Diffraction due to surface tension waves on water

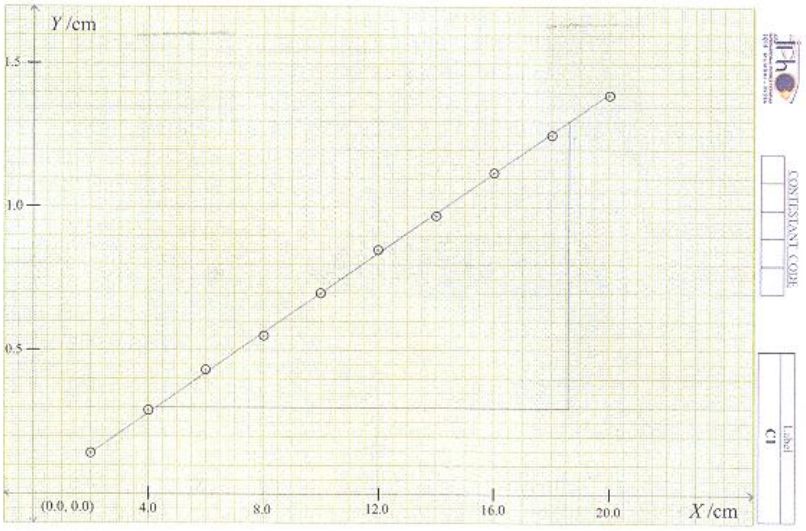
Part C: Measurement of angle, θ

[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

$\theta = 4.0°$

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 $\ln(x_1)$

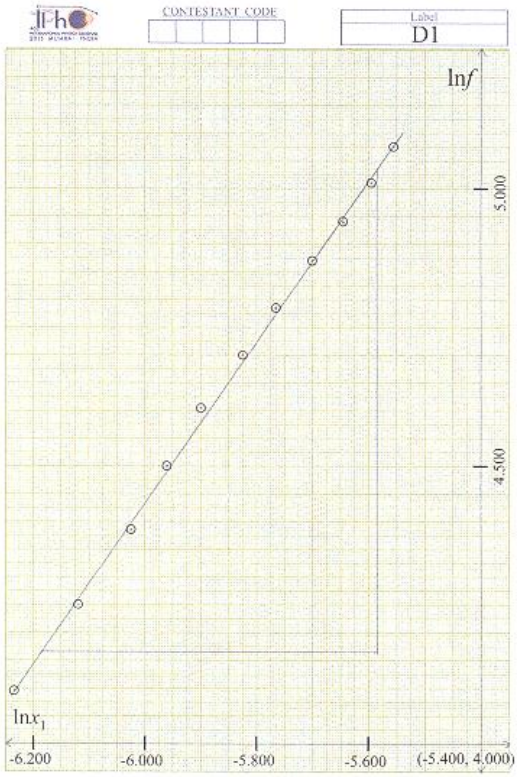


Table D2		
Obs. No.	**ln x_1**	**ln f**
1	-6.235	4.094
2	-6.119	4.248
3	-6.024	4.382
4	-5.960	4.500
5	-5.900	4.605
6	-5.823	4.700
7	-5.767	4.787
8	-5.702	4.868
9	-5.644	4.942
10	-5.594	5.011
11	-5.557	5.075

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

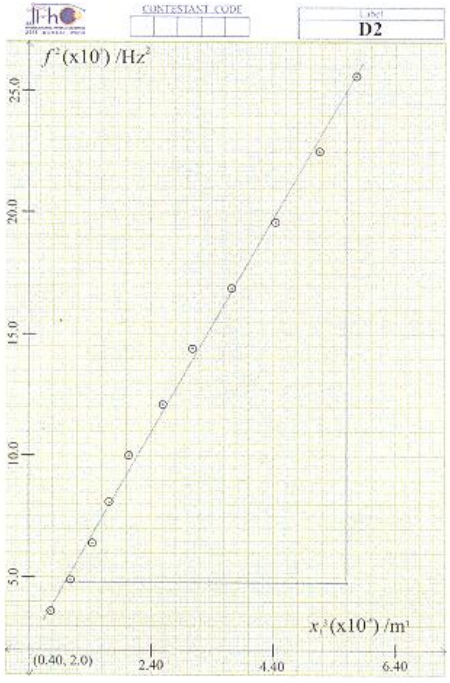
Obs. No.	$f^2(\times 10^3)$ /Hz^2	$x_1^3(\times 10^{-8})$ /m^3
1	3.6	0.75
2	4.9	1.07
3	6.4	1.42
4	8.1	1.72
5	10.0	2.06
6	12.1	2.59
7	14.4	3.07
8	16.9	3.73
9	19.6	4.44
10	22.5	5.15
11	25.6	5.75

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:



$$\text{Slope} = 4.39\times 10^{11}\ \text{Hz}^2/\text{m}^3$$

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

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

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

Part E: Determination of the viscosity of the water sample

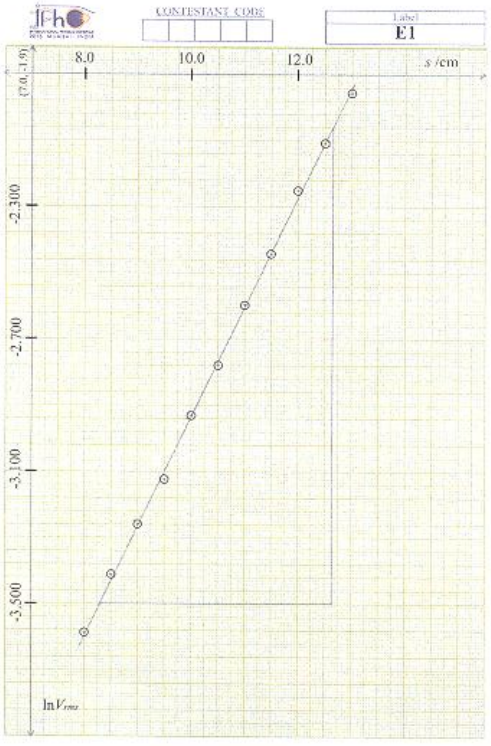
[E1]: Frequency of the signal generator = **100 Hz**

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}

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

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

[E3]:

Determination of viscosity, η:

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

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

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

Marking Scheme

Experiment II - Diffraction due to surface tension waves on water

Note:

1. Calculations should be reported up to atleast two significant figures otherwise 0.1 mark will be deducted.
2. Marks for axes labels and units will be given only if atleast one data point is correctly plotted

		Marks			
Part C	**Measurement of angle, θ**			**1.6**	
C1	Observations		**1.0**		
	6 or more readings	0.6			
	5 readings	0.5			
	4 readings	0.4			
	Less than 4 readings	0			
	Writing unit for X	0.1			
	Writing unit for Y	0.1			
	Recording observations with proper least count of X	0.1			
	Recording observations with proper least count of Y	0.1			
C2	Graph		**0.6**		
	a. Proper Choice of scale (scale may not be written explicitly)	0.1			
	b. Variable written along axes	0.1			
	c. Units mentioned	0.1			
	d. Correct plotting of points	0.1			
	Value of θ				
	$3.9° \le \theta \le 4.1°$	0.2			
	$3.8° \le \theta < 3.9°$ and $4.1° < \theta \le 4.2°$	0.1			
	$\theta < 3.8°$ or $\theta > 4.2°$	0			
Part D	**Determination of the surface tension, σ**			**5.2**	
D1	l_1, l_2 and L		**0.3**		
	Measurement of l_1, l_2 and calculation of L	0.2			
	Units of l_1 and l_2	0.1			
D2	Observations		**2.8**		
	6 or more readings ($2x_2$ values within range)	2.4			
	5 readings	2.0			
	4 readings	1.6			
	Less than 4 readings	0			
	Writing unit for f	0.1			
	Writing unit for $2x_2$	0.1			
	Calculation of x_1	0.1			
	Writing proper least count for x_1	0.1			
D3	Determination of q		**0.9**		
	Deciding $\ln(f)$ versus $\ln(x_1)$	0.1			
	Calculation table	0.2			
	Graph $\ln(f)$ versus $\ln(x_1)$ (Other correct graphs also carry equal weightage)				
	a. Proper Choice of scale (scale may not be written explicitly)	0.1			
	b. Variables written along axes	0.1			
	c. Correct plotting of points	0.1			
	d. Slope ($1.45 \le$ slope ≤ 1.55)	0.2			
	Slope ($1.35 \le$ slope < 1.45 and $1.55 <$ slope ≤ 1.65)	0.1			
	Otherwise	0			

	Writing dispersion relation with rounded off g value	0.1			
D4	Calculation for the graph		1.2		
	Identifying the variables	0.1			
	Calculation of variables	0.2			
	Writing units for the variables	0.2			
	Graph (ω^2 versus k^3) (Other correct graphs also carry equal weightage)				
	a. Proper Choice of scale (scale may not be written explicitly)	0.1			
	b. Variable written along axes	0.1			
	c. Units mentioned	0.1			
	d. Correct plotting of points	0.1			
	Value of surface tension, σ				
	$55\ \text{mN/m} \le \sigma \le 65\ \text{mN/m}$	0.2			
	$50\ \text{mN/m} \le \sigma \le 55\ \text{mN/m}$ or $65\ \text{mN/m} \le \sigma \le 70\ \text{mN/m}$	0.1			
	$\sigma < 50\ \text{mN/m}$ or $\sigma > 70\ \text{mN/m}$	0			
	Units of σ (mN/m)	0.1			
Part E	**Determination of the attenuation constant and the viscosity of water**			**3.2**	
E1	Observations		1.9		
	6 or more readings	1.8			
	5 readings	1.5			
	4 readings	1.2			
	Less than 4 readings	0			
	Writing proper least counts of s and V_{rms}	0.1			
E2			1.0		
	Deciding to plot $\ln(V_{rms})$ versus s	0.1			
	Calculation table	0.2			
	Graph				
	a. Proper Choice of scale (scale may not be written explicitly)	0.1			
	b. Variable written along axes	0.1			
	c. Units mentioned	0.1			
	d. Correct plotting of points	0.1			
	Value of δ				
	$11\ \text{m}^{-1} \le \delta \le 15\ \text{m}^{-1}$	0.2			
	$9\ \text{m}^{-1} \le \delta < 11\ \text{m}^{-1}$ or $15\ \text{m}^{-1} < \delta \le 17\ \text{m}^{-1}$	0.1			
	$\delta < 9\ \text{m}^{-1}$ or $\delta > 17\ \text{m}^{-1}$	0			
	Unit of δ (m^{-1})	0.1			
E3	Value of viscosity, η		0.3		
	$0.7 \times 10^{-3}\ \text{Pa·s} \le \eta \le 1.1 \times 10^{-3}\ \text{Pa·s}$	0.2			
	$0.5 \times 10^{-3}\ \text{Pa·s} \le \eta < 0.7 \times 10^{-3}\ \text{Pa·s}$ or $1.1 \times 10^{-3}\ \text{Pa·s} < \eta \le 1.3 \times 10^{-3}\ \text{Pa·s}$	0.1			
	$\eta < 0.5 \times 10^{-3}\ \text{Pa·s}$ or $\eta > 1.3 \times 10^{-3}\ \text{Pa·s}$	0			
	Unit of viscosity (Pa.s)	0.1			
			Total	**10.0**	