**Torque**

**Torque is a moment applied about the longitudinal axis of a body.** (typically called a shaft)

To keep the system in equilibrium, a reaction torque is applied to the shaft.

What would a FBD of the gear look like?

- **Bearing constrains translation**
- **Shaft torque constrains rotation**
Gears - Toothy members that transmit rotary motion from one shaft to another.

- Boe Bot servos use a series of spur gears to transfer motion between parallel shafts.

Pitch diameter = effective diameter of the gear.

If the upper gear has 30 teeth and the lower gear has 10 teeth, then the upper gear will turn \( \frac{3}{1} \) times when the lower gear turns \( \frac{1}{3} \) times.

If \( \text{RPM} = \frac{\text{revolutions}}{\text{minute}} \),
Every force is opposed by an equal and opposite force - Newton's 2nd Law.
**Class Problem:** Consider the gear train below. Assume the gears are supported by bearings and that all gears have compatible teeth.

<table>
<thead>
<tr>
<th>Gear</th>
<th>Teeth</th>
<th>Diameter (inches)</th>
<th>RPM</th>
<th>Torque (in-lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>1.0</td>
<td>3600</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Find the diameter of gears 2, 3, and 4.
(b) Find the RPM of gears 2, 3 and 4 (gears 2 and 3 are joined like many of your servo gears)
(c) Draw a FBD of gear 1, and find all forces that act on the gear.
(d) Draw a FBD of gears 2/3, and find the forces that act on the gear (this double gear doesn’t transmit torque outside the gear train, so there’s really no torque to compute here).
(e) Draw a FBD of gear 4, and find the torque that acts on the gear.