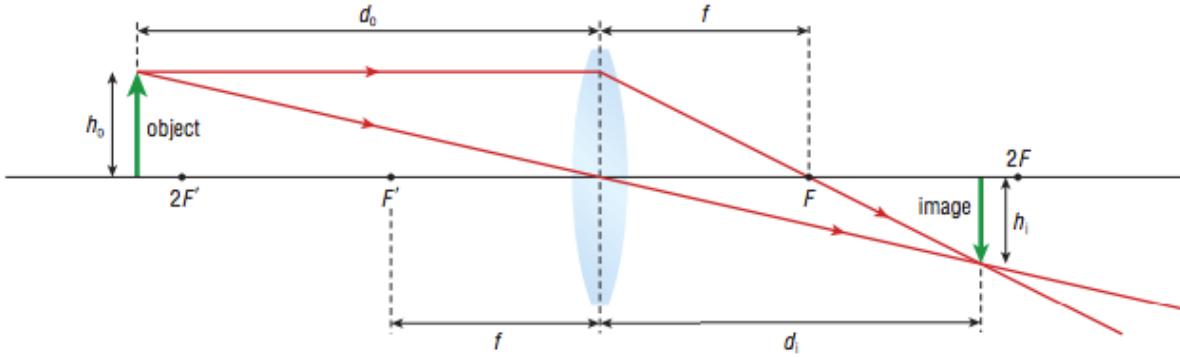


# **Grade 10 Science**

Light and Geometric Optics  
Class 11

## **The Lens Equation**

- Besides a diagram, you can also use algebra to determine the characteristics of an image
- Variables:
  - $d_o$  = distance from the object to the optical centre
  - $d_i$  = distance from the image to the optical centre
  - $h_o$  = height of the object
  - $h_i$  = height of the image
  - $f$  = focal length of the lens; distance from the optical centre to the principal focus



## The Thin Lens Equation

$$\frac{1}{d_0} + \frac{1}{d_i} = \frac{1}{f}$$

- Object distances ( $d_0$ ) are always positive
- Image distances ( $d_i$ ) are positive for real images (opposite side) and negative for virtual (same side)
- The focal length is positive for converging lenses and negative for diverging lenses



## Checkpoint



- a) A converging lens has a focal length of 17cm. A candle is located 48cm from the lens. What type of image will be formed and where will it be located?
- b) A diverging lens has a focal length of 29cm. A virtual image of a marble is located 13cm in front of the lens. Where is the marble located?

## The Magnification Equation

$$M = \frac{h_i}{h_0} = -\frac{d_i}{d_0}$$

- Object ( $h_0$ ) and image ( $h_i$ ) heights are positive when measured upward from the principal axis and negative when measured downward
- Magnification is positive for an upright image and negative for an inverted image



## Checkpoint



- a) A toy of height 8.4cm is balanced in front of a converging lens. An inverted, real image of height 23cm is noticed on the other side of the lens. What is the magnification of the lens?
- b) A coin of height 2.4cm is placed in front of a diverging lens. An upright, virtual image of height 1.7cm is noticed on the same side of the lens as the coin. What is the magnification of the lens?

**Table 1** Sign Conventions for Lenses

Variable	Positive	Negative
(object distance) $d_o$	always	never
(image distance) $d_i$	real image (image is on opposite side of lens as object)	virtual image (image is on same side of lens as object)
(height of object) $h_o$	when measured upward	when measured downward
(height of image) $h_i$	when measured upward	when measured downward
(focal length) $f$	converging lens	diverging lens
(magnification) $M$	upright image	inverted image

# Applications of Lenses

- Cameras use a converging lens to produce an inverted, smaller, real image on the film or digital sensor
- Object must be located more than  $2F'$  and the image will be between  $F$  and  $2F$ ; cannot change the film so the lens moves back and forth to focus

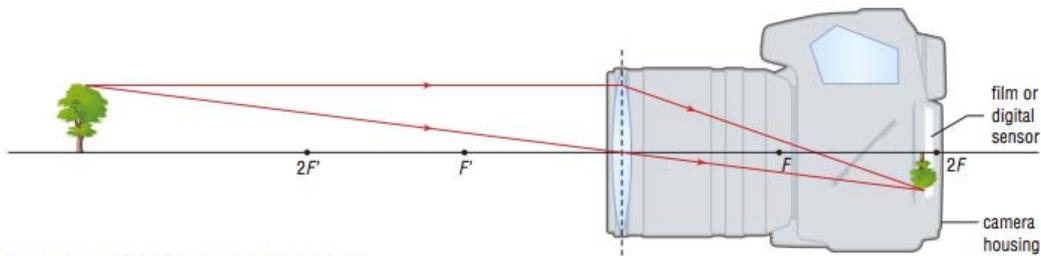


Figure 1 A camera produces a smaller, real image.

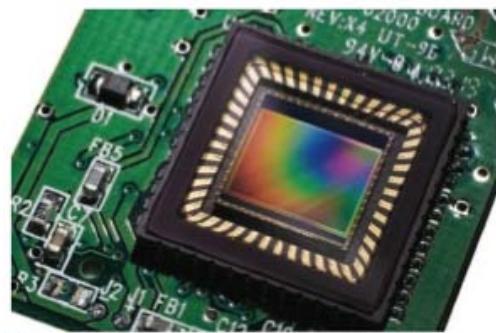
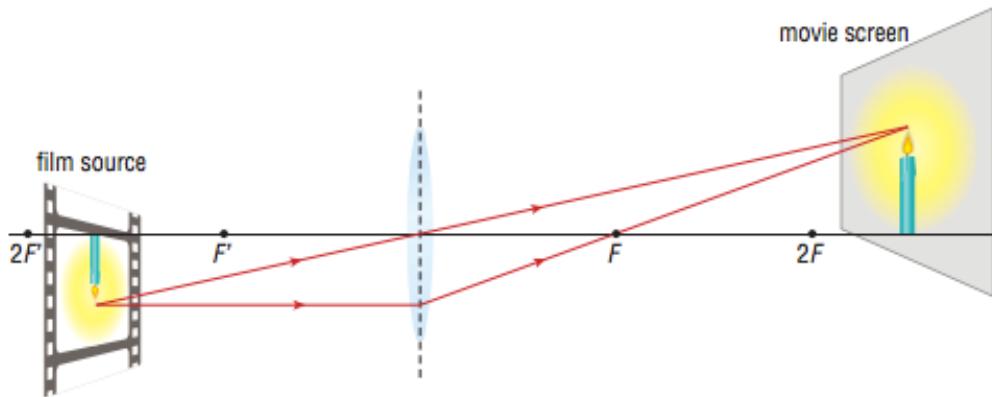


Figure 2 In a digital camera, a charge-coupled device (CCD) replaces the film found in a traditional camera.

- Traditional film was developed by George Eastman in 1884
- Digital cameras use a charge-coupled device (CCD) to capture the light

## Movie Projector

- Takes a small object and projects a large, inverted, real image on a screen
- Film must be located  $F'$  and  $2F'$  and loaded upside down for image to be upright



## Magnifying Glass

- Converging lens in which object is between  $F'$  and the lens
- Human brain extends the refracted rays backwards to produce an enlarged, virtual image

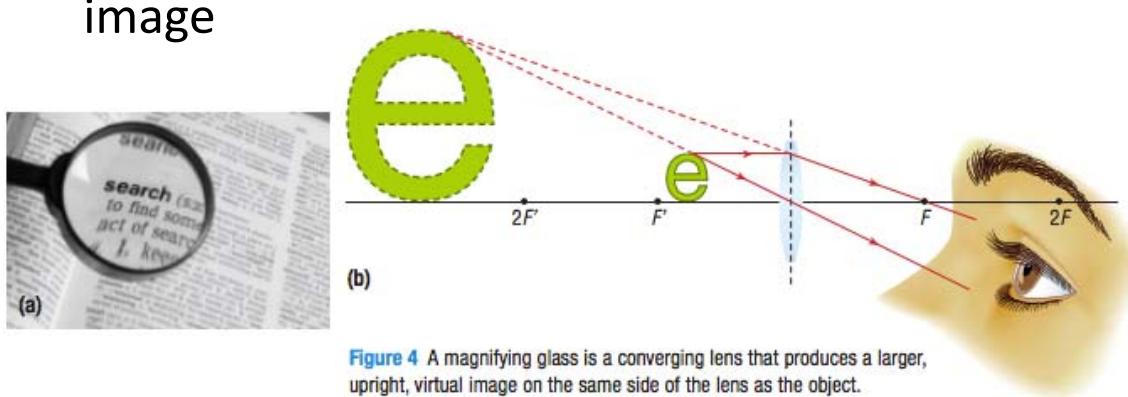
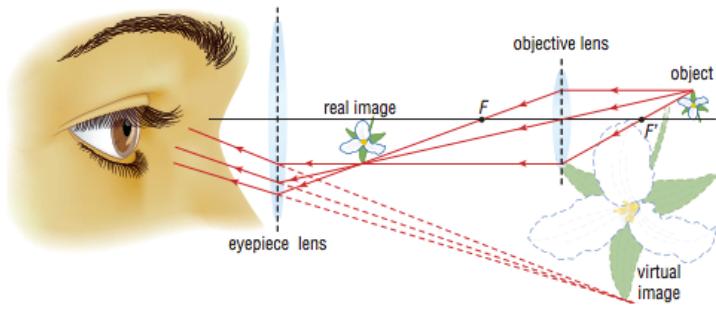


Figure 4 A magnifying glass is a converging lens that produces a larger, upright, virtual image on the same side of the lens as the object.

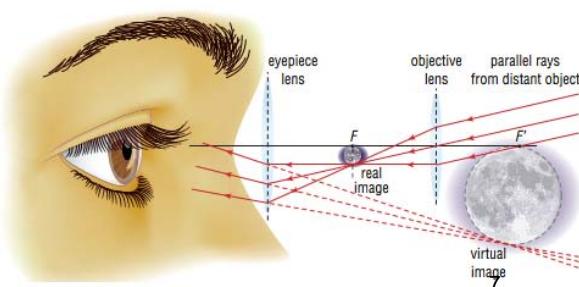
# Compound Microscope

- Arrangement of two converging lenses to produce two enlarged, inverted images: one real and one virtual
  - Real image is in the body tube of the microscope
  - Virtual image is the one you see through the eyepiece



# Telescope

- The object you are looking at is so far beyond  $2F'$  that incident rays passing through the lens are considered to be parallel
- Produces two enlarged, inverted images, one real image that is inside the telescope and one larger virtual image that you see



# The Human Eye

- Iris – opens and closes to let in more or less light
- Pupil – where light enters the eye
- Cornea – causes light to converge
- Lens - causes light to converge
- Retina – where the image is focused; sends electrical signals to the brain through the optic nerve

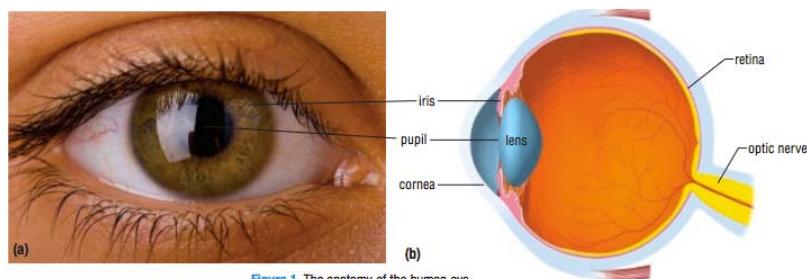
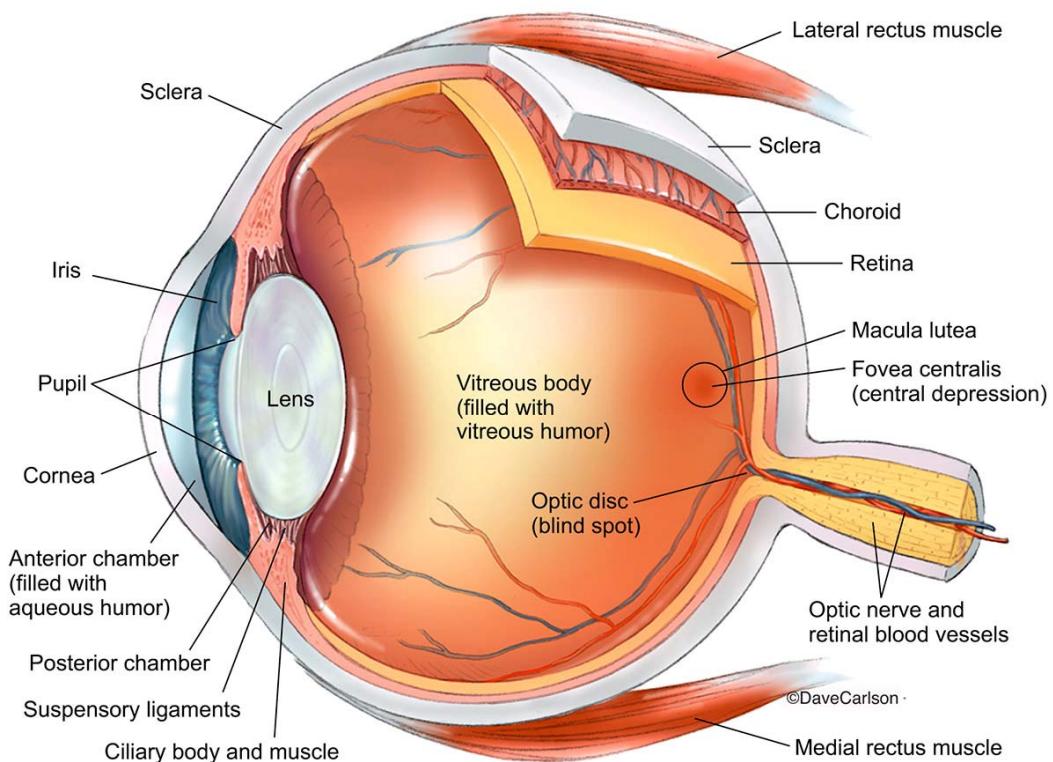


Figure 1 The anatomy of the human eye



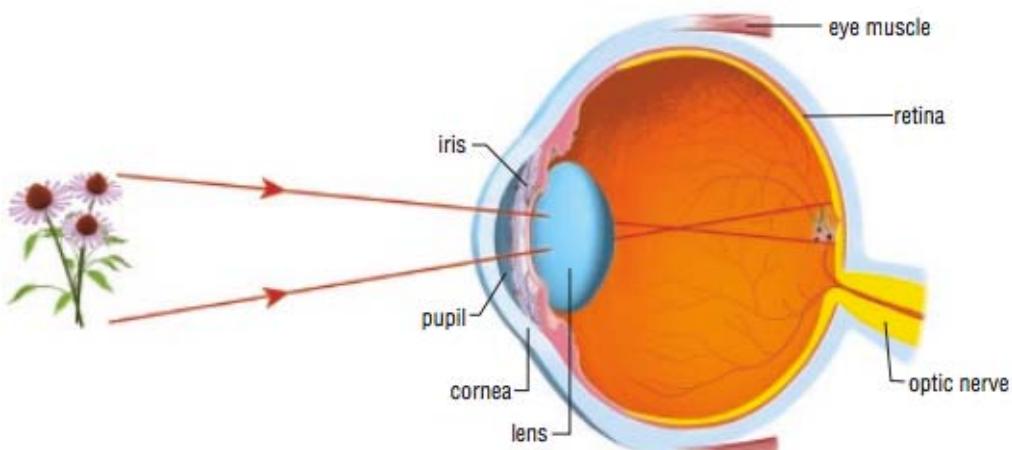
Right Eye (viewed from above)

# Find Your Blind Spot



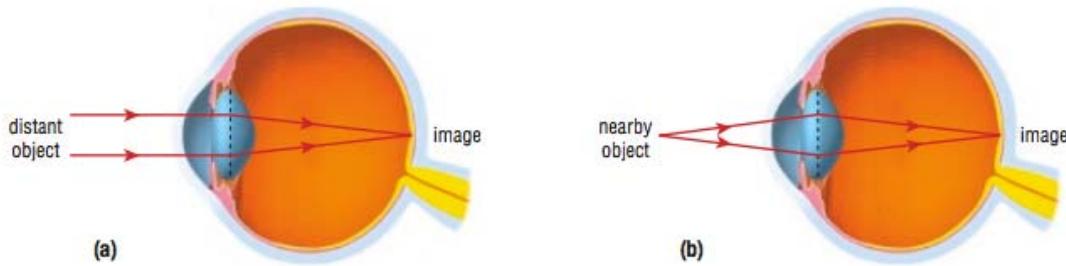
- Find your blind spot, close your left eye and focus on the small ball until the larger ball disappears

- The eye is a light gathering instrument, we see with our brain
- Brain flips the real, inverted image on the retina so that we see an upright image



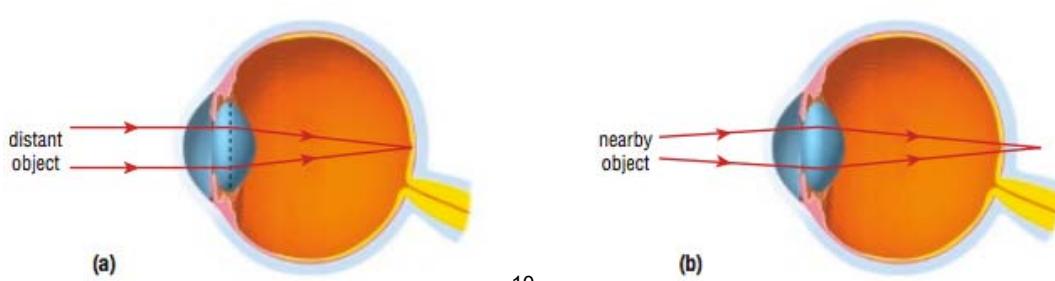
## Accommodation in Healthy Eyes

- Ciliary muscles help the eye focus by changing the shape of the lens which changes the focal length to allow focusing on the retina
- Lens gets fatter when focused on nearby objects



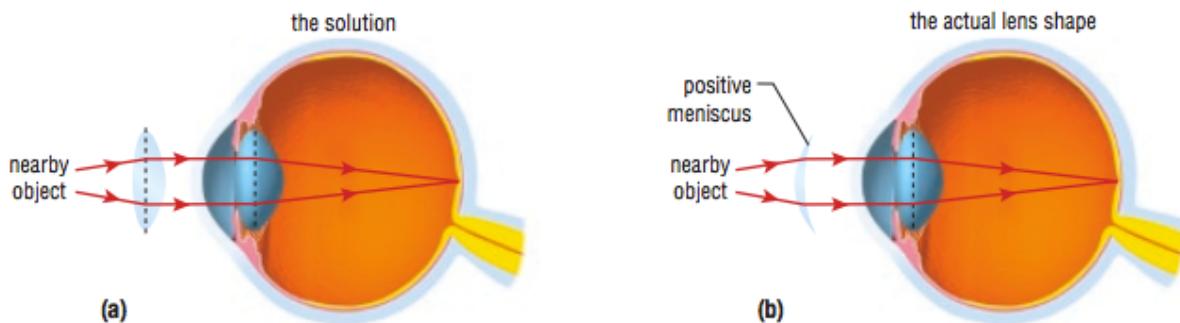
## Hyperopia (Far-sightedness)

- Inability to see near
- Occurs because distance between the lens and retina is too small or cornea-lens combination is too weak
- Light focuses behind the retina



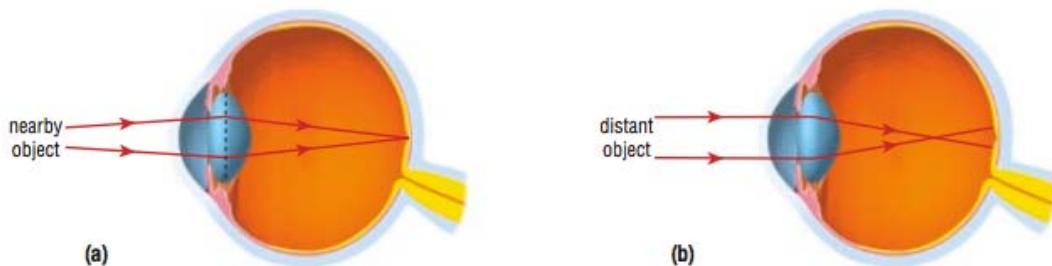
## Correcting Hyperopia

- Needs help in refracting light – uses a converging lens
- **Presbyopia** – caused by age; eye lens loses elasticity



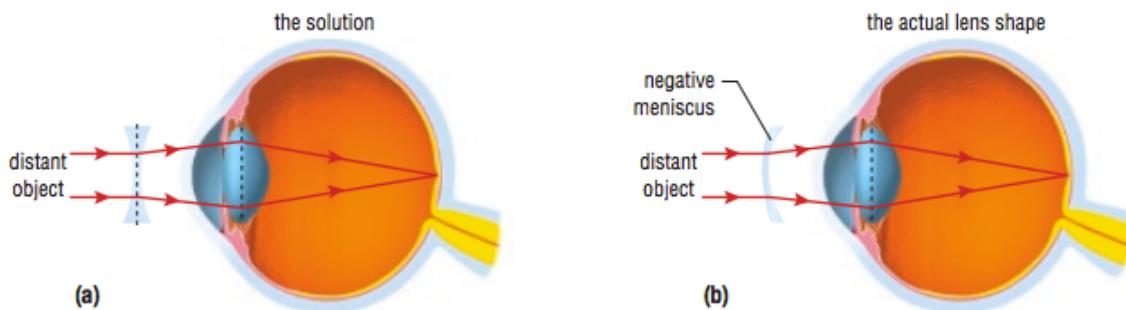
## Myopia (Near-Sightedness)

- Inability to see far
- Distance between lens and the retina is too large or cornea-lens combination converges too strongly
- Light focuses in front of the retina



## Correcting Myopia

- Corrected with a diverging lens
- Positive meniscus and Negative meniscus are lenses with a modified shape to make glasses more cosmetically appealing than a regular lens



## Contact Lenses

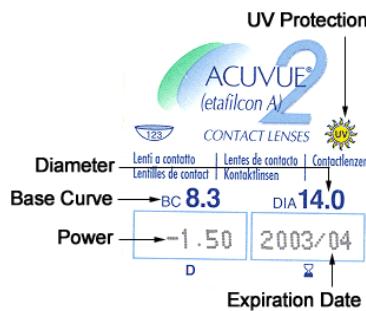
- Lens placed in front of the cornea
- Shaped to correct hyperopia and myopia
- Proximity to the eyeball allows the optic zone (central part of the lenses that contains the corrective power) to be smaller than glasses



# Diopters (D)

- Contact lens and eyeglass lens powers are expressed in diopters (D)
- Lens powers that correct nearsightedness start with a (-) and farsightedness start with a (+) sign

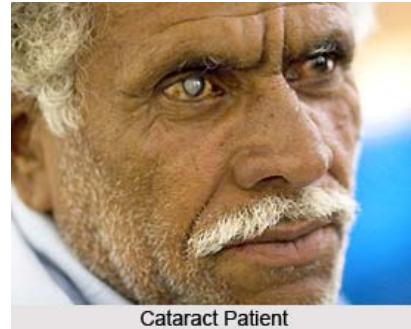
$$D = \frac{1}{f}$$



## Common Eye Problems

- **Astigmatism** - light fails to focus on a single point on the retina; instead multiple focus points occur
  - Symptoms: Causes vision to be blurred, lights seem to come from all directions
- **Glaucoma** – pressure buildup due to fluid in the aqueous humor damaging the optic nerve; can lead to blindness
  - Symptoms: Tends to be inherited; loss of peripheral or side vision, appearance of halos around lights

- **Cataract** – Clumping of proteins in the lens due to old age, UV light, diabetes, etc.
  - Symptoms: Blurred vision, glaring lights, dull colours; can lead to blindness
  - Can be helped with cataract surgery in which the clouded lens is replaced with a clear plastic intraocular lens
  - Patients regain clear vision



Cataract Patient