Kuwait University | **Physics Department**

General Physics II | **PHY 102**

جامعة الكويت
KUWAIT UNIVERSITY

Final Examination
Summer Semester 2025 – 2026

July 27, 2026
Time: 6:00 – 8:00 PM

Name: …………………………………… Student ID: ………..………………

Sec. No: ……………………………..… Serial No: …………………………..…

Instructors: Drs. Abdulmuhsen, 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)

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

$|e| = 1.60 \times 10^{-19}\ \mathrm{C}$ (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

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

For use by Instructors only

Problems	1	2	3	4	5	6	7	8	**Questions**	**Total**
Marks										

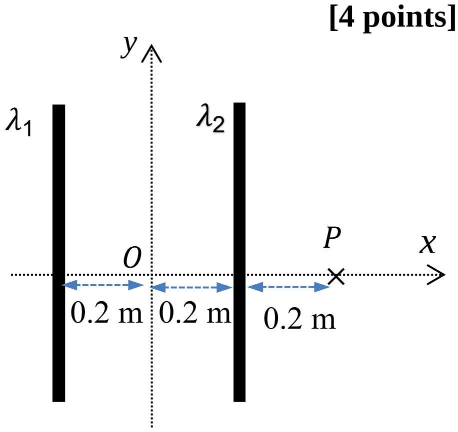
Instructions to the Students:

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. Two very long uniformly charged lines with linear charge densities $\lambda_1 = 9\ \mathrm{nC/m}$ and $\lambda_2 = -9\ \mathrm{nC/m}$ are fixed perpendicular to the x-axis, as shown. If a point charge q is placed at the origin, O, the net electric force acting on it is $\vec{F} = -(2\ N)\hat{\imath}$. Calculate the net electric force acting on charge q when it is at point P.

[4 points]



$$\vec{F}_{net,O} = q\vec{E}_{net,O} = q\left(\frac{|\lambda_1|}{2\pi\varepsilon_0 0.2\mathrm{m}} + \frac{|\lambda_2|}{2\pi\varepsilon_0 0.2\mathrm{m}}\right)\hat{\imath}$$

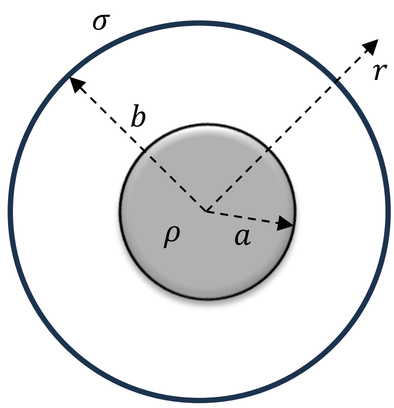
$$q\,\frac{|\lambda_1|}{2\pi\varepsilon_0}\left(\frac{1}{0.2\mathrm{m}} + \frac{1}{0.2\mathrm{m}}\right)\hat{\imath} = -(2\ \mathrm{N})\hat{\imath} \implies q = -1.24\times 10^{-3} C$$

$$\vec{F}_{net,P} = q\vec{E}_{net,P} = q\,\frac{|\lambda_1|}{2\pi\varepsilon_0}\left(\frac{1}{0.6\mathrm{m}} - \frac{1}{0.2\mathrm{m}}\right)\hat{\imath} =$$

$$= -(2\ \mathrm{N})\left(\frac{1}{10}\right)\left(\frac{1}{0.6} - \frac{1}{0.2}\right)\hat{\imath} = (0.67\ \mathrm{N})\hat{\imath}$$

2. A sphere of radius $a = 5$ cm with a uniform volume charge density $\rho = -6\ \mu\mathrm{C/m^3}$ is inside a concentric thin conducting spherical shell of radius $b = 10$ cm with uniform surface charge density $\sigma = 12\ \mathrm{nC/m^2}$. Calculate the magnitude and direction of the net electric field $\vec{E}$ at distance $r = 14$ cm from the center.

[4 points]



Gauss's Law: $\oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\varepsilon_0} \Rightarrow$

$$\pm E(4\pi r^2) = \frac{Q_{encl}}{\varepsilon_0}$$

(The sign of the LHS is the same as the sign of the yet unknown Q_{encl}.)

$$Q_{encl} = \rho\frac{4\pi}{3}a^3 + \sigma 4\pi b^2 = -1.63\ \mathrm{nC}$$

$$-E = \frac{Q_{encl}}{\varepsilon_0 4\pi r^2} = -750\ \ \mathrm{N/C},$$

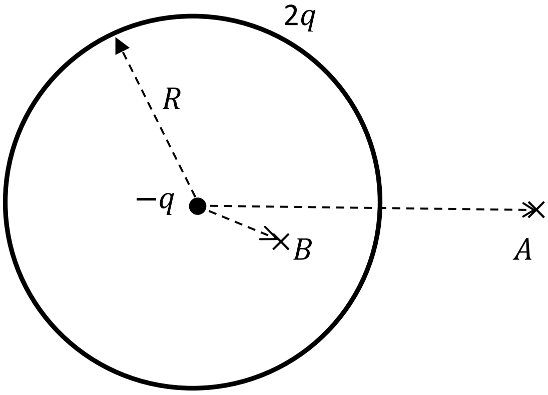
$$E = 750\ \ \mathrm{N/C};\quad \text{inward}$$

3. A spherical surface of radius $R = 1.0$ m has charge $2q$ uniformly distributed on it and a point charge $-q$ is fixed at its centre. If $V = 0$ at infinity, the electric potential at point A is 480 V. Point A is at distance $r_A = 1.5$ m from the centre and point B is at distance $r_B = 0.8$ m. What is the electric potential at point B? **[4 points]**

$$V_A = V_{-q,A} + V_{2q,A} \Longrightarrow 480 \text{ V} = k\frac{-q}{r_A} + k\frac{2q}{r_A} \Rightarrow$$

$$q = 80 \text{ nC}$$

$$V_B = V_{-qB} + V_{2qB} = k\frac{-q}{r_B} + k\frac{2q}{R} = 540 \text{ V}$$



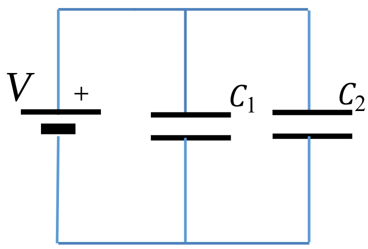
4. Two air-filled capacitors, $C_1 = C_2$, are connected to a battery, $V = 24$ V, as shown, so the energy stored in the two capacitors is 80 μJ. Then, we fully fill the space between the plates of only C_2 with a dielectric material of dielectric constant K, so the final energy stored in the two capacitors will be 240 μJ. Find the value of K. **[4 points]**

$$C_{eq} = C_1 + C_2 = 2C_1$$

$$U_{in} = \frac{C_{eq}V^2}{2} = 80 \text{ μJ}$$

$$U_{fin} = \frac{(C_1 + KC_1)V^2}{2} = 240 \text{ μJ} \Rightarrow$$

$$C_1 + KC_1 = 3(C_1 + C_1) \Rightarrow K = 5$$



5. A cylindrical metal wire has length $L = 4$ m, radius $r = 0.3$ mm and a potential difference $V = 40$ V is applied between its ends. If the resistivity of the wire is 18.7×10^{-8} Ω·m, and the concentration of the free electrons is 8.5×10^{28} /m^3, how much time is required for an electron to travel the length of the wire? **[4 points]**

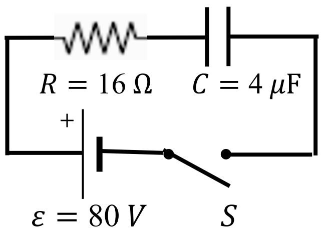
$$E = \frac{V}{L} = 10\ \text{V}/m$$

$$\rho = \frac{E}{J} \Rightarrow J = \frac{E}{\rho} = 5.3 \times 10^7 \text{A/m}^2$$

$$J = nqv_d = nq\frac{L}{t} \Longrightarrow$$

$$t = nq\frac{L}{J} = 1017\ s$$

6. In the circuit below, initially the capacitor is uncharged and the switch S is closed at time $t = 0$ s. Find the current I in the circuit at time t_1 at which the energy stored in the capacitor is $\frac{4}{9}$ of its final value. **[5 points]**



$$Q(t) = \varepsilon C\left[1 - e^{-\frac{t}{RC}}\right] \quad \Rightarrow \quad U(t) = \frac{Q^2}{2C} = \frac{(\varepsilon C)^2\left[1-e^{-\frac{t}{RC}}\right]^2}{2C}$$

$$U(\infty) = \frac{(\varepsilon C)^2}{2C} \qquad \Rightarrow \frac{4}{9} = \left[1 - e^{-\frac{t_1}{RC}}\right]^2$$

$$e^{-\frac{t_1}{RC}} = \frac{1}{3}$$

$$I(t) = \frac{dQ(t)}{dt} = \frac{\varepsilon}{R}e^{-\frac{t}{RC}}$$

$$I(t_1) = \frac{\varepsilon}{R}\frac{1}{3} = 1.67\ \text{A}$$

7. A proton moves momentarily with a velocity of $\vec{v} = \left(4 \times 10^5 \frac{\text{m}}{\text{s}}\right)\hat{\imath} + \left(8 \times 10^5 \frac{\text{m}}{\text{s}}\right)\hat{\jmath} + (3 \times 10^5 \frac{\text{m}}{\text{s}})\hat{k}$ in a uniform magnetic field $\vec{B} = B_y\hat{\jmath}$. If the radius of the helical path is $R = 0.06$ m, what is the magnitude of B_y? **[3 points]**

$$v_\perp = \sqrt{v_x^2 + v_z^2} = 5 \times 10^5 \frac{\text{m}}{\text{s}}$$

$$R = \frac{mv_\perp}{|q|B_y} = 0.06\ m \Rightarrow B_y = \frac{mv_\perp}{|q|R} = 0.087\ \text{T}$$

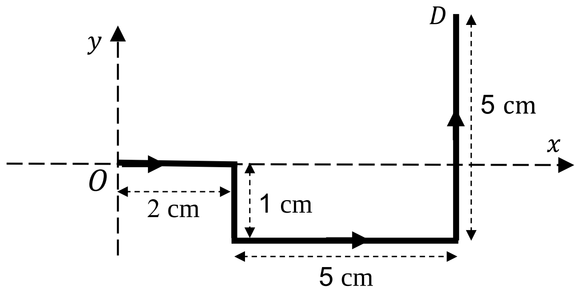
8. A 4-A current flows in the wire from point O to point D, as shown. Calculate the magnetic force vector acting on the wire by a uniform magnetic field $\vec{B} = (6\ \text{T})\hat{\imath} + (4\ \text{T})\hat{\jmath}$. **[4 points]**

$$\vec{L}_{eff} = (0.07\ \text{m})\hat{\imath} + (0.04\ \text{m})\,\hat{\jmath}$$

$$\vec{F}_B = I\vec{L}_{eff} \times \vec{B} =$$

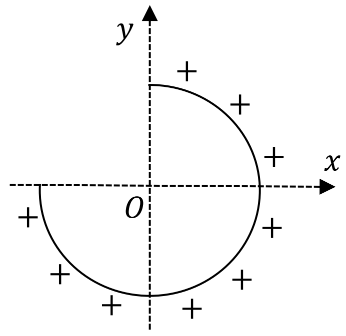
$$= 4A[(0.07\ \text{m})\hat{\imath} + (0.04\ \text{m})\,\hat{\jmath}] \times [(6\ T)\hat{\imath} + (4\ T)\hat{\jmath}]$$

$$= (1.12\ \text{N})\hat{k} - (0.96\ \text{N})\hat{k} = (0.16\ \ \text{N})\hat{k}$$



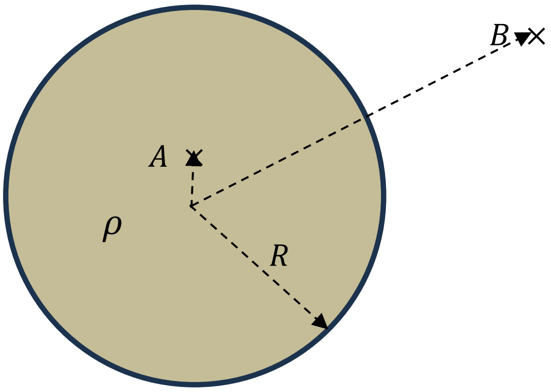
PART II: Conceptual Questions (each carries 1 point). Tick the best answer:

1. The circular arc in the figure is uniformly charged as shown. The direction of the net electric field at the origin is



   a) $+\hat{\imath}+\hat{\jmath}$.
   b) $-\hat{\imath}-\hat{\jmath}$.
   c) $+\hat{\imath}-\hat{\jmath}$.
   d) $-\hat{\imath}+\hat{\jmath}$. ⇐

2. A uniformly charged insulating sphere has radius R. Point A is at distance $R/4$, and point B is at distance $2R$ from the centre. Which relation is correct for the magnitude of electric fields at these points?

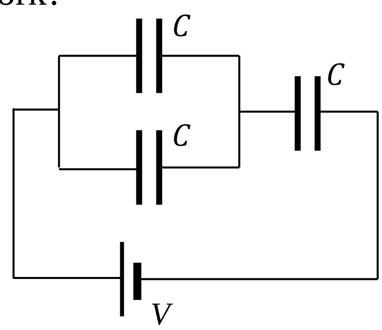


   a) $E_A > E_B$.
   b) $E_A < E_B$.
   c) $E_A = E_B$. ⇐
   d) If $\rho < 0$, $E_A > E_B$; otherwise $E_A < E_B$.

3. Two systems of charges A and B are made of identical magnitude of charges q, as shown. If the total potential energy of system A is U, the total potential energy of system B is

   a) U.
   b) $-U$. ⇐
   c) $3U$.
   d) $-3U$.

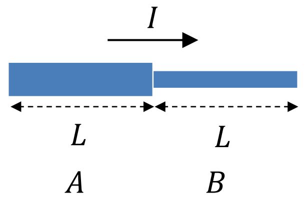
4. Three identical capacitors are connected into a network as shown. Which statement is correct for the equivalent capacitance, C_{eq}, of the network?



   a) $C_{eq} < C$. ⇐
   b) $C_{eq} > C$.
   c) $C_{eq} = C$.
   d) There is not enough information to decide.

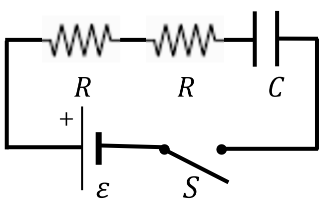
5. Cylindrical wire A has length L, radius $2r$. Cylindrical wire B is made of the same material, and has length L, radius r. These wires are welded together at their ends and a current I flows in them as shown. The magnitude of electric field in wire B is

a) larger than in wire A. $\Leftarrow$
b) smaller than in wire A.
c) the same as in wire A.
d) zero.



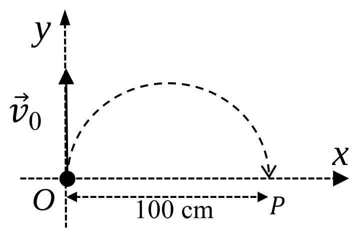
6. In the R-C circuit below the capacitor is originally uncharged and the switch S is closed at time $t = 0$ s. The initial current in the circuit is

a) $I_0 = \frac{\varepsilon}{R}$.
b) $I_0 = \frac{2\varepsilon}{R}$
c) $I_0 = \frac{\varepsilon}{2R}$. $\Leftarrow$
d) 0.



7. At point O, a proton has a velocity $\vec{v}_0 = v_0\hat{j}$. Find the direction of the uniform magnetic field that will make the proton to move on a semi-circular path from point O to point P

a) $\hat{j}$.
b) $\hat{k}$. $\Leftarrow$
c) $-\hat{k}$.
d) $-\hat{\imath}$.



8. In a velocity selector the magnitude of the uniform electric field is E and the magnitude of the uniform magnetic field is B. If a charged particle moves through the region of perpendicular magnetic and electric fields along a straight line, it has a speed of

a) $v = \frac{B}{E}$.
b) $v = \frac{E}{B}$. $\Leftarrow$
c) $v = \frac{B^2}{E^2}$.
d) $v = 0$.