Lenses

Physics – Leaving Cert

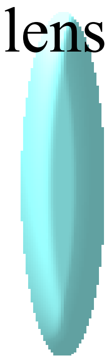
Quick Notes

Lenses

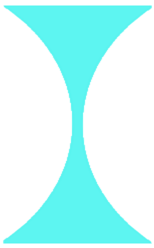
The most important topic in the study of refraction is that of lenses. Within a lens, the light bends on entering the lens and again on exiting the lens.

There are two main types of lenses

Converging (convex)



Diverging (concave)



Terminology:

As a lens has two refracting surfaces, a lens has two focal points, one on either side of the lens.(Note – for lenses we don't talk about C, we talk about the position 2F)

The midpoint of the lens is called the optical centre.

A straight line through the centre of the lens, at right angles to the surface, is called the principle axis.

Rules for image formation:

A ray of light which strikes the lens parallel to the principle axis travels through the lens and comes out through the focus on the other side.

A ray of light which passes through the focus on its own side before hitting the lens travels through the lens and comes out parallel to the principle axis

A ray of light which strikes the optical centre is undeviated.

The image is formed where these rays meet.

For a converging lens:

Object outside 2F	Image is real, inverted , diminished , located between F and 2F on the other side of the lens
Object at 2F	Image is real, inverted, same size as object, located at 2F on the other side of the lens
Object between 2F and F	Image is real, inverted, magnified, located outside 2F on the other side of the lens
Object at F	Image at infinity
Object inside F	Image is virtual, erect, magnified, located behind the object

For a diverging lens the image is always virtual, erect, smaller and on the same side of the lens as the object.

Calculation of image position and size.

The same formulae can be applied to lenses as to mirrors. In performing these calculations the 'real is positive'convention is used. Real distances are given by positive numbers, virtual distances are given by negative numbers.

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

Where f = focal length, u = distance from object to lens, v = distance from image to lens.

$$magnification\ (m) = \frac{image\ height}{object\ height} = \frac{image\ distance}{object\ distance} = \frac{v}{u}$$

For a diverging lens:

The same rules for image formation apply, the difference being that the focus and image distance are now both negative.

Power of a lens

The more common way of describing a lens is in terms of its power (p)

$P = \frac{1}{f}$.Measured in m^{-1}.

Lens combinations

When two lenses are placed in contact the power of the system is given by

$$P_{total} = P_1 + P_2$$

Note: for converging lenses P is positive, for diverging lenses P is negative.

The Eye

The single most important optical instrument is the human eye. The iris controls the amount of light that enters the eye through the opening called the pupil.

The focusing system of the eye consists of the cornea, aqueous humour, lens and vitreous humour.

The image is formed on the retina and the information transmitted to the brain via the optic nerve.

Note: the object is always outside the focus of the eye. Hence the imageformed on the retina is always real and inverted. The brain translates this information into an image that is the right way up.

The eye needs to be able to focus on both distant objects and on nearby objects. It does this by changing the shape of the lens (thin for distant objects, fat for nearby objects).

The lens is surrounded by a ring of muscle called the cilary muscle. For distant objects the muscle is relaxed, giving a thin lens. To view nearby objects the muscle contracts, creating a fatter lens. This ability of the lens to change shape as required is called **the power of accommodation.**

Near point = the nearest distance at which the eye can comfortably focus on an object

Far point =The furthest point at which the eye can focus on an object

Defects of vision

In a short-sighted eye, even when the lens is at its thinnest, the light rays from a distant object form their image in front of the retina. This condition can be corrected with a diverging lens.

In a long-sighted eye, even when the lens is at its fattest, the light from a nearby object is brought to a focus behind the retina. This can be corrected by using a converging lens.