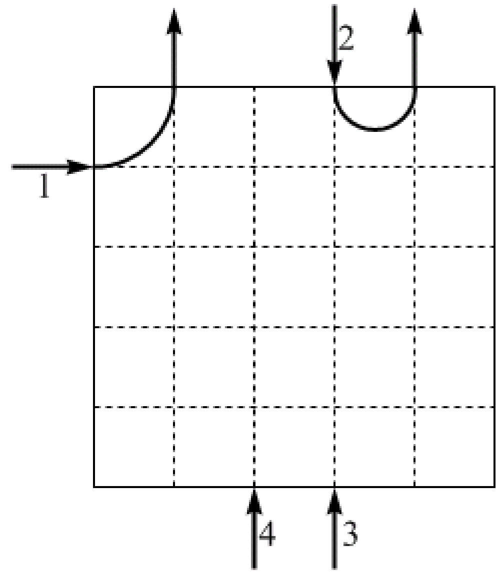
PROBLEM 1 – 20 points



Four particles pass through a square region of uniform magnetic field. The magnetic field inside the square region is perpendicular to the page, and the field outside the region is zero. The paths followed by particles 1 and 2 are shown; while for particles 3 and 4 the direction of their velocities and the points at which they enter the region are shown. The paths of all particles lie in the plane of the paper.

Particle 1 has a mass *m*, a speed *v*, and a positive charge +*q*.

[3 points] (a) In which direction is the uniform magnetic field in the square region?

[ ] into the page [ ] out of the page

[3 points] (b) Assume that the only thing acting on the particles as they move through the magnetic field is the field. As particle 1 moves through the field its kinetic energy:

[ ] increases [ ] decreases [ ] stays the same

[2 points] (c) What is the sign of particle 2's charge?

[ ] positive [ ] negative

[3 points] (d) If particle 2's mass is *m* and its charge has a magnitude of *q*, what is its speed?

[ ] $\frac{v}{4}$ [ ] $\frac{v}{2}$ [ ] v [ ] 2v [ ] 4v

[3 points] (e) Particle 3 has a mass 2*m*, a speed 2*v*, and a charge -2*q*. On the diagram above, sketch its path through the region of magnetic field. Be as precise as you can in showing where the particle leaves the field and what direction it is traveling in at that point.

[3 points] (f) Particle 4 has a mass 2*m*, a speed 2*v*, and no charge. On the diagram above, sketch its path through the region of magnetic field. Be as precise as you can in showing where the particle leaves the field and what direction it is traveling in at that point.

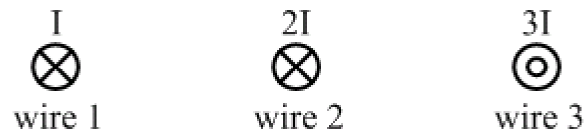
[3 points] (g) Which particle feels the largest magnitude force as it passes through the field?

[ ] 1 [ ] 2 [ ] 3 [ ] 4

PROBLEM 2 – 5 points

Three equally spaced long straight wires are shown in the diagram. The currents in the wires are as follows:

Wire 1 carries a current I into the page.
Wire 2 carries a current of 2I into the page.
Wire 3 carries a current of 3I out of the page.



[3 points] (a) Each wire experiences a net force because of the other two wires. Rank the three wires based on the magnitude of the net force per unit length they experience, from largest to smallest.

[ ] 1>2>3 [ ] 1>3>2 [ ] 1=3>2 [ ] 2>1>3 [ ] 2>3>1 [ ] 2>1=3

[ ] 3>1>2 [ ] 3>2>1 [ ] 3=2>1 [ ] 1=2=3 [ ] none of these

[2 points] (b) What direction is the net force experienced by wire 1 due to the other two wires?

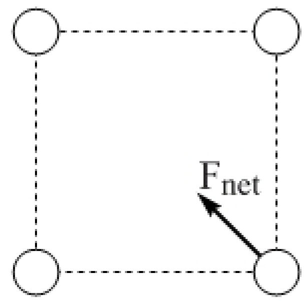
[ ] left [ ] right [ ] into the page [ ] out of the page [ ] down [ ] up

[ ] the net force on wire 1 is zero

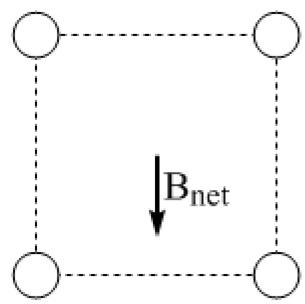
PROBLEM 3 – 12 points

Four long straight parallel wires pass through the corner of a square. **Each wire carries the same magnitude current**, but it is up to you to determine whether the current in any particular wire is directed out of the page or into the page.

[2 points] (a) The net force on the wire in the bottom-right corner is directed toward the top-left corner of the square. By using the symbol ⊙ for out of the page and/or ⊗ for into the page show a possible configuration of current directions that would produce this force. In other words, label each wire with its current direction.



[5 points] (b) The net magnetic field at the exact center of the square from the four current-carrying wires is directed straight down. By using the symbols ⊙ for out of the page and ⊗ for into the page, show a possible configuration (if there is one) of current directions that would produce the required magnetic field at the center of the square.

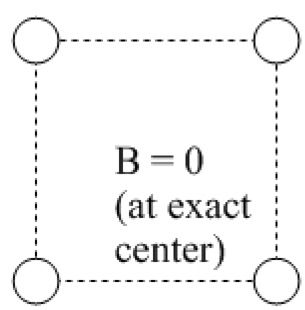


How many different configurations (different combinations of current directions) are there that would produce the required magnetic field?

[ ] 0 [ ] 1 [ ] 2
[ ] 3 [ ] 4 [ ] 5 or more

Justify your answer:

[5 points] (c) The net magnetic field at the exact center of the square is zero. By using the symbols ⊙ for out of the page and ⊗ for into the page show a possible configuration (if there is one) of current directions that would produce no magnetic field at the center of the square.



How many different configurations (different combinations of current directions) are there that would produce zero net magnetic field at the center?

[ ] 0 [ ] 1 [ ] 2
[ ] 3 [ ] 4 [ ] 5 or more

Justify your answer: