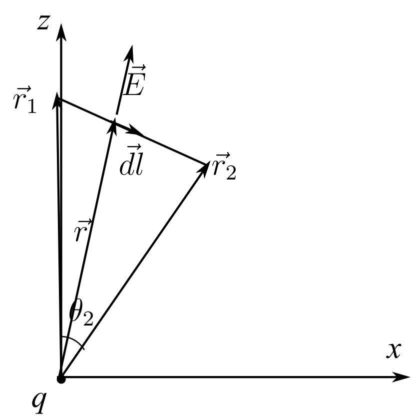
1. **Consider a point charge q at the origin. Find the electric potential at a point $\vec{r}_2 : (r = r_2, \theta = \theta_2, \phi = 0)$ with respect to the potential at $\vec{r}_1 : r = r_1, \theta = 0, \phi = 0$ as reference by evaluating the integral $-\int_{\vec{r}_1}^{\vec{r}_2} \vec{E} \cdot \vec{dl}$ along a straight line joining $\vec{r}_1$ to $\vec{r}_2$.**



2. (a) **A charge distribution $\rho_1(\vec{r})$ produces a potential $\phi_1(\vec{r})$ in a region τ and another charge distribution $\rho_2(\vec{r})$ produces a potential $\phi_2(\vec{r})$ in the region. Prove that**

$$\int_\tau \rho_1 \phi_2 d^3\vec{r} = \int_\tau \rho_2 \phi_1 d^3\vec{r}$$

How do you interpret this result.

   (b) **The interaction energy of two point charges q_1 and q_2 placed at $\vec{r}_1$ and $\vec{r}_2$ is given as $\epsilon_0 \int \vec{E}_1 \cdot \vec{E}_2 d^3\vec{r}$ where the integration is done over the whole space. Prove that this is equal to $\frac{q_1 q_2}{4\pi\epsilon_0 r_{12}}$ where $r_{12} = |\vec{r}_2 - \vec{r}_1|$ as is expected.**

3. **Prove the mean value theorem in electrostatics which states that in a chargeless region, the average of the potential over the surface of any sphere is equal to the potential at the center of the sphere.**
This is true for any regular polyhedron. If the faces of a regular polyhedron having n faces are maintained at potentials

$V_1, V_2, ..., V_n$ then the potential at the center of the polyhedron is $(V_1 + V_2 + ... + V_n)/n$. How many such regular polyhedron do you think are possible? Look for platonic solids. Tetrahedron, cube, octahedron, dodecahedron and icosahedron.

4. **Prove that in a chargeless region electrostatic potential cannot have a maxima or a minima.**

5. **A chargeless region is bounded by two conducting surfaces.**

   (a) **If a charge Q_1 is placed on conductor 1 while 2 is chargeless the potential in the region is given by the function $\Phi_1(x, y, z)$. If a charge Q_2 is placed on conductor 2 while 1 is chargeless the potential in the region is given by the function $\Phi_2(x, y, z)$.**
   Now if charge Q_1 is placed on conductor 1 and charge Q_2 is placed on 2 prove that the potential in the region will be given by the function $\Phi = \Phi_1 + \Phi_2$.

   (b) **If conductor 1 is maintained at potential V_1 and 2 is grounded the potential in the region is given by the function $\Phi_1(x, y, z)$. If conductor 2 is maintained at potential V_2 and 1 is grounded the potential in the region is given by the function $\Phi_2(x, y, z)$. Now if conductor 1 is maintained at potential V_1 and conductor 2 is maintained at potential V_2 prove that the potential in the region will be given by the function $\Phi = \Phi_1 + \Phi_2$.**

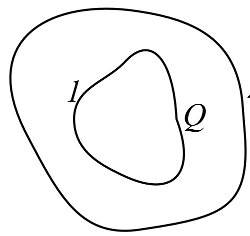
   This result can be extended to a region bounded by any number of conductors.

6. **A conducting sphere of radius a is concentrically surrounded by another conducting spherical shell of radius b.**

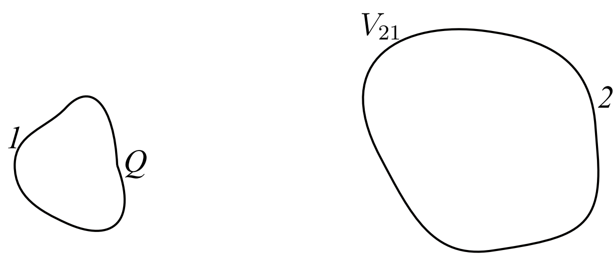
   (a) **A charge Q is placed on the inner conducting sphere. What will be the potential over the outer sphere.**

(b) **Instead if the charge Q is placed over the outer shell, what will be the potential of the inner sphere?**

(c) **How will your answer change if the shapes of the conductors were not spherical but arbitrary.**



(d) **In general if we have two conducting surfaces S_1 and S_2, when a charge Q is placed on conductor 1, the potential on conductor 2 is found to be V_{21}. Whereas when the charge Q is placed on conductor 2 the potential on conductor 1 is found to be V_{12}. Prove that $V_{12} = V_{21}$.**



7. **Two infinitely long wires running parallel to the x axis carry uniform charge densities $+\lambda$ and $-\lambda$.**

   (a) **Find the potential at any point using the origin as the reference.**

   (b) **Show that the equipotential surfaces are circular cylinders. Locate the axis and radius of the cylinder corresponding to a given potential V_0.**