CE2201 Exam 3 **Name** ______________________________

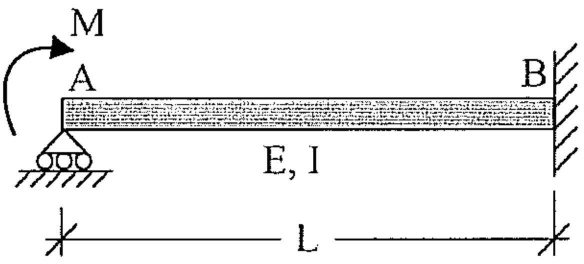
April 26, 2010
2 Hours
Closed Book
Closed Notes
(3) 3x5 Note-cards Allowed
Calculators Allowed
No Collaboration

Read each question carefully. Provide the information required.
Show your calculations for credit.

If I cannot read it, I cannot grade it.

Problem 1. The following indeterminate beam is loaded by a concentrated moment at point A (30 points).

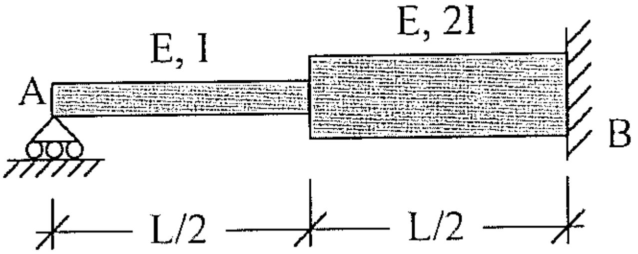
- Find the support reactions using the flexibility method.
  - Clearly draw and identify your released structure.
  - Identify your equation(s) of compatibility.
- Draw the shear and moment diagrams for this loading.



Ignore axial effects

Problem 2. The following indeterminate beam is not loaded, but the support at point A settles downward by a distance of δ. The beam cross-section is *not* constant (20 points).

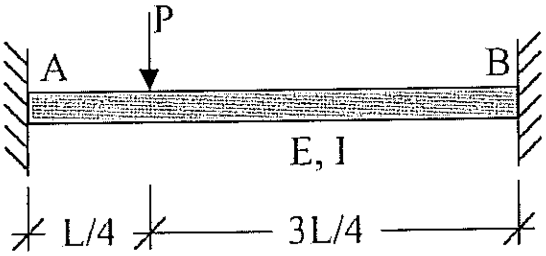
- Find the reaction at support A using the flexibility method.
    - Clearly draw and identify your released structure.
    - Identify your equation(s) of compatibility.
    - Hint: note that δ due to external loading is zero.



Ignore axial effects

Problem 3. The following indeterminate beam is loaded at mid-span (30 points).

- Clearly draw and identify a stable, determinate released structure.
- Derive the equation(s) of compatibility for your released structure in terms of the unknown, released reactions (You must find the appropriate deformations of the released structure. *Do not solve for the unknown reactions*).

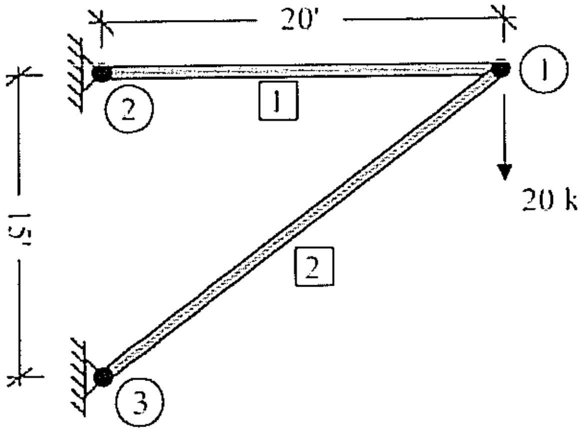


Ignore axial effects

Problem 4. The following indeterminate truss is loaded at joint 1. Both members have an Area of 0.5 in and a Modulus of Elasticity of 29,000 ksi (20 points).

- The local 4x4 stiffness matrices for use in the direct-stiffness method are given.
- Fill in the terms of the global stiffness matrix.
- Subdivide the system into free and supported degrees-of-freedom (*i.e.*, identify $\boldsymbol{K}_{11}$ and $\boldsymbol{K}_{21}$ as well as $\boldsymbol{Q}_f$, δ_f, and $\boldsymbol{Q}_s$).
- Find the x and y-deflections at the free joint using the direct-stiffness method.
- Find the support reactions using the direct-stiffness method.

$$\mathbf{K}_1 = \begin{array}{ccccc} \text{1x} & \text{1y} & \text{2x} & \text{2y} & \\ 60.4 & 0 & -60.4 & 0 & \text{1x} \\ 0 & 0 & 0 & 0 & \text{1y} \\ -60.4 & 0 & 60.4 & 0 & \text{2x} \\ 0 & 0 & 0 & 0 & \text{2y} \end{array} \qquad \mathbf{K}_2 = \begin{array}{ccccc} \text{1x} & \text{1y} & \text{3x} & \text{3y} & \\ 30.9 & 23.2 & -30.9 & -23.2 & \text{1x} \\ 23.2 & 17.4 & -23.2 & -17.4 & \text{1y} \\ -30.9 & -23.2 & 30.9 & 23.2 & \text{3x} \\ -23.2 & -17.4 & 23.2 & 17.4 & \text{3y} \end{array}$$



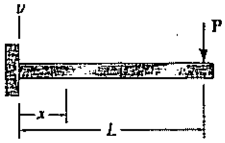
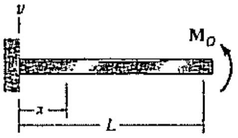
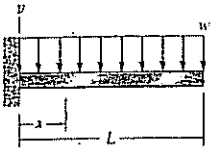
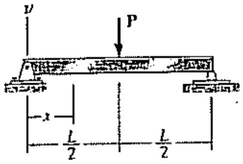
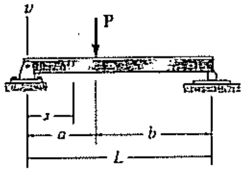
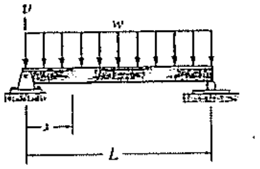
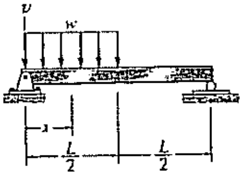
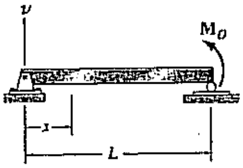
$$\begin{bmatrix} Q1x \\ Q1y \\ Q2x \\ Q2y \\ Q3x \\ Q3y \end{bmatrix} = \begin{bmatrix} \\ \\ \\ \\ \\ \\ \end{bmatrix} \begin{bmatrix} \delta 1x \\ \delta 1y \\ \delta 2x \\ \delta 2y \\ \delta 3x \\ \delta 3y \end{bmatrix}$$

Space for calculations on next page.

Problem 4 continued.

Copied from:
Hibbeler, R. C. (1999), Structural Analysis, 4th Ed., Prentice Hall, Upper Saddle River, NJ, USA.

Beam Deflections and Slopes

Loading	v + ↑	θ + ↶	Equation + ↑ + ↶
	$v_{max} = -\frac{PL^3}{3EI}$ at $x = L$	$\theta_{max} = -\frac{PL^2}{2EI}$ at $x = L$	$v = \frac{P}{6EI}(x^3 - 3Lx^2)$
	$v_{max} = \frac{M_O L^2}{2EI}$ at $x = L$	$\theta_{max} = \frac{M_O L}{EI}$ at $x = L$	$v = \frac{M_O}{2EI}x^2$
	$v_{max} = -\frac{wL^4}{8EI}$ at $x = L$	$\theta_{max} = -\frac{wL^3}{6EI}$ at $x = L$	$v = -\frac{w}{24EI}(x^4 - 4Lx^3 + 6L^2x^2)$
	$v_{max} = -\frac{PL^3}{48EI}$ at $x = L/2$	$\theta_{max} = \pm\frac{PL^2}{16EI}$ at $x = 0$ or $x = L$	$v = \frac{P}{48EI}(4x^3 - 3L^2x), 0 \le x \le L/2$
		$\theta_L = -\frac{Pab(L + b)}{6LEI}$ $\theta_R = \frac{Pab(L + a)}{6LEI}$	$v = -\frac{Pbx}{6LEI}(L^2 - b^2 - x^2)$ $0 \le x \le a$
	$v_{max} = -\frac{5wL^4}{384EI}$ at $x = \frac{L}{2}$	$\theta_{max} = \pm\frac{wL^3}{24EI}$	$v = -\frac{wx}{24EI}(x^3 - 2Lx^2 + L^3)$
		$\theta_L = -\frac{3wL^3}{128EI}$ $\theta_R = \frac{7wL^3}{384EI}$	$v = -\frac{wx}{384EI}(9L^3 - 24Lx^2 + 16x^3)$ $0 \le x \le L/2$ $v = -\frac{wL}{384EI}(8x^3 - 24Lx^2 + 17L^2x - L^3)$ $L/2 \le x \le L$
	$v_{max} = -\frac{M_O L^2}{9\sqrt{3}EI}$	$\theta_L = -\frac{M_O L}{6EI}$ $\theta_R = \frac{M_O L}{3EI}$	$v = -\frac{M_O x}{6EIL}(x^2 - 3Lx + 2L^2)$