Lindsay Liang

Physics - Optics Summary Notes Pt. 2

MAGNIFICATION EQUATION

d_0 = Object Distance

d_i = Image Distance

h_0 = Object Height

h_i = Image Distance

Mag = d_i/d_o OR Mag = h_i/h_o

REFRACTION

- ORDINARY refraction occurs when light travels from one medium to another
- Light that is not reflected is refracted
- Less refractive = greater speed: Air
- More refractive = slower speed: Acrylic
- Light traveling from a less refractive medium to a more refractive medium
    - Light slows down
    - Bends towards the normal
    - Example: Light traveling from air to acrylic – the ray will bend towards the normal
- Light traveling from a more refractive medium to a less refractive medium
    - Light speeds up
    - Bends away from the normal
    - Example: Light traveling from glass to air – the Ray will bend away from the normal

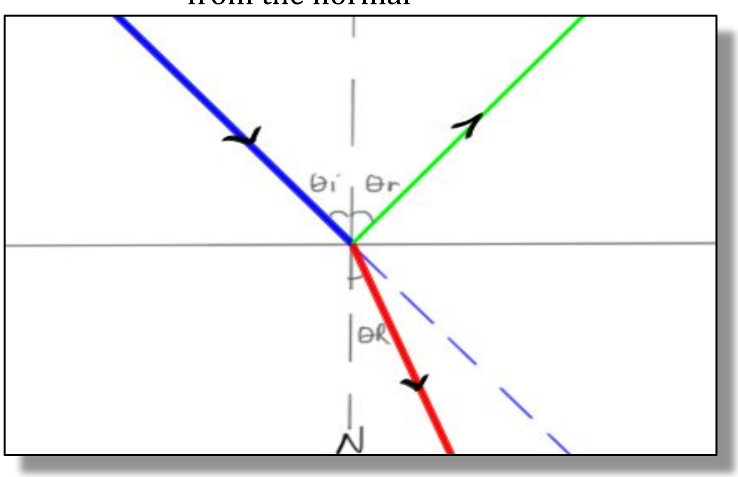


Figure 1: Refraction of a ray going from a less refractive medium to a more refractive medium. Blue – Incident Ray, Green – Reflection Ray, Red – Refraction Ray. Instead of following the dotted blue path, the Ray will bend towards the normal because the light is slowing down.

- The speed of light in a vacuum is 3×10^8m/s (we use the same speed for air)
- Refraction Index Calculation
    - n: Refraction Index
    - c: Speed of light in a vacuum
    - v: Speed of light in the medium
    - $n = c/v$ OR $n = \sin\theta_i / \sin\theta_R$

TOTAL INTERNAL REFLECTION

- Light is traveling into the more refractive medium
- Angle of incidence in the more refractive medium is greater than its critical angle
- As the angle of incident increases, the angle of refraction will increase, UNTIL R = 90 degrees
- Critical Angle - The angle of incidence where R is refracted at an angle of 90 degrees
- If the incident ray has an angle that is greater than its critical angle, the refracted ray does not disappear, but is reflected back into the first medium, meaning that there is no refracting ray

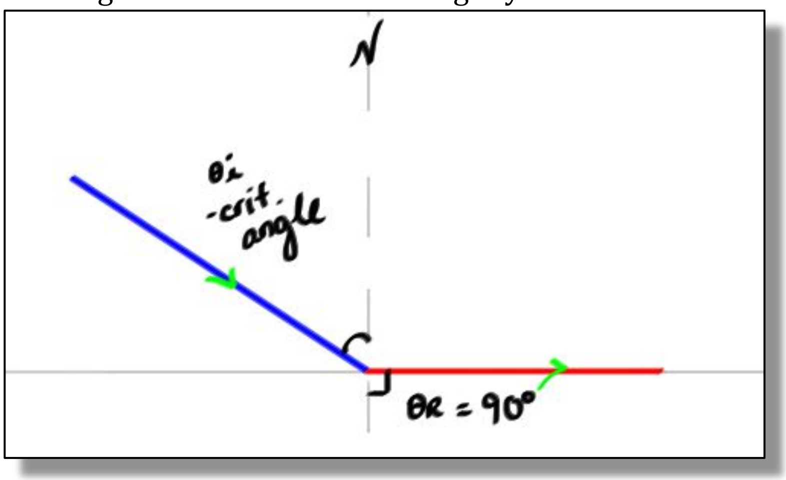


Figure 2: Because the angle of incidence is equal to the medium's critical angle, the angle of Refraction = 90 degrees

- The Critical Angle can be determined using Snell's General Equation:
- $n_1 \sin \theta_i = n_2 \sin \theta_R$, where n_1 is the refraction index of the first medium, and n_2 the index of the second

LENSES

- Like mirrors, there are two types of lenses
  - Converging (Convex)
  - Diverging (Concave)
- Terms
  - Optical Center (O) – Geometric Centre of Lens
  - Principal Axis (PA) – Horizontal line intercepting the optical centre of the lense
  - Axis of Symmetry – Imaginary line perpendicular to the PA, intercepting O
  - Principal Focus (F, and F_1) – Point on the PA where parallel rays to the PA refract. On a converging lens, the F is on the side opposite to the object. On a diverging lens, F is on the same side as the object.
  - Focal length (f) – distance between axis of symmetry and F
- Characteristics
  - **S** - size (magnification)
  - **A** – attitude (upright, inverted)

- **L** – location (beyond F, Between F and 2F)
- **T** – type (Real, virtual)

- Drawing Ray Diagrams – Converging Mirrors
    - Ray 1
        - Starts at top of the object
        - Travels parallel to the PA
        - Hits line of symmetry
        - Refracts by intercepting the Principal Focus
    - Ray 2
        - Starts at the top of the object
        - Travels to intercept O
        - Does not refract

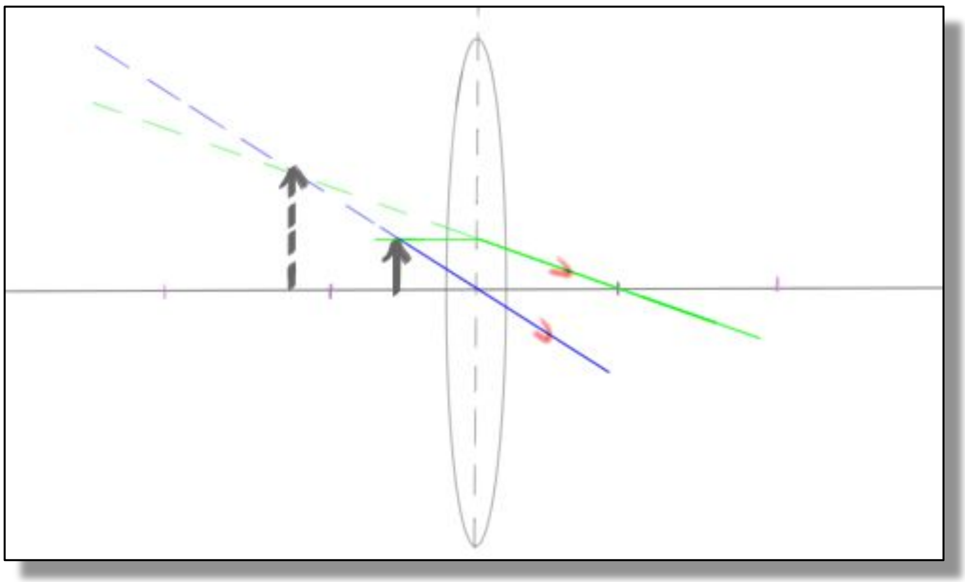
- 

Figure 3: Object between F and Lens

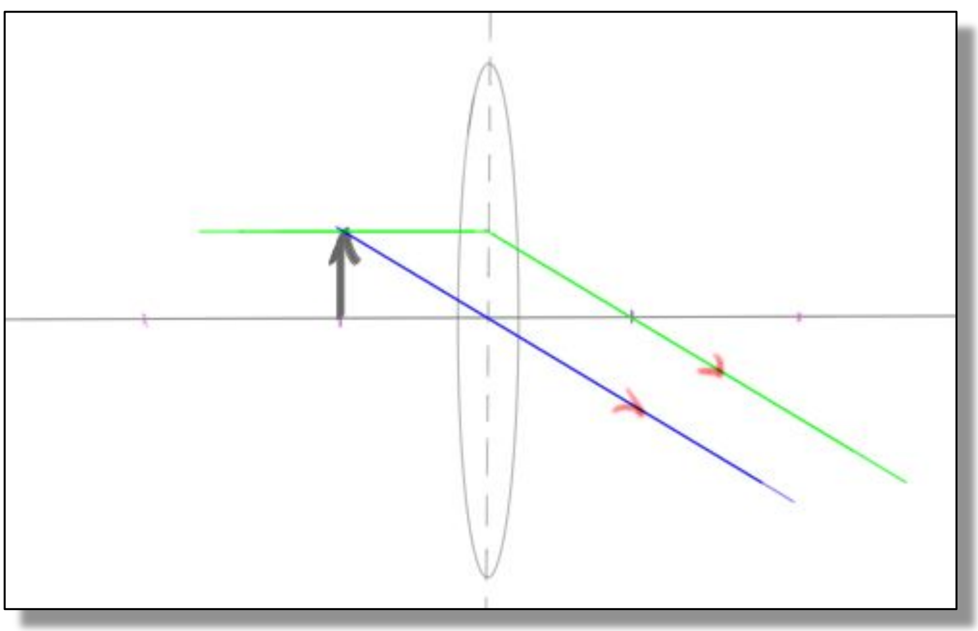
- 

Figure 4: Object at F

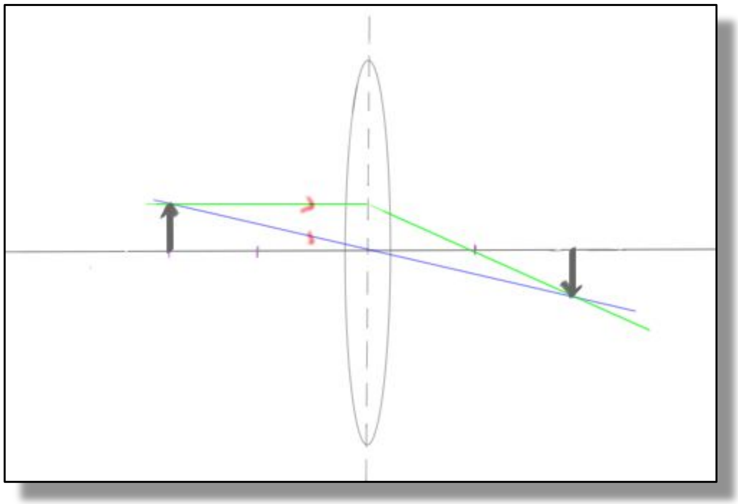


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Figure 5: Object at 2F

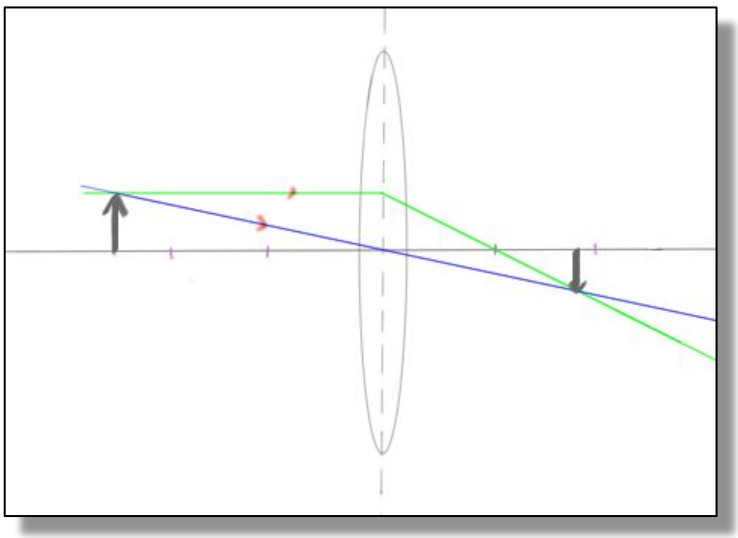

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Figure 6: Object beyond 2F

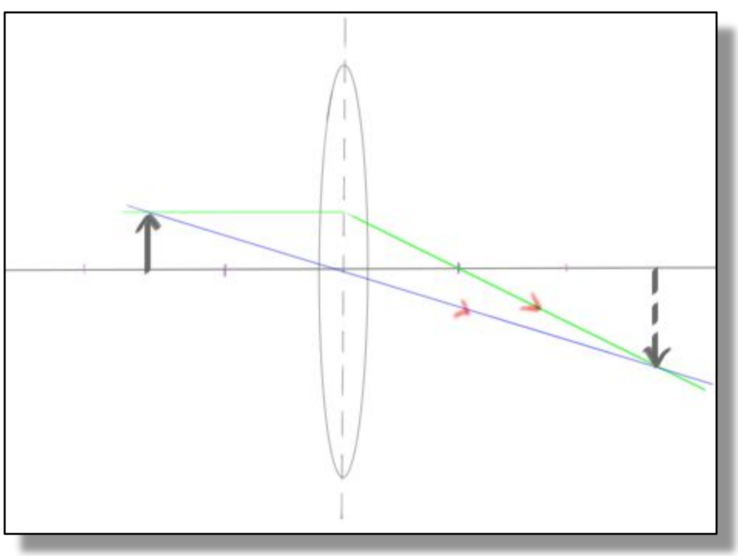

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Figure 7: Object between F and 2F

- Drawing Ray Diagrams – Diverging Mirrors
  - Same image no matter where the object is
  - Ray 1
    - Starts at top of the object
    - Travels parallel to the PA
    - Refracts away from PA
    - Our eyes imagine that the ray reflects back on a straight path, intercepting the Principal Focus
  - Ray 2
    - Starts at top of the object
    - Travels to intercept O

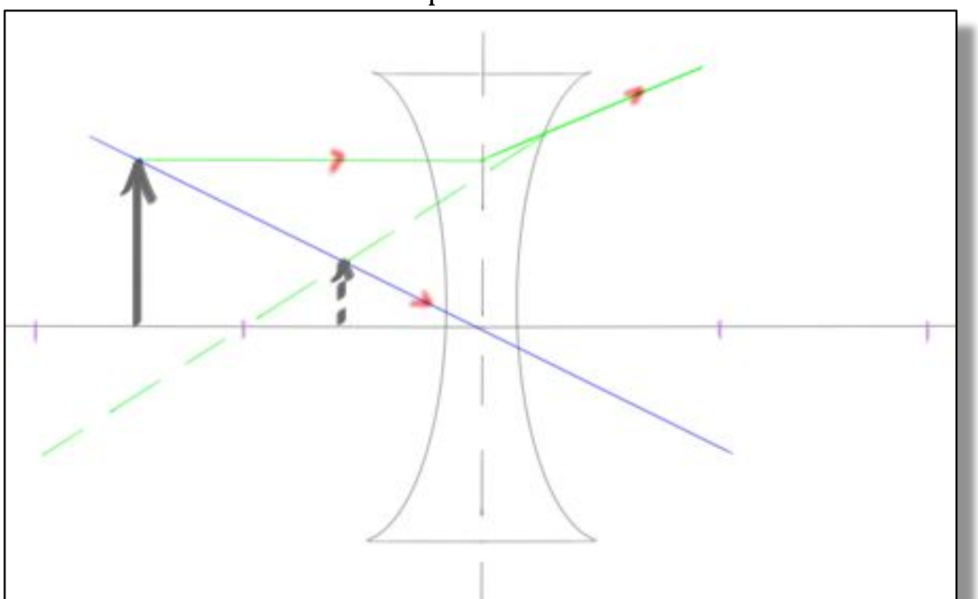

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Figure 8: No matter where the object, the virtual image will always appear at the same place

THE HUMAN EYE

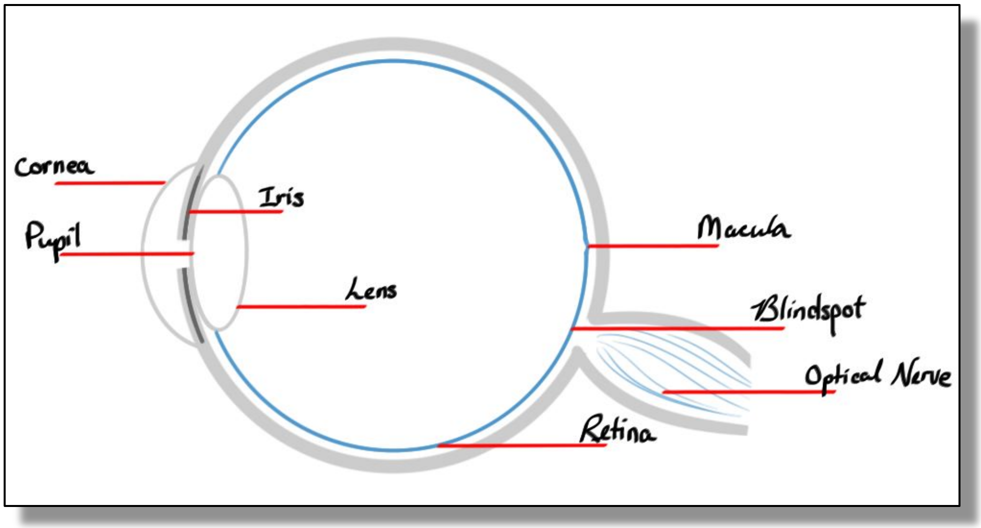

Figure 9: Diagram of the Human Eye - details below

- Cornea
  - Made of strong tissue that protects eye, can heal itself
- Pupil
  - Created by a circular band of muscle (iris)
  - Size is controlled by the Iris
  - Environment with less light - pupil opens up to let in more light
  - Environment with more light – pupil contracts
- Iris
  - The coloured part of the eye
  - Controls amount of light entering the eye
- Retina
  - Where the light forms an image in the back of the eye
  - 2 types of cells
    - Rod cells
      - 120 million
      - Low light sensors
      - Black and white
    - Cone cells
      - 7 million
      - Detect Colour
  - Macula – very sensitive part of the retina that forms images from looking straight ahead
- Blind Spot
  - Where the optical nerve attaches to the retina
  - Cannot detect light
  - Brain fills this with colours that are nearby the object you are looking at
- Light enters through the cornea and passes through the pupil
- Then is focused by the convex lens of the eye
  - Accommodation – the lens' ability to adjust

    - Thins in the middle when the ciliary muscles are relaxed
    - Thickens in the middle when the ciliary muscles are contracted
- Forms an image on the retina (the back of the eye)
- Light rays are absorbed by photoreceptors (light-sensitive cells) in the retina
- This image is inverted and reversed, but our brain corrects this

VISION DEFECTS

Medical Term	**AKA**	**Problem**	**Correction**
Myopia	Nearsighted	Lens-Retina distance too great	Divergent lenses
Hyperopia	Farsighted	Lens-Retina distance too small	Convergent lenses
Presbyopia	Farsighted	Loss of accommodation	Bifocal lenses
Astigmatism		Non-perfect spherical cornea	Lenses with different focal planes
Glaucoma		Damage to optic nerve, often from intraocular pressure	
Cataracts		Opaque-cloudy area on lens	Removal of lens

APPLICATIONS

LEDs

- Light emitting diode
- Emits light when electric current is passed through it
- Is a semiconductor (made by doping conductive metals onto an insulator)
- Only allows electricity to flow in one direction
- To electrodes – Anode, Cathode
- How it works
  - Electrons flow from anode (P side)
  - In the diode, electrons combine with electron holes to produce light
  - Electrons have now lost voltage, and continue to flow to the cathode (n-side)
  - Electrons exit the LED, returning to the power-source

Fiber Optics

- Optical fibers – very thin, long strands of glass, same diameter of human hair
- Bundles of optical fibers – optical cables
- Consists of
  - Core
    - Centre of the fiber where light will travel
  - Cladding
    - Total internal refraction

        - Light escaping the core will hit the cladding at a greater angle than the critical angle
    - Buffer Coating
        - Protects core and cladding from damage/moisture
- Multimode Fibers
    - Less expensive
    - Low bandwidth
    - Signal can only transmit a maximum of 2km
- Single Mode Fibers
    - More expensive
    - Higher bandwidth
    - Signal transmits to a maximum of 60km