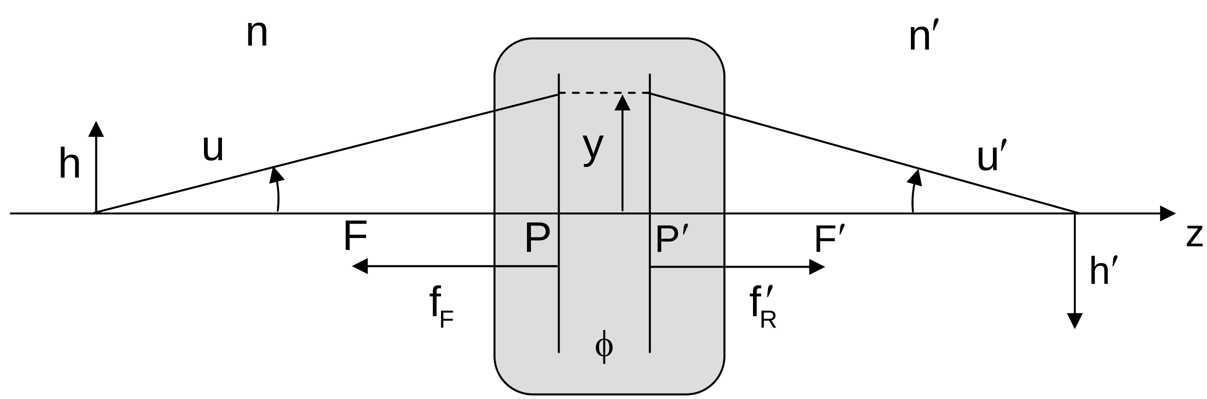
General System

The paraxial refraction equation can be applied to an arbitrary optical system of system power ϕ or focal length f.

The refractive properties of the system serve to define its focal length or power.

The principal planes serve as the planes of effective refraction.

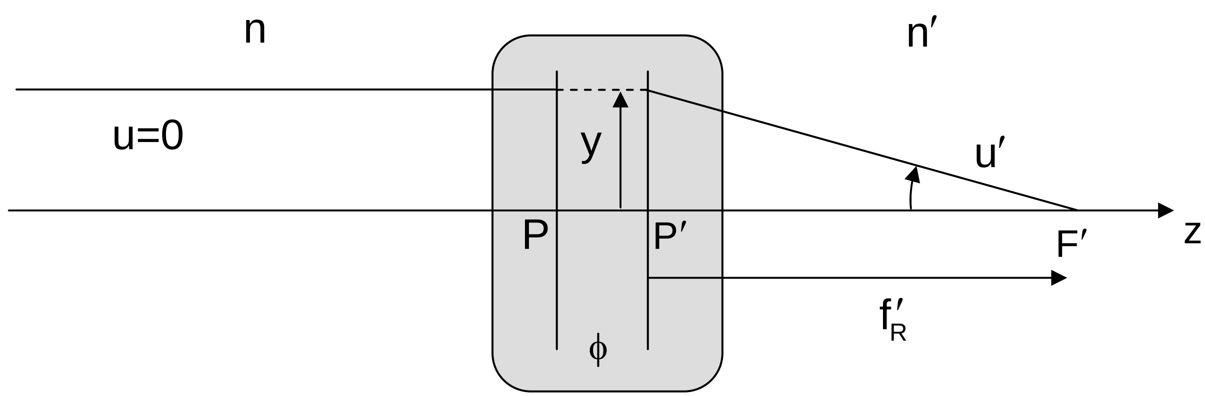


$$n'u' = nu - y\phi$$

$$f = f_E \equiv \frac{1}{\phi}$$

Rear Focal Length of a General System

Trace a ray parallel to the axis. This corresponds to an object at infinity located on the optical axis. The conjugate ray crosses the axis at the rear focal point.



$$n'u' = nu - y\phi$$
$$nu = 0$$
$$n'u' = -y\phi$$
$$-\frac{y}{u'} = \frac{n'}{\phi}$$

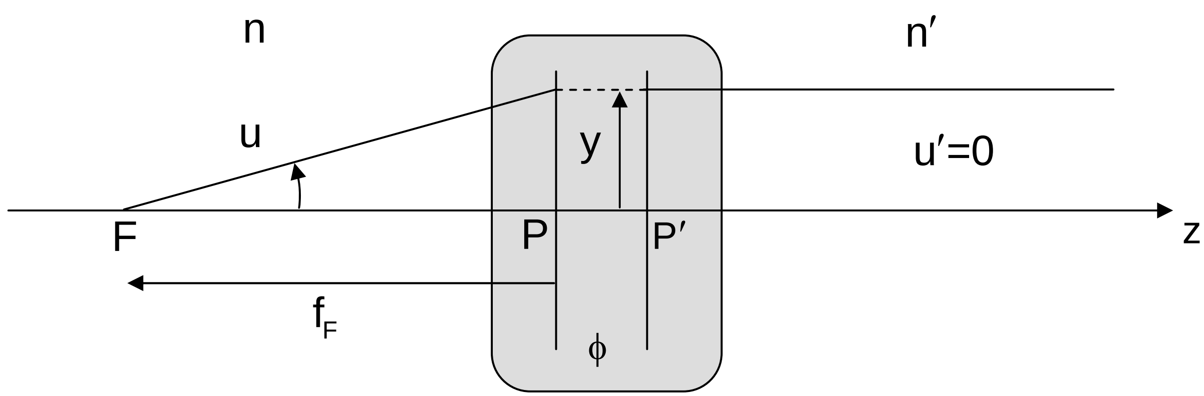
$$u' = -\frac{y}{f'_R}$$
$$f'_R = -\frac{y}{u'}$$
$$f'_R = \frac{n'}{\phi}$$

$$f = f_E \equiv \frac{1}{\phi} = \frac{f'_R}{n'}$$

This is exactly the same relationship as for a single refracting surface.

Front Focal Length of a General System

Trace a ray from an object at the front focal point. The conjugate ray is parallel to the optical axis in image space. This corresponds to an image at infinity located on the optical axis.



$$n'u' = nu - y\phi$$

$$n'u = 0$$

$$nu = y\phi$$

$$\frac{y}{u} = \frac{n}{\phi}$$

$$u = -\frac{y}{f_F}$$

$$f_F = -\frac{y}{u}$$

$$f_F = -\frac{n}{\phi}$$

$$f = f_E \equiv \frac{1}{\phi} = -\frac{f_F}{n'}$$

This is also exactly the same relationship as for a single refracting surface.

$$k = -\frac{f'_R}{f_F} = \frac{n'}{n}$$