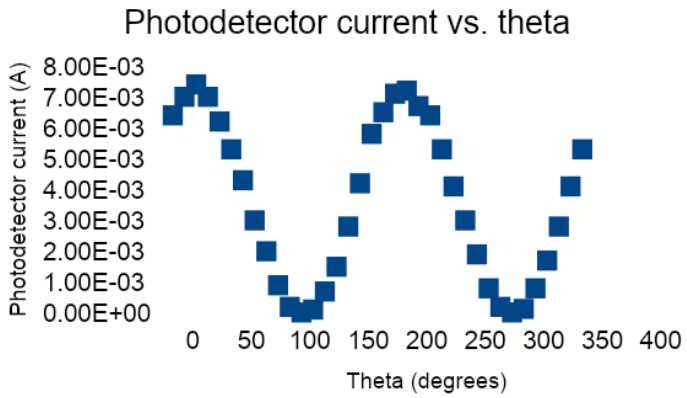
Observations of experiment no. 2 (Optics)

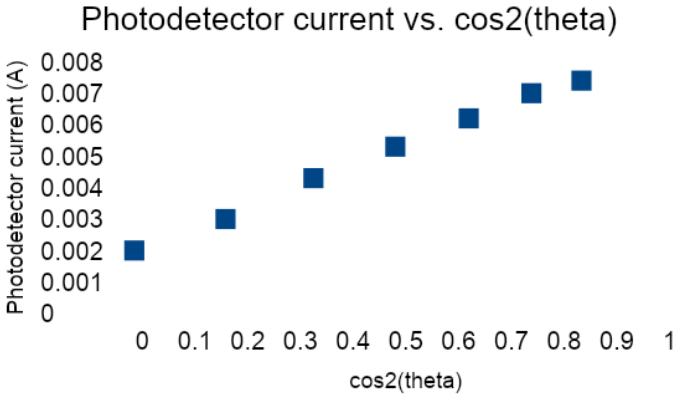
Readings for the verification of the Malus Law:
Least count of polarizer = 2°

Polarizor Angle (degrees)	Photodetector Current (A)
298	2.11 x 10-5
308	1.35 x 10-4
318	8.00 x 10-4
328	1.70 x 10-3
338	2.80 x 10-3
348	4.10 x 10-3
358	5.30 x 10-3
8	6.40 x 10-3
18	7.00 x 10-3
28	7.40 x 10-3
38	7.00 x 10-3
48	6.20 x 10-3
58	5.30 x 10-3
68	4.30 x 10-3
78	3.00 x 10-3
88	2.00 x 10-3
98	9.00 x 10-4
108	2.00 x 10-4
118	2.05 x 10-5
128	1.15 x 10-4
138	7.00 x 10-4
148	1.50 x 10-3
158	2.80 x 10-3
168	4.20 x 10-3
178	5.80 x 10-3
188	6.50 x 10-3
198	7.10 x 10-3
208	7.20 x 10-3
218	6.70 x 10-3
228	6.40 x 10-3
238	5.30 x 10-3
248	4.10 x 10-3
258	3.00 x 10-3
268	1.90 x 10-3
278	8.00 x 10-4
288	2.00 x 10-4

Plot for the verification of the Malus' Law:



or



*Either of the plots is sufficient for the verification of the Malus Law. Also do not emphasise on the value of I(A) in the second plot, it depends upon the range of theta that student has chosen.

Observations for Brewster's Angle Determination:

Least count of vernier scale on rotating table = 2'

Angle of polarizer for P-polarized light = 342°
Photodetector current corresponding to incident intensity of P-polarized part (I_o) = 9.20 x 10^{-3} A

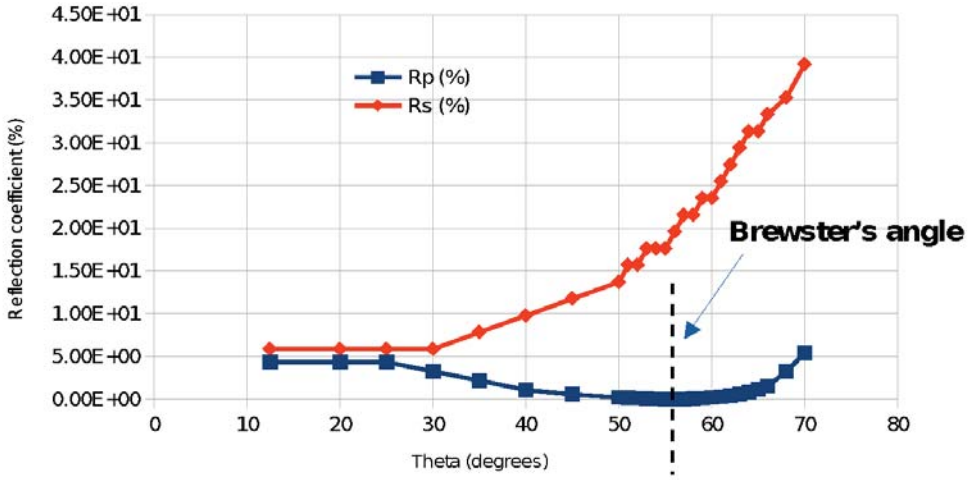
Angle of polarizer for S-polarized light = 252°
Photodetector current corresponding to incident intensity of S-polarized part (I_o) = 5.1 x 10^{-3} A

% reflection coefficient (R_P or R_S) = [Photodetector current (I) / Incident current (I0)]*100

Readings for the measurement of angle

Angles of Incidence	**Photodetector current for P-polarization (I)**	**Photodetector current for S-polarization (I)**	**R_P**	**R_S**
(degrees)	**(A)**	**(A)**	**(%)**	**(%)**
20	4.00 x 10^-4	3.00 x 10^-4	4.35 x 10^0	5.9 x 10^0
25	4.00 x 10^-4	3.00 x 10^-4	4.35 x 10^0	5.9 x 10^0
30	3.00 x 10^-4	3.00 x 10^-4	3.26 x 10^0	5.9 x 10^0
35	2.00 x 10^-4	4.00 x 10^-4	2.17 x 10^0	7.8 x 10^0
40	1.00 x 10^-4	5.00 x 10^-4	1.09 x 10^0	9.8 x 10^0
45	5.30 x 10^-5	6.00 x 10^-4	5.76 x 10^-1	1.2 x 10^1
50	1.92 x 10^-5	7.00 x 10^-4	2.09 x 10^-1	1.4 x 10^1
51	1.45 x 10^-5	8.00 x 10^-4	1.58 x 10^-1	1.6 x 10^1
52	1.01 x 10^-5	8.00 x 10^-4	1.10 x 10^-1	1.6 x 10^1
53	5.70 x 10^-6	9.00 x 10^-4	6.20 x 10^-2	1.8 x 10^1
54	3.10 x 10^-6	9.00 x 10^-4	3.37 x 10^-2	1.8 x 10^1
55	1.20 x 10^-6	9.00 x 10^-4	1.30 x 10^-2	1.8 x 10^1
56	7.00 x 10^-7	1.00 x 10^-3	7.61 x 10^-3	2.0 x 10^1
57	1.90 x 10^-6	1.10 x 10^-3	2.07 x 10^-2	2.2 x 10^1
58	5.30x 10^-6	1.10 x 10^-3	5.76 x 10^-2	2.2 x 10^1
59	1.04 x 10^-5	1.20 x 10^-3	1.13 x 10^-1	2.4 x 10^1
60	1.81 x 10^-5	1.20 x 10^-3	1.97 x 10^-1	2.4 x 10^1
61	2.50 x 10^-5	1.30 x 10^-3	2.72 x 10^-1	2.5 x 10^1
62	3.80 x 10^-5	1.40 x 10^-3	4.13 x 10^-1	2.7 x 10^1
63	5.40 x 10^-5	1.50 x 10^-3	5.87 x 10^-1	2.9 x 10^1
64	7.44 x 10^-5	1.60 x 10^-3	8.09 x 10^-1	3.1 x 10^1
65	1.07 x 10^-4	1.60 x 10^-3	1.16 x 10^0	3.1 x 10^1
66	1.41 x 10^-4	1.70 x 10^-3	1.53 x 10^0	3.3 x 10^1
68	3.00 x 10^-4	1.80 x 10^-3	3.26 x 10^0	3.5 x 10^1
70	5.00 x 10^-4	2.00 x 10^-3	5.43 x 10^0	3.9 x 10^1

Plot for the reflection coefficients:



From the plot and from the data, the Brewster's angle = 56° ± 1°

Error Analysis:

Calculation of log error in refractive index of the glass sheet:

$n_2 = n_1 tan(\theta_B) = 1 \times tan(56^\circ) = 1.483$

$log(n_2) = log(n_2) + log(tan(\theta))$

$\frac{dn_2}{n_2} = \frac{dn_1}{n_1} + \frac{sec^2\theta}{tan(\theta)} d\theta$

$dn_2 \approx 0$ since n_2 is assumed to be a constant = 1

$d\theta$ = range of values between which the true value of our measurement lies (uncertainty in measuring the angle of incidence from the graph) $\approx \frac{57^\circ - 55^\circ}{2} = 1^\circ$, or $1^\circ \times \frac{\pi}{180^\circ} = 0.0174\ radians$ s

$\theta_B = 56^\circ = 0.9774\ radians,\ sec^2(\theta_B) = 3.198,\ tan(\theta_B) = 1.483$

So, $\Delta n_2 = \frac{3.198}{1.483} \times 0.0174 \times 1.5 = 0.056 = 5.6 \times 10^{-2}$

Thus, $\theta_B = 56^\circ \pm 1^\circ$ and $n_2 = 1.48 \pm 0.0\ 6$

Note for evaluators and TAs:

In the experiment recorded on the video the laser was oriented such that the angle of plane of polarization with respect to the vertical was different from 45°, therefore the power of the P- and S- polarizations are not matched. However, the signal is not low for either polarization (P- or S-) as the angle was not kept drastically different from 45°. The only variation from the expected result is the that I_o values for P- and S- polarizations are slightly different. This does not pose any conceptual problem and students should be given full marks for this part.

Additionally, error analysis for reflection coefficient should be considered optional as it is not mentioned in the manual

Reference:

1. Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light, Max Born and Emil Wolf (7th Edition), Cambridge University Press, 2005