EXPERIMENT 1

OBJECT

To find the refractive index of a material given in the form of a prism using a spectrometer.

APPARATUS

1. Spectrometer
2. Mercury Source
3. Spirit level
4. Prism
5. Magnifier
6. Reading lamp

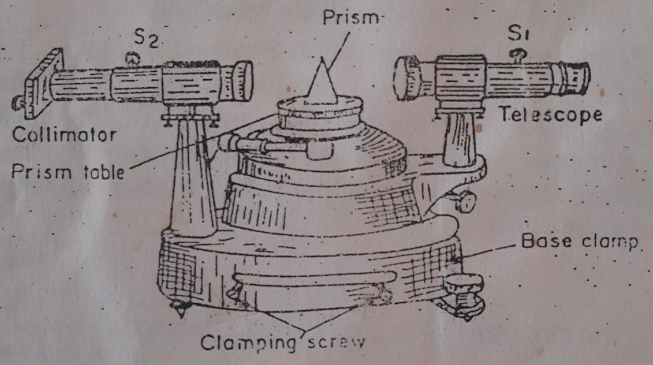

Fig. 1.1.

FORMULA USED

The refractive index 'μ' of the material on the form of a prism, is given by

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

where A is the refracting angle of the prism and δ_m is the angle of minimum deviation.

THEORY

Spectrometer is an optical instrument with the help of which a pure spectrum can be obtained. This is employed for finding the values of angles A and δ_m. The spectrometer is also used to determine the dispersive power of the material of a given prism, and the wavelength of a given source of a light by using a plane transmission diffraction grating.

A spectrometer mainly consists of three parts :

1. The Telescope
2. The Collimator
3. Prism Table

Telescope.–Telescope consists of two lens systems (1) the objective (2) Ramsden's eyepiece.

The objective is fixed at one end of a metal tube and lies toward the prism table while the eye piece can slide in the tube. When a parallel beam of light coming out of the prism falls on the objective, the spectrum produced is viewed through the eyepiece. The angular movement of the telescope is noted with the help of two verniers V_1 and V_2, these verniers are diametrically opposite at each other.

Collimator. The collimator is the device for obtaining a beam of parallel rays from the source of light. It consists of an achromatic lens at the end towards the prism table. At other end of the metal tube a fine-edge slit is placed towards the source. The width of the slit can be adjusted by means of a screw. Collimator is permanently fixed and cannot be rotated like a telescope.

Prism Table. It is a small circular metal disc carried over another metal frame with the help of three levelling screws. The table can be rotated about a vertical axis and its axis coincides with the axis of rotation of the telescope. Some concentric circles and some parallel lines are marked on the surface of the prism table which helps in the correct placing of the prism. It also consists of the prism holder and grating holder.

PROCEDURE

Before starting the experiment the spectrometer has to be set for parallel rays.

(A) Setting of the Spectrometer

The following is the order of the setting :

1. Setting of the Telescope

(*a*) The telescope is first turned towards some white wall, the eye piece is shifted w.r.t. the cross wires till a sharp image of the cross wires is obtained. The eye piece is now fixed w.r.t. the cross wires.

(*b*) The telescope is focussed on a distant object and the parallax between the image and the cross wires is removed. Thus, the telescope is set for parallel rays.

2. Setting of the Collimator

The position of the lens of the collimator is adjusted such that a sharp and well defined image is seen through the telescope.

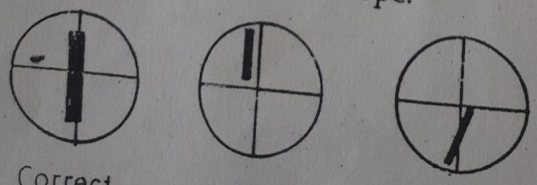

Fig. 1.2.

3. Setting of the Prism Table

The prism table is first made perfectly horizontal with the help of the spirit level and the levelling screws. The height of the prism table must be on the axis of collimator and telescope.

(B) Determination of the angle A of the Prism

1. The prism is mounted on the prism table as shown in Fig. 1.3 with the edge A at the centre of the prism table and base *BC* perpendicular to the axis of the collimator.

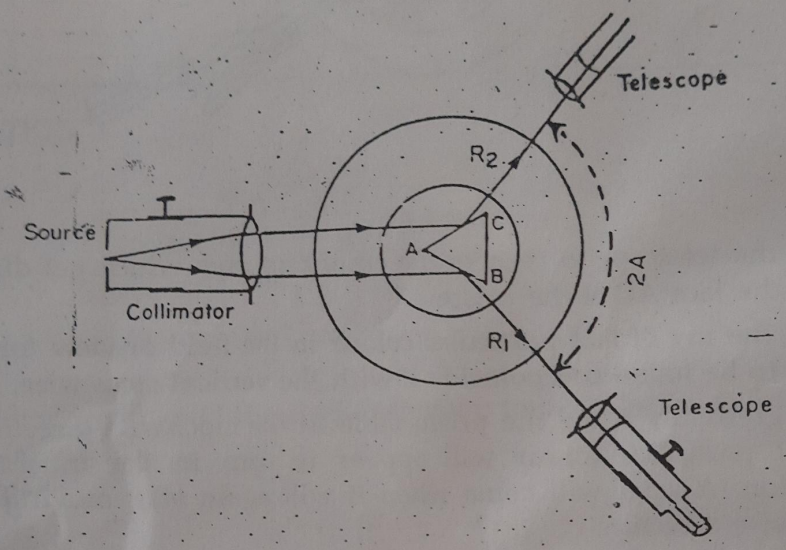

Fig. 1.3.

2. The rays from the collimator fall on the faces *AB* and *AC* of the prism from which these rays get reflected in the direction R_1 and R_2.
3. The telescope is turned to receive the reflected rays R_1. The image of the slit is made to coincide exactly with the vertical cross wire.
4. The main scale and vernier scale V_1 and V_2 are taken.
5. Now the telescope is turned towards the right to receive the ray R_2 and again image of the slit is made to coincide exactly with the vertical cross wire.
6. The M.S. and V.S. readings are again noted.
7. From these readings we get 2A.
8. Half of 2A gives A, the angle of the prism.

(C) Determination of the Angle of Minimum Deviation δm

1. Telescope is placed in front of the collimator and obtain the direct image of the slit in the Telescope without placing the prism.
2. Coincide the image of the slit with the vertical cross-wire making use of the clamping screw and the tangent screw.
3. Note the readings V_1 and V_2.

4. Now place the prism centrally on the prism table as shown in Fig. 1.4, so that the light incident from the collimator falls on the face *AB*.

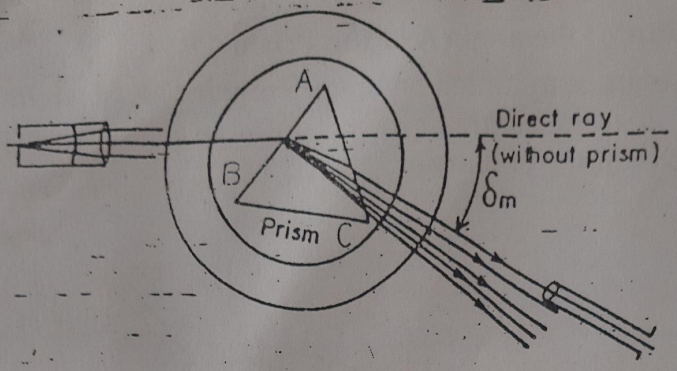

Fig. 1.4.

5. Turn the telescope to receive the emergent rays which get dispersed from the face AC of the prism.
6. Bring the ray of that particular colour in the field of view for which μ has to be found and coincide it with the vertical cross wire.
7. Now gradually rotate the prism table in the clockwise direction, the ray of particular colour will appear to turn in the anticlockwise direction. A stage will come when it will again start moving in the clockwise direction.
8. Coincide that particular position for which the ray just turns back with the cross-wire. This is the position of minimum deviation.
9. Note the main scale reading and vernier scale reading. Find δm from these reading observations :

   Value of the one division of main scale = 0.5 degree

   Total number of vernier divisions = 30

   Least count of vernier $= \frac{0.5}{30} = \frac{1}{60} = 1$ min

Table 1. For Angle A

	Telescope on the left hand side			*Telescope on the right hand side*				*Mean*
	M.S.	V.S.	Total *a*	M.S.	V.S.	Total *b*	*a* ~ *b*	2A
1. V_1								
V_2								
2. V_1								
V_2								

Table 2. For Minimum Deviation δm

	Telescope receiving direct rays			Telescope in min. deviation position				
	M.S.	V.S.	Total c	M.S.	V.S.	Total d	$c \sim d$	Mean δm
Yellow V_1								
V_2								
Violet V_1								
V_2								
Green V_1								
V_2								

CALCULATION

$$\mu = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \ldots.$$

RESULT

The refractive index of the given material is found to be = ... for ..... colour

Standard Value = ...

Error = ...%

PRECAUTIONS

1. The spectrometer must be set for parallel rays before starting the experiment.
2. The reading of both the verniers should be taken.
3. For reading magnifier should be used.
4. The image must be made fine so that a sharp line image is seen.
5. The prism must be placed in the correct position.

Standard Values

Wavelength of Mercury

(*i*) Violet $\Rightarrow 4047 \times 10^{-10}$ m

(*ii*) Yellow $\Rightarrow 5800 \times 10^{-10}$ m

(*iii*) Orange $\Rightarrow 6152 \times 10^{-10}$ m – 6322×10^{-10} m

(*iv*) Green $\Rightarrow 4960 \times 10^{-10}$ m – 5461×10^{-10} m.

Standard value 'μ' of the prism glass = 1.6545 for 6563 Å

= 1.6635 for 5270 Å

$$\frac{6563+5270}{2} \Rightarrow \frac{11833}{2} \Rightarrow 5916 \text{ Å} \approx \text{yellow light}$$

$$\therefore \quad \mu \text{ (yellow)} \Rightarrow \frac{1.6545+1.6635}{2}$$

$$\Rightarrow \frac{3.3180}{3} = 1.659 \approx 1.66$$