3/3/2021 ECS103

CH1. Nature of Light

- Wave or Particle ?

↓ ↳ Fock state (Quantum information), photon

- Coherence optics
  - Interference, Young's double slit
  - Diffraction (Fraunhofer / Fresnel)

- Wave-particle duality (de Broglie)

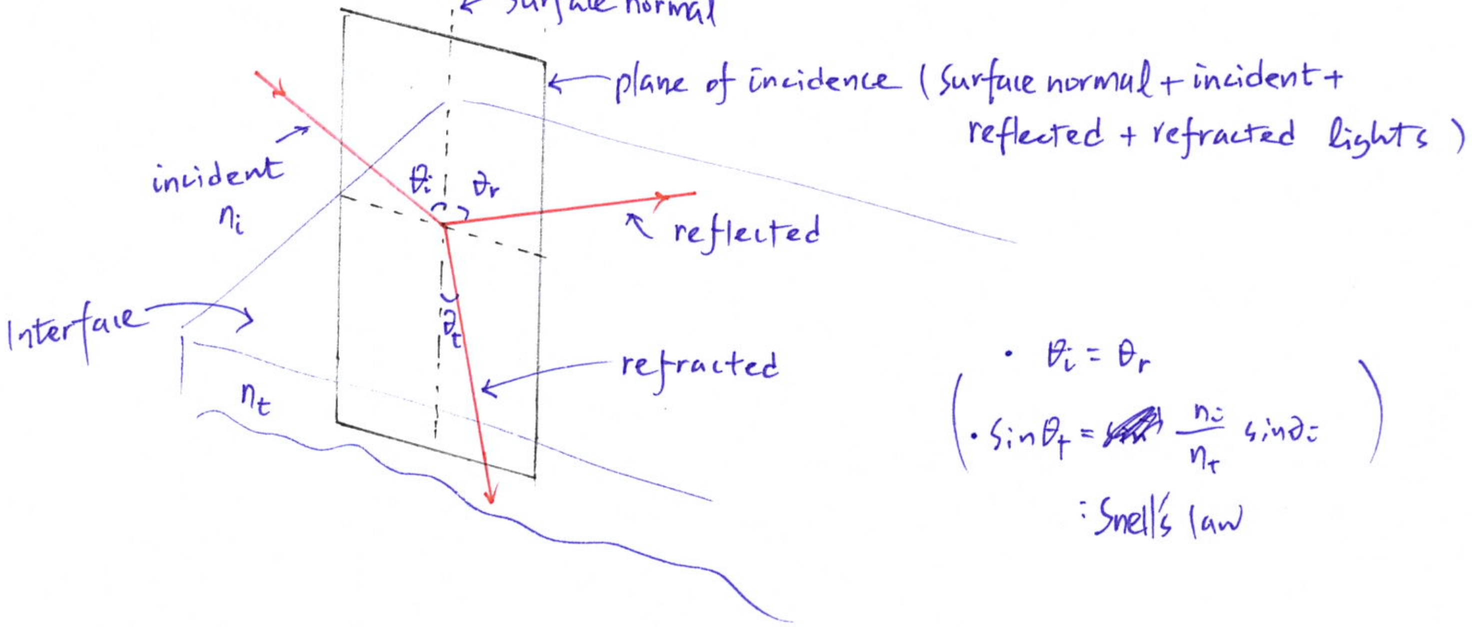
$$\lambda = \frac{h}{p}$$

- Maxwell equation, E/M fields

UV
VIS : 350 ~ 750 (nm) V B G Y O R (see Fig. 1-1)
IR

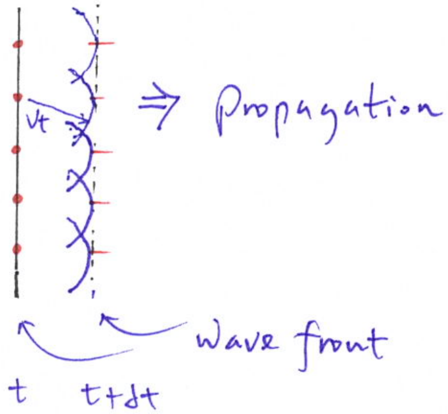
CH2. Geometrical optics

- Assumption : $\lambda \to 0$ (Ray optics)
- Reflection / Refraction



(• $\theta_i = \theta_r$
• $\sin\theta_t = \frac{n_i}{n_t}\sin\theta_i$)
: Snell's law

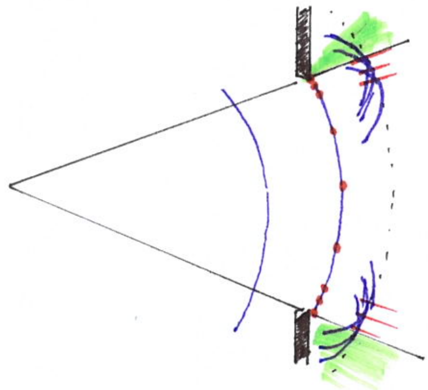
- Huygens' principle



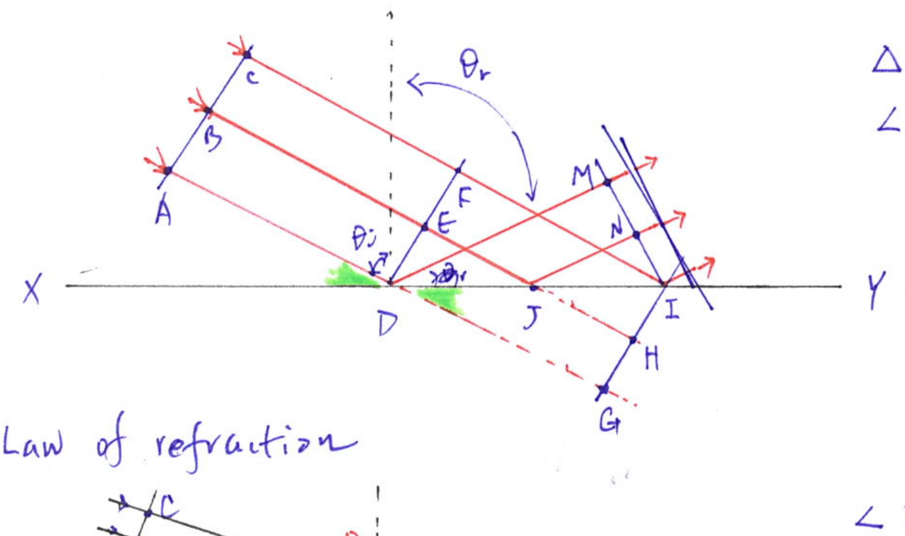
- Each point of the leading surface (wavefront) is regarded as a secondary source of spherical waves (wavelets).

(See Fig. 2-2)

Problem : edge effect → diffraction (see Fig. 2-3)



- Law of reflection



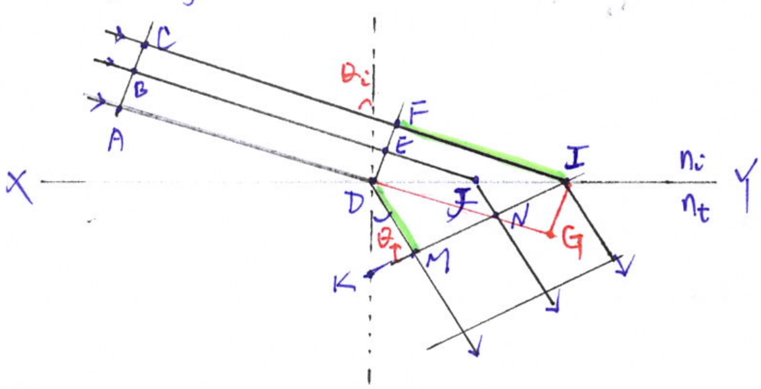
$\angle ADX = \angle IDG$ 엇각

$\triangle DIG = \triangle DIM$

$\angle IDM = \angle IDG$

$\therefore \theta_i = \theta_r$

- Law of refraction



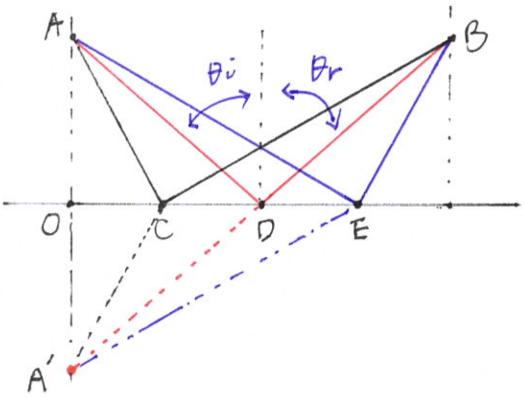
$\angle DIM = \theta_t$

$\angle IDF = \theta_i$

$\sin\theta_i = \frac{FI}{DI}$; $\sin\theta_t = \frac{DM}{DI}$

$\frac{\sin\theta_i}{\sin\theta_t} = \frac{FI}{DM} = \frac{DG}{DM} = \text{Const.}$ $\left(\frac{n_t}{n_i}\right)$

- Fermat's principle



• By Hero,

* Shortest path from A to B ?

→ ADB

If $\overline{AO} = \overline{A'O}$, → $\triangle AOC = \triangle A'OC$

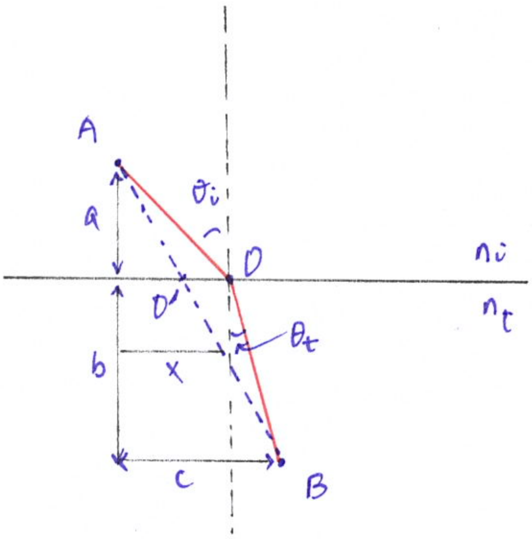
→ $\overline{AC} = \overline{A'C}$

∴ $ACB = A'CB > ADB$

Likewise, $AEB = A'EB > ADB$.

∴ ADB is the shortest path.

→ $\theta_i = \theta_r$.



Q1. What is the shortest path from A to B ?

A1. AO'B

Q2. What is the actual trajectory ?

A2. AOB.

→ Violates the Hero's principle !

· Fermat's principle

: Light travels the path of least time.

Pf> $t = \dfrac{AO}{v_i} + \dfrac{OB}{v_t}$;

Using $\overline{AO} = \sqrt{a^2+x^2}$ & $\overline{OB} = \sqrt{b^2+(c-x)^2}$

$$\rightarrow t = \frac{\sqrt{a^2+x^2}}{v_i} + \frac{\sqrt{b^2+(c-x)^2}}{v_t}.$$

For the least time, (minimum)

$$\frac{dt}{dx} = 0 = \frac{x}{v_i\sqrt{a^2+x^2}} - \frac{c-x}{v_t\sqrt{b^2+(c-x)^2}}$$

Using $\sin\theta_i = \dfrac{x}{AO} = \dfrac{x}{\sqrt{a^2+x^2}}$ & $\sin\theta_t = \dfrac{x}{OB} = \dfrac{c-x}{\sqrt{b^2+(c-x)^2}}$

$$\rightarrow v_t \sin\theta_i = v_i \sin\theta_t \rightarrow \frac{c}{n_t}\sin\theta_i = \frac{c}{n_i}\sin\theta_t \quad \therefore \underbrace{n_i \sin\theta_i = n_t \sin\theta_t}_{\text{Snell's law}}$$