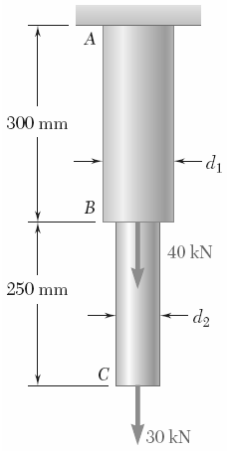
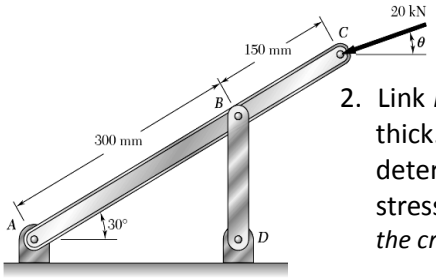
MECHANICS (ME10001)

Tutorial 6: Concept of Stress and Strain - I

1. Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. Knowing that the average normal stress must not exceed 175 MPa in rod AB and 150 MPa in rod BC, determine the smallest allowable values of d1 and d2. Neglect the weight of the rods. [d1=22.57 mm, d2=15.96 mm]

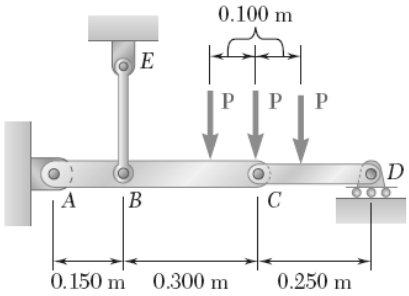


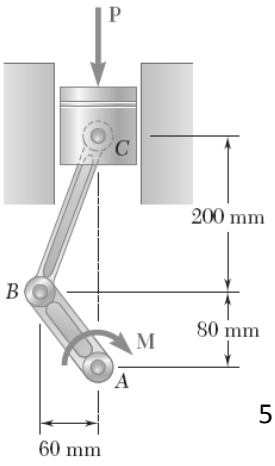


2. Link *BD* consists of a single bar 30 mm wide and 12 mm thick. Knowing that each pin has a 10 mm diameter, determine the maximum value of the average normal stress in link *BD* if (*a*) $\theta=0^0$ and (b) $\theta=90^0$. *Hint: identify the critical section in both the cases.*

[(a) 72.17 MPa (T), (b) 83.33 MPa (C)]

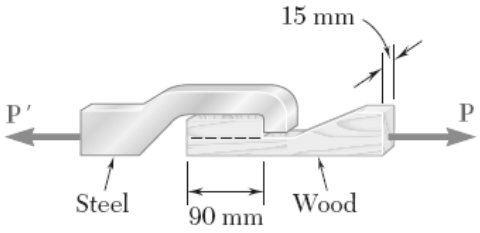
3. Three forces, each of magnitude P=4 kN, are applied to the structure shown. Determine the cross-sectional area of the uniform portion of rod BE for which the normal stress in that portion is 100 MPa. [285.33 mm^2]

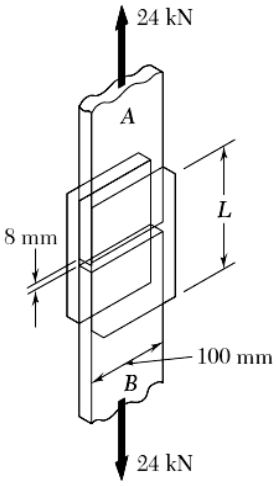




4. A couple M of magnitude 1500 Nm is applied to the crank of an engine. For the position shown, determine (a) the force P required to hold the engine system in equilibrium, (b) the average normal stress in the massless connecting rod BC, which has a uniform cross section of 450 mm^2 . [(a) 17.86 kN, (b) 41.43 MPa]

5. When the force P reached 8 kN, the wooden specimen shown failed in shear along the surface indicated by the dashed line. Determine the average shearing stress along that surface at the time of failure. [5.93 MPa]

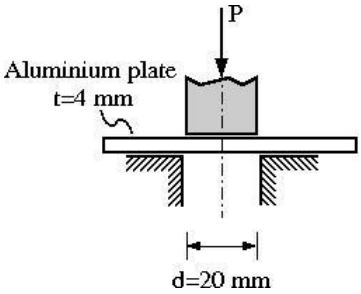


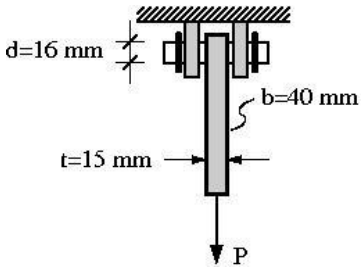


6. The wooden members *A* and *B* are to be joined by plywood splice plates which will be fully glued on the surfaces in contact. As part of the design of the joint and knowing that the clearance between the ends of the members is to be 8 mm, determine the smallest allowable length *L* if the average shearing stress in the glue is not to exceed 800 kPa.

[L=308 mm]

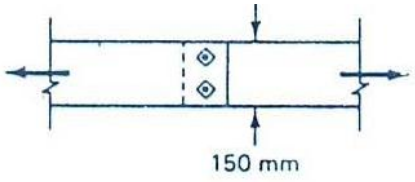
7. A punch of diameter d=20 mm is used to make holes in an Aluminum plate of thickness t=4 mm. If the ultimate shear stress for Aluminum is 275 MPa, estimate the force P required for punching through the plate. [P=69.12 kN]

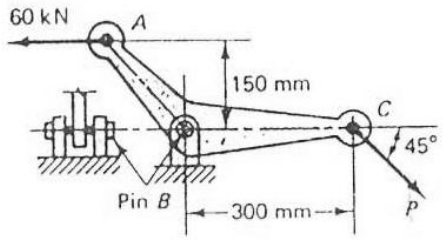




8. An Aluminum bar is attached to its support by a 16 mm diameter pin, as shown in the figure. The thickness t of the bar is 15 mm, and its width b is 40 mm. If the allowable tensile normal stress in the bar is 85 MPa, find the allowable load P. [P=30.6 kN]

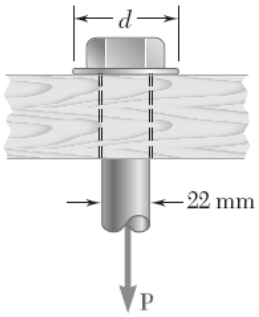
9. Two 10 mm thick steel plates are fastened together by means of two 20 mm bolts that fit tightly into the holes. If the joint transmits a tensile force of 45 kN, determine (a) average normal stress in the plates at the section where no holes occur; (b) the average normal stress at the critical section; (c) the average shear stress in the bolts and (d) the average bearing stress between the bolts and the plates.
[(a) 30 MPa, (b) 40.91 MPa, (c) 71.62 MPa, (d) 112.5 MPa]

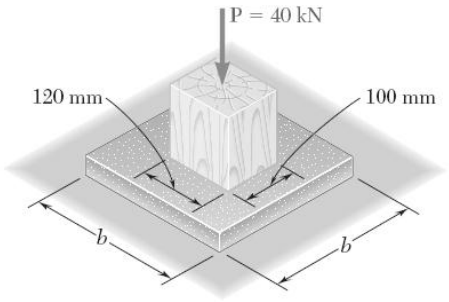




10. What is the required diameter of pin B for the bell crank mechanism, if an applied force of 60 kN is resisted by a force P at C? The allowable shear stress is 100MPa. [d=16.43 mm]

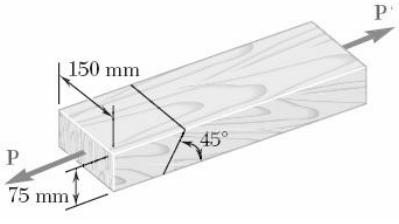
11. The load P applied to a steel rod is distributed to a timber support by an annular washer. The diameter of the rod is 22 mm and the inner diameter of the washer is 25 mm, which is slightly larger than the diameter of the hole. Determine the smallest allowable outer diameter d of the washer, knowing that the axial normal stress in the steel rod is 35 MPa and that the average bearing stress between the washer and the timber must not exceed 5 MPa. [d=63.35 mm]

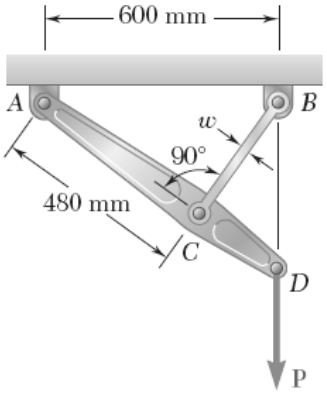




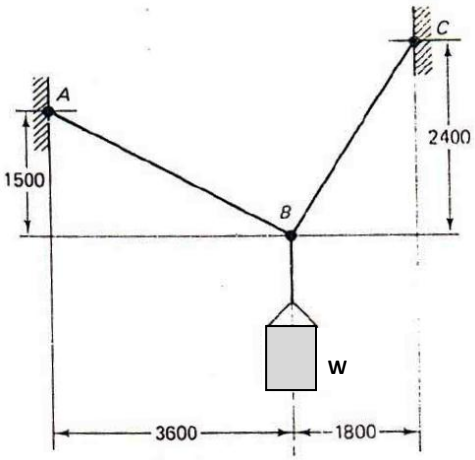
12. A 40 kN axial load is applied to a short wooden post that is supported by a concrete footing resting on undisturbed soil. Determine (a) the maximum bearing stress on the concrete footing, (b) the size of the footing for which the average bearing stress in the soil is 145 kPa.
[(a) 3.33 MPa, (b) 525.23 mm]

13. Two wooden members of uniform rectangular cross section are joined by the simple glued scarf splice shown. Knowing that the maximum allowable shearing stress in the glued splice is 620 kPa, determine (a) the largest load P that can be safely applied, (b) the corresponding tensile stress in the splice. [(a) 13.95 kN, (b) 0.62 MPa]

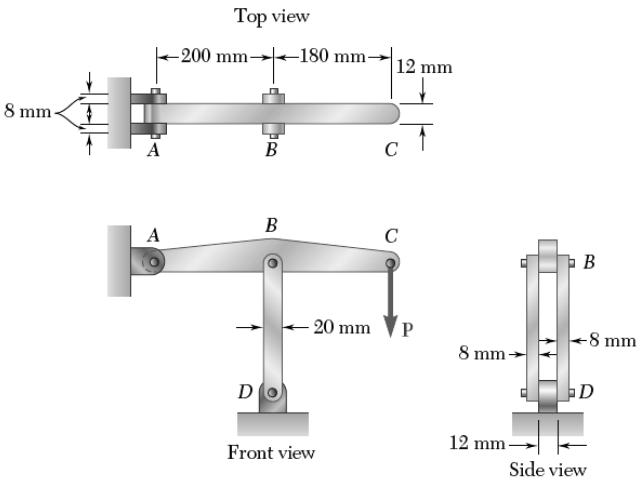




14. Link BC is 6 mm thick and is made of steel with a 450 MPa ultimate strength in tension. What should be its width w if the structure shown is being designed to support a 20 kN load P with a factor of safety of 3? [w=27.78 mm]

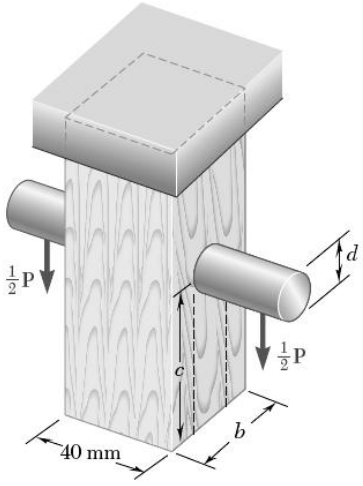


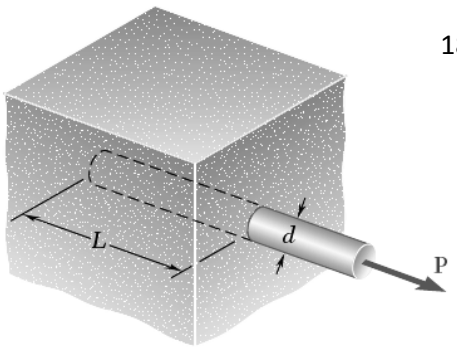
15. Two high strength steel rods of different diameters are attached at A and C and support a weight W. The ultimate strength of the rods is 800 MPa. Rods AB and BC have cross-sectional areas of 200 mm^2 and 400 mm^2 respectively. If the factor of safety is 2, what weight W can be supported by the wires? [W=129.22 kN]



16. In the structure shown, an 8 mm diameter pin is used at A, and 12 mm diameter pins are used at B and D. Knowing that the ultimate shearing stress is 100 MPa at all pins and that the ultimate normal stress is 250 MPa in each of the two links joining B and D, determine the allowable load P if an overall factor of safety of 3.0 is desired. [P=3.72 kN]

17. A load P is supported as shown by a steel pin that has been inserted in a short wooden member hanging from the ceiling. The ultimate strength of the wood used is 60 MPa in tension and 7.5 MPa in shear, while the ultimate strength of the steel is 145 MPa in shear. Knowing that b = 40 mm, c = 55 mm, and d = 12 mm, determine the load P if the overall factor of safety is 3.2. [P=10.25 kN]





18. A force P is applied as shown to a steel reinforcing bar that has been embedded in a block of concrete. Determine the smallest length L for which the full allowable normal stress in the bar can be developed. Express the result in terms of the diameter d of the bar, the allowable normal stress σ_{allow} in the steel, and the average allowable bond stress τ_{allow} between the concrete and the cylindrical surface of the bar. (Neglect the normal stresses between the concrete and the end of the bar.) [$L_{min} = \sigma_{allow}\, d/4\, \tau_{allow}$]