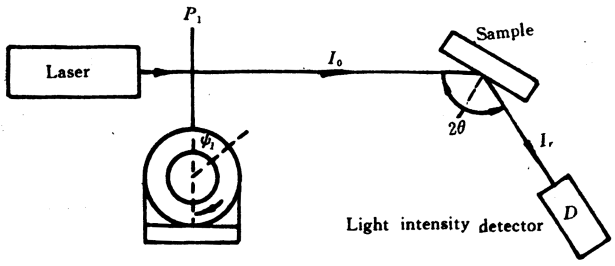
Experimental Problem 1——Solution

1. (a) Determine the transmission axis of the polarizer and the Brewster angle θ_B of the sample by using the fact that the rerlectivity of the *p*-component $R_p = 0$ at the Brewster angle.

Change the orientation of the transmission axis of P_1, specified by the position of the marked line on the degree scale disk (ψ) and the incident angle (θ_i) successively until the related intensity $I_r = 0$.



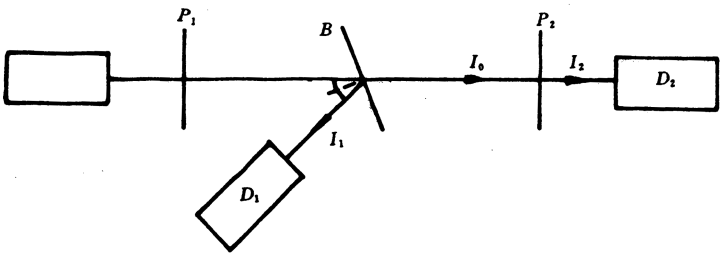
Now the incident light consists of *p*-component only and the incident angle is θ_B, the corresponding values ψ_1 and θ_B are shown below:

ψ_1	140.0°	322.0°	141.0°	322.5°
θ	56.4°	56.4°	56.2°	56.2°

$\psi_1 = 140.5° \pm 0.5°$ or $322.3° \pm 0.1°$

The Brewster angle θ_B is $56.3° \pm 0.1°$

1. (b) Verification of the linear relationship between the light intensity and the microammenter reading.



The intensity the transmitted light passing through two polarized P_1 and P_2 obeys Malus' law

$$I(\theta) = I_0 \cos^2 \theta$$

where I_0 is the intensity of the light polarized by p_1 and incident, I is the intensity of the transmitted light, and θ is the angle between the transmission axes of P_1 and p_2. Thus we can obtain light with various intensities for the verification by using two polarizers.

The experimental arrangement is shown in the figure.

The light intensity detector D_1 serves to monitor the intensity fluctuation of the incident beam (the ratio of I_1 to I_2 remain unchanged), and D_2 measures I_2. Let $i_1(\theta)$ and $i_2(\theta)$ be the readings of D_1 and D_2 respectively, and $\psi_2(\theta)$ be the reading of the marked line position. $i_2 = 0$ when $\theta = 90^\circ$, the corresponding ψ_2 is $\psi_2(90^\circ)$, and the value of θ corresponding to ψ_2 is

$$\theta = |\psi_2 - \psi_2(90°) \pm 90°|$$

Data and results;

$$\psi_2(90°) = 4°$$

ψ_2	94.0°	64.0°	49.0°	34.0°	4.0°
θ	0.0°	30.0°	45.0°	60.0°	90.0°
$i_1(\theta)\mu A$	6.3×1	5.7×1	5.7×1	5.7×1	5.7×1
$i_2(\theta)\mu A$	18.7×5	12.7×5	8.2×5	4.0×5	0.0×5

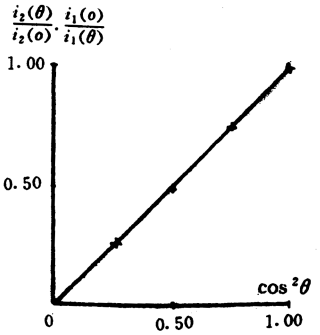
From the above data we can obtain the values of $I(\theta)/I_2(\theta)$ from the formula

$$\frac{I(\theta)}{I_0} = \frac{i_2(\theta)}{i_1(\theta)} \cdot \frac{i_1(0)}{i_2(0)}$$

and compare them with $\cos^2\theta$ for examining the linear relationship. The results obtained are:

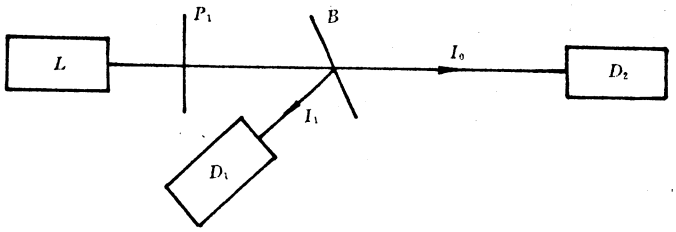
θ	0.0°	30.0°	45.0°	60.0°	90.0°
$\cos^2\theta$	1.00	0.75	0.50	0.25	0.00

$I(\theta)/I_0$	1.00	0.75	0.49	0.24	0.00

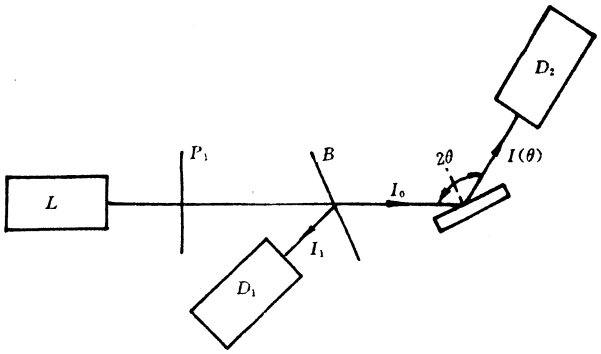


1. (c) Reflectivity measurement

The experimental arrangement shown below is used to determine the ratio of I_0 to I_1 which is proportional to the ratio of the reading (i_{20}) of D_2 to the corresponding reading (i_{10}) of D_1.



Then used the experimental arrangement shown below to measure the relativity R_p of the sample at various incident angle (θ) while the incident light consists of *p*-component only. Let $i_1(\theta)$ and $i_2(\theta)$ be the readings of D_1 and D_2 respectively.



Then the reflectivity is

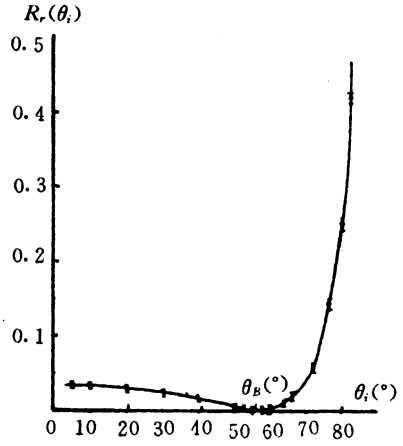
$$R_p(\theta)=\frac{I(\theta)}{I_0}=\frac{i_2(\theta)}{i_1(\theta)}\cdot\frac{i_{10}}{i_{20}}$$

Data and results:

$$\psi_1 = 140.5°$$
$$i_{20} = 19.8 \times 5\mu A$$
$$i_{10} = 13.3\mu A$$

θ(°)	$i_2(\theta)$	$i_1(\mu A)$	$R_p(\theta)$
5	15.1×0.2	11.1	0.037
10	14.9×0.2	11.2	0.036
20	13.3×0.2	11.1	0.032
30	11.4×0.2	12.2	0.025
40	7.8×0.2	14.7	0.014
50	2.3×0.2	16.9	0.0037
53	0.7×0.2	11.3	0.0017
55	0.3×0.2	11.3	0.00059
56.3（dark）	～0	11.5	～0
58	0.3×0.2	11.5	0.0007
60	1.1×0.2	13.5	0.0024
64	6.5×0.2	16.7	0.011
66	7.8×0.2	11.8	0.018
68	16.3×0.2	15.0	0.029
72	5.3×0.1	11.7	0.061
76	13.1×1	14.0	0.13
80	4.4×5	11.7	0.25
84	9.1×5	14.5	0.42

The curve of reflectivity of p-component as a function of incident in plexiglass



2. The Brewster angle θ_B can be found from the above date as

$$\theta_B = 56.3° \pm 0.2°$$

The index of refraction can be calculated as

$$n = \tan\theta_B = 1.50 \pm 0.01$$

The sources of errors are:

1. Detector sensitivity is low.
2. The incident light does not consist of *p*-component only.
3. The degree scales are not uniform.

EXPERIMENTAL PROBLEM 1: Grading Scheme(10 points)

Part 1. Reflectivity of the *p*-component. 7 points, distributed as follows.

a. Determination of the transmission axis of the polarizer (A) in *p*-component measurement, 1 point.

(Error less than ±2°, 1.0point;
error less than ±3°, 0.7point;
error less than ±4°, 0.3point;
error less than ±5°, 0.1 point.)

b. Verification of the linearity of the light intensity detector(2 points). Draws the optical schematic diagram correctly, 1.0 point; (Without the correction of the fluctuation of the light intensity, 0.4 point only);

Uses $I / I_0 \sim \cos^2\theta$ figure to show the "linearity", 0.5 point;

Tabulate the measured data(with 5 points at least)correctly, 0.5 point.

c. Determination of the reflectivity of the p-component of the light as a function of incident angle, 4 points, distributed as follows.

Draws the optical schematic diagram correctly and tabulate the measured data perfectly, 2.0 points;

Plot the reflectivity as the function of incident angle with indication of errors, 2 points.

Part 2. Determination of the refractive index of sample, 3 point.

Brewster angle of sample, 1 point;

(Error less than ±1°, 1.0point;
error less than ±2°, 0.5point;
error less than ±3°, 0.2point;
error larger than ±3°, 0 point.)
The refractive index of sample, 0.5 point.
Discussion and determination of errors, 1.5 points.