Solenoid Assignment

Experimental method

Be very careful not to connect the power supply for more than about one minute. The solenoid will get very hot.

1. In a group of 3 - 4, take one “solenoid test kit”
2. One person will test their test setup at a time.
3. Ask someone to take a photo of you doing the experiment (for your report)
4. Add your allocated number of spacers onto the solenoid
5. Load your allocated number of weights onto the solenoid
6. Connect the current supply
7. Increase the current until the solenoid will just ***hold*** the weight (If you reduce the current by 0.01A then it should not hold the weight)
8. Note the current and voltage at which the solenoid lifted the weight.
9. Repeat the test until you have a total of 5 results.
10. Move onto the test setup for the next person in your group.

Reference Data

Material properties

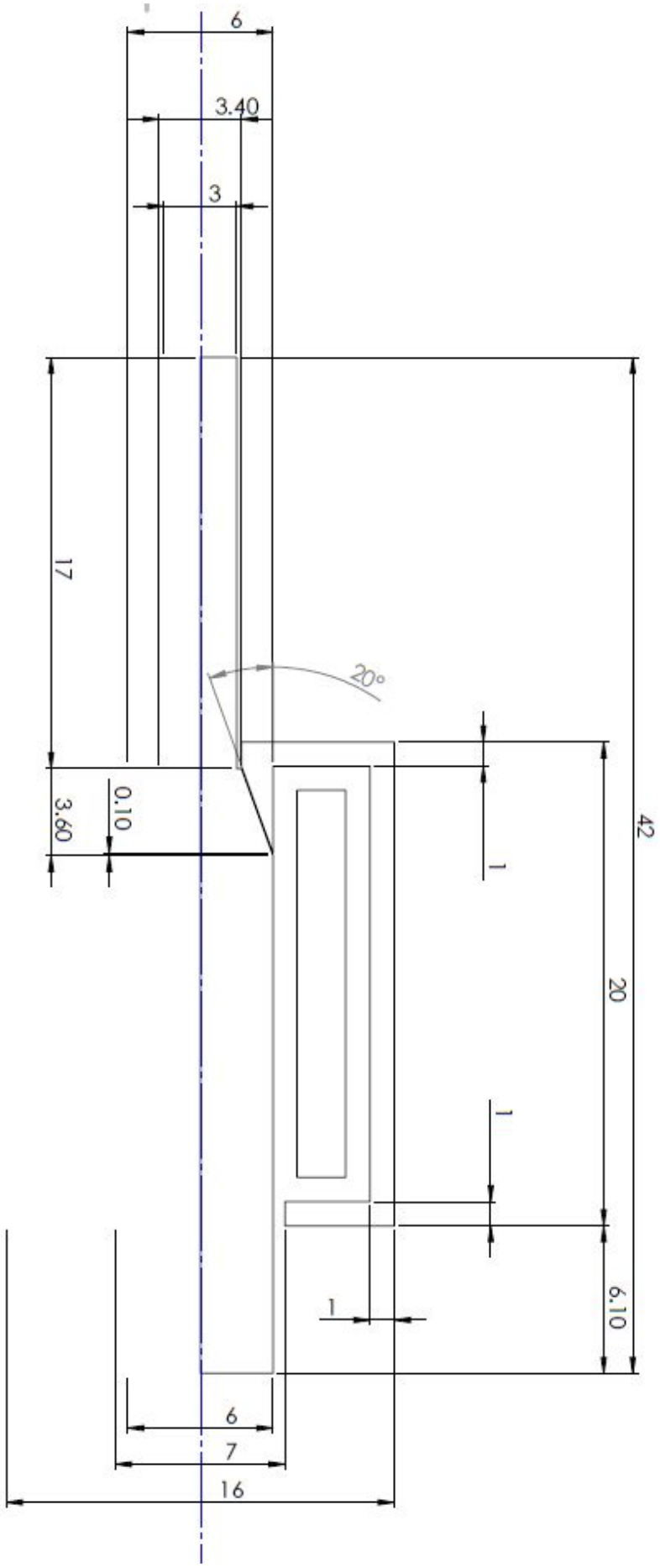
Assume the steel is “1010 Steel”, with a relative permeability of 2000.
The mass of the steel plunger is 4g and each nut is 13g.

Number of turns

Watch the “Teardown” video to determine the number of turns.

Geometry

The figure below shows a section of the solenoid. The centre is an axisymmetric analysis. Assume that the reluctance of the outer shell can be adequately modelled assuming it is also an axisymmetric analysis. The position shown is with 1 spacer washer installed. More washers will move the plunger to the right and increase the tapered air gap.


6
3.40
3
17
20°
3.60
0.10
1
42
20
1
6.10
1
6
7
16

Report

There is no need to do a formal lab report, just address the items below. The “Base work” is what would be expected to be addressed to demonstrate the minimum standard for this course. The “Extension work” allows student looking to excel in the course additional opportunities to demonstrate their knowledge.

Base work (75%)

1. Put in a photo of you doing the experimental work (5%)
2. Clearly present your experimental results for current and voltage from the 5 tests (5%)
3. Show hand calculations (photo or scan) to show an analytical expression relating $\mathbf{F}_y$ to input current and determine the current required to hold your designated weight. (15%)
4. Create a FEMM model for the solenoid in the location defined by your spacers using the drawing above. Manually change the input current in an iterative process until the output force is the same as the weight from your setup. ***You will need to upload this model with your assignment.*** (15%)
5. Compare the analytical, FEA and experimental results and discuss potential reasons for any discrepancies. (15%)
6. State and justify which analytical method you used to determine the force (Lorentz, Virtual work, stress tensor) (5%)
7. State and justify what would you expect to happen if you reversed the direction of current. (5%)
8. How would you improve this experiment to get more accurate results? (10%)

Extension work (25%)

9. Calculate the bare wire diameter for the copper. (5%)
10. By manually changing the dimensions in FEA, determine which dimensions and properties have the greatest impact on the relationship between force and current. What does this “sensitivity analysis” suggest about any discrepancies between your calculations and experimental results? (10%)
11. Using a lua script such as (http://www.femm.info/wiki/coilgun) create a “pull curve for your solenoid (as in figure E7.1.2) (10%) ***You will need to upload this script and any associated .FEM files with your assignment.***