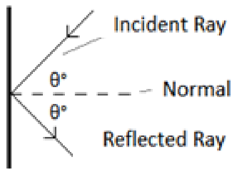
8.2.4 REFLECTION AND REFRACTION

Many communication technologies use applications of reflection and refraction of electromagnetic waves

4.1 Describe and apply the **law of reflection** and explain the effect of reflection from a **plane surface** on waves

- Angle of **incidence**, in relation to the **normal**, is **equal** to the angle of **reflection**
- Normal is a line perpendicular to the reflecting surface at point of incidence
- For example, light will reflect off a mirror with same θ_i and θ_r



4.2 Describe ways in which applications of reflection of **light, radio waves** and **microwaves** have assisted **information transfer**

LIGHT

- Forms **virtual images** of objects placed in front of plane mirror, both **real and virtual** from curved mirrors
    - Telescopes use **parabolic concave mirrors** to reflect light from stars
- **Torches and driving lights** have parabolic reflectors – adjust light source for flood or spot beams
- Light can be repeatedly reflected off **optic fibre** boundaries

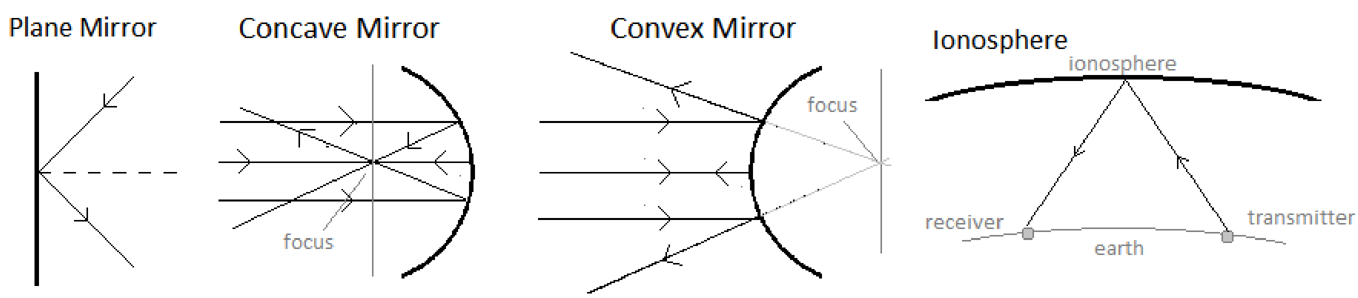
RADIO WAVES

- Radio **sky waves** bounce off **ionosphere** – essentially bouncing off a plane surface
- Radio **space waves** pass the ionosphere and reflect off satellites

MICROWAVES

- **Radar** uses microwaves, reflects off an object to determine distance of the object

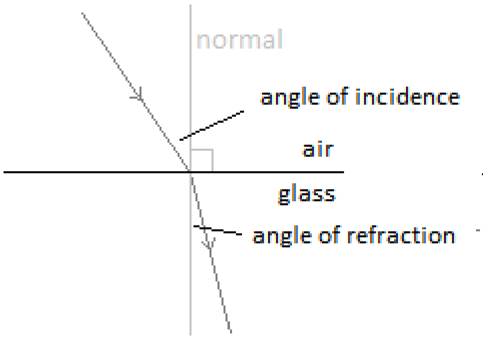
4.3 Describe one **application** of reflection for **plane surfaces, concave surfaces, convex surfaces** and **radio waves** being reflected by the ionosphere

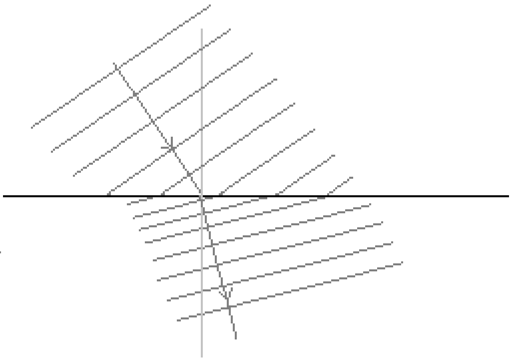


- **Plane surface**: Virtual image, as object appears behind the mirror
    - Used in **household mirrors** – light reflects off mirror surface into the eye
- **Concave surface**: Has a reflecting surface with focal plane in front of mirror
    - Used in **car headlights** – light source at focus will create parallel beams of light
- **Convex surface**: Has a reflecting surface with a focus behind the mirror
    - Used in **driving mirrors** – wider field of view
- **Radio waves reflected off ionosphere**: long wavelength waves reflect well off ionosphere

4.4 Explain that **refraction** is related to the **velocities** of a wave in **different media** and outline how this may result in the **bending of a wavefront**

- **Refraction** – change in **velocity** when travelling from **one medium to another** (causing change in **direction**)
- Travelling into a **more dense medium** = **bending towards** normal, and vice versa





- **Frequency does not change**, but **wavefronts** are closer (= shorter **wavelength**), indicating **lower velocity**
- **Wavelength**

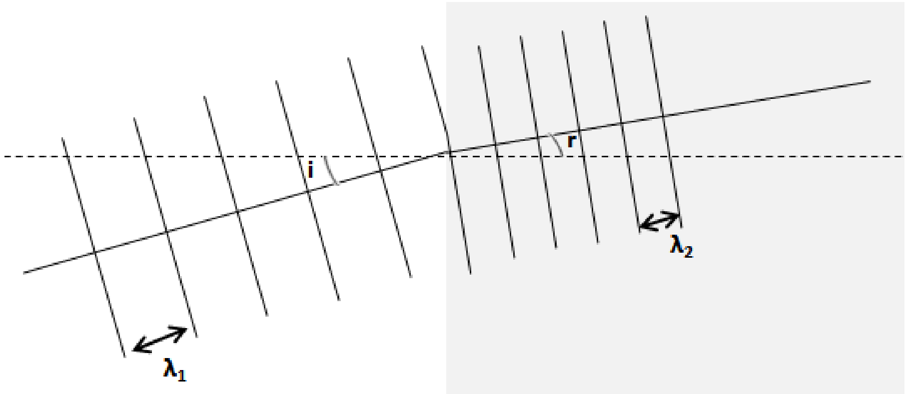
4.5 Define **refractive index** in terms of **changes in velocity** of a wave in passing from one medium to another

- Refractive index (n) – a **ratio** of how much a **wave slows down or speeds up** going into another medium
- **Absolute Refractive Index** – ratio of velocity of wave **in vacuum** to velocity **in the medium**

$$n = \frac{\text{speed of the wave in vacuum}}{\text{speed of wave in medium}} = \frac{3 \times 10^8}{v}$$

4.6 Define **Snell's Law:** $\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$

- **Relative refractive index** – the refractive index of the boundary between two media



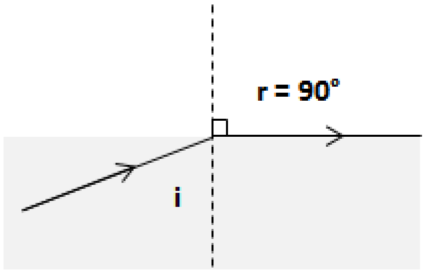
$$\text{Relative refractive index} = \frac{\text{velocity of wave in medium 1}}{\text{velocity of wave in medium 2}} = \frac{v_1}{v_2} = \frac{\sin i}{\sin r} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

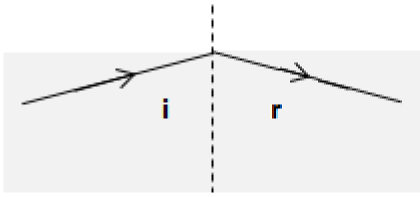
- Where n_1 and n_2 are the **absolute refractive index** of each medium
- Relative refractive index will be **> 1 if medium 1 less dense than medium 2** and **< 1 if medium 1 more dense**

4.7 Identify the **conditions** necessary for **total internal reflection** with reference to the **critical angle**

- When wave travels to a **less dense medium**, ray bends **away** from normal
- Ray can be refracted so that angle of **refraction is bent to 90°** from normal
  - **Angle of incidence** is the **critical angle**
- Critical angle **measured** by using **Snell's Law**:
  - $\frac{n_1}{n_2} = \frac{\sin i}{\sin 90}$

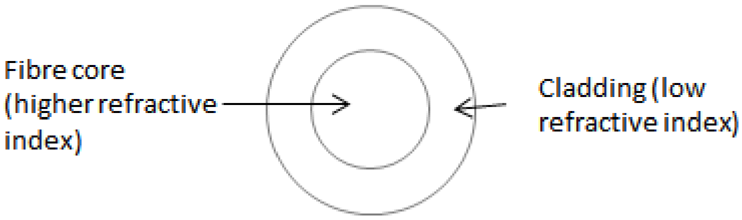
    $\therefore \sin i = \frac{n_1}{n_2}$
- **Total internal reflection** when **angle of incidence bigger than critical angle**
  - Angle follows law of reflection – $\theta_i = \theta_r$





4.8 Outline how **total internal reflection** is used in **optical fibres**

- Light from laser transmitted through optical fibres made of **pure, bubble free glass**
- Uses **total internal reflection** where **core** has **higher refractive index** and **cladding** has **lower refractive index**, with an outer **plastic sheath** to prevent **stray light** from entering



- Used for: **communication** by carrying signals precisely – faster than energy transmission
  - **Medicine** to view inaccessible sites with optical fibres in instruments