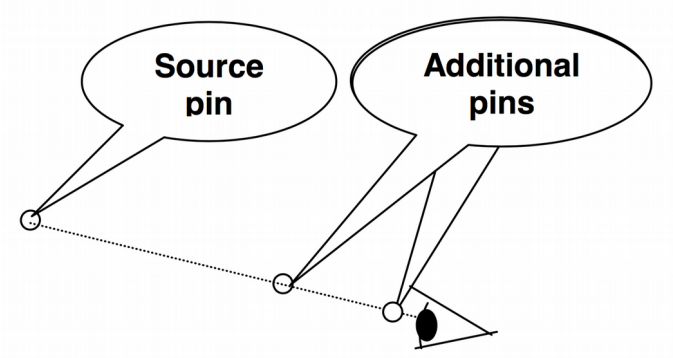
[1]LOCATING IMAGES

I. THE METHOD OF TRIANGULATION

You can find an image by looking at it from two or more points of view and from each one drawing a line in the direction of the image. Where those lines cross (if they do) is the image location. This is called *triangulation*.

Place a piece of paper on the wooden drawing board and pin it down. Then insert a pin (the **source pin**) into the board through the paper. How many lines on the drawing board are needed to locate the pin's position on the board? Explain you reasoning.

Take two additional pins and by eye line up the pins with your **source pin**. This should define a single line that will pass through the **source pin**.



What property of light allows you to line up pins in this manner?

Using the same sighting method as above, define more lines passing through the **source pin** (each new line defined by a set of two additional pins). Move your eye to a slightly different location and add pin sets until you can determine the source pin's location based on your lines **defined by each additional pin set.** It is easiest, I think so anyhow, to leave the pins in place and place a straight edge along each set of additional pins. **Do not** place the straight edge on the source pin since that would defeat the purpose). Be certain to circle and label the pin marks on the paper for easy interpretation. It would be advisable to put the section number (this is section I) on each page. How many lines did you need?

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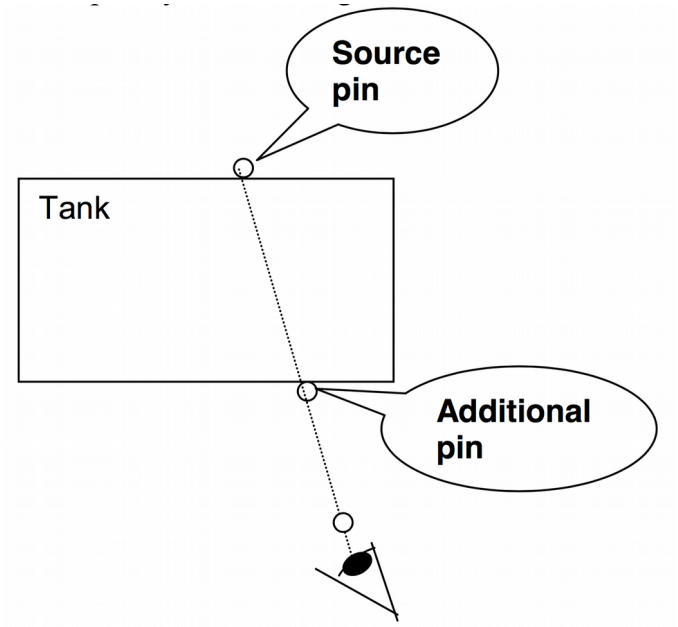
Based on your observations, from where do the rays emanate?

DISCUSS YOUR RESULTS WITH YOUR INSTRUCTOR BEFORE PROCEEDING.

II. EMPTY RECTANGULAR WATER TANK

You are going to place a rectangular tank between the **source pin** and your eye. The tank is made of acrylic with walls approximately 3 mm thick. The source pin is going to be placed directly against the side of the tank.

Prediction: Will you be able to determine the **source pin's** exact location using the same method as in part I when the two additional pins are on the opposite side of the tank? Explain your reasoning.



Remove all pins from the drawing board. Save and label your paper from the previous exercise. (You can turn it over and use the reverse side.) Place a fresh sheet of paper on the wooden drawing board. Perform the measurements by adding sets of pins to define two optical ray paths. Using the two optical ray paths, where is the **source pin** located? (You might need to remove the tank to do this) Does this agree with your prediction? Resolve any discrepancies between your prediction and observations.

Based on your observations, from where do the rays emanate?

III. RECTANGULAR TANK WITH WATER

Suppose you were to fill the tank half-full of water (at least as deep as the pin is long). What impact will the addition of water to the tank have on the location you determine for the **source pin** based on the method of triangulation? Explain your answer.

Remove all pins from the drawing board and save your paper from the previous exercise. Place a fresh sheet of paper on the wooden drawing board. Then insert the source pin into the board through the paper. Place the tank now ½ filled with water just to the side of the **source pin** as before (as shown in the diagram on the preceding page) and determine the *apparent* location of the **source pin** by three different lines of sight. Did your observations agree with your prediction? Resolve any discrepancies.

On your diagram for section III, draw the approximate optical ray path (a different color or dashed lines would be wise) that the light followed from the **source pin** to your eye.

Where is the apparent location of the source pin on your diagram? Does the location of the eye make a difference? Should it? Explain.

What did the light do with respect to the normal lines of the tank's boundaries when it exited the water?

Based on the optical paths exiting the tank in section III, from where do the rays appear to emanate?

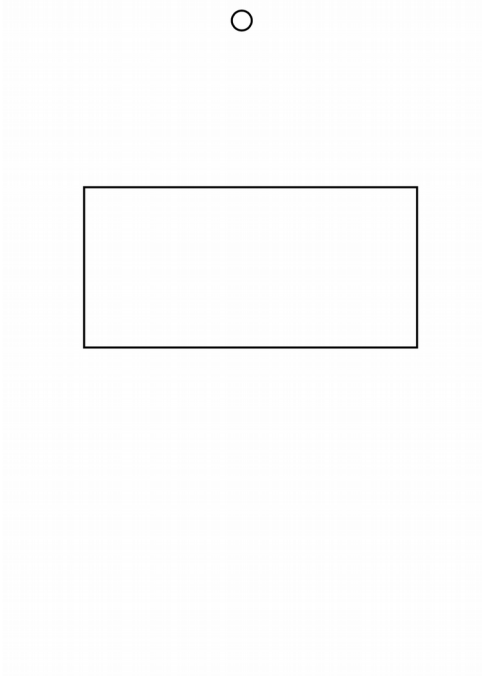
An image can be defined as “An apparent source of rays”. Have you seen any evidence for the existence of an image in this investigation? Account for your answer.

Is it possible to determine an effective index of refraction of the water tank system based on your measurements? If so, please determine it including your uncertainty in the measurements. If not, please explain why it is not possible.

DISCUSS YOUR RESULTS WITH YOUR INSTRUCTOR BEFORE PROCEEDING.

IV. RECTANGULAR WATER TANK WITH SOURCE PIN NOT IN CONTACT WITH TANK.

Suppose you were to place the **source pin** approximately 10 cm from the surface of the tank filled with water. Sketch two different light rays leaving the **source pin** and passing through the tank. Explain why you chose the paths you did. Be certain to take into account the information from previous sections.



Predict where the method of triangulation (as seen by an observer on the opposite side of the tank from the **source pin**) would locate the **source pin**?

If you look through the tank, **predict** where the **source pin** will appear to be located. Explain your answer as accurately as possible (this includes predicting where you would see the apparent location of the source pin).

Remove all pins from the drawing board and save your paper from the previous exercise. Place a fresh sheet of paper on the wooden drawing board. Then insert the source pin into the board through the paper. Place the tank now 1⁄2 filled with water 10 cm from the source pin and determine the apparent location of the source pin through triangulation. You should determine the optical path from the source pin to the tank (How can you do this?). Did your observations agree with your prediction? Resolve any discrepancies.

What did the light do when it **entered** the water with respect to the normal lines of the tank's boundaries?

Recall that an image can be defined as "An apparent source of rays". Have you seen any evidence for the existence of an image since the last time you were asked this question? Account for your answer.

V. QUESTIONS FOR CONSIDERATION.

Be certain to make reference your observations.

1) Without the water tank, is it accurate to say that rays radiate from **source pin**? Explain.

2) With the water filled tank in front of the **source pin**, do rays look as if they radiate from the apparent location of the **source pin**? Explain.

3) If you imagine the **source pin** is a point source, how many images of this point source are there? Explain.

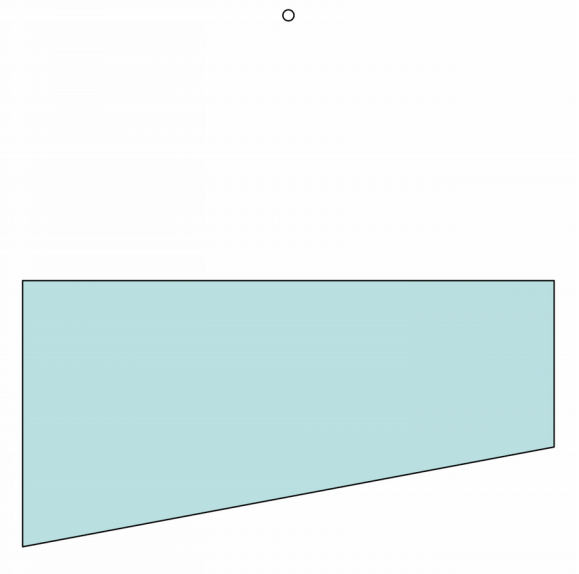
TASKS

TASK 1 – WEDGED TANK

The **source pin** is placed 10cm from a water filled tank shaped like a prism (see scaled drawing below). Predict where an observer on the opposite side of the tank will see the apparent location of the source pin.

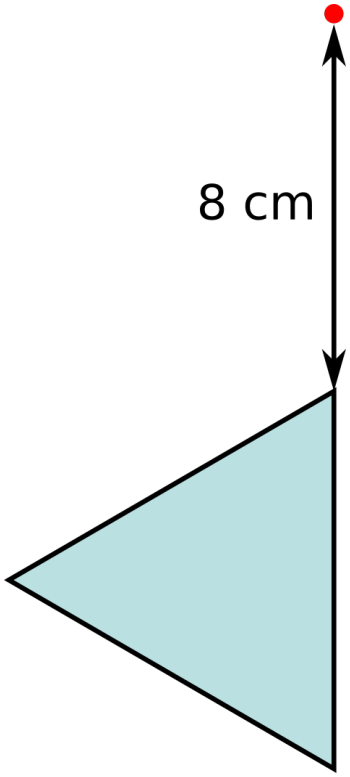
SHOW YOUR PREDICTION TO YOUR INSTRUCTOR.

Now set up the above situation and test your prediction. Where is apparent location of the source pin? Resolve any discrepancies.



TASK 2 – 60º PRISM

Consider a glass prism set up as shown in the figure. Predict where the image of the pin will appear when viewed from the opposite side of the prism. *Hint*: not all rays from the pin to the prism will be visible on the opposite side. Find two that are.



SHOW YOUR PREDICTION TO YOUR INSTRUCTOR.

Now set up the above situation and test your prediction.
Where is apparent location of the source pin?
Resolve any discrepancies.