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4.440 / 4.462 Basic Structural Design  
Spring 2009

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**MIDTERM EXAM (90 minutes)**

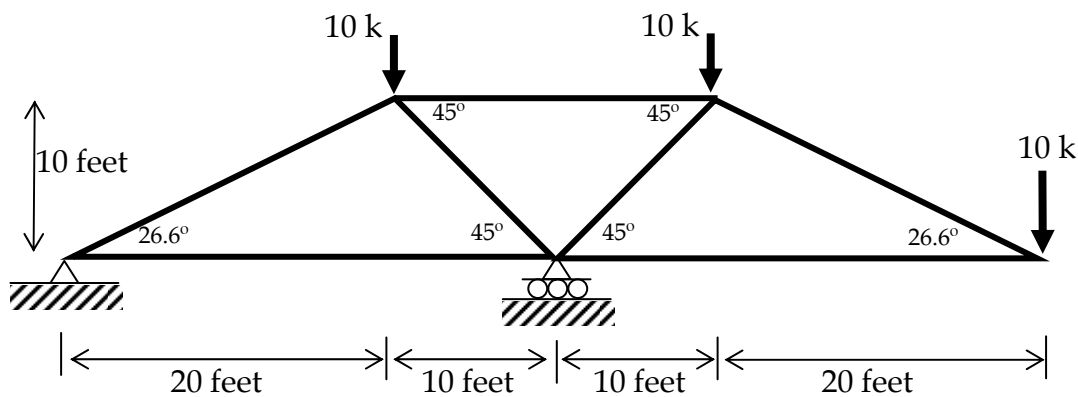
**March 22, 2007**

ANSWER ALL QUESTIONS IN THE EXAM BOOKLET PROVIDED.  
SHOW ALL OF YOUR WORK FOR PARTIAL CREDIT.

1) TRUSS ANALYSIS (28 POINTS)

For the truss illustrated below, determine the internal force in each element.

- What are the external support reactions? (6 pts)
- Solve for the internal forces in the truss. You may use any method you like. (Note: Graphical solutions must be within 5% of the exact solution.) Label each member as tension or compression, together with the value of axial force. (16 pts)
- Name two assumptions necessary for the analysis of trusses. (6 pts)



2) BUCKLING (17 pts)

A timber column carries an axial load of 40 kips. The column is 25 feet tall and is supported by pin connections at each end. If the column is 8" x 8" inches square, what is the safety factor against buckling due to the applied load of 40 kips? (5 pts)

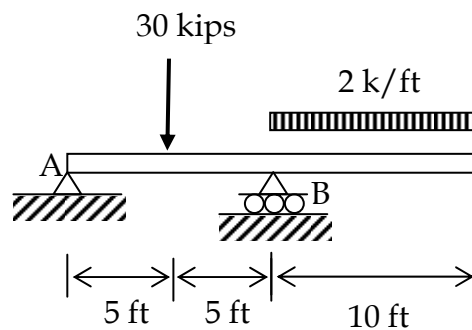
If the allowable axial stress is 2,000 psi, will the design of this column be governed by crushing or buckling? (3 pts)

Suggest three ways to increase the strength of this column. (9 pts)

3) BEAMS (35 pts)

For the beam illustrated below:

- Find the support reactions at A and B due to the applied loads. (6 pts)
- Draw the shear diagram and label all values. (12 pts)
- Draw the moment diagram on the tension side of the beam. Label the location and magnitude of maximum moment. (12 pts)
- If the specified beam is a steel wide flange W18x50, with a depth of 18 inches and a moment of inertia  $I$  of  $800 \text{ in}^4$ , what is the maximum bending stress in this beam? Does it exceed the allowable stress of 18 ksi? (5 pts)



4) SHORT ANSWER (20 PTS) Answer each of the following with sketches or a few sentences.

a) Explain the difference in the structural behavior of a stone lintel on columns (Figure A) and a block arch on columns (Figure B). How would each system fail? (8 pts)

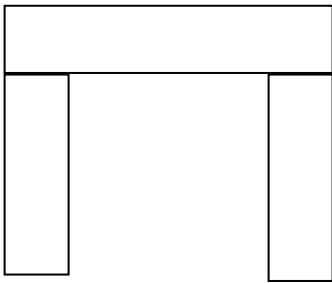


Figure A

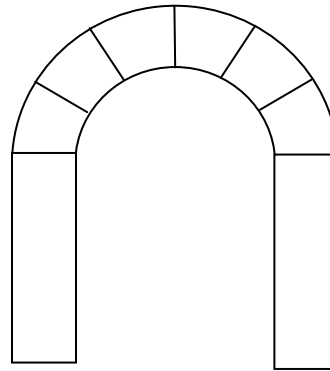


Figure B

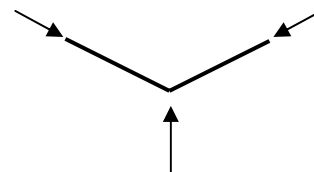
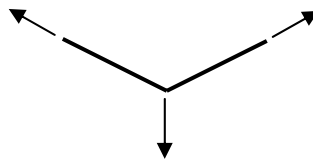
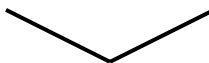
b) Each image below is a cross-section of a structure, which you may consider as a series of forces in tension or compression. For each image, draw the approximate forces which must act on it in order to give this funicular form in pure tension and in pure compression. (12 pts)

Form

Tension

Compression

Example



i) Arch



ii) Rectangle

