Make sure to put your name and your recitation instructor's name on each page of the exam.

This is a closed book exam: calculators are allowed, but no formula sheet. The exam has three parts:

(A) Questions based on the Labs.

(B) 10 multiple choice questions.

(C) Two "show work" problems. For these, you must show all work and intermediate steps in order to receive full credit. It is suggested that you include simple diagrams to clarify to the grader what you are trying to do.

Useful Constants:

\[ K = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2 \]

\[ \varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2 \]

\[ e = 1.6 \times 10^{-16} \text{ C} \]

\[ g = 9.8 \text{ m/s}^2. \]
PART A: LAB QUESTIONS (6 points). Write the letter for the best answer in the space provided.

The figure shows the screen of an oscilloscope when it is correctly connected to a signal generator.

1. The physical quantity measured on the **vertical** axis is _____.
   
   (a) current  
   (b) electric field  
   (c) potential energy  
   (d) voltage difference  
   (e) time

2. The physical quantity measured on the **horizontal** axis is _____.
   
   (a) current  
   (b) electric field  
   (c) potential energy  
   (d) voltage difference  
   (e) time
PART B: MULTIPLE CHOICE. Write the letter for the best answer in the space provided. Questions are worth 5 points each.

1. An electric heater is plugged into a 120 V outlet and produces 1000 W of heat. How much current does the heater draw?

   (answer)
   (a) 8.3 A
   (b) 0.12 A
   (c) 14.4 A
   (d) 4.2 A
   (e) 10 A

2. A charge $q = -3 \mu C$ is placed at a certain point in an electric field and experiences an electric force $F = 0.04 N$ pointing to the left. The electric field $E$ at this point is.

   (answer)
   (a) $7.5 \times 10^{-5} N/C$, pointing up.
   (b) $7.5 \times 10^{-5} N/C$, pointing to the right.
   (c) $7.5 \times 10^{-5} N/C$, pointing to the left.
   (d) $1.3 \times 10^3 N/C$, pointing to the left.
   (e) $1.3 \times 10^4 N/C$, pointing to the right.

3. A solid metal sphere is placed into a strong electric field. In the static situation, which of the following is FALSE?

   (answer)
   (a) The electric field is zero inside the sphere.
   (b) The electric potential is constant throughout the sphere.
   (c) Positive and negative charge exactly balance at every point on the sphere.
   (d) The electric field is perpendicular to the surface just outside the sphere.
   (e) There is no moving charge inside the sphere.

4. A parallel-plate capacitor with an air-gap is connected to a battery and has a certain charge $Q$ as shown in the figure. How would the charge change if the air-gap is filled with quartz? (Assume that the dielectric constant for quartz is $K = 4.0$)

   (answer)
   (a) $Q$ would become 16 times as large.
   (b) $Q$ would become 4 times as large.
   (c) $Q$ would not change.
   (d) $Q$ would become $1/4$ as large.
   (e) $Q$ would become $1/16$ as large.
5. At a distance of 2.0 m from an isolated point charge the electric field is 3 N/C and points towards the point charge. At a distance of 1.0 m from this point charge the electric field is

(Answer)
(a) 0.75 N/C, pointing towards the charge.
(b) 3 N/C, pointing away from the charge.
(c) 6 N/C, pointing away from the charge.
(d) 6 N/C, pointing towards the charge.
(e) 9 N/C, pointing towards the charge.

6. A metal wire of a certain length and diameter has a resistance \( R = 15 \, \Omega \). A second wire is made of the same metal, but is 3 times as long and has 3 times the diameter of the first wire. The resistance of this second wire is:

(Answer)
(a) 45 \, \Omega
(b) 15 \, \Omega
(c) 7.5 \, \Omega
(d) 5 \, \Omega
(e) 1.67 \, \Omega

7. A certain capacitor holds a charge \( Q = 65 \, \mu C \) when it is connected to a 12 V battery. Its capacitance is:

(Answer)
(a) 5.4 \, \mu F
(b) 0.18 \, \mu F
(c) 780 \, \mu F
(d) 4.7 mF
(e) 17.6 \, \mu F

8. Two conducting parallel plates are connected to a 60 V battery as shown in the figure. The area of each plate is 0.2 m² and they are separated by an air-gap \( d = 3 \, \text{cm} \). The electric field \( E \) between the plates is:

(Answer)
(a) 2000 V/m, pointing from plate A to B.
(b) 2000 V/m, pointing from plate B to A.
(c) 500 V/m, pointing from A to B.
(d) 500 V/m, pointing from B to A.
(e) none of the above.
The next two questions refer to the diagram shown below. Four light bulbs, each with the same resistance are connected together as shown. Initially, all four bulbs are glowing and the switch $S$ is open.

![Circuit Diagram](image)

9. If bulb $B$ is removed from the circuit, then what happens to the current through bulb $A$ and through bulb $D$?

   (answer)
   (a) $A$ increases, $D$ decreases.
   (b) $A$ increases, $D$ stays the same.
   (c) $A$ decreases, $D$ increases.
   (d) $A$ decreases, $D$ stays the same.
   (e) $A$ decreases, $D$ decreases.

10. If now the switch $S$ is closed, what happens to the current through bulbs $A$ and $D$?

   (answer)
   (a) $A$ increases, $D$ decreases.
   (b) $A$ increases, $D$ stays the same.
   (c) $A$ decreases, $D$ increases.
   (d) $A$ decreases, $D$ stays the same.
   (e) $A$ decreases, $D$ decreases.
PART C: Problems. You must show all work and all intermediate steps to receive full credit. Sketches or diagrams are often useful.

Problem 1. Point charges \( Q_1 = -5 \, \mu \text{C} \) and \( Q_2 = +5 \, \mu \text{C} \) are placed 0.4 m apart as shown in the figure.

(a) A certain point \( P \) is located 0.3 m above charge \( Q_1 \) as shown. Draw a diagram indicating the directions of the electric field vectors at point \( P \) due to each of the two charges. (5 pts.)

(b) Calculate both the \( x \)- and \( y \)- components of the total electric field vector at point \( P \). (10 pts.)

(c) Calculate the electric potential \( V_p \) at point \( P \). (Assume that the potential at infinite distance is equal to zero) (5 pts.)

(d) Calculate the change in potential energy \( \Delta \text{PE} \) of the system if a third charge \( q_3 = -2 \, \mu \text{C} \) is brought from an infinite distance and placed at point \( P \).
Problem II. Three resistors are connected to a battery as shown, where $R_1 = 10 \, \Omega$, $R_2 = 5 \, \Omega$, $R_3 = 10 \, \Omega$, and $V = 40 \, \text{V}$.

(a) Find the equivalent resistance of this network. (10 pts.)

(b) How much current passes through the battery? (5 pts.)

(c) Find the voltage difference $V_{bc}$ between the points $b$ and $c$ shown in the figure. (5 pts.)

(d) Evaluate the current $i_2$ which passes through resistor $R_2$. (5 pts.)
ANSWERS TO SOME OF THE SAMPLE PHYSICS 112 MIDTERMS

(Note: * means that the material is not included on midterm this quarter)

I. PELZ: April 22, 1992

Part A. *1. D *2. E

      5. 12 N/C and points towards the point charge

Part C

I a) \[ \begin{align*}
    \vec{E}_1 & = -6.0 \times 10^5 \text{ \textnormal{V}} \\
    \vec{E}_2 & = \text{ unspecified} \\
    \vec{E}_k & = \text{ unspecified}
\end{align*} \]

b) \[ \begin{align*}
    E_x & = -1.4 \times 10^5 \text{ \textnormal{N/C}} \\
    E_y & = -3.9 \times 10^5 \text{ \textnormal{N/C}}
\end{align*} \]

c) \[ 0.12 \text{ \textnormal{J}} \]

II a) \[ 13.3 \Omega \]

b) \[ 3.0 \text{ \textnormal{A}} \]

c) \[ 10 \text{ \textnormal{V}} \]

d) \[ 2.0 \text{ \textnormal{A}} \]