

Carleton University
Department of Mechanical and Aerospace Engineering

MECH 4003 A Mechanical Systems Design – Fall 2021

Problem Set 1: Gear Force Analysis and Design

Due: October 14th @ 5:00pm EST on Brightspace

- 16.16 The four helical gears shown in Figure P16.16 have a module in the normal plane of 4 mm and a pressure angle in the normal plane of 0.35 rad. The motor shaft rotates 550 rpm and transmits 20 kW. Other data are on the drawing.
- What is the speed ratio between the motor (input) and output shafts?
 - Determine all force components that the 20-tooth pinion applies to the 50-tooth gear. Make a sketch showing these forces applied to the gear.
 - The same as part (b), except for the force components that the 50-tooth gear exerts on the 25-tooth pinion.

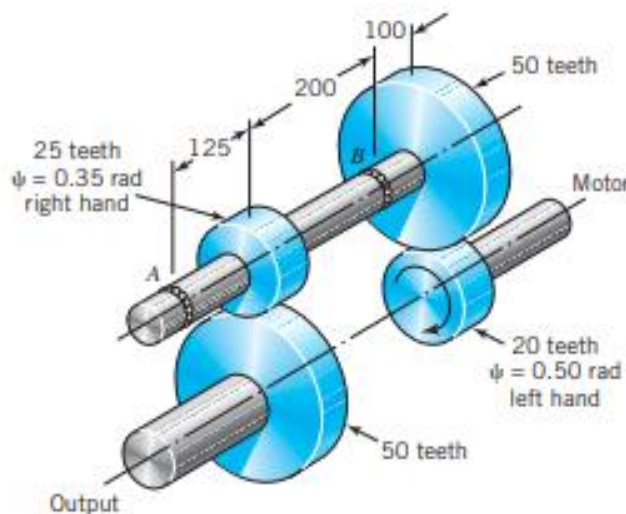


FIGURE P16.16

- 16.22 A pair of straight-tooth bevel gears mounted on perpendicular shafts transmits 50 hp and 1500 rpm of the 30-tooth pinion. The gear has 60 teeth. Face width is 3.0 in., $P = 6$, and $\phi = 20^\circ$. The gear is mounted in the center of a simply supported shaft with a 6-in. span between bearings. Thrust is taken by the bearing having the lighter radial load. Output torque is taken by a flexible coupling connected to a driven machine. Make a sketch of the gear and shaft assembly as a free body in equilibrium.



- 16.39 A worm gear speed reducer has a right-hand triple-threaded worm, 16:1 velocity ratio, $p = 0.25$ in., $\phi_n = 20^\circ$, and $c = 2.500$ in. The worm is driven by a 1000-rpm motor delivering $\frac{1}{2}$ hp. The worm is hardened steel and the gear is chill-cast bronze; $b = 0.5$ in.
- Determine d_w , d_g , N_g , and λ . Compare d_w with recommended values for maximum power-transmitting capacity.
 - Estimate the coefficient of friction and the efficiency of the gears.
 - Based on your estimated coefficient of friction, determine all force components applied to the worm and to the gear. Show these on a sketch similar to Figure 16.20 for clockwise motor rotation as viewed from the worm.
 - Compute the worm torque, gear torque, and gear power output. From the gear power output, check the previously determined value of efficiency.
- 16.18 A helical gear reducer is to be used with a 1500-rpm electric motor and a 500-rpm load which involves a moderate amount of shock. The 25-tooth pinion has $P_n = 8$, $b = 1.8$ in., $\phi_n = 20^\circ$, and $\psi = 26^\circ$. Both gears are made of AISI 8620 steel, with surfaces carburized to give properties listed in Appendix C-7. Manufacturing precision corresponds to curve *B* of Chapter 15, Figure 15.24. Estimate the horsepower that can be transmitted for 10^7 pinion revolutions with 99% reliability and a safety factor of 2. Check for both bending and surface fatigue.
- 16.23 A 1200-rpm electric motor drives a belt conveyor (which imposes moderate shock loading to the drive train) through a straight-tooth bevel gear reduction unit. $N_p = 20$, $N_g = 50$, $P = 10$, $b = 1$ in., and $\phi = 20^\circ$. Both gears are made of steel having a hardness of 300 Bhn. The gear is straddle-mounted and the pinion is overhung, providing a mounting considered to be reasonably good from the standpoint of rigidity. The gears are manufactured to standards corresponding to curve *B* of Chapter 15, Figure 15.24. The design life is 7 years of 1500 hours/year operation. Estimate the horsepower that can be transmitted at 99% gear reliability.
- [Ans.: About 1.6 hp]