

READ THIS PAGE FIRST

There should be just enough time for you to complete this exam if you have prepared. Read each problem carefully before answering. A few moments of reflection can save minutes of unnecessary work. If a question is unclear then ask for clarification.

There are three segments to this final:

Slides
True/False & Short answer
Problem(s)

Each segment should take approximately one hour.

The slides will be shown once - each question will be given orally with three minutes allowed for your answer. At the end, the slides will be quickly reviewed.

You can solve either Problem IIIa in its entirety **or** IIIb & IIIb & IIIc. These are the only two combinations. They both are worth 100 points.

Make sure that your answer is clearly indicated as such after solving each problem, or part of a problem. Unless otherwise indicated, the first one that is found will be assumed to be your answer.

Do not panic if you cannot solve a problem! Move on to the next and come back to it later.

REMEMBER to draw diagrams to help clarify what is given and what should be determined. Label all answers with unites.

Best wishes to you!

Part Ia : Identification (4 points each; total of 20 points)

1. Name: _____
Location: _____
Designer: _____
Year of Construction: _____
One issue that relates to this course that is illustrated with the slide:

2. Name: _____
Location: _____
Designer: _____
Year of Construction: _____
One issue that relates to this course that is illustrated with the slide:

3. Name: _____
Location: _____
Designer: _____
Year of Construction: _____
One issue that relates to this course that is illustrated with the slide:

4. Name: _____
Location: _____
Designer: _____
Year of Construction: _____
One issue that relates to this course that is illustrated with the slide:

5. Name: _____
Location: _____
Designer: _____
Year of Construction: _____
One issue that relates to this course that is illustrated with the slide:

Part Ib : Systems (6 points each; total of 48 points)

6. This is a doorway lintel from an Italian House. Describe the structural systems. Use Free Body Diagrams
7. This is a ferry terminal in Como, Italy. Draw a Free Body Diagram of the structure in cross-section including anticipated loads.

Final Exam
4.440/4.441
Spring 1997

Name : _____

17. This is a connection at the Biltmore Estate Greenhouse. Draw a Free Body Diagram of the corbelled connection. What is the most significant type of load that it must resist?

Part Iia : True/False (2 points each; total of 86 points)

Write the letter of the most correct answer, a "T" or "F," in the box provided.

- | | | |
|-----|--|--------------------------|
| 18. | Stress and Strain are proportional up to the elastic limit. | <input type="checkbox"/> |
| 19. | The forces acting on a two force member will always act along the axis of the member. | <input type="checkbox"/> |
| 20. | The magnitude of the moment of a couple is always the same in the plane of the couple, regardless of where the center of moments is chosen. | <input type="checkbox"/> |
| 21. | A force is an action that freezes the state of motion of the body upon which it acts. | <input type="checkbox"/> |
| 22. | Petrosky find that the concept of failure central to understanding engineering. He notes that engineering design has as its first and foremost objective the obviation of failure. | <input type="checkbox"/> |
| 23. | Riccardo Bofil's housing complex, les Espaces d'Abraux, is a prime example of buildings where the facade and structural backbone are one and the same. | <input type="checkbox"/> |
| 24. | A load is any force that causes forces (or stresses) or deformation in a structure. | <input type="checkbox"/> |
| 25. | A roof with a 60 degree pitch does not have a snow load. | <input type="checkbox"/> |
| 26. | Stability is the capability of a structural element to stand rigid under every foreseeable loading condition. | <input type="checkbox"/> |
| 27. | A minimum of three non-parallel, rigid, lines of stiffening are usually required to laterally brace buildings. | <input type="checkbox"/> |
| 28. | In contrast to a force, a moment does not a point of application. | <input type="checkbox"/> |
| 29. | Due to the clarity and simplicity of graphic statics, Gothic Cathedrals never collapsed. | <input type="checkbox"/> |
| 30. | Petrosky describes the Factor of Safety as a number that is often referred to as a "Factor of Ignorance." | <input type="checkbox"/> |
| 31. | The parallelogram method of resolution of forces can only be used when the forces are at right angles to each other. | <input type="checkbox"/> |
| 32. | A polonceau truss, developed in the 19th century and used in the Gare St. Lazare in Paris, cannot be used with contemporary grades of steel. | <input type="checkbox"/> |
| 33. | Robert Maillart was one of the first structural engineers to take advantage of the introduction of the computer in the design of his bridges. | <input type="checkbox"/> |
| 34. | An open umbrella is a prestressed fabric structure. | <input type="checkbox"/> |

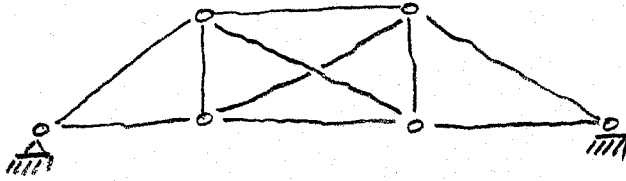
- | | | |
|-----|--|--|
| 35. | The form of a loaded cable system at rest is called its funicular form. | |
| 36. | A tensile structure is only as good as its anchors. | |
| 37. | The only way to reduce the magnitude of the direct stress on a cross-section is to increase its cross-sectional area. | |
| 38. | The magnitude of the bearing stress at the interface of two materials will depend upon the modulus of elasticity of each material. | |
| 39. | Wind load data, collected over the past century, have enabled structural designers to use one single design load for all of North America: 25 psf. | |
| 40. | Elongation of a structural element due to temperature changes is independent of the cross-sectional area of the member. | |
| 41. | Walls, beams and columns can all experience both bending and compressive loading simultaneously. | |
| 42. | The buckling load of a column is independent of the material properties of the column. | |
| 43. | A flag-pole has an effective length that is 1.65 times its construction length. | |
| 44. | The unique free-standing corner columns of the Ionic Temple of Nike were described by Sandaker as columns built with a perfectly parallel profile. | |
| 45. | A column will not experience tensile stress as long as the resultant of the loading passes within the cross-section. | |
| 46. | The Funicular is type of truss similar to the Vierendeel. | |
| 47. | The moment of inertia is the quantitative measure of the resistance of a given area to resist buckling. | |
| 48. | An Arch must be able to develop horizontal reactions. | |
| 49. | A Beam must be able to develop horizontal reactions. | |
| 50. | A Frame must be able to develop horizontal reactions. | |
| 51. | The form (geometry) of an arch will determine the magnitude of the bending moments that it must resist. | |
| 52. | A column with two fixed-ends will support four times the load of one with pinned ends. | |
| 53. | A pinned-end column will support four times the load of one with one fixed and one free end (flag pole) | |

- 54. The critical stress for a column is inversely proportional to the square of the slenderness ratio.
- 55. Intermediate bracing always reduces the buckling length of a column.
- 56. Short columns will fail by crushing at a load which is less than that predicted by the Euler equation.
- 57. There are three wave forms that come from earthquakes. The S wave is the fastest.
- 58. In the design of structures in earthquake prone areas, the most important thing to remember is to remember that “there is good damage and bad damage.”
- 59. The soft story effect is most critical in areas that are liquefaction prone.
- 60. Irregular plan configurations are more susceptible to damage than regular plan configurations in an earthquake.

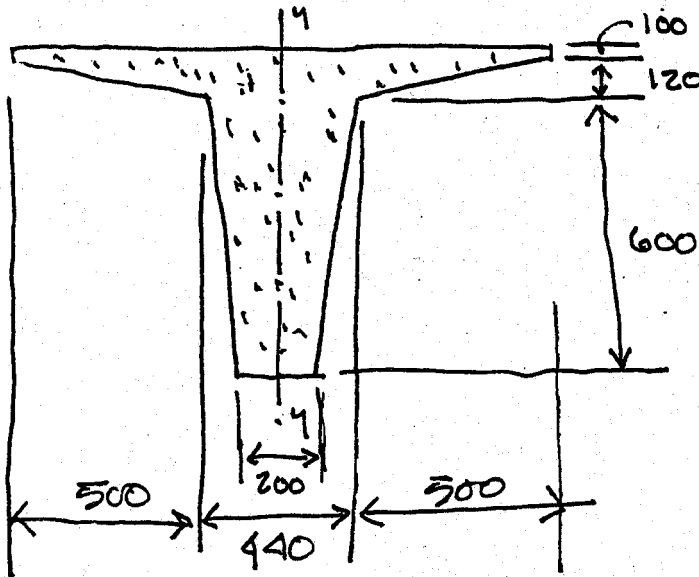
Part IIb : Short Answer (7 points each; total of 14 points)

Choose only two of the four following problems to answer. Draw a large "X" across the problems that you do not want graded.

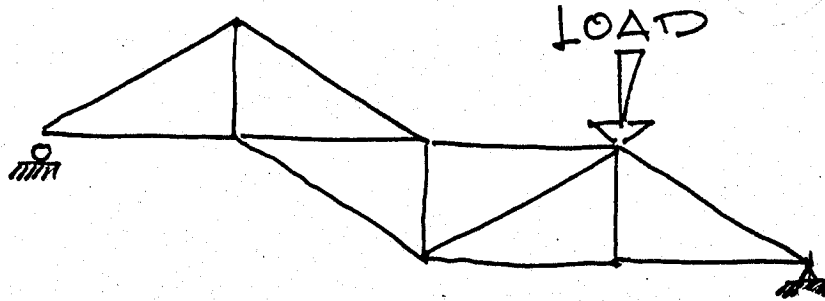
61. The following truss is indeterminate. Why?



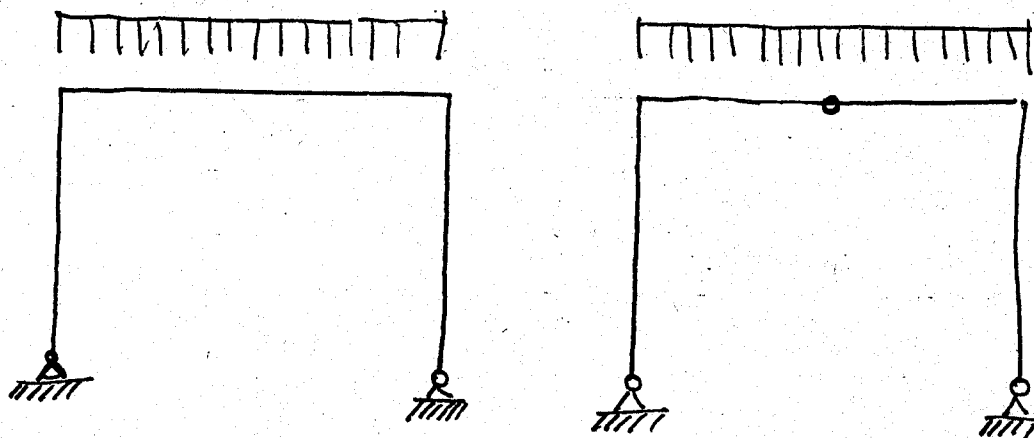
62. Locate the centroid of the pre-stressed single-T beam illustrated below.



63. Using one color to indicate tension and another to indicate compression, draw the relative magnitude of the normal forces that would be found in the truss with the loading indicated below.



64. Draw the moment diagrams for the two frames indicated below.



Part III. You should either do IIIa (100) points) or IIIb + c + d (total of 100 points)

IIIa

Given the system indicated below with the following conditions:

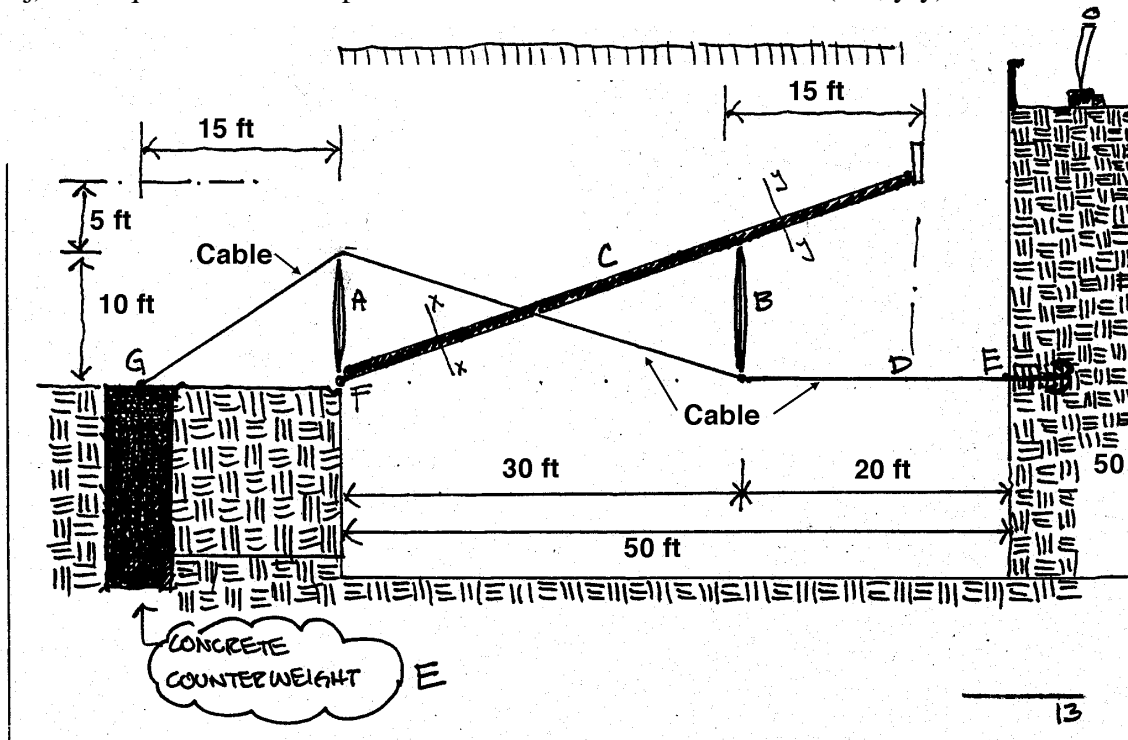
- Beam Spacing 10 feet c.c.
- Snow load of 50 psf.
- Dead load of roofing surface (including secondary structure) of 10 psf
- Wind Velocity of 100 mph, $C_q = 0.3$, $I = 1.0$, C_e (exposure D) assume acting perpendicular to the surface of the beam.

Determine:

a') the various loading combinations that could be critical. draw them with a qualitative representation of the relative magnitudes of the shear and moment that would be present.

Assume that the only loading that we will consider is the full load over all spans....

- a) the reactions at all supports
- b) the magnitude of the internal forces in the rods and struts
- c) the shear and moment diagrams for the beam
- d) the most economical W12 section for beam C ($F_b=24$ ksi, $F_v=14.5$ ksi) based on bending and shear only (If you cannot determine the actual values, use $M_{max} = 67$ kft and $V_{max}=11$ k)
- e) the most economical structural square tubing for member B
- f) the most economical structural square tubing for member A
- g) the smallest single diameter rod to the nearest 1/8th inch ($F_a=22$ ksi) that can be used.
- h) the required size of the sides of a cube for the concrete counterweight to the nearest three inches.
- i) draw an exact stress prism for each of the compression elements at their midspan.
- j) draw qualitative stress prisms for the two locations indicated (x-x, y-y) on the beam.



Final Exam
4.440/4.441
Spring 1997

Name : _____

Problem IIIb (32 points of 100)

Given: the cantilever and loading as indicated.

Determine:

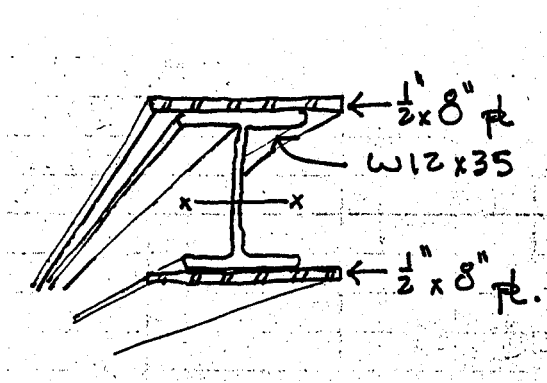
- a) the reactions
- b) the shear, moment and deflection curves
- c) the most economical glue-lam 5-1/8" beam that can be used

Problem IIIc (32 points of 100)

Given: the W12 x 35 column with steel plates welded to each flange. ($E = 29000 \text{ psi}$)

Determine:

the maximum allowable unsupported length if the column is pinned at both ends and must support a load of 350 kips. Assume Euler behavior.



Problem IIIId (34 points of 100)

Given: the building column which is supported against sidesway by a floor plate. The total height is 33 feet, plus a one foot deep footing of concrete. Two loads are implied as indicated. Disregard the weight of the base plate.

Determine:

- the normal force diagram of the column
- the minimum dimension of the square concrete footing W to the nearest 3 inch multiple. Allowable soil pressure is 5 000 psf.
- the minimum dimensions of the steel plate to the nearest inch if the allowable concrete bearing stress is taken as 450 psi.
- the maximum column stress
- the total shortening due to the load if $E = 29000\text{ksi}$.

