# Practice Exam 2 Solutions

Physics 152

Nick Pittman

The capacitance between two spherical shells of radii a, b is

$$C = \frac{4\pi\epsilon_0 ab}{b - a}$$

Consider two spherical shells of radius 4cm, 6cm. Each is loaded with charge +/- 4nC. What is the voltage drop between the two shells?

$$Q = \frac{4\pi\varepsilon_0 ab}{b-a} V$$

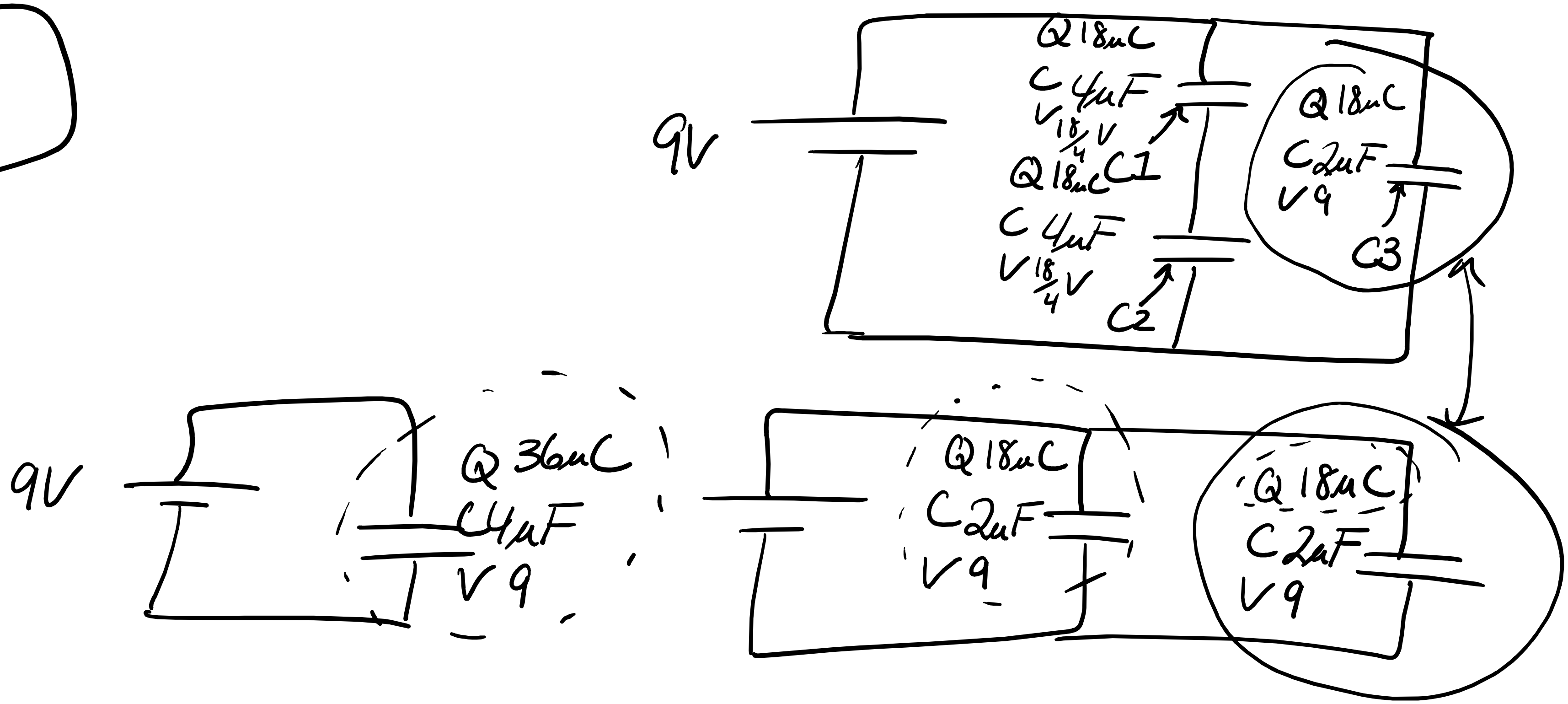
- A)

$$4E\text{-}9 = \frac{4\pi\varepsilon_0 (.04)(.06)}{.06-.04} V$$

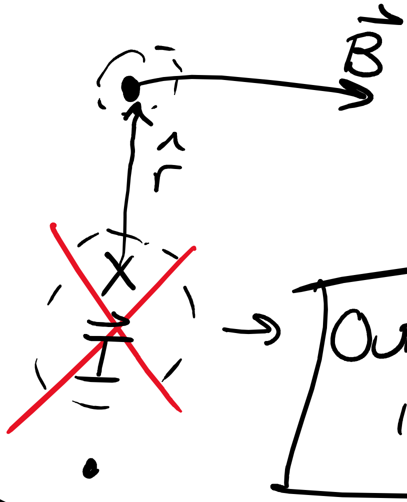
$$4E\text{-}9 = 1.33E\text{-}11\ V \rightarrow \boxed{V = 300V}$$

- Calculate the charge on the plates of capacitor 3 in the given circuit.

$\boxed{18\mu C}$

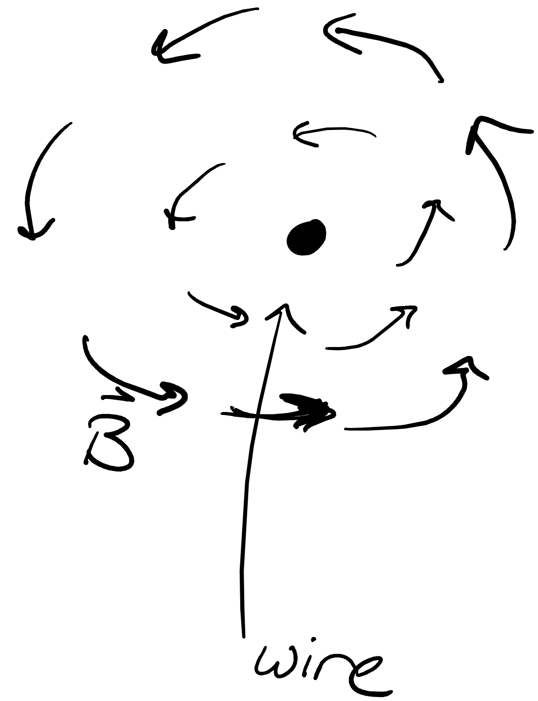


- In the center of the figure there is a long straight wire going into/out of the screen. The magnetic field it creates is also drawn. Find the direction of the current in the wire.




Out of page is correct

$$B \sim I\vec{dl} \times \vec{r}$$



- Inserting a dielectric such as Teflon into a capacitor ________________ the voltage drop and electric field strength between the plates, and ________________ the capacitance. (Assume the capacitor has been disconnected from the battery, so no additional charge flows to the plates after the dielectric has been inserted.)

- ~~A)~~ Increases, Increases
- B) Decreases, Increases
- ~~C)~~ Increases, Decreases
- D) Decreases, Decreases

$C_{new} = C_{air} \cdot K$

- It takes 40J of energy to cause a voltage of 20 mV between the plates of a parallel plate capacitor. If the area of each plate is 4cm^2, what is the distance between the plates?

$$4cm^2 \cdot \left(\frac{1m}{100cm}\right)^2$$

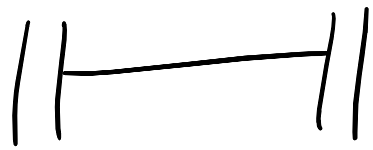
$$4E\text{-}4\ m^2$$

$$W = \frac{1}{2}\frac{A\varepsilon_0}{d}V^2$$

$$40 = \frac{1}{2}\frac{(4E\text{-}4)\varepsilon_0}{d}(20E\text{-}3)^2$$

$$d = \frac{(4E\text{-}4)\varepsilon_0(20E\text{-}3)^2}{80} = \boxed{1.77E\text{-}20 \text{ meters}}$$

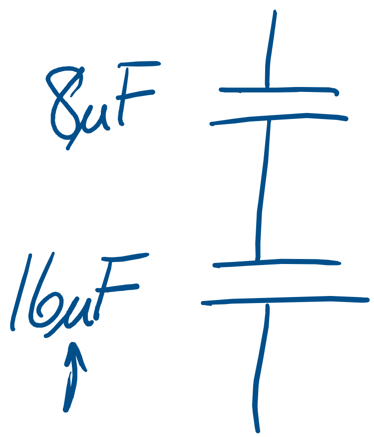
- Find the equivalent capacitance of two 4 microfarad capacitors connected in series.

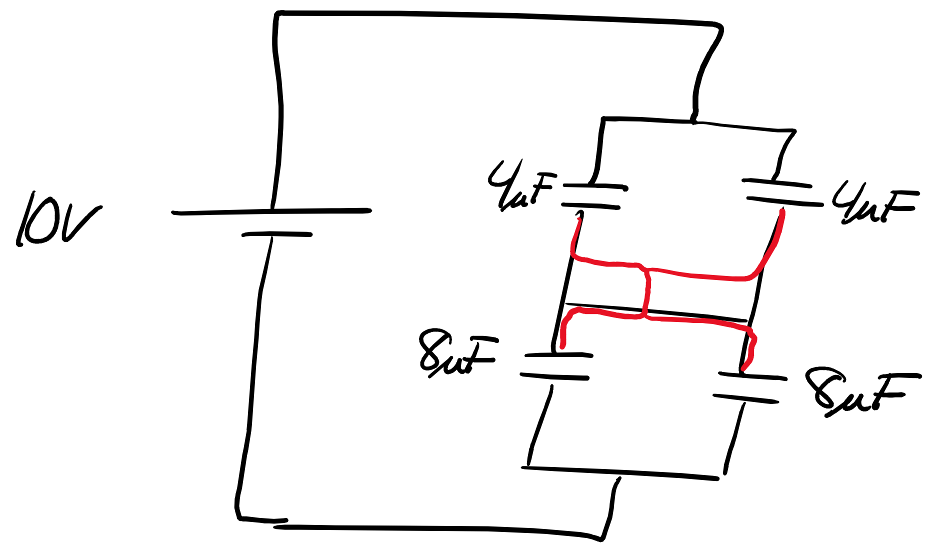


$$\frac{1}{C} = \frac{1}{4\mu F} + \frac{1}{4\mu F} = \frac{1}{2\mu F}$$

$$\boxed{C = 2\mu F}$$

- Find the equivalent capacitance of the circuit shown



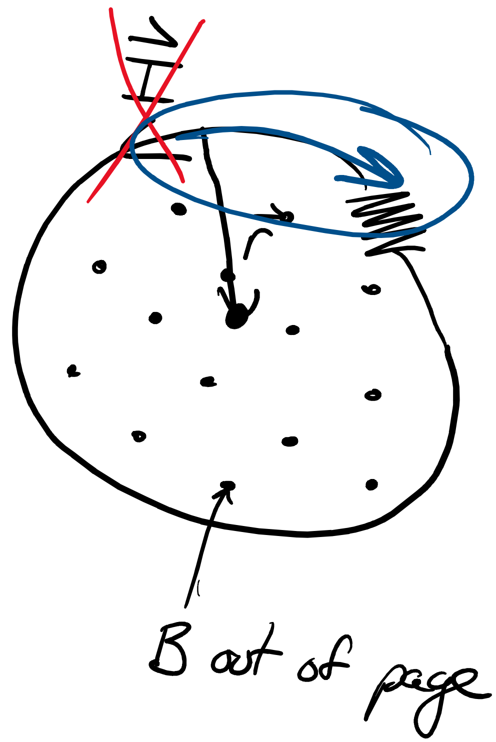

$$\frac{1}{C} = \frac{1}{8} + \frac{1}{16} = \frac{3}{16} \rightarrow \boxed{C = {}^{16}\!/_{3}\,\mu F}$$

- Extra credit: The magnetic field in the figure shown is directed out of the page, and increasing in magnitude. Find the direction of the induced current in the wire loop.

Guess+check $\vec{I}$ direction that produces an into page $\vec{B}$.

$$\vec{B} \sim I\vec{dl} \times \hat{r}$$

$\boxed{I \text{ is clockwise}}$



- Find the size and direction of the current through the top resistor.

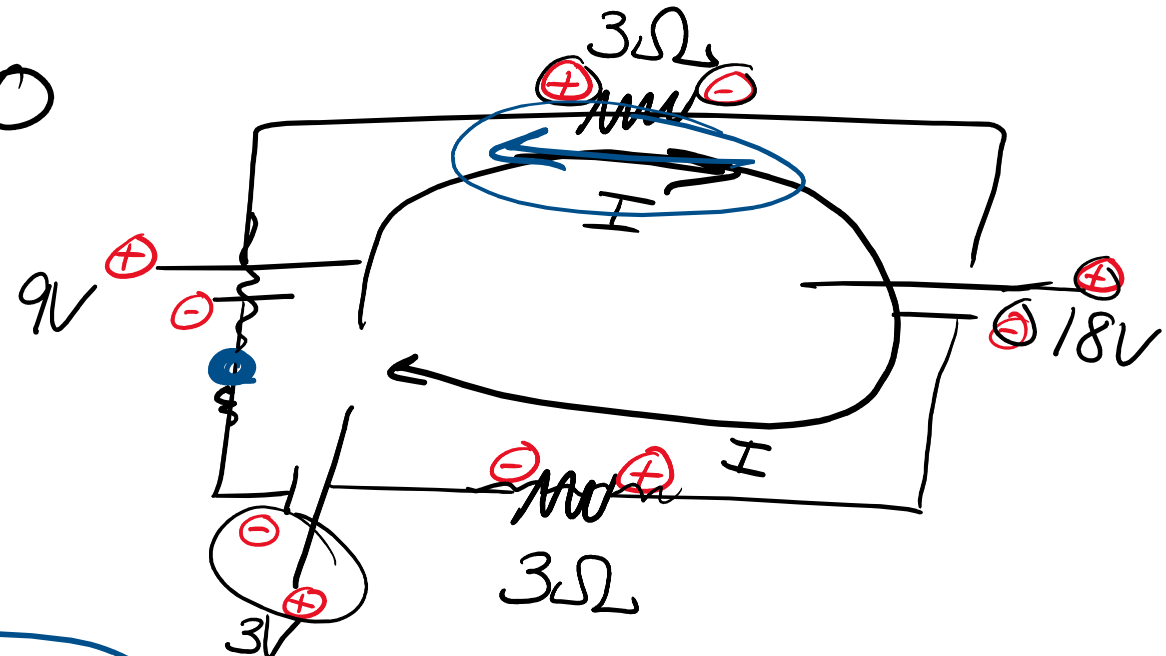
$$+9 - 3I - 18 - 3I - 3 = 0$$

$$-12 - 6I = 0$$

$$-6I = 12$$

$$I = -2$$

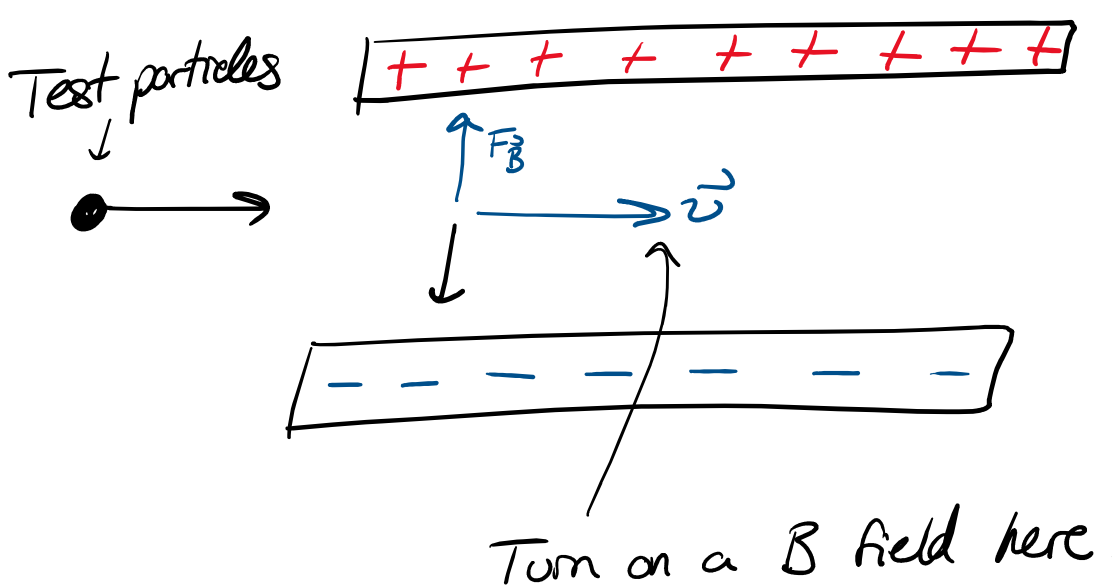
So $I_{top} = 2$ Amps, to left



- What direction magnetic field in the interior region will allow particles to pass through undeflected (provided they have the correct speed)?

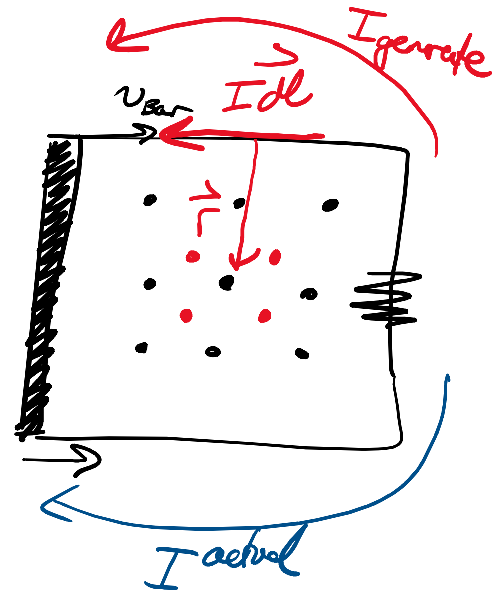
$$F = q\vec{v} \times \vec{B}$$

$\boxed{B \text{ into page}}$



- Extra credit: Moving the metal bar to the right causes the clockwise current shown in the figure to be induced. What direction was the original magnetic field going through the loop?

Into page



- The magnetic field through the center of a 6cm long solenoid is 36 milliTesla. The solenoid is compressed so it is then only 3cm long. What is the new magnetic field?

$$\frac{B = \cancel{\mu_0} \cancel{N} \frac{1}{L} \cancel{I}}{B' = \cancel{\mu_0} \cancel{N} \frac{1}{L'} \cancel{I}}$$

$$\frac{B}{B'} = \frac{\frac{1}{L}}{\frac{1}{L'}} = \frac{L'}{L}$$

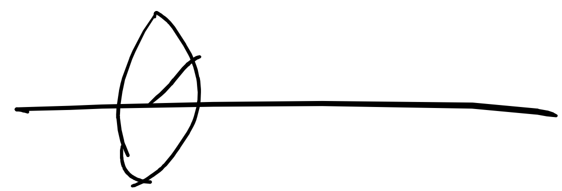
$$\frac{BL}{L'} = B' = \frac{(36E-3)(.06)}{.03}$$

$$\boxed{B' = 72E-3 \text{ Tesla}}$$

- A long straight wire carries a current. The magnetic field 20mm from the wire is 10 microTesla. What is the B field 40mm from the wire?

$$B_{wire} = \frac{\mu_0 I}{2\pi r}$$

$$\boxed{B_{wire} = 5\mu T}$$



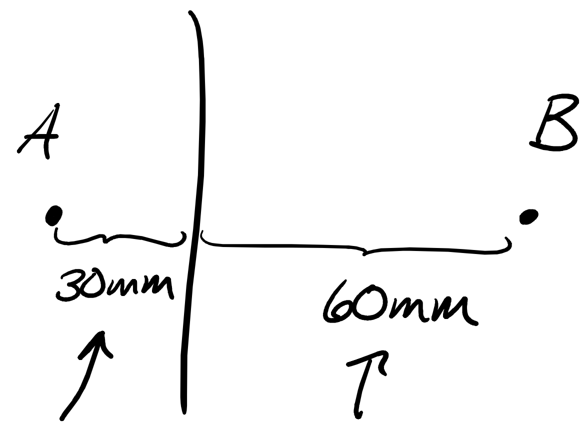
$$B \cdot 2\pi r = \mu_0 I$$

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

$$\frac{B = \frac{\mu_0 I}{2\pi r}}{B' = \frac{\mu_0 I}{2\pi r'}} = \frac{\frac{1}{r}}{\frac{1}{r'}} = \frac{B}{B'} = \frac{r'}{r} \rightarrow B' = B\left(\frac{r}{r'}\right) \quad \frac{1}{2}$$

- The magnetic field strength at point A is of size B_0. What is the magnetic field strength at point B?

$$B_A = B_0 \qquad \boxed{B_B = \frac{B_0}{2}}$$



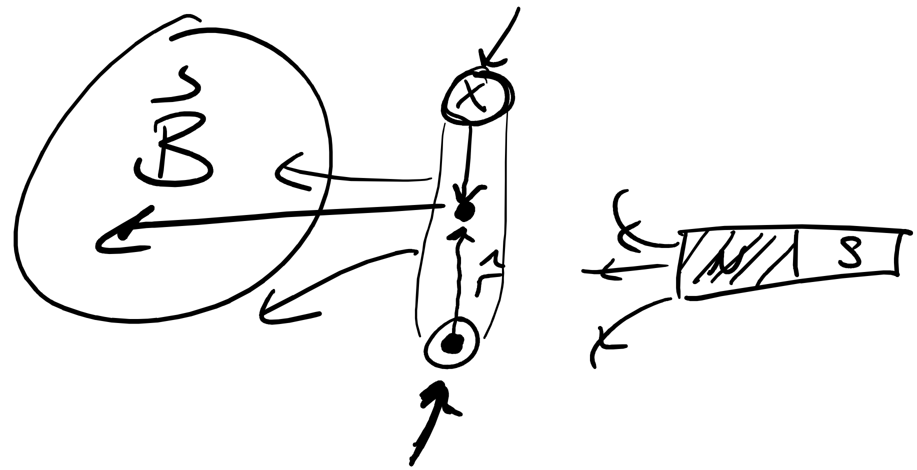

$$\frac{B_A = \dfrac{\mu_0 I}{2\pi r_A}}{B_B = \dfrac{\mu_0 I}{2\pi r_B}}$$

$$\frac{B_A}{B_B} = \frac{r_B}{r_A}$$

$$B_B = \frac{r_A}{r_B} B_A = \frac{B_0}{2}$$

- On which side of the ring shown (a cross section is shown) is the north pole, when trying to treat the ring as an approximate magnetic dipole?

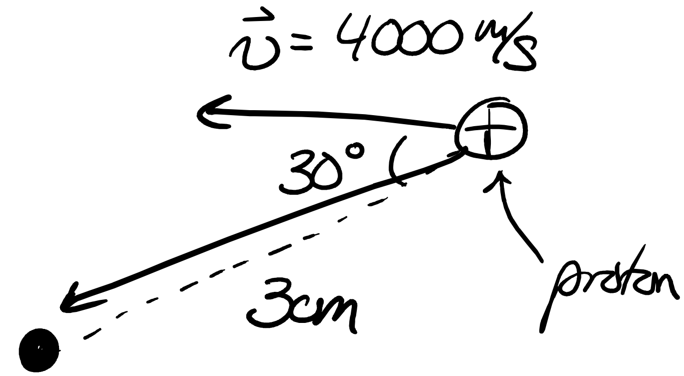
Towards left



- Find the magnetic field created by the moving proton at the black dot, both magnitude and direction.

$$B = \frac{\mu_0}{4\pi}\,\frac{qv\sin\theta}{r^2}$$

$q\vec{v}\times\vec{r}$




$$= \frac{\mu_0}{4\pi}\,\frac{e\cdot 4000\,\sin(30)}{(.03)^2}$$

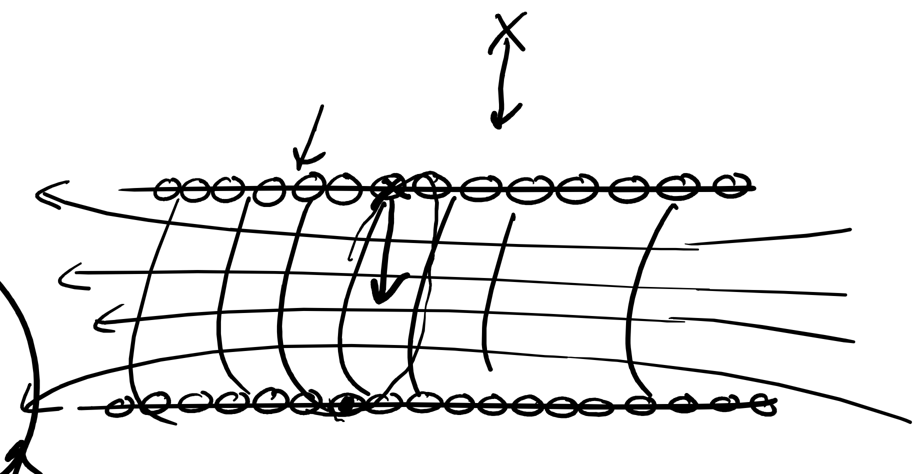
$$= \boxed{3.56E\text{-}20\ T}$$

$\boxed{\text{Out of page}}$

- What direction does current flow in the solenoid to create the shown magnetic field? Cross sections of the little wires are shown.

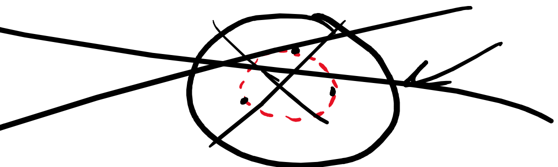
$\vec{B} \sim \overrightarrow{I\,dl} \times \vec{r}$ ✓

Into page on top,
Out of page on bottom

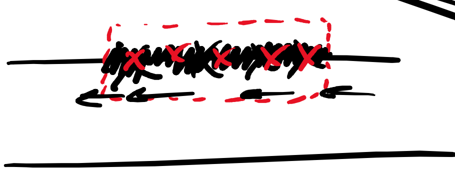


B field

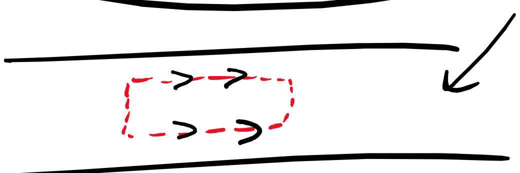
- Which Amperian loop is used in the derivation of the magnetic field inside of an infinite solenoid? (This is a memorization question.) Some solenoids are shown from different angles.
- ~~A)~~



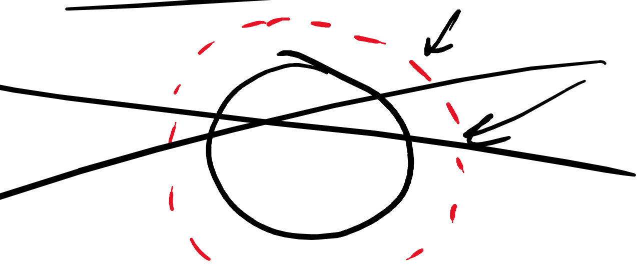
- B)



- C)



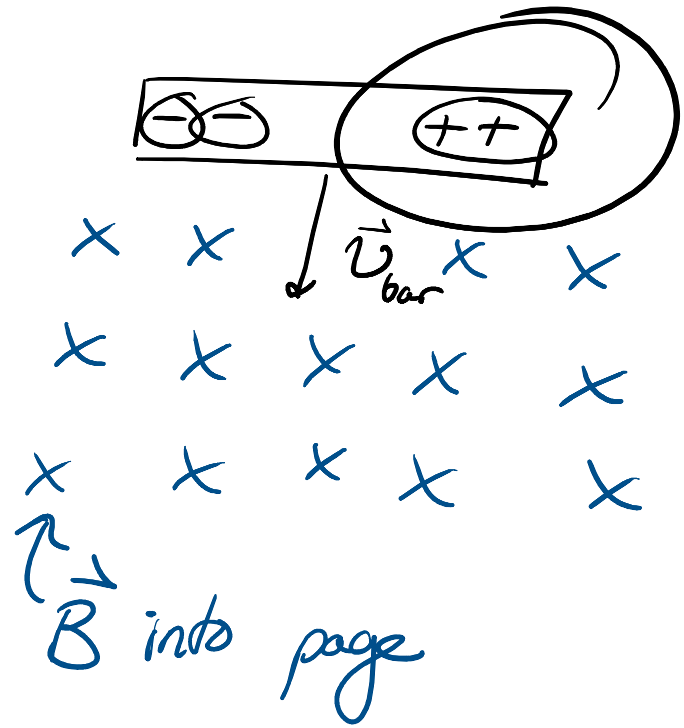
- ~~D)~~



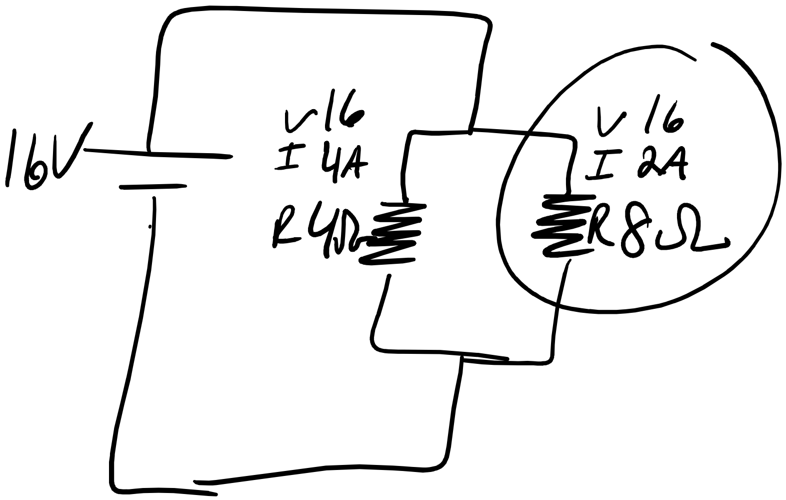
- A metal bar moves through a magnetic field. Which end is at higher voltage due to the flow of charges? (i.e., which end has had positive charges collect on it?)

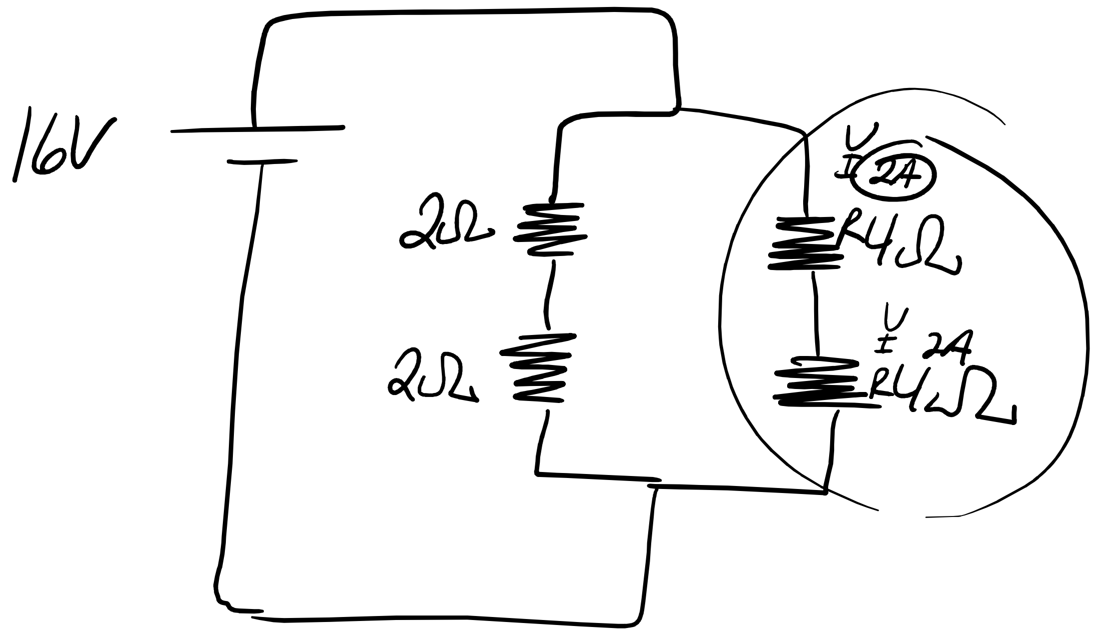
$$\vec{F} = q\vec{v} \times \vec{B}$$

**Right end**



- Find the current flowing through the top 4 Ohm resistor.





2Amps

- Two electrodes of diameter 4cm are placed 2cm apart from each other. They're connected to a 9V battery. How much charge is on each electrode?

$$Q = \frac{A\varepsilon_0}{d} V$$

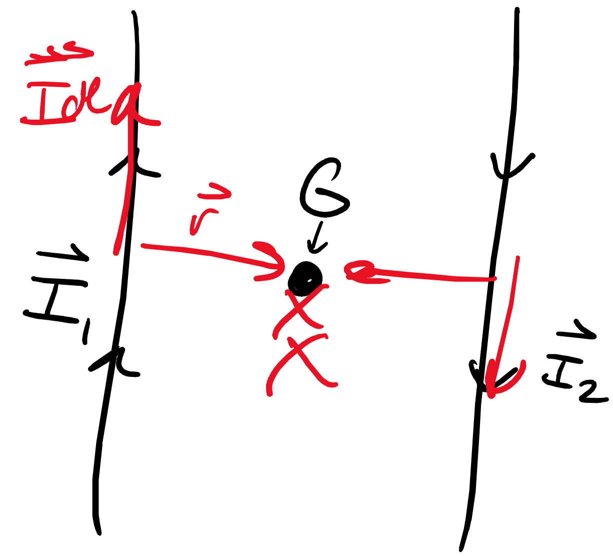
$$= \frac{\pi(.02)^2 \varepsilon_0}{.02} 9$$

$$= \boxed{5E-12 \text{ Coulombs}}$$

- Find the direction of the magnetic field at point G due to the two wires carrying current.

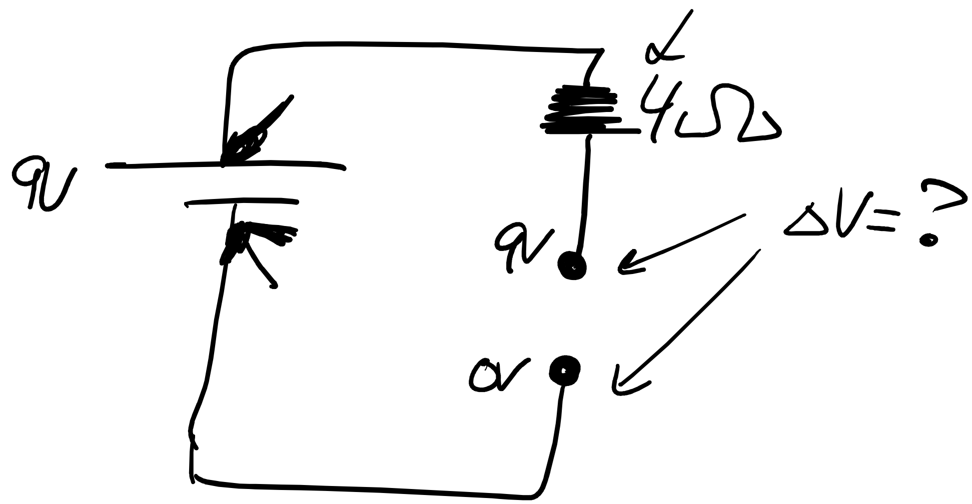
$B \sim \vec{Idl} \times \vec{r}$

Into page



- What is the magnitude of the voltage difference between the two points shown? The wire has a gap in it and hasn't been connected together.

$\boxed{9V}$

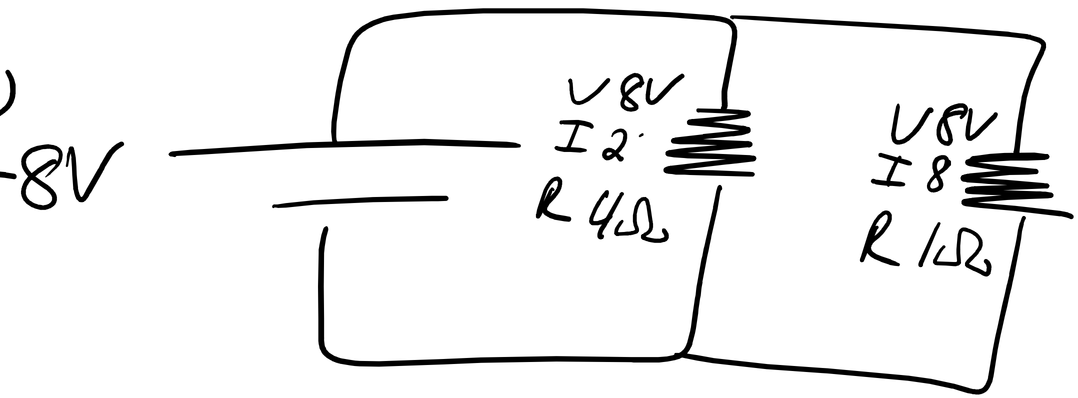


- Which resistor in the following circuit dissipates more power?

$P_L = \frac{V^2}{R}$ $\frac{8^2}{4} = \frac{64}{4} = 16W$

$P_R = \frac{8^2}{1} = 64W$

Right resistor

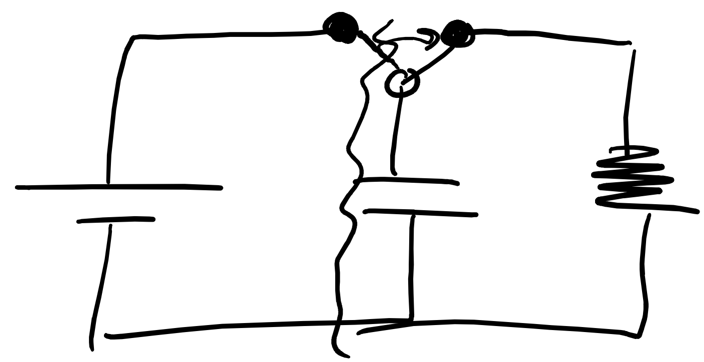


- An RC circuit is composed of a switch separating a 1 microfarad capacitor, a 2 kiloOhm resistor, and a 9V battery. Initially the capacitor is uncharged. Find the current through the circuit .01 seconds after closing the switch.

$$I(t) = \frac{V_0}{R} \cdot e^{-t/RC}$$

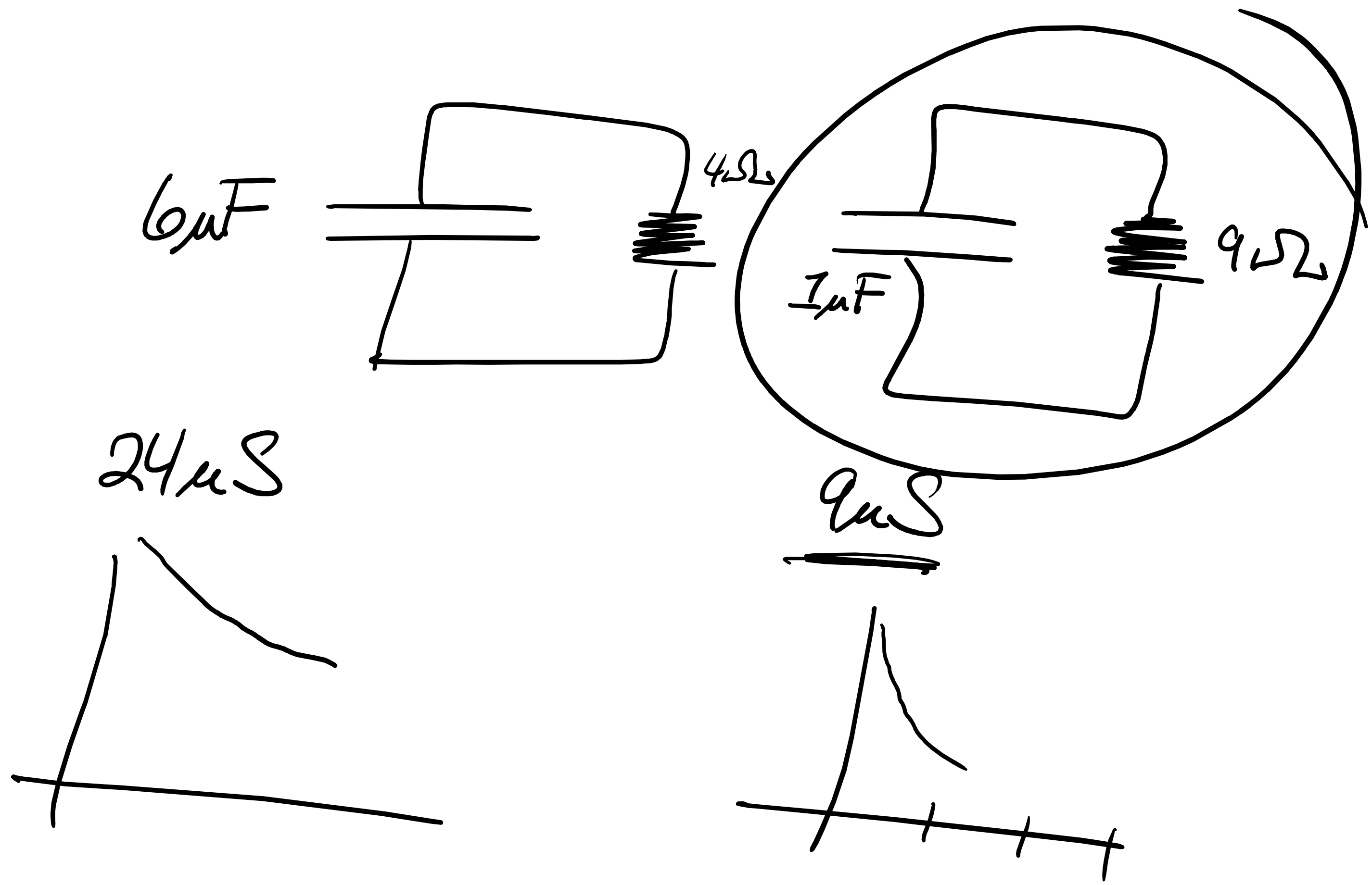
$$= \frac{9}{2000} e^{-.01/(2000 \cdot 1E-6)}$$

$$= \boxed{3E-5 \text{ Amps}}$$



- Which of the following circuits discharges faster? (Determine your answer by comparing the time constants.)

$\tau = RC$



- Consider discharging a capacitor of capacitance 4 microFarads through a 10 kiloOhm resistor. How long does it take for the capacitor voltage to drop to 1/e^2 of its original value? (e is Euler's number, not the electron charge.)

$$\frac{\cancel{V_0}}{e^2} = \cancel{V_0}\, e^{-t/\tau}$$

$$e^{-2} = e^{-t/\tau}$$

$$\frac{V}{V_0} = \frac{1}{e^2}$$

$$2 = \frac{t}{\tau}$$

$$t = 2\tau = 2 \cdot 10000 \cdot 4E{-}6 = \boxed{.08s}$$

- A current of 2A is flowing through a circular-cross-section wire of radius .003 meters. The wire is 10 meters long. If a voltage of 8V is created, compute the wire's resistivity.

$$R = \frac{\rho \cdot L}{A}$$

$$V = IR$$

$$\frac{V}{I}$$

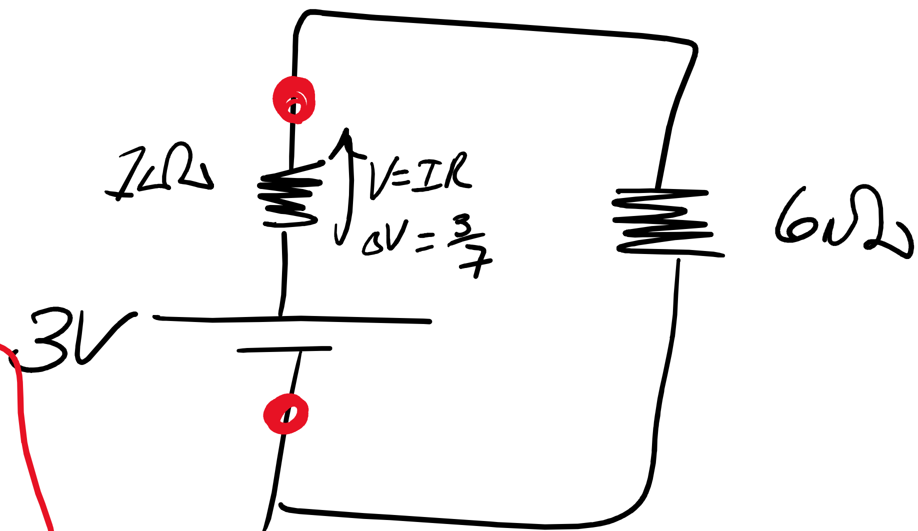
$$\frac{VA}{IL} = \rho$$

Check this

$$\frac{8 \cdot \left(\pi (.003)^2\right)}{2 \cdot 10} = \boxed{1.1E{-5}\ \Omega \cdot m}$$

- NICK’S SECTION ONLY: A 3V battery powers a flashlight bulb (old lights = resistors) of resistance 6 Ohms. The battery has an internal resistance of 1 Ohm. What is the terminal voltage of the battery?

$$I = \frac{3}{7} \text{ Amps}$$




$$3 - 3/7 = \boxed{18/7 \text{ Volts}}$$

- Compute the voltage drop across the 2 Ohm resistor in the circuit shown.