# MEN35101 – Machine Element Design, Fall Term 2020

## 2nd Midterm Exam

## November 26, 2020

## 10:30 am to 12:10 pm

1. You must clearly show *all work in detail* and answers on your answer sheets.

2. Since this is an open-book exam, you must state every source taken from the textbook in writing your answer. For example,

    *"From Figure-A-15-7 of the textbook, $K_t$=X.XX when r/d=...."*

    *"From Table A-20, the ultimate tensile strength of 1015 CD steel is 340 MPa".*

    *"From Table 6-2, a=... and b=... when the shaft has a ground surface.".*

    *"Using Eq. (6-19), $k_a$=..."*

The rotating shaft in the figure below is simply supported at A and B. The shaft is subjected to a constant load $F$ at C. A torque of $T$ is also applied as illustrated in the figure. The shaft is machined from an AISI 1040 cold-drawn steel bar.

(a) **(60pts)** Suppose that the torque is completely reversed between $T = \pm 0.1 \times F$ and $F$ is sufficiently large to cause a fatigue failure after 1 million cycles. Compare safety factors between C and D and predict the critical location of fatigue failure.

(b) **(40pts)** Now the torque is steady at 600 N. m. Find the allowable $F$ for the rotating shaft to achieve the finite life cycle of $10^4$ with the safety factor of 1.2. Use the modified Goodman line for this problems. Compute the safety factor against yielding failure for the allowable $F$.