BRAC UNIVERSITY
Principles of Physics-II (PHY-112)
Department of Mathematics and Natural Sciences

Quiz: 02, **Section**: 30

Date: September 21, 2024

Duration: 30 Minutes | **Summer 2024 (10F-31C)** | Marks: 15

Name: Student ID:

Use SI Units only. Partial Marks will be given for partially correct answers ONLY.

1. You see an unknown charged particle move toward potential downhill in the presence of an external field. The charge contains— **(1)**
   ◯ positive charge ✓ ◯ negative charge ◯ no charge at all ◯ Need more information to comment
2. A planar-shaped equipotential surface would be a suitable Gaussian surface for a— **(1)**
   ◯ line charge ◯ point charge ◯ volume charge ◯ plane charge ✓
3. Which statement claims that the Electric Force is conservative? **(1)**
   ◯ $\oint \vec{E} \cdot d\vec{l} = 0$ ✓ ◯ $\vec{\nabla} \times \vec{E} = 0$ ✓ ◯ $\vec{\nabla} \cdot \vec{E} = 0$ ◯ $\oint \vec{E} \cdot d\vec{a} = 0$
4. Crossing two points of the same equipotential surface will give you— **(1)**
   ◯ always a constant $\vec{E}$ field ◯ no $\vec{E}$ field at all ✓ ◯ $\vec{E}$ field has nothing to do with potential surfaces ◯ $\vec{E}$ field opposite to your path of motion
5. The work done required to move an electron from one point to another point of the same equipotential surface is— **(1)**
   ◯ negative; work done on the system ◯ positive; work done by the system ◯ no work done at all ✓ ◯ undefined
6. Which way do electric field lines point, from high to low potential or from low to high? Explain. **(1)**
   Electric field lines point from regions of high electric potential to low electric potential, indicating the direction in which a positive test charge would move. This relationship can be expressed mathematically as $\vec{E} = -\nabla V$.
7. A charge q_1 is at a distance s from the negative plate of a parallel-plate capacitor (creates a constant electric field in between the plates). Another charge $q_2 = \frac{q_1}{3}$ is also at a distance s from the negative plate. What is the ratio $\frac{\Delta V_2}{\Delta V_1}$? **(2)**
   In case of a uniform electric field:
   $$\Delta V = Ed$$
   $$\Delta V_1 = Es$$
   $$\Delta V_2 = Es$$
   $$\frac{\Delta V_2}{\Delta V_1} = \frac{Es}{Es} = 1$$
8. An electron is released from rest at the center of a parallel-plate capacitor with a 1.0 mm spacing. The electron then strikes one of the plates with a speed of $1.5 \times 10^6\,\mathrm{m\,s^{-1}}$. What is the electric field strength inside the capacitor? **(4)**
   $$\Delta V = Ed$$
   $$\Delta KE = \frac{1}{2}mv^2$$
   $$\Delta KE = q\Delta V$$
   $$\frac{1}{2}mv^2 = qEd$$
   $$E = \frac{mv^2}{2qd}$$
   $$E = \frac{(9.11 \times 10^{-31}\,\mathrm{kg})(1.5 \times 10^6\,\mathrm{m/s})^2}{2(-1.6 \times 10^{-19}\,\mathrm{C})(1.0 \times 10^{-3}\,\mathrm{m})}$$
   $$E \approx 6.4 \times 10^3\,\mathrm{N/C}$$

9. An electric field of strength $15000\,\mathrm{N\,C^{-1}}$ is inside a parallel-plate capacitor of $1.5\,\mathrm{mm}$ spacing. An electron is released from the rest on the negative plate. What is the electron's speed when it reaches the positive plate? **(3)**

$$\begin{aligned}
\text{Electric potential difference:}\quad \Delta V &= Ed \\
\Delta V &= (15000)(1.5\times10^{-3}) = 22.5\,\mathrm{V} \\
\text{Change in kinetic energy:}\quad \Delta KE &= q\Delta V \\
\Delta KE &= (-1.6\times10^{-19})(22.5) = -3.6\times10^{-18}\,\mathrm{J} \\
\Delta KE &= \frac{1}{2}mv^2 \\
-3.6\times10^{-18} &= \frac{1}{2}(9.11\times10^{-31})v^2 \\
v^2 &= \frac{-2(-3.6\times10^{-18})}{9.11\times10^{-31}} \\
v^2 &\approx 7.91\times10^{12} \\
v &\approx \sqrt{7.91\times10^{12}} \approx 2.81\times10^{6}\,\mathrm{m/s}
\end{aligned}$$

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Name: Student ID:

Use SI Units only. Partial Marks will be given for partially correct answers ONLY.

1. You see an unknown charged particle move toward potential uphill in the presence of an external field. The charge contains— **(1)**
   ○ positive charge ○ negative charge ✓ ○ no charge at all ○ Need more information to comment
2. A cylindrical-shaped equipotential surface would be a suitable Gaussian surface for a— **(1)**
   ○ line charge ✓ ○ point charge ○ volume charge ○ plane charge
3. Which statement claims that the Electric Force is conservative? **(1)**
   ○ $\oint \vec{E} \cdot d\vec{l} = 0$ ✓ ○ $\vec{\nabla} \times \vec{E} = 0$ ✓ ○ $\vec{\nabla} \cdot \vec{E} = 0$ ○ $\oint \vec{E} \cdot d\vec{a} = 0$
4. Crossing (downhill) two equally spaced equipotential surfaces will give you— **(1)**
   ○ always a constant $\vec{E}$ field ✓ ○ no $\vec{E}$ field at all ○ $\vec{E}$ field has nothing to do with potential surfaces
   ○ $\vec{E}$ field opposite to your path of motion
5. The work done required to move a proton from one point to another point of the same equipotential surface is— **(1)**
   ○ negative; work done on the system ○ positive; work done by the system ○ no work done at all ✓
   ○ undefined
6. Which way do electric field lines point, from high to low potential or from low to high? Explain. **(1)**
   Electric field lines point from regions of high electric potential to low electric potential, indicating the direction in which a positive test charge would move. This relationship can be expressed mathematically as $\vec{E} = -\nabla V$.
7. A charge q_1 is at a distance s from the negative plate of a parallel-plate capacitor (creates a constant electric field in between the plates). Another charge $q_2 = \frac{q_1}{3}$ is also at a distance s from the negative plate. What is the ratio $\frac{\Delta V_1}{\Delta V_2}$ of their potential energies? **(2)**
   In case of a uniform electric field:
   $$\begin{aligned} \Delta V &= Ed \\ \Delta V_1 &= Es \\ \Delta V_2 &= Es \\ \frac{\Delta V_2}{\Delta V_1} &= \frac{Es}{Es} = 1 \end{aligned}$$
8. An electron is released from rest at the center of a parallel-plate capacitor with a 1.0 mm spacing. The electron then strikes one of the plates with a speed of $1.5 \times 10^6\ \mathrm{m\,s^{-1}}$. What is the electric field strength inside the capacitor? **(4)**
   $$\begin{aligned} \Delta V &= Ed \\ \Delta KE &= \frac{1}{2}mv^2 \\ \Delta KE &= q\Delta V \\ \frac{1}{2}mv^2 &= qEd \\ E &= \frac{mv^2}{2qd} \end{aligned}$$

$$E = \frac{(9.11 \times 10^{-31}\,\text{kg})(1.5 \times 10^{6}\,\text{m/s})^2}{2(-1.6 \times 10^{-19}\,\text{C})(1.0 \times 10^{-3}\,\text{m})}$$
$$E \approx 6.4 \times 10^{3}\,\text{N/C}$$

9. A proton is released from the rest on the positive plate of a parallel-plate capacitor. It crosses the capacitor and reaches the negative plate with a speed of $40\,\text{km}\,\text{s}^{-1}$. What will be the final speed of an electron released from rest at the negative plate?

(3)

Change in kinetic energy of the proton:

$$\Delta KE_p = \frac{1}{2} m_p v_p^2$$
$$\Delta KE_p = \frac{1}{2}(1.67 \times 10^{-27})(40 \times 10^{3})^2$$
$$\Delta KE_p \approx 1.34 \times 10^{-21}\,\text{J}$$

Electric potential difference: $\Delta V = \frac{\Delta KE_p}{q_p}$

$$\Delta V = \frac{1.34 \times 10^{-21}}{1.6 \times 10^{-19}} \approx 0.008375\,\text{V}$$

Change in kinetic energy of the electron:

$$\Delta KE_e = |q_e| \Delta V$$
$$\Delta KE_e = (1.6 \times 10^{-19})(0.008375) \approx 1.34 \times 10^{-21}\,\text{J}$$

Final speed of the electron:

$$\Delta KE_e = \frac{1}{2} m_e v_e^2$$
$$1.34 \times 10^{-21} = \frac{1}{2}(9.11 \times 10^{-31}) v_e^2$$
$$v_e^2 = \frac{2 \cdot 1.34 \times 10^{-21}}{9.11 \times 10^{-31}}$$
$$v_e^2 \approx 2.94 \times 10^{19}$$
$$v_e \approx \sqrt{2.94 \times 10^{19}} \approx 5.43 \times 10^{9}\,\text{m/s}$$