Phys 152 First Midterm Test
February 9, 2005
1 hour and 15 minutes

Professor: Dr. Edward J. Brash

Rules and Regulations:

1. Calculators, with memory cleared, are permitted.
2. You may bring as many pencils, pens, and erasers with you as you like.
3. No other material is permitted.
4. The test consists of 20 multiple choice questions, followed by 2 questions where you should present full solutions. The multiple choice questions are worth 1 point each (20 points total), and the two full solution questions are worth 10 points each (20 points total).
5. You should complete your solutions to the full solution questions on the test paper itself. Use the back of the test paper if necessary.
6. Your solutions to the full solution problems should, in general, contain a combination of diagrams, equations, and English word sentences explaining your strategy and thought process.

STUDENT NAME: ____________________________________________

STUDENT ID NUMBER:_____________________________________

SIGNATURE:______________________________________________
Section A: Multiple Choice Questions

1. The SI unit of electric current is the ampere. One ampere is equivalent to:

A) 1 Volt/Coulomb
B) 1 Coulomb/Volt
C) 1 Coulomb/Second
D) 1 Second/Coulomb

2. The surface area of a sphere of radius R is equal to:

A) $2\pi R$
B) $\pi R^2$
C) $4\pi R^2$
D) $4\pi R^3$

Questions 3 to 10 inclusive refer to the following diagram of a parallel plate capacitor:

![Diagram of a parallel plate capacitor with arrows indicating electric field.](image)

The battery, denoted by the two parallel horizontal lines on the left hand side, provides a voltage, $V=10\ \text{V}$. The separation between the plates is $d=0.10\ \text{m}$. The area of the plates is $(0.01\ \text{m} \times 0.01\ \text{m})$. The gap between the plates is filled with air.

3. The direction of the force on a positive test charge placed between the plates is:

A) to the left
B) to the right
C) downward
D) upward
4. According to the normal convention, the voltage at the top plates is

A) 10 V
B) -10 V
C) 0 V
D) 100 V

5. The unit of capacitance, the Farad, is equal to:

A) 1 Coulomb/Volt
B) 1 Newton/Coulomb
C) 1 Volt/Meter
D) 1 Volt/Coulomb

6. The magnitude of the electric field between the plates is:

A) 10 N/C
B) 10 V/m
C) 100 V/m
D) 1 V/m

7. Imagine that the gap between the plates is filled with glass, rather than air. In this case, the capacitance would:

A) remain the same
B) increase
C) become zero
D) decrease

8. Imagine that the air gap were reduced from 0.10 m to 0.05 m. In this case, the capacitance would:

A) increase by a factor of four.
B) decrease by a factor of four.
C) decrease by a factor of two.
D) increase by a factor of two.
9. In order to increase the capacitance of this device, one could:

A) decrease the air gap  
B) increase the area of the plates  
C) insert a dielectric material between the plates  
D) all of the above

10. The electrical potential energy at the bottom plate, according to the normal convention, is:

A) 10 J  
B) Infinity  
C) Zero  
D) Undefined

Questions 11 to 15, inclusive refer to the following situation:

Consider a solid conducting sphere of radius $R$. A total amount of charge, $+Q$, is transferred to the sphere, and the system is allowed to reach equilibrium.

11. The final charge distribution can be best described as:

A) uniformly distributed throughout the sphere  
B) uniformly distributed on the surface of the sphere  
C) concentrated at the centre of the sphere  
D) concentrated at the top and bottom of the sphere

12. The electric field inside the sphere is:

A) Undefined  
B) Infinite  
C) Zero  
D) Cannot be determined
13. The electric field lines at the surface of the sphere are:

A) pointing outwards
B) perpendicular to the surface of the sphere
C) Neither A or B
D) Both A and B

14. The electric potential on the surface of the sphere is:

A) Zero
B) Constant
C) Infinite
D) Perpendicular to the electric field

15. Consider a Gaussian sphere of radius R/2 centered on the center of the sphere. The electric flux through this surface is equal to:

A) Infinity
B) \( \frac{Q}{\varepsilon_0} \)
C) \(-\frac{Q}{\varepsilon_0}\)
D) Zero

Questions 16 to 20, inclusive, refer to the following situation:

Consider two point charges, Q1 and Q2, which are separated by a distance, d.

16. If the distance between the charges is doubled, then the magnitude of the force between the charges:

A) triples
B) increases
C) decreases by a factor of four
D) remains the same
17. Suppose that Q1 is positive and Q2 is negative. At the midpoint between the two charges, the electric field vector:

A) is zero  
B) is infinite  
C) points towards Q2  
D) points towards Q1

18. Suppose that Q1 and Q2 are both positive, and equal in magnitude as well. At the midpoint between the two charges, the electric field vector:

A) is zero 
B) is infinite  
C) points towards Q2  
D) points towards Q1

19. Suppose that Q1 and Q2 are both positive. At the midpoint between the two charges, the electric potential will be:

A) zero  
B) infinite  
C) negative  
D) positive

20. The potential an infinite distance away from both charges will be:

A) zero  
B) infinite  
C) negative  
D) positive
Section B: Full Solution Questions

1. The electric field between the plates of a parallel-plate capacitor is horizontal, uniform and has a magnitude $E$. A small object with a charge of $-2.80 \text{ \mu C}$ is attached to the string. Assume that the tension in the string is 0.350 N, and the angle it makes with the vertical is $19^\circ$.

(a) What is the mass of the object?

(b) What is the magnitude of the electric field?
2. Points A and B have electric potentials of 287 V and 129 V, respectively. When an electron released from rest at point A arrives at point C its kinetic energy is $K_A$. When the electron is released from rest at point B, however, its kinetic energy when it reaches point C is $K_B = 4K_A$.

(a) What is the electric potential at point C?

(b) What is the kinetic energy $K_A$
Potentially Useful Equations and Constants

**Quadratic Formula**

The roots of \( ax^2 + bx + c = 0 \) are given by

\[
x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
\]

**Physical Constants**

<table>
<thead>
<tr>
<th></th>
<th>c</th>
<th>( 3.00 \times 10^8 ) m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of Light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coulomb’s Law Constant</td>
<td>( k = \frac{1}{4\pi\varepsilon_0} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( e )</td>
<td>( 8.99 \times 10^9 ) \text{ Nm}^2/\text{C}^2</td>
</tr>
<tr>
<td>Electron Charge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permittivity of Free Space</td>
<td>( \varepsilon_0 )</td>
<td>( 8.854 \times 10^{-12} ) \text{ C}^2/\text{Nm}^2</td>
</tr>
<tr>
<td>Electron Mass</td>
<td>( m_e )</td>
<td>( 9.11 \times 10^{-31} ) \text{ kg}</td>
</tr>
<tr>
<td>Proton Mass</td>
<td>( m_p )</td>
<td>( 1.67 \times 10^{-27} ) \text{ kg}</td>
</tr>
</tbody>
</table>

**Electric Field**

\[
\vec{F} = q\vec{E}
\]

**Point Charges**

\[
|\vec{F}_E| = k\frac{|q_1||q_2|}{r^2}
\]

\[
|E| = k\frac{|q|}{r^2}
\]

\[
V = k\frac{q}{r}
\]

\[
U = k\frac{q_1 q_0}{r}
\]

**Gauss’ Law**

\[
\Phi = \frac{Q_{enclosed}}{\varepsilon_0}
\]

\[
\Phi = \vec{E} \cdot \vec{A} = EA \cos(\theta)
\]
Electric Potential and Electric Potential Energy

\[ V = Ed \]
\[ E = -\frac{\Delta V}{\Delta x} \]
\[ U = q_0 V \]
\[ \Delta U = q_0 \Delta V \]
\[ W = -\Delta U \]
\[ \frac{1}{2}m_e^2 + U_A = \frac{1}{2}m_e^2 + U_B \]

Capacitance

\[ C = \frac{Q}{V} \]
\[ C = \frac{\epsilon_0 A}{d} \]
\[ \epsilon = \frac{\epsilon_0}{\epsilon} \]
\[ U = \frac{1}{2}CV^2 \]
\[ U_{\text{volume}} = \frac{1}{2}\epsilon_0 E^2 \]