Name: _____

Student ID: _____

Physics 1C - Winter 2022: Midterm 1

February 1, 2022

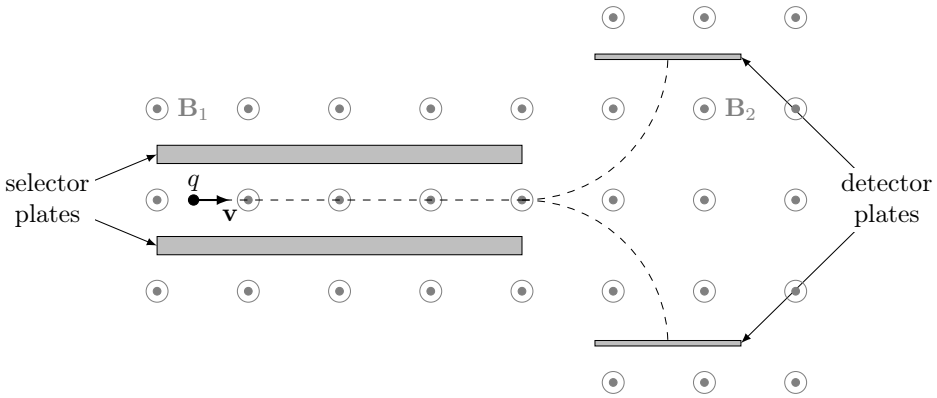
- Write your name and student ID at the top.
- Answer ALL 4 questions.
- Write your answers inside the borders on this handout. **Show all your work.** PLEASE write clearly so the graders can give you all the points you deserve.
- You are allowed to use the textbook and lecture notes, but you are not allowed to communicate with your classmates.
- You have 60 minutes. Upload your exam to Gradescope as soon as you are done. You will have 10 minutes after the end of the exam to upload your submission.

(extra space)

Problem 1

(28/100)

You are designing a mass spectrometer in which He^+ ions (with charge $q = +1.60 \times 10^{-19}$ C and mass $m = 6.65 \times 10^{-27}$ kg) are to be selected with a velocity of $\mathbf{v} = (2.00 \times 10^5 \text{ m/s})\,\hat{\mathbf{i}}$. The magnetic field in the selector is directed out of the page and is given by $\mathbf{B}_1 = (1.00 \text{ T})\,\hat{\mathbf{k}}$, as indicated in the figure.



(a) (6 points) What strength and direction must the electric field $\mathbf{E}$ in the selector have if it is to select the desired velocity $\mathbf{v}$?

(b) (6 points) Outside of the velocity selector, there is a second magnetic field given by $\mathbf{B}_2 = (2.00 \text{ T})\,\hat{\mathbf{k}}$. What is the resulting radius of the orbit for the He^+ ions?

(c) (12 points) The ions strike one of the detector plates, completing a quarter of an orbit. How long does it take for an ion to emerge from the velocity selector and strike one of the plates?

(d) (4 points) Which plate (top or bottom) will the He^+ ions strike?

(problem 1 extra space)

Problem 2

(28/100)

Consider an LC circuit with a 500 mH inductor and a 0.500 µF capacitor.

(a) (4 points) What is the angular frequency ω of the circuit?

You now add a 1.00 kΩ resistor into the circuit to make an LRC series circuit.

(b) (6 points) What is the resulting angular frequency ω' of damped oscillations?

(c) (8 points) By what percentage does the damped angular frequency ω' differ from the original frequency ω?

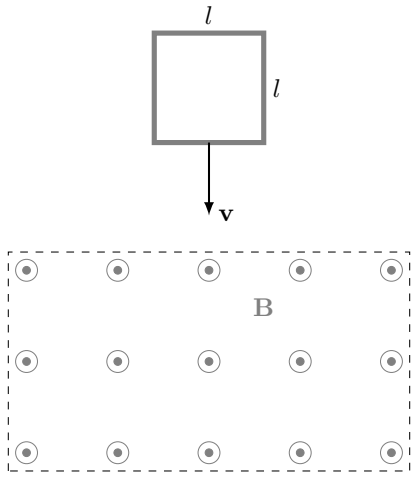
(d) (10 points) What resistance would result in a critically damped LRC circuit?

(problem 2 extra space)

Problem 3

(24/100)

A square loop with resistance R and side length l moves at constant velocity $\mathbf{v}$ and enters a region with a uniform magnetic field $\mathbf{B}$ directed out of the page. An external force ensures that the loop moves at the same velocity $\mathbf{v}$ at all times as the loop enters and exits the region with the magnetic field.



Find the magnitude and direction (clockwise or counterclockwise) of the induced current in the loop, as well as the total magnetic force on the loop, during the following time intervals:

(a) (9 points) After the front end of the loop has entered the magnetic field, but before the back end has entered the magnetic field.

(b) (6 points) After the loop is completely engulfed by the magnetic field, but before it begins to leave the magnetic field.

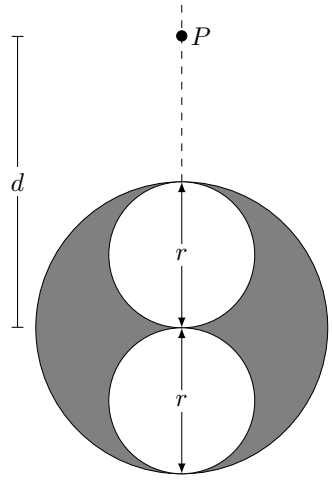
(c) (9 points) After the front end of the loop has left the magnetic field, but before the back end has left the magnetic field.

(problem 3 extra space)

Problem 4

(20/100)

A long cylindrical conductor of radius r carries a current I directed out of the page that uniformly distributed throughout its cross sectional area. The conductor has two cylindrical cavities of diameter r, as shown below.



Find the magnitude and direction of the magnetic field at a point P a distance $d = 2r$ above the center of the conductor. (Hint: You can think of the cavities as current-carrying conductors embedded within the cylinder that exactly cancel the currents carried by the cylinder within that cross sectional area. Think about what current you would need in the cavity regions to exactly cancel the current carried by the cylindrical conductor in those regions.)

(problem 4 extra space)