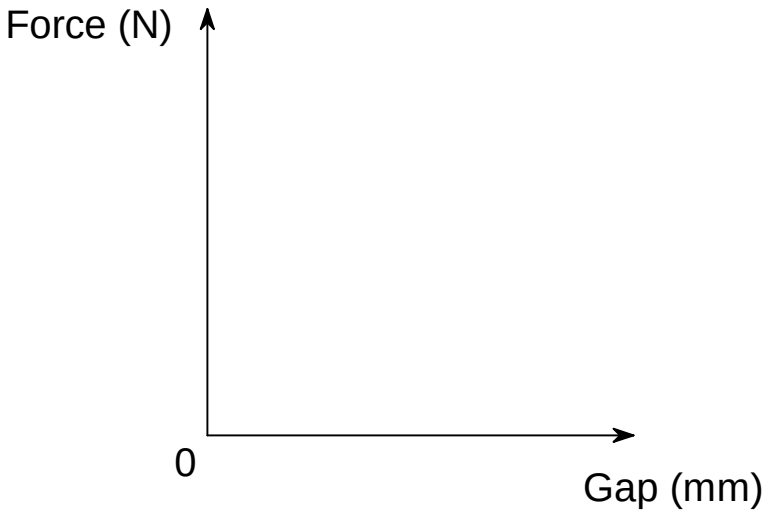
Solenoid Energy Analysis

A solenoid consists of a coil of wire, which creates a magnetic field when energized and pulls in an iron plunger. The strength of magnetic fields decays very rapidly with distance. As the solenoid stroke length (distance the plunger travels) increases, the force on the plunger drops off correspondingly.

Measure the maximum force on the plunger when it is fully inserted in the solenoid. Make sure to use the best suited spring scale to get a good resolution reading. Assume the force drops off rapidly and is negligible with a stroke length of 1mm for the small kit solenoid. Create a rough estimate of the force-distance curve below. The actual response will be curved, but as a rough estimate you can use a straight line.



Estimate the energy output in Joules that occurs in a single activation of solenoid, which is the area under the curve. (estimate you do not need to integrate this)

$$work = \int_0^h F(x) * x$$

To calculate power, estimate retraction time as due to an average force acting on the mass of the plunger. This is also a rough estimate since the acceleration is not constant, but it will give you a ball park number.

Fave ≈ Fmax/2

a ≈ Fave/mass (since F=ma)

h = max distance solenoid can pull plunger in

For constant acceleration

$$t_{retraction} = \sqrt{2h/a}$$

$$Power = \frac{work}{t_{retraction}}$$