20S-PHYSICS1C-1 Quiz 2

CHARLES ZHANG

TOTAL POINTS

17 / 30

QUESTION 1

1 2a 5 / 5

- ✓ + **3.5 pts** **Magnitude**
- ✓ + **1 pts** **Direction**
- ✓ + **0.5 pts** **Reasoning for the direction**
- \+ **0 pts** Incorrect

QUESTION 2

2 2b 5 / 10

- ✓ + **3 pts** **Correct Condition**
- \+ **3 pts** Correct direction
- ✓ + **2 pts** **Correct functional dependence of electric field**
- \+ **1 pts** Additional corroborating details
- \+ **1 pts** Correct qualitative plot close to the wire
- \+ **0 pts** Incorrect

QUESTION 3

3 2c 7 / 10

- ✓ + **4 pts** **Correct Final expression for electric field**
- ✓ + **3 pts** **Intermediate steps**
- \+ **3 pts** Correct direction near the wire
- \+ **0 pts** Incorrect

QUESTION 4

4 2d 0 / 5

- \+ **5 pts** Correct
- \+ **2.5 pts** Partially correct
- ✓ + **0 pts** **Incorrect**

1CS20 QUIZ 2

Full Name (Printed) Charles Zhang

Full Name (Signature)

Student ID Number 305-413-659

- The exam is open-book and open notes. You will probably do better to limit yourself to a single page of notes you prepared well in advance.
- **All work must be your own.** You are not allowed to collaborate with anyone else, you are not allowed to discuss the exam with anyone until all the exams have been submitted (after the close of the submissions window for the exam).
- You have 30 minutes to complete the exam and sufficient time to scan the exam and upload it to GradeScope. The exam *must* be uploaded to GradeScope within the time alloted (that is, by the end of the lecture hour). We will only except submissions through GradeScope and will not accept any exam submitted after the submission window closes (CAE students must contact Corbin for instructions).
- **Given the limits of GradeScope, you must fit your work for each part into the space provided.** You may work on scratch paper, but you will not be able to upload the work you do on scratch paper, so it is essential that you copy your complete solution onto the exam form for final submission. We can only consider the work you submit on your exam form.
- **For full credit the grader must be able to follow your solution from first principles to your final answer.** ***There is a valid penalty for confusing the grader.***
- It is YOUR responsibility to make sure the exam is scanned correctly and uploaded before the end of the submission window. The graders may refuse to grade pages that are significantly blurred, solutions to problems that are not written in the correct place, pages submitted in landscape mode and/or work that is otherwise illegible - if any of this occurs, you may not receive *any* credit for the affected parts.
- Focus on the concepts involved in the problem, the tools to be used, and the set-up. If you get these right, all that's left is algebra.
- **Have Fun!**

The following must be signed before you submit your exam:

By my signature below, I hereby certify that all of the work on this exam was my own, that I did not collaborate with anyone else, nor did I discuss the exam with anyone while I was taking it.

Signature

A long, straight wire carries a current $I(t)$...

- 2a) (5 points) *Derive* the magnetic field (vector) at some point a distance r from the wire. Explain how you obtained the direction of that vector.

$$\int \vec{B} \cdot d\vec{s} = \mu_0 I_{encl}$$ ← r is outside wire → $I_{encl} = I(t)$

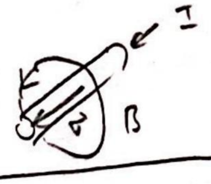
$$B \int d\vec{s} = \mu_0 I(t)$$

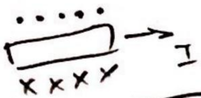
$$B(2\pi r) = \mu_0 I(t)$$

$$B = \frac{\mu_0 I(t)}{2\pi r}$$

$$\boxed{\vec{B} = \frac{\mu_0 I(t)}{2\pi r} \hat{\phi}}$$, $\hat{\phi}$ obtained using RHR, wire is long/straight → no obvious + or − direction
↳ it cannot depend on $\hat{r}$ or $\hat{z}$ because then there would be ϕ reliance

- 2b) (10 points) Under what conditions will that wire give rise to an electric field? Assume these conditions are met and use symmetry (as I did in class) to obtain a mathematical description of the electric field so generated. The more correct detail you provide, the more points you will receive. Do a quick, qualitative plot of the electric field for points near the wire.



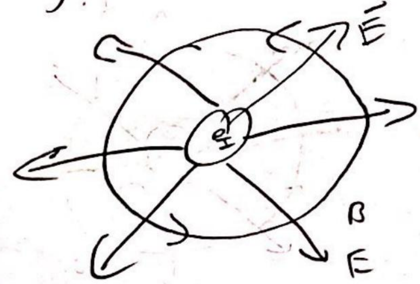


The wire gives rise to an $\vec{E}$-field as long as $\dot{I}(t) \neq 0$.

$$\int \vec{E} \cdot d\vec{s} = -\frac{\partial}{\partial t} \int \vec{B} \cdot d\vec{A}$$ →

all charges emit a $\vec{E}$ field in all directions, those in the $\hat{z}$ direction cancel each other out, only $\hat{r}$ matters.

by symmetry: for all points near the wire



the wire can't tell where it is in z-direction
↳ can't rely on z, $\hat{\phi}$ or $\hat{z}$

- 2c) (10 points) Show that in the region right around the wire, the electric field varies logarithmically with distance from the wire. What direction ~~will the electric~~ field point near the wire if the current is increasing in time?

$$\vec{E} = I\vec{L}\times\vec{B}$$ ← This isn't a formula :C

$$B = \frac{\mu_0 (I(t))}{2\pi r}\hat{\phi}$$

$$\vec{E} = IL\left(\frac{\mu_0 I(t)}{2\pi r}\right)\hat{r}$$

$$\frac{d\vec{E}}{dr} = IL\left(\frac{\mu_0 I(t)}{2\pi r}\right)\hat{r}$$

$$d\vec{E} = IL\left(\frac{\mu_0 I(t)}{2\pi r}\right)\hat{r}\,dr$$

$$\int d\vec{E} = \frac{I^2 L \mu_0}{2\pi}\hat{r}\int_0^r \frac{1}{r}\,dr$$

$$\boxed{\vec{E} = \frac{I^2 L \mu_0}{2\pi}\ln|r|\hat{r}}$$

$$\mathcal{E}_i = -\frac{\partial \Phi}{\partial t}$$

↳ increasing current = increasing magnetic field

↳ increasing $\vec{B}$ → increasing Φ_B

↳ $\frac{\partial \Phi}{\partial t}$ is +

↳ $\mathcal{E}_i$ is −

$$\oint E\cdot dr = -\frac{\partial \Phi_D}{\partial t}$$ → negative value

$\vec{E}$ points in direction of current flow when current increases?

- 2d) (5 points) Assuming you've done everything correctly, there's still a problem with your solution. What is that problem? With the time that remains (remember, you only get 30 minutes to take the quiz!) discuss a possible shortcoming in your approach and/or a way to address the problem.

There are no sources/sinks to the electric field, therefore the field lines must make a full loop. This is a result of us doing the analysis for r close to the wire. In order to address the problem, we must take in to consideration the ends of the wire (which we ignored in previous parts), as the wire is not infinite.