Example: Deformation of highly viscous liquid

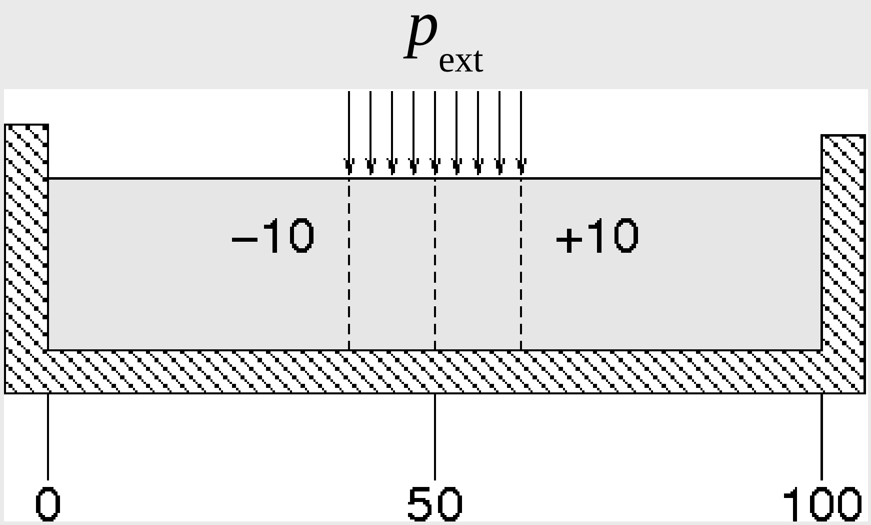
Elmer Basic Course

Authors: T. Zwinger and M. Lyly

CSC

Problem Outline

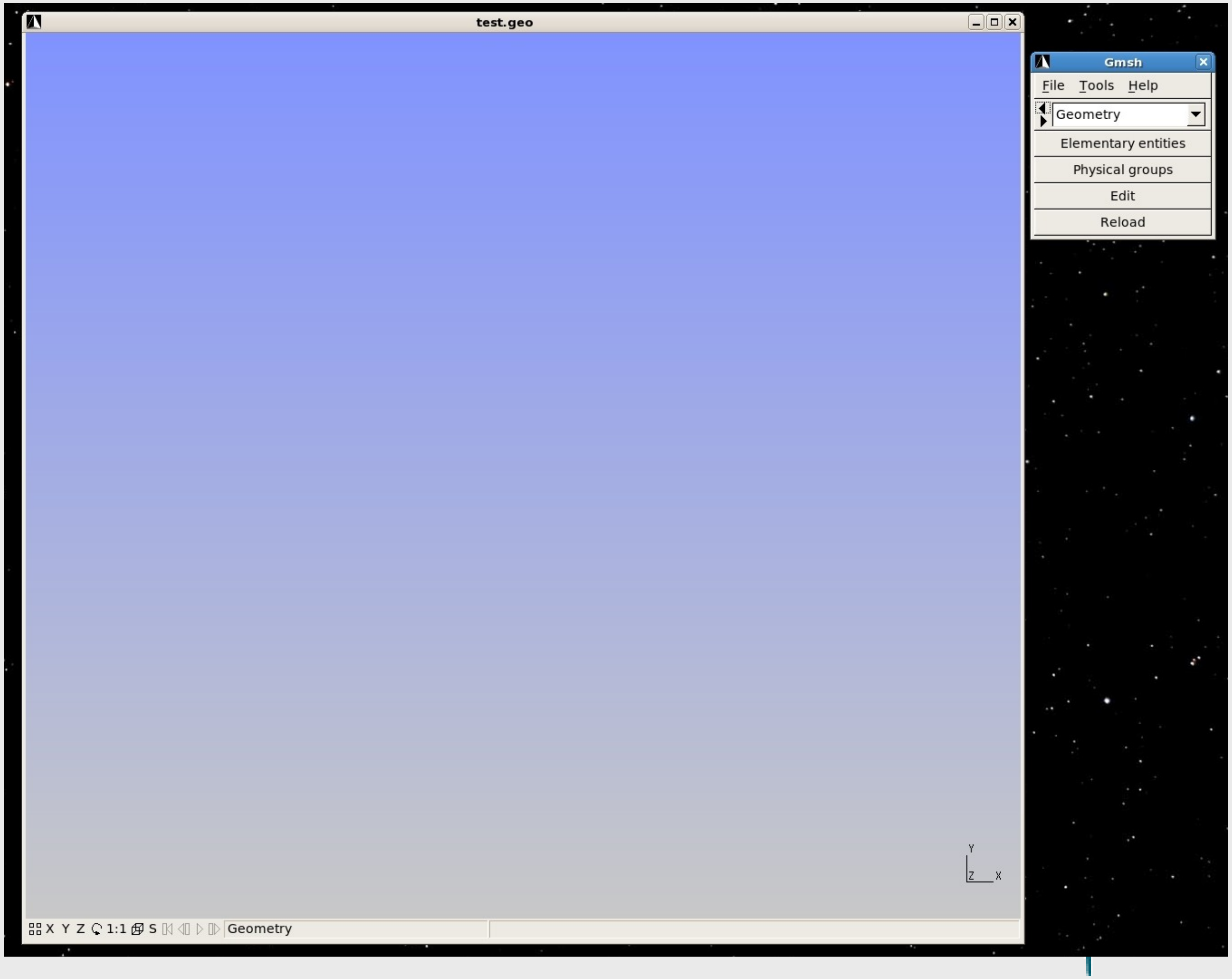
- **Geometry**
  - Square with 100 x 20 m
  - Free surface
- **Dynamics:**
  - Constant load ±10m around middle
  - p_{ext} = 1 MN m^{-2}
  - Gravity in *-y*
- **Material (similar to temperate ice):**
  - $\mu = 10^{14}$ kg m^{-1} s^{-1}
  - $\rho = 900$ kg m^{-3}
- **Integration time:**
  - 4 years in steps of 1 months (48 steps)



Units in meters

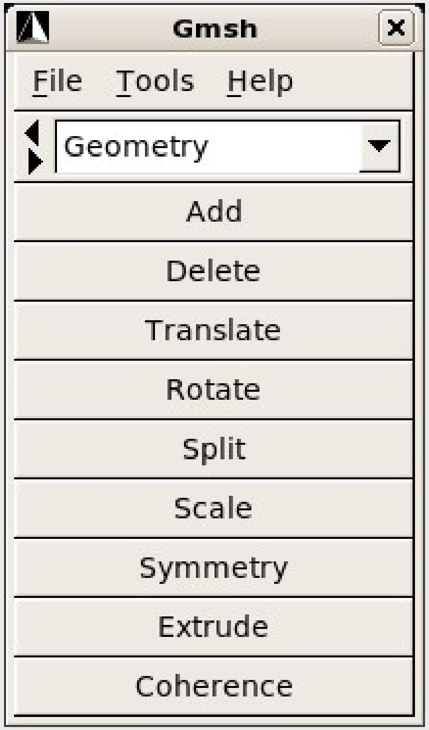
Meshing with GMSH

1. ***Elementary entities***



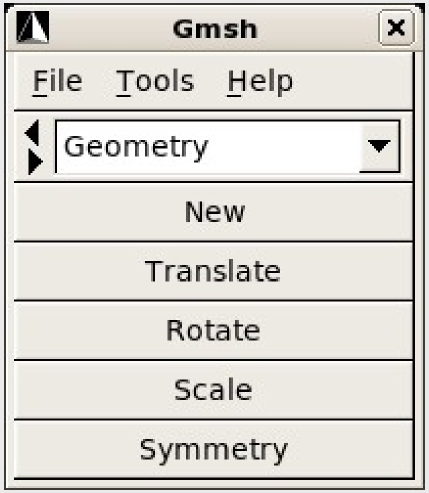
Meshing with GMSH

1. ***Elementary entities***
2. ***Add***



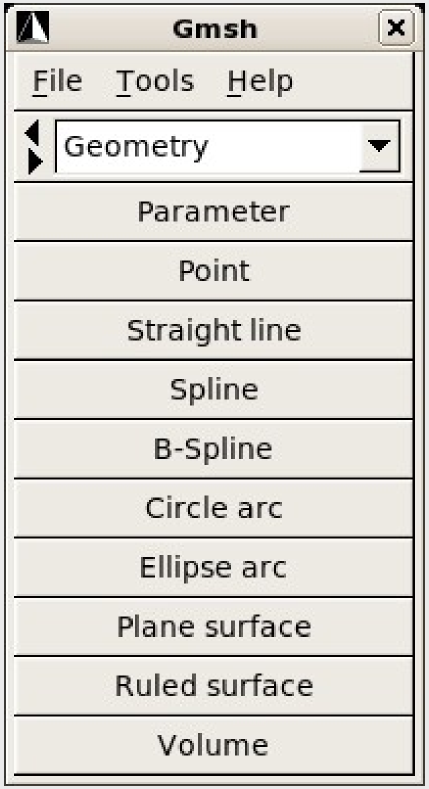
Meshing with GMSH

1. ***Elementary entities***
2. ***Add***
3. ***New***



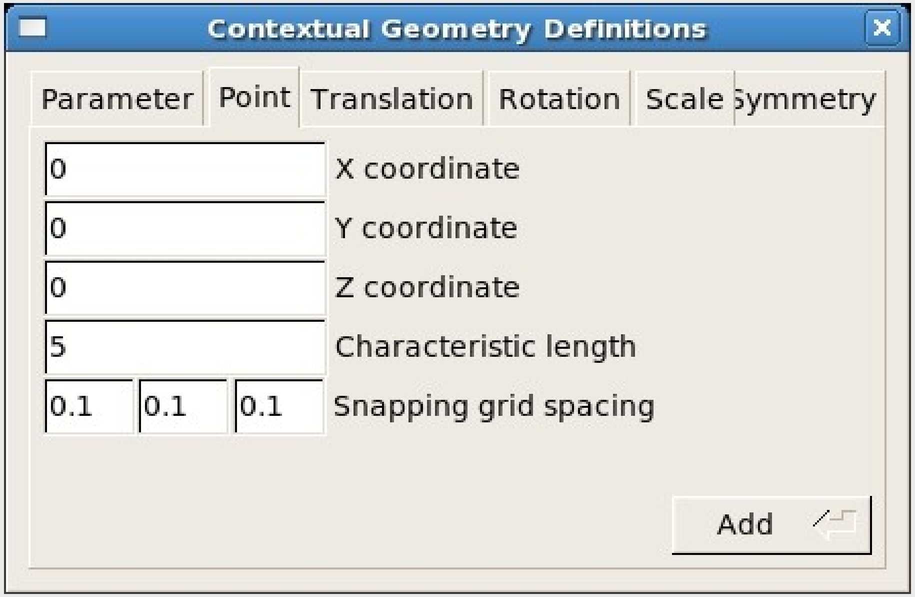
Meshing with GMSH

1. ***Elementary entities***
2. ***Add***
3. ***New***
4. ***Point***



Meshing with GMSH

1. ***Elementary entities***
2. ***Add***
3. ***New***
4. ***Point***
    1. *(0,0,0) length 5*
    2. *(100,0,0) length 5*



0 X coordinate

0 Y coordinate

0 Z coordinate

5 Characteristic length

0.1 0.1 0.1 Snapping grid spacing

Meshing with GMSH

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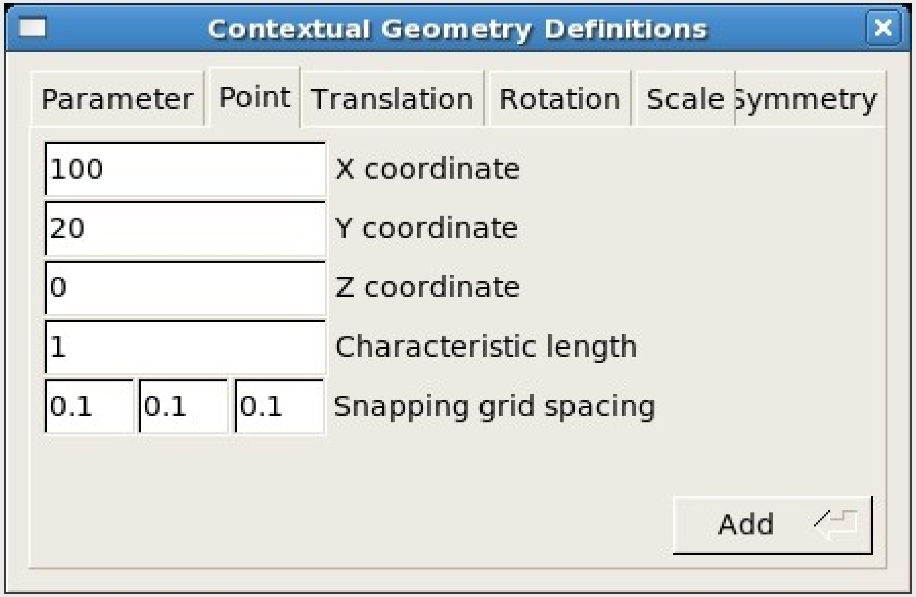
   1. *(0,0,0) length 5*
   2. *(100,0,0) length 5*
   3. *(100,20,0) length 1*
   4. *(0,20,0) length 1*



100 X coordinate

20 Y coordinate

0 Z coordinate

1 Characteristic length

0.1 0.1 0.1 Snapping grid spacing

Meshing with GMSH

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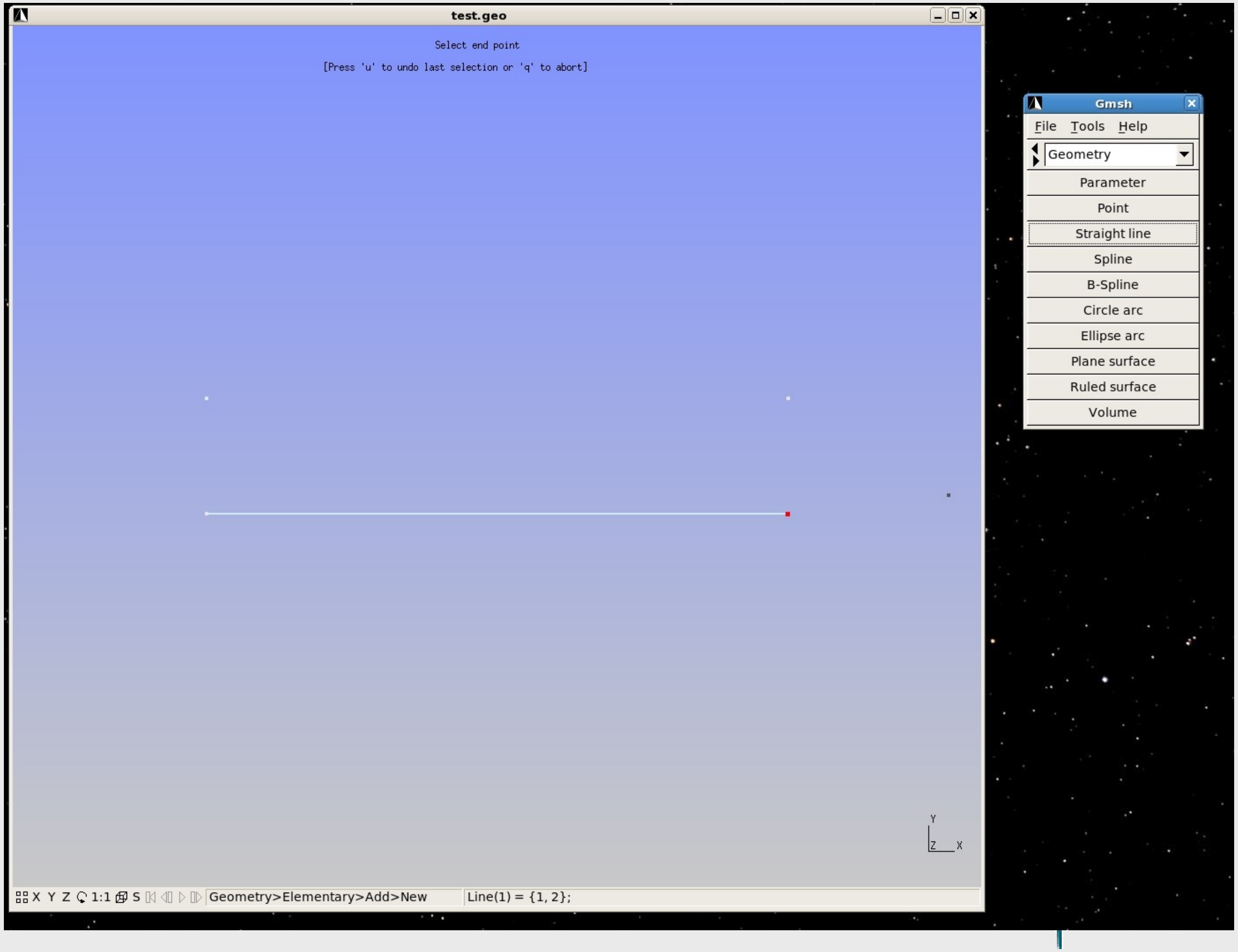
   1. *(0,0,0) length 5*
   2. *(100,0,0) length 5*
   3. *(100,20,0) length 1*
   4. *(0,20,0) length 1*
5. ***Line***
   1. *Click on consecutive points*
   2. *"q" when ready*



Select end point

[Press 'u' to undo last selection or 'q' to abort]

Geometry>Elementary>Add>New

Line(1) = {1, 2};

Meshing with GMSH

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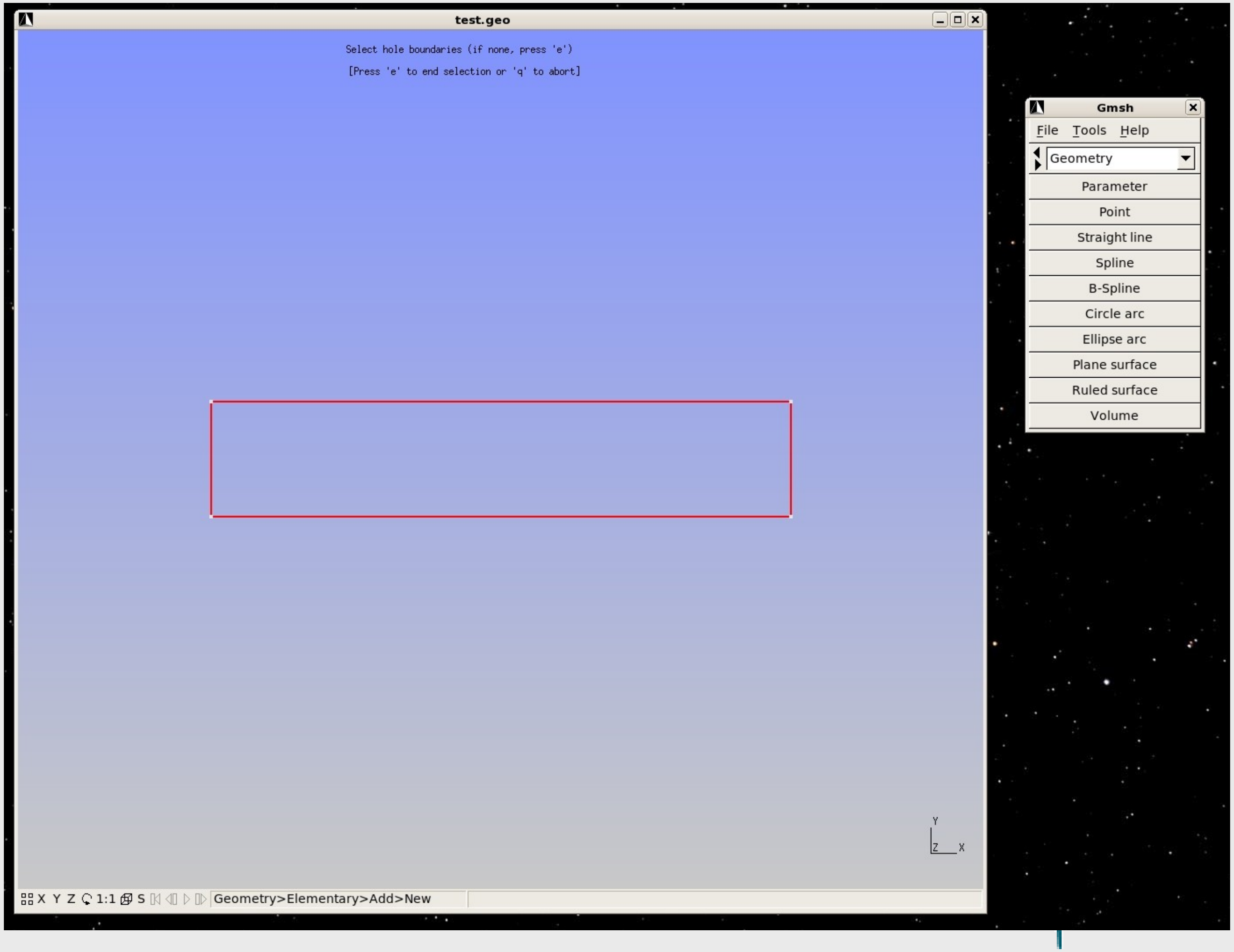
5. ***Line***
    1. *Click on consecutive points*
    2. *“q” when ready*
6. ***Plane Surface***
    1. *Click on line*



test.geo

Select hole boundaries (if none, press 'e')

[Press 'e' to end selection or 'q' to abort]

Geometry>Elementary>Add>New

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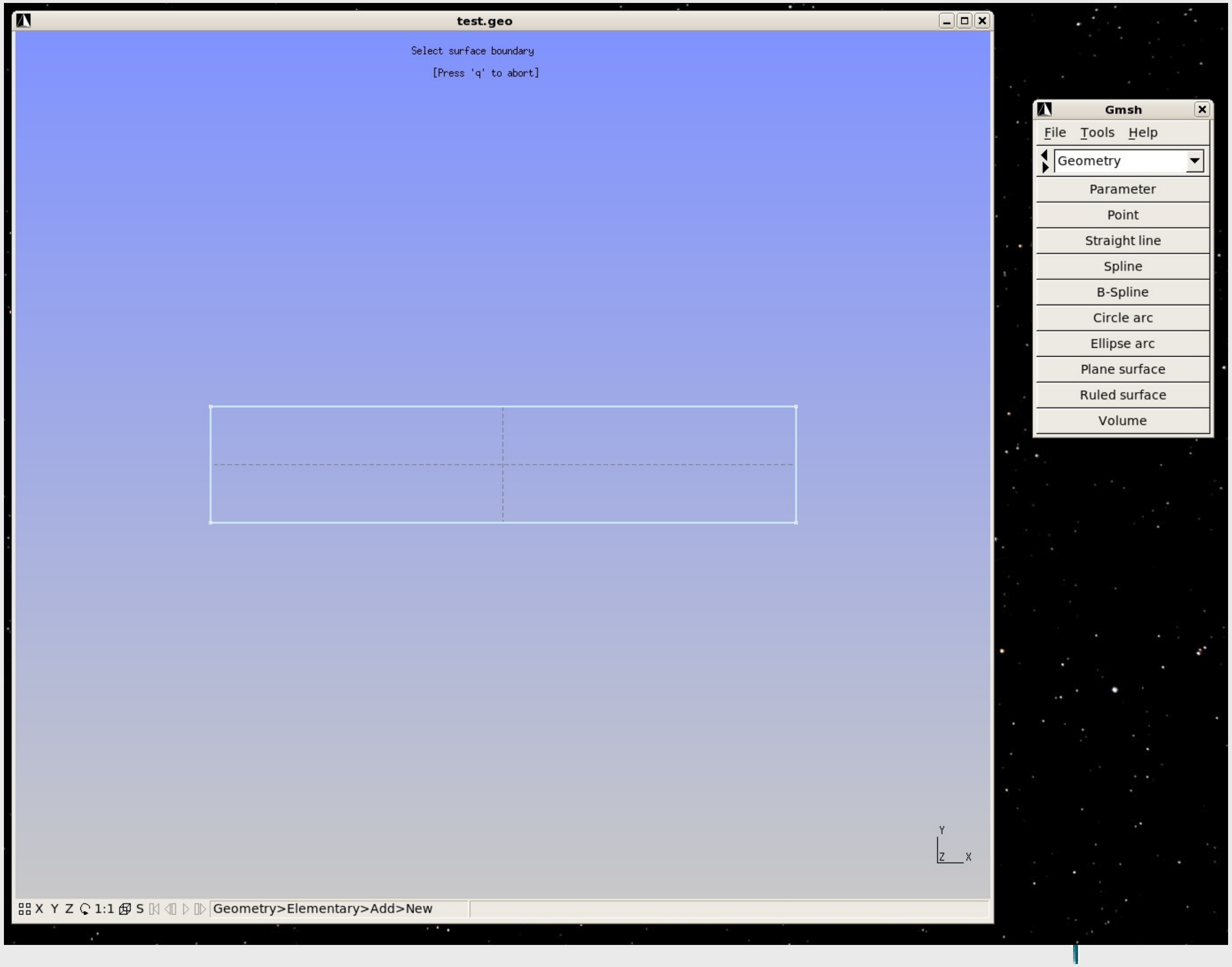

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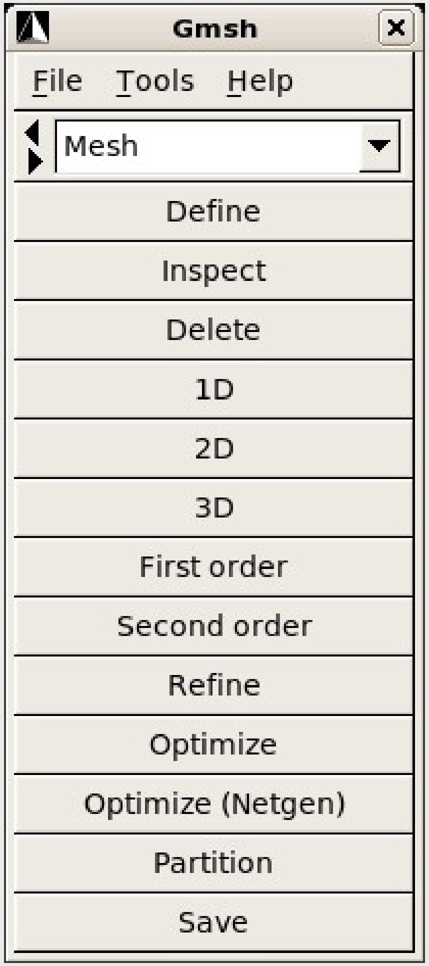
6. ***Plane Surface***
    1. *Click on line*
7. ***Mesh***
    1. *Press “2D”*
    2. *Press Save*



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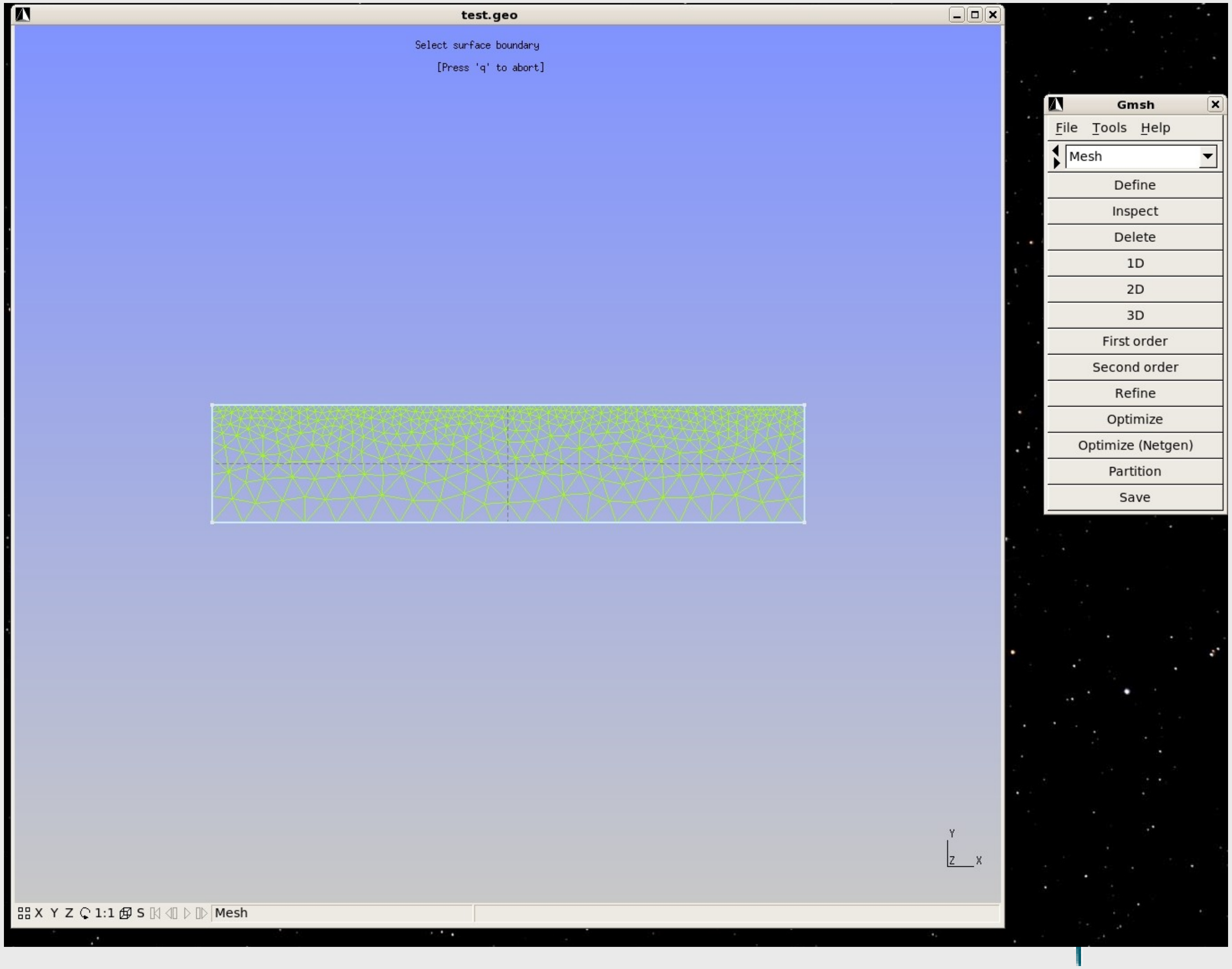
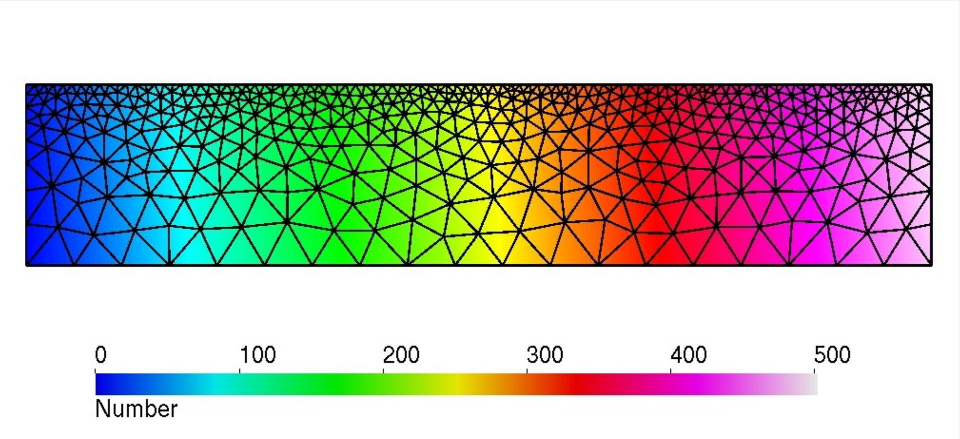


Select surface boundary

[Press 'q' to abort]

Transferring the Mesh



Obtaining a pre-view for ElmerPost

```
ElmerGrid 14 3 deform.msh -autoclean -order 1.0 0.1 0.01
```

Obtaining a mesh directory for ElmerSolver

```
ElmerGrid 14 2 deform.msh -autoclean -order 1.0 0.1 0.01
```

Boundary Conditions

- **Initial Condition**

  ```
  Mesh Update 1/2 = 0
  Velocity 1/2 = 0
  FreeSurf = 20.0
  ```

- **Sidewalls:**

  ```
  Velocity 1/2 = 0
  Mesh Update 1 = 0.0
  ```

- **Bottom wall:**

  ```
  Velocity 1/2 = 0
  Mesh Update 1/2 = 0.0
  ```

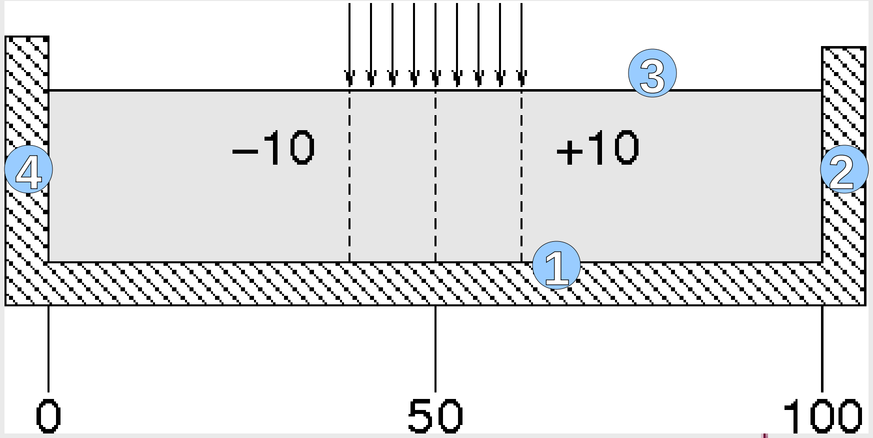
- **Body Force:**

  ```
  Flow BodyForce 1 = 0
  Flow BodyForce 2 = -9.81
  ```

- **Free surface:**

  ```
  Body ID = 2
  Mesh Update 1 = 0
  Mesh Update 2 = Variable FreeSurface
      Real MATC “tx – 20.0”
  ```

```
External Pressure = Variable Coordinate 1
   Real
      0.0      0
      39.999   0
      40      -1000000
      60.0    -1000000
      60.001   0
      100      0
   end
```



Postprocessing

Velocities in m a^{-1}

Elmer-Post:

```
math v = Velocity_abs * 60 * 60 * 24 * 365.25
```

Visualizing the deformation

```
math orignodes = nodes
```

Edit ▸Timestep Control ...

Do after frame:

```
math nodes = orignodes + Mesh.Update(0:2,time($t))
```

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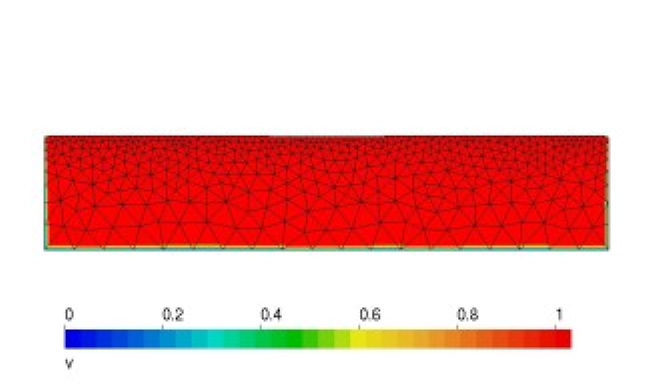

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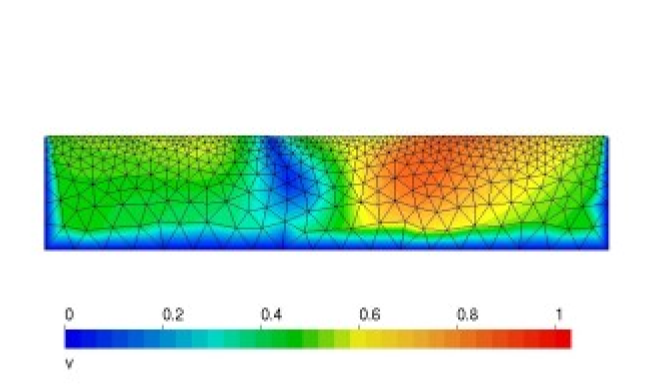

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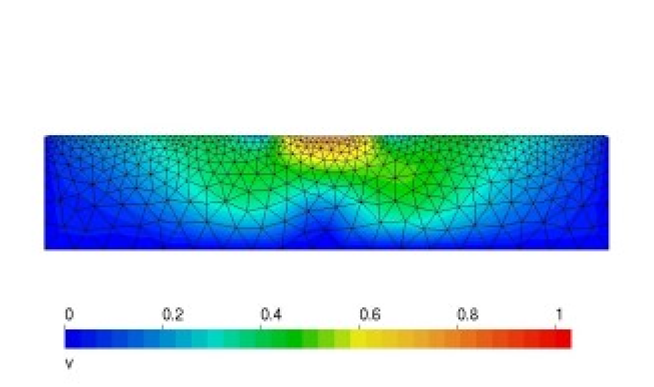

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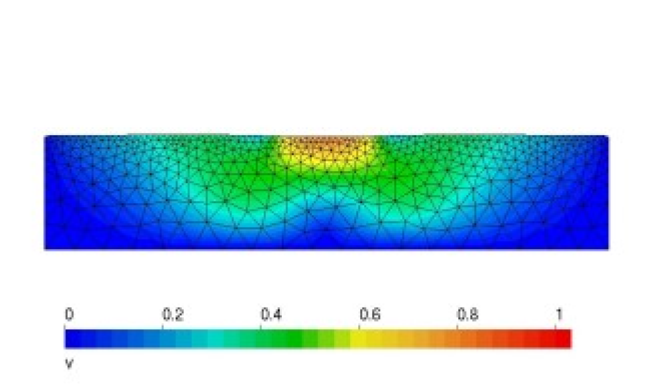

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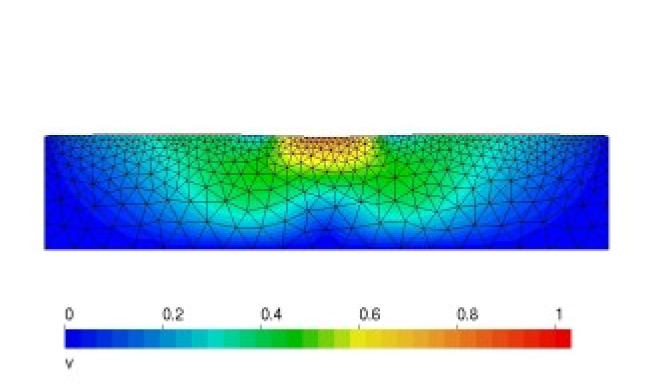

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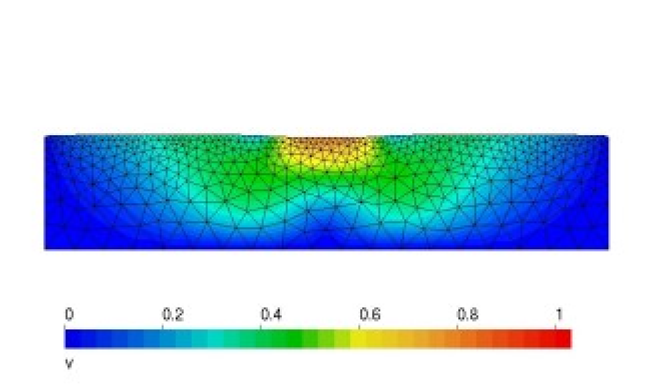

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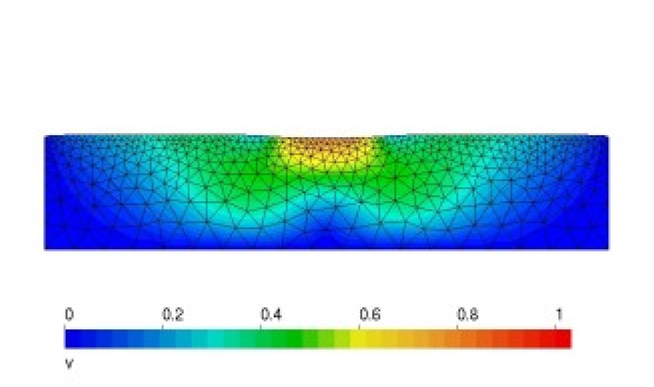

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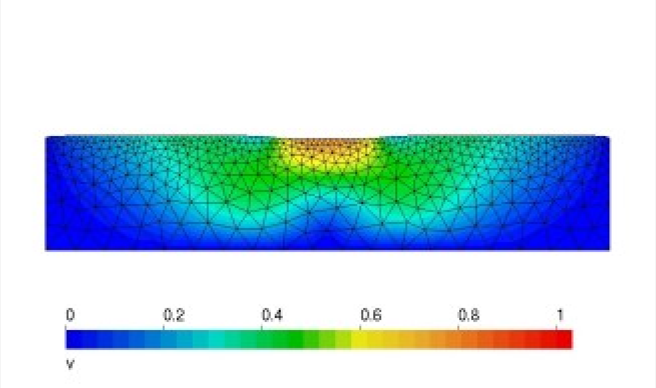

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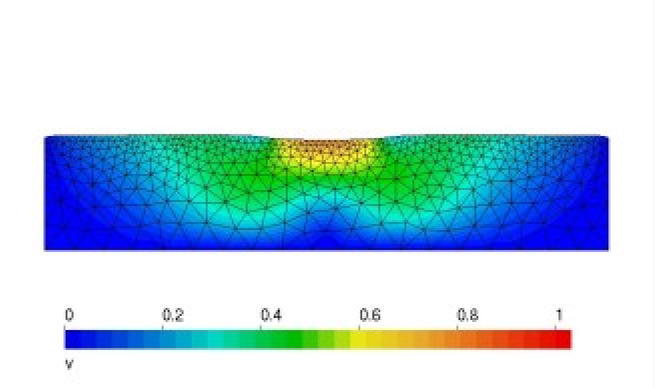

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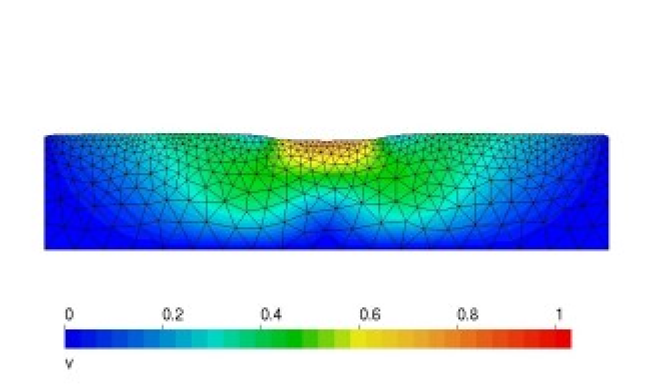

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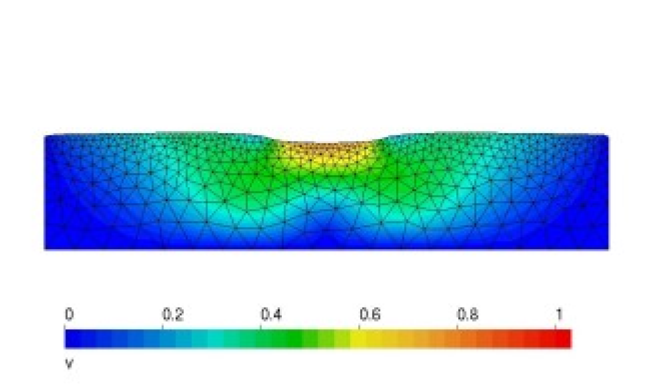

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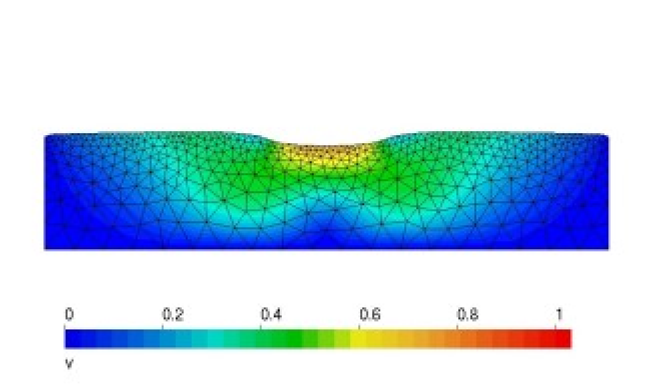

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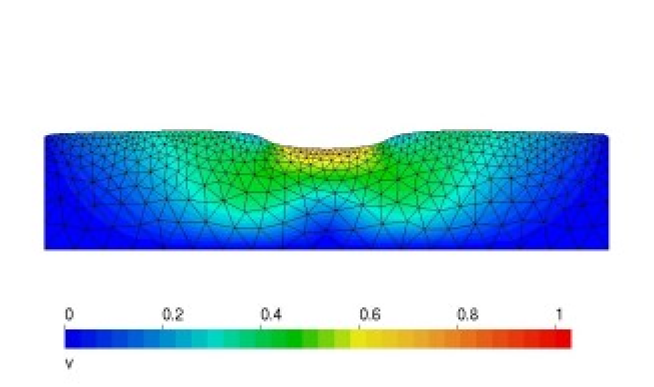

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Do after frame:

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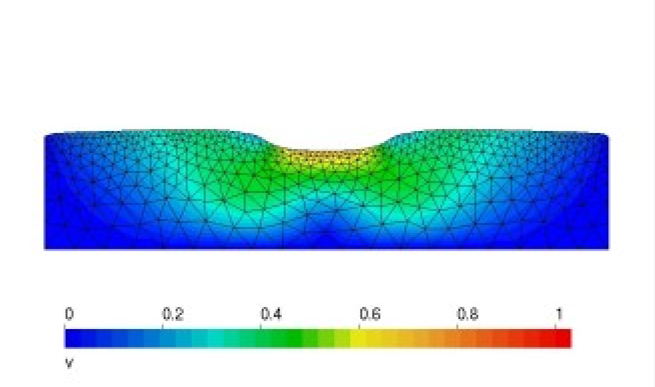
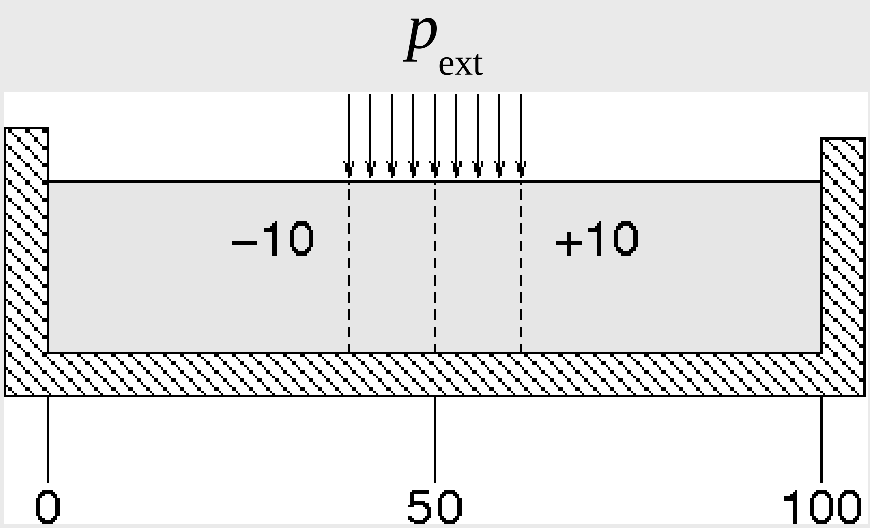


Exercises

- **Write MATC function:**

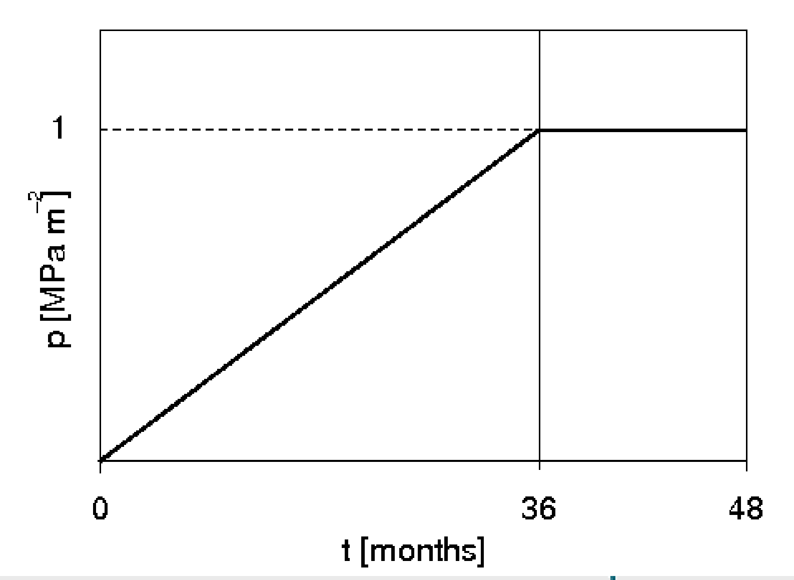
```
    $ function externalload(X) {\
      if (X(0) > 40) {\
         if (X(0) < 60)\
           _externalload = -1.0E06;\
         else _externalload = 0.0;\
      }else _externalload = 0.0;\
    }

    External Pressure = Variable Coordinate 1
      Real MATC “externalload(tx)”
```



- **Increase load with time:**

```
$ function externalload(X) {\
if (X(0) > 40) {\
 if (X(0) < 60){\
  if (X(1) < (3.0 * 31446926)){\
   _externalload =\
    -1.0E06 * X(1)/(3.0 * 31446926);\
  }else _externalload = -1.0E06;\
 }else _externalload = 0.0;\
}else _externalload = 0.0;\
}
External Pressure = Variable Coordinate 1, Time
   Real MATC “externalload(tx)”
```


p [MPa m^{-2}]
t [months]