Last Name: First Name:

Physics 102 Spring 2006: Test 2—Free Response and Instructions

- Print your LAST and FIRST name on the front of your blue book, on this question sheet, the multiple-choice question sheet and the multiple-choice answer sheet.
- TIME ALLOWED 90 MINUTES
- The test consists of two free-response questions and 15 multiple-choice questions.
- The test is graded on a scale of 100 points; the free-response questions are worth a total of 70 points, and the multiple-choice questions account for 30 points (two points each).
- Answer the two free-response questions in your blue book. Answer the multiple-choice questions by marking a dark X in the appropriate column and row in the table on the multiple-choice answer sheet.
- Consult no books or notes of any kind. You may use a hand-held calculator in non-graphing, non-programmed mode.
- Do NOT take test materials outside of the class at any time. Return this question sheet along with your blue book and multiple-choice question sheet.
- Write and sign the Pledge on the front of your blue book.

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Show your work for the free-response problems, including neat and clearly labeled figures, in your blue book.

Answers without explanation (even correct answers) will not be given credit.

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I. (35 pts) The sketch below shows a simple RC circuit. The capacitor is initially uncharged, and at $t = 0$ the switch S is closed. Express your answers in terms of V_0, R_1, R_2, and C.

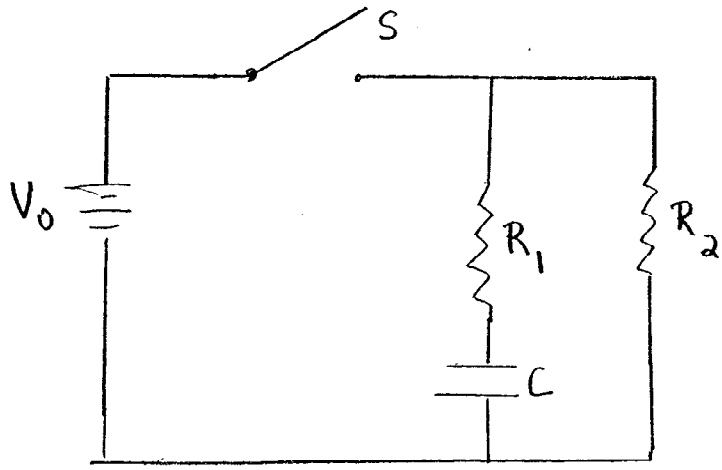
5 (a) Determine the current through each resistor immediately after the switch is closed.

10 (b) Determine the charge on the capacitor $Q(t)$ as a function of time after the switch is closed. What are the initial charge $Q(t = 0)$, the final charge $Q(t \to \infty)$, and the time constant? Sketch $Q(t)$ vs. t.

5 (c) Determine the current through the capacitor $I(t)$ as a function of time after the switch is closed. What are the initial current $I(t = 0)$, the final current $I(t \to \infty)$, and the time constant? Sketch $I(t)$ vs. t.

5 (d) Determine the current through each resistor a long time after the switch is closed.

10 (e) After the switch has been closed for a long time, it is opened again. Determine the current through the capacitor $I(t)$ as a function of time after the switch is opened. What are the initial current $I(t = 0)$, the final current $I(t \to \infty)$, and the time constant in this case? Sketch $I(t)$ vs. t.



II.(25 pts) In the mass spectrometer shown below, singly charged Cl^+ ions are passed through a velocity selector and then enter a region of uniform magnetic field, with the magnetic field pointing out of the page. The goal is to separate the isotopes Cl^{35} and Cl^{37} by at least 2cm in the mass spectrometer after they have traveled a semicircular path as shown. The magnetic field in the mass spectrometer is 1T. Take the mass of the Cl ions to be 35amu and 37amu where 1 amu (atomic mass unit)=1.66 $\times 10^{-27}$kg. The charge of the electron is 1.6 $\times 10^{-19}$C.

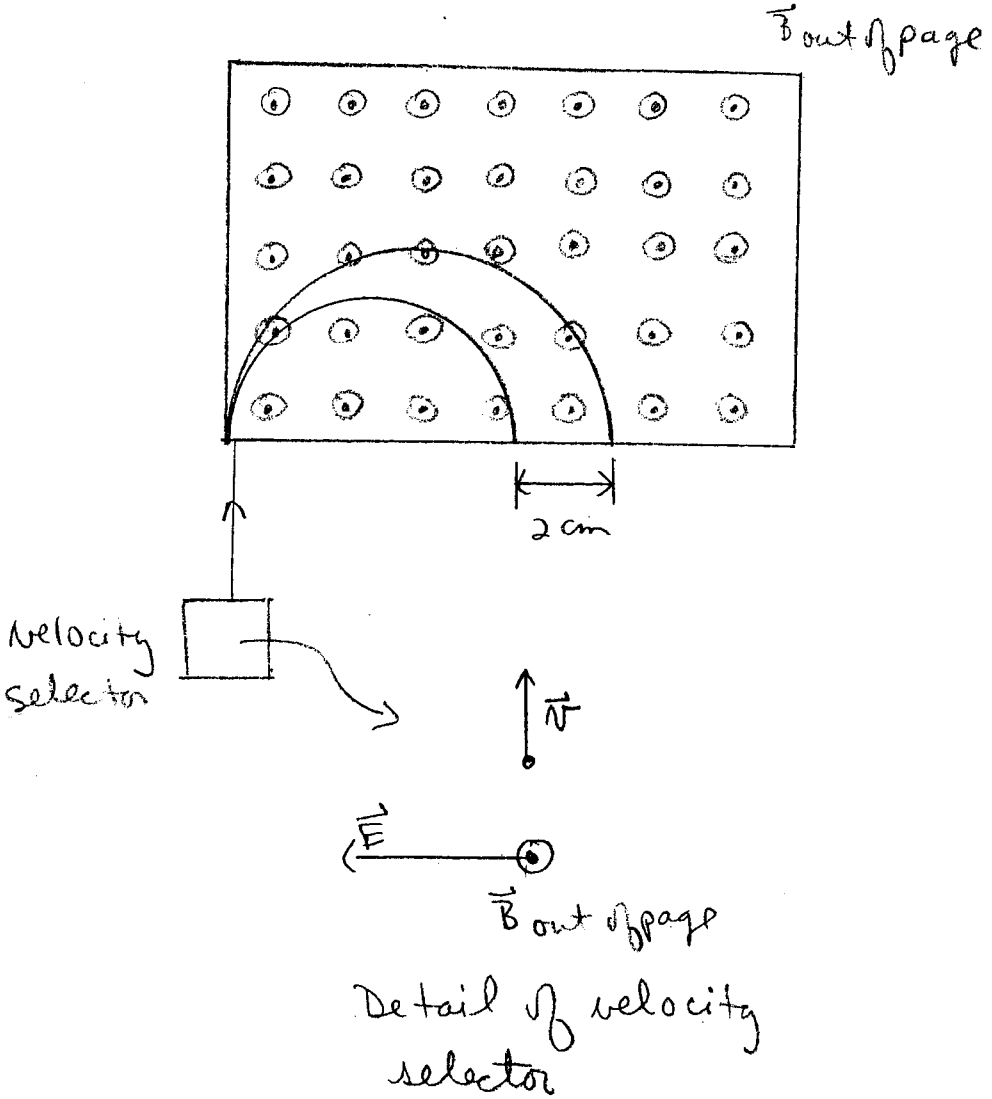
5 (a) Show that the radius of curvature of a particle of charge q, velocity v, and mass m in a uniform magnetic field B is $R = \frac{mv}{qB}$.

7 (b) Determine the velocity that the ions must have as the enter the mass spectrometer so that they land 2cm apart after they have traveled a complete semicircle.

4 (c) At that velocity, what is the radius of curvature of the Cl^{35} ions?

5 (d) The velocity selector consists of perpendicular $\vec{E}$ and $\vec{B}$ fields which are both perpendicular to the direction of the incoming ions. Show that when a charged particle enters such a region of crossed $\vec{E}$ and $\vec{B}$ fields, there is one value of the velocity v_o for which the force on the charged particle is zero.

4 (e) If the magnitude of $\vec{B}$ in the velocity selector is 1T, what magnitude of the electric field $\vec{E}$ will select the velocity you found in (a)?



Last Name: First Name:

Physics 102 Spring 2007: Exam #2 —Multiple-Choice Questions

1. A parallel-plate capacitor is attached to a battery that maintains a constant potential difference V between the plates. While the battery is still connected, a glass slab with dielectric constant $\kappa > 1$ is inserted so as to partially fill the space between the plates. The stored energy

   (A) increases.

   (B) remains the same.

   (C) decrease.

2. Compare the effective capacitance between the points represented by the black dots of the three circuits below. Assume all capacitors have the same capacitance. Rank the effective capacitance of the circuits labeled A, B, and C from highest to lowest.

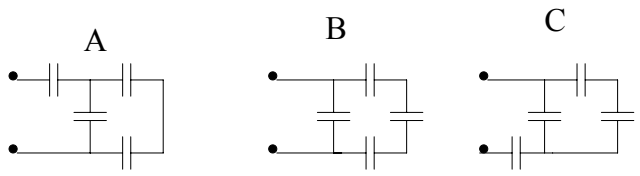
   (A) $A > C > B$.

   (B) $A = C > B$.

   (C) $A > C = B$.

   (D) $B = C > A$.

   (E) $B > C = A$.



3. A fixed resistor of resistance R is in series with a variable resistor and an ideal battery (potential difference V). Originally the fixed and variable resistors have the same resistance. As the resistance of the variable resistor is *decreased*, the power dissipated through the fixed resistor

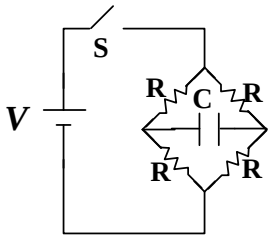
   (A) increases.

   (B) decreases.

   (C) remains the same.

   (D) cannot be determined without more information.

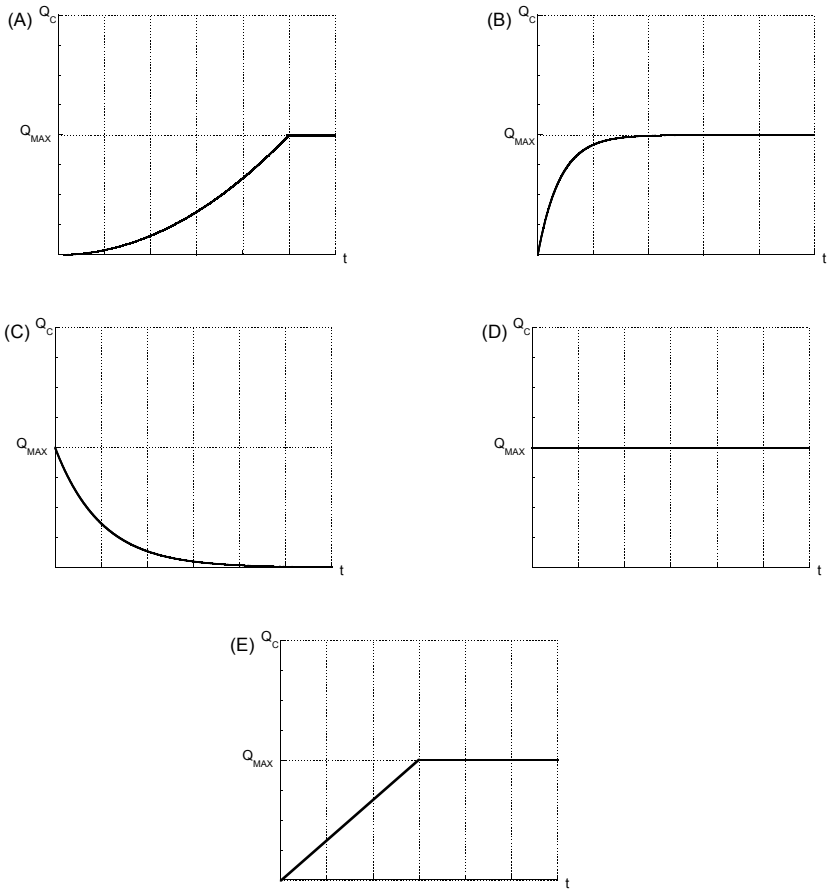
For questions 4 and 5, refer to the circuit below involving a battery V, a switch S, four identical resistors, R, and a capacitor, C. Initially the capacitor is uncharged and the switch is open.



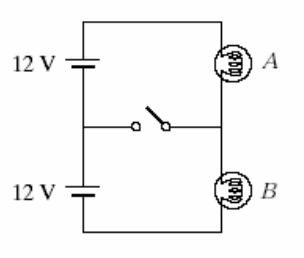
4. What is the current provided by the battery immediately after the switch is closed?

   (A) $I = 4\,V/R$
   (B) $I = 2\,V/R$
   (C) $I = V/R$
   (D) $I = V/2\,R$
   (E) $I = V/4\,R$

5. Which of the graphs most accurately depicts the charge on the capacitor as a function of time?

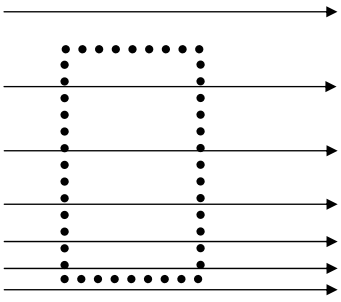


6. The light bulbs in the circuit are identical (i.e., equal resistors) and assumed to be Ohmic. When the switch is closed,



(A) The intensity of light bulb A increases.
(B) The intensity of light bulb A decreases.
(C) The intensity of light bulb B increases.
(D) The intensity of light bulb B decreases.
(E) nothing changes.

7. For the magnetic field and loop (represented by the dots) depicted below and to the right, which (if any) of the following statements is NOT true?

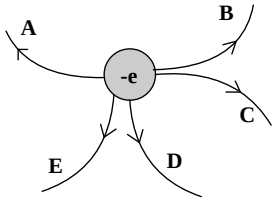


(A) The line integral of the magnetic field around the loop is positive when taken in the counterclockwise direction.
(B) If a current was flowing around the loop, there would be a net force on the loop.
(C) If a current was flowing around the loop, there would be a net torque on the loop.
(D) There must be some current encircled by the loop going out of the page to produce such a magnetic field.
(E) All statements are true.

8. In a recent lab experiment, a student measured the resistivity of Play-Doh to be $\rho = 25\,\Omega\,cm$. She first constructed a cylinder of Play-Doh with a uniform radius r, and length L. If she creates a new cylinder of Play-Doh that has a uniform radius $r/2$ and length $4\,L$, how does the resistance of the new cylinder of Play-Doh (R_1) compare to the resistance of the original cylinder of Play-Doh (R_0).

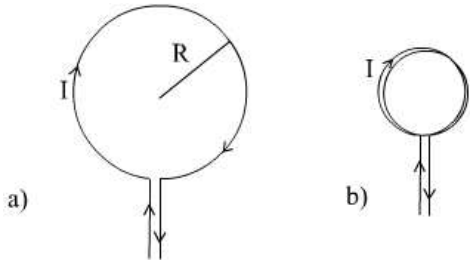
(A) $R_1 = 16R_0$.
(B) $R_1 = 8R_0$.
(C) $R_1 = R_0$.
(D) $R_1 = R_0/8$.
(E) $R_1 = R_0/16$.

9. An electron is released from rest in a region of space where a uniform electric field $\vec{\mathbf{E}}$ exists pointing *up* the page and a uniform magnetic field $\vec{\mathbf{B}}$ is pointing *out* of the page. Which path in the figure below best represents the motion of the electron after if is released?



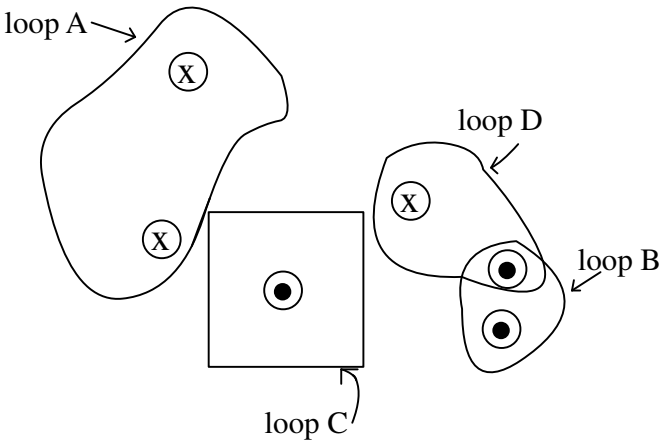
10. A loop of wire of length L carrying a current I can be wound once as in the figure (a) below, or twice as in figure (b). The ratio of the magnitude of the magnetic field B_a at the center of the single loop to the magnitude B_b (B_a/B_b) at the center of the double loop is

(A) 1/4.
(B) 1/2.
(C) 1.
(D) 2.
(E) 4.

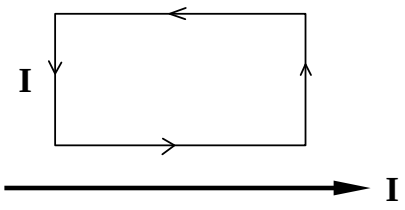


11. Consider four equal currents going into or out of the page as indicated in the figure below. Rank the line integral of the magnetic field $\oint \vec{B} \cdot d\vec{l}$ (from greatest to least) integrated in the clockwise direction.

(A) $A = B > C > D$.
(B) $A > C > B > D$.
(C) $D > B > C > A$.
(D) $A > D > C > B$.
(E) $A > D > B > C$.



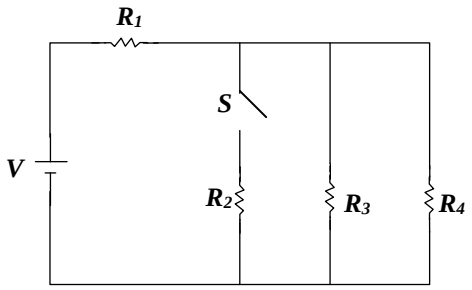
14. A rectangular loop of wire of length l and width w carrying current I is placed near a very long wire carrying current I in the +x direction as shown in the figure below. Which of the following statement(s) is (are) correct?



I. The current loop experiences a net force.
II. The current loop experiences no net force.
III. The magnetic dipole moment of the current loop, $\vec{\mu}$, points into the page.
IV. The magnetic dipole moment of the current loop, $\vec{\mu}$, points out of the page.
V. The current loop experiences no net torque.
VI. The current loop experiences a net torque.

(A) Only II and V are correct.
(B) Only I and VI are correct.
(C) Only I, III and IV are correct.
(D) Only I, IV and V are correct.
(E) Only II IV and VI are correct.

15. The circuit shown below consists of four resistors labeled R_1, R_2, R_3 and R_4, an ideal battery V, and a switch S. What happens to the voltage difference across the resistor labeled R_4, when the switch is closed?



(A) The voltage difference across R_4 decreases after the switch is closed.
(B) The voltage difference across R_4 increases after the switch is closed.
(C) The voltage difference across R_4 stays the same after the switch is closed.
(D) The values of R_1, R_2, R_3 and R_4 are needed in order to answer this question.

Last Name: First Name:

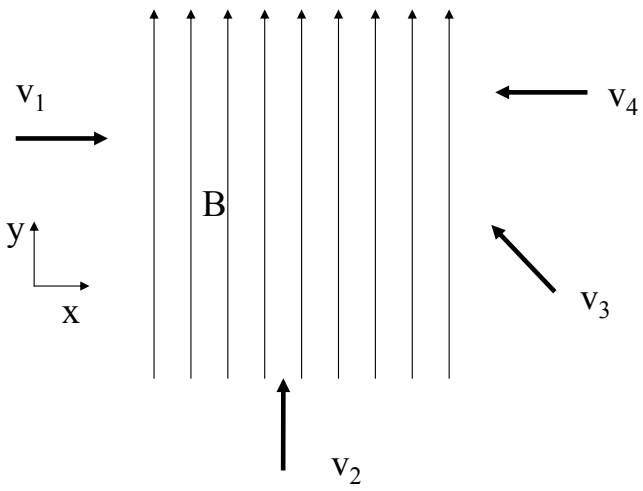
Physics 102 Spring 2006: Exam #2 —Multiple-Choice Questions

1. A charged particle, q, is moving with speed v perpendicular to a uniform magnetic field. A second identical charged particle is moving with speed $2\,v$ perpendicular to the same magnetic field. The time to complete one full circular revolution for the first particle is T_1. The time to complete one full circular revolution for the particle moving with speed $2\,v$ is

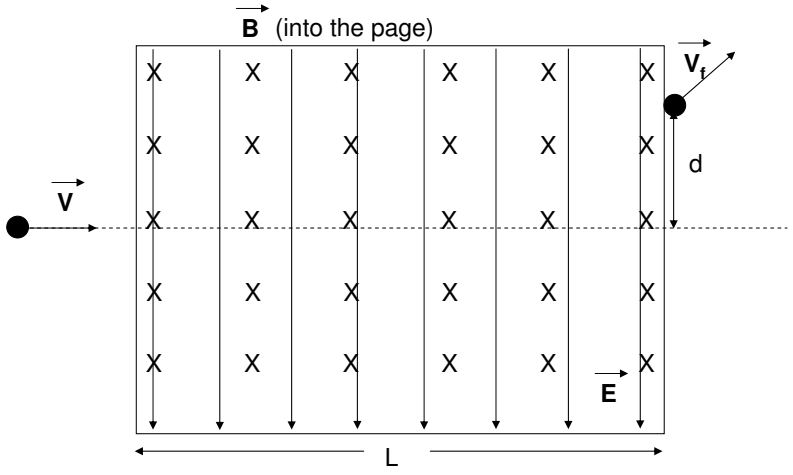
   (a) $\frac{T_1}{4}$.
   (b) $\frac{T_1}{2}$.
   (c) T_1.
   (d) $2\,T_1$.
   (e) $4\,T_1$.

2. Four free-particles with the same ***negative*** charge and the same initial speed are incident on the same region of constant magnetic field pointed in the $+y$-direction (as shown below). Rank the z-component of the force due to the magnetic field on the particles from greatest to least. (The $+z$-direction points out of the page.)

   (a) $F_{z_{v1}} = F_{z_{v2}} = F_{z_{v3}} = F_{z_{v4}}$.
   (b) $F_{z_{v1}} = F_{z_{v4}} > F_{z_{v3}} > F_{z_{v2}}$.
   (c) $F_{z_{v2}} > F_{z_{v3}} > F_{z_{v1}} = F_{z_{v4}}$.
   (d) $F_{z_{v1}} > F_{z_{v2}} > F_{z_{v3}} > F_{z_{v4}}$.
   (e) $F_{z_{v4}} > F_{z_{v3}} > F_{z_{v2}} > F_{z_{v1}}$.



For questions 3, refer to the figure below, depicting a positively charged particle deflected upward a distance d in a region of length L. Uniform magnetic and electric fields are contained in the region specified by the box. The magnetic field is directed perpendicular to the plane of the page and is directed into the page. The electric field is directed down the page.

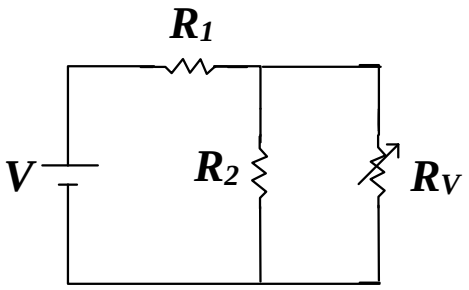


3. Which of the following statement(s) is (are) true?

I. The electric field does positive work.
II. The electric field does no work.
III. The electric field does negative work.
IV. The speed of the particle is such that $v > \frac{E}{B}$.
V. The speed of the particle is such that $v = \frac{E}{B}$.
VI. The speed of the particle is such that $v < \frac{E}{B}$.

(a) only I and IV are true
(b) only III and IV are true
(c) only III and VI are true
(d) only II, III and IV are true
(e) only I, III, and IV are true

4. In the circuit depicted below, R_V is a variable resistor. If the resistance of R_V is increased, what happens to V_1 (the potential difference across R_1) and V_2 (the potential difference across R_2).

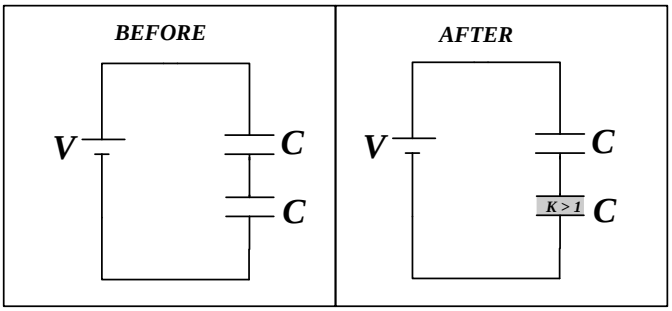


   (a) V_1 decreases and V_2 increases.
   (b) V_1 decreases and V_2 decreases.
   (c) V_1 increases and V_2 increases.
   (d) V_1 increases and V_2 decreases.

5. If the potential difference across a capacitor of capacitance C doubles, the capacitance of the capacitor is

   (a) 4 C.
   (b) 2 C.
   (c) C.
   (d) 1/2 C.
   (e) 1/4 C.

8. Two identical capacitors are connected in series as shown in the figure below. A dielectric slab ($\kappa > 1$) is placed between the plates of one capacitor, and the battery remains connected. Which of the following statement(s) is (are) correct following the insertion of the dielectric?



I. The charge supplied by the battery decreases.

II. The charge supplied by the battery does not change.

III. The capacitance of the system increases.

IV. The capacitance of the system decreases.

V. The electrostatic potential energy decreases.

(a) Only I is correct.

(b) Only II is correct.

(c) Only III is correct.

(d) Only IV is correct.

(e) III, and V are correct.