16. Light travels from point A to B along the path AO and OB as shown by the heavy solid lines. The parameters are $\phi_a=45^\circ$, $n_1=\sqrt{2}$, the height $AC=18$ cm, and the depth $DB=6\sqrt{3}$ cm. The other distances in the figure can be calculated from these parameters; some of them you will find useful are $OD=6$ cm, $OC=18$ cm, $CE=(36-12\sqrt{3})$ cm, and $DE=(12\sqrt{3}-12)$ cm.

(a) Use Snell’s law to determine the angle of refraction $\phi_b$.

(b) Determine the distances AO and OB, then calculate the time it would take light to travel from A to B along the path AOB.

(c) Suppose you did not know about Snell’s law and thought that light might travel in a straight line from point A to B (path 1). Determine the distances AE and BE, then calculate the time it would take light to travel from A to B along path 1.

(d) Another possibility is path 2. Determine the distances AD, then calculate the time it would take light to travel from A to B along path 2.

(e) Compare your answers to parts (b), (c) and (d); how is the travel time along the correct path (part b) related to the travel time along other paths?
17. A positive lens whose focal length is 4 cm is 8 cm in front of a flat mirror. An object in the form of an arrow is placed 5 cm from the lens as shown in the figure which is drawn on a one-to-one scale.

(a) Light leaving the arrow is incident on the lens and is focused to produce an image; calculate the position of that image. Is it real or virtual?
(b) The image studied in part (a) is an object for the flat mirror. Is this object real or virtual? Where is the image produced by the flat mirror? Is it real or virtual?
(c) Light reflected by the mirror passes back through the lens and the image produced by the flat mirror is thus an object for the lens. Is this object real or virtual? Where is this final image produced by the lens? Is it real or virtual?
(d) In the figure, draw the arrow corresponding to the image produced by the flat mirror as calculated in part (b). Draw to scale and give it the correct orientation. Then, using it, draw two rays to construct the final image produced by the lens.
18. This figure shows an end view of two long, parallel wires perpendicular to the plane of the page. They carry currents $I_1$ and $I_2$ in the directions indicated (perpendicular to the plane of the figure). Where along the y-axis could you place a third, long straight wire, parallel to the other two, so that it would experience no net force. Calculate the position and explicitly show it on the figure. Take $I_1=5.0 \text{ A}$, $I_2=15.0 \text{ A}$, and $a=10 \text{ cm}$. 

\[ y \]

\[ \hat{y} \]

\[ a \]

\[ \bullet \]

\[ \times \]