Chapter 5: Lenses

There are 2 types of lenses, convex (converging) and concave (diverging) lenses.

Focusing Property of Lenses

Convex Lens

If parallel beams of light hit the lens (parallel to the principal axis), the light will be refracted through a point known as the **focus**.

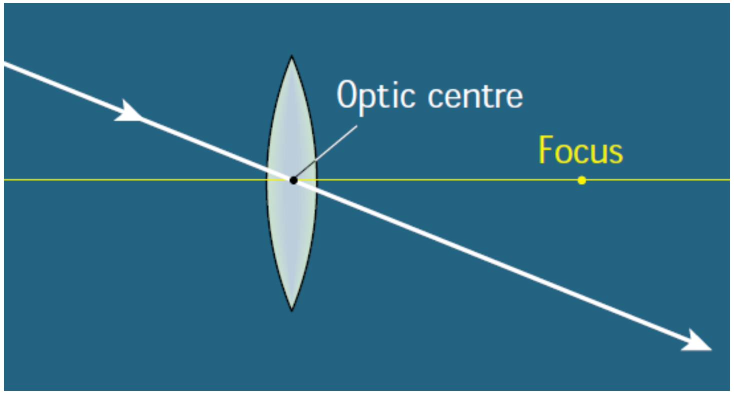
Concave Lens

If a parallel beam of light hits a concave lens, it will be refracted as if it is coming from one point, i.e the **focus**.

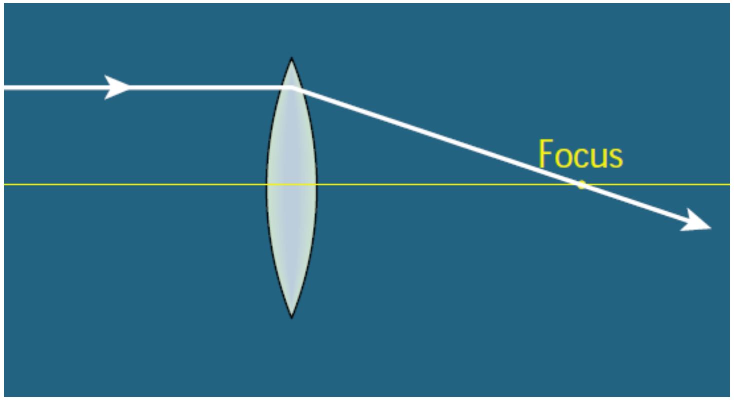
Note:

- There is a focus at both side of the lens.
- Each focus is the same distance from the optic centre.

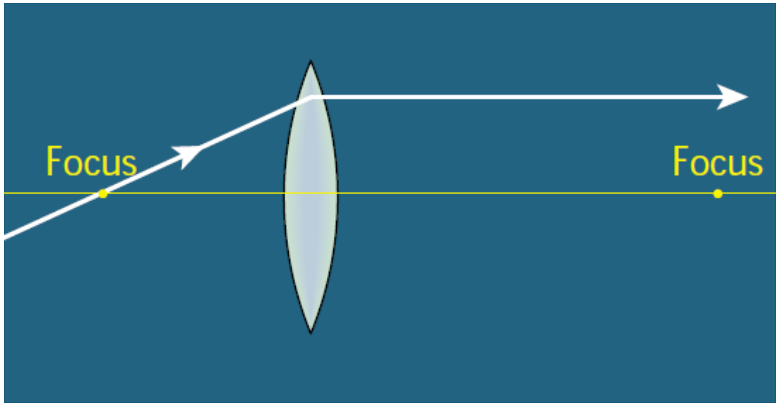
Refraction of Light by a Convex Lens



A ray which strikes the optic centre passes straight through it.



A ray which strikes the lens travelling parallel to the axis passes through the focus at the other side of the lens.



A ray which passes through the focus, then strikes the lens, will emerge parallel to the principal axis.

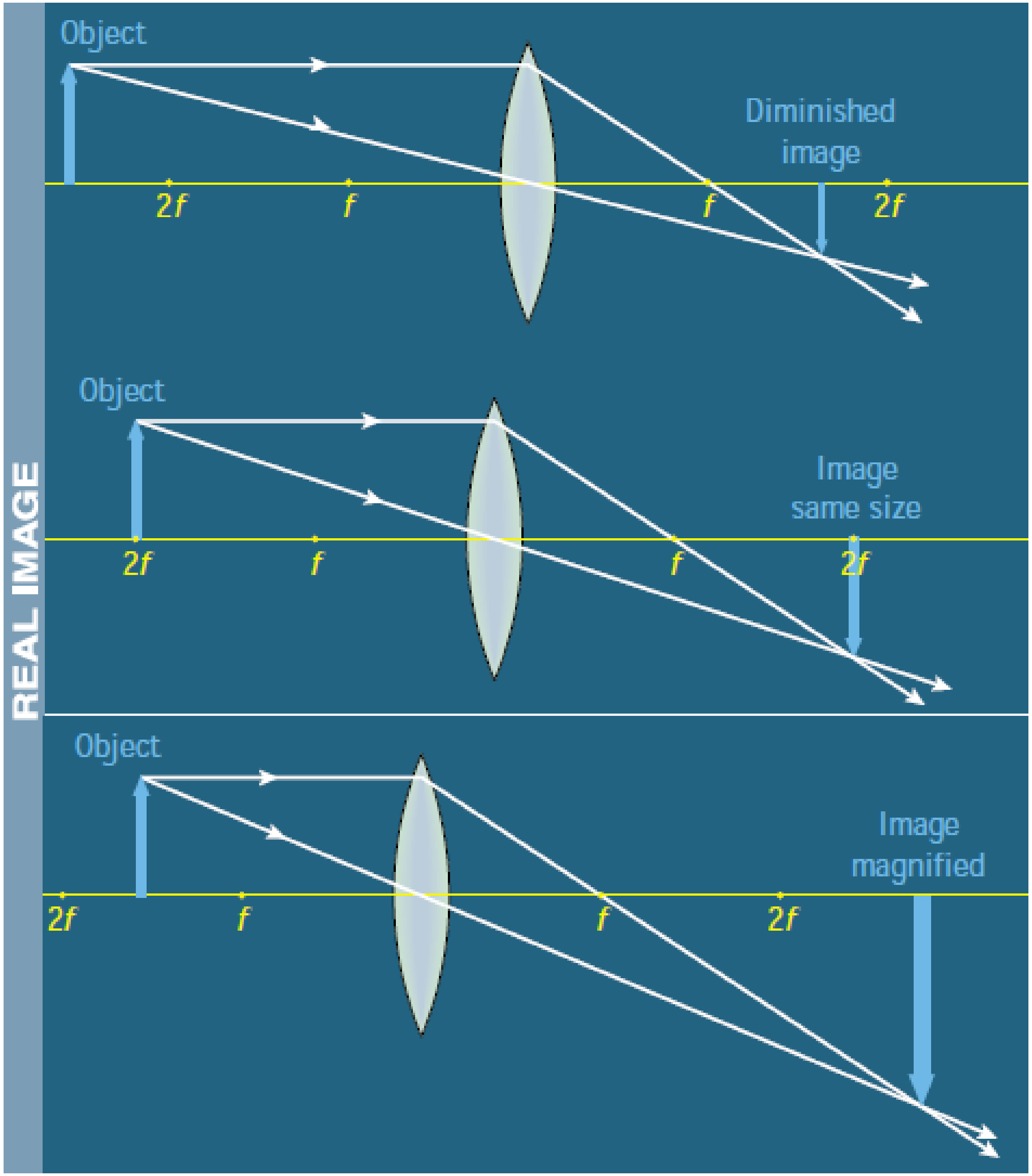
Convex Lens (converging Lens)

Using the 3 rules just mentioned, we can draw an image of an object in a convex mirror.

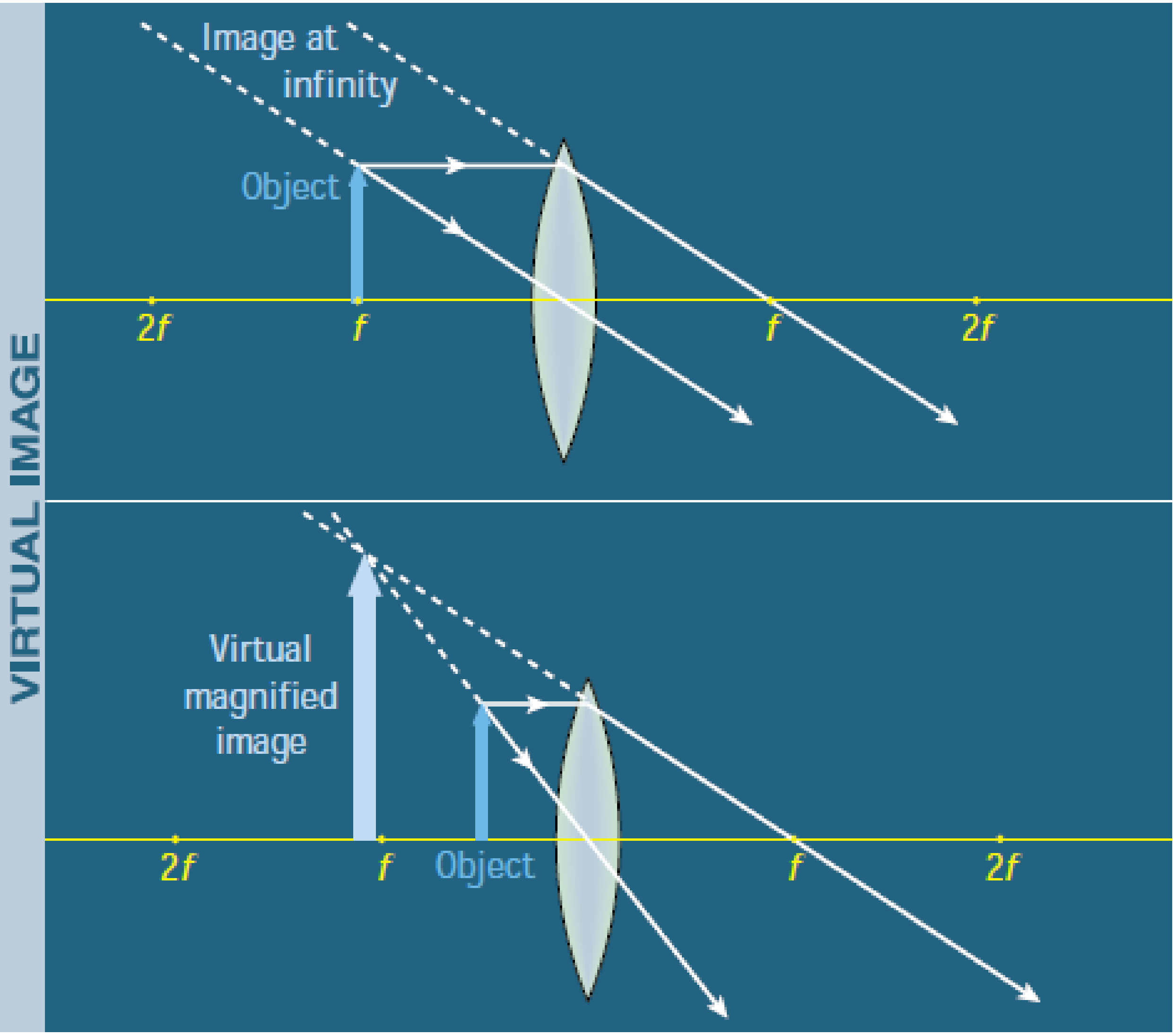
Note for diagram above:

The image is **Real**. (actual intersection of rays)
It can be shown on a screen.
Only 2 rays need to be drawn to find the image.

If the object is <u>outside</u> the focus, the image is <u>real</u>, inverted and located at the opposite side of the lens to the object.



If the object is <u>inside</u> the focus, the image is <u>virtual</u>, upright and located on the same side of the lens as the object.



Convex Formula: $$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$$

Note: u is always positive!!

v is **+** for real and **–** for virtual

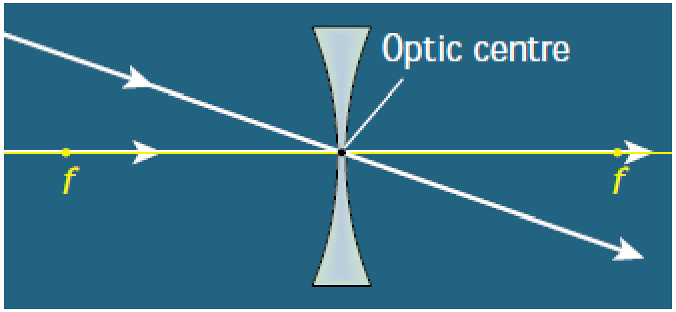
Magnification Formula: $$m=\frac{Height\ of\ image}{Height\ of\ object}=\frac{Image\ distance}{Object\ distance}=\frac{\boldsymbol{v}}{\boldsymbol{u}}$$

Example 5.1

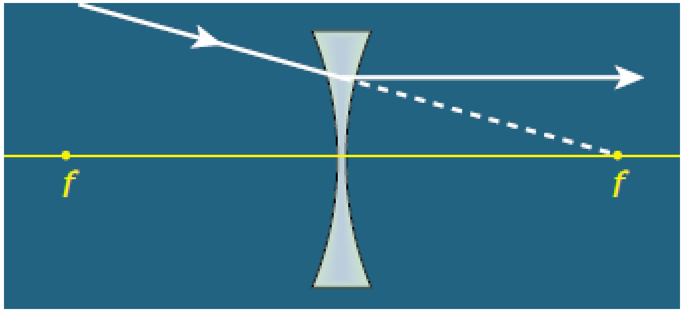
An object is placed 20 cm in front of a convex lens of focal length 15 cm. Find the position, nature and magnification of the image. If the object is 3 cm high, what is the height of the image?

Rules for the Concave Lens.

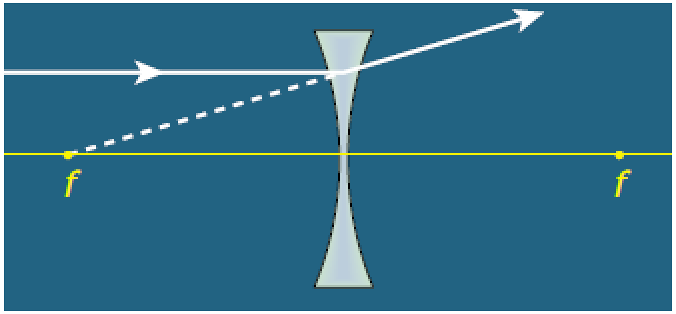
All 3 rules are identical to the convex lens.



A ray which hits the optic centre, passes right through the lens.



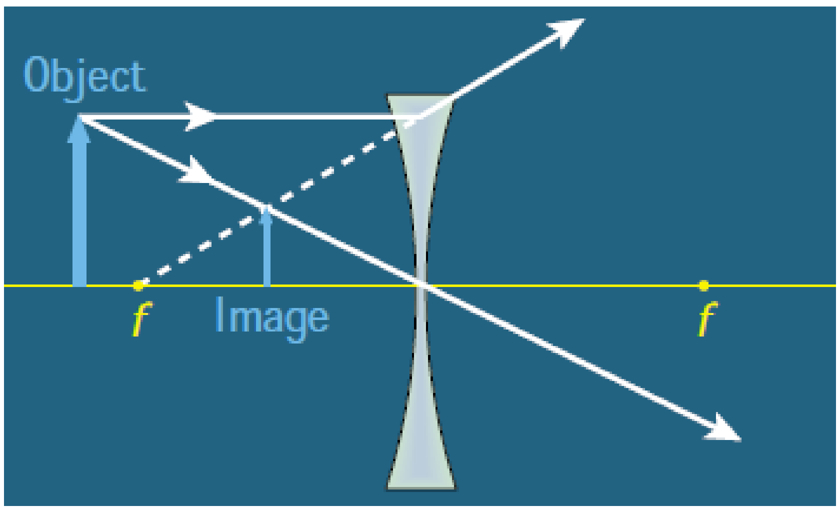
A ray heading for the focus, will emerge parallel to the principal axis after striking the lens.

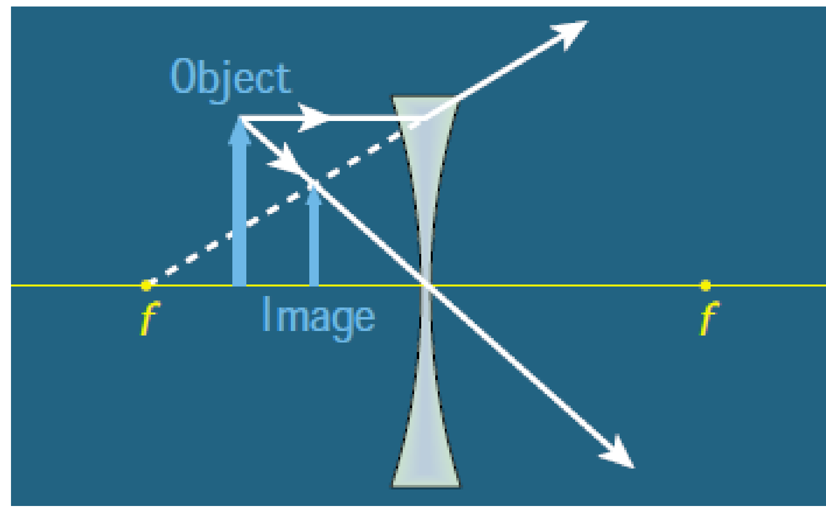


A ray striking the lens parallel will exit as if it were coming from the focus.

Images formed on a Concave Lens (Diverging Lens)

In the concave lens, the image is always **virtual**, **upright** and **diminished**. The nearer the object is to the lens, the bigger is becomes.
The image is always located at the **same side** as the object.





Note:

1. apparent intersection of rays
2. upright
3. size of the image depending on the object distance.

Concave Formula: $$\frac{1}{u} - \frac{1}{v} = -\frac{1}{f}$$

Magnification Formula: $$m = \frac{Height\ of\ image}{Height\ of\ object} = \frac{Image\ distance}{Object\ distance} = \frac{\boldsymbol{v}}{\boldsymbol{u}}$$

Example 5.2

An object is placed 10 cm in front of a diverging lens of focal length 30 cm. Find the position, magnification and nature of the image.

Answer:

Firstly, it's a diverging lens (concave lens), so the nature of the image is virtual.

Use the formula and input u = 10 and f = 30

$$\frac{1}{10} - \frac{1}{v} = -\frac{1}{30}$$

$$-\frac{1}{v} = -\frac{1}{30} - \frac{1}{10}$$

$$\frac{1}{v} = \frac{1}{30} + \frac{1}{10}$$

$$\frac{1}{v} = \frac{2}{15}$$

$$2v = 15$$

$$v = 7.5\ cm$$

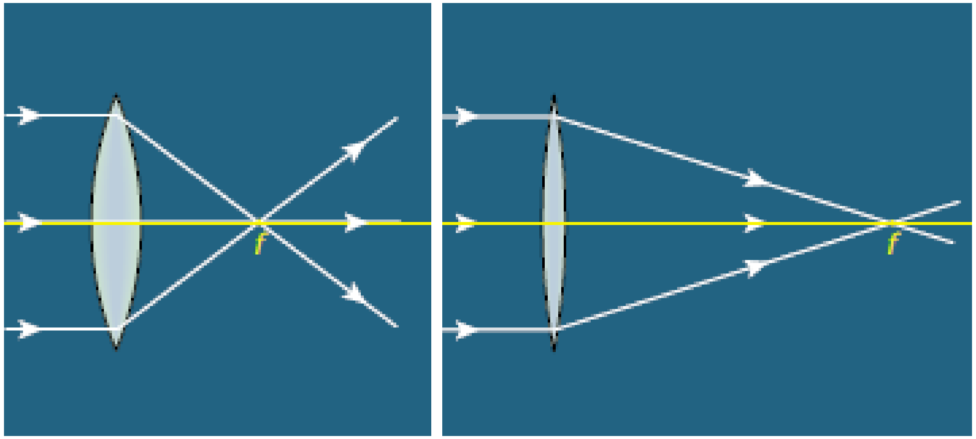
Magnification

$$m = \frac{v}{u} = \frac{7.5}{10} = \frac{3}{4}$$

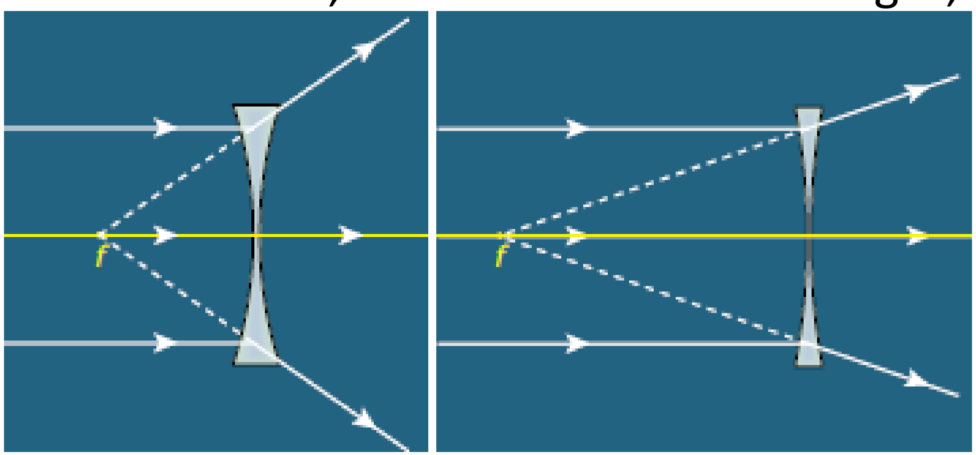
Page 51, answer Q 1 and 2

Power of a lens

For a **convex lens**, the shorter the focal length, the greater the converging power.



Similarly, for a **concave lens**, the shorter the focal length, the greater the diverging power.



Formula:

$$Power\ of\ a\ lens = \frac{1}{focal\ length}$$

+ for a convex lens
– for a concave lens

Two Lens in Contact

When 2 lens are combined, we simply add the powers

$$P = P_1 + P_2$$

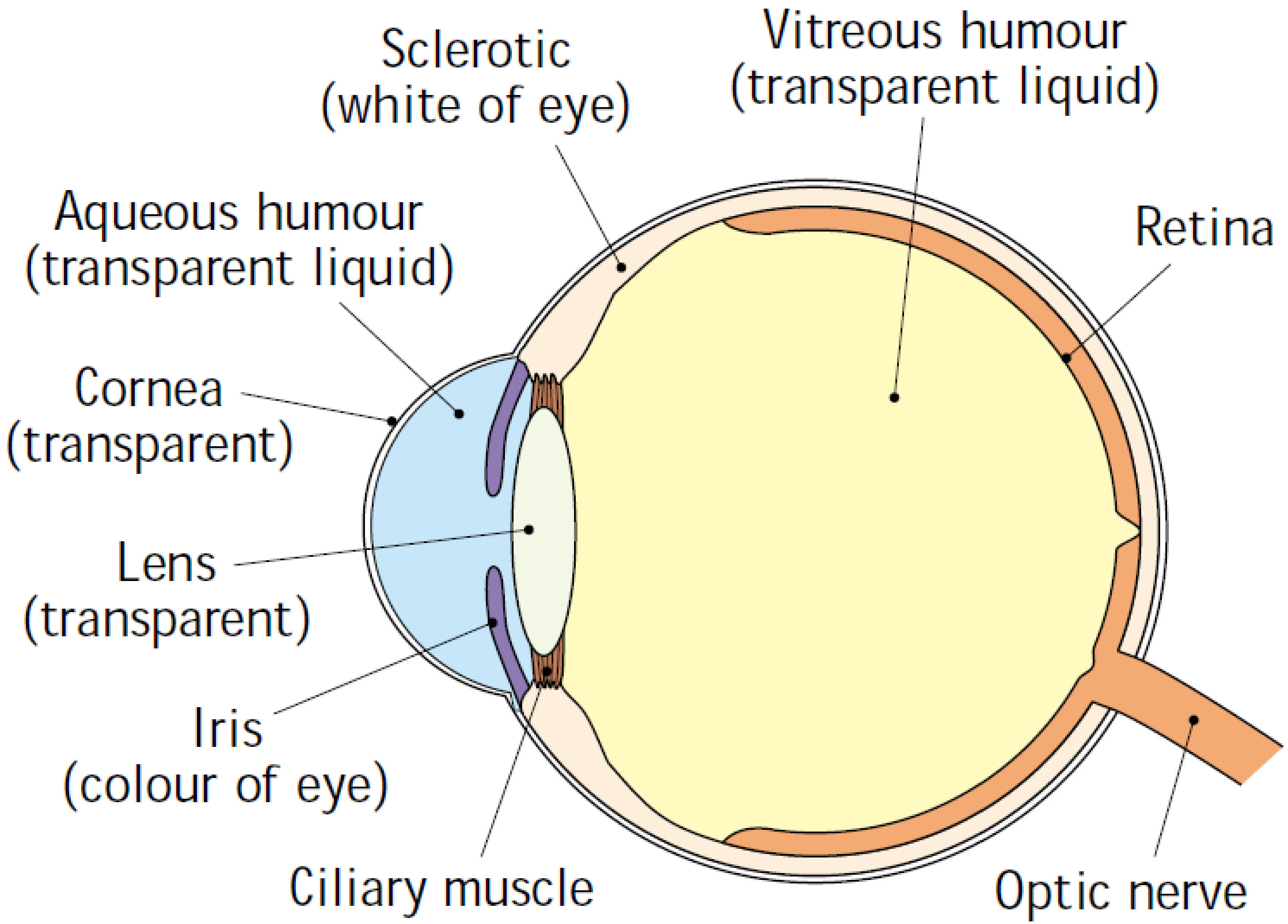
The combined focal length is also found by:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

+ for a convex lens
– for a concave lens

Look over problems 6, 7, 8 on page 52 and try questions 1-10 on page 53.

The Eye


Sclerotic
(white of eye)
Vitreous humour
(transparent liquid)
Aqueous humour
(transparent liquid)
Retina
Cornea
(transparent)
Lens
(transparent)
Iris
(colour of eye)
Ciliary muscle
Optic nerve

When light enters the eye, it gets focused to the **retina**. The retina is full of light sensitive nerves that send messages to the brain through the optic nerve. The image on the retina is up-side-down, but the brain sees the opposite.

The **iris** (colour of eye) controls the amount of light entering the eye but adjusting the size of the pupil. Dark room = large pupil. Bright room = small pupil.

The **cornea** and **lens** (along with the **aqueous humour** and **vitreous humour**) focus the light to the back of the eye.

The image is blurred if it is brought into focus in front or behind the retina.

The **ciliary muscle** adjusts the focal length of the lens.

When it relaxes, the lens is thin with its greatest focal length and the eye can see objects very far away.

When it contracts, the lens flattens, giving it a short focal length to see close up objects.

A short sighted person can see nearby objects clearly but can't focus distant objects.

Short sightedness can be corrected with a **concave** lens.

A long sighted person can see distant objects clearly, but can't focus nearby objects.

Long sightedness can be corrected with a **convex** lens.