Mechanical Properties: strength, hardness, ductility, brittleness, toughness, stiffness, & impact resistance
Mfg. Properties: castability, machinability rating, machining speeds & feeds
Physical Properties: density, M.P., thermal conductivity, specific heat, & coeff. of thermal expansion
Optical Properties: transparency / opacity, color, R.I., pleochroism, birefringence, dispersion, extinction
Acoustic Props: sound / reflection / transfer
Atomic Props: atomic mass / number / weight
Chemical Props: pH / reactivity / surface tension & energy
Electrical Props: capacitance / permittivity
Magnetic Props: Curie temp / permeability

Wishes Vs Reality: strong materials → stubborn, ductile → delicate

Alloy & Composites: combination of ≥ 2 metals & ≥ 2 types of materials (metals, polymers, & ceramics)
Bronze / Brass / Cast Iron Vs. Laminar / fiber-reinforced / particulate composites

Alloys: corrosion resistance, strength, lighter, thermal / electrical compatibility, durable
Composites: strength-to-weight ratio, durability, design flexibility, cost-effective

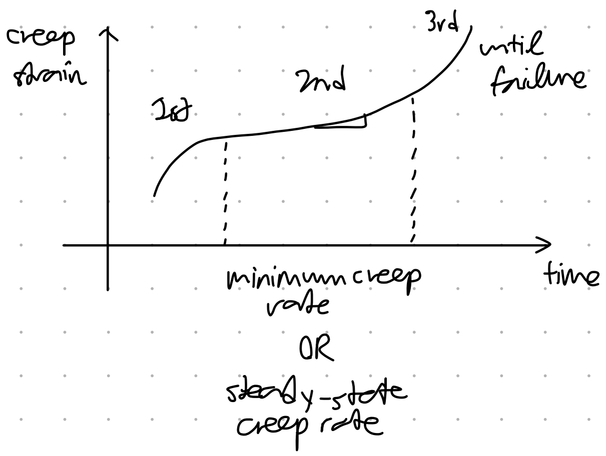
Tensile Tests mechanical test that measures response of a material to a stretching force.
stress - strain → pulled until failure, elongation measured
used for: material selection, Q.C., product development

extrinsic properties: relates to how much of the material is present
intrinsic properties

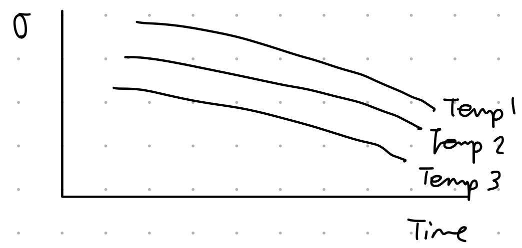
Engineering Stress: $\sigma = F/A_0$, force per cross-sectional area (MPa) intrinsic prop.
amount of withstandable force before failing

Engineering Strain: $\varepsilon = (L-L_0)/L_0 = \Delta L/L_0$, % change in length of material
intrinsic prop., unitless; amount of deformation when subjected to external load.

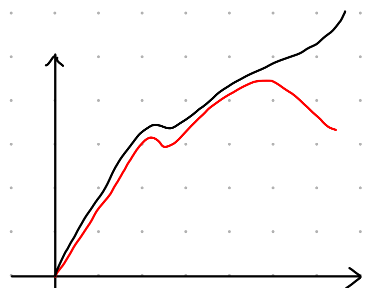
Creep: time-dependent deformation of a material while under an applied load < yield strength
occurs mostly at elevated temp.



Stress rupture test: similar to creep testing but w/ higher stresses / always done until failure



Engineering Stress Strain
assumes cross-sectional area stays constant (not true irl b/c it ↓ due to elastic & plastic deformation).



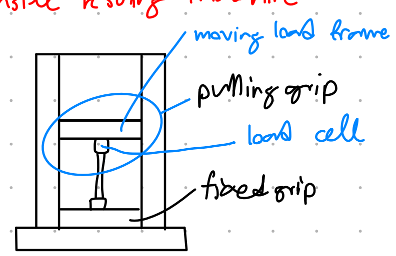
True Stress-Strain Curve
applied load / actual cross-sectional area

Tensile Test (How to)
Select the material → cut the material to ASTM's size & shape, avoid damage → place in grips of universal tester & pull until failure

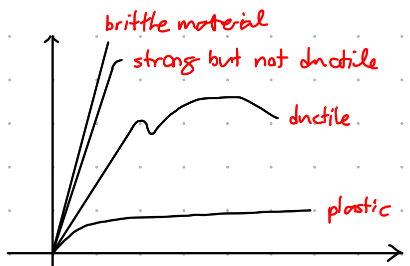
Why tensile test?
→ material selection, Q.C., product design & development, & refining prototypes

ASTM: American Society for Testing & Materials
ASTM D882: in the form of thin sheeting (film < 1.0mm thick)

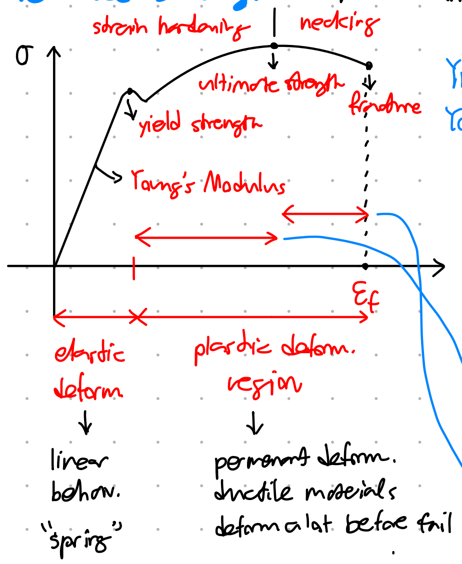
Tensile Testing Machine:



force vs displacement
↳ stress vs strain



Strength: ability of a material to resist deformation under external loads
Tensile Strength: maximum stress that a material can support w/o fracture



Yield Strength: max. stress before permanent deformation (MPa).
Young's Modulus: material's stiffness / resistance to elastic deformation under load
higher = more σ needed to create same amount of strain

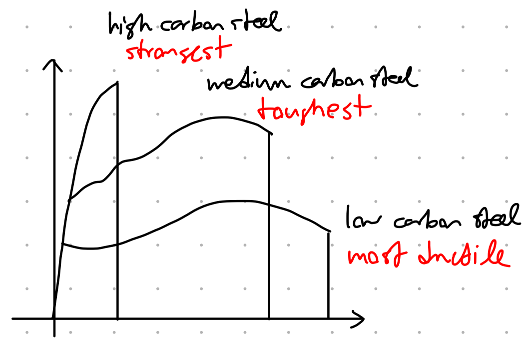
ε_f: maximum strain @ fracture
max. amount of deformation
→ provides info about ductility
ductile: $\varepsilon_f \uparrow$, brittle: $\varepsilon_f \downarrow$

Strain Hardening region: material → stronger & more difficult to be stretched.

Ductility: ability to stretch plastically before fracturing

Necking Region: material necks until failure
flatter necking region = easier to pull out into wires, ductile!

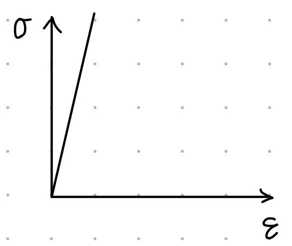
Toughness: ability to absorb energy & plastically deform w/o. fracturing
$J \cdot m^{-3}$
must be both strong & ductile. Area under σ-ε curve.



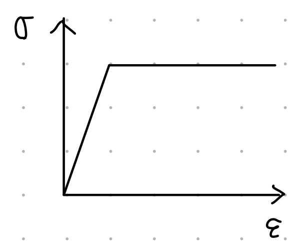
How Materials Break:

experimental variations: changes that affect results of experiment (temp., strain rate, specimen geometry, loading direction).

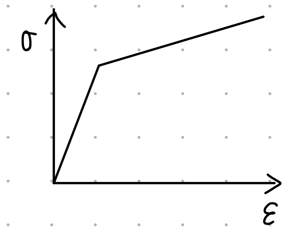
Perfectly elastic:
fractures rather than yield to plastic flow; brittle materials



Elastic & Perfectly Plastic:
behaves like molten cheese! when heated to sufficiently high temp.



Elastic & Strain Hardening Materials
Most ductile metals behav. this way when cold worked



Mechanical Properties From Tensile Tests

Strength: ability to resist deformation under external loads

Hardness: resistance towards penetration / scratching
↳ compression test

Ductility: deform plastically before fracture, occurs after elastic range's exceeded.

Stiffness: resistance of a material to deformation under external loads; app. to elasticity E.

Toughness: ability of a material to absorb energy & deform plastically before fracturing. opp. of brittleness. Area under σ-ε curve

Brittleness: tendency of a material to fracture upon application of stress; opp. of toughness. fractures w/o significant deformation

Elasticity: ability of a material to return to its original shape after deformation
it is ∝ length of elastic region

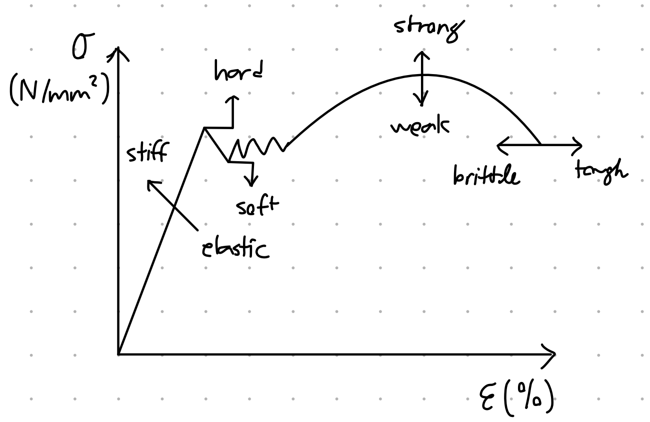
Plasticity: ability to undergo permanent deformation w/o breaking; ∝ length of plastic region

Malleability: ability to be deformed under compression w/o cracking.

Cohesion: ability to resist separation of its particles

Fatigue: tendency of failure under cyclic loading

Creep: tendency of deformation under constant load overtime.



Stiff (steeper) / elastic (shallow)
Hard (higher) / soft (lower)
Strong (↑ tensile F) / weak (necks fast, tears easily)
Brittle (low tensile F, breaks fast)
/ tough (form marked deform. before breaking).