Problem 1

The figure below shows a side view of a flat surface with area 3.0 cm$^2$ in a uniform magnetic field. If the magnetic flux through this area is 0.90 mWb, calculate the magnitude of the magnetic field, and find the direction of the area vector (use magnetic flux...it's just like electric flux).

\[ \beta = \frac{\Phi}{A} = \frac{0.90 \times 10^{-6} \text{ Wb}}{(3 \times 10^{-4} \text{ m}^2) \cos 60^\circ} = \frac{0.90 \times 10^{-6}}{1.5 \times 10^{-4}} = 0.06 \text{ T} \]

Problem 2

There is almost no helium in ordinary air, so helium sprayed near a leak in a vacuum system will quickly show up in the output of a vacuum pump connected to such a system. You are designing a leak detector that uses a mass spectrometer to detect He$^+$ ions (charge $+e = 1.602 \times 10^{-19}$ C, mass $6.65 \times 10^{-27}$ kg). The ions emerge from the velocity selector with a speed of $1.00 \times 10^5$ m/s. They are curved in a semicircular path by a magnetic field $B$ and are detected at a distance of 10.16 cm from the slit $S$ in the figure below. Calculate the magnitude of the magnetic field $B$.

\[ R = \frac{1}{2} (10.16 \times 10^{-2} \text{ m}) \]
\[ R = \frac{m v}{2 B} \Rightarrow B = \frac{m v}{2 R} \]
\[ B = \frac{(6.65 \times 10^{-27} \text{ kg}) (1 \times 10^5 \text{ m/s})}{(1.6 \times 10^{-19} \text{ C})(5.08 \times 10^{-2} \text{ m})} = 0.0817 \text{ T} \]

Problem 3

A thin, horizontal copper rod is 1.00 m long and has a mass of 50.0 g. What is the minimum current in the rod that can cause it to float in a horizontal magnetic field of 2.00 T?

\[ \text{If the rod is to float, the magnetic force must be directed upward and have a magnitude equal to the weight of the rod. Thus, } \]
\[ B L I \sin \theta = mg \]
\[ \Rightarrow I = \frac{mg}{B L \sin \theta} \]
\[ \text{for a minimum current, } \sin \theta = 1 \]
\[ \Rightarrow I_{\text{min}} = \frac{(0.05 \text{ kg})(9.80 \text{ m/s}^2)}{(2.00 \text{ T})(1.00 \text{ m})} = 0.245 \text{ A} \]