Midterm 2 solutions

Fall 2001

MEEN 3200
1) In this problem, your job is to critique the cam design that your engineering assistant has just presented you.

   a) Consider the computer generated SVAJ plots shown below. Sketch any parts of the diagram that your assistant has neglected to include. (10 pts)

   b) Identify any components of the SVAJ diagram that violate the Fundamental Law of Cam Design. (10 pts)

   c) Briefly describe the purpose of the Fundamental Law of Cam Design and how it accomplishes this goal. (10 pts)

   PURPOSE: PROLONG CAM LIFE.
   HOW: LIMITS FORCES RESULTING FROM DISCONTINUITIES
As indicated above, if phi is too large, excessive side forces will occur. This will result in excessive wear and poor performance.

If rho is too small, the follower will not follow the desired lift profile. In the case of a small negative rho, the follower will not be capable of tracking the profile and will actually become nested in the cam. In the case of a small positive rho, the cam profile will again be unable to produce the desired lift profile because the cam would be undercut, producing cusp like features which would be impossible to manufacture and follow.
2) Consider the compound planetary gear system shown. Planet gears 4 and 6 are fixed to the same shaft, which is supported by the carrier (labeled 5). The carrier also supports the planet gear 3. Gear 3 and the shaft supporting gears 4 and 6 are supported by bearings such that they can all rotate relative to the carrier.

The system has an input speed of \( \omega_2 = 10 \text{ RPM} \). Given that gear 7 is not permitted to rotate, determine the output speed of the carrier, \( \omega_5 \). (30 pts)

Assume that:
\( N_2 = 24 \), \( N_3 = 18 \), \( N_4 = 30 \), \( N_6 = 36 \), and \( N_7 = 54 \).

\[
\frac{w_7}{w_2} = \frac{w_7 - w_A}{w_2 - w_A} = \left( \frac{w_3}{w_7} \right) \left( \frac{w_4}{w_5} \right) \left( \frac{w_6}{w_7} \right)
\]

\[
= \left( -\frac{N_2}{N_3} \right) \left( -\frac{N_3}{N_4} \right) \left( 1 \right) \left( \frac{N_6}{N_7} \right)
\]

\[
= \left( -\frac{N_2 N_6}{N_4 N_7} \right) = \frac{w_7 - w_A}{w_2 - w_A}
\]

\[
\Rightarrow w_A = 3.478 \text{ RPM}
\]
3) Consider the torque capacity of a spur gear.
   
   a) Estimate the maximum torque capacity of a spur gear with an involute tooth profile and a 20° pressure angle. Assume that the gear has a maximum allowable stress of 10,000 psi, 16 teeth, a face width of 0.500 inches, a diametral pitch of 20 teeth/inch, and that one tooth supports the load. Calculate your estimate using the Lewis equation (with out dynamic effects compensation) with a Lewis Form Factor of Y=0.296. (15pts)

   \[
   \sigma = \frac{W_r}{F Y}
   \]

   \[
   W_r = \frac{\sigma F Y}{P_d} = \frac{(10000 \times 0.5 \times 0.296)}{20}
   \]

   \[
   = 75 \text{ lb}
   \]

   \[
   T = F \cdot r = F \cdot \frac{N}{P_d} \cdot \frac{1}{2} = (5) \left( \frac{16}{20} \right)^{\frac{1}{2}}
   \]

   \[
   = 29.6 \text{ in-lb}
   \]

   b) Given that the Lewis equation provides a very rough estimate, what is the name (abbreviation is okay) of the American gear organization that you should reference for more reliable estimates? (5 pts)

   AMERICAN GEAR MANUFACTURERS
   ASSOCIATION (AGMA)