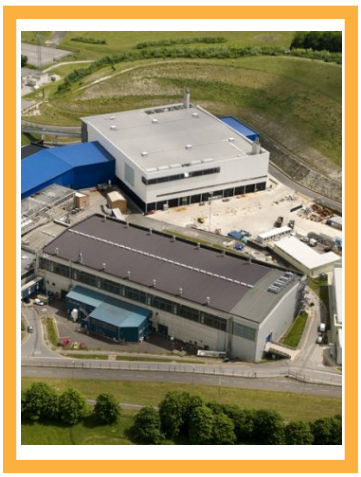
FEEL THE STRAIN

What does ISIS do?

ISIS Neutron & Muon source is based at Rutherford Appleton Laboratory, Oxford. Accelerated protons collide with a target to produce neutrons and muons. These are used to observe the position and movement of atoms. Neutron scattering is used in a huge range of disciplines. Our 36 instuments have studied the effect of neutron radiation on spacecraft, dated archaelogical artefacts and investigated various hydrogels for effective drug delivery.



Stress & strain in solids

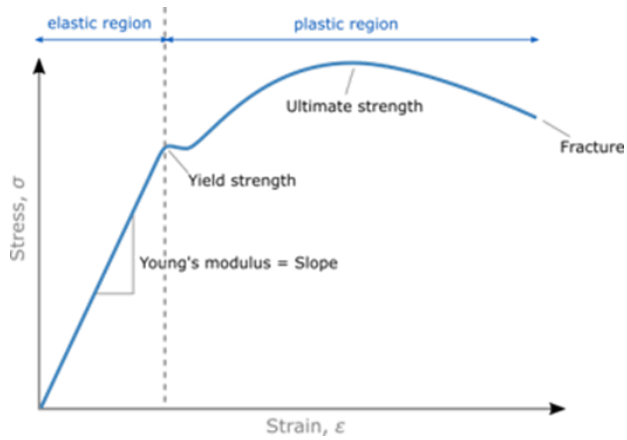
Stress is the force per unit area applied to a material. This stress causes atoms to move. The equation for stress is:

$$\sigma = \frac{\text{Force}}{\text{Area}}$$

Strain describes the deformations within a material. Strain is a dimensionless unit as it is a ratio of initial length and change in length.

The relationship between stress and strain can be observed using a **stress-strain graph**. This is plotted by gradually applying a load to a material and measuring deformation.

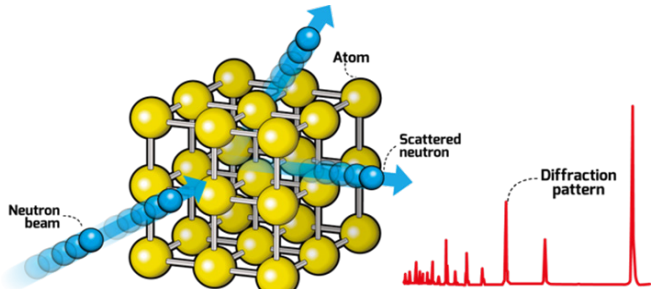
Different materials will behave differently under the same stress. The graph shown is typical for low carbon steel, a ductile material important in engineering.

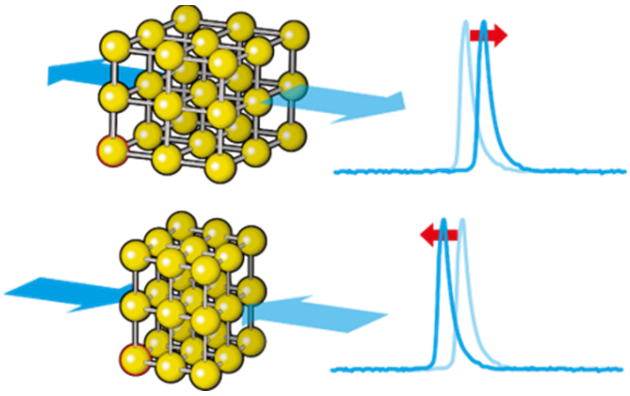


In the **elastic region**, stress and strain are proportional. The gradient of the line gives **Young's modulus**, or the stiffness of the material. The steeper the gradient, the stiffer the material. Deformations to the material are reversible.

Once the **yield strength** - also called the elastic limit - is exceeded, any deformation is irreversible. This is called the **plastic region**.

Firing **neutrons** at the atoms in a sample causes them to scatter. Measuring the angles at which they scatter creates a **diffraction pattern**. The peaks represent the distance between atoms.

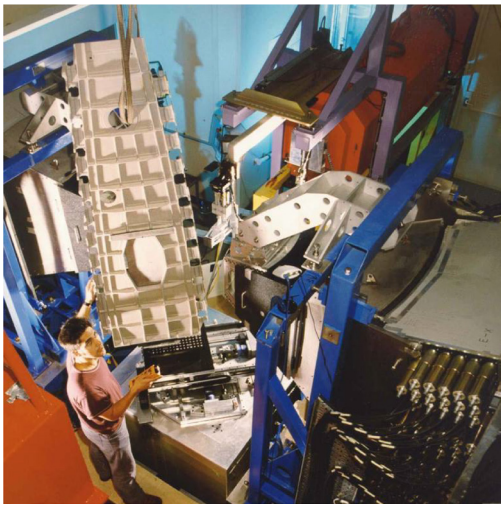




Then, stress is applied. If the peak shifts to the right, the material is **under tension**. If the peak shifts to the left, the material is being **compressed**. This reveals a materials' strength and resistance to fracture.

Research on Engin-X

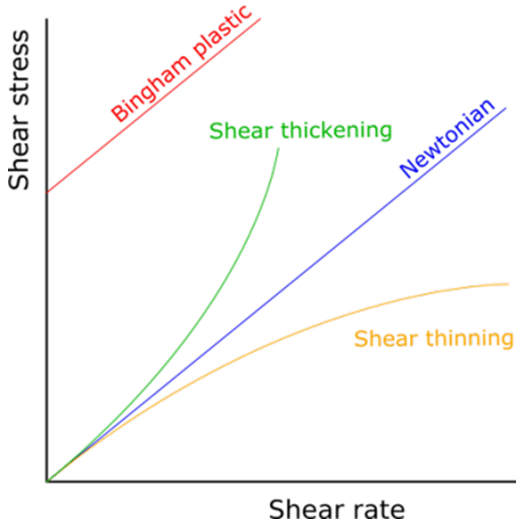
Engin-X uses neutron diffraction to measure strain. Subjects can be subjected to stress loads up to 100kN and temperatures up to 1000°C.
Engin-X can replicate the cosmic radiation an airplane will experience in its entire lifetime in a matter of hours. Scientists have used the instrument to reveal areas of potential stress and therefore weakness in aircraft parts, and subsequently focusing airplane development on these weaknesses. This research helps to make air flight as safe as possible.



Liquid stress & strain

Fluids are different to a solid. The shear stress depends on how quickly you apply the strength. The shear rate depends on the **viscosity** of the liquid. Fluids are classed as either Newtonian or non-Newtonian.

For **Newtonian** fluids, viscosity is only dependent on temperature and pressure. Therefore, we see a linear relationship between shear rate and shear stress.
The viscosity of a **non-Newtonian** fluid changes dependent on the force applied. When you increase shear rate, the viscosity of shear thickening liquids **increases**. The viscosity of shear thinning liquids **decreases**.
Bingham plastics are exceptions: although solid at first, a particular stress value results in Newtonian fluid-like behaviour.



Research on Sans2d and LOQ

'Smart hydrogels' are matrixes of fluids and polymers which can be injected as a liquid.
The temperature and pressure of your body transforms the complex into a soft gel. This allows for gradual drug release in a specific part of the body, potentially reducing the number of hospital visits and side effects a patient must endure.
Researchers used the ISIS instruments Sans2d and LOQ to investigate the optimum concentrations of smart hydrogels.

Oobleck experiment

Oobleck is a non-Newtonian fluid. It is easy to make, and great for experiments!

You will need...

1.5-2 cups of cornflour
1 cup of water
Bowl
Wooden spoon

Mix your cornflour and water together in the bowl with the spoon and start investigating its properties!

Some things to think about...

What happens to oobleck when you apply different shear rates?
Is oobleck shear thickening or shear thinning?