

Last Name: _____ First Name _____ Network-ID _____

Discussion Section: _____ Discussion TA Name: _____

Turn off your cell phone and put it out of sight.

Keep your calculator on your own desk. Calculators cannot be shared.

This is a closed book exam. You have ninety (90) minutes to complete it.

1. Use a #2 pencil. Do not use a mechanical pencil or pen. Darken each circle completely, but stay within the boundary. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner. Be especially careful that your mark covers the **center** of its circle.
2. **This Exam Booklet is Version A.** Mark the **A** circle in the **TEST FORM** box near the middle of your answer sheet. **DO THIS NOW!**
3. Print your **NETWORK ID** in the designated spaces at the *right* side of the answer sheet, starting in the left most column, then **mark the corresponding circle** below each character. If there is a letter "o" in your NetID, be sure to mark the "o" circle and not the circle for the digit zero. If and only if there is a hyphen "-" in your NetID, mark the hyphen circle at the bottom of the column. When you have finished marking the circles corresponding to your NetID, check particularly that you have not marked two circles in any one of the columns.
4. Print **YOUR LAST NAME** in the designated spaces at the *left* side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL**.
5. Do not write in or mark the circles in any of the other boxes (STUDENT NUMBER, DATE, SECTION, SCORES, SPECIAL CODE).
6. Sign your name (**DO NOT PRINT**) on the **STUDENT SIGNATURE line**.
7. On the **SECTION line**, print your **DISCUSSION SECTION**. You need not fill in the **COURSE** or **INSTRUCTOR** lines.

Before starting work, check to make sure that your test booklet is complete. You should have 18 numbered pages plus three Formula Sheets.

Academic Integrity—Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including dismissal from the University.

Exam Grading Policy—

The exam is worth a total of **146** points, composed of three types of questions.

MC5: *multiple-choice-five-answer questions, each worth 6 points.*

Partial credit will be granted as follows.

- (a) If you mark only one answer and it is the correct answer, you earn **6** points.
- (b) If you mark *two* answers, one of which is the correct answer, you earn **3** points.
- (c) If you mark *three* answers, one of which is the correct answer, you earn **2** points.
- (d) If you mark no answers, or more than *three*, you earn **0** points.

MC3: *multiple-choice-three-answer questions, each worth 3 points.*

No partial credit.

- (a) If you mark only one answer and it is the correct answer, you earn **3** points.
- (b) If you mark a wrong answer or no answers, you earn **0** points.

MC2: *multiple-choice-two-answer questions, each worth 2 points.*

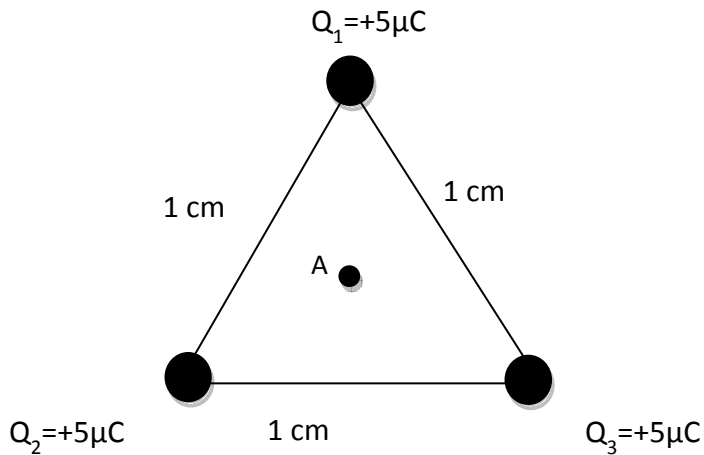
No partial credit.

- (a) If you mark only one answer and it is the correct answer, you earn **2** points.
- (b) If you mark the wrong answer or neither answer, you earn **0** points.

Some helpful information:

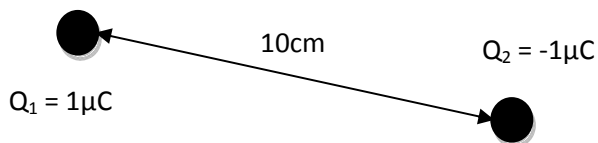
- A reminder about prefixes: p (pico) = 10^{-12} ; n (nano) = 10^{-9} ; μ (micro) = 10^{-6} ; m (milli) = 10^{-3} ; k (kilo) = 10^{+3} ; M or Meg (mega) = 10^{+6} ; G or Gig (giga) = 10^{+9} .

1. Three $+5 \mu\text{C}$ charges sit at the vertices of an equilateral triangle. Each side of the triangle is 1 cm long. What is the magnitude of the electric field at point A, which lies at the center of the triangle?



- $2.5 \times 10^8 \text{ N/C}$
- $5 \times 10^9 \text{ N/C}$
- 0 N/C
- $-5 \times 10^9 \text{ N/C}$
- $-2.5 \times 10^8 \text{ N/C}$

2. Two charges are located 10 cm apart, as shown below.

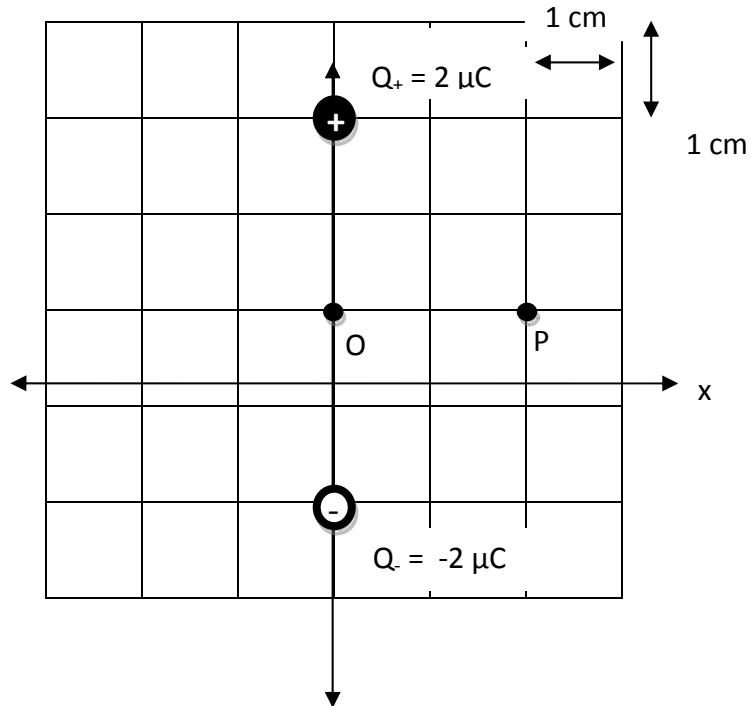


How much work must **you** do to exchange the location of charges Q_1 and Q_2 ? Assume that the charges never touch.

- Depends on the path taken
- -0.9 J
- 0 J
- 0.9 J
- 1.8 J

The next three questions pertain to the following situation:

A $+2 \mu\text{C}$ charge is placed at the coordinates $(x=0 \text{ cm}, y= 2 \text{ cm})$, and a $-2 \mu\text{C}$ charge is placed at the coordinates $(x=0 \text{ cm}, y= -2 \text{ cm})$, as shown below.



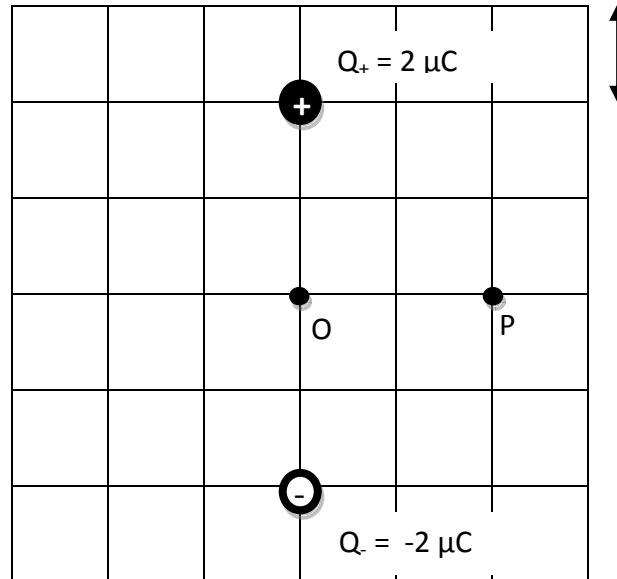
3. Point P is located at the coordinates $(x=2 \text{ cm}, y= 0 \text{ cm})$, as shown. In which direction does the electric field point at P?

- a. $+x$
- b. $-x$
- c. $+y$
- d. $-y$
- e. None of the above

4. What is the magnitude of the electric field at point O, located at the origin?

- a. $4.49 \times 10^7 \text{ N/C}$
- b. $8.99 \times 10^7 \text{ N/C}$
- c. 0 N/C

The next question continues from the previous page:

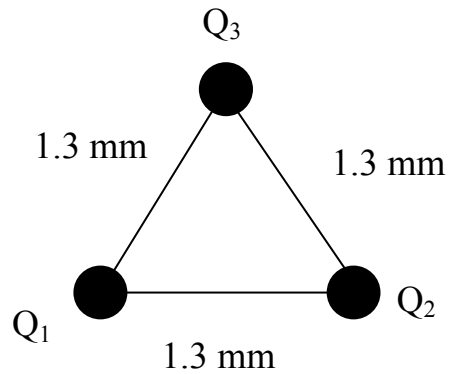


5. How much work would be required by you to move the positive charge Q_+ from its initial position ($x=0 \text{ cm}$, $y=2 \text{ cm}$) to point O ($x=0 \text{ cm}$, $y=0 \text{ cm}$), if the negative charge Q_- was fixed in place?

- a. -0.899 J
- b. -4.49 J
- c. 0 J
- d. 4.49 J
- e. 0.899 J

The next three questions pertain to the following situation:

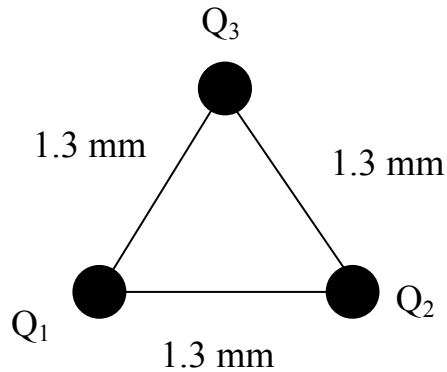
Three charges Q_1 , Q_2 , and Q_3 are fixed to the corners of an equilateral triangle. Each side of the triangle is 1.3 mm long.



6. How much work is required by you to put the charges in this configuration if $Q_1 = Q_2 = Q_3 = +4.2 \mu\text{C}$?

- a. 488 J
- b. 366 J
- c. 244 J
- d. 122 J
- e. 0 J

The next two questions continue from the previous page:



7. How much work is required by you to put the charges in this configuration if $Q_1 = Q_2 = +4.2 \mu\text{C}$ and $Q_3 = -4.2 \mu\text{C}$?

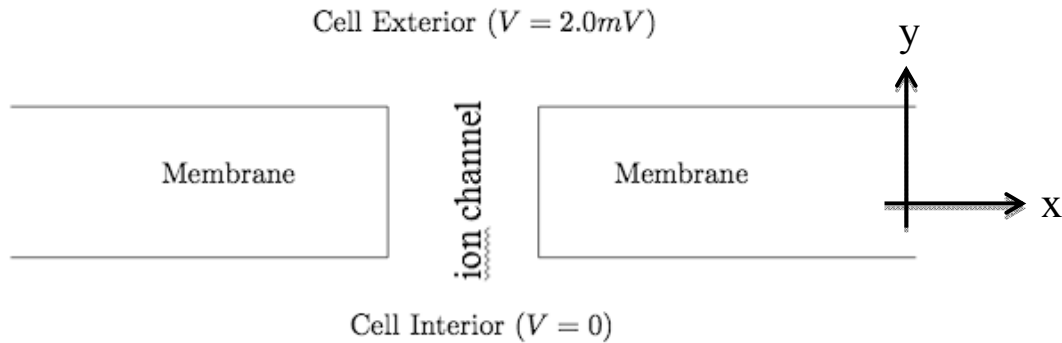
- a. 366 J
- b. 122 J
- c. 0 J
- d. -122 J
- e. -366 J

8. Each charge has mass 1.0 kg, and $Q_1 = Q_2 = Q_3 = +4.2 \mu\text{C}$. Starting with the charges in the configuration shown, Q_2 and Q_3 are held fixed in place, and Q_1 is suddenly allowed to move. With what speed will Q_1 have when it is infinitely far from the other two? Ignore the force of gravity.

- a. 0 m/s
- b. 7.23 m/s
- c. 13.2 m/s
- d. 22.1 m/s
- e. 58.0 m/s

The next two questions pertain to the following situation:

This next problem is meant to develop a very simple model of an ion channel, which is a structure that occurs in biological systems. Here you will explain how ions move through cell membranes via potential differences.



9. Which direction does the electric field point inside the channel?

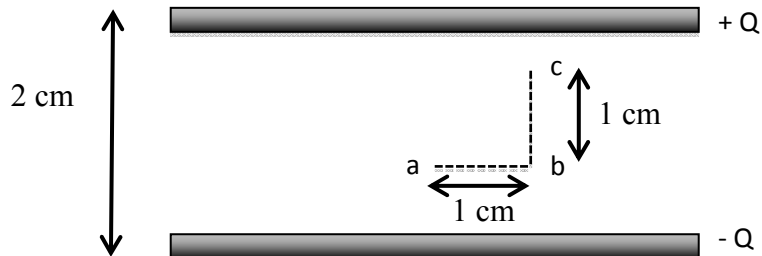
- a. $+x$
- b. $+y$
- c. $-x$
- d. $-y$
- e. There will be no electric field.

10. A potassium ion (K^+) moves from the outside to the inside of the cell. Given that the charge on a potassium ion is $1.60 \times 10^{-19} \text{ C}$ and the mass of the potassium ion is $6.49 \times 10^{-26} \text{ kg}$, find the speed of ion inside the cell if it starts at rest outside the cell. Assume that the electric field in the ion channel is uniform, and that the potential inside and outside the cell is constant.

- a. 1.25 m/s
- b. 10.7 m/s
- c. 99.3 m/s
- d. 348 m/s
- e. 9871 m/s

The next two questions pertain to the following situation:

A parallel plate capacitor is shown below with $C = 10.0 \mu\text{F}$ and $d = 2.0 \text{ cm}$. The capacitor was charged by a 5.0 V battery, and then the battery was disconnected.



11. How much work W_{ab} would you have to do to move a $+1.0 \text{ C}$ charge horizontally by 1 cm from point **a** to point **b**? How much work W_{bc} would you have to do to move a $+1.0 \text{ C}$ charge vertically by 1 cm from point **b** to point **c**?

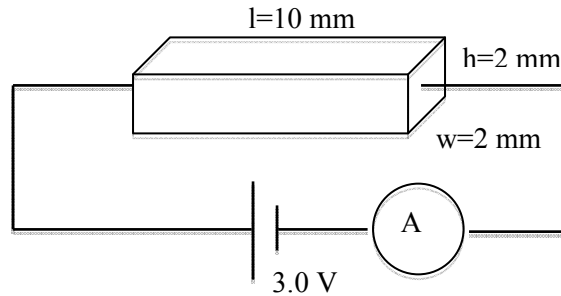
- $W_{ab} = 0 \text{ J}$, $W_{bc} = 2.5 \text{ J}$
- $W_{ab} = -2.5 \text{ J}$, $W_{bc} = 0 \text{ J}$
- $W_{ab} = 0 \text{ J}$, $W_{bc} = -2.5 \text{ J}$
- $W_{ab} = -2.5 \text{ J}$, $W_{bc} = -2.5 \text{ J}$
- $W_{ab} = 2.5 \text{ J}$, $W_{bc} = -2.5 \text{ J}$

12. If the capacitor is filled with polystyrene, which is a dielectric, how does the charge and energy stored in the capacitor change? The battery remains disconnected during this process.

- Charge increases; energy does not change
- Charge decreases; energy decreases
- Charge increases; energy decreases
- Charge does not change; energy decreases
- Charge increases; energy increases

The next two questions pertain to the following situation:

A resistor formed from a $2\text{ mm} \times 2\text{ mm} \times 10\text{ mm}$ piece of carbon is placed in a circuit in series with an ammeter and 3 V battery.



13. How much current will the ammeter measure if the resistivity of the carbon is $0.6\ \Omega\cdot\text{m}$?

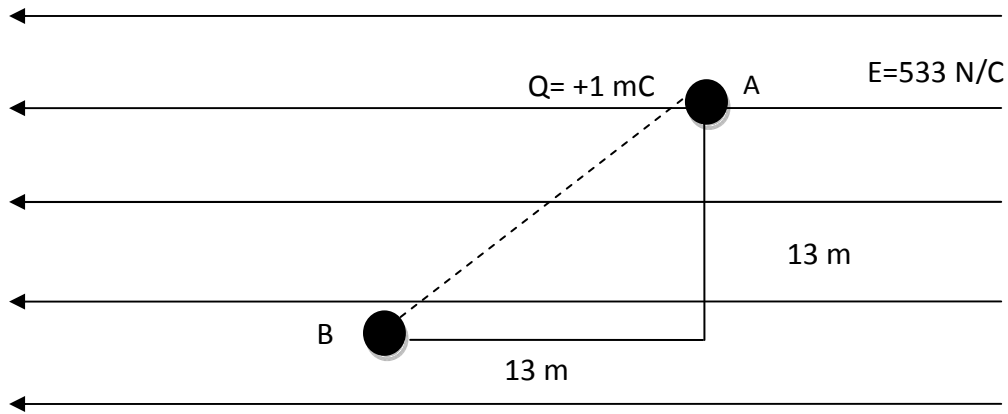
- a. 1.0 mA
- b. 2.0 mA
- c. 3.0 mA

14. How much current does the ammeter measure if the width w and height h of the resistor are both doubled?

- a. 4.0 mA
- b. 2.0 mA
- c. 8.0 mA

The next two questions pertain to the following situation:

Consider the motion of the two charges in the uniform electric field shown below.



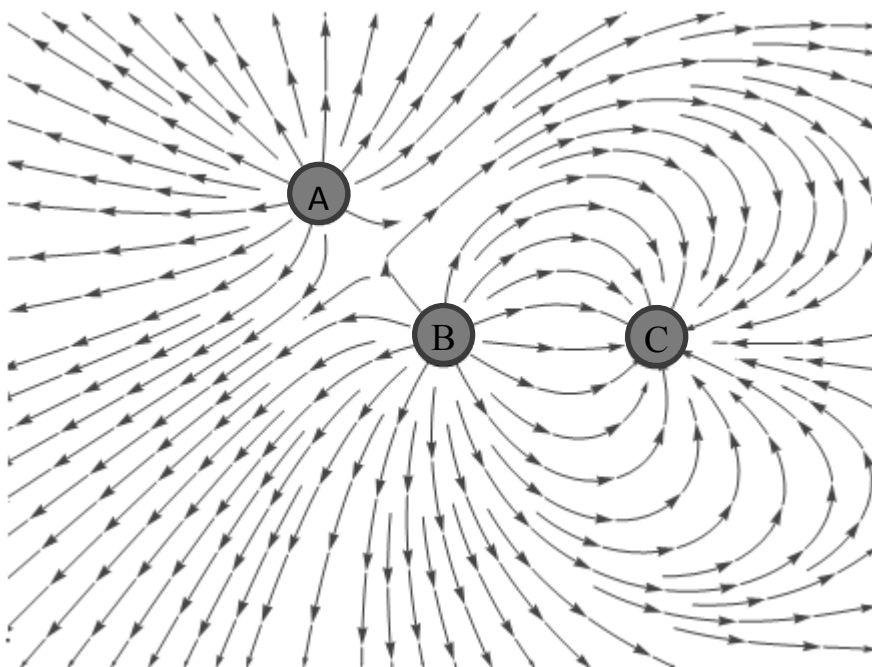
15. How much work is done by the field on the charge Q as it moves from A to B along the solid path?

- a. 0 J
- b. 6.93 J
- c. -6.93 J
- d. 90 J
- e. -90 J

16. The work done by you on the charge Q to move it from A to B along the dashed path is greater than zero.

- a. True
- b. False

17. Consider the electric field lines connecting the charged objects shown above. Which of the following statements is correct?

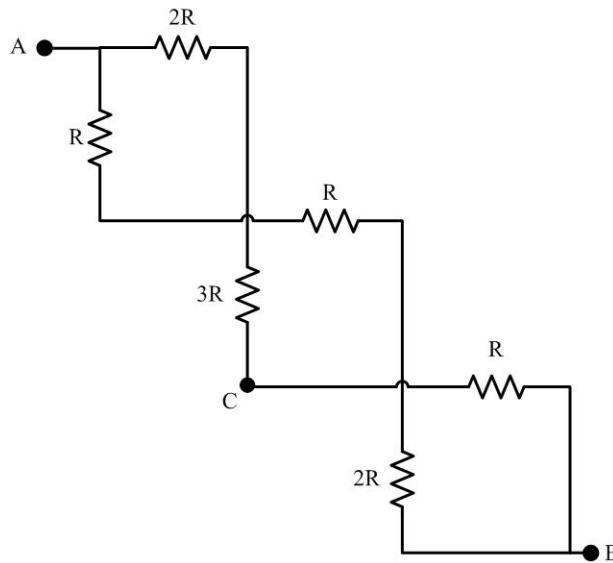


- a. A is positive and C is positive
- b. A is negative and C is negative
- c. A is negative and B is positive
- d. A is positive and C is negative
- e. none of the above

18. Air is normally insulating, but when it is subjected to a sufficiently strong electric field of 3×10^6 N/C it becomes conducting. This phenomenon is known as dielectric breakdown and makes sparks and lightning possible. Two electrodes are separated by 1 cm and the voltage is increased until a spark is created. How long does it take for an electron to move across the gap? Treat the electrodes as a parallel plate capacitor. The mass of the electron 9.1×10^{-31} kg and the charge of the electron is 1.6×10^{-19} C.

- a. 1.95×10^{-10} s
- b. 3.80×10^{-20} s
- c. 1.90×10^{-20} s
- d. 2.08×10^{-7} s
- e. 1.38×10^{-10} s

The next two problems refer to the diagram below:

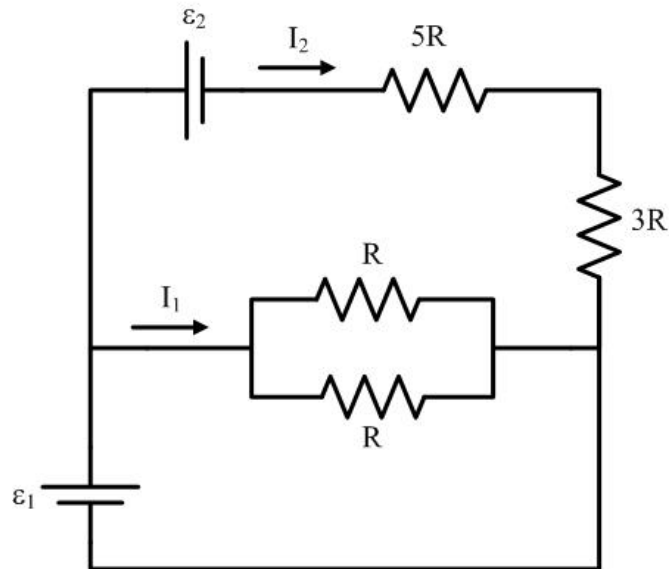


19. What is the equivalent resistance of the circuit elements between points A and B in terms of resistance R ?

- $5R/2$
- $7R/3$
- $12R/5$
- $21R/10$
- $45R/14$

20. A 3 Volt battery is connected between points A and B, forming a complete circuit. What is the voltage difference between point A and point C if $R=1$ Ohm?

- 1 Volt
- $(4/3)$ Volts
- $(3/2)$ Volts
- 2 Volts
- $(5/2)$ Volts

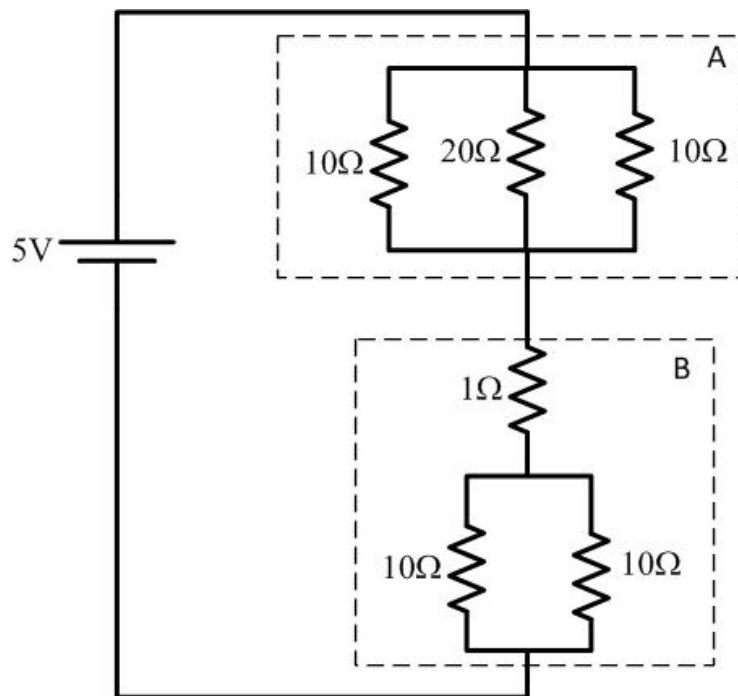


21. Which of the equations below correctly describe the circuit above?

- I. $\varepsilon_1 - 8I_2R - \varepsilon_2 = 0$
- II. $\varepsilon_1 - \frac{1}{2}I_1R = 0$
- III. $\varepsilon_2 + 8I_2R - \frac{1}{2}I_1R = 0$

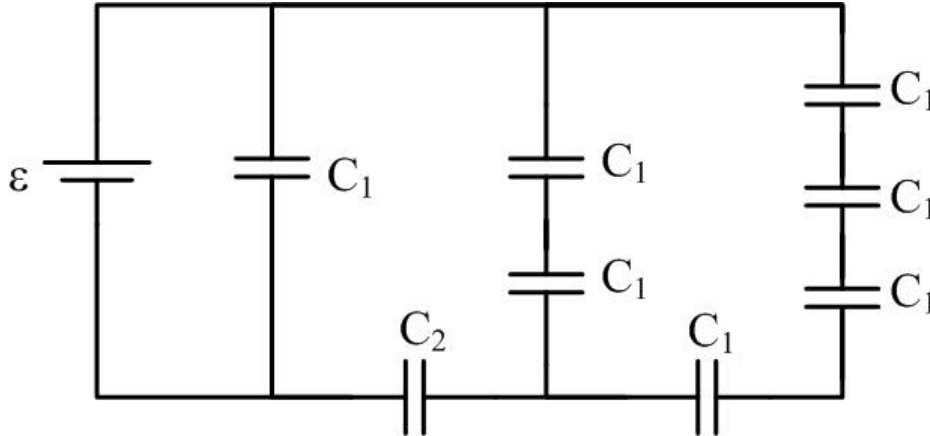
- a. I and II
- b. II and III
- c. I and III
- d. I, II and III
- e. None of the above.

22. What is the ratio of the power dissipated in block A to the power dissipated in block B (that is, what is P_A/P_B)?



- a. $2/3$
- b. $4/5$
- c. 1
- d. $5/4$
- e. $3/2$

The next two problems pertain to the following situation:



23. What is the equivalent capacitance of the circuit diagram above if all the capacitors have capacitance C ?

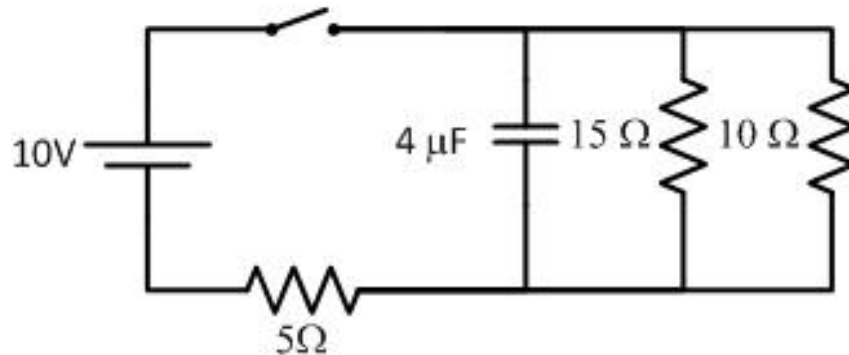
- a. $19C/12$
- b. $12C/19$
- c. $13C/7$
- d. $10C/7$
- e. $9C/7$

24. How much charge Q_2 is stored on capacitor C_2 if all the capacitors have capacitance C ?

- a. $Q_2 = 3C\epsilon/7$
- b. $Q_2 = C\epsilon/2$
- c. $Q_2 = C\epsilon/4$
- d. $Q_2 = C\epsilon/3$
- e. $Q_2 = 19C\epsilon/12$

The next three questions pertain to the following situation:

The switch in the circuit shown below has been open for a long time so that the capacitor is initially uncharged.



25. What is the current through the 5 Ω resistor immediately after the switch is closed?
- 2.0 A
 - 0.9 A
 - 0 A
26. What is the voltage across the capacitor after the switch has been closed for a long time?
- 4.55 V
 - 5.45 V
 - 7.5 V
 - 8.2 V
 - 10 V
27. The after the switch has been closed for a long time, it is then opened again. What is the current through the 15Ω after the switch has been open for 30μs?
- 0.260 A
 - 0.257 A
 - 0.220 A
 - 0.104 A
 - 0.156 A

**Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?**

KEY

Exam 1 – Fall 2011

1. c
2. b or c
3. d
4. b
5. a
6. b
7. d
8. d
9. d
10. c
11. a
12. d
13. b
14. c
15. b
16. b
17. d
18. a
19. c
20. e
21. d
22. a
23. d
24. a
25. a
26. b
27. d