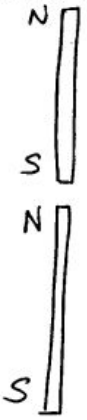
key yellow

10. (15 pts) Two identical bar magnets of length 25 cm and square pole face of area 15 cm^2 have magnetization $M = 0.4 \times 10^6$ A/m. Determine their pole strengths. If the magnets are placed in a line, with the N pole of one **2** cm from the S pole of the other, estimate their force of attraction. Estimate the field that the large N pole makes at the S pole of the smaller. Briefly explain your reasoning.



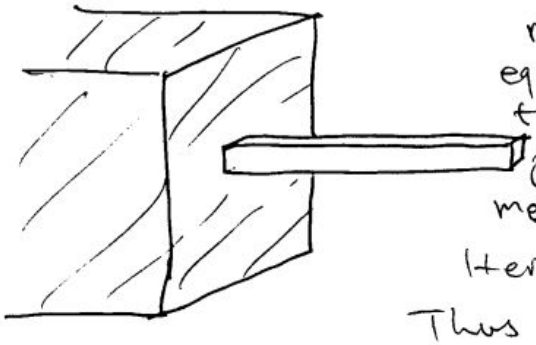
① $M = \sigma_m = \frac{q_m}{A}$ so $q_m = MA = \left(0.4\times10^6 \frac{A}{m}\right)(15\times10^{-4} m^2)$
$= 6\times10^2 A\cdot m$

② $|\vec{F}| = \frac{k_m q_m^2}{r^2} = \frac{10^{-7}\frac{N}{A^2}(600 A\cdot m)^2}{(0.02m)^2} = 90N.$

③ $|\vec{B}| = \frac{k_m q_m}{r^2} = \frac{10^{-7}\frac{N}{A^2}\,600 A\cdot m}{(0.02m)^2} = 0.15\frac{N}{A\cdot m} = 0.15\,T.$

④ We are treating the poles as points.

11. (15 pts) A 25 cm long permanent magnet has a 0.6 cm by 0.6 cm cross-section. Its north pole is placed against a refrigerator door (made of 'soft' iron). A force of .084 N is required to pull the magnet off the door. Estimate its magnetization (magnetic moment per unit volume). Briefly explain your reasoning.



① Treat the pole faces as planes, with the response of the refrigerator ~~body~~ being an equal and opposite sheet of charge. Neglect the other poles.

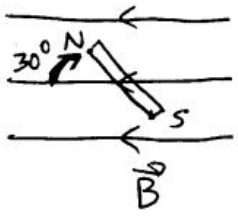
② Then the force on the S image is of magnitude $|\vec{F}| = |Q_S||\vec{B}_N|$

Here $|Q_S| = \frac{M}{\sigma_m}A$ and $|\vec{B}_N| = 2\pi k_m \sigma_m = 2\pi k_m M$

Thus $|\vec{F}| = (MA)(2\pi k_m M) = 2\pi k_m A M^2$

$\therefore M = \sqrt{\frac{|F|}{2\pi k_m A}} = \sqrt{\frac{0.084N}{2\pi\times10^{-7}\frac{N}{A^2}(0.006m)^2}} = 6.1\times10^4 \frac{A}{m}$

12. (10 pts) A magnet of length 8 cm, mass 75 g, and magnetic moment 1.6 A-m^2 is in a horizontal magnetic field $\vec{B}$. Find its pole strength. If the torque on it is 0.0036 N-m when its axis is at 30° to the field, determine $|\vec{B}|$.



① $\mu = q_m l$ so $q_m = \frac{\mu}{l} = \frac{1.6 A\,m^2}{0.08 m} = 20 A\cdot m.$

② $|\vec{\tau}| = |\vec{\mu}||\vec{B}|\sin\theta$

$|\vec{B}| = \frac{|\vec{\tau}|}{|\vec{\mu}|\sin\theta} = \frac{0.0036 N\cdot m}{1.6 A m^2 \sin 30^\circ} = 4.5\times10^{-3} T$