RECAP: Maxwell's EQNS: 4 EQNS THAT UNIFY ELECTRICITY AND MAGNETISM.

CHANGING E FIELD \rightarrow \text{induced} \rightarrow \text{CHANGING B FIELD}

\Rightarrow \text{LIGHT IS A WAVE}

ASIDE: WAVE EQUATION

\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2}

y(x, t) = A \cos(ct) \sin(x)

\text{FREQ} = \delta = \frac{1}{T}

c = \lambda \delta
WAVE PROPAGATES IN Z DIRECTION

↑ REPRESENTS DIRECTION AND MAGNITUDE OF E FIELD IN A PLANE TRANSVERSE TO MOTION

/ REPRESENTS DIRECTION AND MAGNITUDE OF B FIELD IN A PLANE TRANSVERSE TO MOTION

E AND B FIELDS OSCILLATE TOGETHER BUT PERPENDICULAR TO EACH OTHER → THE EM WAVE PROPAGATES PERPENDICULARLY TO BOTH FIELDS.
THE WAVE NATURE OF LIGHT.

DEBATE THAT SHAPED MUCH OF 18th & 19th CENTURIES.

LIGHT AS PARTICLE (NEWTON)
LIGHT AS A WAVE (HOOKE)

WAVES OF ALL TYPES EXHIBIT: INTERFERENCE, DIFFRACTION, REFRACTION

**INTERFERENCE**

![Interference Diagram](image)
Waves interfere but particles do not.

The reflected light interferes construct or destructive or somewhere in between.

The different colors are due to the different thickness of the film of oil.
**Diffraction:**

Example: Light diffraction of clouds in sunset (silver lining) - CD
Double Slit Diffraction

Incident plane wave

Single slit envelope

Single slit
Double slit
REFRACTION

Air \rightarrow Glass

$u_{\text{air}} \approx c$

$\frac{c}{n}$

$n = \text{index of refraction}$

$n_{\text{glass}} \approx 1.3$

Air \rightarrow Glass

Wind \rightarrow Air

BENT TOWARDS NORMAL

SLOW FAST

BENT AWAY FROM THE NORMAL.
Imagine that the **fronts** are rows of soldiers and the **rays** are lines of soldiers. The soldiers move more slowly through mud. If they approach it at an angle, then the soldiers on the left will reach the mud first, and slow down first. This will cause the lines of soldiers (the **rays**) to bend.
**Refraction by a Converging Lens**

Incident rays which travel parallel to the principal axis will refract through the lens and converge to a point.

**Refraction by a Diverging Lens**

Incident rays traveling parallel to the principal axis will refract through the lens and diverge, never intersecting.
Dispersion: Normal light is a collection of many frequencies.

Degree by which light is bent depends on frequency.

Blue light refracts more than red light due to the difference in wavelength. This causes blue light to deviate from its original path by a greater angle than the red light.
**THE ELECTROMAGNETIC SPECTRUM**

- **Wavelength (in meters)**:
  - Longer: Soccer Field, House, Baseball.
  - Shorter: This Period, Cell, Bacteria, Virus, Protein, Water Molecule.

- **Common name of wave**:
  - Radio Waves, Infrared, Ultraviolet, "Hard" X-rays, Gamma Rays.

- **Sources**:

- **Frequency (waves per second)**:
  - Lower: $10^6$, $10^7$, $10^8$, $10^9$, $10^{10}$.
  - Higher: $10^{11}$, $10^{12}$, $10^{13}$, $10^{14}$, $10^{15}$, $10^{16}$, $10^{17}$, $10^{18}$, $10^{19}$, $10^{20}$.

- **Energy of one photon (electron volts)**:
  - Lower: $10^{-9}$, $10^{-8}$, $10^{-7}$, $10^{-6}$, $10^{-5}$.
  - Higher: $10^{-4}$, $10^{-3}$, $10^{-2}$, $10^{-1}$, $1$, $10^1$, $10^2$, $10^3$, $10^4$, $10^5$, $10^6$.

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**Notes**:
- **Radio**: wide (1-1000m) oscillations of charge.
- **IR**: random thermal motion of molecules due to their thermal energy. We can feel IR, but not see it.
- **Visible**: transitions of $e^-$ inside atoms.
- **UV**: can split molecules — cancerous.
- **X-ray**: from $e^-$ collisions on metals — hospitals.
- **$\gamma$-ray**: from radioactive materials — biological damage.
The diagram illustrates the electromagnetic spectrum, ranging from gamma rays to radio waves. The atmosphere is divided into several layers:

- **Troposphere** (weather), typically below 10 km.
- **Stratosphere** (ozone layer at 20-30 km, and where jets fly at 10 km).
- **Mesosphere** (meteors burn up), above the stratosphere.
- **Thermosphere** (auroras), at the highest levels of the atmosphere.

Each layer is associated with different phenomena and technologies, such as satellite communications and weather forecasting. The diagram also highlights the concept of optical and radio windows, representing specific regions within the spectrum that are transparent to certain types of radiation.