

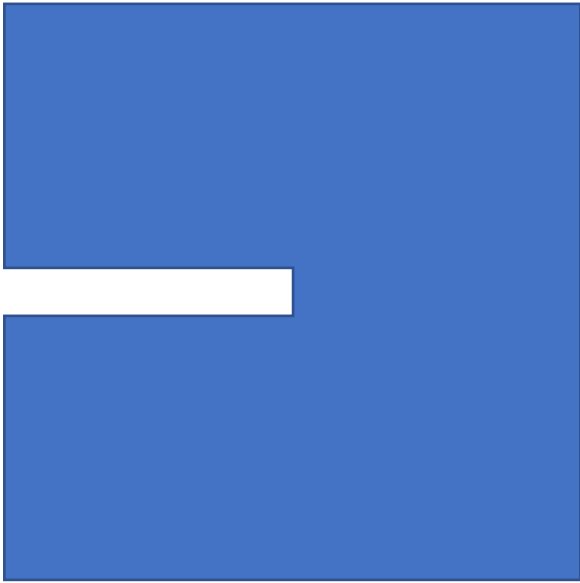
Solving phase field problem with FEniCS

03/01/2023

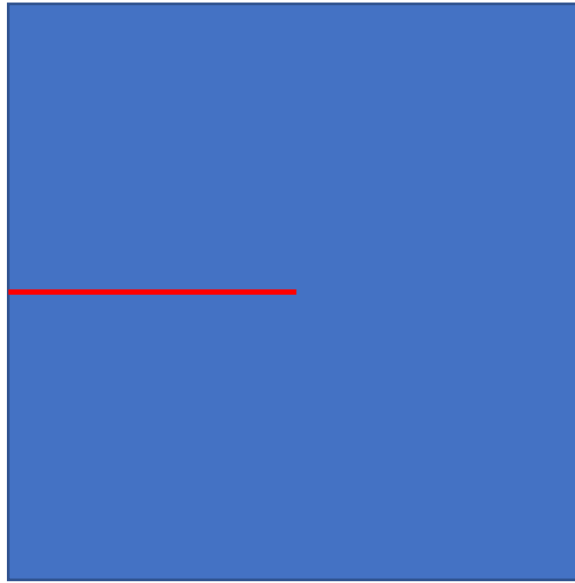
Outline

- Mesh generation
 - mesh with pre-existing crack/notch/damage
 - Software: FEniCS inbuilt/Gmsh/Abaqus
- Solving the elasticity problem with pre-crack in FEniCS
 - With single load step
 - with multiple load steps
- Solving the Phase field damage problem with a staggered scheme
 - Stress degradation
 - Weak form of the phase field equations
 - Calculate the history variable (crack driving force)

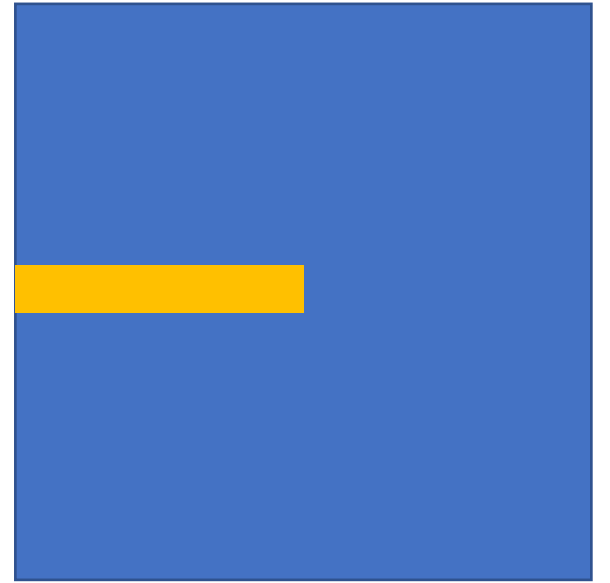
Mesh generation



Pre-existing notch

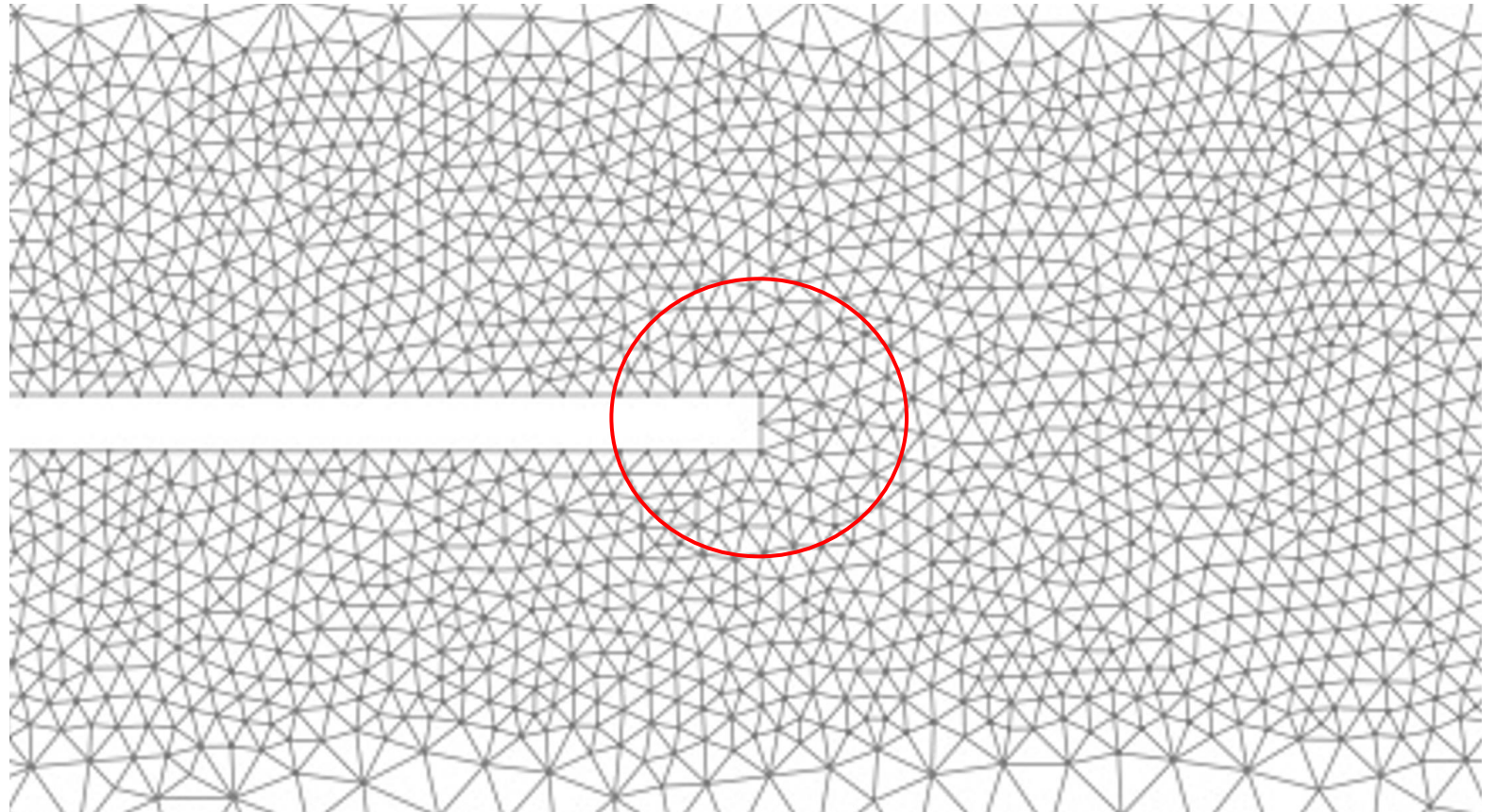
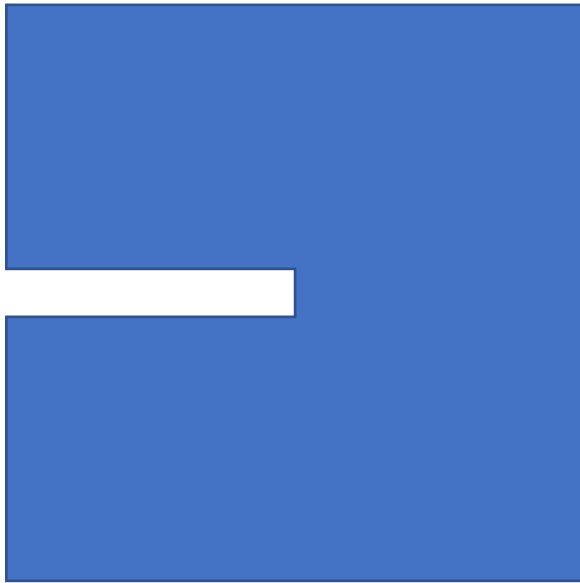


Pre-existing crack

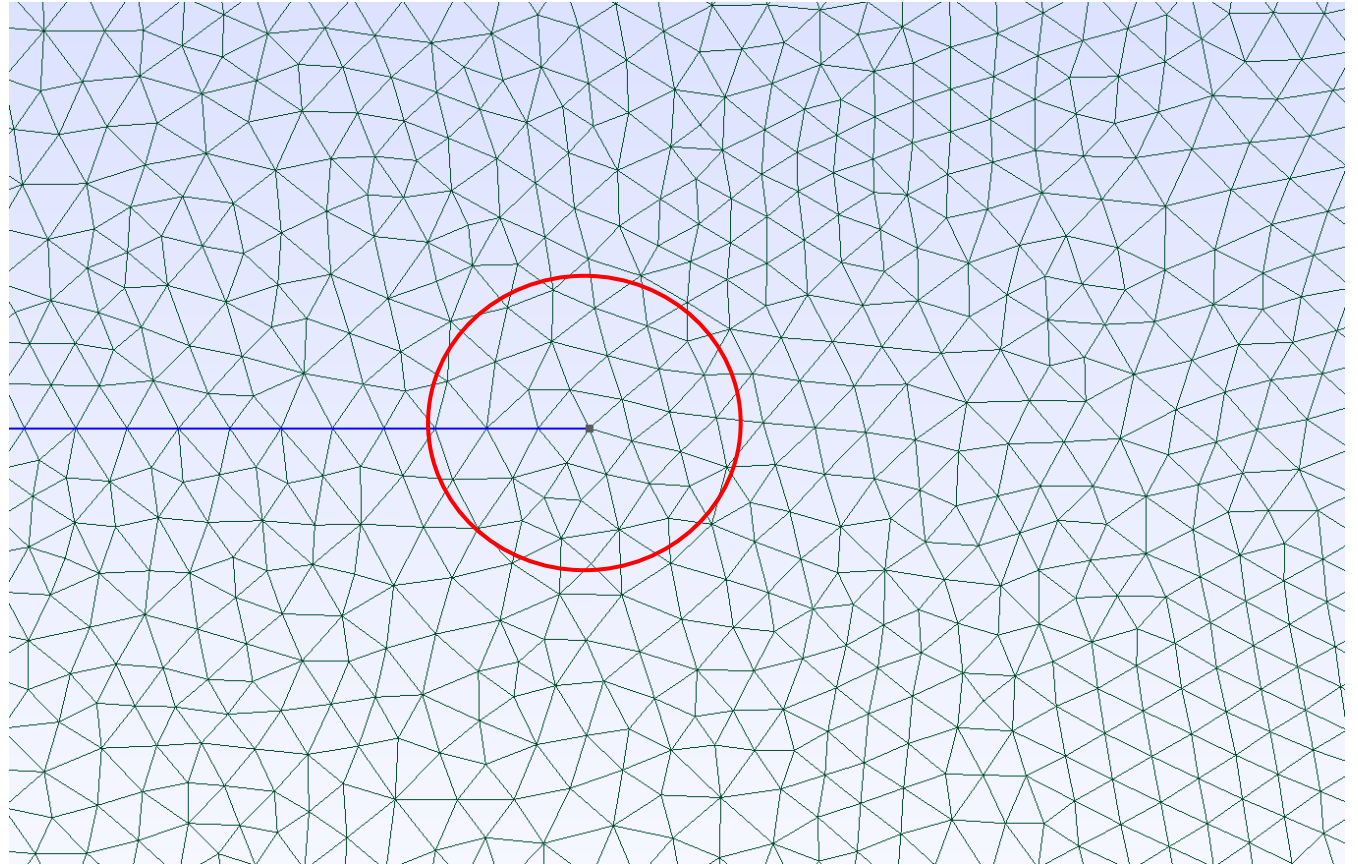
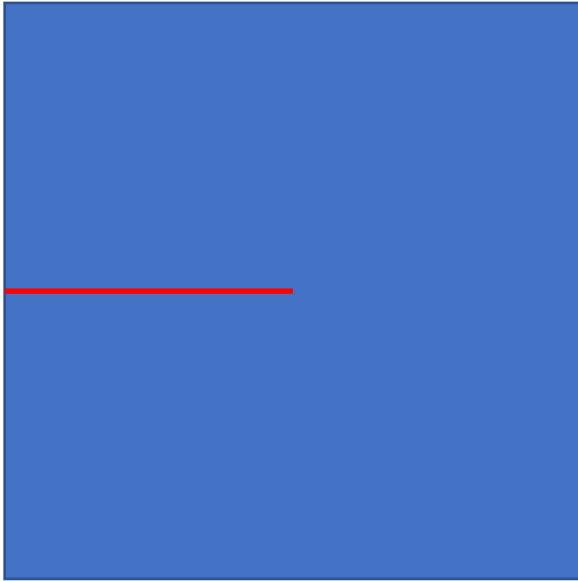


Pre-existing damage

Mesh generation: Pre-existing notch



Mesh generation: Pre-existing crack



Mesh generation: Pre-existing damage



1. Generate mesh without notch or crack.
2. Specify $D=1$ in the orange area in FEniCS code. (For example, where $0 < x < 0.5$ and $0.5 - \text{eps} < y < 0.5 + \text{eps}$)

Mesh generation: Software

- FEniCS inbuilt: mshr
 - Pros: Easy to use and don't need to install new software
 - Cons: Simple domain (not work for pre-existing crack); uniformed mesh size
- Gmsh
 - Pros: Easy to install; works for complex domain and mesh; Python API
 - Cons: GUI is hard to use; Need to learn how to write the code
- ABAQUS
 - Pros: Familiar; works for complex domain and mesh
 - Cons: Hard to install; Need to modified my code to convert input file to the xml file for FEniCS

Mesh generation: Software

- Tutorial on Github

https://github.com/YuxiangGao0321/FEniCS_tutorial_2023/blob/main/MeshforCrack.md

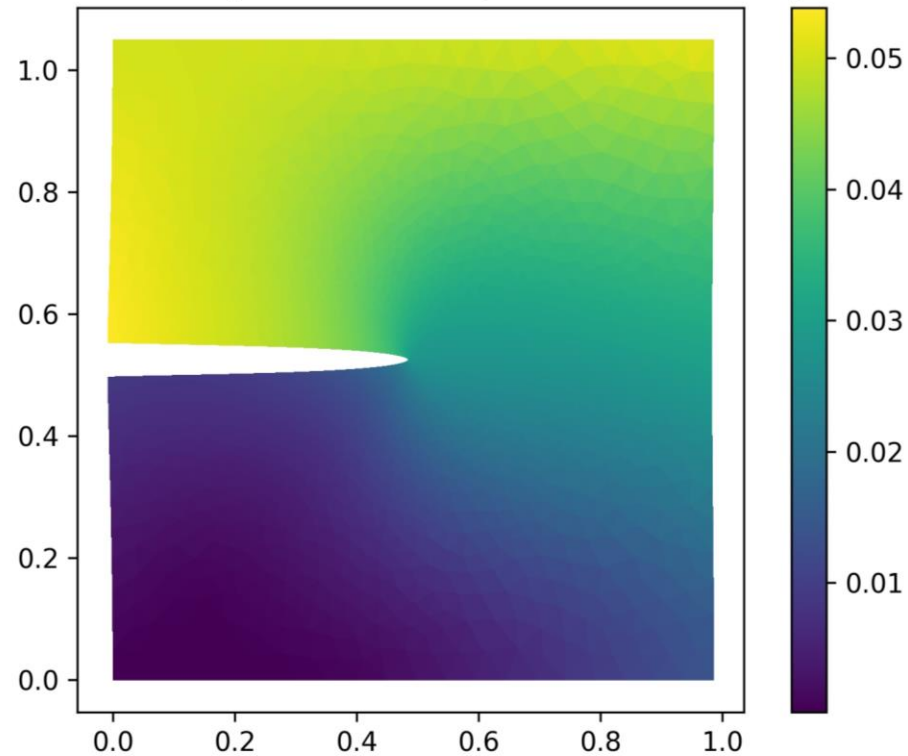
- FEniCS inbuilt: mshr
- Gmsh

Solving the elasticity problem with pre-crack

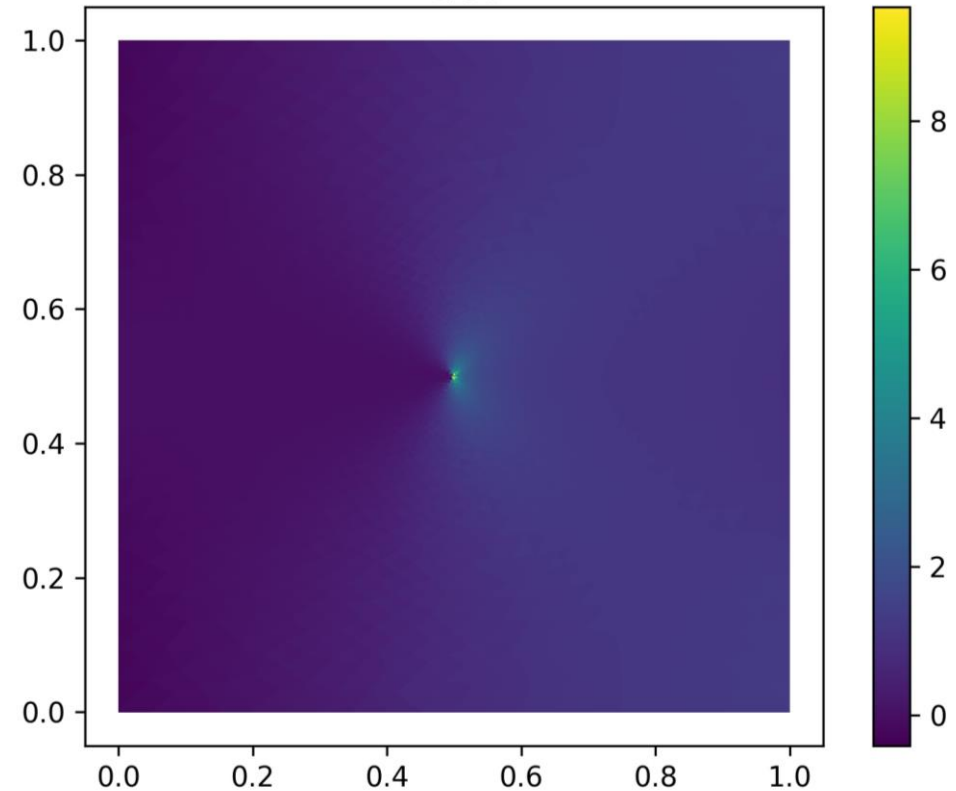
- With single step
- Only need to import the new mesh into our code for Project 1 (2D)

Solving the elasticity problem with pre-crack

Deformed displacement field(scale factor = 10.0)

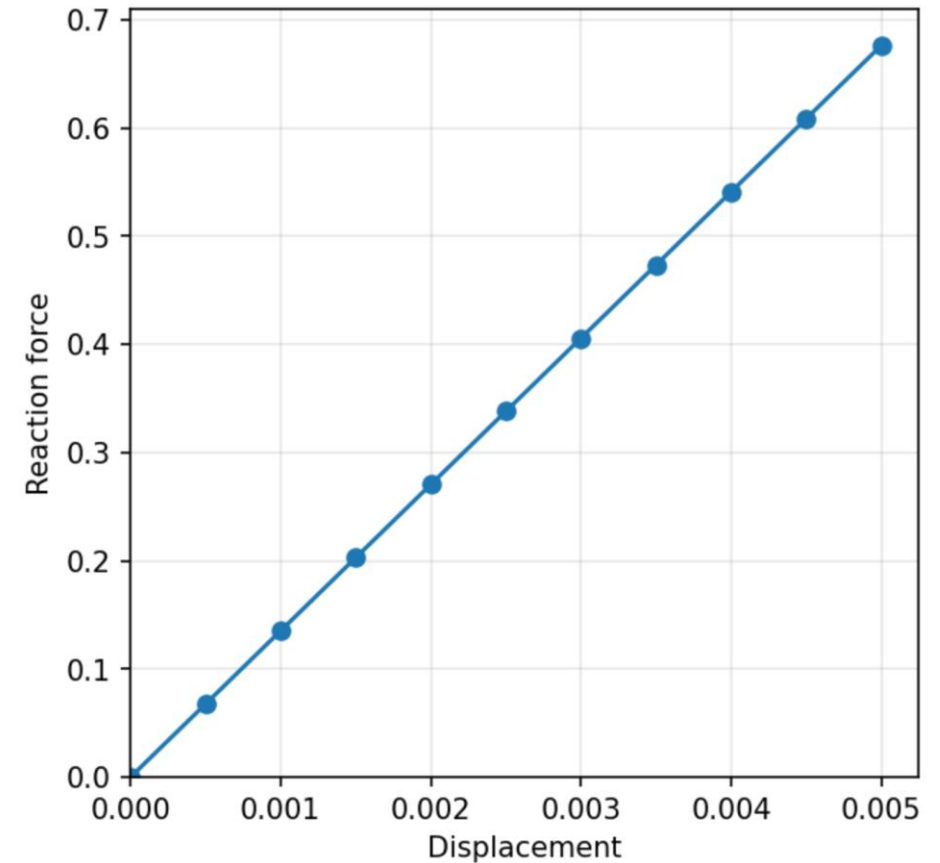


sig_yy



Solving the elasticity problem with pre-crack

- With multiple load step
- Prescribe the displacement incrementally
 - For example, $y_{\text{top}} = 0.0005, 0.001, 0.0015, \dots$



Solving the elasticity problem with pre-crack

- With multiple load step
- Prescribe the displacement incrementally
 - For example, $y_{\text{top}} = 0.0005, 0.001, 0.0015, \dots$
- In elasticity problem, we always solve a new equation. In the phase field problem, the damage field and history variable will be stored after each step.

Solving the Phase field damage problem with a staggered scheme

- Stress degradation
- $\boldsymbol{\sigma} = ((1 - D)^2 + \textit{eps})\mathbf{C}:\boldsymbol{\epsilon}$
- Weak form of the phase field equations
- $\eta\dot{D} = (l_c\Delta D - \frac{1}{l_c}D + 2(1 - D)\frac{H}{G_c})$