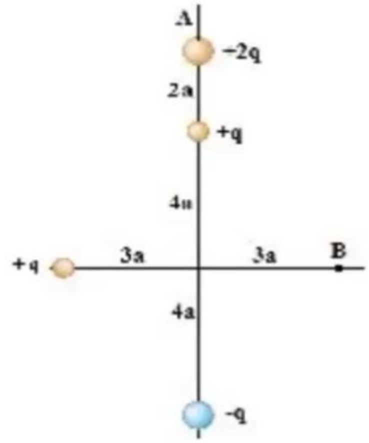
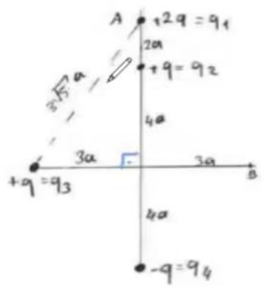
1. a) Find the electrical work required to move the **+2q** charge from point A**(0,6)** to B**(3a,0)** in Figure 1.
b) Determine the total potential energy of the new system.




$$U_x = U_{21} + U_{31} + U_{41}.$$

$$\frac{2kq^2}{2a} +$$

(a) +2q yükünü A(0,6a)'dan. B(3a,0)'ye götürmek için yapılan işi;

$$U_{12} = k\frac{q_1 q_2}{r_{12}}$$

$$U_A = k\frac{2q(q)}{2a} + k\frac{q(2q)}{3\sqrt{5}a} + k\frac{(-q)(2q)}{10a}$$

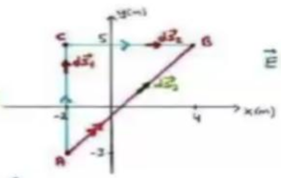
$$U_A = U_{21} + U_{31} + U_{41}$$

$$= k\frac{q^2}{a} + k\frac{2q^2}{3\sqrt{5}a} - k\frac{q^2}{5a}$$

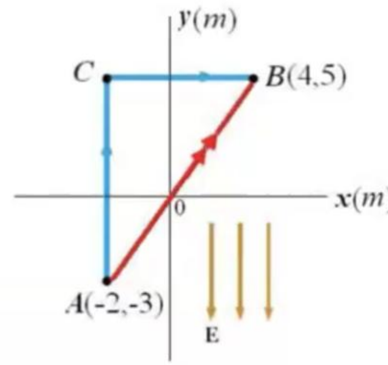
$$= k\frac{q^2}{a}\left(\frac{4}{5} + \frac{2}{3\sqrt{5}}\right)$$

2. An electric field of **325 V/m** is applied along the **-y axis**. The coordinates of points **A** and **B** in Figure 2 are given as **(-2, -3) m** and **(4, 5) m**, respectively.
Calculate the **potential difference ($V_B$ - $V_A$)** along ACB and AB paths

$d\vec{s}_1 = dy\,\hat{j}$
$d\vec{s}_2 = dx\,\hat{i}$
$d\vec{s}_3 = dx\,\hat{i} + dy\,\hat{j}$




$\vec{E} = -325\,\hat{j}$ (V/m)




Şekil 2

$$V_B - V_A = -\int_A^B \vec{E} \cdot d\vec{s}$$

ACB yolu için:

$$V_B - V_A = -\int_A^C \vec{E} \cdot d\vec{s}_1 - \int_C^B \vec{E} \cdot d\vec{s}_2$$

$$V_B - V_A = -\int_A^C (-325\,\hat{j}) \cdot dy\,\hat{j} - \int_C^B (-325\,\hat{j}) \cdot dx\,\hat{i} \qquad (\hat{j} \cdot \hat{i} = 0)$$

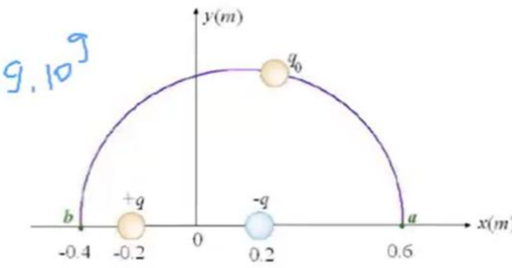
$$V_B - V_A = 325 \int_A^C dy$$

$$V_B - V_A = 325 \int_{-3}^{5} dy = 325 \left[ y \right]_{-3}^{5} = 325 \left[ 5 - (-3) \right]$$

$$\boxed{V_B - V_A = 2600 \text{ (V)}}$$

3. An electric dipole consists of a **+5 μC** charge at **x = 0.2 m** and a **-5 μC** charge at **x = -0.2 m**, as shown in Figure 3.
A test charge of **+3 μC** is moved from **x = 0.6 m** to **x = 0.4 m**, following a path that makes an angle of **0.5 m** with the **y-axis**.
Determine the work done to move the test charge at a constant velocity along this path.

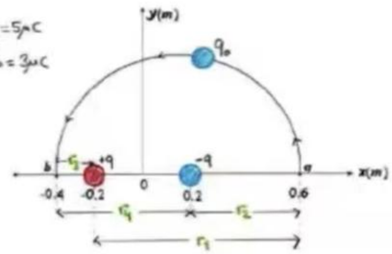
$k = 9.10^9$




**Şekil 3**

$q = 5\mu C$

$q_0 = 3\mu C$




$W_{a \to b} = \Delta U = q_0 \Delta V = q_0 (V_b - V_a)$

$W_{a \to b} = 3.10^{-6} [150000 - (-56250)]$

$W_{a \to b} \cong 0,62\ (J)$

$V = k \frac{q}{r}$

$V_a = k \frac{q}{r_1} - k \frac{q}{r_2}$

$V_a = 9.10^9 \left( \frac{5.10^{-6}}{0,8} - \frac{5.10^{-6}}{0,4} \right)$

$V_a = -56250\ (V)$

$V_b = k \frac{q}{r_3} - k \frac{q}{r_4}$

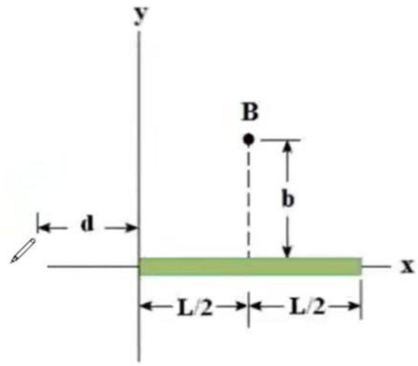
$V_b = 9\ 10^9 \left( \frac{5.10^{-6}}{0,2} - \frac{5.10^{-6}}{0,6} \right)$

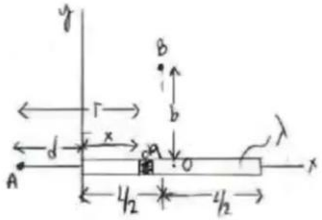
$V_b = 150000\ (V)$

$V_a = k \frac{q}{r_1} - k \frac{q}{r_2}$

$V_a = 9.10^9 (5$

4. A rod of length **L** with a uniform charge density **λ** is aligned along the **x-axis,** as shown in Figure 4.
a) Calculate the **electric potential** at points **A** and **B**.
b) If the charge density varies as **$\lambda = \alpha x$** ($\alpha$ is a constant), determine the electric potential at **A** and **B**.




(a) A ve B noktalarındaki elektriksel potansiyeller;

$V = k\int \frac{dq}{r}$ ile;

$dq = \lambda dx$

$V_A = k\int_0^L \frac{dq}{r} = k\int_0^L \frac{\lambda dx}{r}$ $\boxed{r = d + x}$

$V_A = k\lambda \int_0^L \frac{dx}{x+d}$ [integral tablosu: $\int \frac{dx}{(ax+b)} = \frac{1}{a}\ln(ax+b)$]

5. a) An electron accelerates between two plates due to an applied electric field, gaining **$5.25 \times 10^{-15}$ J** of energy. Find the potential difference between the plates and identify which plate has the higher potential.
b) An electric field **E = (5i + 3j - 2k) kV/m** exists in a region.
If **point A** is at the origin and **point B** is at (4,3,0) m, determine the potential difference **($V_A$ - $V_B$)**.

$W = q\Delta V$

$5{,}25.10^{-15} = 1{,}6\ 10^{-19}$

$\vec{E} = 5\hat{i} + 3\hat{j} - 2\hat{k}$

$\Delta V = -$

(a) $W = \Delta K = q|\Delta V|$

$5{,}25.10^{-15} = 1{,}6.10^{-19}\,|\Delta V|$

$|\Delta V| = 32{,}8.10^{3}\,V$

Elektrik alan, yüksek potansiyele sahip plakadan düşük potansiyele sahip plakaya doğru oluşur. Elektron ise elektrik alana ters yönde hareket eder. Bu bilgiler ışığında B plakası daha yüksek potansiyele sahiptir!

(b) $V_B - V_A = -\int_A^B \vec{E}\cdot d\vec{r}$ $\quad A(0,0,0) \longrightarrow B(4,3,0)$

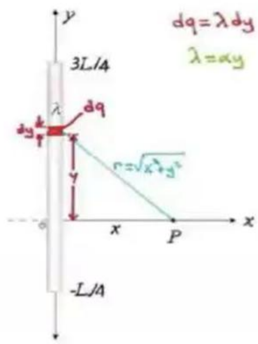
$V_B - V_A = -\int_A^B E_x\,dx + \int_A^B E_y\,dy - \int_A^B E_z\,dz$

$V_B - V_A = -\int_0^4 5x^2\,dx + \int_0^3 3\,dy - \cancel{\int_0^0 2\,dz}$

$V_B - V_A = -\frac{5x^3}{3}\Big|_0^4 + 3y\Big|_0^3$

$V_B - V_A = -97{,}6\,kV$

6. A rod of length **L** and total charge **Q** has a charge density of **λ** = $\alpha y$
a) Find the **electric potential** at point **P** on the **x-axis**.
b) Using the potential, derive the **x-component** of the electric field at point **P**.
c) If a charge **q** is placed at **P**, determine the **electric force** acting on it along the x-axis.




$dq = \lambda dy$

$\lambda = \alpha y$

$$V = k\int \frac{dq}{r}$$

a) $$V_P = k\int \frac{dq}{r} = k\int \frac{\lambda dy}{\sqrt{x^2+y^2}}$$

$$V_P = k\int_{-L/4}^{3L/4} \frac{\alpha y\, dy}{\sqrt{x^2+y^2}}$$

$x^2+y^2 = u$

$2y\,dy = du$

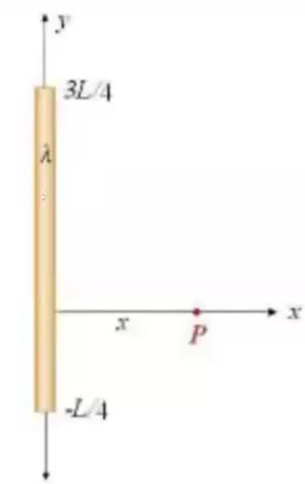
$y = -\frac{L}{4}$ ; $u = x^2+\frac{L^2}{16}$

$y = \frac{3L}{4}$ ; $u = x^2+\frac{9L^2}{16}$

$$V_P = \frac{k\alpha}{2}\int_{x^2+\frac{L^2}{16}}^{x^2+\frac{9L^2}{16}} \frac{du}{u^{1/2}}$$

$$V_P = k\alpha\left[u^{1/2}\right]_{x^2+\frac{L^2}{16}}^{x^2+\frac{9L^2}{16}}$$

$$\boxed{V_P = k\alpha\left(\sqrt{x^2+\frac{9L^2}{16}} - \sqrt{x^2+\frac{L^2}{16}}\right)}$$



7. A sphere of **radius R** carries a charge **Q**, but the charge density varies as **$\rho = Ar^2$** (non-uniform distribution).
Using **Gauss's Law,**
a) Determine the **electric field** inside and outside the sphere.
b) Calculate the **electric potential** at a point inside the sphere.

$$V_A = \frac{A}{20\epsilon_0}\left(5R^4 - r^4\right)$$

$r > R$

a) $$\Phi_E = \oint \vec{E}\cdot d\vec{A} = \frac{q_{iç}}{\epsilon_0}$$

$$q_{iç} = Q = \int_0^r \rho\, dV = \int_0^R Ar^2 4\pi r^2 dr = A4\pi \frac{R^5}{5}$$

$$E_{dış} 4\pi r^2 = 4\pi A \frac{R^5}{5\varepsilon_0} \Rightarrow \vec{E}_{dış} = \frac{AR^5}{5\epsilon_0 r^2}\hat{r}$$

$r < R$

$$q_{iç} = \int_0^r \rho\, dV = \int_0^r Ar^2 4\pi r^2 dr = A4\pi \frac{r^5}{5}$$

$$E_{iç} 4\pi r^2 = 4\pi A \frac{r^5}{5\epsilon_0}$$

$$\vec{E}_{iç} = A\frac{r^3}{5\epsilon_0}\hat{r}$$

b) $$V_A - V_\infty = V_A = -\int_\infty^R \vec{E}_{dış}\cdot d\vec{s} - \int_R^r \vec{E}_{iç}\cdot d\vec{s} \qquad ds = dr$$

$$V_A = -\int_\infty^R \frac{AR^5}{5\epsilon_0 r^2}dr - \int_R^r A\frac{r^3}{5\epsilon_0}dr$$

$$V_A = \frac{AR^5}{5\epsilon_0}\left(\frac{1}{R} - 0\right) - \frac{A}{5\epsilon_0}\left(\frac{r^4}{4} - \frac{R^4}{4}\right)$$