Physics 122 Spring 2025

Third Exam

Wednesday, April 9, 2025

You have 45 minutes to complete the exam.

There are two problems each worth 50 points

Guidelines

1. **Write your name clearly on this cover page.**

2. If you have done and understand the homework, you will be fine. While the exam starts, if you need to relax yourself, you can draw something here:

3. Do not open the exam until you are instructed to.

4. Write your answer on the blank pages provided for each problem. If you need more space you may request additional paper and staple it to your exam when you finish.

5. The questions are on the last three pages of this booklet. Please separate those pages from the rest of the booklet. You do not need to submit the questions, only your answers.

6. After you complete your work (or time is up) you should scan it and upload it to Canvas. Look for an Assignment called "Third Exam". You are responsible of the quality of your submission. **A correct Canvas submission will give you 1 extra credit point.**

7. After scanning **submit the hard copy** of your work. The proctors will let you know where the submission bins are located.

8. The exam is closed book. You are only allowed the provided formula sheet.

9. Keep your work clear, neat and well-organized. Illegible answers might be graded as incorrect. Often it helps to put a box around your final answer.

10. Use pictures and words to **explain what you are doing**. State the central physics concept associated with each problem (e.g. Coulomb's law, Gauss's law, superposition). You will earn partial credit for knowing how to solve the problem even if you are not able to fully implement the solution.

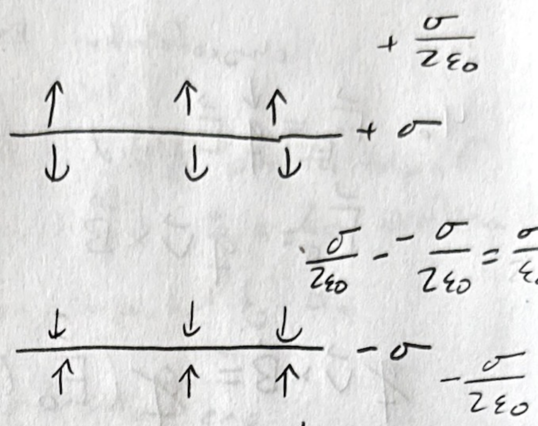
Write your name here: Trevor Swan

1. $E_0 = \frac{\sigma_{free}}{\varepsilon_0}$

$E_K = \left(\frac{\sigma_{free}}{\varepsilon_0}\right) K$

$E_K = \frac{\sigma_{free}}{\varepsilon_0}(1+\chi)$

$$\boxed{\vec{E} = E_0(1+\chi)(-\hat{k})}$$



Inside should be in the $-\hat{k}$ direction

2. $\vec{P} = \chi \varepsilon_0 \vec{E}_K$

$$\boxed{\vec{P} = \chi \varepsilon_0 \left(E_0(1+\chi)\right)(-\hat{k})}$$

3. $\sigma_B^{(top)} = \hat{n}\cdot(\vec{P}_{in} - \vec{P}_{out})$ $\qquad \hat{n}\cdot\hat{k} = 0^\circ$, $\cos\theta = 1$

$= \hat{n}\cdot\left(\chi\varepsilon_0 E_0(1+\chi)(-\hat{k}) - \chi\varepsilon_0(\tfrac{1}{2}E_0)\hat{k}\right)$

$= -\chi\varepsilon_0 E_0(1+\chi) - \chi\varepsilon_0(\tfrac{1}{2}E_0)$

$= -\chi\varepsilon_0 E_0(1+\chi+\tfrac{1}{2})$

$$\boxed{\sigma_{B,\text{top and bottom}} = -\chi\varepsilon_0 \frac{\sigma_{free}}{\varepsilon_0}\left(\frac{3}{2}+\chi\right)}$$

$\sigma_{free} > 0$ for top and $\chi > 0$, so $\sigma_{B,top} < 0$

$\sigma_{free} < 0$ for bottom, but $\chi > 0$, so $\sigma_{B,bottom} > 0$

Will be the same by symmetry, just opposite signs charge of electron

4. $\vec{F}_E = \underset{\uparrow}{q}\,\vec{E}_{field} = q\left(E_0(1+x)(-\hat{k})\right)$

$\vec{F}_B = q\,\vec{v}\times\vec{B}$

$\cancel{q}\,\vec{v}\times\vec{B} = \cancel{q}\left(E_0(1+x)(-\hat{k})\right)$ ← should be equal!

$\vec{v}\times\vec{B} = \left(E_0(1+x)(-\hat{k})\right)$

magnitude?

$$B = \frac{E_0(1+x)}{v_0}$$

direction

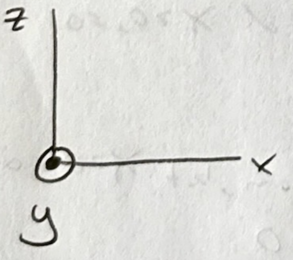
$\vec{v}\times\vec{B} = -\hat{k}$

$\hat{\imath}\times ? = -\hat{k}$

B should be out of the page $\odot$ by RHR (right hand rule).

$$\vec{B} = \frac{E_0(1+x)}{v_0}\ \odot$$

Given

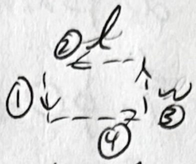


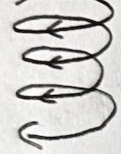
so $\vec{B}$ should be $+\hat{\jmath}$

$$\boxed{\vec{B} = \frac{E_0(1+x)}{v_0}\,(\hat{\jmath})}$$

This was done before announcement about coordinate system.

Exam 3 Problem 2

1. I will choose an ampere loop  on the top of the solenoid. This will allow me to cancel out 3 sides of the loop to make the inner side only be impacted by B.



Current is moving clockwise from above, so I must be in the downward direction.

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{enc}$$

$$\underbrace{\cancel{\left(\int \vec{B} \cdot d\vec{s}\right)_1}}_{\theta=90^\circ} \to 0 + \underbrace{\cancel{\left(\int \vec{B} \cdot d\vec{s}\right)_2}}_{B=0 \text{ outside}} \to 0 + \underbrace{\cancel{\left(\int \vec{B} \cdot d\vec{s}\right)_3}}_{\theta=90^\circ} \to 0$$

$$+ \left(\int \vec{B} \cdot d\vec{s}\right)_4 = \mu_0 I_{enc}$$

In terms of given geometry, by the RHR, $\vec{B} = B(\hat{\imath})$

$$\int \vec{B} \cdot d\vec{s} = \mu_0 I_{enc} \quad n l = \# \text{loops}$$

$$B\, l \cos\theta = \mu_0 (n\, l\, I(t))$$

$$\boxed{B = \mu_0 n I(t)} \quad \boxed{\vec{B} = B\,\hat{\imath}}$$

geometry difficult to decipher, from side view it should be to the right.

2. (i) $\oint \vec{E} \cdot d\vec{l} = -\frac{d}{dt} \oint \vec{B} \cdot d\vec{a}$

$$E \int dl \cos\theta = -\frac{d}{dt} B \int da \cos\theta$$

$$E(2\pi r) = -\frac{d}{dt}\left[B(\pi R^2)\right]$$

$$E(2\pi r) = -\frac{d}{dt}\left[\mu_0 n I(t) \pi R^2\right]$$

$$\boxed{E = \frac{\mu_0 n R^2 \frac{dI}{dt}}{2r}} \quad \boxed{E \text{ will be radially inwards}}$$

(ii) $\oint \vec{E} \cdot d\vec{l} = -\frac{d}{dt}\oint \vec{B} \cdot d\vec{a}$

$E\int d\vec{l} = -\frac{d}{dt}\oint 0 \cdot d\vec{a}$

$\boxed{E = 0}$ outside solenoid as solenoid produces magnetic field inside only.