AP Physics C

Unit 2&3 Test: Electric Potential, Conductor & Capacitance

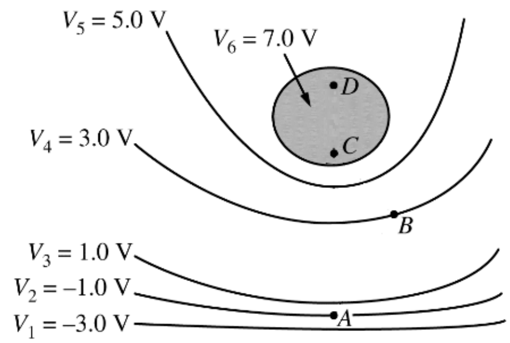
Directions: You know the thing. This is a physics test. You're graded for your justification for the final answer, not just for the final answer. You're going to lose credit if you don't justify your answer. It's absolutely incredible that this has to go in the directions, you have to actually get the problem correct to receive full credit. Here some constants you will need to use: $\varepsilon_0 = 8.85x10^{-12},\ k = 9x10^9$

1. The electric potential along an x-axis is given by the expression, $V(x) = 9x - 3x^3$. At point(s) along the line does the electric field switch direction? **(6 pts)**

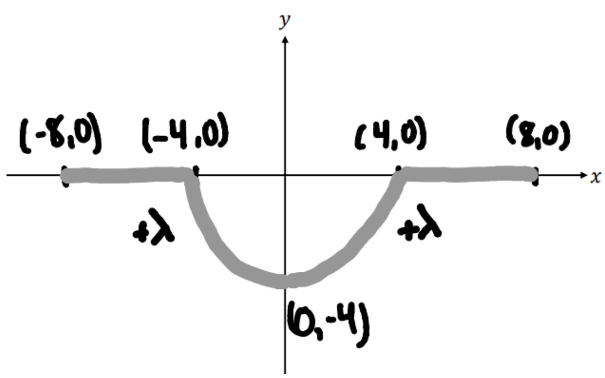
2. Equipotential lines due to an electric field in a certain region of space are illustrated in the figure below. Points A and B are located on lines V_2 and V_4, respecively, and points C and D are located within the equipotential region V_6. **(8 pts)**

a) Specify where it would take positive or negative work to move a positive charge from D to A. Justify your answer.

b) How much power would be required by an external force to move a 8.0 μC charge from rest to at point D to rest at point A via the path DCBA in a span of 3 s?



3. Oh no, who could have done such a thing!? A hoodlum points a linear of charge with charge density $+\lambda$ on the Cartesian plane as shown. The two straight parts are along the x-axis, and the curved section is a perfect semi-circle with a radius of 4. Determine an expression for the amount of work required to bring a test charge of charge +q from infinity to the origin. **(10 pts)**

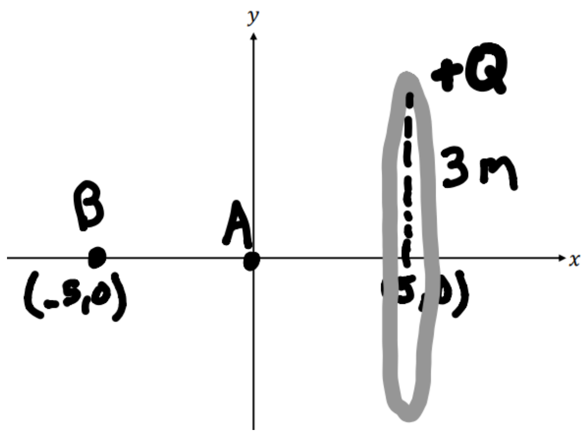


4. A ring of total charge Q = 3 C has a radius of 3 m and lies parallel to the x-axis and concentric with the point (5,). **(15 pts)**

a) Determine the electric potential at the origin due to the charged ring.

b) A charged particle of mass m = 0.1 kg and a charge q = 0.001 C is placed at the origin. Calculate the kinetic energy of the particle when it reaches point B, which is at (-5,0)

c) Set-up (including bounds), an integral that could be evaluated to calculate the electric field due to the ring at point B. You do not need to evaluate the integral.



*For 5 and 6, only brief justifications are need. Don't spend time writing paragraphs

5. A capacitor is fully charged, and disconnected from its power source. The capacitor has capacitance C, an electric field of E, stores a charge Q, and potential energy U. While it is disconnected from the power supply the distance between the plates is suddenly doubled. **(10 pts)**

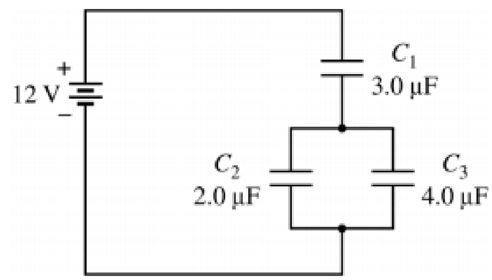
a) What is the new value of Q after the plates are moved apart?
b) What is the new value of E after the plates are removed?
c) What is the new value of U after the plates are moved apart?

6. Another capacitor is fully charged, as is tradition. This one has a plastic dielectric because dielectrics are part of the AP Physics C curriculum. While the capacitor is still connected to the battery, the dielectric is carefully removed due to SMART board related budget cuts. **(10 pts)**

a) What happens to the charge stored in the capacitor after the dielectric is removed?
b) What happens to the electric field between the capacitor plates after the dielectric is removed?
c) What happens to the energy stored in the capacitor after the dielectric is removed?

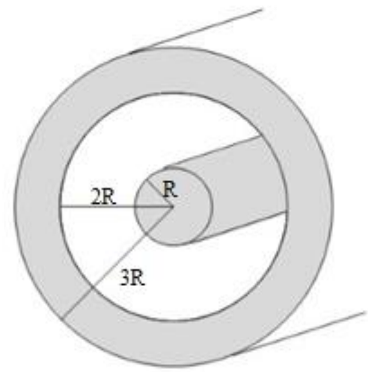
7. There's a circuit. Wow. (6 pts)

a) Which capacitor stores the most charge?
b) What is the equivalent capacitance?

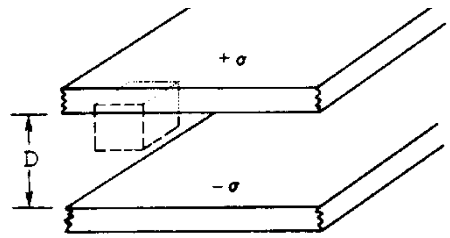


8. Consider a cylinder capactior of length $\boldsymbol{L = 0.2\ m}$ and linear charge density $\boldsymbol{\lambda = 1\ mC/m}$ (bruh, those m's don't cancel). The capacitor has a solid cylinder conductor inside with positive charge and radius R. The outer cylindrical shell has inner radius 2R, out radius 3R, and negative charge. **R = 0.05** m for this question. **(18 pts)**

a) Calculate the charge density on the inner surface of the outside cylinder.
b) Use Gauss's law to derive an expression for the electric field as a function of distance r form the center for $R < r < 2R$.
c) Calculate the potential difference between the plates of the capacitor.
d) Calculate the capacitance of the cylinder.



9. A parallel-plate capacitor consists of two conducting plates separated by a distance $D = .0005\ m$ as shown. The two plates have an equal but opposite surface charge per unit area, $\sigma = 5\frac{nC}{m^2}$. The charge on either plate resides entirely on the inner surface facing the opposite plate. Each plate is a square of side length $0.03\ m^2$. **(17 pts)**



a) By applying Gauss's law to the rectangular box whose upper surface lies entirely within the top conducting plate, as shown in the following diagram, calculate the magnitude of the electric field E between the plates.
b) Calculate the energy stored between the plates.
c) A dielectric of dielectric constant $\kappa = 3.0$ is now carefully inserted in between the plates. Note that the dielectric not connected to the battery.

i. Does the energy stored in the electric field between the plates increase, decrease, or remain the same? Justify your answer.
ii. Calculate the induced charge density on the dielectric.