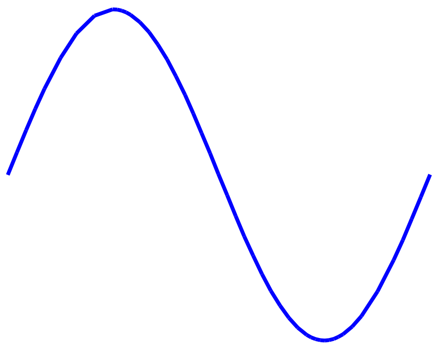
Waves and Velocity



Wave has wavelength λ
and frequency f

Time to travel one wavelength
in distance is 1/f

So speed is distance / time

$$v = \frac{\lambda}{1/f} = \lambda f$$

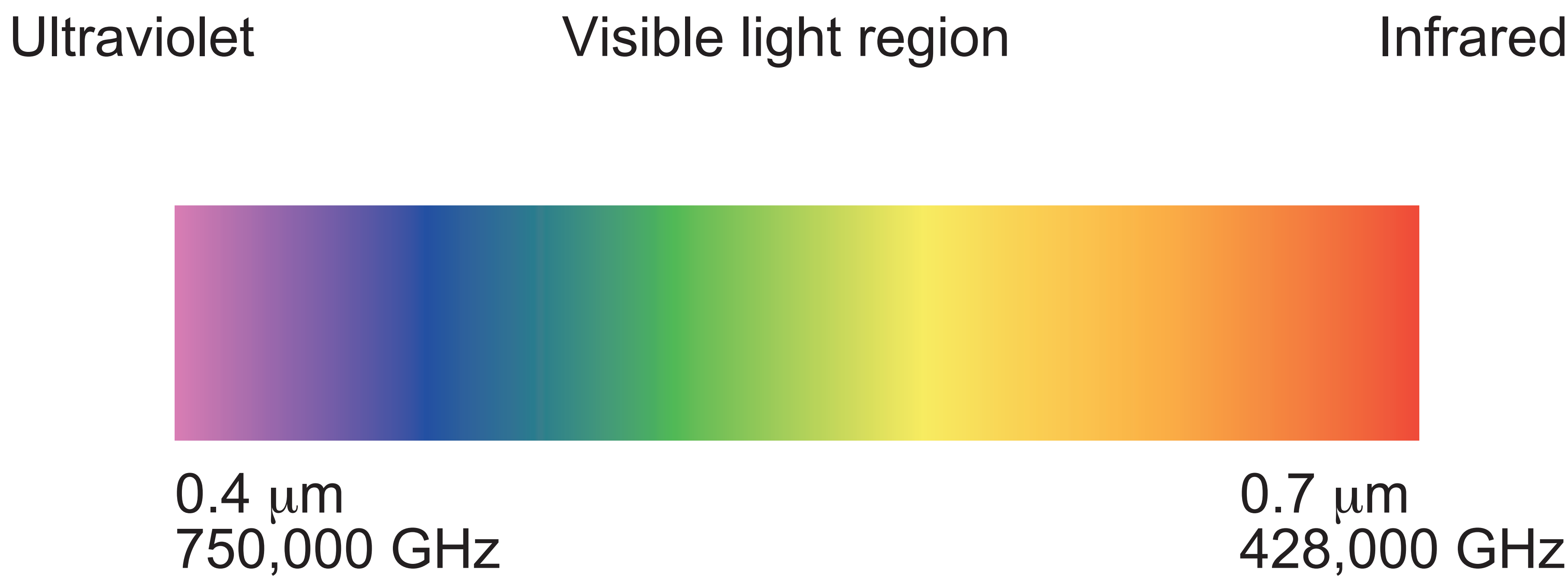
Velocity = wavelength x frequency

Speed of wave can change depending on the medium
through which it travels.

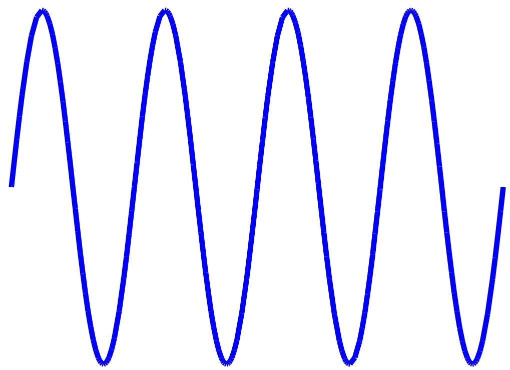
Speed of light through a vacuum is constant (299,792,458 m/s)

Speed of light through other materials (glass) is different.

Light Spectrum



Microwaves



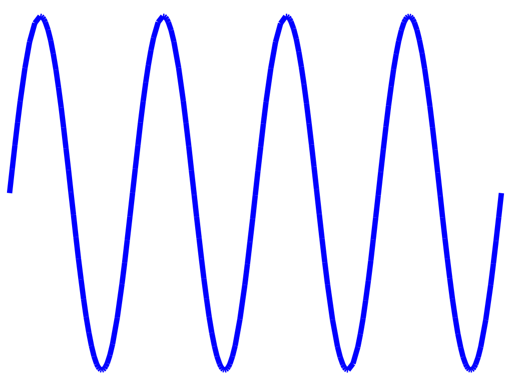
Wavelength range 1 mm to 1 m

any waves with

Frequency range 300 GHz to 0.3 GHz

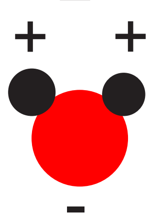
Microwaves and Water

higher freq waves are absorbed more
lower freq waves are absorbed less
- we want to pick a freq that heats food thoroughly

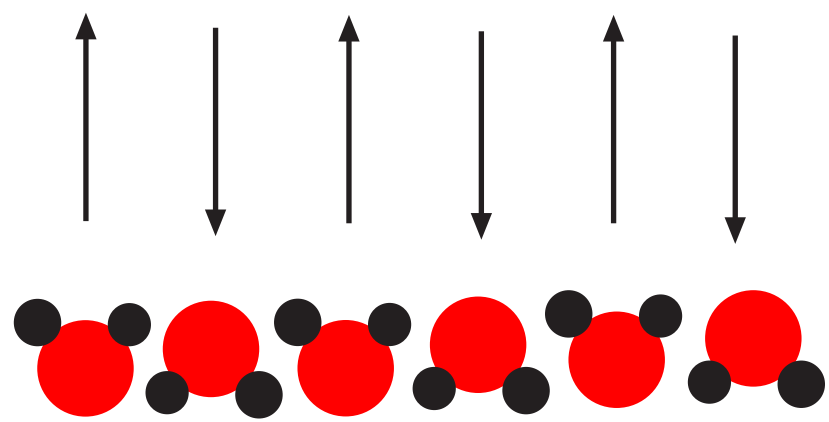


Electromagnetic waves
2.45 GHz frequency
12 cm wavelength

H_2O



water is a polar molecule



Electric field oscillates
and reverses direction
causing the water molecules
to flip back and forth
generating heat

so food is essentially heated by having their water molecules rotated back and forth

Cooking

Microwaves can only be used to heat polar liquids (water)

Can’t heat oil

note: vegetable oil is polar, so can heat

Can’t heat ice (molecules can’t rotate)

microwaves won’t work on ice in a vacuum, but will work in air,
since the energy in the air will gradually melt the ice and then the microwaves will work on the melted part

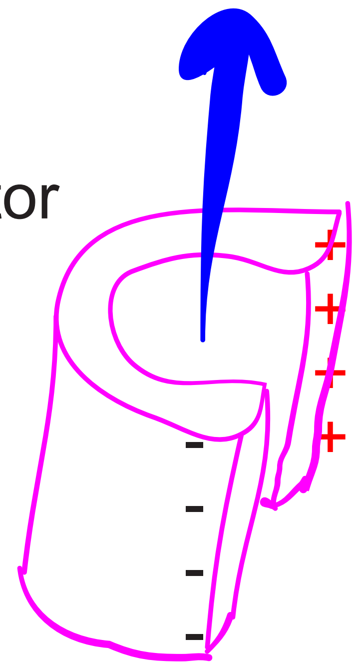
How to Make Microwaves

Magnetic Field

Tank Circuit

Resonator

Inductor

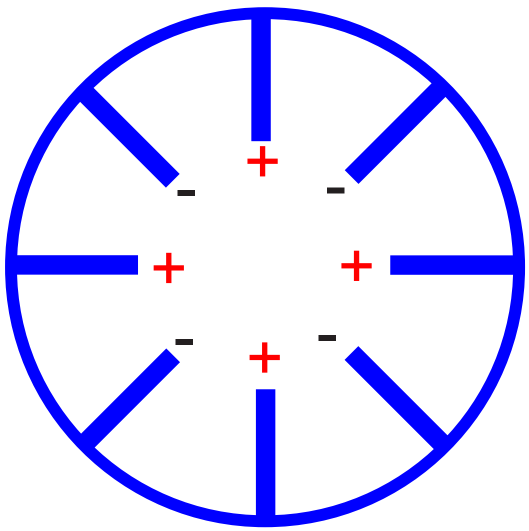


Capacitor

Need something that will oscillate fast
Need to produce power (like radio transmitter)

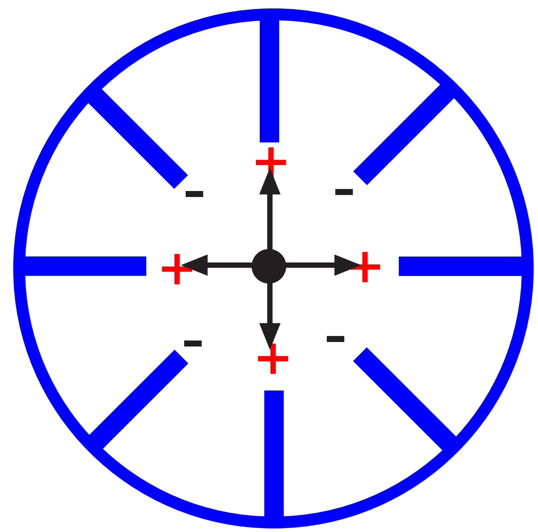
Magnetron 1

8 tank circuits
all working together



Need to extract power
(to cook food)
Need to replace that power

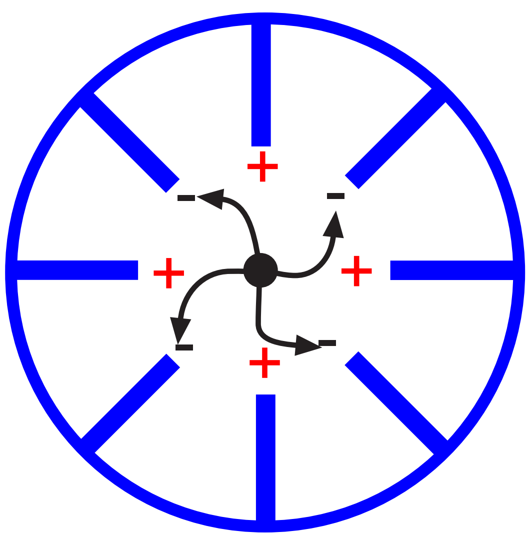
Add a filament at -4000V
to produce electrons,
These will flow to the
positive terminals



This will remove charge
from tank circuit
and interfere with
microwave production

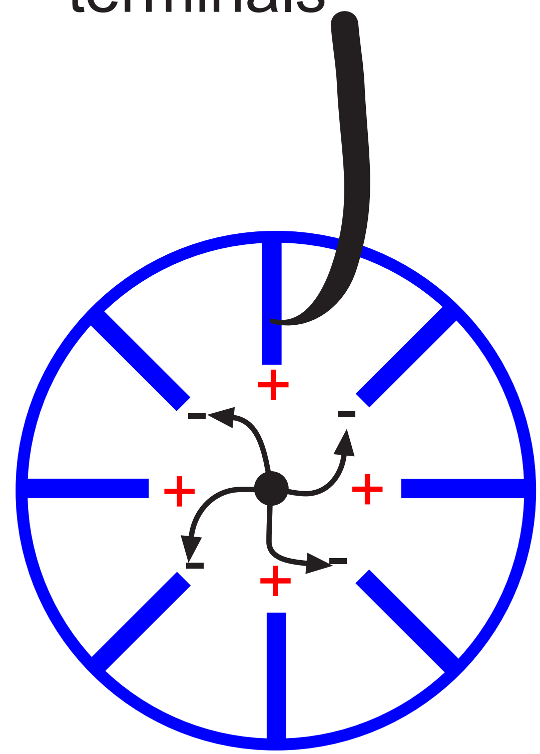
Magnetron 2

Add a magnetic field
(out of the page)
This causes the electrons
to bend their path and hit
the negative terminals,
charging the system more



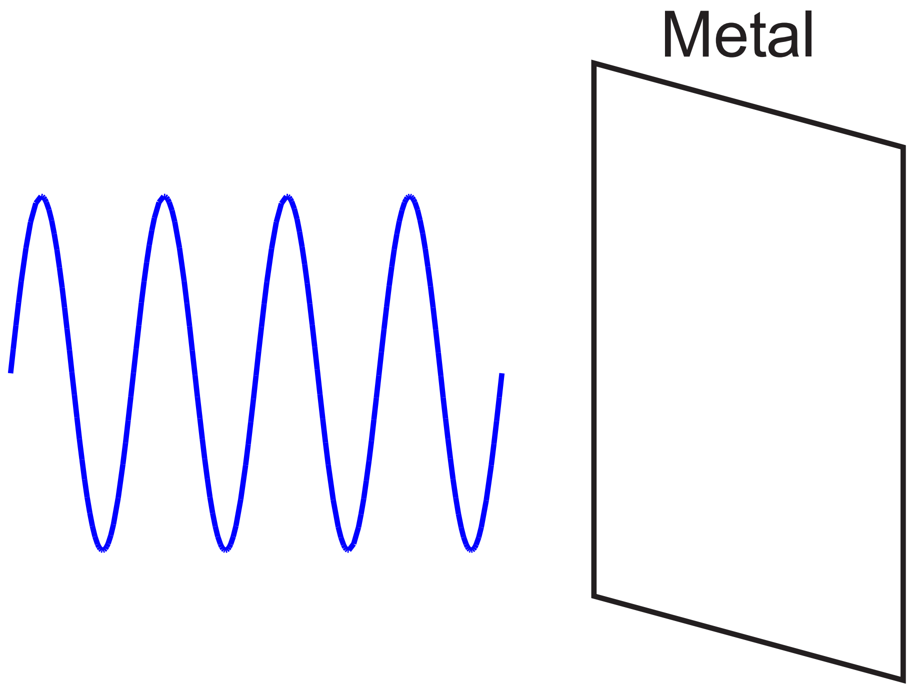
Need an antenna

Attach antenna
(1/4 wave) to
one of the
terminals



the metal mesh panel in front of door keeps microwaves inside
microwaves are polarized, so the holes int he mesh must be smaller than wavelengths

Microwaves and Metal



Create electric
field in metal
(current)

If metal has resistance, it will heat up

Inside of microwave is metal to keep the microwaves
inside (reflects like light).
The metal is thick so resistance is low and it does not heat up

basically: think metal inside microwave is fine
thin metal is not

Sparks

Electric field can be large near sharp points

Get arcing (or sparks)

Very thin metal, such as the gold rim of a plate or glass has large resistance and will heat up and melt, damaging the plate.

If a spark occurs near something combustible, fire results.

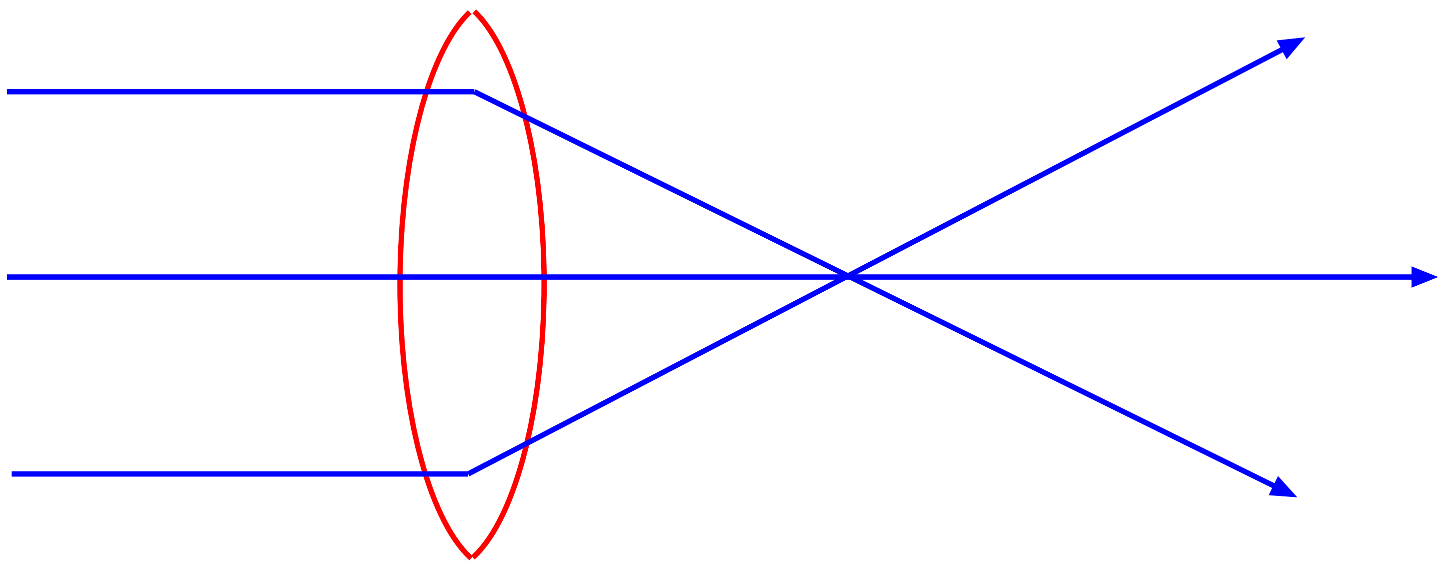
lightbulb in microwave: can explode, but otherwise will light up
CD in microwave: sparks, plastic melts

Geometrical Optics
Lenses

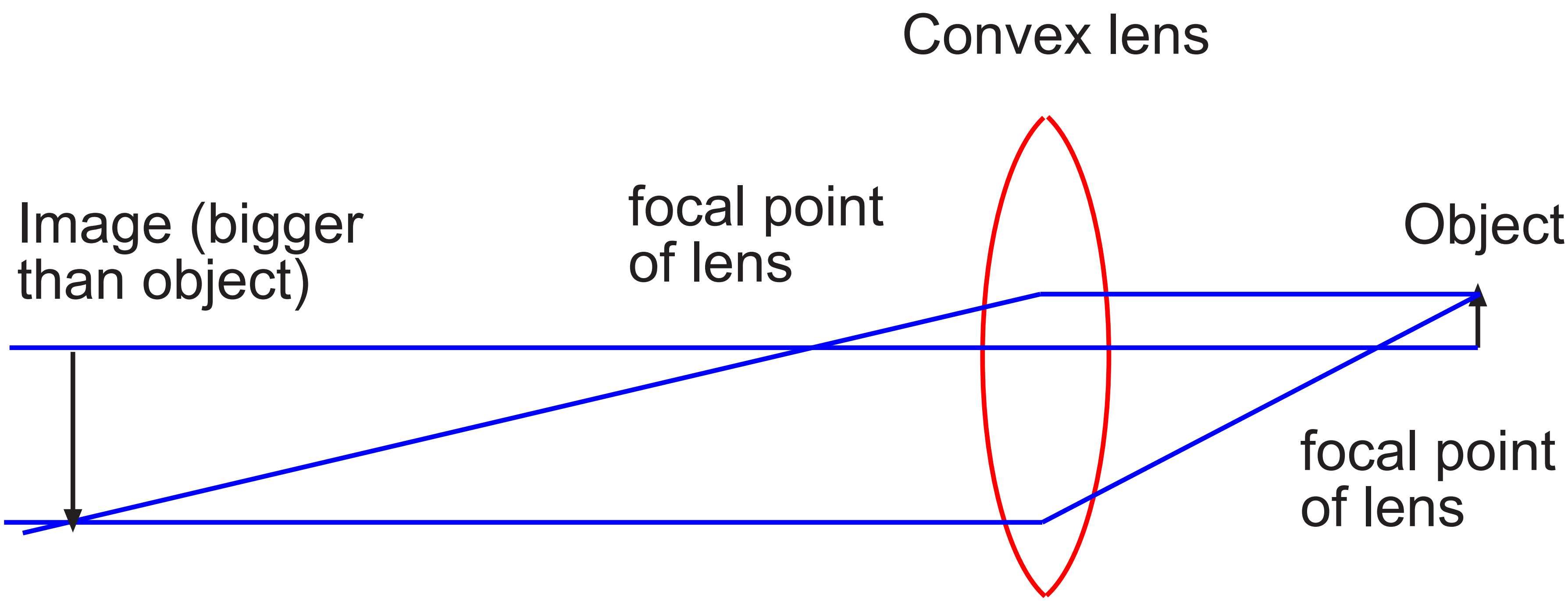
Convex lens focuses parallel light to a spot at the focal point.

Increases energy density

Limit to how small spot is (about the wavelength of light)

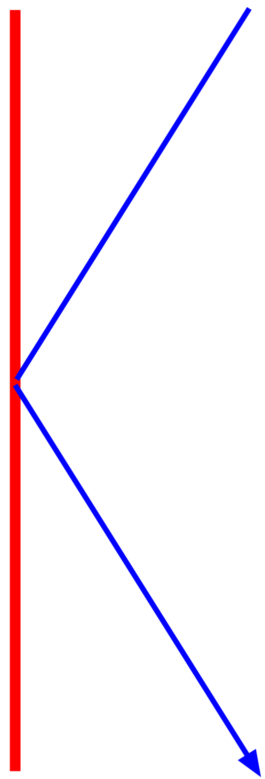


Magnifying Glass



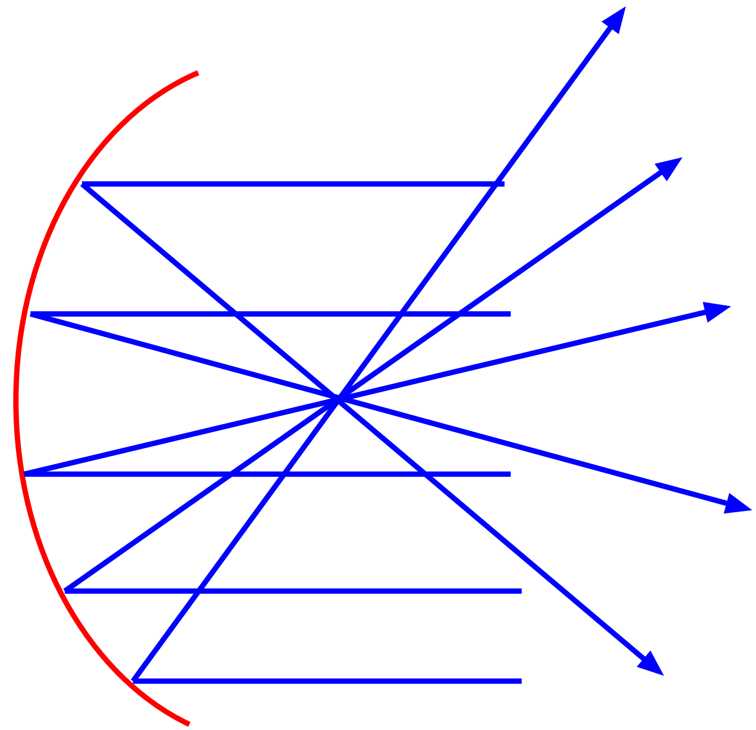
Flat Mirror

Mirror reflects light. incident angle is the same as reflected angle

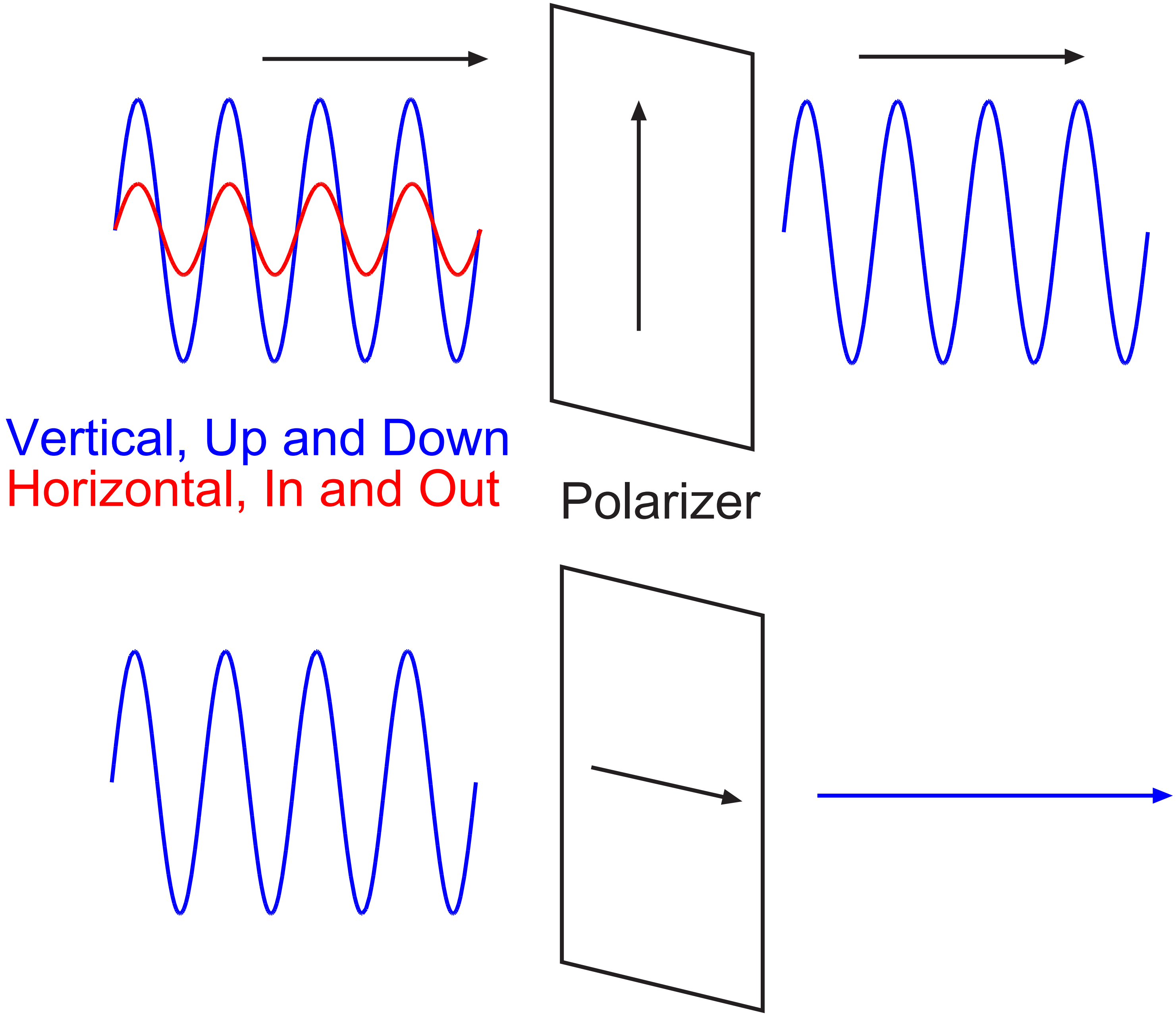


Parabolic Mirror

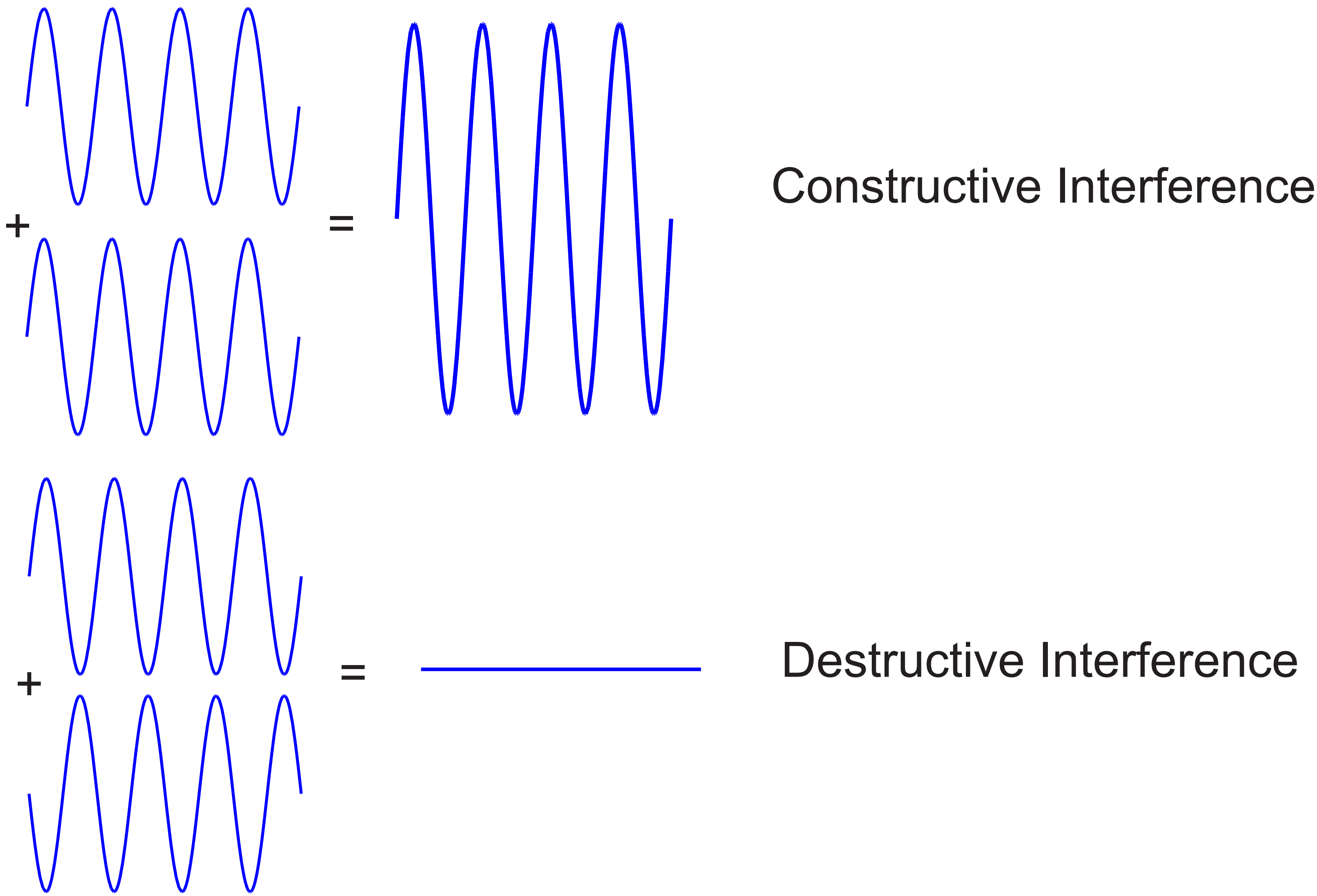
Parabolic mirror acts like a lens



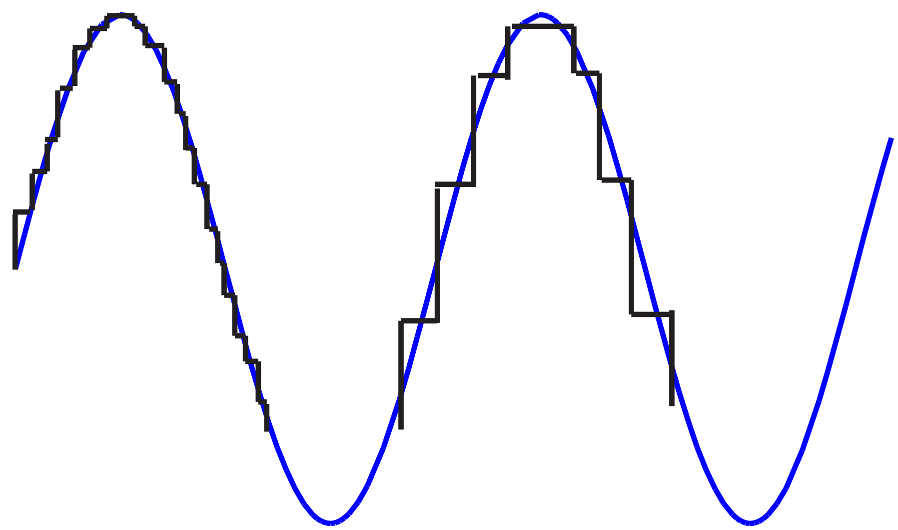
Polarizers



Interference



Digital Representation of Sound



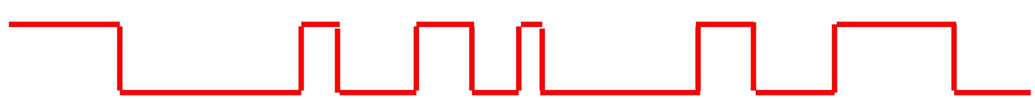
Measure the height of the wave at different point and assign a value to it.

If measurements are often, good reproduction.

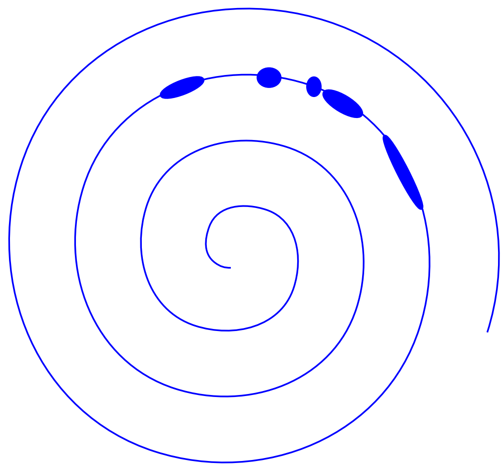
If measurements are infrequent, poor reproduction.

Use binary to represent the heights (1’s and 0’s)
1011 = 1x8 + 0x4 + 1x2 + 1X1 = 11

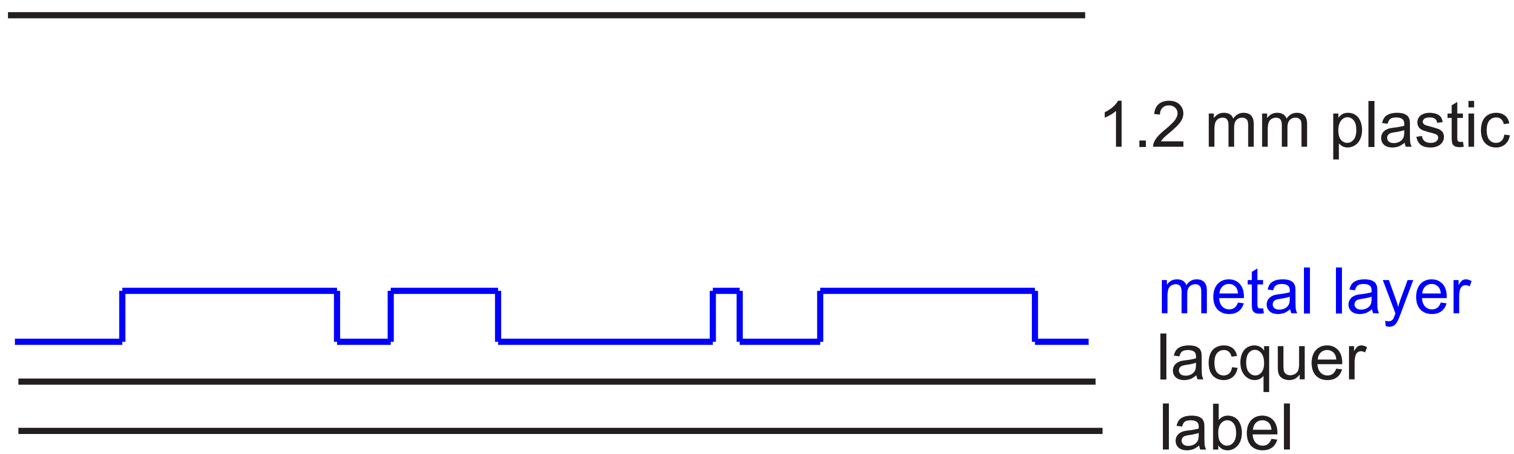
In a CD, use 16 bits to represent the height, the waveform can then be represented by strings of 1’s and 0’s
11110000010011010000110011100



Compact Disc



CD is written in a long spiral (5.378 km).
Pits are 110 nm high, 500 nm wide
and between 833 and 3560 nm long
The CD reads from the inside to the out.



Light is focussed on the metal layer and depending on the pattern of pits either constructively or destructively interferes as it is reflected. This is measured by a detector which translates this to 1's and 0's.

CD Player Optics