Physics III Lecture: Thin Lenses

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Spherical Refracting Surfaces

Where your image is going to be located based on Snell's law for a spherically refracting surface

$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$$

$$M = -\frac{n_1 q}{n_2 p}$$

Quantity	Positive When...	Negative When...
Object Location (p)	object is in front of surface (real object)	object is in back of surface (virtual object)
Image Location (q)	image is in the back of surface (real image)	image is in front of surface (virtual object)
Image height h'	image is upright.	image is inverted.
Radius (R)	center of curvature is in the back of surface (convex)	center of curvature is in front of the surface (concave)

Practice Problem 1

Important equations

$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$$

Actually solving it

$$\frac{n_2}{q} = \frac{n_2 - n_1}{R} - \frac{n_1}{p}$$

$$q = \frac{n_2}{\frac{n_2 - n_1}{R} - \frac{n_1}{p}}$$

$$q = -8.35cm$$

Converging Lenses

Fill in images

Diverging Lenses

Fill in images

Thin Lenses

- Thin lens equation
$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$
- Lens-Maker's equation
$$\frac{1}{f}=(n-1)\Big(\frac{1}{R_1}-\frac{1}{R_2}\Big)$$
- Magnification equation:
$$M=\frac{h'}{h}=-\frac{q}{p}$$
- Mathematically, mirrors and lenses are the same thing

Sign Conventions for Thin Lenses

Quantity	Positive When...	Negative When...
Image height (h')	image is upright	center of curvature is in front of lens
R_1 and R_2	center of curvature is in back of lens	

Practice Problem 2

The approach

- R_1 is positive
- R_2 is negative

$$\frac{1}{f}=(n-1)\Big(\frac{1}{R_1}-\frac{1}{R_2}\Big)$$
$$f=\frac{1}{(n-1)\Big(\frac{1}{R_1}-\frac{1}{R_2}\Big)}$$
$$f=\frac{1}{(1.50-1)\Big(\frac{1}{2.00cm}-\frac{1}{2.50cm}\Big)}=20cm$$

Practice Problem 3

The approach

$$
\begin{aligned}
&d = 180cm \\
&M = -5 \\
&\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \\
&M = -\frac{q}{p} \implies q = -Mp = 5p \\
&p + q = 180cm \implies p + 5p = 180cm \\
&p = 30cm
\end{aligned}
$$

We have p, but that hasn't answered the question. However, we do have everything we need to solve for f.

- Given:

$$f = \frac{1}{(n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

- We can find:

$$f = +25cm$$

Practice Problem 4 *WILL BE ON EXAM*