ME 452: Machine Design II Spring Semester 2020

Name of Student: ____

Please circle your lecture division number: Division 1 9:30 am – 10:20 am Division 2 1:30 pm – 2:20 pm

MIDTERM EXAM

Tuesday, March 10th, 2020

8:00 pm – 10:00 pm in Room EE 129

OPEN BOOK AND OPEN LECTURE NOTES

For full credit you must show your work and calculations clearly and logically on the sheets of paper attached to the end of each problem. Work that cannot be followed is assumed to be in error.

Use only the blank pages for all your work and write on one side of the paper only. Please do not write on the exam pages.

Please draw any diagrams or free body diagrams clearly and to a reasonable scale.

If you use extra paper, then staple this paper to the end of your exam and clearly label the problem number(s).

Include your name at the top of each page of your exam.

Problem 1 (25 points)	
Problem 2 (25 points)	
Problem 3 (25 points)	
Problem 4 (25 points)	
Total (100 points)	

ME 452: Machine Design II **MIDTERM EXAM**

Name of Student: ____________________________ **Circle one: Division 1 Division 2**

Problem 1 (25 points). The circular shaft shown in Figure 1 is rotating in the simply supported bearings at points O and C. The constant force at point A is $F_A = 225$ N, the constant force at point B is $F_B = 275$ N, and the constant shaft torque is $T = 150$ N.m. The shaft has a tensile yield strength $S_{yt} = 190$ MPa, a compressive yield strength $S_{yc} = 220$ MPa, and an ultimate tensile strength $S_{ut} = 335$ MPa. The fully corrected endurance strength of the shaft is $S_e = 125$ MPa. The fatigue stress concentration factors at the groove in the shaft for normal stress are $K_f = K_{fm} = 2.25$ and for shear stress are $K_{fs} = K_{fsm} = 1.95$. The infinite life fatigue factor of safety for the critical element at the mid-section of the shaft is $n_f = 3$.

(i) Determine the minimum diameter d of the groove in the shaft using the Goodman criterion.

For the critical element at the mid-section of the shaft determine:

(ii) The von Mises mean stress, von Mises alternating stress, and the von Mises maximum stress.

(iii) The factor of safety guarding against first-cycle yielding using the Langer line.

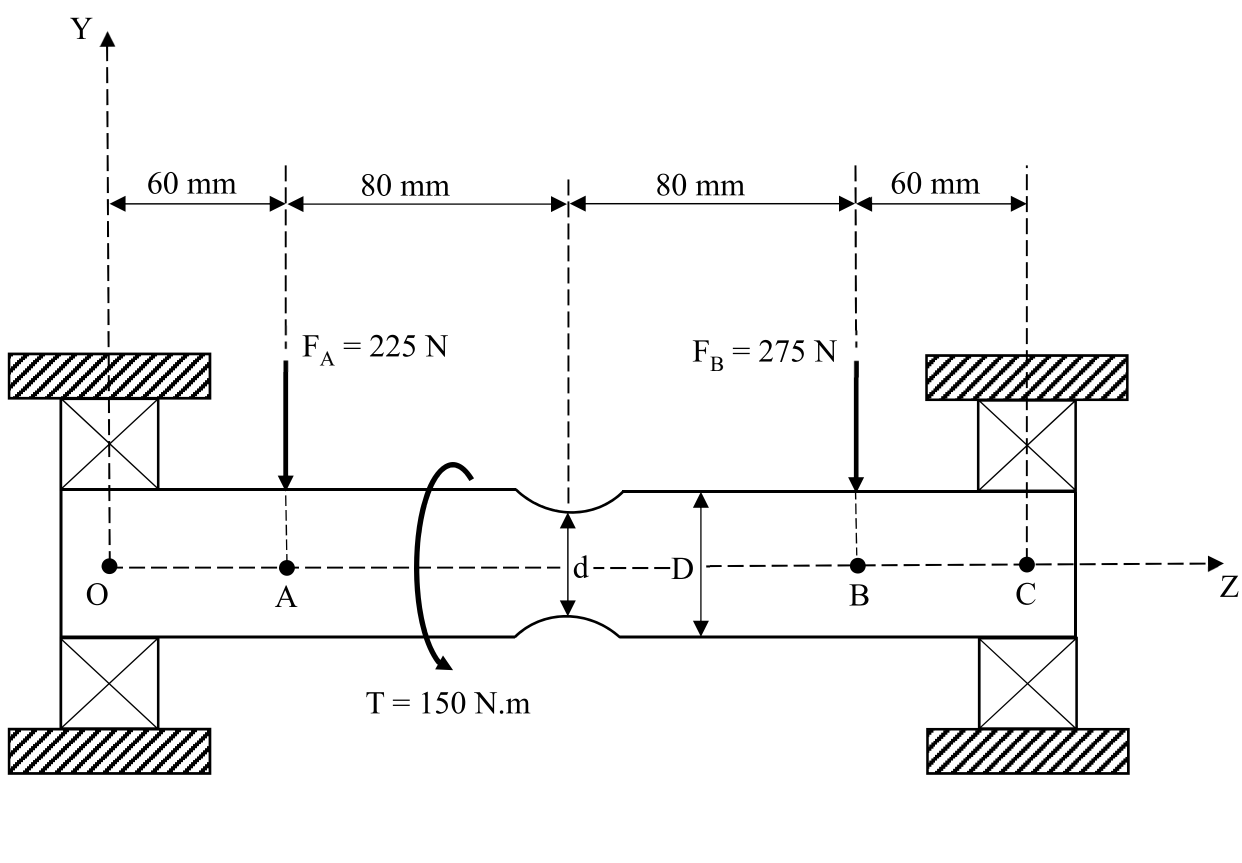

Figure 1. A simply supported rotating shaft (Not drawn to scale).

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Problem 2 (25 points). Figure 2 shows the cam and flat-faced follower of a valve train used in a single cylinder engine. In the position shown, the base circle of the carbon steel cam is assumed to be rolling, with minimum slipping, on the face of the titanium alloy follower. The vertically downward load acting on the follower stem is $F = 8000\,\text{N}$. The radius of the base circle of the cam is $R = 50\,\text{mm}$ and the thickness of both the cam and the follower into the paper (that is, the X-axis) is a constant 40 mm. If the effects of friction can be neglected then determine:

(i) The half-width of the contact patch.
(ii) The maximum pressure acting on the contact patch.
(iii) The principal normal stresses on element O on the surface of: (a) the cam, and (b) the follower.
(iv) The maximum shear stress acting on element B of the cam where the depth $OB = 0.25\,\text{mm}$.

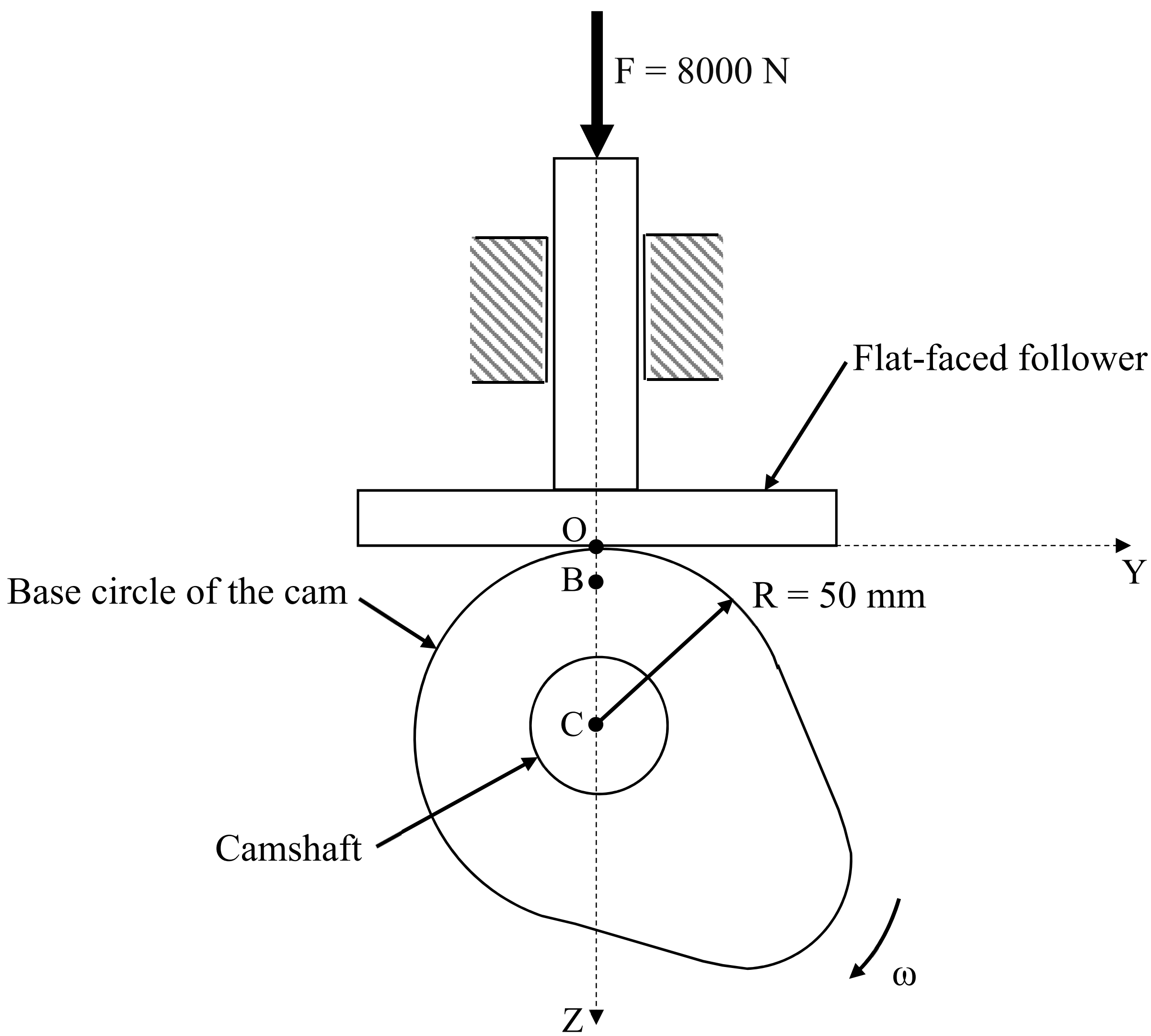

Figure 2. A cam and flat-faced follower. (Not drawn to scale).

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Problem 3 (25 points). The full journal bearing shown in Figure 3 is required to support a steady state load of 400 lbs. The journal must rotate at a constant speed of 1200 rpm. The length of the bearing is 5 inches, the diameter of the journal is 4 inches, and the radial clearance is 0.02 inches. The common petroleum lubricant SAE grade 50 oil is to be used in the journal bearing and the operating temperature is 100°F. If the coefficient of friction variable is 7.7 and the flow variable is 3.6 then determine:
(i) The Sommerfeld number for the bearing.
(ii) The friction torque acting on the journal.
(iii) The thermal energy loss at steady state.
(iv) The flow ratio required to maintain a temperature rise of 5°F.

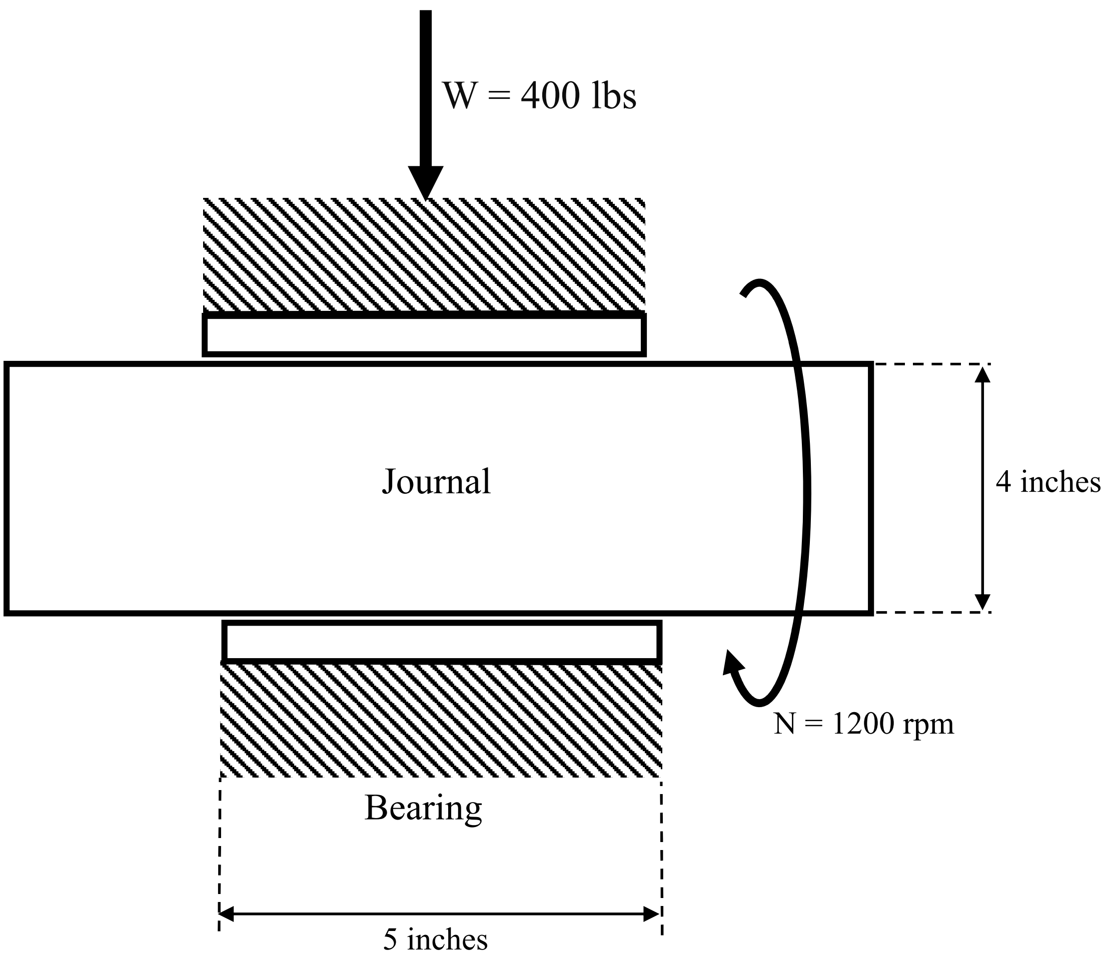

Figure 3. A full journal bearing. (Not drawn to scale).

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Problem 4 (25 points). For the commercial quality spur gearset shown in Figure 4, the diametral pitch is $8\,\text{inches}^{-1}$. The pitch circle diameter of the input gear is 5 inches and the pitch circle diameter of the output pinion is 3 inches. The teeth of the gearset are full-depth with a pressure angle of 20° and the face widths of the gear and the pinion are 1.25 inches. The gear is rotating at 500 rpm and transmits 5 horsepower to the pinion. The gear has a light shock load and the pinion has a moderate shock load where the loads are applied at the tips of the teeth. The gear and the pinion are solid gears, made of carburized and hardened Grade 1 steel with a repeatedly applied bending strength $S_t = 55\text{ kpsi}$, and are operating at room temperature. The known AGMA factors for the gear and pinion are: dynamic factor $K_v = 1.25$, size factor $K_s = 1.0$, and load distribution factor $K_m = 1.0$. Determine:

(i) The tangential and radial components of the load acting on the meshing gear teeth.
(ii) The AGMA normal stress due to bending of the <u>pinion teeth</u>.
(iii) The AGMA bending fatigue factor of safety for <u>the pinion</u> for 10^9 cycles at 99.5% reliability.

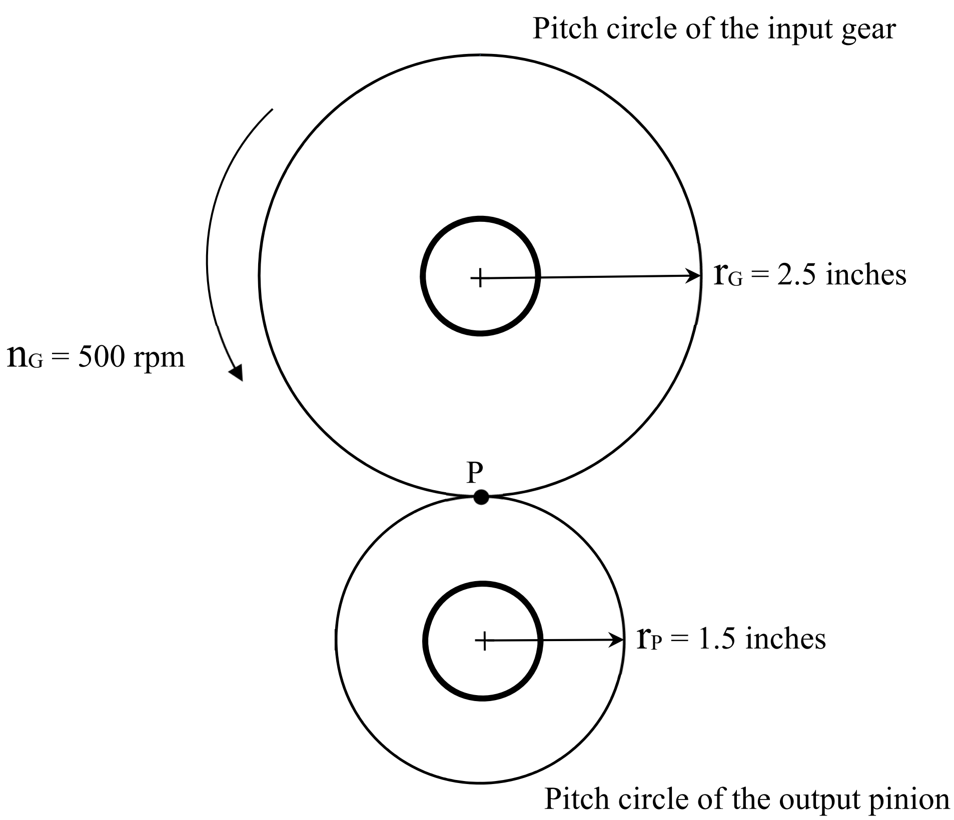

Figure 4. A commercial quality spur gearset. (Not drawn to scale).