Generalities

Lectures:

1st → general intro to plasticity and user-material models.

2nd → yield surface and plastic flow
→ 1st UMAT with elasticity (FORTRAN crash course)
↳ homework "assignment"

3rd → work-hardening & visco-plasticity

4th → Return-map algorithm
→ 2nd UMAT with von Mises plasticity.
↳ homework "assignment"

2 weeks to find a topic

⇒ Project ready

5th → Damage and fracture

→ 3rd UMAT with failure + VUSDFLD subroutine

6th → Large-strain plasticity.

Project :

→ report : example to come in 2nd lecture

↳ journal article style

→ individual or group ?

Exam :

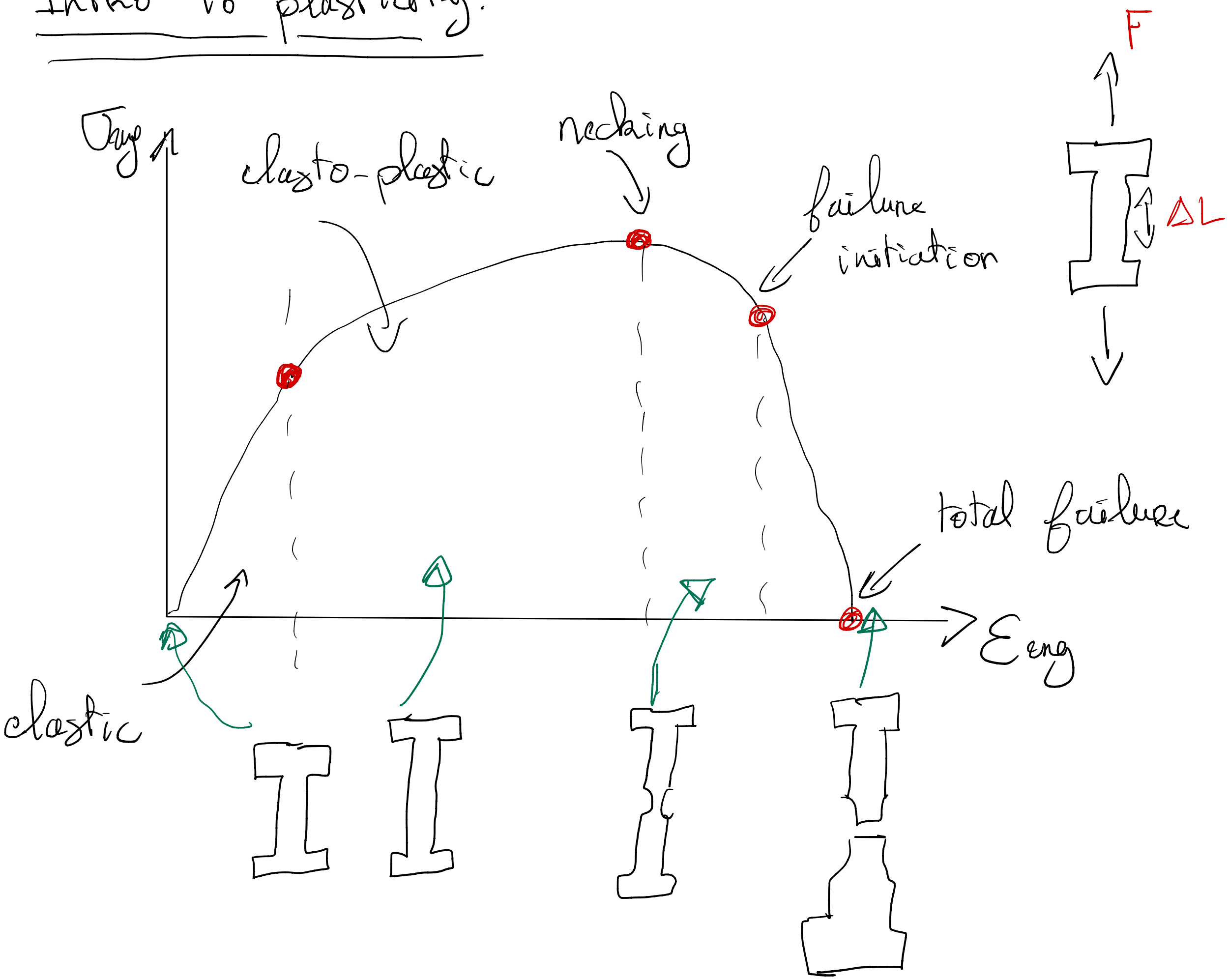
→ new date.

→ Oral exam → 60 minutes

↳ 30 min to prepare

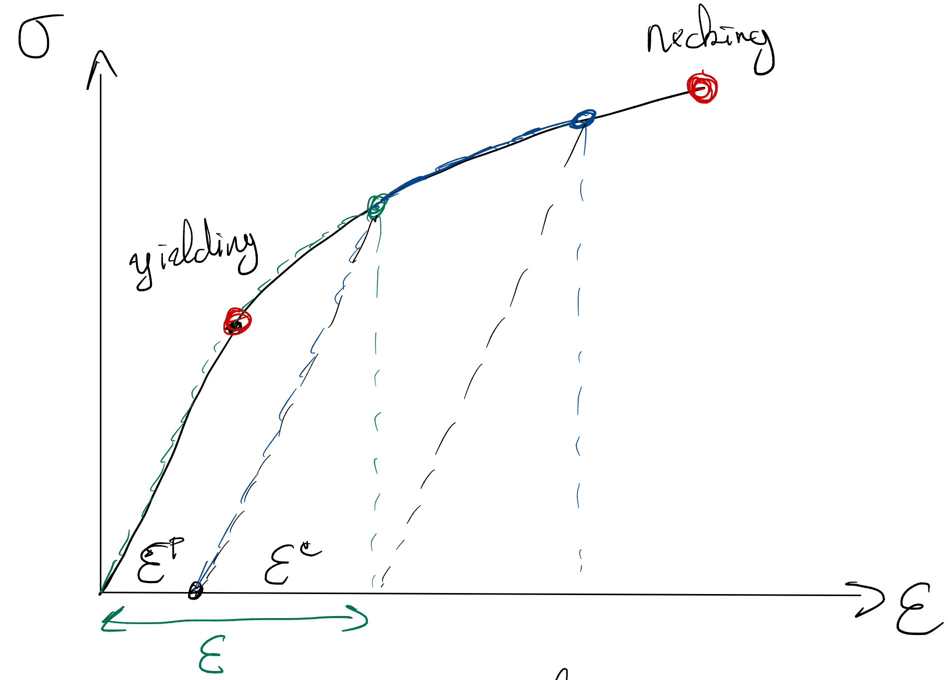
↳ 30 min for questions

Intro to plasticity.



$\Rightarrow \quad \sigma_{eng} = \dfrac{F}{A_0}$ engineering stress

$\varepsilon_{eng} = \dfrac{\Delta L}{L_0}$ engineering strain



σ, ε are true stress, true strain

$$\sigma = \frac{F}{A}, \quad \varepsilon = \log\left(1 + \frac{\Delta L}{L_0}\right)$$

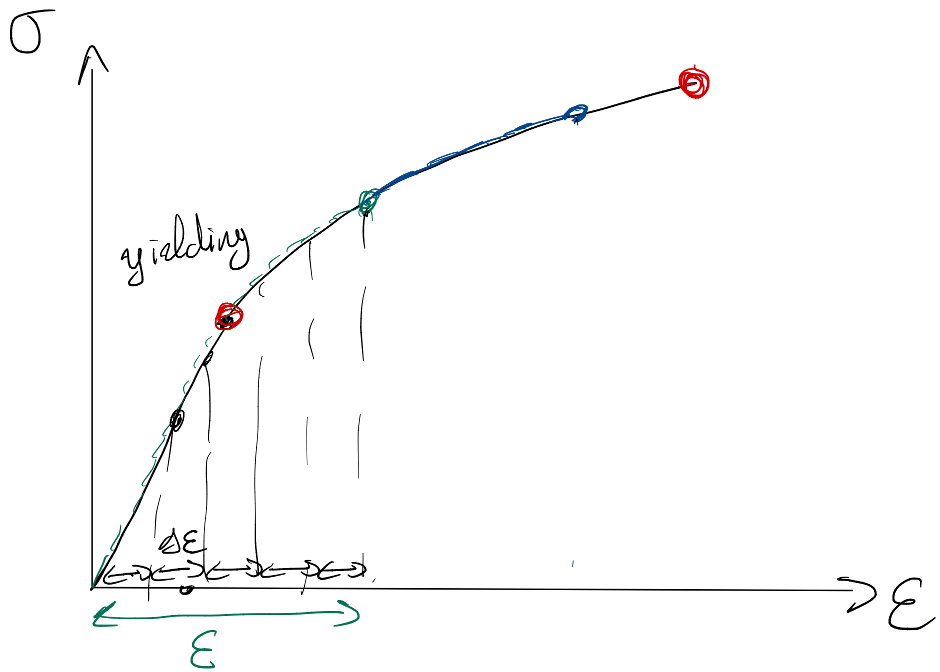
$\Rightarrow$ for a given ε we have both elastic strains ε_e and plastic strains ε_p

$\Rightarrow$ In a UMAT: for a given ε what is the corresponding σ?

Two general settings:

$\rightarrow$ additive decomposition: $\varepsilon = \varepsilon^e + \varepsilon^p$

$\rightarrow$ multiplicative decomposition: $\mathbb{F} = \mathbb{F}^e \cdot \mathbb{F}^p \Rightarrow$ hyper-elastic



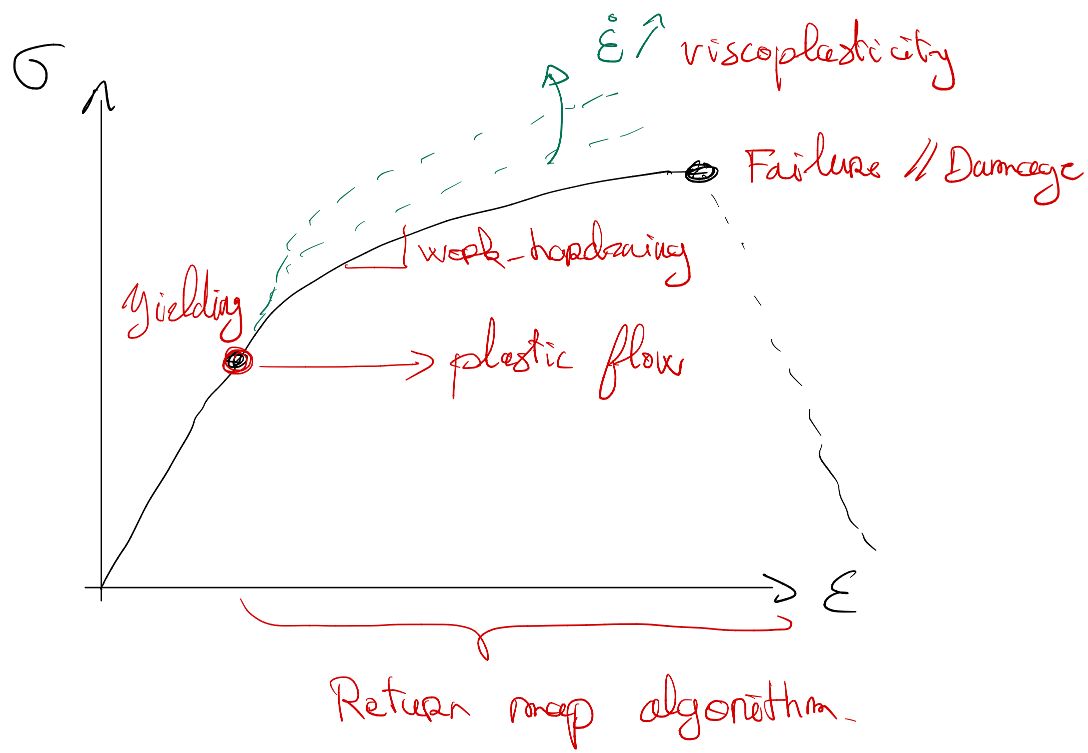
n is the timestep

$$\sigma^{n}, \Delta\varepsilon^{n+1} \Rightarrow \text{UMAT} \Rightarrow \sigma^{n+1}$$

$\Downarrow$

Implicit $\Leftrightarrow$ Explicit

$\|\Delta\varepsilon\| \simeq 0{,}01$ / $0{,}1$ $\Leftrightarrow$ $\Delta\varepsilon$ $\rightsquigarrow$ $\|\Delta\varepsilon\| \approx 1e^{-5} // 1e^{-6}$



UMAT structure

$$\sigma^{n}, \Delta\varepsilon^{n+1} \Rightarrow \text{UMAT} \Rightarrow \sigma^{n+1}$$

→ Elastic trial step

→ Check the yield surface

- elastic
- plastic flow
  ↓
  RMAP

→ update variables

→ go to next timestep