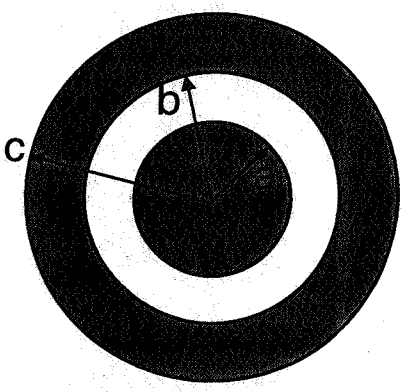
Name: _____

Recitation Instructor: name1 name2 name3 name4

Problem 1, 25 points total. A long conducting cylindrical shell is concentric about a long wire. The shell has outer radius c and inner radius b, while the wire has radius a: a < b < c. The wire has a uniform current 5i into the page and the shell has a uniform current 8i out of the page. A cross-section of the arrangement is shown to the right. Use Ampere's Law to answer the following questions.



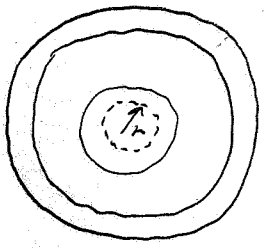
(a) What is the magnetic field, **B**(r), for r < a?

$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 i_{enc}$

$B(2\pi r) = \mu_0 J A_{enc}$

$= \mu_0 \left(\frac{5i}{\pi a^2}\right)(\pi r^2)$

$B = \frac{\mu_0}{2\pi}(5i)\frac{r}{a^2}$ ✓ CW ✓

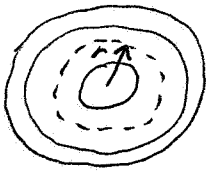


(b) What is the magnetic field, **B**(r), for a < r < b?

$B(2\pi r) = \mu_0 i_{enc}$

$= \mu_0 5i$

$B = \frac{\mu_0(5i)}{2\pi r}$ CW ✓



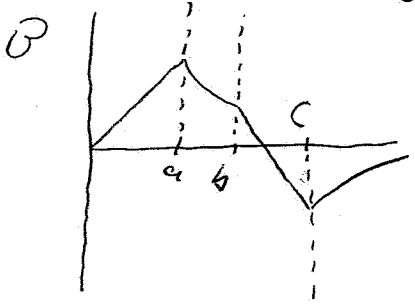
(c) What is the magnetic field, **B**(r), for r > c?

$B(2\pi r) = \mu_0 i_{enc}$

$= \mu_0 |5i - 8i|$

$B = \frac{\mu_0(3i)}{2\pi r}$ ✓ CCW ✓

(d) At what value of r does the magnetic field have the largest magnitude?



$r = a$ ✓

Physics 132, Sample Final Page Score _____

Name: _____

Recitation Instructor: name1 name2 name3 name4

Problem 2, 13 points total. Consider the arrangement of wires shown in the figure. There are four straight sections and two sections that are quarter-circles that lie on a common circle of radius R. Point P is at the center of the circle. R = 2.0 m, i = 8.0 A. What is the magnetic field at location P?

$\vec{B} = \vec{B}_{\text{straight sections}} + \vec{B}_1 + \vec{B}_2$

$= 0$

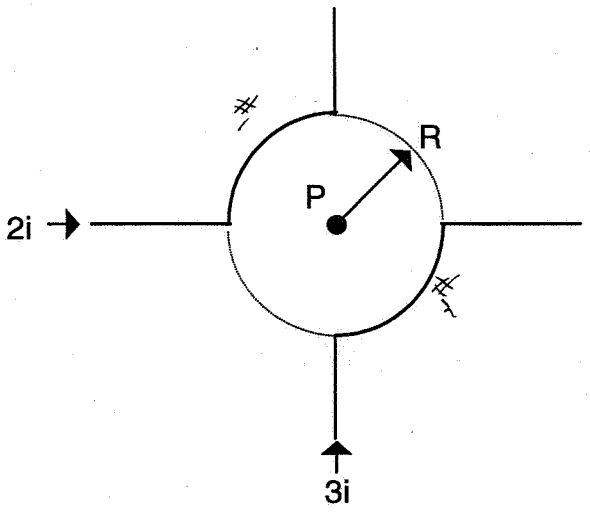
$\vec{B}_1 = \frac{1}{4} B_{\text{loop}} \otimes = \frac{1}{4} \frac{\mu_0 (2i)}{2R} \otimes$

$\vec{B}_2 = \frac{1}{4} B_{\text{loop}} \odot = \frac{1}{4} \frac{\mu_0 (3i)}{2R} \odot$

$\vec{B} = \vec{B}_1 + \vec{B}_2$

$= \frac{1}{4} \frac{\mu_0 i}{R} \otimes + \frac{3}{8} \frac{\mu_0 i}{R} \odot$

$= \frac{1}{8} \frac{\mu_0 i}{R} \odot$ ✓

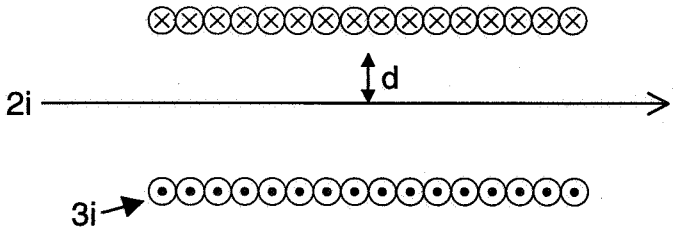


Problem 3, 13 points total. A long wire carrying a current 2i runs through the center of a long solenoid carrying a current 3i, as shown in cross-section. The solenoid has n turns per unit length. What is the magnetic field a distance d above the wire?

$\vec{B} = \vec{B}_{\text{solenoid}} + \vec{B}_{\text{wire}}$

$= \mu_0 (3i) n \,(\text{left}) + \frac{\mu_0 (2i)}{2\pi d} \odot$

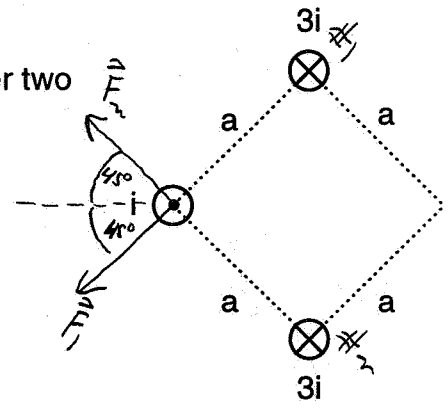
$= 3 \mu_0 i n \,(\text{left}) + \frac{\mu_0 i}{\pi d} \odot$ ✓



Name: _____

Recitation Instructor: name1 name2 name3 name4

Problem 4, 24 points total. Three very long wires of length L lie parallel to each other, and are arranged through three of the vertices of a square with sides of length a. A cross-section of this arrangement is shown in the figure. The currents and their directions are marked. Neglect the effect of fringing fields.



(a) What is the magnetic force, **F**, on the leftmost wire due to the other two wires?

$\vec{F}$ is to the left ✓

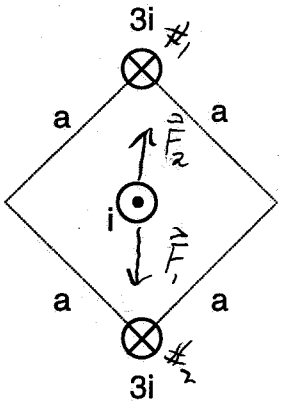
$F = 2\,(F_1 \cos 45°)$

$= 2\,\dfrac{\mu_0 L i (3i)}{2\pi a}\,\dfrac{1}{\sqrt{2}}$

$= \dfrac{3}{\sqrt{2}}\,\dfrac{\mu_0 i^2 L}{\pi a}$ ✓

(b) Suppose we move the leftmost wire to the center of the square. Now what is the magnetic force on it?

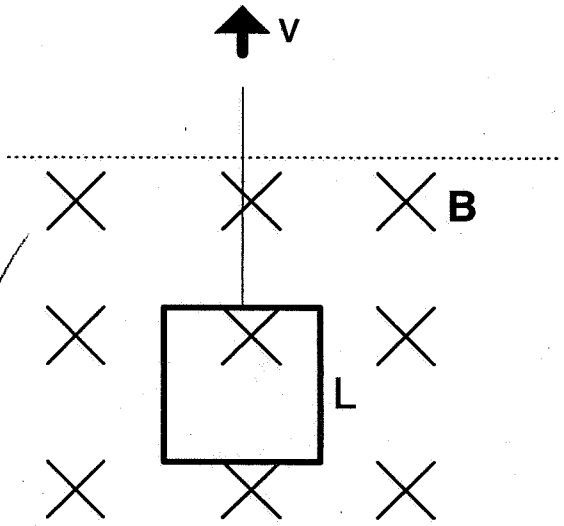
$\vec{F} = \vec{F}_1 + \vec{F}_2 = 0$ ✓



Name: _____

Recitation Instructor: name1 name2 name3 name4

Problem 5, 25 points total. A conducting square loop with sides of length L is pulled up by a string at constant speed v in a uniform magnetic field, B, going into the page as shown. The loop's resistance is R and its mass is m.



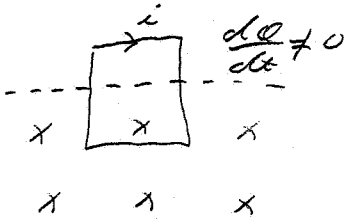
(a) What is the current in the loop before it reaches the dotted line?

$i = \mathcal{E}/R = 0$ b/c $\mathcal{E} = 0$ b/c Q_B = constant ✓

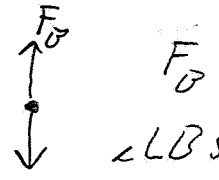
(b) What is the current in the loop after the top of the loop passes above the line, but before the bottom does?

$i = \mathcal{E}/R = \frac{BLv}{R}$ ✓

CW ✓



(c) The string is cut and the loop falls down. It reaches terminal velocity before the top of the loop passes back into the magnetic field. What is the magnitude of its terminal velocity?

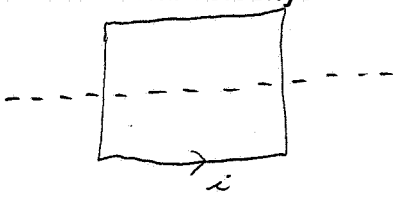


$F_B = mg$

$iLB\sin 90° = mg$

$\left(\frac{BLv_t}{R}\right)LB = mg$

$v_t = \frac{mgR}{B^2L^2}$ ✓



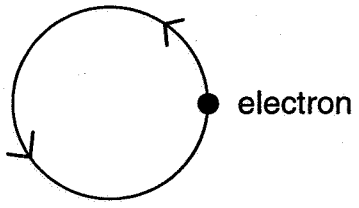
Name: _____

Recitation Instructor: name1 name2 name3 name4

MULTIPLE CHOICE/SHORT ANSWER SECTION (100 points)

There is no partial credit and you do not need to show any work.

1. Electrons are going around a circle in a counterclockwise direction as shown. They produce a magnetic field whose direction at the center of the circle is:



A) into the page.
B) out of the page.
C) to the left.
D) to the right.
E) undefined, because the magnitude of the field is zero.

2. Four 20 Ω resistors are connected in parallel and the combination is connected to a 20 V emf device. The current in the device is:

A) 0.25 A B) 1.0 A C) 4.0 A D) 5.0 A E) 100 A

3. Pulling the plates of an isolated charged capacitor apart:

A) increases the capacitance.
B) does not affect the capacitance.
C) increases the potential difference.
D) does not affect the potential difference.
E) decreases the potential difference.

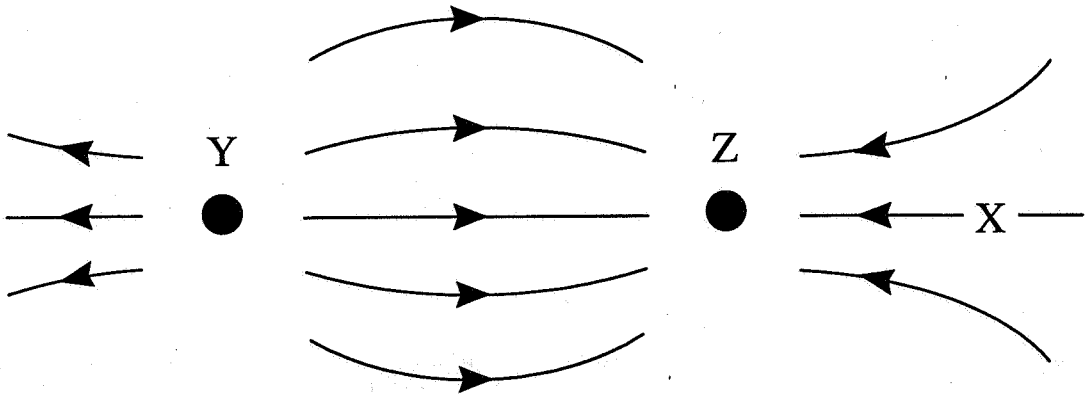
4. An electron is moving north in a region where the magnetic field is south. The magnetic force exerted on the electron is:

A) zero B) up C) down D) east E) west

Name: _____

Recitation Instructor: name1 name2 name3 name4

5. The diagram shows the electric field lines in a region of space containing two small charged spheres (Y and Z). X marks a location in space.



A) Y is negative and Z is positive.
B) the magnitude of the electric field is the same everywhere.
C) the electric field is strongest midway between Y and Z.
(D) a small negatively charged body placed at X would be pushed to the right.
E) Y and Z must have the same sign.

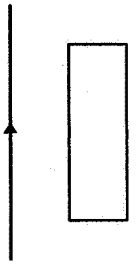
6. 10 C of charge are placed on a spherical conducting shell. A -3 C point charge is placed at the center of the cavity. What is the net charge on the inner surface of the shell is?

+3C ✓

7. An electron traveling north enters a region where the electric field is uniform and points north. The electron:

A) speeds up
(B) slows down
C) veers east
D) veers west
E) continues with the same speed in the same direction

8. A long straight wire is in the plane of a rectangular conducting loop. The straight wire carries an increasing current in the direction shown. The current in the rectangle is:



A) zero
B) clockwise
(C) counterclockwise
D) clockwise in the left side and counterclockwise in the right side
E) counterclockwise in the left side and clockwise in the right side

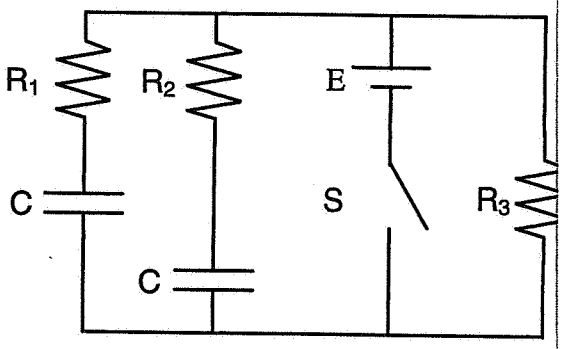
Name: _____

Recitation Instructor: name1 name2 name3 name4

9. A 2 meter stick is parallel to a uniform 200 N/C electric field. The potential difference between its ends is:

A) 0
B) 1.6×10^{-17} V
C) 3.2×10^{-17} V
D) 100 V
E) 400 V

The next two problems are about the circuit shown in the figure. The battery is ideal and the wires have negligible resistance. Initially the switch is open and the capacitors are uncharged. Then the switch is closed.



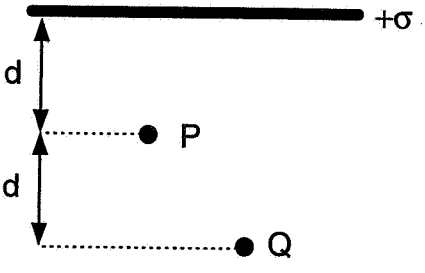
10. Just after the switch is closed, what is the current through resistor R_3?

$i_3 = \mathcal{E}/R_3$

11. A long time after the switch is closed, what is the current through the battery?

$i = \mathcal{E}/R_3$

12. Consider the two positions marked P and Q underneath a large sheet of charge with charge density $+\sigma$, shown in cross-section. Which statement is true about the potentials at these two positions?

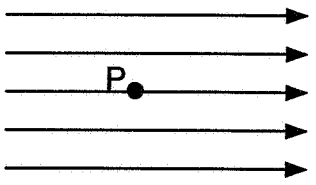


A) $V_P < V_Q$
B) $V_P = V_Q$
C) $V_P > V_Q$
D) $V_P = k\sigma/d$, $V_Q = k\sigma/2d$
E) There is insufficient information to establish a relation between the potentials at P and Q.

Name: _____

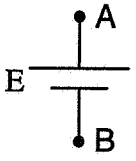
Recitation Instructor: name1 name2 name3 name4

13. Given the uniform electric field shown in the figure, and the position P, which statement is true?



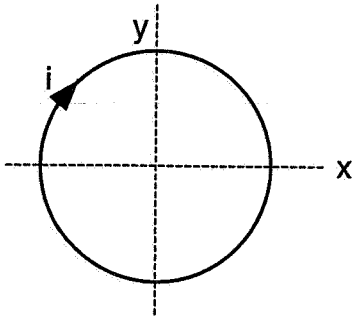
A) Potential increases to the right.
B) The force on an electron at P would be to the left.
C) The electric field between the lines is zero.
D) The electric field magnitude increases to the right.
E) None of the above statements are true.

14. Which statement about batteries is false?



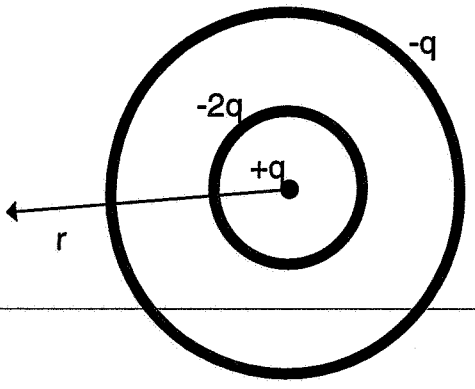
A) An ideal battery can supply an arbitrarily large amount of current.
B) The change in potential moving from A to B equals -E.
C) The voltage drop across a real battery is independent of the current it supplies.
D) A proton would have a higher potential energy at point A than at point B.
E) A current running from A to B would charge the battery.

15. A current loop lies in the plane of the page with the current going clockwise. Initially the loop is not moving. Then a magnetic field is applied in the negative y direction. Which way will the loop rotate?



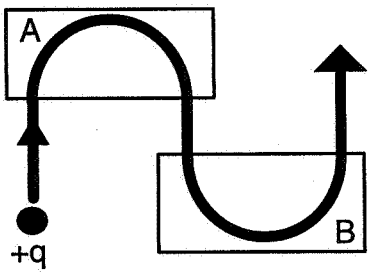
A) About the x-axis.
B) About the y-axis.
C) About an axis centered on the loop and perpendicular to the page.
D) The loop will not rotate at all.
E) There is not sufficient information to determine the answer.

16. What is the electric field a distance r outside the charge distribution shown: a point charge inside two concentric, spherical, charged shells?



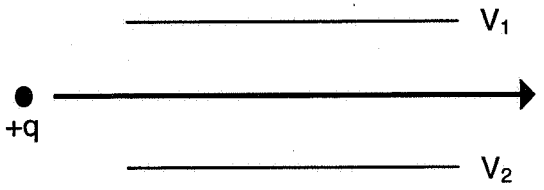
A) $2kq/r^2$, radially inwards.
B) kq/r^2, radially inwards.
C) Zero.
D) kq/r^2, radially outwards.
E) $2kq/r^2$, radially outwards.

17. There are uniform magnetic fields perpendicular to the plane of the page in the boxed regions. A positively charge particle follows the trajectory shown. What are the directions of the magnetic fields in region A and B?



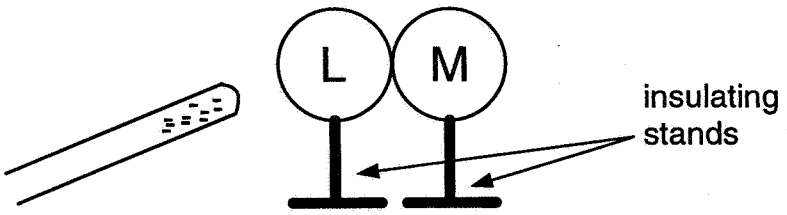
A) A: into the page; B: into the page
B) A: into the page; B: out of the page
C) A: out of the page; B: into the page
D) A: out of the page; B: out of the page
E) There is not sufficient information to answer this question.

18. A positively charged particle enters the region between two large, parallel conducting plates and travels through undeflected as shown. There is a magnetic field in the region between the two plates pointing towards the right. How are the electric potentials of the two plates related? (Neglect the effect of fringe fields.)



A) $V_1 < V_2$
B) $V_1 = V_2$
C) $V_1 > V_2$
D) They cannot be related without a reference potential.
E) They cannot be related without knowing the distance between the plates.

19. Two uncharged metal spheres, L and M, are in contact. A negatively charged rod is brought close to L, but not touching it, as shown. The two spheres are slightly separated and the rod is then withdrawn. As a result:



A) both spheres are neutral.
B) both spheres are positive.
C) both spheres are negative.
D) L is negative and M is positive.
E) L is positive and M is negative.

20. Three resistors, R_1, R_2, R_3, are in series with each other. $R_1 < R_2 < R_3$. There is a current running through R_1. Which statement is true?

A) R_1 has the largest potential difference across it.
B) R_3 has the largest potential difference across it.
C) The potential difference across each resistor is the same.
D) The power dissipated by each resistor is the same.
E) If the resistors are made of the same material, and have the same cross-sectional area, then R_1 is the longest.