MET 4501 Fall 2024: In-Class Quiz 7 Name: SOLUTION

INSTRUCTIONS:

This quiz is open-book and open-note, and you may work with your classmates. Please answer all questions and show all of your work.

GIVEN:

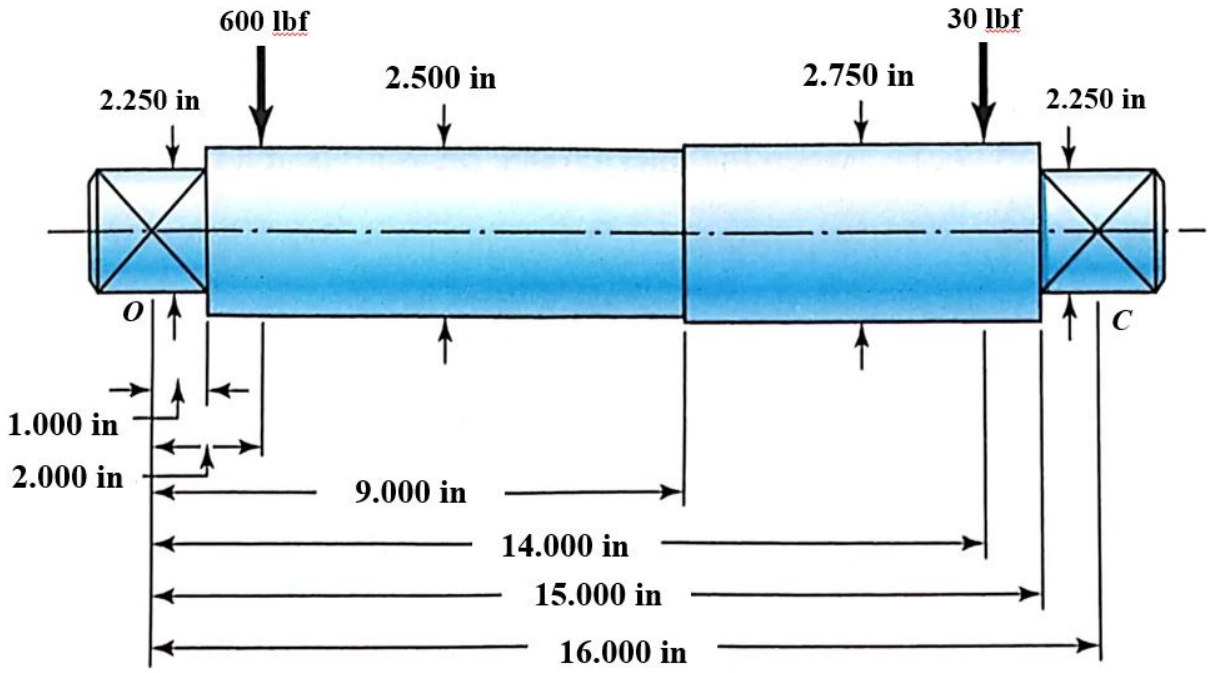
The steel shaft shown is simply supported by journal bearings at *O* and *C*.

The lubricant is SAE 40 and the operating temperature is 65 °F.

The shaft rotates at 900 rpm.

The shaft diameter at *O* and *C* is 2.250 in and the bearing (bore) diameter is 2.255 in. The bearing is 2 in long.

Note that 1 reyn = 1 lbf·s/in^2= 1 psi·s

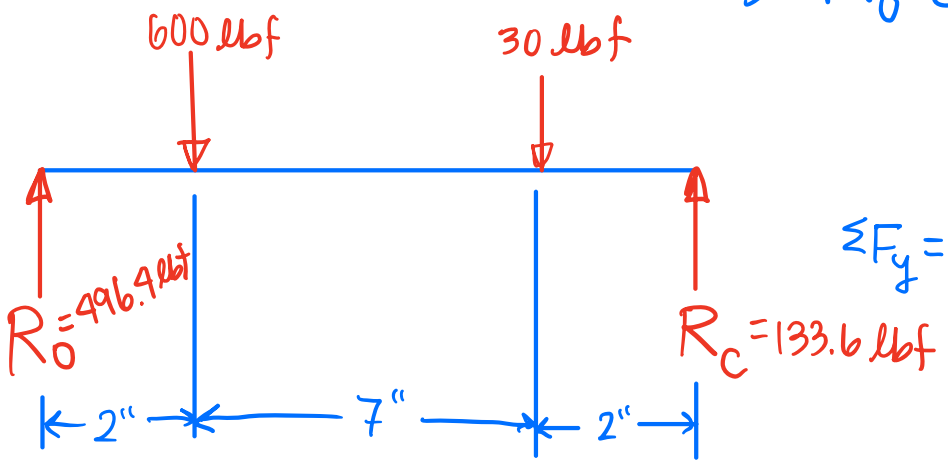


FIND:

(a) The radial load supported by bearing *O*.
(b) The Sommerfeld number (*S*) for the bearing at *O*.
(c) The minimum film thickness (h_0) in the bearing at *O*.

BONUS: Find the side flow (Q_s).

(a) DRAW A FBD



$\circlearrowleft +) \Sigma M_O = 0 = -(600\ lbf)(2\ in) - (30\ lbf)(9\ in) + R_C(11\ in)$

$R_C = 133.6\ lbf$

$\Sigma F_y = R_O - 600 - 30 + 133.6$

$\boxed{R_O = 496.4\ lbf}$

(b) $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$

$r = \frac{d}{2} = \frac{2.250\ in}{2} = 1.125\ in$

$c = \frac{D-d}{2} = \frac{2.255 - 2.250}{2} = 0.0025\ in$

$\mu = 100\ \mu reyn$ (SEE FIGURE ON NEXT PAGE)

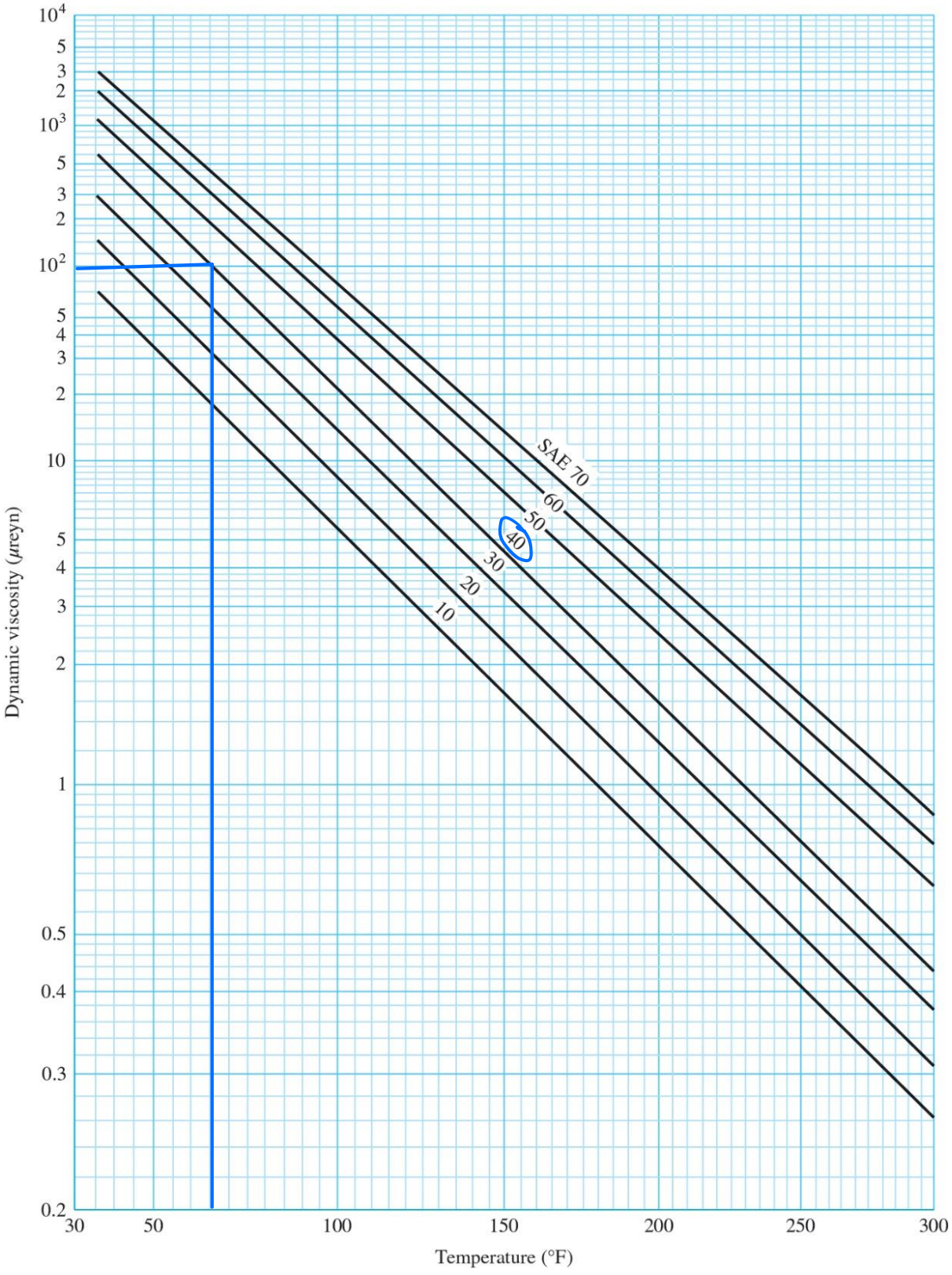
$= 100 \times 10^{-6}\ reyn = 100 \times 10^{-6}\ psi \cdot s$

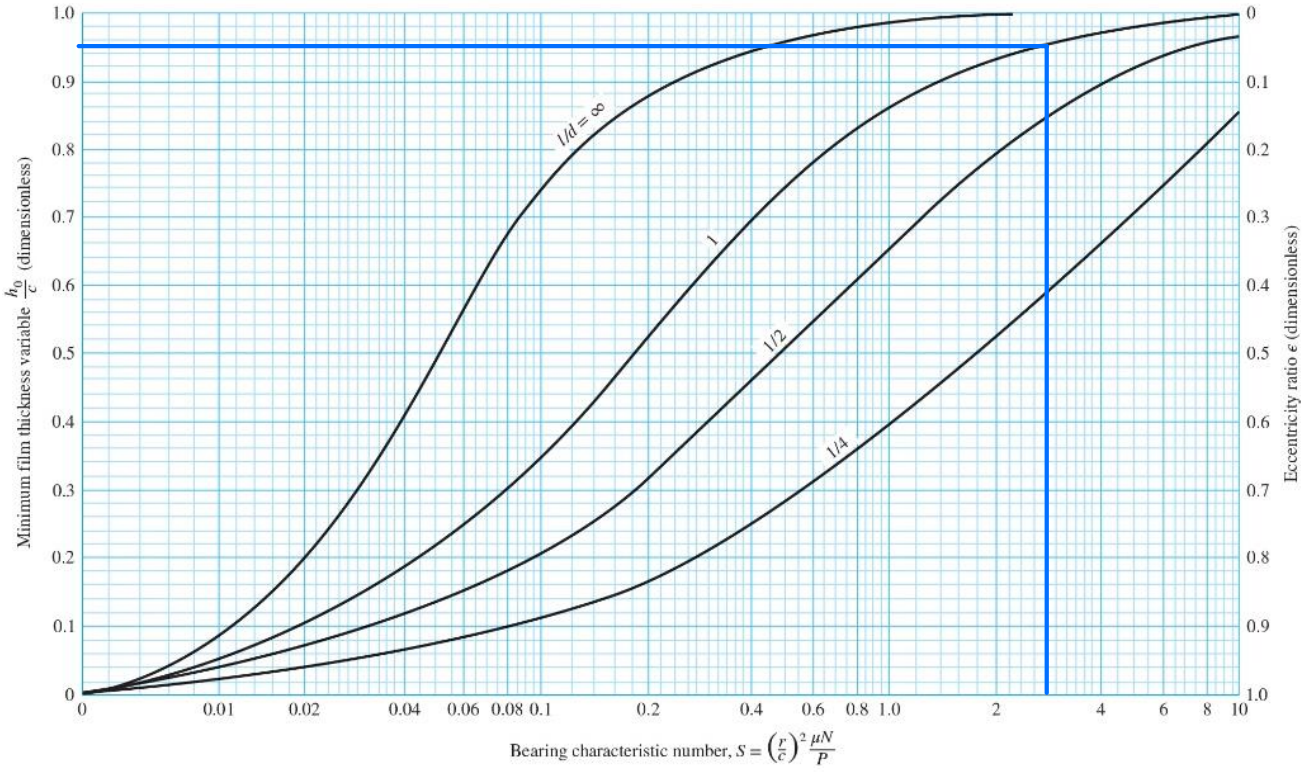
$N = 900\ \frac{rev}{min} \cdot \frac{1\ min}{60\ s} = 15\ \frac{rev}{s}$

$P = \frac{W}{2rl} = \frac{R_O}{2(1.125\ in)(2\ in)} = \frac{496.4\ lbf}{2(1.125\ in)(2\ in)} = 110.3\ psi$

$S = \left(\frac{1.125\ in}{0.0025\ in}\right)^2 \frac{(100 \times 10^{-6}\ psi \cdot s)\left(15\ \frac{rev}{s}\right)}{110.3\ psi}$

$\boxed{S = 2.75}$

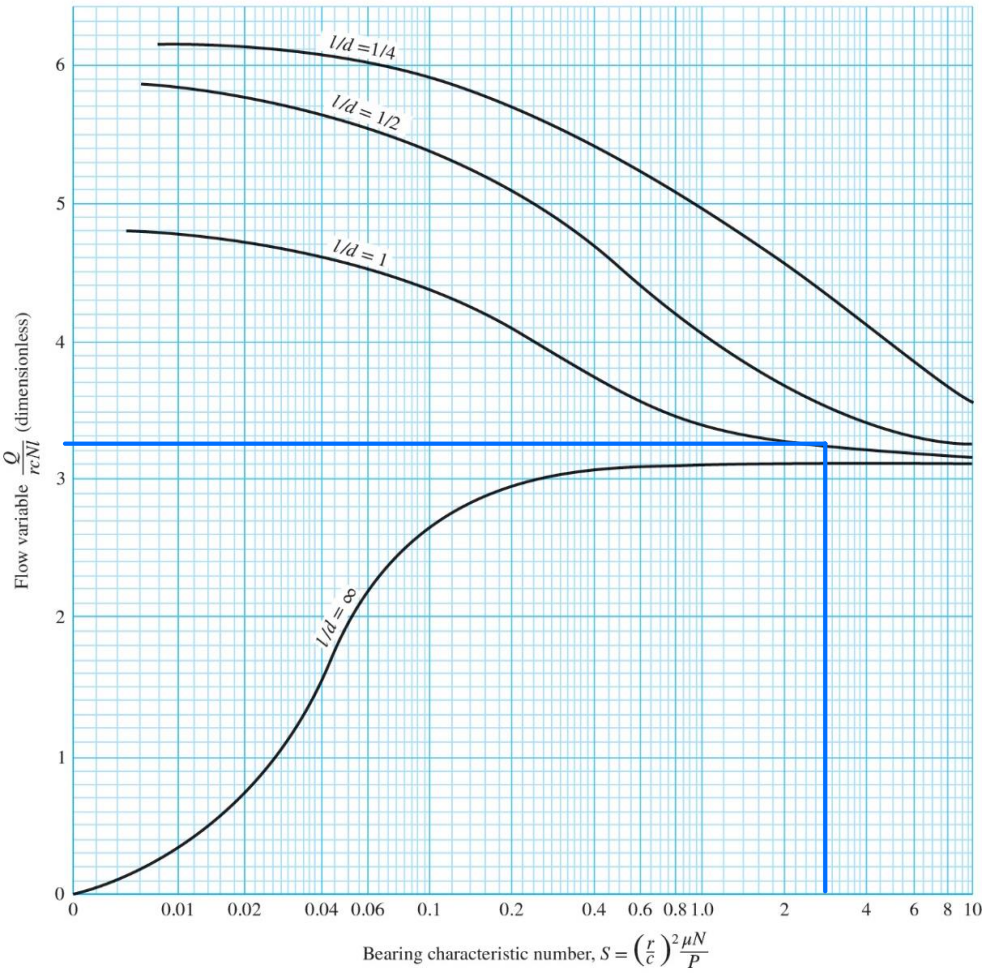


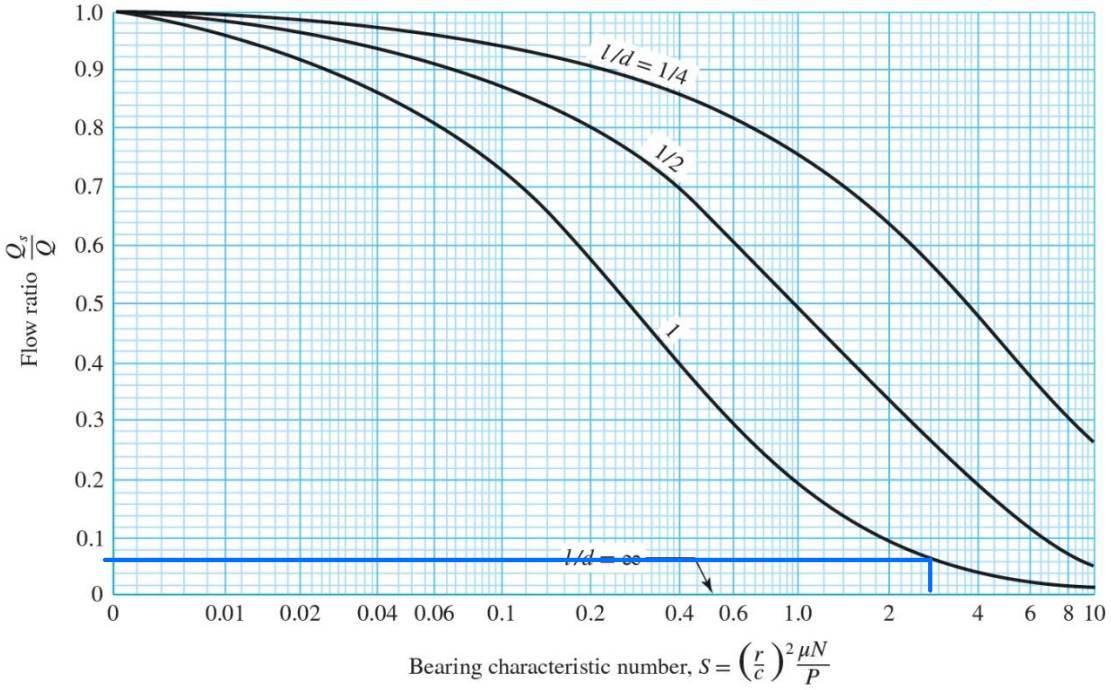


(c) $\frac{l}{d} = \frac{2.0\text{ in}}{2.25\text{ in}} \cong 1$

$\frac{h_0}{c} \approx 0.95 \Rightarrow h_0 = 0.95(0.0025\text{ in})$

$\boxed{h_0 = 0.002375\text{ in}}$


l/d = 1/4
l/d = 1/2
l/d = 1
l/d = ∞
Flow variable $\frac{Q}{rcNl}$ (dimensionless)
0
1
2
3
4
5
6
0
0.01
0.02
0.04
0.06
0.1
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
Bearing characteristic number, $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$


l/d = 1/4
1/2
1
l/d = ∞
Flow ratio $\frac{Q_s}{Q}$
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
0.01
0.02
0.04
0.06
0.1
0.2
0.4
0.6
1.0
2
4
6
8
10
Bearing characteristic number, $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$

BONUS: $\frac{Q}{rcNl} = 3.25$ USING FIGURE ABOVE

$$\Rightarrow Q = 3.2(1.125\ in)(0.0025\ in)\left(15\ \tfrac{rev}{s}\right)(2\ in)$$

$$Q = 0.27\ in^3/s$$

$$\frac{Q_s}{Q} = 0.06 \quad \text{USING FIGURE ABOVE}$$

$$\Rightarrow Q_s = 0.06(0.27\ in^3/s)$$

$$\boxed{Q_s = 0.0162\ in^3/s}$$