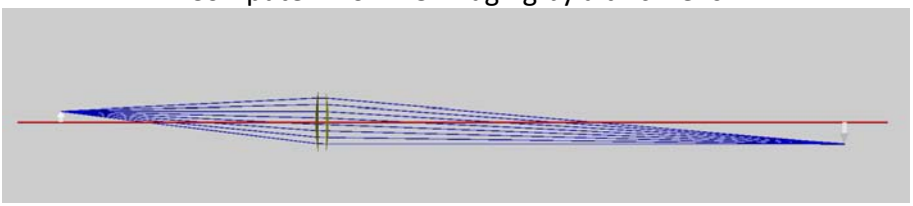
Computer Work 23 Imaging by a thick lens



We all know that when we use the imaging diagram, we only draw three optical rays:
(1) goes first parallel to the optical axis, and after the lens, it goes straight and passes the back focal point;
(2) goes straight to the center of the lens, and after the lens, it keeps its direction;
(3) goes straight and pass the front focal point, and after the lens, it goes parallel to the optical axis;
Then the three rays will meet together at a point and form the image. The question is how we know that all other rays will all go through the same point. We want to simulate this. You will use the following parameters: An arrow object at (-6 cm, 0, 0) with arrow length = 0.25 cm. A glass (n_glass = 1.5) of two spherical surfaces form the lens. The central thickness of the lens is 0.3 cm. The radius of curvature of both surfaces are 4 cm. By hand calculation with the above 3 rays, you will find the position of the image and the magnification.
(1) Find the focal lengths before the lens and after the lens, counted from the central point of the lens.
(2) Now, do the simulation for other rays (with angles from -0.125 to 0.05 radians) to see if they meet at the same point.
(3) Is $\frac{1}{o}+\frac{1}{i}=\frac{1}{f}$ satisfied?

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from visual import *

scene = display(title="Ray",background=(0.8, 0.8, 0.8), width=1200, height=300, center = (3,0,10), fov = 0.004)

R = 4.0
thickness = 0.3
g1center = (-R + thickness/2.0, 0, 0)
g2center = (R - thickness/2.0, 0, 0)
curve_range = [0.005 * t for t in range(259,314)]
lens_surface1 = [(R*cos(theta), R *sin(theta) ) for theta in curve_range]
circle1 = paths.arc(pos=g1center, radius=0.0000001, angle2=2*pi, up = (1,0,0))
lens_surface2 = [(-R*cos(theta), -R *sin(theta) ) for theta in curve_range]
circle2 = paths.arc(pos=g2center, radius=0.0000001, angle2=2*pi, up = (1,0,0))
extrusion(pos=circle1, shape=lens_surface1, color=color.yellow)
extrusion(pos=circle2, shape=lens_surface2, color=color.yellow)
curve(pos=[(-7,0,0),(13,0,0)], color=color.red, radius = 0.02)
arrow(pos=(-6,0,0), axis=(0,0.25,0), shaftwidth=0.1)

(your code here)
```