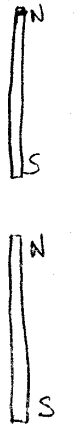
Yellow

10. (15 pts) Two identical bar magnets of length 20 cm and square pole face of area 0.06 cm^2 have magnetization $M = 0.8 \times 10^6$ A/m. Determine their pole strengths. If the magnets are placed in a line, with the N pole of one 4 cm from the S pole of the other, estimate their force of attraction. Estimate the field that ~~the large~~ one N pole makes at the S pole of the ~~smaller~~ other. Briefly explain your reasoning.



$M = \frac{\mu}{V}$, so $\mu = MV = MA\ell = (0.8\times10^6 \frac{A}{m})(.06\times10^{-4} m^2)(.2m) = 0.96\ A\text{-}m^2$

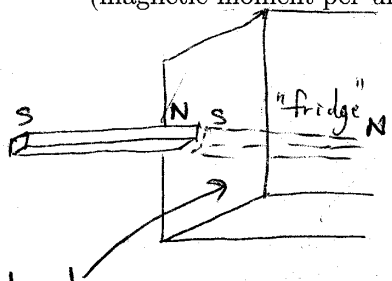
Also, $\mu = q_m \ell$, so $q_m = \frac{\mu}{\ell} = \frac{0.96\ A\text{-}m^2}{.2m} = 4.8\ A\text{-}m$

$|\vec{F}| = \frac{k_m q_m^2}{r^2} = \frac{(10^{-7}\frac{N}{A^2})(4.8A\text{-}m)^2}{(.04m)^2} = 1.44\times10^{-3} N$

$|\vec{B}| = \frac{k_m q_m}{r^2} = \frac{(10^{-7}\frac{N}{A^2})(4.8A\text{-}m)}{(.04m)^2} = 3.0\times10^{-4} T$

Treat the poles as points.

11. (15 pts) A 16 cm long permanent magnet has a 0.28 cm-by-0.3 cm cross-section. Its north pole is placed against a refrigerator door (made of 'soft' iron). A force of .0062 N is required to pull the magnet off the door. Estimate its magnetization (magnetic moment per unit volume). Briefly explain your reasoning.



induced image (added in solution to problem)

Treat the poles as sheets.

$|\vec{F}| = q_m |\vec{B}_{-q_m}| = (\sigma_m A)(2\pi k_m \sigma_m)$

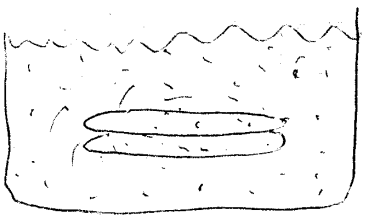
$= 2\pi k_m A \sigma_m^2$

$\Rightarrow \sigma_m = \sqrt{\frac{|\vec{F}|}{2\pi k_m A}} = 3.43\times10^4 \frac{A}{m}$

But $\sigma_m = \frac{q_m}{A} = \frac{q_m \ell}{A\ell} = \frac{\mu}{V} = M$,

so $M = 3.43\times10^4 \frac{A}{m}$

12. (10 pts) A parallel plate capacitor of area 160 cm^2 and plate separation 2.2 mm is immersed in a bath of insulating fluid. For a charge of $\pm$62 nC there is 125 V across the plates. The breakdown voltage is 3.8×10^5 V. Find the dielectric constant and the breakdown field.



$C = \frac{Q}{\Delta V} = \frac{62\times10^{-9} C}{125 V} = 4.96\times10^{-10} F$

But also $C = \frac{\kappa A}{4\pi k d} = \kappa \frac{160\times10^{-4} m^2}{4\pi \cdot 9\times10^9 \frac{N\text{-}m^2}{C^2} \cdot (2.2\times10^{-3} m)}$

$= \kappa (6.43\times10^{-11} F)$

$\Rightarrow \kappa = \frac{4.96\times10^{-10} F}{6.43\times10^{-11} F} = 7.71$

$E_{breakdown} = \frac{\Delta V_{breakdown}}{d} = \frac{3.8\times10^5 V}{2.2\times10^{-3} m} = 1.727\times10^8 \frac{V}{m}$