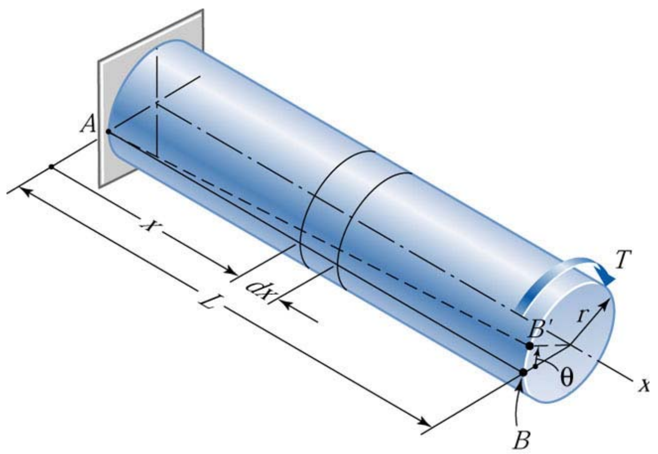
# 1.Torsion Test : Theory and Experimental Procedure

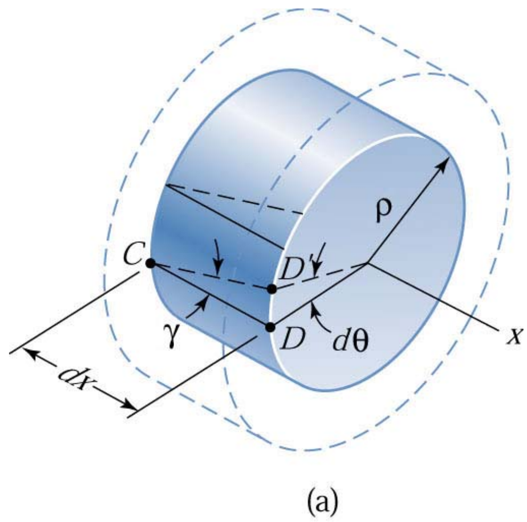
## 1 Theory of Pure Torsion

The Torsion Test is based on the **Theory of Pure Torsion**

If a material is subjected to twisting by the application of a couple a shear stress will be induced within the material. If a couple is applied to a cylindrical rod in such a way that the axis of the couple is coincident with the axis of the rod, then the rod is said to be subject to pure torsion. At any point within the cross-section of a rod subjected to pure torsion, there will be a pure shear stress established in a direction normal to the radius of the rod at that point.




(a) Circular beam subjected to torque T




(b) dx section

The assumptions made in the Theory of Pure Torsion or made in deriving the equation for pure torsion are as follows:

- The material is homogeneous and isotropic
- Hooke's law is obeyed by the material.i.e deformation are withing within proportionality limit **(Important)**
- The shaft is circular in section and remains planar even after torque is applied on it
- The cross-section of the shaft remains uniform throughout.
- The shaft is subjected to pure torque only.
- The shaft is not subjected to any initial torque. i.e initial deflection is zero
- The stress of the material should not exceed the elastic limit i.e no permanent deformation is caused due to loading

The torsion equation is given as follows:

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$$

The given equation hold for the condition of **Pure Torque**.Every diameter of the material rotates through the same angle i.e The shear strain $\gamma$ varies linearly in the radial direction

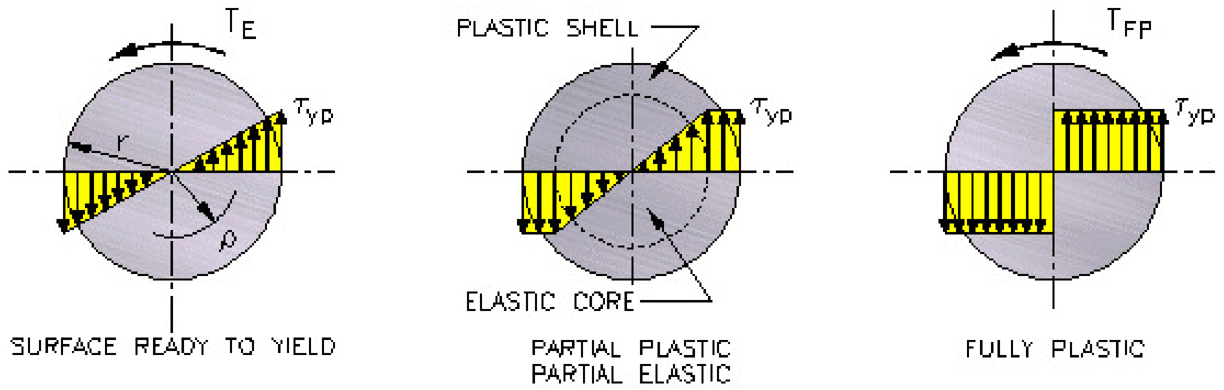



**Figure 5** Torsion Stress Distributions

Figure 2: Types of Torques acting on a cross section:(a)Pure Torsion, (b) Partially Elastic Torsion, (c) Fully Plastic Torsion

Thus, continuing with the Pure Torsion Assumption,we find the Shear Modulus (G) through our experiment.

## 2 Procedure

1. Measure the length and diameter of the Aluminium 6061 Rod
2. Subtract the Zero Errors to obtain the true dimensions
3. Weigh the masses to be used for the experiment
4. Clamp the rod in the Torsion Test Apparatus
5. Check for any zero error present in the apparatus. If possible,set the reading to zero when no mass is attached
6. Gradually add weights and note down the reading of the deflection while loading
7. After having put all the weights,remove them one by one and note down the reading in deflection while unloading as well
8. Complete 20 such cycles of loading and unloading
9. For each reading calculate Shear Stress and Shear Strain using the formula:

$$ShearStress = \frac{Torque * RadialDistance}{J} = \frac{(mgd) * r}{J}$$

and

$$ShearStrain = \frac{Deflection(radian) * RadialDistance}{L} = \frac{\theta r}{L}$$

where,
m = mass attached to the apparatus
Radial Distance = from centroidal longitudinal axis to the outer surface
d = length of lever used to apply torque in Torsion Test Apparatus

10. Plot the Data points for each cycle

11. Sketch the best fit straight line through the points for each plot

12. Measure the Slope of the best fit line

Slope of the best fit line in a Stress vs Strain Plot gives the value of the Young's Modulus

Since we made a plot between Shear Stress and Shear Strain, the Slope of the best fit line gives us the value of the Shear Modulus (G)