

MEN35101 – Machine Element Design, Fall Term 2017

1st Midterm Exam

September 28, 2017

10:00 am to Noon

You must clearly show all work in detail and answers on the answer sheets provided.

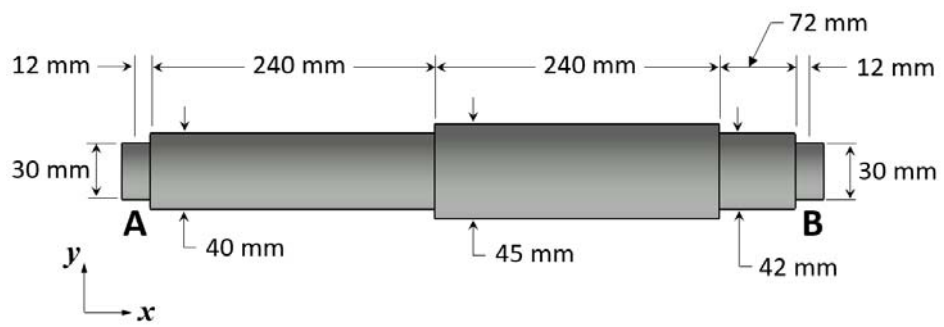
Put your name and student ID on the cover of the answer sheets.

Q1. (50pts) Consider the shaft shown in the figure. The shaft is supported by two bearing at A and B and subjected to forces of $F_C = 9$ kN and $F_D = 12$ kN at C and D, respectively. Torques are also applied at C and D with $T_C = 1.2$ kN and $T_D = 1.2$ kN as shown in the figure. The shaft is made of an aluminum alloy with the yield strength of $S_y = 250$ MPa. Neglect transverse shear stresses due to bending.

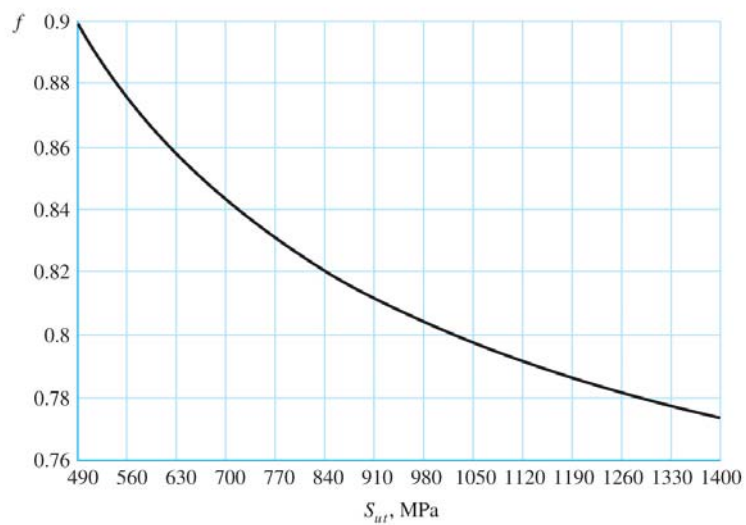
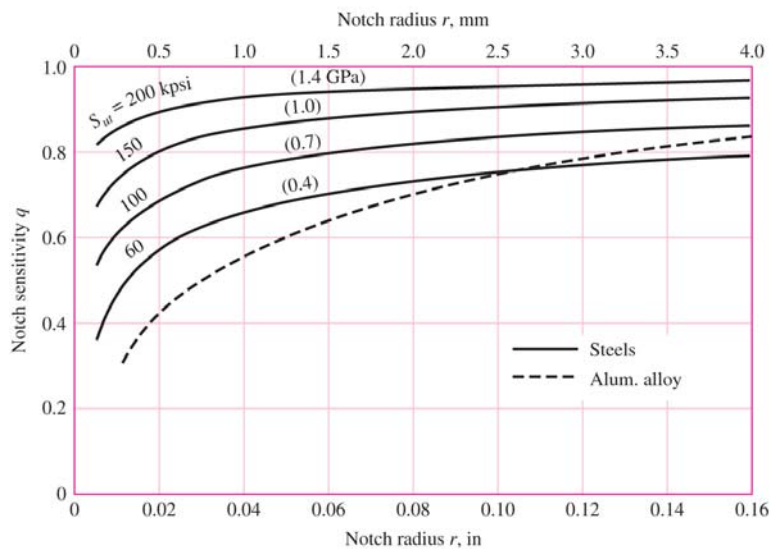
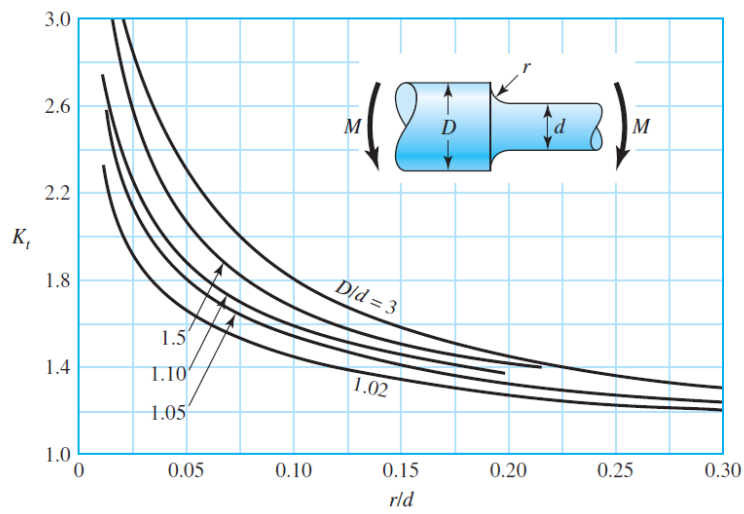
- (a) **(10pts)** Determine bearing reaction forces by assuming that the bearings act as simple supports and the shaft is in the static equilibrium state.
- (b) **(10pts)** Draw bending-moment diagrams for the shaft in xy - and xz -planes.
- (c) **(15pts)** Find resultant bending moments at C and D. Which location is more critical between C and D?
- (d) **(15pts)** Find the safety factors against yielding at C and D. Are they safe from yielding? What failure theory should you use?

Q2. (50pts) The shaft shown in the figure is now rotating and subjected to the forces of $F_C = 9$ kN and $F_D = 12$ kN only ($T_C = T_D = 0$). The shaft is machined from AISI cold-drawn steel, of which the yield strength and the ultimate strength are 490 MPa and 590 MPa, respectively. Neglect transverse shear stresses due to bending. (Hint: When a shaft is rotating, bending stress is completely reversed.)

- (a) **(20pts)** Find stresses due to bending at C, D and two fillets. Where is the critical location?
- (b) **(30pts)** Find the fatigue factor of safety based on achieving infinite life at the critical location determined from (a). If infinite life is not predicted, estimate the number of cycles to failure.



All fillets are 1.5 mm R.



Surface Finish	S_{ut} kpsi	Factor a	S_{ut} MPa	Exponent b
Ground	1.34	1.58		-0.085
Machined or cold-drawn	2.70	4.51		-0.265
Hot-rolled	14.4	57.7		-0.718
As-forged	39.9	272.		-0.995