EXPERIMENT

AIM

To find the refractive index of a liquid by using a convex lens & a plane mirror.

MATERIALS REQUIRED

A set of materials consisting of a double convex lens with a focal length of approximately 25 cm, a flat mirror, liquid (glycerine), retort stand, spherometer, plumb line, index pin and a meter scale.

DIAGRAM

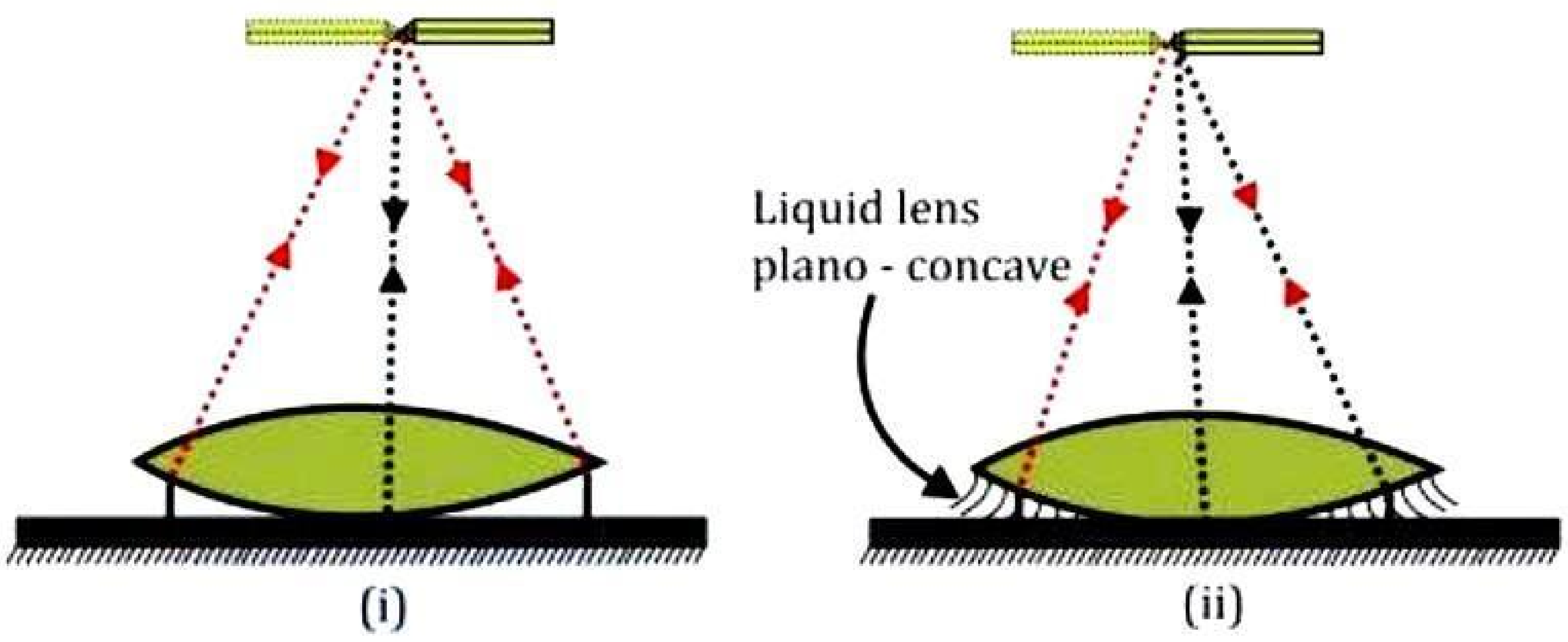

Fig. Experimental arrangement to determine the focal length of (i) convex lens;(ii) combination of liquid lens and convex lens

THEORY

The combined system of two lenses, consisting of a convex glass lens and a plano-concave liquid lens, yields a combined power denoted by:

$$P = P_1 + P_2 \text{ ....(i)}$$

Here, P_1 represents the power of the convex lens, P_2 is the power of the concave lens, and P is the power of the combined system. If f_1 denotes the focal length of the convex lens, f_2 represents the focal length of the concave lens, and F is the focal length of the combined system, then equation **(i) can be** expressed as:

$$\frac{1}{F} = \frac{1}{f_1} - \frac{1}{f_2} \text{.........(ii)}$$

Additionally, the following relationship holds:

$$\frac{1}{f_2} = (\mu - 1)\left(\frac{1}{r} - \frac{1}{s}\right) \text{.........(iii)}$$

Here, μ is the refractive index of the liquid forming the plano-concave lens, r is the radius of curvature of the liquid surface in contact with the convex lens, and s is the radius of curvature of the liquid surface in contact with the plane mirror. However, considering r as the radius of curvature of the convex lens and s as infinity (plane surface), the equation simplifies to:

$$\frac{1}{f_2} = (\mu - 1)\left(\frac{1}{r}\right) \text{.........(iv)}$$

Substituting equation (iv) into equation (ii), we derive:

$$\frac{1}{F} = \frac{1}{f_1} - (\mu - 1)\frac{1}{r}$$

$$\frac{1}{F}=\frac{1}{f_1}-(\mu-1)\frac{1}{r}$$

This leads to:

$$(\mu-1)\frac{1}{r}=\frac{1}{f_1}-\frac{1}{F}$$

And further simplification results in:

$$(\mu-1)=r\left(\frac{1}{f_1}-\frac{1}{F}\right)\text{........(v)}$$

PROCEDURE

1. Position the retort stand and apparatus either on a low-level table or on the ground to facilitate easy adjustments and readings.
2. Place a horizontal wooden plank on the table and position the plane mirror on it with its reflective surface facing upwards. Clean the provided convex lens and position it on the plane mirror.
3. Secure the optical index pin in the retort stand clamp, ensuring that the pin's tip aligns with the vertical line passing through the lens's center. An inverted image of the pin becomes visible when observing vertically downward along the lens's principal axis.
4. Once the inverted image of the pin is obtained, gradually adjust the pin's height until its tip coincides with the tip of its inverted image without any parallax. The distance between the pin's tip and the optic center of the lens represents the lens's focal length.
5. Measure the distance (d) from the pin's tip to the top of the lens using a meter scale and a plumb line. Remove the lens, measure the distance (dy) from the pin's tip to the plane mirror's surface. The average of these distances provides the focal length (f_1) of the convex lens. Repeat steps 1 to 4 five times.
6. Remove the convex lens, place a few drops of the given liquid (glycerin) on the plane mirror, and reposition the convex lens. The liquid forms a thin film between the plane mirror and the convex lens, resembling a plano-concave lens. This liquid lens is equivalent to adding a concave lens with a focal length (f_2) to the convex lens with focal length (f_1). Proceed with step 5 to determine the combined focal length (F) of the two lenses.
7. Employ a spherometer to determine the radius of curvature of the lens's surface.

OBSERVATIONS

1. Spherometer LC measurement = ______ cm
2. Record the focal length of the convex lens by measuring the distance from the tip of the pin to both the lens and the mirror.
3. Document the focal length of the combined lenses by measuring the distance from the tip of the pin to the top of the lens and the plane mirror.
4. Document the radius of curvature of the lens surface utilizing a spherometer.

S. No.	Distance of the tip of the pin		Focal length, $f_1=\frac{d_1+d_2}{2}$ (cm)	Mean f_1(cm)
	From tip of the lens, d_1 (cm)	From the plane mirror d_2 (cm)		
1.				
2.				
3.				

4.				
5.				

CALCULATION

1. Determine the distance between any legs of the spherometer, $d = \cdots$ cm.
2. Compute the radius of curvature of the convex lens using the formula:

$$r = \frac{d^2}{6h} + \frac{h}{2}$$

3. Compute the refractive index of the provided liquid using the formula:

$$\mu = 1 + r\left(\frac{1}{f_1} - \frac{1}{F}\right)$$

RESULT

The refractive index of the provided liquid (glycerin), μ = ...

PRECAUTIONS

1. Before starting the experiment, clean the convex lens and the plane mirror.
2. Clamp the object needle horizontally so that its tip touches the principal axis normally.
3. The principal axis of the convex lens should be vertical.
4. To see the image, keep your eye at the least distance of distinct vision.
5. Parallax should be removed tip to tip.
6. Take a very small quantity of experimental liquid.

SOURCES OF ERROR

1. The base of the plane mirror may not be horizontal.
2. The object needle may not be horizontal.
3. The liquid may be impure.
4. The carelessness of the experimenter.

VIVA- VOCE

Q 1. What is the Refractive Index of a medium?
Ans. The ratio of the velocity of light in a vacuum to the velocity of light in the given medium.

Q 2. Which substance has the greatest refractive index?
Ans. Diamond (2.42) has the greatest refractive index.

Q 3. State true or false: The refractive index is dimensionless.
Ans. True. The refractive index is a dimensionless quantity.

Q 4. What is the speed of light in a vacuum?
Ans. The speed of light in a vacuum is 3×10^8 m/s.

Q 5. Which is the phenomenon that is responsible for the sunrise and sunset?
Ans. Atmospheric refraction is the phenomenon that causes the sunrise and sunset.

Q 6. Can the refractive index of a medium be less than or equal to 1?
Ans. The Refractive index of a transparent medium is always greater than 1. because the speed of light in any medium is always less than that in a vacuum.