General Loading and Strain

Ductile or Brittle ?

according to the stress-strain diagram we have two types of materials

Ductile

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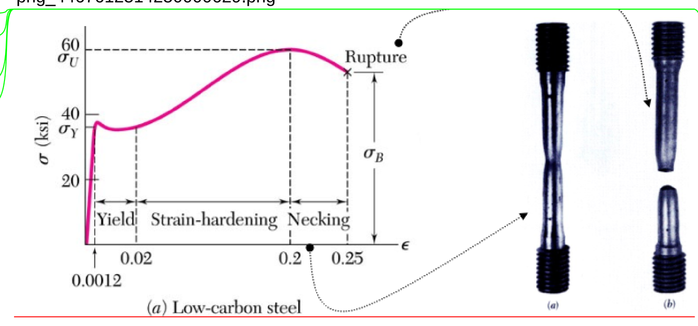
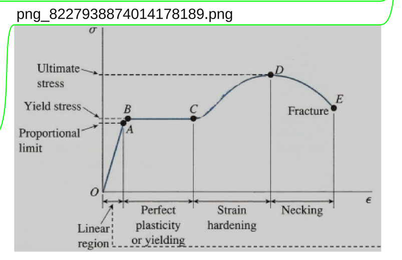


- you can notice that it didn't break immediately but the thickness reduced until rupture
- the yield strength is not always perfect horizontal line
- we can determine the yield strength using the offset method
- png_8227938874014178189.png



  - the ideal behaviour
- like structural steel/gold/mild or low-carbon steel and alloys of other metals
- they **yield** at normal temprature
- they **fail** due to maximum **shear** stress (45 deg)

Brittle

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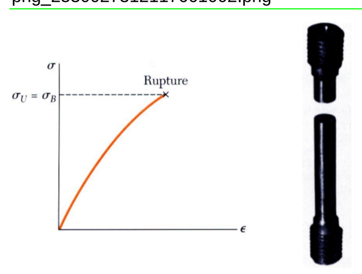
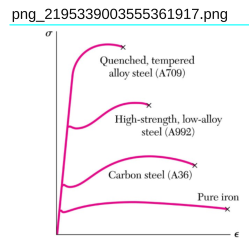


- like cast iron, glass and stone
- they rupture suddenly
- they fail due to maximum normal stress

Hook's Law

- we focus our interest on the elastic region (straight line portion)
- in this part the stress is directly proprtional to the strain with E as the constant of proportion
- ¾ = E ²
  - E is the Modulus of Elasticity
    - png_2195339003555361917.png



    - While strength, ductility and corrosion resistance are affected by
      - alloying
      - heat treatment
      - manufacturing process
    - **E** is the same
    - the **stiffness** of the material or the ability to **resist deformation** within linear range is the same and **independent** on the strength
  - or Young's Modulus
- largest value of stress is the yield stress
  - the yield stress = proportional limit obeys hook's law

Elastic and Plastic

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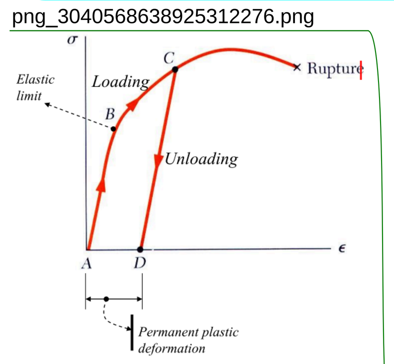
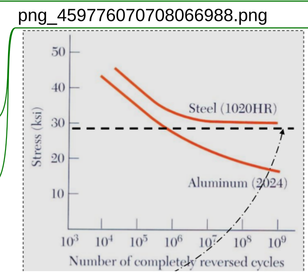


- if the strain disappears when the stress is removed, the material is elastic
  - الاستك ،
  - when it doesn't return -> plastic
- the largest stress for which this process happens is called elastic limit

The Fatigue

- when the load is repeated thousands/millions of times then the rupture will occur at a much lower stress than the original static one
- png_459776070708066988.png



  - stress-n diagram
  - note that if the applied stress is within the **endurance limit** of the material, fatigue failures will not occur for any number of cycles

General Loading

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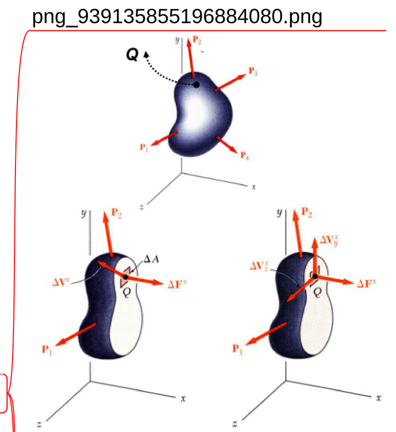
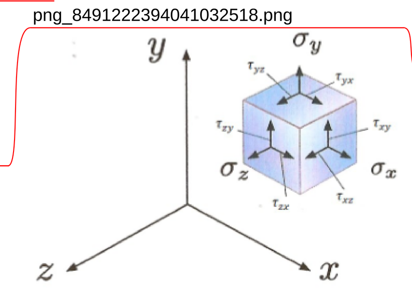
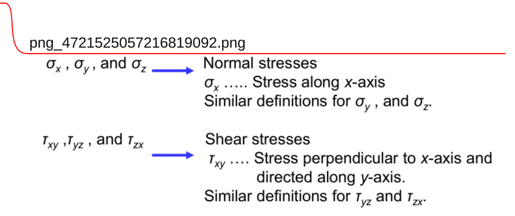


- for any rigid body there exist a stress in each direction/plane
- consider the following cross section
  - png_8491222394041032518.png



  - png_4721525057216819092.png

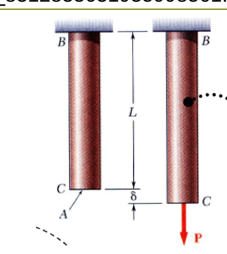


Factor of Saftey

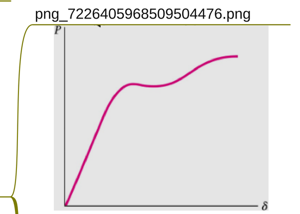
- $F\,S = \frac{¾_u}{¾_{all}} = \frac{\text{ultimate stress}}{\text{allowable stress}}$
  - ultimate stress is the stress at which the specimen will break or begins to carry less load
- $F\,S = \frac{P_u}{P_{all}} = \frac{\text{ultimate load}}{\text{allowable load}}$
- if you're given the minimum FS
  - so we can increase it :)
    - so the maximum load will be the smallest one
- maximum FS
  - maximum force/load = largest one

Normal Strain under axial Loading

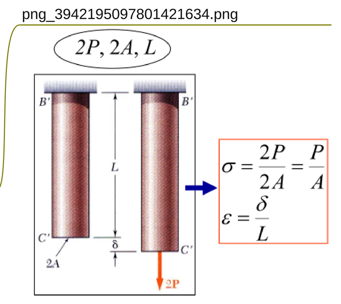
- png_8312833631935998561.png



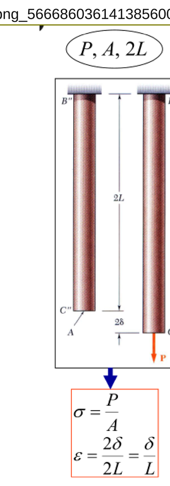
  - when you increase the load P there will be a deformation delta
  - there is a relation between the load and the deformation
    - png_7226405968509504476.png



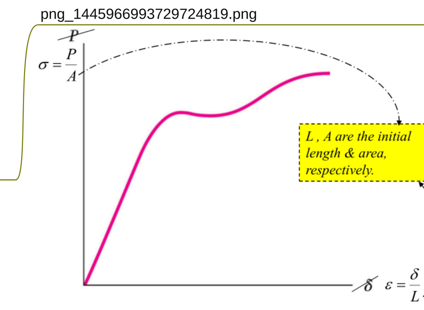
    - load-deformation diagram
    - linear then non-linear
    - this diagram **cannot** ***directly*** predict the deformation of a a rod same material but diff dimensions
    - the deformation depends logically on the L and A cross-sectional
- Strain is the deformation per unit length
  - $2 = \frac{\pm}{L}$
  - and we know that $¾ = \frac{P}{A}$
  - if we multiplied the load and the area by a constant the stress and strain will be the same
    - png_3942195097801421634.png



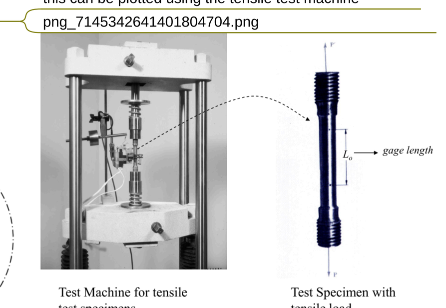
  - if we multiplied the length by a constant the stress and strain will be the same
    - png_5666860361413856005.png



  - so we can use a Stress-Strain Diagram instead of the one with deformation and load
    - png_1445966993729724819.png

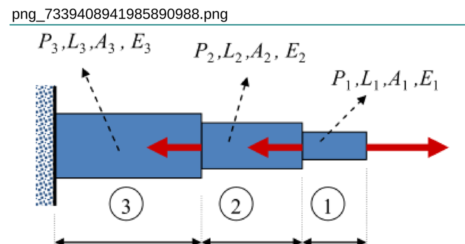


    - this can be plotted using the tensile test machine
      - png_7145342641401804704.png

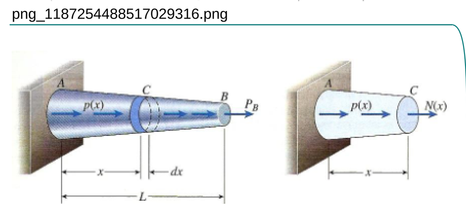


Deforamtion under axial loading

- from the equations of stress and strain
  - $\pm = \frac{P\,L}{E\,A}$
    - plea ،ية
  - when to use that equation ?
    - Elastic range
    - Homogenous rod (Constant E)
    - Uniform rod (constant A)
    - Centric loading applied at the ends
  - if not fulfilled we reduce the problem to multiple problems
    - $\pm = \sum_i \frac{P_i L_i}{E_i A_i}$
      - png_7339408941985890988.png

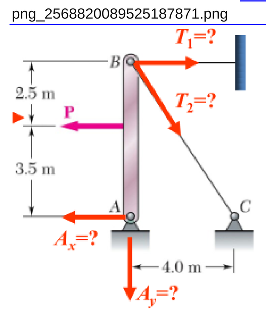


    - $\pm = \int_0^L \frac{P(x)}{E\,A(x)}\,dx$
      - png_1187254488517029316.png

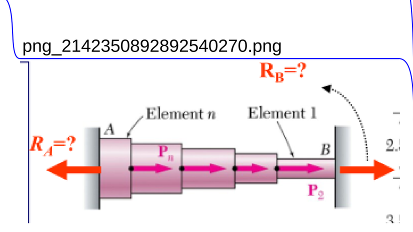


Statically indeterminate problems

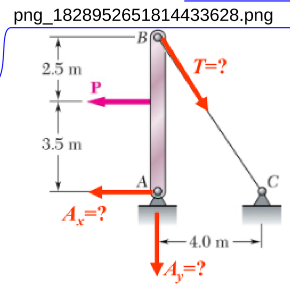
- Statically indeterminate
  - structures for which the mechanics(Equilibrium Equations) alone **cannot** solve
  - png_2568820089525187871.png



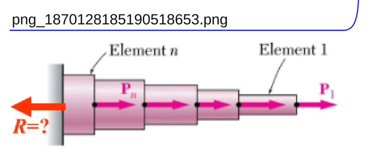
  - png_2142350892892540270.png



  - whenever a structure is held by more supports than required to maintain equilibrium we call it so
- Statically determinate
  - **can** be solved
  - png_1828952651814433628.png



  - png_1870128185190518653.png



- How to solve ?
  - we solve using the deformation info.
    - for example
      - $\pm_1 = \pm_2$
- Degree of indeterminacy
  - = no: of unknowns - No: of equations of equilibrium
    - if there are additional supports, this will not solve the problem but will lead to additional (redundant) reactions need to be determined
    - redundant reactions are replaced with unknown loads which with the other loads will produce compatible *deformations* like when the total deformation is zero and so on
    - these equations are called **compatibility/geometry** equations
    - deformations due to actual loads $\pm_L$ and deformations due to redundant reactions $\pm_R$ are determined separately using force-displacment equations and then added or superposed according to the compatibility equations