# Rwanda Coding Academy (RCA)

## Year I

## 2023 - 2024

# Applied Physics I-Electrostatics:

# Assignment 2

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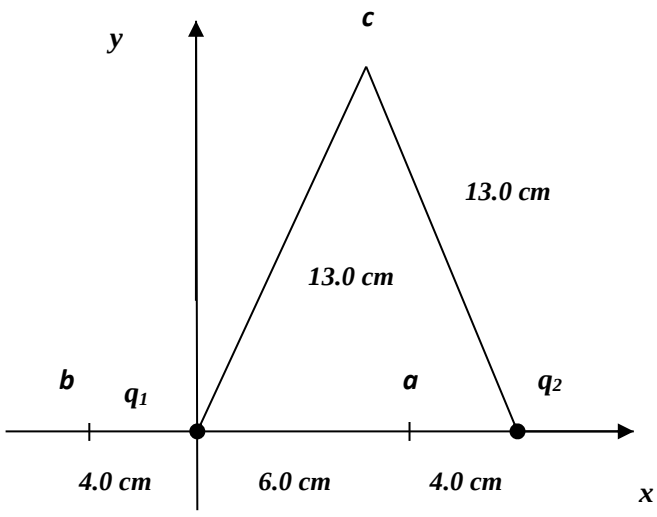
1. An electric charge located at point $P$ (1, 15$^o$, 5) is said to be in which coordinate system?
   (i) Cartesian system
   (ii) Cylindrical system
   (iii) Spherical system
   (iv) Space system
2. Explain briefly a Faraday cage and give one example of it.
3. Lightning causes the earth to acquire a negative charge, and this charge creates an electric field in the air. Treating the earth as a flat conductor, estimate the surface charge density on the ground by using Gauss's law when the field in the air is 100 N/C.
4. The HCl molecule has a dipole moment of $3.4 \times 10^{-30} C.m$, (i) what torque does the molecule experience in an electric field of $4 \times 10^6 N/C$ when the axis of the dipole makes an angle of $32°$ with the direction of the electric field? (ii) Calculate the maximum torque experienced by each HCl molecule.
5. Point charges $q_1$and $q_2$of $+12nC$and$-12nC$, respectively, are placed 0.10 m apart. This combination of two charges with equal magnitude and opposite sign is called an electric dipole. Compute the electric field caused by $q_1$, the field caused by $q_2$, and the total field:
   (a) at point a;
   (b) at point b; and
   (c) at point c. (See figure 1).

Figure 1




a) $\vec{E}_a = (9.8 \times 10^4 N \cdot C^{-1})\vec{\imath}$; b) $\vec{E}_b = (-6.2 \times 10^4 N \cdot C^{-1})\vec{\imath}$; c) $\vec{E}_c = (4.9 \times 10^3 N \cdot C^{-1})\vec{\imath}$.

6. Two identical charged spheres, each having a mass of 3 .00 × $10^{-2}$ kg, hang in equilibrium as shown in the **figure 2a** The length L of each string is 0.150 m, and the angle θ is 5.00$^o$ Find the magnitude of the charge on each sphere.

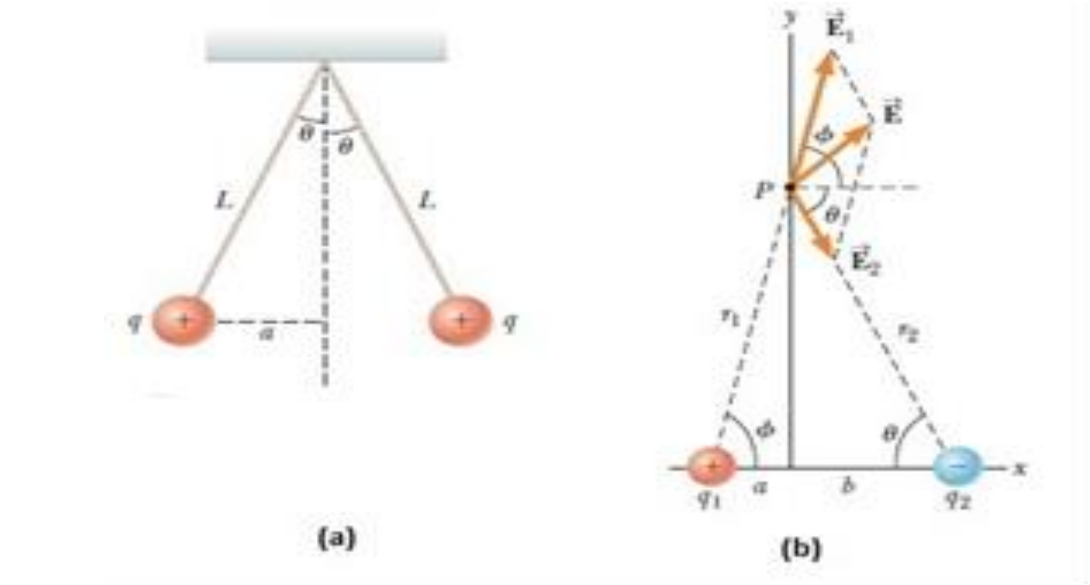



Figure 2

7. Charges q1 and q2 are located on x axis, at distance a and b, respectively, from the origin as shown in the figure 2b. (a) Find the component of the net electric field at point P, which is at position (0, y). (b) Evaluate the electric field at point P in the special case that |q1| = |q2 | and a = b. (c) Find the electric field due to the electric dipole when point P is a distance y ≫ a from the origin.
8. Two 1.20-m non conducting wires meet at a right angle. One segment carries +2.50μC of charge distributed uniformly along its length, and the other carries −2.50μC distributed uniformly along it, as shown in Figure 3. (a) Find the magnitude and direction of the electric field these wires produce at point P, which is 60.0 cm from each wire. (b) If an electron is released at P, what are the magnitude and direction of the net force that these wires exert on it?

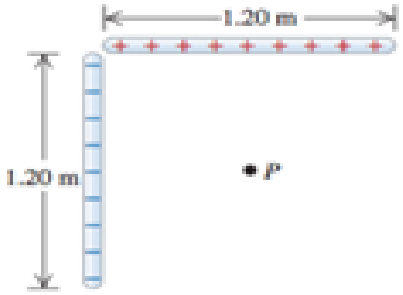



Figure 3

9. Three charges are at the corners of an isosceles triangle as shown in Figure 4 (a). The $\pm 5.00\text{-}\mu C$ charges form a dipole. (a) Find the force (magnitude and direction) the -10.00-$\mu C$ charge exerts on the dipole. (b) For an axis perpendicular to the line connecting the

$\pm$5.00-$\mu C$ charges at the midpoint of this line, find the torque (magnitude and direction) exerted on the dipole by the - 10.00- $\mu C$ charge.

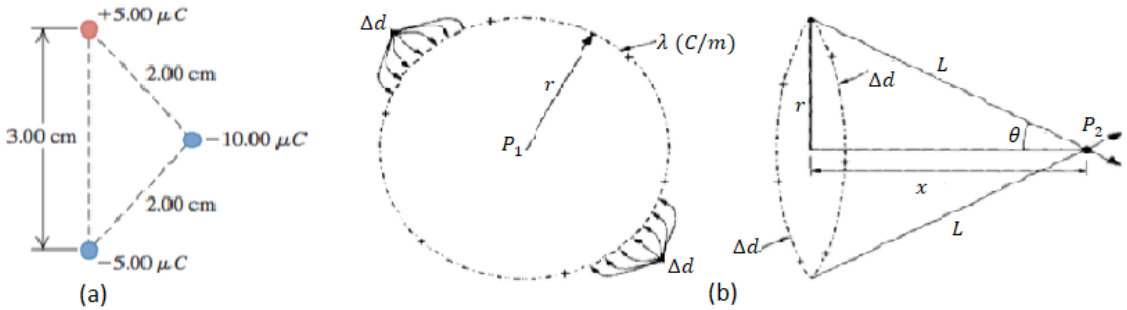



Figure 4

10. A uniformly charged conducting sphere of 1.2 $m$ diameter has a surface charge density of 8.1 $\mu C/m^2$. What is the total electric flux leaving out of the surface of that sphere?
11. Two-point charges $q_1 = +4.00\ \mu C$ and $q_2 = -2.00\ \mu C$ are located along the $X - axis$ at $X = 2\ m$ and $X = 4\ m$. What is the magnitude of electric flux due to this point charge through spherical surfaces centered at the origin with radius 1.00 $m$ and 5.00 $m$?
12. Define the following terms:
    (a) The linear charge density λ of the apparent line of charge
    (b) The surface charge density σ
    (c) The volume charge density
13. Suppose we have a ring of radius r, as in figure 4 (b)below, Positive charge is uniformly distributed along the ring, with a linear charge density of λ (C/m) throughout its length.
    (i) Calculate the electric field produced by the charge on the ring at a point $P_2$ on the axis of the ring at a distance x from the plane of the ring.
    (ii) If r = 15Cm and $\lambda = 6.3 \times 10^{-8}$ C/m, what field is produced at the point x=20 Cm?
14. Calculate the electric flux through the rectangle of sides 5 cm and 10 cm kept in the region of a uniform electric field 100 N/C when the angle θ is 60°. Suppose θ becomes zero, what is the electric flux?

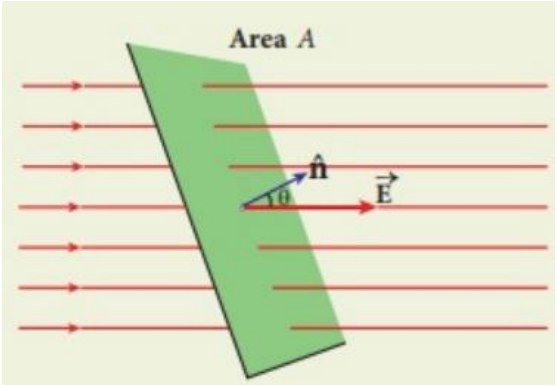



Figure 5

15. A flat sheet of paper of area 0.250 $m^2$ is oriented so that the normal to the sheet is at an angle of 60° to a uniform electric field of magnitude 14 N/C. (a) Find the magnitude of the electric flux through

the sheet. (b) Does the answer to part (a) depend on the shape of the sheet? Why or why not? (c) For what angle $\phi$ between the normal to the sheet and the electric field is the magnitude of the flux through the sheet (i) largest? and (ii) Smallest? Explain your answers.

16. A charged ring has a radius of 2.2 m and a uniform linear charge density of $8.0\ \mu C/m$. If the distance from the center of the ring to point P is 10.0 m, calculate the electric field.
17. A uniformly charged ring of radius 15 cm has a total charge of 50 μC. Find the electric field on the central perpendicular axis of the ring at: (a) 0 cm, (b) 1 cm, (c) 10 cm, and (d) 100 cm. (e) What do you observe about the values you just calculated?
18. A non-conductive rod of length L has a total negative charge −Q that is uniformly distributed along its length, see Fig. below. (a) Find the linear charge density of the rod. (b) Use the coordinates depicted in the figure to prove that the electric field at point P, a distance a from the right end of the rod, has the same form as the one given by Eq. $E = \frac{kQ}{a(a+L)}$. (c) When P is very far from the rod, i.e. $a \gg L$, show that the electric field reduces to the electric field of a point charge (i.e. the rod would look like a point charge). (d) If L = 15 cm, Q = 25μC, and a = 20 cm, find the value of the electric field at P

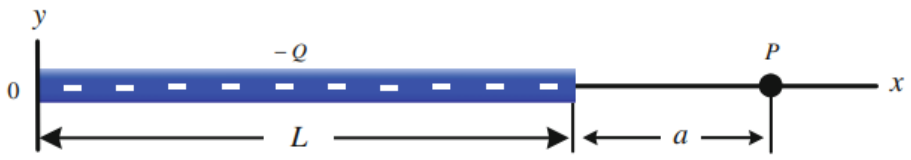



Figure 6

19. A disk with radius 0.10 m is oriented with its normal unit vector $\vec{n}$ at an angle of 30° to a uniform electric field $\vec{E}$ with magnitude $2.0 \times 10^3 N \cdot C^{-1}$.
    a) What is the electric flux through the disk if $\measuredangle(\vec{n}, \vec{E}) = 30°$?
    b) What is the flux through the disk if it is turned so that its normal is perpendicular to $\vec{E}$?
    c) What is the flux trough the disk if its normal is parallel to $\vec{E}$?
20. Consider a circular plate of radius 12 cm. Its plane makes an angle of 30 ° with a uniform electric field $\vec{E} = 450\vec{\imath}\ N \cdot C^{-1}$ (see figure 7). What is the electric flux through the plate?

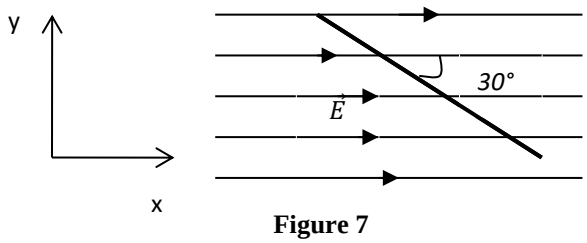



**Figure 7**

**Proposed answer:**

$\varphi_E = 10.2N \cdot m^2 \cdot C^{-1}$.

21. Consider a square plate of length of 12 cm located in an xy-plane. What is the electric flux through the plate in a uniform electric field $\vec{E} = (70\vec{\imath} + 90\vec{k})N \cdot C^{-1}$?
22. A flat surface of area 3.20 $m^2$ is rotated in a uniform electric field of magnitude E = 6.20 × $10^5$ N/C. Determine the electric flux through this area (a) when the electric field is perpendicular to the surface and (b) when the electric field is parallel to the surface.
23. A solid conductor with a cavity carries a total charge of + *7 nC*. Within the cavity, insulated from the conductor, is a point charge of – *5 nC*. How much charge is on each surface (inner and outer) of the conductor?
24. A point charge of 16 μC is placed at the center of a spherical shell conductor carrying an electric charge of -8 μC.
    a) Determine the electric field inside and outside the shell.
    b) What are the charges on the inner and outer surfaces of the shell?
    c) Draw the electric field lines.
25. A uniformly charged, straight filament 7.00 m in length has a total positive charge of 2.00 C. An uncharged cardboard cylinder 2.00 cm in length and 10.0 cm in radius surrounds the filament at its center, with the filament as the axis of the cylinder. Using reasonable approximations, find
    (a) the electric field at the surface of the cylinder and
    (b) the total electric flux through the cylinder.
26. A pyramid with horizontal square base, 6.00 m on each side, and a height of 4.00 m is placed in a vertical electric field of 52.0 N/C. Calculate the total electric flux through the pyramids four slanted surfaces.
27. Positive charge Q is distributed uniformly over each of two spherical volumes with radius R. One sphere of charge is centered at the origin and the other at x=2R (figure 8). Find the magnitude and direction of the net electric field due to these two distributions of charge at the following points on the x-axis: (a) x=0; (b) x=R/2; (c) x=R; (d) x=3R.
28. Repeat problem 27, but now let the left-hand sphere have positive charge Q and let the right-hand sphere have negative charge -Q.