

# MAE 4700/5700: ANSYS Section

Fridays 1:25-2:15 pm

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# Co-ordinates

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- Office hours in the Swanson Lab (163 Rhodes)
  - TBA



# Computer Labs with ANSYS

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- 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

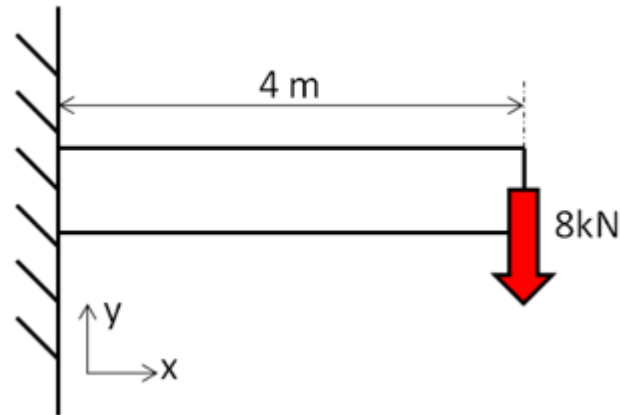
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- Purpose:
  - Learn to *apply* FEA to engineering problems using ANSYS
  - Prepare for project
- Plan:
  - Initially solve some HW problems using ANSYS
    - Compare MATLAB and ANSYS solutions
  - Move on to more complex problems.



# 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

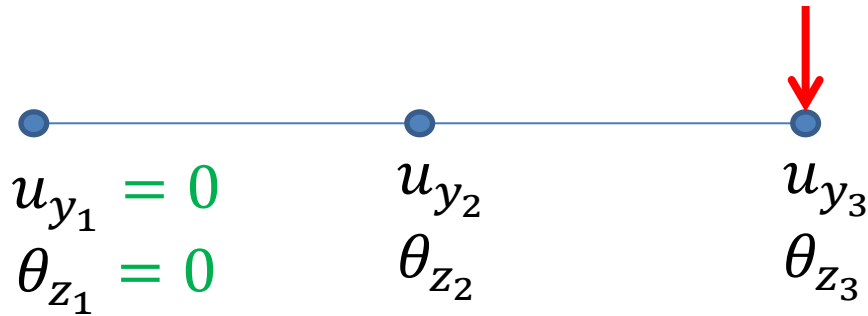
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- Beams will appear in HW3
- One problem will be on ANSYS solution of cantilever beam
  - Save work from this section for submission with HW3



# Cantilever Beam: Degrees of Freedom

- Consider 2-element mesh



Reaction force at node 1

Reaction moment at node 1





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# SECTION MEETING #2

## 9/7/2012

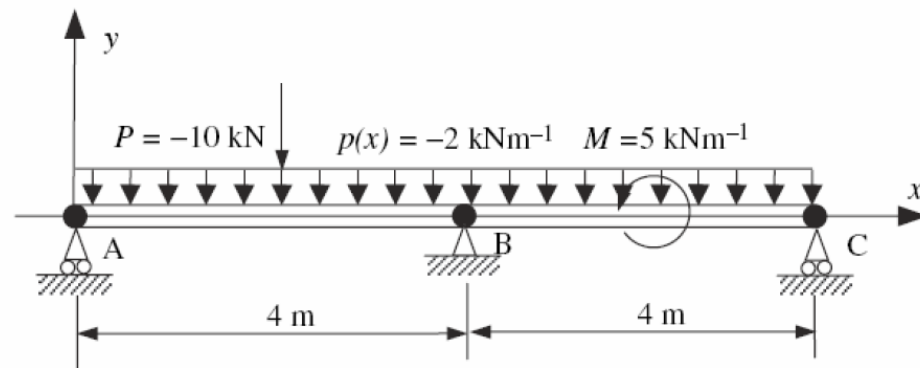


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# Cantilever Beam

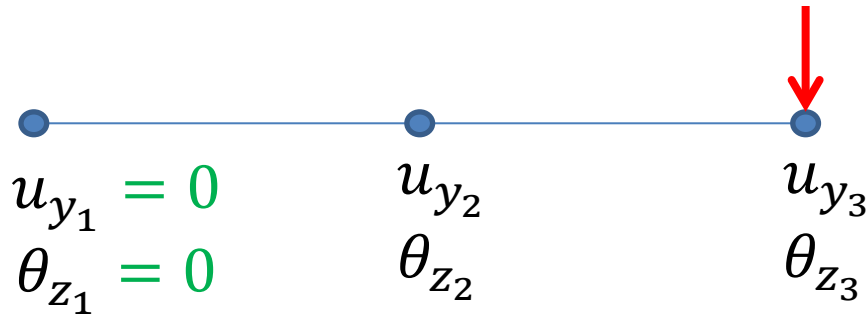
- First ANSYS exercise
  - Can do trusses but need to use scripting (advanced functionality)
  - Pin-jointed trusses rarely occur in practice
- ANSYS beam problem will appear in HW3

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



# Cantilever Beam: Degrees of Freedom

- Consider 2-element mesh



Reaction force at node 1

Reaction moment at node 1



# Cantilever Beam

## Beam element stiffness matrix

Offset type	Centroid
Model Type	Beam
<b>Material</b>	
Assignment	Go Big Red
Nonlinear Effects	Off
Thermal Strain Effects	Off

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

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

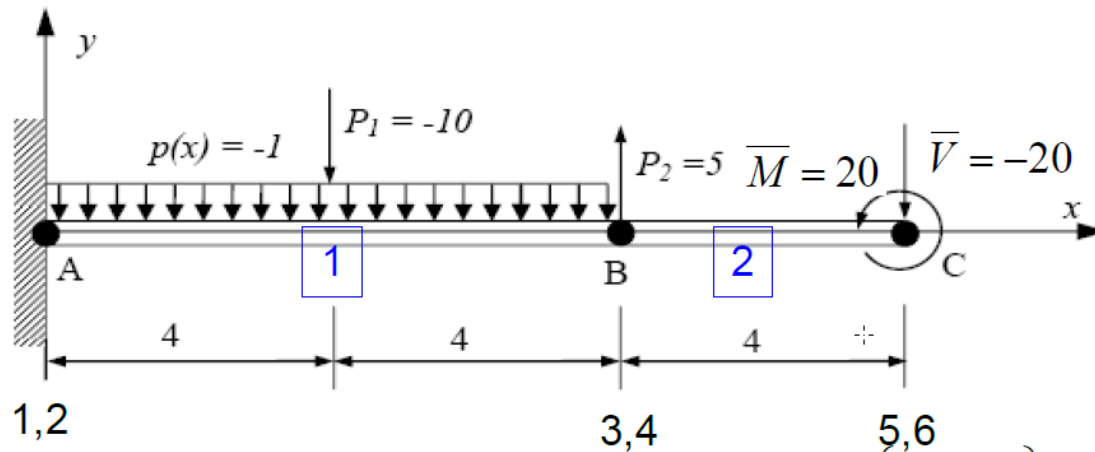
<b>Details of Line Body</b>	
Body	Line Body
Faces	0
Edges	1
Vertices	2
Cross Section	Rect1
Offset Type	Centroid

Poisson ratio doesn't  
 appear in  $K^e$



# Solve Step

## Beam Lecture, Page 43



$$10^3 \begin{bmatrix} 0.23 & 0.94 & -0.23 & 0.94 & 0 & 0 \\ 0.94 & 5.00 & -0.94 & 2.50 & 0 & 0 \\ \hline -0.23 & -0.94 & 2.11 & 2.81 & -1.88 & 3.75 \\ 0.94 & 2.50 & 2.81 & 15.00 & -3.75 & 5.00 \\ 0 & 0 & -1.88 & -3.75 & 1.88 & -3.75 \\ 0 & 0 & 3.75 & 5.00 & -3.75 & 10.00 \end{bmatrix} \begin{Bmatrix} u_{y1} = 0 \\ \theta_{y1} = 0 \\ u_{y2} \\ \theta_{y2} \\ u_{y3} \\ \theta_{y3} \end{Bmatrix} = \begin{Bmatrix} -9 + R_{u1} \\ -15.3 + R_{g1} \\ -4 \\ 15.3 \\ -20 \\ 20 \end{Bmatrix}$$



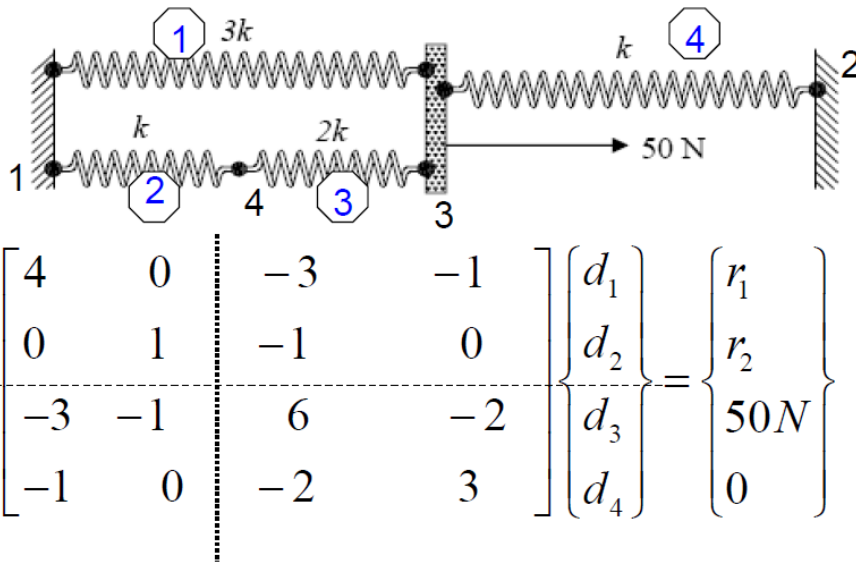
# Bending Moment and Shear Force

- 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

$$k \begin{bmatrix} 4 & 0 & -3 & -1 \\ 0 & 1 & -1 & 0 \\ -3 & -1 & 6 & -2 \\ -1 & 0 & -2 & 3 \end{bmatrix} \begin{Bmatrix} d_1 \\ d_2 \\ d_3 \\ d_4 \end{Bmatrix} = \begin{Bmatrix} r_1 \\ r_2 \\ 50N \\ 0 \end{Bmatrix}$$

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

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



# HW3 Tips

- Apply distributed load using *Line Pressure*
- *Simply Supported* boundary condition sets  $u_x$  and  $u_y$  to zero but leaves  $\theta_z$  free
- Displacement boundary condition can be used to input specific values for  $u_x$  and  $u_y$

