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Section: 16

PHY152Lab MP3

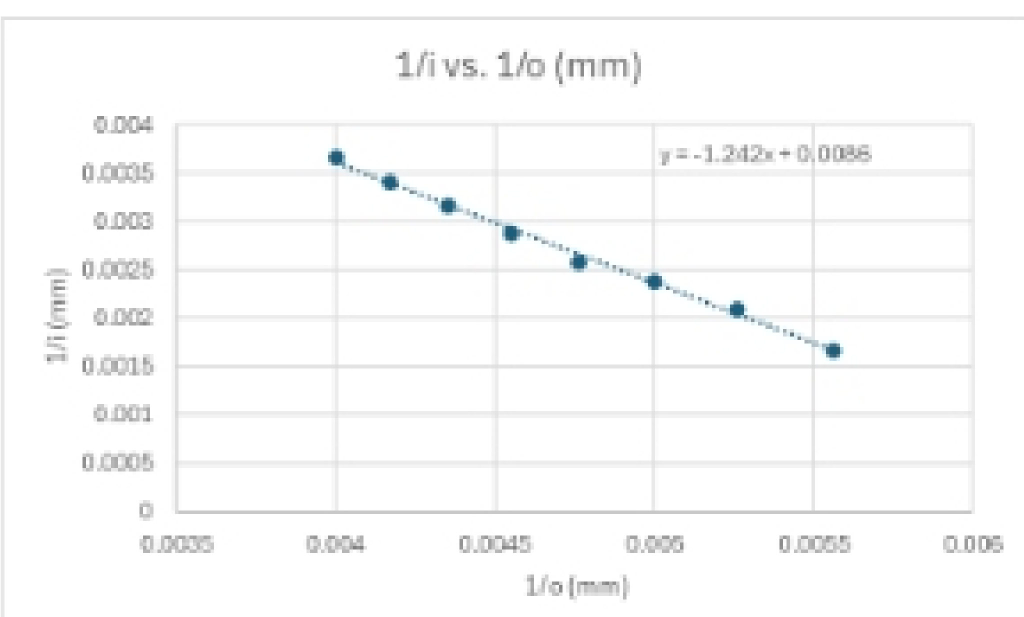
VI-1

Index of Refraction: 1.72

$$n = \sqrt{1 + \frac{4d^2}{R^2}} = \sqrt{1 + \frac{4(6.5mm)^2}{(9.3mm)^2}} = 1.72$$

VI-2

o (mm)	l (mm)	t (mm)	i (mm)	$\frac{1}{o}$ (mm)	$\frac{1}{i}$ (mm)
180	355	953	598	0.00556	0.00167
190	365	843	478	0.00526	0.00209
200	375	797	421	0.00500	0.00238
210	385	772	387	0.00476	0.00258
220	395	744	349	0.00455	0.00287
230	405	721	316	0.00435	0.00316
240	415	709	294	0.00417	0.00340
250	425	698	273	0.00400	0.00366



s: $-1.242mm$

σ_s: $0.0351mm$

$s \pm \sigma_s = -1.242mm \pm 0.0351mm$

b: $0.0086mm$

σ_b: $0.000166mm$

$b \pm \sigma_b = 0.0086\ mm \pm 0.000166mm$

$$f = \frac{1}{b} = \frac{1}{0.0086mm} = 116.3mm$$

$$\sigma_f = \frac{\sigma_b}{b} f = \frac{0.000166mm}{0.0086mm}(116.3mm) = 2.25mm$$

$$f \pm \sigma_f = 116.3mm \pm 2.25mm$$

The manufacturer's focal length (127mm) is > the calculated range (114.1mm, 118.6mm).

VI-3

Length of Feature: $x = 9.50\,mm$ $\sigma_x = 0.1\,mm$

Length of Feature Image: $x' = 17.7\,mm$ $\sigma_{x'} = 0.1\,mm$

Lens Position: $l = 292\,mm$ $\sigma_l = 0.5\,mm$

Object Position: $a = 212\,mm$ $\sigma_a = 0.5\,mm$

Image Position: $t = 416\,mm$ $\sigma_t = 0.5\,mm$

Measured:

$$M_{calc} = \frac{x'}{x} = \frac{17.7\ mm}{9.5\ mm} = 1.86$$

$$\sigma_{M_{calc}} = \sqrt{(\frac{\sigma_{x'}}{x'})^2 + (\frac{\sigma_x}{x})^2} = \sqrt{(\frac{0.1mm}{17.7mm})^2 + (\frac{0.1mm}{9.5mm})^2} = 0.0119$$

$$M_{calc} \pm \sigma_{M_{calc}} = 1.86 \pm 0.0119 = (1.85,\ 1.87)$$

Expected:

$$i = t - l = 416\,mm - 292\,mm = 124\,mm \qquad \sigma_i = \sqrt{\sigma_l^2 + \sigma_t^2} = \sqrt{(0.5mm)^2 + (0.5mm)^2} = 0.707\,mm$$

$$o = l - a = 292\,mm - 212\,mm = 80\,mm \qquad \sigma_o = \sqrt{\sigma_l^2 + \sigma_a^2} = \sqrt{(0.5mm)^2 + (0.5mm)^2} = 0.707\,mm$$

$$M_{exp} = \frac{i}{o} = \frac{124\ mm}{80\ mm} = 1.55 \qquad \sigma_{M_{exp}} = \sqrt{(\frac{\sigma_i}{i})^2 + (\frac{\sigma_o}{o})^2} = \sqrt{(\frac{0.707mm}{124mm})^2 + (\frac{0.707mm}{80mm})^2} = 0.0105$$

$$M_{exp} \pm \sigma_{M_{exp}} = 1.55 \pm 0.0105 = (1.54,\ 1.56)$$

The calculated M is slightly > the expected M. The same goes for $\sigma_{M_{calc}}$ and $\sigma_{M_{exp}}$.

VI-4

Mirror Position: $m = 264\,mm$ $\sigma_m = 0.5\,mm$

Object Position: $a = 212\,mm$ $\sigma_a = 0.5\,mm$

Calculations:

$$f = \frac{m-a}{2} = \frac{264\ mm - 212\ mm}{2} = 26\,mm \qquad \sigma_f = \frac{\sqrt{\sigma_m^2 + \sigma_a^2}}{2} = \frac{\sqrt{(0.5mm)^2 + (0.5mm)^2}}{2} = 0.354\,mm$$

$$f \pm \sigma_f = 26\,mm \pm 0.354\,mm = (25.65\,mm,\ 26.35\,mm)$$

The expected f (25 mm) is slightly < the measured f (25.65 mm, 26.35 mm)

VI-5

θ (degrees)	I (Fc)	$\frac{I}{I_0}$ (Fc)	$cos^2θ$
20	4.62	0.821	0.883
40	3.03	0.538	0.587
60	1.40	0.249	0.250
80	0.220	0.0391	0.0302
100	0.0600	0.0107	0.0302
120	1.06	0.188	0.250
140	2.82	0.501	0.587
160	4.47	0.794	0.883
180	5.20	0.924	1.00
200	4.64	0.824	0.883
220	3.08	0.547	0.587
240	1.33	0.236	0.250
260	0.160	0.0284	0.0302
280	0.0600	0.0107	0.0302
300	1.15	0.204	0.250
320	2.77	0.492	0.587
340	4.01	0.712	0.883

Calculations:

$cos^2θ = cos^2(0) = 1$

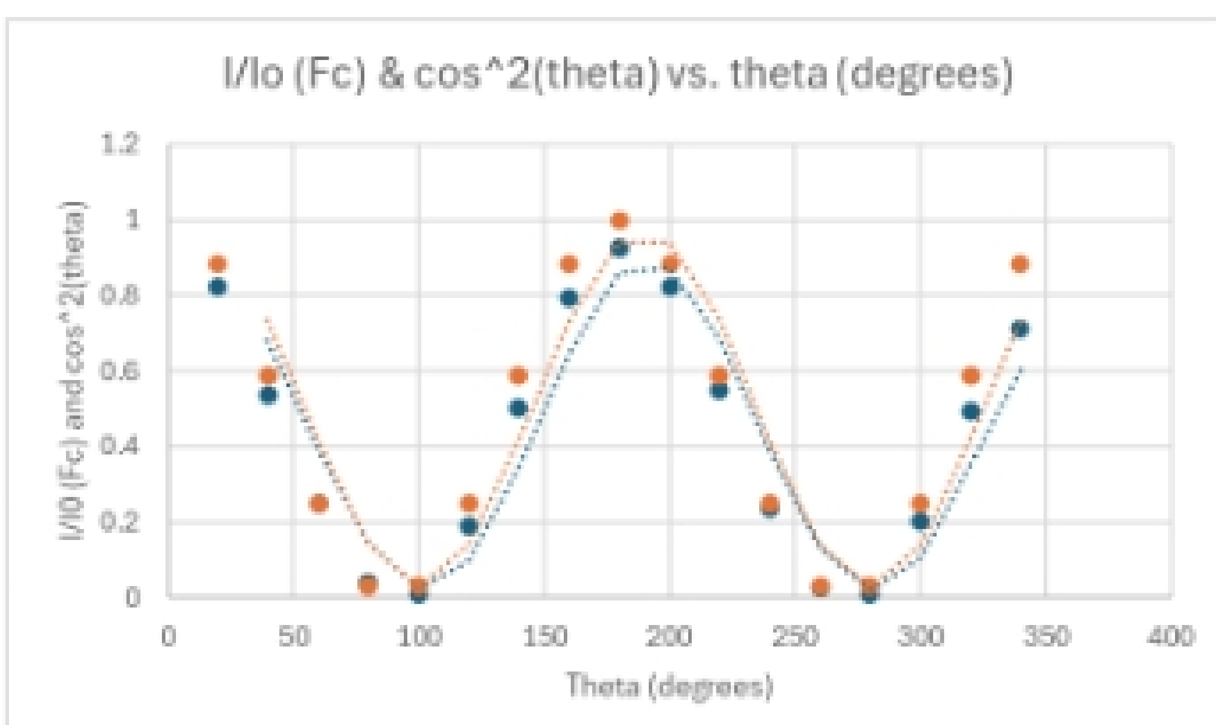
$I_0 = 5.63\ Fc$

*for $θ = 20^{\circ}$

Malus' Law: $I = I_0 cos^2(θ)$

$I = 5.63\ Fc \cdot 0.883$

$I = 4.97\ Fc$



The plotted data is very similar, but the graphs do not overlap, therefore our data does not support Malus' Law.