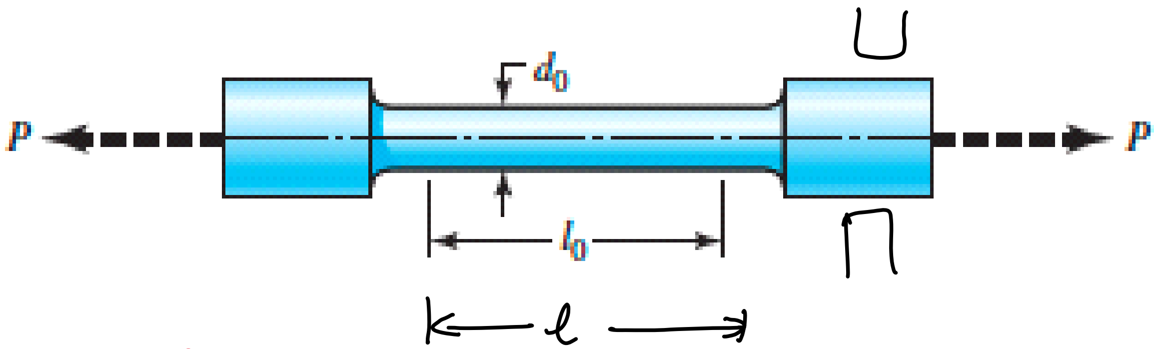
specimen

Material strength and stiffness



Instron

↗ changes as P ↑

P - external load

l_0 - gauge length

d_0 - diameter

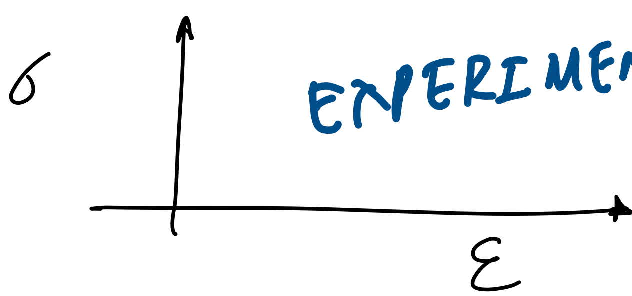
Stress

$$\sigma = \frac{P}{A} = \frac{P}{(\pi d^2/4)} = \frac{4P}{\pi d^2}$$

Engineering Strain

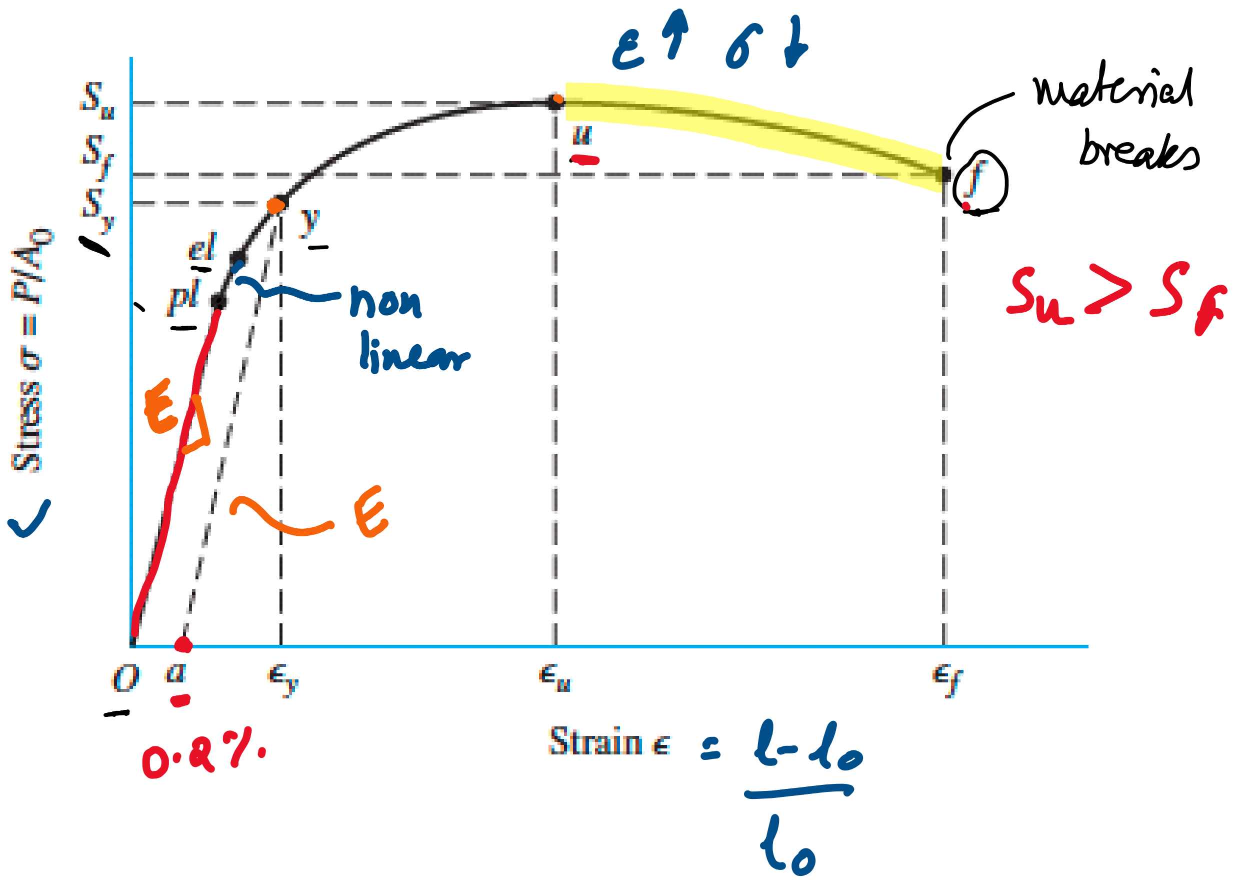
$$\varepsilon = \frac{l - l_0}{l_0} = \frac{\Delta l}{l_0}$$

P ↑ l ↑ d ↓ ε ↑



EXPERIMENTALLY (NEXT PAGE)

ductile (metals)



(i) pl – proportional limit. This is the point uptil which the $\sigma - \varepsilon$ curve is linear

(ii) el – elastic limit

from pl – el system is non-linear

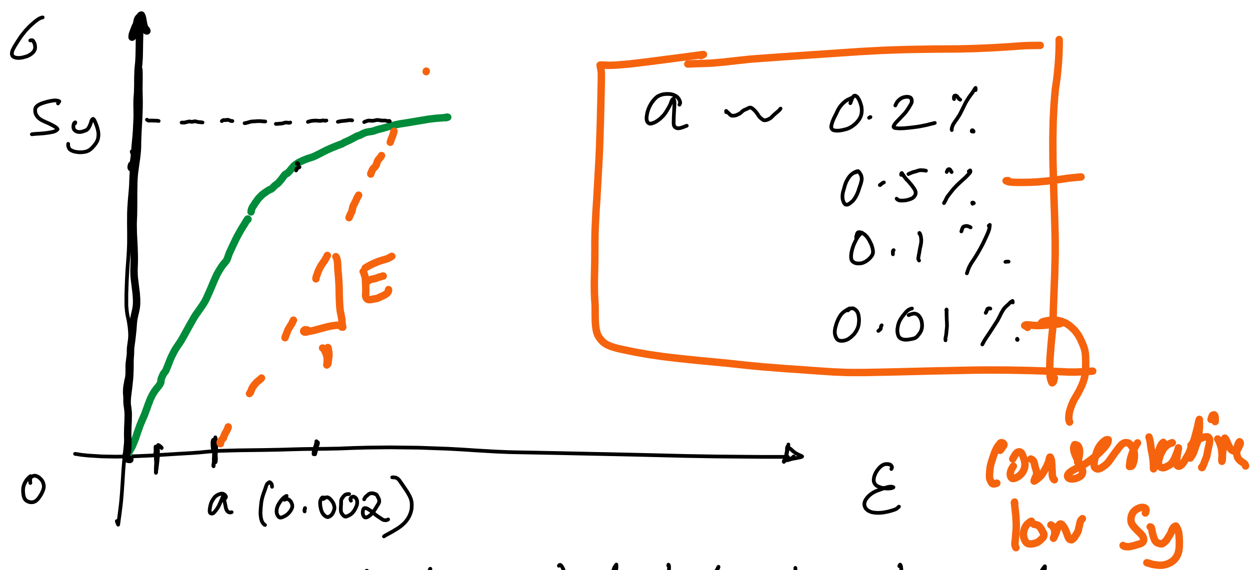
Beyond el, the material becomes plastic. That is, when P is reduced to zero, it does not go back to its original length l_0

y : yield point

el-y : the strain increases faster than the stress

stress at 'y' is called the yield strength S_y ← important design number.

An offset method is used to compute S_y



① Assume an offset point 'a' to be at 0.2% (= 0.002)

② Draw a straight line from 'a' with a slope of E

③ The point of intersection of this line with the σ-ε curve is S_y

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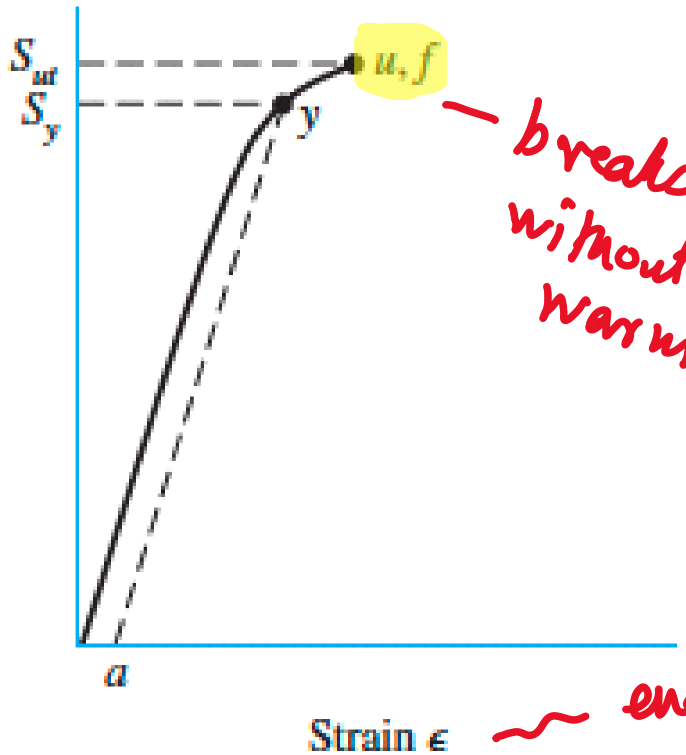
with the σ-ε curve is S_y

(iv) U – ultimate or maximum strength
S_u

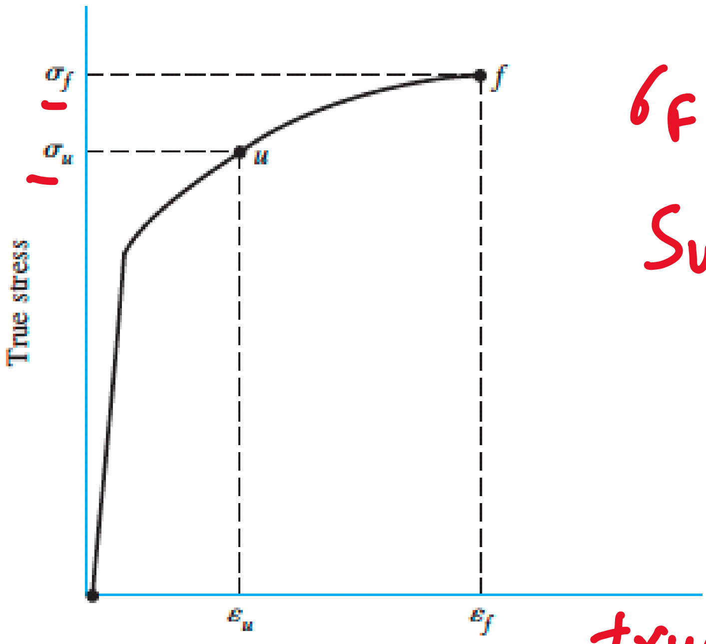
(v) F – fracture point / material breaks brittle (ceramic, glass, graphite)



The behavior of a brittle material is similar to a ductile material upto point y

u, f are the same points. Here the material breaks / fractures

True stress-strain



$\sigma = \frac{P}{A}$

$\sigma_f > \sigma_u$

$S_u > S_f$

true strain $= \ln\left(\frac{l}{l_0}\right)$

$$\varepsilon_t = \int_{l_0}^{l} \frac{dl}{l} = \ln l \Big|_{l_0}^{l} = \ln\left(\frac{l}{l_0}\right)$$