PHYS 2212 Test 2
Fall 2014

Name(print) Key ______________ **Lab Section** ______________

Lab section by day and time: Greco(N,P), Zangwill(Q)						
Monday	12:05-2:55pm	N01 or Q01	3:05-5:55pm	N02 or P01	6:05-8:55pm	Q02 or P02
Tuesday	12:05-2:55pm	N03 or P03	3:05-5:55pm	Q03 or P04	6:05-8:55pm	
Wednesday	12:05-2:55pm	N05 or P05	3:05-5:55pm	Q05 or P06	6:05-8:55pm	N04 or Q04
Thursday	12:05-2:55pm	P07 or N06	3:05-5:55pm	N07 or Q06	6:05-8:55pm	

Instructions

- Read all problems carefully before attempting to solve them.
- Your work must be legible, and the organization must be clear.
- You must show all work, including correct vector notation.
- **Correct answers without adequate explanation will be counted wrong.**
- Incorrect work or explanations mixed in with correct work will be counted wrong. Cross out anything you do not want us to grade
- Make explanations correct but brief. You do not need to write a lot of prose.
- Include diagrams!
- **Show what goes into a calculation, not just the final number, e.g.:** $\frac{a \cdot b}{c \cdot d} = \frac{(8\times10^{-3})(5\times10^{6})}{(2\times10^{-5})(4\times10^{4})} = 5 \times 10^4$
- Give standard SI units with your results.

Unless specifically asked to derive a result, you may start from the formulas given on the formula sheet, including equations corresponding to the fundamental concepts. If a formula you need is not given, you must derive it.

If you cannot do some portion of a problem, invent a symbol for the quantity you can not calculate (explain that you are doing this), and use it to do the rest of the problem.

Honor Pledge

"In accordance with the Georgia Tech Honor Code, I have neither given nor received unauthorized aid on this test."

____

Sign your name on the line above

PHYS 2212

Please do not write on this page.

Problem	Score	Grader
Problem 1 (25 pts)		
Problem 2 (25 pts)		
Problem 3 (25 pts)		
Problem 4 (25 pts)		

Problem 1 (25 Points)

The following program is intended to calculate and display the electric and magnetic field at a specified observation location. Complete the program below by filling in the missing VPython code. When possible, please use the names already defined in the program.

```
from visual import *
## Constants
mzofp = 1e-7
oofpez = 9e9
qe = 1.6e-19

## Objects
proton = sphere(pos=vector(3e-10,0,0), radius=1e-11, color=color.red)
velocity = vector(-5.2e4,0,0) # The proton's velocity
r_obs = vector(0,8e-11,0) # The observation location
deltat = 1e-19 # Timestep

while proton.x < 5e-10:
```

Fill in the missing code needed to calculate the electric and magnetic field vector at the observation location

```
r = r_obs - proton.pos
rhat = r/mag(r)
```
} 5pts

```
Efield = oofpez * qe * rhat /(mag(r)**2)
```
} 10pts

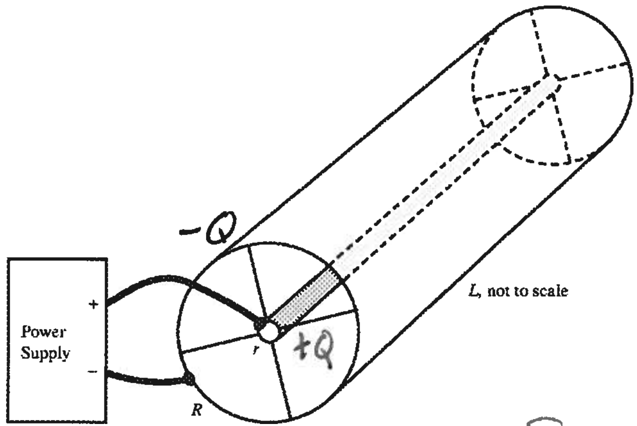
```
Bfield = mzofp * qe * cross(velocity,rhat)/(mag(r)**2)
```
} 10pts

[Note: no penalty if student displays vectors or arrows for $\vec{E}$ & $\vec{B}$.]

```
# Update the proton's position
    proton.pos = proton.pos + velocity*deltat
```

Problem 2 (25 Points)

A long thin metal wire with radius r and length L is surrounded by a concentric long, narrow metal tube of radius R. Insulating spokes (not shown in the diagram) hold the wire in the center of the tube and prevent electrical contact between the wire and the tube. A power supply is connected to the device as shown. A power supply maintains a charge of $+Q$ on the inner wire and $-Q$ on the outer tube. Like a spherical metal shell, the field produced by the cylindrical metal tube is zero at every point inside the tube. Determine the potential difference between the inner wire and the outer tube $V_{tube} - V_{wire}$? Be sure to show your work and check the sign of your answer.



Ch: -1.0
Minor: -4.0
Major: -8.0
BTN: -20

$$\Delta V = -\int \vec{E} \cdot d\vec{l}$$

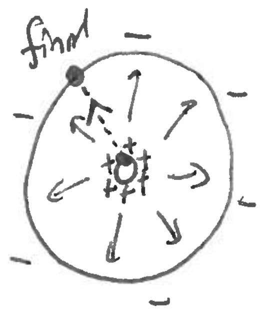
$$= -\int_r^{r+R} \frac{1}{4\pi\epsilon_0 L} \frac{2Q}{r'} \, dr'$$

$$= \left(-\frac{Q}{2\pi\epsilon_0 L}\right) \int_r^R \frac{1}{r'} \, dr'$$

$$= \left(-\frac{Q}{2\pi\epsilon_0 L}\right) \ln\left(\frac{R}{r}\right)$$

$$= \frac{Q}{2\pi\epsilon_0 L} \underbrace{\ln\left(\frac{r}{R}\right)}_{\text{"negative"}}$$

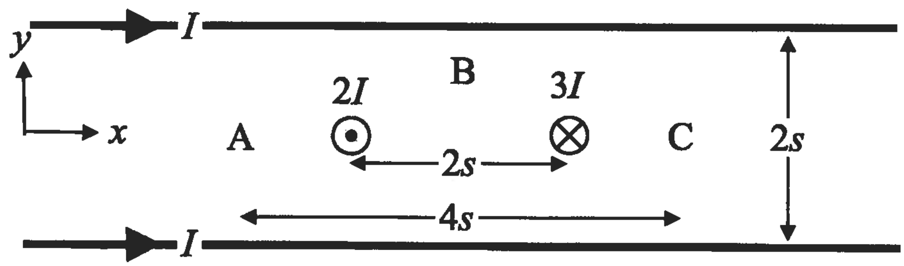
$\boxed{\text{Note: } \Delta V < 0}$



$(< 0$ as expected$)$

Problem 3 (25 Points)

Two infinitely long parallel wires each carry a current I in the $+x$ direction. Two more infinitely long parallel wires carry current perpendicular to the xy plane. One of these wires carries a current $2I$ in the $+z$ direction. The other carries a current $3I$ in the $-z$ direction as indicated in the diagram.



(a 5pts) At point A in the xy plane, the net magnetic field points in the (circle all that apply)

(A) +z direction
(B) +y direction
(c) -x direction
(d) -y direction
(e) none of these

All

(b 5pts) At point B in the xy plane, the net magnetic field points in the (circle all that apply)

(A) +z direction
(B) +y direction
(c) -x direction
(d) -y direction
(e) none of these

$\vec{B}_{net} = +\hat{x}, +\hat{y}, -\hat{z}$ ⇒ Any work or choice that supports this gets credit

(c 5pts) At point C in the xy plane, the net magnetic field points in the (circle all that apply)

(A) +z direction
(B) +y direction
(c) -x direction
(d) -y direction
(e) none of these

All

(d 10pts) On the x-axis, the net magnetic field is zero at a distance d from the wire with current $2I$. This value of d is (circle one)?

(A) s
(B) $2s$
(C) $3s/2$
(D) $4s$
(E) $5s/2$

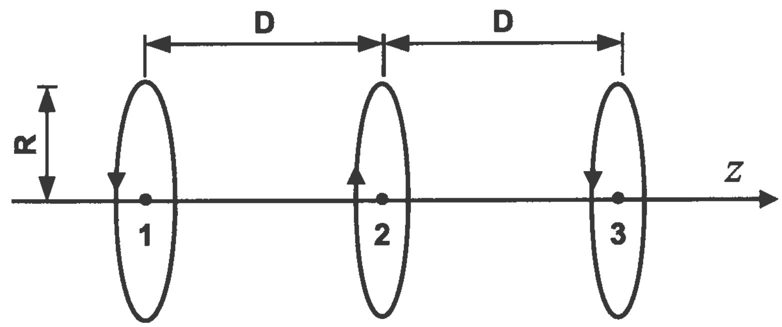
All

$$-\frac{\mu_0}{4\pi}\frac{2(2I)}{d} + \frac{\mu_0}{4\pi}\frac{2(3I)}{(2s+d)} = 0$$

Solve for d: $d = 4s$

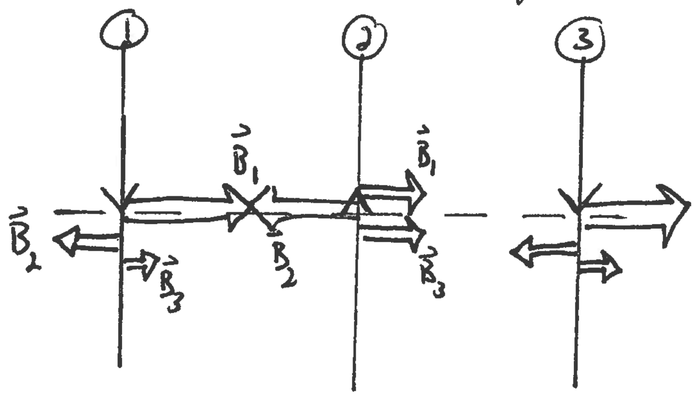
Problem 4 (25 Points)

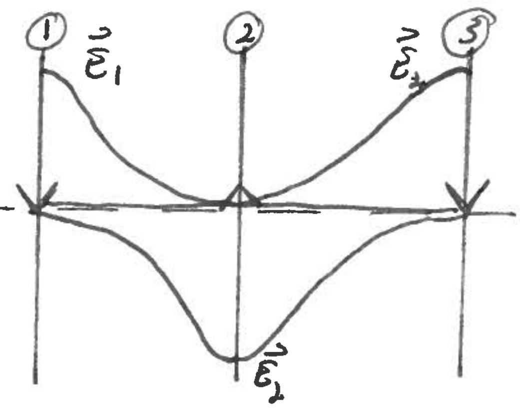
Three identical and equally spaced circular loops each carry a current I. The direction of current circulation in the two outer loops is the same, which is opposite to the direction of current circulation in the middle loop as indicated in the diagram. Assume that the loop separation D is large compared to the loop radius R (the drawing is not to scale $D >> R$). For each loop (in the xy-plane), the arrow labels the direction of the current in the part of the loop closest to you. The points labeled 1, 2, and 3 are at the center of their respective loops and on the z-axis.



(a 5pts) At which of the numbered point(s) is the net magnetic field largest? Briefly explain how you know this.

Largest at points 1 & 3. We can see this graphically with arrows or by plotting the individual fields





TA discuss

(b 5pts) At which of the numbered point(s) is the net magnetic field smallest? Briefly explain how you know this.

As seen in part (a), the field is smallest at 2. This is because both outer rings contribute a field in the opposite direction the field from the center ring.

TA discuss

(c 5pts) At which of the numbered point(s) is the net magnetic field zero? Briefly explain how you know this. If the field is zero at none of the numbered points state this explicitly.

Because $D >> R$ the field will not be zero at any location (As seen in the graph at (a)).

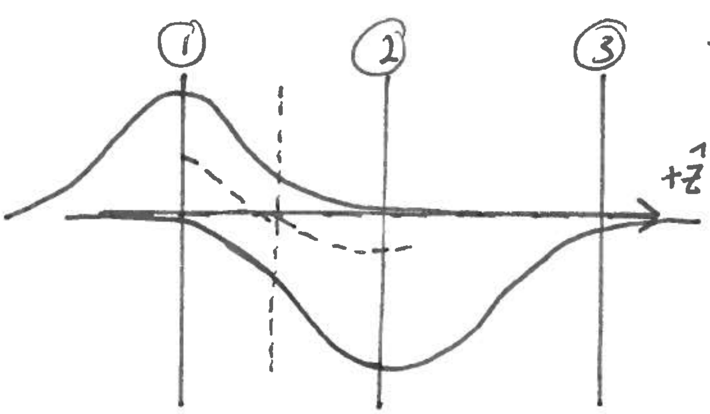
For example at location 2, the net field (+z to the right)

$$\vec{B}_{net} = \frac{\mu_0}{4\pi}\frac{2I\pi R^2}{D^3} - \frac{\mu_0}{4\pi}\frac{2I\pi R^2}{(R^3)} + \frac{\mu_0}{4\pi}\frac{2I\pi R^2}{D^3}$$

TA discuss

$$\vec{B}_{net}\Big|_{@2} \neq 0 \quad \text{Because } D >> R.$$

(10 points) Determine if the net magnetic field is zero anywhere (except at infinity) along the z-axis. If you find that the field is zero, you should not solve for the exact location but please show work supporting your answer.



→ The net field will be zero at some location on either side of loop 2.

→ Far from the loops the net field points in the +z direction

→ to see that there is a zero, consider the net field Between only the two outer loops. The fields have the same magnitude but opposite directions at the midpoint.

→ The third ring's field is weak at this location and simply shifts the zero over a small amount.