$$\eta = \frac{8\pi I_2 l}{\left(T_2^2 - T_1^2\right) r^4} \qquad (2.4)$$

The moment of inertia I_2 of the ring is given by

$$I_2 = \frac{MR_1^2 + MR_2^2}{2}$$

Where R_1 and R_2 are internal and external radii of the ring and M is mass of the ring. Again from (2.1) and (2.3) we get,

$$I_1 = \left[\frac{T_1^2}{T_2^2 - T_1^2}\right] I_2 \qquad (2.5)$$

Thus moment of inertia of the combination of circular disc with the wire is determined from 2.5

PROCEDURES:

(1) Suspend the circular disc by given wire of a suitable length and thickness from a rigid support.

(2) Make horizontal with the help of the leveling screw and spirit level.

(3) Mark on the circumference of the disc for counting the torsion oscillations.

(4) Rotate slightly the circular table in the horizontal plane. Then record the time period for 10 oscillations and calculate T_1. Repeat this process for changing length of the wire.

(5) Now place given circular ring on the circular disc in such a way that the axis of the wire passes through the centre of gravity of the ring.

(6) Again record time period T_2 by given rotation to the combination for each length.

(7) Measure the length of the wire by meter scale and radius by screw gauge.

(8) Finally calculate moment of inertia of the ring, modulus of rigidity of wire and moment of inertia of the circular disc.

(9) Plot a graph between $(T_2^2 - T_1^2) \sim l$ and $(T_2^2 - T_1^2) \sim T_1^2$ then draw conclusions.

OBSERVATIONS:

(i) Mass of ring = M = 300 gm

(ii) Mass of disc = M' = 1200 gm

(iii) Radius of wire = r = 0.0475 cm

(iv) Radius of circular disc (R) = 6.1 cm

(v) Radius of ring:

Internal radius (R_1) = 5.1 cm and

External radius (R_2) = 6.2 cm

Table 1: Determination of time period

SN	Length(l)	Determination of T_1				Determination of T_2			
		Time for 10 Oscillation			Time Period (T_1)	Time for 10 Oscillation			Time Period (T_2)
		1	2	Mean		1	2	Mean	
1.	30	23.81	24.25	24.03	2.403	30.19	30.19	30.19	3.019
2.	40	28.69	28.34	28.515	2.8515	35.50	35.44	35.47	3.547
3.	50	31.87	32.19	32.03	3.203	40.09	40.41	40.25	4.025
4.	60	35.81	35.85	35.83	3.583	44.12	44.47	44.295	4.429
5.	70	38	38.19	38.095	3.8095	47.87	47.63	47.75	4.775

DATA ANALYSIS:

a. Moment of inertia of the ring

$I_2 =$ 9667.5 gmcm^2

b. Calculation of η and I_1

SN	l	T_1^2	T_2^2	$T_2^2 - T_1^2$	η	$\bar{\eta}$	I_1	$\bar{I}$
1.	30	5.774	9.114	3.34	4.287×10^{11}		16712.61	
2.	40	8.131	12.581	4.45	4.29×10^{11}	4.20802×10^{11}	17664.36	
3.	50	10.259	16.200	5.671	4.208×10^{11}		17488.78	17419.99
4.	60	12.837	19.616	6.779	4.224×10^{11}		18306.78	
5.	70	14.512	22.800	8.288	4.0311×10^{11}		16927.45	

c. Conclusion of the graph:

(i) $\eta = 4.150 \times 10^{11}$ dynes/cm^2

(ii) $I_1 = 17788.2$ gmcm^2

$\eta_{std} = 4 \times 10^{11}$ dynes/cm^2

(4) Error calculation: (random error)

Calculated η_i	Deviation from Mean $\delta\eta_i = \eta_i - \bar{\eta}$	Square of Deviation $\delta_i\eta_i^2$	Best Estimated of Standard Error σ_η	Calculated I_1	$\delta I_1 = I_1 - \bar{I}_1$	δI_1^2	σI_1
4.287×10^{11}	7.898×10^{9}	6.23×10^{19}		16712.61	-707.38	500386 .4644	
4.29×10^{11}	8.198×10^{9}	6.720×10^{19}		17664.36	244.37	59716 .6969	
4.208×10^{11}	-2×10^{6}	4×10^{12}	4.699×10^{9}	17488.78	68.79	4732. 0641	28.229
4.224×10^{11}	1.598×10^{9}	2.553×10^{18}		18306.78	886.79	786396 .5041	
4.0311×10^{11}	-1.76×10^{10}	3.097×10^{20}		16927.45	-492.54	242595 .6516	
$\Sigma\eta_i = 2.10401\times10^{12}$		$\Sigma\delta\eta_i^2$ 4.417×10^{20}		87099.98		15938 27.381	.

- **RESULTS:**

(i) The value of $\eta = \bar{\eta} \pm \sigma_\eta$ = $4.20802\times10^{11} \pm 4.699\times10^{9}$

(ii) Standard value of η = 4×10^{11} dynes/cm²

(iii) Percentage error = … …

(iv) The value of $I_1 = \bar{I} \pm \sigma I_1$ = 17419.99 ± 28.229

(v) Theoretical value of $I_1 = M' R^2/2$ = 22326

- **DISCUSSION**

In the lab, we oscillated a torsional pendulum by rotating at an angle. Then in the same length we placed the circular ring on the pendulum disc and oscillated it and recorded time for 10 oscillations. The time with disc was noted as T_2 and without disc as T_1. The same procedure was done for various lengths and graph was plotted from the data.

- **CONCLUSION :**

Thus, with the help of data from the graph, we were able to determine modulus of elasticity and moment of inertia of circular disc.

PRECAUTIONS:

(i) The wire must be tight so that l is fixed.

(ii) The center of gravity of ring must be in the axis of rotation

(iii) Time should be noted for uniform oscillations.

(iv) ... ...

ANSWER THE FOLLOWING QUESTIONS:

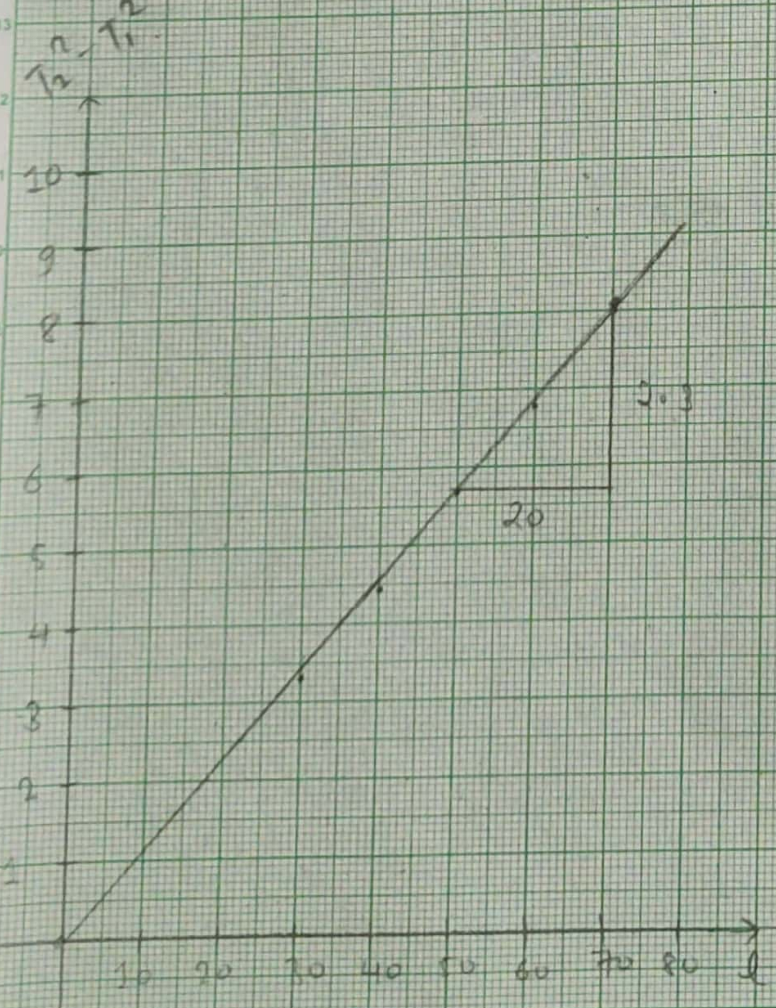
Graph for modulus of elasticity

$T_2^2 - T_1^2$ vs l

Scale:

X-axis : 10 divisions = 10 cm

Y-axis : 10 divisions = 1



$$Slope = \frac{\Delta y}{\Delta x}$$

$$= \frac{2.3}{20}$$

$$= 0.115$$

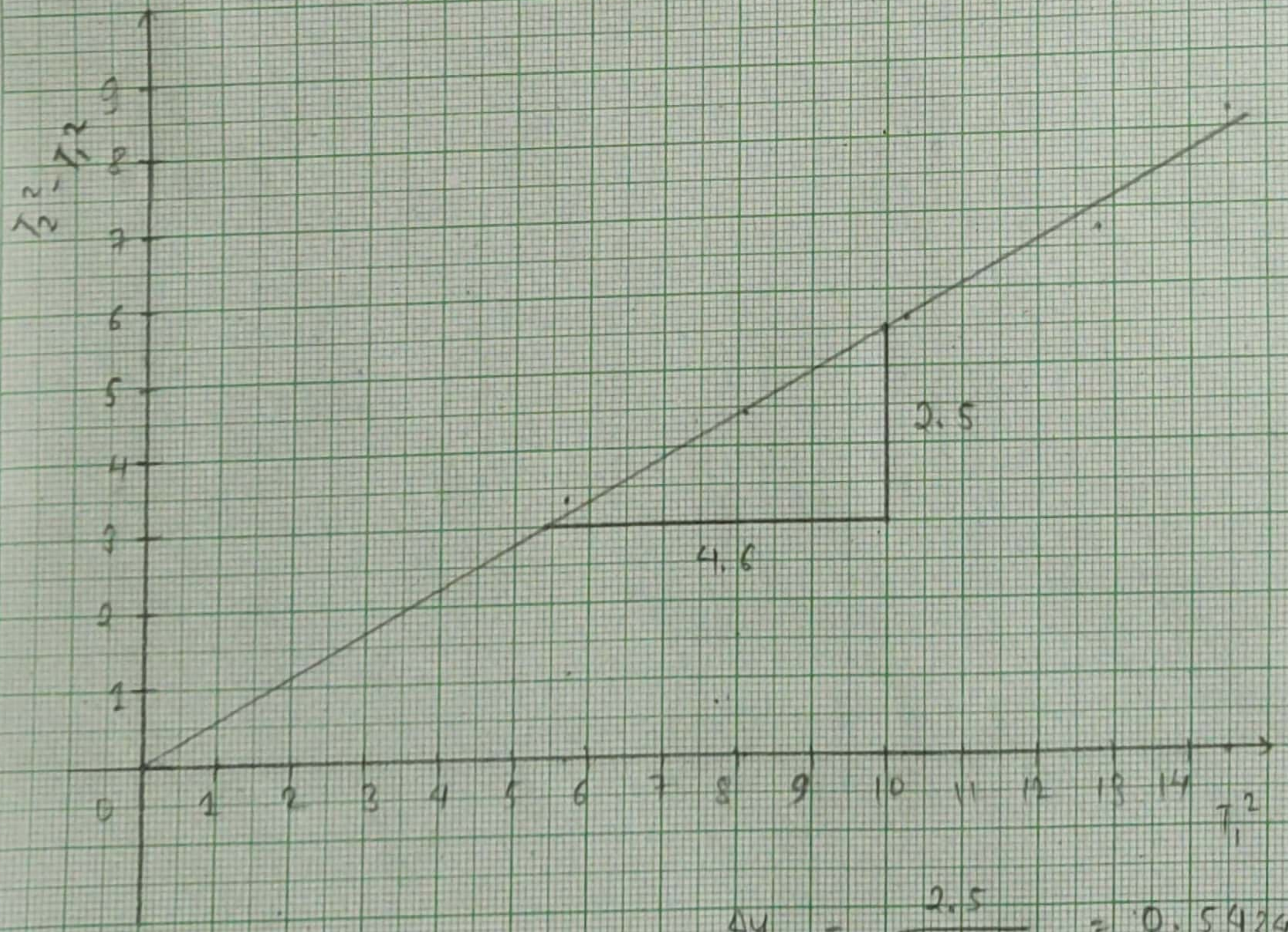
Graph for calculation of moment of inertia

$T_2^2 - T_1^2$ vs T_1^2

Scale:

X-axis : 10 divisions = 1 sec²

Y-axis : 10 divisions = 1 sec²



$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{2.5}{4.6} = 0.5434$$