Kuwait University — Physics Department

General Physics II — PHY 102

جامعة الكويت
KUWAIT UNIVERSITY

Second Midterm Examination
Spring Semester 2025 - 2026

April 18, 2026
Time: 3:30 PM – 5:00 PM

Name: …… Student No: ……

Section No: …… Serial No: ……

Instructors: Drs. Abdullah, Ali, Al-Mumin, Lajko, Sharma, & Vagenas

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Fundamental constants

$k = \frac{1}{4\pi\varepsilon_o} = 9.0\times10^{9}\ \text{N.m}^2/\text{C}^2$ (Coulomb constant)

$\varepsilon_o = 8.85 \times 10^{-12}\ \text{C}^2/(\text{N}\cdot\text{m}^2)$ (Permittivity of free space)

$\mu_0 = 4\pi \times 10^{-7}\ \text{T}\cdot\text{m/A}$ (Permeability of free space)

$|e| = 1.60 \times 10^{-19}\ \text{C}$ (Elementary unit of charge)

$N_A = 6.02 \times 10^{23}$ (Avogadro's number)

$g = 9.8\ \text{m/s}^2$ (Acceleration due to gravity)

$m_e = 9.11 \times 10^{-31}\ \text{kg}$ (Electron mass)

$m_p = 1.67 \times 10^{-27}\ \text{kg}$ (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.**

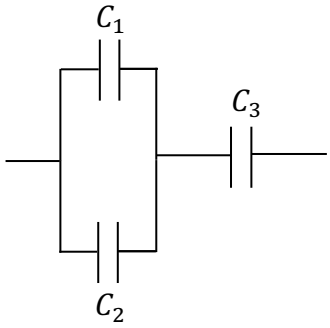
PART I: Solve the following problems. Show your solutions in detail.

1. In the given network of capacitors, $C_1 = 5$ nF and $C_2 = 15$ nF. The total electric energy stored in the network is 32 nJ, and the total electric charge is 16 nC. Find the capacitance C_3. **[4 points]**

$$U_{total} = \frac{1}{2}\frac{{Q_{total}}^2}{C_{eq}} \Longrightarrow C_{eq} = 4 \text{ nF}$$

$$C_{12} = C_1 + C_2 \Longrightarrow C_{12} = 20 \text{ nF}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_{12}} + \frac{1}{C_3} \Longrightarrow C_3 = 5 \text{ nF}$$



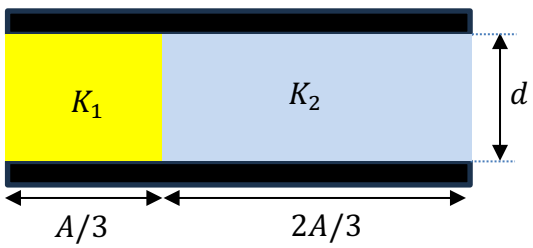
2. An air-filled parallel-plate capacitor with surface area A and plate separation d, has capacitance $C_0 = 15$ nF. Then, the capacitor is filled with a dielectric slab of dielectric constant $K_1 = 3$ filling $1/3$ of the space between the plates, and a slab of dielectric constant $K_2 = 5$ filling $2/3$ of the space between the plates, as shown. Calculate the capacitance of this capacitor. **[3 points]**

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

$$C_1 = K_1 \varepsilon_0 \frac{A/3}{d} \Longrightarrow C_1 = C_0 \Longrightarrow C_1 = 15 \text{ nF}$$

$$C_2 = K_2 \varepsilon_0 \frac{2A/3}{d} \Longrightarrow C_2 = \frac{10}{3} C_0 \Longrightarrow C_2 = 50 \text{ nF}$$

$$C_{eq} = C_1 + C_2 \Longrightarrow C_{eq} = 65 \text{ nF}$$



3. A cylindrical aluminum wire with length $L = 5$ cm is connected to a battery which produces an electric field of magnitude E. The aluminum has resistivity $\rho = 2.75 \times 10^{-8}$ Ω·m and concentration of moving charges is $n = 1.81 \times 10^{29}$ m^{-3}. The average travel time of the electrons along the length of the wire is 4.5 mins. Find the magnitude of the electric field E. **[3 points]**

$v_d = \frac{L}{\Delta t} \Longrightarrow v_d = 1.85 \times 10^{-4}$ m/s

$J = nqv_d \Longrightarrow J = 5.36 \times 10^{6}$ A/m^2

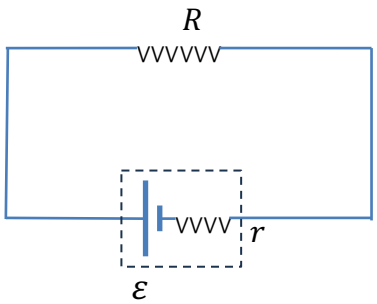
$E = \rho J \Rightarrow E = 0.15$ V/m

4. In the circuit below, the **terminal voltage** across the battery is 15 V. The power dissipated on resistor R is 25 W. The internal resistance of the battery is 0.6 Ω. Calculate the electromotive force ε of the battery. **[3 points]**

$P_R = \frac{V_{term}^2}{R} \Longrightarrow R = \frac{V_{term}^2}{P_R} \Longrightarrow R = 9\ \Omega$

$I = \frac{V_{term}}{R} \Longrightarrow I = 1.67$ A

$V_{term} = \varepsilon - Ir \Longrightarrow \varepsilon = V_{term} + Ir \Longrightarrow \varepsilon = 16$ V



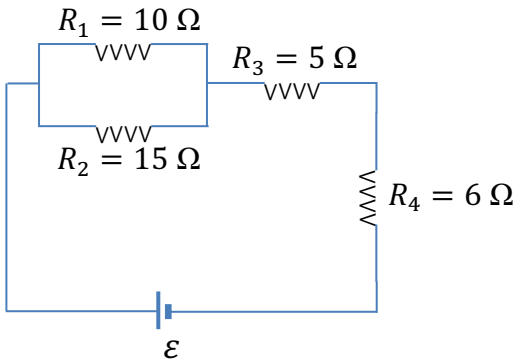
5. In the circuit shown below, the electric current through resistor R_4 is 2 A. Find the power dissipated on resistor R_1. **[4 Points]**

$I = I_4 = 2$ A

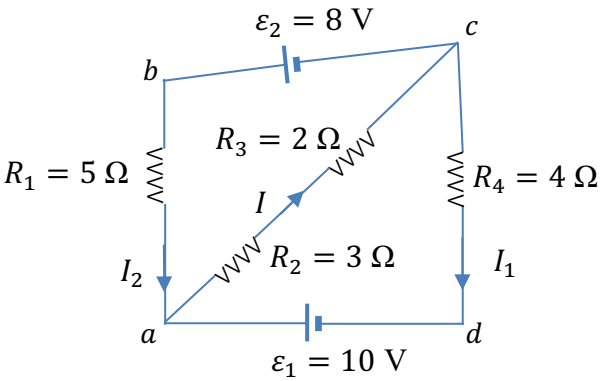
$\frac{1}{R_{12}} = \frac{1}{R_1} + \frac{1}{R_2} \Longrightarrow R_{12} = 6\ \Omega$

$V_{12} = IR_{12} \Longrightarrow V_{12} = 12$ V

$P_1 = \frac{(V_{12})^2}{R_1} \Longrightarrow P_1 = 14.4$ W



6. Find the electric currents I_1, I_2, I, and the potential difference V_{ac} in the circuit below. **[5 Points]**



Junction rule: $I = I_1 + I_2$ (1)

Loop rules:

Upper loop (acba)

$8 + 5I_2 - 3I - 2I = 0 \Longrightarrow$

$8 - 5I_1 - 10I_2 = 0$ (2)

Big loop (abcda)

$10 + 5I_2 - 8 - 4I_1 = 0 \Longrightarrow 2 - 4I_1 + 5I_2 = 0$ (3)

Multiply (2) with 4 and (3) with (-5), then subtract them.

$I_1 = 0.923$ A (4)

From (3), we get:

$I_2 = 0.338$ A

From (1), we get:

$I = 1.261$ A

$V_a - 5I = V_c \Longrightarrow V_{ac} = 6.31$ V

PART II: Conceptual Questions (each carries 1 point). Tick the best answer:

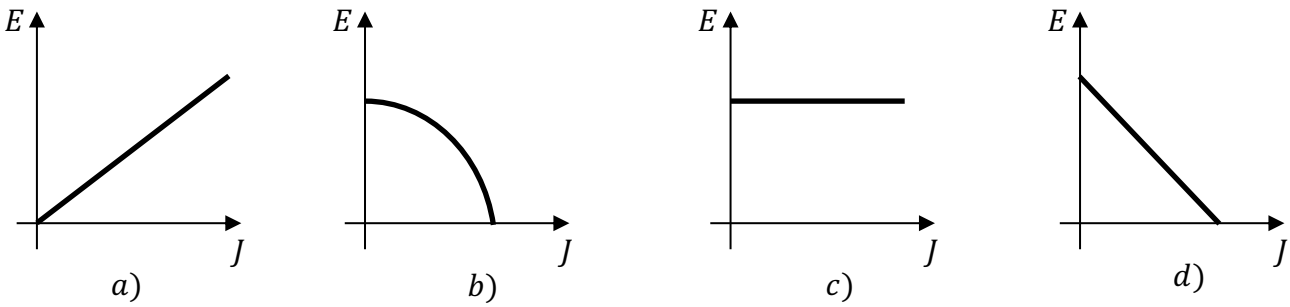
1. Which statement is correct?

   a) The capacitor is a device that stores electric current and electric potential energy.
   b) The capacitor is a device that stores electric charge and electric potential energy. **(ANSWER)**
   c) The capacitor is a device that stores electric charge and electric current.
   d) The capacitor is a device that absorbs electric charge and electric potential energy.

2. An air-filled parallel-plate capacitor with plate separation d, area A, and capacitance C is charged by a battery V. Then the battery is disconnected and a slab of dielectric material is inserted completely filling the space between the plates of the capacitor. The electric potential energy of the capacitor will

   a) remain the same.
   b) increase.
   c) decrease. **(ANSWER)**
   d) be zero.

3. Which diagram shows the magnitude of the electric field versus the current density (E *vs* J) of a metallic wire?



(ANSWER)

4. The Kirchhoff 's junction rule is a consequence of the
   a) conservation of electric potential energy.
   b) conservation of electric charge. **(ANSWER)**
   c) conservation of mechanical energy.
   d) conservation of momentum.

5. Applying the Kirchhoff's loop rule in a closed loop, we must travel the closed loop

   a) only clockwise
   b) only counter-clockwise
   c) either clockwise or counter-clockwise. **(ANSWER)**
   d) based on the polarity of the source of emf.

6. In a network of resistors, there are 10 identical resistors of resistance R each one of them. The total resistance of this network is maximized when

   a) all the 10 resistors are connected in parallel.
   b) 5 resistors in series followed by 5 resistors in parallel.
   c) all the 10 resistors are connected in series. **(ANSWER)**
   d) none of the above.