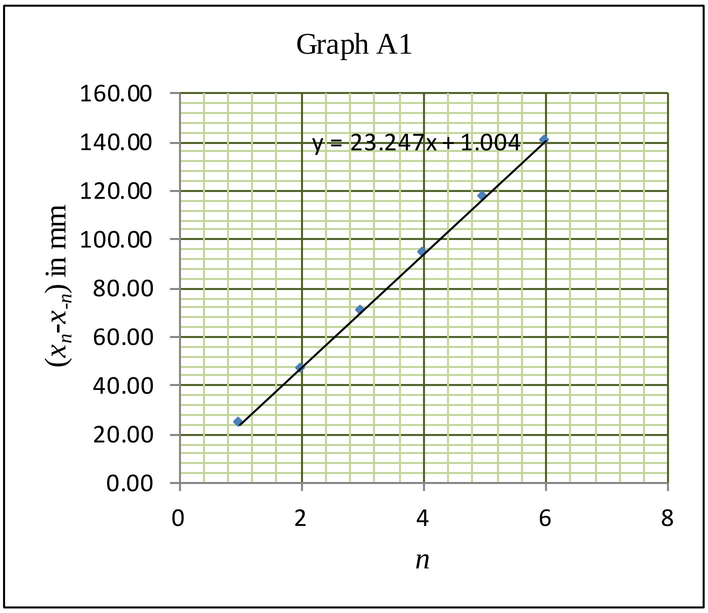
Part A: Determination of geometrical parameters of a helical spring

<table>
<tr><th>Tasks</th><th>Description</th><th>Marks</th></tr>
<tr><td>A1</td><td>Number of attached pattern marking sheet(s) for Part A: 2 with label(s): P1, P2 (patterns on page 7)</td><td>0.7</td></tr>
<tr><td>A2</td><td>Table A1: Observations from pattern P1
<table>
<tr><th>Sr. No.</th><th>Order (n)</th><th>$(x_n - x_{-n})$ in mm</th></tr>
<tr><td>1</td><td>1</td><td>24.40</td></tr>
<tr><td>2</td><td>2</td><td>47.24</td></tr>
<tr><td>3</td><td>3</td><td>70.69</td></tr>
<tr><td>4</td><td>4</td><td>94.08</td></tr>
<tr><td>5</td><td>5</td><td>117.53</td></tr>
<tr><td>6</td><td>6</td><td>140.28</td></tr>
</table></td><td>0.5</td></tr>
<tr><td>A3</td><td>

Graph A1 for determination of a_1: n versus $(x_n - x_{-n})$
Slope of the graph A1 = 23.25 mm
Calculation of a_1:
$$a_1 = 2 \times \lambda \times \frac{D}{\text{Slope}} = 2 \times \lambda \times \frac{2770}{23.25}$$
$a_1 = 0.151$ mm</td><td>0.7</td></tr>
</table>

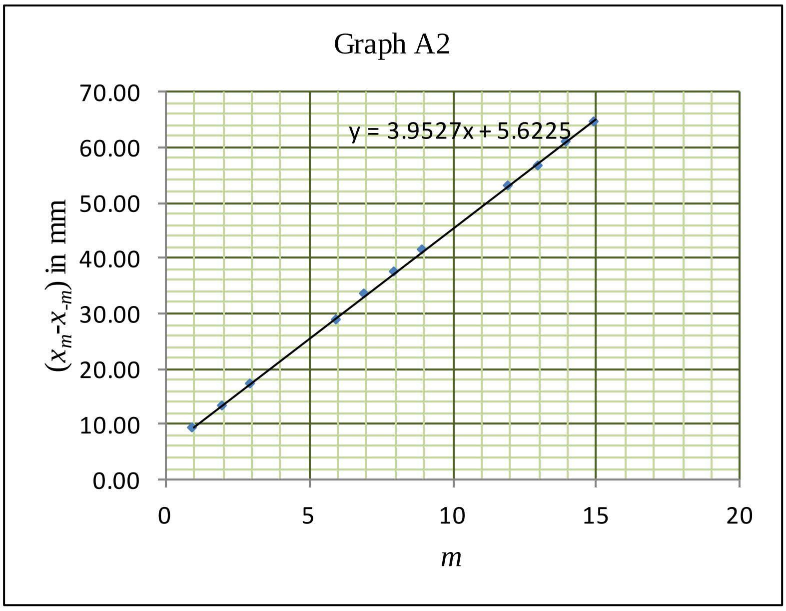
A4

Table A2: Observations from pattern P1

Sr. No.	m	$(x_m - x_{-m})$ in mm
1	1	9.39
2	2	13.43
3	3	17.53
4	6	28.98
5	7	33.53
6	8	37.66
7	9	41.61
8	12	52.93
9	13	56.76
10	14	61.03
11	15	64.74

0.8

A5



Graph A2 for determination of d_1: m versus $(x_m - x_{-m})$

Slope of the graph A2 = 3.95 mm

Calculation of d_1:

$$d_1 = 2 \times \lambda \times \frac{D}{\text{Slope}} = 2 \times 0.000635 \times \frac{2770}{3.95}$$

$$d_1 = 0.89\ mm$$

0.6

A6

$$\alpha_1 = \ 10.96°$$

0.2

A7

Expression of P in terms of d_1 and α_1:

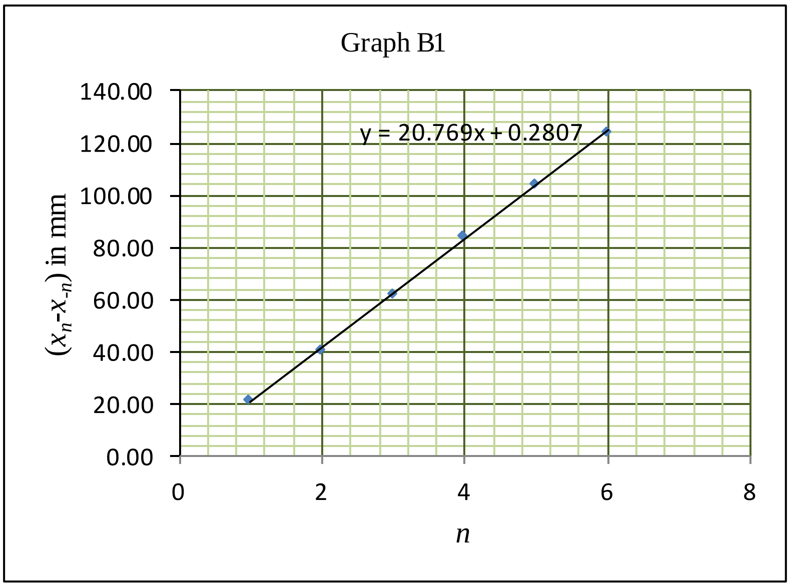
$$P = \frac{d_1}{\cos \alpha_1} = \frac{0.89}{\cos 10.96}$$

$$P = 0.91 \text{ mm}$$

0.2

<table>
<tr><td>A8</td><td>Expression of R in terms of P and α_1:
$\tan\alpha_1 = \frac{P}{2\pi R}$
$R = \frac{P}{2\times\pi\times\tan\alpha_1} = \frac{0.91}{2\times\pi\times\tan 10.96}$
$R = 0.75$ mm</td><td>0.2</td></tr>
<tr><td colspan="2" align="right">Total</td><td>3.9</td></tr>
</table>

Part B: Determination of geometrical parameters of double-helix-like pattern

<table>
<tr><th>Tasks</th><th>Description</th><th>Marks</th></tr>
<tr><td>B1</td><td>Attached pattern marking sheet number(s): 2 with label(s): P3, P4 (patterns on page 7)</td><td>1.1</td></tr>
<tr><td>B2</td><td>Table B1: Observations from pattern P3
<table>
<tr><th>Sr. No.</th><th>Order (n)</th><th>$(x_n - x_{-n})$ in mm</th></tr>
<tr><td>1</td><td>1</td><td>21.24</td></tr>
<tr><td>2</td><td>2</td><td>41.12</td></tr>
<tr><td>3</td><td>3</td><td>62.41</td></tr>
<tr><td>4</td><td>4</td><td>84.40</td></tr>
<tr><td>5</td><td>5</td><td>104.41</td></tr>
<tr><td>6</td><td>6</td><td>124.25</td></tr>
</table></td><td>0.5</td></tr>
<tr><td>B3</td><td>

Graph B1 for determination of a_2: n versus $(x_n - x_{-n})$
Slope of the graph B1 = 20.8 mm
Calculation of a_2: $a_2 = 2\times\lambda\times\frac{D}{\text{Slope}} = 2\times 0.000635\times\frac{795}{20.8}$
$a_2 = 0.049$ mm</td><td>0.5</td></tr>
</table>

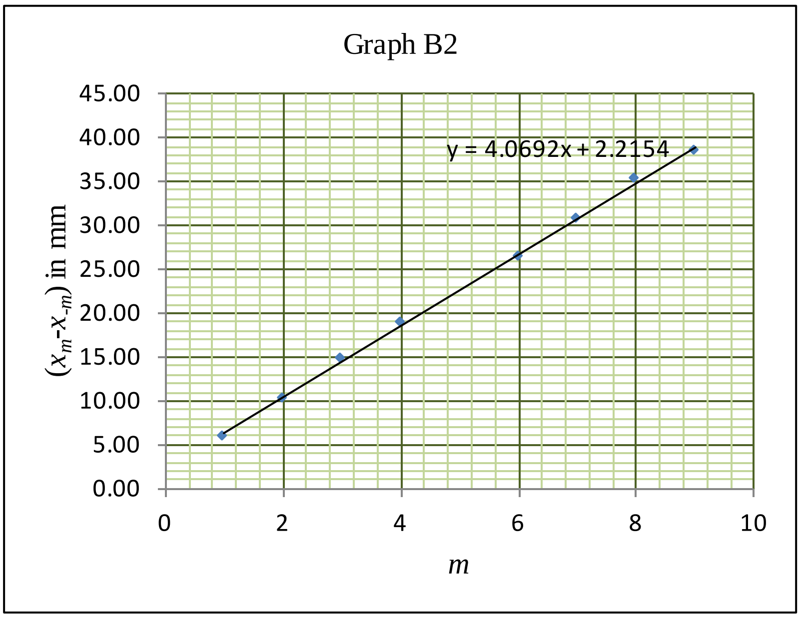
B4

Table B2: Observations from pattern P3

Sr. No.	m	$(x_m - x_{-m})$ in mm
1	1	5.84
2	2	10.29
3	3	14.83
4	4	18.84
5	6	26.44
6	7	30.65
7	8	35.26
8	9	38.34

1.2

B5



Graph B2 for determination of s: m versus $(x_m - x_{-m})$

Slope of the graph B2 = 4.07 mm

Calculation of s: $s = 2 \times \lambda \times \frac{D}{\text{Slope}} = 2 \times 0.000635 \times \frac{795}{4.07}$

$s = 0.248$ mm

0.5

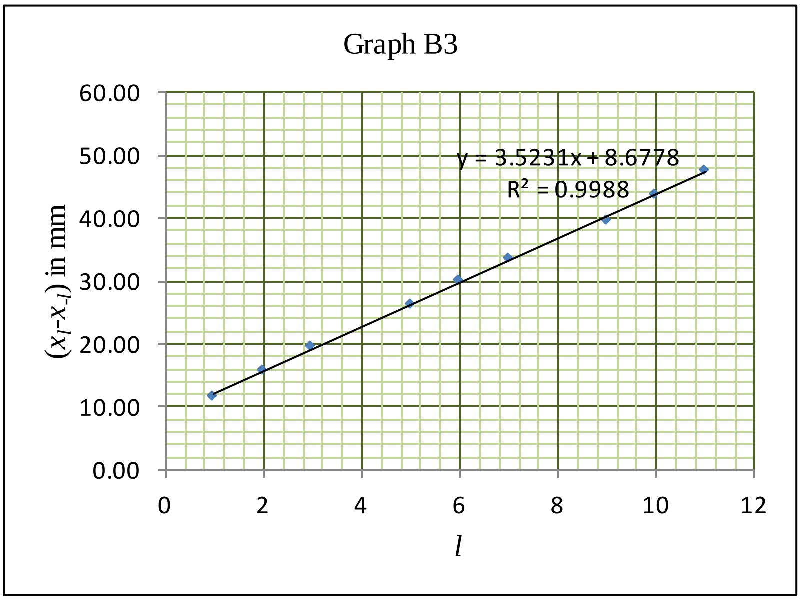
B6

Table B3 Observations from pattern P4

Sr. No.	Order (l)	$(x_l - x_{-l})$ in mm
1	1	11.64
2	2	15.77
3	3	19.71
4	5	26.33
5	6	30.14
6	7	33.69
7	9	39.62
8	10	43.70
9	11	47.75

1.6

B7



Graph B3 for determination of d_2: l versus $(x_l - x_{-l})$

Slope of the graph B3 = 3.52 mm

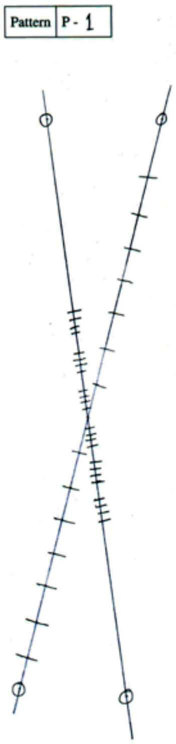
Calculation of d_2: $d_2 = 2 \times \frac{\lambda \times D}{\text{Slope}} = 2 \times 0.000635 \times \frac{2770}{3.52}$

$d_2 = 1.00$ mm

0.5

B8 $\alpha_2 = 9.88°$ **0.2**

Total **6.1**



Pattern P1 ($D = 2770$ mm)

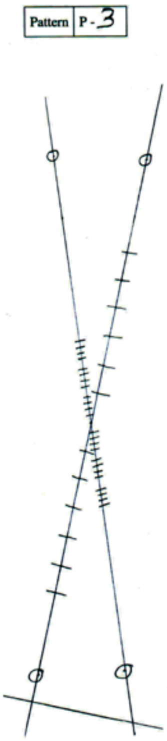
$$\tan 2\alpha_1 = \frac{42.43}{105.40}$$

$$\alpha_1 = 10.96\,°$$

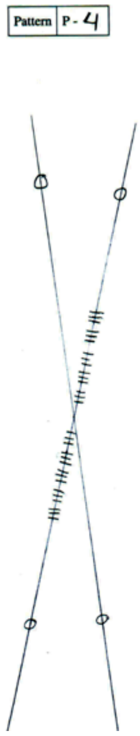
Pattern P2

$$\tan 2\alpha_2 = \frac{36.67}{102.04}$$

$$\alpha_2 = 9.88°$$



Pattern P3 ($D = 795$ mm)



Pattern P4 ($D = 2770$ mm)

Diffraction due to surface tension waves on water

Part C: Measurement of angle, θ

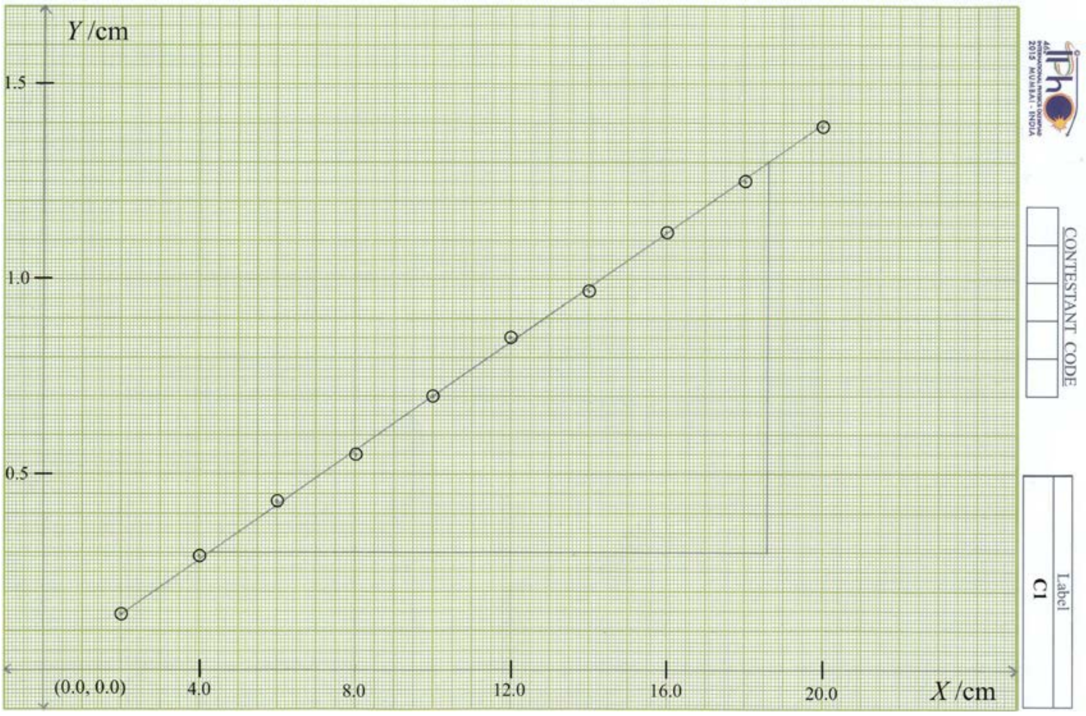
[C1]

Table C1

Obs. no.	X /cm	Y /cm
1	2.0	0.136
2	4.0	0.285
3	6.0	0.425
4	8.0	0.549
5	10.0	0.703
6	12.0	0.846
7	14.0	0.965
8	16.0	1.124
9	18.0	1.251
10	20.0	1.390

[C2]

Graph C1 for determination of θ: X versus Y



Slope = 0.0699

$\boxed{\theta = 4.0°}$

Part D: Determination of the surface tension of the liquid

[D1]:

l_1 = 98.5 cm	l_2 = 5.5 cm	L = 1.04 m

[D2]:

Table D1

Obs. no.	f /Hz	$2x_2$ /cm	x_1 /cm	x_1 /m
1	60	0.782	0.196	0.00196
2	70	0.880	0.220	0.00220
3	80	0.966	0.242	0.00242
4	90	1.030	0.258	0.00258
5	100	1.096	0.274	0.00274
6	110	1.184	0.296	0.00296
7	120	1.253	0.313	0.00313
8	130	1.336	0.334	0.00334
9	140	1.415	0.354	0.00354
10	150	1.489	0.372	0.00372
11	160	1.545	0.386	0.00386

[D3]:

$$\omega^2 = \frac{\sigma}{\rho} k^q$$

$$f^2 = \frac{1}{4\pi^2}\frac{\sigma}{\rho}\left(\frac{2\pi}{\lambda}\frac{\sin\theta}{L}\right)^q (x_1)^q$$

$$\ln f = \frac{1}{2}\ln\left[\frac{1}{4\pi^2}\frac{\sigma}{\rho}\left(\frac{2\pi}{\lambda}\frac{\sin\theta}{L}\right)^q\right] + \frac{q}{2}\ln x_1$$

Graph for determination of q: $\ln(f)$ versus $\ln(x_1)$

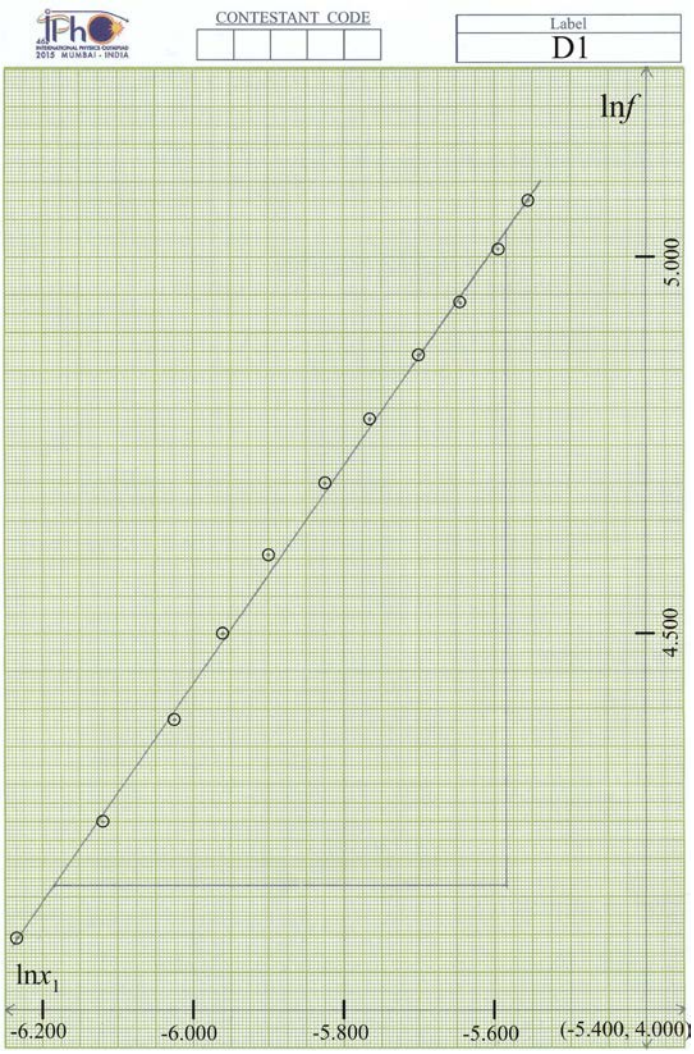


Table D2		
Obs. No.	**ln x_1**	**ln f**
1	-6.235	4.094
2	-6.119	4.248
3	-6.024	4.382
4	-5.960	4.500
5	-5.900	4.605
6	-5.823	4.700
7	-5.767	4.787
8	-5.702	4.868
9	-5.644	4.942
10	-5.594	5.011
11	-5.557	5.075

Slope = 1.45

q = 2.90

Determination of surface tension:

Equation 2:

$$\omega^2 = \frac{\sigma}{\rho} k^3$$

[D4]:

Graph for determination of σ: f^2 versus x_1^3

Table D3

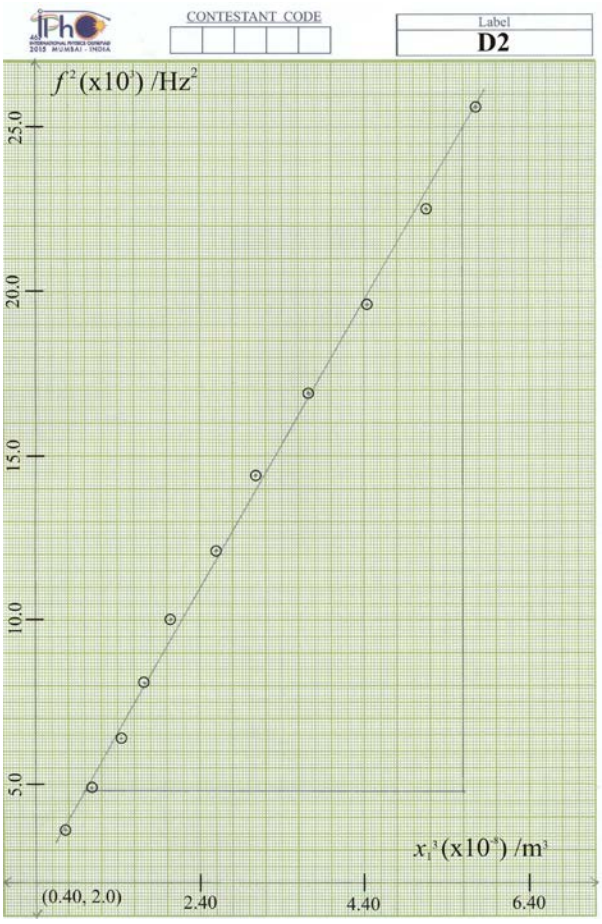
Obs. No.	**$f^2(\times 10^3)$ /Hz^2**	**$x_1^3(\times 10^{-8})$ /m^3**
1	3.6	0.75
2	4.9	1.07
3	6.4	1.42
4	8.1	1.72
5	10.0	2.06
6	12.1	2.59
7	14.4	3.07
8	16.9	3.73
9	19.6	4.44
10	22.5	5.15
11	25.6	5.75

Surface Tension:

$$\omega^2 = \frac{\sigma}{\rho} k^3$$

$$f^2 = \frac{\sigma}{\rho} \frac{2\pi}{\lambda^3} \frac{\sin^3\theta}{L^3} (x_1)^3$$

Calculations:



Slope = 4.39 × 10^{11} Hz^2/m^3

$$\therefore \text{Slope} = \frac{\sigma}{\rho} \frac{2\pi}{\lambda^3} \frac{\sin^3\theta}{L^3} = \frac{\sigma}{1000} \times \frac{2\times 3.14}{(635\times 10^{-9})^3} \frac{(0.0698)^3}{(1.04)^3}$$

$$\therefore \frac{\sigma}{1000} \times 7.415\times 10^{15} = 4.39\times 10^{11}$$

$$\boxed{\therefore \sigma = 59.2\text{mN/m}}$$

Part E: Determination of the viscosity of the water sample

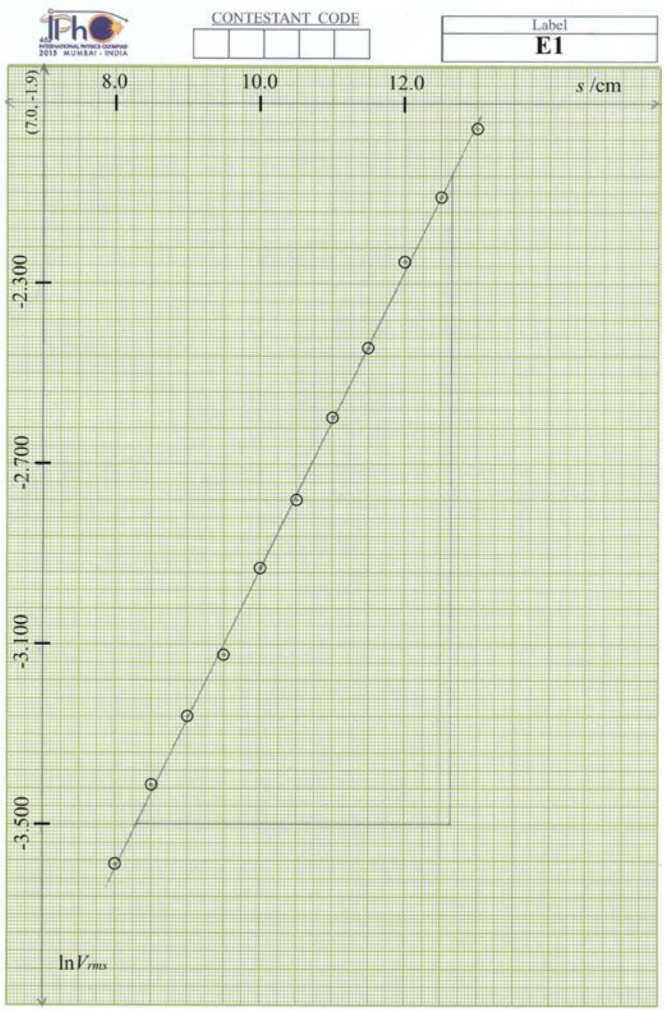
[E1]: Frequency of the signal generator = **100 Hz**

Table E1

Obs. No.	s /cm	V_{rms} /V	$\ln(V_{rms})$
1	8.0	0.0276	-3.590
2	8.5	0.0330	-3.411
3	9.0	0.0385	-3.257
4	9.5	0.0441	-3.121
5	10.0	0.0534	-2.930
6	10.5	0.0622	-2.777
7	11.0	0.0745	-2.597
8	11.5	0.0870	-2.442
9	12.0	0.1050	-2.254
10	12.5	0.1215	-2.108
11	13.0	0.1412	-1.958

[E2]:

Graph for determination of δ: ln (V_{rms}) versus s



Slope = 0.331 cm^{-1}

$$\therefore \delta = 0.4 \times 0.3310 = 0.1324 \text{cm}^{-1}$$

$$\boxed{\delta = 13.2 \text{ m}^{-1}}$$

[E3]:

Determination of viscosity, η:

$$\delta = \frac{8}{3}\frac{\pi \eta f}{\sigma}$$

$$\eta = \frac{3}{8}\frac{\delta\sigma}{\pi f} = \frac{3}{8} \times \frac{13.2 \times 59.2 \times 10^{-3}}{3.14 \times 100} = 0.933 \text{mPa.s}$$

$$\boxed{\eta = 0.93 \text{ mPa.s}}$$