CE C30/ME C85, Section 2, Final Examination

Open books and notes, online, 3 hours

Maximum of 3 one-sided pages per problem

Wednesday, December 16, 2020

LAST NAME: ____________________

FIRST NAME: ____________________

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BOX YOUR ANSWERS

NUMBER PAGES PER PROBLEM

Page 1.1, **Page 1.2**, ...
Page 2.1, ...
...

Problem 1:	**/15**
Problem 2:	**/20**
Problem 3:	**/15**
Problem 4:	**/20**
Problem 5:	**/15**
Problem 6:	**/15**
TOTAL:	**/100**

CE C30/ME C85, Section 2, Fall Semester 2020

Online Examinations Honor Code Statement

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(1) I have worked out this examination individually,

(2) I have not discussed nor communicated about any part of the exam with anybody, in any way, during the exam,

(3) I have complied with the time assigned to the exam and its submission, acknowledging that no late submissions are accepted, and

(4) The pages included in the PDF file that I am submitting form the totality of my exam, complying with the limitation of three one-sided pages maximum per problem.

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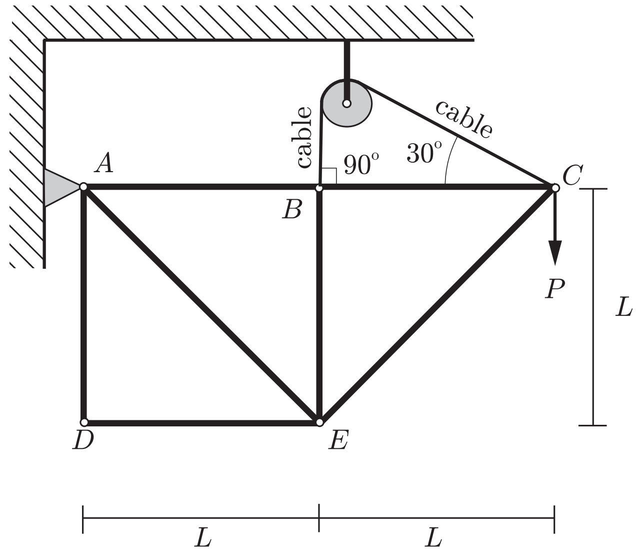
Problem #1 (15%)

The truss depicted in the figure is held by a single cable going through a pulley (which is free to rotate), connecting joints C and B as shown (vertical at B, 30° at C). All the members of the truss have a $a \times a$ square section and are made of a linear elastic material with young modulus E.



1. Determine the tension in the cable and the forces in all the members of the truss for the loading shown (a vertical force P at joint C).
2. Determine the maximum load P_{max} that can be applied so no member buckles.

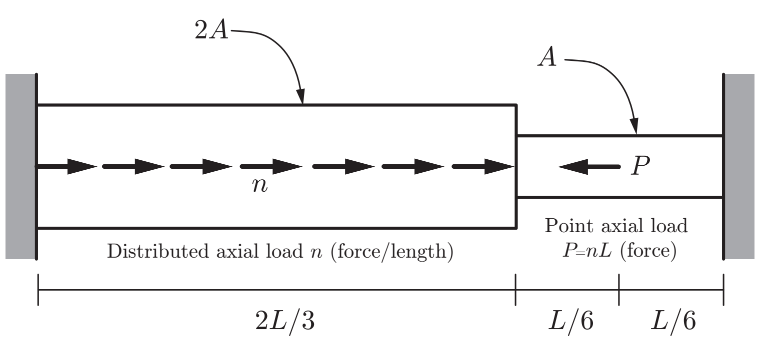
Remark: Express your results in terms of P, L, a and E, as needed.

Problem #2 (20%)

A composite bar of total length L is made by welding together two bars of lengths $L/3$ and $2L/3$, and cross section areas A and $2A$, respectively, as shown in the figure. The composite bar is loaded by constant distributed axial loads n (force/length) on the long side and by a point axial load $P = nL$ at the middle of the short side as shown, while kept attached to two rigid walls. The material can be considered to be isotropic linear elastic with Young modulus E. Determine:

1. The <u>reactions</u> at both ends.
2. The distribution of the <u>axial stress</u> along the composite bar (draw a plot with the characteristic values). Specify carefully the part that is in tension and compression.
3. The <u>displacement</u> of the connection between the two bars. Specify clearly its direction.

Remark: Express your results in terms of n, L, A and E, as needed.

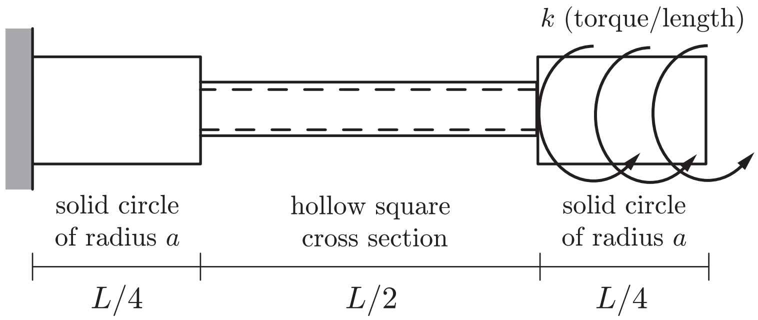


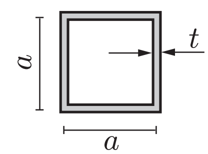
Problem #3 (15%)

A shaft of total length L has a hollow square section of side a and thickness $t \ll a$ along its middle half $L/2$, welded to two solid pieces of length $L/4$ each and circular cross section of radius a. All parts are made of the same material, which can be considered isotropic linear elastic with shear modulus G up to the yield limit τ_{yp} in shear. The shaft is subjected to a constant distributed torque k (torque/length) along one end piece, while fixed at the opposite end, as shown in the figure. Determine:

1. The angle of twist at the free end while the shaft remains elastic.
2. The maximum value of k that can be applied before the shaft starts yielding.

Remark: Express your answers in terms of k, L, τ_{yp}, G, a and t, as necessary.



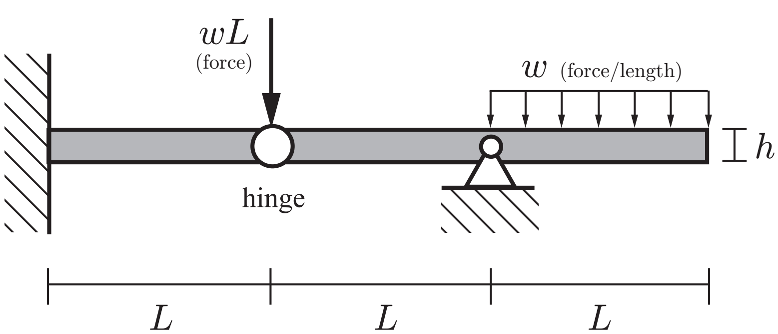


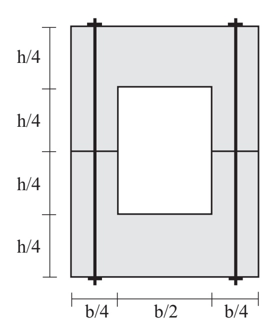
Problem #4 (20%)

A beam is made by bolting together two pieces, leaving a hollow $h \times b$ rectangular cross section as shown. The beam is loaded as depicted in the figure and can be considered to be made of an isotropic linear elastic material with Young modulus E and Poisson ratio ν.

1. Draw carefully the bending moment and shear force diagrams (indicate clearly all the characteristic values).
2. Determine the maximum tensile and compressive stresses acting on a cross section.
3. If the bolts are to be located at a constant spacing along the beam, determine the maximum spacing if the bolts can only take a maximum force F_{max}^{bolt} in shear.

Remark: Express your results in terms of w, h, b, L, E, ν and F_{max}^{bolt}, as needed.

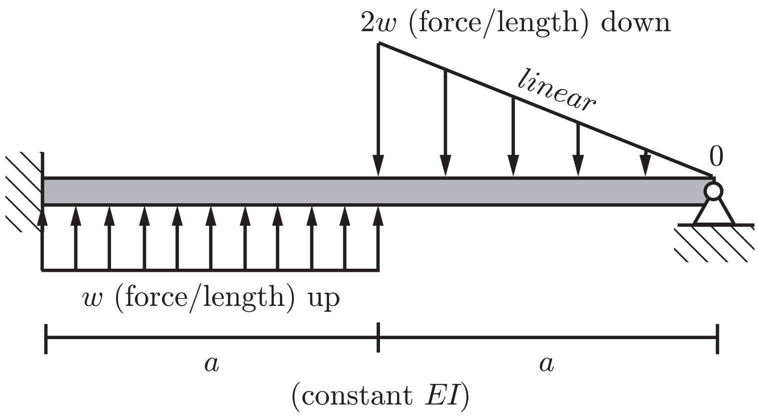




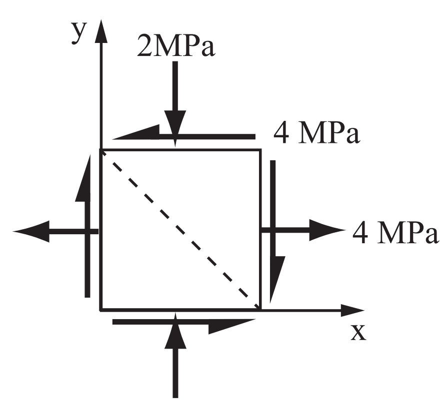
Problem #5 (15%)

For the beam shown in the figure with its loading, determine:

1. The beam's deflection $v(x)$. Sketch the deflected shape of the beam.
2. The bending moment $M(x)$ and transverse shear force $V(x)$ diagrams. Plot your answer indicating characteristic values.
3. The reacting forces and moments at the supports. Indicate clearly their directions.



Problem #6 (15%)



1. Sketch the Mohr circles for the state of stress sketched in the figure, with plane stress in the z direction (perpendicular to the paper). Determine the principal stresses and the planes where they act (sketch clearly a block oriented along these directions with the corresponding stresses).
2. If the block shown in the figure is originally square, determine the relative elongation of the diagonal (shown as a dashed line) if the material is linear elastic with Young modulus $E = 200\,GPa$ and Poisson ratio $\nu = 0.3$. Indicate if it stretches or contracts.
3. If the material is observed to yield when this precise state of stress is reached, determine the uniaxial yield limit of material σ_{yp} that Tresca's criterion predicts.