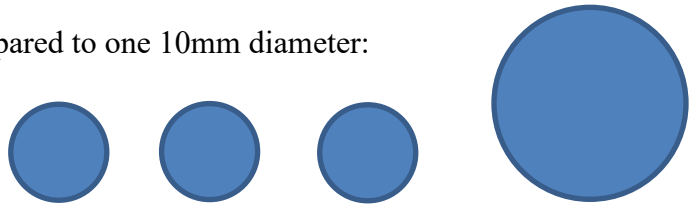
ME 328 – Machine Design
Spring 2019, Assignment 10

1) *(5 pts) Educational purpose: is there more to design than number crunching? (hint: yes).* Briefly describe the main advantage(s) to using a high strength fastener (such as SAE Grade 5 or higher, or ISO Class 8.8 or higher). Describe the main "dangers" or risks associated with using high strength fasteners. There must be advantages and disadvantages otherwise there would not be multiple strengths to choose from.

2) (10 pts) DESIGN PROBLEM. *Educational purpose: remember, numbers resulting from analysis or testing never provide The Answer to a design problem – they only provide data for the engineer to interpret. So interepret*….Analyze and comment on two different designs of a tension joint. One option is to use a single M10X1.5 fastener; the other option is to use three M5X0.8 fasteners. Both are coarse pitch. The joint has an external force applied cycling between **zero and 20kN** (tension). For the 3- fastener option, assume the applied load is divided equally between the fasteners. Grip length of the fasteners is 60mm. The fasteners are class 9.8 preloaded to 75% of proof. Evaluate the two designs for joint separation and infinite fatigue life. Discuss the quantitative results and qualitative advantages and disadvantages of both options (why may 3 be better or worse than 1?). Note that the total cross-section area of three 5mm fasteners is 25% less than the single 10mm fastener and since the axial stress is proportional to cross-section, one might conclude that the 10mm fastener will have lower stress (but that conclusion may be false).

	k_b	k_m
5mm (Qty, 3)	67.8 kN/mm	858 kN/mm
10mm (Qty, 1)	271 kN/mm	1810 kN/mm

Scale of three 5mm compared to one 10mm diameter:



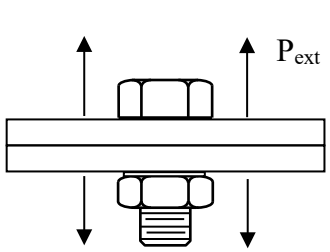
Partial answer:
For the 10mm: FOS fatigue = 2.5, FOS separation = 1.6

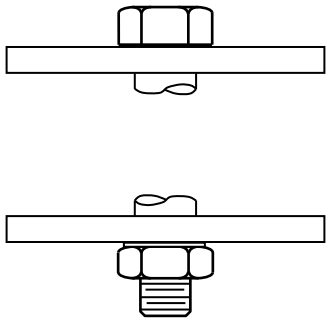
3) (10 pts) DESIGN PROBLEM *Educational purpose: learn to design a fastened tension joint with consideration to joint separation.* Given a 3/8-24 UNF SAE Grade 5 bolt. An external tensile load of 2200 pounds is applied to the joint. On the same graph, plot factor of safety for joint separation and also the load factor (n) as a function of preload (for preload from zero to 100% of proof). Assume grip length is 2.4 inches. Based on this, what can you generally say about preload magnitude (is higher better, worse, same)? What preload would you recommend for this part assuming no fatigue loading?

4) (10 pts) The "spinning disks" problem shows up yet once again in your life (probably for its last appearance). It is shown on the next page, just in case you have forgotten what it looks like. Assume that the disks are spinning at 1000RPM and the transmitted force is 80kN, and the

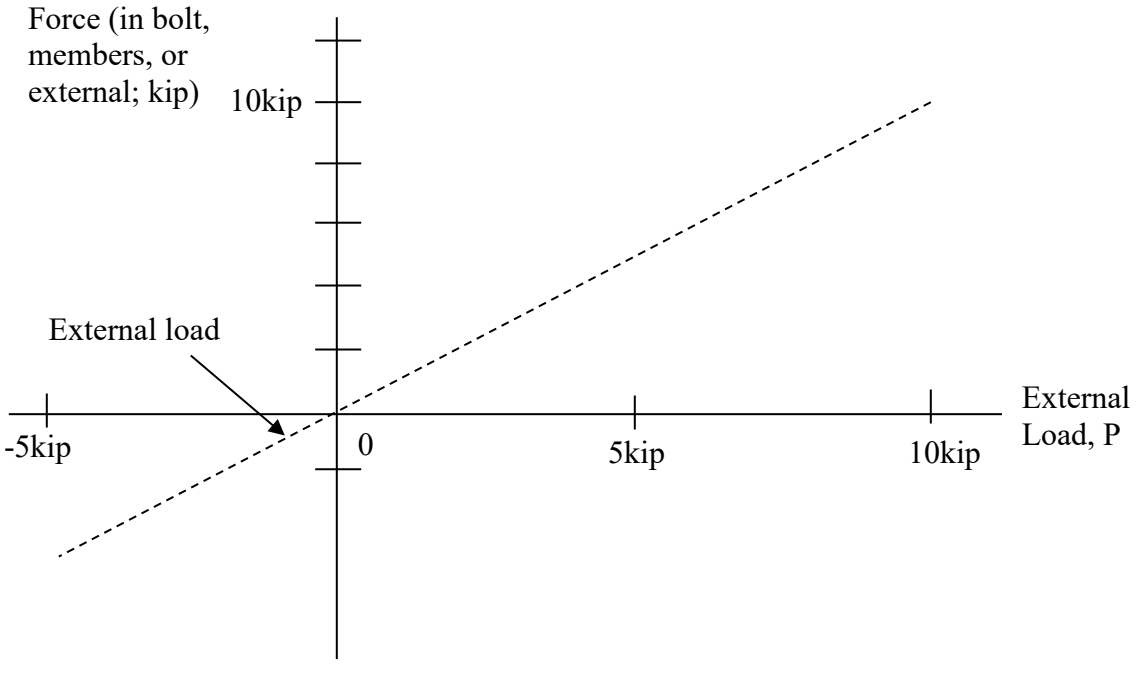
"spinning disk machine" itself weighs 700kg. Assume there are 4 support fasteners connecting the bracket to the main structural frame (MJ 12X1.25 – ISO Class 9.8, 30mm grip length). They are tightened to 75% of proof. The life criterion for the machine is for it to run 80 hours per week, 50 weeks per year for at least 1 year. Determine the fatigue factor of safety (if it less than 1, then it fails to meet the life criterion). See sketch on last page.

5) (15 pts) *Educational purpose: of all the problems on this assignment,* ***this is the MOST IMPORTANT****. It should help you <u>understand</u> how force is carried in a tension joint. Understanding is more important that being able to use a calculator.* Given: A fastened tensile joint has a joint constant, C = 0.2, and requires an external force of 6000 pounds to cause joint separation. Create free body diagrams by showing all three forces (F_b, F_m, P_{ext}) on the sectioned sketch below. Plot to scale the force in the bolt as well as the force between the members as a function of external load for an external load going from 5000 pounds **compression** to 10,000 pounds **tension**. The three forces on the graph (external, bolt, members) must show that equilibrium is maintained. Use a straight edge and be neat and clear. Assume no failure (yielding nor fracture) in the bolt. Discuss, explain or show calculations to justify your graph. Notice that the equation $F_b = CP + F_i$ is an equation for a line (of the form: $y = mx + b$), as is the equation $F_m = (1\text{-}C)P - F_i$. NOTE: regarding "sign" of F_m (positive or negative); in FBD language, if *up* is positive then *down* is negative. But what really matters is that your interpretation of the FBD results in $\Sigma\mathbf{F}=0$.

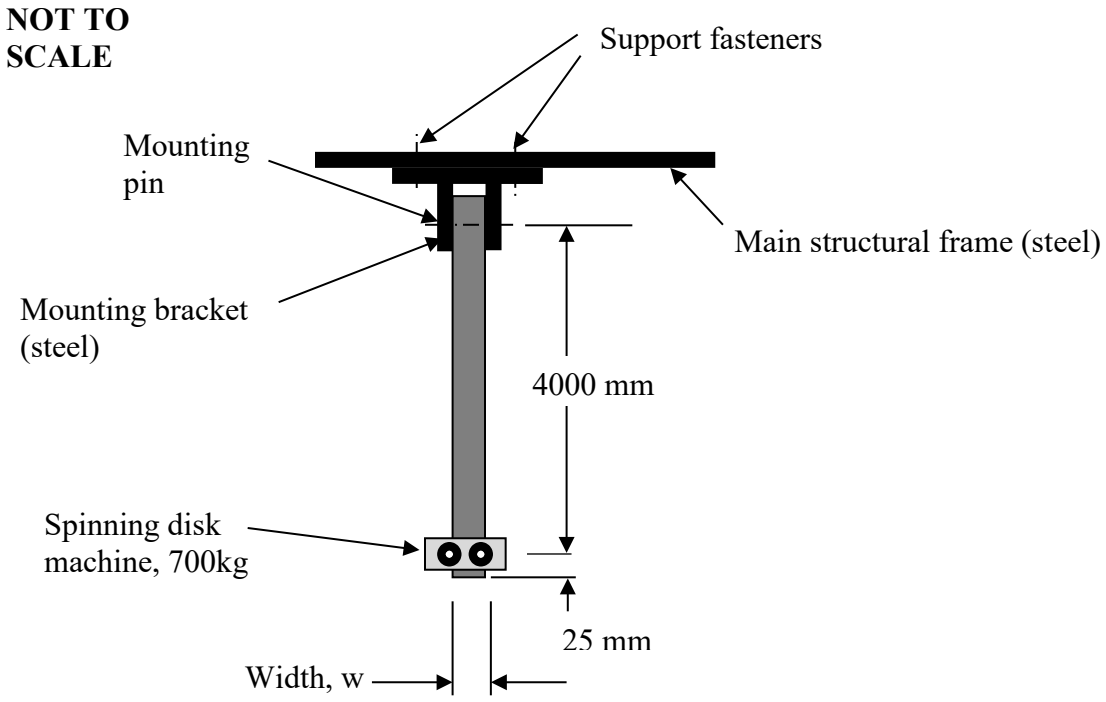




Complete this graph:



Sketch for spinning disk machine:



6. (5pts) **Educational purpose**: *so many more terms, so much less time….* Define the following terms, use sketches if appropriate, and cite your sources (URL's are acceptable): burr, flashing, swarf, festoon, collet, clevis.