Assignment 2.1

On "FEM Modelling: Introduction":

1. Identify the symmetry and antisymmetry lines in the two-dimensional problems illustrated in the figure. They are:

   (a) a circular disk under two diametrically opposite point forces (the famous "Brazilian test" for concrete)
   (b) the same disk under two diametrically opposite force pairs
   (c) a clamped semiannulus under a force pair oriented as shown
   (d) a stretched rectangular plate with a central circular hole.
   (e) and (f) are half-planes under concentrated loads.

2. Having identified those symmetry/antisymmetry lines, state whether it is possible to cut the complete structure to one half or one quarter before laying out a finite element mesh. Then draw a coarse FE mesh indicating, with rollers or fixed supports, which kind of displacement BCs you would specify on the symmetry or antisymmetry lines.

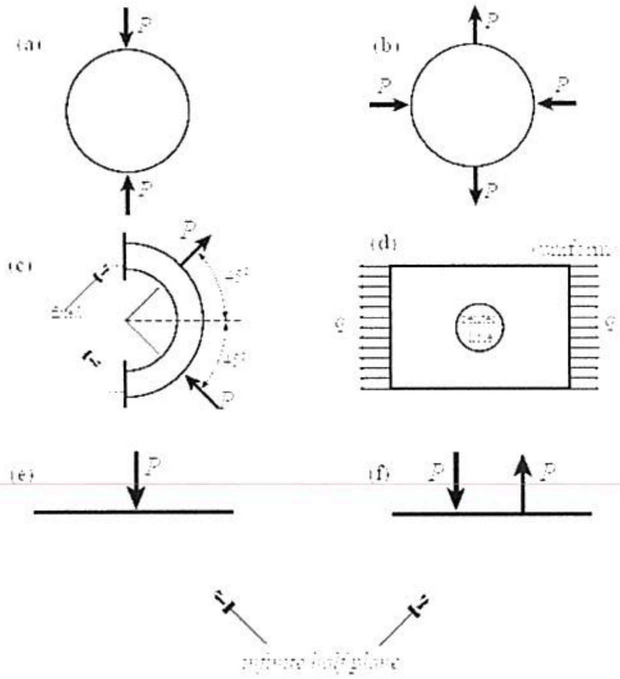


Figure 2.1.- Problems for assignment 2.1

Assignment 2.2

Explain the difference between "*Verification*" and "*Validation*" in the context of the FEM-Modelling procedure.

Assignment 2.3

On "Variational Formulation":

1. A tapered bar element of length l and areas A_i and A_j with A interpolated as

$$A = A_i(1-\xi) + A_j\xi$$

and constant density ρ rotates on a plane at uniform angular velocity ω (rad/sec) about node i. Taking axis x along the rotating bar with origin at node i, the centrifugal axial force is $q(x)=\rho A\omega^2 x$ along the length in which x is the longitudinal coordinate $x=x^e$.

Find the consistent node forces as functions of ρ, A_i, A_j, ω and l, and specialize the result to the prismatic bar $A = A_i = A_j$.

Date of Assignment: 17 / 02 / 2020
Date of Submission: 24 / 02 / 2020

The assignment must be submitted as a pdf file named **As2-Surname.pdf** to the CIMNE virtual center.

$$F = m\,a = m \cdot \frac{v^2}{r}$$

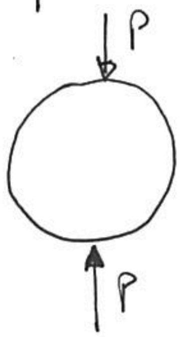
①

Assignment 2

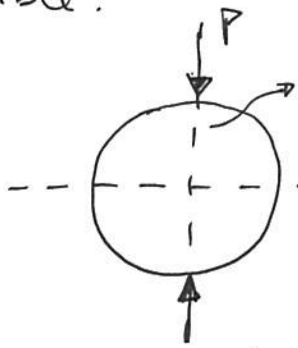
José Andino
Saint Antonin

(2.1) Identify symmetry lines and use them to cut the structure to a half or a quarter as possible.

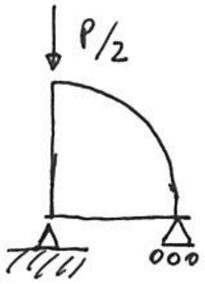
a)



answer:

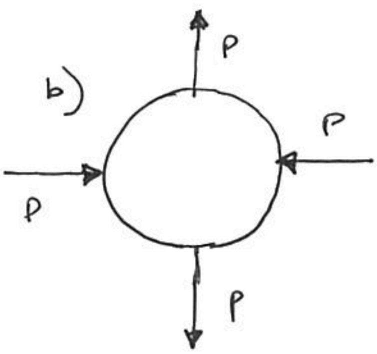


it can be appropriatly modelled by 1/4 using half the load:

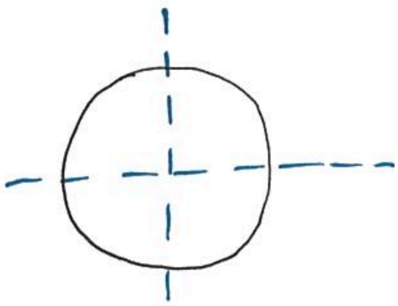


the center will not move (forces cancel out)

b)

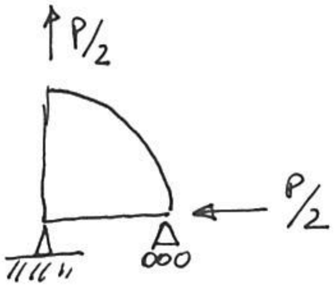


answer



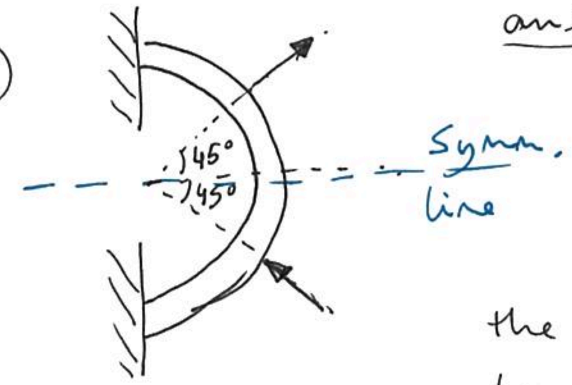
as in the prior case, stresses cancel out in the center (center is fixed)

the

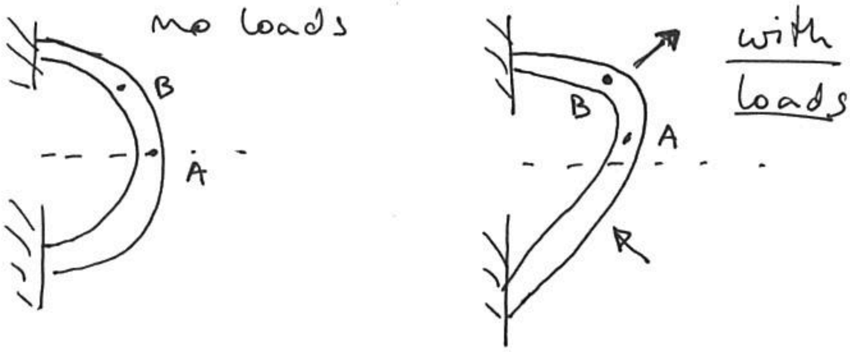


2

c)

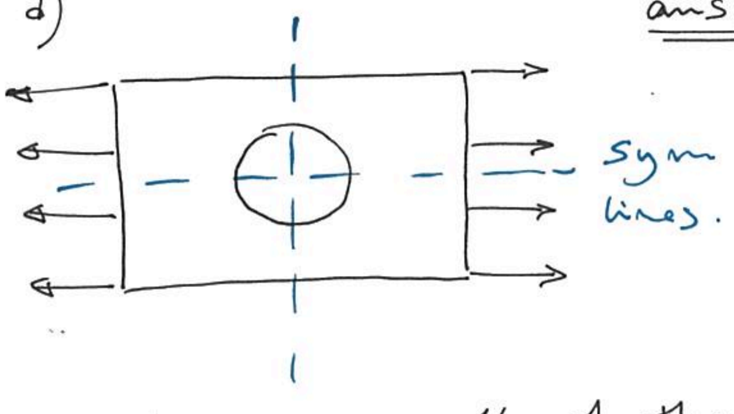


answer: although there is a symmetry line the forces do not cancel out. furthermore the deformation will not be symmetric:

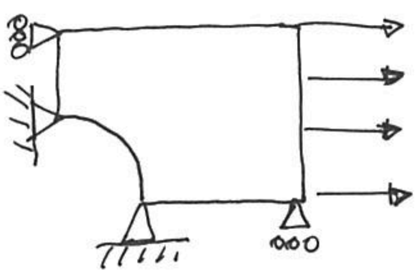


therefore, the system needs to be modelled in full

d)

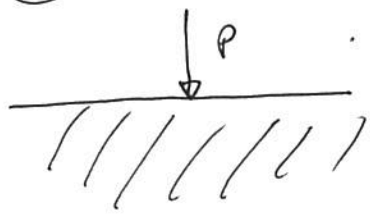


answer: the system has two axes of symmetry, along which diplacements cancel. therefore ½ of the sytem is enough to capture al deformations



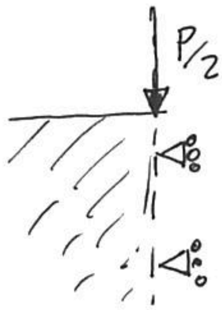
(3)

e)

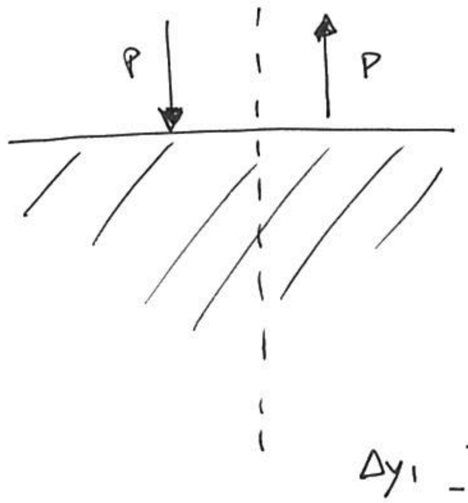


infinite half plane

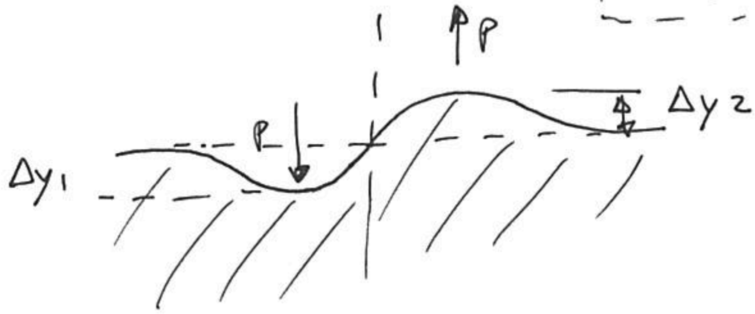
<u>answer:</u> there is a vertical line of symmetry. deformations and stresses will be the same on both side. model 1/2 of the system.



f)



<u>answer</u> there is an anti symmetry axis. after deformation it would look like thi



I'm not sure at all that $\Delta y_1 = \Delta y_2$ (that is that deformations are anti-symmetric. I would advise modelling the whole system.

2.2 Verification: is the process of ensuring that the discrete solution arrived at is a 'good enough' answer to the mathematical problem initially proposed:

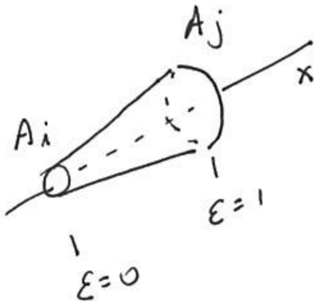
- Does the discretization represent the problem correctly (convergence, consistency)?
- Did our method correctly solve the discrete problem?

Validation: compare the model predictions with the experimental results. the sources of error could also be in: unknown properties of the materials or inadequate physical modelling. verification would not capture those two sources of error! Hence we need validation.

5

2.3 Find model forces on a rotating bar of variable section.

$$A(x) = A_i(1-\varepsilon) + A_j(\varepsilon)$$

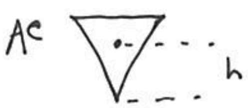


take a cross sectional slice of the bar

neglecting gravity, the body force at the center of each element is

$$f^e = m^e a = m^e \frac{v^2}{r} = A^e \rho \frac{v^2}{r} = A^e \rho\, \omega^2 r^e$$

where $v = \omega r^e$ is the tangential velocity. and r^e is the distance of the center of the element to the axis of rotation. the coordinate ε affect the radius. Assuming equilateral triangles of side a



$$A^e = \frac{\sqrt{3}}{4} a^2 \Rightarrow a = 1.516\, A^e$$

$$r = h = r^e = \frac{a}{2\cos 30} = 3.24\, a$$

$$= 4.9\, A^e$$

(6) Applying the forces on each node equally

$$f^e_\alpha = \frac{A^e \rho w^2 r^e}{3} = [A_i(1-\varepsilon) + A_j(\varepsilon)]^2 \rho w^2 . (1.6)$$

node

with $r^e = 4.9 A^e = 4.9(A_i(1-\varepsilon) + A_j \varepsilon)$

this way, the force is equaly distributed in the three nodes.