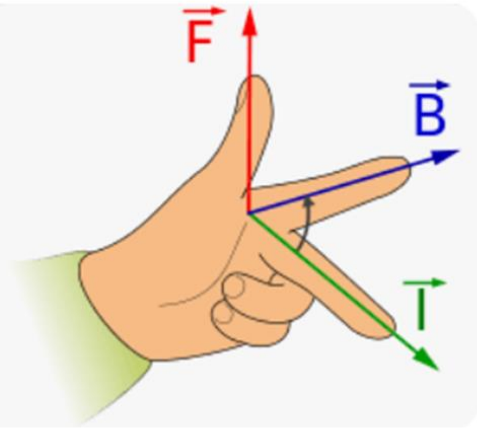
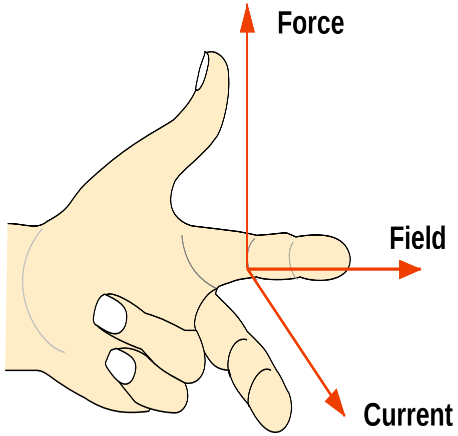
Electromagnetic force F=Bil

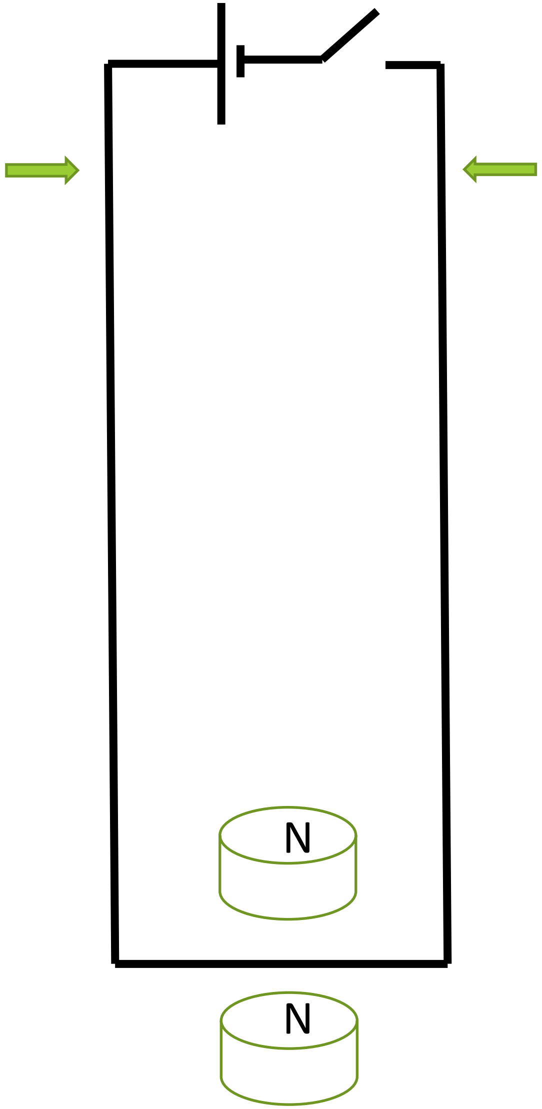
A trapeze made from bare copper wire.

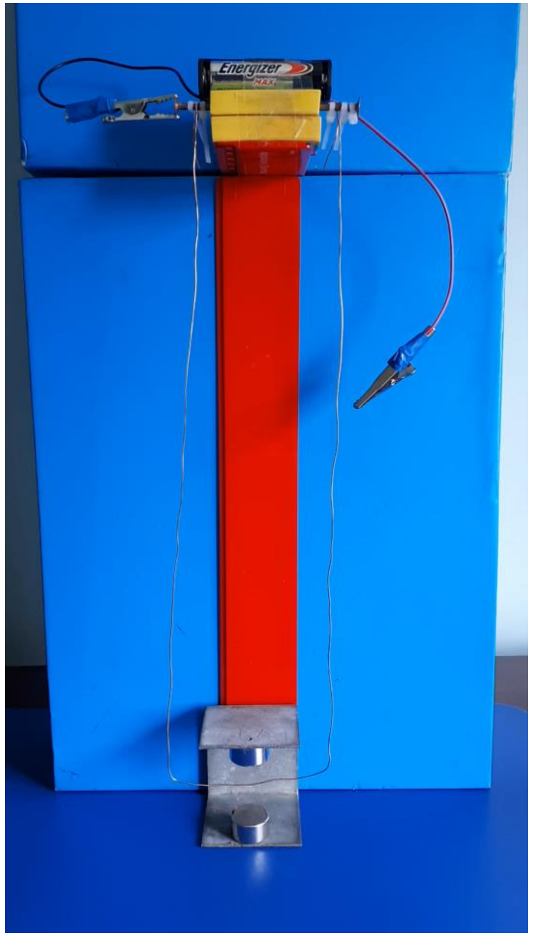
Current from AA battery causes a temporary magnetic field surrounding the wire.

The permanent magnetic field due to a pair of neodymium magnets interacts with the temporary field
causing the wire to be kicked out









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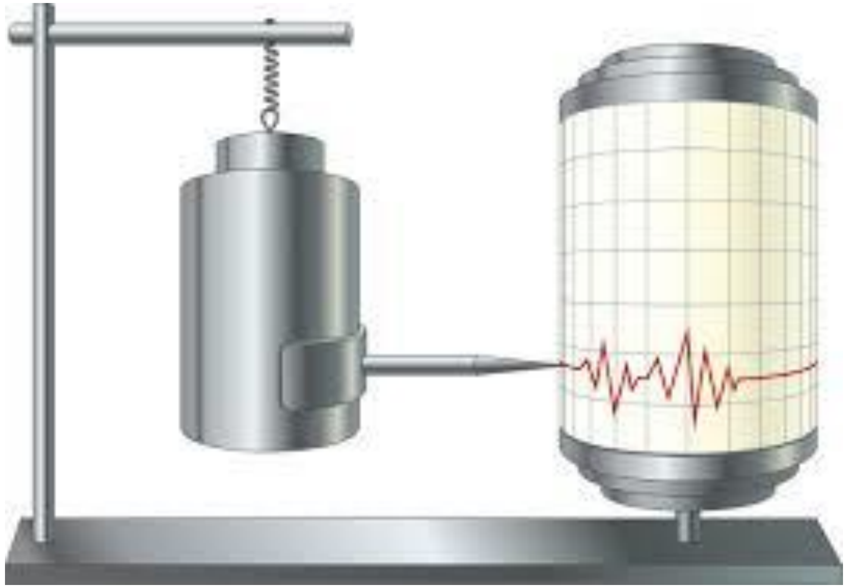
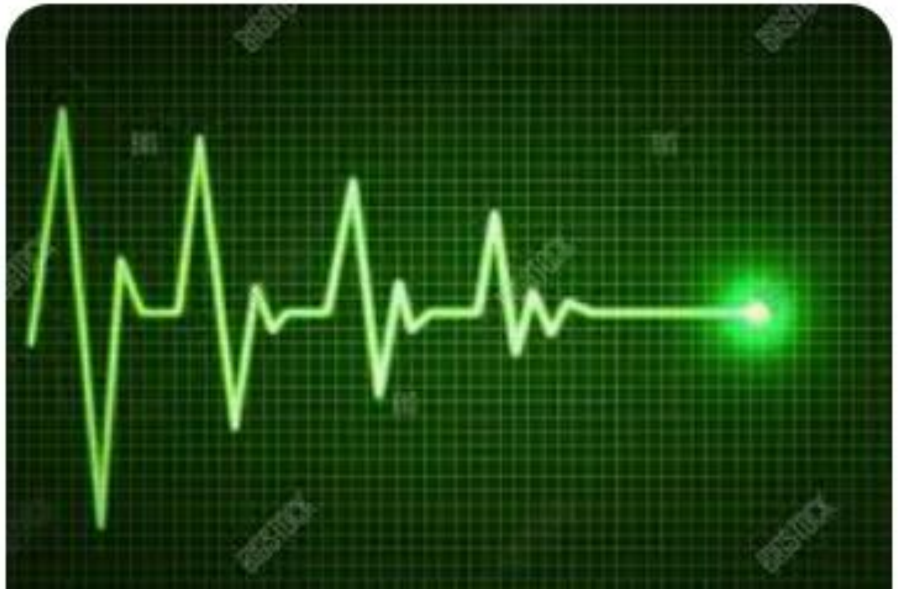
Seismometers oscillations

Seismometers -- earth tremors on a graph



Heart monitors show cardiographs

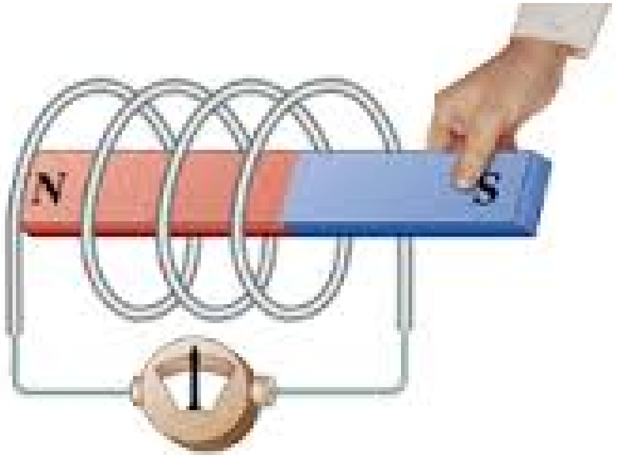


Galvanometers

Oscillating needle

indicates a.c.

Alternating current



$$E = \frac{d\Phi}{dt}$$

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Clackers - - toys, popular in 1970s Newton's cradle

Newton's cradle

3 big ideas:

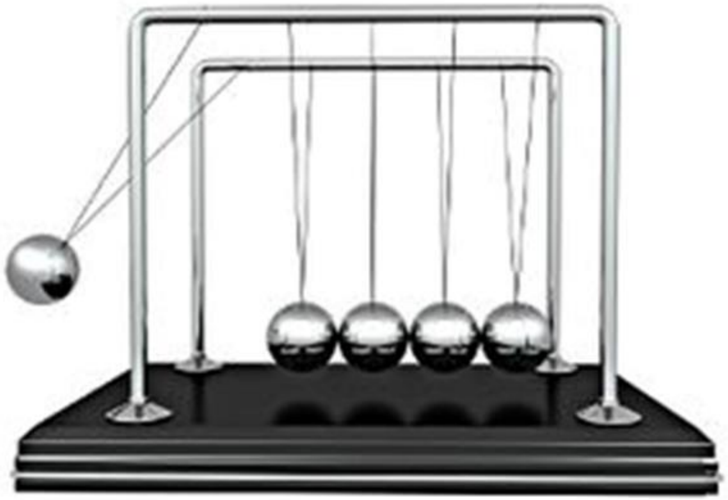
conservation of energy,

conservation of momentum

friction.

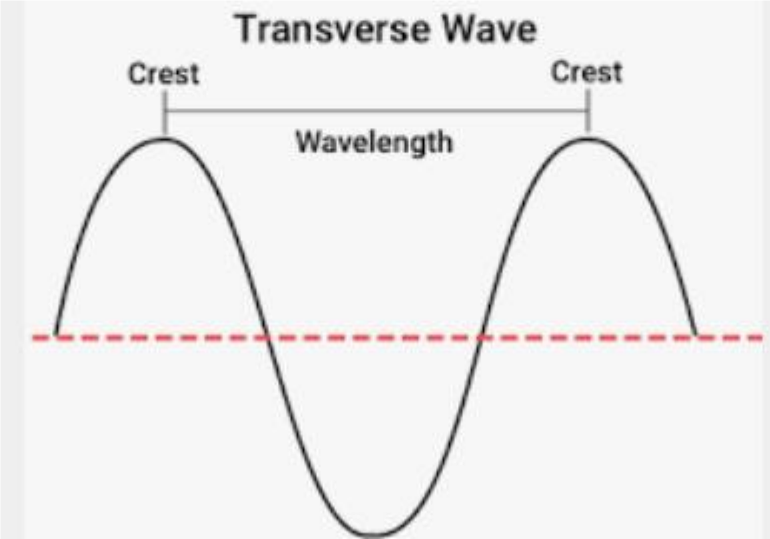
The collisions are nearly elastic.

Some energy is dissipated as sound



Clackers

2 slinkies joined to show change of wave speed in different media



$v = f\lambda$

A change in λ means a change in v