# L21 Physics of Eyes and Vision

## Focal length, Power of accommodation, and the optical density

### What is the focal length of lens?

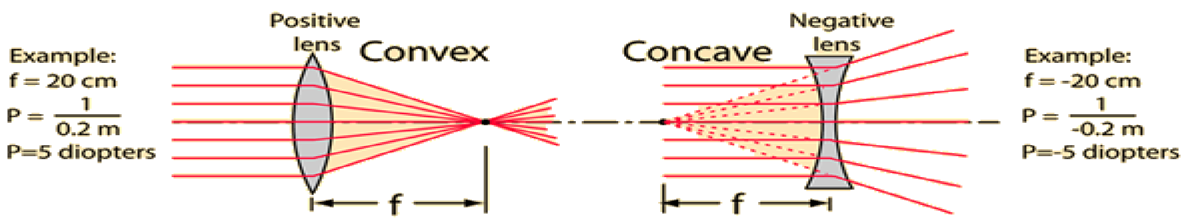
- **Focal length: is the distance between the center of a convex lens or a concave lens and the focal point of the lens - the point where parallel rays of light meet, or converge.**
- **The focal length of an optical system is a measure of how strongly the system converges or diverges light.**
- **A system with a shorter focal length has greater optical power than one with a long focal length; that is, it bends the rays more sharply, bringing them to a focus in a shorter distance.**

**The lens strength (in diopters): is defined as the inverse of the focal length in meters.**

**lens strength= 1/ focal length**

**P(diopter) = 1/ F(m)**

**P & F are positive for convex lens and negative for concave**




## Power of Accommodation

**The process by which the ciliary muscles change the focal length of an eye lens to focus distant or near objects clearly on the retina is called the accommodation of the eye.**
**The ability of the eye to focus objects lying at different distances is called the power of accommodation of the eye.**

**Power of accommodation of normal eye =1/*F***

**If F is measured in meters, then 1/F is the lens strength in diopters (D) =$m^{-1}$**

**A positive (converging or convex) lens with a focal length of 0.1 m has strength of 10 D.**

**A negative (diverging or concave) lens with a focal length of -0.5 m has strength of -2 D.**

**Light from distant objects is focused onto the retina at the back of the eye.**

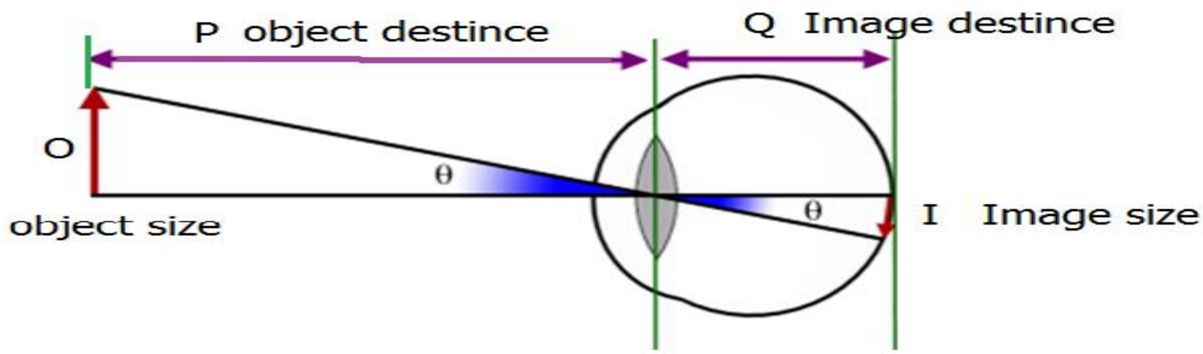
The focal length needs to be about 2 cm (0.02m). (The normal diameter of an eyeball)

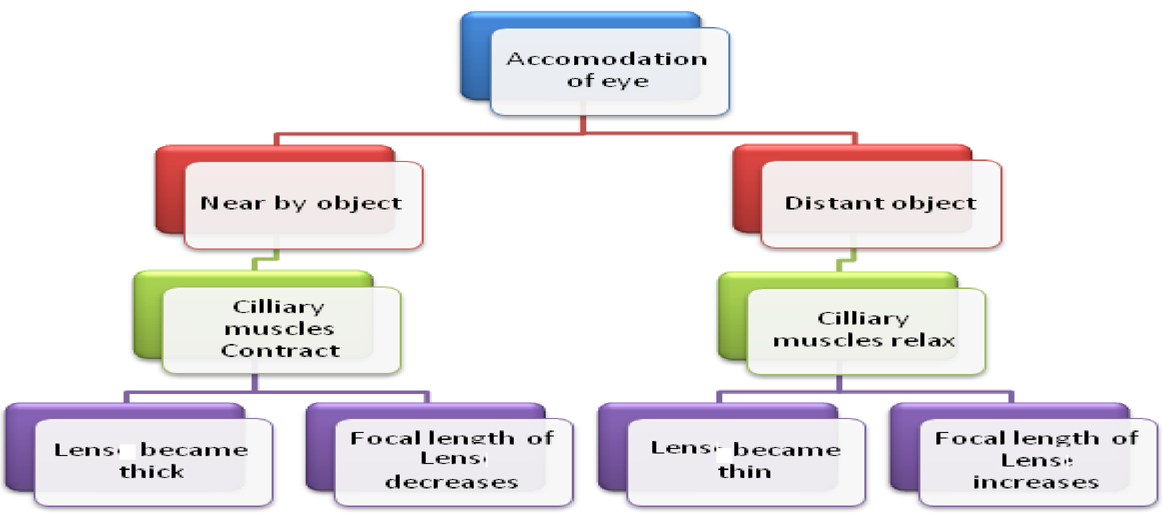
**Relationship between F, P, and Q of the lens:**

There is a simple relationship between the focal length F, the object distance P, and the image distance Q of the lens

$$1/F = 1/P + 1/Q$$

If F is measured in meters, then 1/F is the lens strength in diopters (D) = $m^{-1}$

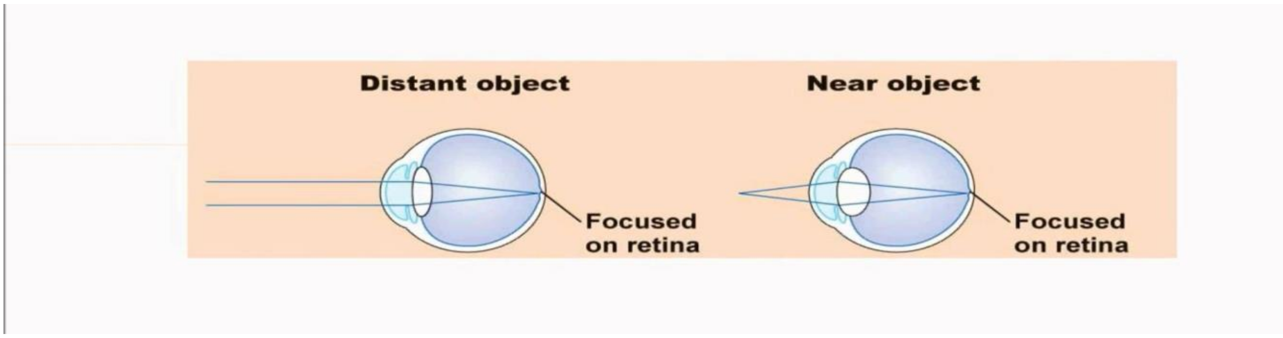



## How Does an Eye Focus Objects at Varying Distances?

- To focus on distant objects the ciliary muscles relax making the eye lens thin.As a result the focal length of the eye lens increases and we see the distant objects.
- To focus on nearby objects the ciliary muscles contract making the eye lens thick. As a result the focal length of the eye lens decreases and we see the nearby objects.

In short it is the adjustment of the focal length of the eye lens, which enables us to focus on objects situated at different distances.




## Near point or Least Distance of Distinct Vision

**The minimum distance from the eye at which an object appears to be distinct is called least distance of distinct vision or near point.**

**The distance is represented by d is about 25cm from the eye. If the object is held closer to the eye than the distance the image formed will be blurred and fuzz. The location of the near point, however, changes with age. For example, for infants it is only 5 to 8 cm.**

## Far Point

**Far point of the eye is the maximum distance up to which the normal eye can see things clearly. It is infinity for a normal eye.**

## Range of Vision

**The distance between the near point and the far point is called the range of vision.**


**The ability of the eye to focus on objects over a wide range is called accommodation.**

**Power of accommodation of normal eye** $=1/F$

$1/F = 1/nearpoint - 1/farpoint$

$1/F = (1/u + 1/v)\_{(N.P)} - (1/u + 1/v)\_{(F.P)}$

$1/F = (1/(0.25) + 1/(0.02))\_{(N.P)} - (1/"\infty" + 1/(0.02))\_{(F.P)}$

$1/F = 1/(0.25) - 1/"\infty"$

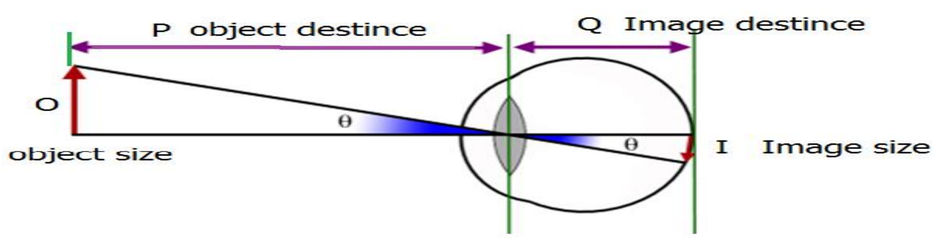
$= 4$ **Diopter**

## Image size

**Simple relation between the object and image size, object and image distance comes from the ratio of the lengths of sides of similar triangles.**

**I: is image size Q: is image distance O: is object size P: is object distance**

**Thus we can write** **O/P=I/Q**




**EXAMPLE:**

**How big is the image on the retina of a fly on a wall 3.0m away? Assume the fly is 3mm in diameter and Q=0.02m.**

**Solution**

$O/P=I/Q$ $\quad I=\frac{Q*O}{P} \quad I=\frac{0.02*0.003}{3}$

$I= 2 \times 10^{-5} m=20\mu m$

**Optical Density OD**

**The ability of the eye to recognize separate lines also depends on the relative "blackness "and "whiteness" , the contrast between two areas is defined as optical density OD**

$$OD = Log\ ( I_0/I)$$

**Where $I_O$ is the light intensity without absorber and I is intensity with absorber**

**EXAMPLE:**

**A piece of film that transmits 10% of the incident light has an optical density**

$$OD = Log(1/0.1) = 1.0$$

**How Sharp Are Your Eyes (Visual acuity)**

- **Is defined as the inverse of the angle θ (in minutes) by which the two nearest points are separated ,that is Visual acuity =1/ θ per minute**

**This separation will depend on the structure of the retina .If a distinction between two points of light is to be made , then there must be at least one unstimulated receptor cell between those stimulated. Hence minimum spacing will be twice the diameter of the receptor cell.**

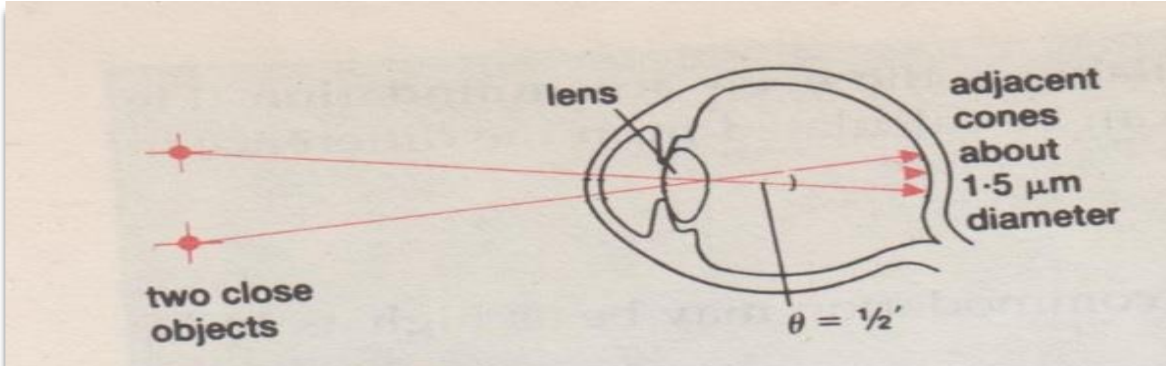


Fig 2.7 Visual acuity.

**Normal vision relies on the following :( Normal Vision 6/6)**

**•Both eyes in alignment (extraocular muscles functioning)**

**•Clear cornea**

**•Clear lens of the eye**

**•Clear ocular media (aqueous and vitreous)**

**•Intact retina, optic nerve, visual pathway**

**Visual acuity depends on a number of factors including:**

- **Refractive error**
- **Size of the pupil**
- **Illumination**
- **Time of exposure of the target**
- **Area of the retina stimulated**
- **State of adaptation of the eye**
- **Eye movement**

**H.W1:**

**A film that absorbs 99% of the light has an optical density**

**H.W2:**

**What is the amount of light transmitted by a film of O.D = 0.5?**