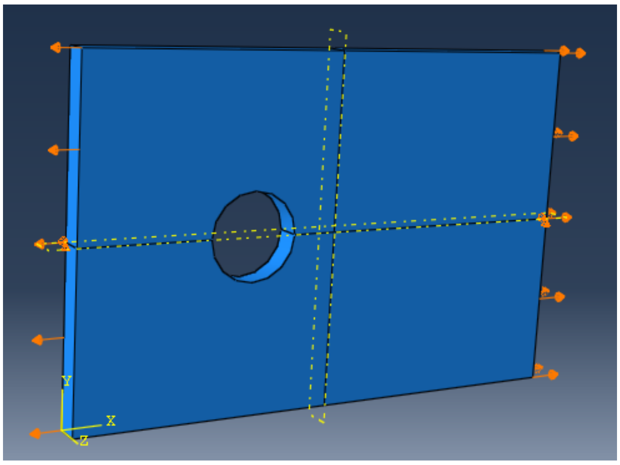
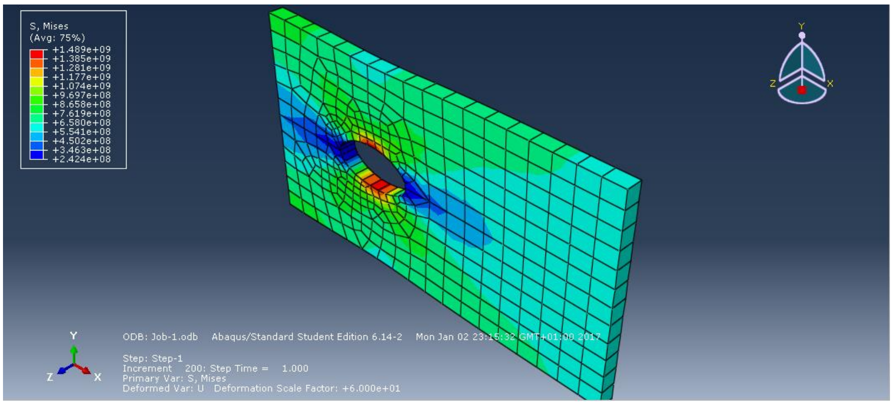
HOMEWORK 3

PART 1

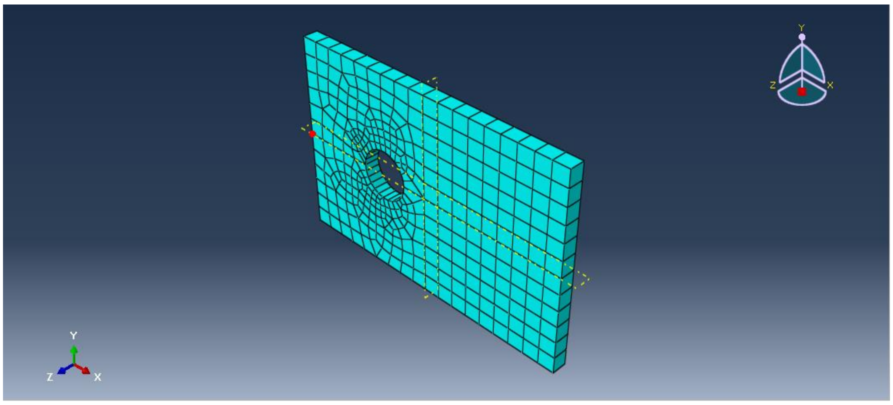
Firstly, it has been analyzed a steel plate with a hole in the body in its elastic range. Then, some plastic condition would be introduced in the model. As it can be seen in the following figure, a displacement is applied in the vertical faces and the transverse line at the surface is fixed.



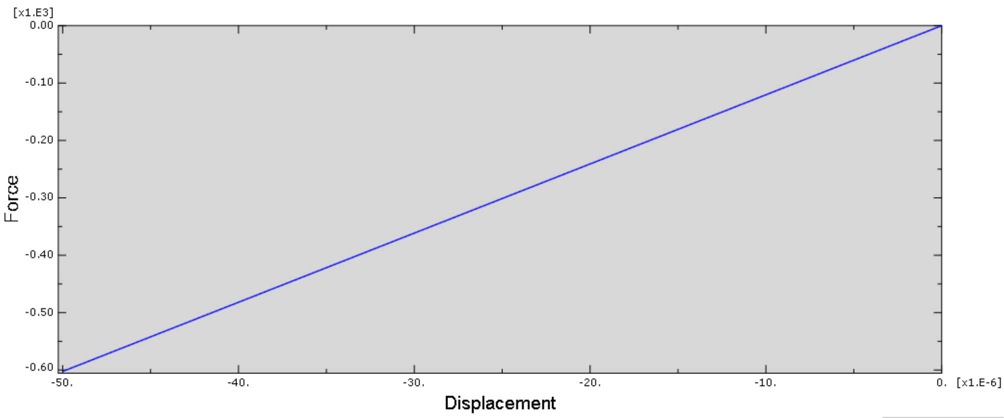
a) **Plot the distribution of Von Mises stresses in the plate.**
In the following figure can be seen that the maximum stresses are located near the hole and they spread along the vertical direction. However, the minimum stresses are concentrated on the X-X axis.



b) **Plot the force-displacement curve at the point set.**
It can be chosen any point of the model but I have chosen one in the extreme of the plate, where the displacement is applied.

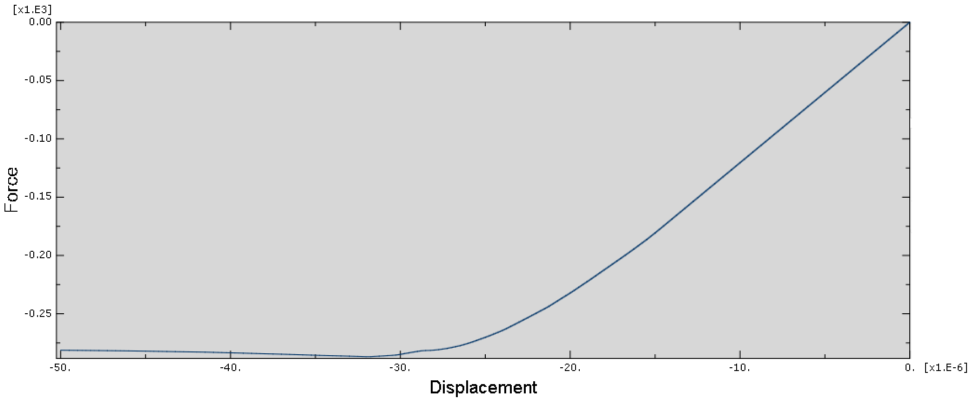


The response of the point under elastic condition should be linear and, as it was expected, the force rise gradually as a result of increasing the displacement. This means that the plate work in the elastic range. The force will grow infinitely while continuing increasing the displacement, because only elastic parameters are defined in the model.



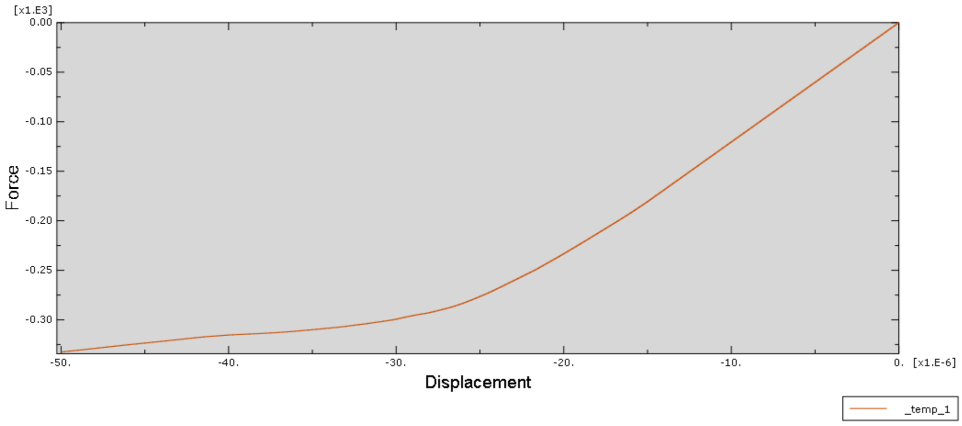
c) Add the plastic properties and compare the results. Discuss the differences in the Force-displacement curve for the three different cases.

- **ELASTIC-PERFECTLY PLASTIC MATERIAL:** f_y = 460 MPa.
  In the following figure it can be seen two clearly differences parts. In the first part, the forces increase linearly, which means that it is working in the elastic range. In the second part (approximately after 0.5 second), the force doesn´t grow when the displacement increase because it is elastic perfectly plastic material. Therefore, the elastic limit would be exceeded at this point and the plastic parameters would start acting.

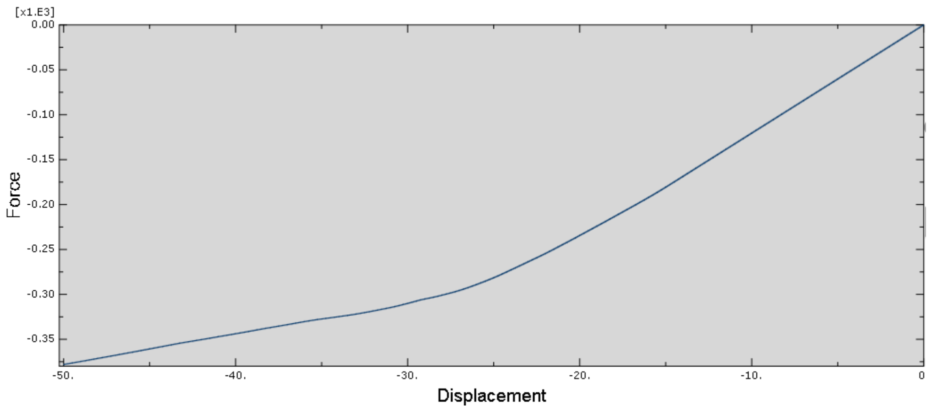


- **PLASTIC MATERIAL:** f_y (ε_y = 0) = 460 MPa; f_y (ε_y = 0.005) = 520 MPa.

  The force increase linearly until the elastic limit (f_y = 460 MPa) and then the followed slope is defined by the second point given. The following figure shows that the force continues increasing while the deformation grows.



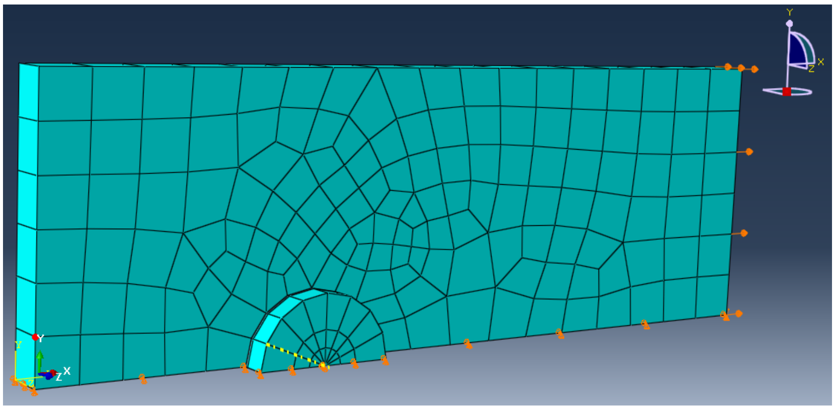
- **PLASTIC MATERIAL:** f_y (ε_y = 0) = 460 MPa; f_y (ε_y = 0.002) = 520 MPa.
  The slope is steeper in the plastic part than in the previous case and the forces are higher for the same displacement as it can be shown in the force-displacement graphics.



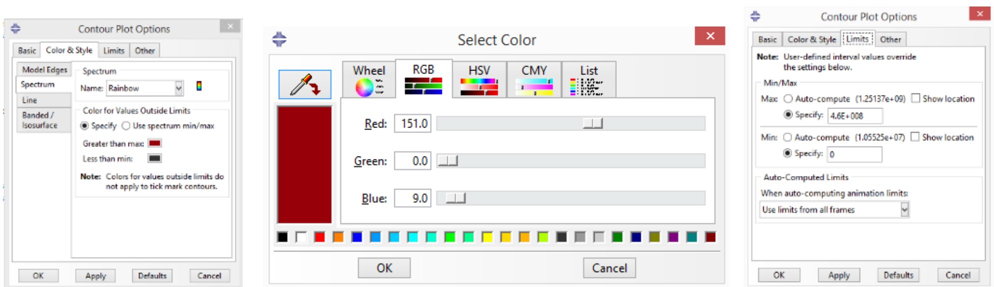
In conclusion, the first part is similar in all three cases because they are in the elastic range (f_y = 460 MPa), therefore the force increase linearly. The plastic part is different especially between the first and the other cases. The force doesn´t increase in the elastic-perfectly plastic material and in the other two cases the force increases following two different slopes defined by the characteristic of the material (ε_y = 0.005; ε_y = 0.002). The maximum force generated at the end of the step would be different for the three cases and the maximum one is going to be obtained for the elastic material.

PART 2

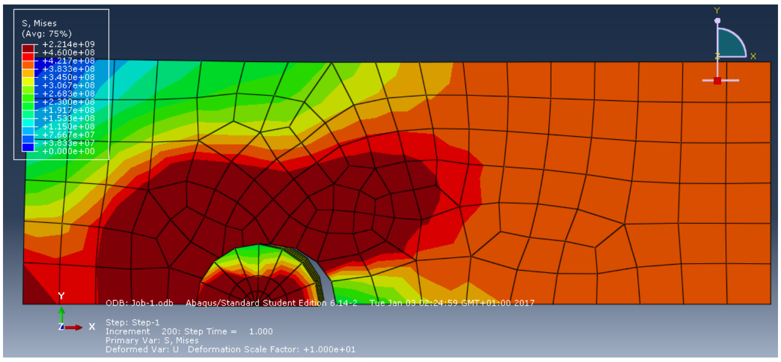
In this second part, the same plate will be studied but in this case a fixed pin is going to be introduced in the hole, and due to simplification reasons only half of the plate is going to be modelized.



a) **Plot the distribution of Von Mises stresses on the deformed shape with an amplification factor of 10. Set scale of stresses between 0-460 MPa and make that stresses over this limit are plotted in dark red.**
Some visualization options have been changed to display better the deformed shape and the stresses:

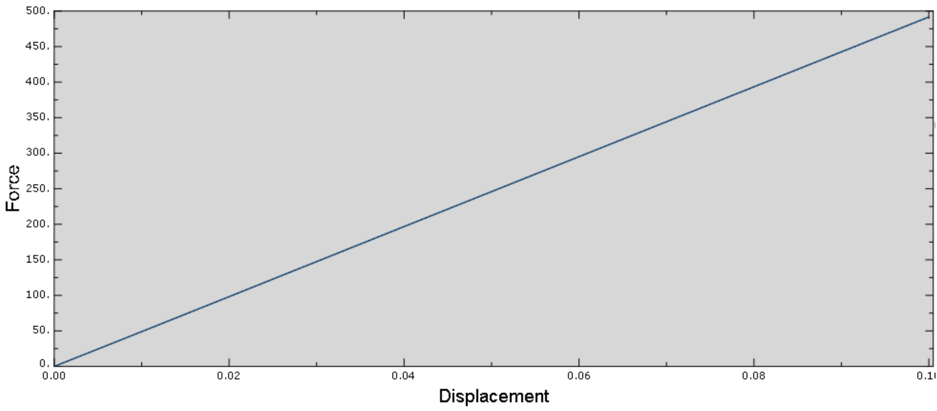


The maximum stresses are concentrated near the fixed pin and it can be seen clearly the gap between the pin and the deformed plate. This separation isn´t as strong as it is showed in the figure, this is because it is applied an amplification factor to see better the results.



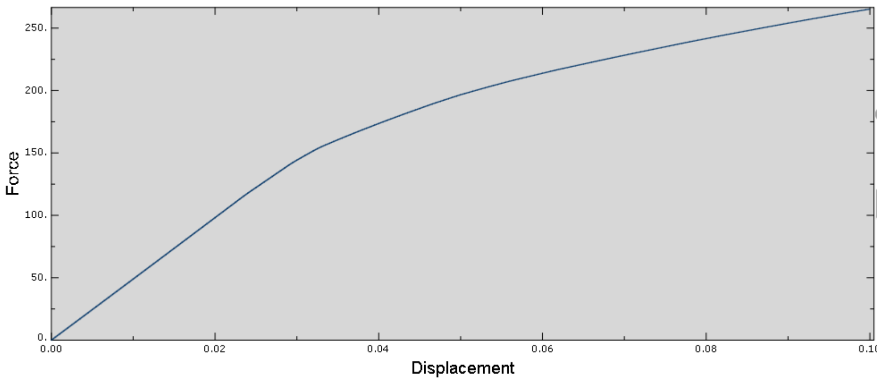
b) Plot the force-displacement curve for the horizontal reaction at the point-set.

The force-displacement curve is linear because only elastic inputs are introduced in the model. The force increases infinitely while the displacement grows.



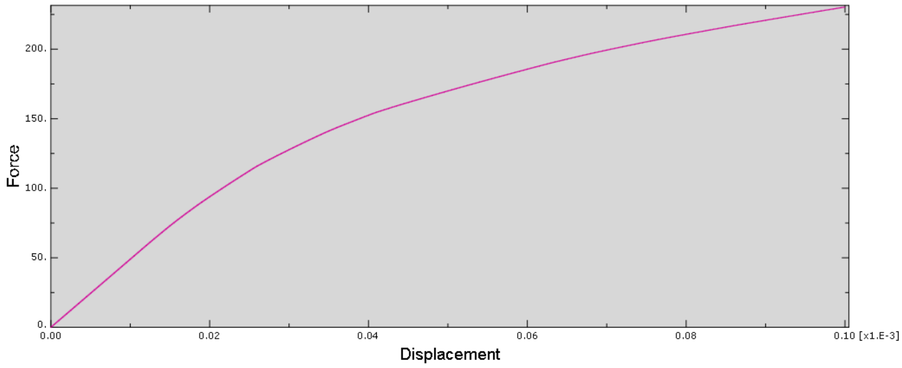
c) Add the plastic properties to the two materials, one for the plate, and another one for the pin and compare the results with the elastic case.

- **<u>Case 1:</u>** f_y (ε_{py} = 0) = 900 MPa; f_y (ε_{py} = 0.003) = 1000 MPa.
  The elastic range extends to 0.03 and then, the plastic force grows no linearly up to the end of the step. The maximum value of the force is a little larger than 250 N.



- **<u>Case 2:</u>** f_y (ε_{py} = 0) = 320 MPa; f_y (ε_{py} = 0.005) = 400 MPa.

The elastic range is smaller (t < 0.02) and the plastic curve is less steep than in the previous case. Because of this reason the maximum force is smaller than in the above case at the end of the step.



At the beginning, they work in the elastic range and they curve is quite similar. When the material exceeds the elastic limit the force gradient decreases. For elastic material continues growing in the same way withstanding a horizontal force of 490 N. However, the plastic material reaches lower values at the end of the step (<250 MPa).