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

*NAME:*__________________________ *8:00 AM*

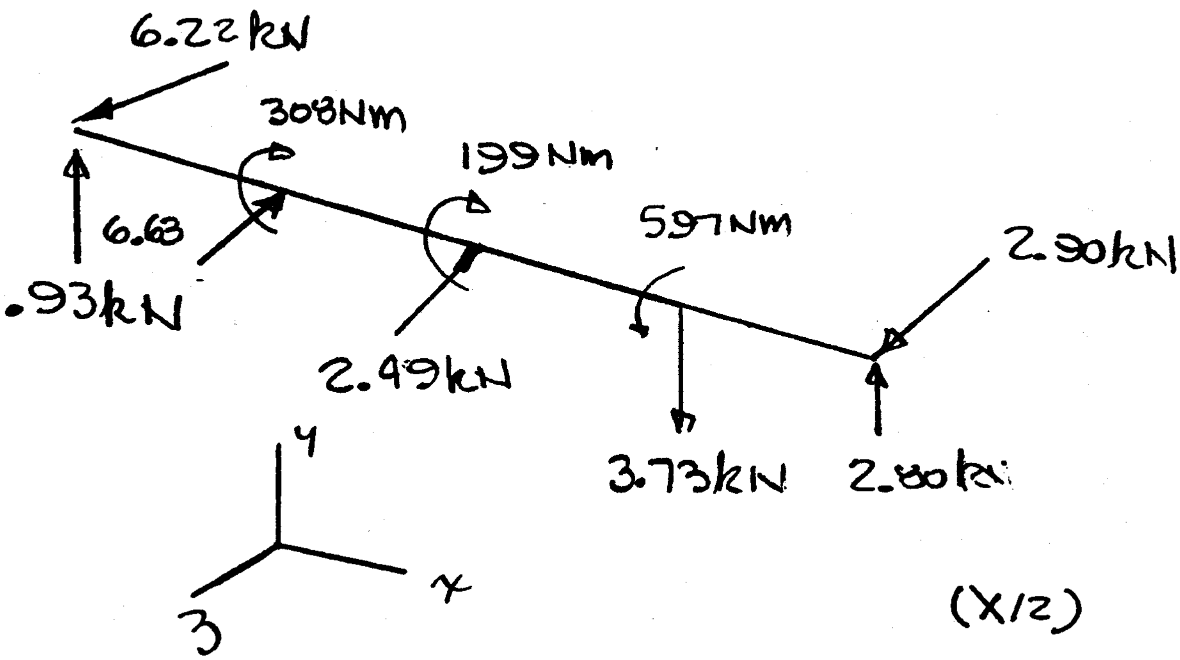
- *Read all problems carefully. Check the board for any additions or corrections.*
- *Show all work, which must be neat and orderly to be graded. That is, sloppy work will not be graded!*
- *Return this page with your solutions. Show no work on this page.*

(1) A sliding element bearing has an L/d ratio of 1, a diameter of 38-mm, and a load of 2500-N, corresponding to a rotational speed of 20- rev/second. The lubricant is SAE 40 oil with a viscosity of 20-MPa-s. Determine the temperature rise across the bearing, the 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 ratio of 667.

(2) For the design of problem (1) select a 200 series rolling element bearing which has a reliability of 95% and must last for 25,000 hours. The application is gearing.

(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 15,000-N. Can this bearing be operated at 25,000-N for an additional 250,000 cycles? The bearing is an 02 series with a bore diameter of 80-mm.



(1)
$$\left.\begin{aligned} l/d &= 1 \\ d &= 38\text{ mm} \\ l &= 38\text{ mm} \\ W &= 2500\text{N} \end{aligned}\right\} \quad P = \frac{W}{ld} = \frac{2500\text{N}}{.038 \times .038\text{ m}^2} = 1.73\text{MPa}$$

$\frac{r}{c} = 667$

$N = 20\text{ rev/sec}$

SAE 40

$T_{AVG} = 72.5°C \quad (\mu = 20\text{ mPa sec})$

FIRST, THE SOMMERFIELD NUMBER:

$$S = \left(\frac{r}{c}\right)^2\left(\frac{\mu N}{P}\right) = (667)^2\left(\frac{20\times10^{-3}\cancel{\text{Pa}}\,\cancel{\text{sec}}\left(20\frac{\text{rev}}{\cancel{\text{sec}}}\right)}{1.73\times10^6\,\cancel{\text{Pa}}}\right)$$
$$= 0.10$$

NOW THE TEMPERATURE RISE:

$$\Delta T_c = \frac{8.30P}{1-.5\frac{Q_s}{Q}}\;\frac{\frac{r}{c}f}{\frac{Q}{rcNl}} = \frac{8.30(1.73)}{1-.5(.72)}\;\frac{2.6}{4.4} = 13°C$$

IN & OUT TEMPS:

$$T_i = T_{AVG} - \tfrac{1}{2}\Delta T = 72.5 - 6.5 = 66°C$$
$$T_o = T_{AVG} + \tfrac{1}{2}\Delta T = 72.5 + 6.5 = 79°C$$

COEFFICENT OF FRICTION:

$$\frac{r}{c}f = 2.6 \rightarrow f = \frac{2.6}{667} = 0.0039$$

ECCENTRICITY:

$$\varepsilon = 0.66 \rightarrow e = \varepsilon c = 0.66\left(\frac{.019\text{ m}}{667}\right) = 0.0188\text{ mm}$$

① CONT'D

TOTAL & SIDE FLOWS

$$\frac{Q}{rcNl} = 4.4 \rightarrow Q = 4.4(.19\,mm)\left(\frac{19\,mm}{.667}\right) 20\frac{rev}{sec}(38\,mm)$$
$$= 1810\ mm^3/sec$$

$$\frac{Q_s}{Q} = .72 \rightarrow Q_s = .72(1810) = 1303\ mm^3/sec$$

MAX OIL PRESSURE:

$$\frac{P}{P_{max}} = 0.4 \rightarrow P_{max} = \frac{1.7\,MPa}{.4} = 4.3\ MPa$$

POWER LOST:

$$2\pi N f W r = 2\pi(20\ rev/sec)\ 0.0039(2500N)(.019m)$$
$$= 23.3\ WATTS$$

② 200 SERIES ROLLING ELEMENT
95% RELIABILITY $\rightarrow K_R = 0.62$
$25000\ \cancel{hr} \times 20\,rev/\cancel{sec} \times 60\frac{\cancel{sec}}{min} \times 60\frac{min}{\cancel{hr}} = 1.8E9$ CYCLES
GEARING $\rightarrow K_a = 1.2$

$$C_{req} = K_a F_e\left(\frac{L}{K_R L_R}\right)^{0.3} = 1.2(2500N)\left(\frac{1.8E9}{(.62)\,90E6}\right)^{0.3}$$
$$= 8.5\ kN$$

CHOOSE 35 mm BORE 207 OR LARGER RADIAL BALL
OR 40 mm BORE 208 OR LARGER ANGULAR BALL

SHAFT IS 38 mm $\rightarrow$ BEARING MUST BE 208.

EXAM #2 – BEARINGS CONT'D
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(3) UNABLE TO EVALUATE $\Sigma M_z$ OR $\Sigma M_y$, THEREFORE IT IS NOT KNOWN IF DRAWING IS CORRECT.

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

$l_1 = 2.5E6$

$l_2 = .25 E6$

$$\left.\begin{array}{l} L_1 = 1E6 \left(\frac{70.2}{15}\right)^{3.33} = 171 E6 \\ L_2 = 1E6 \left(\frac{70.2}{25}\right)^{3.33} = 31 E6 \\ l_2 \leq 30.5 E6 \rightarrow \text{NEW LOAD O.K.} \end{array}\right\} \text{DEEP GROOVE}$$

$$\left.\begin{array}{l} L_1 = 1E6 \left(\frac{80.6}{15}\right)^{3.33} = 270 E6 \\ L_2 = 1E6 \left(\frac{80.6}{25}\right)^{3.33} = 49 E6 \\ l_2 \leq 48.5 E6 \rightarrow \text{NEW LOAD O.K.} \end{array}\right\} \text{ANGULAR CONTACT}$$