MEN35101 – Machine Element Design, Fall Term 2020

1st Midterm Exam

October 15, 2020

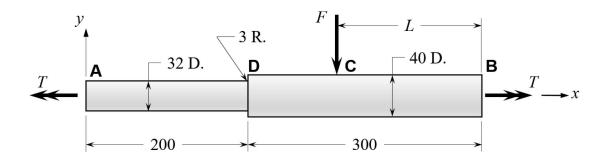
10:30 am to Noon

- 1. You must clearly show all work in detail and answers on the answer sheets provided.
- 2. Since this is an open-book exam, you must state every source taken from the textbook in writing your answer. For example,

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"From Figure-A-15-7 of the textbook, K_t=X.XX when r/d=..."
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The shaft shown in the figure is subjected to a force of F and a torque of T. Dimensions are given in millimeters.

- (a) **(20pts)** Draw the bending moment and shear force diagrams of the shaft when L=180 mm and F=10 kN.
- (b) **(20pts)** Suppose that the shaft is made of a ductile material having a yield strength of 210 MPa . When L=180 mm, F=10 kN and T=4 N. m, determine the critical location between $\bf C$ and $\bf D$. Is failure predicted at the critical location? If you use one of the failure theories for the answer, explain in detail the reason of your selection of that theory.
- (c) **(30pts)** Now suppose that the shaft is made of a brittle material with a ultimate strength of 150 MPa. When L=80 mm, F=10 kN and T=0 N. m, determine the critical location between **C** and **D**. Is failure predicted at the critical location? What is the factor of safety?
- (d) **(30pts)** Supposing that the shaft is made of an aluminum alloy, find the slope at **A** using the Castigliano's theorem when L=180 mm, F=10 kN and T=0 N. m. (Note: Unless you use the designated theorem, you will get zero for this part regardless of your answer.)



[&]quot;From Table A-20, the ultimate tensile strength of 1015 CD steel is 340 MPa".

[&]quot;From Table 6-2, a=... and b=... when the shaft has a ground surface.".

[&]quot;Using Eq. (6-19), $k_a = ...$ "