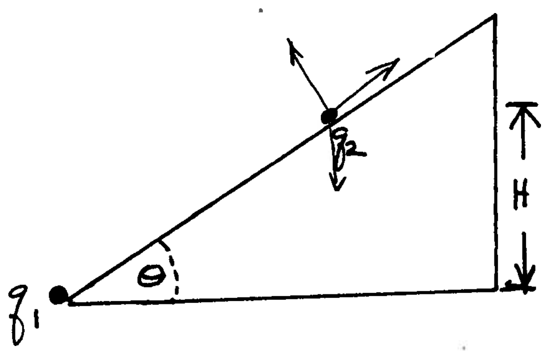
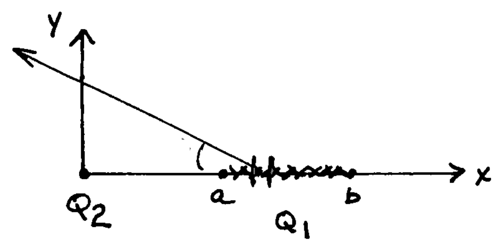
1. (25 points) A tiny ball with positive charge, $q_1$, is fixed at the bottom of a frictionless inclined plane. A second small ball, with mass $m$ and positive charge, $q_2$, is placed on the inclined plane at the position shown. If $m$, $q_1$, $q_2$, and $\theta$ are known, what must $H$ be if the second ball is to remain at rest?



2. (25 points)A charge $Q_1$ is uniformly spread along the x axis from $x = a$ to $x = b$. A charge $Q_2$ is placed at the origin. Find the y component of the electric field at the point $x = 0, y = H$.



3. (25 points)An electric field is measured in some region and found to be given by

$$\vec{E} = \alpha x^2 \vec{i}_x + \beta y^2 \vec{i}_y.$$

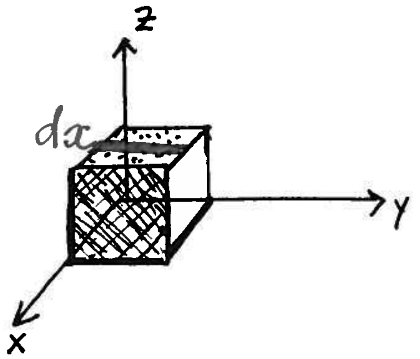
Here $\alpha$ and $\beta$ are known constants. For this field find the difference in the electric potential between the point $x = 0, y = c$ and the point $x = c, y = 0$. Verify that this field is conservative by evaluating the derivatives of the electric potential function.

4. (25 points)

a. A cube of sides $a$ is located at the origin. An electric field is present given by

$$\vec{E} = bx^2\vec{i}_x + cx\vec{i}_z,$$

Find the electric flux through the shaded side marked on the figure.




$d\Phi = \vec{E} \cdot d\vec{S}$

$\vec{S}_{side} = a^2 \vec{i}_x$

$\Phi_{side} = b a^2 a^2 = b a^4$

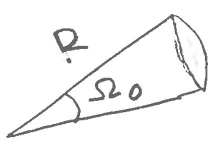
Find the electric flux through the top (dotted) of the cube.

$d\vec{S}_{top} = a\, dx\, \vec{i}_z$

$d\Phi_{top} = cx \cdot a\, dx$

$\Phi_{top} = \int_0^a c x a\, dx = ca \frac{x^2}{2}\Big|_0^a = \frac{ca^3}{2}$

b. A point charge q is located at the center of a sphere of radius R. A cone of solid angle $\Omega_0$ is drawn starting at the charge. What is the electric flux through the area of the sphere which is intersected by the cone?




$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{R^2}$ ; $S = R^2 \Omega_0$

$\Phi = \vec{E} \cdot \vec{S} = ES = \frac{1}{4\pi\varepsilon_0} \frac{q}{R^2} R^2 \Omega_0 =$

$= \frac{1}{4\pi\varepsilon_0} q \Omega_0$

$\Phi = \frac{1}{4\pi\varepsilon_0} q \Omega_0$