Diffraction due to surface tension waves on water[1]

Part C: Measurement of angle, θ

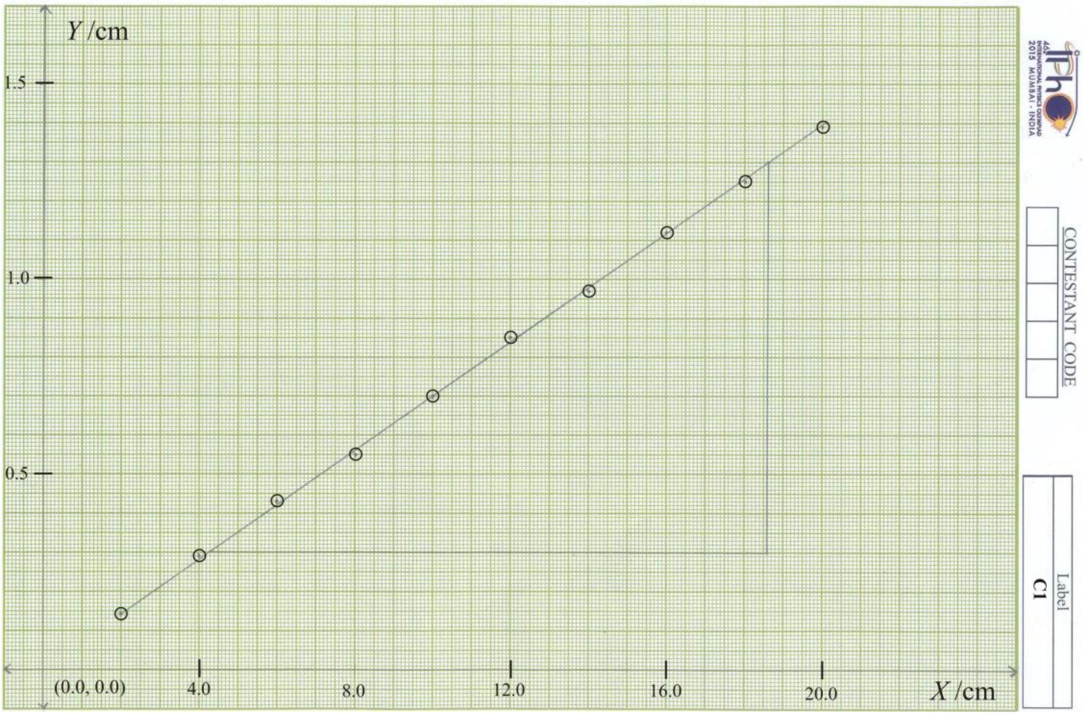
[C1]

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



[1]*Shirish Pathare (HBCSE, Mumbai)and K G M Nair (CMI, Chennai) were the principal authors of this problem. The contributions of the Academic Committee, Academic Development Group and the International Board are gratefully acknowledged.*

Slope = 0.0699

$\theta = 4.0°$

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 $\ln(x_1)$

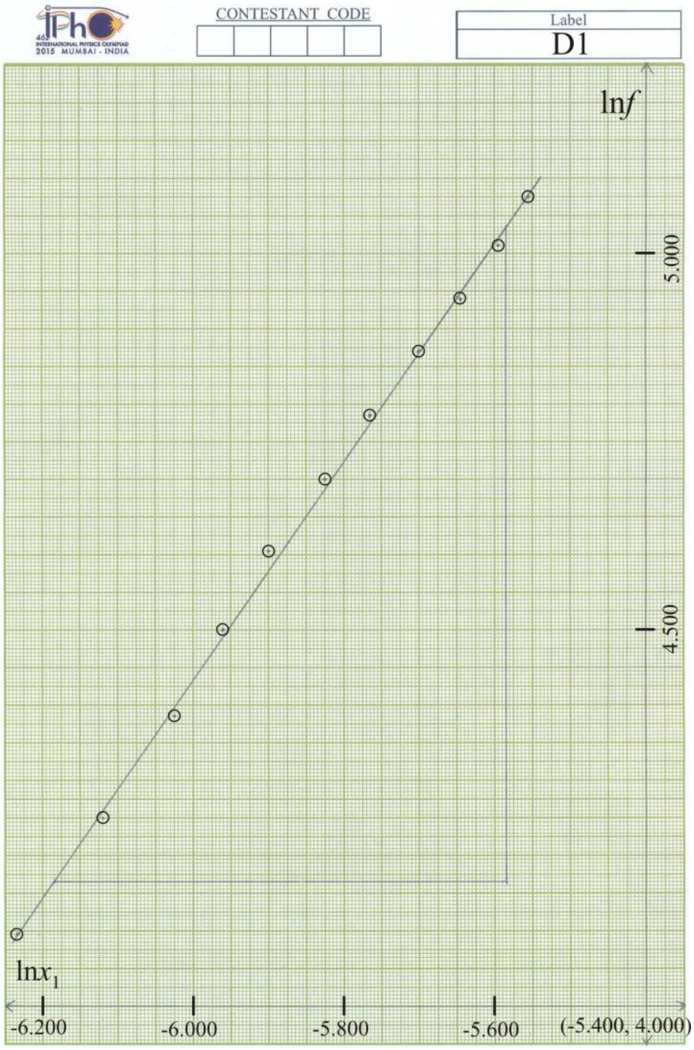


Table D2

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:

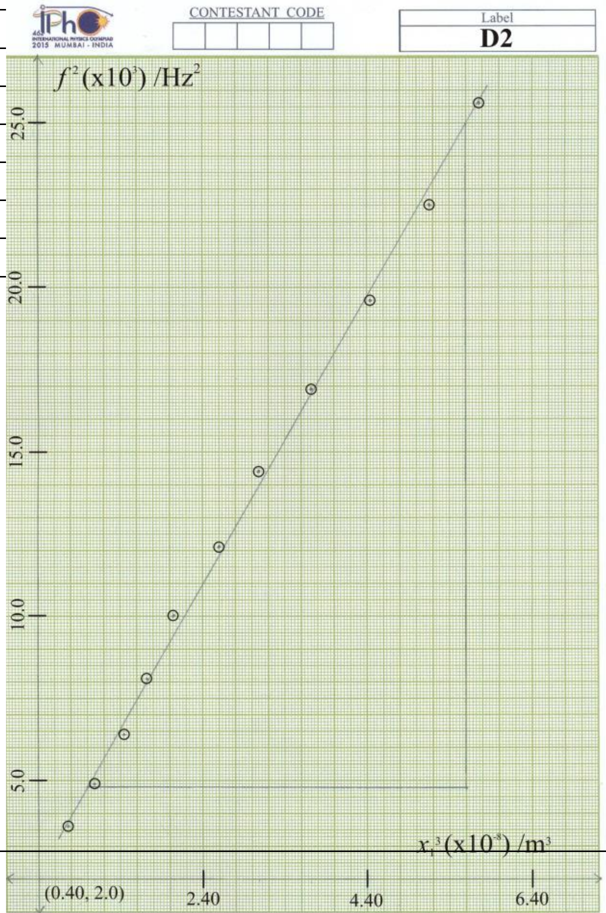
$$\omega^2 = \frac{\sigma}{\rho} k^3$$

[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



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

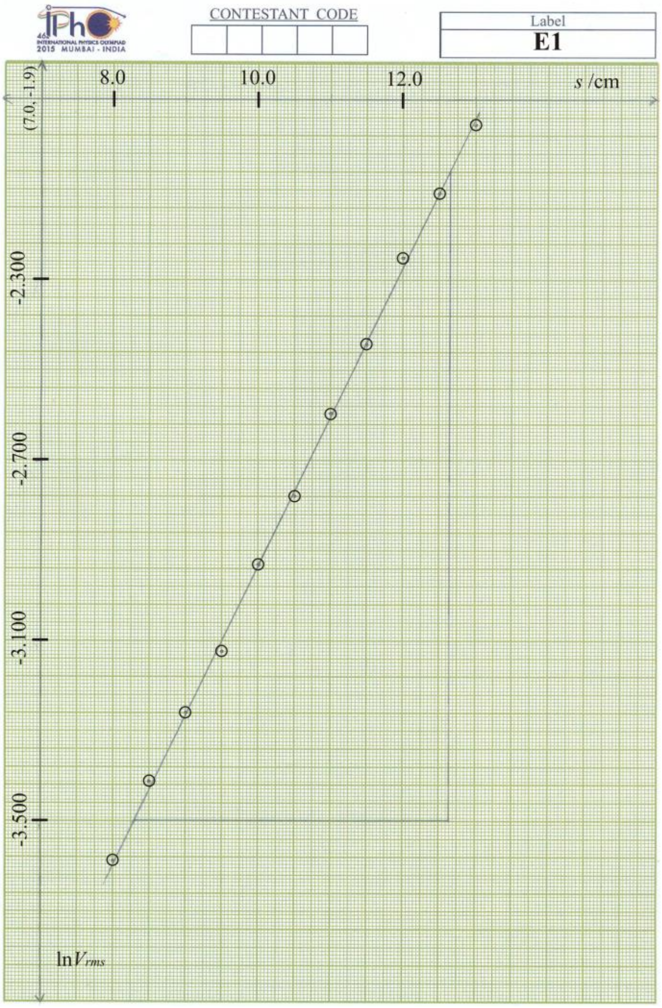
[E1]: Frequency of the signal generator = **<u>100 Hz</u>**

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:

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

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

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