İZMİR UNIVERSITY
OF ECONOMICS

IZMIR UNIVERSITY OF ECONOMICS
Faculty of Arts and Sciences

Term	: 2023-2024 Spring
Course ID	: PHYS 102
Exam	: Midterm Exam
Date	: 04.04.2024
Duration	: 75 min
Instructor	:

Full Name : ....

Student ID : ....

Classroom : .... **Section :** ....

Information on exam rules

Electronic devices such as laptops, mobile phones, and smartwatches are generally prohibited in the examination room. However, exceptions can be made for individuals with special needs, provided they have valid medical documentation. Requests for exceptions must be submitted with prior written approval from the academic advisor, and they should include details on the necessary measures to maintain the integrity and security of the examination.

Please refrain from engaging in cheating or any other prohibited activities during the examination. Suspected cheating may result in a score of zero on your exam, and any students found cheating may face disciplinary actions in accordance with law #2547. This includes actions such as using unauthorized electronic devices, communicating with classmates, exchanging exam or formula sheets, or using unauthorized written materials during the exam, all of which qualify as attempted cheating.

Students can use only simple calculators during the exam.

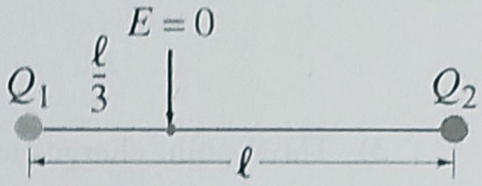
Declaration

I affirm that the activities and assessments completed as part of this examination are entirely my own work and comply with all relevant rules regarding copyright, plagiarism, and cheating. I acknowledge that if there is any question regarding the authenticity of any portion of my assessment, I may be subject to oral examination. The signatory of evidence records may also be contacted, or a disciplinary process may be initiated as per law #2547.

Signature of Student:

Group	1	2	3	4	5
Score	/20	/20	/20	/20	/20
Total	/100				

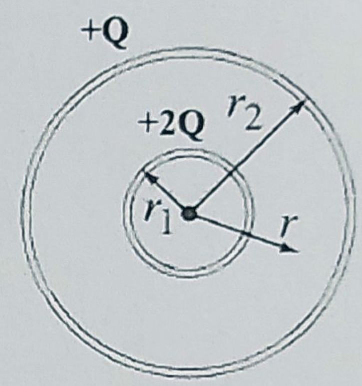
1) You are given two unknown point charges, Q_1 and Q_2. At a point on the line joining them, one-third of the way from Q_1 to Q_2, the electric field is zero (Fig.). What is the ratio $\frac{Q_1}{Q_2}$?



$E_1 = E_2$

$$k.\frac{Q_1}{(\ell/3)^2} = k\frac{Q_2}{\left(\ell-\frac{\ell}{3}\right)^2} \Rightarrow \cancel{k}.\frac{Q_1}{\frac{\cancel{\ell^2}}{\cancel{9}}} = \cancel{k}.\frac{Q_2}{\frac{4\cancel{\ell^2}}{\cancel{9}}} \Rightarrow \frac{Q_1}{Q_2} = \frac{1}{4}$$

2) Suppose that we have two thin concentric spherical shells of radii r_1 and r_2 ($r_1 < r_2$). The inner shell has a total charge +2Q and the outer shell +Q (see Fig.). Determine the electric field for **(a)** $0 < r < r_1$, **(b)** $r_1 < r < r_2$, and **(c)** $r > r_2$



a) $0 < r < r_1$, $Q_{enc} = 0$

$$\oint \vec{E}.d\vec{A} = \frac{Q_{enc}}{\varepsilon_0} \Rightarrow E.(4\pi r^2) = \frac{\overset{0}{Q_{enc}}}{\varepsilon_0} \Rightarrow \vec{E} = 0$$

b) $r_1 < r < r_2$, only the charge on the inner shell will be enclosed , $Q_{enc} = +2Q$

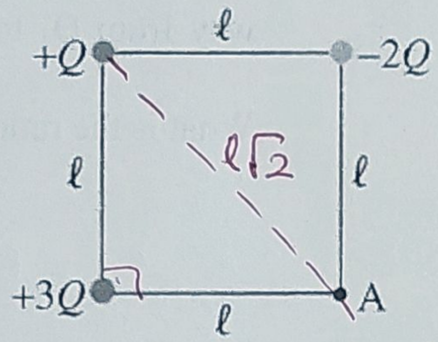
$$\oint \vec{E}.d\vec{A} = E(4\pi r^2) = \frac{\overset{+2Q}{Q_{enc}}}{\varepsilon_0} \Rightarrow E.4\pi r^2 = \frac{2Q}{\varepsilon_0} \Rightarrow E = \frac{\cancel{2}Q}{\cancel{4}\pi\varepsilon_0 r^2} = \frac{Q}{2\pi\varepsilon_0 r^2}$$

c) $r > r_2$, the charge on both shells will be enclosed.

$Q_{enc} = 3Q$

$$\oint E.dA = \frac{\overset{3Q}{Q_{enc}}}{\varepsilon_0} \Rightarrow E.4\pi r^2 = \frac{3Q}{\varepsilon_0} \Rightarrow E = \frac{3Q}{4\pi\varepsilon_0 r^2}$$

3) Three point charges are arranged at the corners of a square of side l as shown in Fig. What is the potential at the fourth corner (point A), taking V=0 at a great distance? (Write your answer in terms of Q and l)

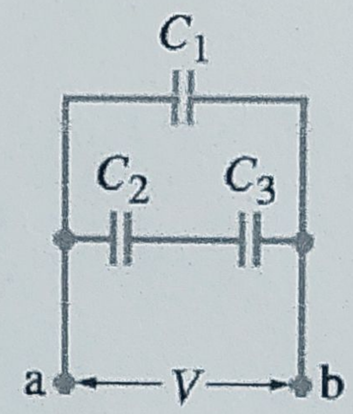


The potential at the corner is the sum of the potentials due to each of the charges, using $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{(3Q)}{\ell} + \frac{1}{4\pi\varepsilon_0}\frac{Q}{\ell\sqrt{2}} + \frac{1}{4\pi\varepsilon_0}\frac{(-2Q)}{\ell} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{\ell}\left(1+\frac{1}{\sqrt{2}}\right)$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{\sqrt{2}\,Q}{2\ell}\left(\sqrt{2}+1\right)$$

4) *(a)* Determine the equivalent capacitance of the circuit shown in Fig. ***(b)*** If $C_1 = C_2 = 2C_3 = 24.0\ \mu F$, how much charge is stored on each capacitor when V = 35.0 V?



a) $C_{eq} = C_1 + \left(\frac{1}{C_2} + \frac{1}{C_3}\right)^{-1} = C_1 + \left(\frac{C_3 + C_2}{C_2 C_3}\right)^{-1}$

$$C_{eq} = C_1 + \frac{C_2 C_3}{C_3 + C_2}$$

b) For C_1, the full 35V is across the capacitance

$$Q_1 = C_1 V = (24\times10^{-6} F)(35\ V) = 8.40\times10^{-4} C$$

for C_2 and C_3 $(C_2 = 2C_3 = C \rightarrow C_2 = C,\ C_3 = \frac{C}{2})$

$C_{eq} = \left(\frac{1}{C} + \frac{1}{\frac{C}{2}}\right)^{-1} = \frac{C}{3}$ $\quad Q_{eq} = C_{eq}\cdot V = \frac{1}{3}(24\times10^{-6} F)\cdot(35\ V)$

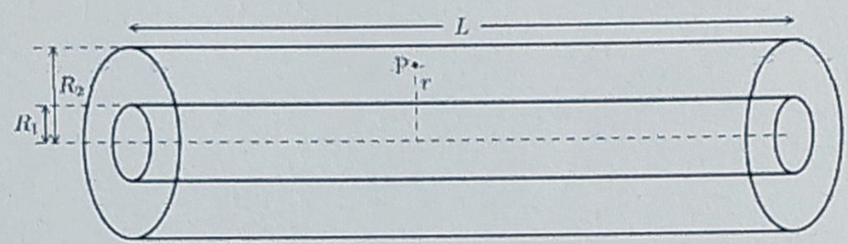
$$Q_{eq} = 2.80\times10^{-4} C = Q_2 = Q_3$$

5) A cylindrical capacitor consists of two long, coaxial, metal cylinders of radii R_1 and R_2 ($R_1 < R_2$) and the same length L, as shown Fig. Assume that the inner cylinder has a total charge of $+\boldsymbol{Q}$ and the outer cylinder has a total charge of $\boldsymbol{-Q}$.

(a) Use Gauss's Law to calculate the electric field at the point P in the diagram below, which is a distance r away from the axis.

(b) Calculate the potential difference between the outer and the inner cylindrical shell.

(c) Determine the capacitance of the cylindrical capacitor.



a) $\oint \vec{E}\cdot d\vec{A} = \frac{\overset{\to Q}{Q_{enc}}}{\varepsilon_0} \Rightarrow E \cdot 2\pi r L = \frac{Q}{\varepsilon_0} \Rightarrow E = \frac{Q}{2\pi \varepsilon_0 r L}$

b) $V_1 - V_2 = -\int_2^1 E \cdot dl = -\frac{Q}{2\pi\varepsilon_0 L}\int_{R_2}^{R_1}\frac{dr}{r} = -\frac{Q}{2\pi\varepsilon_0 L}\ln\frac{R_1}{R_2} = \frac{Q}{2\pi\varepsilon_0 L}\ln\frac{R_2}{R_1}$

c) $C = \frac{Q}{V} = \frac{\cancel{Q}}{\frac{\cancel{Q}}{2\pi\varepsilon_0 L}\cdot \ln\frac{R_2}{R_1}} = \frac{2\pi\varepsilon_0 L}{\ln\left(\frac{R_2}{R_1}\right)}$