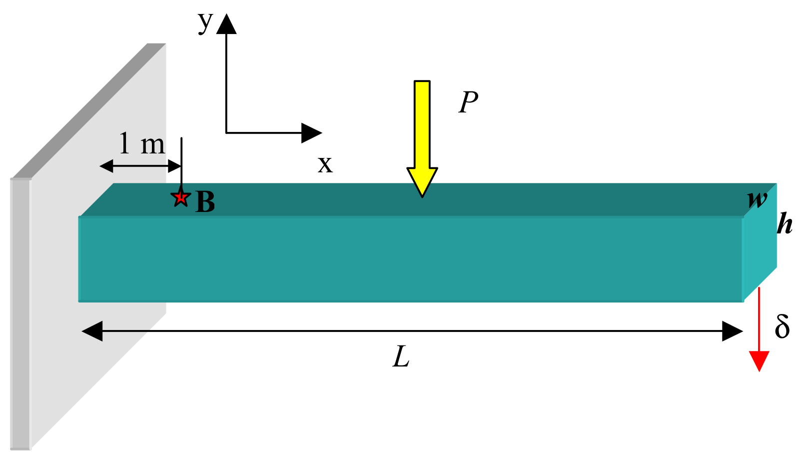
2.31 Assignment 5

Due Wed, Oct 10 at 9:30 am

A cantilever beam is loaded by a lateral force P=10 N at midspan.
The dimensions of the beam are:
L = 10 m, h=w=1 m.
The material is linear elastic with a Young's modulus E=1MPa, and Poisson ratio ν= 0.



1) Pen and paper work (no FE)

Calculate the deflection at the free end, δ, and the axial stress $\sigma_{xx}(B) = \sigma_B$ at 1 m from the support, on the top face of the beam.

2) FE model

a. Create a coarse FE model of the beam as a plane stress structure in 2D space using linear full integration quadrilateral elements.

Things to keep in mind as you set up the model:

PROPERTY : In section property you want to create a *solid* *homogeneous* section of thickness 1m.
In material properties you have to input Mechanical props (E, ν) as well as the density.

STEP : Choose static, linear perturbation.

LOAD : To position the concentrated load at the midspan on the top surface of the beam, you have to create a geometric point midway along the top edge. To do so, use the **Tools→Partition→Edge→Use Parameters** tool.

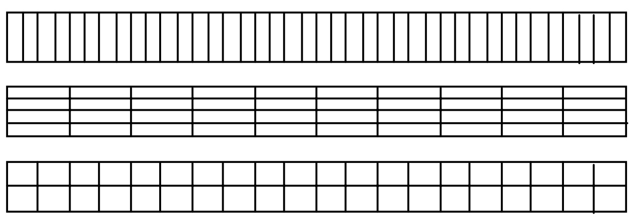
MESH : Seed the assembly with a global element size of 1.0. In the mesh dialog choose standard linear quads, and make sure you click off the reduced integration option. (you should have CPS4 as element type). This will give you a 1x10 mesh.

JOB : Create a job called *S4_1x10* (or something of this sort) and submit the analysis.

Look at the results in the VISUALIZATION module of ABAQUS/CAE:
Plot and print the contours of s11 (=σ_{xx}) over the beam → attach the plot to your assignment. Use **Query** to obtain δ and σ_B
How does the FE prediction compare w/ your beam theory estimate? Why?

b. Study the effects of varying mesh density. Create FE models of the beam with finer meshes. In addition to the 1x10 meshes create models with 2x20, and 4x40 elements simply by reducing the typical dimensions for the seeds to 0.5 and 0.25 respectively. Run the jobs, plot and print the s11 contours, and obtain the corresponding δ and σ_B predictions. Create a table where you report these FE predictions normalized by the theoretical estimates.
Now look at the effects of varying mesh densities along the length and height of the beam: consider the three meshes below, which have 40 elements but different mesh densities in the two directions:

1x40
4x10
2x20



Which mesh do you think will perform better? Why?
Create the meshes and run the jobs (you will need to specify the seeds on each edge). Plot and print the s11 contours, obtain the corresponding δ and σ_B and fill in your table.
Which mesh performed better? Why? Had you guessed right?
Can you think of another mesh that contains the same number of elements (40) of the same type, but is superior to the three meshes above for this particular problem? Create the model, run it and check if you are right.

c. Study the effects of varying element type. For the 1x10 mesh try the following elements:
Linear Quads, reduced integration.
Linear Quads, incompatible modes.
Quadratic Quads, full integration.
Quadratic Quads, reduced integration.
Run the jobs, plot and print the s11 contours, obtain the corresponding δ and σ_B predictions and fill in your table. Comment on the results.