Massachusetts Institute of Technology
Physics Department

8.01X **Fall 2001**

Solutions for Experiment Magnetic Force Law

Problem 1: Experiment FM (40 points)

a. Measure the width of your magnets. **I measured a width of 4 mm for each magnet.**

b. Measure the center-to-center distance between the magnets as a function of the force pressing the magnets together. (See Experiment FM for details).

c. Tabulate the data, with two columns labeled Force (in N), and Center-to-Center Distance, S_c (in mm). **My data is shown in table 1.**

d. Make two plots of the data, one on linear paper and the other on log-log paper with center-to-center distance S_c (in mm), along the horizontal axis and Force (in N) along the vertical axis. **See graphs 1 and 2.**

e. **Analysis**: On the log-log paper try to fit a straight line between the data points to match your best-fit curve. If you cannot match one straight line, you may be able to find two different regions where there are straight-line fits. This means that the force between these magnets can be described by different inverse powers at different distances. Calculate the slope of the log F vs. $\log S_c$ best-fit straight lines. This gives the approximate power law for the force between the magnets for different ranges of center-to-center separation distance. **I found two straight lines fit the data.**

The first covered the range of values 9 mm< S_c < 23 mm. This corresponded to the most widely separated distances between the faces of the magnet. For this range my best straight line fit on the log-log graph corresponded to a power law behavior

$$F = 33.4(S_c)^{-1.97}$$

where S_c is measured in mm and the force is measured in newtons.

The second covered the range of values 5 mm< S_c < 9 mm. This covered the distances when the magnets were very closely together although I noticed that the point in which the magnets were practically touching did not lie on the straight line. I did not include the point ((4.1 mm, 0.711 N) in my power law fit. For this range my best straight line fit on the log-log graph corresponded to a power law behavior

$$F = 2.69(S_c)^{-0.90}$$

where S_c is measured in mm and the force is measured in newtons.

f. Try to explain your results. Why should the power law vary when the magnets are very close together or further apart? **When the separation between the magnets is small compared to their width and length we can approximate the magnets as infinite planes. Since any finite gap is in effect zero compared to infinity, you would not expect the force to vary—another way of thinking about this is that with ∞ featureless planes there is no scale of length and no way of telling how far away you are. This is why there is a slower variation of F with S_c when S_c is small. On the other hand, for very large distances one can expect F to go with some inverse power law.**

Tab 6 I

Trial	wgt (g)	force (N)	center to center (mm) S_c	
magnet m	7.6	0.074	22	
m + cup c	10.1	0.099	19	
m+c+ 5 pennie	22.6	0.221	13	
m+c+10 p	35.1	0.344	10	
m+c+15 p	47.6	0.466	7	
m+c+20 p	60.1	0.589	5.5	
m+c+25 p	72.6	0.711	4.1