Photogrammetry (CE 474) [4]

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Camera Lens

A **camera lens** (also known as **photographic lens** or **photographic objective**) is an optical lens or assembly of lenses used in conjunction with a camera body and mechanism to make images of objects either on photographic film or on other media capable of storing an image chemically or electronically.

Aperture and focal length

The two fundamental parameters of an optical lens are the focal length and the maximum aperture.

The **focal length** of a lens is the distance between the optical center of the lens and the film plane (for film cameras).

The longer the focal length, the more it "magnifies" the subject. On the other hands, the higher focal length means cameras could see farther.

Aperture and focal length

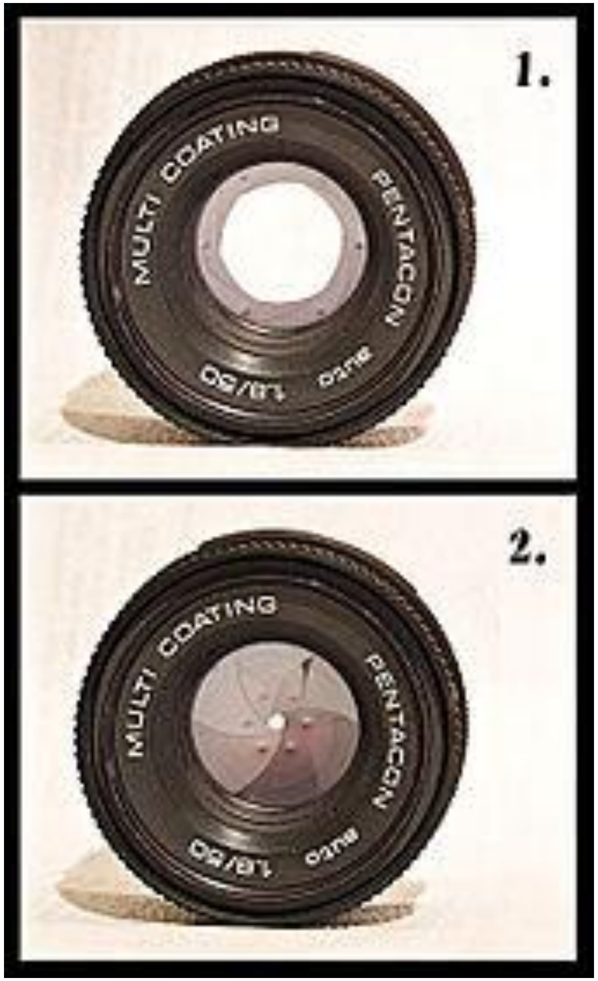
The aperture determines the light intensity of the image.

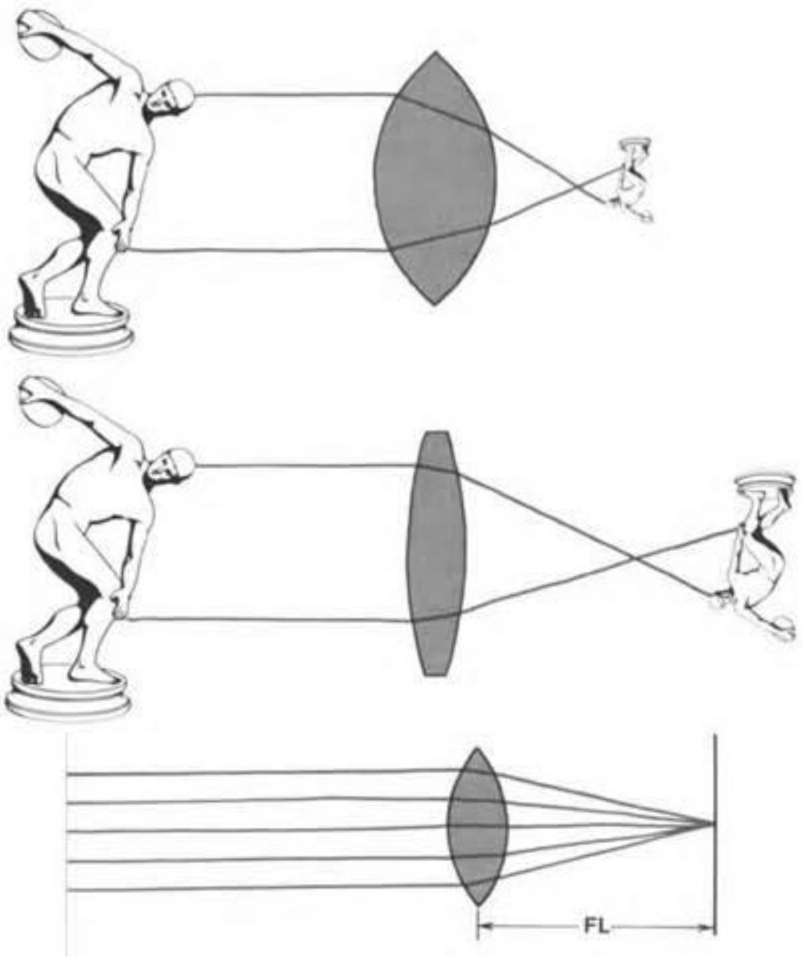
f-stops are a measure of the **aperture** of a lens.

In other words, f-stops tell us how wide open the iris of a lens is. Specifically, they express the ratio of focal length to apparent lens aperture, so they have no units.

The smaller the number, the wider the effective aperture, and the more light will go through the lens.

Aperture and focal length



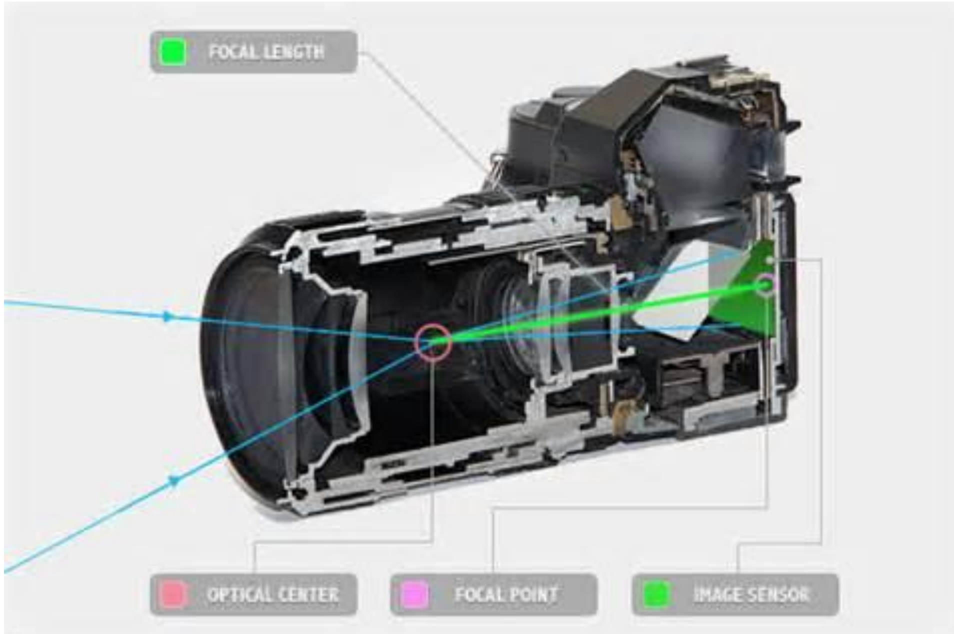


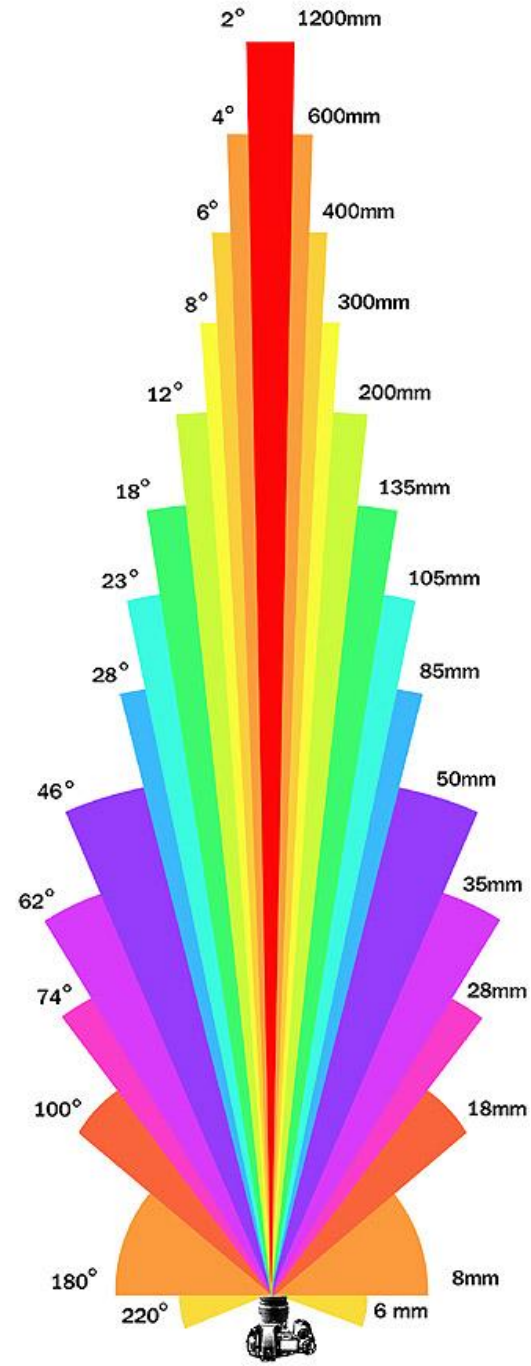
Focal length

- For a given photographic system the focal length determines the angle of view
- short focal lengths giving a wider field of view than longer focal length lenses.

Report 1: Types of camera lens used in:

- A) close range photogrammetry
- B) aerial photogrammetry
- C) What is the relationship between f-stop, focal length and the diameter of the lens opening


FOCAL LENGTH
OPTICAL CENTER
FOCAL POINT
IMAGE SENSOR


2°
1200mm
4°
600mm
6°
400mm
8°
300mm
12°
200mm
18°
135mm
23°
105mm
28°
85mm
46°
50mm
62°
35mm
74°
28mm
100°
18mm
180°
8mm
220°
6 mm

28 mm

50 mm

70 mm

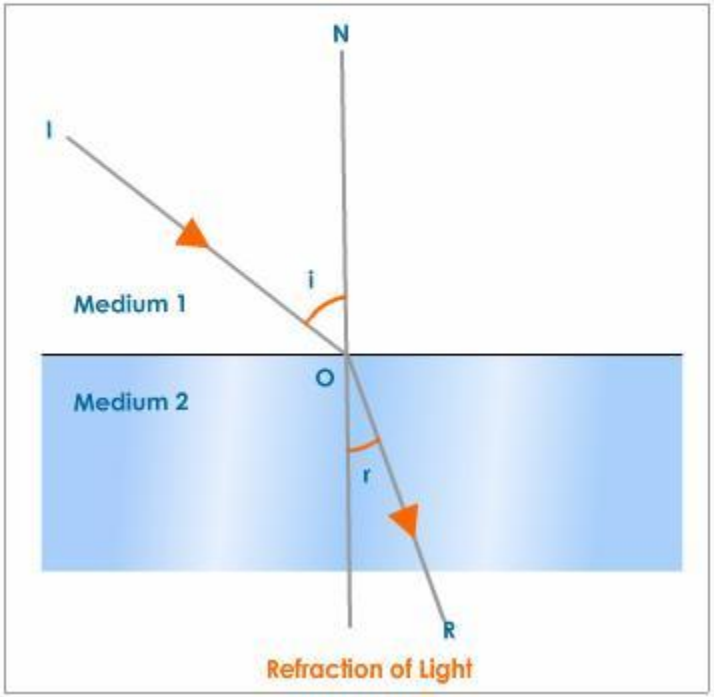
210 mm

Refraction of Light

What is Refraction?

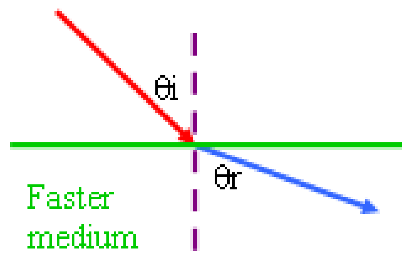
Refraction is the bending of a wave when it enters a medium where it's speed is different. The refraction of light when it passes from a fast medium to a slow medium bends the light ray toward the normal to the boundary between the two media. The amount of bending depends on the indices of refraction of the two media and is described quantitatively by Snell's Law.

Refraction

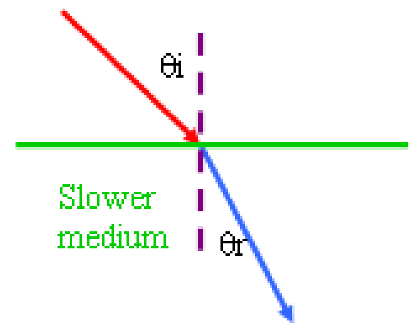


Refraction of Light

Light waves moving into a faster medium.



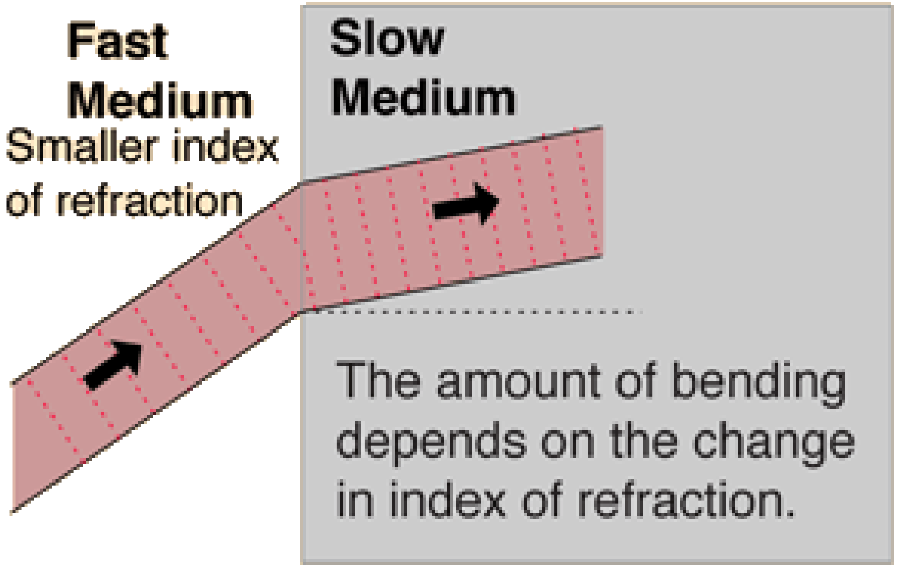
Light waves moving into a slower medium.



In both situations the incident ray is red, the refracted in blue. The normal is in purple and the boundary between the media is green. θi and θr are the incident and refracted angles respectively.

Index of Refraction

The index of **refraction** is defined as the speed of light in vacuum **divided** by the speed of light in the medium.



index of refraction

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

velocity of light in vacuum

velocity of light in the medium

Index of Refraction

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

index of refraction

velocity of light in vacuum

velocity of light in the medium

v in this equation is the speed of light in a medium having an index n, and c represents the speed of light in vacuum.

C = 3 E8 (m/s)

Examples

- **Problem 1**

The speed of light in an unknown medium is measured to be 2.76 x 10^8 m/s. (a) What is the index of refraction of the medium?

Solution:

The index is found to be:

$n = c/v = (3.00 \times 10^8 \text{ m/s})/(2.76 \times 10^8 \text{ m/s})$

$= 1.09$.

Examples

- **Problem 2**

Optical fibers are generally composed of silica, with an index of refraction around 1.44. How fast does light travel in a silica fiber?

Solution:

The speed of light in this fiber is found to be

$$v = c/n = (3.00 \text{ x } 10^8 \text{ m/s})/(1.44)$$

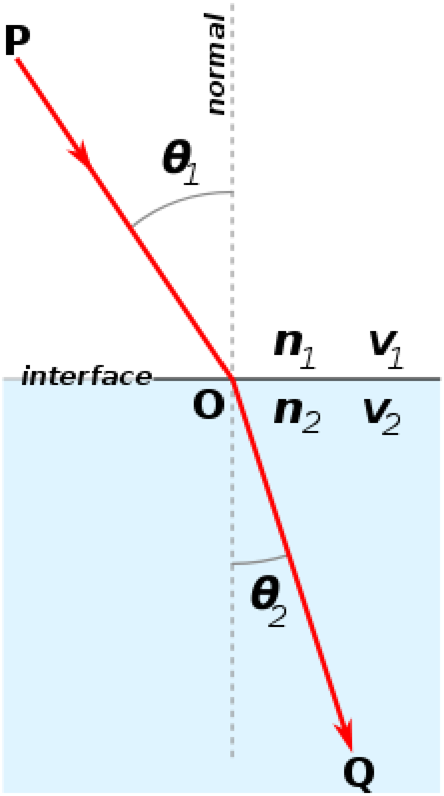
$$= 2.08 \text{ x } 10^8 \text{ m/s}$$

Law of Refraction

Refraction law

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\alpha = \theta_1 - \theta_2$$

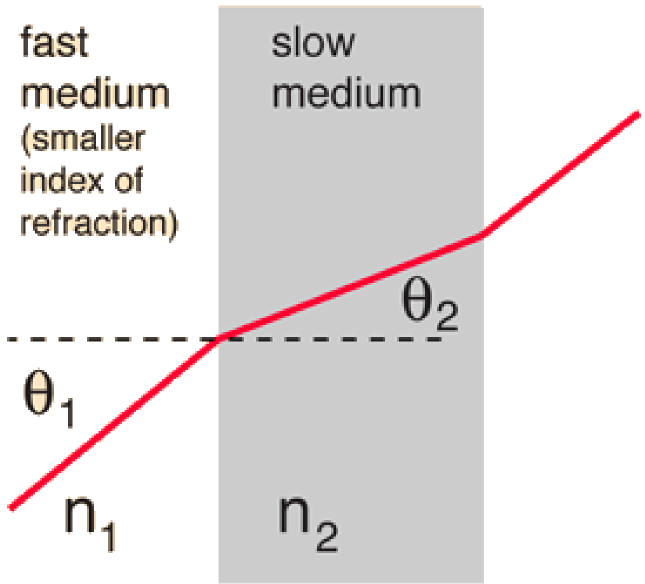


Law of Refraction

Snell's Law

Snell's Law

$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1}$$



Problem

It is required to move an array by 2 mm from its normal pass. If the incident angle on the wall equals 30^o and refraction index in the air equals 1.02, Refraction index of the wall = 1.40. Find the thickness of the wall.

Solution:

$n_1 = 1.02$ $\quad$ $n_2 = 1.40$

$\theta_1 = 30^o$ $\quad$ $\theta_2 = ?^o$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\theta_2 = \sin^{-1}\frac{n_1 \sin\theta_1}{n_2} \qquad \theta_2 = \sin^{-1}\frac{1.02 \sin 30}{1.4}$$

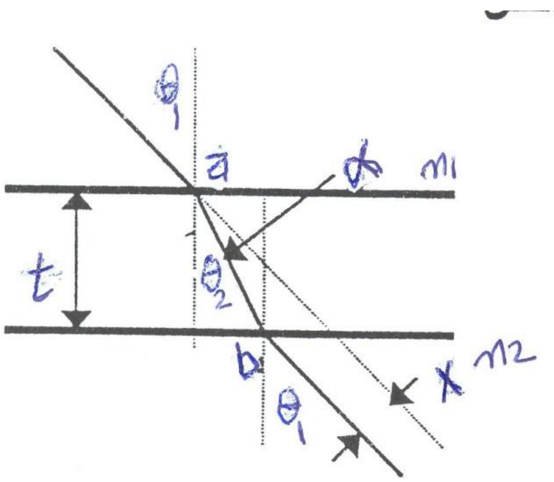
$$\theta_2 = 21^0\ 21'\ 49.07''$$

$$\alpha = 30^0 - 21^0\ 21'\ 49.07'' = 8^0\ 38'\ 10.93''$$

From the figure:

$$\frac{x}{ab} = \sin\alpha$$

$$ab = \frac{x}{\sin\alpha} = \frac{2}{\sin\alpha} = 13.319\text{mm}$$



$$\frac{t}{ab} = \cos\theta_2$$

$$t = ab\cos\theta_2 = 13.319\cos 21^0\ \ 21'\ \ 49.07''$$

$$t = 12.404\ \text{mm}$$

So the thickness of the used wall equals 1.24 cm is required to move the array from his pass by 2 mm.