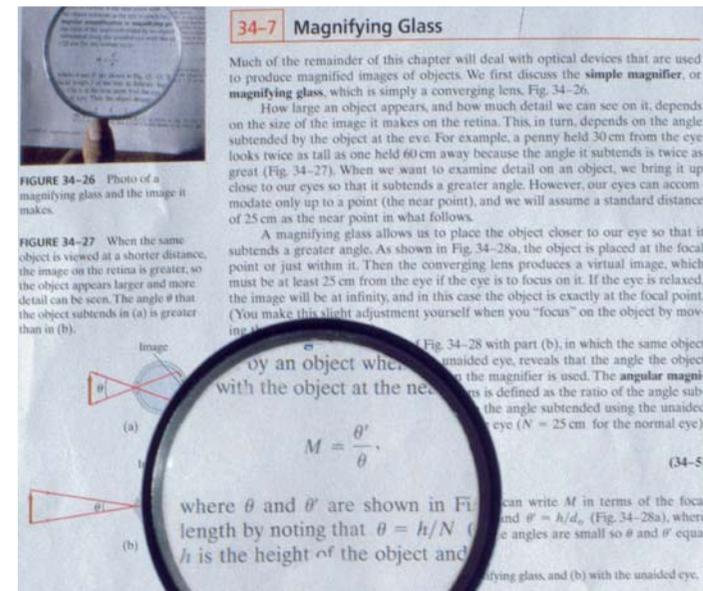


## Kapitel 3.8.

# Optische Abbildung durch Brechung

## Linsen und optische Instrumente



**34-7 Magnifying Glass**

Much of the remainder of this chapter will deal with optical devices that are used to produce magnified images of objects. We first discuss the **simple magnifier**, or **magnifying glass**, which is simply a converging lens. Fig. 34-26.

How large an object appears, and how much detail we can see on it, depends on the size of the image it makes on the retina. This, in turn, depends on the angle subtended by the object at the eye. For example, a penny held 30 cm from the eye looks twice as tall as one held 60 cm away because the angle it subtends is twice as great (Fig. 34-27). When we want to examine detail on an object, we bring it up close to our eyes so that it subtends a greater angle. However, our eyes can accommodate only up to a point (the near point), and we will assume a standard distance of 25 cm as the near point in what follows.

A magnifying glass allows us to place the object closer to our eye so that it subtends a greater angle. As shown in Fig. 34-28a, the object is placed at the focal point or just within it. Then the converging lens produces a virtual image, which must be at least 25 cm from the eye if the eye is to focus on it. If the eye is relaxed, the image will be at infinity, and in this case the object is exactly at the focal point. (You make this slight adjustment yourself when you "focus" on the object by moving the eye.)

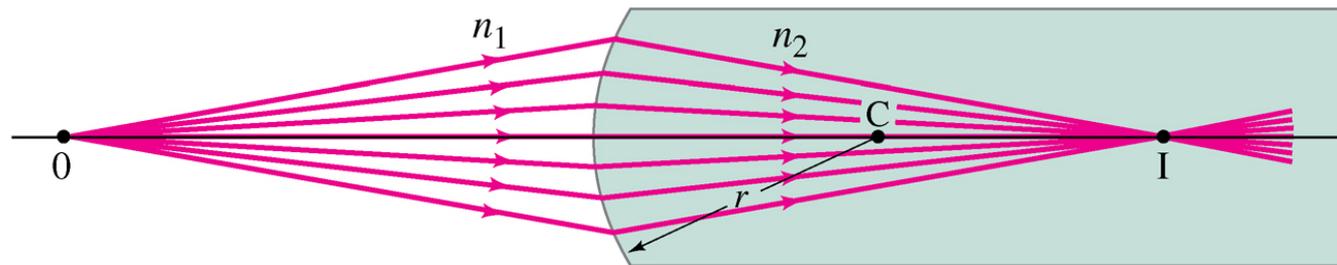
Figure 34-28 with part (b), in which the same object is viewed with the unaided eye, reveals that the angle the object subtends with the magnifier is used. The **angular magnification** is defined as the ratio of the angle subtended using the magnifier to the angle subtended using the unaided eye ( $N = 25$  cm for the normal eye):

$$M = \frac{\theta'}{\theta} \tag{34-5}$$

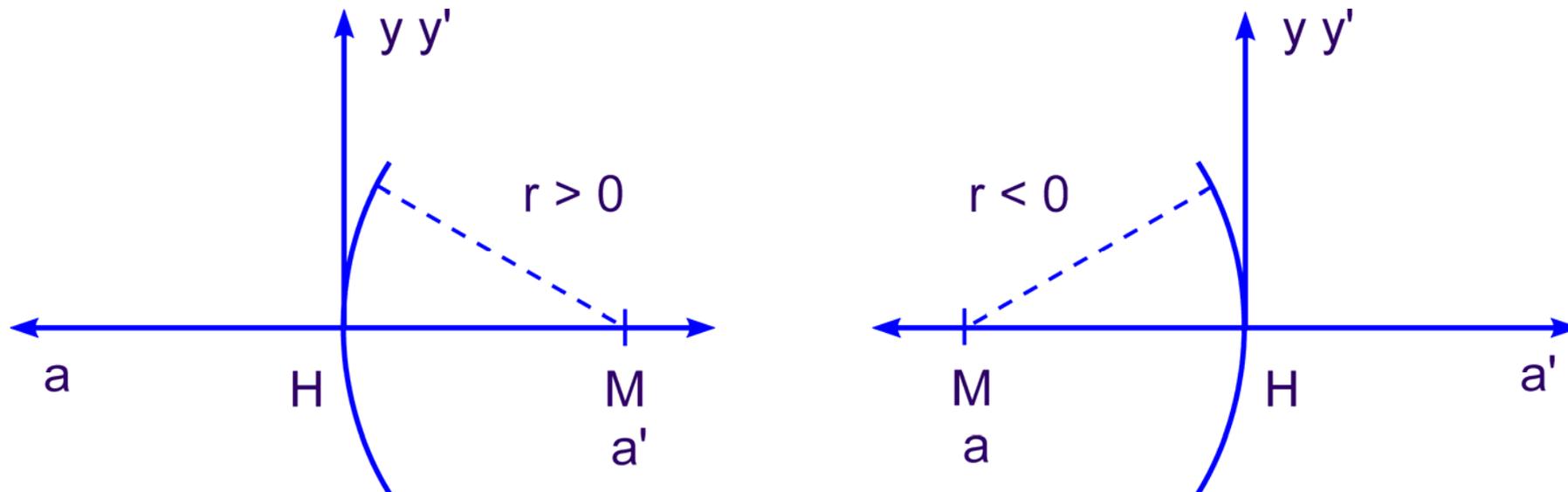
where  $\theta$  and  $\theta'$  are shown in Fig. 34-28. We can write  $M$  in terms of the focal length by noting that  $\theta = h/N$  (where  $h$  is the height of the object and  $N$  is the near point distance) and  $\theta' = h/d_o$  (Fig. 34-28a), where  $d_o$  is the object distance. For small angles,  $\theta$  and  $\theta'$  equal

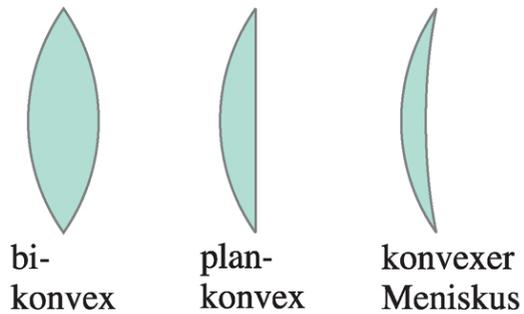
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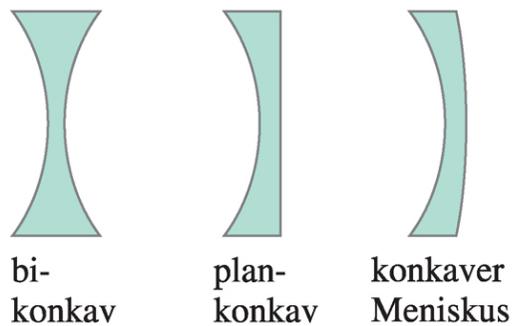


## Linsenkoordinaten





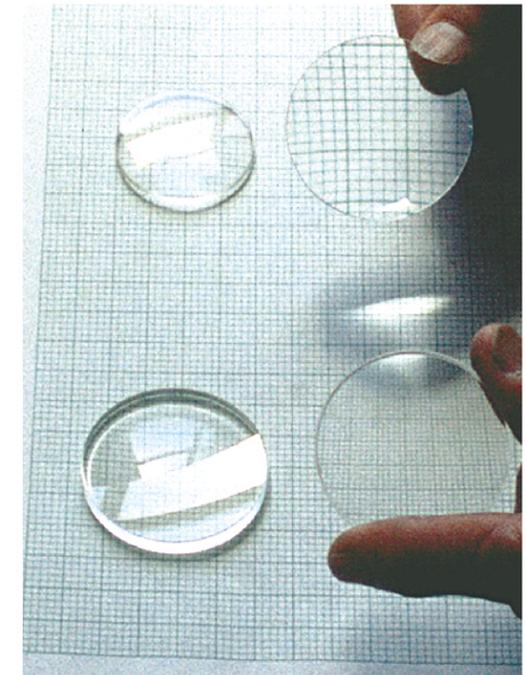
(a) Sammellinsen



(b) Zerstreuungslinsen



(c)

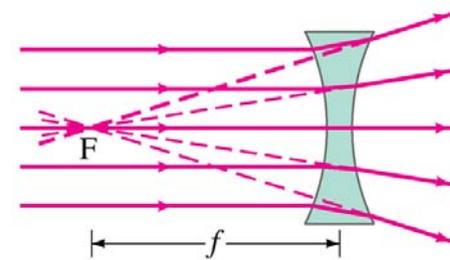
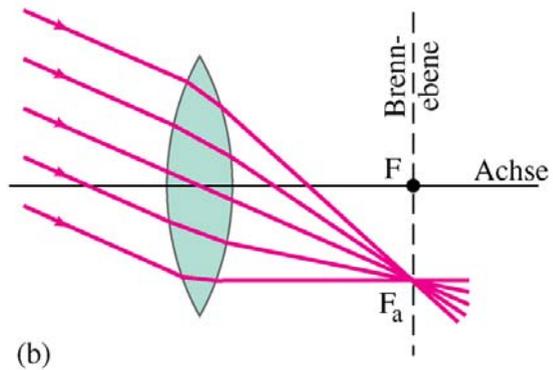
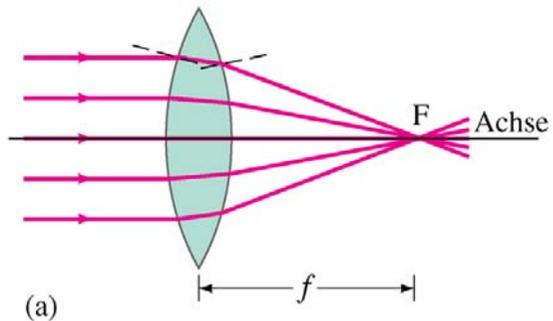


(d)

(a) Sammellinsen und (b) Zerstreuungslinsen. (c) Foto einer Sammellinse (links) und einer Zerstreuungslinse. (d) Sammellinsen (oben) und Zerstreuungslinsen, die jeweils flach auf dem Tisch liegen (links) bzw. angehoben sind, um die Abbildungseigenschaften zu demonstrieren.

# Physik

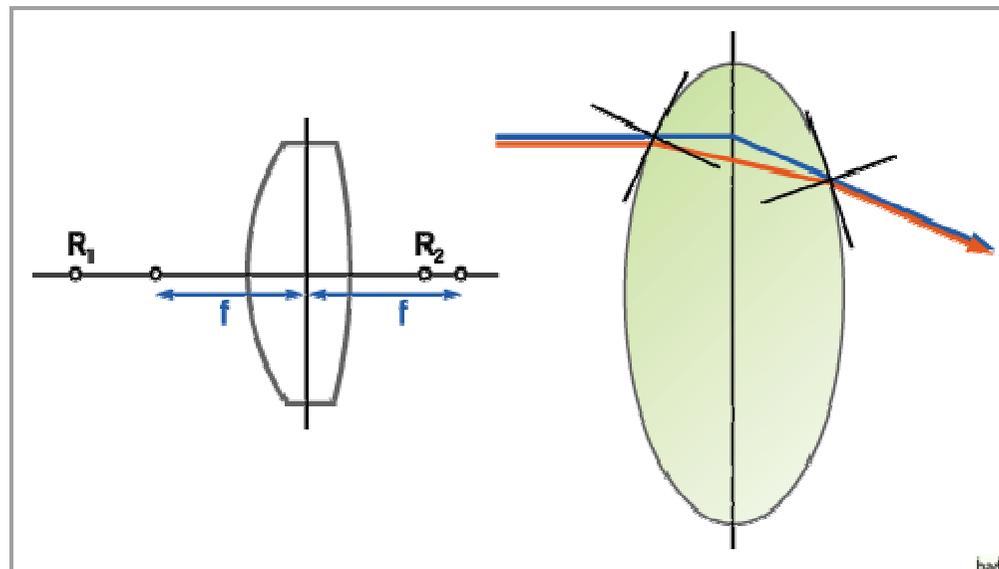
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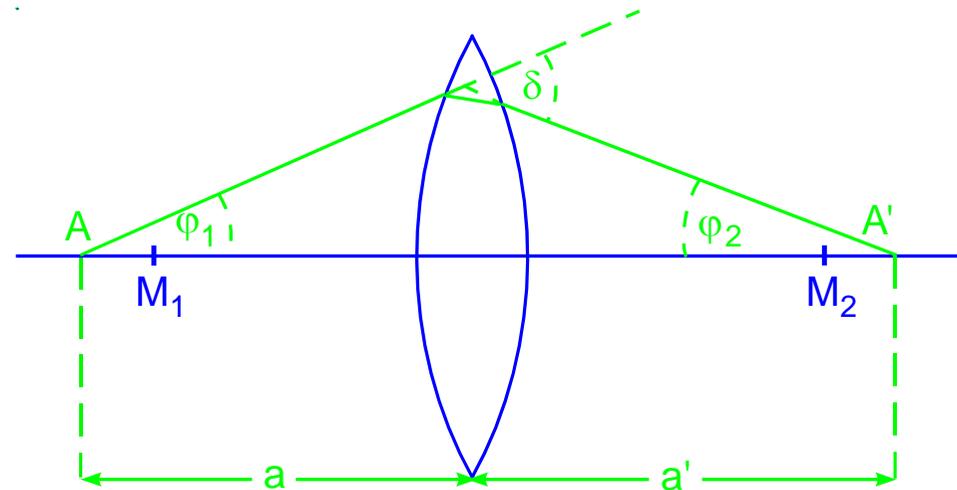
Zerstreuungslinse

Parallele Strahlen werden durch eine dünne Sammellinse fokussiert.

## Dünne Linse

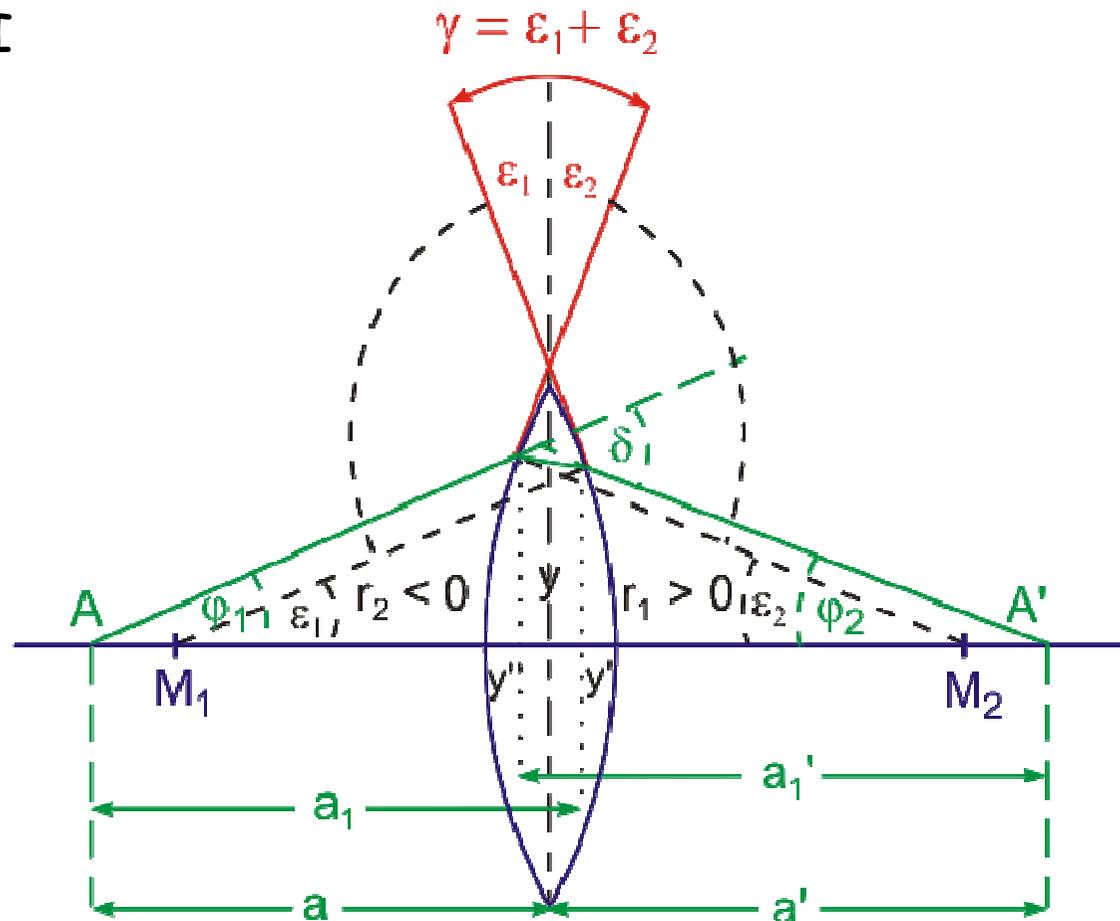


## Winkelbeziehung



## Ableitung der Linsengleichung

### Prisma II



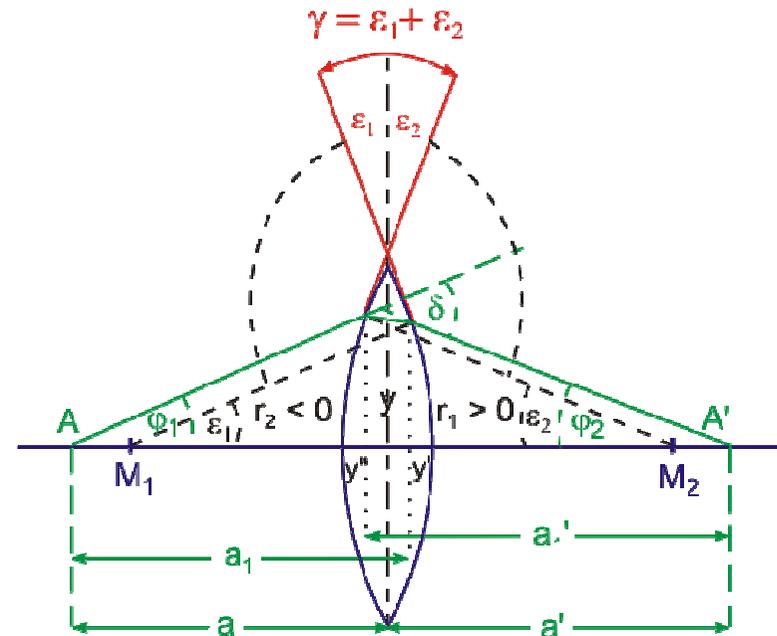
## Ableitung der Linsengleichung

$$\delta = \varphi_1 + \varphi_2 = (n-1) \cdot \gamma = (n-1) \cdot (\varepsilon_1 + \varepsilon_2)$$

$$\frac{y'}{a_1} = \tan \varphi_1 \approx \varphi_1 \approx \frac{y}{a} \quad \frac{y'}{-r_2} = \sin \varepsilon_1 \approx \varepsilon_1 \approx \frac{-y}{r_2}$$

$$\frac{y''}{a_1'} = \tan \varphi_2 \approx \varphi_2 \approx \frac{y}{a'} \quad \frac{y''}{r_1} = \sin \varepsilon_2 \approx \varepsilon_2 \approx \frac{y}{r_1}$$

$$\frac{1}{a} + \frac{1}{a'} = \frac{1}{f} = (n-1) \cdot \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$$



## Abbildungsgleichungen für eine dünne Linse

in Scheitelpunktskoordinaten

$$\frac{1}{a} + \frac{1}{a'} = \frac{1}{f} = (n-1) \cdot \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$$

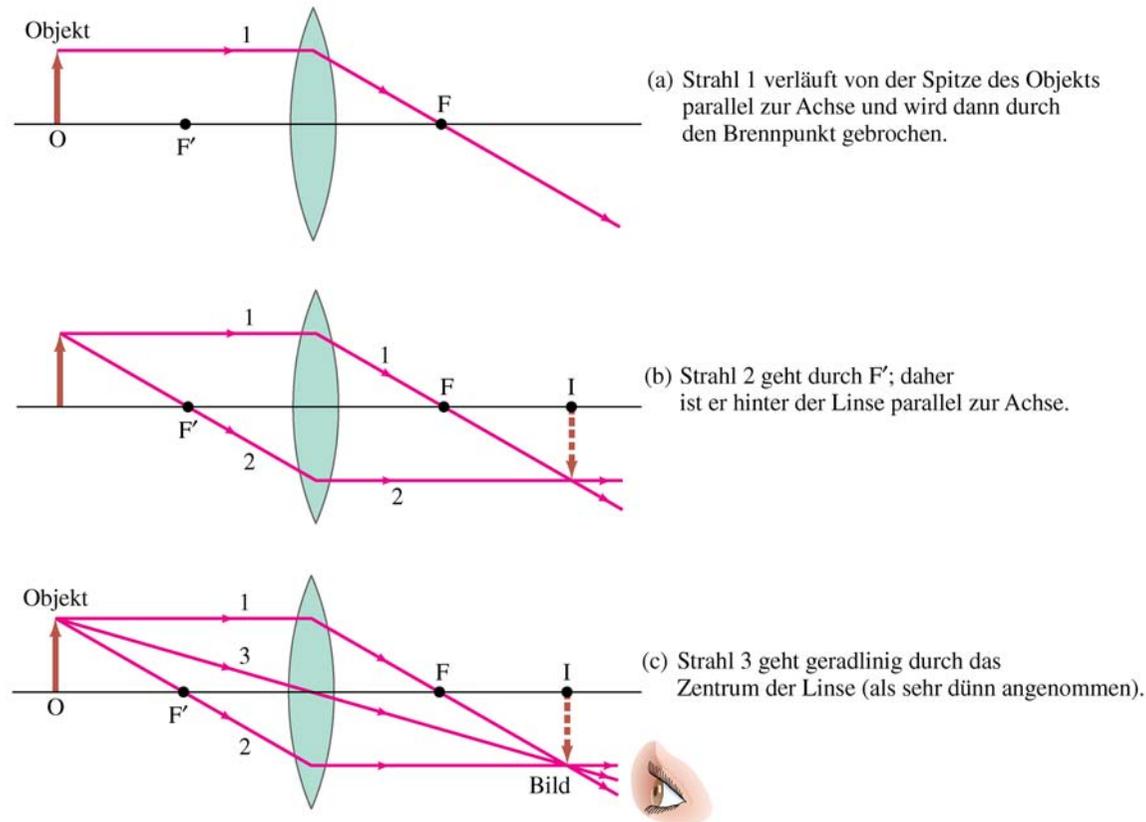
$$\beta = \frac{y'}{y} = -\frac{a'}{a}$$

Umrechnung in Brennpunktskoordinaten  $a - f = x$

$$a' - f = x'$$

$$xx' = f^2$$
$$\beta = \frac{y'}{y} = -\frac{x'}{f} = -\frac{f}{x}$$

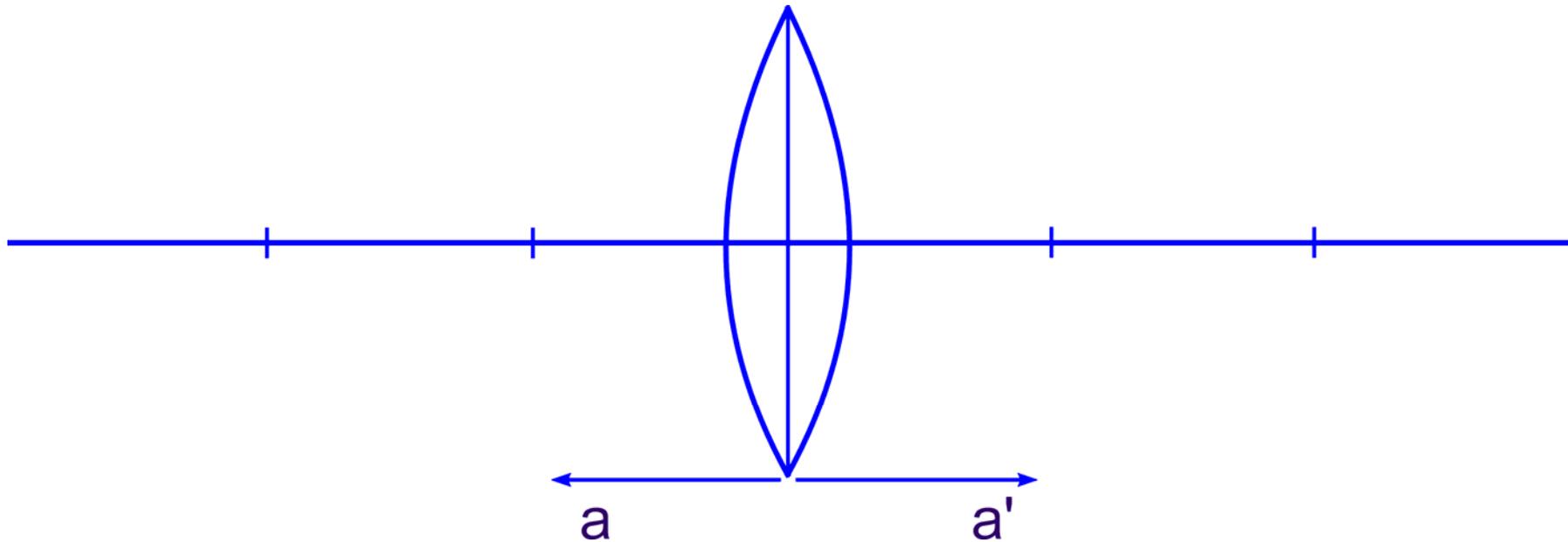
Linsenmachergleichung  $\frac{1}{f} = (n-1) \cdot \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$

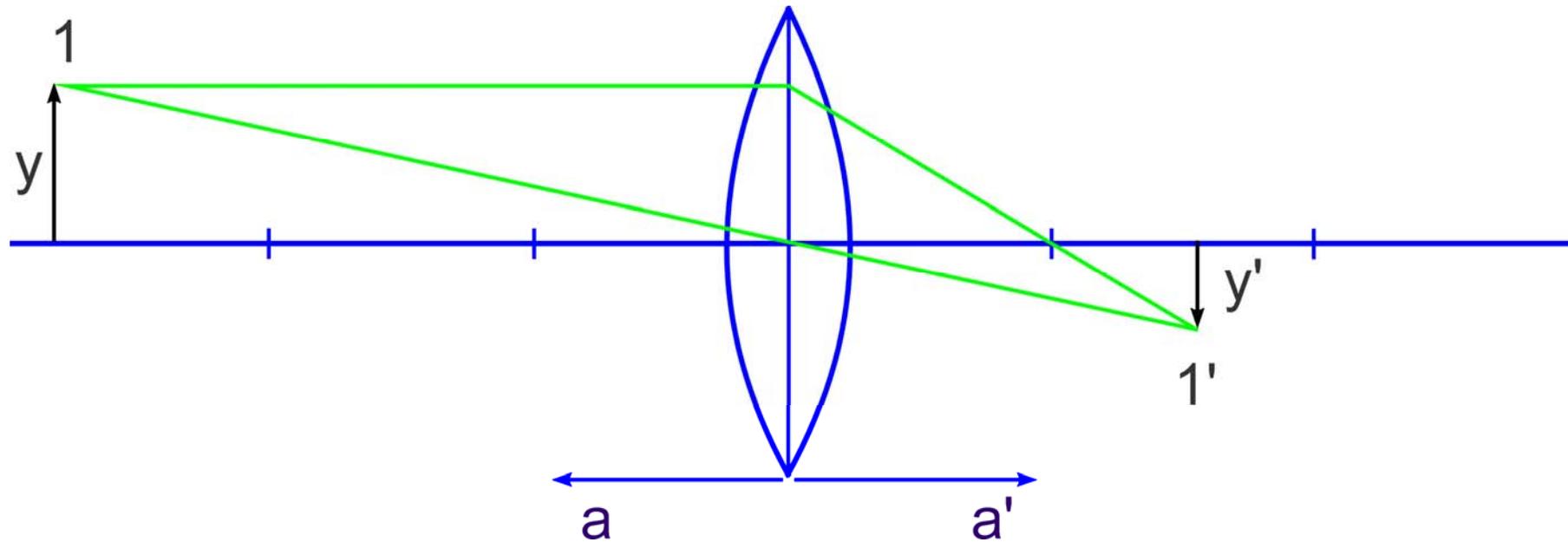


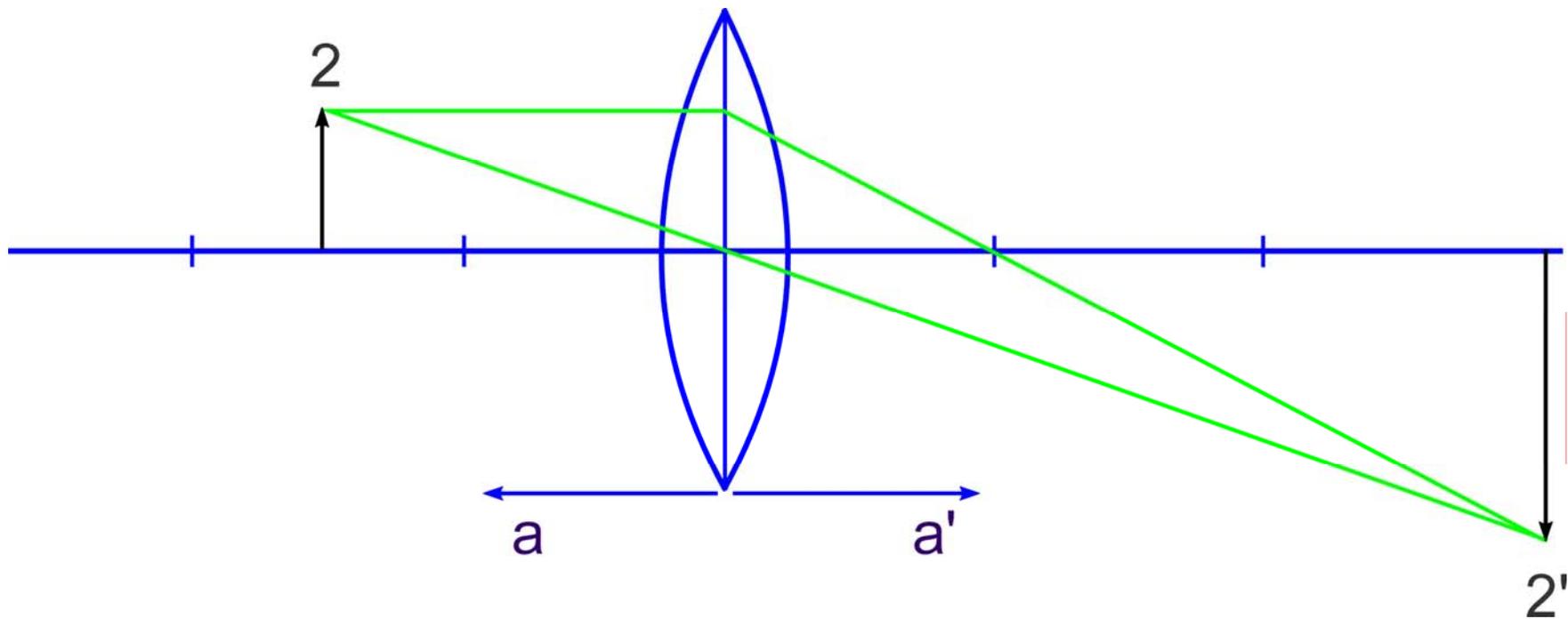
Bestimmung des von einer Sammellinse erzeugten Bildes durch Strahlverfolgung.

# Physik

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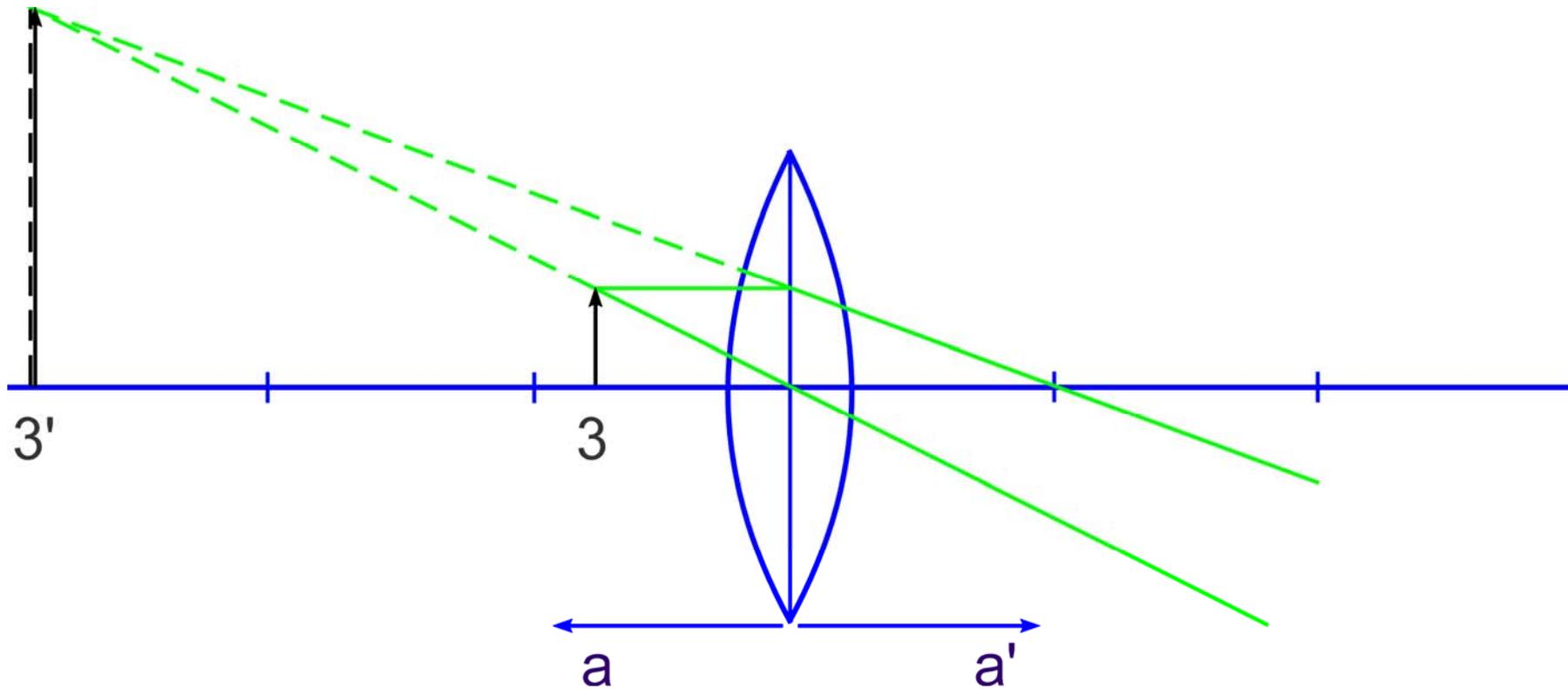






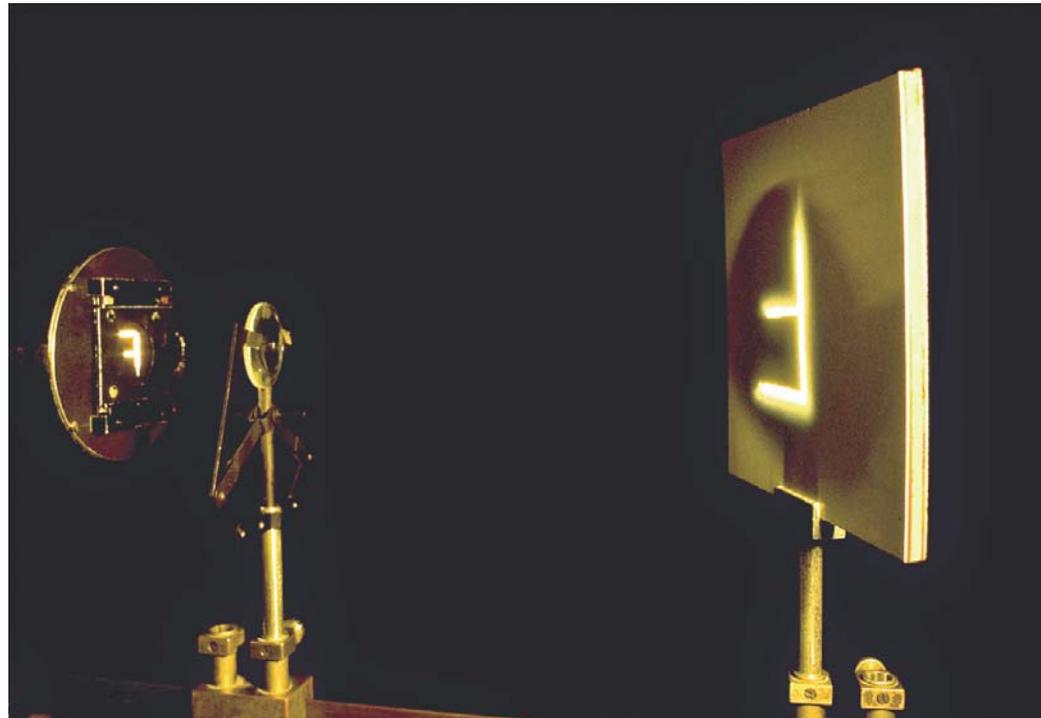
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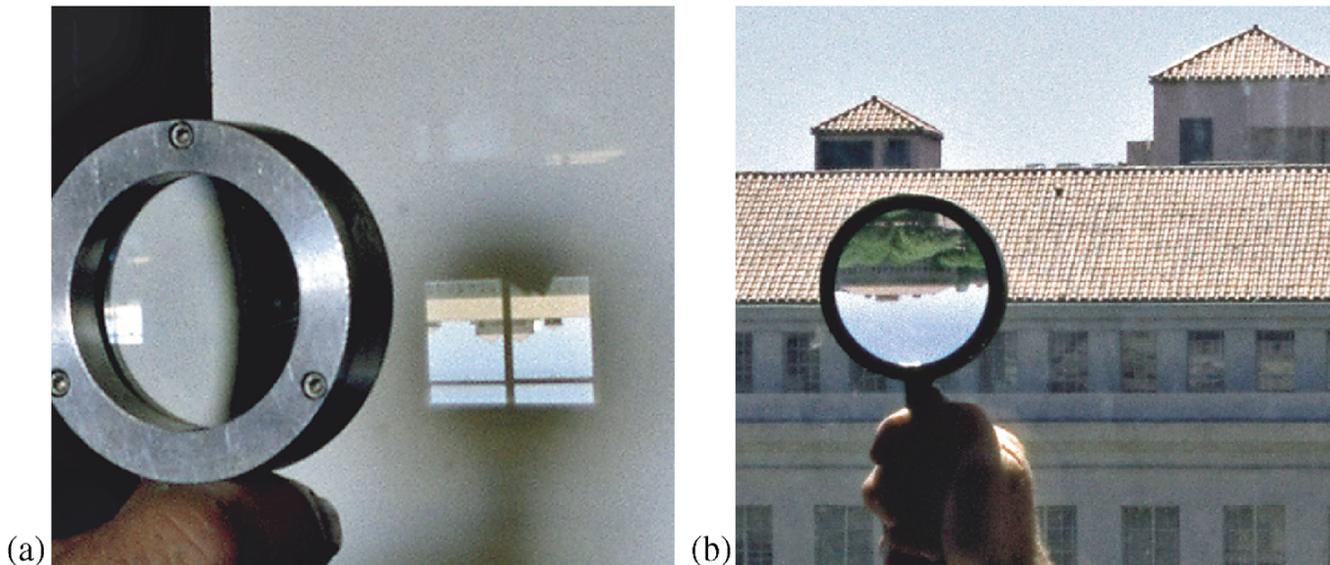


# Physik

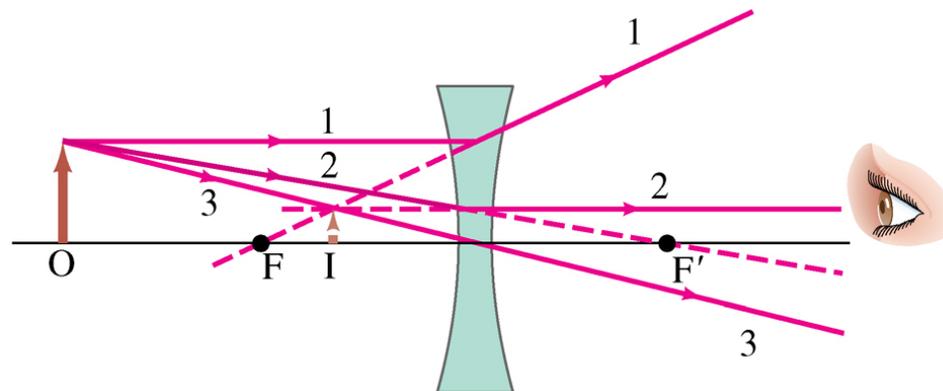
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Eine Sammellinse (in der Halterung, links) erzeugt ein Bild (das große „F“ auf der rechten Seite) eines leuchtenden Objekts (das helle „F“ auf der linken Seite).

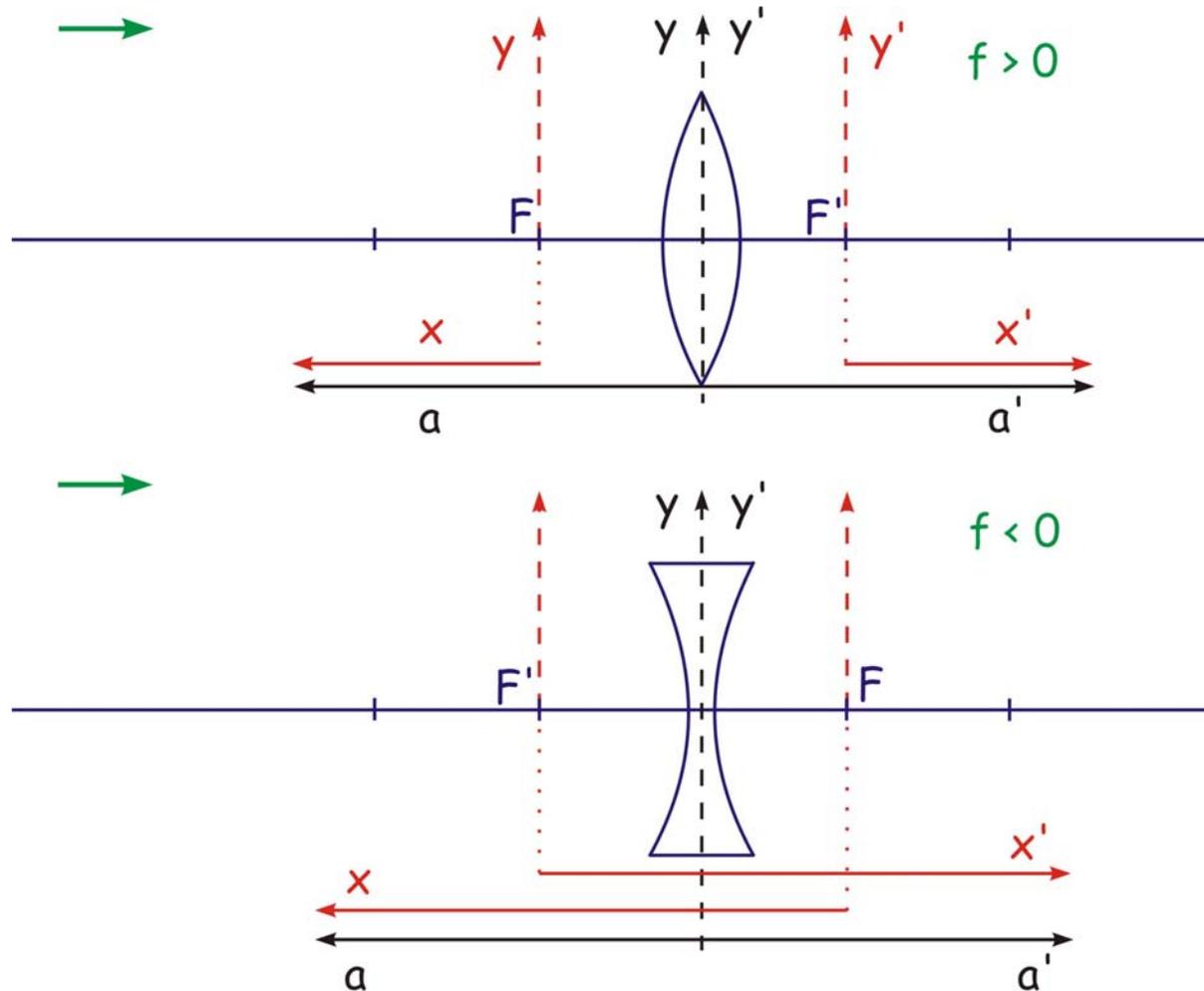


(a) Eine Sammellinse kann auf einer Projektionsfläche ein reales Bild erzeugen (hier von einem entfernten Gebäude). (b) Dieses reale Bild ist ebenfalls für das Auge direkt sichtbar.

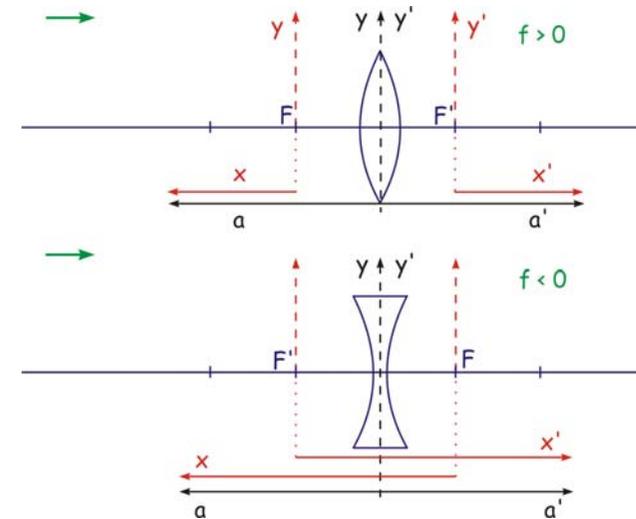


Erzeugung des Bildes einer Zerstreuungslinse durch Verfolgung des Strahlenverlaufs.

## Abbildungsgleichungen für eine dünne Linse



## Abbildungsgleichungen für eine dünne Linse



in Scheitelpunktskoordinaten

$$\frac{1}{a} + \frac{1}{a'} = \frac{1}{f} = (n-1) \cdot \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$$

$$\beta = \frac{y'}{y} = -\frac{a'}{a}$$

Umrechnung in Brennpunktskoordinaten

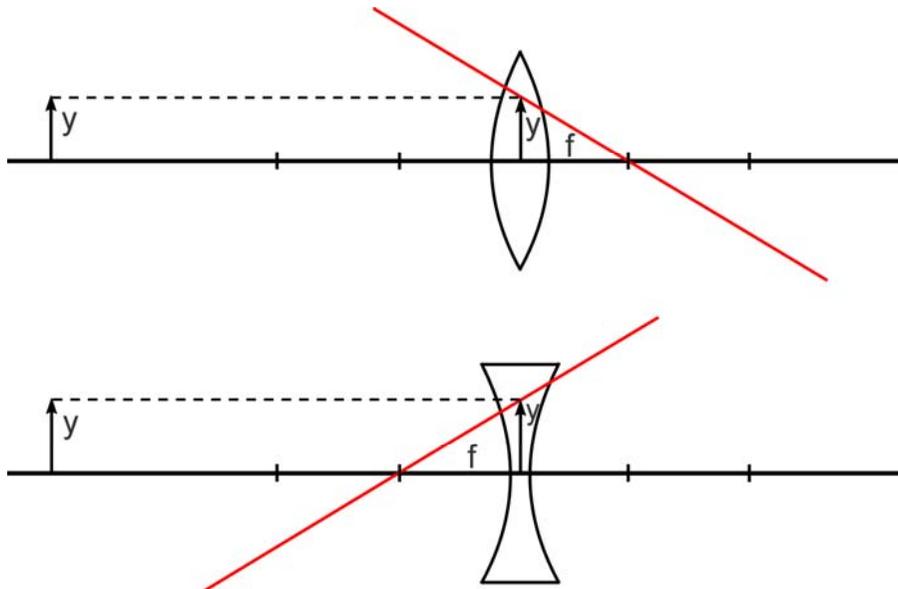
$$a - f = x$$

$$a' - f = x'$$

$$xx' = f^2$$
$$\beta = \frac{y'}{y} = -\frac{x'}{f} = -\frac{f}{x}$$

Linse Gleichung in Brennpunktskoordinaten, Bildgerade

$$x \cdot x' = f^2 \quad ; \quad \beta = \frac{y'}{y} = -\frac{x'}{f}$$



$$x' = \frac{f^2}{x}$$

Bildgerade

$$y' = -\frac{y}{f} x'$$