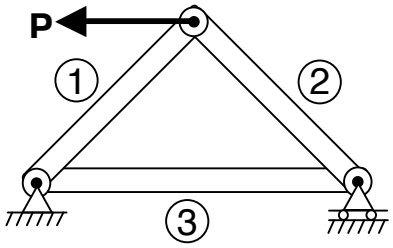
Department of Aeronautics & Astronautics
MIT
Field Exam, Jan. 2009

Question – Materials & Structures

A mechanical connection for a new vehicle has been designed as shown below using pin joints. Each of the three pinned structural elements has square cross-section of sidelength b, isotropic modulus E, and Poisson's ratio ν. Elements 1 and 2 have length ℓ, and the angle with horizontal is 45 deg.



(i) Develop an analysis to describe stress and strain in element 1.

(ii) Write the strain energy for a uniaxially-loaded bar. Write the same for element 1.

(iii) Metals like aluminum alloys are not brittle, whereas ceramics such as alumina (oxide of aluminum) are. Discuss what makes them so, and contrast their behavior.

(iv) Discuss failure in elements 1 and 2 for the case of all the elements being either aluminum (metal) or alumina (ceramic).

(v) How would your answer to (i) change if all of the elements were (of the same) orthotropic material?

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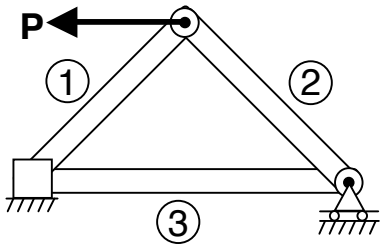
For the questions that follow, the mechanical connection has been redesigned so that the left pin support is now a clamp, as shown below. All other aspects of the design are unchanged.



(vi) Set-up and discuss an analysis that would allow you to describe stress and strain in element 1.

(vii) Discuss any differences in the strain energy for element 1 between this configuration and the previous one.

(viii) Comment on any damage tolerance differences between this configuration and the previous one.