CE C30/ME C85, Section 2, Final Examination

Open books and notes, online, 3 hours

Maximum of 3 one-sided pages per problem

Tuesday, May 12, 2020 (8-11am PST)

LAST NAME: ______________________________

FIRST NAME: ______________________________

LAST 4 DIGITS OF STUDENT ID #: ___ ___ ___ ___

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, Spring Semester 2020

Online Examinations Honor Code Statement

LAST NAME: ____

FIRST NAME: ____

<u>LAST 4 DIGITS</u> OF STUDENT ID #: ___ ___ ___ ___

By signing below, I acknowledge that, following the earlier established and agreed rules for online examinations in this course:

(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.

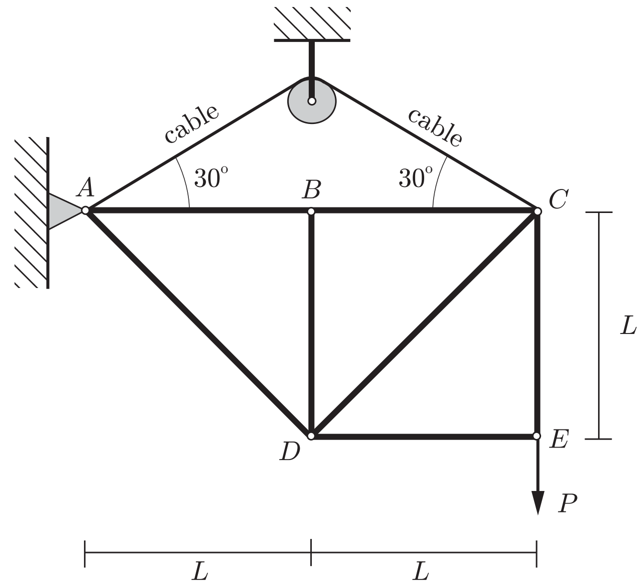
SIGNATURE: ____

DATE & TIME: ____

Please sign, date and upload with your examination as PDF to the `bcourses` website.

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 A and C as shown (at 30° at both joints). 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 E).

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.

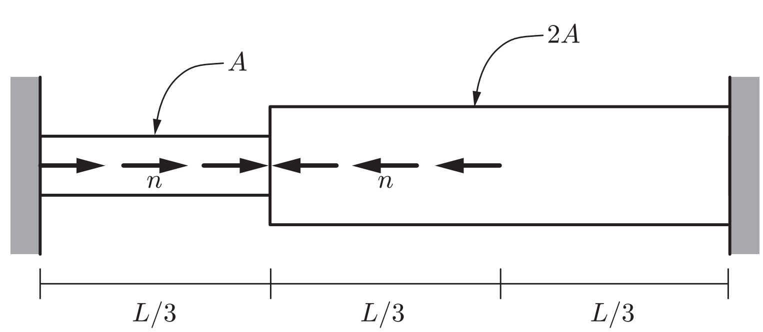
Problem #2 (20%)

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 opposite directions 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 reactions at both ends.

2. The distribution of the axial stress along the composite bar (draw a plot with the characteristic values). Specify carefully the part that is in tension and compression.

3. The displacement of the connection between the two single bars. Specify clearly its direction.

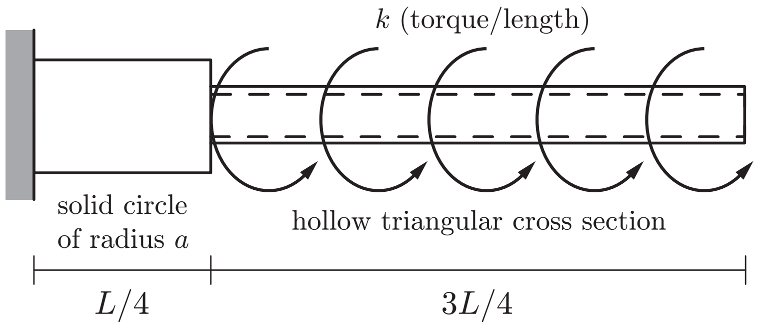


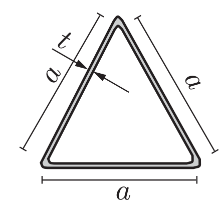
Problem #3 (15%)

A shaft consists of a solid base of length $L/4$ and circular cross section of radius a, with its remaining $3L/4$ length having the hollow triangular cross section of thickness $t \ll a$ shown on the right. 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 its hollow part, while fixed at the opposite end, as shown in the left figure. Determine:

1. The angle of twist at the free end on the right 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.



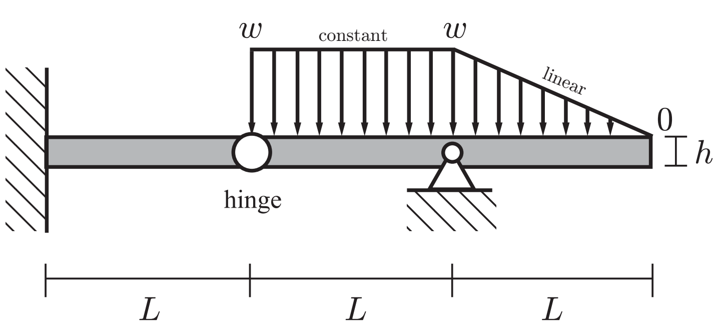


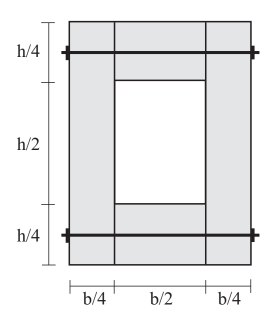
Problem #4 (20%)

A beam is made by bolting together four 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.

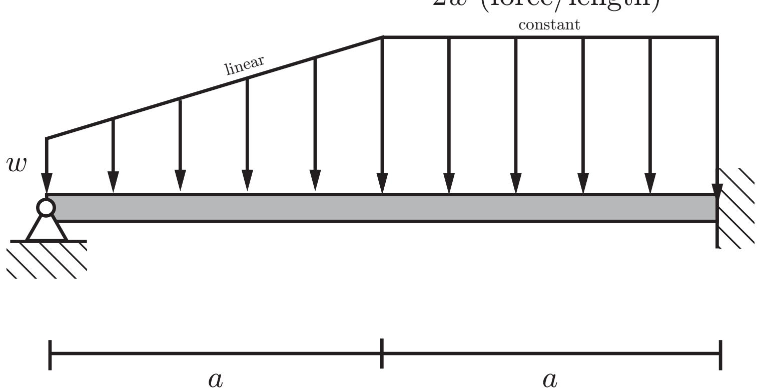




Problem #5 (15%)

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

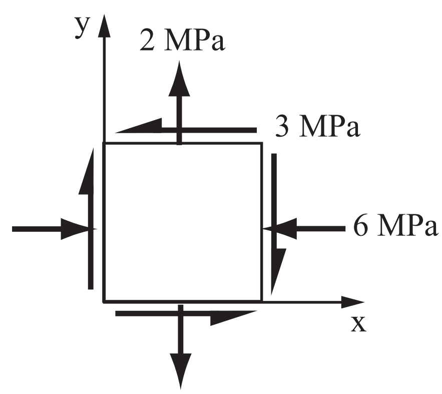
1. The beam's deflection $v(x)$. Sketch the deflected shape of the beam.
2. The bending moment $M(x)$ and transverse shear force $V(x)$ diagrams. Plot your answer indicating characteristic values.
3. The reacting forces and moments at the supports. Indicate clearly their directions.



(constant EI)

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. Determine the relative change of thickness in the z direction if the material is isotropic linear elastic with Young modulus $E = 200\,GPa$ and Poisson ratio $\nu = 0.3$. Indicate clearly if it stretches or contracts. (Assume the block is $1 \times 1 \times 1\ m^3$ if you need the dimensions in your calculations).



3. If the stress σ_z starts varying while keeping the stress components in the $x - y$ plane fixed, determine the possible range of variation before yielding occurs according to Tresca criterion with an uniaxial yield limit of $\sigma_{yp} = 12\ MPa$.