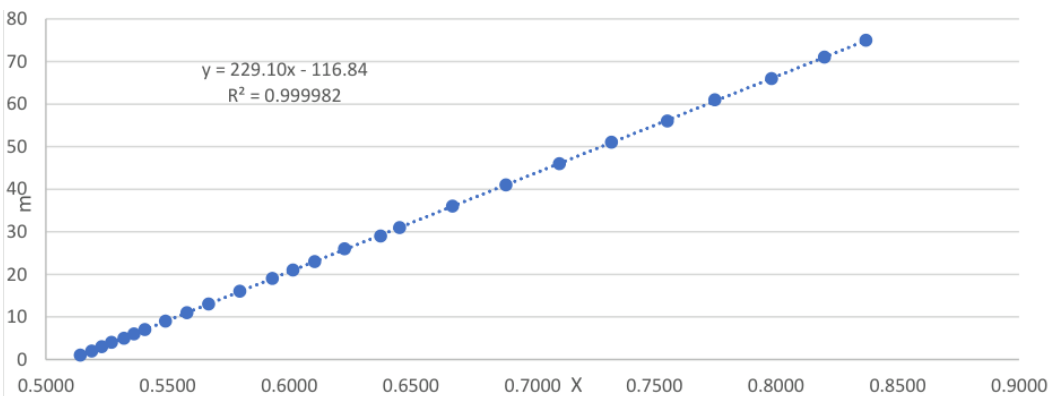
Problem E2- Solution

A.1			
number	m	θ_m (degrees)	$\sqrt{n^2 - \sin^2\theta_m} - \cos\theta_m$
1	1	9.00	0.5142
2	2	13.00	0.5188
3	3	15.75	0.5229
4	4	18.00	0.5270
5	5	20.50	0.5322
6	6	22.25	0.5362
7	7	24.00	0.5406
8	9	27.00	0.5491
9	11	29.75	0.5579
10	13	32.25	0.5668
11	16	35.50	0.5798
12	19	38.50	0.5931
13	21	40.25	0.6015
14	23	42.00	0.6105
15	26	44.25	0.6228
16	29	46.75	0.6375
17	31	48.00	0.6453
18	36	51.25	0.6671
19	41	54.25	0.6891
20	46	57.00	0.7110
21	51	59.50	0.7325
22	56	62.00	0.7555
23	61	64.00	0.7750
24	66	66.25	0.7982
25	71	68.25	0.8200
26	75	69.75	0.8371

A.2



A.3

B = 229.1

A = -116.8

A.4

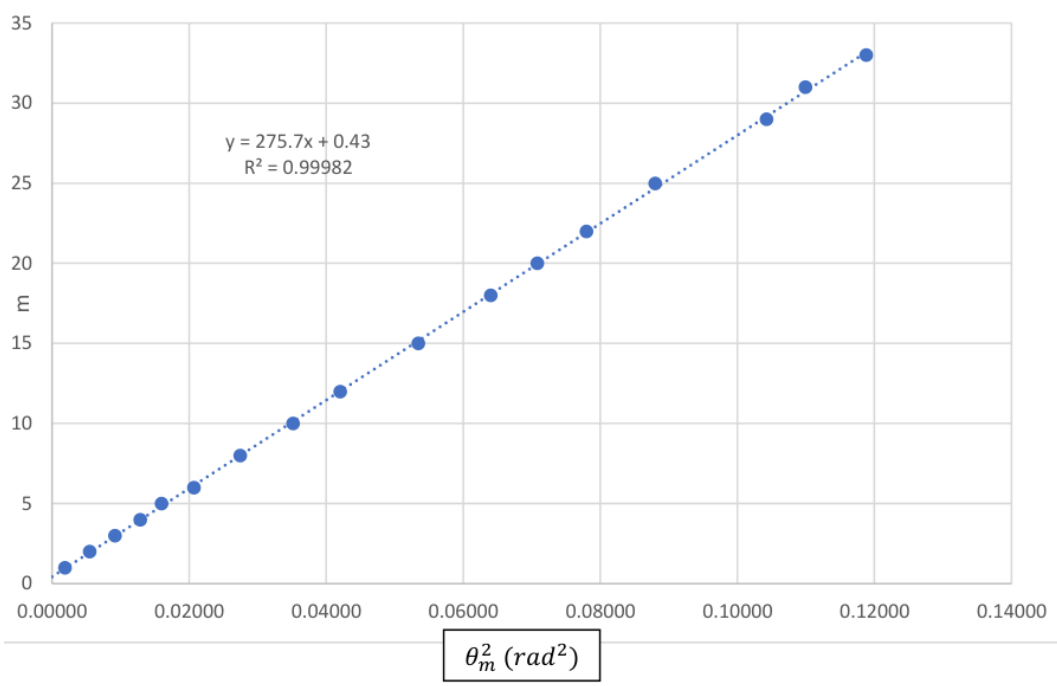
h = $(148.9 \pm 0.1)\,\mu m$

B.1			
number	m	θ_m (degrees)	θ_m^2 (rad^2)
1	1	2.50	0.00190
2	2	4.25	0.00550
3	3	5.50	0.00921
4	4	6.50	0.01287
5	5	7.25	0.01601
6	6	8.25	0.02073
7	8	9.50	0.02749
8	10	10.75	0.03520
9	12	11.75	0.04206
10	15	13.25	0.05348
11	18	14.50	0.06405
12	20	15.25	0.07084
13	22	16.00	0.07798
14	25	17.00	0.08803
15	29	18.50	0.10426
16	31	19.00	0.10997
17	33	19.75	0.11882

B.2

$$m = \frac{H}{2\lambda}\left(1 - \frac{1}{n}\right)\theta_m^2$$

B.3



B.4

B = 275.7

A =0.43

B.5

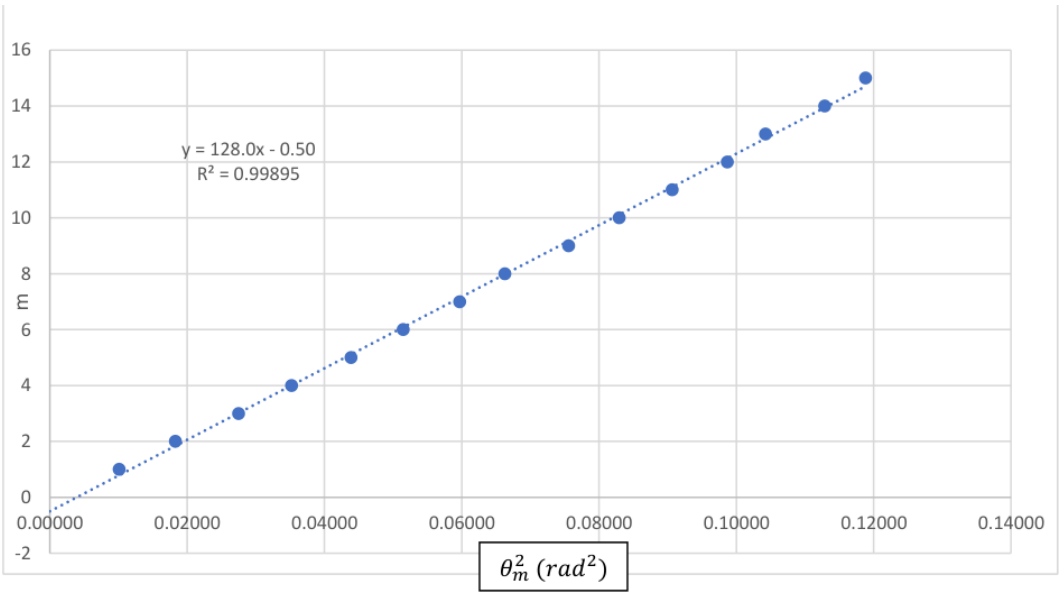
H = $(1.061 \pm 0.004)\, mm$

C.1			
number	m	θ_m (degree)	θ_m^2 (rad^2)
1	1	5.75	0.01007
2	2	7.75	0.01830
3	3	9.50	0.02749
4	4	10.75	0.03520
5	5	12.00	0.04386
6	6	13.00	0.05148
7	7	14.00	0.05971
8	8	14.75	0.06627
9	9	15.75	0.07556
10	10	16.50	0.08293
11	11	17.25	0.09064
12	12	18.00	0.09870
13	13	18.50	0.10426
14	14	19.25	0.11288
15	15	19.75	0.11882

C.2

$$m = \frac{H}{2\lambda}\left(N - \frac{N^2}{n}\right)\theta_m^2$$

C.3



C.4

B = 128.0

A = −0.50

C.5

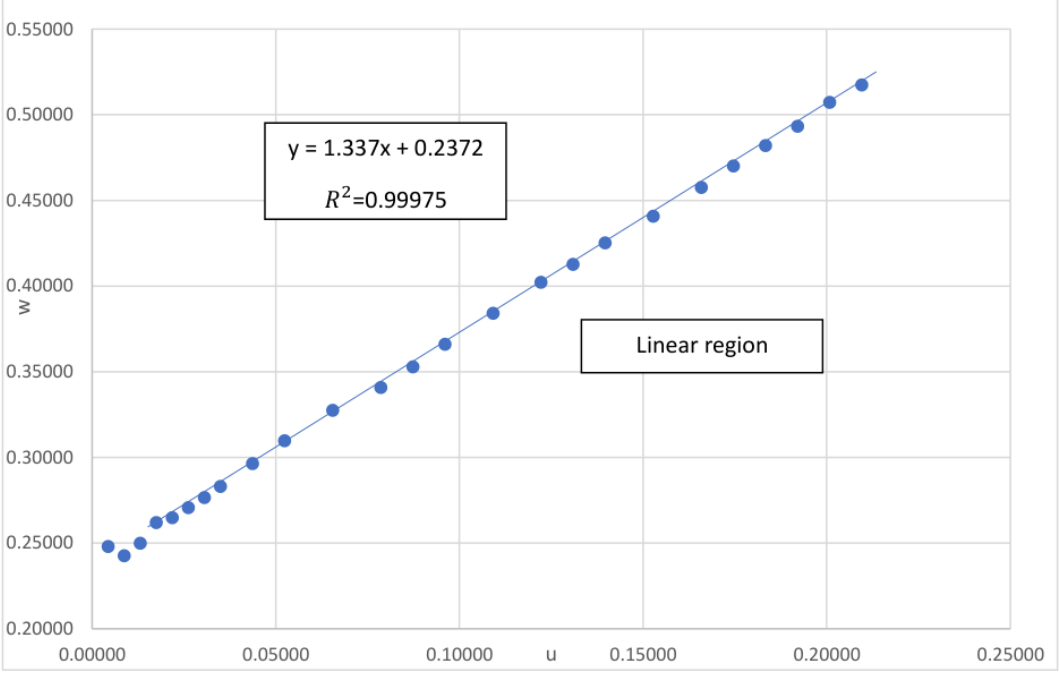
N = 1.332 ± 0.002

D.1			D.3	
number	m	θ_m (degree)	u	w
1	1	13.25	0.00436	0.24795
2	2	19.00	0.00873	0.24265
3	3	23.00	0.01309	0.24981
4	4	26.00	0.01746	0.26200
5	5	29.00	0.02182	0.26474
6	6	31.50	0.02619	0.27069
7	7	33.75	0.03055	0.27653
8	8	35.75	0.03492	0.28307
9	10	39.25	0.04365	0.29637
10	12	42.25	0.05238	0.30973
11	15	46.25	0.06547	0.32743
12	18	50.00	0.07857	0.34076
13	20	52.00	0.08730	0.35289
14	22	53.75	0.09603	0.36608
15	25	56.25	0.10912	0.38415
16	28	58.50	0.12222	0.40213
17	30	60.00	0.13095	0.41261
18	32	61.25	0.13968	0.42517
19	35	63.25	0.15277	0.44072
20	38	65.00	0.16587	0.45761
21	40	66.00	0.17460	0.47008
22	42	67.00	0.18333	0.48193
23	44	68.00	0.19205	0.49320
24	46	68.75	0.20078	0.50715
25	48	69.75	0.20951	0.51739

D.2

$$\mathrm{u} = \frac{m\lambda}{h} \qquad \mathrm{w} = \frac{\frac{m\lambda}{h}\left(n + \frac{m\lambda}{2h}\right)}{1 - \cos\theta_m}$$

D.4



By removing the first 3 points

D.5

B = 1.337

A = 0.2372

D.6

$N_B = 1.337 \pm 0.005$

$N_A = 1.3319 \pm 0.0005$

Theoretical calculations:

B.2 & C.2:

$$m = \frac{H}{\lambda}\left(\sqrt{n^2 - N^2\sin^2\theta_m} - N\cos\theta_m\right) - \frac{H}{\lambda}(n-N)$$

$$\theta_m \ll 1: \quad \sin\theta_m \approx \theta_m\ ; \quad \cos\theta_m \approx 1 - \frac{\theta_m^2}{2}$$

$$m = \frac{H}{\lambda}\left(n\sqrt{1 - \frac{N^2\theta_m^2}{n^2}} - N\left(1 - \frac{\theta_m^2}{2}\right)\right) - \frac{H}{\lambda}(n-N)$$

$$m = \frac{H}{\lambda}\left(n\left(1 - \frac{N^2\theta_m^2}{2n^2}\right) - N\left(1 - \frac{\theta_m^2}{2}\right)\right) - \frac{H}{\lambda}(n-N)$$

$$m = \frac{H}{2\lambda}N\left(1 - \frac{N}{n}\right)\theta_m^2$$

$$N = 1: \quad m = \frac{H}{2\lambda}\left(1 - \frac{1}{n}\right)\theta_m^2$$

D.2:

$$m = \frac{h}{\lambda}\left(\sqrt{n^2 - N^2\sin^2\theta_m} - N\cos\theta_m\right) - \frac{h}{\lambda}(n-N)$$

$$\frac{m\lambda}{h} + n - N(1-\cos\theta_m) = \sqrt{n^2 - N^2\sin^2\theta_m}$$

$$\left(\frac{m\lambda}{h}\right)^2 + 2n\left(\frac{m\lambda}{h}\right) + n^2 + N^2(1-\cos\theta_m)^2 - 2N(1-\cos\theta_m)\left(\frac{m\lambda}{h} + n\right) = n^2 - N^2\sin^2\theta_m$$

$$\left(\frac{m\lambda}{h}\right)^2 + 2n\left(\frac{m\lambda}{h}\right) + N^2(2-2\cos\theta_m) - 2Nn(1-\cos\theta_m) - 2N(1-\cos\theta_m)\left(\frac{m\lambda}{h}\right) = 0$$

$$\frac{\frac{m\lambda}{h}\left(n + \frac{m\lambda}{2h}\right)}{1-\cos\theta_m} + N^2 - Nn - N\left(\frac{m\lambda}{h}\right) = 0$$

$$\frac{\frac{m\lambda}{h}\left(n + \frac{m\lambda}{2h}\right)}{1-\cos\theta_m} = N(n-N) + \left(\frac{m\lambda}{h}\right)N$$

$$w = N(n-N) + uN$$

Error calculations:

Linear equation slope and intercept uncertainties:

$$\Delta B = B\sqrt{\frac{1}{n-2}\left(\frac{1}{r^2}-1\right)} \qquad ; \qquad \Delta A = \Delta B\sqrt{\bar{x}^2+\sigma_x^2}$$

C.5:

$$B = \frac{H}{2\lambda}\left(N - \frac{N^2}{n}\right) \Rightarrow \left(N - \frac{N^2}{n}\right) = \frac{2\lambda}{H}B \equiv c$$

$$\Rightarrow \frac{\Delta c}{c} = \sqrt{\left(\frac{\Delta B}{B}\right)^2 + \left(\frac{\Delta H}{H}\right)^2}$$

$$\left(N - \frac{N^2}{n}\right) = c \Rightarrow N = \frac{n}{2} \pm \sqrt{\left(\frac{n}{2}\right)^2 - c\,n}$$

A negative sign is unacceptable in this equation.

$$N = \frac{n}{2} + \sqrt{\left(\frac{n}{2}\right)^2 - c\,n} \Rightarrow \Delta N = \frac{n}{2\sqrt{\left(\frac{n}{2}\right)^2 - c\,n}}\,\Delta c$$

D.6:

$$N_A(n - N_A) = A \Rightarrow N_A = \frac{n}{2} \pm \sqrt{\left(\frac{n}{2}\right)^2 - A}$$

A negative sign is unacceptable in this equation.

$$N_A = \frac{n}{2} + \sqrt{\left(\frac{n}{2}\right)^2 - A} \Rightarrow \Delta N_A = \frac{\Delta A}{2\sqrt{\left(\frac{n}{2}\right)^2 - A}}$$

Of course, this is calculated by ignoring the error of u and w. Since there is an h value in u and w, the h error causes an error in this quantity that is not included.