Example 2:

A light beam travels at 1.94×10^8 m s^{-1} in quartz. The wavelength of the light in quartz is 355 nm.

a. Find the index of refraction of quartz at this wavelength.

b. If this same light travels through air, what is its wavelength there?

(Given the speed of light in vacuum, $c = 3.00 \times 10^8$ m s^{-1})

No. 33.3, pg. 1278, University Physics with Modern Physics,11th edition, Young & Freedman.

Solution: $v=1.94 \times 10^8$ m s^{-1}, $\lambda=355 \times 10^{-9}$ m

a. By applying the equation of absolute refractive index, hence

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

$$n = 1.55$$

b. By using the equation below, thus

$$n = \frac{\lambda_0}{\lambda}$$

$$\lambda_0 = n\lambda$$

$$\lambda_0 = 5.50x10^{-7}\, m @ 550\, nm$$

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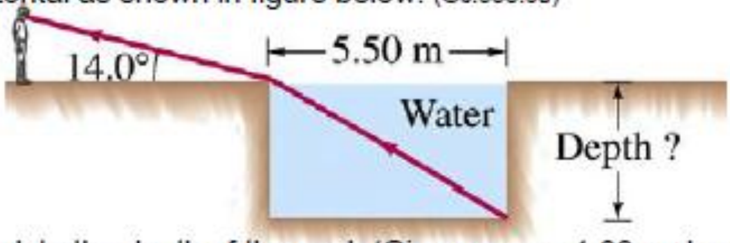
Example 3 : (H.W)

We wish to determine the depth of a swimming pool filled with water by measuring the width (x = 5.50 m) and then noting that the bottom edge of the pool is just visible at an angle of 14.0° above the horizontal as shown in figure below. (Gc.835.60)

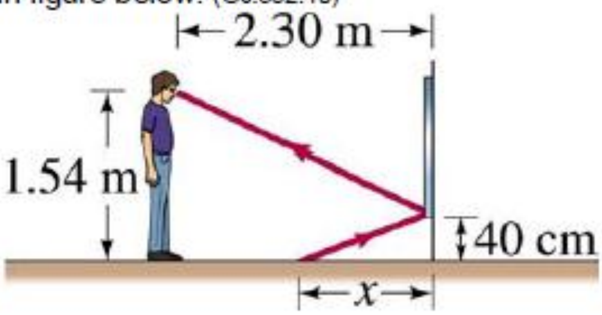


Calculate the depth of the pool. (Given n_{water} = 1.33 and n_{air} = 1.00)

Ans. : 5.16 m

Example 4 : (H.W)

A person whose eyes are 1.54 m above the floor stands 2.30 m in front of a vertical plane mirror whose bottom edge is 40 cm above the floor as shown in figure below. (Gc.832.10)



Find x.

Ans. : 0.81 m

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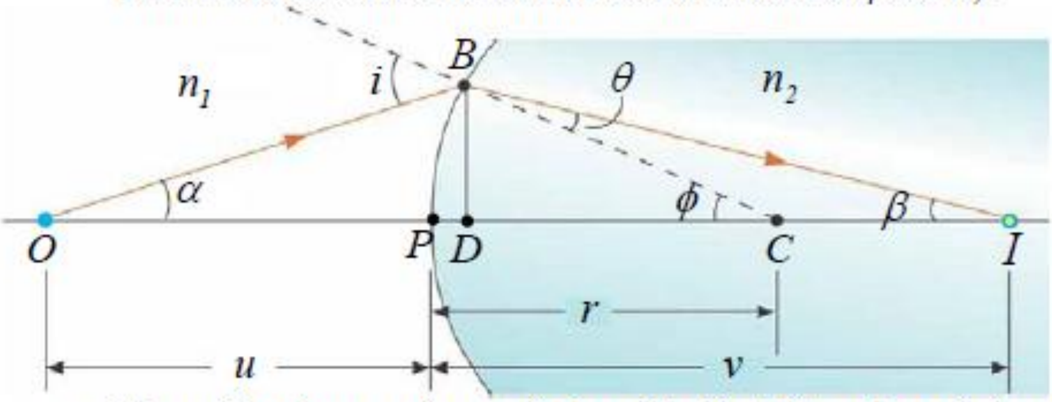
1.2. Refraction of Spherical Surfaces

- Figure below shows a spherical surface with radius, r forms an interface between two media with refractive indices n_1 and n_2.



- The surface forms an image I of a point object O as shown in figure above.
- The incident ray OB making an angle i with the normal and is refracted to ray BI making an angle θ where $n_1 < n_2$.
- Point C is the centre of curvature of the spherical surface and BC is normal.

- From the figure,

$$\triangle BOC \Rightarrow i = \alpha + \phi \quad \text{------(1)}$$

$$\triangle BIC \Rightarrow \phi = \beta + \theta$$

$$\theta = \phi - \beta \quad \text{------(2)}$$

- From the Snell's law

$$n_1 \sin i = n_2 \sin\theta$$

By using △BOD, △BCD and △BID thus

$$\tan\alpha = \frac{BD}{OD};\ \tan\phi = \frac{BD}{CD};\ \tan\beta = \frac{BD}{ID}$$

By considering point B very close to the pole P, hence

$$\sin i \approx i;\ \sin\theta \approx \theta;\ \tan\alpha \approx \alpha;\ \tan\phi \approx \phi;\ \tan\beta \approx \beta$$

$$OD \approx OP = u;\ CD \approx CP = r;\ ID \approx IP = v$$

then Snell's law can be written as

$$n_1 i = n_2\theta \quad \text{------(3)}$$

- By substituting eq. (1) and (2) into eq. (3), thus

$$n_1(\alpha + \phi) = n_2(\phi - \beta)$$

$$n_1\alpha + n_2\beta = (n_2 - n_1)\phi$$

then

$$n_1\left(\frac{BD}{u}\right) + n_2\left(\frac{BD}{v}\right) = (n_2 - n_1)\left(\frac{BD}{r}\right)$$

$$\frac{n_1}{u}+\frac{n_2}{v}=\frac{(n_2-n_1)}{r}$$ → **Equation of spherical refracting surface**

where

v : image distance from pole

u : object distance from pole

n_1 : refractive index of medium 1
(Medium containing the incident ray)

n_2 : refractive index of medium 2
(Medium containing the refracted ray)

- Note :
  - If the refraction surface is **flat (plane)** :

    $r=\infty$ then $$\frac{n_1}{u}+\frac{n_2}{v}=0$$

  - The equation (formula) of linear magnification for refraction by the spherical surface is given by

$$M=\frac{h_i}{h_o}=-\frac{n_1 v}{n_2 u}$$

- Sign convention for **refraction** :

Physical Quantity	Positive sign (+)	Negative sign (-)
Object distance, u	Real object (in front of the refracting surface)	Virtual object (at the back of the refracting surface)
Image distance, v	Real image (opposite side of the object)	Virtual image (same side of the object)
Focal length, f	Convex surface	Concave surface
Radius of curvature, r	Convex surface	Concave surface
Linear magnification, M	Upright (erect) image	Inverted image