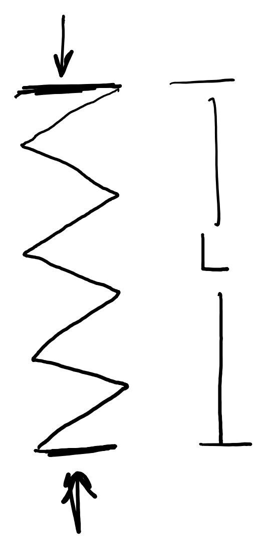
- Review of spring design
- spring buckling check
- MIDTERM exam will only cover WELDS & SPRINGS
- Placed exercise problems to prepare for exam
  - Problems will be solved next Monday in class
- Design of Rolling-element bearings

Spring buckling (instability)

Springs can buckle in the same way beams under axial load can buckle



Condition for stability

$$L_0 < \underbrace{\frac{\pi D}{\alpha}}_{\text{geometry}} \underbrace{\sqrt{\frac{2(E-G)}{2G+E}}}_{\text{material}}$$

for Steel

$$L_0 < 2.63 \frac{D}{\alpha}$$

$D \equiv$ mean coil diameter

$\alpha \equiv$ end condition

$\alpha = 0.5$ for flat parallel surfaces

$L_0 < 5.26\, D$ Condition for stability (steel- fixed ends)

<u>For Small Spring</u>

$L_0 = 42^{mm}$

$D = 5.5^{mm}$

$\Rightarrow 5.26D = 29^{mm}$

$L_0 > 5.26D \Rightarrow$ buckles

For the larger Spring

$L_0 = 102^{mm}$

$D = 29^{mm}$

$\Rightarrow 5.26(D) = 152^{mm}$

$L_0 < 5.26D \Rightarrow$ stable

Applied moment

$M_A = FL$

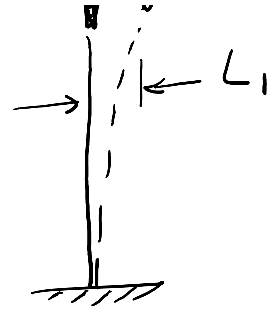
Applied moment

Applied moment

$M_A = 0$

after moving it by hand

$M_A = F L_1$



Design of Ball / Roller bearings

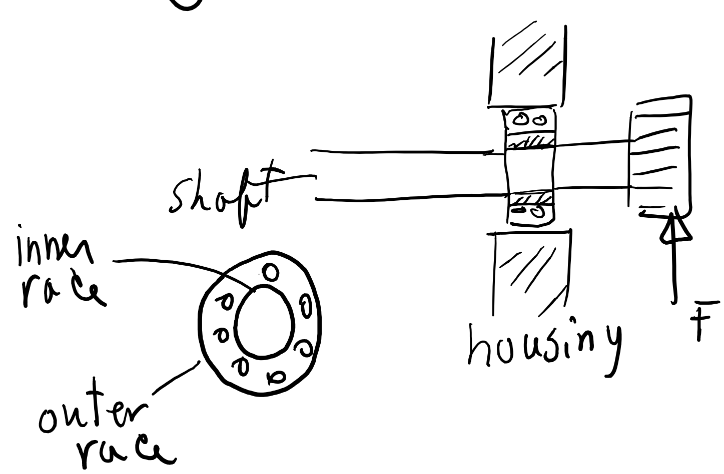
- If you follow my notes, the chapter is very easy
- If you read the book, the chapter is very hard

Scope:

- Ball / Roller bearings
- Constant loads

What parameters are necessary to select a bearing (Givens)

- Radial load $\equiv F_R$
- Life in Cycles $\equiv L$
- Reliability $\equiv R$



(Given … radial load)

Given
- F_R (application radial load)
- L (application life
- R (" reliability)

Find suitable bearing

We select bearings base on manufacturer's bearing capacity catalogs)

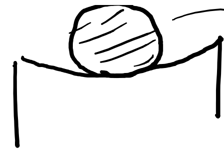
. Catalogs are tabulated based on Radial loads (capacities) for a Particular life (10^6 is most common) and 90% reliability

$L_{catalog} \equiv L_{10}$ (usually 1 million cycles)

$Capacity \equiv C_{10}$ (Radial load Capacity)

$R = 90\%$ (0.90)

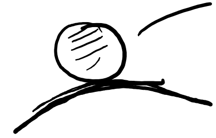
Life-load relationship for ball-bearings [based on contact stresses and fatigue theory) or $FL^{0.333} = cte$



ball

For Roller bearings

$$FL^{0.3} = cte$$



Cylinder

Q: If a ball-bearing life is to be doubled, by factor the application radial load should be reduced for the same reliability

$$F_1 L_1^{0.333} = F_2 L_2^{0.333}$$

if $L_2 = 2L_1$

$$\Longrightarrow \quad F_2 = \frac{F_1}{1.26}$$

Q: If ball bearing load is doubled, by what factor life needs to be reduced for the same reliability

$$F_1 L_1^{0.333} = F_2 L_2^{0.333}$$

$F_2 = 2F_1$

$$\Longrightarrow L_2 = \frac{L_1}{8}$$

Q: In an application $F_0 = 150$ lbs, the application factor is 1.4 (overload factor), the life is 1 million, and reliability is 90%. using the sample page from Catalog in the book, find suitable bearing size (Series II deep groove bearing)

$F_R = 150$ lbs

$K_a = 1.4$

$C_{10,min} = (1.4)(150) = 210$ lbs

$C_{10,min} = 210 \underbrace{(4.45)}_{lbs \rightarrow N} = 934.5$ N

$C_{10,min} = 0.93$ KN

From Catalog

$C_{10,selected} = 5.07$ KN

Bore size $= 10$ mm

Q: Suppose $F_R = 500$ lbs, $K_a = 1.4$ and

$L \equiv 8$ hrs per day for 1 year

@ 1000 rpm

$R = 90\%$

Find: Suitable ball bearing (deep groove)
Series-II

$$L = 8(60)(1000)(365) = 175.2 * 10^6 \text{ cycles}$$

$$C_{10,min} = K_a F_R \underbrace{\left(\frac{L}{L_{10}}\right)^{0.333}}_{\text{Converts additional life to additional capacity}}$$

$$C_{10,min} = (1.4)(500 * 4.45)\underbrace{\left(\frac{175.2 * 10^6}{10^6}\right)^{0.333}}_{5.59}$$

$$C_{10,min} = 17412.8 \text{ N}$$

$$C_{10,min} = 17.4 \text{ KN}$$

From Catalog

$C_{10,sel} = 19.5$ KN   Bore $= 30$ mm

What Does this mean:

If I test a large number of these bearing with the given radial load, after 175.2 million cycles, 90% of the bearing show no sign of damage

- The standar organization for bearings is ABMA

American Bearing Manufacturer's Association

Q: A ball bearing load of 150 lbs, Application factor of 1.4. life of 50 million cycles and reliability of 95%. Select a suitable deep groove ball bearing (Series-II)

Process

$$R \longrightarrow \underbrace{x}_{\text{life divider}} \longrightarrow \underbrace{\frac{L}{x}}_{\text{life adjusted for reliability}} \longrightarrow C_{10,min}$$

where is this

(Excel file from class web site)

$$\boxed{C_{10,min} = K_a F_R \left(\frac{L/x}{L_{10}}\right)^{0.333}}$$

fror roller bearings

$$\boxed{C_{10,min} = K_a F_R \left(\frac{L/x}{L_0} \right)^{0.3}}$$