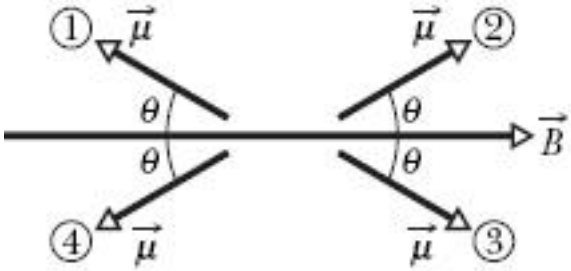
Homework 8: Hard-Copy Homework Due Wednesday 3/30

Special instructions for this homework: Please show all work necessary to solve the problems, including diagrams, algebra, calculus, or whatever else may be needed. For the first five concept questions (1-5) write at least a sentence justifying your answer. You will need to turn in this homework in paper form, with your name on it, either in person in class Wednesday, or under my office door (414 Van Allen) by 11pm Wednesday night.

Note: This homework will be graded exactly like the midterms.

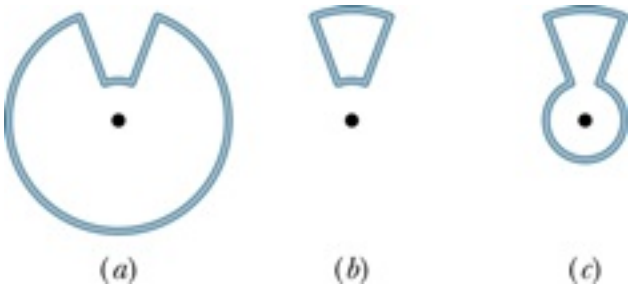
Question 1 [Torque on Dipoles]:
The figure shows four orientations, at angle θ, of a magnetic dipole moment in a magnetic field.



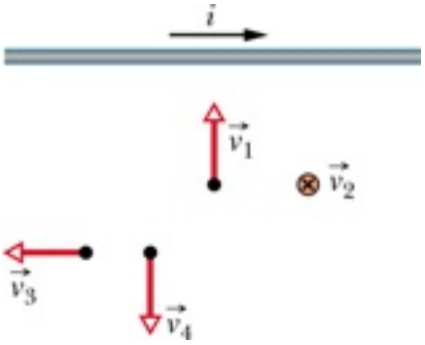
a. If the dipole moment is rotated from orientation 2 to orientation 1 by an external agent [i.e., your hand], is the work done on the dipole by the agent positive, negative, or zero?

b. Rank the work done on the dipole by the agent for these three rotations, greatest first: 2->1, 2->4, 2->3. If multiple rotations rank equally, use the same rank for each, then exclude the intermediate ranking (i.e. if objects A, B, and C must be ranked, and A and B must both be ranked first, the ranking would be A:1, B:1, C:3). If all rotations rank equally, rank each as '1'.

Question 2 [Field of a Circular Arc]. The figure shows three circuits, each consisting of two radial lengths and two concentric circular arcs, one of radius r and the other of radius $R > r$. The circuits have the same current through them and the same angle between the two radial lengths. Rank the circuits according to the magnitude of the net magnetic field at the center, greatest first.



Question 3 [Magnetic Field of a Wire] The figure represents a snapshot of the velocity vectors of four electrons near a wire carrying current i. The four velocities have the same magnitude; velocity v_2 is directed into the page. Electrons 1 and 2 are at the same distance from the wire, as are electrons 3 and 4. Rank the electrons according to the magnitudes of the magnetic forces on them due to current i, greatest first.

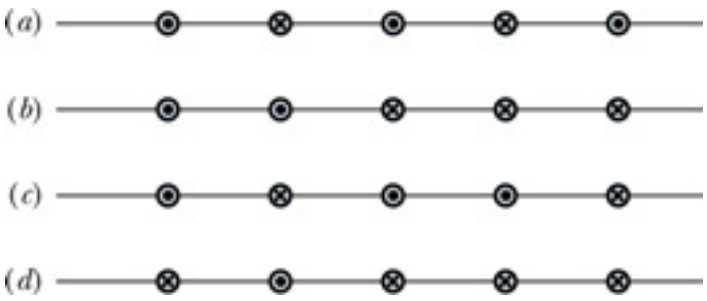


Question 4 [Ampere's Law]

The figure shows four circular Amperian loops (*a*, *b*, *c*, *d*) and, in cross section, four long circular conductors (the shaded regions), all of which are concentric. Three of the conductors are hollow cylinders; the central conductor is a solid cylinder. The currents in the conductors are, from smallest radius to largest radius, 4 A out of the page, 9 A into the page, 5 A out of the page, and 3 A into the page. Rank the Amperian loops according to the magnitude of the line integral of B around each loop, greatest first.

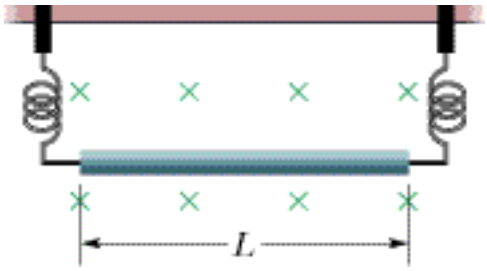
Question 5 [Forces Between Current-Carrying Wires]

The figure shows four arrangements in which long, parallel, equally spaced wires carry equal currents directly into or out of the page. Rank the arrangements according to the magnitude of the net force on the central wire due to the currents in the other wires, greatest first.



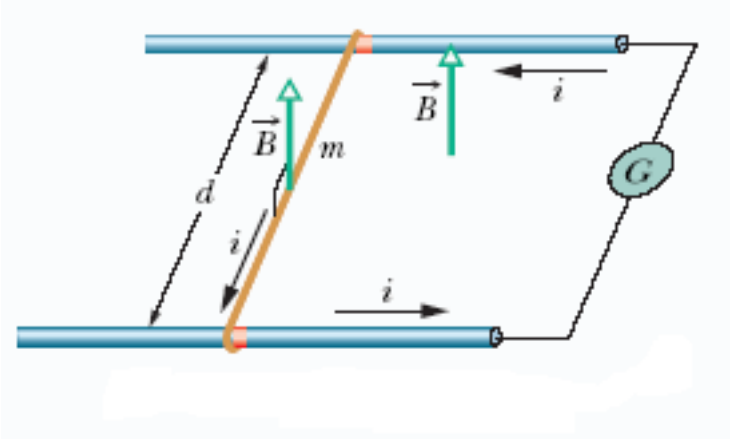
Question 6 [Magnetic Forces]:

A wire of length L and mass m is suspended by a pair of flexible leads in a uniform magnetic field of magnitude B (see the figure for direction). What is the **(a)** magnitude and **(b)** direction (left or right) of the current required to remove the tension in the supporting leads?



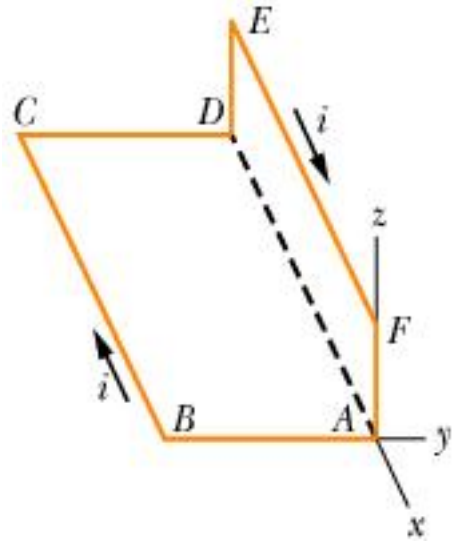
Question 7 [Rail Gun]:

In the figure below, a metal wire of mass *m* can slide with negligible friction on two horizontal parallel rails separated by a distance *d*. The track lies in a vertical uniform magnetic field of magnitude *B*. At time $t = 0$ s, device G is connected to the rails, producing a constant current *i* in the wire and rails (even as the wire moves). What are the wire's **(a)** speed as a function of time *t* and **(b)** direction of motion?



Question 8 [Magnetic Dipole Moment]:

The figure shows a current loop *ABCDEFA* carrying a current $i = 5$ A. The sides of the loop are parallel to the coordinate axes shown, with $AB = 20$ cm, $BC = 30$ cm, and $FA = 8$ cm. In unit-vector notation, what is the magnetic dipole moment of this loop? Hint: Consider an equivalent set of current loops.



Question 9 [Ampere's Law]:

Imagine a long hollow cylindrical conductor with outer and inner radii a and b, carrying a uniformly distributed current i. Find the magnetic field magnitude $B(r)$ as a function of the radial distance r **(a)** in the range $b < r < a$, **(b)** at $r = a$, **(c)** for the case with $b = 0$.

Question 10 [Forces Between Current-Carrying Wires]:

In the figure, five long parallel wires in the xy plane are separated by distance d, have length L, and carry identical currents I out of the page. Each wire experiences a magnetic force due to the other wires. What is the magnitude of the net magnetic force on **(a)** wire 1, **(b)** wire 2, **(c)** wire 3, **(d)** wire 4, **(e)** wire 5?