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. You may find the version of this Exam Booklet at the top of page 2. Mark the version circle in the TEST FORM box near the bottom right on the face 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.

1 of 18 pages
26 problems
This Exam Booklet is Version A. Mark the A circle in the TEST FORM box near the bottom right on the face of your answer sheet. DO THIS NOW!

Exam Grading Policy—

The exam is worth a total of 123 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. There are seven capacitors all with capacitance C connected in the network indicated below.

What is the equivalent capacitance of this network between points A and B?

a. $\frac{5}{6}$ C  
b. $\frac{2}{3}$ C  
c. $\frac{5}{17}$ C  
d. $\frac{20}{5}$ C  
e. $\frac{42}{7}$ C
The following situation pertains to the next three questions:

A network of fully charged capacitors and a battery is drawn below. The components have the following values: \( C_1 = 10 \, \mu F \), \( C_2 = 20 \, \mu F \), \( C_3 = 30 \, \mu F \), \( C_4 = 40 \, \mu F \), \( C_5 = 50 \, \mu F \), \( C_6 = 60 \, \mu F \), and \( \mathcal{E} = 12 \, \text{Volts} \). The points A and B are labeled on the diagram.

2. What is the equivalent capacitance of this entire network?
   
   a. \( C_{eq} = 23.8 \, \mu F \)
   b. \( C_{eq} = 123.5 \, \mu F \)
   c. \( C_{eq} = 52.8 \, \mu F \)
   d. \( C_{eq} = 100.1 \, \mu F \)
   e. \( C_{eq} = 65.9 \, \mu F \)

3. What is the electric charge stored on capacitor \( C_1 \) ?
   
   a. \( Q_2 = 95.1 \, \mu C \)
   b. \( Q_2 = 120.0 \, \mu C \)
   c. \( Q_2 = 131.0 \, \mu C \)
   d. \( Q_2 = 85.3 \, \mu C \)
   e. \( Q_2 = 201.3 \, \mu C \)

4. Suppose the branch from point A to point B, including capacitors \( C_5 \) and \( C_6 \), were removed from the circuit. The charge stored on \( C_1 \) would
   
   a. increase.
   b. decrease.
   c. stay the same.
The next three questions pertain to the following situation:

A capacitor is in a circuit with a battery as shown. This capacitor has square plates with sides $s = 2.2$ cm and has no dielectric between the plates. Each plate has a charge of magnitude $Q = 10$ pC.

5. What is the electric field, $E$, between the plates?

a. $E = 2.33 \times 10^3$ N/C  

b. $E = 1.54 \times 10^3$ N/C  

c. $E = 3.14 \times 10^4$ N/C  

d. $E = 5.98 \times 10^3$ N/C  

e. $E = 6.79 \times 10^4$ N/C

6. The capacitor has a stored energy, $U_1$, without any dielectric between the plates. Now a slab of dielectric material with dielectric constant $K = 2.0$ is placed between the plates, with the same width as the plate separation.

The new stored energy of the capacitor $U_2$ is

a. the same as $U_1$.  

b. less than $U_1$.  

c. larger than $U_1$. 

The next question continues from the previous page.

7. A conducting slab replaces the dielectric, and the distance between the plates is doubled. The stored energy is now $U_3$.

Compare this stored energy $U_3$ with the original stored energy $U_1$.

a. $U_3 = \frac{3}{2} U_1$
b. $U_3 = 4 U_1$
c. $U_3 = U_1$
d. $U_3 = \frac{1}{4} U_1$
e. $U_3 = \frac{2}{3} U_1$
The next four questions refer to the following circuit:

8. If all four resistors have resistance R, what is the total equivalent resistance for this circuit?
   a. 4R
   b. 2R
   c. R
   d. R/4
   e. R/2

9. What is the current supplied by the battery if each resistor has resistance R?
   a. $\varepsilon / R$
   b. $2R / \varepsilon$
   c. $\varepsilon / 3R$
   d. $2 \varepsilon / R$
   e. $\varepsilon / 4R$
10. How much power is dissipated in this circuit if each resistor has resistance R?

a. $\varepsilon^2 / R$

b. $2 \varepsilon^2 / R$

c. $R / 2 \varepsilon^2$

d. $\varepsilon^2 / 4R$

e. $\varepsilon^2 / R$

11. What is the electric potential difference $V_A-V_B$ if $\varepsilon=10 \text{ V}$, $R_1=R_2=10 \Omega$, and $R_3=R_4=5 \Omega$?

a. 0.2 V

b. 5 V

c. 10 V

d. 0 V

e. 0.25 V
The next two questions pertain to the following diagram.

The following diagram has three charges, Q₁, Q₂, Q₃, and three points in space, A, B, C.

12. Where is the magnitude of the electric field strongest?
   a. A
   b. B
   c. C

13. What is true about the magnitude of the charges?
   a. Q₁>Q₂>Q₃
   b. Q₁=Q₂=Q₃
   c. Q₃>Q₂>Q₁
14. What is a valid Kirchhoff loop rule for the circuit shown above?

a. $\varepsilon_1 + I_1 R_1 - I_2 R_2 = 0$

b. $I_4 R_4 + I_3 R_3 - I_1 R_1 - I_2 R_2 = 0$

c. $-\varepsilon_2 - I_2 R_2 + I_4 R_4 = 0$
The next two questions pertain to the circuit shown below:

15. Switch B is opened. What is the current $I_1$ if switch A is left closed for a long time?
   a. 2 A  
   b. 0.5 A  
   c. 0 A

16. Switch B is opened and switch A is left closed for a long time. Then switch A is opened and switch B is closed. What is the current $I_2$ immediately after switch B is closed?
   a. 2 A  
   b. 0.5 A  
   c. 0 A
17. A resistor is created using a cube of carbon. The resistivity of carbon is $3.5 \times 10^{-5} \, \Omega \cdot \text{m}$. The length of each side of the cube is $10^{-6} \, \text{m}$. The cube is hooked up to a 1.5 V battery as shown below. How much current flows through the cube?

a. $4.3 \times 10^{10} \, \text{A}$  
b. 0.043 A  
c. 23.3 A  
d. 0.1 A  
e. 1.5 A
18. A perfectly conducting sphere is hung from a light cotton string attached to a fixed support \((t_1)\). A conducting rod with a net negative charge is made to touch the sphere \((t_2)\) and then moved away.

Which direction does the insulating sphere move at time \(t_3\), when the rod is held nearby?

a. toward the rod
b. away from the rod
c. does not move
The next two questions pertain to the following situation:

An insulating sphere of mass $m = 9.3 \text{ kg}$ and charge $Q = +4.6 \text{ mC}$ is hung on a light cotton string and then placed in an external electric field. The electric field is unknown in magnitude and points upward. The tension in the string is measured to be 76 N.

19. What is the magnitude of the external electric field?
   a. $E = 480 \text{ N/C}$
   b. $E = 630 \text{ N/C}$
   c. $E = 1900 \text{ N/C}$
   d. $E = 3300 \text{ N/C}$
   e. $E = 5400 \text{ N/C}$

20. Let the original tension in the string be $T_0$. The charge $Q$ is changed from $+4.6 \text{ mC}$ to $-4.6 \text{ mC}$. What is the relationship between the new tension $T_{\text{new}}$ and the original tension $T_0$?
   a. $T_{\text{new}} < T_0$
   b. $T_{\text{new}} = T_0$
   c. $T_{\text{new}} > T_0$
21. How much work was needed by an external force to assemble the three charges into the configuration above, assuming they started infinitely far away from each other?

a. \( W = -4.6 \times 10^{-2} \) J  
b. \( W = -6.5 \times 10^{-2} \) J  
d. \( W = +6.5 \times 10^{-2} \) J  
c. \( W = +4.6 \times 10^{-2} \) J  
e. \( W = +9.1 \times 10^{-2} \) J
The next two questions pertain to the following situation:

Two charges are located on the x-axis at positions $-6$ m and $+2$ m respectively. Each grid spacing is 1 meter.

22. What is the net electric field at the origin due to the two charges?
   a. $-4.50$ V/m
   b. $-2.25$ V/m
   c. $+9.00$ V/m

23. Calculate the electric potential at the origin due to the two charges.
   a. $3.9$ V
   b. $4.6$ V
   c. $12$ V
   d. $27$ V
   e. $32$ V
The next two questions continue from the previous page:

Another charge with mass \( m = 4.3 \times 10^{-17} \) kg is added to the configuration at the origin. The +9nC and +3nC charges are held stationary, while the 4nC charge is free to move.

24. What is the magnitude of the force on the 4 nC charge?
   a. \( 8 \times 10^{-9} \) N
   b. \( 1.8 \times 10^{-8} \) N
   c. \( 3.9 \times 10^{-8} \) N

25. What is the speed of the 4nC charge after it is released and has traveled infinitely far away?
   a. \( v = 9.3 \times 10^{3} \) m/s
   b. \( v = 1.8 \times 10^{4} \) m/s
   c. \( v = 3.7 \times 10^{4} \) m/s
   d. \( v = 7.1 \times 10^{4} \) m/s
   e. \( v = 8.5 \times 10^{4} \) m/s
The next question pertains to the following situation:

Three charges are located at (0,0), (7 m,0), and (0, 3m), as shown below. Each grid spacing is 1 meter.

26. What is the net electric field at the point indicated at (7 m, 3 m)?

a. 0.76 V/m
b. 2.4 V/m
c. 5.9 V/m
d. 12 V/m
e. 39 V/m

Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?
KEY
Exam 1 – Spring 2012

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