AUB / FEA / Mech. Eng'g MIDTERM - MECH 420 /Fall '16-17 October 25, 2016	Name: ID:	Duration: 90 minutes

Open book: Only Shigley's Mechanical Engineering Design textbook is allowed
Scientific calculators are allowed
Return the entire question booklet and the answer sheets to the instructor
Show all your work for full credit and circle your answers

Problem 1 (60): A schematic of a clutch-testing machine is shown. The steel shaft rotates at a constant speed ω. An axial load P is applied to the shaft. The torque T induced by the clutch face onto the shaft is given by

$$T = \frac{fP(D+d)}{4}$$

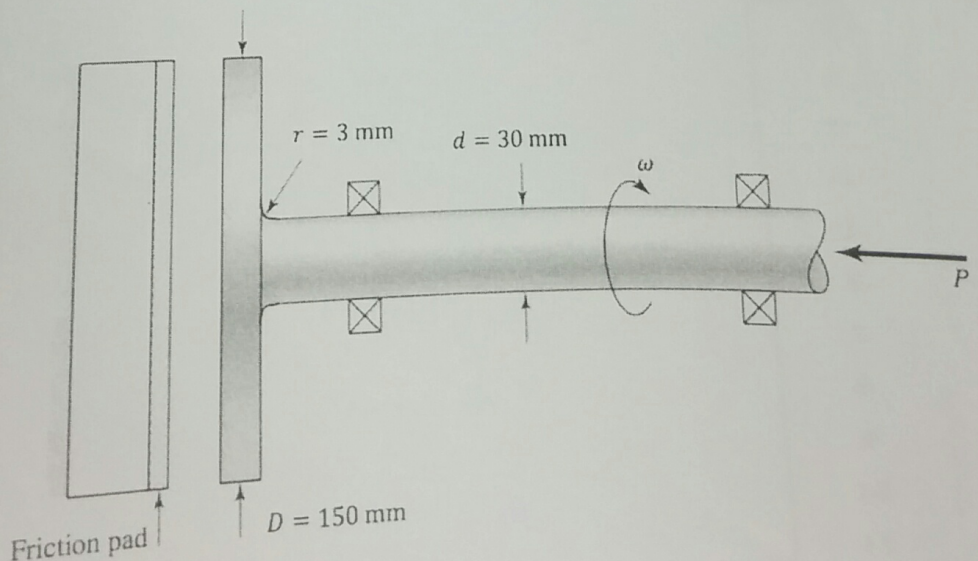
where D and d are defined in the figure and $f = 0.3$ is the coefficient of friction of the clutch face. The theoretical stress-concentration factors for the fillet are $K_t = 3.0$ and $K_{ts} = 1.8$ for the axial and torsional loading, respectively.

Static analysis: P and T are constant static loads:

a) Identify the worst location and draw a representative stress element
b) Compute the nominal principal stresses, maximum shear stress, and von-Mises stress
c) Choose a material for the shaft:
   1. Find the maximum allowable load P such that the shaft has a factor of safety of 3 if a ductile material is used (No need to be conservative). The ductile material has $S_y = 580$ MPa and $S_{ut} = 690$ MPa.
   2. Find the maximum allowable load P such that the shaft has a factor of safety of 3 if a brittle material is used (No need to be conservative). The brittle material has $S_{ut} = 430$ MPa and $S_{uc} = 1300$ MPa.
   3. Which material do you recommend to use?

Fatigue analysis: The axial load P becomes repeated with a maximum value of $P_{\max} = 35$ kN. Using the ductile material and the modified Goodman criteria, compute the following:

d) The endurance limit
e) The fatigue factor of safety
f) The estimated number of cycles to failure



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Problem 2 (40): The figure below shows the input shaft of a gearbox, supported by bearings A and B and driven by an electric motor. The tangential and radial forces experienced by the spur gear are F_t= 206 N, and F_r =75 N respectively. An end-mill key-seat is used to couple the gear to the shaft. The shaft is machined from AISI 1035 CD steel. Assume 99% reliability and room temperature operation.

a) Draw the force and moment diagrams for the shaft.
b) For a fatigue factor of safety of 2, determine the minimum size of the shaft to endure infinite number of cycles using ASME elliptic criterion.
c) From deflection consideration, is the design acceptable?