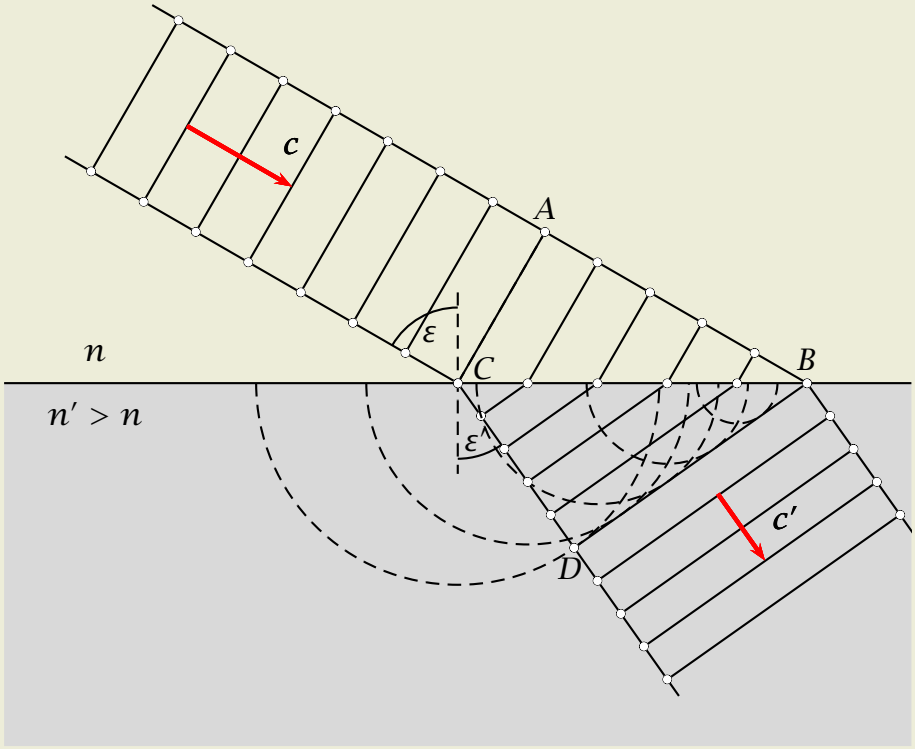
Some PSTricks macros for the study of refraction



Geometrical optics

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September 13, 2011

1 HUYGENS' principle

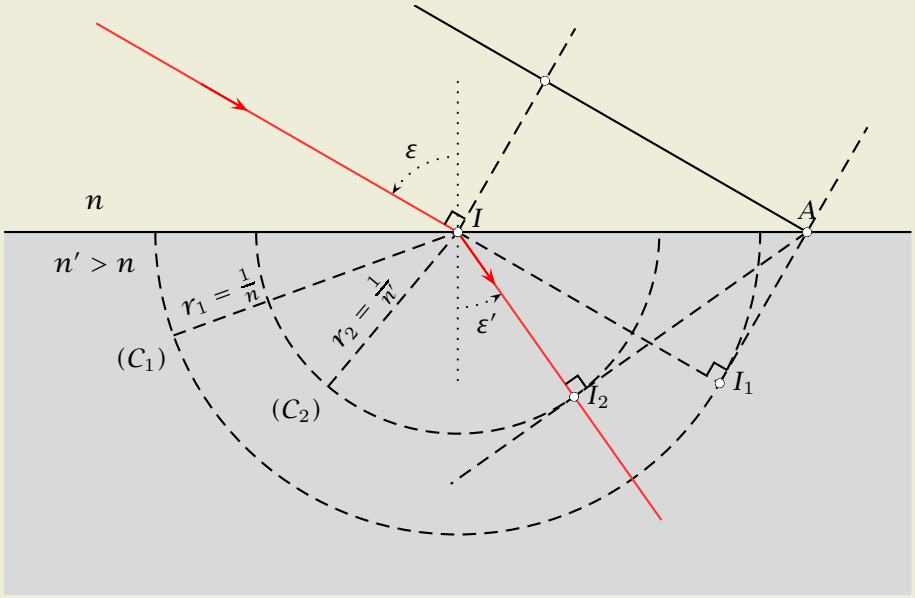

Figure 1: Construction of the refracted ray

1. We draw the semi-circles (C_1) and (C_2) with the center at I with radii $r_1 = \frac{1}{n}$ and $r_2 = \frac{1}{n'}$, respectively.
2. We draw the extension of the incident ray which intersects (C_1) at I_1.
3. We construct the tangent line to circle (C_1) at I_1 which intersects the incident plane at point A.
4. From point A we draw the line, tangent to the circle (C_2). The point of tangency on (C_2) is denoted I_2. This is how the path of the refracted ray is determined.

2 Law of refraction (SNELL'S LAW)

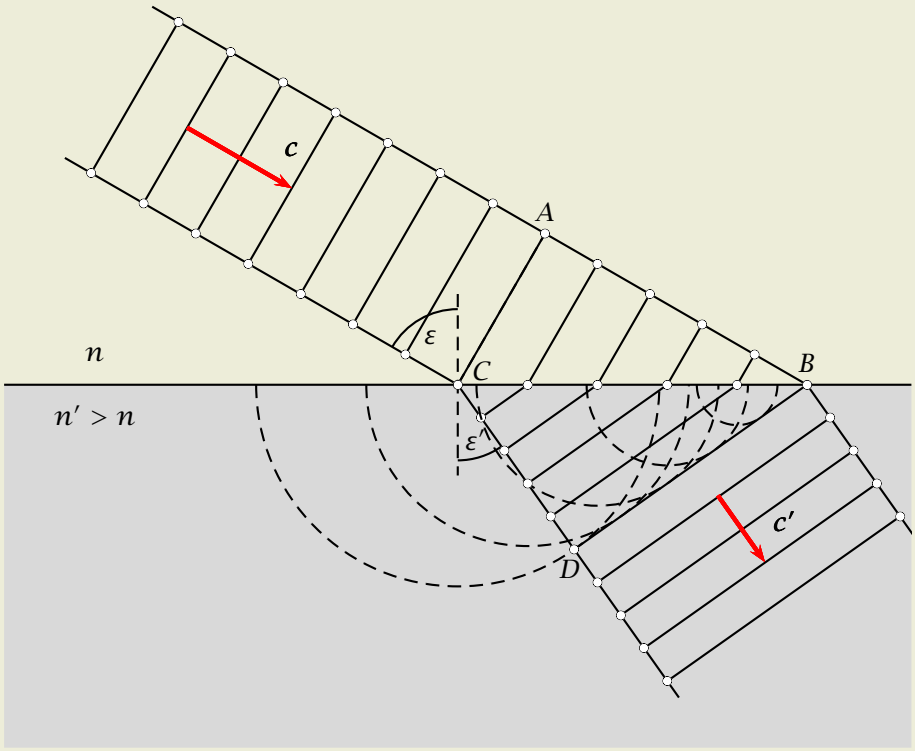

Figure 2: Incident and refracted wave fronts

From the geometry shown in the diagram above, we see, for the angle ε of the incident wave and the angle ε' of the refracting wave, that

$$\sin\varepsilon = \frac{AB}{CB} = \frac{c\Delta t}{CB} \quad \text{respectively} \quad \sin\varepsilon' = \frac{CD}{CB} = \frac{c'\Delta t}{CB}.$$

Division shows that

$$\frac{\sin\varepsilon}{\sin\varepsilon'} = \frac{c}{c'}. \tag{1}$$

For the speeds c and c' of the waves we get

$$c = \frac{c_{\text{vac}}}{n} \quad \text{respectively} \quad c' = \frac{c_{\text{vac}}}{n'}. \tag{2}$$

Inserting (2) into equation (1) above, we see

$$\frac{\sin\varepsilon}{\sin\varepsilon'} = \frac{c}{c'} = \frac{c_{\text{vac}}}{n} \cdot \frac{n'}{c_{\text{vac}}} = \frac{n'}{n}$$

thus,

$$\boxed{n \cdot \sin\varepsilon = n' \cdot \sin\varepsilon'.} \tag{3}$$

Equation (3) is called SNELL'S LAW of refractions.

3 The used PStricks macros

3.1 HUYGENS' principle

The command is:

```
\Huygens{1.5}{60}
```

The first argument is the *relative index of refraction* $\frac{n'}{n}$, and the second argument is the *angle of incidence* ε in degrees as shown in the figure 2 on page 3.

3.2 Law of refraction (SNELL'S LAW)

The command is:

```
\ondelettes{1.5}{60} % {relative index}{angle of incidence}
```

The first argument is the *relative index of refraction* $\frac{n'}{n}$, and the second argument is the *angle of incidence* ε in degrees as shown in the figure 1 on page 2.