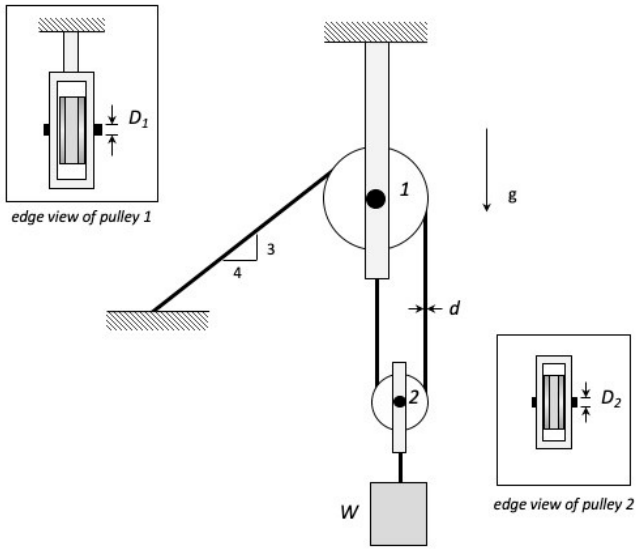
Problem 2.1 (*10 points*)



The cable-pulley system shown supports a block having a weight of W, where the diameter of the cable is d, and the diameters of the pulley pins 1 and 2 are D_1 and D_2, respectively. The pulley pins and cable are made from the same grade of steel, with the steel having tensile and shear strengths of σ_Y and τ_Y, respectively. The minimum design factors of safety for the pins and the cable are FS_P and FS_C, respectively. The weight of the pulleys and of the cable can be considered to be negligible compared to the weight of the block. For this problem:

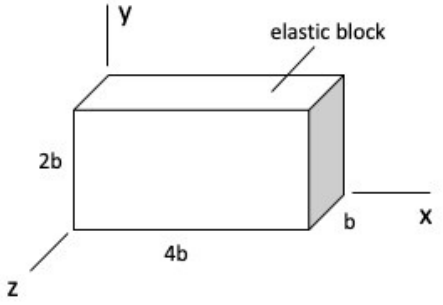
a) Draw individual free body diagrams of the pulleys. From these, determine the tension in the cable and the reaction forces on the pulleys by the pulley pins.

b) Determine the diameters of the pulley pins that satisfy their design factors of safety.

c) Determine the diameter of the cable that satisfies its design factor of safety.

For this problem, use the following: $W = 3\text{kN}$, $\sigma_Y = 250\ MPa$, $\tau_Y = 0.5\ \sigma_Y$, $FS_P = 3.0$ and $FS_C = 4.0$.

Problem 2.2 (*10 points*)

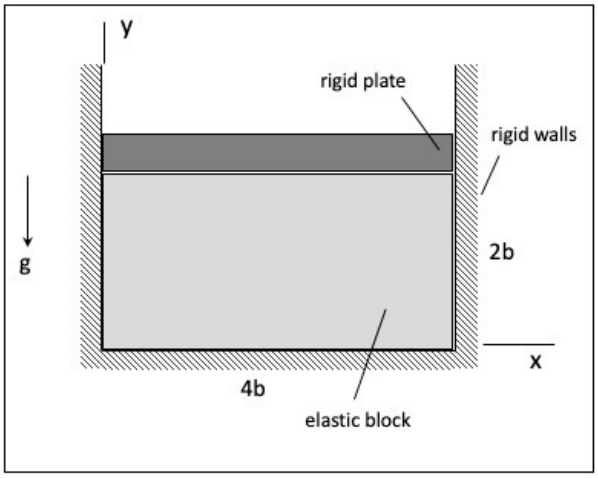


A block with the dimensions shown above is made up of material having Young's modulus of E, a Poisson's ratio of ν and a coefficient of thermal expansion of α. The weight of the block is negligible.

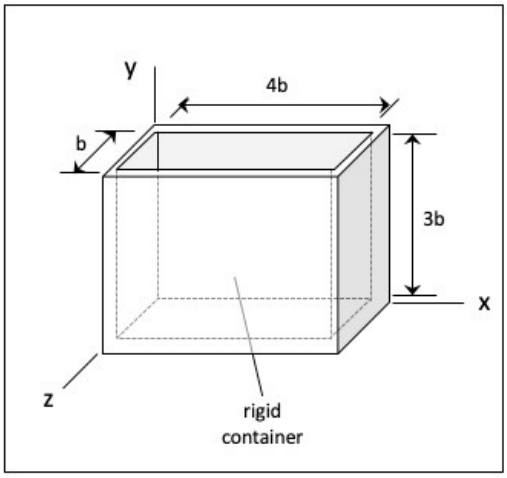
a) The block is placed in a rigid container, with no restraints placed on the z-faces of the block, as shown in the figure below left. The temperature of the block is held constant as a rigid plate of weight W is placed on the top surface of the block, as shown. Determine the xyz-components of stress and strain, as well as the xyz-dimensions of the block resulting from the weight of the plate.

b) The block is now placed in a rigid container, with restraints placed on the z-faces (in addition to restraints on the x-faces) of the block, as shown. The temperature of the block is increased by an amount of ΔT and the rigid plate is no longer resting on the top surface of the block. The starting block dimensions before heating are the same as in Part A and the block will not overflow the container. Determine the xyz-components of stress and strain, as well as the xyz-dimensions of the block resulting from the temperature increase of the block.

Leave your answers in terms of, at most, W, E, α, ν, ΔT and b.

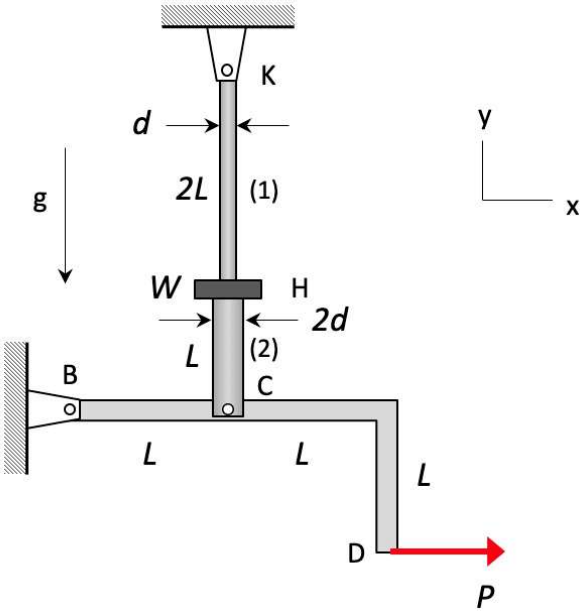


Part (a)



Part (b)

Problem 2.3 (*10 points*)



A rigid, L-shaped bar BD is pinned to fixed ground at end B. A rod CK connects point C on the bar BD with the fixed-ground pin at K. Rod CK is made up of elements (1) and (2), with each element having a circular cross-section and made up of a material with a Young's modulus of E, and with the elements connected by a rigid coupler H (with the coupler having a weight of W). The diameters of elements (1) and (2) are d and $2d$, respectively. Consider the weights of bar BD and elements (1) and (2) to be negligible compared to the weight of H. A force P acts to the right at end D of bar BD, where $P = 2W$.

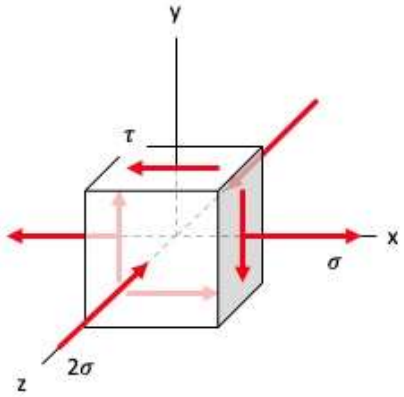
a) Draw individual free body diagrams (FBDs) of the coupler H and of bar BD. Using your FBDs, determine the loads carried by elements (1) and (2). State whether the elements are in tension or in compression.

b) Determine the elongations of elements (1) and (2).

c) Assuming small rotations, determine the angle of rotation of bar BD.

Leave your answers in terms of, at most, E, L, W and d.

Problem 2.4 (*6 points*) – *submit you answers directly on Gradescope*



The state of stress at a given point on a structure is shown above in terms of its *xyz*-components, where the structure is made of a material having a Young's modulus of *E* and a Poisson's ratio of ν, where $0 < \nu < 0.5$. State whether each of the *xyz*-components of strain (ϵ_x, ϵ_y, ϵ_z, γ_{xy}, γ_{yz}, γ_{xz}) is: i) negative, ii) zero, or iii) positive.