

PhET: Bending Light

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1 Memory Bank

- **Optics:** Snell's Law states that, for an interface between two media with *indices of refraction* n_1 and n_2 , light leaves one medium with an angle θ_1 and enters the second medium with an angle θ_2 as follows:

$$n_1 \sin \theta_1 = n_2 \sin \theta_2 \quad (1)$$

The two angles are defined with respect to vertical.

- **Optics:** Fresnel's equations give the fraction of power (in light) that is reflected (R) or transmitted (T) by an interface between media with indices of refraction n_1 and n_2 :

$$R = \left| \frac{n_1 - n_2}{n_1 + n_2} \right|^2 \quad (2)$$

Note that, to conserve power, $T = 1 - R$.

- **Optics:** When light hits an interface at an angle, Fresnel's equations must be modified:

$$R = \left| \frac{n_1 \cos \theta_1 - n_2 \cos \theta_2}{n_1 \cos \theta_1 + n_2 \cos \theta_2} \right|^2 \quad (3)$$

- PhET simulation: <https://phet.colorado.edu/en/simulations/bending-light>

2 Light Can Refract and Reflect

1. Navigate to the PhET simulation above. (a) Click on the introduction tab, and activate the laser by pressing the red button. Set the upper index of refraction to 1.0 and the lower index of refraction to 1.6 using the controls at the right. (b) Using the protractor, measure the incident angle with respect to vertical, and the transmission angle with respect to vertical. Repeat this measurement for 15 different angles between 0 and 90 degrees (with respect to vertical). (c) Solve Snell's law for the transmission angle (Eq. 1). (d) Create a 2D scatter plot in Excel, and add your prediction from Snell's law to the graph. Do the data match the prediction?

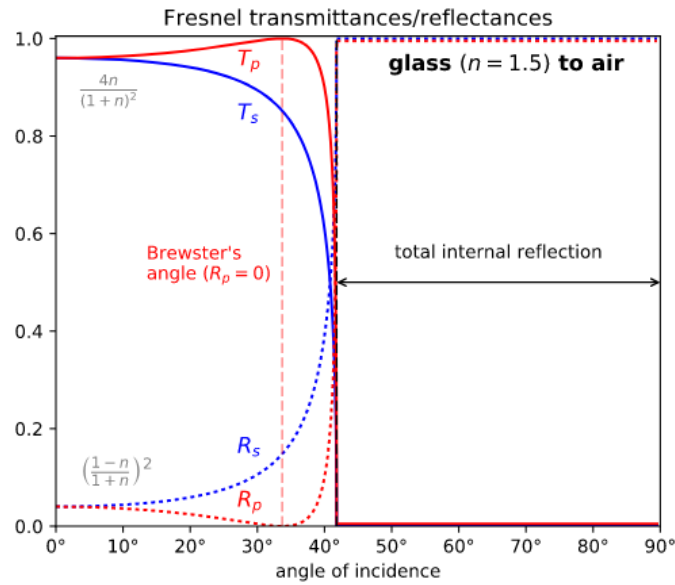


Figure 1: The Fresnel equations plotted for light moving from glass to air.

2. Click on the More Tools tab below, and (a) switch the upper medium to glass and the lower to air. (b) Using the intensity meter, determine the fraction of power reflected and transmitted versus angle. (c) Do the data agree with Fig. 1 below? We are using the R_s (blue) curves. (d) At what angle do you observe total internal reflection (that is, no transmitted power)?