Thursday Reading Assessment: Unit 3, Magnetic Forces and Fields

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1 Memory Bank

- $\vec{F} = I\vec{L} \times \vec{B}$ ... Lorentz Force on a Current
- $\vec{F} = q\vec{v} \times \vec{B}$ ... Lorentz Force on a Charge
- $B = (\mu_0 I)/(2\pi r)$ ... The magnetic field B *caused* by the current I a distance r away.

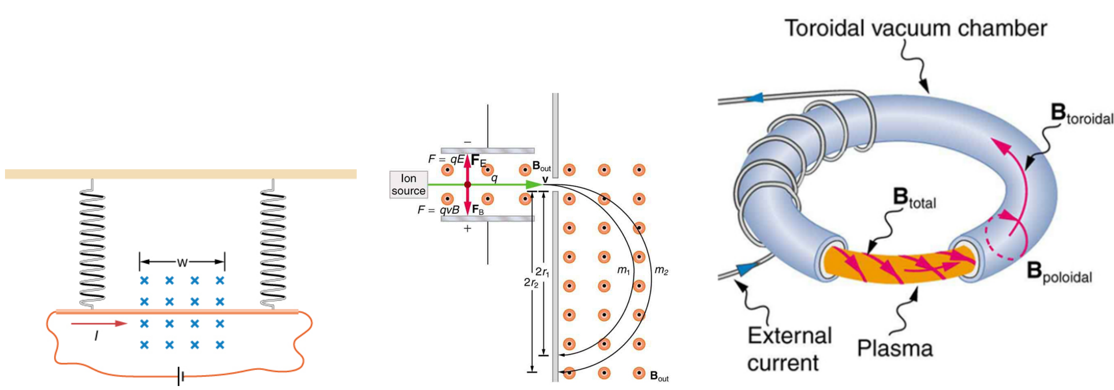

Figure 1: (Left) A current-carrying rod suspended by springs in a B-field. (Right) Current 1 causes a B-field to exert a Lorentz force on wire 2. Note that the RHR-2 determines the vector direction of the B-field.

2 Forces on Currents and Charges

1. (a) Consider Fig. 1 (left). A metal rod of mass m and length L is hung from the ceiling using two springs of spring constant k. A uniform magnetic field of magnitude B pointing perpendicular to the rod and spring exists in a region of space covering a length w of the copper rod. Determine the change in the length Δy of the springs when a current I runs through the copper rod. (b) Consider Fig. 1 (middle). Suppose two ions of equal charge q are launched from the ion source with masses $m_1 = 2m$ and $m_2 = m$. In the first stage, the E and B-fields are tuned to create $F_{\text{net}} = 0$. Show that the velocity of the ions must be $v = E/B$. (c) In the second stage, $E = 0$ but we have the same B-field. What are the radii r_1 and r_2, in terms of the given variables? (d) Consider the *tokamak* in Fig. 1 (right). Using the right-hand rule, convince yourself that the external current creates a B-field inside the toroid that runs along the circumference of the toroid. If there are charged particles moving around the ring, trapped by the toroidal field, use the right-hand rule again to convince yourself these charged particles create a *poloidal* field.