Linear Magnification (m) – This is the factor by which the size of the object has been magnified by the lens in a direction which is perpendicular to the axis of the lens.
Linear magnification can be calculated by using:

$$m = \frac{image\ height}{object\ height} = \frac{I}{O} \text{ OR } \frac{image\ distance}{object\ distance} = \frac{v}{u}$$

Lenses

Magnification $\frac{v}{u}$	Effect on Image Compared to Object
greater than 1	magnified
equal to 1	equal size
less than 1	diminished

Images

Difference between Real and Virtual Images

Virtual Image	Real Image
The image is observed at a point from which rays seem to come from (no light rays actually pass through this imaginary point).	The image is formed where the light rays actually meet.
No image is obtained on a screen placed at this point.	An image will be formed on a screen placed at this point.

Lenses

Virtual Image Produced by	Real Images Focused on
A magnifying glass placed closed to an object.	Screen placed behind a magnifying glass which is in front an open window.
Plane mirror.	The film of a camera.
Spectacle used for correcting long and short sight.	The retina of the eye.
	The screen used with a projector.

Differences between Real and Images formed by Lenses

Virtual Images	Real Images
Cannot be formed on a screen.	May be formed on a screen.
Are not formed by the intersection of real rays.	Are formed by the intersection of real rays.
Are erect.	Are inverted.
Are on the same side of the lens as the object.	Are on the opposite side of the lens.

Lenses

The Eye

Diagram of The Eye

Cornea – This is the tough transparent part of the eye, found at the front of the eye.

Sclera – This is the white, tough part of the eye.

Iris – This is the coloured part of the eye, which surrounds the pupil controlling the amount of light entering the eye.

Pupil – The pupil is the dark hole in the middle of the eye, it allows the eye to adjust different light intensities.

Lens – The lens is a bi-concave converging lens of a jelly-like, flexible and transparent material. The ciliary muscles change the size of the lens, to focus on far and near objects, by the process accommodation.

Retina – This is the light sensitive part of the eye, and is made up of rods and cones. This is where the images are formed.

Choroid – This supplies the eye with blood, and reduces reflection within the eye.

Eye Defects

Long Sight – In some people the eyeball is shorter from back to front than is usual; in others, the lens is too flat. Light from a distant object can be focused on to the retina, but from a close object the focus is behind the retina, because the rays are not bent enough. Wearing convex lenses can help these people to overcome this eye defect, known as long sight.

Short Sight – If the lens is too curved, or the eyeball is too deep from the cornea to retina, the rays from a distant object are bent more than necessary. The image is thus formed in the jelly in front of the retina, and is blurred by the time it reaches the retina. Persons with eye defect are said to be shortsighted. Wearing concave lenses helps the individual to see far objects clearly.

See P.F.C., Pg. 39, for

Cameras

Comparing The Lens of Camera to The Human Eye

	Eye	Pinhole Camera	Lens Camera
Type of lens	Converging	None	converging
Method of focusing	Change of lens: thicker for near objects	All distances focused if pinhole is small	Lens move from the film for near objects.
Light control	a) iris b) sensitivity of retina	a) hole size b) exposure c) sensitivity of film	a) iris diaphragm b)exposure time or shutter speed c) sensitivity of film

Pinhole Camera

Facts:

1.) The image is inverted.
2.) No focusing is required.
3.) A larger pinhole gives a brighter image, but less distinct.
4.) A longer pinhole camera gives a larger image, but it is less bright.
5.) The image is said to be a real image , because it is formed by rays of light on a screen.
6.) A virtual image is one you cannot touch.

Periscope

The periscope helps to see around corners; they are used in submarines. In the periscope the reflecting surface are facing each other, and are parallel but set so the that the angles incidence and reflection will be 45°, turning the ray of light through 90° at each mirror

Lenses

(1.) An object 6cm high is placed 20cm away from a converging lens of focal length 8cm. Find a scale drawing the position, size and nature of the image; the object should be drawn at right angles to the principal axis.

(2.) An object 2cm high is placed 3cm away from a converging lens of focal length 5cm. Draw a ray diagram of how the image is formed, and find the position and height of the image.

(3.) An object 1cm tall is placed 25cm away from a converging lens, with a focal length of 20cm. Find by a scale drawing the position and size of the image formed.

(4.) An object 4cm tall is placed 30cm away from a converging lens, with a focal length of 20cm. Use a ray diagram to describe the image formed.

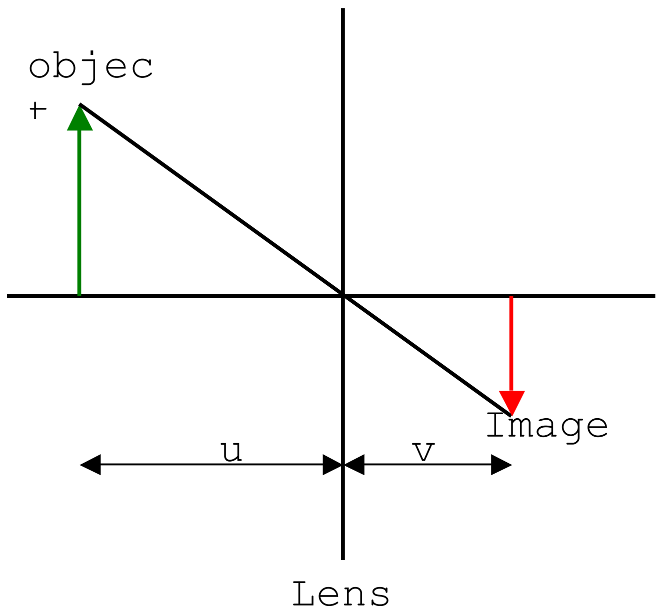
Lens Formula:

Magnification

Linear Magnification (m) = $\frac{\text{height of image}}{\text{height of object}}$

OR

= $\frac{\text{Image distance}}{\text{Object distance}}$



Example: A building is 6m high, and it is 80m from a converging camera lens. If the camera forms an image which is 6mm high, (a) What is the magnification;

(b) How far must the camera film be behind the lens for the image to be formed.

object height = 6m (6 000mm)
image height = 6mm
object distance = 80m (80 000mm)

(a) magnification $= \frac{I}{O} = \frac{6}{6000} = 0.001$

(b) mag. $= \frac{v}{u}$

$0.001 = \frac{v}{80{,}000}$

v = 0.001 x 80 000mm = 80mm

Power of Lens (F)

When a lens is powerful it deviates rays more precisely. It will converge (or diverge) parallel rays to (or from) a focus in a short distance (a powerful lens will have a short focal length).

$$F = \frac{1}{f(always\ in\ meters)}$$

The power of lens is measured in dioptre (D).
1D is the power of the lens, of focal length 1 (Diverging lens have a negative power).

The lens formula

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

$$\frac{u+v}{uv} = \frac{1}{f}$$

$$f = \frac{uv}{u+v}$$

N.B. When using the lens formula distances to real objects and images are given positive values, whereas distances to virtual objects are given negative values.

Examples:

(1.) A film projector is used to produce a real image on a screen. The screen is 30m away from the lens, and 3.0cm from the lens of the projector, calculate, (a.) magnification; (b.) height of the image on the screen if the object on the film is 5mm high.

(a.) mag. $= \frac{v}{u} = \frac{3000}{3} = 1000$

(b.) mag. $= \frac{v}{u}$

$1000 = \frac{v}{5}$

v = 1000 x 5mm = 5000mm

v = 5000mm

(2.) A converging lens with a power of +3.0D, is used in a pair of spectacles. Calculate: (a.) Its focal length; (b.) The position of the image formed, if an object is 25cm from its optical centre.

(a.) $F = \frac{1}{f}$

$3.0 = \frac{1}{f}$

$f = \frac{1}{3.0} = 0.33m$=33cm

(b) $f = \frac{uv}{u+v}$

$$33 = \frac{25v}{25 + v}$$

$33(25 + v) = 25V$

$825 + 33v = 25v$

$825 = 25v - 33v$

$825 = -8v$

$v = 825/-8$

$v \approx -103$cm

mag. $= \frac{v}{u} \approx \frac{103}{25} \approx 4.125$

(b.) Image is virtual, erect 103cm on the same side of the lens as the object is magnified by 4.125.

(3.) A diverging lens has a power of -2.0D, calculate, (a.)focal length; (b.) the position and nature of the image it forms, of an object 2m away from it.

(a.) $F = \frac{1}{f}$

$-2.0 = \frac{1}{f}$

$f = \frac{1}{-2} = -0.5m$

(b.)

$$f = \frac{uv}{u+v}$$

$$-0.5 = \frac{2v}{2+v}$$

$-0.5(2 + v) = 2V$

$-1 - ½v = 2v$

$-1 = 2v + ½v$

$-1 = 2½v$

$v = -1/2½$

$v = 0.4m$

$\text{mag.} = \frac{v}{u} = \frac{0.4}{2} = 0.2$

(b.) The image is virtual, and erect. 0.4m on the same side of the lens as the object is. Diminished by 0.2.