Homework 7. Gear Box Calculations
Assigned: 11/29/12, Due: Date of Final Exam

NOTE: the final exam will principally cover material similar to what is contained in this homework assignment.

The second major part of the final exam will relate to questions related to the functions of your catapult design (all parts). These questions may bring in calculations from the other parts of the course and may involve design sketches.

1. What is the optimal spacing for a 13 tooth in mesh with a 44 tooth spur gear. Both gears have 32 pitch and 20 degree pressure angle?
2. What is the optimal spacing for a 20 tooth and a 60 tooth spur gear with 1 module and 20 degree pressure angle?
3. You have access to 32 pitch, 20 degree PA gears with the following teeth (12, 24, 36, 48, 60) and module 1.5, 20 degree PA gears with the following teeth (16, 32, 48, 64). The 32 pitch gears are brass (yield strength=70 MPa) and the 1.5 module gears are steel (yield strength=1500 MPa). Design a gear box with a gear ratio between 30 and 36. If the gear box is exposed to a maximum input torque of 1 Newton meter, fill in the entries in the table on the next page and calculate the required face width to keep the tooth stress below $0.3\sigma_y$. If the maximum speed of the motor is $10000\,rpm$, calculate the output speeds.

   Calculate the bearing loads as follows:

   The forces acting on the axles (assuming 4 stages) are:

   stage 1 axle: $\vec{B}_1 + W_{t1}\hat{i} + W_{n1}\hat{j} = \hat{0}$

   stage 2 axle: $\vec{B}_2 - W_{t1}\hat{i} - W_{n1}\hat{j} + W_{t2}\hat{i} + W_{n2}\hat{j} = \hat{0}$

   stage 3 axle: $\vec{B}_3 - W_{t2}\hat{i} - W_{n2}\hat{j} + W_{t3}\hat{i} + W_{n3}\hat{j} = \hat{0}$

   stage 4 axle: $\vec{B}_4 - W_{t3}\hat{i} - W_{n3}\hat{j} = \hat{0}$

   The magnitudes can be calculated (remembering the relation between W_t and W_n) as:

   $\|\vec{B}_1\| = W_{t1}\,sec(\phi)$, $\|\vec{B}_2\| = (W_{t1} - W_{t2})\,sec(\phi)$, $\|\vec{B}_3\| = (W_{t2} - W_{t3})\,sec(\phi)$, $\|\vec{B}_1\| = W_{t3}\,sec(\phi)$

Stage	Z_i	Z_o	P_d or m	ϕ	τ_i	$\tau_o = \frac{Z_o}{Z_i}\tau_i$	$W_t = \frac{2\tau_i P_d}{Z_i} = \frac{2\tau_i}{m Z_i}$	$W_n = W_t \tan(\phi)$	$\|\vec{B}\|$	F	$0.3\sigma_y$	$\sigma = \frac{54 W_t P_d}{\pi^2 F} = \frac{54 W_t}{\pi^2 F m}$
No.	teeth	teeth	$\frac{teeth}{inch}$ or $\frac{mm}{teeth}$	*degree*	$N \cdot m$	$N \cdot m$	N	N	N	mm	*MPa*	*MPa*
1				20								
2				20								
3				20								
4				20								
5				20								