AE351 - IITK
LAB 2 - Torsion Testing

<u>Lab Objective</u>: Perform a torsion (shear) test on a shaft with a circular cross section and measure the shear modulus of a material using two different methods.

<u>Procedure</u>:

1. Go through the 'Notes on torsion experiments' detailed in next section.

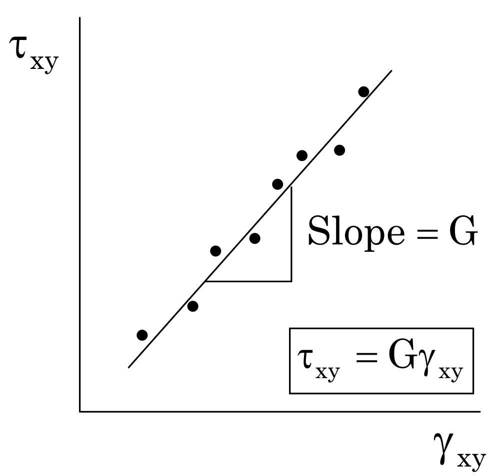
2. Torsion test experimental setup includes:
   a. Torsion test fixtures for holding the specimen and for applying the torque.
   b. Strain indicator equipment to measure strains.
   c. Carefully machined cylindrical shaft of aluminum mounted with a 0-45-90 strain gage rosette.

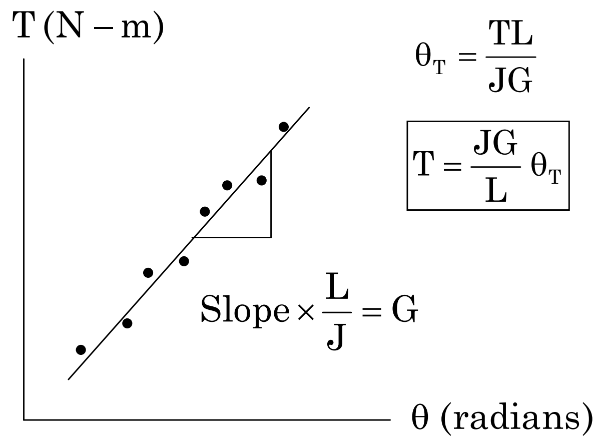
3. Apply loads to the torque arm. The load range and the load increment will be given by your lab instructor.

4. At each load, record the three strain gage readings, and the vertical deflection of the torque arm.

5. Determine the torque, shear strain, and the angle of twist for each applied load. Tabulate all measurements and calculations.

6. Use the measured data to generate plots of Shear Stress vs. Shear Strain (τ_{xy} vs. γ_{xy}), and Torque vs. Angle of Twist (T vs. θ_T).





7. Using linear regression fit the data (Draw a best possible straight line fit passing through all the data). Calculate shear modulus using the slope of the straight line fit (See, the plots).

8. Compare experimentally measured G to the published value for your specimen material. Calculate the percent differences between the measured and published values.

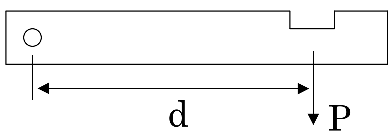
9. Identify sources of errors in your measurements.

Prepare a complete lab report. Use the provided Lab Format as a guideline for preparing your report.

Notes on the Torsion Experiment

1. Calculation of Applied Torque

Torque Arm

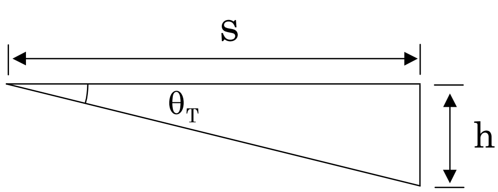


The torque is given by,

$$T = Pd\,,$$

where P is the applied load, and d is the length of the torque arm

2. Calculation of the Angle of Twist

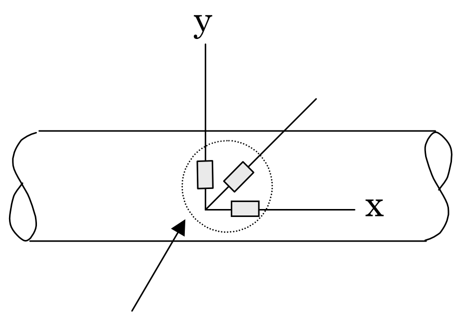


The angle of twist is measured by,

$$\tan\theta_T = \frac{h}{s}\,,$$

where h is the vertical deflection of the torque arm measured using a deflection dial gage, and s is the distance between the center of the shaft and the dial gage.

3. Calculation of Shear Strain from the 0-45-90 Strain Gage Rosette Data



$0^\circ - 45^\circ - 90^\circ$ Strain Gage Rosette

From strain transformation equation the normal strain for a given orientation can be calculated by using mechanics of solids equation,

$$\varepsilon_n(\theta) = \varepsilon_x \cos^2\theta + \varepsilon_y \sin^2\theta + \gamma_{xy}\sin\theta\cos\theta$$

Applying this relation at each of the gage angles leads to:

$$\varepsilon_0 = \varepsilon_x$$

$$\varepsilon_{45} = \frac{\varepsilon_x + \varepsilon_y + \gamma_{xy}}{2}$$

$$\varepsilon_{90} = \varepsilon_y$$

The shear strain can be obtained by rearranging the above expressions, where ε_0, ε_{45}, and ε_{90} are the strain values recorded using 0-45-90 strain gage rosette.

$$\gamma_{xy} = 2\varepsilon_{45} - \varepsilon_0 - \varepsilon_{90}$$

Measurements and Tabulation

h = Vertical deflection of torque arm at gage location (mm)
r = Radius of the rod being twisted (mm)
s = Arm length till the location of the deflection gage (mm)
L = Length of the rod between two fixed ends (mm)

Units of calculated parameters:

Torque: T (N)
Angle of Twist θ (radians)
Shear strain γ_{xy} μ strains (10^{-6})
Shear stress τ_{xy} (MPa)

Other quantity to be calculated:

- Polar Moment of Inertia: $J = (\pi r^4/2)$ mm^4

#	load (N)	$\varepsilon_0(\mu)$	$\varepsilon_{45}(\mu)$	$\varepsilon_{90}(\mu)$	h (mm)	$\theta=\tan^{-1}(h/s)$	T=load*d(arm)	γ_{xy}	τ_{xy}
1									
2									
3									
4									
5									
6									

Calculate shear modulus from the T vs. θ and the τ_{xy} vs. γ_{xy} plots. Determine the error by comparing the published value of G for the material-in-consideration.