Kuwait University **Physics Department**

General Physics II **PHY 102**

جامعة الكويت
KUWAIT UNIVERSITY

Final Examination
Fall Semester 2025 – 2026

December 28, 2025
Time: 6:00 – 8:00 PM

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

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

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

Fundamental constants

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

$\varepsilon_o = 8.85\times10^{-12}\ \text{C}^2/(\text{N}\cdot\text{m}^2)$ (Permittivity of free space)

$\mu_0 = 4\pi\times10^{-7}\ \text{T.m/A}$ (Permeability of free space)

$|e| = 1.60\times10^{-19}\ \text{C}$ (Elementary unit of charge)

$N_A = 6.02\times10^{23}$ (Avogadro's number)

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

$m_e = 9.11\times10^{-31}\ \text{kg}$ (Electron mass)

$m_p = 1.67\times10^{-27}\ \text{kg}$ (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

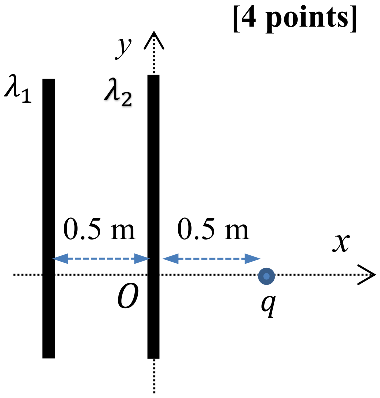
Problems	1	2	3	4	5	6	7	8	9	10	**Questions**	**Total**
Marks												

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 $\lambda_1 = -12$ μC/m, $\lambda_2 = 18$ μC/m are placed parallel with the y-axis, as shown. A particle of charge $q = -4$ μC and mass $m = 4 \times 10^{-3}$kg is released on the x-axis as shown. Calculate the acceleration vector $\vec{a}$ of q. **[4 points]**

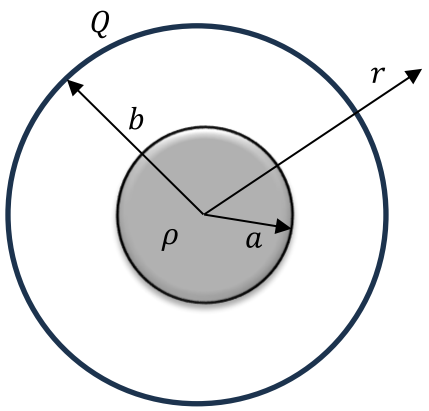


$$\vec{E} = \frac{\lambda_1}{2\pi\varepsilon_0 1m}\hat{\imath} + \frac{\lambda_2}{2\pi\varepsilon_0 0.5m}\hat{\imath} = 4.32 \times 10^5\ \frac{\text{N}}{\text{C}}\hat{\imath}$$

$$\vec{F} = q\vec{E} = -(1.73\text{ N})\hat{\imath}$$

$$\vec{a} = \frac{\vec{F}}{m} = -(432.5\frac{m}{s^2})\hat{\imath}$$

2. A sphere of radius $a = 5$ cm with a uniform volume charge density $\rho = -3\ \mu\text{C/m}^3$ is inside a concentric thin conducting spherical shell of radius $b = 10$ cm and charge Q = 1.26 nC. Calculate the magnitude and direction of the net electric field $\vec{E}$ at $r = 12$ cm. **[3 points]**

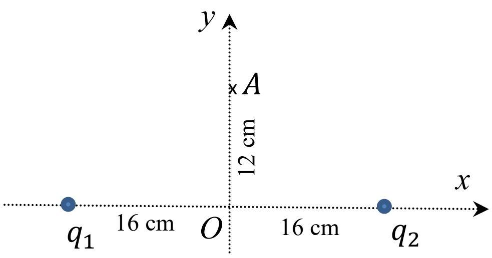


Gauss's Law: $\oint \vec{E} \cdot d\vec{A} = \frac{Q_{encl}}{\varepsilon_0} \Rightarrow E(4\pi r^2) = \frac{Q_{encl}}{\varepsilon_0}$

$$Q_{encl} = \rho\frac{4\pi}{3}a^3 + Q = -0.311\text{ nC}$$

$$E = \frac{Q_{encl}}{\varepsilon_0 4\pi r^2} = -194.2\ \text{ N/C},\quad \text{inward}$$

3. Two charges $q_1 = q_2 = 12\ \mu\text{C}$ are fixed on the x-axis, as shown. A third charge $q_3 = -4\ \mu\text{C}$ with mass $m = 0.05$ kg is released from rest at point A. Calculate the speed of q_3 at point O. **[3 points]**



Mechanical Energy conservation:

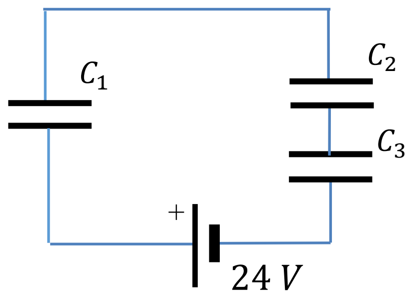
$$U_{q_3}^{A} = U_{q_3}^{O} + K_{q_3}^{O} = U_{q_3}^{O} + \frac{m}{2}v^2$$

$$U_{q_3}^{A} = q_3(V_A^1 + V_A^2) = q_3\left(k\frac{q_1}{0.2\ \text{m}} + k\frac{q_2}{0.2\ \text{m}}\right) = -4.32\ \text{J}$$

$$U_{q_3}^{O} = q_3(V_O^1 + V_O^2) = q_3\left(k\frac{q_1}{0.16\text{m}} + k\frac{q_2}{0.16\text{m}}\right) = -5.4\ \text{J}$$

$$U_{q_3}^{A} - U_{q_3}^{O} = \frac{m}{2}v^2 \Rightarrow v = 6.57\ \text{m/s}$$

4. A network of capacitors $C_1 = 4\ \mu\text{F}$, $C_2 = 6\ \mu\text{F}$, and $C_3 = 12\ \mu\text{F}$, is charged by a battery, as shown. Determine the potential difference across C_2. **[3 points]**

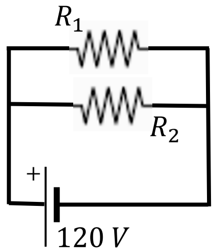


$$C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)^{-1} = 2\ \mu\text{F}$$

$Q = C_{eq}V = 48\ \mu\text{C}$ $\quad Q_2 = Q$

so $V_2 = \frac{Q}{C_2} = 8\ \text{V}$

5. Two resistors, $R_1 = 20\ \Omega$ and R_2, are connected across a 120-V emf device as shown so that 16 A current flows through the emf device. What is the value of R_2? **[3 points]**

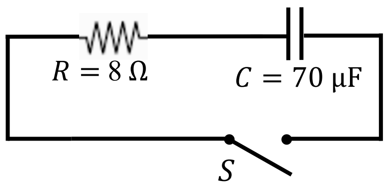


$$R_{eq} = \frac{V}{I} = 7.5\ \Omega$$

$$R_{eq} = \frac{R_1 \cdot R_2}{R_1 + R_2} \Longrightarrow R_2 = 12\ \Omega$$

6. In the circuit below, the capacitor has an initial charge $Q_0 = 400\ \mu C$. The switch S is closed at $t = 0$. Calculate the current in the circuit at the time when the energy stored in the capacitor is $\frac{1}{9}$ of its initial value.

[4 points]



$$q(t) = Q_0 e^{-\frac{t}{RC}} \Rightarrow U = \frac{Q_0^2 (e^{-\frac{t}{RC}})^2}{2C} = U_0 e^{-\frac{2t}{RC}}$$

$$\frac{U_0}{9} = U_0 e^{-2t_1/RC} \Rightarrow e^{-t_1/RC} = \frac{1}{3}$$

$$\Rightarrow I = -\frac{dq}{dt} = \frac{Q_0}{RC} e^{-t_1/RC}$$

$$I = \frac{Q_0}{RC} e^{-\frac{t_1}{RC}} = \frac{Q_0}{RC} \frac{1}{3} = 0.24\ \text{A}$$

7. A particle of charge $q = 4$ C enters a region of uniform electric and uniform magnetic fields with initial velocity $\vec{v} = (6 \text{ m/s})\hat{\imath}$. The uniform magnetic field is $\vec{B} = (0.5 \text{ T})\hat{\imath} + (2.0 \text{ T})\hat{\jmath}$ and the net initial force on the particle is $\vec{F} = (12 \text{ N})\hat{\imath} + (16 \text{ N})\hat{k}$. Find the uniform electric field $\vec{E}$. **[3 points]**

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B} \Rightarrow \vec{E} = \frac{\vec{F} - q\vec{v} \times \vec{B}}{q}$$

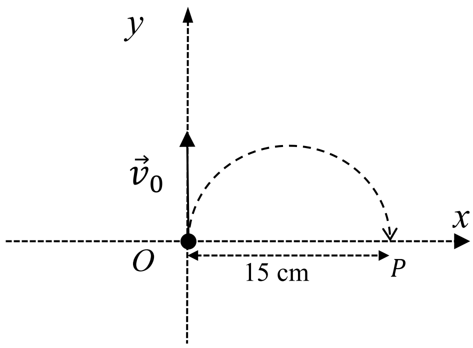
$$\vec{E} = \left(3 \frac{\text{N}}{\text{C}}\right)\hat{\imath} - (8 \frac{\text{N}}{\text{C}})\hat{k}$$

8. An electron at point O has a velocity $\vec{v}_0 = (1.6 \times 10^6 \frac{\text{m}}{\text{s}})\hat{\jmath}$. Find the magnitude and the direction of the magnetic field that will cause the electron to follow the semi-circular path from O to P. **[3 points]**

$$R = \frac{0.15 \text{ m}}{2} = 0.075 \text{ m}$$

$$R = \frac{mv_\perp}{|q|B} \Rightarrow B = \frac{mv_\perp}{|q|R} = 1.21 \times 10^{-4} \text{T}$$

Direction is into the page or $-\hat{k}$.

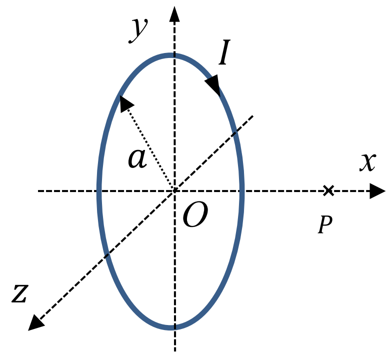


9. A circular current loop centred at the origin has radius $a = 10$ cm and current $I = 5$ A. The symmetry axis of the loop is the x-axis. If at point P, shown in the figure, the magnitude of the magnetic field is $\frac{1}{2}$ of that at the origin, find the distance of point P from the origin. **[3 points]**

$$B_P = \frac{1}{2} B_O$$

$$\frac{\mu_0 I a^2}{2(x^2+a^2)^{3/2}} = \frac{1}{2}\frac{\mu_0 I a^2}{2a^3}$$

$$x = 0.0766 \text{ m}$$



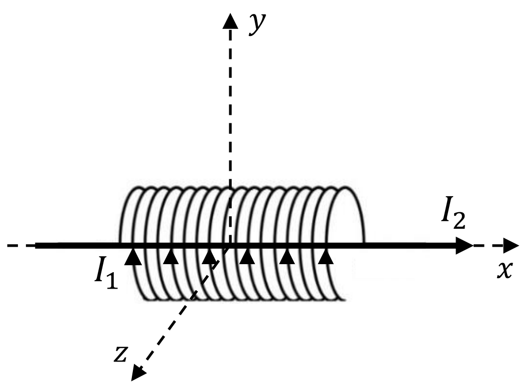
10. A 2-m long solenoid has 3000 turns, radius 6 cm, and current $I_1 = 20$ mA. The solenoid is placed on the x-axis, as shown. A very long straight wire is inserted along the x-axis with current $I_2 = 6\,A$. Find the magnitude of the net magnetic field at 2 cm distance from the origin on the $+y$-axis. **[3 points]**

$$\vec{B}_1 = -\mu_0 n I_1 \hat{\imath} = -(3.77 \times 10^{-5}\text{T})\hat{\imath}$$

$$\vec{B}_2 = \frac{\mu_0 I_2}{2\pi d}\hat{k} = (6 \times 10^{-5}\text{T})\hat{k}$$

$$\vec{B} = \vec{B}_1 + \vec{B}_2$$

$$B = \sqrt{B_1^2 + B_2^2} = 7.09 \times 10^{-5}\text{T}$$

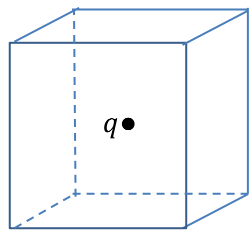


PART II: Conceptual Questions (each carries 1 point). Tick the best answer:

1. If two charged particles, with q charge on each, are separated by a distance d, the magnitude of the force between them is F. What is the magnitude of the force between them if each charge is doubled and the separation changes to $d/2$?

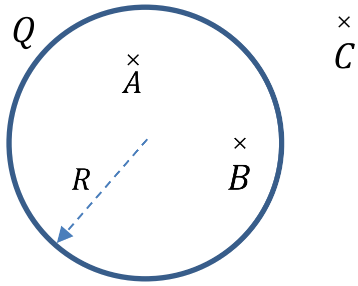
a) F.
b) $4F$.
c) $16F$. ⇐
d) $F/4$.

2. A point charge q is placed at the centre of a cube, as shown. What is the electric flux through one face of the cube?



a) $\frac{q}{\varepsilon_0}$.
b) $\frac{q}{2\varepsilon_0}$.
c) $\frac{q}{3\varepsilon_0}$.
d) $\frac{q}{6\varepsilon_0}$. ⇐

3. A conducting sphere with charge $Q > 0$ has radius R. At the points $A, B,$ and C the electric potential is $V_A, V_B,$ and V_C, respectively. Which relation is correct?



a) $V_A = V_C$.
b) $V_B = V_C$.
c) $V_A < V_C$.
d) $V_B > V_C$. ⇐

4. If N identical capacitors, each have capacitance C, are connected in series. The equivalent capacitance of this network is

a) C/N. ⇐
b) NC.
c) N^2C.
d) C.

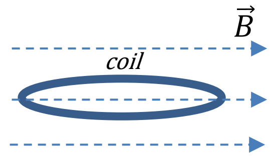
5. If a current through a resistor is increased by a factor of 2, the dissipated power

a) decreases by a factor of 2.
b) increases by a factor of 2.
c) decreases by a factor of 4.
d) increases by a factor of 4.

6. In an *R*-*C* circuit after the switch is closed at time $t = 0$, the current will be $\frac{1}{e}$ of its initial value at $t_1 = \tau$. The current will be $\frac{1}{e^2}$ of its initial value at

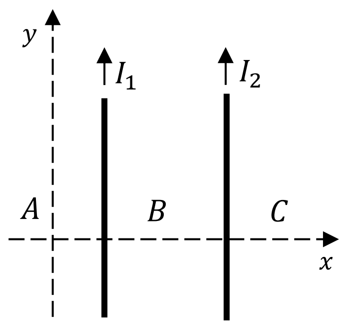
a) $t_2 = \tau/2$.
b) $t_2 = 2\tau$.
c) $t_2 = \tau^2$.
d) $t_2 = 2\tau^2$.

7. A coil is placed in a magnetic field so that the plane of the coil is parallel to the direction of the magnetic field. The magnitude of the magnetic flux through the coil can be changed



a) by changing the magnitude of the magnetic field.
b) by changing the area of the coil.
c) by changing the angle between the direction of the magnetic field and the plane of the coil.
d) by reversing the magnetic field direction suddenly without changing its magnitude.

8. Two parallel wires carrying currents I_1, and I_2 are in the xy-plane as shown. On the x-axis, the magnitude of the net magnetic field can be zero



a) in region A.
b) in region B.
c) in region C.
d) in none of the regions.