12/19/2023

Submit the compressed file as `(ID)_(name).zip` to [ftp://cdl.hanyang.ac.kr → CAE/Final_Lab] folder. It should contain the final results of each problem (equations and graphs) using PowerPoint `(ID.ppt)` and COMSOL files (`problem#-#.mph`).

1. [PDE solving] Solve the mixed boundary value problem for a Poisson equation as follows. Plot the surface of solution 'u' and compute the solution values at the four points. (15 pts)

Mixed Boundary Value Problem for a Poisson Equation

Solve the mixed boundary value problem for the Poisson equation

$$\nabla^2 u = u_{xx} + u_{yy} = f(x, y) = 12xy$$

shown in Fig. 457a.

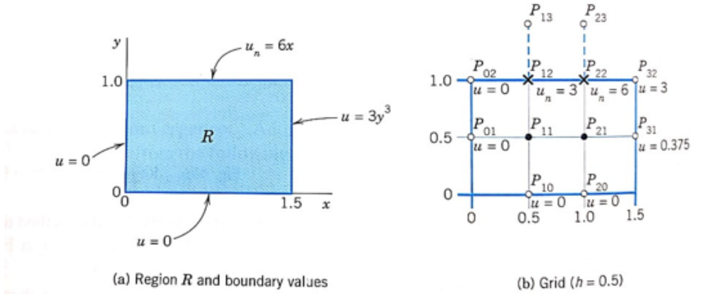


Fig. 457. Mixed boundary value problem in Example 1

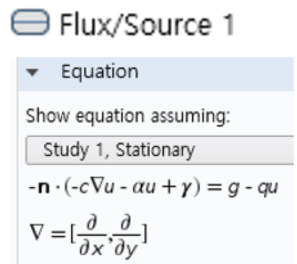
$$u_{xx} + u_{yy} = f(x, y) = 12xy$$

Dirichlet B.C

$$u(0, y) = u(y, 0) = 0,\ u(1.5, y) = 3y^3$$

Neumann B.C

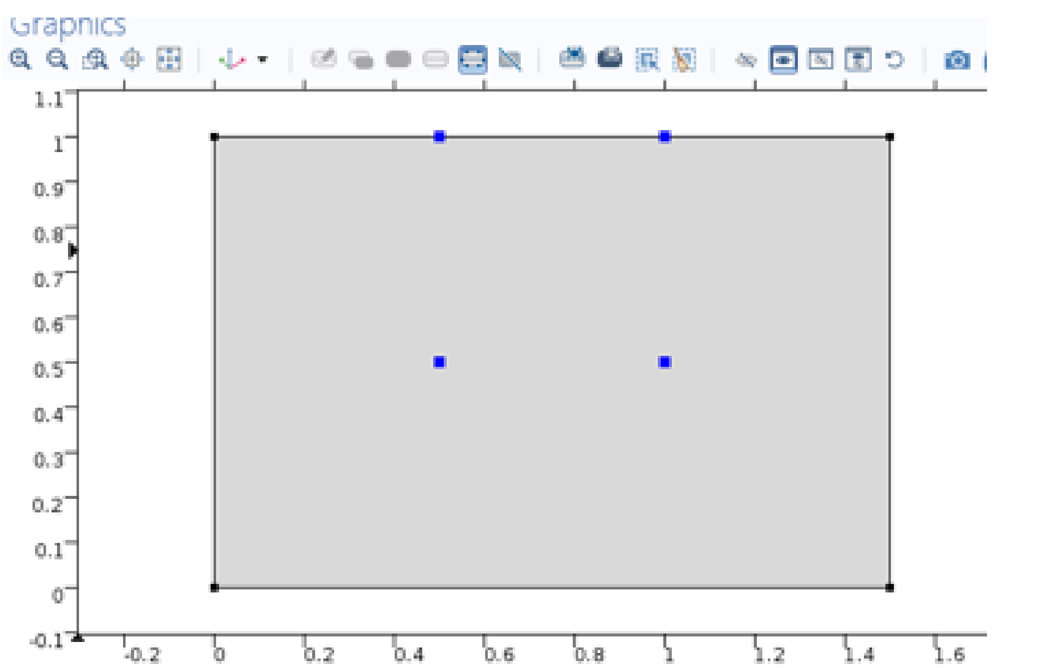
$$u_y(x, 1) = 6x$$



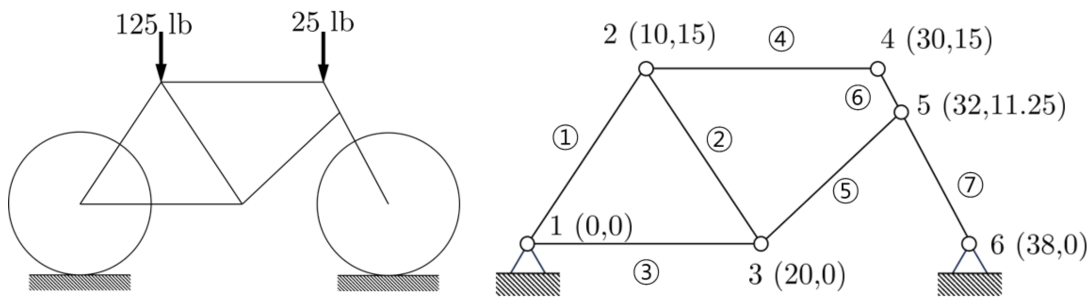
Exact sol.

$$u_{11} = 0.125,\ u_{12} = 1$$

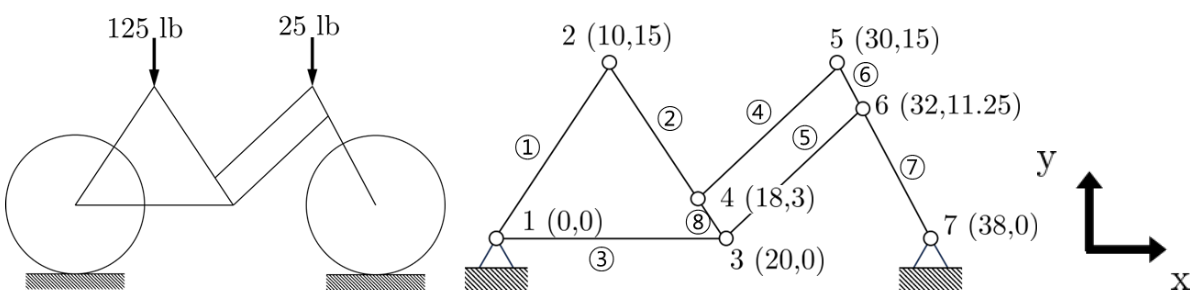
$$u_{21} = 0.250,\ u_{22} = 2$$



2. [2D Beam] Consider the following two bicycle frame models. Answer the following questions based on your analysis of these models:



Design 1



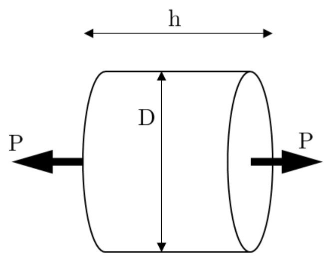
Design 2

[Material property]	[Crosssection data]
Desgin 1	$A_1 = 0.1 \ [in^2]$
$E = 30 \times 10^6$ psi	$A_2 = A_3 = A_4 = A_5 = 0.15 \ [in^2]$
Design 2	$A_6 = A_7 = A_8 = 0.3 \ [in^2]$
$E = 10 \times 10^6$ psi	$I_1 = 0.01 \ [in^4]$
	$I_2 = I_3 = I_4 = I_5 = 0.02 \ [in^4]$
	$I_6 = I_7 = I_8 = 0.1 \ [in^4]$

1) Plot the Total displacement for each model and evaluate the y-direction displacements at the node at 2. (15 pts)
2) Plot the von-mises stress (line type) for two bicycle frame models and determine which design is preferable based on structural stiffness, providing an explanation for your choice (10 pts)

3. [Stress concentration] The following cylinder bar with fillet (30 pts total)

Simple model

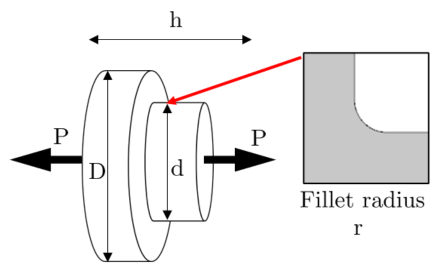


$$\sigma = \frac{F}{A} = \frac{4P}{\pi D^2}$$

Geometry
$D = 1.5m$
$d = 1m$
$h = 2m$
Element order : linear
Material property
$E = 210GPa$
$\nu = 0.3$

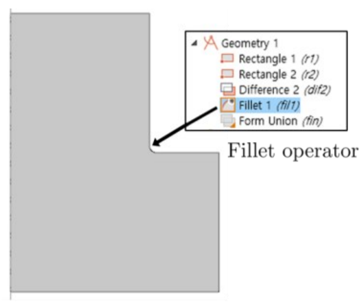
Load $P = \frac{9\pi}{16}$

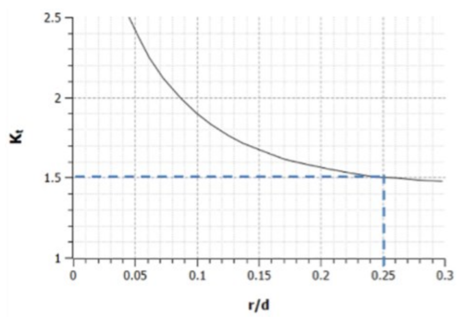
Fillet model



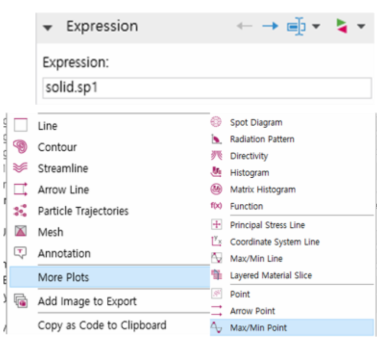
$$\sigma_{\max} = K_t \sigma_{norm}$$

$$K_t = f\left(\frac{r}{d}, \frac{D}{d}\right)$$





Calculate σ_{max} using Max/Min point plot



R(m)	Analytic Kt	FEM Kt
0.05	2.4	
0.1	1.9	
0.15	1.68	
0.2	1.57	
0.25	1.5	

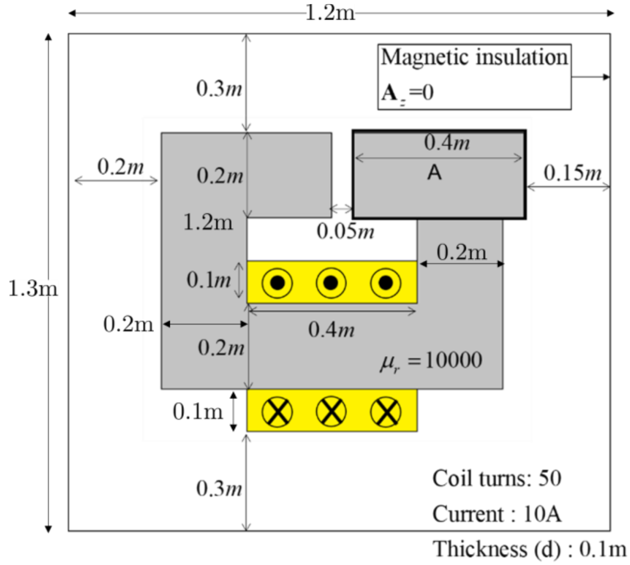
(1) Construct the full 3D model and plot the surface of the first principal stress and the Calculate norm stress (10 pts)

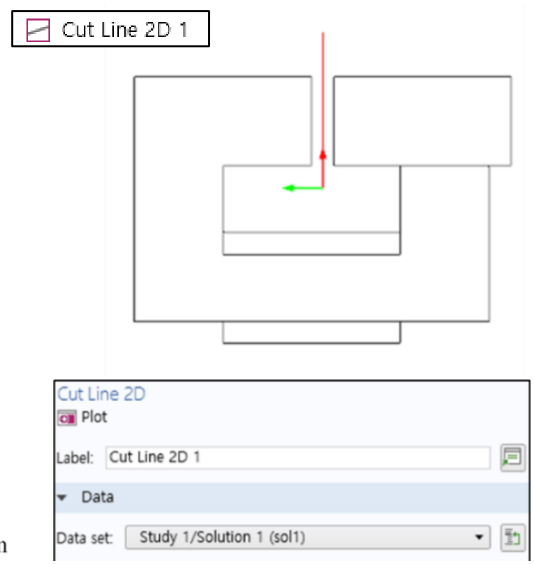
(hint: use Domain Probe 1 *(dom1)* average value of first principal stress “solid.sp1”)

(2) Construct the 2d axisymmetric fillet (r=0.25) model, Compute maximum value of the first principal stress. Check the stress by mesh dependency applying free triangle. Plot the graph as d.o.fs vs stress changing mesh size. (mesh option: extremely coarse ~ extremely fine) (10 pts)

(3) Calculate the value of K when changing the fillet radius (0.05 ~ 0.25 m) as shown in the table. Compare the values of K between the analytic and COMSOL results and fill the table. (mesh option: normal) (10 pts)

4. [Magnetic Actuator] For the actuator and boundary conditions shown, solve the Poisson equation by Magnetic Fields *(mf)*. (Use **Fine** discretization level.) (30 pts total)





1) Draw a Magnetic flux density norm distribution along the Cut Line 2D 1 by 1D Plot Group / Line Graph (15 pts total)

2) Evaluate the magnetic force using Maxwell stress tensor method by Boundary Probe 1 *(bnd1)*, Boundary Probe 2 *(bnd2)*, Global Variable Probe 2 *(var2)* (15 pts total) Analytic solution : 1.4289 N

Hint:

Magnetic force (Maxwell Stress Tensor Method)

$$f_x = \frac{d}{\mu_0}\left[\int \frac{B_x B_x}{2} dy + \int B_x B_y dx\right]$$

d : thickness

μ_0 : vaccum permeability

B : flux density

f : force