## Sizing a Servo System

## Part 1, Newton's Laws of Motion

To understand sizing, you need to understand the mechanical concepts of motion; these all directly or indirectly employ Newton's Laws of Motion.

For the sake of being comprehensive (albeit brief), Newton's three laws:

I. An object at rest tends to stay at rest. An object in motion tends to stay in motion (Newton's Law of Inertia).
II. The force to move (or stop) a body is equal to the body's mass times its acceleration/deceleration (F = ma).
III. For every action there is an opposite an equal reaction.

All laws of linear and rotary motion are derived from Sir Isaac's aforementioned three fundamental laws.

Regarding rotary motion (we'll discuss linear motion another time), we need to understand several concepts in order to properly size a drive system:

I. Torque
II. Inertia
III. Speed
IV. Friction

Torque is defined as the force times the radius of the applied force. In order to move a rotary load, we must apply torque. (T = F*r). Since force is usually expressed in pounds and radius in inches, the units for torque are lb-in. or some derivation thereof (such as lb-ft. or oz-in). These, of course, are English units; the metric units would be Newton-meters.

Rotary inertia is defined as the 'center of moment' of a rotating object. It is calculated from knowing an object's dimension, weight and/or material properties. As an example, a cylinder's inertia can be calculated from knowing the radius of the cylinder, the length of the cylinder and the weight of the cylinder. The 'old' PacSci catalog (its also available online) has a good description and some formulas for calculating inertia. Units of inertia (English) are typically in lb-in-s^2. We can discuss this concept further in person, since it is not the simplest of concepts.

Speed needs no description.

Friction is actually a very complex matter of chemistry and materials but - fortunately for us - we can model it as a simple relationship between two materials, represented by a dimensionless number ( a coefficient of friction) between 0 and 1 (0 being no friction and

~1 being an extremely high coefficient of friction). Friction, obviously, can hinder or help an object trying to be moved or stopped, respectively.

If you have information on all of these four categories, you can calculate torque and power requirements for an application! Notice that from Newton's second law, if the acceleration of an object is zero, it requires no force to move (or stop moving)!!! Your first Brain teaser question (which you should be adequately prepared to answer by your reading of this):

If what I say is true (about Newton's second law), why doesn't an object keep moving when a force is no longer applied? Think of spinning one of those rotary tops....I have to apply a force to start it spinning but when I take the force away, the top will eventually stop spinning (why is that?)