1. Given the gear train shown, if Gear 2 is the input gear and Gear 5 is the output gear, with \( N_2 = N_4 = 40 \) teeth, \( N_3 = N_5 = 160 \) teeth, pitch \( P = 8 \) teeth/in., and 20° pressure angle, full-depth gears:
   a. What is the speed ratio \( \omega_5/\omega_2? \)
   b. Is the direction of rotation reversed?
   c. What is the circular pitch?
   d. What is the center distance between the shafts of Gear 2 and Gear 5?
   e. What is the minimum gearbox width?
   f. Will tooth undercutting be required?
   g. What is the contact ratio?
   h. If the input torque is 100 ft-lb (and there is no angular acceleration or imbalance), what are the horizontal and vertical components of the force on the Gear 2 bearing?
Problem 1 cont’d.
2. Given the epicyclic gear train shown, if \( \omega_2 \) is the input rotational velocity, which setup would result in a greater speed reduction:
   a. Lock the outside sun gear link 5 \( (\omega_5 = 0) \) and use \( \omega_3 \) as the output, or
   b. Lock the planet carrier link 3 \( (\omega_3 = 0) \) and use \( \omega_5 \) as the output?
   For each case, work out the speed ratio and state whether the direction of rotation is reversed.
Problem 2 cont’d.
3. If the planet gear from Question 2 is a standard full-depth gear with 20º pressure angle and 1 inch radius, what is the:
   a. Diametral pitch
   b. Circular pitch
   c. Addendum
   d. Dedendum
   e. Pitch radius of the inside sun gear
Design a high-speed cam with radial roller follower with the following requirements (as shown below):

- dwell from 0 to 180° at a lift of 0
- dwell from 240° to 300° at a lift of 0.320 inches
- simple harmonic rise and return transitions.

4. Create rough sketches of the position (y), “velocity” (y'), “acceleration” (y'') and jerk (y''') in the graphs below. It is not necessary to state values for maximums or minimums. Assume that the rise and return portions are symmetrical.
5. What is the maximum acceleration in terms of in/\(\text{rad}^2\)? Give maximum accelerations in both + y and – y directions.

6. What is the maximum acceleration in terms of in/s^2 if the cam is rotating at a rate of 3000 rpm? Give maximum accelerations in both + y and – y directions.
7. What is the smallest base circle radius that can be specified to have a maximum pressure angle less than 30°? Hint: use nomograph.

8. What is the largest roller radius possible to avoid undercuts? Hint: use minimum radius-of-curvature chart.
### Gear Design

**TABLE 6.1 Standard Tooth Sizes**

<table>
<thead>
<tr>
<th>Standard Diametral Pitch U.S. Customary, teeth/in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
</tr>
<tr>
<td>1, 1 3/4, 1 1/2, 1 1/3, 2, 2 1/4, 3 1/2, 3, 4, 6, 8, 10, 12, 16</td>
</tr>
<tr>
<td>Fine</td>
</tr>
<tr>
<td>20, 24, 32, 40, 48, 64, 80, 96, 120, 150, 200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>54, teeth/teeth</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preferred</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1.25, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 16, 20, 25, 32, 40, 50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Next choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.125, 1.375, 1.75, 2.25, 2.75, 3.5, 4.5, 5.5, 7, 9, 11, 14, 18, 22, 26, 36, 43</td>
</tr>
</tbody>
</table>

**TABLE 6.2 Standard Tooth Systems for Spur Gears**

<table>
<thead>
<tr>
<th>System</th>
<th>Pressure Angle, $\phi$ (deg)</th>
<th>Addendum, $a$</th>
<th>Dedendum, $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full depth</td>
<td>$20^\circ$</td>
<td>1/P or Inv</td>
<td>1.25/P or 1.25m</td>
</tr>
<tr>
<td>Full depth</td>
<td>$22.5^\circ$</td>
<td>1/P or Inv</td>
<td>1.25/P or 1.25m</td>
</tr>
<tr>
<td>Full depth</td>
<td>$25^\circ$</td>
<td>1/P or Inv</td>
<td>1.25/P or 1.25m</td>
</tr>
<tr>
<td>Stub teeth</td>
<td>$20^\circ$</td>
<td>0.8/P or 0.8m</td>
<td>1/P or Inv</td>
</tr>
</tbody>
</table>
Motion Equations

Simple Harmonic Motion – Full Rise

\[
y = \frac{L}{2} \left(1 - \cos \frac{\pi \theta}{\beta}\right)
\]

\[
y' = \frac{\pi L}{2\beta} \sin \frac{\pi \theta}{\beta}
\]

\[
y'' = \frac{\pi^2 L}{2\beta^2} \cos \frac{\pi \theta}{\beta}
\]

\[
y''' = -\frac{\pi^3 L}{2\beta^3} \sin \frac{\pi \theta}{\beta}
\]

Nomograph to compute Pressure Angles

For radial roller follower
Minimum Radius of Curvature Charts

Simple Harmonic Motion – Full Rise