Experiment

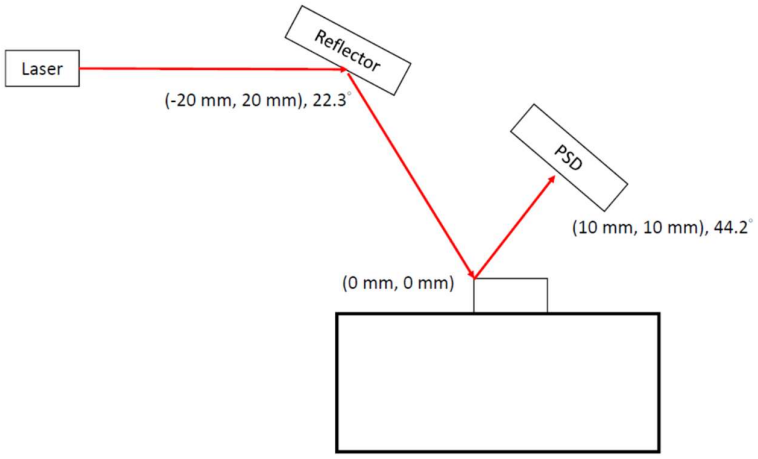
A1-1

中文 (Official)

Elasticity of cantilever

Part A. Alignment of light path

A1. 0.6 pt



A2. 0.8 pt

time (s)	position d (m)	time (s)	position d (m)	time (s)	position d (m)
3	-6.415×10^{-4}	48	1.198×10^{-4}	93	6.85×10^{-5}
6	5.261×10^{-4}	51	-4.46×10^{-5}	96	7.36×10^{-5}
9	4.843×10^{-4}	54	1.488×10^{-4}	99	8.73×10^{-5}
12	3.349×10^{-4}	57	-7.70×10^{-5}	102	7.93×10^{-5}
15	-5.386×10^{-4}	60	8.75×10^{-5}	105	6.39×10^{-5}
18	7.91×10^{-5}	63	1.604×10^{-4}	108	3.22×10^{-5}
21	-2.762×10^{-4}	66	-1.93×10^{-5}	111	6.05×10^{-5}
24	1.398×10^{-4}	69	1.159×10^{-4}	114	3.20×10^{-5}
27	-2.039×10^{-4}	72	7.10×10^{-5}	117	4.71×10^{-5}

30	-4.42×10^{-5}	75	3.6×10^{-6}	120	8.26×10^{-5}
33	-1.988×10^{-4}	78	-1.79×10^{-5}		
36	-2.77×10^{-5}	81	9.21×10^{-5}		
39	1.195×10^{-4}	84	6.00×10^{-5}		
42	1.960×10^{-4}	87	1.361×10^{-4}		
45	2.192×10^{-4}	90	5.72×10^{-5}		

A3. 1.0 pt

d (m)	$\bar{d}$ (m)	$d - \bar{d}$ (m)	standard deviation
6.85×10^{-5}	6.267×10^{-5}	5.5×10^{-6}	1.88×10^{-5}
7.36×10^{-5}		1.09×10^{-5}	
8.73×10^{-5}		2.46×10^{-5}	
7.93×10^{-5}		1.66×10^{-5}	
6.39×10^{-5}		1.2×10^{-6}	
3.22×10^{-5}		-3.05×10^{-5}	
6.05×10^{-5}		-2.2×10^{-6}	
3.20×10^{-5}		-3.07×10^{-5}	
4.71×10^{-5}		-1.56×10^{-5}	
8.26×10^{-5}		1.99×10^{-5}	

reference value of measurement (with standard deviation)：

$6.267 \times 10^{-5} \pm 1.88 \times 10^{-5}$ m

Experiment

A1-3

中文 (Official)

Part B. Deformation of cantilever beam and deduction of Young's modulus

B1. answer sheet. 1.0 pt

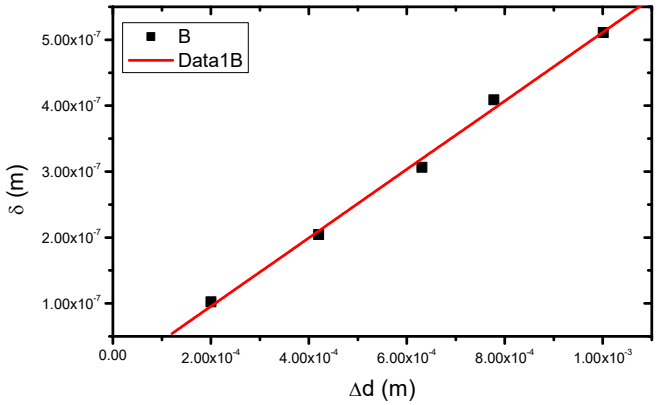
F (N)	d (m)	$\bar{d} = d_0$ (m)
0	-1.82×10^{-5}	-1.386×10^{-5}
	-1.09×10^{-5}	
	-6.69×10^{-5}	
	1.72×10^{-5}	
	9.5×10^{-6}	

F (N)	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
2.00×10^{-9}	1.9136×10^{-4}	2.0046×10^{-4}
	2.0016×10^{-4}	
	1.9766×10^{-4}	
	2.0096×10^{-4}	
	2.1216×10^{-4}	
4.00×10^{-9}	4.2336×10^{-4}	4.2018×10^{-4}
	4.1536×10^{-4}	
	4.3526×10^{-4}	
	4.0346×10^{-4}	
	4.2346×10^{-4}	
6.00×10^{-9}	6.4136×10^{-4}	6.3112×10^{-4}
	6.4646×10^{-4}	
	6.4256×10^{-4}	
	6.2186×10^{-4}	
	6.0336×10^{-4}	
8.00×10^{-9}	7.1906×10^{-4}	7.7770×10^{-4}
	7.8006×10^{-4}	
	8.0506×10^{-4}	
	7.7736×10^{-4}	
	8.0696×10^{-4}	

1.000×10^{-8}	1.01216×10^{-3}	1.00106×10^{-3}
	1.00076×10^{-3}	
	1.00336×10^{-3}	
	9.7846×10^{-4}	
	1.01076×10^{-3}	

B2. 1.0 pt

F (N)	δ (m)	$\overline{\Delta d}$ (m)
2.00×10^{-9}	1.022×10^{-7}	2.0046×10^{-4}
4.00×10^{-9}	2.044×10^{-7}	4.2018×10^{-4}
6.00×10^{-9}	3.066×10^{-7}	6.3112×10^{-4}
8.00×10^{-9}	4.088×10^{-7}	7.7770×10^{-4}
1.000×10^{-8}	5.109×10^{-7}	1.00106×10^{-3}



B3. 0.4 pt

$C_1 = 5.196 \times 10^{-4}$

Experiment

A1-5

中文 (Official)

Part C. Double layer cantilever beam

C1. 1.0 pt

T (K)	d (m)	$\bar{d} = d_0$ (m)
300	-2.28×10^{-5}	-2.836×10^{-5}
	-7.24×10^{-5}	
	-1.61×10^{-5}	
	-2.84×10^{-5}	
	-2.1×10^{-6}	

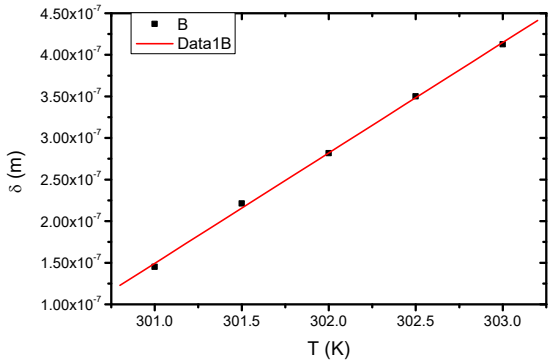
T (K)	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
301	2.8506×10^{-4}	2.7928×10^{-4}
	2.7186×10^{-4}	
	2.7466×10^{-4}	
	2.7436×10^{-4}	
	2.9046×10^{-4}	
301.5	4.1276×10^{-4}	4.2568×10^{-4}
	4.1336×10^{-4}	
	4.6276×10^{-4}	
	4.3956×10^{-4}	
	3.9996×10^{-4}	
302	5.4146×10^{-4}	5.4186×10^{-4}
	5.4676×10^{-4}	
	5.3386×10^{-4}	
	5.6706×10^{-4}	
	5.2016×10^{-4}	
302.5	6.9866×10^{-4}	6.7330×10^{-4}
	6.6726×10^{-4}	
	6.6416×10^{-4}	
	6.8296×10^{-4}	
	6.5346×10^{-4}	
303	7.6026×10^{-4}	7.9410×10^{-4}

	7.7046×10^{-4}	
	7.9706×10^{-4}	
	8.1346×10^{-4}	
	8.2926×10^{-4}	

C2. 1.0 pt

T (K)	$\overline{\Delta d}$ (m)	δ (m)
301	2.7928×10^{-4}	1.451×10^{-7}
301.5	4.2568×10^{-4}	2.212×10^{-7}
302	5.4186×10^{-4}	2.816×10^{-7}
302.5	6.7330×10^{-4}	3.499×10^{-7}
303	7.9410×10^{-4}	4.127×10^{-7}

Slope: 1.337×10^{-7}



C3. 0.6 pt

4.98×10^{10} N/m^2 (Pa)

Experiment

A1-7

中文 (Official)

Part D. Test of molecular-absorption-induced bending of a cantilever beam

D1. 0.6 pt

	d (m)	$\bar{d} = d_0$ (m)
Sample 0	3.4×10^{-6}	-7.2×10^{-6}
	-1.15×10^{-5}	
	-1.61×10^{-5}	
	2.09×10^{-5}	
	-3.25×10^{-5}	

	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
Sample 1	-8.2414×10^{-4}	-8.2552×10^{-4}
	-8.2884×10^{-4}	
	-8.2794×10^{-4}	
	-8.1934×10^{-4}	
	-8.2584×10^{-4}	

D2. Assume the function form of the displacement and coverage ratio (CR) 0.6 pt

can be expressed as： $\delta = C_2 \frac{CoverageRatio}{EI^*} L^4$. Estimate C_2 based on your data obtained in A9. You can use the correlation between δ and $\overline{\Delta d}$ in A6.

-7.89×10^{-2}

Experiment

A1-8

中文 (Official)

D3. 0.8 pt

	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
Sample 2	-6.1734×10^{-4}	-6.0866×10^{-4}
	-6.0434×10^{-4}	
	-6.0054×10^{-4}	
	-5.9884×10^{-4}	
	-6.2224×10^{-4}	
	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
Sample 3	-2.4924×10^{-4}	-2.4588×10^{-4}
	-2.6224×10^{-4}	
	-2.4764×10^{-4}	
	-2.4854×10^{-4}	
	-2.2174×10^{-4}	

D4. 0.6 pt

Sample 2: 0.738%

Sample 3: 0.298%

Experiment

A1-1

中文 (Official)

Elasticity of cantilever (10 points)
(Marking scheme)

Part A. Alignment of light path

A1 (marking scheme)	Total 0.6 pt
1. Draw 4 devices (laser, reflector, cantilever, and PSD) with relatively correct positions	0.2 pt
Draw 2 or 3 devices (from laser, reflector, cantilever, and PSD) with relatively correct positions	0.1 pt
2. Correctly plot the path of laser beam.	0.2 pt
3. Correctly mark the coordinates and angle of the reflector.	0.1 pt
4. Correctly mark the coordinates and angle of the PSD.	0.1 pt

A2. (marking scheme)	Total 0.8 pt
1. Fill in at least 40 sets of data.	0.2 pt
Fill in 20-39 sets of data.	0.1 pt
2. There are 10 data in the second column for d with fluctuation around 1.0000×10^{-3}.	0.2 pt
There are 5 data in the second column for d with fluctuation around 1.0000×10^{-3}.	0.1 pt
3. There are 10 data in the fourth column for d with fluctuation around 1.000×10^{-4}.	0.2 pt
There are 5 data in the fourth column for d with fluctuation around 1.000×10^{-4}.	0.1 pt
4. There are 10 data in the sixth column for d with fluctuation around 1.00×10^{-5}.	0.2 pt
There are 5 data in the sixth column for d with fluctuation around 1.00×10^{-5}.	0.1 pt

A3. (marking scheme)	Total 1.0 pt
1. Fill in 10 data in the first column d (m).	0.1 pt
2. The value in the second column $\bar{d}$ (m) is within $\pm$ two standard	0.2 pt

deviations. The value in the second column $\bar{d}$ (m) is reasonable (order of magnitudes).	0.1 pt
3. Fill in 10 data in the third column $d - \bar{d}$ (m).	0.1 pt
4. The value in the fourth column "standard deviations" is within $1.00 \times 10^{-5} \leq x \leq 5.00 \times 10^{-5}$. The value in the fourth column "standard deviation" is within $1.0 \times 10^{-6} \leq x < 1.00 \times 10^{-5}$ or $5.00 \times 10^{-5} < x \leq 5.000 \times 10^{-4}$.	0.4 pt 0.2 pt
5. Correctly write down the reference value of measurement (with standard deviation) as $\bar{d} \pm$ standard deviation (m).	0.2 pt

Part B. Deformation of cantilever beam and deduction of Young's modulus

B1. (marking scheme)	Total 1.0 pt
1. In the first table, the third column for $\bar{d} = d_0$ (m) is within $-3.0 \times 10^{-5} \leq x \leq 3.0 \times 10^{-5}$. In the first table, the third column for $\bar{d} = d_0$ (m) is within $-6.0 \times 10^{-5} \leq x < -3.0 \times 10^{-5}$ or $3.0 \times 10^{-5} < x \leq 6.0 \times 10^{-5}$。	0.5 pt 0.2 pt
2. In the second table, completely and reasonably fill in five rows. In the second table, completely and reasonably fill in four rows. In the second table, completely and reasonably fill in three rows. In the second table, completely and reasonably fill in two rows. In the second table, completely and reasonably fill in one row.	0.5 pt 0.4 pt 0.3 pt 0.2 pt 0.1 pt

B2. (marking scheme)	Total 1.0 pt
1. The ratio of data in the second column δ and that in the first column F is 5.12×10^{1}.	0.4 pt
2. Correctly mark x-axis as $\overline{\Delta d}$ (m)	0.2 pt
3. Correctly mark y-axis as δ (m)	0.2 pt
4. Correctly mark the data points on the plot.	0.2 pt

Experiment

A1-3

中文 (Official)

B3. (marking scheme)	Total 0.4 pt
1. The value of C_1 is within $4.6 \times 10^{-4} \leq x \leq 5.4 \times 10^{-4}$。 The value of C_1 is within $4.2 \times 10^{-4} \leq x < 4.6 \times 10^{-4}$ or $5.4\times 10^{-4} < x \leq 5.8 \times 10^{-4}$.	0.4 pt 0.2 pt

Part C. Double layer cantilever beam

C1. (marking scheme)	Total 1.0 pt
1. In the first table, the third column for $\bar{d} = d_0$ (m) is within $-3.0 \times 10^{-5} \leq x \leq 3.0 \times 10^{-5}$. In the first table, the third column for $\bar{d} = d_0$ (m) is within $-6.0 \times 10^{-5} \leq x < -3.0 \times 10^{-5}$ or $3.0 \times 10^{-5} < x \leq 6.0 \times 10^{-5}$.	0.5 pt 0.2 pt
2. In the second table, completely and reasonably fill in five rows. In the second table, completely and reasonably fill in four rows. In the second table, completely and reasonably fill in three rows. In the second table, completely and reasonably fill in two rows. In the second table, completely and reasonably fill in one row.	0.5 pt 0.4 pt 0.3 pt 0.2 pt 0.1 pt

C2. (marking scheme)	Total 1.0 pt
1. The ratio of data in the third column δ and the second column $\overline{\Delta d}$ is the same as the value of C_1 in B3.	0.2 pt
2. Correctly mark x-axis as T (K)。	0.2 pt
3. Correctly mark y-axis as δ (m)。	0.2 pt
4. Correctly mark the data points on the plot.	0.2 pt
5. Slope is within $1.0 \times 10^{-7} \leq x \leq 1.5 \times 10^{-7}$ (m/K)	0.2 pt

C3. (marking scheme)	Total 0.6 pt
1. Young's modulus is within $3.0 \times 10^{10} \leq x \leq 6.0 \times 10^{10}$ Young's modulus is within $1.0 \times 10^{10} \leq x < 3.0 \times 10^{10}$ or $6.0 \times 10^{10} < x \leq 9.0 \times 10^{10}$	0.4 pt 0.2 pt
2. Unit: N/m^2 or (Pa)	0.2 pt

Experiment

A1-4

中文 (Official)

Part D. Test of molecular-absorption-induced bending of a cantilever beam

D1. (marking scheme)	Total 0.6 pt
1. Sample 0: the third column for d_0 is within $-3.0\times10^{-5}\le x\le 3.0\times10^{-5}$ Sample 0: the third column for d_0 is within$-6.0\times10^{-5}\le x< -3.0\times10^{-5}$ or $3.0\times10^{-5}< x\le 6.0\times10^{-5}$	0.2 pt 0.1 pt
2. Completely and reasonably fill in the table for Sample 0.	0.2 pt
3. Completely and reasonably fill in the table for Sample 1.	0.2 pt

D2. (marking scheme)	Total 0.6 pt
1. C_2 is within $-7.0\times10^{-2}\le x\le -8.0\times10^{-2}$ (N/m) C_2在$-5.0\times10^{-2}\le x\le -7.0\times10^{-2}$ or $-8.0\times10^{-2}\le x\le -10.0\times10^{-2}$ (N/m)	0.6 pt 0.3 pt

D3. (marking scheme)	Total 0.8 pt
1. Sample 2: value of $\overline{\Delta d}$ (m) within $-6.3\times10^{-4}\le x\le -5.7\times10^{-4}$ Sample 2: value of $\overline{\Delta d}$ (m) within $-6.6\times10^{-4}\le x< -6.3\times10^{-4}$ or $-5.7\times10^{-4}< x\le -5.4\times10^{-4}$。	0.4 pt 0.2 pt
2. Sample 3: value of $\overline{\Delta d}$ (m) within $-2.7\times10^{-4}\le x\le -2.1\times10^{-4}$ Sample 3: value of $\overline{\Delta d}$ (m) within $-3.0\times10^{-4}\le x< -2.7\times10^{-4}$ or $-2.1\times10^{-4}< x\le -1.8\times10^{-4}$。	0.4 pt 0.2 pt

D4. (marking scheme)	Total 0.6 pt
1. Sample 2: coverage ratio within $0.6\%\le x\le 0.8\%$ Sample 2: coverage ratio within $0.4\%\le x\le 0.6\%$ or $0.8\%\le x\le 10.0\%$	0.3 pt 0.1 pt
2. Sample 3: coverage ratio within $0.25\%\le x\le 0.35\%$ Sample 3: coverage ratio within $0.15\%\le x\le 0.25\%$ or $0.35\%\le x\le 0.45\%$	0.3 pt 0.1 pt

Experiment
Solution

A2

English

Q2 Exploring the spatial structure of the sample with optical methods

Solution

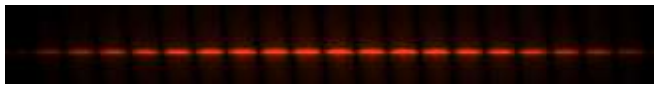
Part A. Collimation of light and sample

A.1 0.5 pt

(X_{sample}, Y_{sample})= **(3700, -2900)**

A.2 0.5 pt

Interference pattern:



Order, fringe	-2, Dark	-1, Dark	1, Dark	2, Dark
(x, y)	**(-0.98 , 0)**	**(-0.38, 0)**	**(0.34, 0)**	**(0.98, 0)**
S (cm)	**0.98**	**0.38**	**0.34**	**0.98**
ΔS (cm)	**0.65**			

Part B. Exploration of sample structure size

B.1 0.5 pt

$$d = \frac{m \times \lambda}{\sin\left(\tan^{-1}\left(\frac{S}{L}\right)\right)}$$

Experiment
Solution

A2

English

B.2 1.5 pt

L = **60 cm**

λ = **488 nm**

Data	1	2	3	4	5
(x, y)	(-4.04, 4.68)	(3.00, 5.50)	(4.08, -4.60)	(5.76, 0.48)	(-5.68, 0.56)
S (cm)	**6.18**	**6.26**	**6.15**	**5.78**	**5.71**
$\bar{S}$ (cm)	$\mathbf{6.02 \pm 0.11}$				
$tan^{-1}\left(\frac{\bar{S}}{L}\right)$	$\mathbf{0.0999 \pm 0.0019}$				

λ = **514 nm**

Data	1	2	3	4	5
(x, y)	(3.32,5.64)	(6.16,0.48)	(4.46,-4.90)	(-3.12,-5.64)	(-6,-0.64)
S (cm)	**6.54**	**6.18**	**6.63**	**6.45**	**6.03**
$\bar{S}$ (cm)	$\mathbf{6.37 \pm 0.11}$				
$tan^{-1}\left(\frac{\bar{S}}{L}\right)$	$\mathbf{0.1057 \pm 0.0019}$				

λ = **632.8 nm**

Data	1	2	3	4	5
(x, y)	(4.04,7.00)	(7.44,0.68)	(5.24,-5.96)	(-3.96,-7.04)	(-7.44,-0.68)
S (cm)	**8.08**	**7.47**	**7.94**	**8.08**	**7.47**
$\bar{S}$ (cm)	$\mathbf{7.81 \pm 0.14}$				
$tan^{-1}\left(\frac{\bar{S}}{L}\right)$	$\mathbf{0.1294 \pm 0.0023}$				

λ = **694.3 nm**

Data	1	2	3	4	5
(x, y)	(-5.84,6.50)	(8.20,0.76)	(-4.28,-7.72)	(5.96,-6.60)	(4.48,7.72)
S (cm)	**8.74**	**8.24**	**8.83**	**8.89**	**8.93**

$\bar{S}$ (cm)	$\mathbf{8.73 \pm 0.13}$
$tan^{-1}\left(\frac{\bar{S}}{L}\right)$	$\mathbf{0.1444 \pm 0.0021}$

B.3 1.0 pt

$$a = 5.627\ \mu m$$

λ (nm)	d (µm)	a (µm)
488	4.89	5.65
514	4.87	5.63
632.8	4.90	5.66
$\bar{a}$ (µm)	$\mathbf{5.627 \pm 0.020}$	

Experiment
Solution

A2

English

Part C. Exploration of sample structure size

C.1 0.8 pt

λ = **488 nm**

L=90 cm, Axis1				
Order, fringe	4, Bright	5, Bright	6, Bright	7, Bright
(x, y)	**(3.01, 1.46)**	**(3.67, 1.91)**	**(4.30, 2.24)**	**(5.00, 2.50)**
S (cm)	**3.35**	**4.14**	**4.85**	**5.59**
$tan^{-1}\left(\frac{S}{L}\right)$	**0.0372**	**0.0459**	**0.0538**	**0.0620**

L=90 cm, Axis 2				
Order, fringe	4, Bright	5, Bright	6, Bright	7, Bright
(x, y)	**(-1.64, 3.46)**	**(-2.07, 4.19)**	**(-2.41, 4.95)**	**(-2.87, 5.73)**
S (cm)	**3.83**	**4.67**	**5.51**	**6.41**
$tan^{-1}\left(\frac{S}{L}\right)$	**0.0425**	**0.0519**	**0.0611**	**0.0711**

λ = **514 nm**

L=90 cm, Axis1				
Order, fringe	4, Bright	5, Bright	6, Bright	7, Bright
(x, y)	**(3.08, 1.56)**	**(3.76, 1.92)**	**(4.44, 2.28)**	**(5.20, 2.60)**
S (cm)	**3.45**	**4.22**	**4.99**	**5.81**
$tan^{-1}\left(\frac{S}{L}\right)$	**0.0383**	**0.0469**	**0.0554**	**0.0645**

L=90 cm, Axis 2				
Order, fringe	4, Bright	5, Bright	6, Bright	7, Bright
(x, y)	**(-1.76, 3.68)**	**(-2.26, 4.38)**	**(-2.58, 5.34)**	**(-3.22, 6.04)**
S (cm)	**4.09**	**4.92**	**5.93**	**6.84**
$tan^{-1}\left(\frac{S}{L}\right)$	**0.0454**	**0.0547**	**0.0658**	**0.0759**

$\lambda =$ **632.8 nm**

L=90 cm, Axis1				
Order, fringe	4, Bright	5, Bright	6, Bright	7, Bright
(x, y)	**(3.84, 1.96)**	**(4.68, 2.44)**	**(5.48, 2.88)**	**(6.44, 3.32)**
S (cm)	**4.31**	**5.28**	**6.19**	**7.25**
$tan^{-1}\left(\frac{S}{L}\right)$	**0.0479**	**0.0586**	**0.0687**	**0.0803**

L=90 cm, Axis 2				
Order, fringe	4, Bright	5, Bright	6, Bright	7, Bright
(x, y)	**(-2.28, 4.56)**	**(-2.84, 5.48)**	**(-3.36, 6.52)**	**(-3.84, 7.52)**
S (cm)	**5.10**	**6.17**	**7.33**	**8.44**
$tan^{-1}\left(\frac{S}{L}\right)$	**0.0566**	**0.0685**	**0.0813**	**0.0935**

Experiment
Solution

A2

English

λ = **694.3 nm**

L=90 cm, Axis 1				
Order, fringe	4, Bright	5, Bright	6, Bright	7, Bright
(x, y)	**(4.24, 2.12)**	**(5.08, 2.80)**	**(6.04, 3.20)**	**(7.04, 3.68)**
S (cm)	**4.74**	**5.80**	**6.84**	**7.96**
$tan^{-1}\left(\frac{S}{L}\right)$	**0.0526**	**0.0644**	**0.0758**	**0.0882**

L=90 cm, Axis 2				
Order, fringe	4, Bright	5, Bright	6, Bright	7, Bright
(x, y)	**(-2.48, 5.00)**	**(-3.08, 6.04)**	**(-3.60, 7.16)**	**(-4.16, 8.28)**
S (cm)	**5.58**	**6.78**	**8.01**	**9.27**
$tan^{-1}\left(\frac{S}{L}\right)$	**0.0619**	**0.0752**	**0.0888**	**0.103**

Experiment
Solution

A2

English

C.2 0.7 pt

λ (nm)	ΔS_ℓ (cm)	ℓ (µm)	ΔS_w (cm)	w (µm)
488	0.748	58.7	0.860	51.1
	0.750	58.5	0.842	52.1
514	0.787	58.8	0.920	50.3
	0.794	58.3	0.891	51.9
632.8	0.978	58.2	1.12	51.1
	0.960	59.3	1.11	51.4
694.3	1.07	58.2	1.23	50.9
	1.07	58.2	1.22	51.4

$$\ell = 58.59\ \mu\text{m}$$
$$w = 50.78\ \mu\text{m}$$

Experiment

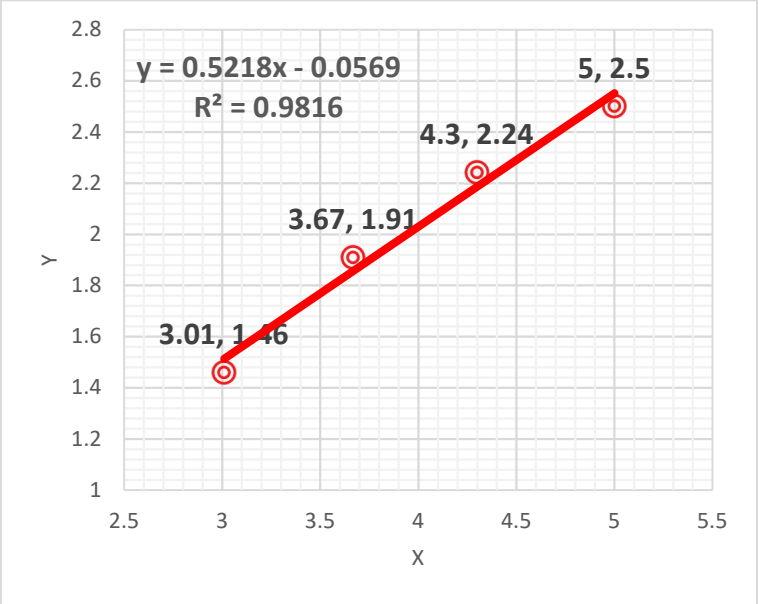
Solution

A2

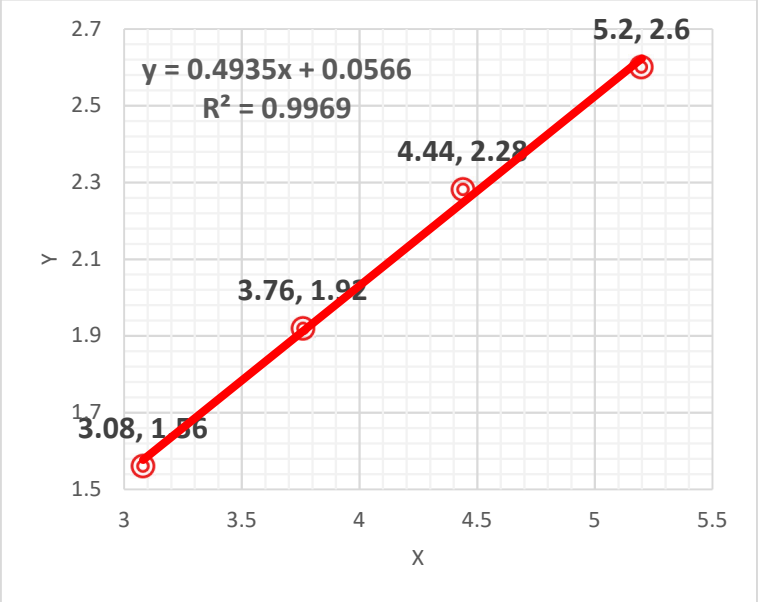
English

C.3 $\phi = 27°$ 1.0 pt

$\lambda =$ **488 nm** Axis 1 (long) $\phi =$ **27.6°**



$\lambda =$ **514 nm** Axis 1 (long) $\phi =$ **26.2°**

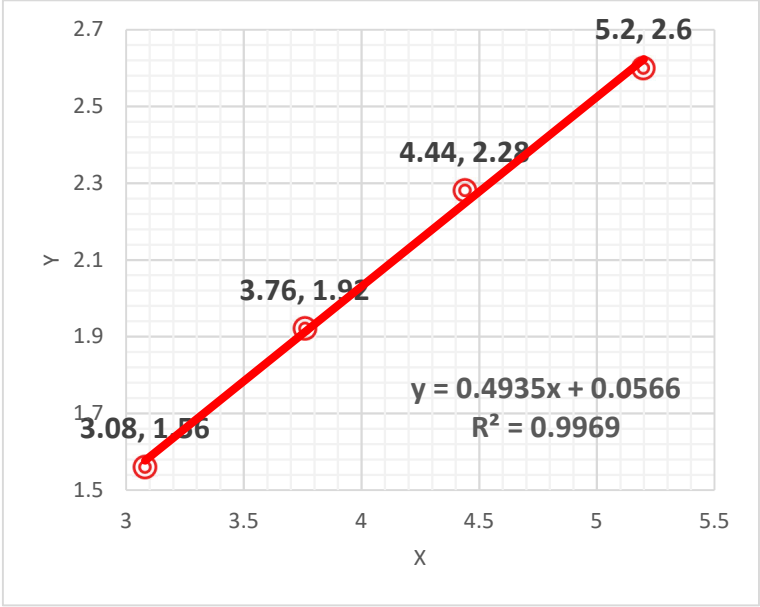


Experiment Solution

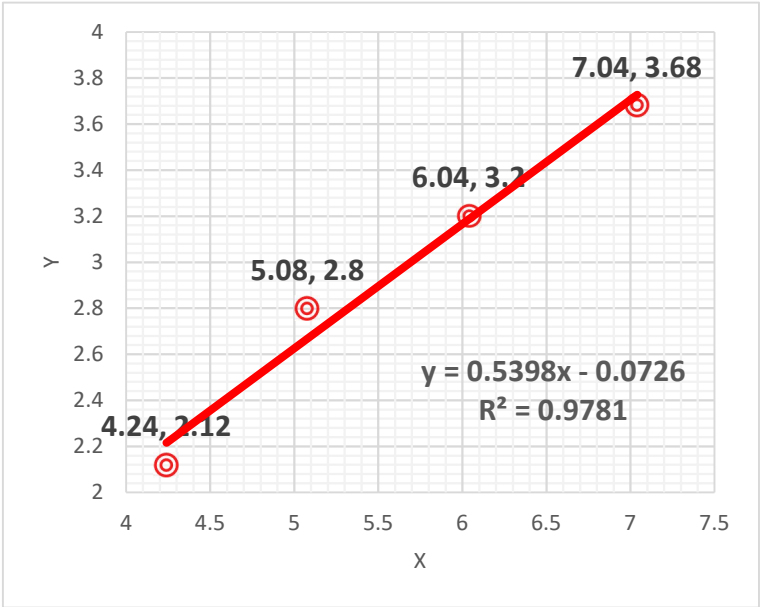
A2

English

$\lambda =$ **632.8 nm** Axis 1 (long) $\phi =$ **27.7**



$\lambda =$ **694.3 nm** Axis 1 (long) $\phi =$ **28.4**



Experiment

Solution

A2

English

Part D. Exploration of sample structure size

D.1 1.9 pt

Laser wavelength λ = **914 nm**			
The center coordinates of the fine diffraction bright spot (x, y) long			
(1.98, 0.40)	**(2.36, 1.62)**	**(2.64, 1.68)**	**(3.02, 1.68)**
(1.96, 0.82)	**(2.32, 1.22)**	**(2.70, 1.28)**	**(3.02, 1.30)**
(1.98, 1.24)	**(2.32, 0.84)**	**(2.66, 0.84)**	**(3.04, 1.66)**
(1.98, 1.66)	**(2.36, 0.42)**	**(2.62, 0.40)**	**(2.98, 0.50)**
The center coordinates of the fine diffraction bright spot (x, y) short			
(-2.06, 3.48)	**(-1.72, 3.48)**	**(-1.38, 3.46)**	**(-1.06, 3.46)**
(-2.08, 3.08)	**(-1.74, 3.08)**	**(-1.40, 3.14)**	**(-1.00, 3.12)**
(-2.08, 2.64)	**(-1.74, 2.65)**	**(-1.38, 2.62)**	**(-1.02, 2.62)**
(-2.06, 2.16)	**(-1.68, 2.22)**	**(-1.36, 2.22)**	**(-1.02, 2.14)**
Calculate the distances between adjacent spots ΔS_x 、ΔS_y			

	ΔS_x (cm)	ΔS_y (cm)
long	**0.346**	**0.410**
short	**0.348**	**0.428**

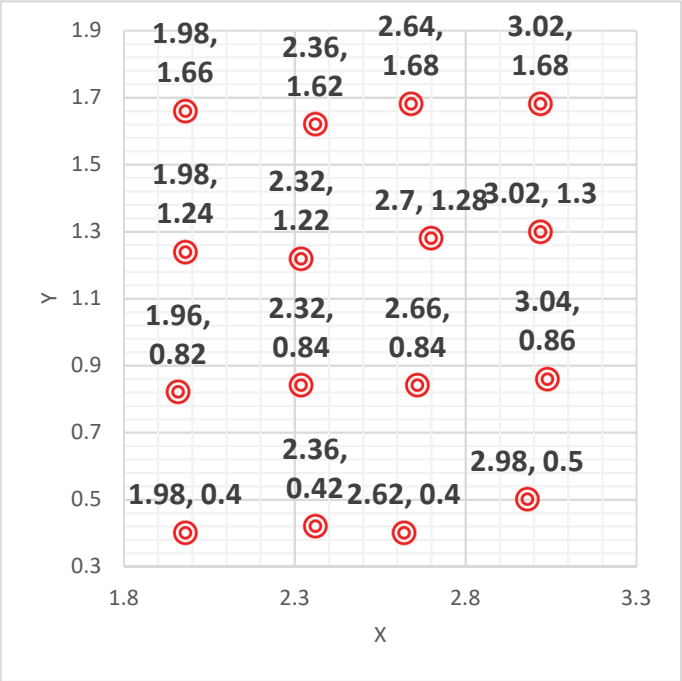
Experiment
Solution

A2

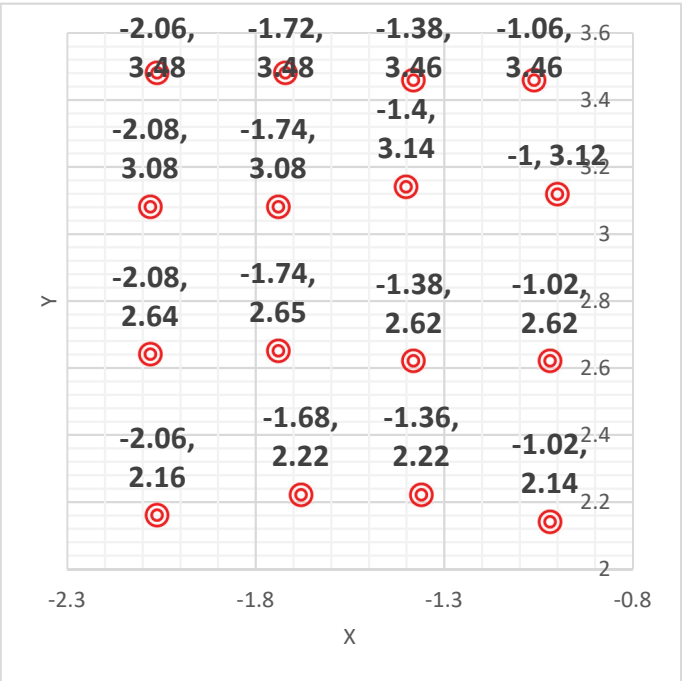
English

D.1.

long



short



Experiment Solution

A2

English

Laser wavelength λ = **1152 nm**			
The center coordinates of the fine diffraction bright spot (x, y) long			
(2.16, 0.56)	**(2.60, 0.56)**	**(3.04, 0.56)**	**(3.48, 0.56)**
(2.12, 1.16)	**(2.58, 1.16)**	**(3.06, 1.14)**	**(3.48, 1.12)**
(2.12, 1.64)	**(2.60, 1.66)**	**(3.04, 1.68)**	**(3.48, 1.66)**
(2.14, 2.26)	**(2.62, 2.22)**	**(3.08, 2.18)**	**(3.48, 2.24)**
The center coordinates of the fine diffraction bright spot (x, y) **short**			
(-3.44, 4.44)	**(-2.68, 4.42)**	**(-2.20, 4.42)**	**(-1.78, 4.42)**
(-3.10, 3.86)	**(-2.70, 3.88)**	**(-2.24, 3.84)**	**(-1.82, 3.88)**
(-3.20, 3.38)	**(-2.74, 3.38)**	**(-2.22, 3.34)**	**(-1.76, 3.34)**
(-3.14, 2.78)	**(-2.68, 2.78)**	**(-2.22, 2.78)**	**(-1.76, 2.76)**

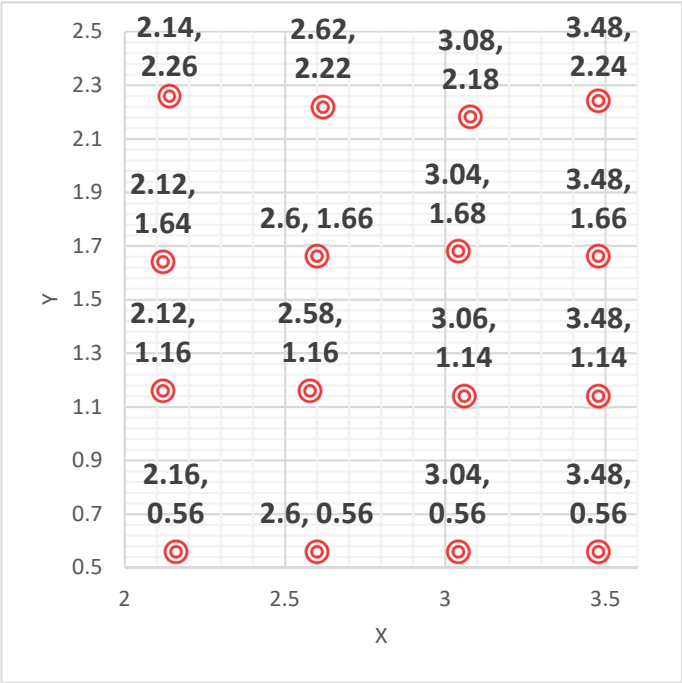
	ΔS_x (cm)	ΔS_y (cm)
long	**0.448**	**0.555**
short	**0.452**	**0.550**

Experiment
Solution

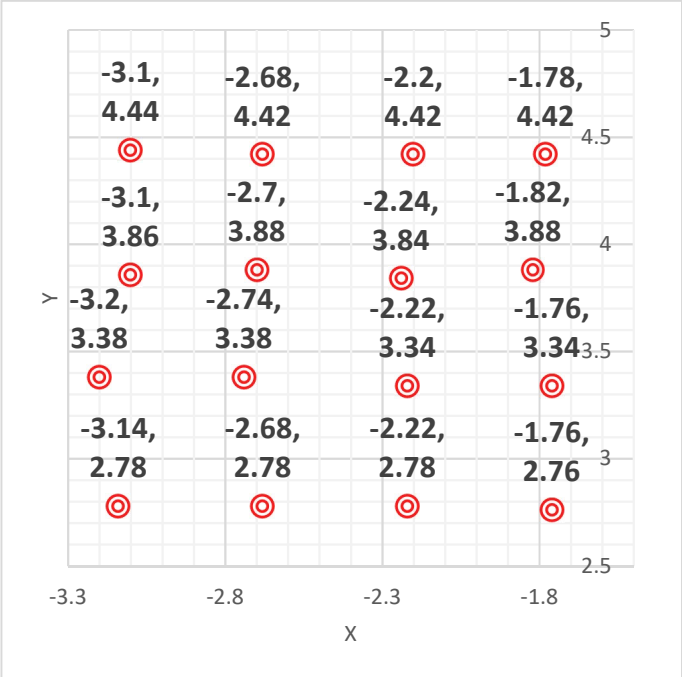
A2

English

long



short



Experiment Solution

A2

English

Laser wavelength λ = **1444 nm**

The center coordinates of the fine diffraction bright spot (x, y) long

(3.34, 0.02)	**(3.86, 0.02)**	**(4.42, 0.02)**	**(4.94, 0.04)**
(3.34, 0.70)	**(3.84, 0.72)**	**(4.42, 0.70)**	**(4.94, 0.74)**
(3.36, 1.42)	**(3.86, 1.42)**	**(4.44, 1.40)**	**(5.00, 1.46)**
(3.34, 2.08)	**(3.86, 2.08)**	**(4.48, 2.08)**	**(5.00, 2.10)**

The center coordinates of the fine diffraction bright spot (x, y) **short**

(-3.86, 4.16)	**(-3.32, 4.18)**	**(-2.74, 4.18)**	**(-2.14, 4.16)**
(-3.84, 3.48)	**(-3.28, 3.48)**	**(-2.72, 3.48)**	**(-2.12, 3.48)**
(-3.80, 2.78)	**(-3.26, 2.78)**	**(-2.72, 2.78)**	**(-2.12, 2.80)**
(-3.78, 2.02)	**(-3.26, 2.06)**	**(-2.70, 2.06)**	**(-2.00, 1.98)**

計算圖形斑點間距ΔS_x、ΔS_y **0.5 pt**

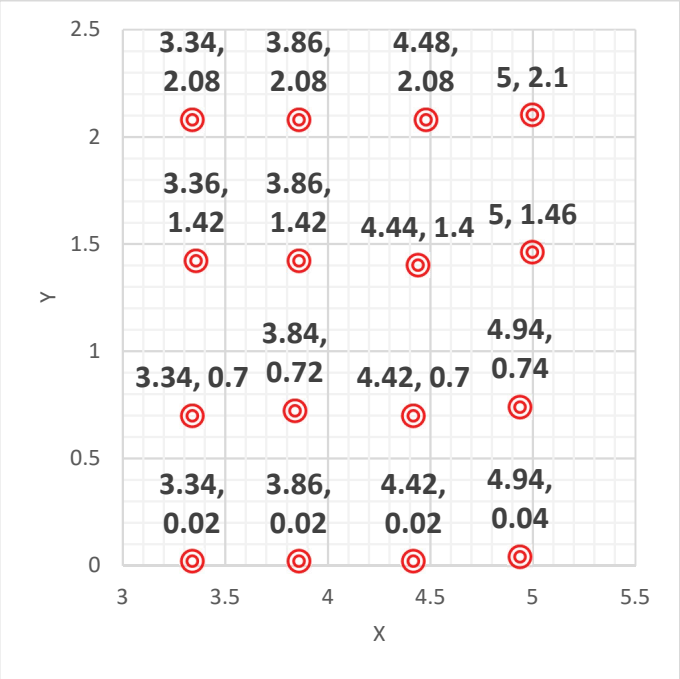
	ΔS_x (cm)	ΔS_y (cm)
long	**0.542**	**0.687**
short	**0.575**	**0.713**

Experiment Solution

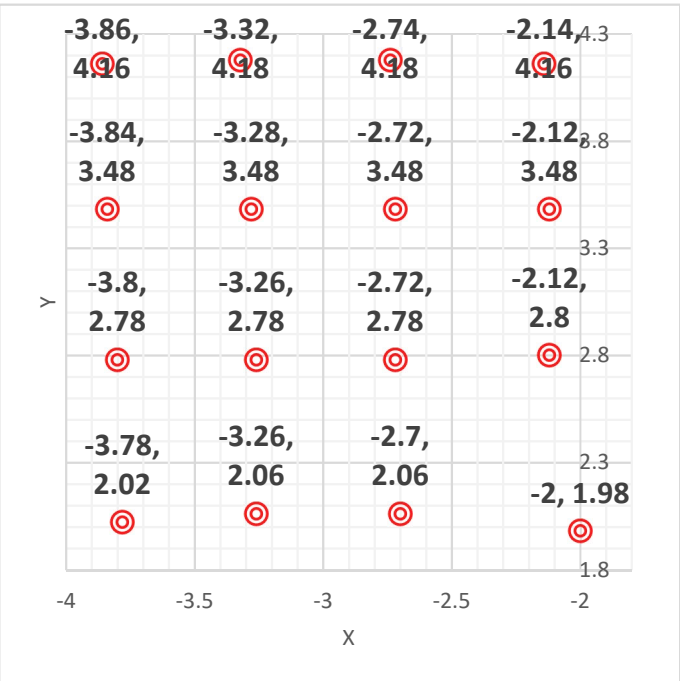
A2

English

long



short



Experiment

Solution

A2

English

D.2 0.6 pt

$d_x = 249.3\ \mu m$ $d_y = 198.2\ \mu m$

λ (nm)		d_x (µm)	d_y (µm)
914	long Axis	251	211
	short Axis	250	203
1152	long Axis	244	197
	short Axis	242	199
1444	long Axis	253	199
	short Axis	239	192

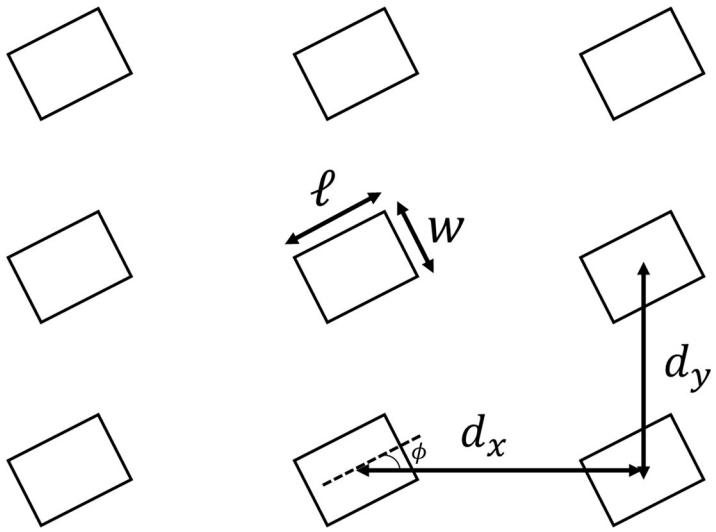
Experiment
Solution

A2

English

Part E. Exploration of sample structure size

E.1. 1.0 pt



$(a, \ell, w, d_x, d_y, \phi) =$

(5.627 um, 58.59 um, 50.78 um, 249.3 um, 198.2 um, 27 degree)

Experiment
Marking Scheme

E2

English

Q2 Exploring the spatial structure of the sample with optical methods (10 points)

Part		Score	Partial Score	Remarks	Totals
A	A1	0.5	0.25	For X: within ±300 ; ±(400~600), 0.1 pt	1.0
			0.25	For Y: within±500 ; ±(600~1000), 0.1 pt	
	A2	0.5	0.1	Interference pattern shown	
			0.15	First order: (x,y) and S within (±0.08, ±0.08)	
			0.15	Second order: (x,y) and S within (±0.08, ±0.08)	
			0.1	ΔS within ±0.04	
B	B1	0.5	0.5	Correct formula for d	3.0
	B2	1.5	0.25x3	(x,y) and S, each column, 0.05 pt	
			0.25x3	$tan^{-1}\left(\frac{\bar{S}}{L}\right)$: within ±10%; ±11%~20%, 0.1pt	
	B3	1.0	0.1x3	Correct calculation for d, 0.1 pt each	
			0.2x3	Correct calculation for a, 0.2 pt each	
			0.1	$\bar{a}$; within 0.35%	
C	C1	0.8	0.1x4	$tan^{-1}\left(\frac{S}{L}\right)$ within 2% for 4-7 order on Axis1 within 2%~5%, 0.05 pt	2.5
			0.1x4	$tan^{-1}\left(\frac{S}{L}\right)$ within 2% for 4-7 order on Axis2 within 2%~5%, 0.05 pt	
	C2	0.7	0.15	ΔS_ℓ correct calculation by average; without average values 0.1 pt	
			0.15	ΔS_w correct calculation by average; without average values 0.1 pt	
			0.2	Correct calculation for ℓ	
			0.2	Correct calculation for w	
	C3	1.0	0.4	Correct drawing	
			0.6	Angle ϕ ; ± 1.50°; ±1.51° ~ ±3.00°, 0.3pt	

Experiment
Marking Scheme

E2

English

				90°- ϕ within ±1.50°, 0.2pt; 90°- ϕ within ±1.51°~ ±3.00°, 0.1pt		
D	D1	1.9	1.2	correct coordinates and diagram score scaled from numbers of bright spots (from 2×2 to 4×4)		2.5
			0.2	notation of $\triangle S_x$ and $\triangle S_y$		
			0.5	0.1	calculation methods	
				0.4	0.4 for $\triangle S_x$ and $\triangle S_y$ within ± 0.4 cm 0.2 for $\triangle S_x$ and $\triangle S_y$ within ± 1.0 cm	
	D2	0.6	0.6	d_x ; d_y within ± 2.5%		
			0.4	d_x ; d_y within ± 5%		
			0.2	d_x ; d_y with ± 10%		
E	E1	1.0	0.2	Correct mark for ℓ		1.0
			0.2	Correct mark for w		
			0.2	Correct mark for d_x		
			0.2	Correct mark for d_x		
			0.2	Correct mark for ϕ		