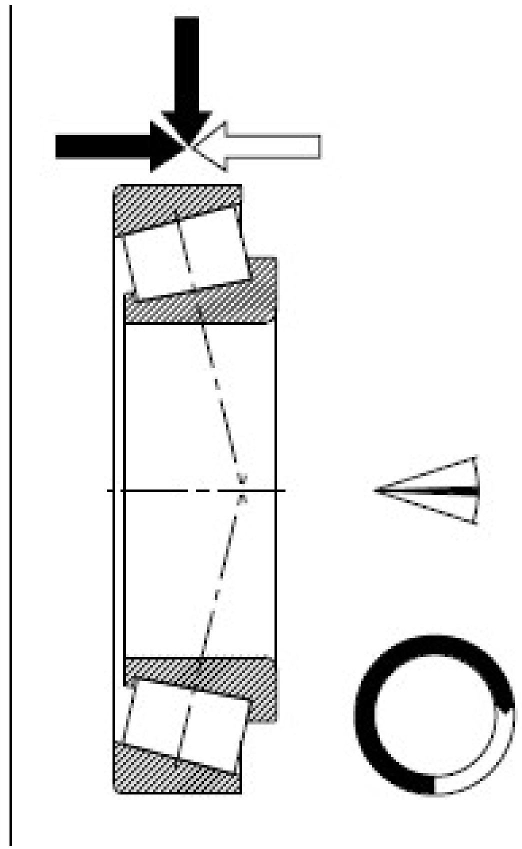
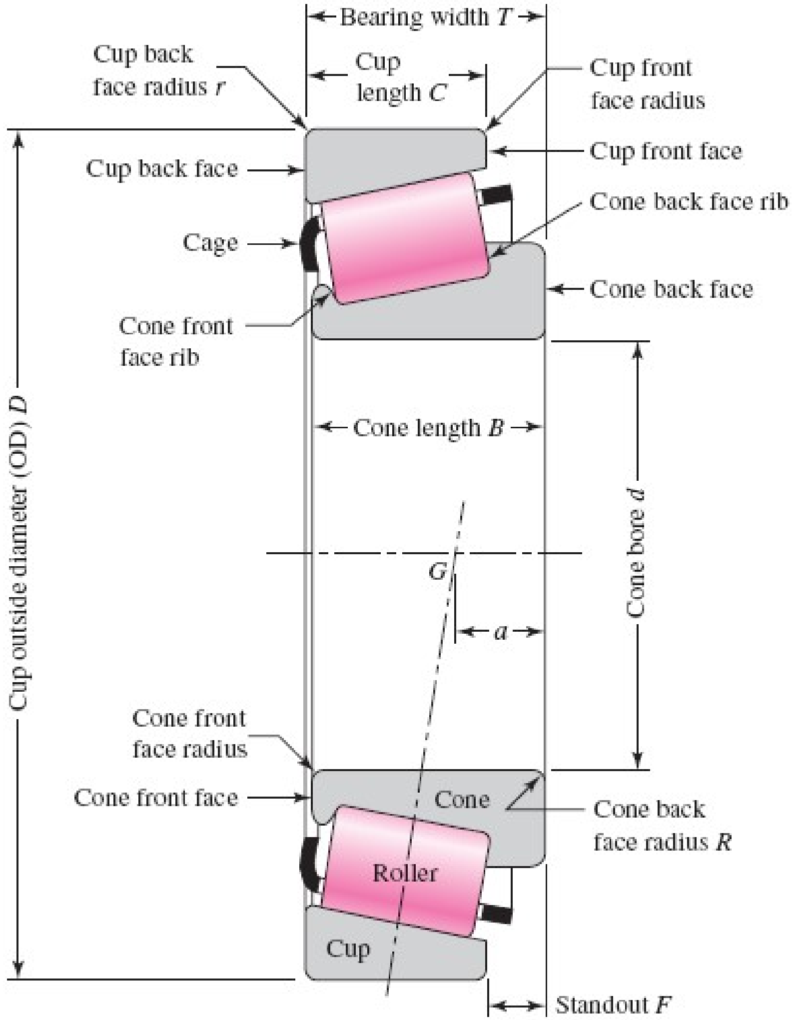
Due to their contact angle (5...28°), tapered roller bearings can accommodate both radial and axial loads



Selection of Tapered Roller Bearings

The four components of a tapered roller bearing assembly are the
- Cone (inner ring)
- Cup (outer ring)
- Tapered rollers
- Cage (spacer-retainer



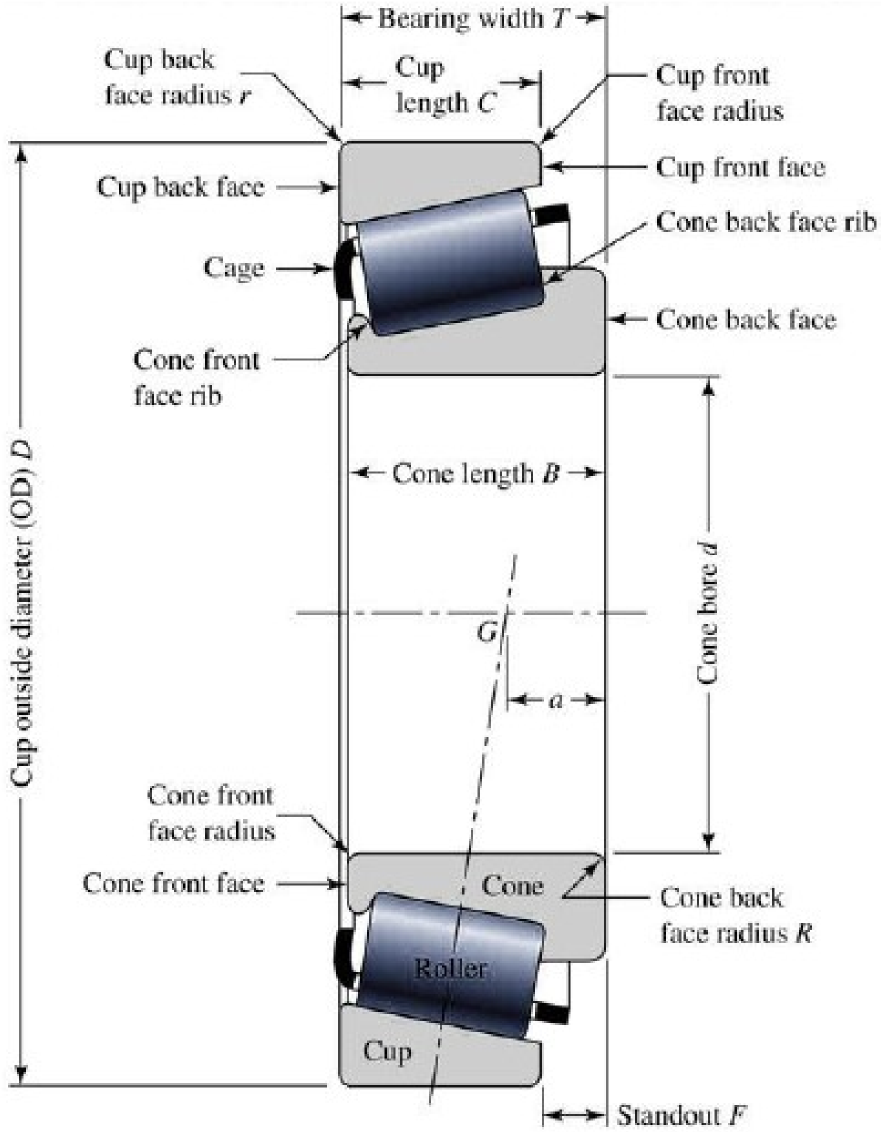
Four Components:

◆Cone (inner ring)

◆Cup (outer ring)-
sliding surface

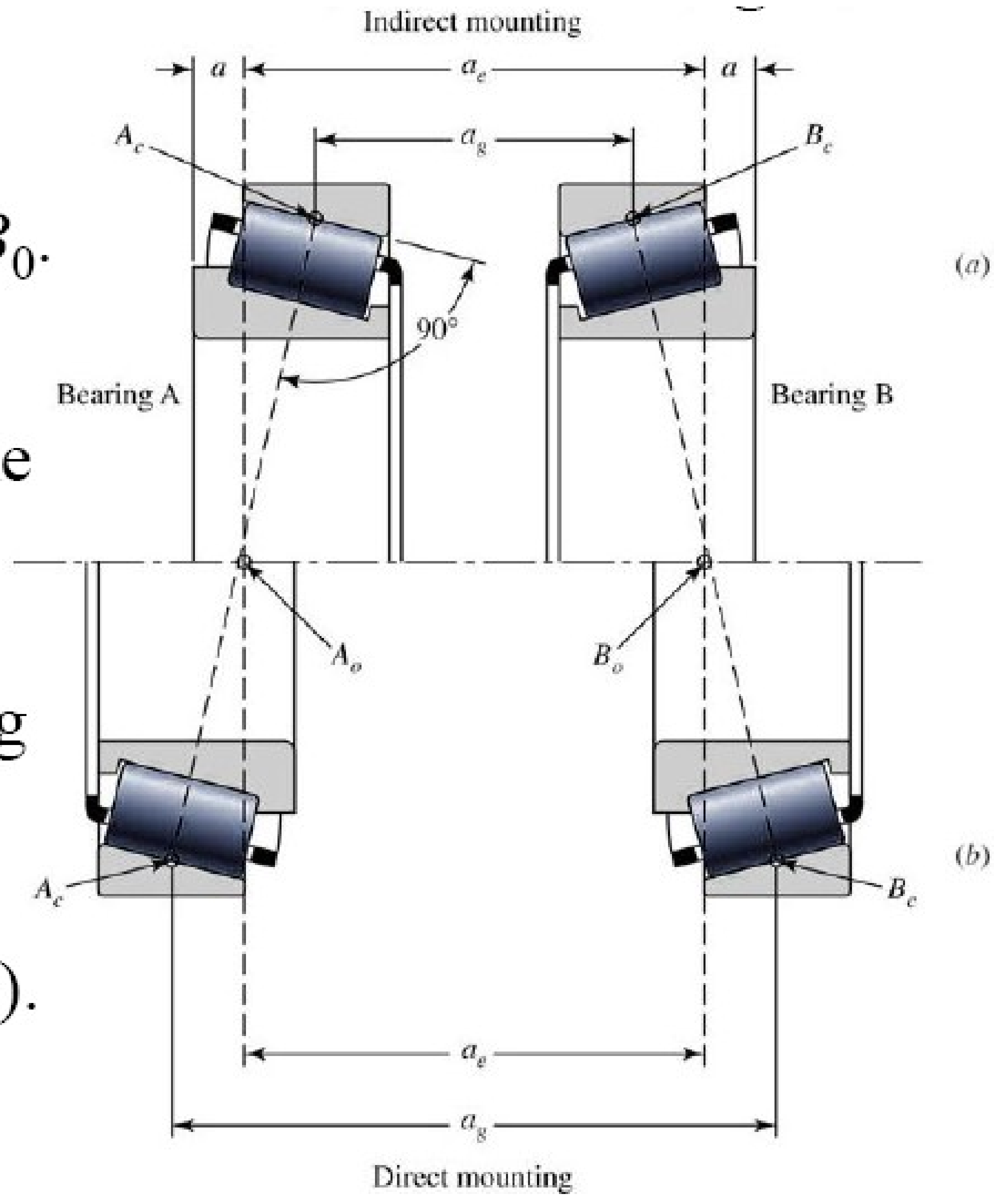
◆Tapered rollers

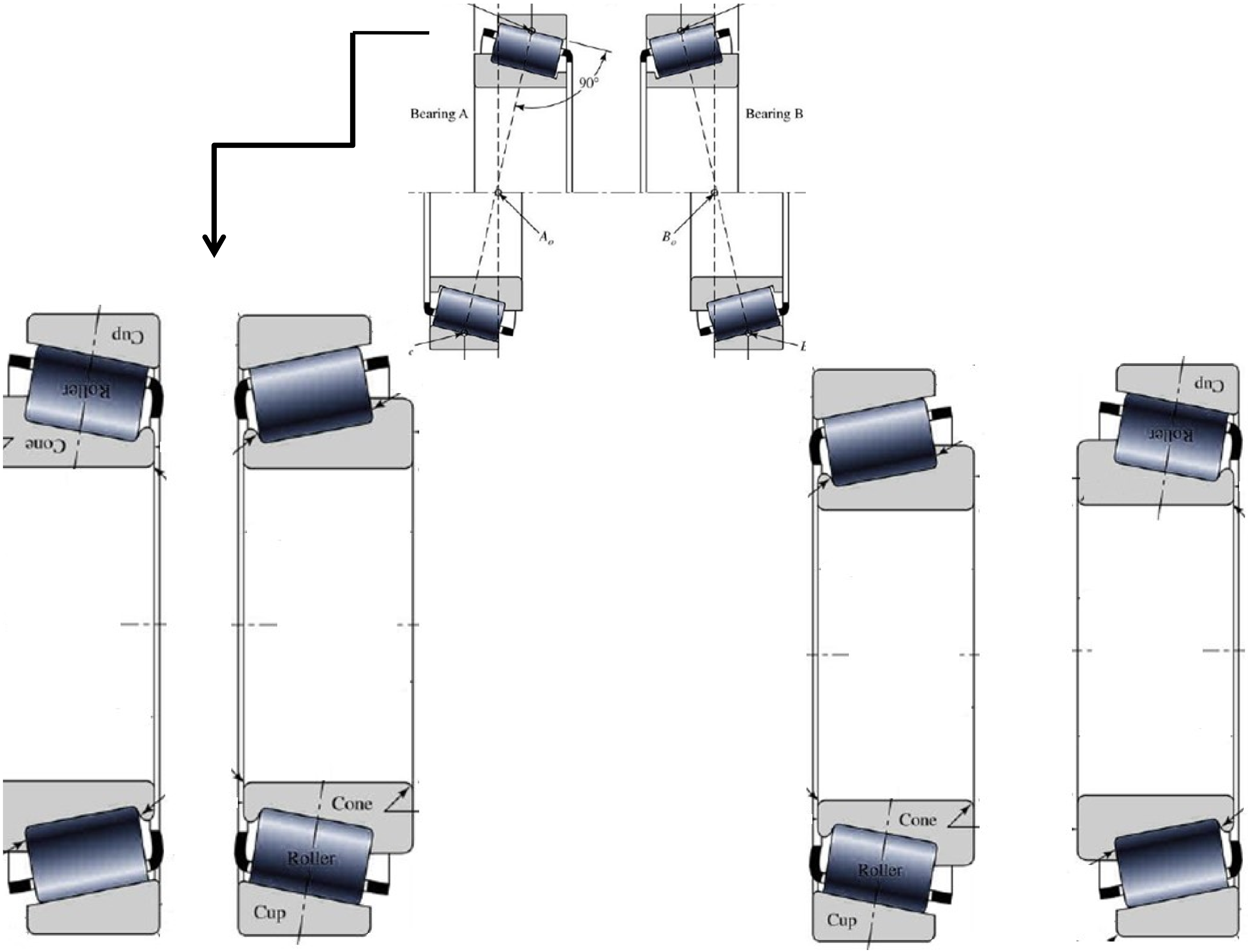
◆Cage (spacer, retainer)



◆The radial loads act perpendicular to the shaft axis through points A_0 and B_0.

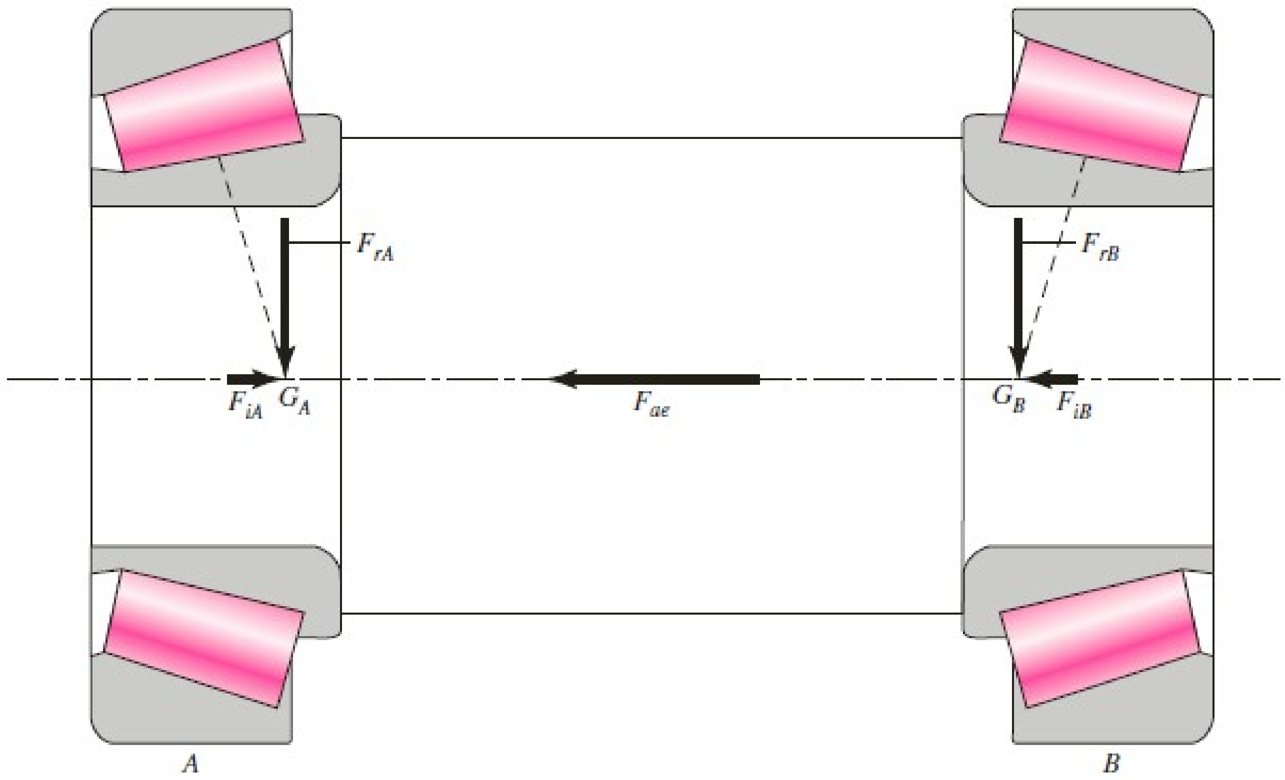
◆The geometric spread a_g for the direct mounting (cone backs facing each other) is greater than for indirect mounting (cone fronts facing each other), however, the system stability is the same (a_e is the same in both cases).



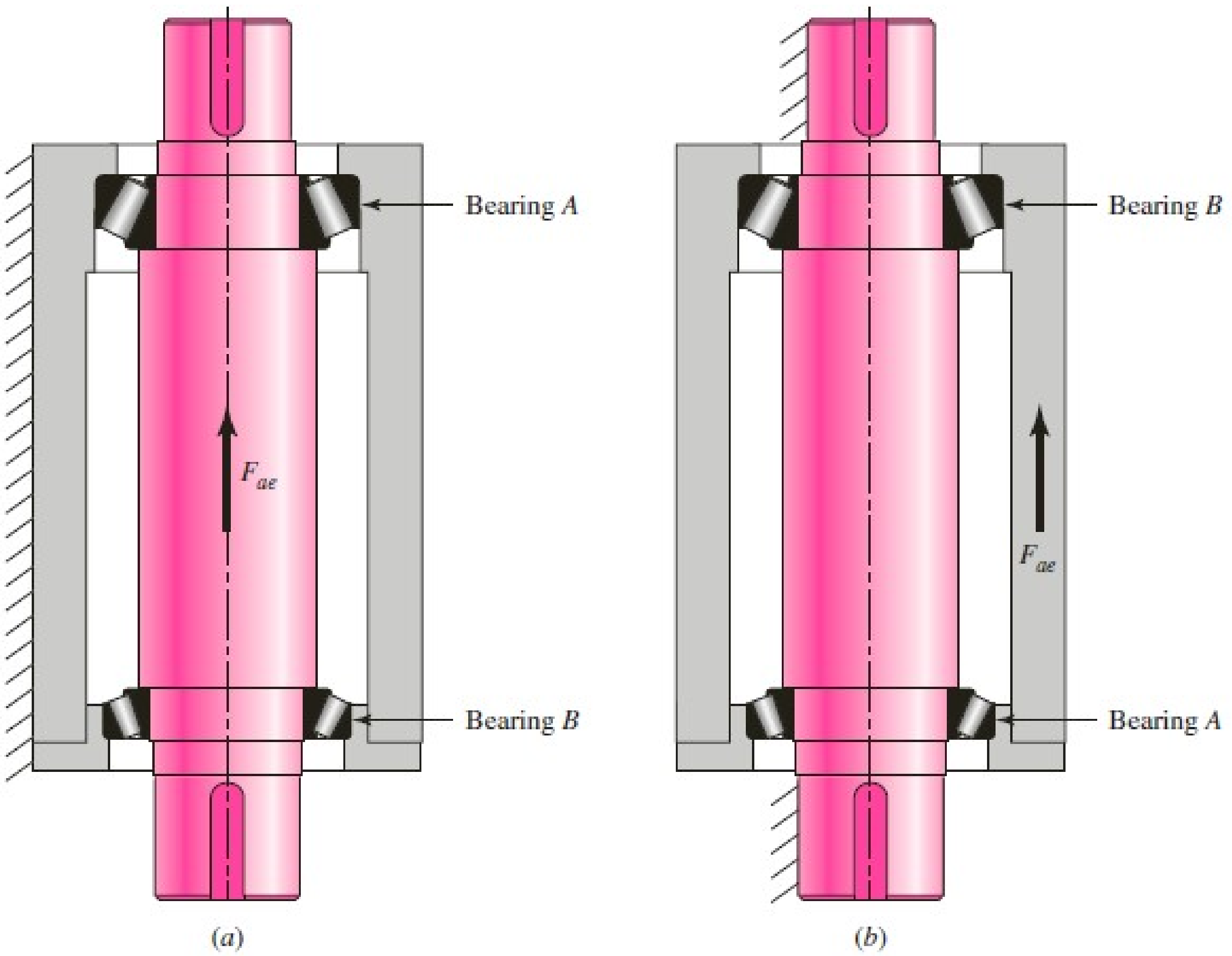


Bearing A
90°
Bearing B
A_o
B_o
Cup
Roller
Cone
Cone
Roller
Cup
Cone
Roller
Cup
Cup
Roller

Direct-mounted tapered roller



First, determine visually which bearing is being “squeezed” by the external thrust load, and label it as bearing *A*



A radial load will induce a thrust reaction.
The load zone includes about half the rollers and subtends an angle of approximately 180°.

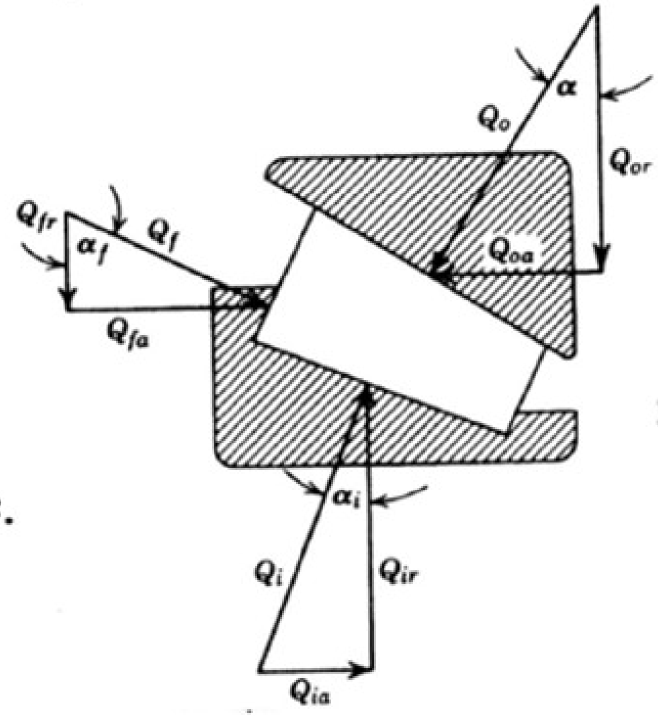
Using the symbol F_i for the induced thrust load from a radial load with a 180° load zone, Timken provides

$$F_i = \frac{0.47 F_r}{K} \qquad (11\text{-}15)$$

where K is a geometric factor

$K = 0.389 \cot\alpha$

where α is half the included cup angle.



The *K factor can be first approximated with 1.5 for a radial* bearing and 0.75 for a steep angle bearing

Second,

- If the effective radial load is less than the actual radial load, use the actual load

$$If\ F_{iA} \le (F_{iB} + F_{ae}) \left\{ \begin{aligned} F_{eA} &= 0.4F_{rA} + K_A\left(\frac{0.47F_{rB}}{K_B} + F_{ae}\right) \\ F_{eB} &= F_{rB} \end{aligned} \right\}$$

$$if\ F_{iA} \ge (F_{iB} + F_{ae}) \left\{ \begin{aligned} F_{eB} &= 0.4F_{rB} + K_B\left(\frac{0.47F_{rA}}{K_A} - F_{ae}\right) \\ F_{eA} &= F_{rA} \end{aligned} \right\}$$

$$C_{10} \cong F_D \left(\frac{x_D}{x_0 + (\theta - x_0)(1 - R_D)^{1/b}} \right)^{1/a} \quad \text{or}$$

$$x_D = x_0 + (\theta - x_0)\,(1 - R_D)^{1/b} \left(\frac{C_{10}}{F_D} \right)^{a}$$

Timken uses a two-parameter Weibull model with $x_0 = 0$, $\theta = 4.48$, and $b = 3/2$.

For a Timken tapered roller bearing with $a = 10/3$, and $L_{10} = 90 \cdot 10^6$ revolutions

$$x_D = L_D / 90 \cdot 10^6 = 4.48\,(1 - R_D)^{2/3} \left(\frac{C_{10}}{F_D} \right)^{10/3}$$

$$L_D = 4.48\,(1 - R_D)^{2/3} \left(\frac{C_{10}}{F_D} \right)^{10/3} 90 \cdot 10^6$$

- The catalog rating C_{10} corresponding to 90% reliability.

- The subscript 10 denoting 10% failure level.

- Timken denoted its catalog rating as C_{90}, the subscript 90 standing for at 90 million revolutions.

- The failure fraction is still 10% (90% reliability) where F_D is the dynamic equivalent load of the combination F_r and F_a

The particular values of X and Y are According to Timken

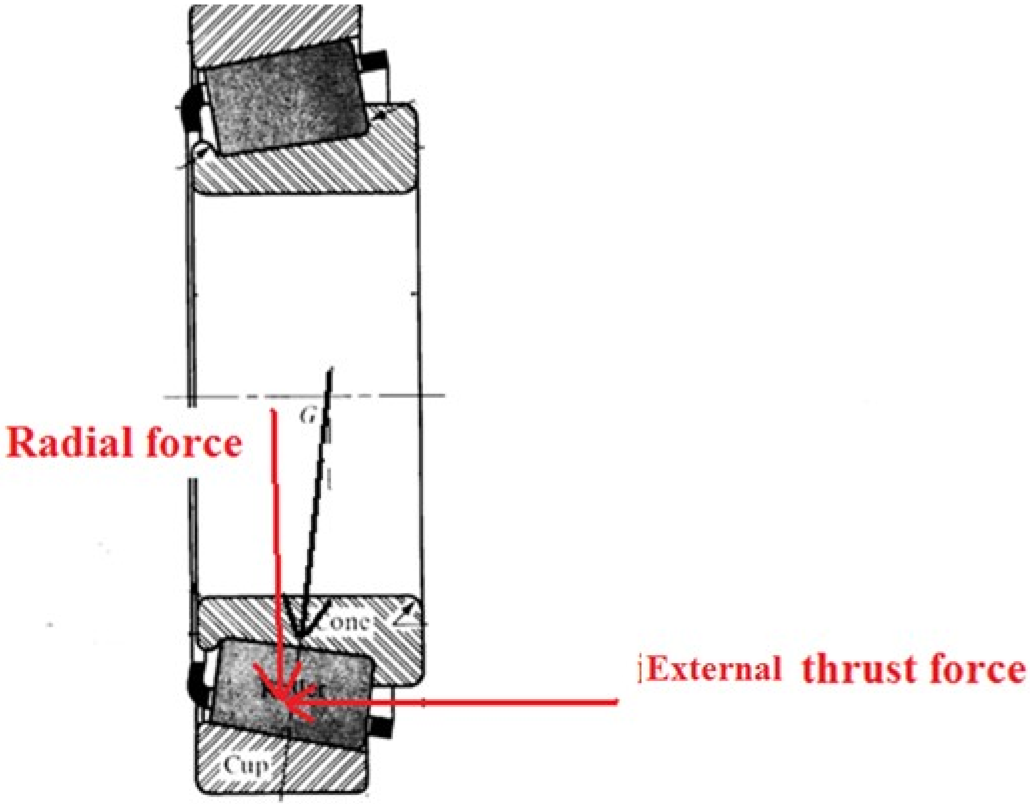
X=0.4, V=1 for all cases and Y=K

Fe=0.4Fr+KFa

$$F_{eA} = 0.4F_{rA} + K_A F_{aA}$$

$$F_{eB} = 0.4F_{rB} + K_B F_{aB}$$

Bearing A induces thrust on B and vice versa



G
Radial force
Cone
Cup
External thrust force

The shaft depicted in Fig. 11-18a carries a helical gear with a tangential force of 3980 N, a separating force of 1770 N, and a thrust force of 1690 N at the pitch cylinder with directions shown.

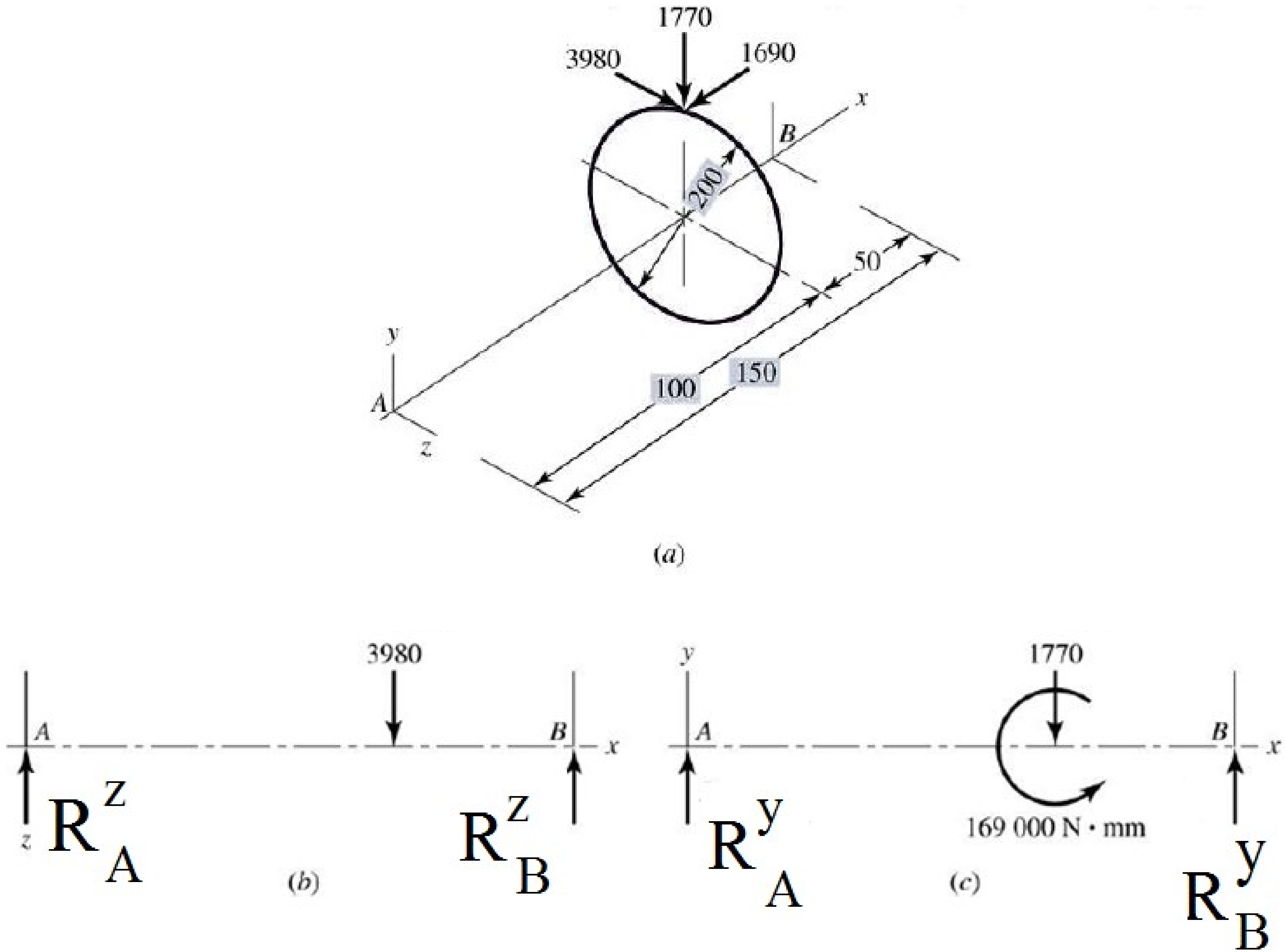
The pitch diameter of the gear is 200 mm.

The shaft runs at a speed of 800 rpm, and the span (effective spread) between the *direct-mount* bearings is 150 mm.

The design life is to be 5000 h and an application factor of 1 is appropriate.

The lubricant will be ISO VG 68 (68 cSt at 40 °C) oil with an estimated operating temperature of 55 °C.

If the reliability of the bearing set is to be 0.99, select suitable single-row tapered-roller Timken bearings.



1770
3980
1690
x
B
200
50
y
A
z
100
150
3980
A
B
x
z
R_A^z
R_B^z
y
1770
A
B
x
169 000 N · mm
R_A^y
R_B^y

(a)

(b)

(c)

$$R_A^z = \frac{3980(50)}{150} = 1327\text{ N}$$

$$R_B^z = \frac{3980(100)}{150} = 2653\text{ N}$$

The reactions in the *xy* plane are

$$R_A^y = \frac{1770(50)}{150} + \frac{1690(100)}{150} = 1717\text{ N}$$

$$R_B^y = \frac{1770(100)}{150} - \frac{1690(100)}{150} = 53.3\text{ N}$$

$$F_{rA} = \left(R_{zA}^2 + R_{yA}^2\right)^{1/2} = \left(1327^2 + 1717^2\right)^{1/2} = 2170\text{ N}$$

$$F_{rB} = \left(R_{zA}^2 + R_{yA}^2\right)^{1/2} = \left(2653^2 + 53.3^2\right)^{1/2} = 2654\text{ N}$$

Trial 1: For the left bearing, we will use $K_A = K_B = 1.5$ to start.

for direct mounting and F_{ae} to the right is positive

$$\frac{0.47F_{rA}}{K_A} <?> \frac{0.47F_{rB}}{K_B} + F_{ae}$$

$$\frac{0.47(2170)}{1.5} <?> \frac{0.47(2654)}{1.5} + (1690)$$

$$680 < 2522$$

Therefore, we use the upperset of equations to find the thrust loads :

The dynamic equivalent F_{eA} and F_{eB} are

$$F_{eA} = 0.4F_{rA} + K_A F_{aA} = 0.4(2170) + 1.5(2522) = 4651\ \text{N}$$

$$F_{eB} = F_{rB} = 2654\ \text{N}$$

$$\textit{If}\ F_{iA} \le (F_{iB} + F_{ae}) \begin{cases} F_{eA} = 0.4F_{rA} + K_A\left(\frac{0.47F_{rB}}{K_B} + F_{ae}\right) \\ F_{eB} = F_{rB} \end{cases}$$

$$\textit{if}\ F_{iA} \ge (F_{iB} + F_{ae}) \begin{cases} F_{eB} = 0.4F_{rB} + K_B\left(\frac{0.47F_{rA}}{K_A} - F_{ae}\right) \\ F_{eA} = F_{rA} \end{cases}$$

Estimate R_D as $\sqrt{0.99} = 0.995$ for each bearing.

For bearing A, the catalog entry C_{10} should equal or exceed

$$C_{10} = (1)(4651)\left[\frac{5000(800)60}{4.48\cdot(1-0.995)^{2/3}(90\cdot 10^6)}\right]^{3/10} = 11486\ \text{N}$$

select 15100 cone and 15245 cup, which will work:

$K_A = 1.67,\ C_{10} = 12100\ \text{N}$

For bearing B, the catalog entry C_{10} should equal or exceed

$$C_{10} = (1)(2654)\left[\frac{5000(800)60}{4.48\,(1-0.995)^{2/3}(90\cdot 10^6)}\right]^{3/10} = 6554\ \text{N}$$

Tentatively select the bearing identical to bearing A, which will work:

$K_B = 1.67,\ C_{10} = 12100\ \text{N}$

SINGLE-ROW STRAIGHT BORE

									cone				cup			
bore	outside diameter	width	rating at 500 rpm for 3000 hours L_{10}		factor	eff. load center	part numbers		max shaft fillet radius	width	backing shoulder diameters		max housing fillet radius	width	backing shoulder diameters	
			one-row radial	thrust			cone	cup								
d	D	T	N lbf	N lbf	K	a②			R①	B	d_b	d_a	r①	C	D_b	D_a
25.400 1.0000	**60.325** 2.3750	**19.842** 0.7812	**11000** 2480	**6550** 1470	**1.69**	**−5.1** −0.20	**15578**	**15523**	**1.3** 0.05	**17.462** 0.6875	**32.5** 1.28	**30.5** 1.20	**1.5** 0.06	**15.875** 0.6250	**51.0** 2.01	**54.0** 2.13
25.400 1.0000	**61.912** 2.4375	**19.050** 0.7500	**12100** 2730	**7280** 1640	**1.67**	**−5.8** −0.23	**15101**	**15243**	**0.8** 0.03	**20.638** 0.8125	**32.5** 1.28	**31.5** 1.24	**2.0** 0.08	**14.288** 0.5625	**54.0** 2.13	**58.0** 2.28
25.400 1.0000	**62.000** 2.4409	**19.050** 0.7500	**12100** 2730	**7280** 1640	**1.67**	**−5.8** −0.23	**15100**	**15245**	**3.5** 0.14	**20.638** 0.8125	**38.0** 1.50	**31.5** 1.24	**1.3** 0.05	**14.288** 0.5625	**55.0** 2.17	**58.0** 2.28

Trial 2:

Use $K_A = K_B = 1.67$ from the tentative bearing selection.

$$\frac{0.47F_{rA}}{K_A} <?> \frac{0.47F_{rB}}{K_B} + F_{ae}$$

$$\frac{0.47(2170)}{1.67} <?> \frac{0.47(2654)}{1.67} + 1690$$

$$611 < 2437$$

The dynamic equivalent P_A and P_B are

$$F_{eA} = 0.4F_{rA} + K_A F_{aA} = 0.4(2170) + 1.67(2437) = 4938\text{N}$$

$$F_{eB} = F_{rB} = 2654\text{ N}$$

For bearing A,

$$C_{10} = (1)(4938)\left[\frac{5000(800)60}{4.48\cdot(1-0.995)^{2/3}(90\cdot 10^6)}\right]^{3/10} = 12195\text{ N}$$

Although this catalog entry exceeds slightly the tentative selection for bearing A we will keep it.

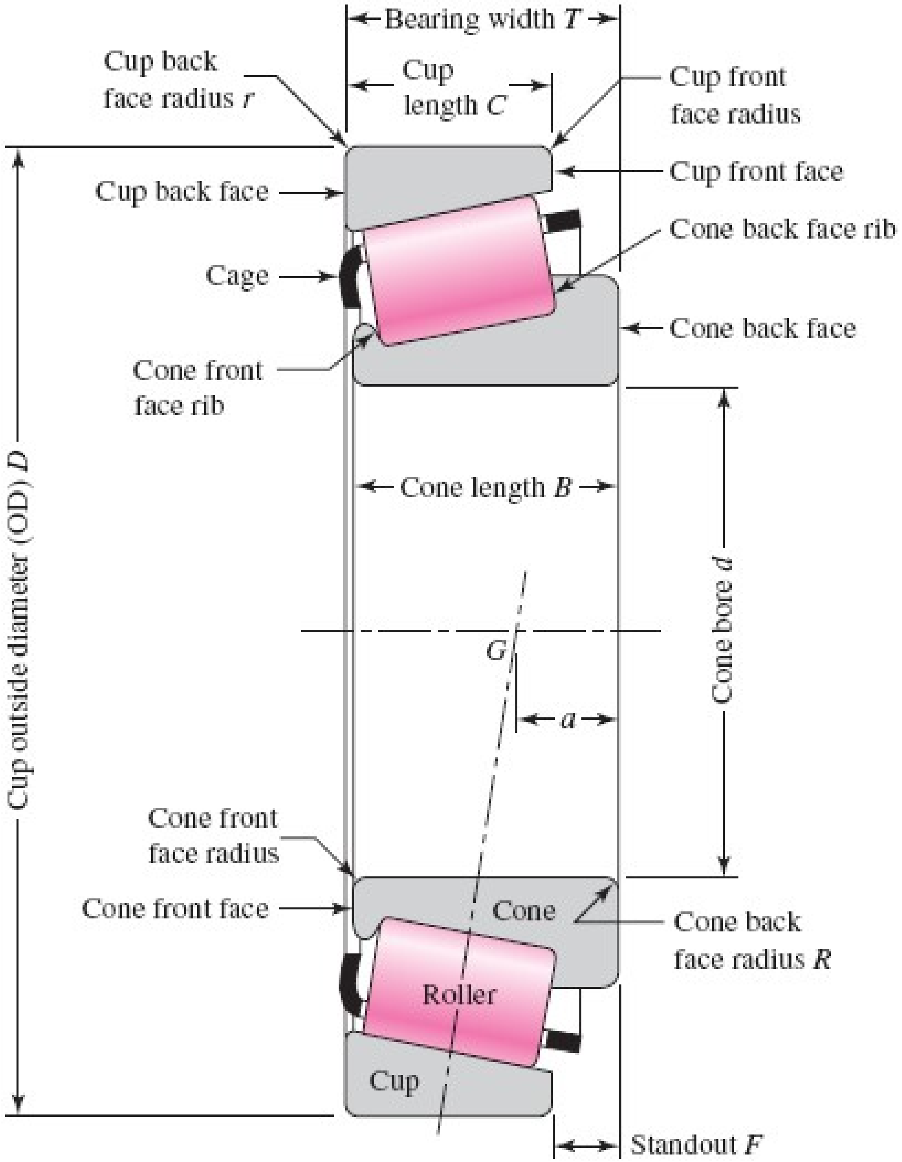
For bearing B, $P_B = F_{rB} = 2654$ N.

$$C_{10} = (1)(2654)\left[\frac{5000(800)60}{4.48\cdot(1-0.995)^{2/3}(90\cdot 10^6)}\right]^{3/10} = 6554\text{ N}$$

Select cone and cup 15100 and 15245, respectively, for both bearing A and B.

the effective load center is located at $a = -5.8$ mm.

Thus the shoulder - to - shoulder dimension should be $150 - 2(5.8) = 138.4$ mm.


Bearing width T
Cup back face radius r
Cup length C
Cup front face radius
Cup back face
Cup front face
Cone back face rib
Cage
Cone back face
Cone front face rib
Cone length B
Cup outside diameter (OD) D
Cone bore d
G
a
Cone front face radius
Cone front face
Cone
Cone back face radius R
Roller
Cup
Standout F