Steve Smith Tuition: Maths Notes

Drawing Ray Diagrams for Converging Lenses

Contents

Prerequisites

None.

Notes

None.

Document History

Date	Version	Comments
7 June 2012	1.0	Initial creation of the document.

1 Introduction

This document has been written to try and help understand how to draw ray diagrams through thin converging lenses, for varying positions of the object.

In each diagram, the red arrow denotes the object, and the green arrow denotes the image. If the image is real, it will be solid; if the image is virtual, it will be dotted.

To draw ray diagrams, place an object so that it has one end (the "bottom") on the lens axis (the horizontal line running through the middle of the lens), and the other end (the "top") directly above the bottom of the object. Then draw two rays from the top of the object: one going horizontally toward the lens, which gets refracted by the lens down through the focal point of the lens (denoted by F in these diagrams); the other going straight through the centre of the lens. This ray does not get refracted by the lens (so long as the lens is thin enough).

Lenses are designed so that the two rays follow those paths. The focal point of a lens is the point through which rays parallel to the lens axis would be refracted through after they have passed through the lens; rays passing through the centre of the lens don't get refracted at all (for a very thin lens), because at that point on the lens, the two lens surfaces are both vertical, so that as the ray passes through the lens, it leaves in the same direction that it enters.

Where these two rays cross must be the location of the top of the image. The bottom of the image must lie on the lens axis, as a ray from the bottom of the object must just travel along the lens axis, go through the lens without being refracted, and continue out along the lens axis on the other side of the lens.

2 Object More Than 2F from the Lens

When the object is more than twice the focal length of the lens from the lens (but less than an infinite distance away from the lens. See section 7), we have the situation shown in Figure 1.

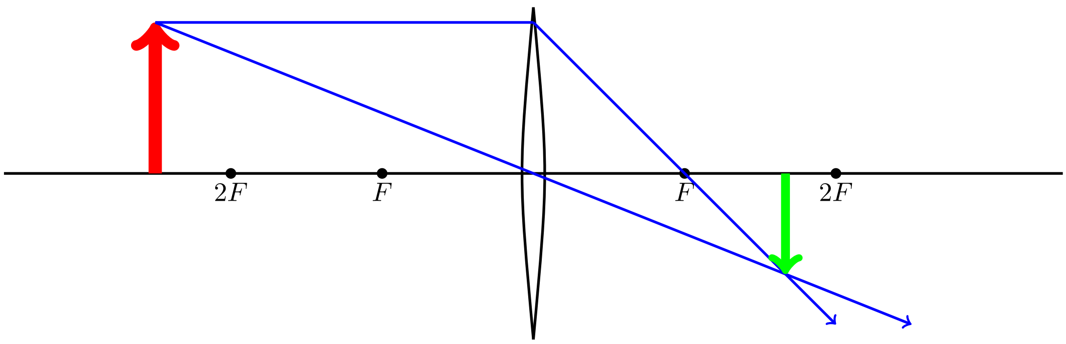

Figure 1: Object More Than 2F from the Lens

The image falls between F and 2F on the other side of the lens. It is inverted and diminished.

3 Object At 2F From the Lens

Moving the object closer to the lens, so that it is at a distance of twice the focal length of the lens (2F) from the lens, we have the situation shown in Figure 2.

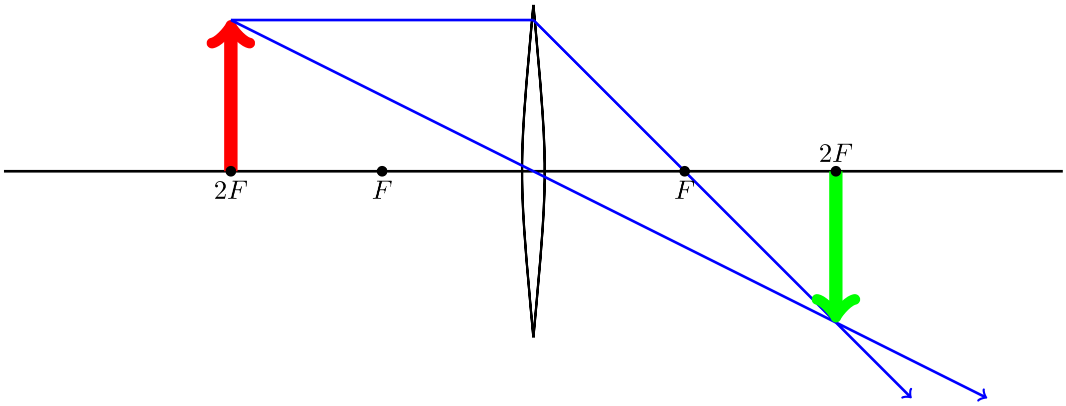

Figure 2: Object At 2F from the Lens

Here, the image falls at 2F on the other side of the lens. The image is inverted and the same size as the object.

4 Object Between 2F and F From the Lens

Moving the object closer still to the lens, so that it is between 2F and F from the lens, we have the situation shown in Figure 3.

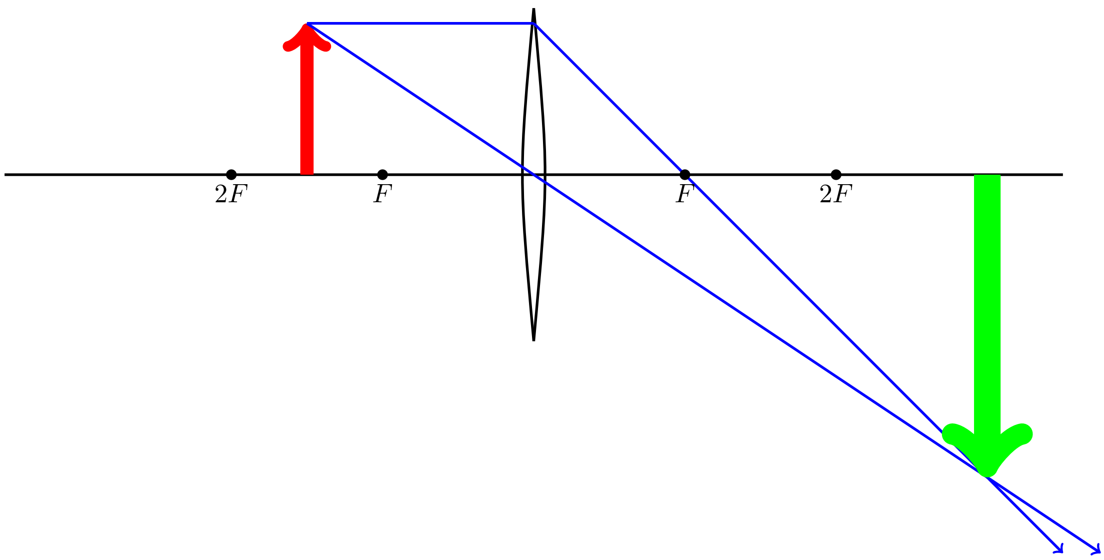

Figure 3: Object Between 2F and F From the Lens

In this case the image falls further away than 2F on the other side of the lens. The image is inverted and magnified.

5 Object at F From the Lens

When the object has been moved so that it is at the focal point F from the lens, we have the situation shown in Figure 4.

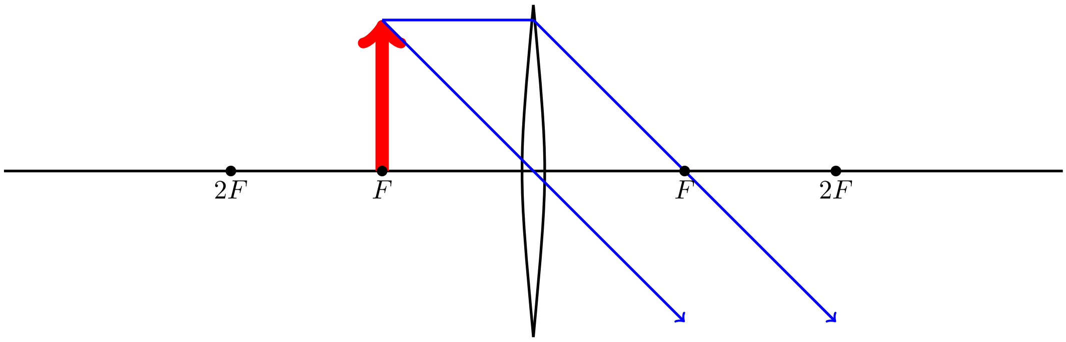

Figure 4: Object at F From the Lens

In this case, because of the geometry of the rays from the top of the object, those rays emanate from the other side the lens *parallel*. The image is said to be located at infinity!

6 Object Closer Than F From the Lens

When the object is closer to the lens than it's focal length, we have the situation shown in Figure 5.

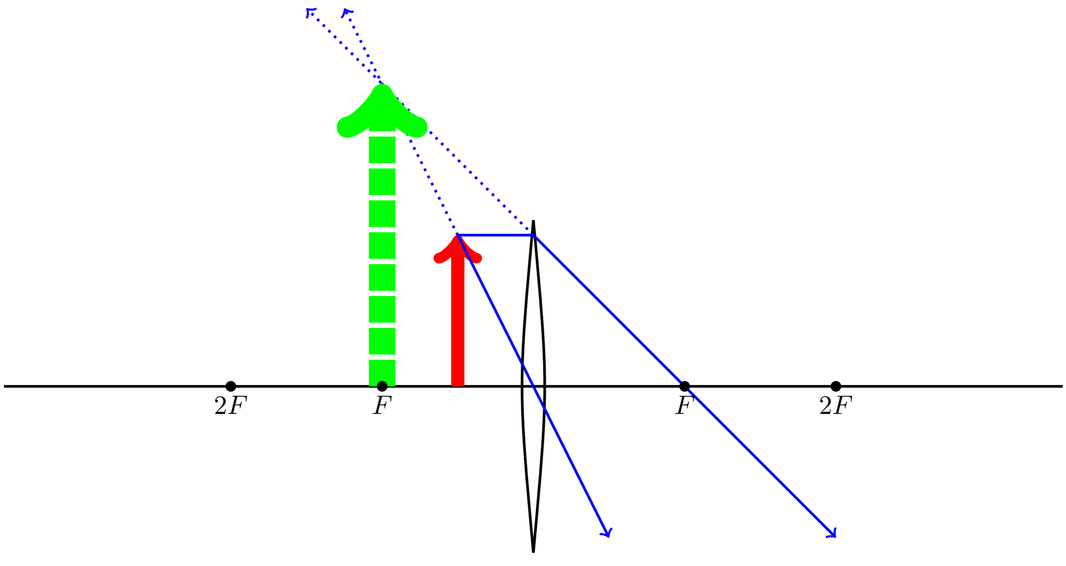

Figure 5: Object Closer Than F From the Lens

In this case, the lens is behaving like a magnifying glass. The image is virtual, upright, and magnified. It is virtual because you can't focus the image on a screen. You have to look at the image *through the lens*, because in order to see where the rays seem to cross you have to look from the right of Figure 5 through the lens.

7 Object At Infinity

Finally, when the object is at infinity, we have the situation shown in Figure 6.

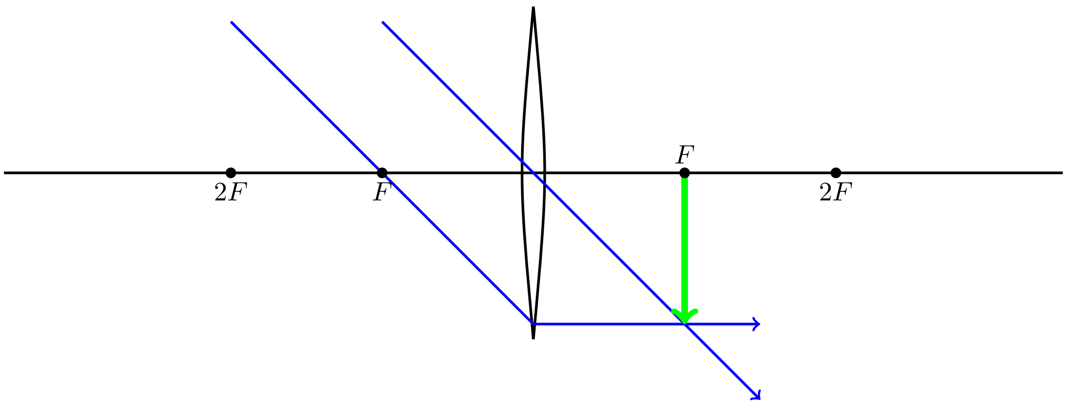

Figure 6: Object at Infinity from the Lens

The image falls at F on the other side of the lens. This is the reverse situation to that in section 5.

This is the situation that is used in the normal adjustment of an astronomical telescope, for both the objective and eyepiece lenses.