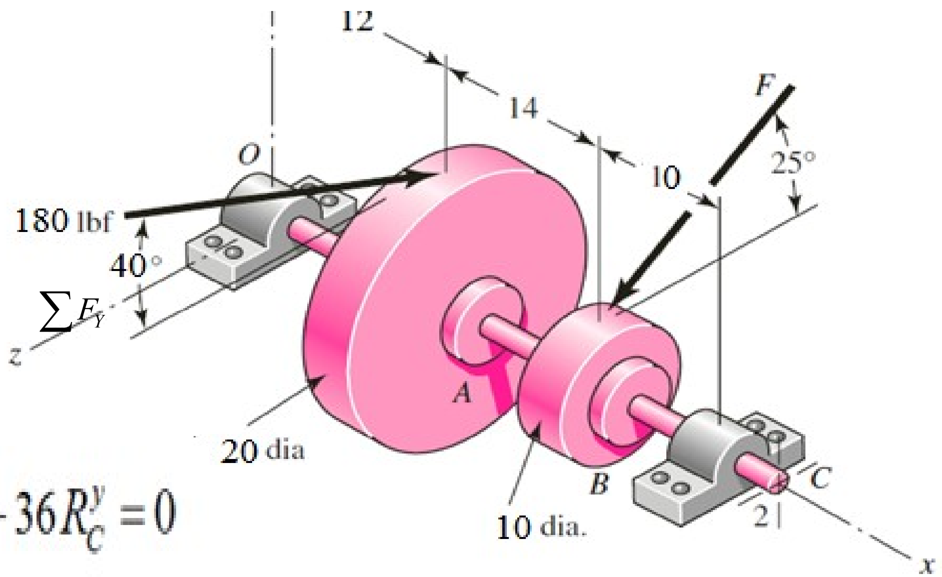
Q2(13p).A gear-reduction unit uses the countershaft depicted in the figure. Find the two bearing reactions.The bearings are to be angular-contact ball bearings, having a desired life of 50 kh when used at 400 rev/min. Use 1.2 for the application factor and a reliability goal for the bearing pair of 0.98.

a-Select the bearings from Table 11–2.



$$R = \sqrt{0.98} = 0.99$$

T=10(180cos40)=-1378.9lbf.in

T1+T2=0

F=1378.9/5cos25=304.28 lbf

$$\Sigma M_O^z = -12(180\sin 40) - 26(304.28\sin 25) + 36 R_C^y = 0$$

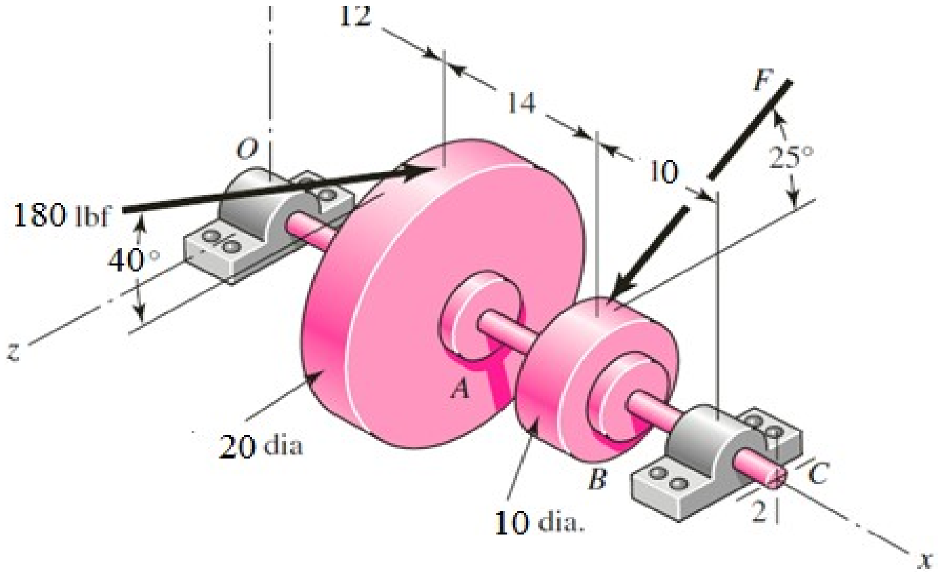
R^y_c=131.4

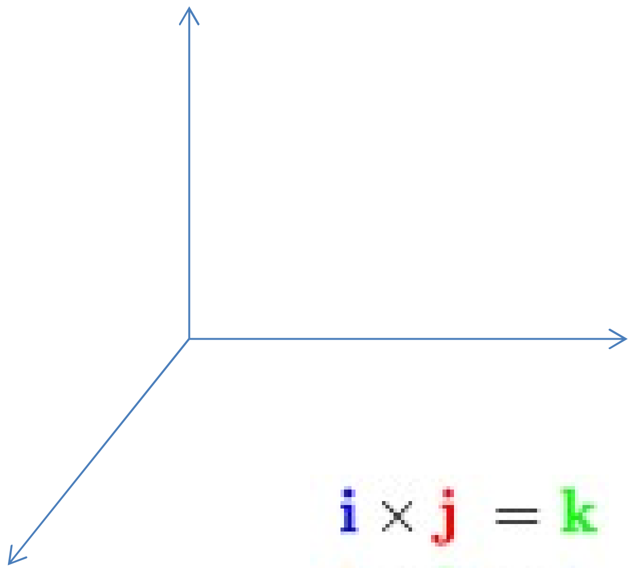
$$\sum F_y = 0$$

R^y_c-180sin40-Fsin25+R_o^y=

R_o^y=112.86

$$\Sigma M_O^y = 12(180\cos 40^\circ) - 26(F\cos 25) - 36 R_C^z = 0$$





$$\mathbf{i} \times \mathbf{j} = \mathbf{k}$$
$$\mathbf{j} \times \mathbf{k} = \mathbf{i}$$
$$\mathbf{k} \times \mathbf{i} = \mathbf{j}$$

R_c^z=-153.2
R_o^z=Fcos25-180cos40-153.2= 15.136
Ro=$15.1^2 + 112.86^2$=114
Rc=$153.2^2+131.4^2$=201.8

$$x = L/L_{10}$$

$$x_D = \frac{50000(400)(60)}{10^6} = 1200$$

$$C_{10} = a_f F_D \left[\frac{x_D}{x_0 + (\theta - x_0)(\ln 1/R_D)^{1/b}} \right]^{1/a} \quad (11\text{–}6)$$

$$C_{10} = (1.2)(201.8) \left[\frac{1200}{0.02 + 4.439\ (1-0.99)^{1/1.483}} \right]^{1/3}$$

$$C_{10} = 242.16 \left[\frac{1200}{0.02 + 4.439\ (0.0448)} \right]^{1/3}$$

$$C_{10} = 242.16 \left[5484.46 \right]^{1/3}$$

C10= 18.9 kN

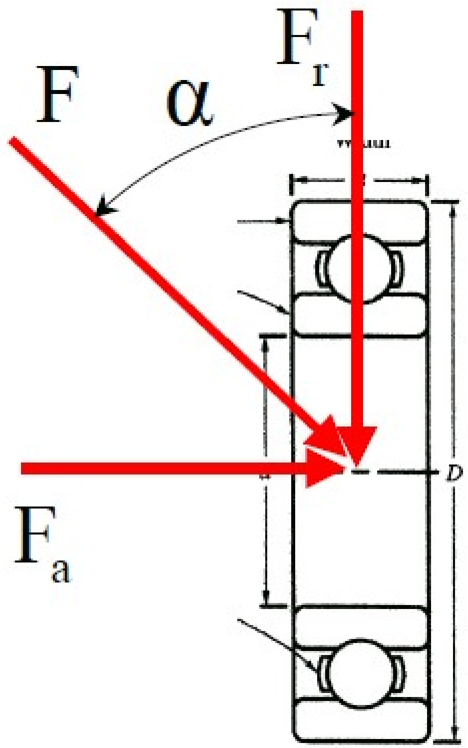
Bore, mm	OD, mm	Width, mm	Fillet Radius, mm	Shoulder Diameter, mm		Load Ratings, kN			
						Deep Groove		Angular Contact	
				d_S	d_H	C_{10}	C_0	C	C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0

11-6 Combined Radial and Thrust Loading

❖Bearings are usually operated with some combination of radial and thrust load.

❖Catalog ratings are based only on radial loads. Follow the guideline in catalogs to obtain the equivalent radial load.

✓**In order to choose the bearing, an equivalent radial load Fe must be found**



How to handle combined loading

- What about combined radial, Fr, and axial loading , Fa?
  - Use an equivalent load, Fe, that does the same amount of damage.

$$F_e = X_i \; V \; F_r + Y_i \; F_a$$

- Where V = 1.2 for outer ring rotation and 1 for inner ring
  - This has to do with the fact that outer ring fails more often
- X_i and Y_i are a function of the
  - Axial load, Fa
  - Static load rating, Co

$$C_0 = M n_b d_b^2 \text{......(ball\_bearings)}$$

$$C_0 = M n_r l_c d \text{......(roller\_bearings)}$$

$$where$$

$$C_0 = bearing\_static\_load\_rating\_(lbf, kN)$$

$$n_b = no.\_of\_balls$$

$$n_r = no.\_of\_rollers$$

$$d_b = diameter\_of\_balls\_(in., mm)$$

$$d = diameter\_of\_rolers\_(in., mm)$$

$$l_c = length\_of\_contact\_line\_(in., mm)$$

M is specified asgiven in this table.

M	in and lbf	mm and kN
Radial ball	$1.78(10)^3$	$5.11(10)^3$
Ball thrust	$7.10(10)^3$	$20.4(10)^3$
Radial roller	$3.13(10)^3$	$8.99(10)^3$
Roller thrust	$14.2(10)^3$	$40.7(10)^3$

A ball bearing is capable of resisting radial loading and a thrust loading. These can be combined.

- Fa = the axial thrust load.
- Fr = the radial load.
- Fe = equivalent radial load that does the same damage as the combined radial and thrust loads together.
- The abscissa *e is defined by* the intersection of the two lines.

$$\frac{F_e}{VF_r} = 1, \frac{F_a}{VF_r} \le e$$

$$\frac{F_e}{VF_r} = X + Y\frac{F_a}{VF_r} => \frac{F_a}{VF_r} > e,$$

$$F_e = X_i VF_r + Y_i F_a$$

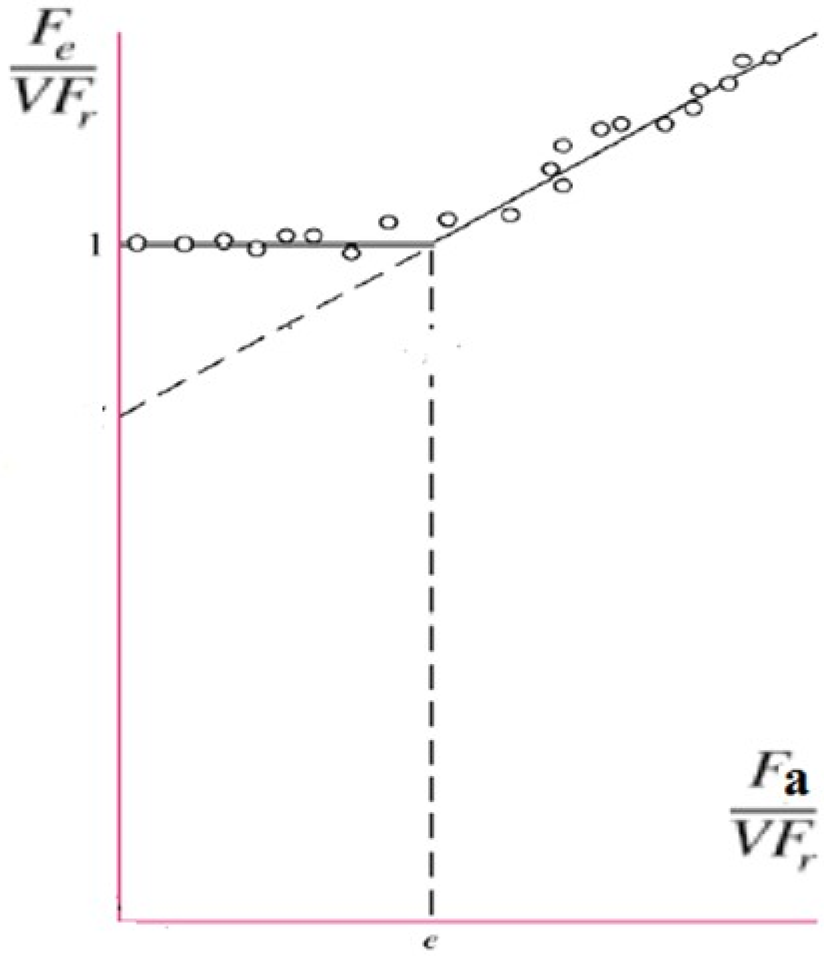
Where $i=1$ when $F_a/VF_r<e$

$i=2$ when $F_a/VF_r>e$

V=1 when the inner ring rotates

V=1.2 when the outer ring rotates

X> the intercept of the line with vertical



F_a/C_0	e	$F_a/(VF_r) \le e$ X_1	Y_1	$F_a/(VF_r) > e$ X_2	Y_2
0.014*	0.19	1.00	0	0.56	2.30
0.021	0.21	1.00	0	0.56	2.15
0.028	0.22	1.00	0	0.56	1.99
0.042	0.24	1.00	0	0.56	1.85
0.056	0.26	1.00	0	0.56	1.71
0.070	0.27	1.00	0	0.56	1.63
0.084	0.28	1.00	0	0.56	1.55
0.110	0.30	1.00	0	0.56	1.45
0.17	0.34	1.00	0	0.56	1.31
0.28	0.38	1.00	0	0.56	1.15
0.42	0.42	1.00	0	0.56	1.04
0.56	0.44	1.00	0	0.56	1.00

*Use 0.014 if $F_a/C_0 < 0.014$.

Ex:An SKF 6210 angular-contact ball bearing (a=3)has an axial load Fa of 1.8 kN applied, a radial load Fr of 2.2 kN applied with the outer ring stationary. The basic static load rating $C_0$is 19.8kN and the basic load rating C10is 35 kN.
Estimate the L_D life at a speed of 720 r/min.

V=1 and Fa/Co=1.8/19.8=0.09
Interpolate for e in Table 11-1; e= 0.285
since Fa/ (VFr)=1800/ [(1)2200]=0.818
Interpolate Y2 we get Y2=1.527
Fe=X2VFr+Y2Fa=0.56(1)2.2+1.527(1.8)=3.96kN

$$C_{10}L_{10}^{1/a} = F\,L^{1/a}$$

$$L_D = \frac{60L_R n_R}{60n_D}\left(\frac{C_{10}}{F_e}\right)^3 = \frac{10^6}{60(720)}\left(\frac{35}{3.96}\right)^3 = 15982h$$

Bearing Specifications

Bearings are defined by a two digit number: dimension-series code

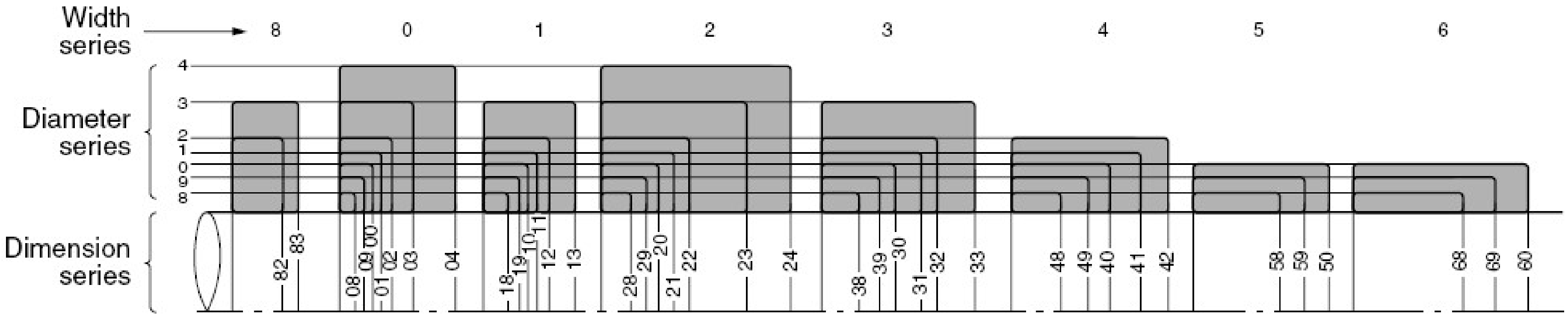
First number is the width series, 0,1,2,3,4,5 and 6

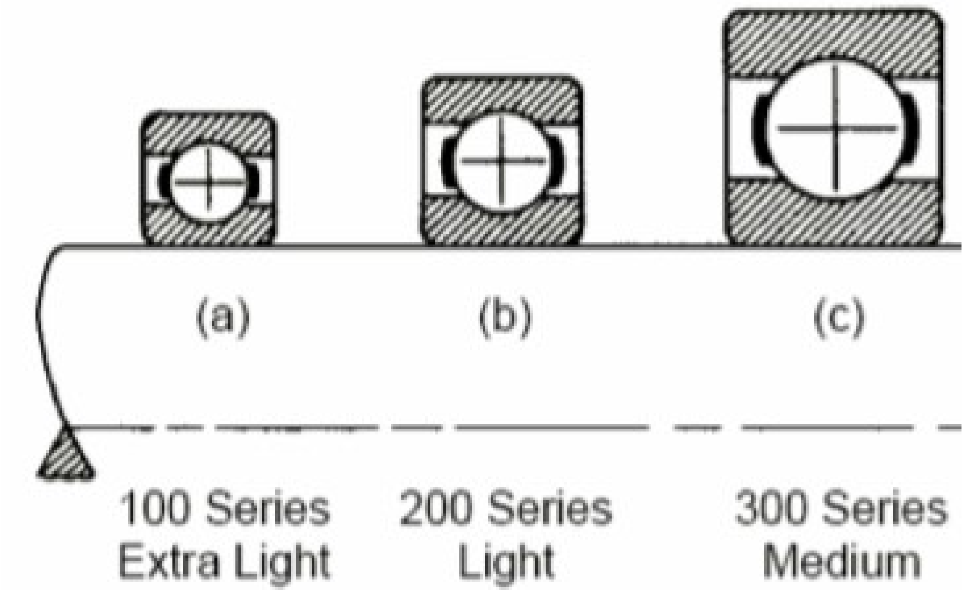
		Dimension series		
		Diameter series (outer diameter dimensions)	Width series (width dimensions)	Height series (height dimensions)
Radial bearings (excluding tapered roller bearings)	number	7, 8, 9, 0, 1, 2, 3, 4	8, 0, 1, 2, 3, 4, 5, 6	——
	dimensions	small ←→ large	small ←→ large	
Tapered roller bearings	number	9, 0, 1, 2, 3	0, 1, 2, 3	——
	dimensions	small ←→ large	small ←→ large	
Thrust bearings	number	0, 1, 2, 3, 4	——	7, 9, 1, 2
	dimensions	small ←→ large		small ←→ large

Second number is the diameter series

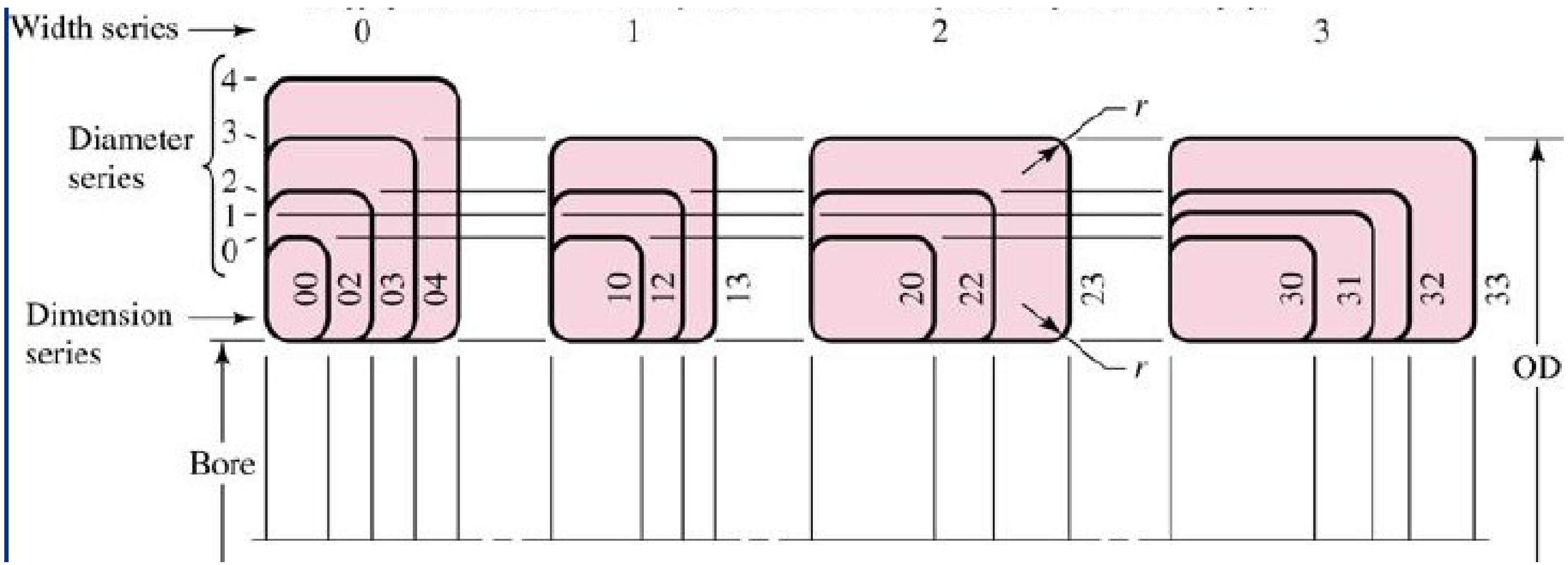
Dimension series for radial bearings

Bearing Specifications





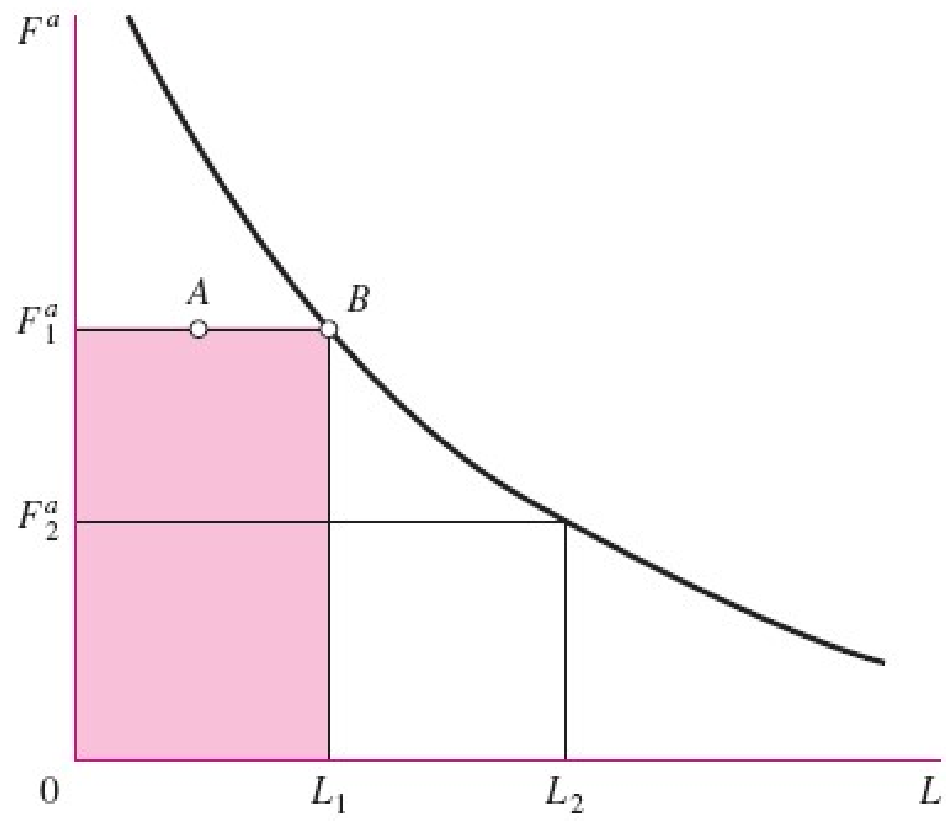
ABMA Boundary Dimensions



11-7 Variable Loading

Equation (11–1) can be written as
$F^a L$ = *constant* = K

If a load level of *F1 is selected and run to the failure criterion, then the area under the F1-L1 trace* is numerically equal to *K. The same is true for a load level F2; that is, the area under the F2-L2 trace is numerically equal to K*



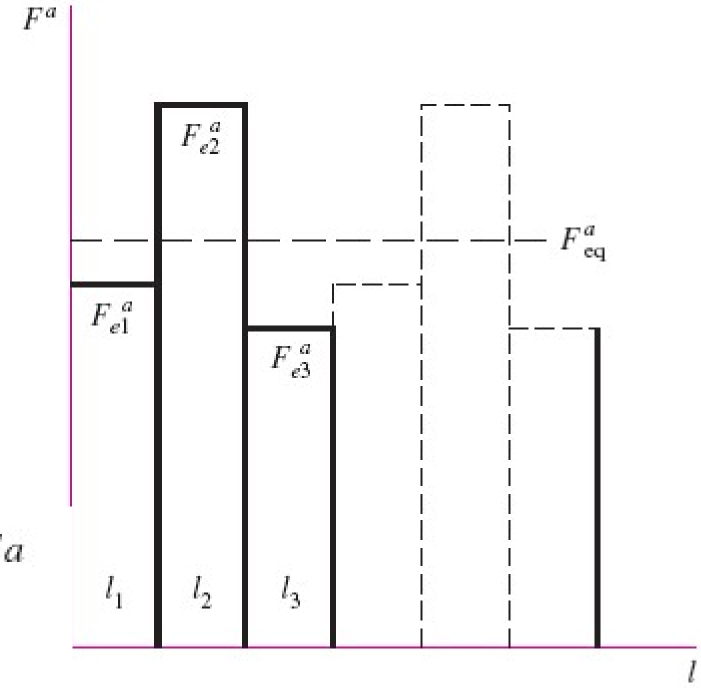
load level *F1, the area from L = 0 to L = L $_A$ does damage measured by F^a L $_A$ = D.*

- Piecewise constant loading in a cyclic pattern

The damage done by loads *Fe1, Fe2, and Fe3 is*

$$D = F_{e1}^a l_1 + F_{e2}^a l_2 + F_{e3}^a l_3$$

The equivalent steady load *Feq when* run for *l1 + l2 + l3 revolutions does the same damage D.*



$$D = F_{eq}^a (l_1 + l_2 + l_3)$$

$$F_{eq} = \left[\frac{F_{e1}^a l_1 + F_{e2}^a l_2 + F_{e3}^a l_3}{l_1 + l_2 + l_3} \right]^{1/a} = \left[\sum f_i F_{ei}^a \right]^{1/a}$$

fi is the fraction of revolution run up under load Fei

Fei are equivalent steady radial loads for combined radial–thrust loads

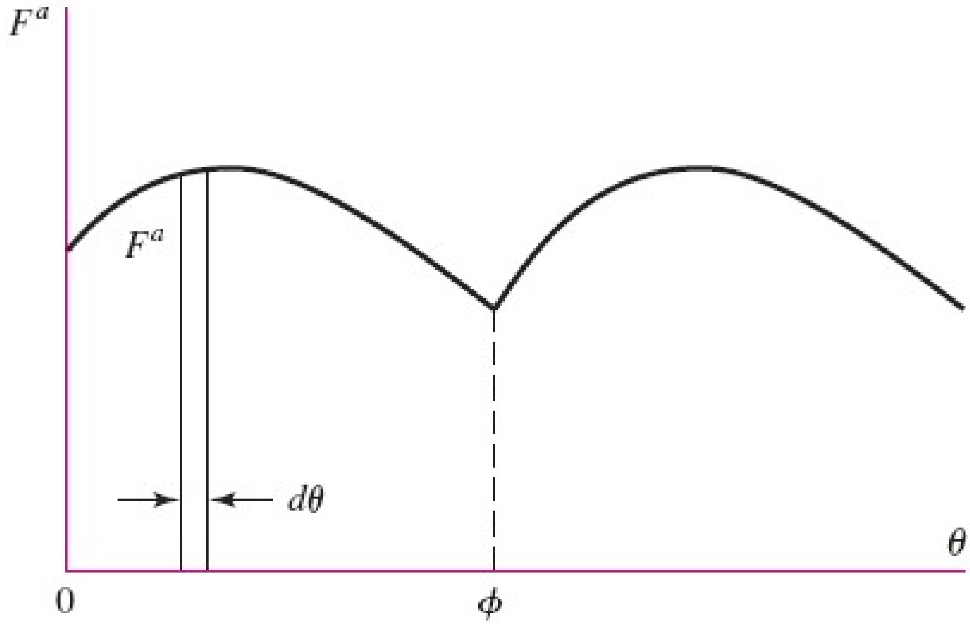
Since *li can be expressed* as *ni ti , where ni is the rotational speed at load Fei and ti is the duration of that speed,* then it follows that

$$F_{eq} = \left[\frac{\sum n_i t_i F_{ei}^a}{\sum n_i t_i} \right]^{1/a}$$

The character of the individual loads can change, so an application factor (a_f) *can be* prefixed to each *Fei as* $(a_{fi} Fe_i)^a$ *;*

$$F_{eq} = \left[\sum f_i (a_{fi} F_{ei})^a \right]^{1/a} \qquad L_{eq} = \frac{K}{F_{eq}^a}$$

- Continuously variable loading in a repeatable cyclic pattern



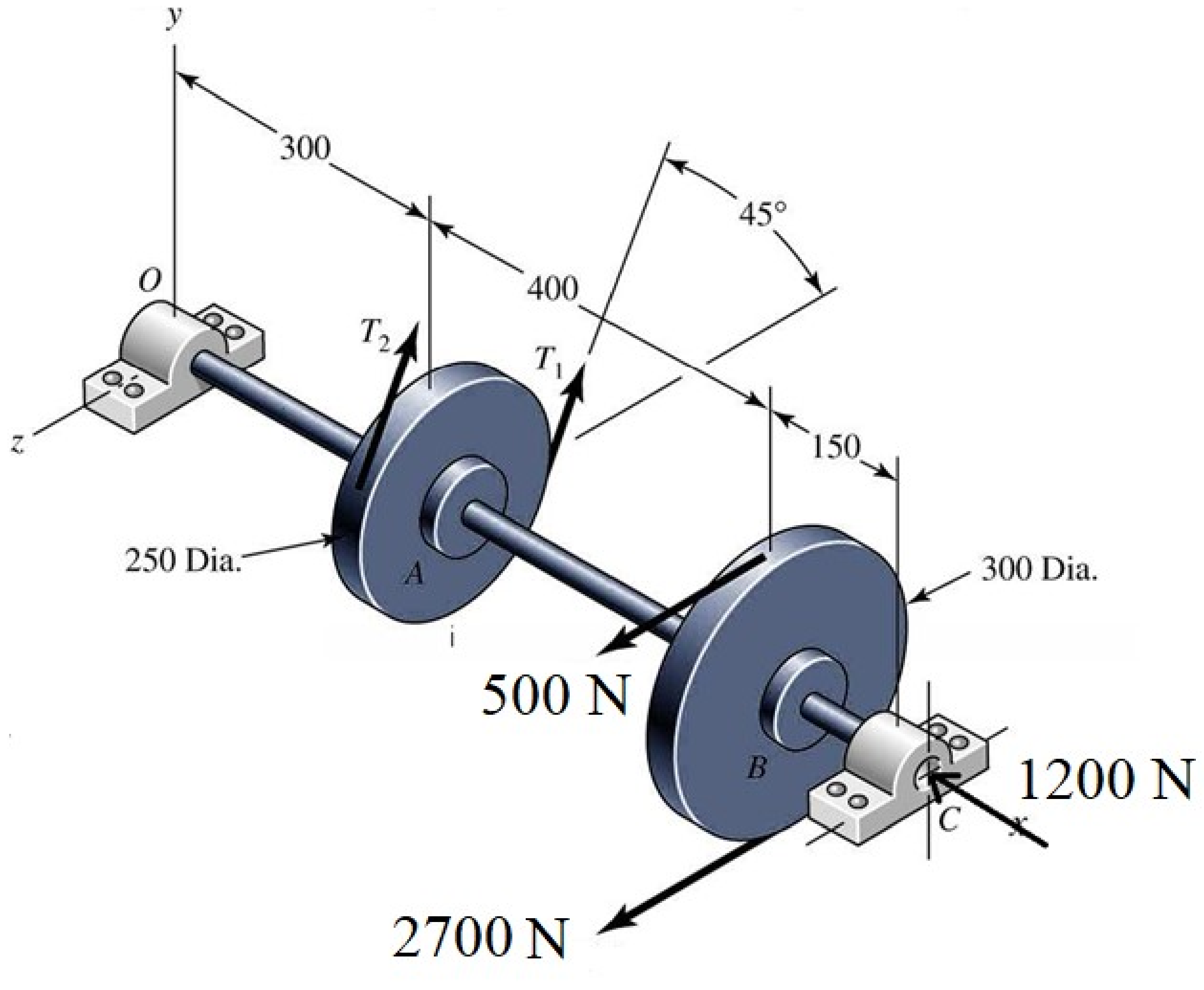
$$F_{eq} = \left[\frac{1}{\phi}\int_0^{\phi} F^a d\theta\right]^{1/a} \qquad L_{eq} = \frac{K}{F_{eq}^a}$$

Selection of ball and cylindrical roller bearing

This selection procedure contains an iterative process:

- -Choose Y2from Table 11-1
- -Find C10
- -Tentatively indentifya suitable bearing 11-2, note Co
- -Using Fa/Coenter Table 11-1 to obataina new value of Y2
- -If the same bearing is obtain, stop
- -If not, take next bearing and go to step 4.

Ex: The figure is a schematic drawing of a countershaft that supports two V- belt pulleys (they are hold in place using keys)The countershaft runs at 1200r/min and the bearings are to have a life of 10 kh at a combined reliability of 0.98. for the Weibull parameters are b=1.483, X_0= 0.2, θ=4.439+0.2. The application factor is to be 1.2. The belt tension on the loose side of pulley A is 15 percent of the tension on the tight side.



$$\sum T = (2700\text{-}500)*150 - (T_1 - 0.15T_1)*125 = 0$$

$$T_1 = 310\ 6N$$

$$T_2 = 46\ 6N$$

$$\sum M_O^Z = 1.15 \times 3106 \times 300 \times \sin 45 + R_C^Y \times 850 = 0$$

$$R_C^Y = -891\ N$$

$$\sum M_o^y = -(2700+500) * 700 + (1.15T1) \times 300 \times \cos 45 + R_c^z \times 850 = 0$$

$$R_c^z = 174\,4N$$

$$\sum F_y = -89\ 1 + 1.15 \times 3106 \times \sin 45 + R_O^Y = 0$$

$$R_O^Y = -1634.7\ \text{N}$$

$$\sum F_z = (2700+500) - (1.15T_1)\cos 45 + R_o^z + 174\,4 = 0$$

$$R_o^z = 2418.3\ \text{N}$$

$$F_O = \sqrt{\quad + \quad} = 2918.97\ \text{N}$$

$$F_C = \sqrt{174\ 4^2 + 89\ 1^2} = 1958.4\ \text{N}$$

with V=1

$$\frac{F_e}{VF_r} = X + \frac{Y}{V}\frac{F_a}{F_r} = 0.56 + 1.63\frac{1200}{(1)1958.6} = 1.56$$

$$Fe = 1.56VF_r = 1.56(1)1958.6 = 3052.8N$$

$$C_{10} = 1.2*3.052\left[\frac{393.2}{0.02 + 4.439(1 - 0.99)^{1/1.483}}\right]^{1/3} =$$

$$1.2*3.052(12.15) = 44.52 \text{ kN}$$

Table 11–2

Dimensions and Load Ratings for Single-Row 02-Series Deep-Groove and Angular-Contact Ball Bearings

Bore, mm	OD, mm	Width, mm	Fillet Radius, mm	Shoulder Diameter, mm d_S	Shoulder Diameter, mm d_H	Load Ratings, kN Deep Groove C_{10}	Load Ratings, kN Deep Groove C_0	Load Ratings, kN Angular Contact C_{10}	Load Ratings, kN Angular Contact C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0
85	150	28	2.0	99	136	83.2	53.0	90.4	63.0
90	160	30	2.0	104	146	95.6	62.0	106	73.5
95	170	32	2.0	110	156	108	69.5	121	85.0

From Table 11–2, angular-contact bearing 02-55 mm has $C_{10} = 46.2$ kN. C_0 is 28.5 kN. Step 4 becomes, with F_a in kN,

$$\frac{F_a}{C_0} = \frac{1.2}{28.5} = 0.0421$$

which makes e from Table 11–1 approximately 0.24.

F_a/C_0	e	$F_a/(VF_r) \le e$ X_1	Y_1	$F_a/(VF_r) > e$ X_2	Y_2
0.014*	0.19	1.00	0	0.56	2.30
0.021	0.21	1.00	0	0.56	2.15
0.028	0.22	1.00	0	0.56	1.99
0.042	0.24	1.00	0	0.56	1.85
0.056	0.26	1.00	0	0.56	1.71
0.070	0.27	1.00	0	0.56	1.63
0.084	0.28	1.00	0	0.56	1.55
0.110	0.30	1.00	0	0.56	1.45
0.17	0.34	1.00	0	0.56	1.31
0.28	0.38	1.00	0	0.56	1.15
0.42	0.42	1.00	0	0.56	1.04
0.56	0.44	1.00	0	0.56	1.00

$$Fa/(VFr)=1200/(1*1958.4)=0.61$$

Y2=1.85

$$\frac{F_e}{V F_r} = X + \frac{Y}{V}\frac{F_a}{F_r} = 0.56 + 1.85\frac{1200}{(1)1958.6} = 1.69$$

$$F_e = 1.77 V F_r = 1.69(1)1958.6 = 3316.82$$

$$C_{10} = 1.2 * 3.316(12.15) = 48.35 \text{ kN}$$

Frm table 11-2 angular contact bearing 02-60 mm has C10=55.9 kN Co=35.5 kN

Fa/Co=1200/35500=0.034

F_a/C_0	e	$F_a/(VF_r) \le e$ X_1	Y_1	$F_a/(VF_r) > e$ X_2	Y_2
0.014*	0.19	1.00	0	0.56	2.30
0.021	0.21	1.00	0	0.56	2.15
0.028	0.22	1.00	0	0.56	1.99
0.034					
0.042	0.24	1.00	0	0.56	1.85

$e=0.23$ $Y_2=1.93$

$Fe=0.56*1*1958.6+1.93*1200=3412.82$ N

$C10=1.2*3.412*12.15=49.75$ kN

from table 11-2 an angular contact 02-60 mm is still selected

The ball bearing at *C involves a thrust component. This selection procedure* requires an iterative procedure. Assuming $Fa/(V F_r) > e$,

1 Choose *Y2 from Table 11–1.*
2 Find *C10.*
3 Tentatively identify a suitable bearing from Table 11–2, note *C0.*
4 Using *Fa/C0 enter Table 11–1 to obtain a new value of Y2.*
5 Find *C10.*
6 If the same bearing is obtained, stop.
7 If not, take next bearing and go to step 4.

take the middle entry from Table 11–1:

X2 = 0.56 Y2 = 1.63.

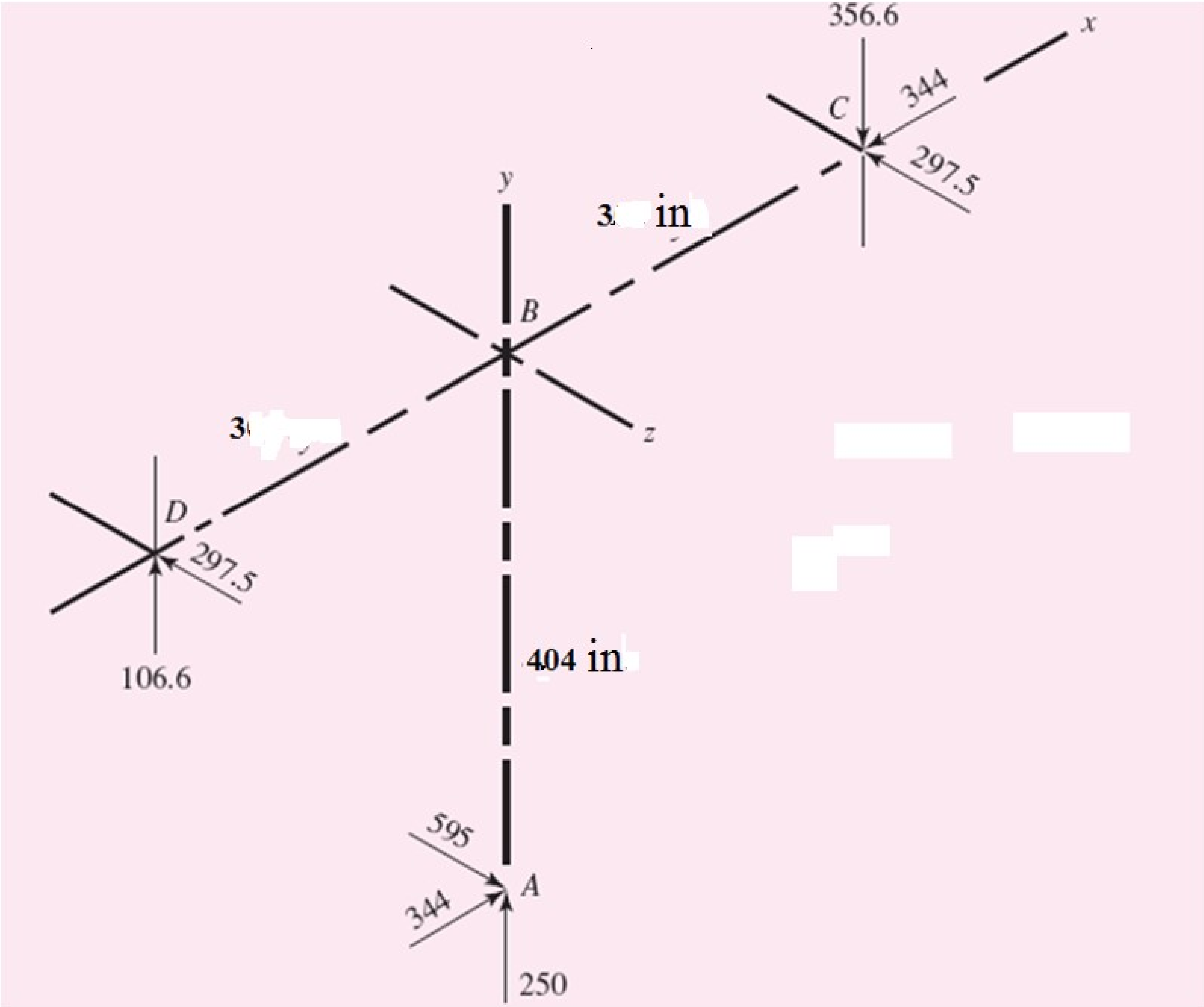
11–8 **Selection of Ball and Cylindrical Roller Bearings**

Ex- The second shaft on a parallel-shaft 25-hp foundry crane speed reducer contains a helical gear with a pitch diameter of 8.08 in. Helical gears transmit components of force in the tangential, radial, and axial directions . The components of the gear force transmitted to the second shaft are shown in the Figure below at point *A.*

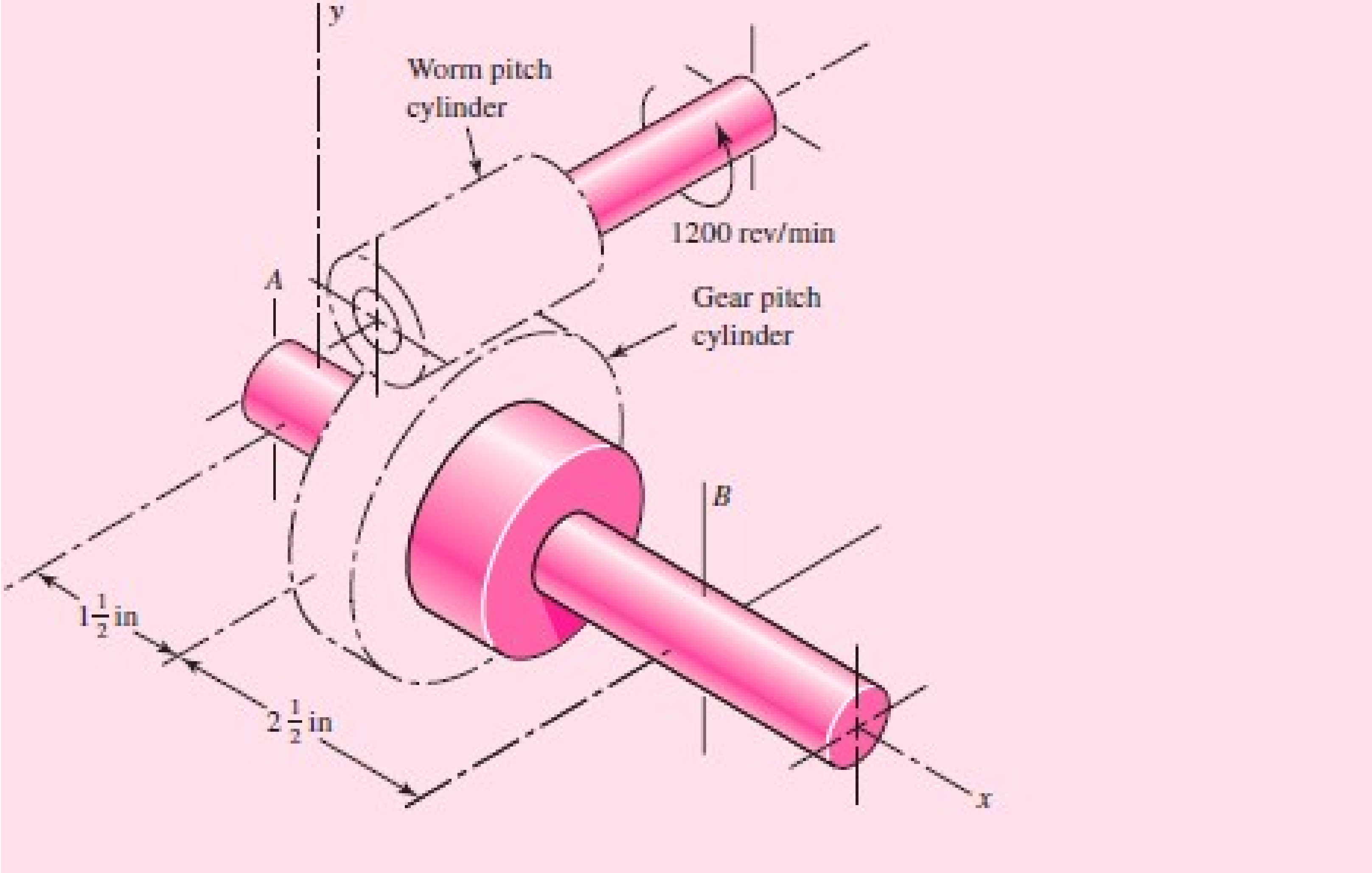
The bearing reactions at *C and D, assuming simple-supports, are also shown. A ball* bearing is to be selected for location *C to accept the thrust, and a cylindrical roller* bearing is to be utilized at location *D. The life goal of the speed reducer is 10 kh, with* a reliability factor for the assembly of all four bearings (both shafts) to equal or exceed 0.96 for the Weibull parameters are b=1.483, X_0= 0.2, θ=4.439+0.2. The application factor is to be 1.2.

(*a) Select the roller bearing for location D.*

(*b) Select the ball bearing (angular contact) for location C, assuming the inner ring* rotates.



356.6
x
C
344
297.5
y
3 in
B
z
3
D
297.5
106.6
404 in
595
A
344
250


y
Worm pitch
cylinder
1200 rev/min
A
Gear pitch
cylinder
B
1½ in
2½ in
x

The torque transmitted is *T = 595(4.04) = 2404 lbf.in*

The speed at the rated horse power,

$$n_D = \frac{63\,025H}{T} = \frac{63\,025(25)}{2404} = 655.4 \text{ rev/min}$$

-The radial load at *D is* $\sqrt{106.6^2 + 297.5^2} = 316.0$ *lbf,*

-the radial load at C is

$\sqrt{356.6^2 + 297.5^2} = 464.4$ lbf

The individual bearing reliabilities, if equal, must be

2 bearing for each shaft so at least $\sqrt[4]{0.96} = 0.98985$.= ٠,٩٩

The dimensionless design life for both bearings is

$$x_D = \frac{L}{L_{10}} = \frac{60L_D n_D}{60L_R n_R} = \frac{60(10\,000)655.4}{10^6} = 393.2$$

a = 10/3 for the roller bearing at D, the catalog rating should be equal to or Greater than

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

$$= 1.2(316.0) \left[\frac{393.2}{0.02 + 4.439(1 - 0.99)^{1/1.483}} \right]^{3/10} = 3591 \text{ lbf} = 16.0 \text{ kN}$$

Choose a 02-25 mm series, or a 03-25 mm series cylindrical roller bearing from Table 11–3.

	02-Series				03-Series			
Bore,	OD,	Width,	Load Rating, kN		OD,	Width,	Load Rating, kN	
mm	mm	mm	C_{10}	C_0	mm	mm	C_{10}	C_0
25	52	15	16.8	8.8	62	17	28.6	15.0
30	62	16	22.4	12.0	72	19	36.9	20.0
35	72	17	31.9	17.6	80	21	44.6	27.1
40	80	18	41.8	24.0	90	23	56.1	32.5
45	85	19	44.0	25.5	100	25	72.1	45.4
50	90	20	45.7	27.5	110	27	88.0	52.0
55	100	21	56.1	34.0	120	29	102	67.2
60	110	22	64.4	43.1	130	31	123	76.5
65	120	23	76.5	51.2	140	33	138	85.0
70	125	24	79.2	51.2	150	35	151	102
75	130	25	93.1	63.2	160	37	183	125
80	140	26	106	69.4	170	39	190	125
85	150	28	119	78.3	180	41	212	149
90	160	30	142	100	190	43	242	160

The ball bearing at *C involves a thrust component. This selection procedure* requires an iterative procedure. Assuming $Fa/(V F_r) > e$,

1 Choose ***Y2 from Table 11–1.***
2 Find ***C10.***
3 Tentatively identify a suitable bearing from Table 11–2, note ***C0.***
4 Using ***Fa/C0 enter Table 11–1 to obtain a new value of Y2.***
5 Find ***C10.***
6 If the same bearing is obtained, stop.
7 If not, take next bearing and go to step 4.

take the middle entry from Table 11–1:

$X2 = 0.56$ $Y2 = 1.63$.

with $V = 1$,

$$\frac{F_e}{V F_r} = X + \frac{Y}{V}\frac{F_a}{F_r} = 0.56 + 1.63\frac{344}{(1)464.4} = 1.77$$

$$F_e = 1.77 V F_r = 1.77(1)464.4 = 822 \text{ lbf} \qquad \text{or} \qquad 3.66 \text{ kN}$$

From Eq. (11–7), with $a = 3$,

$$C_{10} = 1.2(3.66)\left[\frac{393.2}{0.02 + 4.439(1 - 0.99)^{1/1.483}}\right]^{1/3} = 53.4 \text{ kN}$$

From Table 11–2, angular-contact bearing 02-60 mm has $C_{10} = 55.9$ kN. C_0 is 35.5 kN. Step 4 becomes, with F_a in kN,

$$\frac{F_a}{C_0} = \frac{344(4.45)10^{-3}}{35.5} = 0.0431$$

which makes e from Table 11–1 approximately 0.24. Now $F_a/[VF_r] = 344/[(1)\ 464.4] = 0.74$, which is greater than 0.24, so we find Y_2 by interpolation:

F_a/C_0	Y_2	
0.042	1.85	
0.043	Y_2	from which $Y_2 = 1.84$
0.056	1.71	

Table 11–2

Dimensions and Load Ratings for Single-Row 02-Series Deep-Groove and Angular-Contact Ball Bearings

Bore, mm	OD, mm	Width, mm	Fillet Radius, mm	Shoulder Diameter, mm d_S	Shoulder Diameter, mm d_H	Load Ratings, kN Deep Groove C_{10}	Load Ratings, kN Deep Groove C_0	Load Ratings, kN Angular Contact C_{10}	Load Ratings, kN Angular Contact C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0
85	150	28	2.0	99	136	83.2	53.0	90.4	63.0
90	160	30	2.0	104	146	95.6	62.0	106	73.5
95	170	32	2.0	110	156	108	69.5	121	85.0

F_a/C_0	e	$F_a/(VF_r) \le e$		$F_a/(VF_r) > e$	
		X_1	Y_1	X_2	Y_2
0.014*	0.19	1.00	0	0.56	2.30
0.021	0.21	1.00	0	0.56	2.15
0.028	0.22	1.00	0	0.56	1.99
0.042	0.24	1.00	0	0.56	1.85
0.056	0.26	1.00	0	0.56	1.71
0.070	0.27	1.00	0	0.56	1.63
0.084	0.28	1.00	0	0.56	1.55
0.110	0.30	1.00	0	0.56	1.45
0.17	0.34	1.00	0	0.56	1.31
0.28	0.38	1.00	0	0.56	1.15
0.42	0.42	1.00	0	0.56	1.04
0.56	0.44	1.00	0	0.56	1.00

*Use 0.014 if $F_a/C_0 < 0.014$.

From Eq. (11–8*b*),

$$\frac{F_e}{VF_r} = 0.56 + 1.84\frac{344}{464.4} = 1.92$$

$$F_e = 1.92VF_r = 1.92(1)464.4 = 892 \text{ lbf} \qquad \text{or} \qquad 3.97 \text{ kN}$$

The prior calculation for C_{10} changes only in F_e, so

$$C_{10} = \frac{3.97}{3.66}53.4 = 57.9 \text{ kN}$$

From Table 11–2 an angular contact bearing 02-65 mm has $C_{10} = 63.7$ kN and C_0 of 41.5 kN. Again,

$$\frac{F_a}{C_0} = \frac{344(4.45)10^{-3}}{41.5} = 0.0369$$

making e approximately 0.23. Now from before, $F_a/VF_r = 0.74$, which is greater than 0.23. We find Y_2 again by interpolation:

F_a/C_0	Y_2	
0.028	1.99	
0.0369	Y_2	from which $Y_2 = 1.90$
0.042	1.85	

From Eq. (11–8*b*),

$$\frac{F_e}{VF_r} = 0.56 + 1.90\frac{344}{464.4} = 1.967$$

$$F_e = 1.967VF_r = 1.967(1)464.4 = 913.5 \text{ lbf} \qquad \text{or} \qquad 4.065 \text{ kN}$$

The prior calculation for C_{10} changes only in F_e, so

$$C_{10} = \frac{4.07}{3.66} 53.4 = 59.4 \text{ kN}$$

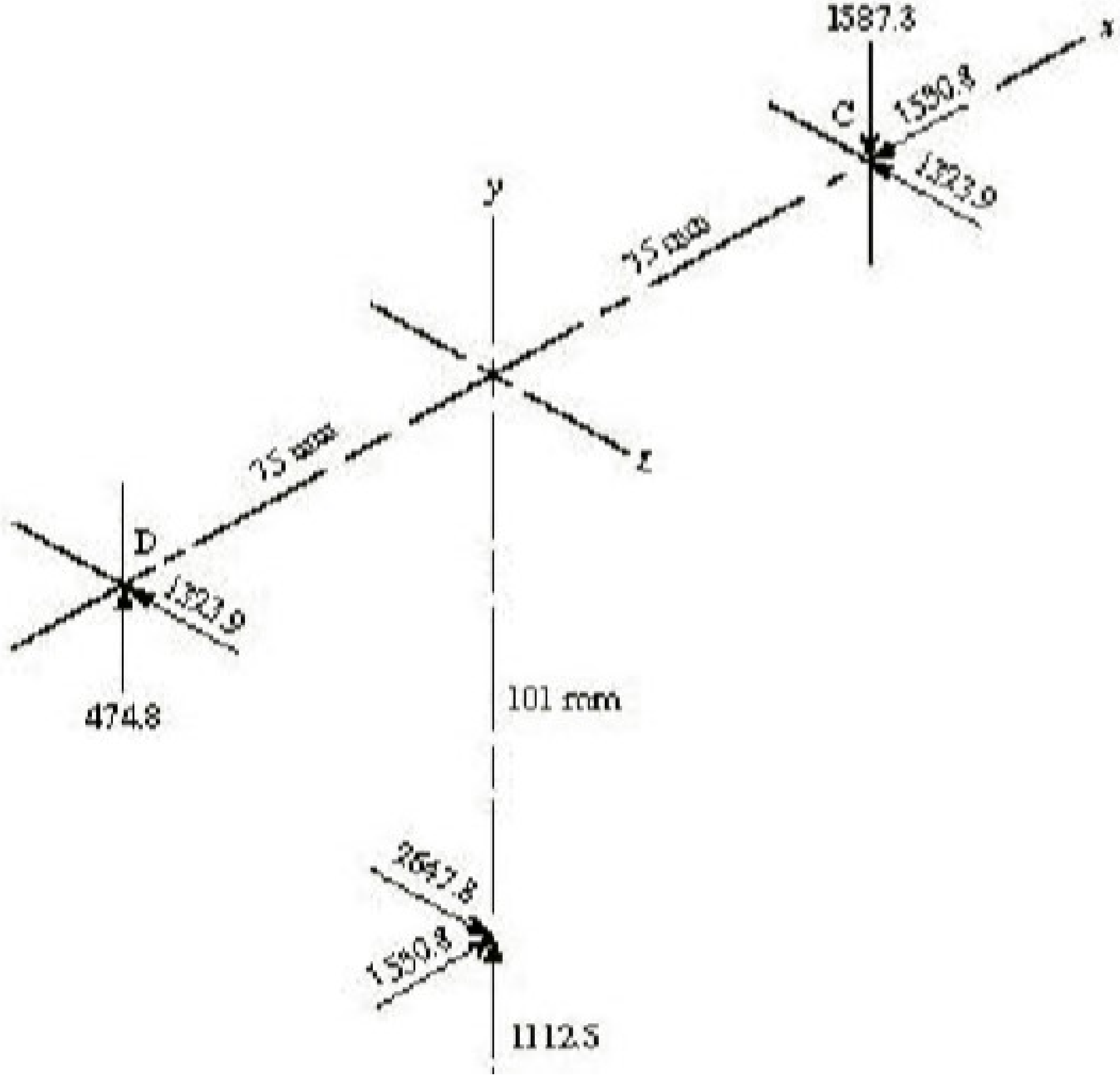
Answer From Table 11–2 an angular-contact 02-65 mm is still selected, so the iteration is complete.

Ex

The second shaft on a paralel-shaft 18.5kW foundry crane speed reducer has bearing reaction as shown in Fig . A ball bearing is to be selected for location C to accept the thrust, and a cylindrical roller bearing is to be utilized at location D. The life goal equal or exceed 0.96. The application factor is to be 1.2

- Select the roller bearing for location D
- Select the ball bearing (angular contact) for location C.

- The life goal of the speed reducer is 10kh. The desired speed is 656 rev/min.


1587.3
x
C
1530.8
1323.9
y
75 mm
75 mm
z
D
1323.9
474.8
101 mm
2647.8
1530.8
1112.5

The radial load at D is $\sqrt{474.8^2 + 1323.9^2} = 1406.5N$

The radial load at C is $\sqrt{1587.3^2 + 1323.9^2} = 2066.9N$

At D desired life is

$$x_D = \frac{L}{L_{10}} = \frac{60L_D n_D}{60L_R n_R} = \frac{60(10000)656}{10^6} = 393.6$$

$$C_{10} = 1.2(1406.5)\left[\frac{393.6}{0.02 + 4.439(1 - 0.99)^{1/1.483}}\right]^{3/10} = 15986N = 16kN$$

Choose a 02-25 mm series, or a 03-25mm series cylindrical roller bearing from Table 11-3

From Table 11-1, we find X_2=0.056 Y_2=1.63, from

Eq. (11-7), $\frac{Fe}{VFr} = 0.56 + 1.63\frac{1530.8}{(1)2066.9} = 1.77$

$$Fe = 1.77 Vfr = 1.77(1)2066.9 = 3.658\, kN$$

From Eq. (11-6),

$$C_{10} = 1.2(3.658)\left[\frac{393.6}{0.02 + 4.439(1 - 0.99)^{1/483}}\right]^{1/3} = 53.37\, kN$$

From Table 11-2, angular-contact bearing 02-60mm has C'_{10}=55.9kN.C_{10}=35.5kN

$$\frac{F_a}{[VF_r]} = \frac{1530.8}{[(1)2066.9]} = 0.74$$

e=0.24 from Table 11-1.

$$\frac{F_a}{C_o} = \frac{1530.8 10^{-3}}{35.5} = 0.043$$

F_a/c_o	Y_2
0.042	1.85
0.043	Y_2
0.056	1.71

$$\frac{0.043 - 0.042}{0.056 - 0.042} = \frac{Y_2 - 1.85}{1.71 - 1.85}$$

$$Y_2 = 1.84$$

$$\frac{Fe}{VFr} = 0.56 + 1.84 \frac{1530.8}{2066.9} = 1.922$$

$$Fe = 1.922 VF_r = 1.922 (1) 2066.9 = 3.972 kN$$

$$C_{10} = \frac{3.972}{3.658} 53.37 = 57.95 kN$$

From Table 11-2 an angular contact bearing 02-65 mm has C'_{10}=63.7kN and C'_0=41.5kN

$$\frac{F_a}{C_0} = \frac{1530.810^{-3}}{41.5} = 0.0369$$

$$\frac{F_a}{(VF_r)} = \frac{1530.8}{[1(2066.9)]} = 0.74$$

e approximately 0.23, now

$$\frac{0.039 - 0.028}{0.042 - 0.028} = \frac{Y_2 - 1.99}{1.85 - 1.99}$$

Which is greater than 0.23. We find Y_2;

$$Y_2 = 1.90$$

$$\frac{Fe}{VFr} = 0.56 + 1.90\frac{1530.8}{2066.9} = 1.967$$

$$Fe = 1.967VFr = 1.967(1)2066.9 = 4.066kN$$

$$C_{10} = \frac{4.066}{3.658}53.37 = 59.32kN$$

From Table 11-2 an angular contact 02-65mm is still selected, so iteration is complete.