Physics 102                Exam 1                Spring 2013

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 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. Print your UIN# in the STUDENT NUMBER designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box.

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 14 numbered pages plus three (3) 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.
6. Consider an uncharged spherical conducting shell as shown. If charges are transferred to it, which statement is TRUE regarding their behavior?

a. They will be distributed uniformly throughout the conductor.
b. They will spread on the inner surface.
c. They will spread on the outer surface.

7. Consider the circuit below. Which of the following equations is incorrect?

\[ \varepsilon_1 - I_1 R_1 - I_2 R_2 = 0 \]
\[ \varepsilon_1 - I_1 R_1 - I_3 R_3 = 0 \]
\[ \varepsilon_2 - I_2 R_2 - I_3 R_3 = 0 \]
The next three questions pertain to the following situation:

An ideal battery of voltage $\mathcal{E} = 12 \text{ V}$ is connected to a circuit of resistors.

![Circuit Diagram](image)

13. Assume all of the resistors have resistance $R$. What is the equivalent resistance, $C_{eq}$, for the circuit?

a. $C_{eq} = 3R/2$

b. $C_{eq} = 5R$

c. $C_{eq} = 5R/7$

d. $C_{eq} = 4R/3$

e. $C_{eq} = 13R/9$

14. If the resistance of each resistor $R = 75 \Omega$, what is $P_1$, the power dissipated by resistor $R_1$?

a. $P_1 = 1.9 \text{ W}$

b. $P_1 = 9.0 \text{ W}$

c. $P_1 = 5.7 \text{ W}$

15. What is the voltage $V_{ab}$ difference between points $a$ and $b$, as labeled on the circuit?

- **Answer:** $V_{ab} = 2.4 \text{ V}$

  1. Combine $R_4$ and $R_5$ to get $R_{eq}$:
     
     \[
     \frac{1}{R_{eq}} = \frac{1}{R_4} + \frac{1}{R_5} \quad \Rightarrow \quad R_{eq} = \frac{R_4 R_5}{R_4 + R_5}
     \]

  2. Use total resistance of $R_2, R_3, R_{eq}$ in series to find the current:
     
     \[
     \mathcal{E} + IR \rightarrow 12 = I(75) \quad \Rightarrow \quad I = \frac{12}{75}
     \]

  3. Use the current to find the voltage change across both parallel resistors:
     
     \[
     V_{eq} = IR_{eq} = \frac{12}{75} \cdot \frac{R_4 R_5}{R_4 + R_5} = 2.4 \text{ V}
     \]
The next three questions pertain to the following situation:

Consider the circuit below. $\varepsilon_1 = 15$ V, $\varepsilon_2 = 5$ V, $R_1 = 1$ $\Omega$, $R_2 = 2$ $\Omega$.
Initially the switch $S$ is open.

![Circuit Diagram]

21. What is the current $I_1$ in resistor $R_1$?

a. $I_1 = 0$ A  

b. $I_1 = 6.25$ A  

c. $I_1 = 3.33$ A  

d. $I_1 = 1.50$ A  

e. $I_1 = 17.5$ A

When the switch is open, current flows through the outer loop (blue).

Write Kirchhoff loop equation:

$\varepsilon_1 - I_1 R_1 - I_2 R_2 - \varepsilon_2 = 0$

Since there are no active junctions, $I_1 = I_2$

$\varepsilon_1 - I_1 (R_1 + R_2) - \varepsilon_2 = 0$

$I_1 = \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_2} = \frac{10}{3}$

22. Now the switch $S$ is closed. What is the current $I_3$?

a. $I_3 = 0$ A  

b. $I_3 = 6.25$ A  

c. $I_3 = 3.33$ A  

d. $I_3 = 1.50$ A  

e. $I_3 = 17.5$ A

With the switch closed, current $I_3$ can flow.

By the junction rule, $I_1 = I_2 + I_3$

We'll also need two Kirchhoff loops:

Blue loop: $\varepsilon_1 - I_1 R_1 - I_2 R_2 - \varepsilon_2 = 0$

Pink loop: $\varepsilon_1 - I_1 R_1 = 0$

From pink loop equation, $I_1 = \frac{\varepsilon_1}{R_1}$

Put this into the blue loop equation,

$I_1 = \frac{\varepsilon_1}{R_1} - I_2 - \varepsilon_2 = 0 \rightarrow I_2 = -\frac{\varepsilon_2}{R_2}$ looks like $I_2$ flows to the left!

Going back to the junction rule,

$I_1 = I_2 + I_3$

$\frac{\varepsilon_1}{R_1} = -\frac{\varepsilon_2}{R_2} + I_3 \rightarrow I_3 = \frac{\varepsilon_1}{R_1} + \frac{\varepsilon_2}{R_2} = 17.5$ A

12 of 15 pages  
(27 problems)
The next five questions pertain to the following situation:

Consider the circuit below. $\varepsilon = 5 \text{ V}$, $R_1 = 2 \ \Omega$, $R_2 = 1 \ \Omega$, and $C = 15 \ \mu\text{F}$. Initially the switch $S$ is at position B and the capacitor $C$ is fully discharged.

At $t = 0$, the switch $S$ is flipped to position A.

23. What is the current $I_2$ in resistor $R_2$ immediately after setting the switch to A?
   a. $I_2 = 0 \ \text{A}$
   b. $I_2 = 1.67 \ \text{A}$
   c. $I_2 = 12.5 \ \text{A}$
   d. $I_2 = 6.33 \ \text{A}$
   e. $I_2 = 5.00 \ \text{A}$

24. At some time $t > 0$ later, the current through $R_2$ is found to be $I_2 = 1.0 \ \text{A}$. What is the charge $Q$ on the capacitor $C$ at that precise time?
   a. $Q = 30 \ \mu\text{C}$
   b. $Q = 250 \ \mu\text{C}$
   c. $Q = 75 \ \mu\text{C}$
The next three questions continue from the previous page:

After a long time, the switch $S$ is reset to position B. The next three questions pertain to this situation.

25. What is the magnitude of the current $I_2$ in resistor $R_2$ immediately after resetting the switch to B?

a. $I_2 = 0$ A  
  b. $I_2 = 6.67$ A  
  c. $I_2 = 5.00$ A  
  d. $I_2 = 12.5$ A  
  e. $I_2 = 1.33$ A

26. In what direction around the circuit does the current $I$ flow immediately after resetting the switch?

a. Clockwise  
  b. Counterclockwise

27. Eventually, the current decays gradually to zero as shown in the figure below. Which formula best represents the time constant $\tau$ for this decay?

a. $\tau = R_1 C$  
  b. $\tau = R_2 C$  
  c. $\tau = (R_1 + R_2) C$

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 2013

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