# Practice Test 3 - Spring 2013

Work four of the six problems. Place the problems in the order you wish them graded. The first two problems form the first half test; the second two problems form the second half test.

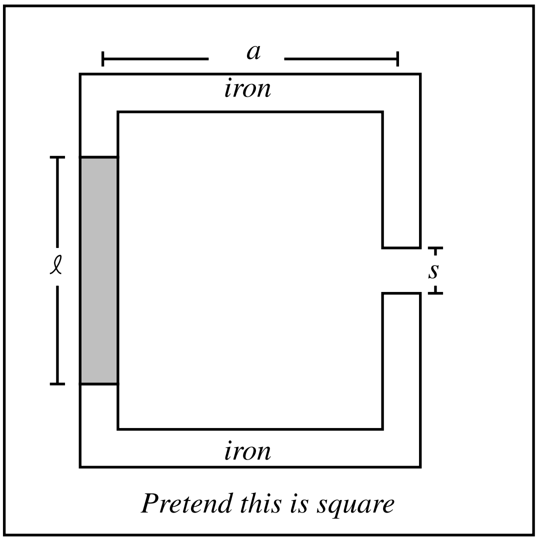
**Problem 3.1** Two straight wires carry a current $I$ in the $+\hat{y}$ direction. The wires run through the points $\pm\ell\hat{x}$. The wires have length $D$ and are centered on the $x$ axis. Compute the vector potential at the origin.

**Problem 3.2** A cylindrical conductor of radius $a$ has a current density that increases with radius, $\vec{J}(s) = J_0 s^2 \hat{z}$. The current density is zero outside the wire. Compute the magnetic field everywhere.

**Problem 3.3** As part of an honors project in UPII this semester, a student used a stack of NdFeB magnets to power a hand generator. Each magnet was a cylinder of height $h = 1\text{mm}$ and radius $r = 1\text{cm}$. The student made the approximation that the magnetic field of a stack of six magnets was six times the magnetic field of one. The magnetization of NdFeB is $1.02 \cdot 10^6\,\text{A/m}$. Compare the field at the center of a single magnet with the field at the center of a stack of six magnets. You may model the bound current of a single magnet as a ring, but may not use this model for the stack. You may use the formula for the field of the current distribution of the stack if you included it on your formula card, if not you will have to re-derive it.

**Problem 3.4** A thin square wafer has constant magnetization density $\vec{M} = M_0\hat{z}$. The wafer is $\ell$ long on each side and has thickness $d$ in the $\hat{z}$ direction. Compute the magnetic field at the center of the wafer.

**Problem 3.5** A horseshoe magnet is formed into a square. It is made using a section of NdFeB permanent magnetic material with magnetization density $1.02 \cdot 10^6$A/m of length $\ell = 2$cm. The square has average side length $a = 3$cm and a gap with width $s = 1$cm. Compute the magnetic field in the gap. The relative permeability of iron is 100. Note, this problem may be worked in the same manner as the other magnets formed of rings of various materials worked in the homework.




**Problem 3.6** A cylindrical stainless steel channel with relative permeability $\mu_r$, inner radius $a$ and outer radius $b$, confines a plasma with current density

$$\vec{J} = \frac{J_0 a}{s} \sin\left(\frac{\pi s}{a}\right) \hat{z}$$

where the axis of the solenoid is the $z$-axis and $J_0$ is a constant. Compute $\vec{H}$, $\vec{B}$, and $\vec{M}$ everywhere.