Optics – The Study of Light

**Refraction**

Light **refracts** when passing between two substances **at an angle**.

- Light slows down in glass. Here the left side slows down first causing the light to bend to the left.
- Light speeds up in air. Here the left side speeds up first causing the light to bend to the right.

**Reflection**

Light reflects at shiny boundaries we call mirrors.

- **Normal** – an imaginary line 90° (perpendicular to a surface).
- **Angle of Incidence** – the angle between the incoming ray and the normal.
- **Angle of Reflection** – the angle between the outgoing ray and the normal.

**Focus**

Every lens or mirror has a place where all of the parallel rays will meet. This is known as the **focal point** or **focus**.

**Straight Lines**

Mirrors and lenses can make things look bigger or smaller because our eyes always think that light comes from straight lines, even if they have been refracted or reflected.

**Object vs. Image**

- The **object** is what you are looking at: the actual thing.
- The **image** is what you think you see: the object enlarged, reduced, or moved.

**Lenses**

Lenses work by refraction, by the light bending when moving between two substances.

- A convex lens magnifies.
  - **Convex lens**
  - A convex lens is **convergent** — the light rays come together.
- A concave lens reduces.
  - **Concave lens**
  - A concave lens is **divergent** — the light rays spread apart.

**Concave or Convex**

- Concave looks like the sides have caved in.
  - Convex — the middle is bigger than the ends.

**Optical Systems**

Microscopes and telescopes are optical systems that use combinations of lenses and/or mirrors to magnify light. Combining optical devices allows us to see very distant or very small objects.

- A convex mirror reduces.
  - **Convex mirror**
  - A convex mirror is divergent.
- A concave mirror magnifies
  - **Concave mirror**
  - A concave mirror is convergent.
1. Optics A. The study of how light behaves.
2. Image B. A lens or mirror that is bigger in the middle.
3. Object C. Light rays that spread apart.
4. Concave D. Where your eyes think something is.
5. Convex E. Light rays that come together.
6. Convergent F. What you are actually looking at.
7. Divergent G. A lens or mirror that is bigger at the ends.

The angle of incidence is: _____
The angle of reflection is: _____
The normal is: ___________
The incident ray is: __________
The reflected ray is: __________

You stand 2 feet in front of a mirror. How far away does your image seem?

A convex lens is convergent/divergent and magnifies/reduces.
A concave lens is convergent/divergent and magnifies/reduces.
A convex mirror is convergent/divergent and magnifies/reduces.
A concave mirror is convergent/divergent and magnifies/reduces.

What quantities are these units for?

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If a sound is 60 dB loud. Answer how many dB these would be:
1) A sound twice as loud:
2) A sound half as loud:

A sound wave has a wavelength of 20 m. Find its frequency.

If a sound wave’s frequency is 100 Hz. What is its period?

You yell into a canyon and it takes 3 seconds for the echo to come back to you. How far away is the other side of the canyon?

Find its period: _______________________

What harmonic is this? __________________

Could a human hear this frequency? ________

Mark the nodes and anti-nodes.

How many wavelengths is it? ___________

Find the fundamental frequency:

5th harmonic frequency:

Can we hear this frequency? ___________
How Lasers Work

Lasers give off light of one particular wavelength. This comes from forcing a substance (usually a gas) to give off light. This light bounces back and forth between mirrors, causing other atoms to give off more light. When the light is powerful enough it escapes as a laser beam.

Why We Use Lasers

- **Laser light** is compact: it doesn’t spread out like regular light. That’s why we use them for pointers and why they don’t bend in prisms.
- **Lasers can be powerful.** Some lasers are used in industry and medicine for precision cutting. Military lasers are just now able to blow up incoming missiles.
A convex lens is convergent/divergent and magnifies/reduces.
A concave lens is convergent/divergent and magnifies/reduces.
A convex mirror is convergent/divergent and magnifies/reduces.
A concave mirror is convergent/divergent and magnifies/reduces.

1. Total internal reflection
2. Critical angle
3. Fiber optics
4. Incandescent
5. Fluorescent
6. Filament

How can light be redirected by fiber optics?
Can a fiber optic cable be bent any direction? Why or why not?
You have an office building and need to cut cost. What kind of lights will you use and why?
Light is passed through a polarizer. How could you cancel out light with a second polarizer?
What element is photoluminescent and why?
Why don’t lasers spread out into a rainbow in a prism?

A convex lens is convergent/divergent and magnifies/reduces.
A concave lens is convergent/divergent and magnifies/reduces.
A convex mirror is convergent/divergent and magnifies/reduces.
A concave mirror is convergent/divergent and magnifies/reduces.

| Angle of incidence: _______ |
| Angle of reflection: _______ |
| Normal: _________________ |
| Incident ray: ____________ |
| Reflected ray: ___________ |

If the angle of incidence is 25°, what is the angle of reflection?
If the angle between the incident and reflected rays is 80°, what is the angle of reflection?
If an image look 20 meters away in a mirror how far away is the object?
An object is 4 meters away from a mirror. How far away does the image look?

| A. Light created from high heat. |
| B. The part of a light bulb that glows when hot and makes incandescent light. |
| C. When all light cannot escape glass or another medium and stays inside. |
| D. The angle past which light cannot escape. |
| E. Technology based on bending light in cables. |
| F. Efficient light from UV radiation. |

1. Polarization
2. Polarizer
3. Photoluminescence
4. Phosphorous
5. Laser

A. An object that screens out all but light in one direction.
B. Light amplification by stimulated emissions of radiation.
C. An element that releases light slowly; used in glow-in-the-dark objects.
D. The act of only allowing one-directional light to pass through a “filter”.
E. Objects that give off light slowly.

Show where the 3 light rays will go.
Concave or convex lens?
What do we call the dot?
Magnifying or reducing?
Convergent or divergent?

Show where the light will go.
Concave or convex mirror?
Magnifying or reducing?
Convergent or divergent?

| Use RGB to make these colors. |
| Use CMYK to make these colors. |

Cyan _______ Yellow _______ Blue _______ Red _______
White _______ Black _______ White _______ Black _______
Green _______ Magenta _______ Green _______ Magenta _______

Using CMYK—What color does yellow absorb?
What colors does cyan reflect?

What has more energy: Radio waves or Visible light?
What has a shorter wavelength: Ultraviolet or Gamma rays?
What has a higher frequency: Visible light or Infrared?

A sound wave has a period of 0.5 secs. Find its frequency.
Find the wavelength of the above wave.
If the fourth harmonic of a standing wave is 48 Hz, find the fundamental frequency.
You hear your echo 6 seconds after you yell into a canyon. How wide is the canyon?