İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy102 Physics II
Midterm Examination
March 25, 2026 08:30 – 10:00
Good Luck!

NAME-SURNAME:

SIGNATURE:

ID:

DEPARTMENT:

INSTRUCTOR:

DURATION: 90 minutes

◇ **Answer all the questions.**
◇ **Write the solutions explicitly and clearly. Use the physical terminology.**
◇ **You are allowed to use Formulae Sheet.**
◇ **Calculator is allowed.**
◇ **You are not allowed to use any other electronic equipment in the exam.**

Question	Grade	Out of
1A		15
1B		10
2		20
3		20
4		20
5		15
TOTAL		100

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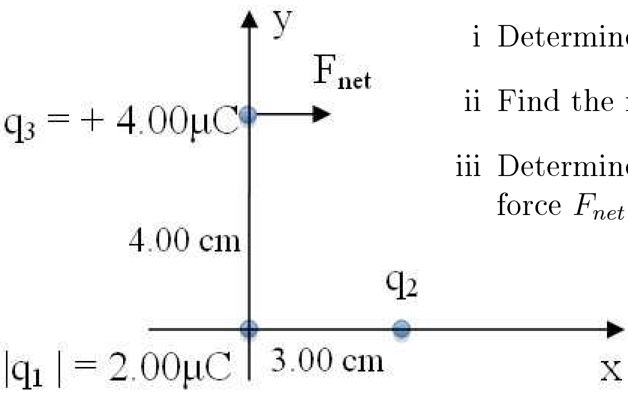
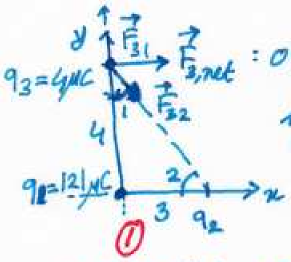
1. A) Three point charges are placed as shown in the figure. The magnitude of q_1 is 2.00 μC but sign and value of the charge q_2 are not known. The charge q_3 is +4.00 μC and the net electric force F on q_3 is entirely in $+x$-direction.



i Determine the sign of charges q_1 and q_2.

ii Find the magnitude of charge q_2.

iii Determine the magnitude of the net force F_{net} on q_3.



$\vec{F}_{3,net}$: only +x-direction.

i) it implies that $\boxed{\begin{array}{l} q_2<\phi \\ \& \; q_1>\phi \end{array}}$ 3

1: arcsin $\frac{3}{5}$ = 37°

2: arc Sin $\frac{4}{5}$ = 53°

ii) $F_{31,y} = F_{32,y} \rightarrow k\frac{|q_3||q_1|}{r_{31}^2} = k\frac{|q_3||q_2|}{r_{32}^2}\cos 37°$ 2 2

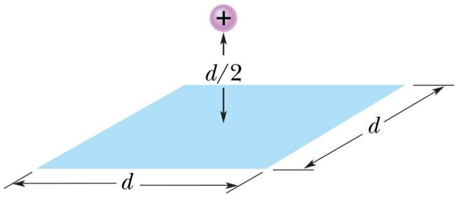
$\Rightarrow |q_2| = \frac{r_{32}^2}{r_{31}^2}\frac{|q_1|}{\cos 37} = \frac{(5\times10^{-2}m)^2}{(4\times10^{-2}m)^2}\frac{2\times10^{-6}C}{\cos 37} = \boxed{3.9\mu C}$ 1 1

iii) $\vec{F}_{3,net} = F_{3net,x}\hat{i} + F_{3net,y}\hat{j}$ $\{ F_{3,net,y} = \phi$ since $|F_{31,y}| = |F_{32,y}|$

$\rightarrow F_{3net,x} = F_{32,x} = k\frac{|q_3||q_2|}{r_{32}^2}\sin 37° = 8.99\times10^9\frac{Nm^2}{C^2}\frac{4\times10^{-6}C \; 3.9\times10^{-6}C}{(5\times10^{-2}m)^2}(0.60)$ 2 1

$\boxed{F_{3,net} \cong 34N}$ 1 1

B) In the figure below, a positively charged particle is at a distance $d/2$ directly above the center of a square of side $d = 2.0$ cm.



The magnitude of the electric flux through the square is 6.0×10^{-9} N.m^2/C. What is the magnitude of the electric charge of the particle?

Gauss' Law

$\varepsilon_0 \Phi_E = q_{enc}$ 4

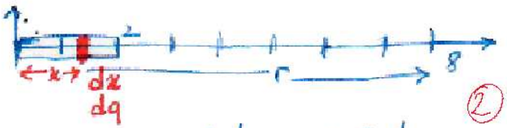
$\varepsilon_0 = 8.85 \times 10^{-12} C^2/Nm^2$

$\Phi_E \left(\text{through the square}\right) = 6.0 \times 10^{-9} Nm^2/C$

$\Rightarrow q_{enc} = (6.0\times10^{-9} Nm^2/C)(8.85\times10^{-12} C^2/Nm^2)$ 3

$\boxed{= 0.531 \times 10^{-19} C}$ 2 1

2. A charge of 40 nC is uniformly distributed along the axis from x = 0 to x=2 m. Determine the magnitude of the electric field at a point on the x-axis with x =8 m.



$E(x=8) = ?$ 2

2 $E = k\frac{q}{r^2} \rightsquigarrow dE = k\frac{dq}{r^2}$ & $\lambda = \frac{Q}{L} = \frac{dq}{dx}$ 2

$\rightarrow dE = k\frac{\lambda dx}{r^2} = k\frac{\lambda dx}{(8-x)^2} = k\lambda\frac{dx}{(8-x)^2}$ 4 $\left\{ \boxed{\lambda = \frac{40\times10^{-9}C}{2m}} \right.$ 4

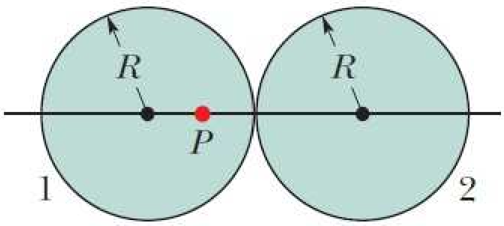
$\rightarrow \int dE = k\lambda\int_0^2\frac{dx}{(8-x)^2} = k\lambda\left.\frac{1}{8-x}\right|_0^2 = k\lambda\left(\frac{1}{8-2} - \frac{1}{8-0}\right) = k\lambda\left(\frac{1}{6} - \frac{1}{8}\right)$ 2

$\rightarrow E(x=8) = \int dE = \left(8.99\times10^9\frac{Nm^2}{C^2}\right)\frac{40\times10^{-9}C}{2m}\frac{(8-6)m}{48m^2} = \boxed{7.49\ N/C}$

magnitude

3 1

3. Figure below shows, in cross section, two solid spheres with *uniformly distributed charge* throughout their volumes. Each sphere has radius R. Point P lies on a line connecting the centers of the spheres, at radial distance $R/2$ from the center of sphere 1.



If the net electric field at point P is zero, what is the ratio q_2/q_1 of the total charges?
(**Hint:** Use Gauss' Law.)

Net $\vec{E}$ is zero at point P. $|\vec{E}_2| = |\vec{E}_1|$ 2 $\overleftarrow{\vec{E}_2} \overset{P}{\cdot} \overrightarrow{\vec{E}_1}$

Solid sphere → need a spherical Gaussian surface

$\oint \vec{E}\cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$ 3

sphere 2: $\overleftarrow{dA}$ $\overleftarrow{E_2}$ $E_2\int dA = \frac{q_{enc}}{\varepsilon_0}$

→ $E_2 4\pi(R+R/2)^2 = \frac{q_2}{\varepsilon_0}$ 3 → $E_2 = \frac{q_2}{4\pi(R+R/2)^2\varepsilon_0}$ //

sphere 1: $\overrightarrow{dA}$ $\overrightarrow{E_1}$

$E_1\int dA = \frac{q_{enc}}{\varepsilon_0}$ → $E_1 4\pi(R/2)^2 = \frac{q_{enc}}{\varepsilon_0}$ 3

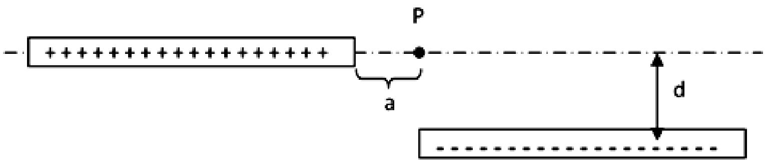
$\left\{\begin{array}{ll} \frac{4}{3}\pi R^3 & q_1 \\ \frac{4}{3}\pi\left(\frac{R}{2}\right)^3 & q_{enc} \end{array}\right\}$ 4 $q_{enc} = \frac{\frac{4}{3}\pi(R/2)^3}{\frac{4}{3}\pi R^3} q_1 = q_1/8$ //

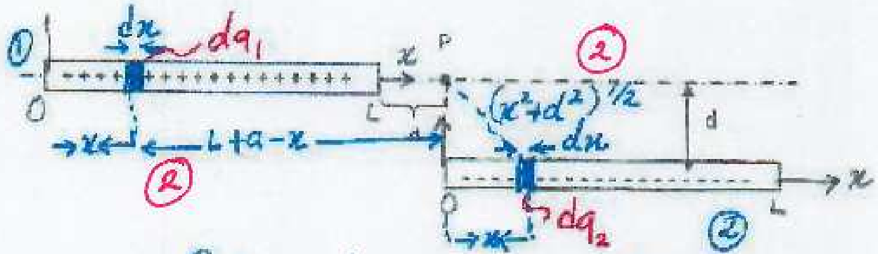
⇒ $E_1 = \frac{q_1/8}{4\pi(R/2)^2\varepsilon_0}$ //

⇒ Net $|\vec{E}| = 0$ → $|\vec{E}_2| = |\vec{E}_1|$ → $\frac{q_2}{4\pi\frac{9}{4}R^2\varepsilon_0} = \frac{q_1/8}{4\pi R^2/4\,\varepsilon_0}$

⇒ $\boxed{\frac{q_2}{q_1} = \frac{9}{8} = 1.125}$ 5

4. Two very thin non-conducting rods are placed together as shown. Both rods have lengths of L and they carry uniform charges of $+q$ and $-q$ over their lengths. Find the potential at point P at a distance a and d from the positively and negatively charged rods as shown. Don't perform integration.





$$V_{1\,at\,P} = \int dV = \int \frac{1}{4\pi\varepsilon_0}\frac{dq_1}{r_1}$$

$dq_1 = \lambda\, dx$ (3)

$r_1 = L + a - x$

$$V_{2\,at\,P} = \int dV = \int \frac{1}{4\pi\varepsilon_0}\frac{dq_2}{r_2}$$

(3) $dq_2 = -\lambda\, dx$

$r_2 = \sqrt{x^2+d^2}$

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

$dV = \frac{1}{4\pi\varepsilon_0}\frac{dq}{r}$ (2)

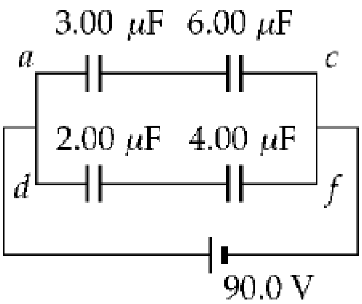
$dq = ?$

$dq = \lambda\, dx$ (2)

$$\boxed{V_{tot} = V_{1\,at\,P} + V_{2\,at\,P}} = \boxed{\frac{\lambda}{4\pi\varepsilon_0}\left(\int_0^L \frac{dx}{(L+a-x)} - \int_0^L \frac{dx}{\sqrt{x^2+d^2}}\right)}$$

(3) (3)

5. For the system of capacitors shown in Figure;



Find

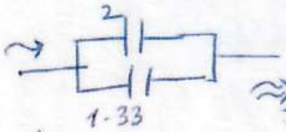
i the equivalent capacitance of the system,

ii the charge on each capacitor,

iii the potential across each capacitor.

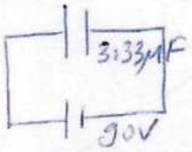
i) $C_{eqv} = ?$ 3 ‖ 6 ‖ — $\sim \frac{1}{C_{ac}} = \frac{1}{3\mu F} + \frac{1}{6\mu F} \Rightarrow C_{ac} = 2\,\mu F$

2 ‖ 4 ‖ — $\sim \frac{1}{C_{df}} = \frac{1}{2\mu F} + \frac{1}{4\mu F} \Rightarrow C_{df} = 1.33\,\mu F$ (2)

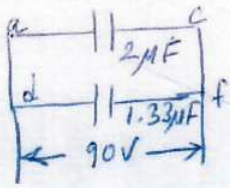


$\Rightarrow C_{eqv} = 3.33\,\mu F$ (2) (1)

ii)



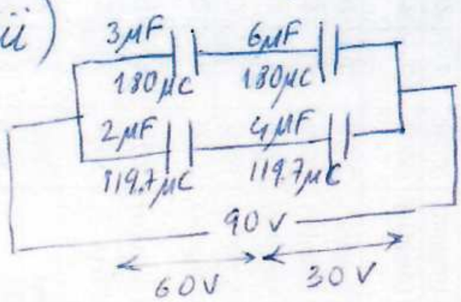
$C = \frac{Q}{V} \sim Q = C_{eqv} * V = (3.33\times10^{-6}F)\,90V = 299.7\,\mu C$ (2) (total charge)



$Q_{ac} = (2\mu F)\,90V = 180\,\mu C = q_a = q_c$ (2)

$Q_{df} = (1.33\mu F)\,90V = 119.7\,\mu C = q_d = q_f$ (2)

iii)



$V_a = \frac{q_a}{C_a} = \frac{180\mu C}{3\mu F} = \boxed{60V}$ (1)

$V_c = \frac{180\mu C}{6\mu F} = \boxed{30V}$ (1)

$V_d = \frac{119.7\mu C}{2\mu F} \simeq \boxed{60V}$ (1)

$V_f = \frac{119.7\mu C}{4\mu F} \simeq \boxed{30V}$ (1)