Hooke’s Law

Stress and strain take completely different forms in unlike situations. Normally, the stress and strain are proportional to each other for tiny deformations, and this is referred to as Hooke’s Law. Steel displays linear-elastic behavior in most engineering applications; Hooke's law is valid for it throughout its elastic span. Hooke's law is only valid for a part of the elastic range for some other materials, such as aluminum.

Hooke’s Law Definition

Hooke’s Law states that: “Hooke’s law defines that the strain of the substance is proportional to the applied stress within the elastic limit of that substance.”

When the elastic materials are stretched or compressed, the atoms and molecules disfigure until the force is applied, and when the force is removed, they return to their previous state.

Hooke’s law Formula

Mathematically, within the proportional limit of a material Hooke’s law formula, important for the GATE exam is expressed as follows-

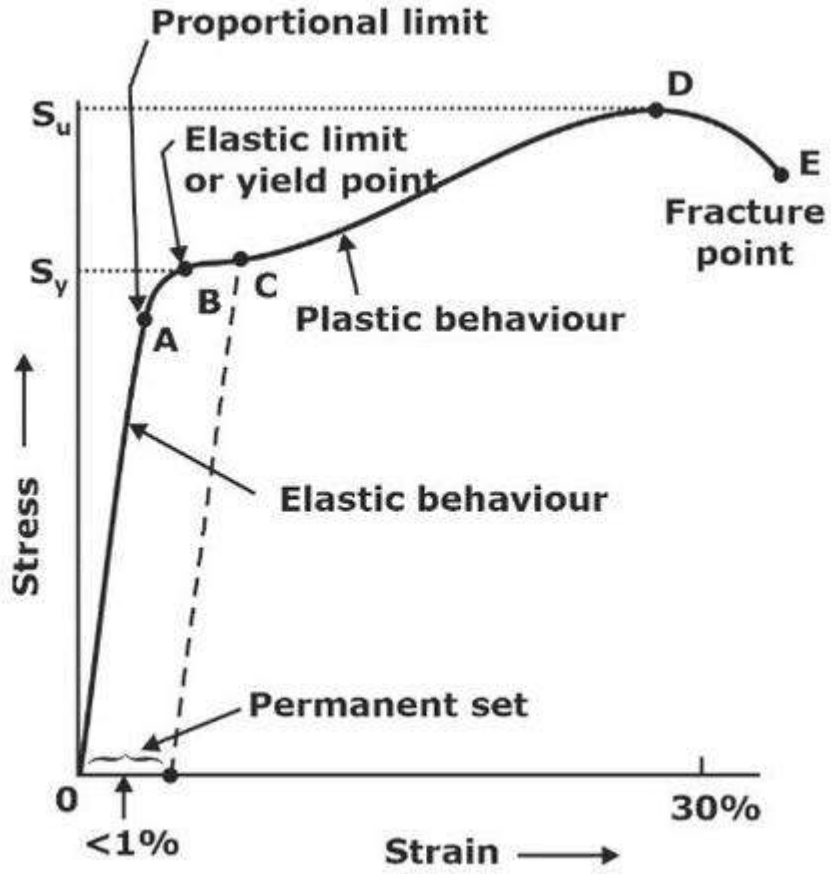
$$\sigma = E\varepsilon$$

Where in SI units

- σ is the stress; Pa
- E is the modulus of elasticity or Young’s modulus, Pa (Normally GPA)
- ε is the strain, dimensionless

Hooke’s Law Graph

The figure below shows the stress-strain curve for mild steel.



The material shows elastic behavior up to the proportional limit; beyond that, the material loses elasticity and shows plasticity.

From the emergence to the proportional limit nearing yield strength, the straight line suggests that the material follows Hooke's law. Beyond the elastic limit between the proportional limit and yield strength, the material no longer has its elasticity and shows plasticity. Candidates can expect 1-2 questions based on this in the GATE question paper. The area from emergence to the proportional limit under the curve falls under the elastic span. The area under the curve from a proportional limit to the fracture point/rupture falls under the plastic span.

The material's ultimate strength is based on the stress-strain curve's maximum ordinate value (from emergence to rupture). The value gives the rupture strength at a point of rupture.

Hooke's Law Applications

Hooke's Law is used in all branches of science and engineering to understand elastic materials' behavior as per the GATE syllabus; there is no replacement for Hooke's law. Following are some of the applications of Hooke's Law:

- It is used as a fundamental principle behind the manometer, spring scale, and the balance wheel of the clock.
- Hooke's law sets the foundation for seismology, acoustics, and molecular mechanics.

Hooke’s Law Disadvantages

Even though Hooke’s law is used widely in Engineering, it’s not a universal principle. The law is not applicable as soon as the elastic limit of a material is surpassed. Usually, for solid particles, Hooke’s law provides precise results when the deformations are small. Numerous materials deviate from Hooke’s law even well before reaching the elastic limit. Following are some of the disadvantages of Hooke’s Law:

- Hooke’s law comes to an end when applied beyond the elastic limit of a material.
- Hooke’s law is correct for solid bodies if the forces and deformations are small.
- Hooke’s law isn’t a universal principle and solely applies to materials as long as they aren’t stretched well past their capacity.