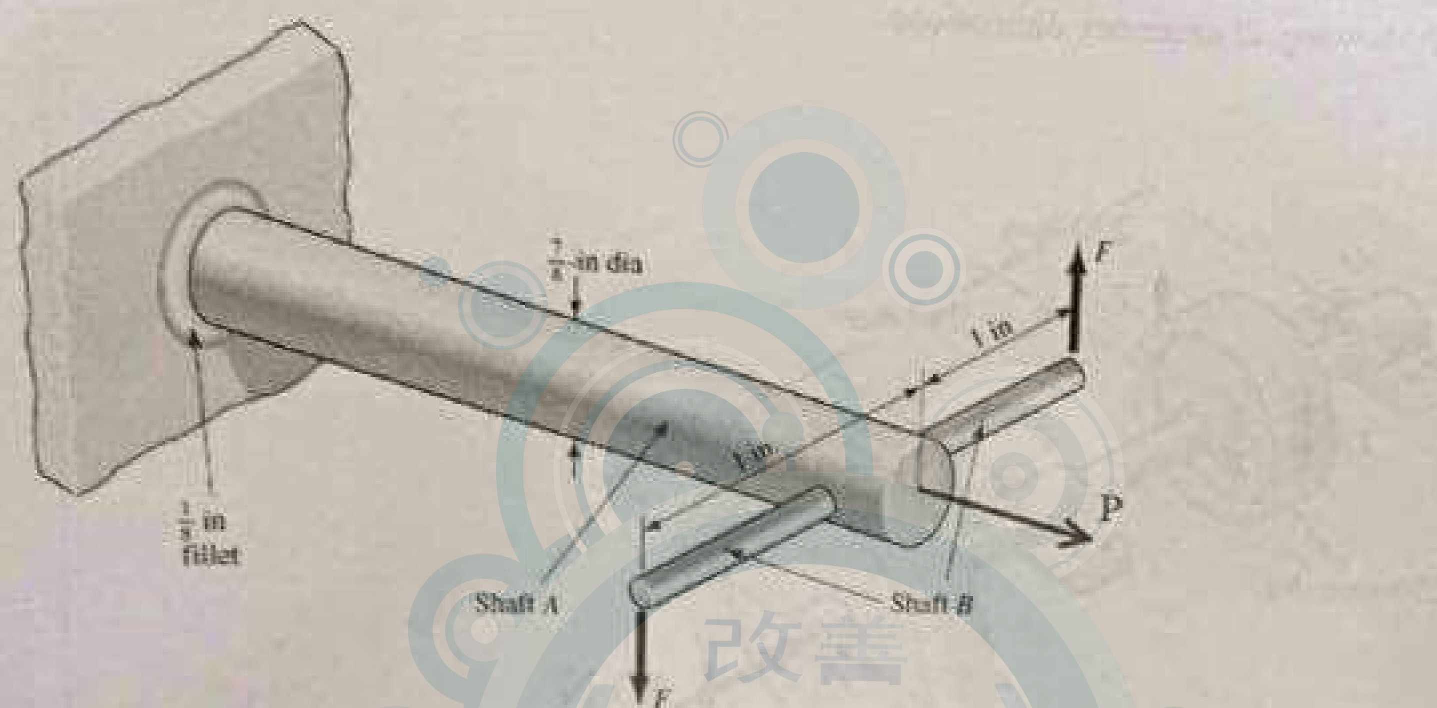
Final Examination

Machine design elements

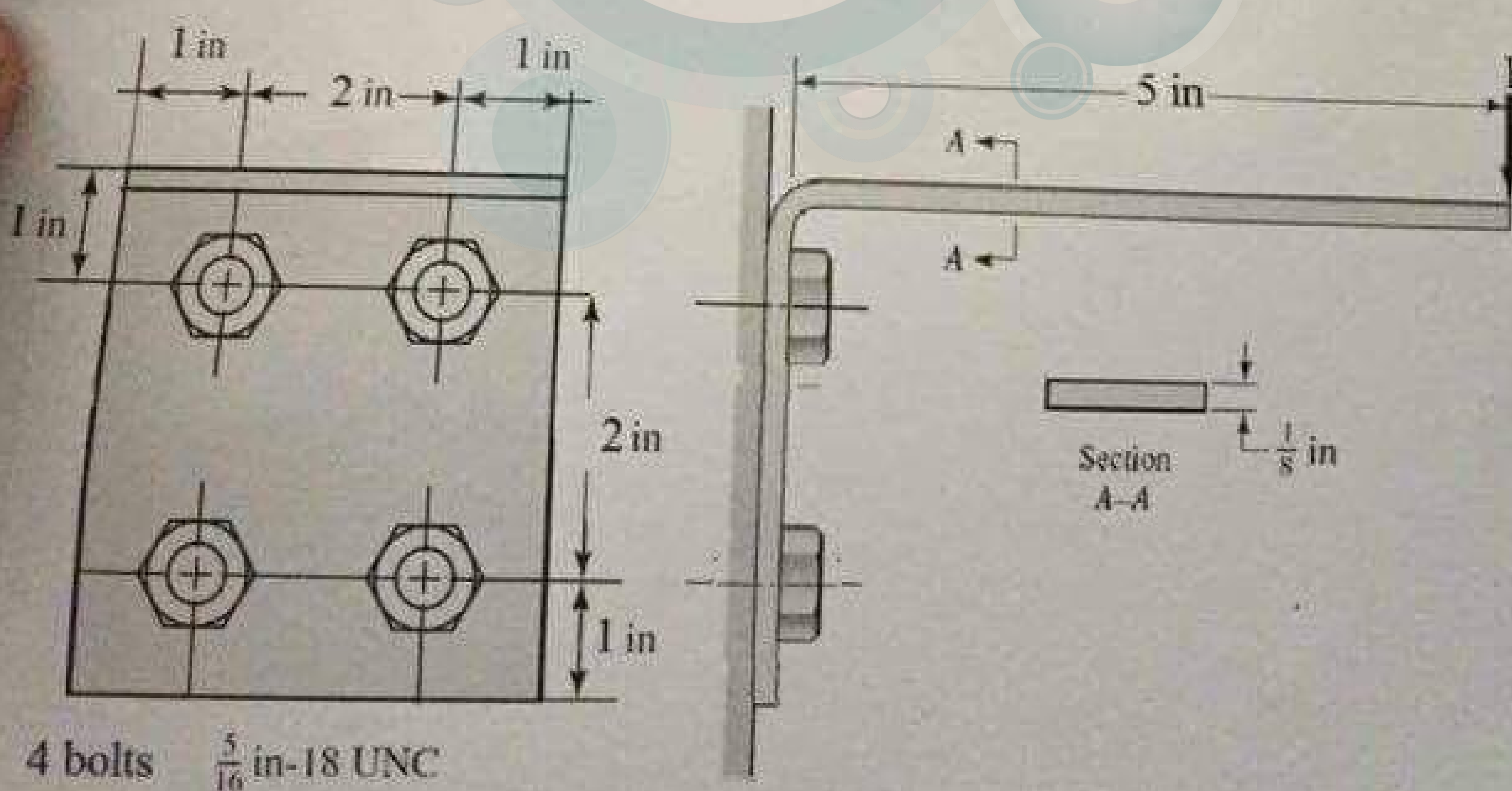
Q1(10P). In the figure shown, shaft *A*, made of AISI 1035 hot-rolled steel, is welded to a fixed support and is subjected to loading by equal and opposite forces *F* via shaft *B*. A theoretical stress-concentration factors Kt and *Kts* of 2 and 1.6 respectively are induced by the 18-in fillet. The length of shaft *A* from the fixed support to the connection at shaft *B* is 2 ft. The load *F* cycles from 150 to 500 lbf and the load P cycles from 0 to 100 lbf. For shaft A, find the factor of safety for infinite life using the modified Goodman fatigue failure criterion.



Q2(20P). Shown in the figure is a 5 by 4-in latching spring that supports a load of $F = 50$ lbf. The inside radius of the bend is 1/8in.

(*a*) using curved-beam theory, determine the stresses at the inner and outer surfaces at the bend.

(*b*) determine the shear stress and the tensile stress in the bolts



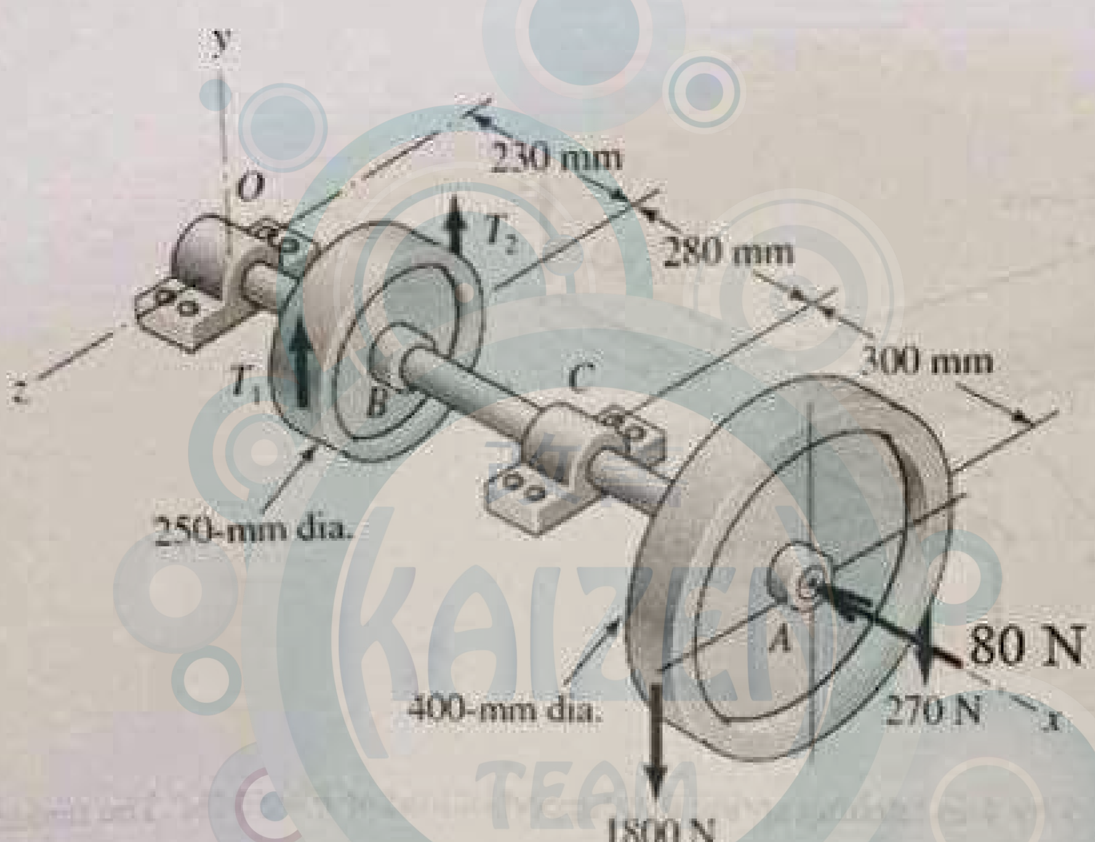
Q3(20P)- A belt-driven jack-shaft is shown in the figure below. The weight of each pulley is 900 N. The shaft is made of AISI 1050 CD (hardened steel) and is driven by a motor at 1200 rpm. All important surfaces have a ground finish. If the shaft is to be designed for an infinite life with a reliability of 99.9% and a safety factor of 1.5. The power is transmitted through the shaft and delivered to the belt on pulley *B*. Assume the belt tension on the loose side at *B* is 15 percent of the tension on the tight side. Determine:

a-Select two bearings for O and C using an application factor of unity and a desired life for each bearing is 9 kh with a 95 percent reliability for the two bearings. (use direct mount)

b-Draw shear-force and bending-moment diagrams for the shaft.

c- Using a factor of safety of 2.5 determine the minimum allowable diameter of the shaft based on a fatigue- failure analysis Modified Goodman. (Make any necessary assumptions).

d-draw the resulting shaft showing all necessary dimensions



Final Exam:

Q3): (20 p): weight = 900 N

$R = 95 \rightarrow$ for two bearing

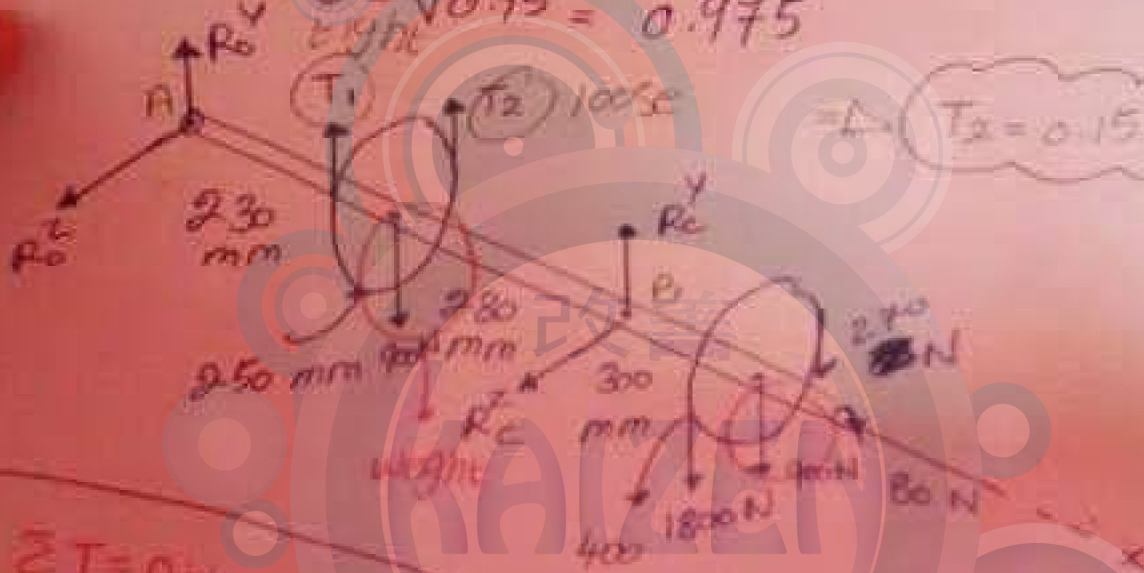
$n_D = 1200$ rpm AISI 1050 CD steel (ground)

For two bearing → $R = 99.9\%$ $K_{or}\, n = 1.5$

loose side = 15% tight side

ⓐ $l_D = 9{,}000$ hr $a_f = 1$ Direct

$R_D = \sqrt{0.95} = 0.975$



$\Rightarrow T_2 = 0.15\,T_1$

$\Sigma T = 0$:

$(1800 - 800)(0.2) + (T_2 - T_1)(0.125) = 0$ (270)

$200 + (0.15T_1 - T_1)(0.125) = 0$

$200 - 0.85\,T_1(0.125) \Rightarrow T_1 = 1882.35$ N

$\Rightarrow T_2 = 282.35$ N

$\Sigma M_O^y = 0$: $-R_C^z(0.51) = 0 \Rightarrow R_C^z = 0$

$\Sigma M_O^z = 0$: $(1882.35 + 282.35 - 900)(0.23) + R_C^y(0.51)$

$- (1800 + 80 + 900)(0.81)$

axial
CH.7
d

completely reversed / Constant] → by default completely Reversed

$\sum T = 0$;

$$(1800-270)(0.2)+(0.15T_1-T_1)(0.125)=0$$

$$\Rightarrow 306=(0.85)(0.125)T_1$$

$$\Rightarrow T_1 = 2880\ N$$

$$T_2 = 432\ N$$

$\sum M_O^y = 0$; $-R_C^z(0.51)=0 \Rightarrow R_C^z = 0$

$\sum M_O^z = 0$; $(2880+432-900)(0.23)+R_C^y(0.51)$

$$-(1800+270+900)(0.81)=0$$

$$\Rightarrow R_C^y = 3629.3\ N$$

$\sum F^y = 0$;

$$R_O^y+(2880+432)-900+3629.3-(1800+270+900)=0$$

$$R_O^y = -3071.3\ N$$

$\sum F^z = 0$; $R_O^z = 0$

$\Rightarrow Fr_{(B)} = 3629.3\ N$

$Fr_{(A)} = +3071.3\ N$

$Fae = 80\ N$

$$Fi_{(A)} = \frac{0.47(+3071.3)}{1.5} = +962.34\ N$$

$Fi_{(B)} = 1137.18\ N$

$Fe_{(A)} = (0.4)(+3071.3)+1.5(1137.18+80)$

$= ~~597.25~~\ N = ~~2147.16~~\ N$ 3054.32

$C_{10} = ~~1440.1\ N~~$ 6623.95 N

$Fe_{(B)} = 3629.3\ N$

$$C_{10} = (1)(3.6293)\left[\frac{7.2}{0+4.48(1-0.975)^{1/1.5}}\right]^{3/10}$$ 2.4112

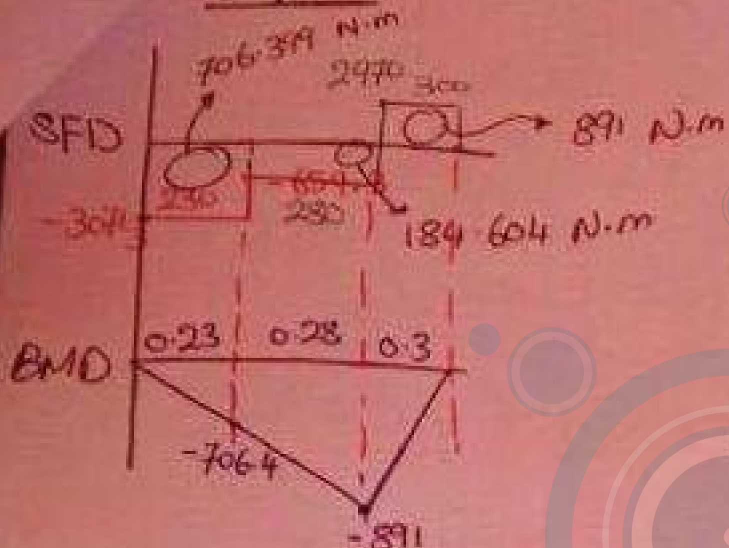
$$x_0 = \frac{(1200)(9{,}000)(60)}{90(10)^6} = 7.2$$

$\Rightarrow C_{10} = 8.751 = 8751\ N$

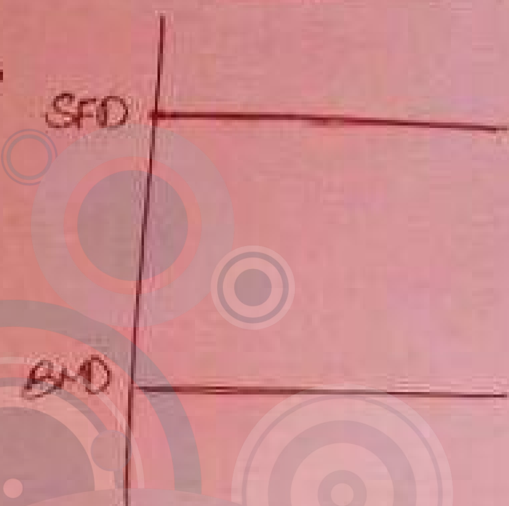
8751 – 9751

9520 k=1 *

Select Single Row Timken Tappered Bearing with Bore Diameter 25 mm & outside Diameter = 52 mm & cone = 32205-B & cup = 32205-B xy-plane



xz-plane



$M_{max} = 891$ N.m

(c) $n_f = 2.5$ $T = (432 - 2880)(0.125) = -306$ N.m

$M = 891$ N.m

$T_a = 0$ $M_m = 0$

$T_m = -306$ N.m $M_a = 891$ N.m

$K_a = a\,S_{ut}^{\,b}$ $S_{ut} = 690$ Mpa

$S_y = 580$ Mpa

$= 1.58(690)^{-0.085} = 0.9065$

$K_b = 0.9$ $K_c = 0.54$ $K_d = K_e = K_f = 1$

$S_e' = 0.5(690) = 345$ Mpa

$\Rightarrow S_e = 166.07$ Mpa $\Rightarrow$ Assume Sharp fillet Radius ($\frac{r}{d} = 0.02$)

$K_t = 3.0$ (Axial) $K_t = 2.7$ (Bending) $K_{ts} = 2.2$

$$d = \left(\frac{16(2.5)}{\pi} \left\{ \frac{1}{166.07(10)^6} \left[(4)(2.7(891))^2 \right]^{1/2} + \left[3(2.2(306))^2 \right]^{1/2} \frac{1}{690(10)^6} \right\} \right)^{1/3}$$

$$d = \left(\frac{16(2.5)}{\pi} \left\{ 2.897(10)^{-5} + 1.689(10)^{-6} \right\} \right)^{1/3}$$

$d = 73.09$ mm

$$\tau_{max} = \frac{53.77}{\frac{\pi}{4}\left(\frac{5}{16}\right)^2} = 701.1 \text{ psi} = 0.7011 \text{ kpsi}$$

$\frac{5}{16}$ in - 18 UNC

$$\sigma_{axial} = \frac{50}{\left(4 - 2\times\frac{5}{16}\right)\left(\frac{1}{8}\right)} = 118.52 \text{ psi} = 0.11852 \text{ kpsi}$$

$(w - 2d)(t)$

Q1): (10 P) AISI 1035 (HR) Steel

Fixed

$K_t = 2$

$K_{ts} = 1.6$

$r = \frac{1}{8}$ in

$F_{min} = 150$ lb

$F_{max} = 500$ lb

$P_{min} = 0$

$P_{max} = 100$ lb

$S_{ut} = 72$ kpsi

$S_y = 39.5$ kpsi

$d = \frac{7}{8}$

Axial

$\sigma_{min} = 0$

$$\sigma_{max} = \frac{100}{\frac{\pi}{4}\left(\frac{7}{8}\right)^2} = 166.3 \text{ psi} = 0.1663 \text{ kpsi}$$

$\sigma_a = \sigma_m = 0.08315$ kpsi

$q = 0.81$

$K_f = 1.81$

Torsion

$T_{min} = (150)(2) = 300$ lb.in

$T_{max} = (500)(2) = 1000$ lb.in

$$\tau_{min} = \frac{(300)\left(\frac{7}{16}\right)}{\frac{\pi}{2}\left(\frac{7}{16}\right)^4} = 2.281 \text{ kpsi}$$

$\tau_{max} = 7.6$ kpsi

$\tau_m = 4.941$ kpsi

$\tau_a = 2.66$ kpsi

$q_s = 0.94$

$K_{fs} = 1.56$

$$\sigma_a' = \left\{\left[\frac{(1.81)(0.08315)}{0.85}\right]^2 + 3\left[(1.56)(2.66)\right]^2\right\}^{1/2} = 7.19 \text{ kpsi}$$

$$\sigma_m' = \left\{\left[(1.81)(0.08315)\right]^2 + 3\left[(1.56)(4.941)\right]^2\right\}^{1/2} = 13.35 \text{ kpsi}$$

(20 P) 5*4 in F = 50 lb $r = \frac{1}{8}$ in

ⓐ

$$\sigma_i = -\frac{M c_i}{A e r_i} \qquad \sigma_o = \frac{M c_o}{A e r_o}$$

4 in, $\frac{1}{8}$ in

$r_i = \frac{1}{8}$ in $= 0.125$ in

$r_o = \frac{2}{8}$ in $= 0.25$ in

$r_c = \frac{1}{8} + \frac{1}{16} = 0.1875$ in

$$r_n = \frac{h}{\ln(r_o/r_i)} = \frac{\frac{1}{8}}{\ln(2/8 / \frac{1}{8})} = 0.1803 \text{ in}$$

$e = r_c - r_n = 7.2(10)^{-3}$ in

$c_o = r_o - r_n = 0.0697$ in

$c_i = r_n - r_i = 0.0553$ in

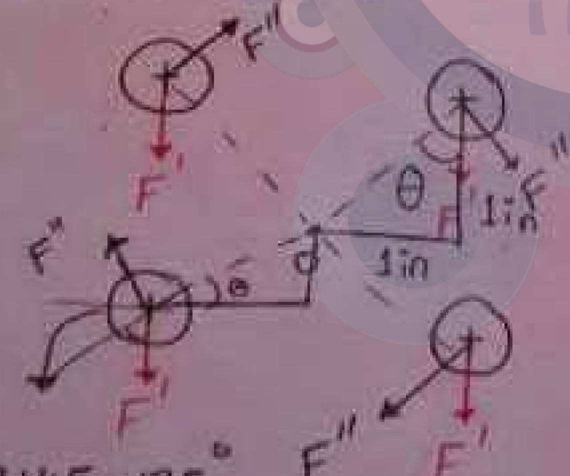
$A = 4(\frac{1}{8}) = 0.5$ in^2

$M = (50)(5) = 250$ lb.in

$$\sigma_i = -\frac{(250)(0.0553)}{(0.5)(7.2)(10)^{-3}(0.125)} = -4.27 \text{ kpsi}$$

$\sigma_o = 19.36$ kpsi

ⓑ



$M = 250$ lb.in

$r_n = 1.414$ in

$F' = 12.5$ lb F/4

$$F'' = \frac{(250)}{4(1.414)} = 44.2 \text{ lb}$$

$\alpha = 90 + 45 = 135°$

$$\theta = \cos^{-1}\left(\frac{1}{1.414}\right) = 45°$$

$\alpha = 45°$

$F_R = 53.77$ lb

$F_R = 36.45$ lb

Q3) : (20 P)

$2.937(10)^{5}$

AISI 1050 (CD)

$n_D = 1200$ rpm

Ground finish

99.9%

$n = 1.5$

$F_{ae} = 80$ N

$F_{r(A)} = R_o = 3071.3$

$F_{r(B)} = R_C = 3629.3$

$r = (0.02)(73.08) = 1.46$ mm

$K_t = 2.7$

$q = 0.79$

$K_f = 2.34$

$K_{ts} = 2.2$

$q_s = 0.82$

$K_{fs} = 1.98$

$d = 73.27$ mm $\rightarrow K_b = 0.769$

$S_e = 141.9$

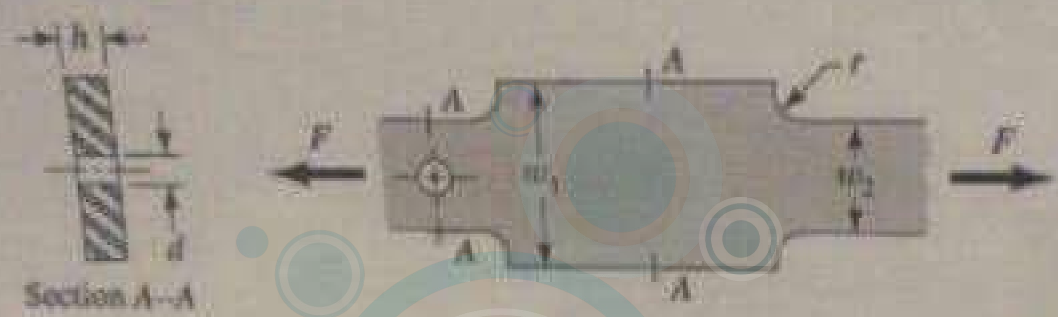
Final Examination

Machine design elements

Q1(15P). The figure shows the free-body diagram of a connecting-link portion having stress concentratio at three sections. The dimensions are r = 1.5 mm, d = 6 mm, h = 4 mm, w_1 = 20 mm, and w_2 = 15 mm. The force F fluctuate between a tension of 800 N and a compression of 1 kN. The connecting link is made of AISI 1030 CD. Using the modified Goodman failure theory determine:

a-the fatigue factors of safety for the hole and the fillet.

b-number of cycles to failure



Q2(15P). Shown in the figure is a 20 by 250-mm rectangular steel bar cantilevered to a 250-mm steel channel using five tightly fitted bolts located at A, B, C, D and E. For $F_1 = F_2 = 16$ kN load find

(a) The resultant load on each bolt

(b) The maximum shear stress in each bolt

* Final Exam form ①:

Q1): AISI 1035 (HR) steel $r = \frac{1}{8}$ in

$K_t = 2$ $K_{ts} = 1.6$

F 150 lb → 500 lb

P 0 → 100 lb

$T_{min} = 150(1) + 150(1) = 300$ lb.in

$T_{max} = 500(1) + 500(1) = 1000$ lb.in

$\tau_{min} = \frac{(300)\left(\frac{7}{16}\right)}{\frac{\pi}{2}\left(\frac{7}{16}\right)^4} = 2.28$ KPSi

$\tau_{max} = \frac{(1000)\left(\frac{7}{16}\right)}{\frac{\pi}{2}\left(\frac{7}{16}\right)^4} = 7.6$ KPSi

$\tau_a = \frac{7.6 - 2.28}{2} = 2.66$ KPSi

$\tau_m = \frac{7.6 + 2.28}{2} = 4.94$ KPSi

$\sigma_{min} = 0$

$\sigma_{max} = \frac{100}{\frac{\pi}{4}\left(\frac{7}{8}\right)^2} = 0.1663$ KPSi

$\sigma_a = \sigma_m = \frac{0.1663}{2} = 0.08315$ KPSi

$S_{ut} = 72$ KPSi

$q = 0.78$

$q_s = 0.83$

$K_f = 1 + 0.78(2-1) = 1.78$

$K_{fs} = 1 + 0.83(1.6-1) = 1.50$

$\sigma_a' = \left\{\left[\frac{1.78 \times 0.08315}{0.85}\right]^2 + 3\left[1.5 \times 2.66\right]^2\right\}^{1/2} = 6.913$ KPSi

$\sigma_m' = \left\{\left[1.78 \times 0.08315\right]^2 + 3\left[1.5 \times 4.94\right]^2\right\}^{1/2} = 12.84$ KPSi

$S_e = \left(14.4(72)^{-0.718}\right)\left(0.879(0.32375)^{-0.107}\right)(0.59)(1)(1)(1)(0.5(72))$

$S_e = 14.07$ KPSi

$d_e = 0.37\left(\frac{7}{8}\right) = 0.32375$ in

(b) <u>At the hole:</u>

$$N = \left(\frac{\sigma_{rev}/n}{a}\right)^{1/b} \qquad a = \frac{(f S_{ut})^2}{S_e} = \frac{((0.89)(520))^2}{190.03} = 1127.1 \text{ MPa}$$

$$b = -\frac{1}{3}\log\left(\frac{0.89 \times 520}{190.03}\right) = -0.1289$$

$$\sigma_{rev} = \frac{\sigma_a}{1 - \frac{\sigma_m}{S_{ut}}} = \frac{25 \times 1.87}{1 - \left(\frac{2.78 \times 1.87}{520}\right)} = 47.22 \text{ MPa}$$

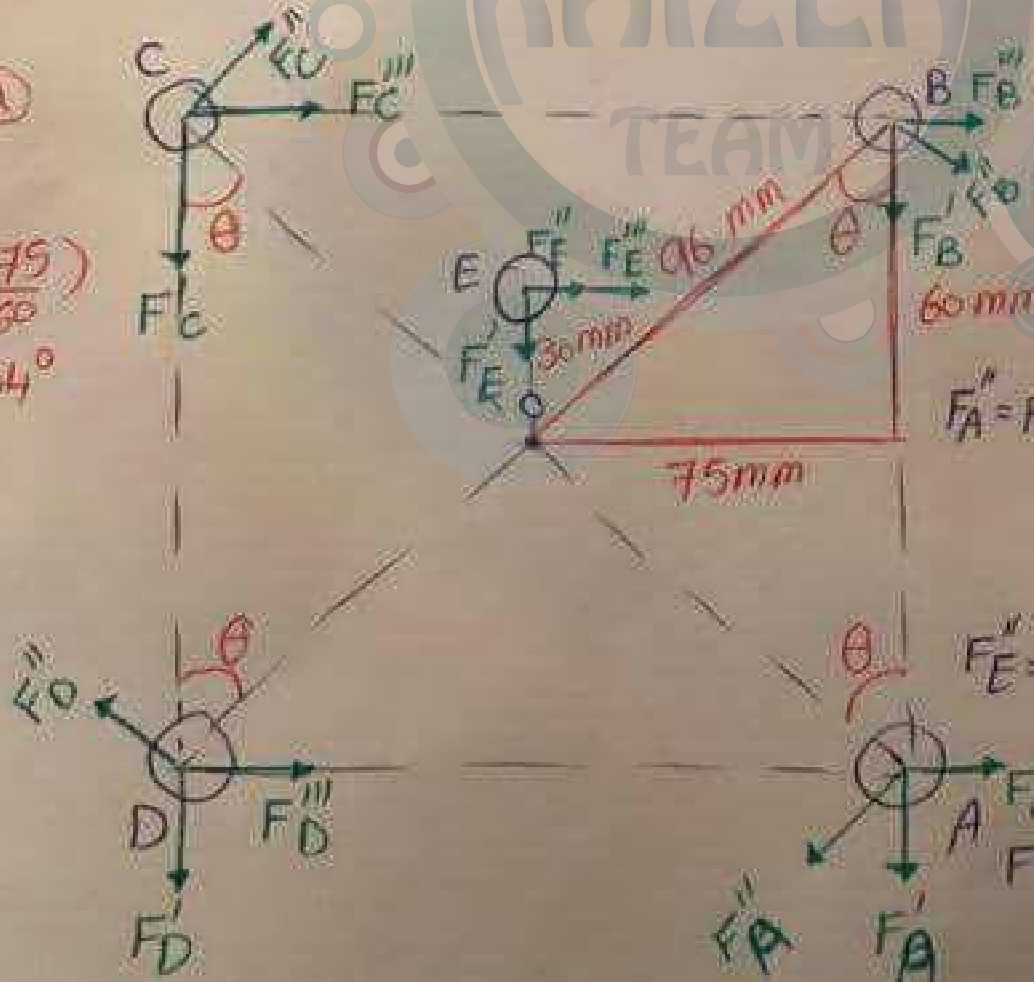
$S_y = 440$ MPa

$$1.87(25 + 2.78) = \frac{440}{n}$$

$$n = 8.47$$

$$N = \left(\frac{47.22/8.47}{1127.1}\right)^{1/-0.1289} = 772.1(10)^{15} \text{ cycle's}$$

Q2): (a)



$$\theta = \tan^{-1}\left(\frac{75}{60}\right) = 51.34^\circ$$

$$F' = \frac{16}{5} = 3.2 \text{ KN}$$

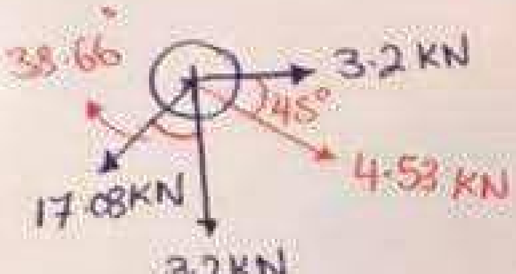
$$M_O = 16(420) = 6720 \text{ N.m}$$

$$F''_A = F''_B = F''_C = F''_D = \frac{(6720)(96)}{4(96)^2 + (30)^2} = 17.08 \text{ KN}$$

$$F''_E = \frac{(6720)(30)}{4(96)^2 + (30)^2} = 5.34 \text{ KN}$$

$$F''' = \frac{16}{5} = 3.2 \text{ KN}$$

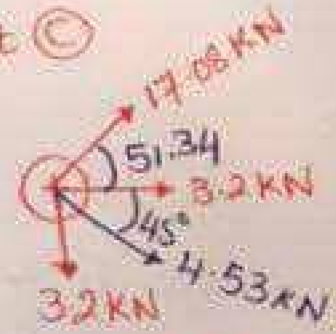
Bolt (A)



$\alpha = 83.66^\circ$

$F_{R_A} = 18.15\ KN$

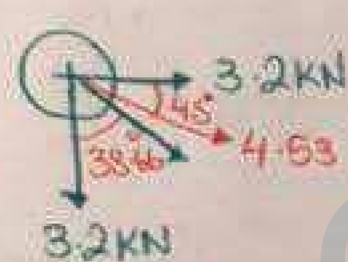
Bolt (C)



$\alpha = 96.34^\circ$

$F_{R_C} = 17.18\ KN$

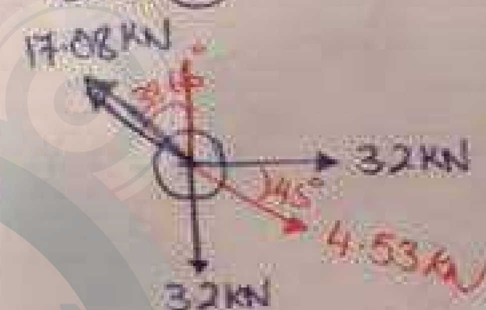
Bolt (B)



$\alpha = 6.34^\circ$

$F_{R_B} = 21.59\ KN$

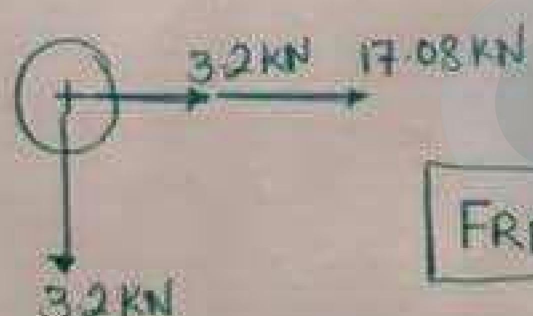
Bolt (D)



$\alpha = 173.66^\circ$

$F_{R_D} = 12.59\ KN$

Bolt (E)



$F_{R_E} = 20.53\ KN$

(b) $\tau_{max} = \dfrac{21.59(10)^3}{\frac{\pi}{4}(16)^2(10)^{-6}} = 107.38\ Mpa$

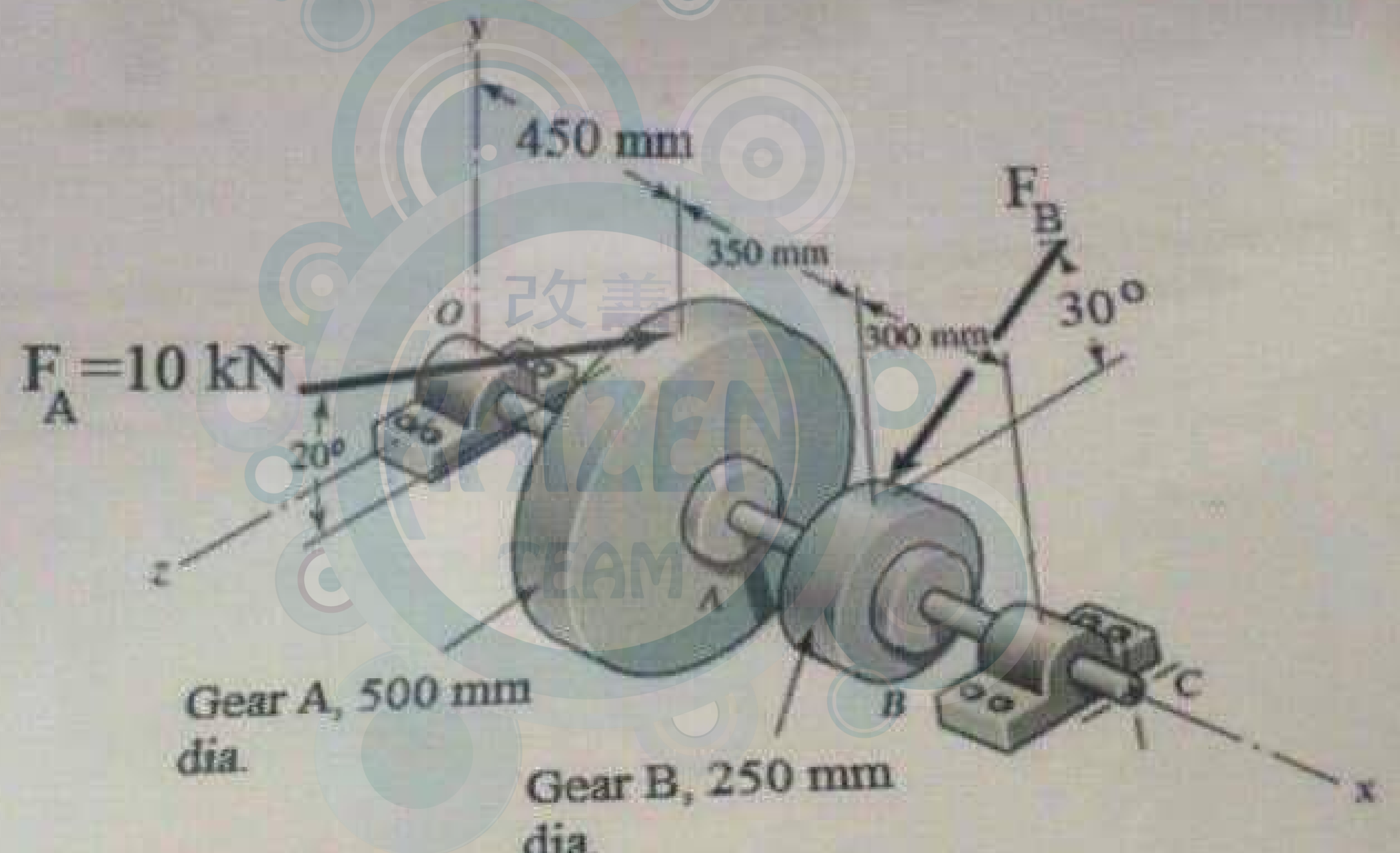
[redacted]

3(20P)- The shaft shown in the figure is made of *AISI 1018 cold-drawn steel and is driven by a moto* 100 rpm. If the shaft is to be designed for an infinite life with a *reliability of 99% and a safety factor of* The power is delivered to the shaft on gear A. Determine:

a-Select two bearings for O and C using an application factor of unity and a desired life for each bearing is 1 kh with a 99 percent reliability.

b-Draw shear-force and bending-moment diagrams for the shaft.

c- Using a factor of safety of 2.5 determine the minimum allowable diameter of the shaft based on a fatigue- failure analysis Modified Goodman. (Make any necessary assumptions).



ΣM=0

P3): AISI 1018 CD steel

(b) $\Sigma T = 0;\ F_B \cos(30^\circ)(0.125) - 10(10^3)\cos(20^\circ)(0.25) = 0$

$F_B = 21.7\ KN$

$\Sigma M_O^y = 0;\ 10\cos(20^\circ)(450) - 21.7\cos(30^\circ)(800) - R_C^z(1100) = 0$

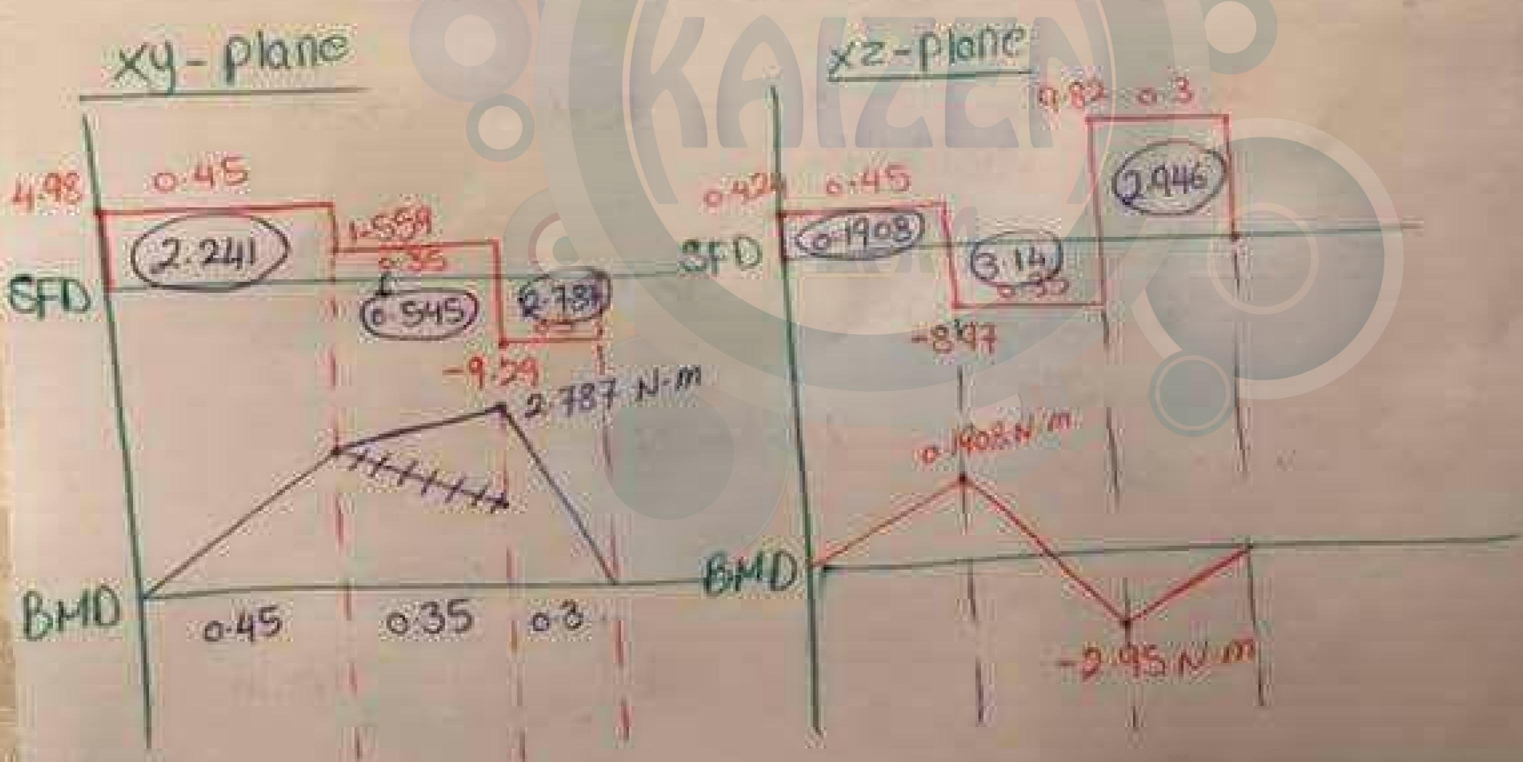
$R_C^z = -9.82\ KN$

$\Sigma M_O^z = 0;\ -10\sin(20^\circ)(450) - 21.7\sin(30^\circ)(800) + R_C^y(1100) = 0$

$R_C^y = 9.29\ KN$

$\Sigma F^y = 0;\ R_O^y - 10\sin(20^\circ) - 21.7\sin(30^\circ) + 9.29 = 0$ $R_O^y = 4.98\ KN$

$\Sigma F^z = 0;\ R_O^z + 21.7\cos(30^\circ) - 10\cos(20^\circ) - 9.82 = 0$ $R_O^z = 0.424\ KN$



$$M_{max} = \sqrt{(2.95)^2 + (2.787)^2} = 4.06\ N\cdot m$$

$M_a = 4.06\ KN\cdot m$ $M_m = 0$

$T_a = 0$ $T_m = 2.35\ KN\cdot m$

(c) $n = 2.5$

$$T = (2880 - 432)(0.125) = 306 \text{ N·m}$$

$T_a = 0$ $T_m = 306$ N·m

Sharp fillet Radius $K_t = 2.7$ $K_{ts} = 2.2$ $\frac{r}{d} = 0.02$

$\frac{D}{d} = 1.5$ $K_b = 0.9$

$S_e' = 0.5(690) = 345$ MPa $S_{ut} = 690$ MPa

$K_f = K_e = K_d = 1$ $K_c = 0.59$ $K_b = 0.9$

$K_a = 4.51(690)^{-0.265} = 0.798$

$S_{e1} = 146.15$ MPa

$$d = \left(\frac{16(2.5)}{\pi}\left\{3.292(10)^{-5} + 1.6898(10)^{-6}\right\}\right)^{1/3} = 76.1 \text{ mm}$$

$K_b = 1.51(76.1)^{-0.157} = 0.7649$ $S_{e2} = 124.24$ MPa

$r = 0.02(76.1) = 1.52$ mm

$q = 0.81 \rightarrow K_f = 1 + 0.81(2.7-1) = 2.38$

$q_s = 0.84 \rightarrow K_{fs} = 1 + 0.84(2.2-1) = 2.01$

$$d = \left(\frac{16(2.5)}{\pi}\left\{3.414(10)^{-5} + 1.544(10)^{-6}\right\}\right)^{1/3} = 76.88 \text{ mm}$$

$K_b = 1.51(76.88)^{-0.157} = 0.7637$ $S_{e3} = 124.05$ MPa

$r = 0.02(76.88) = 1.54$ mm $K_f = 2.38$ $K_{fs} = 2.01$

$$d = \left(\frac{16(2.5)}{\pi}\left\{3.419(10)^{-5} + 1.544(10)^{-6}\right\}\right)^{1/3} = 76.91 \text{ mm}$$

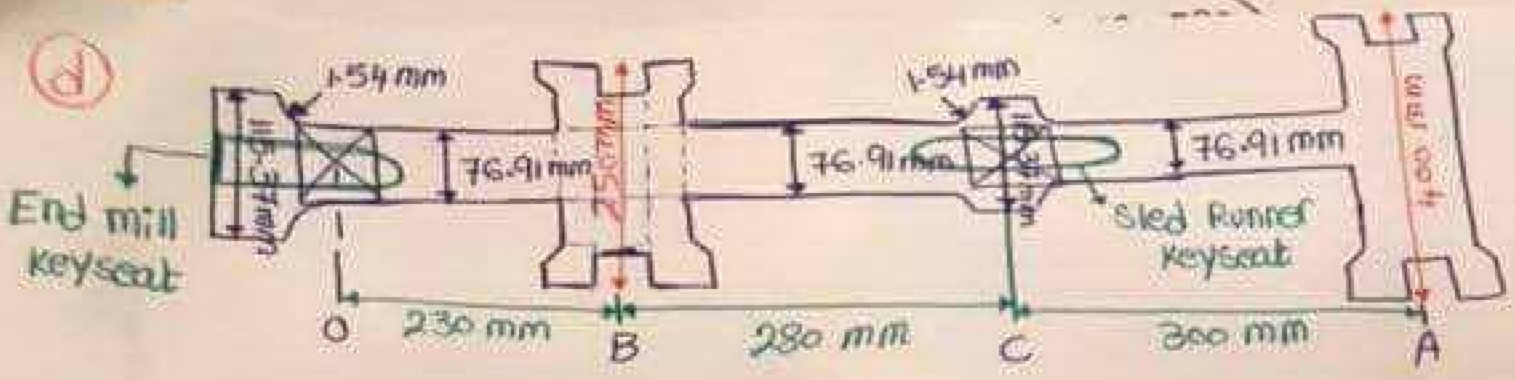
$K_b = 0.7636$ $S_{e4} = 124.04$ MPa

Stop

$d = 76.91$ mm $r = 1.54$ mm $D = 115.37$ mm

$N = \left(\frac{\sigma_{rev}/n}{a}\right)$ $a = \frac{(f\,S_{ut})^2}{S_e} = \frac{((0.81)(520))^2}{190.03} = 1127.1$ MPa

(d)



*Final Exam form ②:

Q1): AISI 1030 (CD) steel $S_{ut} = 520$ MPa

F → −1,000 N → 800 N

(a)

*** Hole:**

$\frac{d}{w} = \frac{6}{15} = 0.4$

$K_t = 2.08$ $q = 0.81$

$K_f = 1.87$

$\sigma_{min} = \frac{-1000}{(15-6)(4)(10)^{-6}} = -27.78$ MPa

$\sigma_{max} = \frac{800}{(15-6)(4)(10)^{-6}} = 22.22$ MPa

$\sigma_a = +25$ MPa

$\sigma_m = -2.78$ MPa

$\frac{(1.87)(25)}{190.03} + \frac{(1.87)(2.78)}{520} = \frac{1}{n_f}$

$n_f = 3.91$

*** fillet:**

$\frac{D}{d} = \frac{20}{15} = 1.33$

$\frac{r}{d} = \frac{1.5}{15} = 0.1$ $q = 0.76$

$K_t = 1.96$

$K_f = 1.73$

$\sigma_{min} = \frac{-1000}{(15)(4)(10)^{-6}} = -16.67$ MPa

$\sigma_{max} = \frac{800}{(15)(4)(10)^{-6}} = 13.33$ MPa

$\sigma_a = 15$ MPa

$\sigma_m = -1.67$ MPa

$S_e = \left(4.51(520)^{-0.265}\right)(1)(0.85)(0.5(520))$

$= 190.03$ MPa

$\frac{(1.73)(15)}{190.03} + \frac{(1.73)(1.67)}{520} = \frac{1}{n_f}$

$n_f = 7.04$

KN

6720 N.m

96)

(30)²

kN

34 KN

⑥

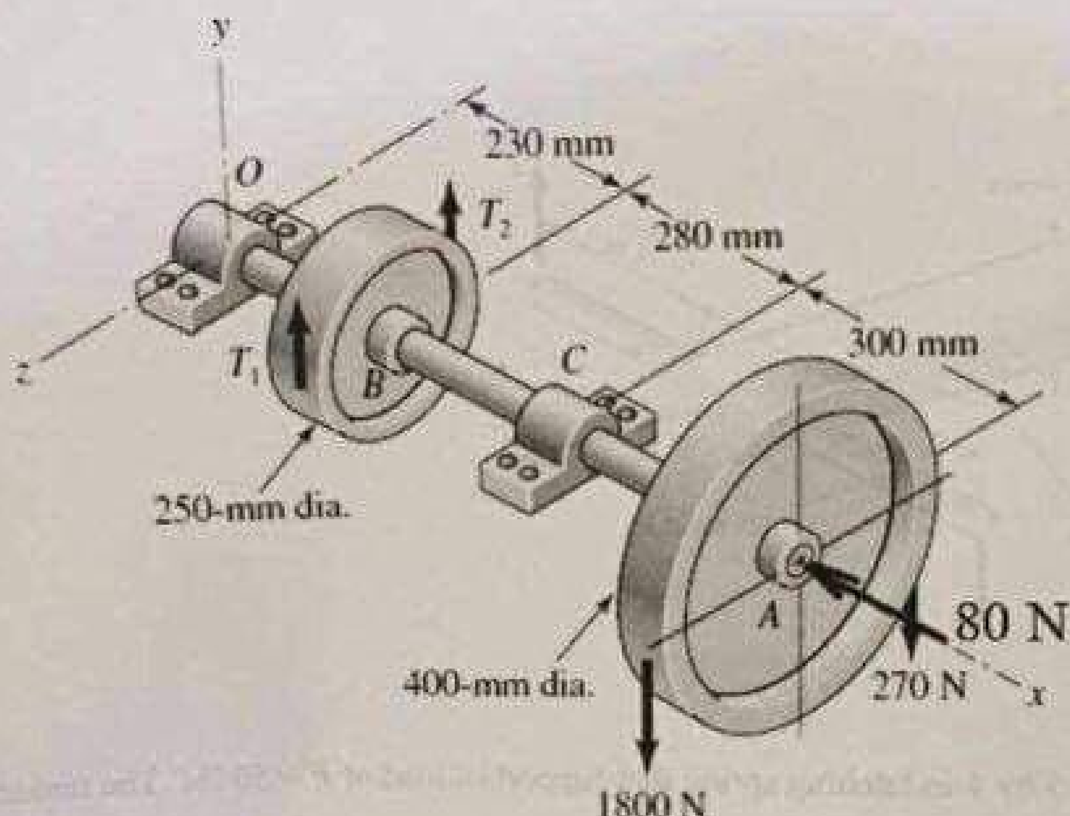
Q3(20P)- A belt-driven jack-shaft is shown in the figure below. The weight of each pulley is 900 N. The shaft is made of AISI 1050 CD (hardened steel) and is driven by a motor at 1200 rpm. All important surfaces have a ground finish. If the shaft is to be designed for an infinite life with a reliability of 99.9% and a safety factor of 1.5. The power is transmitted through the shaft and delivered to the belt on pulley *B*. Assume the belt tension on the loose side at *B* is 15 percent of the tension on the tight side. Determine:

a-Select two bearings for O and C using an application factor of unity and a desired life for each bearing is 9 kh with a 95 percent reliability for the two bearings. (use direct mount)

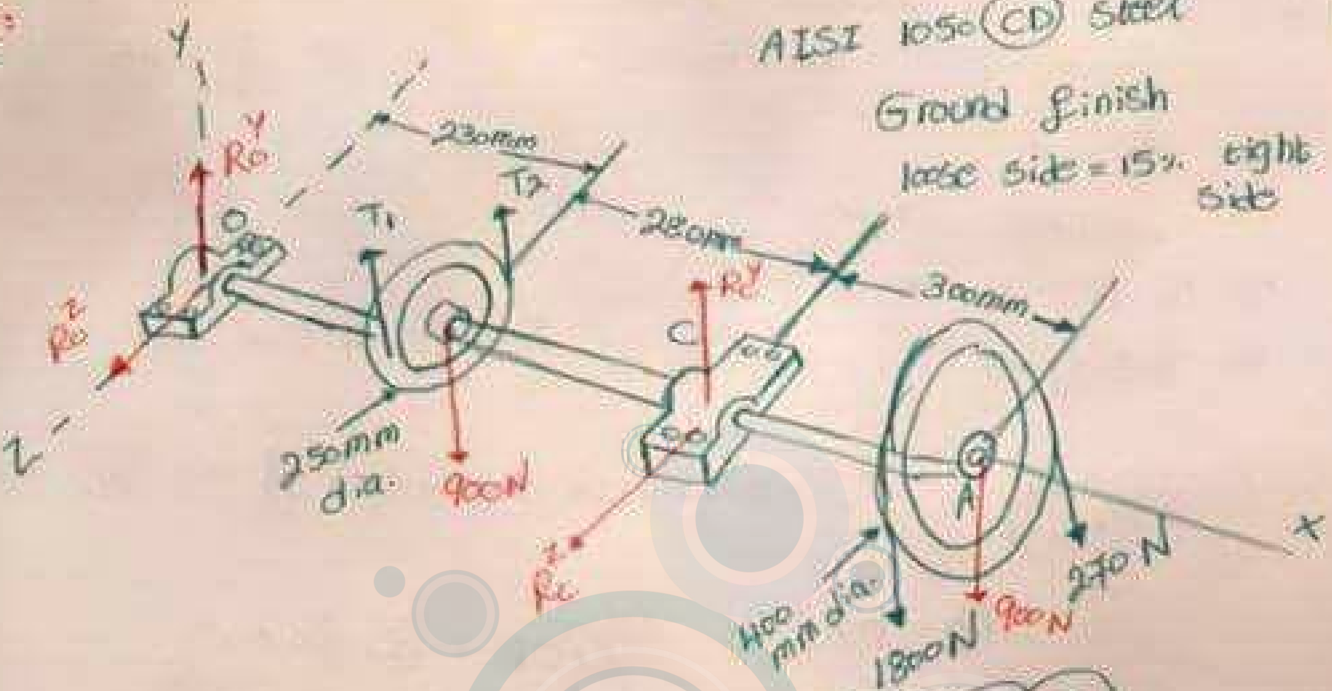
b-Draw shear-force and bending-moment diagrams for the shaft.

c- Using a factor of safety of 2.5 determine the minimum allowable diameter of the shaft based on a fatigue- failure analysis Modified Goodman. (Make any necessary assumptions).

d-draw the resulting shaft showing all necessary dimensions



Q3):



AISI 1050 (CD) steel

Ground finish

loose side = 15% tight side

T_1 : tight T_2 : loose $T_2 = 0.15\, T_1$

(b) $\Sigma T = 0;\ (1800-270)(0.2) + (T_2 - T_1)(0.125) = 0$

$306 + (0.15\, T_1 - T_1)(0.125) = 0$

$T_1 = 2880\ N$ $T_2 = 432\ N$

$\Sigma M_O^y = 0;\ -R_C^z(0.51) = 0$ $R_C^z = 0$

$\Sigma M_O^z = 0;\ (2880+432-900)(0.23) + R_C^y(0.51) - (1800+900+270)(0.81) = 0$

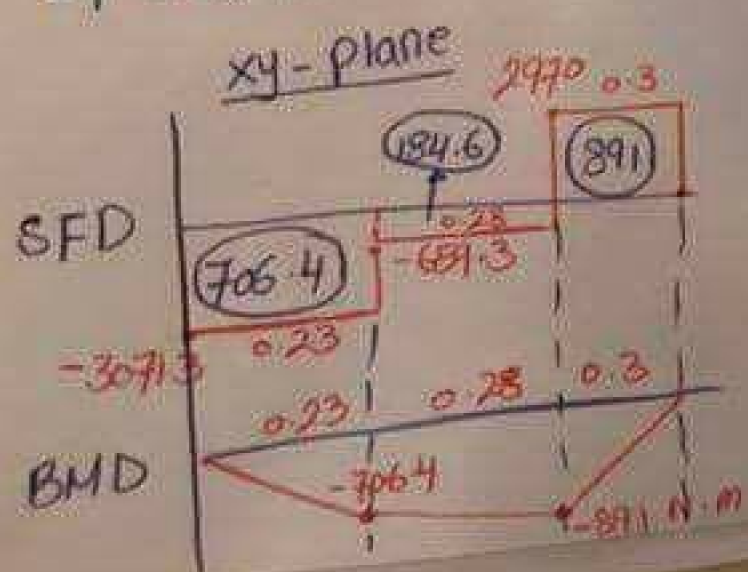
$R_C^y = 3629.3\ N$

$\Sigma F^y = 0;\ R_O^y + 2880 + 432 - 900 + 3629.3 - 1800 - 900 - 270 = 0$

$R_O^y = -3071.3\ N$

$\Sigma F^z = 0;\ R_O^z + 0 = 0$ $R_O^z = 0$

xy-plane



$M_{max} = 891\ N\cdot m$

$M_a = 891\ N\cdot m$ $M_m = 0$

3

Ⓒ Sharp fillet Radius $n = 2.5$

$K_f = K_t = 2.7$ $K_{fs} = K_{ts} = 2.2$ $\frac{r}{d} = 0.02$ $\frac{D}{d} = 1.5$

$K_b = 0.9$

$S_{ut} = 440$ MPa

$S_e' = 0.5(440) = 220$ MPa

$K_f = K_d = K_e = 1$ $K_c = 0.59$

$K_a = (4.51(440)^{-0.265}) = 0.8988$

$S_{e1} = 104.997$ MPa

$$d = \left(\frac{16(2.5)}{\pi}\left\{2.088(10)^{-4} + 2.0351(10)^{-5}\right\}\right)^{1/3} = 142.89 \text{ mm}$$

$K_b = 0.6929$ $S_{e2} = 80.83$ MPa

$r = 0.02(142.89) = 2.86$ mm

$q = 0.78$ $K_f = 2.33$

$q_s = 0.82$ $K_{fs} = 1.98$

$$d = \left(\frac{16(2.5)}{\pi}\left\{2.341(10)^{-4} + 1.832(10)^{-5}\right\}\right)^{1/3}$$

$= 148.03$ mm $K_b = 0.689$

$S_{e3} = 80.38$ MPa

$r = 2.96$ mm $K_f = 2.33$

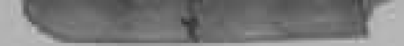
$K_{fs} = 1.98$

$$d = \left(\frac{16(2.5)}{\pi}\left\{2.354(10)^{-4} + 1.832(10)^{-5}\right\}\right)^{1/3} = 147.82 \text{ mm}$$

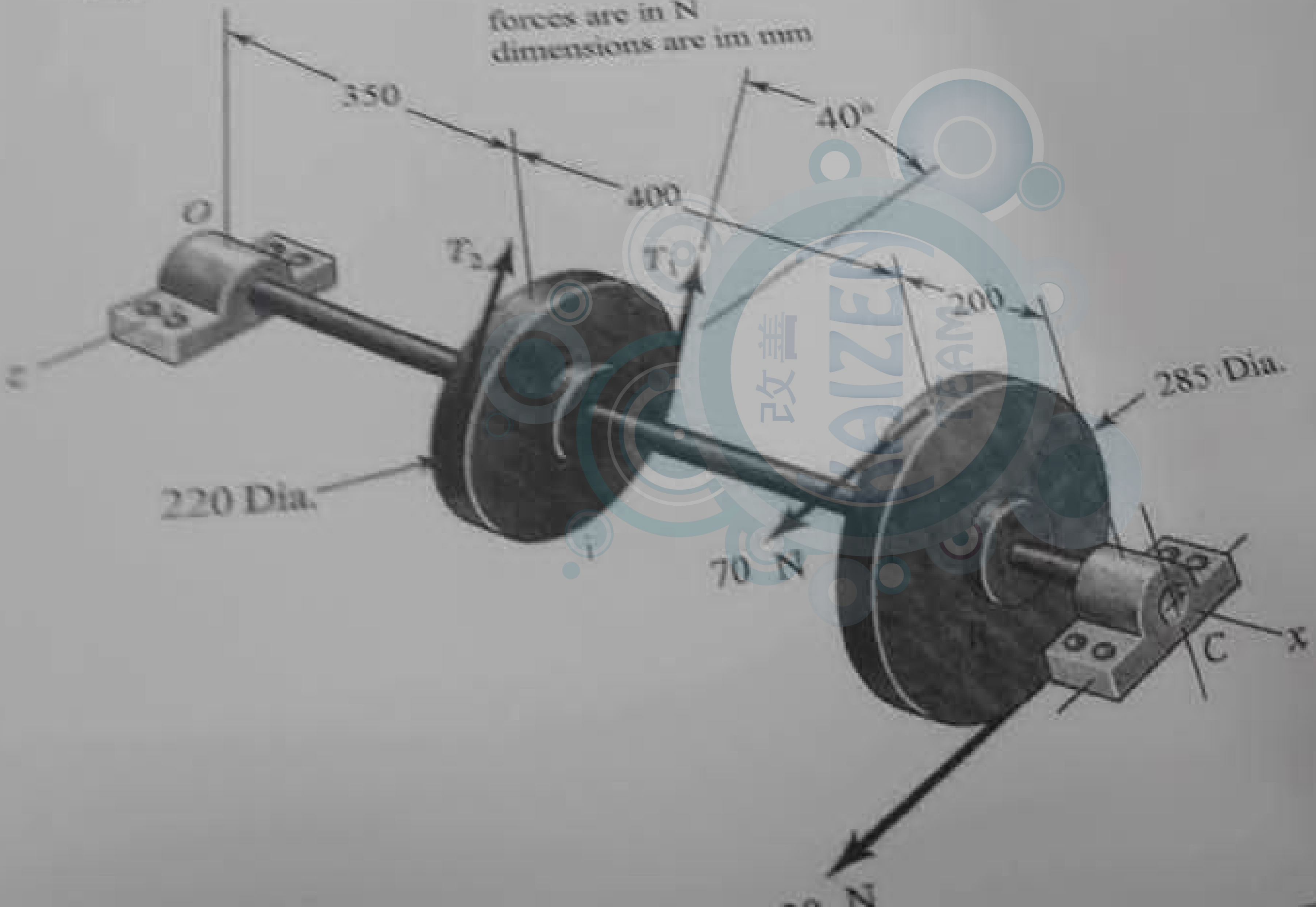
$K_b = 0.6892$ $S_{e4} = 80.4$ MPa

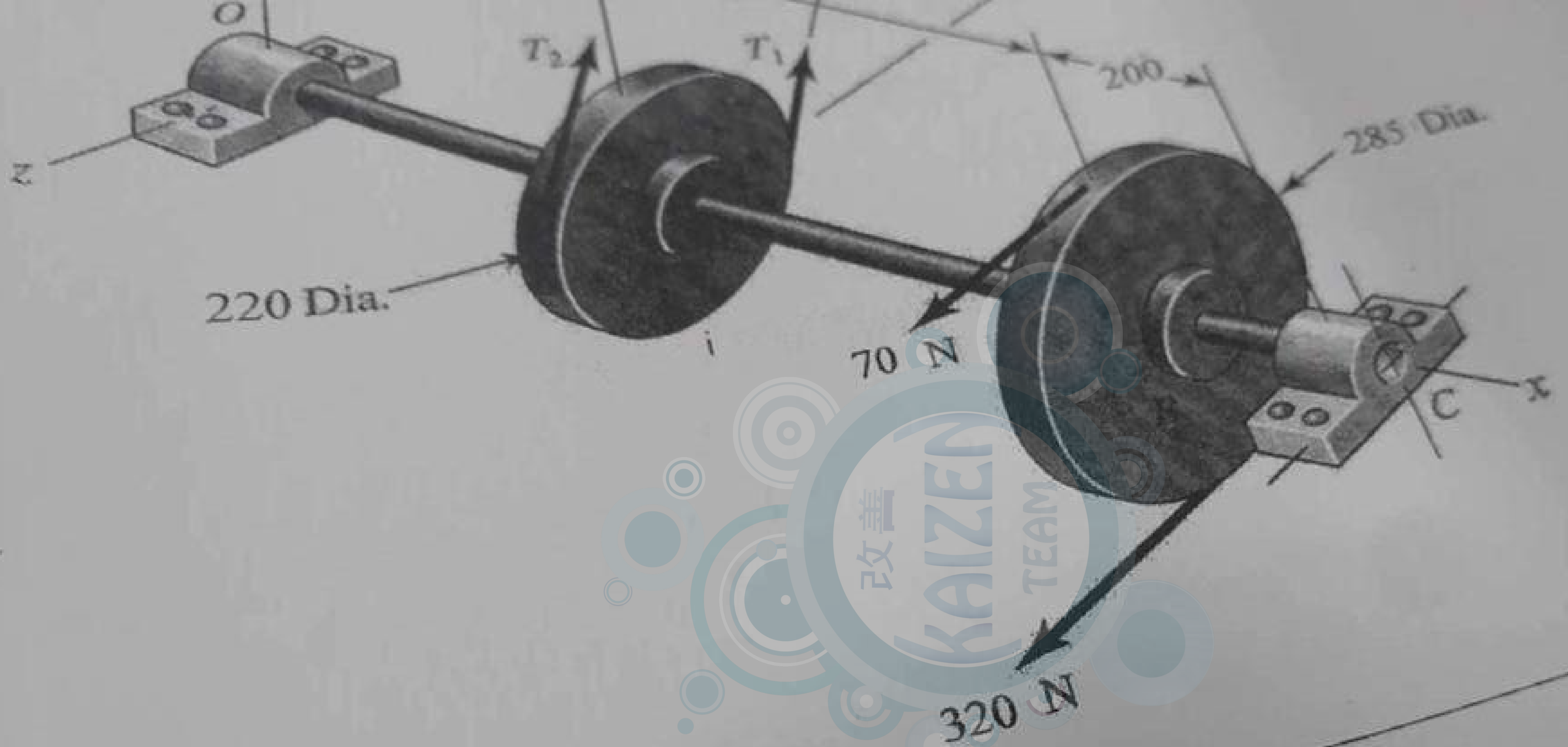
Stop

Final Answer



Q2(16points). The figure shows a shaft mounted in bearings at C and O and having pulleys at A and B. the bearings are to have a life of 90 kh at a combined reliability of 0.99. The countershaft runs at 1600 rev/min. The belt tension on the loose side of pulley A is 10 percent of the tension on the tight side.
a-Select deep-groove bearings for use at C and O using an application factor of 1.2
b-If a 100 N axial stress is applied at point C in the -x direction will the same bearings chosen in part a be suitable



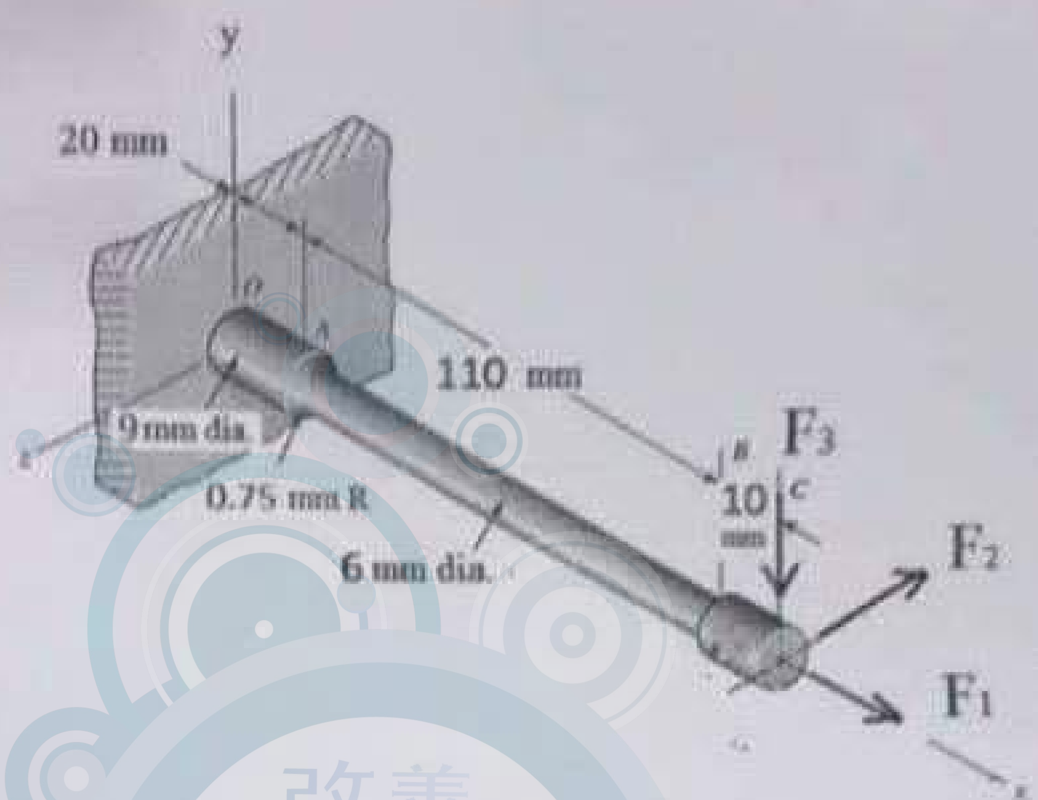


O
T_2
T_1
200
285 Dia.
z
220 Dia.
70 N
C
x
320 N

Q1(15P). Q1(15points) The bar in the figure is made of AISI 1006 cold-drawn steel and is loaded by the forces $F1 = 500$ N, $F2 = 3$ kN, and $F3 = 10$ kN

a) For the critical stress element, determine the principal stresses and the maximum shear stress

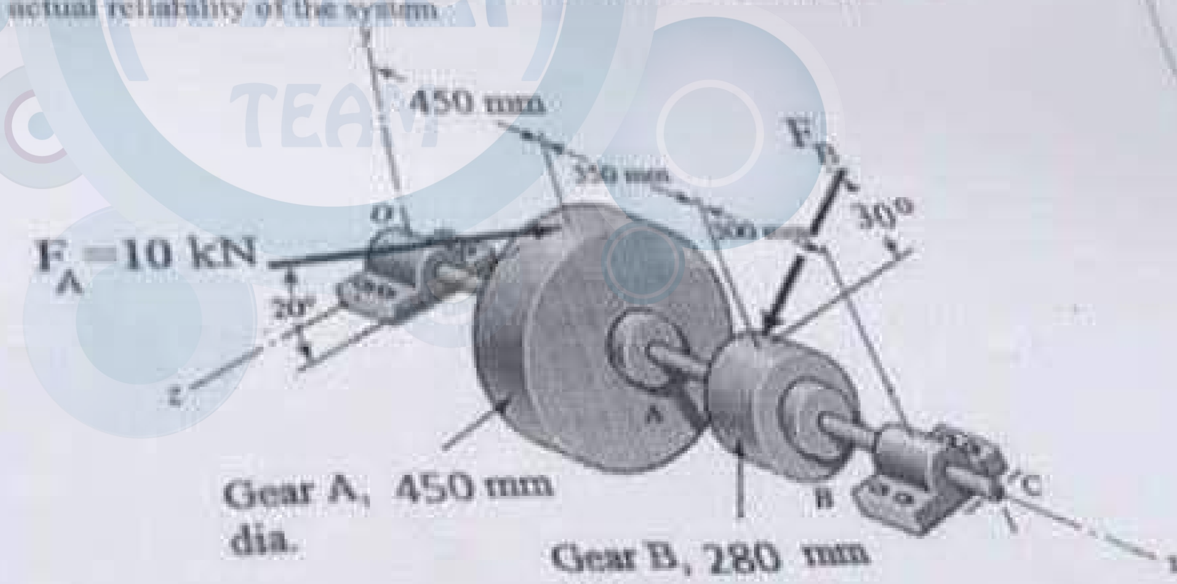
b) Compute the factor of safety, based upon the distortion energy theory, for the critical stress element of the member shown in the figure



Q2(15P)- The shaft shown in the figure is made of AISI 1018 cold-drawn steel and is driven by a motor at 90 rpm. The power is delivered to the shaft on gear A.

a-Select two angular contact ball bearings for O and C using an application factor of unity and a desired life for each bearing is 900h with a 98 percent reliability.

b- what is the actual reliability of the system.



Midterm Exam: Machine design elements

Q1(14points) The shoulder shaft in the figure is made of AISI 1006 cold-drawn steel and is loaded by a bending moment $M = 2$ kN.m. , and a torque $T = 250$ N · m.

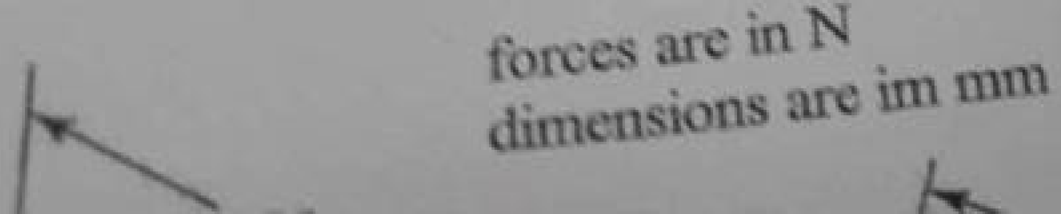
a) For the critical stress element, determine the principal stresses and the maximum shear stress

b) Compute the deterministic factors of safety, based upon the distortion energy theory, for critical stress element of the member shown in the figure

Q2(16points). The figure shows a shaft mounted in bearings at C and O and having pulleys at A and B. the bearings are to have a life of 90 kh at a combined reliability of 0.99. The countershaft runs at 1600 rev/min. The belt tension on the loose side of pulley A is 10 percent of the tension on the tight side.

a-Select deep-groove bearings for use at C and O using an application factor of 1.2.

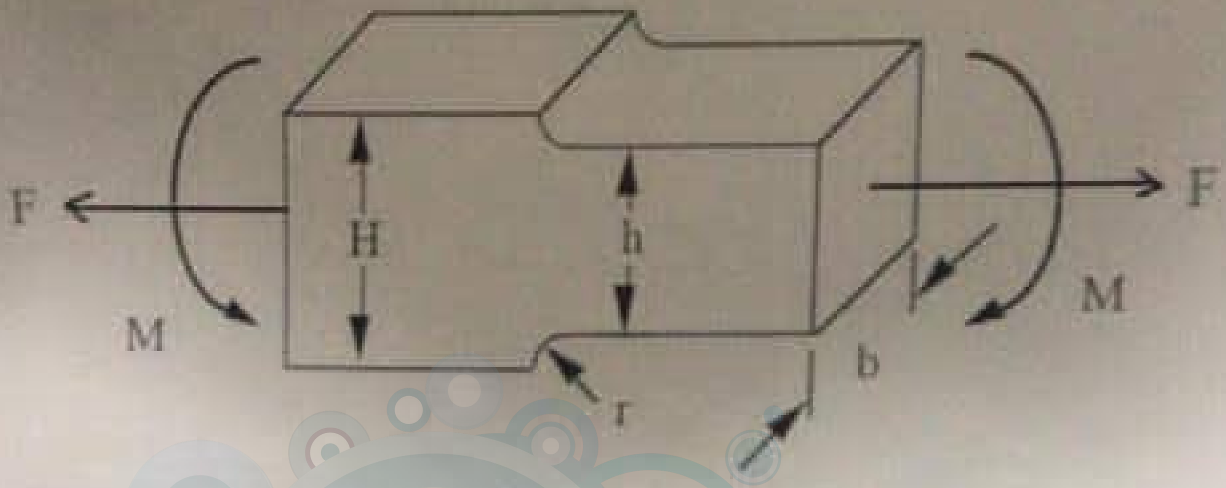
b-If a 100 N axial stress is applied at point C in the -x direction will the same bearings chosen in part a be suitable.



Final Examination

Q1(15P): The figure shows the free-body diagram of a machine part. The dimensions are r = 2.5 m H = 35 mm h = 25 mm b = 20 mm. The part is loaded with a force F that fluctuate between a tensi of 800 N and a compression of 1 kN and a bending moment M that fluctuates between zero-to-1 N.m to give an infinite fatigue life with 99% reliability. The part is made of AISI 1040 CD. T surface is machined. Using the modified Goodman failure theory determine:

a-the fatique factors of safety for the part



Q2.(15P). A screw clamp similar to the one shown in the figure has a handle with diameter 3/16 in made of cold-drawn AISI 1006 steel. The screw has Acme threads with a major diameter 1 in and is 5 3/4 in long. The screw material is made of steel lubricated with machine oil and the nut material is made from cast iron. A force of 12 lb.f will be applied to the handle at a radius of 5 in from the screw centre line :

a- what will be the clamping force

b-Given that n_f=3 determine the von Mises stress at the root of the thread