ME-340 EXAM #02 *November 12, 1998*

*NAME:*________________________ *8:00 AM*

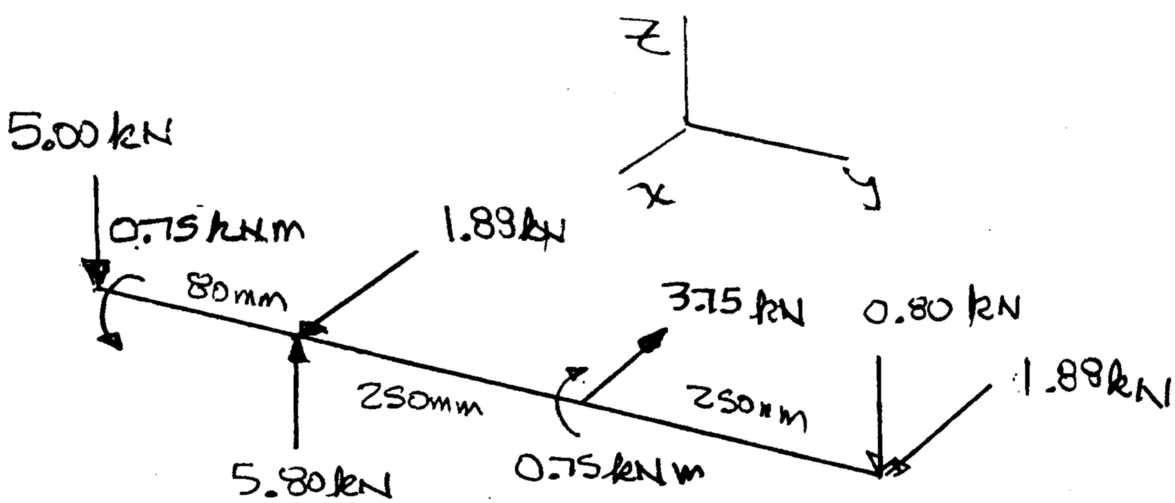
- *Read all problems carefully. Check the board for any additions or corrections.*
- *Show all work, which must be neat and orderly to be graded. That is, sloppy work will not be graded!*
- *Show no work on this page. Return this page with your solutions.*

(1) A sliding element bearing has a length of 2.50 inches, a diameter of 1.25 inches, and a load of 400 pounds, corresponding to a rotational speed of 1150 rev/minute. The lubricant is SAE 40 with a viscosity of 10μreyn. Determine the temperature rise across the bearing, supply and outlet oil temperatures, coefficient of friction, eccentricity, total and side oil flows, maximum oil pressure, and the power lost in the bearing. Use a radial clearance 0.001 inches.

(2) For the design of problem (1) select a 300 series rolling element bearing which has a reliability of 95% and must last for 20,000 hours. The application is one with moderate impact.

(3) For the figure shown below, verify the free body diagram is correct.

(4) A bearing has been operated at 2,500,000 cycles at 25,000-N. Can this bearing be operated at 15,000-N for an additional 250,000 cycles? The bearing is an 02 series with a bore diameter of 60-mm.



(155)

EXAM #2 - BEARINGS
TEST CODE 155

ME 340
11/12/98

① $l = 2.5\text{ in}$
$d = 1.25\text{ in}$
$\frac{l}{d} = 2$
$W = 400\text{ lb}$

$\rightarrow P = \frac{W}{ld} = \frac{400\text{ lb}}{(2.5)(1.25)\text{ in}^2} = 128\text{ psi}$

$c = 0.001\text{ in}$

$\frac{r}{c} = \frac{0.625}{0.001} = 625$

$N = 1150\ \frac{\text{rev}}{\text{min}} \times \frac{1\text{ min}}{60\text{ sec}} = 19.2\text{ rev/sec}$

SAE 40

T_{AVG} @ 10 μreyn = 122°F

FIRST, THE SOMMERFIELD NUMBER:

$$S = \left(\frac{r}{c}\right)^2\left(\frac{\mu N}{P}\right) = (625)^2\left(\frac{10\times10^{-6}\text{ reyn}\,(19.2\ \frac{\text{rev}}{\text{sec}})}{128\text{ psi}}\right) = 0.59$$

NOW THE TEMP RISE:

$$\Delta T_F = \frac{0.103P}{1-0.5\frac{Q_s}{Q}}\ \frac{\frac{r}{c}f}{\frac{Q}{rcNl}} = \frac{0.103(128)}{1-0.5(0.15)}\ \frac{10}{3.5} = 41°F$$

IN & OUT TEMPS:

$T_{AVG} = 122°F$

$T_i = T_{AVG} - \frac{1}{2}\Delta T = 122 - 20.5 = 121.5°F$

$T_o = T_{AVG} + \frac{1}{2}\Delta T = 122 + 20.5 = 142.5°F$

COEFFICIENT OF FRICTION:

$\frac{r}{c}f = 10\ ;\ f = \frac{10}{625} = 0.016$

ECCENTRICITY:

$\varepsilon = 0.12 = e/c \rightarrow e = 0.12(0.001) = 0.00012\text{ in}$

① CONT'D

TOTAL & SIDE FLOWS;

$$\frac{Q}{rcNl} = 3.5 \rightarrow Q = 3.5(.625\,in)(0.001\,in)(19.2\,\tfrac{rev}{sec})(2.5\,in) = 0.105\,in^3/sec$$

$$\frac{Q_s}{Q} = 0.15 \rightarrow Q_s = 0.15(.105\,in^3/sec) = 0.016\,in^3/sec$$

MAX OIL PRESSURE:

$$\frac{P}{P_{max}} = 0.65 \rightarrow P_{max} = \frac{128\,psi}{0.65} = 197\,psig$$

POWER LOST:

$$H_p = \frac{fWrN}{1050} = \frac{0.016(400\,lb)\,0.625\,in(19.2\,\tfrac{rev}{sec})}{1050} = 0.073\,hp$$

② 300 series brg.

reliab = 95% → $k_R = 0.62$

20,000 hrs × 1150 rev/min × 60 min/hr = 1.38 E9 CYCLES

MODERATE IMPACT → $k_a = 1.75$ (1.5–2.0)

$$C_{REQ} = K_a F_e \left(\frac{L}{K_R L_R}\right)^{0.3} = 1.75(400\,lb)\left(\frac{1.38\,E9}{.62(90\,E6)}\right)^{0.3} = 1{,}833\,lb = 8.2\,kN$$

CHOOSE 30mm BORE RADIAL BALL → 306 OR LARGER
OR 30 mm BORE ANGULAR CONTACT → 306 OR LARGER

SHAFT IS 1.25 in → 31.75 mm dia. → 307 BRG

EXAM #2 - BEARINGS (CONT'D)
TEST CODE 155

(3)

$\Sigma F_x = 1.88\,kN - 3.75\,kN + 1.88\,kN = 0$

$\Sigma F_y = 0$

$\Sigma F_z = -5.00\,kN + 5.80\,kN - 0.80\,kN = 0$

$\Sigma M_x = 5.80\,kN(80\,mm) - 0.80\,kN(580\,mm) = 0$

$\Sigma M_y = 0.75\,kNm - 0.75\,kNm = 0$

$\Sigma M_z = -1.88\,kN(80\,mm) + 3.75\,kN(330\,mm) - 1.88\,kN(580\,mm) = 0$

LOOKS LIKE IT'S IN EQUILLIBRIUM TO ME.

(4)

$$\frac{l_1}{L_1} + \frac{l_2}{L_2} \leq 1 \rightarrow l_2 \leq \left(1 - \frac{l_1}{L_1}\right) L_2$$

$l_1 = 2.5\,E6$

$l_2 = .25\,E6$

$L_1 = 1\,E6\left(\frac{47.5}{25}\right)^{3.33} = 8.5\,E6$

$L_1 = 1\,E6\left(\frac{47.5}{15}\right)^{3.33} = 46\,E6$

$l_2 \leq 32\,E6$ ✓

LOADING O.K.

DEEP GROOVE $C = 47.5\,kN$

$L_1 = 1\,E6\left(\frac{55.9}{25}\right)^{3.33} = 15\,E6$

$L_2 = 1\,E6\left(\frac{55.9}{15}\right)^{3.33} = 80\,E6$

$l_2 \leq 67\,E6$ ✓

LOADING OK.

ANGULAR CONTACT $C = 55.9\,kN$