Helical Gears, Bevel Gears and Worm Gears

Helical Gear
Differences from Spur Gears

- Tooth profile is still involute when looking from side of gear, but profile twists around according to helix angle.
- Line of contact is at angle.
- Initial contact is at point instead of line (gears are quieter).
- Contact ratio is higher (quieter).
- Causes sideways (axial) thrust loads.
- Note that meshing gear must have opposite helix direction.
Helix Angle and Pitch

Contact Ratio of Helical Gears

- Contact ratio now also depends on:
  - helix angle
  - gear width
Herringbone Gears

- Avoids axial thrust loads
- More expensive to manufacture.
- Need to allow movement of one of the gears to allow alignment.
- Helix angles can be large, since you don’t need to account for large thrust forces.

Crossed-Axis Helical Gears

- Normal helical gears can actually be used with non-parallel axes!
- But has point contact (not line contact).
- Must have same pressure angle & normal pitch.
- Helix angles can be different.
- Can be same or opposite hand.
Bevel Gears

Differences from Spur Gears

- Non-parallel axes
- Pitch cone instead of pitch cylinder (and spherical tooth ends instead of planar)
- Narrowing teeth

Bevel Gear Relationships

\[
\frac{\omega_1}{\omega_2} = \frac{R_2}{R_3} = \frac{N_2}{N_3}
\]

\(\Sigma\) is shaft angle
\(\gamma_2, \gamma_3\) are pitch angles
\(\gamma_2 + \gamma_3 = \Sigma\)

\[
\tan \gamma_2 = \frac{\sin \Sigma}{\left(\frac{N_2}{N_1}\right) + \cos \Sigma}
\]

\[
\tan \gamma_3 = \frac{\sin \Sigma}{\left(\frac{N_2}{N_1}\right) + \cos \Sigma}
\]
### Some Standards for Bevel Gears

#### TABLE 8. Tooth Proportions for 20° Straight-Tooth Bevel Gears

<table>
<thead>
<tr>
<th>Item</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working depth</td>
<td>$h_k = 2.0 / P$</td>
</tr>
<tr>
<td>Clearance</td>
<td>$c = 0.188 / P + 0.002$ in</td>
</tr>
<tr>
<td>Addendum of gear</td>
<td>$a_G = \frac{0.540}{P} + \frac{0.460}{P} \left(\frac{m_{90}}{m_G}\right)^2$</td>
</tr>
<tr>
<td>Gear ratio</td>
<td>$m_G = \frac{N_G}{N_F}$</td>
</tr>
<tr>
<td>Equivalent 90° ratio</td>
<td>$m_{90} = \begin{cases} m_G \ \sqrt{m_G \frac{\cos \gamma_P}{\cos \gamma_G}} \end{cases}$</td>
</tr>
<tr>
<td>Face width</td>
<td>$F = \frac{1}{3}$ or $F = \frac{10}{P}$, whichever is smaller</td>
</tr>
</tbody>
</table>
| Minimum number of teeth | Pinion: 16 15 14 13  
                    | Gear: 16 17 20 30                                                   |

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#### Diagram:

[Diagram showing bevel gear geometry]
Crown and Face Gears

Spiral Bevel Gears

Spiral bevel gears are to bevel gears as helical gears are to spur gears.

In “hypoid gears,” the axes do not intersect!
Worms & Worm Gears
Nomenclature

Nomenclature

Lead angle $\lambda$
Helix angle
Axial pitch
Worm pitch dia.
Worm
Pitch diameter
Center distance
Worm gear