Introduction [*]

1 Introduction

Back in second year, when you had studied Fluid Mechanics (ME21101) or Thermo-Fluid Science (ME24001), the question *"What is a fluid?"*[†] was discussed. In that discussion, a fluid was defined as:

> *Fluid:* A substance that deforms continuously under the application of shear stresses *no matter how small the shear stresses may be.*

The italicized part of the above definition is the key to demarcating fluids from solids. Thus a solid can be defined as:

> *Solid:* A substance that can support some amount of shear stresses before it begins to deform continuously.

Furthermore, while solids can support both tensile and compressive stresses, fluids can support only compressive stresses. However, as had been mentioned in the introductory discussion on fluids, there is often no clear-cut distinction between fluids and solids. There are many materials which can best be described as something between fluids and solids; for instance, toothpaste, jelly, putty. In this course, however, we will primarily be concerned with materials that do not exhibit any fluid-like behaviour.

Fluid Mechanics was concerned with the velocity, forces, and stresses in fluid flows. Similarly, Mechanics of Solids will be concerned with displacements, forces, stresses, and various limiting conditions associated with the stresses within solids, in general, as well as within solids that constitute various structures of engineering importance.

Again, just like in Fluid Mechanics, we will be working within the purview of the Continuum Hypothesis in Mechanics of Solids too. You can read

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[†]Read that introductory discussion in this link.

up a bit on the continuum hypothesis in the introductory discussion on fluid mechanics.

The course, Mechanics of Solids, will directly build on what you learnt in the second half of first year Mechanics as well as second-year Fluid Mechanics or (the first half of) Thermo-Fluid Science.

2 Why study mechanics of solids?

Mechanics of Solids has a mind-boggling array of applications. These have been summarized by one of the giants of solid mechanics, Professor James Robert Rice in the following[‡]

> Here is a sampling of some of the issues addressed using solid mechanics concepts: How do flows develop in the Earth's mantle and cause continents to move and ocean floors to subduct (i.e., be thrust) slowly beneath them? How do mountains form? What processes take place along a fault during an earthquake, and how do the resulting disturbances propagate through the Earth as seismic waves, shaking, and perhaps collapsing, buildings and bridges? How do landslides occur? How does a structure on a clay soil settle with time, and what is the maximum bearing pressure that the footing of a building can exert on a soil or rock foundation without rupturing it? What materials should be chosen, and how should their proportion, shape, and loading be controlled, to make safe, reliable, durable, and economical structures – whether airframes, bridges, ships, buildings, chairs, artificial heart valves, or computer chips – and to make machinery such as jet engines, pumps, and bicycles? How do vehicles (cars, planes, ships) respond by vibration to the irregularity of surfaces or mediums along which they move, and how are vibrations controlled for comfort, noise reduction, and safety against fatigue failure? How rapidly does a crack grow in a cyclically loaded structure, whether a bridge, engine, or airplane wing or fuselage, and when will

[‡]Taken from this Encyclopaedia Britannica article written by him.

> it propagate catastrophically? How can the deformability of structures during impact be controlled so as to design crash-worthiness into vehicles? How are the materials and products of a technological civilization formed – e.g., by extruding metals or polymers through dies, rolling material into sheets, punching out complex shapes, and so on? By what microscopic processes do plastic and creep strains occur in polycrystals? How can different materials, such as fibre-reinforced composites, be fashioned together to achieve combinations of stiffness and strength needed in specific applications? What is the combination of material properties and overall response needed in downhill skis or in a tennis racket? How does the human skull respond to impact in an accident? How do heart muscles control the pumping of blood in the human body, and what goes wrong when an aneurysm develops?

It is thus patently clear that so far as human beings need to interact with any real-world thing (whether natural or man-made) they can hardly do so *completely* without the application of mechanics of solids. Considering all fields of engineering, this is one of the most fundamental subjects which is why the basic principles were taught to all students in first year. As mechanical engineers, of course, you will need to know more than those basic principles. This is the course where you learn them.