Modulus of Rigidity

Modulus of rigidity or shear modulus is denoted as G, N, or C. Modulus of rigidity is defined as the factor of shear stress to shear strain. The modulus of rigidity is directly proportional to the modulus of elasticity; which is an elastic constant, it depends on the material's quality and properties.

As the modulus of elasticity or quality of material increases, modulus or rigidity increases proportionally. This is also helpful in designing shafts. Different types of materials have different moduli of rigidity.

Modulus of Rigidity Formula

Modulus of rigidity is defined as the ratio of shear stress taken from a body to the shear strain as deformation in angle due to external load. In this, only shear stress has a unit, so the modulus of the rigidity unit is similar to the shear stress unit.

Modulus of Rigidity is the Ratio of

Modulus of Rigidity is the ratio of shear stress and shear strain as shown below:

$$\text{Modulus of rigidity} = \frac{Shear\ Stress}{Shear\ Strain} \text{ Or } \left(\frac{\tau}{\Phi}\right)$$

Modulus of Rigidity Units

The unit of modulus of rigidity in the SI unit is termed Pascal (Pa). It is same as that of Young's Modulous. Generally, it is taken as megapascal (MPa) or Giga Pascal (GPA). The dimensional term is $[M^1L^{-1}T^{-2}]$. Hence we can understand that the modulus of rigidity is the ratio of shear stress to shear strain in the term of GPa mostly. Here GPA is considered as 10^9 pascals or (1e+9) Pa.

The modulus of rigidity has different values for different materials, as we discussed earlier, but the modulus of rigidity is zero for ideal gas. The modulus of rigidity is different from the flexural rigidity. An ideal gas particle has sufficient space,, and does not have any frictional resistance due to not presenting any frictional resistance, tangential stress is also zero.

Modulus of Rigidity Example

Modulus of rigidity differs from the material property or as well as material under environmental conditions. The examples shown in the table provided below are important for the GATE exam. Here, we consider the different materials having different values of modulus of rigidity.

S.No.	Material Type	Modulus of Rigidity
1.	Pure Aluminum	26 Gpa
2.	Alloy Aluminum	26-30 Gpa
3.	Brass	36-41 Gpa
4.	Bronze	36-44 Gpa
5.	Copper	40-47 Gpa
6.	Cast Iron	32-69 Gpa
7.	Mild Steel	75-80 Gpa
8.	Rubber	0.0002-0.0001 Gpa

Relation Between Modulus of Elasticity and Modulus of Rigidity

The modulus of elasticity relates to different parameters like rigidity or shear modulus, bulk modulus and PoisPoisson'sio. When Poisson'Poisson'saries from 0 to 0.5, the modulus of rigidity is defined in the range of 33% of modulus of elasticity to 50% of modulus of elasticity; this shows the behaviour of the material.

The kind of relation modulus of elasticity with the modulus of rigidity is-

Modulus of elasticity (E) = 2 G(1+ μ)

where; G = modulus of rigidity and $\frac{1}{m}$ or μ = Poisson's ratio

OR

Modulus of rigidity (G) = $[\frac{E}{2(1+\mu)}]$

OR

Modulus of rigidity (G) = $[\frac{mE}{2(1+m)}]$

OR

(G/E) = $[\frac{m}{2(1+m)}]$

Relation Between Modulus of Rigidity and Bulk Modulus

The kind relation of the modulus of elasticity with bulk modulus is:

Modulus of elasticity (E) = 3 K(1- 2μ)

OR

Bulk modulus (K) = $[\frac{E}{3\,(1-2\mu)}]$

OR

Bulk modulus (K) = $[\frac{mE}{(3\,1+m)}]$

OR

(K/E) = $[\frac{1}{3\,(1-2\mu)}]$

The relation between modulus of elasticity, bulk modulus, shear modulus and Poisson' ratio.

Modulus of Rigidity of Steel

The modulus of rigidity of steel exists in different metals, alloys, and subordinate metals such as mild steel, stainless steel, wrought steel etc. This modulus of rigidity of steel considers temperature, pressure, and other factors to determine how the modulus of rigidity changes with the variation of these factors. Here we consider steel's steel'sy factors as

- Mild steel modulus of rigidity = approx 79 GPA
- Stainless steel modulus of rigidity = approx 77 GPA