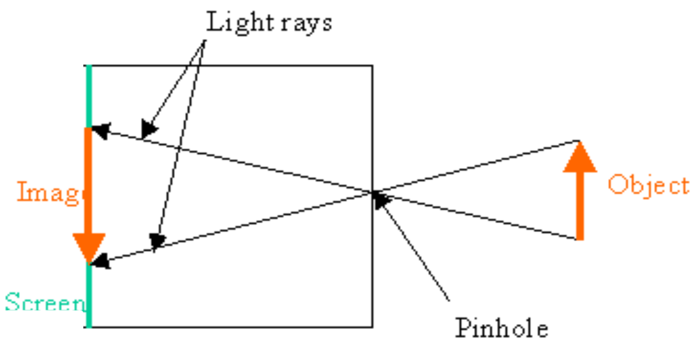
Physics EOY Notes

Reflection

- Clarifications:
  - Virtual/Real Image
    - Virtual when seen in a mirror (Cannot be captured on a screen)
    - Real when seen in a pinhole (can be captured on a screen)
- Technicalities (drawing):
  - Steps to Drawing Sketch/ Diagram:
    - Locate image and draw construction line
    - Draw line from Image to Observer, but only draw solid lines until the ray meets the plane (mirror), then draw dotted line when "inside" the mirror
    - Draw line from object to mirror point, or from point of incidence to object
      - *Ensure that the angle of incidence and the angle of reflection are the same
  - Draw Arrow Head
  - Normal:
    - Should be drawn in dotted lines
    - Perpendicular to the surface of incidence
    - For curved surfaces, draw a circle-centre, then draw out the radius. The radius is the normal.
  - Label angles, etc.
- Transparent vs Opaque Materials
  - As long as materials allow some light to pass through, they're considered transparent.
- Pin-Hole Camera



  - Image is inverted (not laterally inverted)
  - $\frac{Height\ of\ Image}{Height\ of\ Object} = \frac{Image\ Distance\ from\ Pin\ Hole}{Object\ Distance\ from\ Pin\ Hole}$
  - If the hole is made bigger:
    - Image will be brighter (more light can enter the pinhole)
    - Image will be blurred (the big pinhole can be seen as numerous smaller pinholes, each of which form their own images at different positions)
    - Image size (height) will remain the same (as the image, object heights/ distances from pinhole are not changed – only the size of the pinhole is enlarged)
  - If the distance between the object and the pinhole is increased:
    - Image size (height) will become smaller (as it is further away from the pinhole, angle of the rays needs to be close to being perpendicular to the pinhole – try to visualize)

        - Image sharpness will not be changed (because pinhole size is not changed)
        - Image will be less bright (less light will be able to enter the pinhole)
    - How can pinholes help the vision of people with imperfect vision, without wearing lenses (in other words, explain how pinholes work with reference to the human eye)
        - Pinholes allow only certain rays of light to pass through, having the effect of reducing the width of the bundle of "diverging" rays coming from each point on the viewed object. Therefore, this increases the sharpness of the image.
    - Causes objects viewed to appear bigger:
        - Pinholes allow us to focus on the object no matter how close the object is to our eyes (unlike if we were to view an object without pinhole glasses), and so, we can bring the object much closer to our eyes and still be able to focus on it, unlike the scenario where we are not wearing pinhole glasses.
        - As such, pinhole glasses **ALLOW** us to bring it closer to our eyes, therefore giving us the perception that the object is bigger.
        - However, the object isn't really bigger in reality – it's still the same size.
- Laws of Reflection:
    - The incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane,
    - The angle of incidence, *I*, is equal to the angle of reflection
- Mirrors:
    - Mirror Properties:
        - The object can be twice the length of the mirror and still be seen in the mirror.
        - If you stand in front of a mirror, and put 2 pieces of tape to reflect the tip of your head and your foot. The locations of the pieces of tape does not have to be changed if you move closer or away from the mirror.
    - Locating Image:
        - Draw a perpendicular line from the plane to the object (extend plane if necessary).
        - Extend perpendicular line the equal distance as the length of perpendicular line
    - Image Properties:
        - Upright (not inverted, because there isn't a pinhole)
        - Virtual (Cannot be captured on a screen)
        - Laterally inverted
        - Same size as object
            - Image size will always be the same size as the object itself. However, the distance of the object from the mirror equals to the distance of the image from the mirror, so when the distance is increases, the image is located further away (however has the same image size as the object size)
        - Same distance behind the mirror, as the object itself is.
- Diffuse Reflection:
    - When you have an uneven surface as a plane rather than a smooth surface, light rays are reflected in many different directions .

- Although each ray obeys the law of reflection, the many different surface angles that he light encounters in striking a rough surface cause reflection in many different directions.
- Examples:
  - Wet Road – The road on its own would experience diffused reflection, however, when there is a layer of water over the road, the road becomes smooth and experiences regular reflection. In diffuse reflection, the image of the light source would be dispersed, allowing us to see the road (which is the mirror/plane). However, with the water there, there would be regular reflection, which will cause the light source to be reflected fully and more prominently, causing a glare to be formed on the road, which prevents us from being able to see the road properly.
  - Glossy page vs. smooth page – Same concept as wet road example.
  - Moonlit Ocean – If the water surface was completely flat, and not rough, we would see an image of the moon on the water surface. However, since the water surface is rough, the light strikes each of the miniature waves (each acting as a miniature mirror), throughout all the waves in the ocean.

- 2 Mirror Facing Each Other
  - Infinite Reflections
  - Distance is distance from image to new mirror, replicated on the other side of the mirror plane.
- Clarifications
  - Ben stands midway between the mirror and a portrait of width 1m. What is the narrowest mirror so that Ben can see the image of the whole portrait? Does it matter where Ben stands?
    - Draw the images.
    - The big triangle is an extension of the small triangle. It has thrice the height of the triangle (As seen from diagram) so it will have thrice the width of the triangle as well.
    - *This similar triangle property can only be established if it is isosceles or equilateral triangles we are dealing with.

Refraction

- What is Refraction:
  - Bending of a light ray towards of away from the normal as it passes through different mediums.
    - Less dense to denser – towards normal
    - Denser to less dense – away from normal
    - * Normal is perpendicular to the surface of incidence.
- Requirements for Refraction
  - Both mediums need to be transparent (translucent counts as transparent)
- Reasons for Refraction…Why Light Refracts?
  - Least Time Principle:

        - Light aims to get from point A to point B in the shortest time possible. As such, it takes the path that will allow it to reach point B from A in the least time.
        - This accounts for why light travels a bit of an extra distance in the medium it can travel fast in, and why it travels lesser distance in a medium it is very slow in.

- Optical Density:
    - Refraction happens due to the difference in refractive indexes (also known as optical density) of the mediums.
        - Higher the refractive indexes, the more optically dense the medium is.
        - Lower the refractive indexes, the less optically dense the medium is
    - Common Refractive Indices:
        - Water – 1.33
        - Air – 1.003 (round off to 1.00)
        - Glass – 1.52
        - Vacuum 1.00
- Speed of light in mediums:
    1. Take the speed of light (3×10^8 m/s)
    2. Divide this by the refractive index
- Circular surfaces of incidence:
    - Extend the "circle" to make a midpoint – draw a radius line from the midpoint.
    - Radius line is the normal
- Rules of Refraction:
    - If the light ray is perpendicular to the surface (along the normal), then the speed of the light in the new medium is changed, but the direction of light remains the same.
        - Use car-tire analogy
    - Reversibility of Light:
        - If a ray of light follows a certain path from medium A to medium B, it will follow the same path if it is released from medium B to medium A.
- Image Depth:
    - When viewing an object that is in a medium of higher optical density than the medium you are viewing it from, the object appears to be positioned higher than it actually is.
        - As the rays of light refract away from the normal into our eyes (which are located in a medium of lower optical density), the ray of light bends. However, our brain perceives light to be always travelling in a straight line. Hence, we can extend the 2 rays which enter our eyes, to see where the 2 rays meet, and this position will be where our brain perceives the object to be.
        - This position will always be higher than the object itself.
        - Example, we view the bottom of a swimming pool from above – we notice that the pool appears shallower than it actually is.

- This works both ways – when we view an object from a medium of lower optical density than the medium we are viewing it from, (eg. A human as seen by a fish in water) the image will be located further away than the object itself.
- If the viewer is directly above the object (perpendicular to the surface, and if the ray of light lies along the normal), the refractive index of the medium the object is in can be calculated by:
  - [real depth of object]/ [apparent depth of object]

- Image Size:
  - When you see an object located in a medium of higher refractive index from a medium of lower refractive index (eg. Looking down into a pond, at a fish), the object will appear larger than it is.
    - To prove this, you can apply the same principle as above (the perception of light by the human mind), because the human mind would think that the ray of light would travel in a straight line, so we see that when we extend the "straight" lines, the fish would appear bigger than it actually is.
  - When the reverse happens (Fish looks at man outside water), and when the object is in a medium of lower refractive index, the image of the object will appear smaller.
    - To prove this, you can once again extend the "straight" rays of light the fish eye perceives.
- Snell's Law:
  - $n_1 \sin \boldsymbol{\theta}_1 = n_2 \sin \boldsymbol{\theta}_2$
    - Where n1 refers to the refractive index of the first medium
    - Where Theta 1 refers to the angle of incidence
  - By changing the subject of the formula, you can calculate:
    - Angle of Incidence
    - Angle of Refraction
    - Refractive Index of Medium 1
    - Refractive Index of Medium 2
    - Critical Angle
- Critical Angle:
  - Angle at which the refracted ray travels along the boundary of the meeting points of the 2 surfaces.
  - Angle greater than which total internal reflection occurs
- Internal Reflection
  - Partial Internal Reflection:
    - Happens every time there is refraction, but the emergent ray will be weaker than the refracted ray
    - To calculate, apply the law of reflection (incident angle = reflected angle)
    - Applied in Fibre Optics
  - Total Internal Reflection:
    - 2 Conditions must be met:

- Light ray is being refracted from an object of higher refractive index to an object of lower refractive index.
- Angle of incidence must be greater than critical angle.

Nuclear Physics

- 3 types of radiation:

	Alpha Particles	Beta Particles	Gamma Rays
Nature	Helium Nuclei ($^{2}_{4}He$)	Electrons ($^{0}_{-1}e$)	Electromagnetic Waves
Charge	+2 (2 protons, because it's just the nuclei)	-1 (electron)	Neutral
Speed	0.10 c (speed of light)	0.90 c	C

- Ionizing power (the power to cause gas molecules to lose electrons and become ions when radiation is passed through the gas – and once this happens, the gas is considered ionized).
    - Alpha particles: Highest ionizing power
    - Beta particles: Lower ionizing power than alpha particles, but higher than gamma rays.
    - Gamma rays: Lowest ionizing powers.
- Penetrating power (the ability to penetrate through various different types of materials) – the order of penetrating power is exactly the opposite of the order of ionizing power.
    - Alpha particles: Lowest penetrating power amongst the three (can be stopped by one or two sheets of paper/clothes).
    - Beta particles: More penetrating power than alpha particles, but lower than Gamma rays (can be stopped by 5 millimetres of aluminium).
    - Gamma: Highest penetrating power amongst the three. Requires several centimetre of lead to offer protection from penetrating powers.
- Methods of detecting radioactivity
    - Photographic Detectors – Workers in nuclear industries wear film badges, that measures dosage of radioactivity over long periods of time (over months)
    - Gold Leaf Electroscope – When a radioactive source is nearby, the air becomes ionized, and starts to conduct electricity, causing the charge within to "leak", causing a change in the pre-set levels.
    - Geiger-Müller Counter
    - Diffusion Cloud Chamber – Works on the ionizing powers of alpha and beta particles.
- Radioactive Decay