Name of Student: Solution
Last First

Class Time (circle one): 7:30 11:30 2:30

ME 452: Machine Design II
Fall Semester 2014
Class Test 3 - November 7, 2008
OPEN BOOK. CLOSED NOTES.
For Full credit show all of your work, including complete free-body diagrams.

Problem 1 (60 points).

The gear train shown below transmits 1 horsepower at a pinion speed of 2000 rpm. The teeth are 20 degree pressure angle, full depth, and the overall gear ratio for the gear box is 4:1 (that is, the gear box output shaft speed is 500 rpm). Assume highest point of single tooth contact for stress calculations. The number of teeth on gear 2 is twice that of gear 3, that is, $N_2 = 2N_3$. The following factors are known for the pinion on the input shaft:

$F = 4\pi/P$ inches
$K_o = 1.25$ $K_v = 1.3$ $K_B = 1.0$ $K_m = 1.0$ $K_s = 1.0$

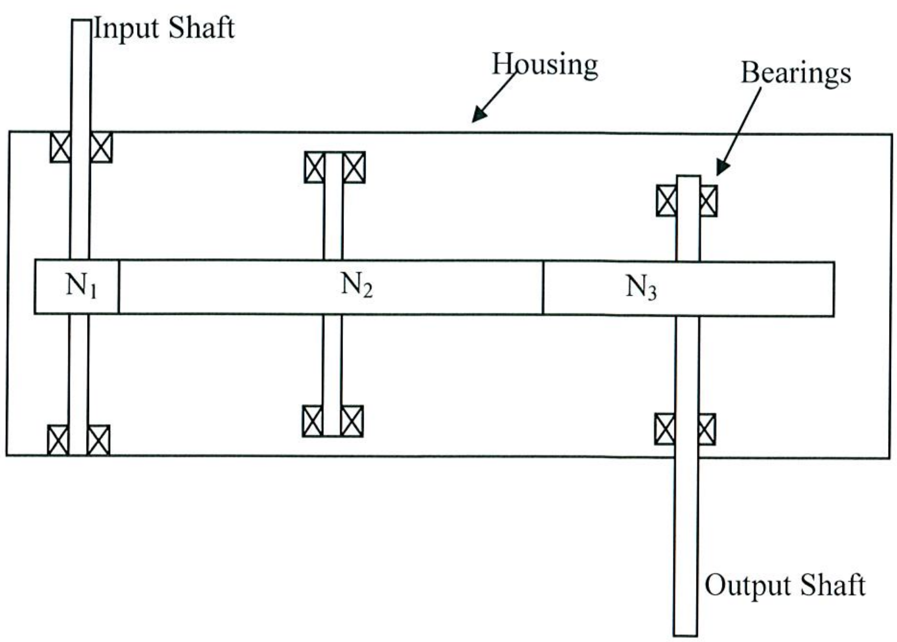
(a) Calculate the minimum number of teeth on the pinion and both gears without undercutting.

(b) Calculate the diametral pitch of the pinion on the input shaft using the AGMA equations when the allowable bending stress is 32,000 psi (use answers from part (a).)

(c) Select the closest preferred diametral pitch (tooth size in general use) that corresponds to your answer in (b).

(d) Calculate the face width for the gears using answers from part (c).

(e) Calculate the center distance between the input and output shafts using your answers from (a) and (c) above.



ME 452 Test 3 Fall 2014

(a) $n_1 = 2000$

$\phi = 20$, full depth

$n_1/n_3 = 4$

HPSTC

$N_2 = 2N_3$

$F = 4\pi/P$

$K_o = 1.25$

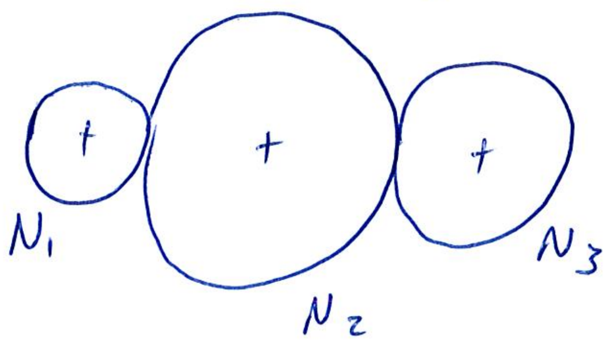
$K_v = 1.3$

$K_B = 1.0$

$K_m = 1.0$

$K_s = 1.0$

(a) find N_1 N_2 N_3 No undercutting



$$m_G = \frac{N_2}{N_1}\frac{N_3}{N_2} = \frac{N_3}{N_1}$$

$$4 = \frac{N_3}{N_1}$$

but $N_3 = N_2/2$ so

$$4 = \frac{N_2}{2N_1} \Rightarrow \boxed{\frac{N_2}{N_1} = 8}$$

$$N_p = \frac{2k}{(1+2m)\sin^2\phi}\left(m + \sqrt{m^2 + (1+2m)\sin^2\phi}\right)$$

$$= \frac{2}{17\sin^2 20}\left(8 + \sqrt{64 + 17\sin^2\phi}\right) = 16.216$$

$\boxed{N_p = 17}$ $\boxed{N_2 = 8N_1 = 136}$ $\boxed{N_3 = 4N_1 = 68}$

(b) $\sigma_{all} = \sigma = \dfrac{W_t P}{F J}(k_o k_v k_s k_m k_B)$

Fig 14-6 pg 753

$J = ~~.259~~ .29$ (to .30)

$F = 4\pi/P$

$d = N_1/P \qquad V = \dfrac{\pi d n}{12} = \dfrac{\pi N_1 n}{12 P}$

$W_t = \dfrac{33000 H}{V} = \dfrac{33000 H \; 12 P}{\pi N_1 n}$ (H = 1, N_1 = 17, n = 2000)

$W_t = 3.7074 P$

So

$$32000 = \frac{(3.7074 P) P P}{4\pi (.295)}(1.25)(1.3)(1)(1)(1)$$

$P^3 = 19691$

$P = 27.0035$ ← Theoretical Need

(c) closest is $\boxed{P = 24}$ (Next smaller is $P = 32$)

(d) $F = 4\pi / P = 4\pi / 24$

$$\boxed{F = .524 \text{ inches}}$$

(e) $C = r_1 + 2r_2 + r_3$

$$= \frac{d_1}{2} + d_2 + \frac{d_3}{2}$$

$$= \frac{N_1/2 + N_2 + N_3/2}{P} \qquad P = \frac{N}{d}$$

$$d = N/P$$

$$C = \frac{17/2 + 136 + 68/2}{24}$$

$$\boxed{C = 7.4375 \text{ inches}}$$

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Problem 2 (40 points).

Consider a 6304 deep groove ball bearing, whose load ratings are provided below. The applied radial load is 250 pounds and the axial load is 100 pounds. The inner ring rotates and the load application factor is 1.0.

(a) Calculate the equivalent radial load.

(b) Calculate the L_{10} life of the bearing, in revolutions, for the applied loads.

(c) Determine the life of the bearing, in revolutions, if the reliability is to be 99.9% using the following parameters:

$$x_0 = 0.02$$
$$(\theta - x_0) = 4.439$$
$$b = 1.483$$

BEARING NUMBER*	BOUNDARY DIMENSIONS						SNAP RING DIMENSIONS Inches			MAX. FILLET RADIUS Shaft & Hsg.	APPROX. WEIGHT	S_L LIMITING SPEED ‡	C_{10} DYNAMIC LOAD RATING	C_o STATIC LOAD RATING
	BORE mm	BORE inch	O. DIAM. mm	O. DIAM. inch	WIDTH mm	WIDTH inch	H	S	t	inch	lb.	rpm	lb.	lb.
6300	10	.3937	35	1.3780	11	.4331	.125	1.562	.044	.025	.13	22000	1400	850
6301	12	.4724	37	1.4567	12	.4724	.125	1.625	.044	.040	.15	20000	1700	1040
6302	15	.5906	42	1.6535	13	.5118	.125	1.821	.044	.040	.20	18000	1930	1200
6303	17	.6693	47	1.8504	14	.5512	.141	2.074	.044	.040	.25	16000	2320	1460
6304	20	.7874	52	2.0472	15	.5906	.141	2.276	.044	.040	.34	14000	3000	1930
6305	25	.9843	62	2.4409	17	.6693	.195	2.665	.067	.040	.58	11000	3800	2550
6306	30	1.1811	72	2.8346	19	.7480	.195	3.091	.067	.040	.83	9500	5000	3400
6307	35	1.3780	80	3.1496	21	.8268	.195	3.406	.067	.060	1.07	8500	5700	4000
6308	40	1.5748	90	3.5433	23	.9055	.226	3.799	.097	.060	1.41	7500	7350	5300
6309	45	1.7717	100	3.9370	25	.9843	.226	4.193	.097	.060	1.95	6700	9150	6700
6310	50	1.9685	110	4.3307	27	1.0630	.226	4.587	.097	.080	2.50	6000	10600	8150
6311	55	2.1654	120	4.7244	29	1.1417	.271	5.104	.111	.080	3.30	5300	12900	10000
6312	60	2.3622	130	5.1181	31	1.2205	.271	5.498	.111	.080	3.81	5000	14000	10800
6313	65	2.5591	140	5.5118	33	1.2992	.304	5.892	.111	.080	4.64	4500	16000	12500
6314	70	2.7559	150	5.9055	35	1.3780	.304	6.286	.111	.080	5.68	4300	18000	14000
6315	75	2.9528	160	6.2992	37	1.4567	.304	6.679	.111	.080	6.60	4000	19300	16300
6316	80	3.1496	170	6.6929	39	1.5354	.346	7.198	.122	.080	9.53	3800	21200	18000
6317	85	3.3465	180	7.0866	41	1.6142	.346	7.593	.122	.100	11.00	3400	21600	18600
6318	90	3.5433	190	7.4803	43	1.6929	.346	7.986	.122	.100	11.60	3400	23200	20000
6319	95	3.7402	200	7.8740	45	1.7717	.346	8.380	.122	.100	13.38	3200	24500	22400
6320	100	3.9370	215	8.4646	47	1.8504	—	—	—	.100	16.34	3000	28500	27000
6321	105	4.1338	225	8.8582	49	1.9291	—	—	—	.100	17.8	2800	30500	30000
6322	110	4.3307	240	9.4488	50	1.9685	—	—	—	.100	21.0	2600	32500	32500
6324	120	4.7244	260	10.2362	55	2.1654	—	—	—	.100	32.3	2400	36000	38000
6326	130	5.1181	280	11.0236	58	2.2835	—	—	—	.12	40.1	2200	39000	43000
6328	140	5.5118	300	11.8110	62	2.4409	—	—	—	.12	48.1	2000	44000	50000
6330	150	5.9055	320	12.5984	65	2.5590	—	—	—	.12	57.8	1900	49000	60000

(2) 6304 bearing

$F_r = 250$ lb

$F_a = 100$ lb

$V = 1.0$

$C_{10} = 3000$ $\quad$ $C_0 = 1930$

(a)

$F_a/C_0 = \frac{100}{1930} = .0518 \Rightarrow .24 \le e \le .26$

$F_a/VF_r = \frac{100}{250} = 0.400$

So $F_a/VF_r > e \Rightarrow X = .56$

for Y:

$\frac{F_a}{C_0}$	Y
.042	1.85
→ .0518 } .7	⇒ 1.752
.056	1.71

$F_e = XVF_r + YF_a$

$= .56(250) + 1.752(100)$

$F_e = 315.2$ lb

(b) $L_{10} = \left(\frac{C_{10}}{F_e}\right)^3$

$= \left(\frac{3000}{315.2}\right)^3$

$L_{10} = 862$ million revolutions

(c) Reliability adjustment

$a_1 = x_0 + (\theta - x_0)\left(\ln\left(\frac{1}{R}\right)\right)^{1/b}$

$= .02 + 4.439\left(\ln\frac{1}{.999}\right)^{1/1.483}$

$a_1 = .0621$

$L_{99.9} = a_1 L_{10} = .0621(862)$

$L_{99.9} = 53.5$ million revolutions