Name_____

Practice Final Exam

1. (20 pts) Briefly describe one way to charge materials that can be charged.

Briefly describe a way to polarize materials that can be polarized.

Briefly describe away to magnetize materials that can be magnetized.

List a variety of materials that can be charged.

List a variety of materials that can be polarized.

List a variety of materials that can be magnetized.

2. (25 pts) A point charge Q_1 is located at *x*=3.0 cm and *y*= 0.0 cm. Another point charge Q_2 is located at *x*=0.0 cm and *y*=-1.0 cm. The net electric field at a position x=3.0 cm and y=-1.0 cm is found to be $\vec{E}_{net} = -3.0\times10^5\ {}^{N}\!/_{C}\,\hat{i} - 9.0\times10^5\ {}^{N}\!/_{C}\,\hat{j}$.

Sketch a picture showing the coordinate axes, charges, and $\vec{E}_{net}$.

What are the values of Q_1 and Q_2?
Please show your work and reasoning.

Ans: Q_1 = -30 nC, Q_2=10 nC

3. *(20 pts)* In a particular region of space, the electric potential, V is given by:
$V(x, y) = 5 + 6\sqrt{x} + 0.7y^3$.

What are the units of each of the constants in this equation? Rewrite the equation with appropriate units.

Find an expression for the electric field, $\vec{E}(x, y)$. (Hint: First find the x and y components of $\vec{E}$.)

What is the force on an electron located at x=5 m and y=2 m?

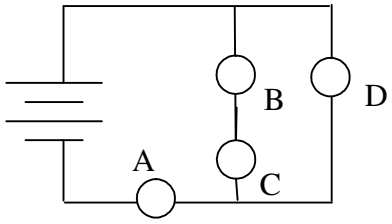
Ans: $\vec{F} = 2.15\times10^{-19}\,N\hat{i} + 1.35\times10^{-18}\,N\hat{j}$

4. (10 pts) A 10 μF parallel-plate capacitor is connected to a 12.0 V battery and has had time to fully charge. A voltmeter is then connected across the capacitor. Draw a picture of the circuit and explain what the voltmeter reads.

The battery is then disconnected without any loss of charge and the plates are pulled apart to twice their original distance. What does the voltmeter read?

Ans: Voltmeter reads 24 volts.

5. (10 pts) Identical bulbs are connected to an ideal battery.
What are the relative brightnesses of the bulbs initially? (e.g., A>B=C>D). Explain.

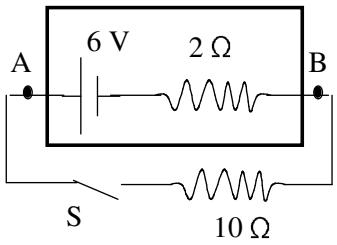


Ans: A>D>B=C

Bulb C is now unscrewed and replaced with a wire. What happens to the brightness of each of the remaining bulbs? Explain.

Ans A>B=D

6. (10 pts) Pictured in the box in the circuit on the right is a bttery with emf 6 V and internal resistance 2 Ω. *A* is the positive terminal of the battery and *B* is the negative terminal.



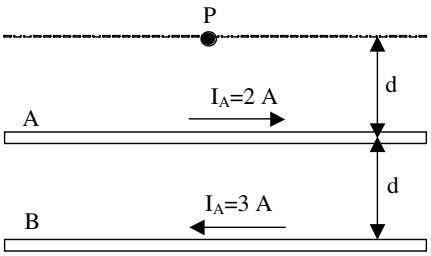
What is the potential difference across the batteries terminals when the switch S is open? Clearly explain or show your reasoning.

Ans: 6 V

What is the potential difference across the batteries terminals when the switch S is closed? Clearly explain or show your reasoning.

Ans: 5 V

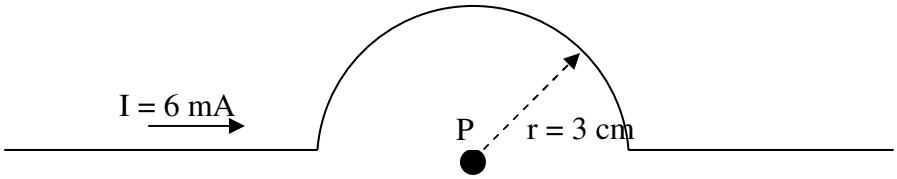
7. (25 pts) Wires A and B are fixed to a frictionless table. Wire A has *2 A* of current to the right and wire B has *3 A* of current to the left. The distance, d, is 0.01 m. What is the magnitude and direction of the magnetic field at point "P"? Clearly show your reasoning.



Wire C is 20 cm long and has 0.5 A of current to the right. It is placed along the dotted line passing through point "P". Does Wire C experience a force? Explain. If so, calculate the force.

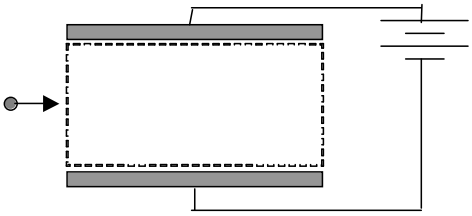
Ans: 10^{-7} N downward toward the other wires.

8. (25 pts) Derive the magnetic field at P using Biot-Savart's Law.



Ans: $6.28X10^{-8}$ T

9. (25 pts) You are in charge of designing a "velocity selector". An electron beam will be shot down the center of a parallel-plate capacitor, as shown. The beam consists of electrons traveling at different speeds, and the plates of the capacitor are 0.001 m apart.



Given that the electric field inside the capacitor is 1.00×10^5 N/C, find the magnetic field required in the dashed region such that electrons coming from the left at speed 1.00×10^6 m/s will pass through the capacitor un-deflected. Clearly show your reasoning.

Ans: 0.1 into the page.

Find the battery (potential) needed for the velocity selector? Clearly show your reasoning.

Ans: voltage is 100 V.

Draw a potential path for an electron traveling at a speed of 0.8×10^7 m/s.

10. *(30 pts)* Just after the switch is closed in the figure, the current begins to increase through the solenoid according too the formula.

$$I(t) = I_0(1 - e^{-t/\tau})$$

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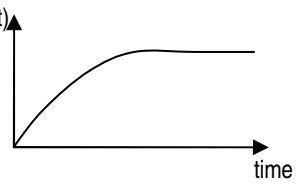
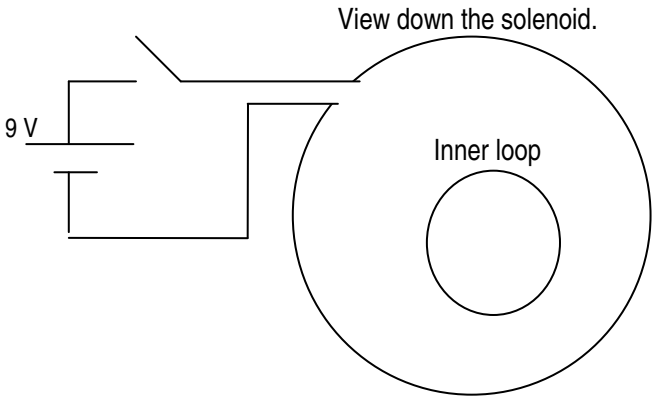


The solenoid has N turns and has a length of L. Write an expression for the magnetic field of the solenoid as a function of time.



A smaller inner loop, radius r_2 and resistance R_2 is placed inside the first loop. What are the directions of the induced magnetic field through and the induced current in the inner loop? Show them on the Figure.

Write an expression for the magnitude of the induced current through the inner loop.

Ans: $I_{loop}(t) = \dfrac{\mu_0 N I_0 \pi r_2^2}{L \tau R_2}(e^{-t/\tau})$

Write an expression for the force on the inner loop.

Ans: $F_{loop}(t) = \dfrac{2\mu_0{}^2 N^2 I_0{}^2 \pi^2 r_2^3}{L^2 \tau R_2}(e^{-t/\tau})(1 - e^{-t/\tau})$ inward. (Fnet = 0).

Is there a force on the solenoid? Explain.