Linear Lead Screw Drive

The linear extension movement will be produced by a lead screw drive and a guide rail system.

Let us assume we will be using a 4 lead M6 lead screw with a thread density of 52 threads per 10cm. Meaning to translate an object 1 cm, we need to rotate the screw 1.3 times.

We will be using the work energy theorem to calculate the torque needed to lift this weight.

Work needed to be done to lift the object: $mgh_1 + W_h + W_{other} = mgh_2$

,where $F = mg$ is the force of the object due to gravitational acceleration

W_h is the energy needed to change the object height

$W_{other} = -\mu F_n \Delta h$ is the energy lost due to friction

After reconfiguring our equation, we get the following: $W_h = F\Delta h + \mu F_n \Delta h$

Work needed to be done to rotate the lead screw an angle of θ: $W_\theta = \tau \Delta\theta$

,where W_θ is the energy needed to rotate the lead screw

$\Delta\theta$ is the angle of rotation

τ is the torque of the motor

Relationship between Δh and $\Delta\theta$: $\Delta h(1.3) = \Delta\theta$

With the above relationship, we now know how the raise height is dependent on the angle of rotation of the lead screw. Therefore we can compare the energy needed to rotate the shaft to the energy needed to lift the shaft.

If we combine the three above equations, we get the following: $\tau = \frac{1}{1.3}(F + \mu F_n)$

Since we want to know the maximum torque we need supplied by our motor, we need to find when the potential energy is increasing. Therefore the maximum torque required by our motor will be encountered when the arm is pointing downwards and is being raised. We will now only examine this one scenario.

Since the motion is strictly vertical, we know that the normal force of friction is parallel to the lead screw, more specifically we know that it is equal to F . This gives us the new equation:

$$\tau = \frac{F(1+\mu)}{1.3} \quad \text{in} \quad [Ncm]$$

and the result:

$$\tau = \frac{5(1+0.3)}{1.3} = 5\,Ncm$$

With such a low torque, we may use a DC motor to drive the screw.