MAE 4700/5700: ANSYS Section

Fridays 1:25-2:15 pm

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Co-ordinates

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  - TBA

Computer Labs with ANSYS

- CIT public labs
  - B7 Upson
  - 318 Phillips
  - ACCEL lab in Carpenter Hall
- 471 Rhodes
- Swanson Lab (163 Rhodes)
  - 16 workstations
  - 2 quad-core processors
  - 30 GB of RAM

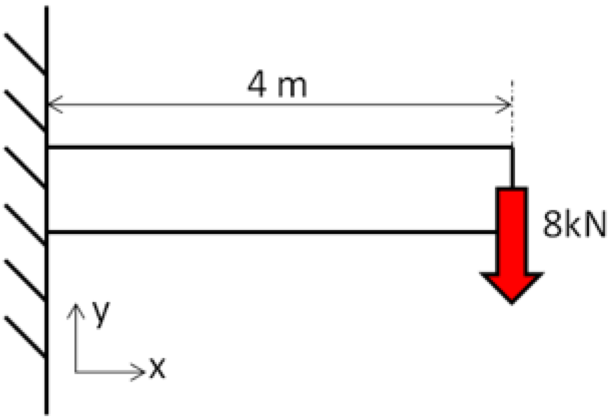
ANSYS Software

- Leading commercial FEA software
- Founded by Cornell alum Dr. John Swanson in 1970
- Can solve structural, thermal, flow and electro-magnetic problems
- Student version available for $25/year
  - Instructions to be provided by e-mail
  - Version 13
    - Labs are using Version 14. V14 files cannot be read into V13.

Friday Sections

- Purpose:
  - Learn to *apply* FEA to engineering problems using ANSYS
  - Prepare for project
- Plan:
  - Initially solve some HW problems using ANSYS
    - Compare MATLAB and ANSYS solutions
  - Move on to more complex problems.

ANSYS Exercise 1
Cantilever Beam



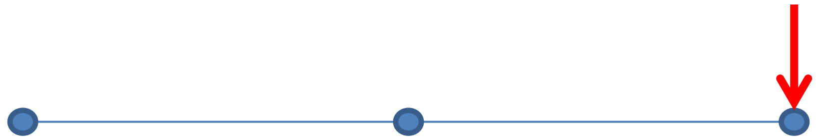
- Truss elements are available in ANSYS
  - Need to use scripting (advanced feature)
  - Not used widely in practice

ANSYS Exercise 1
Cantilever Beam

- Beams will appear in HW3
- One problem will be on ANSYS solution of cantilever beam
  - Save work from this section for submission with HW3

Cantilever Beam: Degrees of Freedom

- Consider 2-element mesh



$u_{y_1} = 0$ u_{y_2} u_{y_3}

$\theta_{z_1} = 0$ θ_{z_2} θ_{z_3}

Reaction force at node 1

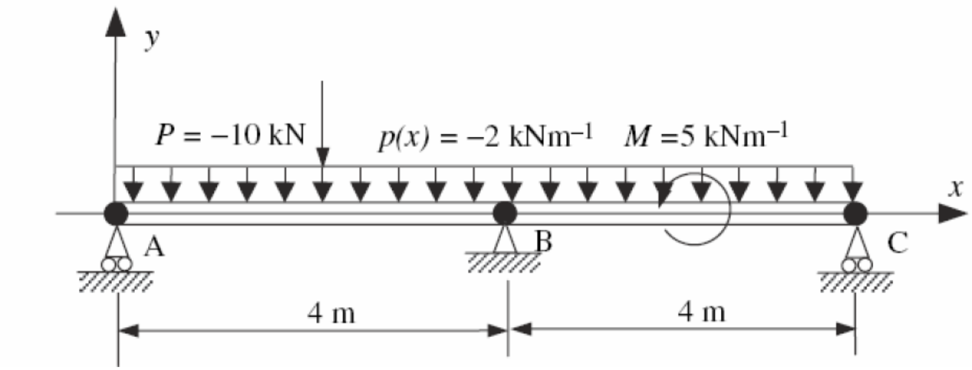
Reaction moment at node 1

SECTION MEETING #2
9/6/2012

Cantilever Beam

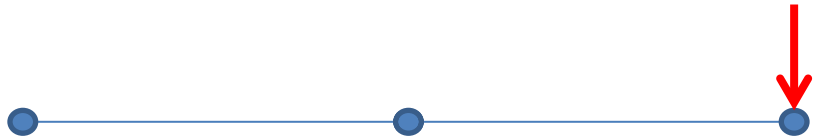
- First ANSYS exercise
  - Can do trusses but need to use scripting (advanced functionality)
  - Pin-jointed trusses rarely occur in practice
- ANSYS beam problem will appear in HW3

Problem 3 – Analysis of a two-span beam (MatLab and Ansys)



Cantilever Beam: Degrees of Freedom

- Consider 2-element mesh



$u_{y_1} = 0$ $\quad$ u_{y_2} $\quad$ u_{y_3}

$\theta_{z_1} = 0$ $\quad$ θ_{z_2} $\quad$ θ_{z_3}

Reaction force at node 1
Reaction moment at node 1

Cantilever Beam
Beam element stiffness matrix

Offset Type	Centroid
Model Type	Beam
Material	
Assignment	Go Big Red
Nonlinear Effects	Yes
Thermal Strain Effects	Yes

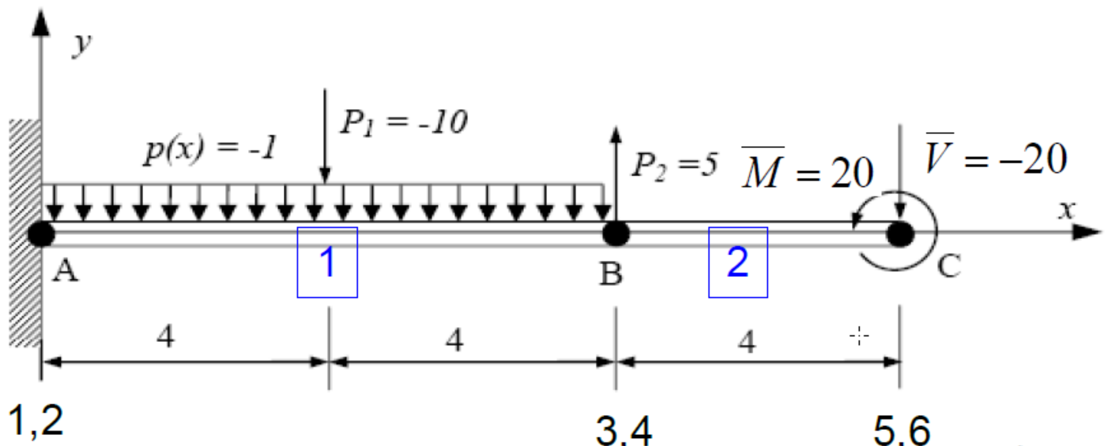
K^e : see page 24 of Lecture 4: Finite element formulation of beam problems

$$K^e = \frac{E^e I^e}{2L^{e^3}} \int_{-1}^{1} \begin{bmatrix} 36\xi^2 & 6\xi(3\xi-1)L^e & -36\xi^2 & 6\xi(3\xi+1)L^e \\ 6\xi(3\xi-1)L^e & (3\xi-1)^2 L^{e^2} & -6\xi(3\xi-1)L^e & (9\xi^2-1)L^{e^2} \\ -36\xi^2 & -6\xi(3\xi-1)L^e & 36\xi^2 & -6\xi(3\xi+1)L^e \\ 6\xi(3\xi+1)L & (9\xi^2-1)L^{e^2} & -6\xi(3\xi+1)L^e & (3\xi+1)^2 L^{e^2} \end{bmatrix} d\xi = \frac{E^e I^e}{L^{e^3}} \begin{bmatrix} 12 & 6L^e & -12 & 6L^e \\ 6L^e & 4L^{e^2} & -6L^e & 2L^{e^2} \\ -12 & -6L^e & 12 & -6L^e \\ 6L^e & 2L^{e^2} & -6L^e & 4L^{e^2} \end{bmatrix}$$

Details of Line Body	
Body	Line Body
Faces	0
Edges	1
Vertices	2
Cross Section	Rect1
Offset Type	Centroid

Poisson ratio doesn't appear in K^e

Solve Step
Beam Lecture, Page 43

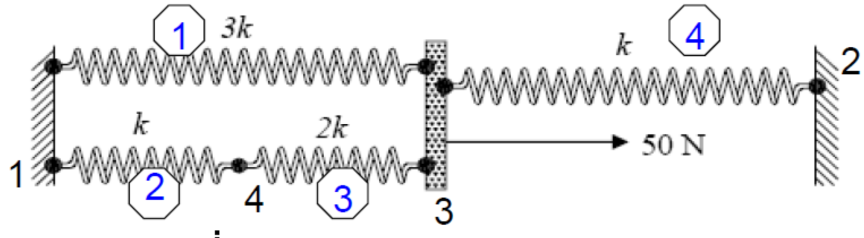


$$
10^3 \begin{bmatrix} 0.23 & 0.94 & -0.23 & 0.94 & 0 & 0 \\ 0.94 & 5.00 & -0.94 & 2.50 & 0 & 0 \\ -0.23 & -0.94 & 2.11 & 2.81 & -1.88 & 3.75 \\ 0.94 & 2.50 & 2.81 & 15.00 & -3.75 & 5.00 \\ 0 & 0 & -1.88 & -3.75 & 1.88 & -3.75 \\ 0 & 0 & 3.75 & 5.00 & -3.75 & 10.00 \end{bmatrix} \begin{Bmatrix} u_{y1} = 0 \\ \theta_{y1} = 0 \\ u_{y2} \\ \theta_{y2} \\ u_{y3} \\ \theta_{y3} \end{Bmatrix} = \begin{Bmatrix} -9 + R_{u1} \\ -15.3 + R_{\vartheta 1} \\ -4 \\ 15.3 \\ -20 \\ 20 \end{Bmatrix}
$$

Bending Moment and Shear Force

- General FEM Procedure (see next slide):
  1. Calculate unknown degrees of freedom
  2. Calculate reactions at known degrees of freedom (for instance, at fixed nodes)
- ANSYS then uses reactions to calculate bending moment and shear force:
  – More accurate than differentiating displacement → $M^1 = EI \frac{d^2 u_y^1}{dx^2}$

Calculation of Reactions



See Lecture 2: Direct approach, page 32

$$k\left[\begin{array}{cc|cc} 4 & 0 & -3 & -1 \\ 0 & 1 & -1 & 0 \\ \hline -3 & -1 & 6 & -2 \\ -1 & 0 & -2 & 3 \end{array}\right]\begin{Bmatrix} d_1 \\ d_2 \\ d_3 \\ d_4 \end{Bmatrix} = \begin{Bmatrix} r_1 \\ r_2 \\ 50N \\ 0 \end{Bmatrix}$$

We partition and apply BCs: $d_1 = d_2 = 0$

$$k\begin{bmatrix} 6 & -2 \\ -2 & 3 \end{bmatrix}\begin{Bmatrix} d_3 \\ d_4 \end{Bmatrix} = \begin{Bmatrix} 50N \\ 0 \end{Bmatrix} \Rightarrow \begin{Bmatrix} d_3 \\ d_4 \end{Bmatrix} = \frac{1}{k}\begin{Bmatrix} 10.7143 \\ 7.1429 \end{Bmatrix} N$$