#### If you need resources for learning C++, just contact me (for the second project)

## Running Ansys after the installation:



So choose shared memory option here before running it on your laptop:





E= 10 MPa





In Ansys truss elements are called links.

- Specify that we are using truss (link) elements.



## -- Define the materials (E1, E2) and sections (A1, A2)

| Preferences<br>Preprocessor<br>Element Type<br>Real Constants  | - | NODES<br>Define Material Model Behavior<br>Material Edit Favorite Help |  | 2021 R2<br>- □ ×   |  |  |  |
|--|---|--|--|--|--|--|--|
| Material Props   |   | Material Models Defined  | Material Models Available                              | Linear Isotropic Properties for Material Number 1          |  |  |  |
| <ul> <li>■ Material Library</li> <li>■ Temperature Units</li> <li>■ Electromag Units</li> <li>■ Material Models</li> </ul> |   | Image: Material Model Number ▲   | la Favorites<br>la Structural<br>la Elastic            | Linear Isotropic Material Properties for Material Number 1 |  |  |  |
| <ul> <li>■ Convert ALPx</li> <li>■ Change Mat Num</li> <li>■ Failure Criteria</li> <li>■ Write to File</li> </ul>          |   |  | <ul> <li>         Isotropic</li></ul>                  | T1<br>Temperatures<br>EX 10000<br>PRYY 0.3                 |  |  |  |
| <ul> <li>Read from File</li> <li>Sections</li> <li>Modeling</li> </ul>   |   |  | <ul> <li>Density</li> <li>Thermal Expansion</li> </ul> |  |  |  |  |
| Meshing  |   |  |  | Add Temperature Delete Temperature Grap                    |  |  |  |
| Checking Ctris Numbering Ctris Archive Model   |   |  |  | OK Cancel Help   |  |  |  |

Copy and paste, and edit E = 10000 for material 2 (E2)



#### Create nodes



Apply and create nodes 2, 3



- Create elements



| references      | -   | NODES    |     |  |     | Elements from | Nodes    |
|-----------------|-----|----------|-----|--|-----|---------------|----------|
| reprocessor     |     | NODE NUM |     |  | _   | 0             |          |
| Element Type    |     |          |     |  | 2   | (* Pick       | C Unpick |
| Real Constants  |     |          | 2   |  | AUG | @ Single      | C Box    |
| Material Props  |     |          |     |  | 1   | C Polygon     | C Circle |
| Sections        |     |          |     |  |     | C Loop        |          |
| Modeling        |     |          |     |  |     | Count =       | 2        |
| Create          |     |          |     |  |     | Maximum =     | 20       |
| Keypoints       |     |          |     |  |     | Minimum =     | 1        |
| Lines           |     |          |     |  |     | Node No       | · -      |
| Areas           | -12 |          |     |  |     | G List of     | Items    |
| Volumes         |     |          | 1 I |  |     | C Min, Ma     | z, Inc   |
| Nodes           |     |          | x_x |  |     |               |          |
| Elements        |     |          |     |  |     | I             |          |
| Elem Attributes |     |          |     |  |     |               |          |
| Auto Numbered   |     |          |     |  |     | OK            | Apply    |
| Thru Nodes      |     |          |     |  |     | Reset         | Cancel   |
| At Coincid Nd   |     |          |     |  |     | Pick All      | Help     |
| Offset Nodes    |     |          | 3   |  |     |               |          |
| Surf / Contact  |     |          | •   |  |     |               |          |
| SpotWeld        |     |          |     |  |     |               |          |

After creating element 2, we change to E2 and A2 to create element e3





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We apply supports (prescribed displacements)



- Loads
  - Analysis Type Define Loads Settings Apply B Structural Displacement
    - ➢ On Lines
    - ➢ On Areas
    - ↗ On Keypoints

       ↗ On Nodes

## Top left node





--- apply the force on node 1

| Meshing                                      | ELEMENTS           |
|--|--------------------|
| Checking Ctrls Numbering Ctrls Archive Model | ELEM NUM           |
| Coupling / Ceqn     Loads                    |                    |
| Analysis Type                                | Apply F/M on Nodes |
| Define Loads                                 | C Bick C Braich    |
| Settings                                     | 3                  |
|  | © Single C Box     |
| Structural                                   | C Loop             |
| Displacement                                 |                    |
| Force/Moment                                 | Count = 1          |
| P On Keypoints                               | Minimum = 1        |
|  | Node No. = 1       |
| P On Node Components                         | G tier of trees    |
| From Reactions                               | C Min Man Ten      |
| From Mag Analy                               | t nan, nex, and    |
| Pressure     Tomporature                     |                    |
| B Inortia                                    |                    |
| Bretnen Sectn                                | OK Apply           |
|  |                    |
| Apply F/M on Nodes                           | $\times$           |
| [F] Apply Force/Moment on Nodes              |                    |
| Lab Direction of force/mom FY                | •                  |
| Apply as Cons                                | stant value        |
| If Constant value then:                      |                    |
| VALUE Force/moment value -1.0                |                    |
| OK L Ante L Court L                          |                    |
| Cancer Cancer                                |                    |
|  |                    |
|  |                    |
|  |                    |



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Postprocessing

Show the deformed shape:



If you want to save the deformed shape or any other thing do the following



For 1D elements (bars, trusses, ...) we list the following:







 First, we compute reaction forces by adding up forces from individual elements that contribute to reaction forces:

| $R_1^2 = f_1^{e_1} + f_1^{e_2} = 0 + 0.5715 = 0.5715$      | (397a) |
|--|--------|
| $R_1^3 = f_3^{e_1} + f_1^{e_3} = 0 + -0.5714 = -9.5714$    | (397b) |
| $R_2^3 = f_4^{e_1} + f_2^{e_3} = 0.4285 + 0.5714 = 0.9999$ | (397c) |
|  |        |

#### Get nodal displacements



### PRINT U NODAL SOLUTION PER NODE

\*\*\*\*\* POST1 NODAL DEGREE OF FREEDOM LISTING \*\*\*\*\*

LOAD STEP= 1 SUBSTEP= 1 TIME= 1.0000 LOAD CASE= 0

THE FOLLOWING DEGREE OF FREEDOM RESULTS ARE IN THE GLOBAL COORDINATE SYSTEM

 NODE
 UX
 UY
 UZ
 USUM

 1
 0.21429E-001-0.28571E-001
 0.0000
 0.35714E-001

 2
 0.50000E-001
 0.0000
 0.50000E-001

 3
 0.0000
 -0.20023E-015
 0.0000
 0.20023E-015

 MAXIMUM ABSOLUTE VALUES

 NODE
 2
 1
 0
 2

 VALUE
 0.50000E-001-0.28571E-001
 0.0000
 0.50000E-001

#### To list element forces use



#### PRINT ELEM ELEMENT SOLUTION PER ELEMENT

\*\*\*\*\* POST1 ELEMENT SOLUTION LISTING \*\*\*\*\*

LOAD STEP 1 SUBSTEP= 1 TIME= 1.0000 LOAD CASE= 0

 EL=
 1 NODES=
 2
 3 MAT=
 1 XC,YC,ZC=
 0.000
 0.2000
 0.000
 AREA=
 0.10000E-01
 LINK180

 FORCE=
 0.71511E-16
 STRESS=
 0.71511E-14
 EPEL=
 0.71511E-16
 Incorrect forces

 TEMP=
 0.00
 0.00
 EPTH=
 0.0000
 -0.6000
 0.000
 AREA=
 0.10000E-01
 LINK180

 EL=
 2 NODES=
 3
 1 MAT=
 1 XC,YC,ZC=
 0.8000
 -0.6000
 0.000
 AREA=
 0.10000E-01
 LINK180

 FORCE=-0.11796E-15
 STRESS=-0.11796E-13
 EPEL=-0.11796E-15
 TEMP=
 0.000
 0.000
 EPTH=
 0.0000

 EL=
 3 NODES=
 2
 1 MAT=
 2 XC,YC,ZC=
 0.8000
 0.000
 AREA=
 0.10000
 LINK180

FORCE= 0.0000 STRESS= 0.0000 EPEL= 0.0000

These are the correct forces

TEMP= 0.00 0.00 EPTH= 0.0000



# The exact solution of this statistically-determinant structure is obtained here (forces do not depend on E and A) Truss Example: Direct solution method



• Since this is a statically determinate structure, we can easily solve the forces and verify our FEM forces.

| $\Sigma F_2 = 0 \implies R_2^3 - \bar{F} = 0 \implies R_2^3 = 1$   | (399a)              |
|--|---------------------|
| $\Sigma M_{n_3} = 0 \implies 2.8R_1^2 - 1.6\bar{F} = 0 \implies R_1^2 = \frac{4}{7} = 0.5714$  | (399b)              |
| $\Sigma F_1 = 0 \implies R_1^2 + R_1^3 = 0 \implies R_1^3 = -\frac{4}{7} = -0.5714$  | (399c)              |
| $\Sigma F_1 = 0(@n_2) \implies R_1^2 + \frac{4}{5} T^e 2 = 0 \implies T^e 2 = -\frac{5}{7} = -0.7143$  | (399d)              |
| $\Sigma F_2 = 0(@n_2) \Rightarrow T^e 1 + \frac{3}{5} T^e 2 = 0 \Rightarrow T^e 1 = \frac{3}{7} = 0.4286$  | (399e)              |
| $\Sigma F_1 = 0(@n_1)  \Rightarrow \ -\frac{4}{5} \frac{T^e 2}{2} - \frac{1}{\sqrt{2}} T^e 3 = 0  \Rightarrow \ T^e 3 = \frac{4}{7} \sqrt{2} = 0.8081$ | (399f)<br>327 / 456 |



Problems with 2D / 3D elements: We create the geometry and apply BC (supports, loads), ... on geometry not on element nodes

#### Define the element



| Toolbar  |  |
|--|--|
| SAVE_DB RESUM_DB QUIT POWRGRPH   | Element Types X  |
| Main Menu (Relation of the second state of the | Defined Element Types:<br>Type 1 PLANE183<br>E183 element type options<br>rPLANE183, Element Type Ref. No. 1<br>Plane tress<br>Plane stress<br>Plane stress<br>OK Cancel Help<br>Magge Way<br>Magge Way<br>Magg |
|  | Add Options Delete   |
| Solution   |  |