

**CHAPTER 6**  
**LIGHT & OPTIC**  
**CAHAYA & OPTIK**

**6.1 Refraction of light**

*Pembiasan cahaya*

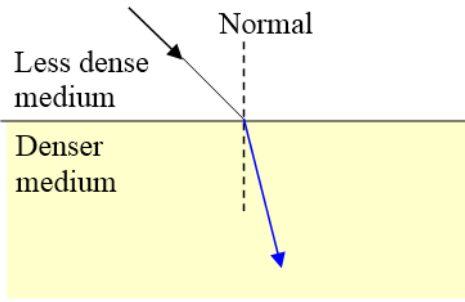
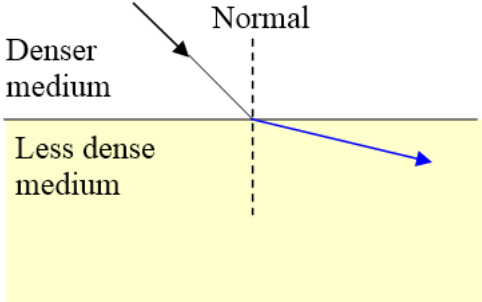
Characteristics refraction of light:

*Ciri-ciri pembiasan cahaya:*

Physical quantity <i>Kuantiti fizik</i>	Less dense <i>Ketumpatan rendah</i>	Denser <i>Lebih tumpat</i>
Angle of refraction <i>Sudut pembiasan</i>	Increased <i>Bertambah</i>	Decreased <i>Berkurang</i>
Speed of light <i>Kelajuan cahaya</i>	Increased <i>Bertambah</i>	Decreased <i>Berkurang</i>
Direction of propagation <i>Arah perambatan</i>	Move away normal line <i>Bergerak menjauhi garis normal</i>	Move towards normal line <i>Bergerak mendekati garis normal</i>

Direction of refraction:

*Arah pembiasan:*

	
<p>When light travels from a less dense medium to a denser medium, the ray is refracted towards normal line.  <i>Apabila cahaya bergerak dari medium yang kurang tumpat ke medium yang lebih tumpat, sinar dibiaskan mendekati garis normal.</i></p>	<p>When light travels from a more dense medium to a less dense medium, the ray is refracted away normal line.  <i>Apabila cahaya bergerak dari medium yang lebih padat untuk medium kurang tumpat, sinar menjauhi garis normal.</i></p>
<p><b>SNELL'S LAW:</b>  <b><i>Hukum Snell:</i></b></p> <p>Snell's law states that:  <i>Hukum Snell menyatakan:</i></p> <p>The ratio of sin (angle of incident) to sin (angle of refraction) is a constant  <i>Nisbah sin (sudut tuju) kepada sin (sudut biasan) adalah malar</i></p> $n = \frac{\sin(\text{incident angle})}{\sin(\text{refracted angle})}$ $n = \frac{\sin i}{\sin r}$	<p>A material with a higher refractive index has a higher density.          The value of refractive index, <math>n &gt; 1</math>          The refractive index has no units.  <i>Bahan dengan indeks biasan yang lebih tinggi mempunyai ketumpatan yang lebih tinggi.</i>  <i>Nilai indeks biasan, <math>n &gt; 1</math></i>  <i>Indeks biasan tidak mempunyai unit.</i></p>

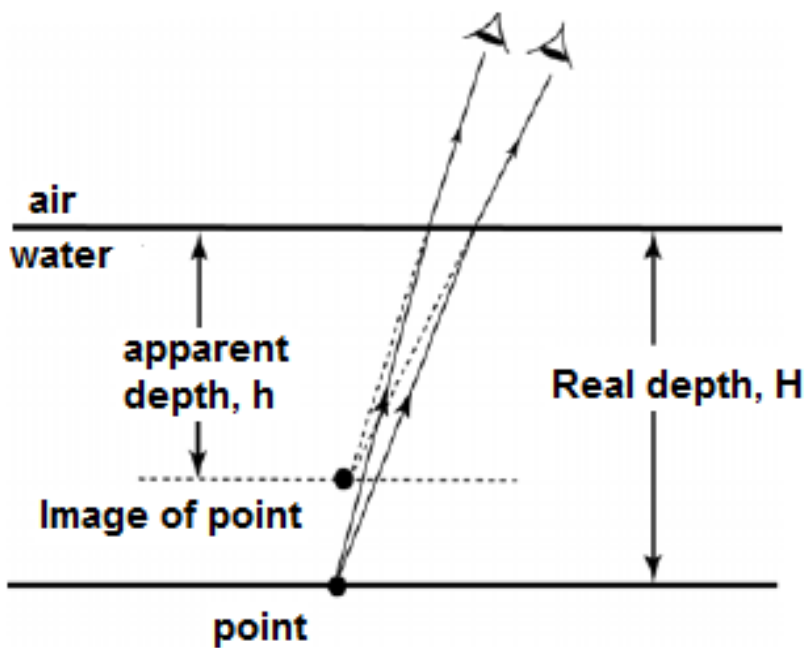
**Refractive index**  
**Indeks biasan**

Snell's Law  
*Hukum Snell*

$$n = \frac{\sin i}{\sin r}$$

n = refractive index (No unit) / *indeks biasan (tiada unit)*  
i = angle of incident (°) / *sudut tuju (°)*  
r = angle of refraction (°) / *sudut biasan (°)*

Real depth/Apparent Depth  
*Kedalaman nyata/Kedalaman ketara*



$$n = \frac{H}{h}$$

n = refractive index (No unit)  
*indeks biasan (tiada unit)*  
H = real depth (m or cm)  
*kedalaman nyata (m atau cm)*  
h = apparent depth (m or cm)  
*kedalaman ketara (m atau cm)*

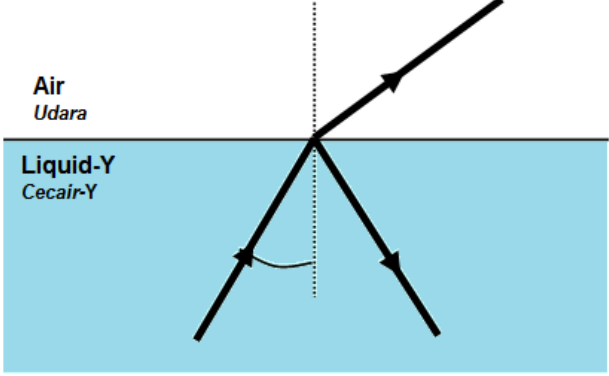
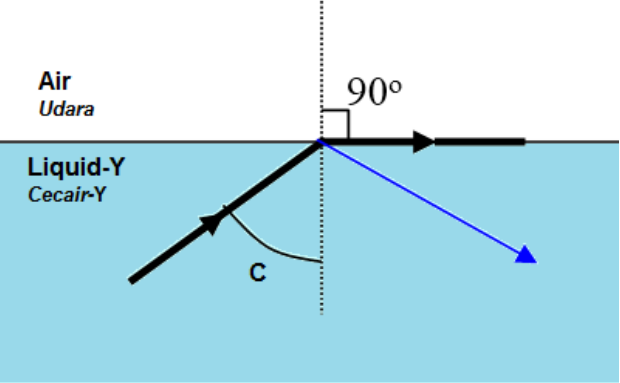
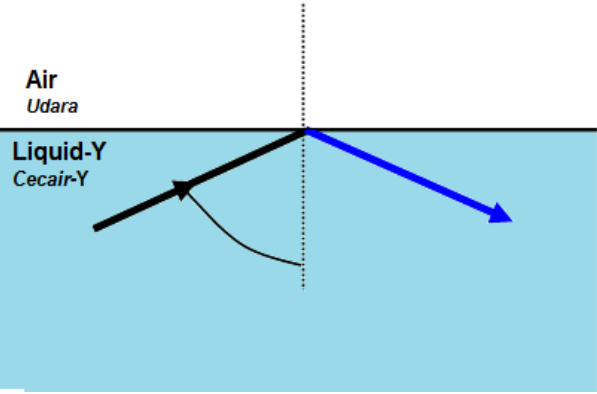
Speed of light  
*Kelajuan cahaya*

$$n = \frac{c}{v}$$

n = refractive index (No unit)  
*indeks biasan (tiada unit)*  
c = speed of light in vacuum (ms<sup>-1</sup>)  
*kelajuan cahaya dalam vakum (ms<sup>-1</sup>)*  
v = speed of light in a medium (like water, glass ...) (ms<sup>-1</sup>)  
*kelajuan cahaya dalam medium (seperti air, kaca...)(ms<sup>-1</sup>)*

## 6.2 Total Internal Reflection

### *Pantulan dalam penuh*

 <p style="text-align: center;">Diagram a / Rajah a</p>	<ul style="list-style-type: none"> <li>➤ When the angle of incidence, <math>i</math> keeps on increasing, <math>r</math> too increases. <i>Apabila sudut tuju, <math>i</math> terus meningkat, <math>r</math> juga meningkat</i></li> <li>➤ And the refracted ray moves away from the normal <i>Dan sinar dibiaskan bergerak menjauhi daripada normal.</i></li> </ul>
 <p style="text-align: center;">Diagram b / Rajah b</p>	<ul style="list-style-type: none"> <li>➤ The refracted ray travels along the glass-air boundary. <i>Sinar dibiaskan bergerak di sepanjang sempadan kaca - udara.</i></li> <li>➤ Angle of refraction, <math>r = 90^\circ</math> <i>Sudut biasan, <math>r = 90^\circ</math></i></li> <li>➤ This is the limit of the light ray that can be refracted in air as the refracted in air cannot be any larger than <math>90^\circ</math>. <i>Ini adalah had sinar cahaya yang boleh dibiaskan di udara sebagai dibiaskan dalam udara tidak boleh mana-mana yang lebih besar daripada <math>90^\circ</math>.</i></li> <li>➤ The angle of incidence in the denser medium at the limit is called the critical angle. <i>Sudut tuju dalam medium yang lebih padat pada had dipanggil sudut genting.</i></li> </ul>
 <p style="text-align: center;">Diagram c / Rajah c</p>	<ul style="list-style-type: none"> <li>➤ If the angle of incidence is increased is increased further so that it is more than the critical angle; <i>Jika sudut tuju bertambah ditingkatkan supaya ia adalah lebih besar daripada sudut genting,</i> <ul style="list-style-type: none"> <li>- no refraction <i>tiada pembiasan</i></li> <li>- all the light is totally in the glass <i>Semua cahaya dalam kaca</i></li> </ul> </li> <li>➤ This phenomenon is called total internal reflection. <i>Fenomena ini dipanggil pantulan dalam penuh.</i></li> </ul>
$n = \frac{1}{\sin c}$ <p> <math>n</math> = refractive index (No unit)  <i>indeks biasan (tiada unit)</i>  <math>c</math> = critical angle (<math>^\circ</math>)  <i>sudut genting (<math>^\circ</math>)</i> </p>	

### 6.3 Image Formation by Lens *Pembentukan Imej oleh Kanta*

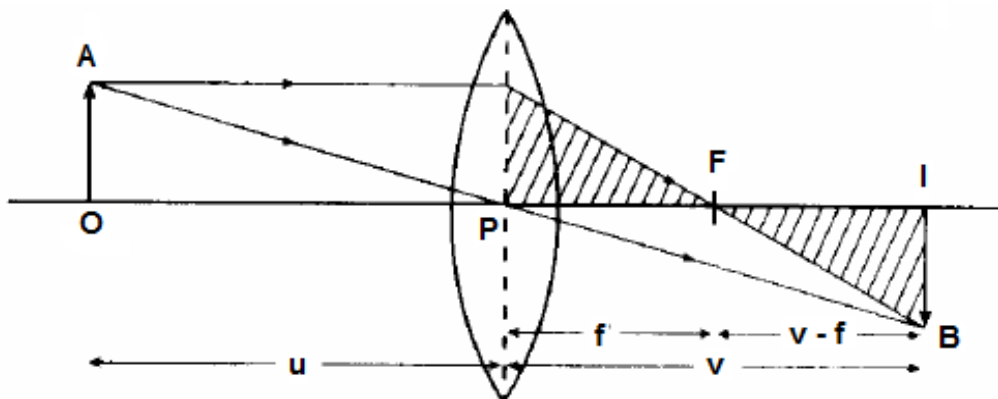
Power <i>Kuasa</i>  $P = \frac{1}{f}$	P = Power (D(Diopter)) <i>Kuasa (D(Diopter))</i> f = focal length (m) <i>panjang fokus (m)</i>
Linear Magnification <i>Pembesaran linear</i>  $m = \frac{v}{u} = \frac{h_i}{h_o}$	m = linear magnification (No unit) <i>pembesaran linear (tiada unit)</i>  u = distance of object (m or cm) <i>jarak objek (m atau cm)</i>  v = distance of image (m or cm) <i>jarak imej (m atau cm)</i>  h <sub>i</sub> = heigth of image (m or cm) <i>ketinggian imej (m atau cm)</i>  h <sub>o</sub> = heigth of object (m or cm) <i>ketinggian objek (m atau cm)</i>

#### Lens Equation *Persamaan kanta*

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Conventional symbol  
*Simbol konvensional*

	<b>POSITIVE <i>POSITIF</i></b>	<b>NEGATIVE <i>NEGATIF</i></b>
u	Real object <i>Objek nyata</i>	Virtual object <i>Imej maya</i>
v	Real image <i>Imej nyata</i>	Virtual image <i>Imej maya</i>
f	Convex lens <i>Kanta cembung</i>	Concave lens <i>Kanta cekung</i>



## Power of a lens (P)

### Kuasa kanta (P)

The power of the lens is given by:

*Kuasa kanta diberi oleh:*

$$\text{Power of lens / kuasa kanta} = \frac{1}{\text{focallength / panjang fokus}}$$

➤ **Sign convention** (for focal length) and the S.I. unit for power of a lens.

**Tanda lazim** (untuk panjang fokus) dan unit S.I. untuk kuasa lensa.

- The focal length of a convex lens is +f  
*Panjang fokus bagi kanta cembung ialah +f*
- The focal length of a concave lens is -f  
*Panjang fokus bagi kanta cekung ialah -f*
- The S.I. unit for the power of a lens is diopter and its symbol is D.  
*Unit S.I untuk kuasa kanta ialah diopter dan simbolnya D.*
- When calculating the power of a lens, the unit of the focal length must be in meter.  
*Apabila mengira kuasa kanta, unit bagi panjang fokus mesti dalam meter.*

## Linear Magnification

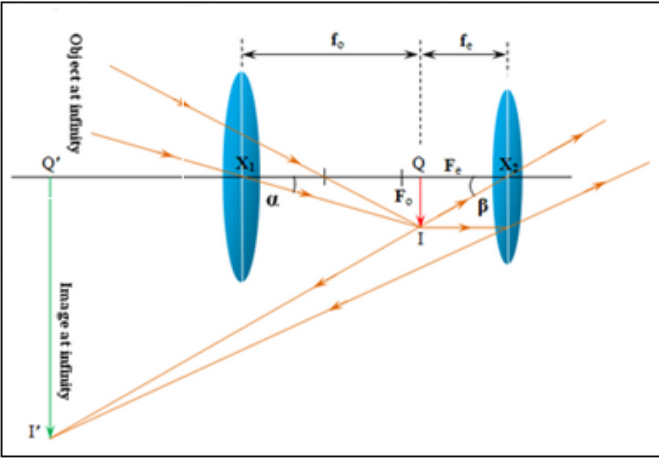
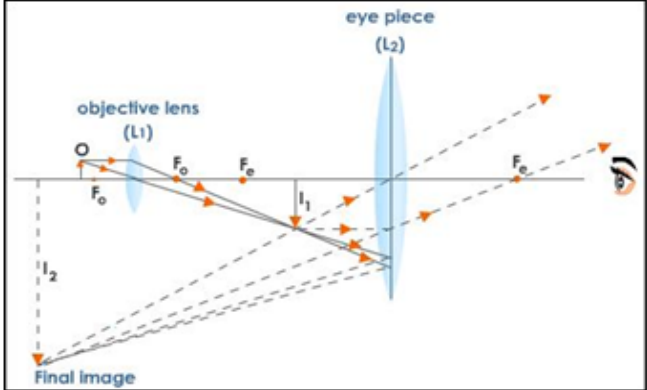
### Pembesaran linear

$$\text{Linear magnification / pembesaran linear} = \frac{\text{height of image / tinggi imej}}{\text{height of object / tinggi objek}}$$

$$m = \frac{h_i}{h_o}$$

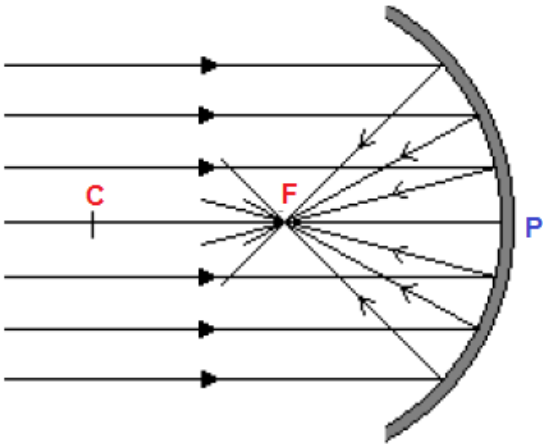
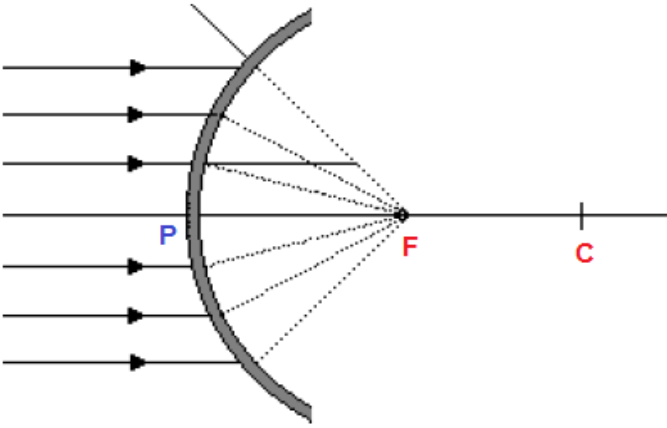
Linear magnification, m <i>Pembesaran linear, m</i>	Size of image <i>Saiz imej</i>
$ m  = 1$	Image and object are the same size <i>Imej dan objek sama saiz</i>
$ m  > 1$	Image is bigger <i>Imej adalah besar</i>
$ m  < 1$	Image is smaller <i>Imej adalah kecil</i>

**6.4 Optical equipment**  
**Peralatan Optik**

<p style="text-align: center;">ASTRONOMICAL TELESCOPE  <i>TELESKOP ASTRONOMI</i></p> 	<p style="text-align: center;">COMPOUND MICROSCOPE  <i>MIKROSKOP MAJMUK</i></p> 
<p style="text-align: center;">Magnification  <i>Pembesaran</i></p> $m = \frac{P_e}{P_o} \quad m = \frac{f_o}{f_e}$ <p><math>m</math> = linear magnification  <i>pembesaran linear</i></p> <p><math>P_e</math> = Power of the eyepiece  <i>Kuasa kanta mata</i></p> <p><math>P_o</math> = Power of the objective lens  <i>Kuasa kanta objektif</i></p> <p><math>f_e</math> = focal length of the eyepiece  <i>panjang fokus kanta mata</i></p> <p><math>f_o</math> = focal length of the objective lens  <i>panjang fokus kanta objektif</i></p>	<p style="text-align: center;">Magnification  <i>Pembesaran</i></p> $m = m_1 \times m_2$ $= \frac{\text{Height of first image, } I_1}{\text{Height of object}} \times \frac{\text{Height of second image, } I_2}{\text{Height of first image, } I_1}$ $= \frac{\text{Height of second image, } I_2}{\text{Height of object, } I_1}$ <p><math>m</math> = Magnification of the microscope  <i>pembesaran mikroskop</i></p> <p><math>m_1</math> = Linear magnification of the object lens  <i>pembesaran linear kanta objek</i></p> <p><math>m_2</math> = Linear magnification of the eyepiece  <i>pembesaran linear kanta mata</i></p>
<p>Distance between eye lens and objective lens  <i>Jarak di antara kanta mata dank anta objektif</i></p> $D = f_o + f_e$ <p><math>D</math> = Distance between eye lens and objective lens  <i>Jarak di antara kanta mata dank anta objektif</i></p> <p><math>f_e</math> = focal length of the eyepiece  <i>panjang fokus kanta mata</i></p> <p><math>f_o</math> = focal length of the objective lens  <i>panjang fokus kanta objektif</i></p>	<p>Distance in between the two lens  <i>Jarak di antara dua kanta</i></p> $D > f_o + f_e$ <p><math>D</math> = Distance between eye lens and objective lens  <i>Jarak di antara dua kanta</i></p> <p><math>f_e</math> = focal length of the eyepiece  <i>panjang fokus kanta mata</i></p> <p><math>f_o</math> = focal length of the objective lens  <i>panjang fokus kanta objektif</i></p>

## 6.5 Image Formation by Spherical Mirror

### *Pembentukan Imej oleh Cermin Sfera*

<b>CURVED MIRRORS:</b> <i>Cermin melengkung:</i>	
<p>Concave mirror <i>Cermin cekung</i></p> 	<p>Convex mirror <i>Cermin cembung</i></p> 
<ol style="list-style-type: none"> <li>1. Light converged <i>Cahaya menumpu</i></li> <li>2. Real principal focus <i>Fokus utama nyata</i></li> <li>3. PF = Distance between the virtual principal focus and the pole of the mirror. <i>PF = jarak di antara fokus utama maya dan kutub cermin</i></li> </ol>	<ol style="list-style-type: none"> <li>1. Light diverging <i>Cahaya mencapah</i></li> <li>2. Virtual principal focus <i>Fokus utama maya</i></li> <li>3. PF = Distance between the real principal focus and the pole of the mirror. <i>PF = jarak di antara fokus utama nyata dan kutub cermin</i></li> </ol>