Kuwait University **Physics Department**

General Physics II **PHY 102**

Second Midterm Examination
Summer Semester 2025 - 2026

July 13, 2026
Time: 6:30 PM –8:00 PM

Name: ……………………………… Student No: …………………

Section No: ………………… Serial No: ………………….

Instructors: Drs. Abdul Mohsen, Alaa, Elias, Peter, & Yahya

Fundamental constants

$k = \dfrac{1}{4\pi\varepsilon_o} = 9.0\times10^{9}\ \mathrm{N.m^2/C^2}$	(Coulomb constant)
$\varepsilon_o = 8.85 \times 10^{-12}\ \mathrm{C^2/(N \cdot m^2)}$	(Permittivity of free space)
$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$	(Permeability of free space)
$\lvert e \rvert = 1.60 \times 10^{-19}\ \mathrm{C}$	(Elementary unit of charge)
$N_A = 6.02 \times 10^{23}$	(Avogadro's number)
$g = 9.8\ \mathrm{m/s^2}$	(Acceleration due to gravity)
$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	(Electron mass)
$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	(Proton mass)

Prefixes of units

$m = 10^{-3}$	$\mu = 10^{-6}$	$n = 10^{-9}$	$p = 10^{-12}$
$k = 10^{3}$	$M = 10^{6}$	$G = 10^{9}$	$T = 10^{12}$

For use by Instructors only

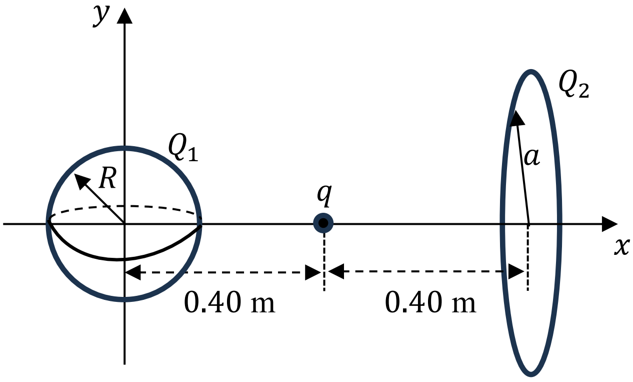
Problems	1	2	3	4	5	6	Questions	Total
Marks								

Instructions to the Students:

1. Mobile or other electronic devices are **strictly prohibited** during the exam.
2. Programmable calculators, which can store equations, are not allowed.
3. **Cheating incidents will be processed according to the university rules.**

PART I: Solve the following problems. Show your solutions in detail.

1. A conducting sphere of radius $R = 0.30$ m and charge $Q_1 = 60$ nC is centered at the origin, as shown. A point charge $q = -20$ nC is placed on the x-axis, as shown, and a uniformly charged ring of charge $Q_2 = -40$ nC and radius $a = 0.60$ m has its symmetry axis aligned with the x-axis. If $V = 0$ at infinity, find the electric potential at the origin. **[5 points]**



$V_{sphere} = k\frac{Q_1}{R} \Longrightarrow V_{sphere} = +1800$ V

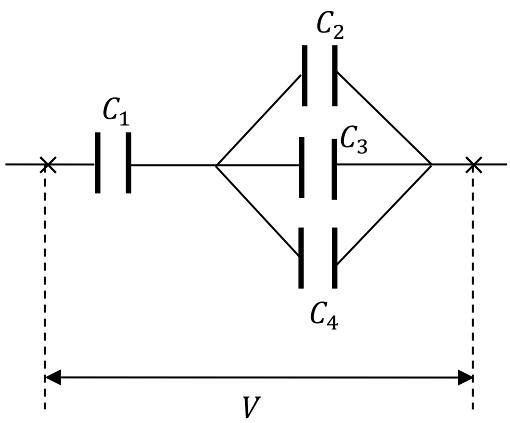
$V_q = k\frac{q}{0.40} \Longrightarrow V_q = -450$ V

$V_{ring} = k\frac{Q_2}{\sqrt{(0.80)^2+(0.60)^2}} \Longrightarrow V_{ring} = -360$ V

$V_{origin} = V_{sphere} + V_q + V_{ring}$

$V_{origin} = 990$ V

2. In the given network of capacitors, $C_1 = 7$ nF, $C_2 = 3$ nF, $C_3 = 6$ nF, and $C_4 = 9$ nF. The network of capacitors is charged by a potential difference V and the electric energy stored in the capacitor C_3 is 15 nJ. Find the electric charge stored on capacitor C_1. **[5 points]**



$U_3 = \frac{1}{2}C_3{V_3}^2 \Longrightarrow V_3 = \frac{2U_3}{C_3} \Longrightarrow V_3 = 2.236$ V

$V_3 = V_2 = V_4 = V_{234} \Longrightarrow V_{234} = 2.236$ V

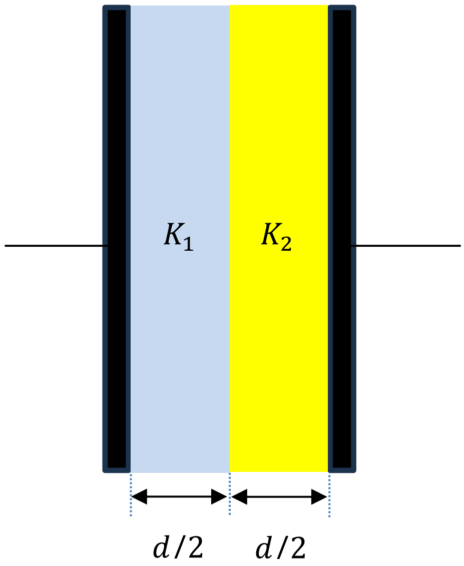
$C_{234} = C_2 + C_3 + C_4 \Longrightarrow C_{234} = 18$ nF

$C_{234} = \frac{Q_{234}}{V_{234}} \Longrightarrow Q_{234} = C_{234}V_{234} \Longrightarrow Q_{234} = 40.248$ nC

<u>Since Q_1 and Q_{234} in series:</u>

$Q_{234} = Q_1 \Longrightarrow Q_1 = 40.248$ nC

3. An air-filled parallel-plate capacitor with surface area A and plate separation d, has capacitance $C_0 = 30$ μF. Then, the capacitor is filled with two dielectric slabs of dielectric constants $K_1 = 5$ and $K_2 = 7$, filling each one of them the $1/2$ of the space between the plates, as shown. Calculate the capacitance of this capacitor. **[4 points]**



$C_0 = \varepsilon_0 \frac{A}{d}$

$C_1 = K_1 \varepsilon_0 \frac{A}{d/2} \Longrightarrow C_1 = 10C_0 \Longrightarrow C_1 = 300$ μF

$C_2 = K_2 \varepsilon_0 \frac{A}{d/2} \Longrightarrow C_2 = 14C_0 \Longrightarrow C_2 = 420$ μF

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} \Longrightarrow C_{eq} = 175$ μF

4. An electric current in a metallic wire varies with time as $I(t) = 20\,t - 0.005$ with electric current $I(t)$ in amperes and time t in seconds. Calculate the electric charge that passes through a cross section of the wire between time $t = 0$ s and $t = 1$ ms. **[4 points]**

$I(t) = \frac{dQ}{dt} \Longrightarrow dQ = I(t)dt$

$Q = \int_0^{1\times10^{-3}} I(t)dt$

$Q = \int_0^{1\times10^{-3}} (20t - 0.005)dt \Longrightarrow Q = 20\frac{t^2}{2}\Big|_0^{1\times10^{-3}} - 0.005\,t\Big|_0^{1\times10^{-3}}$

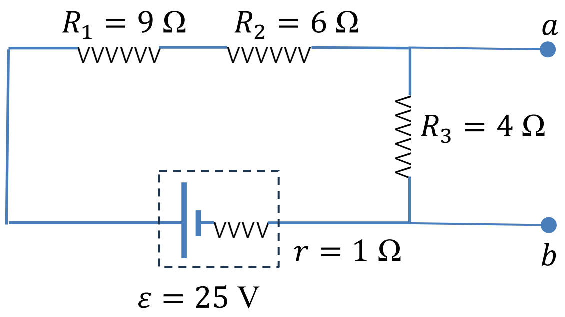
$Q = 5$ μC

5. In the circuit below, find the potential difference, V_{ab}, between points a and b. **[3 points]**

$R_{eq} = R_1 + R_2 + R_r + r \Longrightarrow R_{eq} = 20\ \Omega$

$I = \frac{\varepsilon}{R_{eq}} \Longrightarrow I = 1.25$ A

$V_{ab} = V_3 \Longrightarrow V_{ab} = IR_3 \Longrightarrow V_{ab} = 5$ V



6. In the circuit shown below, find the electric currents I_1 and I_2. **[5 Points]**

$I_3 = I_1 + I_2$

$\varepsilon_1 - 5I_3 - 10I_1 = 0$

$10 - 15I_1 - 5I_2 = 0$ (1)

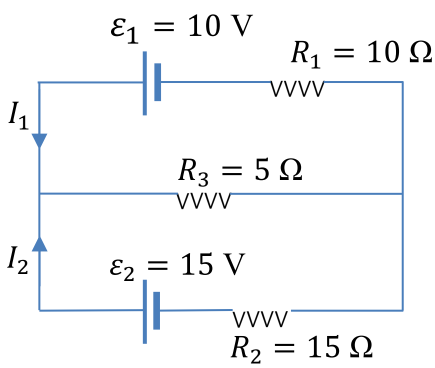
$\varepsilon_2 - 5I_3 - 15I_2 = 0$

$15 - 5I_1 - 20I_2 = 0$ (2)

<u>Multiply (2) with (-3):</u> $-45 + 15I_1 + 60I_2 = 0$ (3)

<u>Add (3) to (1):</u> $-35 + 55I_2 = 0 \Longrightarrow I_2 = 0.636$ A

(1) $\Longrightarrow 10 - 15I_1 - 5 \times 0.636 = 0 \Longrightarrow I_1 = 0.455$ A



<u>**PART II: Conceptual Questions (each carries 1 point). Circle the best answer:**</u>

1. Which statement is correct?

   a) The equipotential surfaces are always parallel to the electric field lines.
   b) The equipotential surfaces are always flat surfaces.
   c) The equipotential surfaces are always perpendicular to the electric field lines. **(ANSWER)**
   d) The equipotential surfaces are always at angle 45^o with the electric field lines.

2. A point charge $q < 0$ is released on the x-axis between points a and b and moves towards the point b. Therefore, the relation between the electric potential V_a at point a and the electric potential V_b at point b, is:

   a) $V_a = V_b$.
   b) $V_a > V_b$.
   c) $V_a < V_b$. **(ANSWER)**
   d) $V_a = V_b = 0$.

3. An air-filled parallel-plate capacitor with plate separation d, area A, and capacitance C_0 is charged by a battery V. The battery remains connected and a slab of dielectric material with dielectric constant K is inserted completely filling the space between the plates of the capacitor. Which statement is correct?

   a) The potential difference of the capacitor decreases by a factor of K.
   b) The potential difference of the capacitor increases by a factor of K.
   c) The electric potential energy decreases by a factor of K..
   d) The electric charge of the capacitor increases by a factor of K. **(ANSWER)**

4. An air-filled parallel-plate capacitor with plate separation d, area A, and capacitance C_0 is charged by a battery V. If the battery is disconnected and a slab of dielectric material with dielectric constant K is inserted completely filling the space between the plates of the capacitor, the energy density u

   a) decreases by a factor K. **(ANSWER)**
   b) increases by a factor K.
   c) decreases by a factor K^2.
   d) remains the same.

5. The negative charges in a metallic wire are moving in the $(-\hat{\jmath})$ direction. The electric current I and the current density J in the wire have directions:

a) I is to $(+\hat{\imath})$ and J is to $(+\hat{\imath})$.
b) I is to $(+\hat{\jmath})$ and J is to $(+\hat{\jmath})$. **(ANSWER)**
c) I is to $(+\hat{\imath})$ and J is to $(-\hat{\jmath})$.
d) I is to $(-\hat{\imath})$ and J is to $(+\hat{\jmath})$.

6. A loop in an electric circuit is

a) a point where three or more conductors (wires) meet.
b) any closed path in the circuit. **(ANSWER)**
c) any single path containing a circuit element between two junctions.
d) any closed path in the circuit that does not include an emf source.

7. Kirchhoff's loop rule follows from the fact that

a) the electrostatic force is conservative. **(ANSWER)**
b) the electric charge is conserved.
c) the electric potential is the same everywhere in a circuit.
d) the electric potential energy is the same everywhere in a circuit.

8. A junction in a circuit is

a) a closed conducting path.
b) a part of a closed conducting path
c) a point next to the source of emf.
d) a point where three or more conductors (wires) meet. **(ANSWER)**