PHYSICS 2020 — Midterm #2

Total – 20 marks — November 28, 2014

"We would be eternally miserable if our errors worried us too much because as we push forward we will make plenty more."
Ernest O. Lawrence, winner of the 1939 Nobel Prize for Physics

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1. **(4 marks)** A series of capacitors is used to accelerate a beam of protons. Each capacitor is charged to $Q = 50$ fC and increases a proton's kinetic energy by 3.2×10^{-16} J. (Recall that a proton accelerated through an electric potential difference of ΔV volts gains $e\Delta V$ J of kinetic energy.) The capacitor plates are 8.854 cm apart. What is the area of the plates? The situation is show in Figure 1.

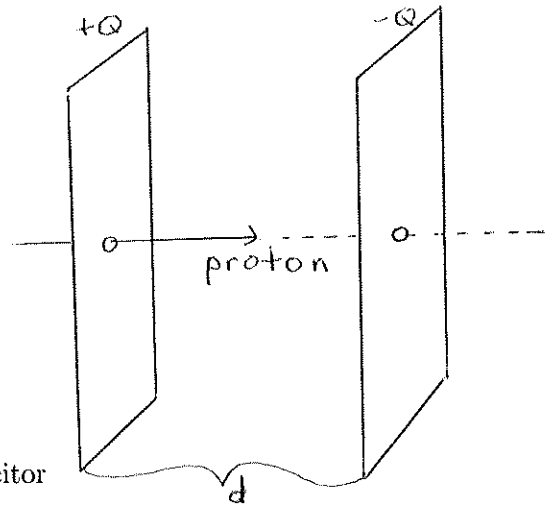

Figure 1 - The capacitor

2. **(16 marks)** A long, thin wire carrying a time-varying current $i_w = 5t$ mA/s is between two conducting rings each having a resistance R of 1 Ω. Ring #1 has a current of $i_1 = 50$ mA, a radius R_1 of 10 cm, and a central axis that is parallel to the current-carrying wire and is 50 cm to the left as shown in Figure 2. The other ring, Ring #2, has a radius of 1 mm and is 2 m from the wire with the orientation shown.

   (a) (4 marks) What are the induced currents in the two rings? Indicate the direction of the induced current.

   (b) (6 marks) Assuming the induced currents in both rings are negligible, at what time does the magnetic field at point P (20 cm above Ring #1) have equal components in two orthogonal directions?

   (c) (6 marks) The current in the wire is fixed at 100 mA. An electron is placed at point P moving straight towards the wire with a speed $\vec{v} = 10^7$ m/s. What is the force $\vec{F}$ on the electron at that point? What then is it's acceleration?

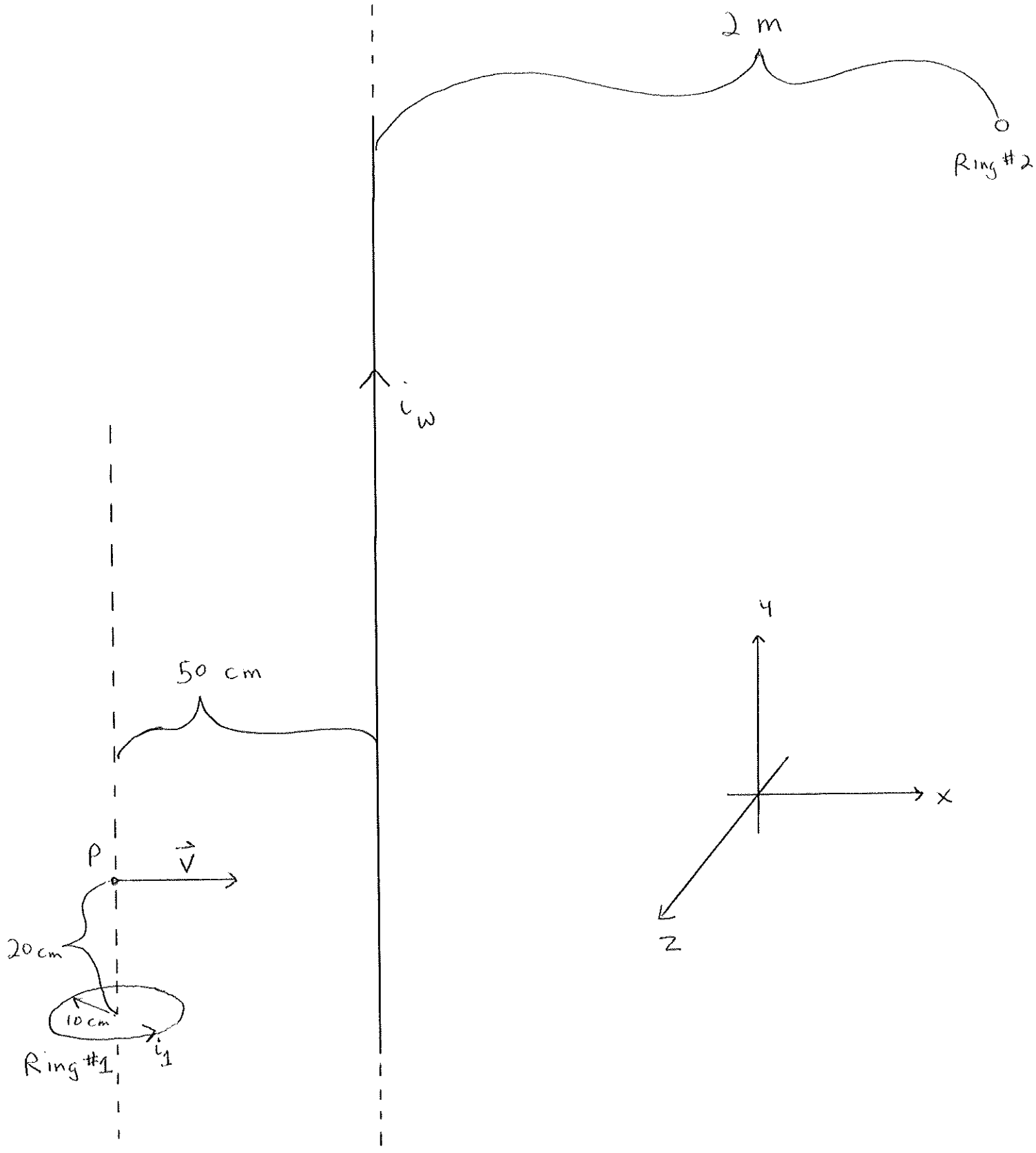

Figure 2 - The rings and wire plus the electron direction for use in part (c)