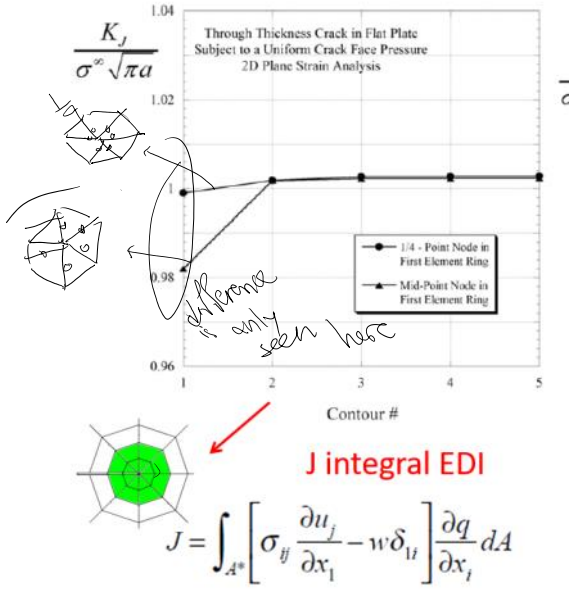
FM20241113

Wednesday, November 13, 2024 9:47 AM



much better than displacement & stress approaches

J integral EDI

$$J = \int_{A^*} \left[\sigma_{ij} \frac{\partial u_j}{\partial x_1} - w\delta_{1i} \right] \frac{\partial q}{\partial x_i} dA$$

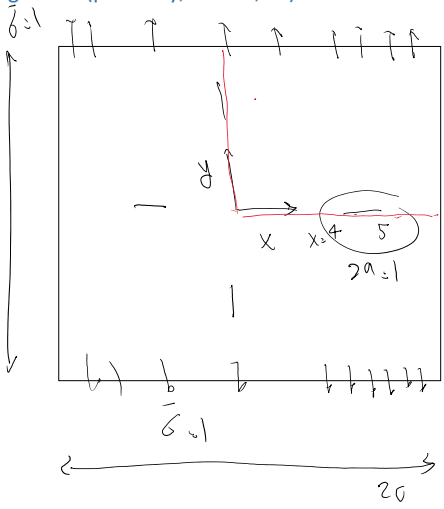
So EDI method is by far the most accurate, most robust, and most general (plasticity, kinetic, ….).

Analytical K assuming infinite domain approx.

$K_I = \bar{\sigma}\sqrt{\pi a} = 1\sqrt{\pi \times 5} = 1.2533$

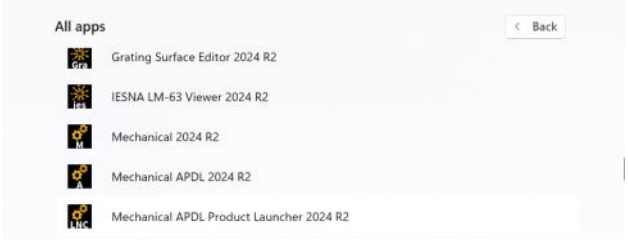
Ex) $\nu = 0$

$G = J = \frac{K_I^2}{E} = 1.5708$

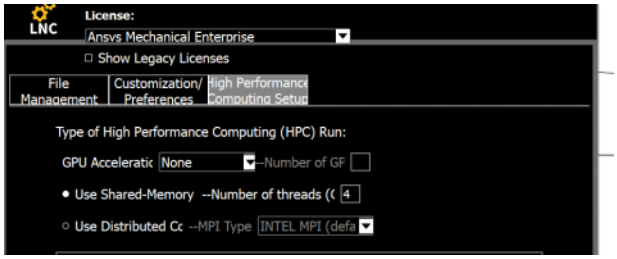


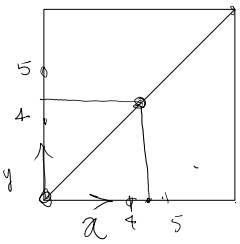
Computing K and J with Ansys:

- Displacement approach
- EDI

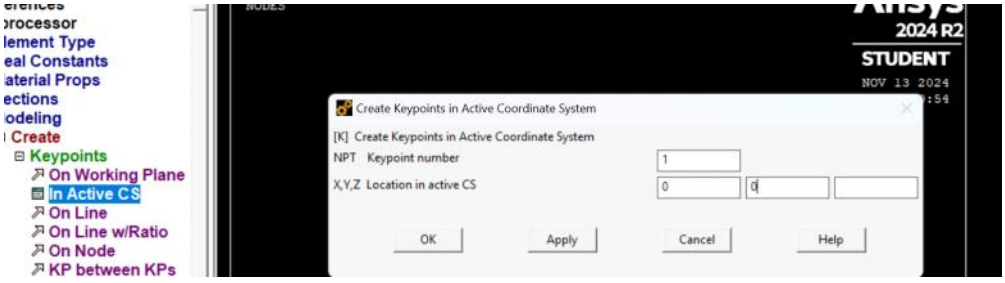


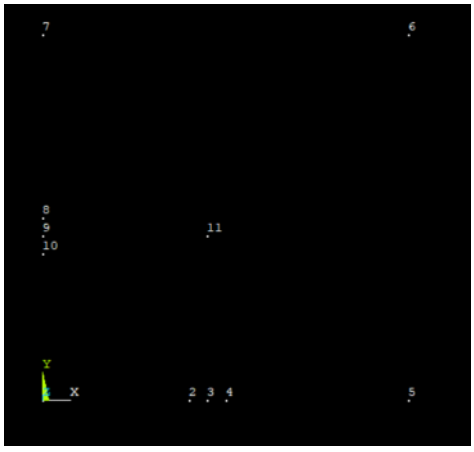
Change this to shared memory:



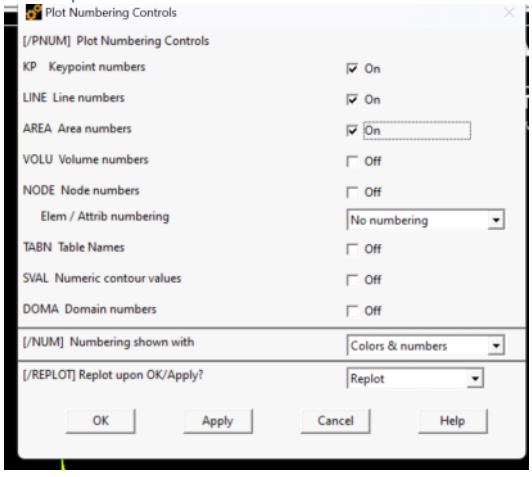


Creating the geometry

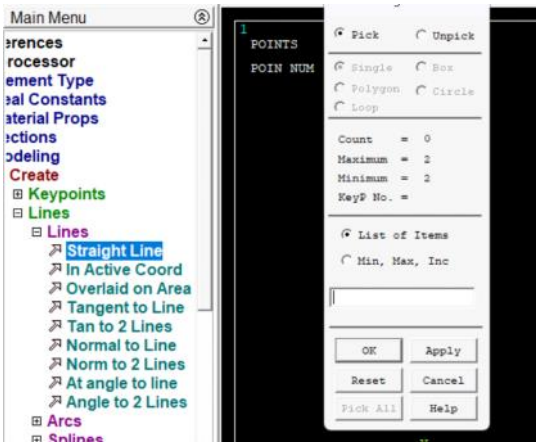


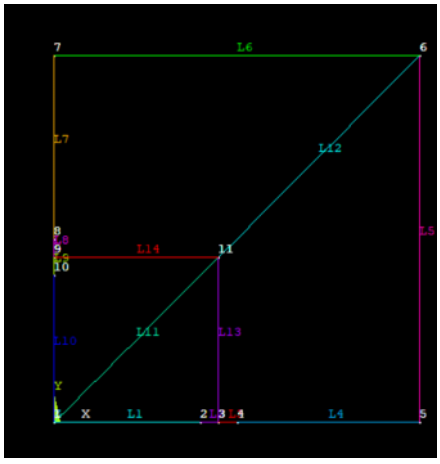


Under plot controls

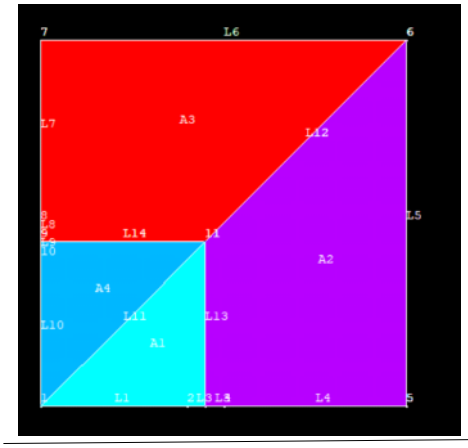


Next we create lines

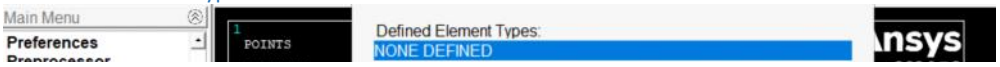




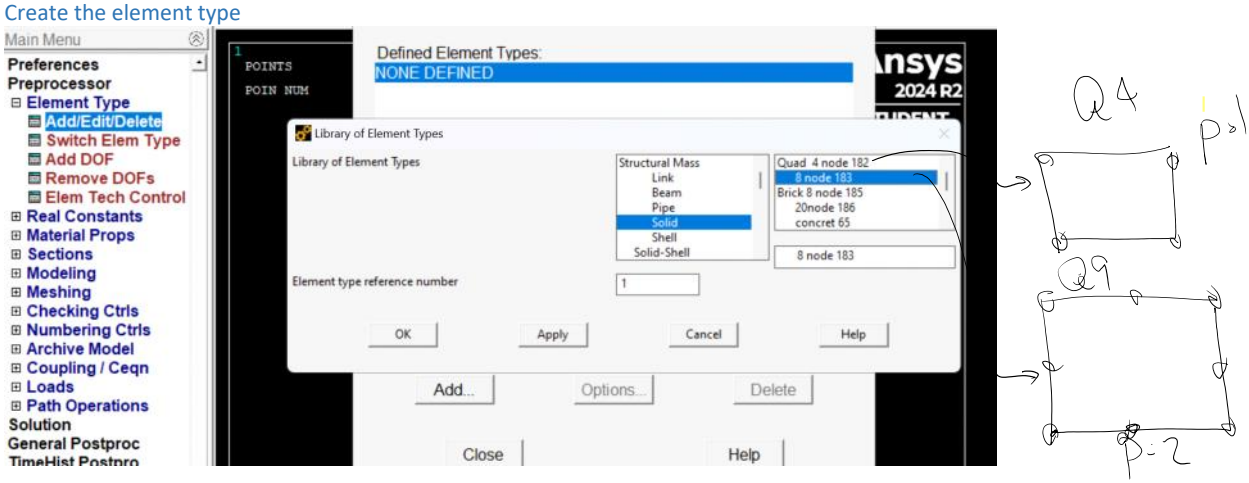
Create areas:



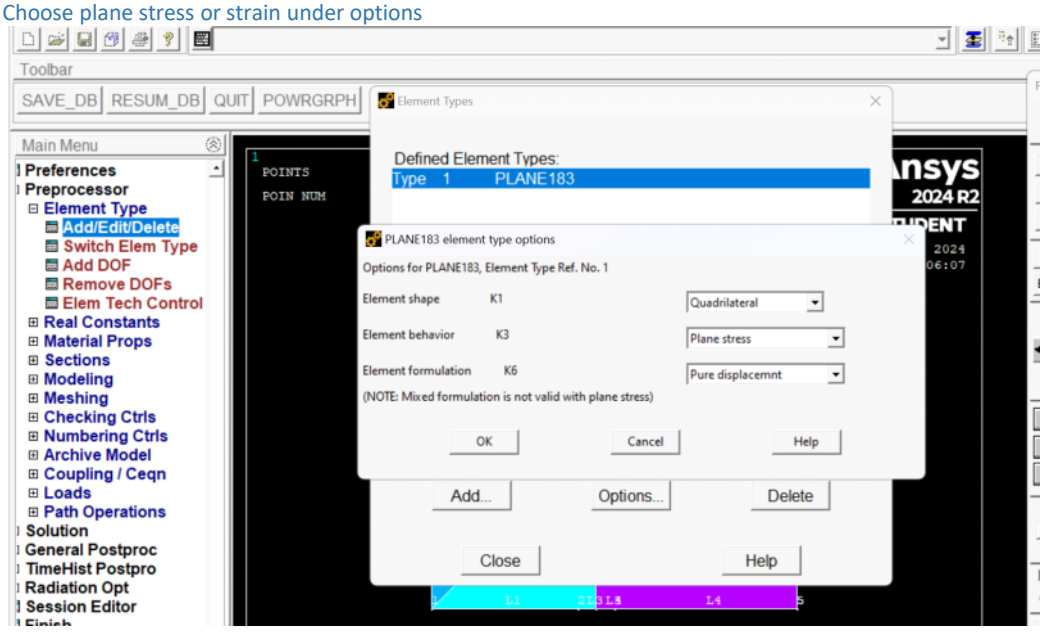
Create the element type



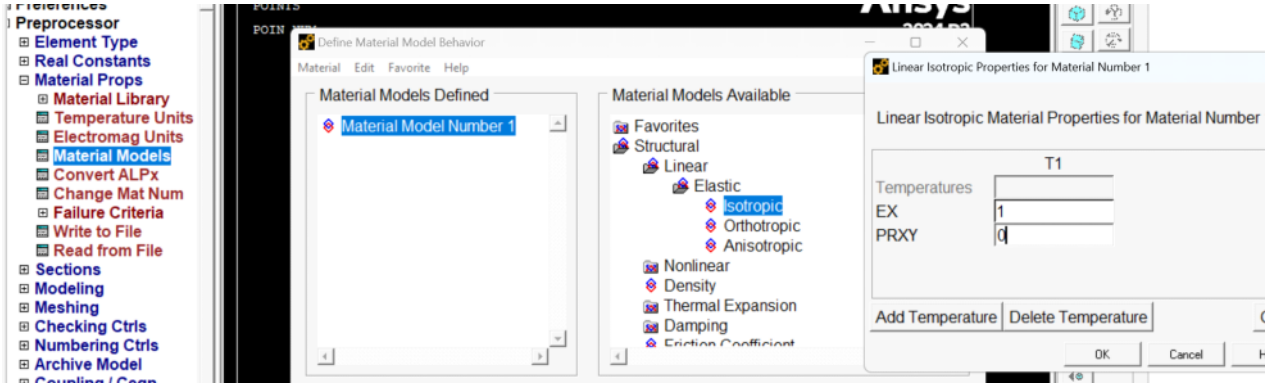
Create the element type



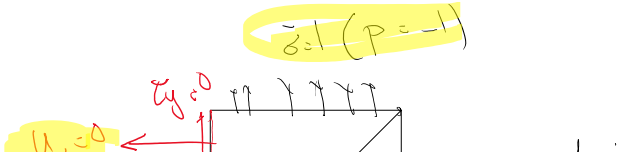
Choose plane stress or strain under options

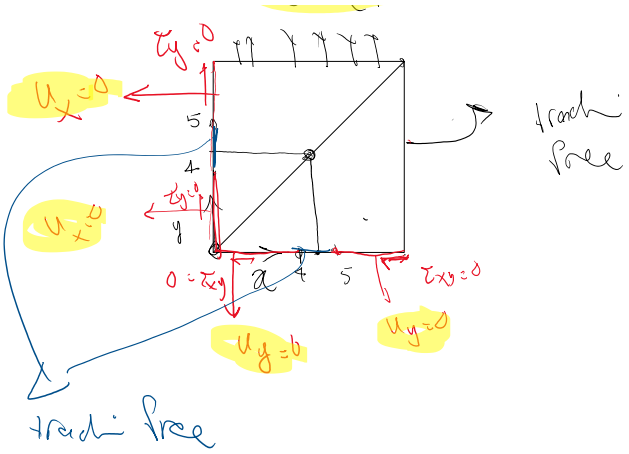


Create the material

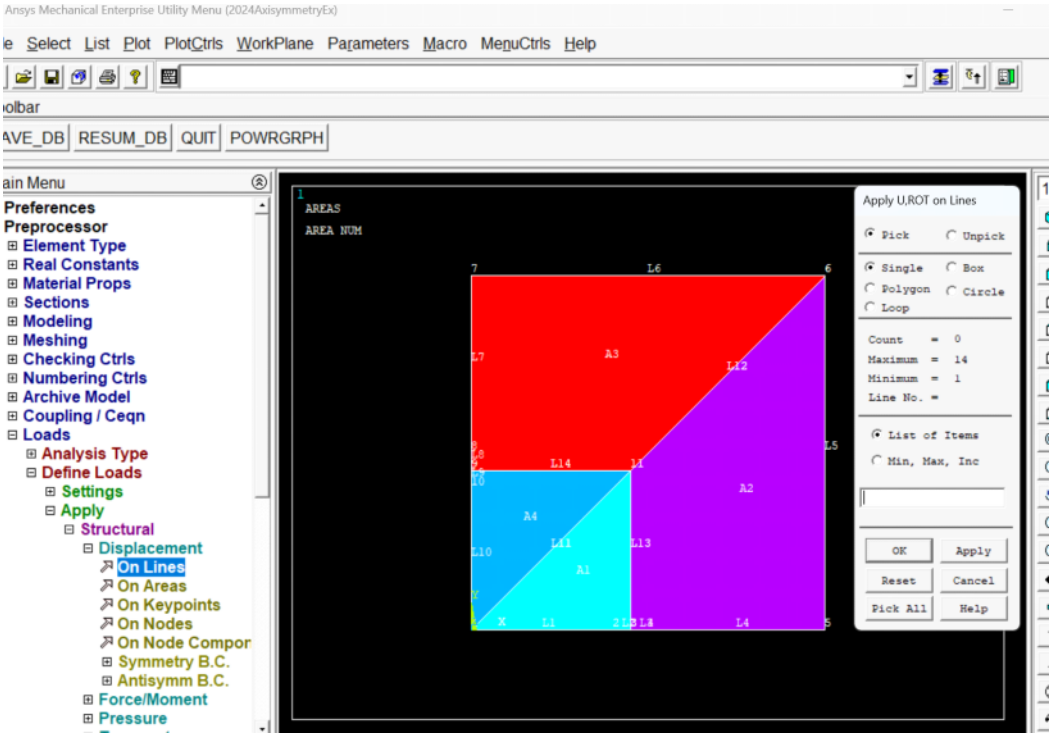


Apply the BCs on the geometry

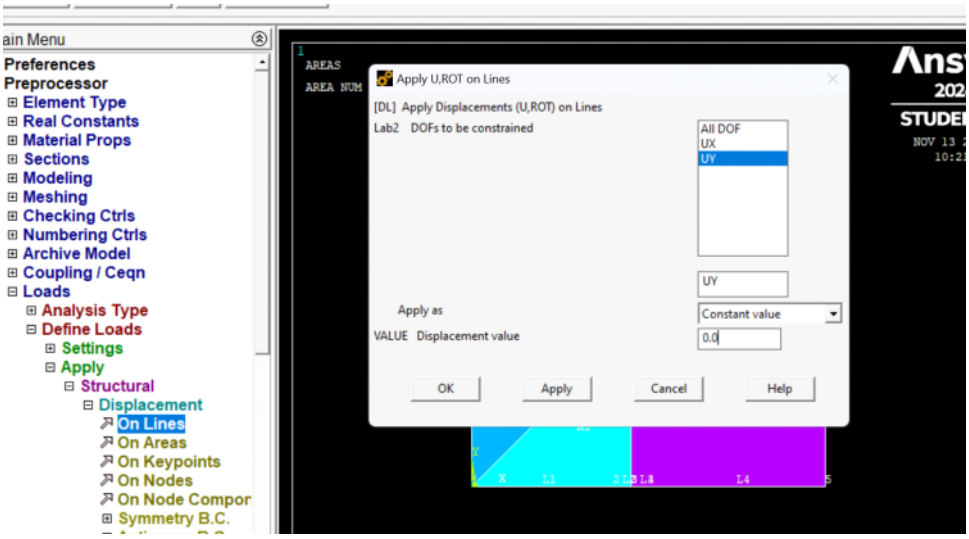


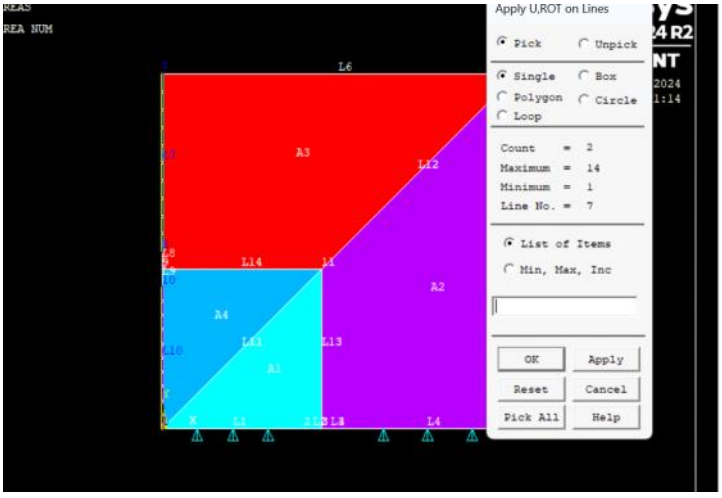


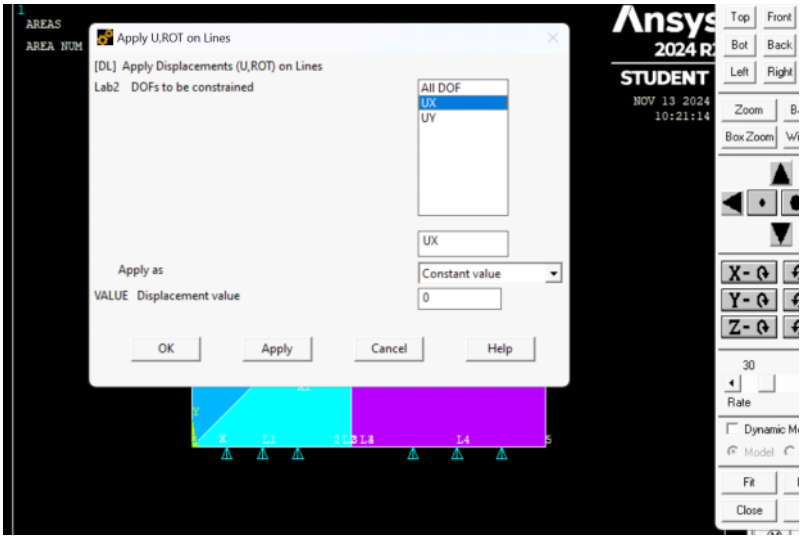
In FEM, the default is traction free. So, if for a direction traction is zero, we don't do anything



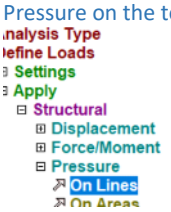
Apply uy = 0 on the left and right segments (bottom edge)

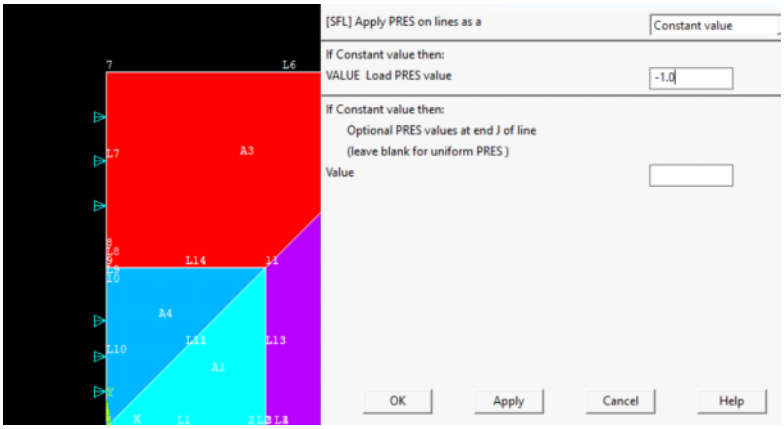




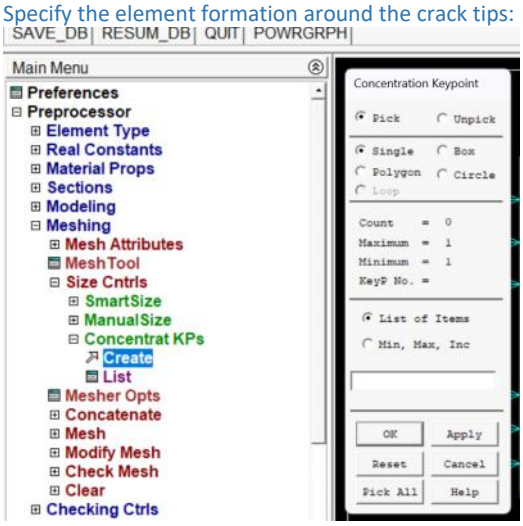


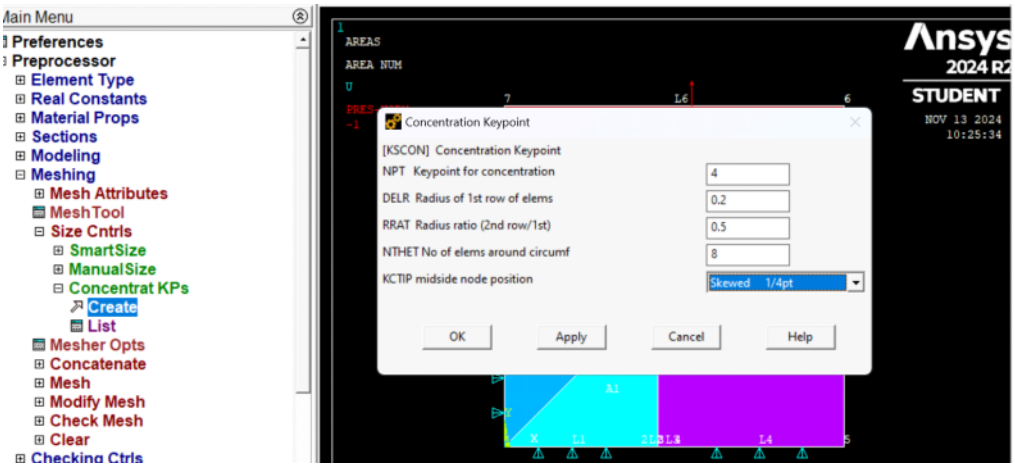
Pressure on the top line:





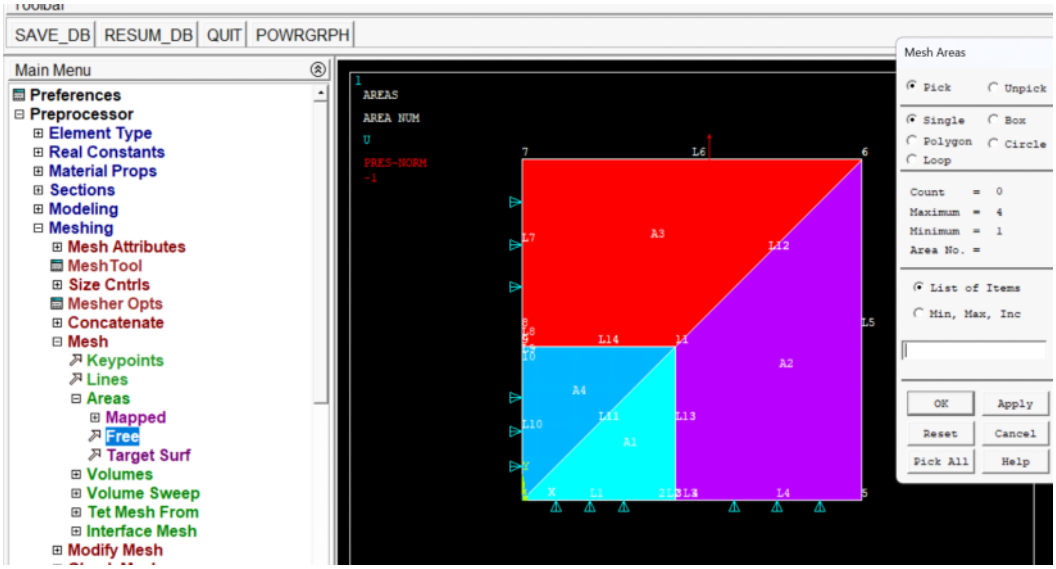
Specify the element formation around the crack tips:



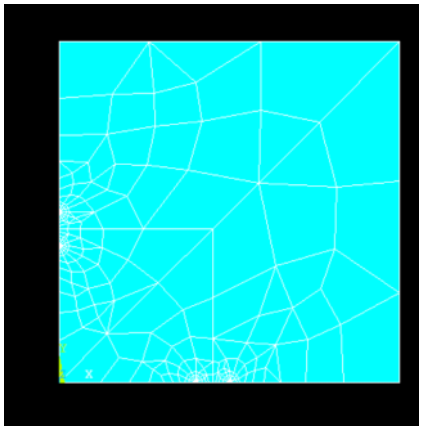


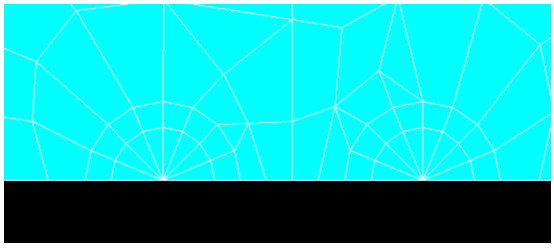
Repeat this for the other 3 CTs

Next we mesh the domain

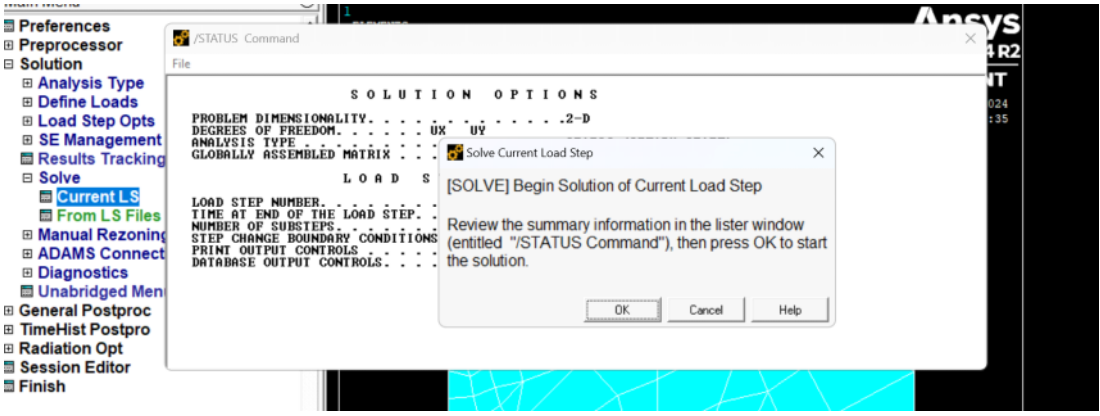


Pick all to mesh the whole domain



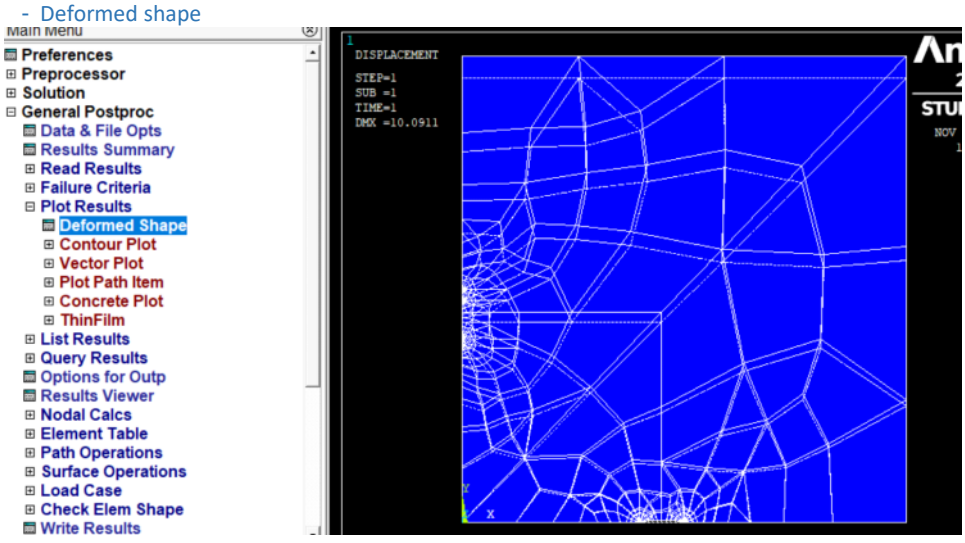


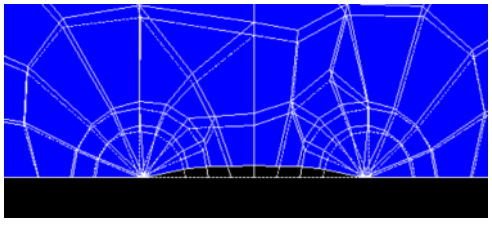
solution

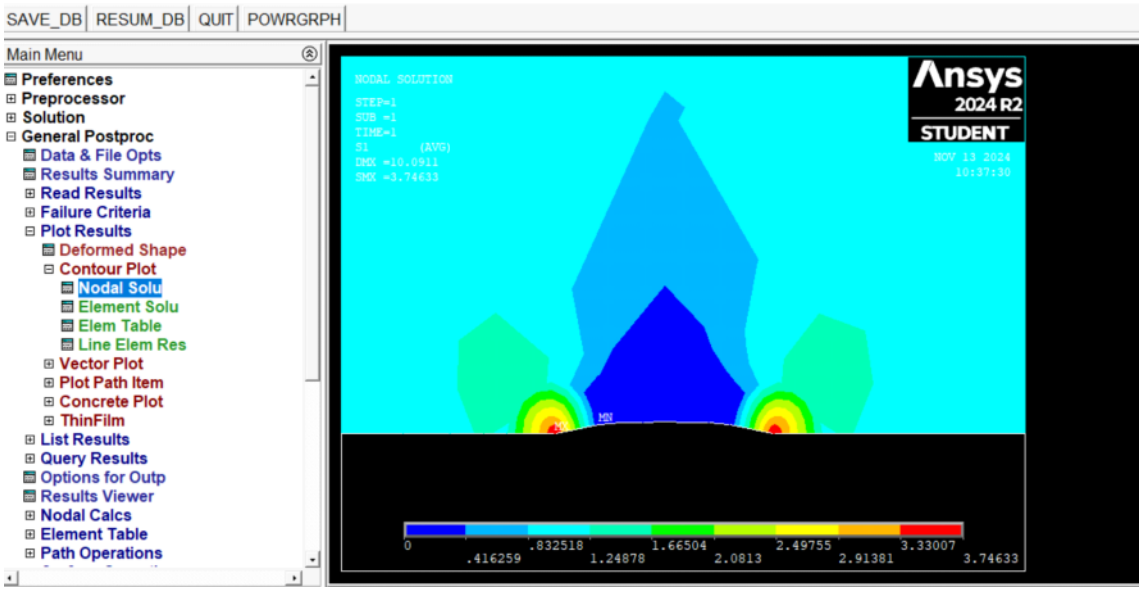


Post processing

- Deformed shape







Calculating SIF:

- Method 1: Displacement

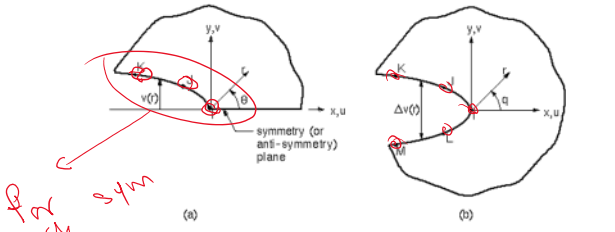


Figure 4) Nodes used for the approximate crack-tip displacements in (a) Half model and (b) Full model

or alternatively from the first quarter point element:

$$v = K_I \frac{\kappa+1}{2G}\sqrt{\frac{r}{2\pi}}$$

$$u' = \overline{u}'_A + \left(-3\overline{u}'_A + 4\overline{u}'_B - \overline{u}'_C\right)\sqrt{\frac{r}{L}} + \left(2\overline{u}'_A + 2\overline{u}'_C - 4\overline{u}'_B\right)\frac{r}{L}$$

$$v' = \overline{v}'_A + \left(-3\overline{v}'_A + 4\overline{v}'_B - \overline{v}'_C\right)\sqrt{\frac{r}{L}} + \left(2\overline{v}'_A + 2\overline{v}'_C - 4\overline{v}'_B\right)\frac{r}{L}$$

Recall for 1D

$$u = u_1 + \frac{\sqrt{x}}{\sqrt{L}}(-3u_1 - u_2 + 4u_3) + \frac{2x}{L}(u_1 + u_2 - 2u_3)$$

$$K_I = \frac{2G}{\kappa+1}\sqrt{\frac{2\pi}{L}}\left(-3\overline{v}'_A + 4\overline{v}'_B - \overline{v}'_C\right)$$

$$\begin{Bmatrix} K_I \\ K_{II} \end{Bmatrix} = \frac{1}{2}\frac{2G}{\kappa+1}\sqrt{\frac{2\pi}{L}}\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}\begin{bmatrix} -3\overline{u}'_A + 4\left(\overline{u}'_B - \overline{u}'_D\right) - \left(\overline{u}'_C - \overline{u}'_E\right) \\ -3\overline{v}'_A + 4\left(\overline{v}'_B - \overline{v}'_D\right) - \left(\overline{v}'_C - \overline{v}'_E\right) \end{bmatrix}$$

278

Mixed mode generalization:

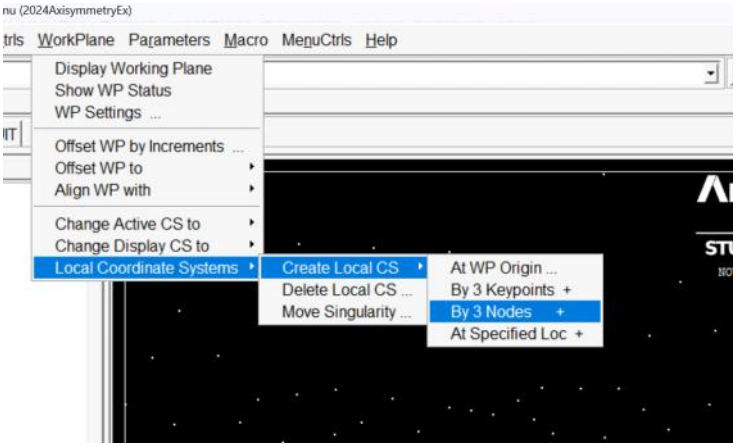
To get K from this approach, we need to do the following:

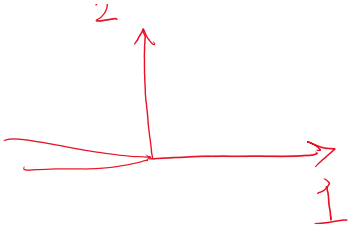
a. Define a local coordinate system
b. Define points 1 to 3 (or 1 to 5) in the figure above.

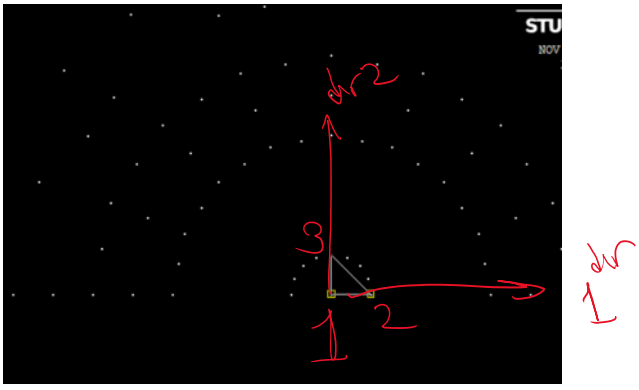
Plot -> nodes

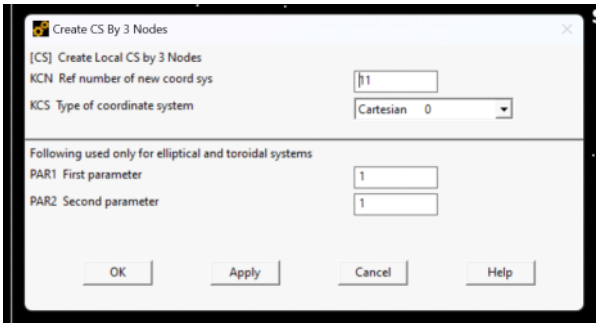
Create a local coordinate system

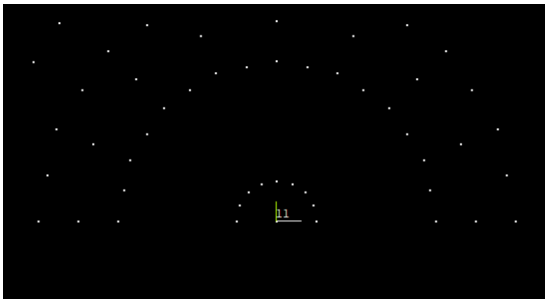
Create a local coordinate system



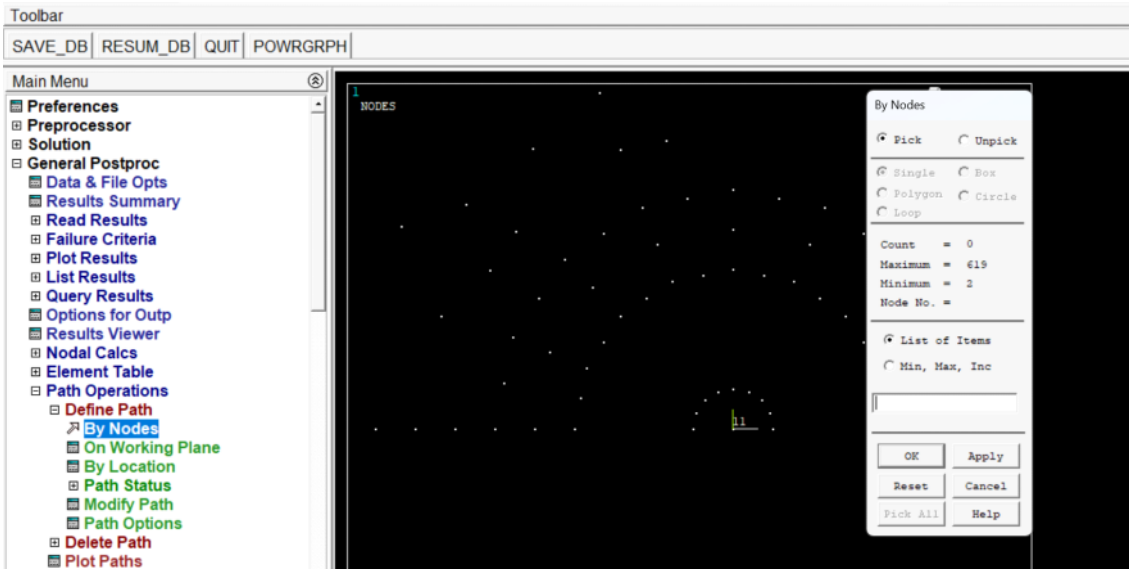


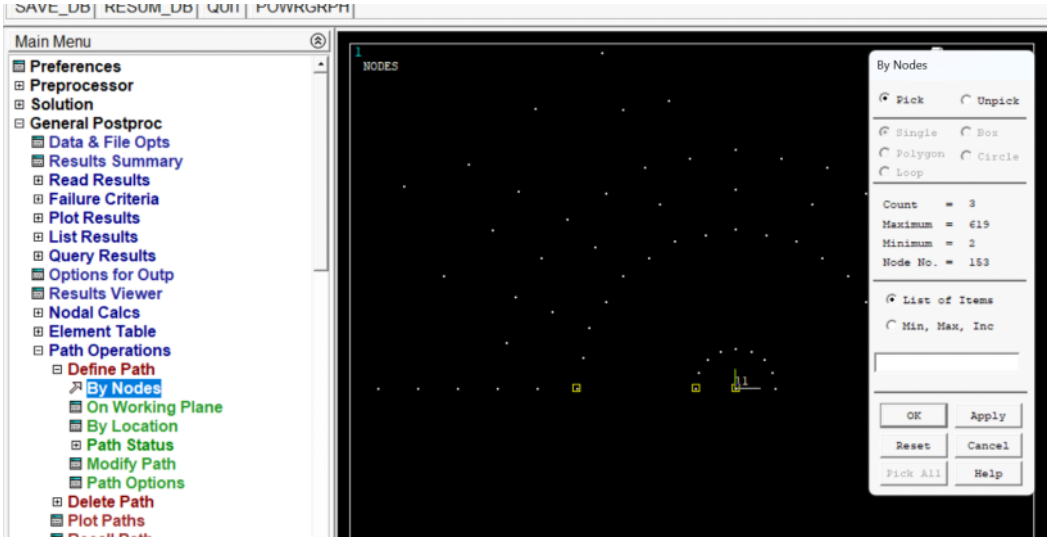


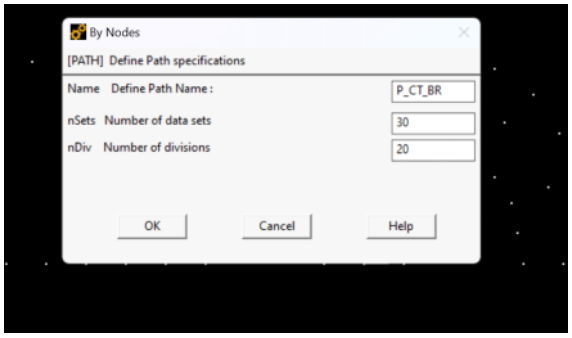




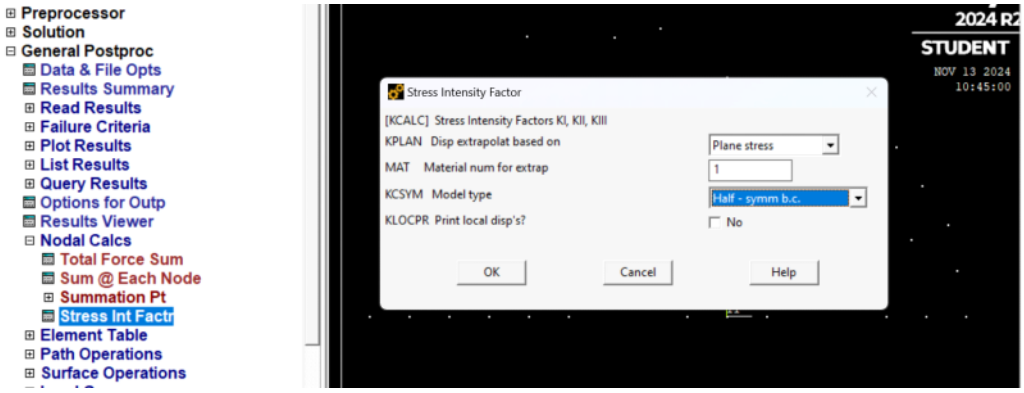
Define the three nodes used to calculate K:
This is done using the "path"








```
 **********  PATH STATUS  **********
 Path      nPts       nSets      nDiv
 P_CT_BR      3        30       20
------
```



**** CALCULATE MIXED-MODE STRESS INTENSITY FACTORS ****

ASSUME PLANE STRESS CONDITIONS

ASSUME A HALF-CRACK MODEL WITH SYMMETRY BOUNDARY CONDITIONS (USE 3 NODES)

EXTRAPOLATION PATH IS DEFINED BY NODES: 147 154 153
WITH NODE 147 AS THE CRACK-TIP NODE

USE MATERIAL PROPERTIES FOR MATERIAL NUMBER 1
EX = 1.0000 NUXY = 0.0000 AT TEMP = 0.0000

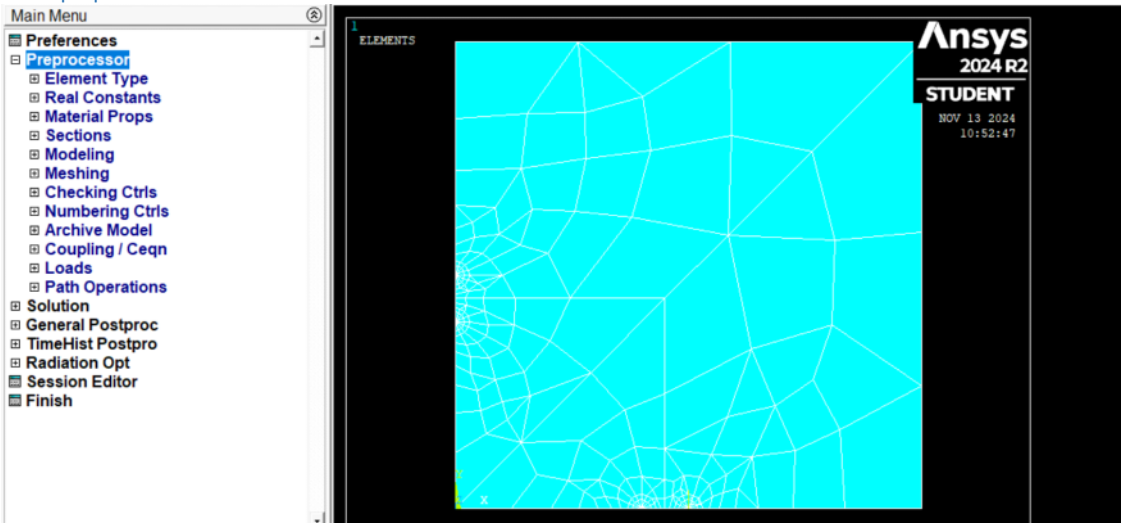
**** KI = 1.2627 , KII = 0.0000 , KIII = 0.0000 ****

Analytical K
assuming infinite domain approx.

$K_I = \sigma\sqrt{\pi a} = 1\sqrt{\pi \times 5} = 1.2533$ (20)

Method 2:
Calculating K through J (Equivalent Domain Integral: EDI)

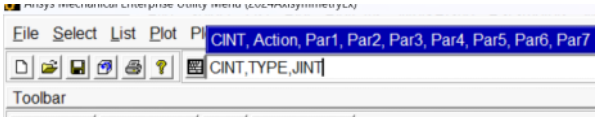
Go to preprocessor



1. Define an integral

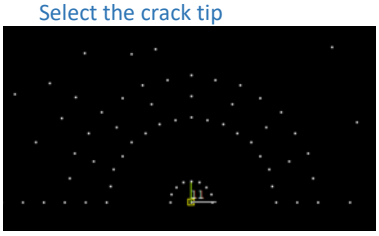
CINT,NEW,1

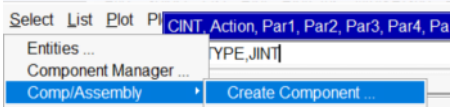
2. Specify the type of contour integral to be done (here it is the J-integral)

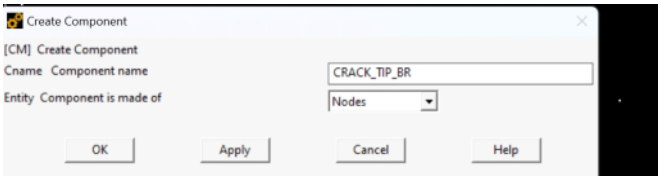


3. We need to create an assembly containing only the crack tip:

Select the crack tip







CINT,CTNC,CRACK_TIP
