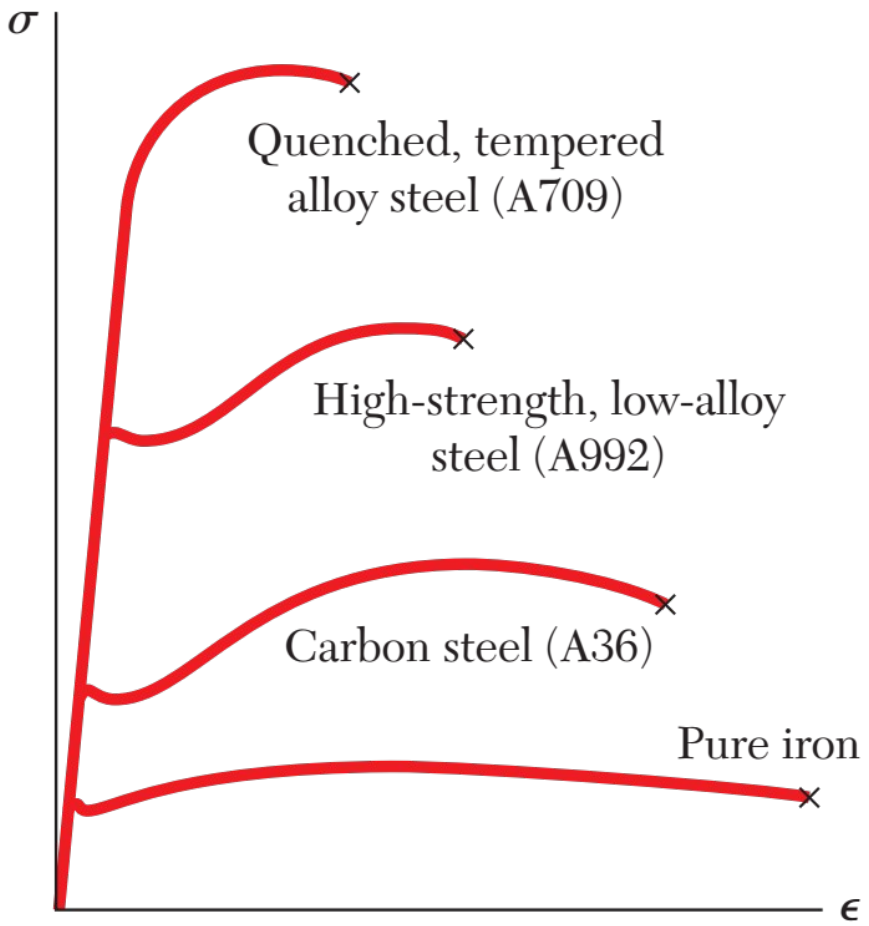
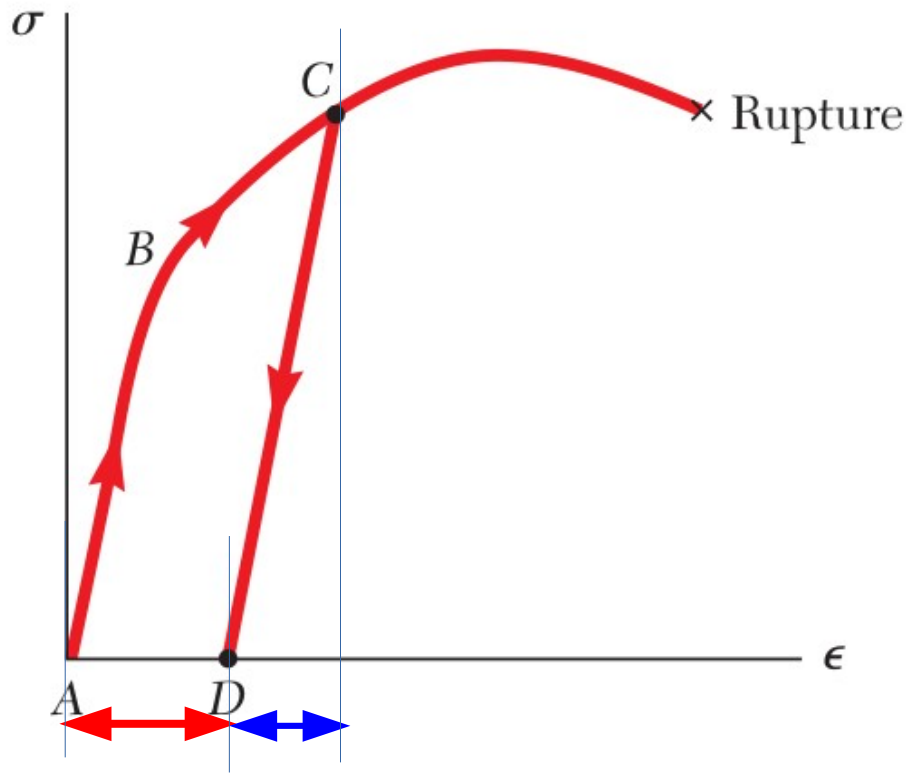
ME231: Solid Mechanics-I

Stress, Strain and Temperature relationship



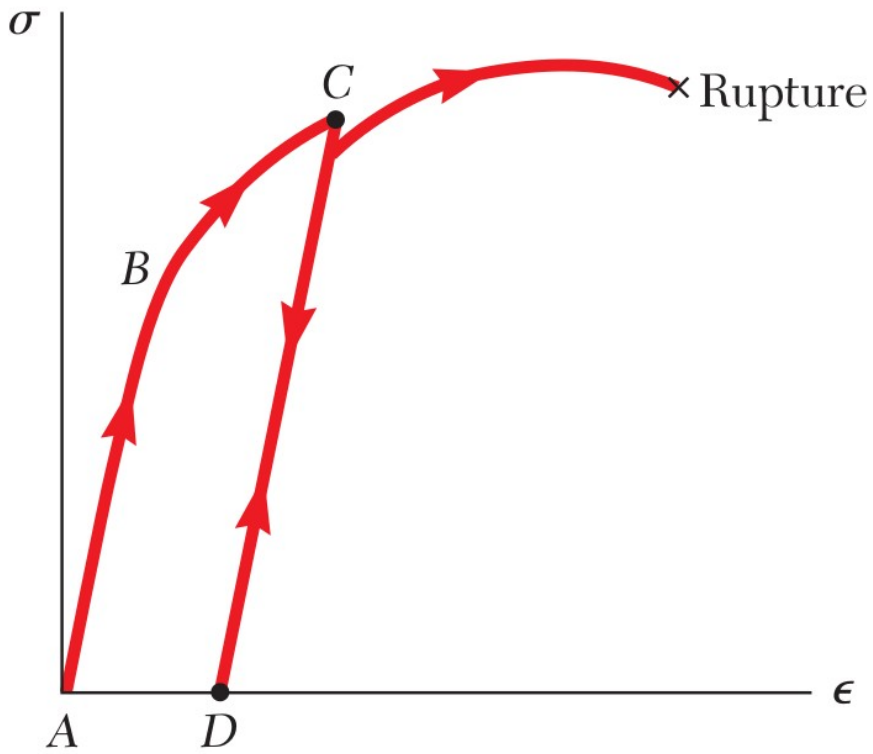
- Some physical properties of structural metals, such as strength, ductility, and corrosion resistance, can be varied by alloying, heat treatment, and the manufacturing process used.
- The stress-strain diagrams of pure iron and three different grades of steel show large variations in the yield strength, ultimate strength, and the ductility.
- However, all of these metals possess the same modulus of elasticity.
- Therefore, if a high-strength steel is substituted for a lower-strength steel and if all dimensions are kept the same, the structure will have an increased load-carrying capacity, but its stiffness will remain unchanged.

Elastic vs. Plastic Behaviour: Unloading



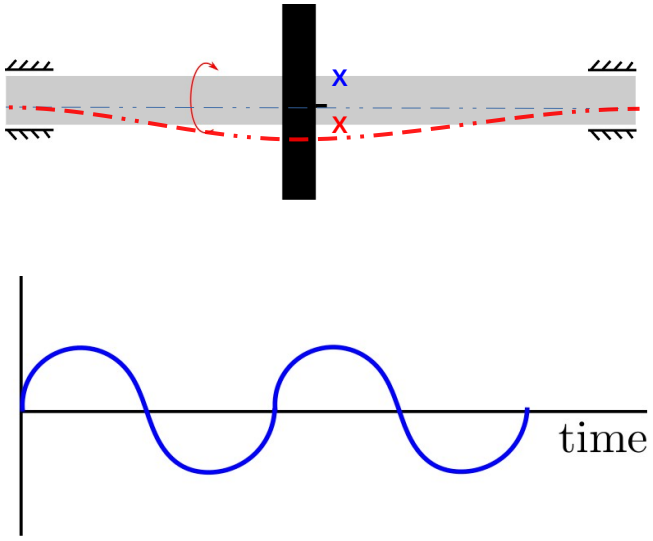
- If a material is subjected beyond its elastic limit (till point C) and then the load is removed; the stress and strain decreases in a linear fashion (path CD). The linear unloading path CD is parallel to the initial loading path AB.
- It should be noted that after complete unloading strain ϵ does not return to zero, which indicates that a permanent set or plastic deformation of the material has taken place.
- Strain recovered during the unloading process is the elastic strain.

Elastic vs. Plastic Behaviour: Reloading



- If the unloaded test specimen is reloaded under tension, stress-strain curve first follow the path DC, then it will bend to the right and connect with the curved portion of the original stress-strain diagram.
- The straight-line portion of the new loading curve is longer than the corresponding portion of the initial one.
- Thus, the proportional limit and the elastic limit have increased as a result of the strain-hardening that occurred during the earlier loading. However, since the point of rupture remains unchanged, the ductility of the specimen, which should now be measured from point D, has decreased.

Repeated loading and fatigue



- Most engineering components experience repeated or fluctuating load
- For example,
  - A beam supporting an industrial crane can be loaded as many as two million times in 25 years (about 300 loadings per working day)
  - An automobile crankshaft is loaded about half a billion times if the automobile is driven 200,000 miles,
  - An individual turbine blade can be loaded several hundred billion times during its lifetime.

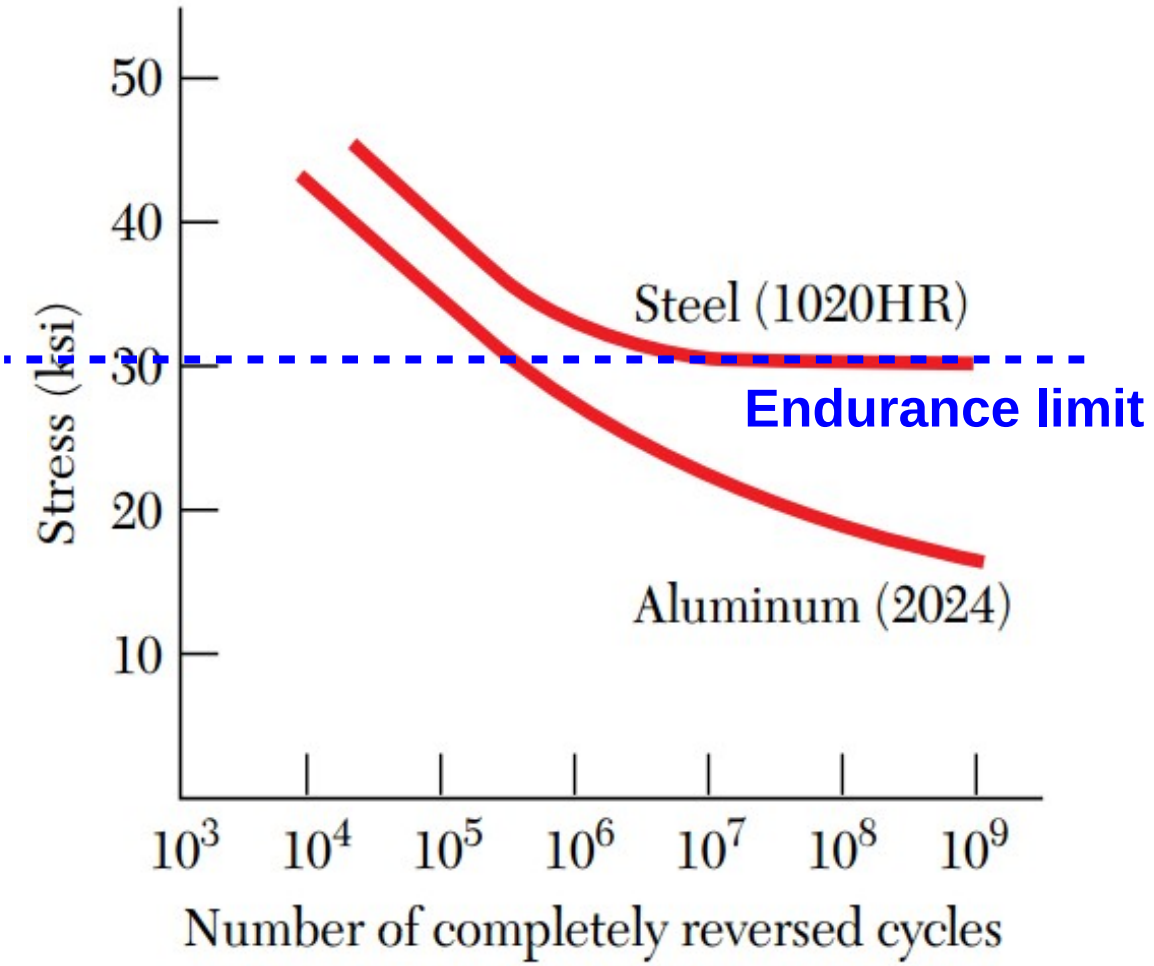
- When loadings are repeated thousands or millions of times, then the rupture can occur at a stress much lower than the static breaking strength; this phenomenon is known as fatigue.
- A fatigue failure is of a brittle nature, even for materials that are normally ductile.

Endurance limit

$\sigma - n$ *curve*

or

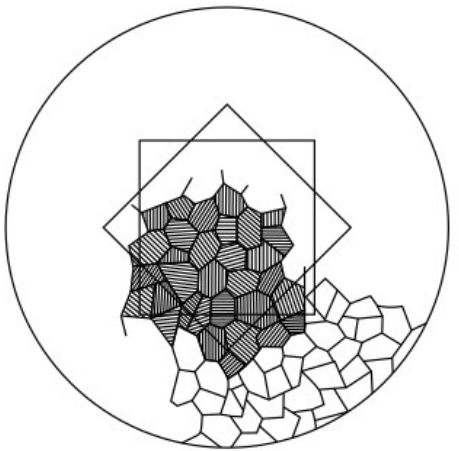
$s - n$ *curve*



Elastic stress-strain relations

- We already developed stress-strain relationship as Hooke's law for special case of one dimensional loading.
- We will now generalize the elastic behaviour and establish the relationship between six components of stress and six components of elastic strain.
- We will restrict our self to all linearly elastic materials. We will also restrict our self to definitions of strain for small deformations.

- We will also assume materials to be homogeneous isotropic. An isotropic material is defined as one whose properties are independent of orientation.
- Materials made up of randomly oriented structural elements may be thought of as being statistically isotropic.
- Homogeneity implied that material properties are independent of position.



Statistically isotropic material