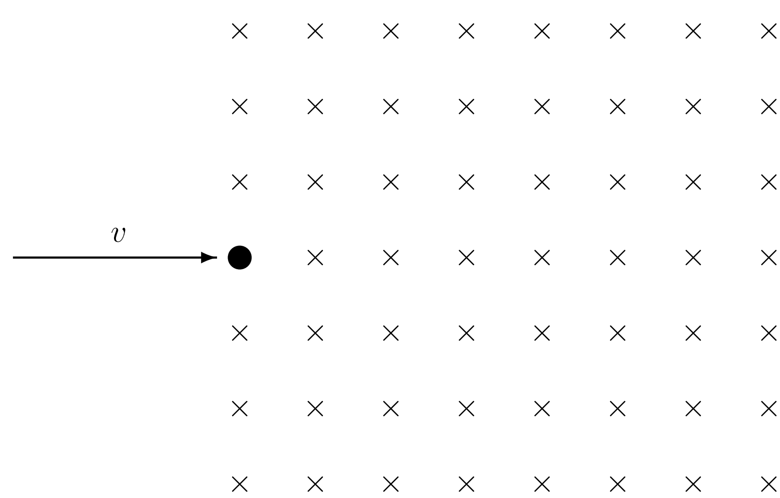
Assignment 6; Phys 186 Name ________________

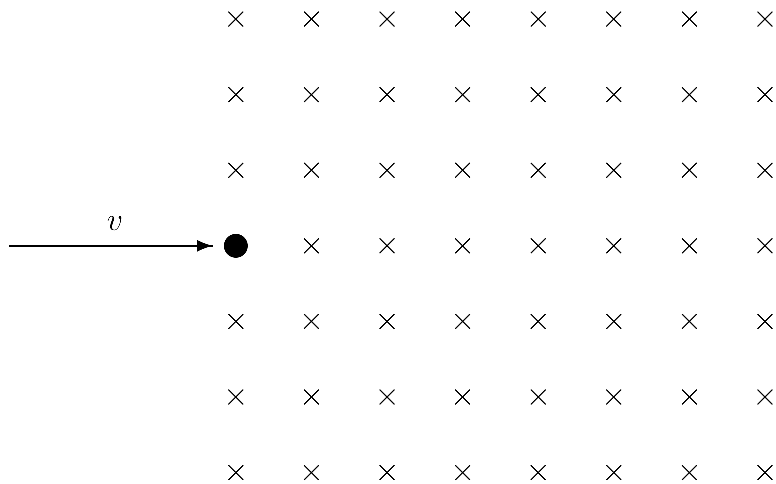
1. (30 points) This question is about charges in electric and magnetic fields.

(a) Magnetic fields act on moving charges. To get electrons moving at high speed, we can accelerate them by using a high voltage. Say an electron with charge $-e$ and mass m starts at rest, and gains kinetic energy by accelerating through a voltage difference of $-V_a$. What is v, its final speed, in terms of e, m, and V_a?

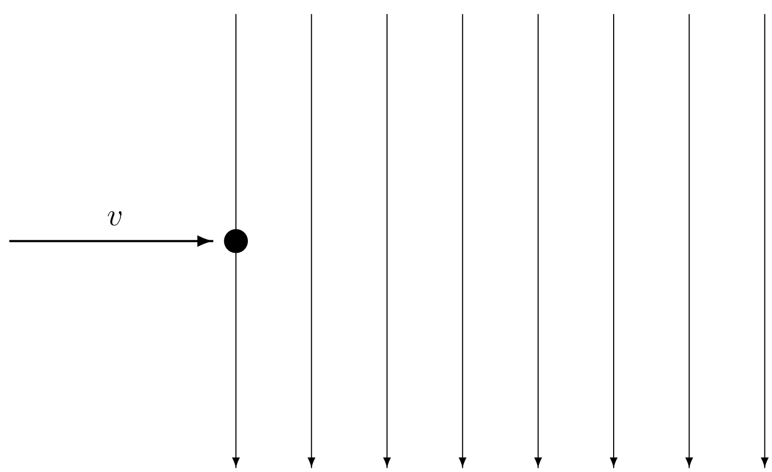
(b) An electron with speed v, moving toward the right, enters a region with a uniform magnetic field with magnitude B. The magnetic field points into the page. What is the magnitude of the magnetic force on the electron, F_B, in terms of B, e, m, and V_a? Draw its direction as the rightward-moving electron just enters the region with the uniform magnetic field into the page.



(c) Draw a diagram showing the *trajectory* of the electron in the same magnetic field. (The black dot is, once again, the electron entering the magnetic field.)



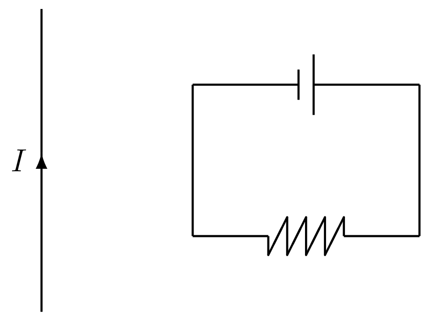
(d) Now say that the electron, instead of emerging into a magnetic field, enters a region with a uniform electric field. The electron with speed v, moving toward the right, comes in between the plates of a parallel plate capacitor that produces an electric field with magnitude E. The field points downward on your page. Draw a diagram showing the trajectory of the electron in the uniform electric field.



(e) The capacitor has a voltage difference of V_c across its plates, which are separated by a distance d. What is E, the magnitude of the electric field in this capacitor, in terms of V_c and d?

(f) Now say that the electron with speed v emerges into an region where *both* a uniform magnetic field and a uniform electric field exists in the ways described in (b) and (d). If the magnitude B is just right, the electric force and magnetic force will cancel each other out and the electron will not be affected. Find this value of B in terms of V_c, V_a, e, m, and d.

2. (30 points) You have a long current-carrying wire, and a circuit next to it:

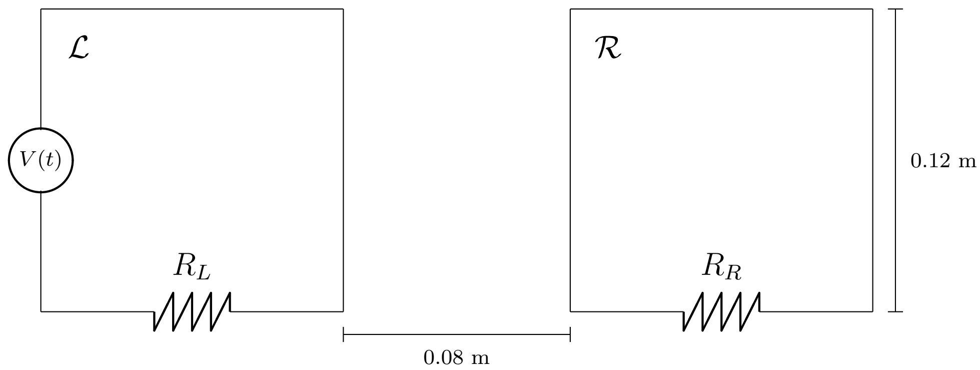


(a) In the picture, draw in the magnetic field produced by the long wire with current I, and indicate the current direction in the circuit.

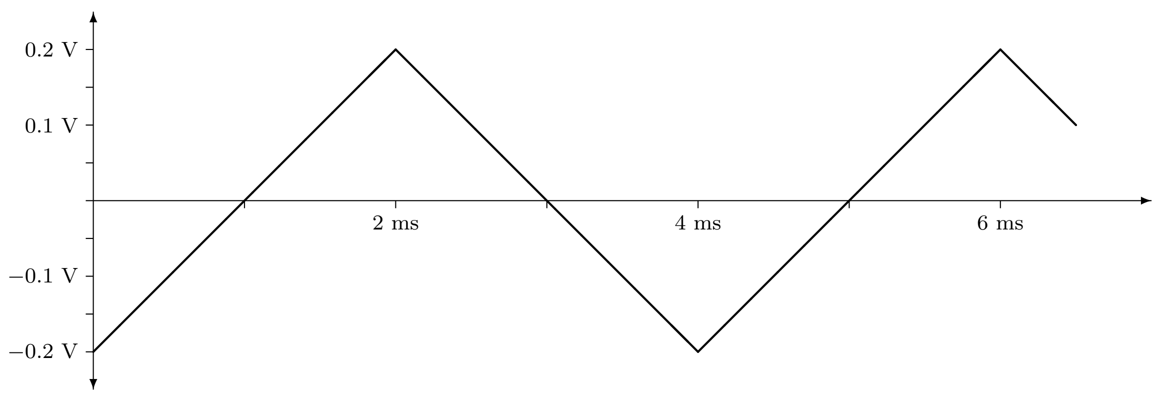
(b) Will the circuit be attracted to the long wire, repelled by it, or will it feel no force? State your reasoning.

(c) If you let the circuit move according to the total magnetic force that might be acting on it, will any extra voltage V_{extra} be induced in the circuit? State your reasoning.

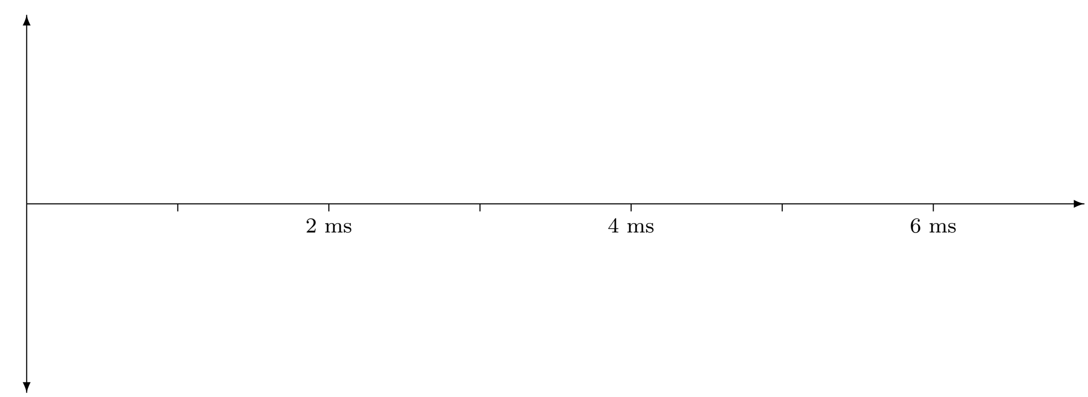
3. (40 points) You have two circuits next to each other:



Each circuit is square with 0.12 m sides, and 0.080 m separates the right edge of the left circuit ($\mathcal{L}$) from the left edge of the right circuit ($\mathcal{R}$). Both have the same resistance values $R_L = R_R = 0.50\ \Omega$, and $\mathcal{L}$ has a voltage source which produces a sawtooth waveform $V(t)$, which looks like the following on an oscilloscope:



(a) Sketch the shape of the waveform you will see if you measure the voltage across R_R with an oscilloscope. Don't put in any voltage numbers—just sketch the waveform.



(b) Now let's make some approximations to estimate the amplitude of the voltage waveform induced in $\mathcal{R}$. There are four wire segments in $\mathcal{L}$: the left, top, right, and bottom on the diagram. The current in each wire produces a magnetic field through $\mathcal{R}$. Only one of the following makes the largest contribution to the magnetic flux through $\mathcal{R}$—we will just take that and ignore the rest. Circle your answer:

The right wire The top and bottom wires The left wire

Brief explanation:

The magnetic field produced by the wire segment you picked will not be uniform through $\mathcal{R}$. But we are looking for a rough estimate, so we will assume that is is uniform. The magnitude of B at what part of $\mathcal{R}$ will be a representative value to use in this uniform approximation?

The right edge The center The left edge

Brief explanation:

Now we need an equation that will help us get the magnetic flux:

$$\text{Loop: } B = \frac{\mu_0 I}{2r} \qquad \text{Long wire: } B = \frac{\mu_0 I}{2\pi r} \qquad \text{Wire: } F = ILB$$

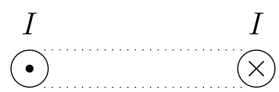
Brief explanation:

Finally, use all this and estimate the *amplitude* of the waveform sketched in part (a).

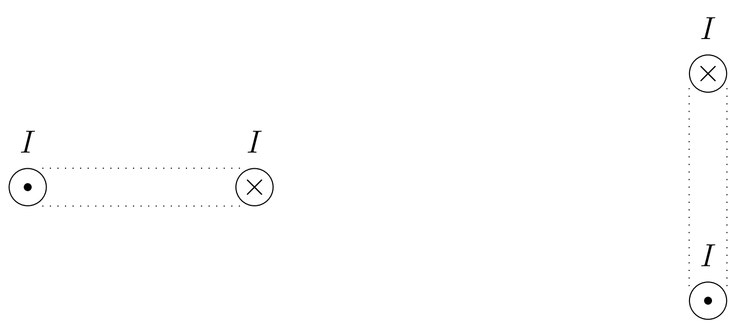
Extra Problems (not graded)

4. (0 points) You have a circular ring which has a constant current I circulating around. This creates a magnetic field.

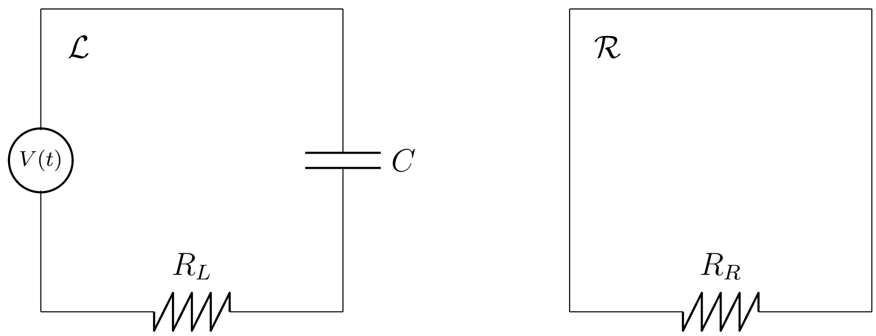
(a) Draw the magnetic field lines for such a ring from a side view. The ring is perpendicular to the page, and the picture shows a section of the ring through its middle. The current direction is indicated by the cross and dot.



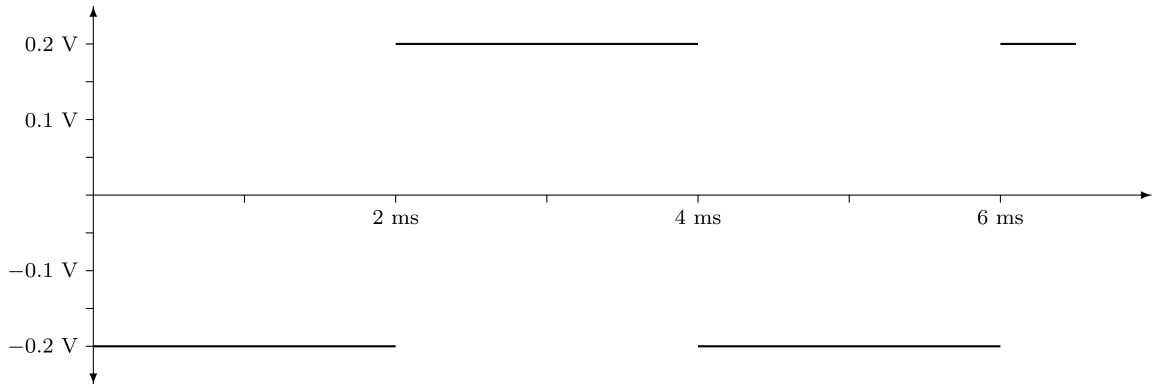
(b) You now put a second, identical current loop further to the right, with a perpendicular orientation. On each end of the second loop (the cross end and the dot end), draw arrows indicating (i) the magnetic field from the first loop, (ii) the magnetic force that end of the loop will feel. If the second loop is free to move, what do you think will happen to it?



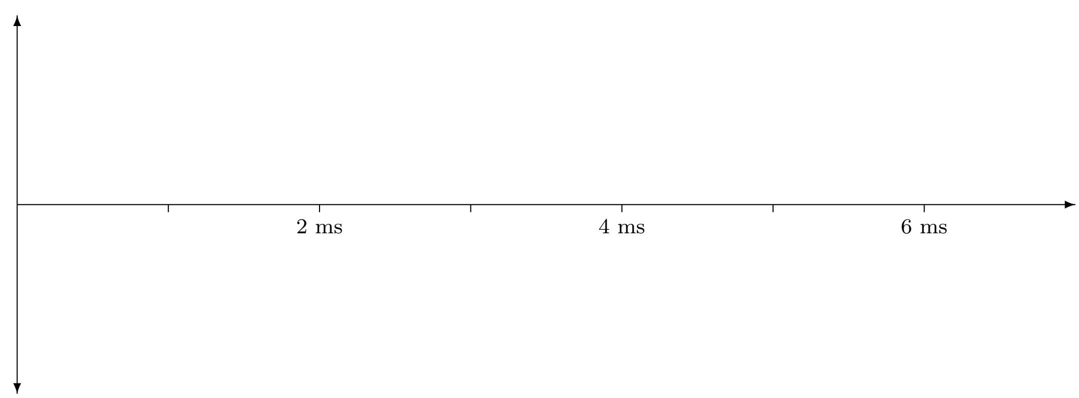
5. (0 points) You have two circuits next to each other:



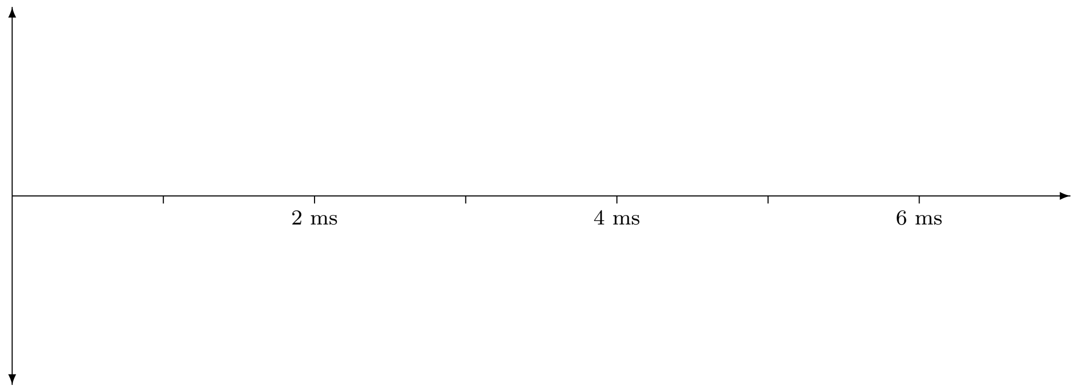
Circuit $\mathcal{L}$ has a voltage source which is a function generator that produces a square waveform $V(t)$, which looks like the following on an oscilloscope:



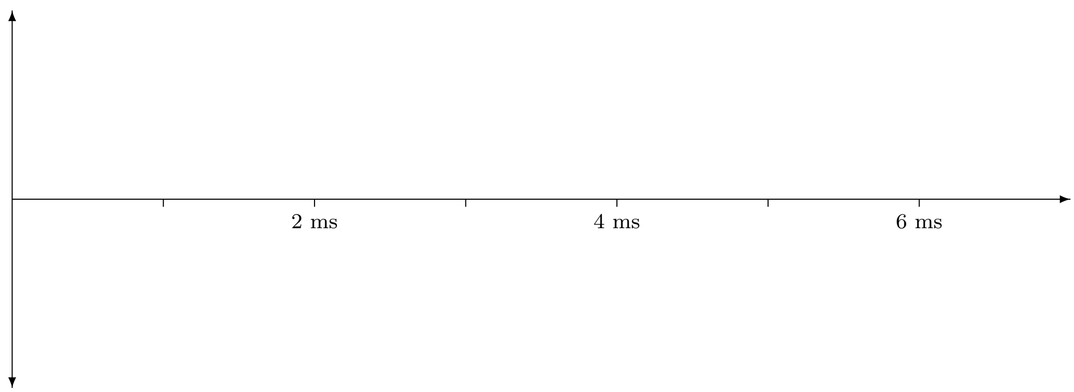
(a) You have the frequency of the function generator set such that the amplitude of the voltage across the capacitor is about 0.18 V (90% of the amplitude of the source voltage). Sketch the shape of the waveform you will see if you measure *the current* in circuit $\mathcal{L}$. Don't put in any numbers—just sketch the waveform. Explain how you arrived at your conclusion.



(b) Now sketch the shape of the waveform you will see if you measure the current in circuit $\mathcal{R}$ under these conditions. Explain how you arrived at your conclusion.



(c) You have the frequency of the function generator set such that the amplitude of the voltage across the capacitor is about 0.02 V (10% of the amplitude of the source voltage). Sketch the shape of the waveform you will see if you measure the current in circuit $\mathcal{L}$.



(d) Now sketch the shape of the waveform you will see if you measure the current in circuit $\mathcal{R}$ under these conditions.