Experimental Set with Many Questions II

ANDRZEJ TRZEBUNIAK

The idea of "Experimental Sets with Many Questions" that is presented in this report can be very helpful in teaching physics. The use of such sets helps the teacher to prepare interesting recapitulation and also optional exercises. These sets can allow students to check their work and can lead to easier understanding and longer keeping of the acquired information.

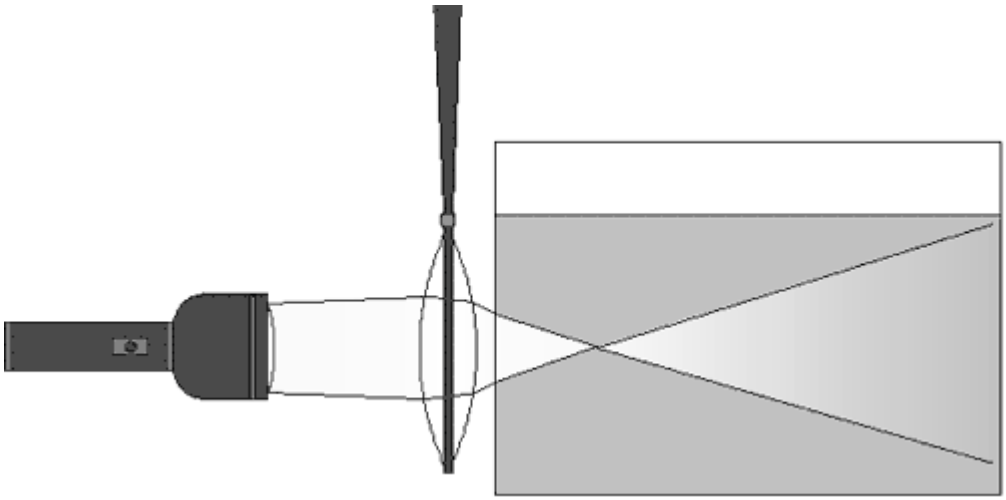
The emphasis in these sets is often put on surprise and seeming discrepancy to students' life experiences. The questions concerning a set are sometimes connected together. The purpose of all these features of the set is to make it easier to remember the presented phenomenon or process and its characteristics for a longer time. This is why the finding of the correct answer must be preceded by a deeper train of thought which is based on the utilization of theoretical facts referring to the issue and their selection for the particular situation that is presented in the experiment.

The sets described in this report were made years ago for the finals of the High School Students' Physical Tournament. It has become a tradition to direct the decisive questions of the final round to experimental sets. This tradition gave these sets the name "Experimental Sets with Many Questions". The principle is to formulate a tight logical series of questions concerning the experiment. Experiments of one set refer either to the same phenomenon and show its various effects or they refer to various physical phenomena that provide similar outcomes. Every question concerns a different modification of the experiment. Students are requested either to predict the result of the experiment or to explain the effect that takes place in the example.

Previously (at the 7thFair of Inventions) I already have introduced two examples illustrating the idea mentioned above; now I want to show another example of such a set. I will present it in the same manner as during the Physical Tournament. The rules of the Tournament limit the number of questions to a maximum of four; the brief characterization of the experiments does not reveal the principle of the phenomenon. As soon as the answer has been given, there follows an experimental verification – a demonstration of the questioned phenomenon.

Aquarium Set

1. A beam of light travels through a converging lens that is placed immediately in front of an aquarium. The beam markedly converges in the aquarium.

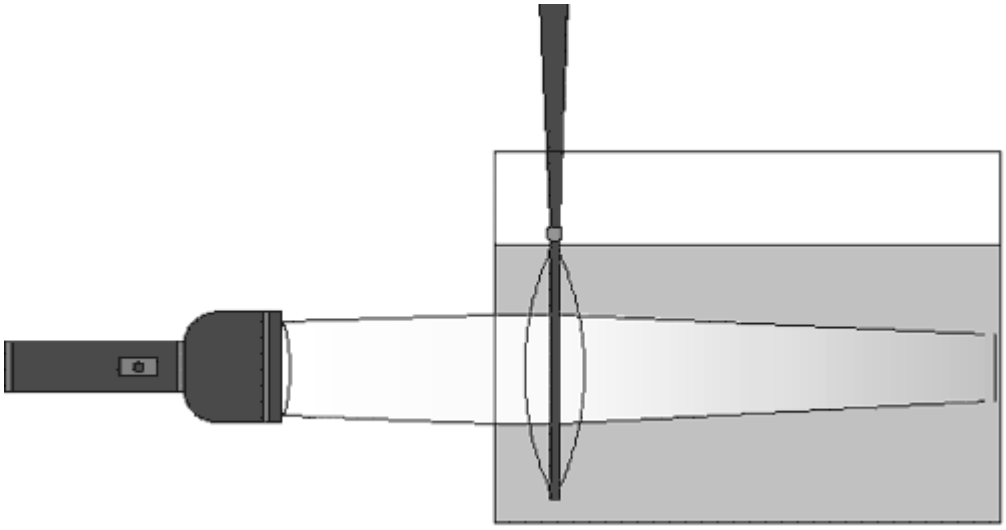


1st Question (prediction):

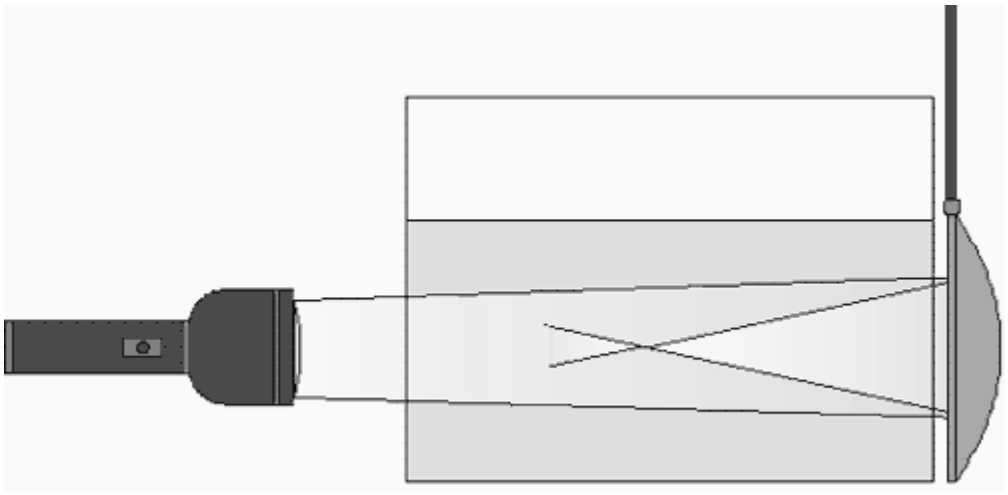
How will the beam change if we put the lens inside the aquarium?

Answer:

Convergence of the beam induced by the lens is smaller when the lens is placed in water, because water has a higher refractive index than air.



2. A concave mirror is placed immediately next to the aquarium through which the beam of light travels.

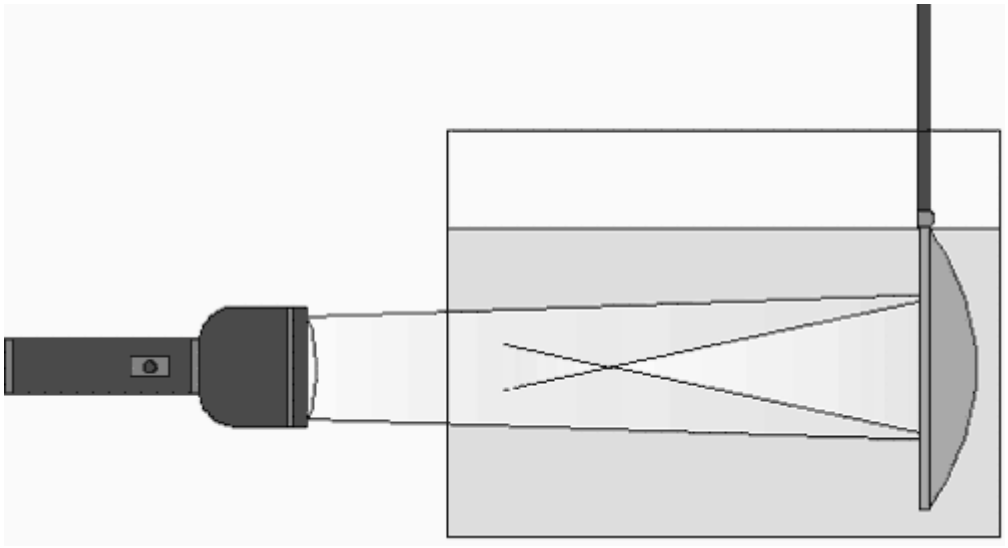


2nd Question (prediction):

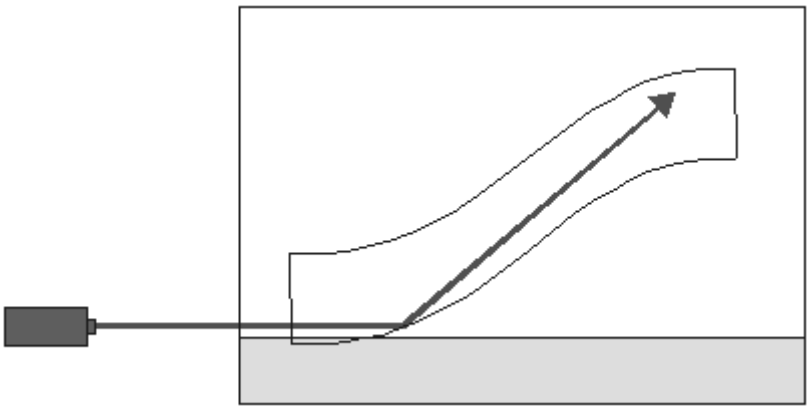
How will the beam change if we put the mirror inside the aquarium?

Answer:

The reflection of the light does not depend on the medium:



3. A horizontal laser beam travels through a bent piece of Perspex that is in an aquarium (see the figure below). Total internal reflection takes place (no part of the beam leaves the Perspex at the point of incidence).

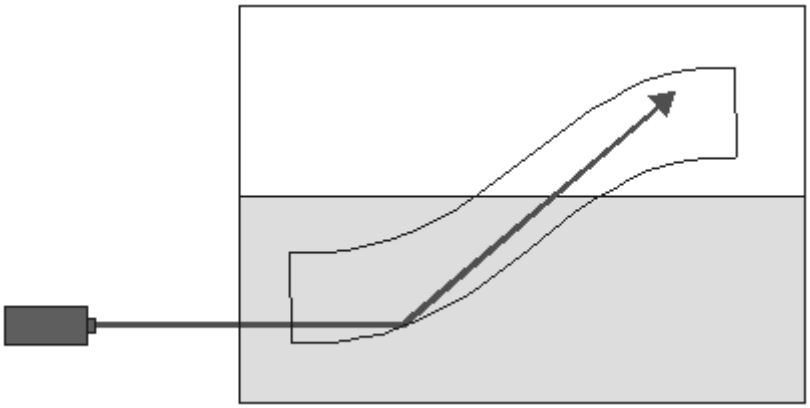


3rd Question (prediction):

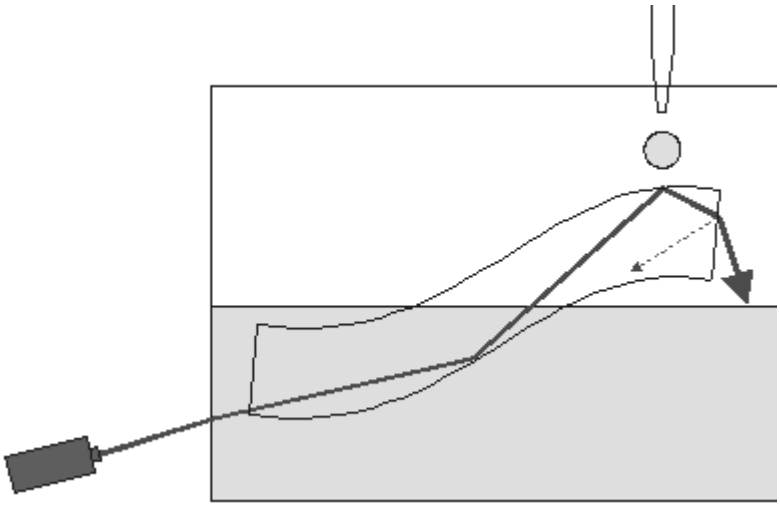
What happens to the beam if we add water to the aquarium so that the point of incidence is submerged?

Answer:

The observer expects that the beam will (partially) refract into water. It is a surprise that the angle of incidence can be so large that even the larger refractive index of water does not change the reflection from total to non-total.



4. The beam hits the top surface of the Perspex with much smaller angle of incidence than in case 3.

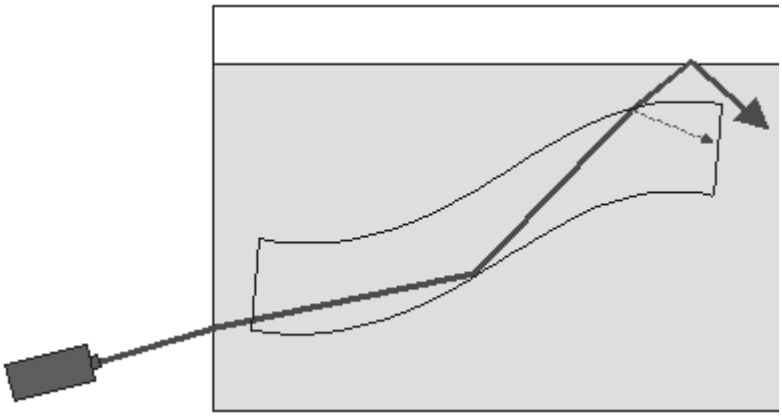


4th Question (explanation):

Explain why the light does not come out in the air when we put a drop of water on the surface of the Perspex at the upper point of incidence.

Answer:

The thin layer of water surely will induce refraction of the beam through the interface between Perspex and water but there occurs total internal reflection on the interface between water and air. It can be shown when we completely submerge the piece of Perspex in water:



While using similar "Experimental Sets with Many Question", it is possible to formulate questions in other ways, change their number or to modify the experimental set. Yet it must be kept in mind that too many questions or too detailed questions can worsen the didactical effect. The number of questions that has been suggested above seems to be optimal.

The surprising nature of the effects that take place in the "Experimental Sets with Many Questions" increases their attractiveness, awakens the interest of the students in the phenomenon and provokes questions. The stimulating of such an attitude in the students is an extremely effective promoter of success in physics education.