Many others might be added, for instance:

Practical Mathematics,

Cracknell, Longmans, \$1.10

Workshop Mathematics,

Castle, Longmans

In two parts, 1s. 6d. each part.

Calculus for Engineers,

Perry, Macmillan, \$2.50

Says Professor David Eugene Smith of Columbia in reference to a similar movement just beginning in our own country, "It is not improbable that the present agitation in the development of preparatory mathematics in this country will penetrate even into our colleges and stir up some new life. When this is done, America will begin to develop for all its schools what England is developing for its technical institutions, books of the spirit of Mr. Saxelby's suited to the peculiar conditions and needs of our country."

May the time speedily come.

AN EXPERIMENT TO DETERMINE THE INDEX OF REFRACTION OF WATER.

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No claim is made for originality in presenting this experiment. It has these advantages: 1st, in the use of a glass prism in determining the index of refraction the distances used are of necessity small, so that a very minute error in "sighting lines" will produce a considerable error in the final result, while in using a jar of water the same error in "sighting" will result in an error of only about one-third or one-fourth as much as with the glass prism, since the distance with water can be taken three or four times as large as with a prism; 2nd, many laboratories may not have enough prisms of the right kind for this experiment, while nearly every laboratory has the apparatus which is needed for determining the index of refraction of water, or if the apparatus is not on hand it can be supplied at a very small cost.

The apparatus needed consists of a battery jar, 6x8 inches, pins, a pair of dividers, a metric rule, and a board of soft wood half an inch thick.

Fill the jar nearly full of water. Place the board in the jar and hold it down, so that its position is firm and steady. Stick two pins into the board, perpendicular to it, just on level with the surface of the water. You can tell when you have the pins just at the surface by the fact that the water will curve up to touch the under side of the pins but will not cover any part of them. Great care should be exercised in placing these pins just at the water surface for this is a likely source of error. Remove the board from the water and see that the pins are pushed in firmly and perpendicularly. With a fine pointed pencil draw a light line connecting the two pins, and at a point on this line about the middle of the board erect a perpendicular and extend above and below the line. On this perpendicular place a pin P about 12 cm. below AA' . About 2 cm. above AA' and along a line parallel to it measure a distance 4 cm. to the right of Pr and place the pin B , and 4 cm. to the left place the pin D . Place the board in the jar of water again and see to it that the water is at the level of the pins AA' when it is pressed down firmly. Place a pin C so that it seems to be in line with B and P . In like manner place a pin E in line with D and P . Remove the board; see that all pins are pushed in firmly and perpendicularly; wipe off the water; and transfer the positions of the pins to a piece of paper by pushing the sheet down over the pins and drawing lines connecting AA' , Pr , CB , ED , extending CB and ED until they cut the line Pr . Call the point of intersection P' . It is the point from which the light waves seem to come when P is viewed through the water and air. (Actually they come from P .) Draw PF and PH . With the dividers draw the arc $Fs'H$ with P' as a center and $P'H$ as a radius. This will represent the front of the wave as it emerges from the water. Draw the arc FsH with P as a center and PH as a radius. This would be the position of the wave front if there were no change in speed in passing from the water to the air.

rs may be considered the distance that light travels in water in a very small interval of time. If light travels in air faster than in water the portion of the wave front at r which emerges from the water first will travel a distance greater than rs in the same small interval of time so that it will be at s' when the parts of the wave near F and H are just emerging from the water. Since the actual position of the wave front is the arc $Hs'F$ with the center of the circle of which it is a part at P' this experiment shows us that light travels faster in air than in water.

The index of refraction of a substance is defined as the ratio between the speed of light in air and in that substance. So $\frac{rs'}{rs}$ gives us the index of refraction of water. But the distances rs' and rs are so small that they cannot be measured with any degree of accuracy. However $\frac{rs'}{rs} = \frac{PH}{P'H}$, the inverse ratio of the radii of the circles, and the distances PH and $P'H$ can be measured quite accurately. This above equation can be shown to be true by methods of geometry and trigonometry within the limits of experimental error. But the reasonableness of it can be presented to the student without going into the mathematical derivation. The curvature of an arc is rigidly defined as the reciprocal of the radius. But it is evident that rs is a measure of the curvature of the arc HsF , that is, it shows how much the arc departs from the straight line HrF ; likewise rs' shows

the curvature of the arc $Hs'F$. Therefore $\frac{rs'}{rs} = \frac{\frac{1}{P'H}}{\frac{1}{PH}}$, or $\frac{rs'}{rs} = \frac{PH}{P'H}$

So by dividing the distance PH by $P'H$ the index of refraction can be found, i. e., the number of times faster light travels in air than in water.

In performing the experiment each student made two trials, and more if the results were not satisfactory; but in nearly every case the error was of the order of one per cent or less. In the second trial the pins B and D were placed at different points, for example, 3 cm. either side of the perpendicular Pr .

This experiment is similar to the method of determining the index of refraction by the ratio of the sines of the angles incidence and refraction in that the apparatus is the same and the method of procedure is the same, but it has the advantage of presenting to the pupil the method of propagation of light, and of giving a clear idea of index of refraction and the cause of refraction, while to the average high school student the "ratio of the sines" means little or nothing and all he learns is that the index of refraction for water is 1.33.