Lenses

Lenses bring light rays to a focus or spread them out. Which is pretty darn useful, I can tell you.

Different Lenses Produce Different Kinds of Image

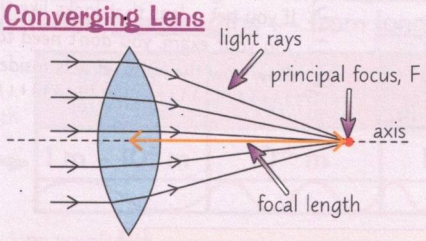
Lenses form images by refracting light (p.34) and changing its direction. There are two main types of lens — converging and diverging. They have different shapes and have opposite effects on light rays.

1) A converging lens bulges outwards in the middle. It causes parallel rays of light to be brought together (converge) at the principal focus. They're sometimes called convex lenses.
2) A diverging (or concave) lens caves inwards. It causes parallel rays of light to spread out (diverge).
3) The axis of a lens is a line passing through the middle of the lens.
4) The principal focus of a converging lens is where rays hitting the lens parallel to the axis all meet.
5) The principal focus of a diverging lens is the point where rays hitting the lens parallel to the axis appear to all come from — you can trace them back until they all appear to meet up at a point behind the lens.
6) There is a principal focus on each side of the lens. The distance from the centre of the lens to the principal focus (F) is called the focal length.

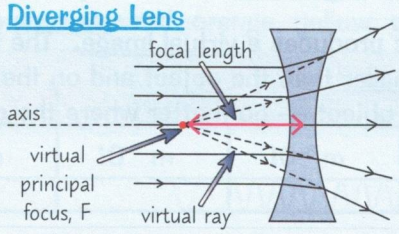
When a ray enters any lens, it bends towards the normal. When it leaves, it bends away from the normal (p.34).

To describe an image, say if it's bigger or smaller than the object, if it's upright or inverted and if it's real or virtual.

Converging Lens



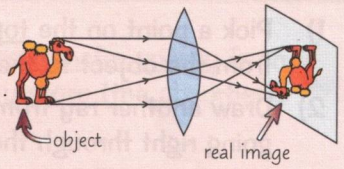
Diverging Lens



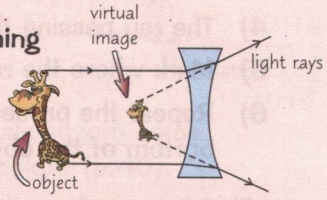
Images are formed at points where all the light rays from a certain point on an object appear to come together.

There are two types of images that can be formed by lenses:

1) A REAL image is formed when the light rays actually come together to form the image. The image can be captured on a screen, because the light rays actually meet at the place where the image seems to be. E.g. the image formed on the eye's retina.



2) A VIRTUAL image is when the light rays from the object appear to be coming from a completely different place to where they're actually coming from. The light rays don't actually come together at the point where the image seems to be, so it cannot be captured on a screen. E.g. magnifying glasses create virtual images.



The Power of a Lens Increases with its Curvature

1) Focal length is related to the power of the lens. The more powerful the lens, the more strongly it converges rays of light, so the shorter the focal length.
2) For a converging lens, the power is positive. For a diverging lens, the power is negative.
3) The curvature of a lens affects its power. To make a more powerful lens from a certain material like glass, you just have to make it with more strongly curved surfaces.
4) Some materials are better at focusing light than others. This means powerful lenses can be made thinner by changing the material they're made from (using a material that's better at focusing light means you don't need to make the lens as curved to get the same focal length).

He's magnificent, that pug...

Make sure you know the differences between real and virtual images — they can be pretty tough.

Q1 What is the principal focus of: a) a converging lens b) a diverging lens? [2 marks]

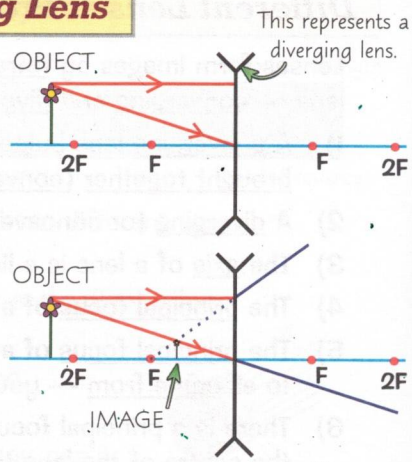
Q2 Sketch parallel rays of light being focused by a converging lens. [2 marks]

Lenses and Ray Diagrams

You need to be able to draw ray diagrams for converging and diverging lenses too.

Draw a Ray Diagram for an Image Through a Diverging Lens

1) Pick a point on the top of the object. Draw a ray going from the object to the lens parallel to the axis of the lens.
2) Draw another ray from the top of the object going right through the middle of the lens.
3) The incident ray that's parallel to the axis is refracted so it appears to have come from the principal focus (F). Draw a ray from the principal focus. Make it dotted before it reaches the lens (as it's virtual here).
4) The ray passing through the middle of the lens doesn't bend.
5) Mark where this ray meets the virtual ray. That's the top of the image.
6) Repeat the process for a point on the bottom of the object. When the bottom of the object is on the axis, the bottom of the image is also on the axis.

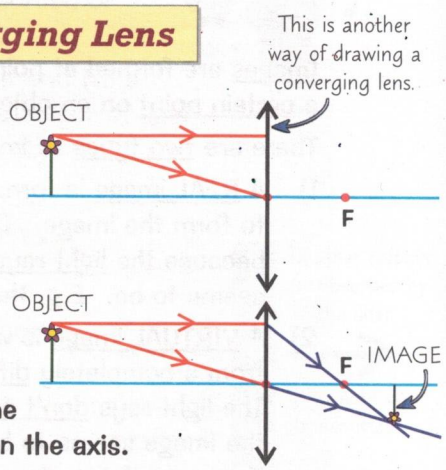


If you get a lens that looks like this in your exam, you don't need to show how the light refracts inside it.

A diverging lens always produces a virtual image. The image is the right way up, smaller than the object and on the same side of the lens as the object — no matter where the object is.

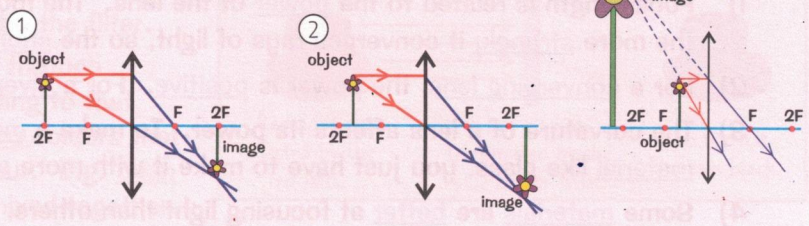
Draw a Ray Diagram for an Image Through a Converging Lens

1) Pick a point on the top of the object. Draw a ray going from the object to the lens parallel to the axis of the lens.
2) Draw another ray from the top of the object going right through the middle of the lens.
3) The incident ray that's parallel to the axis is refracted through the principal focus (F). Draw a refracted ray passing through F.
4) The ray passing through the middle of the lens doesn't bend.
5) Mark where the rays meet. That's the top of the image.
6) Repeat the process for a point on the bottom of the object. When the bottom of the object is on the axis, the bottom of the image is also on the axis.



The distance from the lens to the object affects the size and position of the image:

1) An object 2F (two focal lengths) from the lens produces a real, inverted (upside down) image the same size as the object and at 2F on the other side of the lens.
2) An object between F and 2F will make a real, inverted image bigger than the object and beyond 2F.
3) An object nearer than F will make a virtual image the right way up, bigger than the object and on the same side of the lens.



Warning — too much revision can cause a loss of focus...

Congratulations, you've reached the end of lenses. Why not celebrate with some practice questions?

Q1 What kind of image does a diverging lens produce? [1 mark]

Q2 Draw a ray diagram for an object at a distance of 0.5F in front of a converging lens. [3 marks]