Last Name:________________First Name_________________NetID_______________
Discussion Section:________Discussion TA Name:______________________________

Instructions—
Turn off your cell phone and put it away.
Keep your calculator on your own desk. Calculators may not 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 a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. 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.

2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.

3. Print your NetID in the **NETWORK ID** boxes, and then mark the corresponding circle below each of the letters or numerals. Note that there are different circles for the letter "I" and the numeral "1" and for the letter "O" and the numeral "0". **Do not** mark the hyphen circle at the bottom of any of these columns.

4. You may find the version of **this Exam Booklet at the top of page 2**. Mark the **version** circle in the **TEST FORM** box in the bottom right of your answer sheet. **DO THIS NOW!**

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 11 ***numbered pages*** *plus two Formula Sheets at the end.*

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 expulsion.**

This Exam Booklet is Version A. Mark the **A** circle in the **TEST FORM** box in the bottom right of your answer sheet. **DO THIS NOW!**

Exam Grading Policy—

The exam is worth a total of 111 points, composed of two types of questions.

MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.

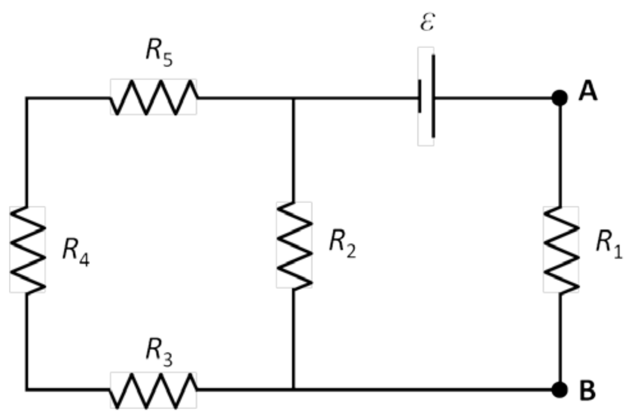
(a) If you mark only one answer and it is the correct answer,
you earn **6** points.
(b) If you mark *two* answers, one of which is the correct answer,
you earn **3** points.
(c) If you mark *three* answers, one of which is the correct answer,
you earn **2** points.
(d) If you mark no answers, or more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

The next three questions pertain to the following situation.

Consider an electrical circuit shown below. It consists of an ideal battery and five resistors, whose values are: $\varepsilon = 12$ V, $R_1 = 4\ \Omega$, $R_2 = R_3 = R_4 = R_5 = 3\ \Omega$.



1. What is the ratio I_2/I_3 of the currents flowing through R_2 and R_3?

a. $I_2/I_3 = 0.333$
b. $I_2/I_3 = 1$
c. $I_2/I_3 = 3$

2. What is the electric potential difference between the points **A** and **B**?

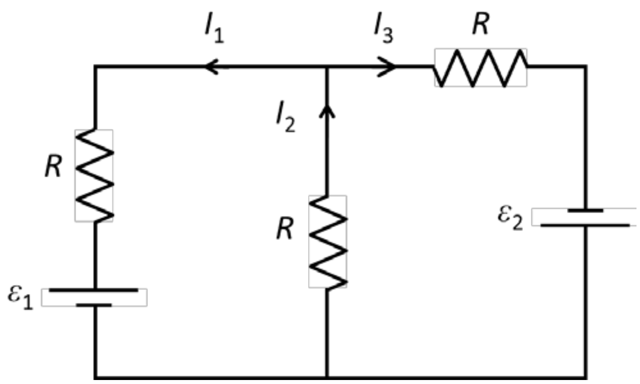
a. $V_A - V_B = +7.68$ V
b. $V_A - V_B = +3.0$ V
c. $V_A - V_B = +1.25$ V
d. $V_A - V_B = -3.0$ V
e. $V_A - V_B = -7.68$ V

3. If the ideal battery is now replaced with a non-ideal battery of the same voltage, how would the current I_1 through R_1 change?

a. stay the same
b. decrease
c. increase

The next two questions pertain to the following situation:

Consider an electrical circuit shown below. It consists of two ideal batteries and three identical resistors, whose values are: $\varepsilon_1 = 12$ V, $\varepsilon_2 = 15$ V, $R = 5\ \Omega$. The positive directions for the currents I_1, I_2 and I_3 are indicated by the directions of the arrows.



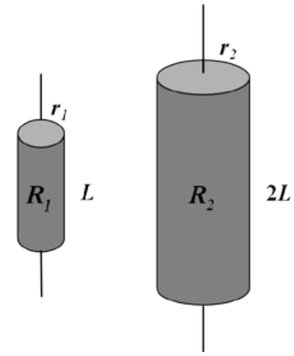
4. Which of the following equations is <u>not</u> valid?

a. $I_1R_1 + I_2R_2 - \varepsilon_1 = 0$
b. $I_2 = I_1 + I_3$
c. $I_2R_2 + I_3R_3 - \varepsilon_2 = 0$

5. What is the current I_1?

a. $I_1 = +2.8$ A
b. $I_1 = +1.2$A
c. $I_1 = +0.2$ A
d. $I_1 = -2.6$ A
e. $I_1 = -1.4$ A

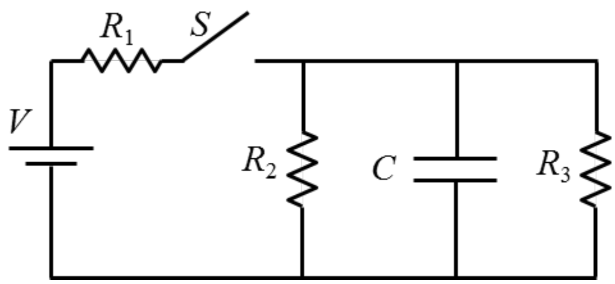
6. Two cylindrical resistors are made of the same material with known resistivity. Their lengths are L and $2L$, respectively, as shown below. If the ratio of their resistance values is $R_2/R_1 = 4$, what is the ratio of their radii r_2/r_1?



a. $r_2/r_1 = 0.5$
b. $r_2/r_1 = 1.414$
c. $r_2/r_1 = 0.707$

The next two questions pertain to the following situation:

A circuit is constructed with three resistors and one capacitor as shown. The values for the resistors are: $R_1 = R_2 = R_3 = 6\ \Omega$. The capacitance is $C = 50\ \mu$F and the battery voltage is $V = 10$V. The switch S is initially open.



7. What is the magnitude of the current through $\boldsymbol{R_2}$ immediately after the switch is closed?

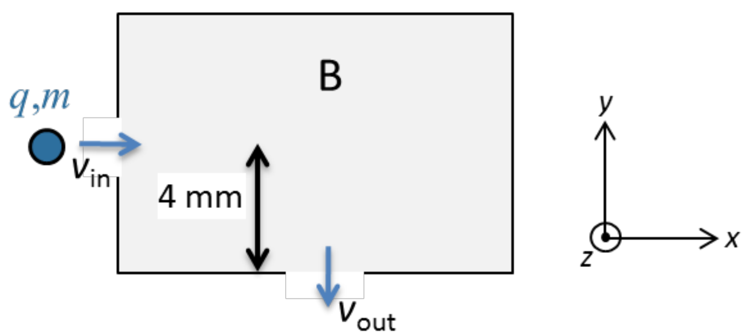
a. 1.67 A
b. 0 A
c. 3.33 A

8. After being closed for a long time the switch is opened again. What is the charge on the capacitor at a time 200 μs after the switch is opened?

a. 9.4×10^{-4} C
b. 1.2×10^{-4} C
c. 4.4×10^{-5} C
d. 1.7×10^{-4} C
e. 6.6×10^{-5} C

The next two questions pertain to the following situation:

A particle of charge $q = 20\ \mu C$ moving with constant velocity $v = 50\ m/s\ \hat{x}$ enters a region containing a constant magnetic field of magnitude 12 T. The particle leaves the field region with a velocity in the $-y$ direction, having moved a vertical distance of 4 mm, as shown below.



9. In what direction could the magnetic field point in order to make the particle have the trajectory shown above?

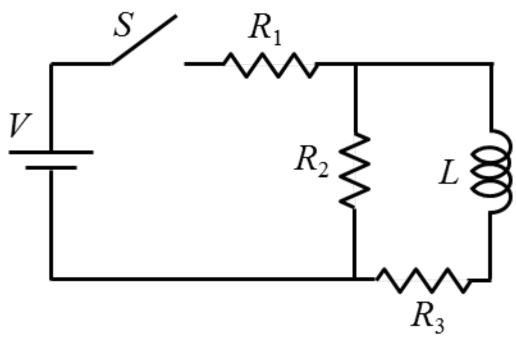
a. +z direction
b. +y direction
c. –z direction

10. Assume that the particle's initial velocity is perpendicular to the direction of the magnetic field, and that it moves only in the x-y plane. Find the mass of the particle.

a. 9.1×10^{-31} kg
b. 1.6×10^{-27} kg
c. 9.6×10^{-6} kg
d. 3.8×10^{-8} kg
e. 1.9×10^{-8} kg

The next three questions pertain to the following situation:

A circuit is constructed with three resistors and one inductor as shown. The values for the resistors are: R_1 = 2 Ω and R_2 = R_3 = 4 Ω . The battery voltage is V = 12V. The switch S is initially open.



11. After the switch has been opened a long time, it is closed. What is the magnitude of the voltage across L immediately after the switch is closed.

a. 0 V
b. 12 V
c. 8 V
d. 24 V
e. 6 V

12. After the switch has been closed a long time it is opened again. What is the magnitude of the current through R_2 immediately after the switch is opened?

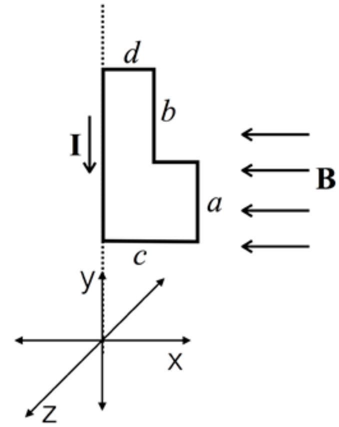
a. 2 A
b. 1.5 A
c. 3 A

13. After the switch is opened, it takes the current a time 6.0 μs to drop to 1/e of its initial value. What is the value of the inductance of the circuit?

a. 24 μH
b. 48 μH
c. 60 μH

The next three questions pertain to the following situation:

A wire loop is attached to an axis (dotted line in Figure) about which it can freely rotate. There is a constant magnetic field and a current flowing counter-clockwise in the wire as shown in the image. The length of the line segments are *a*, *b*, *c*, and *d* as indicated at right.



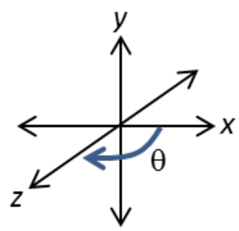
14. What is the net torque about the axis on the wire loop?

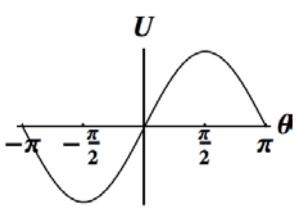
a. -IB(ac+bd) $\hat{y}$
b. IB(ac+bd) $\hat{y}$
c. -IB(a+b+c+d) $\hat{y}$
d. IB(a+b+c+d) $\hat{y}$
e. 0

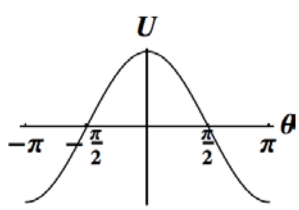
15. The loop is allowed to relax to its lowest energy position. What is the work done on the loop by the magnetic field?

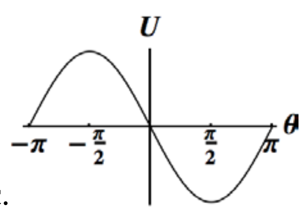
a. 2IB(a+b+c+d)
b. IB(a+b+c+d)
c. IB(ac+bd)
d. –IB(a+b+c+d)
e. –IB(ac+bd)

16. Which of these sketches best represents the potential energy as a function of the rotation of the wire loop? (The angle θ = 0 initially when the loop is in the x-y plane, and increases with clockwise rotation around the y-axis, as depicted at right).



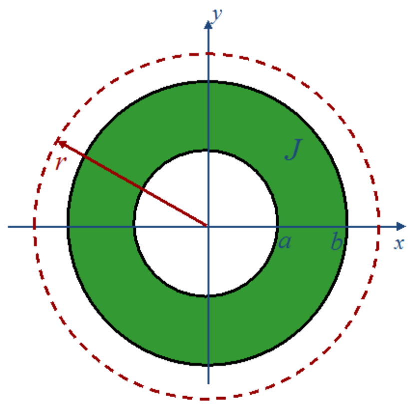
a.


b.


c.


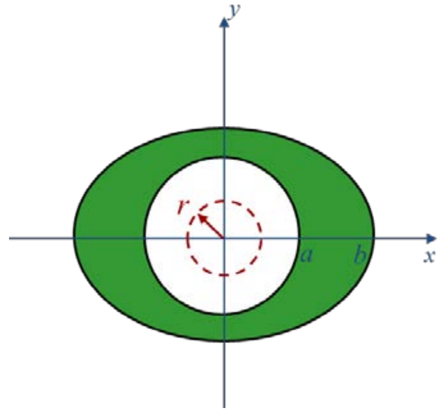
The next two questions pertain to the following situation:

A conducting cylinder is oriented along the z-axis as shown in the picture at right. The inner radius is a = 4 cm, the outer radius is b = 8 cm, and the current density through the cylinder is J = 30 A/m^2.



17. What is the magnitude of the magnetic field at a distance r = 12 cm from the center of the cylinder?

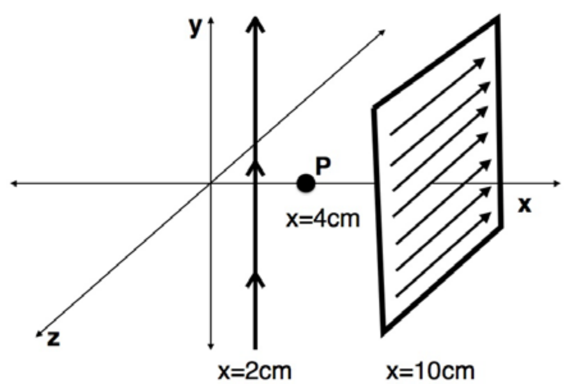
a. $3.4\text{x}10^{-7}$ T
b. $7.5\text{x}10^{-7}$ T
c. $5.9\text{x}10^{-7}$ T
d. $7.5\text{x}10^{-5}$ T
e. $3.4\text{x}10^{-6}$ T



18. Suppose that the cylinder is deformed as shown on the right. The total current remains the same. Which of these statements about the interior of the cylinder (*i.e.*, r < a) is FALSE?

a. The magnetic field is no longer zero for 0 < r < a.
b. Ampere's law can be used to determine the magnetic field.
c. The integral $\oint \vec{B} \cdot d\vec{l}$ over the dotted line to the right is equal to zero.

19. A wire with current I_w = 1 A in the y-direction is situated on the x-axis, a distance 2 cm from the origin. An infinite sheet of current with uniform current density J_s = 2 A/m in the –z direction crosses the x-axis at a distance 10 cm from the origin. [Note that $J \equiv nI$, where n is the number of wires per unit length].

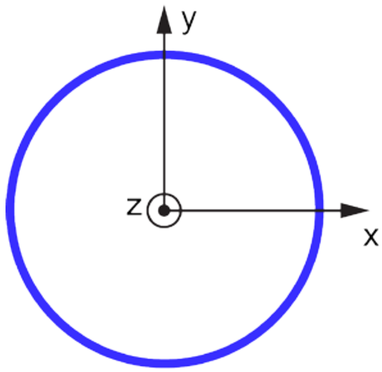


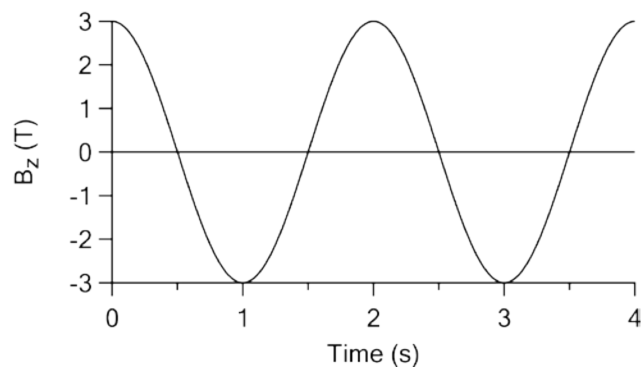
What is the value of the magnetic field at a point P on the x-axis 4 cm from the origin?

a. $(1.3\times10^{-6}\,\hat{y} - 1\times10^{-5}\hat{z})$ T
b. $9\times10^{-7}\,\hat{x}$ T
c. $(8\text{x}10^{-7}\,\hat{y} + 1.3\times10^{-6}\hat{z})$ T
d. $(-1\times10^{-6}\,\hat{y} + 1.3\times10^{-6}\hat{z})$ T
e. $(-2\times10^{-6}\,\hat{y} - 1\times10^{-7}\hat{z})$ T

The next four questions pertain to the situation below.

A circular conducting metal loop of radius 3 cm, lying in the xy-plane, is placed in a spatially uniform, but time-varying magnetic field B_z, which is oriented parallel to the *z*-direction (Note, the positive *z*-direction is pointed out of the page.) The loop has a resistance of 5 Ω. The magnetic field has the sinusoidal time dependence shown on the right: $B_z(t) = B_0 \cos(2\pi f\, t)$, where $B_0 = 3$ T and $f = 0.5$ Hz.





20. Which way is the current circulating in the loop at $t = 0.5$ s?

a. Counter-clockwise
b. Clockwise
c. There is no current at this time

21. What is the magnetic flux through the loop at $t = 2.0$ s?

a. $\Phi = 2.7\times10^{-3}$ T•m^2
b. $\Phi = 5.6\times10^{-3}$ T•m^2
c. $\Phi = 8.5\times10^{-3}$ T•m^2

22. Which way is the current circulating in the loop at $t = 1.0$ s?

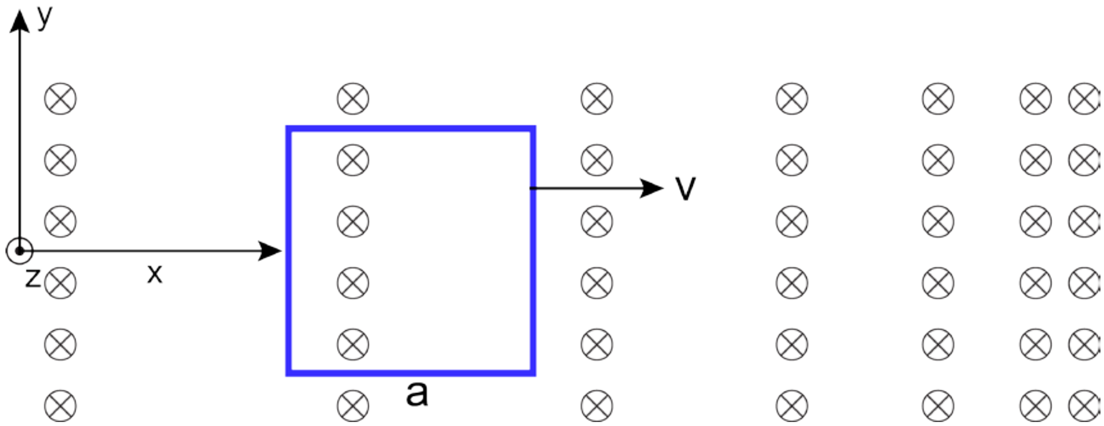
a. Clockwise
b. There is no current at this time
c. Counter-clockwise

23. Calculate the magnitude of the circulating current at $t = 0.8$ s. (Note: Make sure to either set your calculator to radians, or convert the phase into degrees.)

a. $|I| = 2.3$ mA
b. $|I| = 1.4$ mA
c. $|I| = 3.1$ mA
d. $|I| = 4.3$ mA
e. $|I| = 6.9$ mA

The next two questions pertain to the situation below.

A square conducting metallic loop is moving in the x-direction through a region of space with a magnetic field pointing along the negative z-direction. The loop has dimension a = 20 cm, and resistance of 2 Ω. The magnitude of the magnetic field increases linearly in the x-direction $B_z = Ax$, where A = 100 T/m.



24. Calculate the flux through the loop when the left edge of the loop is located at x = 0.7 m. Only consider the flux due to the external field.

a. $\Phi = 2.8\ \mathrm{T{\bullet}m^2}$
b. $\Phi = 3.6\ \mathrm{T{\bullet}m^2}$
c. $\Phi = 3.2\ \mathrm{T{\bullet}m^2}$
d. $\Phi = 2.4\ \mathrm{T{\bullet}m^2}$
e. $\Phi = 5.6\ \mathrm{T{\bullet}m^2}$

25. Calculate the force on the loop when the left edge of the loop is located at x = 2.3 m, and moving with velocity v = 3 m/s.

a. $F = -13\ \mathrm{N}\ \hat{x}$
b. $F = -57\ \mathrm{N}\ \hat{x}$
c. $F = -\ 80\ \mathrm{N}\ \hat{x}$
d. $F = -340\ \mathrm{N}\ \hat{x}$
e. $F = -24\ \mathrm{N}\ \hat{x}$

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