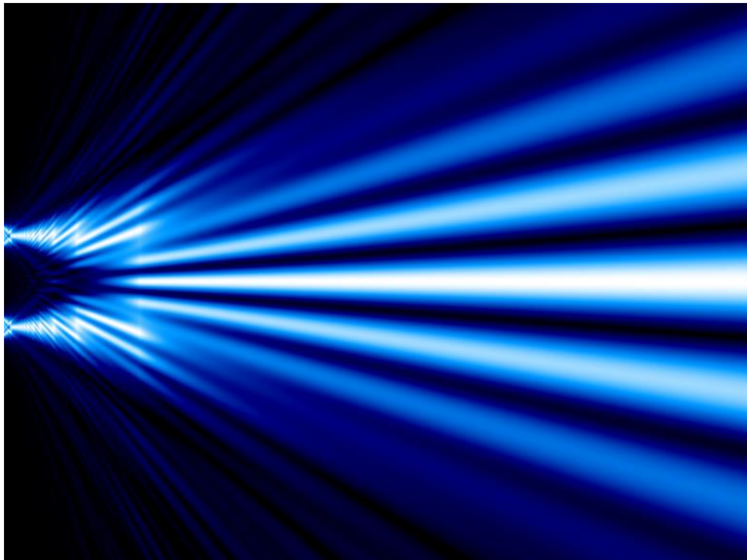
Waves & The Particle Nature of Light

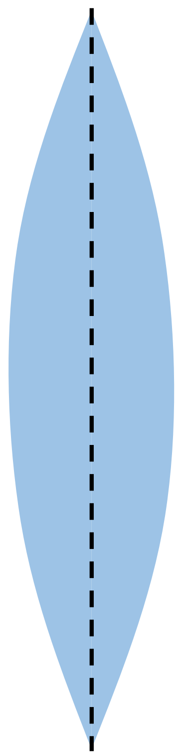
2015 EdExcel A Level Physics Topic 5

Lenses

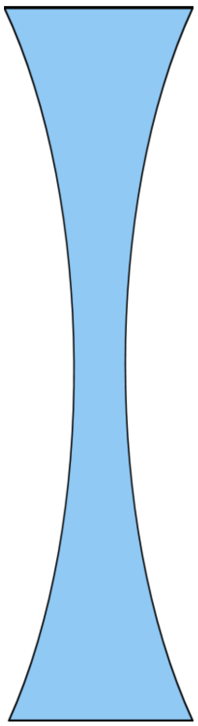


Physics Tutor Online

Types of lenses



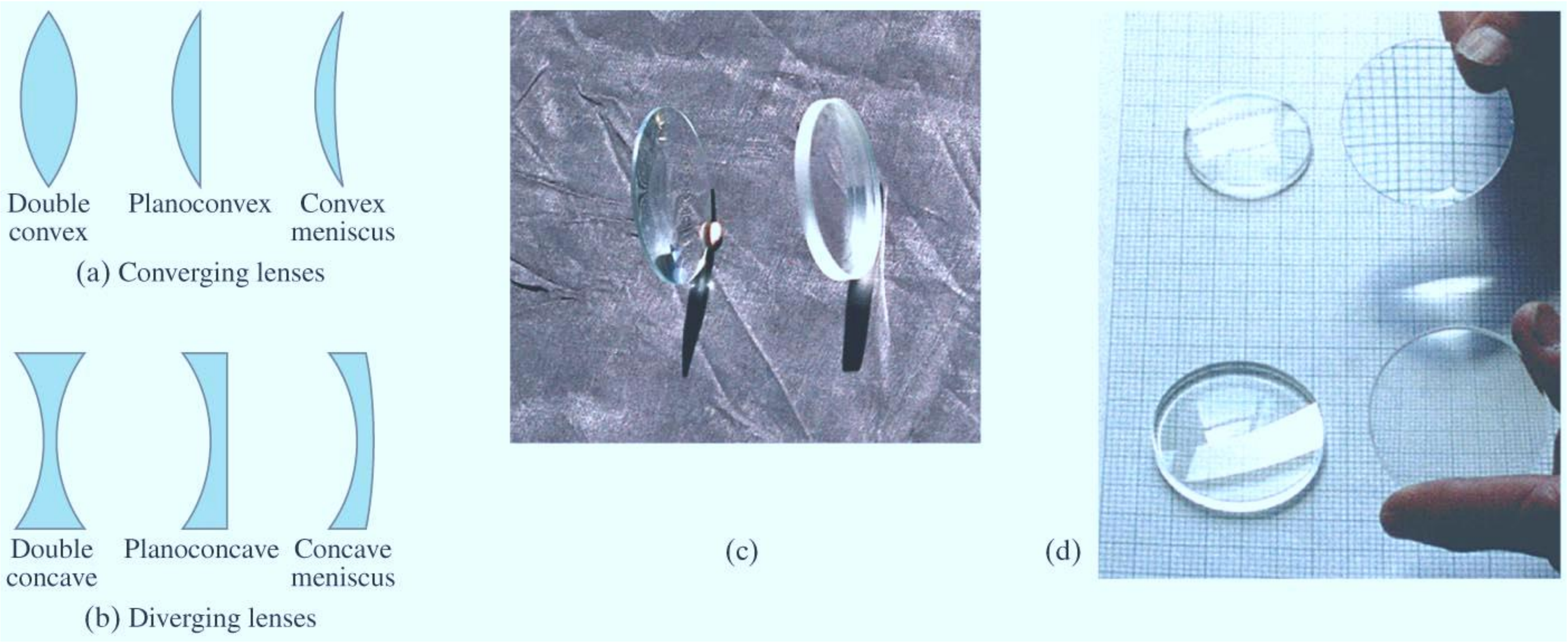
Converging lens
"bi-convex"
has two convex surfaces



Diverging lens
"bi-concave"
has two concave surfaces

Thin Lenses; Ray Tracing

Thin lenses are those whose thickness is small compared to their radius of curvature. They may be either (a) converging or (b).

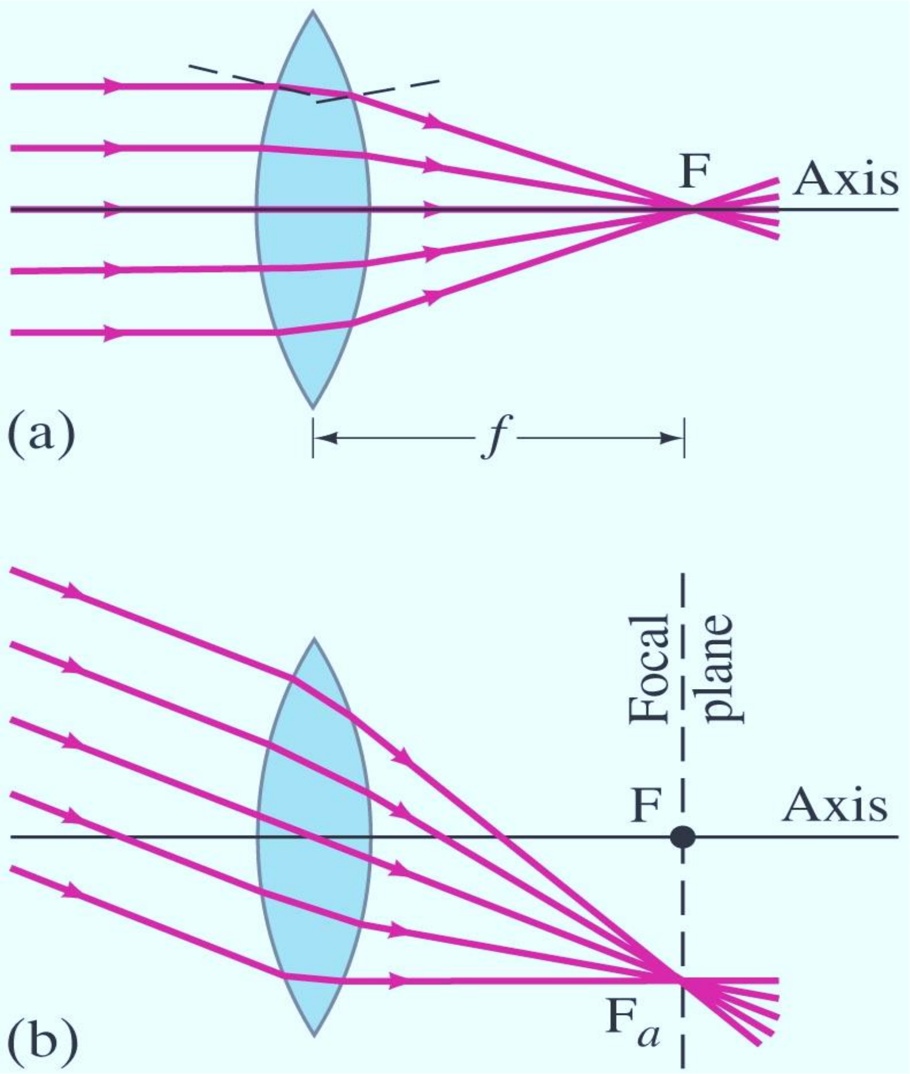


Thin Lenses; Ray Tracing cont.

Parallel rays are brought to a focus by a converging lens (one that is thicker in the center than it is at the edge).

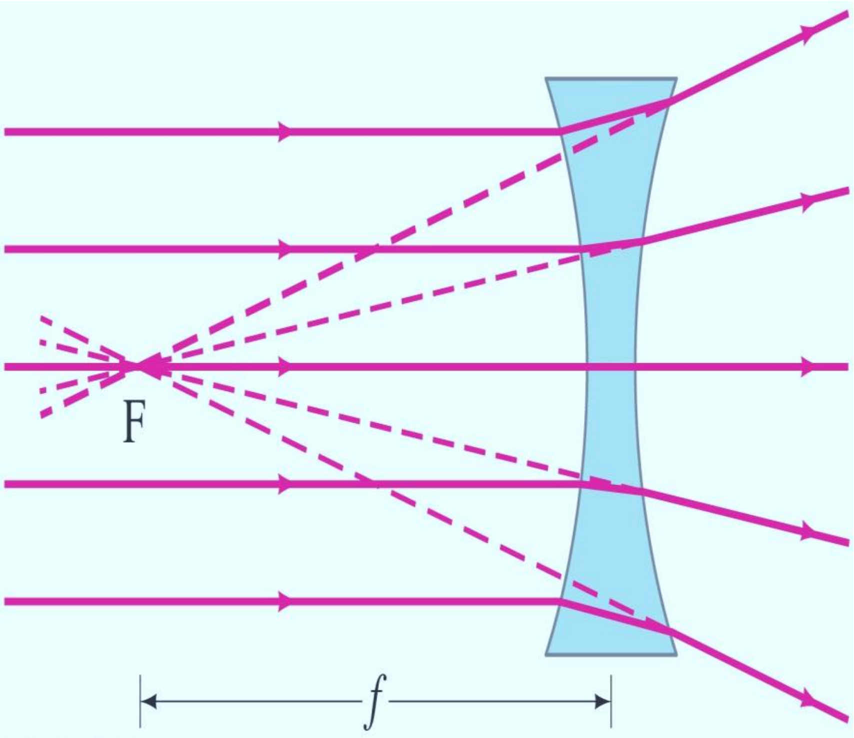
The rays of light are refracted INWARDS and meet at the focus, F.

The image formed is REAL – in other words, it can be seen on a screen.



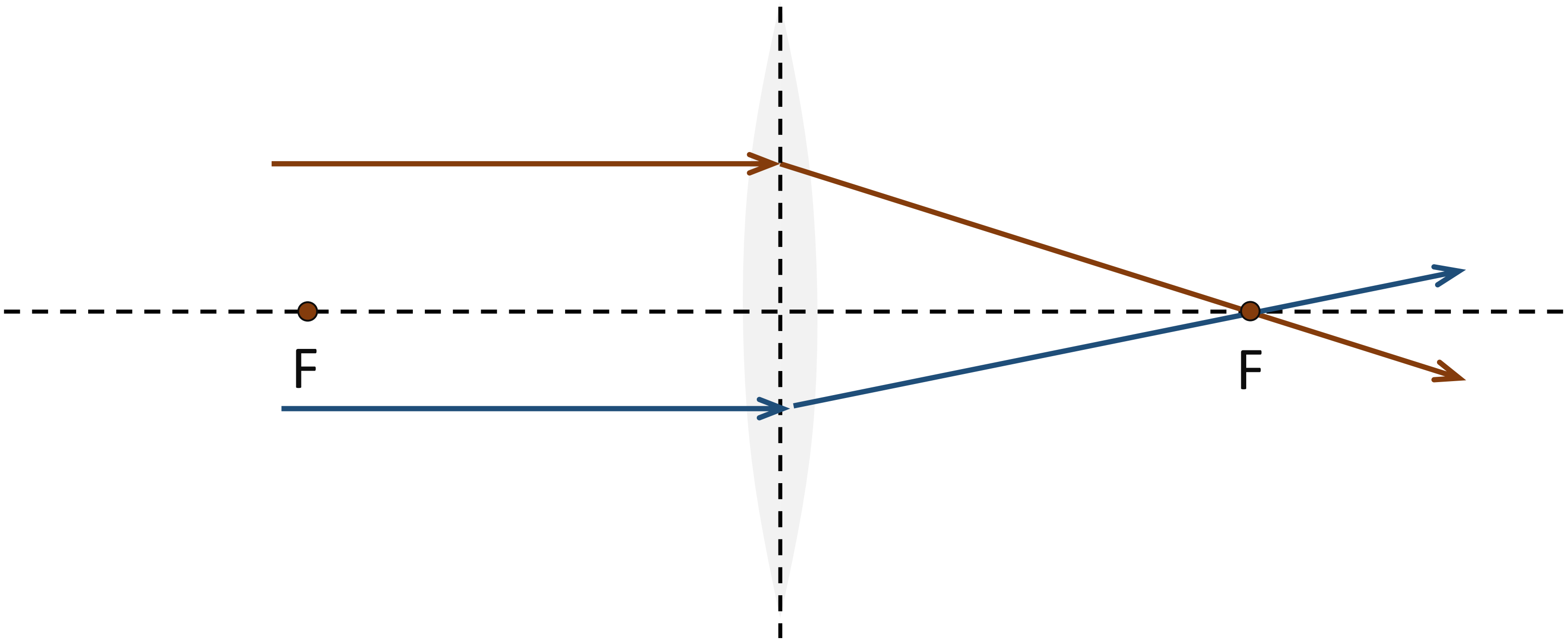
Thin Lenses; Ray Tracing cont.

A diverging lens (thicker at the edge than in the center) makes parallel light diverge; the focal point is that point where the diverging rays *would* converge if projected back. The rays of light are refracted OUTWARDS.



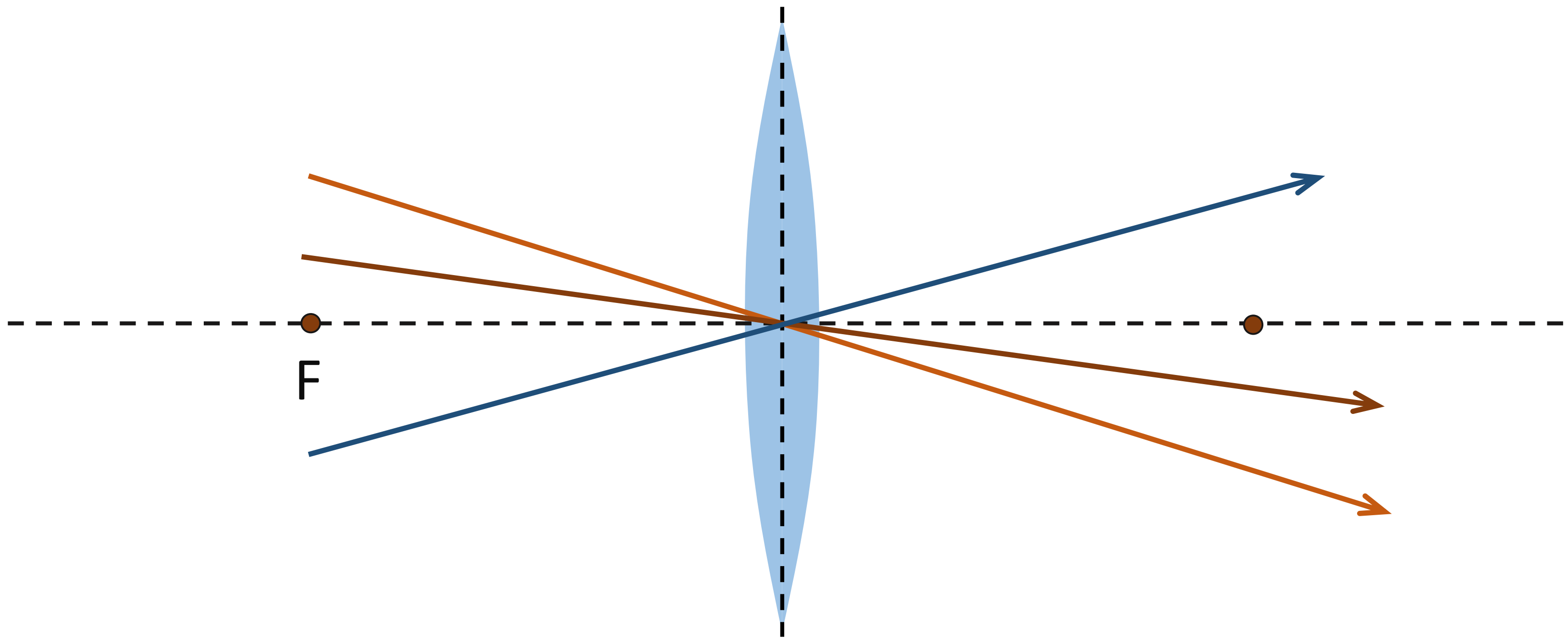
A VIRTUAL image is formed – in other words, the image doesn't actually exist

Converging Lens: Ray Tracing Rules



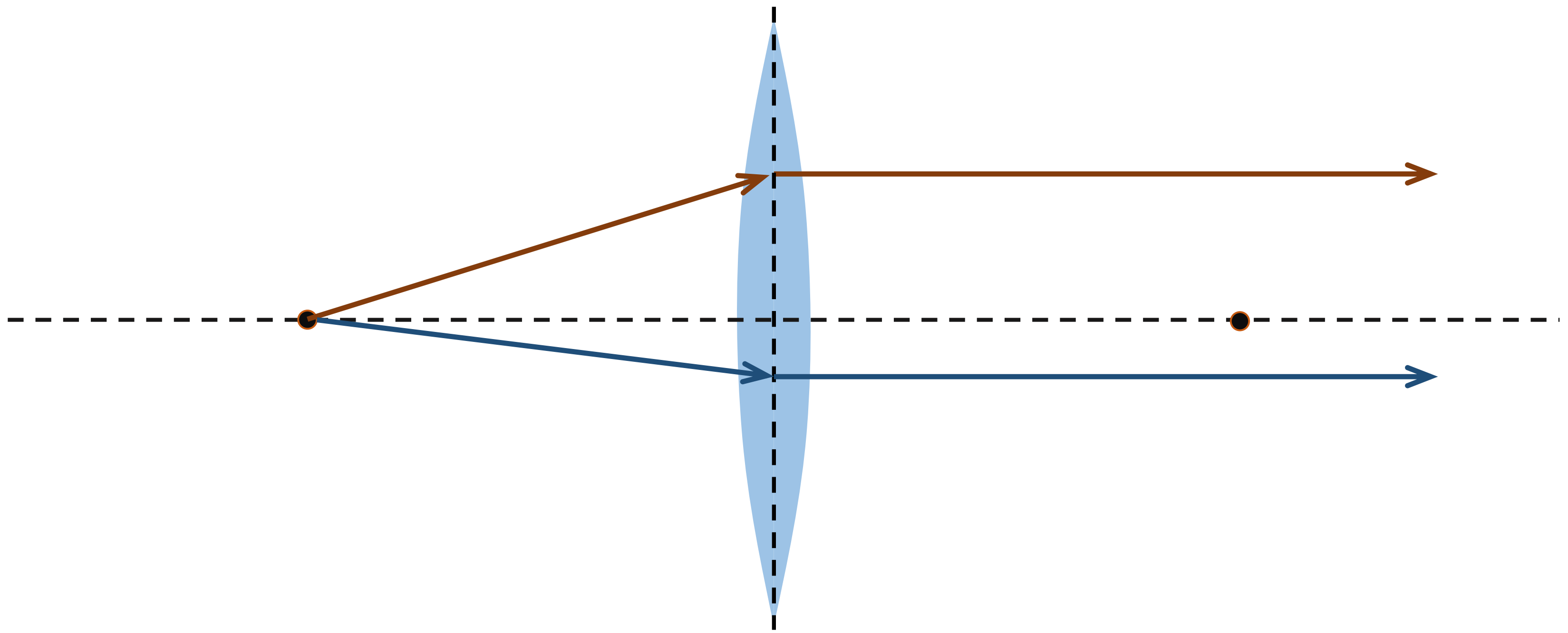
Rule 1: incoming parallel rays are deflected through the focal point.

Converging Lens: Ray Tracing Rules cont.



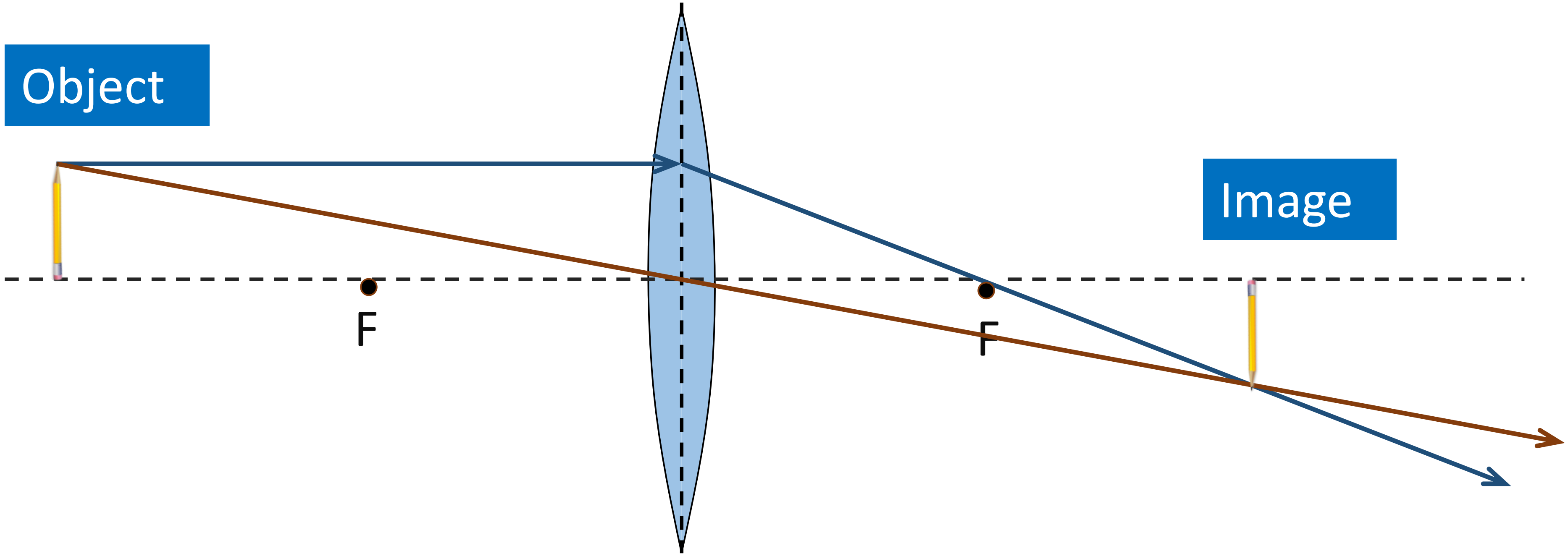
Rule 2: Rays passing through the center of the lens are undeflected, they continue straight through without being bent. Several rays are shown here as examples.

Converging Lens: Ray Tracing Rules cont.



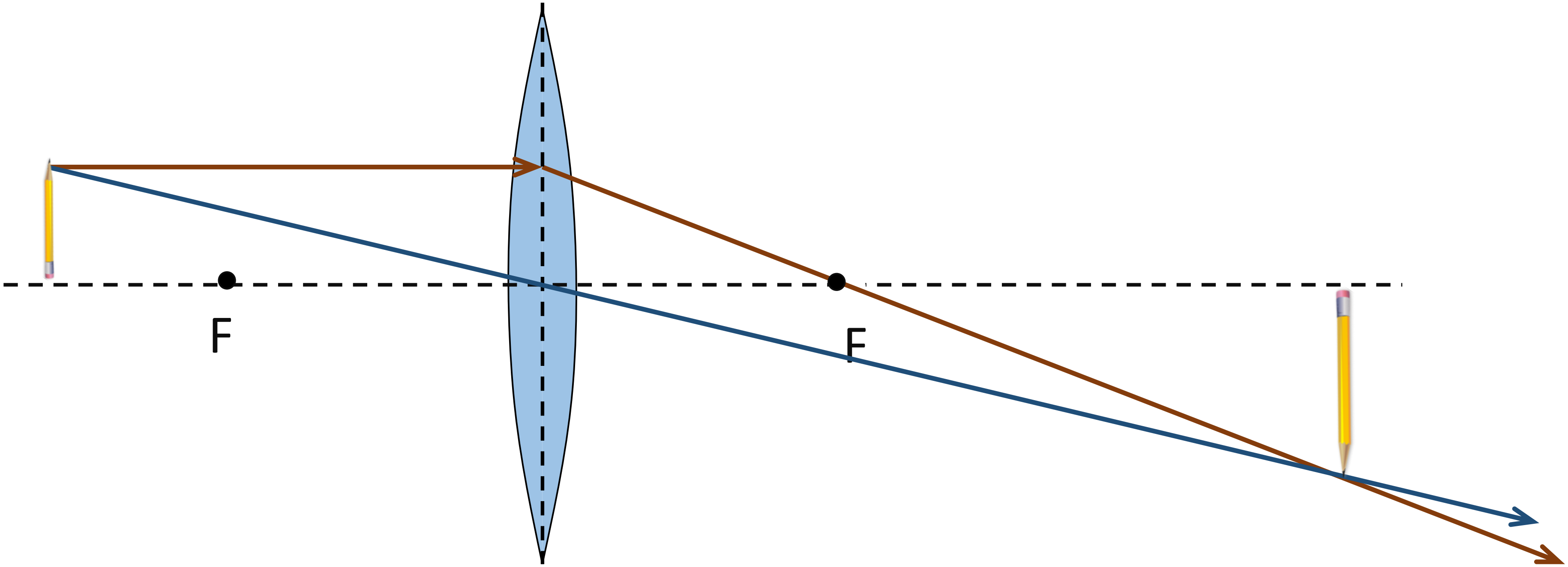
Rule 3: The reverse of Rule 1, rays passing through the focal point are deflected to exit parallel to the axis

Converging Lens: Image Formation



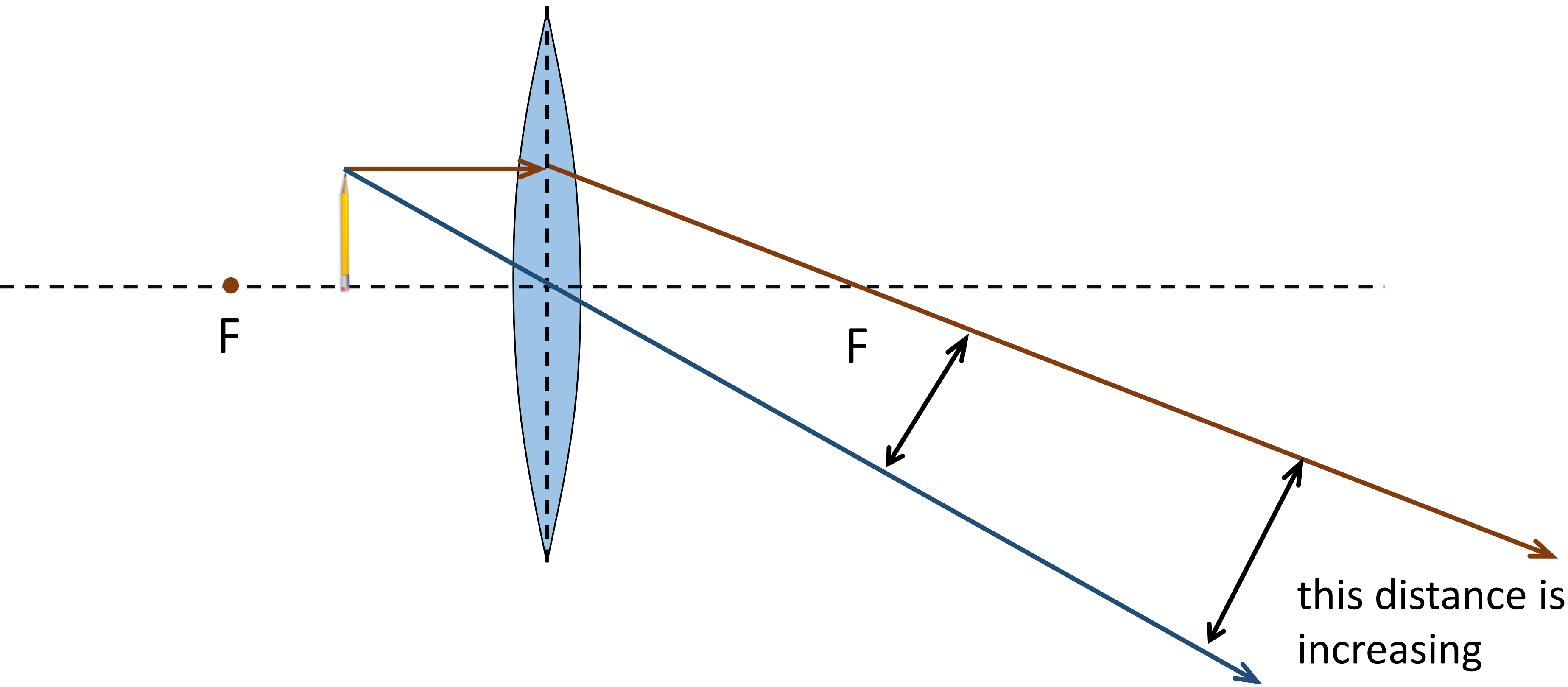
The image is real and inverted. In this case, the image is about the same size as the object, but the size of the image will depend on the position of the object relative to the focal point of the lens. The ray diagram, if traced carefully to scale, can show the size and position of the image.

Converging Lens: Image Formation cont.



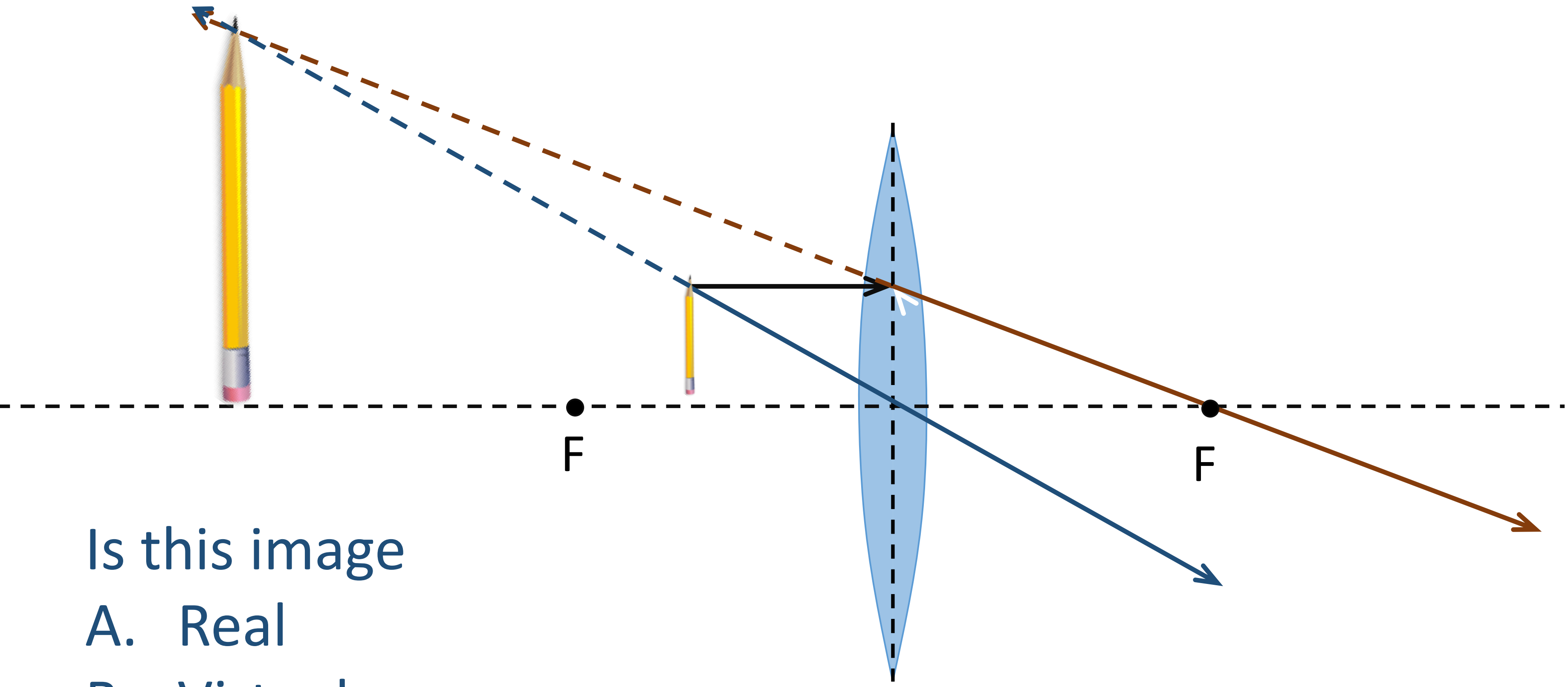
The image is still real and inverted. We've moved the object closer to the lens, and the image is now magnified (larger than the object).

Converging Lens: Image Formation cont.



If we move the object very close to the lens (less than the focal length) the rays passing through the lens are diverging; they will never intersect on the far side of the lens.

Converging Lens: Image Formation cont.

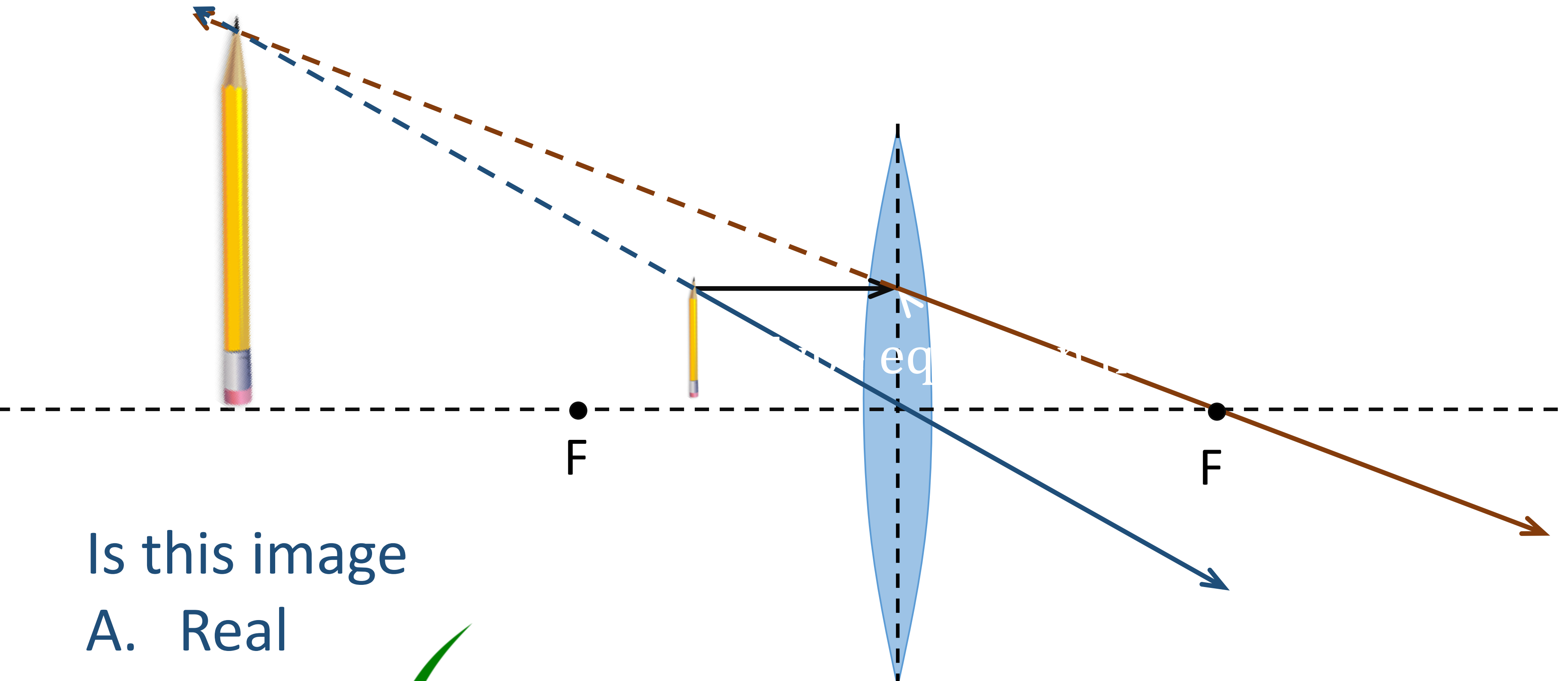


Is this image

A. Real

B. Virtual

Converging Lens: Image Formation cont.



Is this image

A. Real

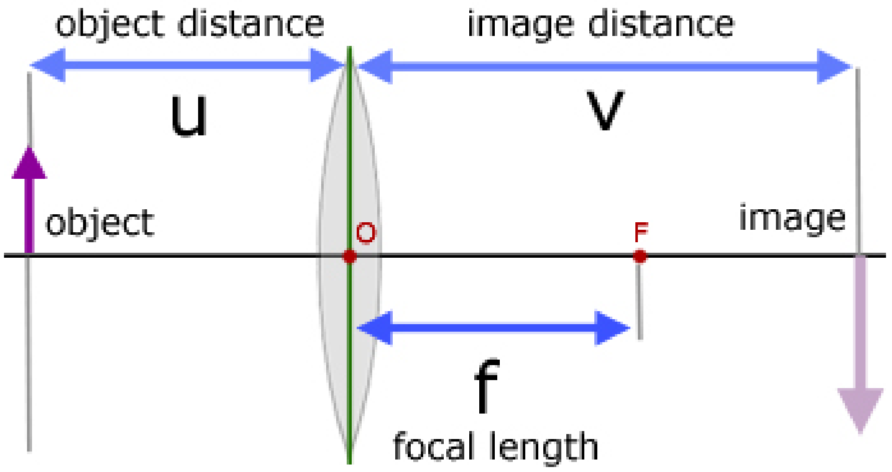
B. Virtual

Recall that a virtual image means no light rays reach the image location. This configuration is what occurs when you use a magnifying glass.

The Lens Equation

The **lens equation** relates the focal length of a spherical thin lens to the object position and the image position.

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



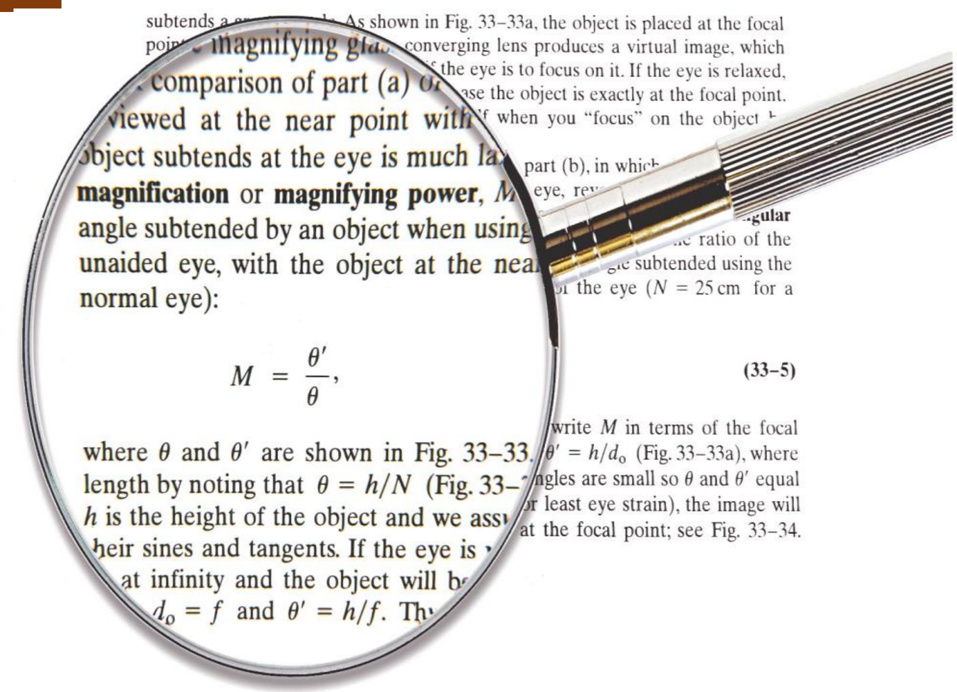
Magnification

Basically, magnification means “how much bigger the object looks”:

$$\text{Magnification} = \frac{\text{Image height}}{\text{Object height}}$$

OR…

$$m = \frac{v}{u}$$



Example

What will be the size of the image, if image distance is 16.67cm and an object size of size 5cm kept at a distance of 25cm from the converging lens?

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Solution:

Image distance $v = 16.67\ cm$

object distance $u = 25\ cm$

object height $h = 5\ cm$

The Linear magnification is given by

$$m = \frac{v}{u} = \frac{image\ height}{object\ height}$$

Image height $h' = \frac{v}{u}\ x\ h$

$$h' = \frac{16.67}{25}\ x\ 5\ = 3.33cm$$

Practice Questions:

1) What is the magnification of a magnifying glass that enlarges a 5mm ant to 25mm?

2) Find the size of the image from relation of the linear magnification of lens, the size of the object is 1 cm is place at a distance of 15cm from a concave mirror and the image is formed at a distance 30cm on the side of the object.

Lens Power & Dioptres

- Power of a lens is inverse of focal length:

$$\text{Power in dioptres} = \frac{1}{\text{focal length in m}}$$

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

- Lens power is measured in dioptres, D (m^{-1})

Converging lenses (for long sighted people) have positive power values and diverging lenses (for short sighted people) have negative power values.

Example

If the focal length of lens is 14 cm what will be the power of that lens?

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If the focal length of lens is 14 cm what will be the power of that lens?

Solution

Power = 1/f

=1/0.14m

=7.14 D

Combining Lenses

In lens combinations, the image formed by the first lens becomes the object for the second lens.

The total magnification is the product of the magnification of each lens.

$$m = m_1 \times m_2 \times m_3 + \ldots$$

The total power of a combination of lenses is equal to the sum of power of each lens.

$$P = P_1 + P_2 + P_3 + \ldots$$