Observations:

Least count of Vernier caliper used = 0.02 mm

Least count of stop watch =0.01 sec

Radius of the disk, r = 35.94 mm

Thickness of the disk, d = 8.86 mm

Outer diameter of the ring, d_1 = 63.82 mm

Inner diameter of the ring, d_2 = 58.20 mm

Average radius of the ring, a = 30.50 mm = 30.50 x 10^{-3} m

Mass of the ring, m= 25.13 g = 25.13 x 10^{-3} kg

Temperature of water = 21 ^{o}C

Table 1: Readings for time period without ring

Serial No.	Time required for 25 oscillations	Time period for one oscillation
1.	87.90	3.52
2.	87.75	3.51
3.	87.60	3.51

Table 2: Readings for time period with ring

Serial No.	Time required for 25 oscillations	Time period for one oscillation
1.	92.25	3.69
2.	92.29	3.69
3.	92.22	3.68

Table 3: Readings for logarithmic decrement in Air (λ_o)

Trial number	Serial no. of oscillation	Maximum Amplitude Left(B_1C_1)	Maximum Amplitude Right(B_2C_2)
1.	1	24	23.40
2.	20	22.70	21.50
3.	40	21.70	20.50
4.	60	20.60	19.40
5.	80	19.60	18.30

Table 5: Readings for logarithmic decrement in Water (λ)

Trial number	Serial no. of oscillation	Maximum Amplitude Left(B_1C_1)	Maximum Amplitude Right(B_2C_2)
1.	1	22.80	21.50
2.	5	16.30	14.80
3.	10	11.70	10.60
4.	15	8.50	7.50
5.	20	6.30	5.40
6.	25	4.60	3.70
7.	30	3.50	2.50
8.	35	2.70	1.90

Calculations

1) Moment of Inertia:

   Instructions are given to students to take any three combinations of T and T', leading to three values of moment of inertia for the torsional pendulum arrangement. They should not calculate mean at this stage.

   Values will be as:-

$$I = ma^2\left(\frac{T^2}{T'^2 - T^2}\right)$$

$$= 2.22 \times 10^{-4} \text{ kg m}^2$$

2) Logarithmic decrement in air (λ_0) **:**

   Corresponding to 20th oscillation:

$$\lambda_0 = \frac{1}{2n} ln\left(\frac{B_1C_1 + B_2C_2}{B_{41}C_{41} + B_{42}C_{42}}\right)$$

$$\frac{1}{40} ln\left(\frac{24 + 23.4}{22.7 + 21.5}\right)$$

$$\mathbf{= 1.7 \times 10^{-3}}$$

3) Logarithmic decrement in water (λ)

$$\lambda = \frac{1}{10} ln\left(\frac{22.8 + 21.5}{16.3 + 14.8}\right)$$

$$\mathbf{= 35.3 \times 10^{-3}}$$

Similarly, we calculate for all values of λ and λ_0.

Now, instead of taking mean of MOI, λ and λ_0, we will calculate viscosity, η by all possible permutations i.e 3*4*7 = 84 (84 values of η)

4) Viscosity, η:

$$\eta = \frac{16I^2}{\Pi\rho T}\left(\frac{1}{r^4 + 2r^3 d}\right)^2 \left(\left(\frac{\lambda - \lambda_0}{\Pi}\right) + \left(\frac{\lambda - \lambda_0}{\Pi}\right)^2\right)^2$$

$$\frac{16(2.22x10^{-4})^2}{3.14\ x\ 997.77\ x\ 3.51}(0.16x10^{12})(112.06\ x\ 10|-6)$$

= 1.2 x 10^{-3} Pascal sec

= 1.2 x 10^{-2} Poise

Following table gives 84 values of η with all possible permutations of MOI, λ and λ_0 .

S.no	MOI	λ	$\boldsymbol{\lambda_0}$	η
1	**0.00022**	**0.0333**	**0.0014**	**0.1152**
2	**0.00022**	**0.0334**	**0.0014**	**0.1155**
3	**0.000224**	**0.035**	**0.0014**	**0.1258**
4	**0.000222**	**0.0334**	**0.0014**	**0.1177**
5	**0.000222**	**0.0333**	**0.0014**	**0.1173**
6	**0.000224**	**0.0343**	**0.0017**	**0.1221**
7	**0.000224**	**0.0323**	**0.0017**	**0.1145**
8	**0.000222**	**0.0343**	**0.0014**	**0.1210**
9	**0.00022**	**0.0334**	**0.0014**	**0.1155**
10	**0.00022**	**0.0343**	**0.0013**	**0.1192**
11	**0.000224**	**0.0334**	**0.0017**	**0.1186**
12	**0.000222**	**0.0332**	**0.0013**	**0.1173**
13	**0.000222**	**0.0339**	**0.0013**	**0.1199**
14	**0.00022**	**0.0343**	**0.0013**	**0.1192**
15	**0.000222**	**0.0333**	**0.0017**	**0.1162**
16	**0.000222**	**0.035**	**0.0017**	**0.1225**
17	**0.000224**	**0.0339**	**0.0014**	**0.1217**

18	**0.00022**	**0.0343**	**0.0014**	**0.1188**
19	**0.000222**	**0.0332**	**0.0017**	**0.1158**
20	**0.00022**	**0.035**	**0.0014**	**0.1214**
21	**0.000222**	**0.035**	**0.0017**	**0.1225**
22	**0.000224**	**0.0332**	**0.0014**	**0.1190**
23	**0.00022**	**0.0333**	**0.0014**	**0.1152**
24	**0.000222**	**0.0332**	**0.0014**	**0.1169**
25	**0.00022**	**0.0332**	**0.0013**	**0.1152**
26	**0.000222**	**0.0323**	**0.0013**	**0.1139**
27	**0.000224**	**0.0343**	**0.0014**	**0.1232**
28	**0.00022**	**0.0339**	**0.0013**	**0.1177**
29	**0.00022**	**0.0323**	**0.0014**	**0.1115**
30	**0.000224**	**0.0333**	**0.0014**	**0.1194**
31	**0.000222**	**0.0334**	**0.0014**	**0.1177**
32	**0.000224**	**0.0334**	**0.0014**	**0.1198**
33	**0.00022**	**0.0323**	**0.0017**	**0.1104**
34	**0.00022**	**0.035**	**0.0014**	**0.1214**
35	**0.00022**	**0.035**	**0.0013**	**0.1217**
36	**0.00022**	**0.0332**	**0.0014**	**0.1148**
37	**0.000222**	**0.0339**	**0.0014**	**0.1195**
38	**0.000224**	**0.0332**	**0.0013**	**0.1194**
39	**0.00022**	**0.0332**	**0.0014**	**0.1148**
40	**0.000224**	**0.0343**	**0.0014**	**0.1232**
41	**0.000224**	**0.0323**	**0.0014**	**0.1156**
42	**0.000224**	**0.0333**	**0.0017**	**0.1183**
43	**0.000224**	**0.0343**	**0.0017**	**0.1221**

44	**0.000222**	**0.0332**	**0.0014**	**0.1169**
45	**0.00022**	**0.0339**	**0.0014**	**0.1174**
46	**0.000222**	**0.0339**	**0.0013**	**0.1199**
47	**0.00022**	**0.0332**	**0.0014**	**0.1174**
48	**0.000224**	**0.0323**	**0.0013**	**0.1194**
49	**0.000222**	**0.0332**	**0.0014**	**0.1136**
50	**0.00022**	**0.0339**	**0.0013**	**0.1152**
51	**0.00022**	**0.0334**	**0.0013**	**0.1177**
52	**0.000224**	**0.035**	**0.0014**	**0.1198**
53	**0.000224**	**0.0343**	**0.0014**	**0.1258**
54	**0.000224**	**0.0343**	**0.0114**	**0.1232**
55	**0.000224**	**0.0323**	**0.0013**	**0.1160**
56	**0.00022**	**0.0332**	**0.0014**	**0.1148**
57	**0.000224**	**0.0333**	**0.0013**	**0.1198**
58	**0.00022**	**0.0334**	**0.0013**	**0.1159**
59	**0.00022**	**0.0339**	**0.0014**	**0.1174**
60	**0.00022**	**0.0323**	**0.0013**	**0.1119**
61	**0.000224**	**0.0343**	**0.0014**	**0.1232**
62	**0.00022**	**0.0323**	**0.0013**	**0.1119**
63	**0.000224**	**0.0334**	**0.0014**	**0.1198**
64	**0.000224**	**0.0333**	**0.0014**	**0.1194**
65	**0.000222**	**0.0323**	**0.0013**	**0.1139**
66	**0.000222**	**0.0323**	**0.0014**	**0.1136**
67	**0.000222**	**0.0332**	**0.0017**	**0.1158**
68	**0.000224**	**0.0332**	**0.0014**	**0.1190**
69	**0.000222**	**0.0339**	**0.0014**	**0.1195**

70	**0.000224**	**0.0339**	**0.0013**	**0.1221**
71	**0.000224**	**0.0333**	**0.0013**	**0.1198**
72	**0.000222**	**0.0323**	**0.0017**	**0.1125**
73	**0.00022**	**0.035**	**0.0014**	**0.1214**
74	**0.000224**	**0.0339**	**0.0017**	**0.1205**
75	**0.000224**	**0.0332**	**0.0014**	**0.1198**
76	**0.000224**	**0.0334**	**0.0014**	**0.1258**
77	**0.000224**	**0.035**	**0.0014**	**0.1144**
78	**0.00022**	**0.0334**	**0.0017**	**0.1184**
79	**0.000222**	**0.0339**	**0.0017**	**0.1152**
80	**0.00022**	**0.0333**	**0.0014**	**0.1236**
81	**0.000222**	**0.035**	**0.0014**	**0.1262**
82	**0.000224**	**0.035**	**0.0013**	**0.1163**
83	**0.00022**	**0.0339**	**0.0017**	**0.1232**
84	**0.000224**	**0.0343**	**0.0014**	**1.1232**

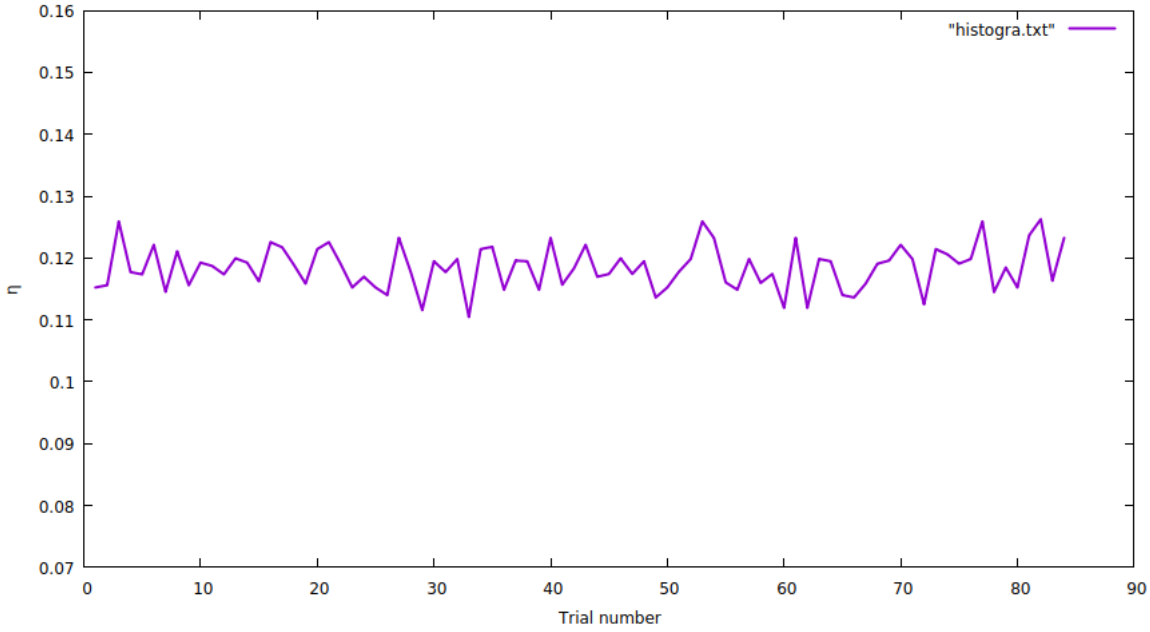
Mean of η values ($<\eta>$) are given as = **0.00118 =1.18 x 10^{-3} Pascal sec**

Mean of the η^2 ($<\eta^2>$) is given as = **1.41 x 10^{-6} (Pascal sec)^2**

Deviation ($\Delta\eta = [<\eta^2> - <\eta>^2]^{1/2}$) is obtained as = **7.47x10^{-5}**

Error analysis includes standard deviation. Log error is not requisite.

Graph should be plotted manually (although here it is plotted by using some software)



Marks breakup (out of 20) for Experiment-5

The experiments is divided in the following sections:
1. Aim of the experiment. **(1 mark)**

2. Apparatus used. **(1 mark)**

3. Theory (only the Formulae used with description of the symbols). **(1 marks)**

If some one has copy-pasted the whole theory from manual, ***reduce 2 marks***.

4. Observation and calculations (tables). **(3 marks)**
(i) Table including 3 moment of inertia values. 1 mark
(ii) Table with λ values. 1mark
(iii) Table with λ_0 values. 1mark

5. Data analysis (along with the hand-made graph-plots, if any). **(6 marks)**
84 viscosity values plotted on graph with their mean. In case table is not provided with all 84 values marks can be awarded.

(a) Right approach right result: full mark for each section of experiment.
(b) Right approach wrong result: half of the full marks associated with that part.
(c) If the graph is not made properly (e.g. no mention of scale, axis….) reduce 1 mark.

6. Error analysis (Maximum possible error and NOT the percentage error). **(6 marks)**
This includes standard deviation calculation.

7. Results. **(1 marks)**
(i) Mention η and Δη

8. Precautions (only the significant/relevant ones). **(1 marks)**

Since it is online lab, if someone forgets to mention the precautions but has done well otherwise, 1 mark may be given.
Clarity is important. So, in case student do not write clearly, please make a note of it on the report and reduce 0.5 marks per section.

Please use the whatsapp group created for optics lab for any queries.