315 THEORY OF MACHINES – DESIGN OF ELEMENTS

Fall, 2023

HW No. 8

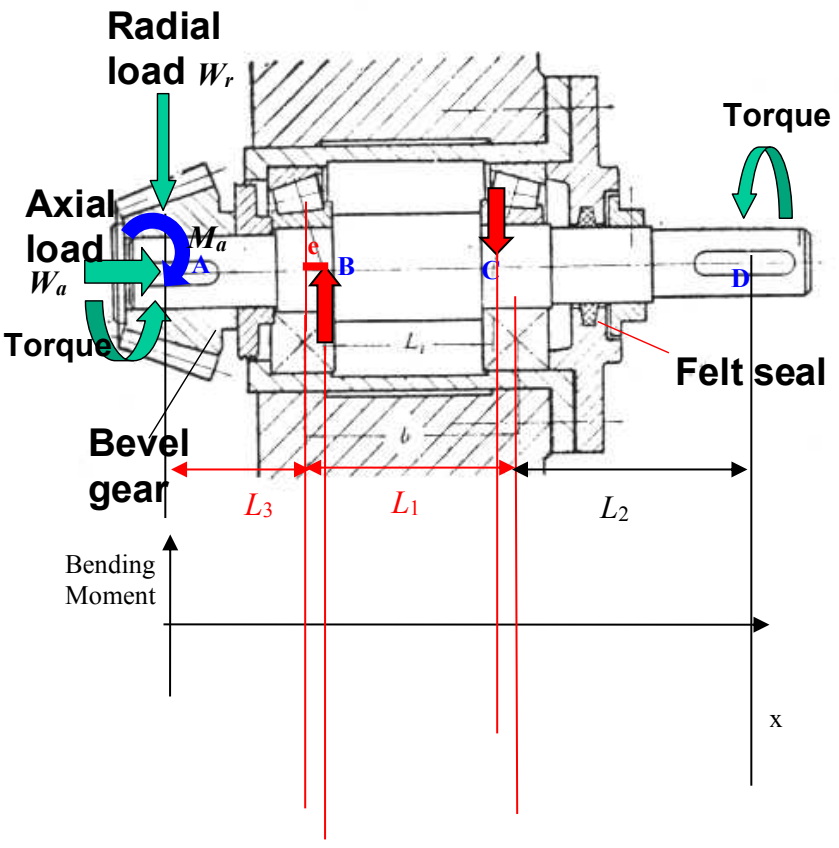
Assigned: 11/9 Due: one week, 11/16, online, pdf in **one single file**.

Typed or written clearly

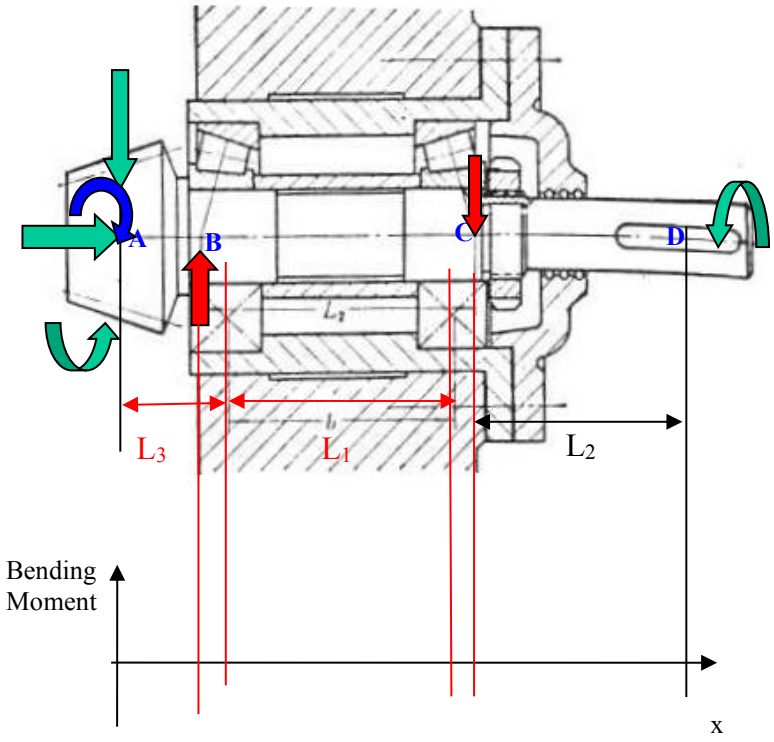
1. (20 points) From the class example we know that the cantilever length of a cantilever beam is important because it determines the maximum bending moment in the beam. Each of the cantilever beam design below uses a pair of Timken ISO 355 tapered-roller bearings of the same size. The bevel gear pitch-circle radius is R =20mm at the location of gearing load application. Compare (I) face-to-face and (II) back-to-back designs, where L_1=40mm, L_2 = 60mm, and L_3=20mm. The forces on the shaft due to the bevel gear are the total radial force, W_r=F (N), the axial force, W_a (which is about F/2 for the current cases), the bending moment due to the axial gear force (which is M_a=W_a*R=0.01F (Nm) for the current design), and the torque, T. Note that the bearing reaction forces are NOT at the centers of the bearing width; rather, they are offset by e=5mm. Forces/torques/moment on the shaft are shown in the diagrams below, please

1) Determine the maximum bending moments in both designs and plot the moment diagrams without solving the reaction forces.
2) Which design has larger radial reaction forces at B and C? No need to calculate.
3) Which design is more reasonable in terms of mechanics?

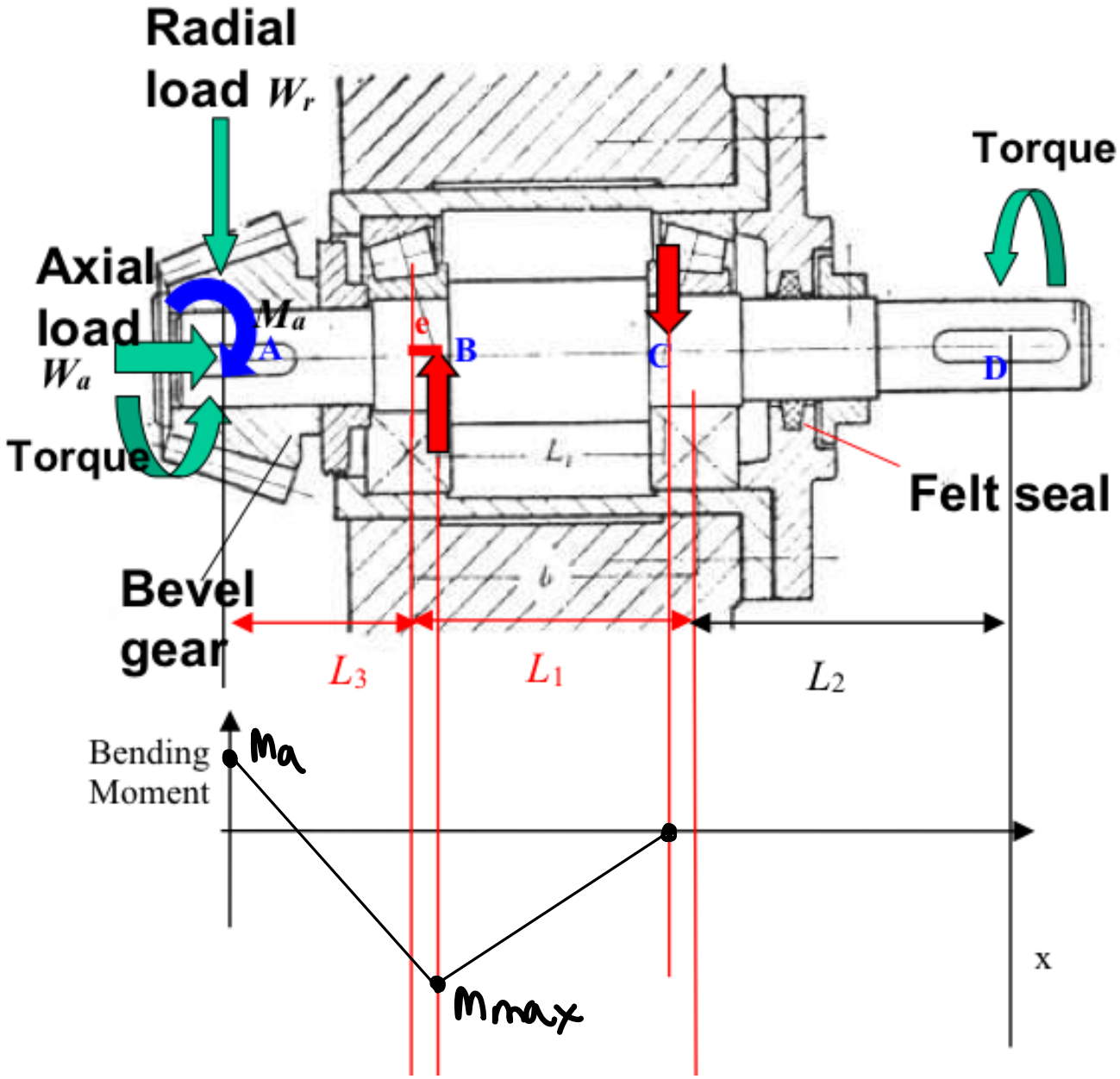
Design (I)



Design (II)



Design (I)



$L_2 = 60\,mm$ $L_1 = 40\,mm$
$L_3 = 20\,mm$

$R = 20\,mm$

$W_r = F$

$W_a = F/2$

$M_a = W_a R = 0.01F$

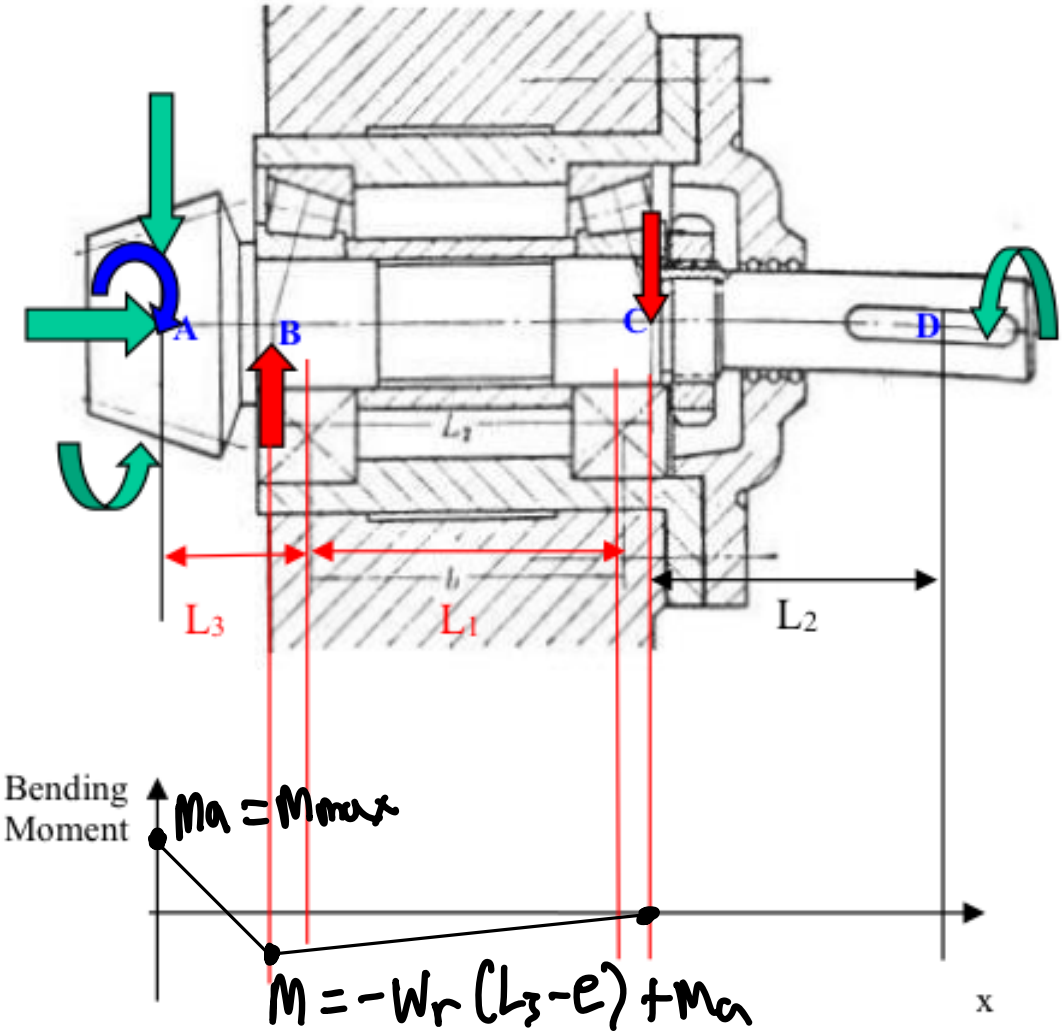
$e = 5\,mm$

$$M_{max} = -W_r(L_3 + e) + M_a$$

$$= -F(0.02 + 0.005) + 0.01F$$

$$\boxed{= -0.015F\ Nm}$$

Design (II)



$M = -W_r (L_3 - e) + M_a$

$= -F(0.02 - 0.005) + 0.01F$

$= -0.005F$ Nm

$M_{max} = 0.01F$ Nm

2. DESIGN 1 HAS LARGER REACTION FORCES AT B AND C. AT B, THE MOMENT IS LARGER IN DESIGN 1 THAN 2, THUS THE RADIAL FORCE @B MUST BE LARGER. AT C, THE RADIAL FORCE IS LARGER IN DESIGN 1 BECAUSE THERE IS LESS LEVERAGE (LENGTH BC IS SHORTER) TO OFFSET THE LARGE MOMENT @ B.

3. DESIGN 2 IS MORE REASONABLE IN TERMS OF MECHANICS BECAUSE M_{max} IS SMALLER FURTHERMORE THE RADIAL FORCES ON THE BEARINGS ARE LESS.

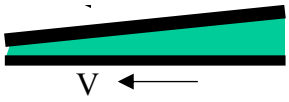
THE CRITICAL POINTS OF DESIGN 1 ARE @ A AND @ B CONSIDERING SHAFT DIAMETER AND BENDING MOMENTS

THE CRITICAL POINT OF DESIGN 2 IS @ B BECAUSE IT HAS THE SMALLEST SHAFT DIAMETER.

THERE ARE FEWER CRITICAL POINTS ON DESIGN 2.

2. Short questions (5 points each, totally 20 points)

1) Can hydrodynamic pressure be generated at the fluid-filled interface shown below, where the bottom surface moves left as indicated by the arrow, the top surface is stationary.

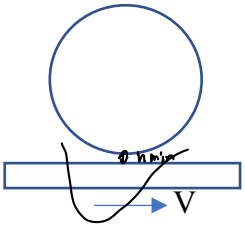


(a) Yes (b) No

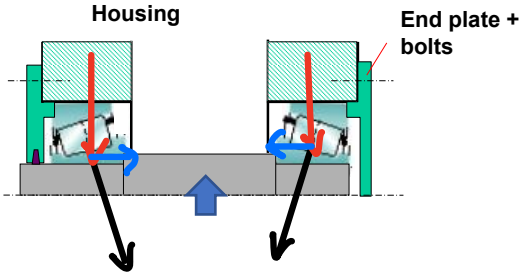
2) Under the same load and speed, and using the same lubricant (oil), a wider (longer) journal bearing runs with a _____ oil film between the surfaces of the shaft and the bearing if the lubricant supply is sufficient?

a) Thicker b) Thinner

3) In the figure below, the roller is stationary while the flat surface is moving to the right, sketch the lubrication pressure distribution at their interface assuming a lubricant is used.

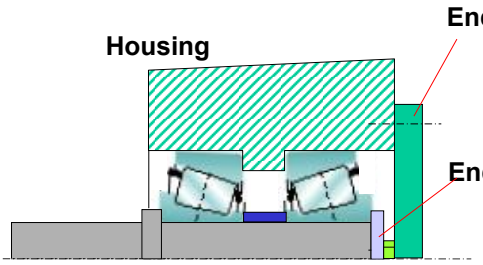


4) The shaft is loaded in the middle, please mark below the forces on the inner rings of the bearings. (only the top half is shown)



INDUCED , RADIAL

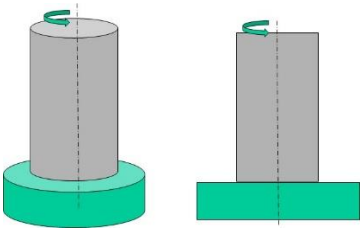
5. The sectional view below shows two bearing in a shaft system (only the top half is plotted). Any mistake(s)? Please mark the mistake(s) and explain the reason briefly.



ADD CLEARANCE BETWEEN BOLT HEAD AND END CAP BECAUSE TWO DISTINCT ROTATING ELEMENTS.
MAKE SHAFT SHORTER AT END PLATE, TO CLAMP ONTO BEARING INNER RING.

6). Which one cannot take axial loading?

7) In the figure below, the grey cylinder rotates about its centerline and on top of the green plate, both are oiled. Their side view is also given. Please mark, on the side view, the oil pressure distribution and explain why.



NO PRESSURE
IF NO WEDGE

8). Bearings 6208 and 6408 have the same bore diameter (True/False) and the same bearing width (True/False); their bore diameters *are:*

6208: d = 40 mm
W = 18 mm

6408: d = 40mm
w = 27mm