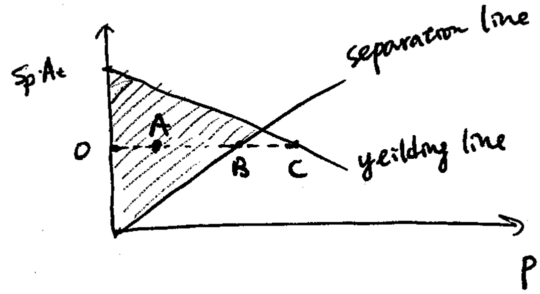
Problem 1

(a)



$F_b = F_i + cp < S_p A_t$

$F_b = F_i + cp < S_p \cdot A_t$, $F_i + n_y cp = S_p \cdot A_t \Rightarrow n_y = \frac{S_p A_t - F_i}{cp}$

$F_m = -F_i + P(1-c) < 0$, $F_i = n_s \cdot P(1-c) \Rightarrow n_s = \frac{F_i}{(1-c)P}$

(b) $c = \frac{k_b}{k_b + k_m} = \frac{\frac{1}{3}}{\frac{1}{3}+1} = 0.25$

$P_{10} =$ ~~$1500\ psi \cdot \pi r^2 = 1500 \cdot 314 \cdot 2^2 = 117,809\ lb$~~
$200 \cdot \pi r^2 = 200 \cdot 314 = 62800$

$P_1 = \frac{62800}{10} = 6280$

$n_y = \frac{85000 \cdot 0.142 - 7500}{(0.25) \cdot 6280} \approx 2.91$ ~~2.85~~

(c) $n_s = \frac{7500}{(1-0.25) \cdot 6280} \approx 1.59$

(d) $n_s = 1 = \frac{7500}{(1-0.25)P} \Rightarrow P = 10,000\ lb$

$\frac{10,000 \times 10}{314} = 318\ Psi$

(e) members are not carrying the external load, only bolt is carry P
or $C = 1$

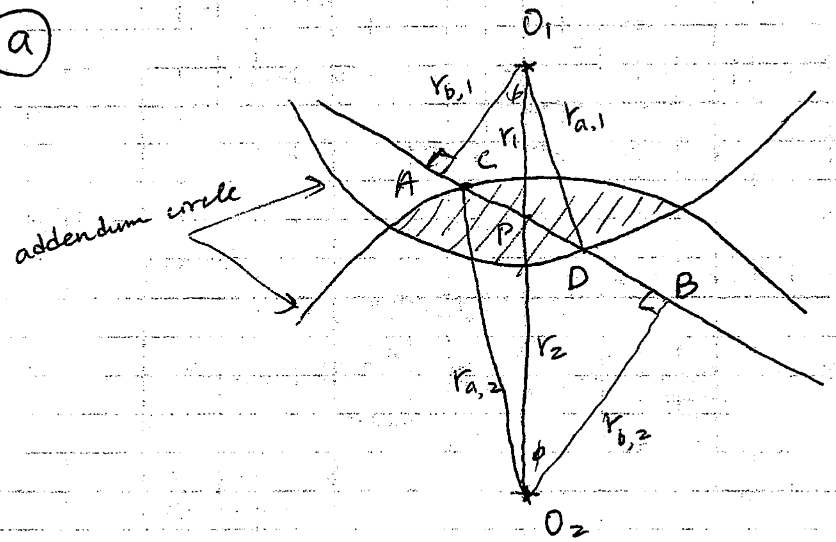
(f) before $n_y = \frac{S_p \cdot A_t - F_i}{cp} = \frac{85000 \cdot 0.142 - 7500}{0.25 \cdot 10,000} \approx 1.79$

after $F_b = F_i + cp = 7500 + 10,000 = 17500$

$S_p \cdot A_t = 85000 \cdot 0.142 = 11985 < 17500 \Rightarrow$ already yeilding

$\frac{11985}{17500} = 0.68$

(a)



r_1, r_2 – radii of pitch circle
$r_{a,1}, r_{a,2}$ – addendum
$r_{b,1}, r_{b,2}$ – dedendum
O_1, O_2 – centers of gear1 & gear2

contact ratio: $\dfrac{\overline{CD}}{\dfrac{2\pi r_b}{N}}$ $\qquad \dfrac{r_b}{N} = \dfrac{r_{b,1}}{N_1} = \dfrac{r_{b,2}}{N_2}$

$1.5 < C.R. < 2.0$

interference if $\overline{BC} > \overline{AB}$ or $\overline{AD} > \overline{AB}$

(b)

d_1 (4th gear) $= 2 \cdot 24 = 48$ mm
d_2 (5th gear) $= 2 \cdot 36 = 72$ mm

$r_{a,1} = r_1 + a = 24 + 2 = 26$
$r_{b,1} = r_1 \cos\phi = 24 \cos 20° = 22.55$
$r_{a,2} = r_2 + a = 36 + 2 = 38$
$r_{b,2} = r_2 \cos\phi = 36 \cos 20° = 33.83$

$$\overline{CD} = \frac{\sqrt{r_{a,1}^2 - r_{b,1}^2} + \sqrt{r_{a,2}^2 - r_{b,2}^2} - \overline{O_1O_2}\sin\phi}{2\pi \dfrac{r_{b,1}}{N_1}}$$

$$= \frac{13.03 + 17.3 - 20.52}{2\pi \cdot \dfrac{22.55}{24}} = 1.66$$

(c)

since $13.03 < 20.52$ OK $\Rightarrow$ No interference
 $17.3 < 20.52$ OK

(D)

$$e = \frac{n_L - n_A}{n_F - n_A} = \frac{0 - n_A}{1000 - n_A} \Rightarrow A\ \text{rpm} = -200\ \text{r/min}$$

$w_6 = 0$
$w_2 = 1000$ rpm
$w_a = ?$

$$w_{6/a} = +w_{5/a} \cdot \frac{N_5}{N_6} = -w_{4/a} \cdot \frac{N_4}{N_5} \cdot \frac{N_5}{N_6} = +w_{2/a} \cdot \frac{N_2}{N_4} \frac{N_4}{N_5} \frac{N_5}{N_6}$$

$$(0 - w_a) = (1000 - w_a) \cdot \frac{24}{144} \Rightarrow -6w_a = 1000 - w_a$$

$$w_a = -200$$

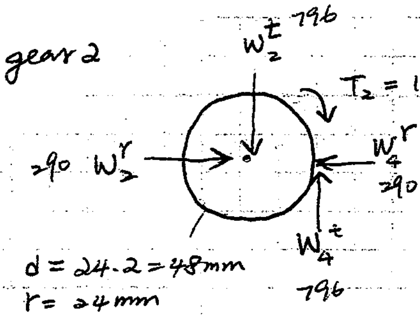
(e) input torque:

$$2000\ W = T_2 \cdot \frac{2\pi \cdot n}{60} \quad (n = 1000) \Rightarrow T_2 = 19.1\ N.m$$

100 percent efficiency $\Rightarrow$ $2000 = T_3 \cdot \frac{2\pi \cdot n}{60} = 95.5\ N.m$ ($n = 200$)

(f)

gear 2

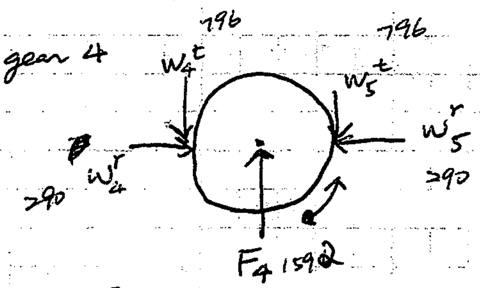


$$W_2^t = \frac{19.1}{24 \times 10^{-3}} = 796\ N$$

$$W_2^r = 796 \cdot \tan 20^\circ = 290\ N$$

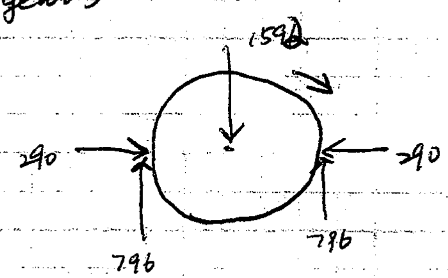
d = 24·2 = 48mm
r = 24mm

gear 4

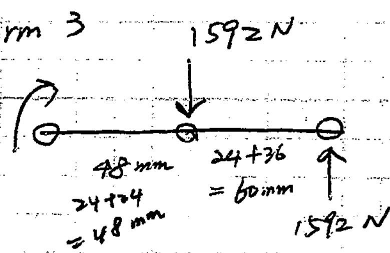


$$F_4 = 2W_4^t = 2 \cdot 796 = 1592\ N$$

gear 5



Arm 3



$$T_{out} = T_3 = \left[1592\,(60+48) - 1592 \cdot 48\right] \times 10^{-3} = 95.5\ N.m$$

The shaft of gear 2 is fixed to the ground & will provide x & y directione force & torque to gear 2

The shafts of gear 4 & gear 5 are rotating with the arm so the forces will be ~~transmitted to~~ ballanced by the arm