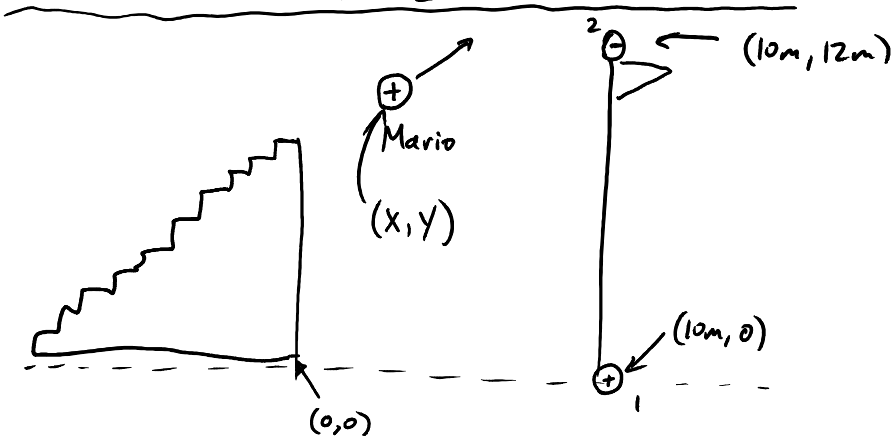
PROBLEM SET 2 SOLUTIONS



Let Mario's position at time t be $(X(t), Y(t))$, and define $(V_x, V_y) = \left(\frac{dX}{dt}, \frac{dY}{dt}\right)$. The forces on Mario are gravity

$$\vec{F}_g = (0, -Mg)$$

The force from the lower charge:

$$\vec{F}_1 = \frac{k \cdot Q^2}{R_1^2} \cdot \hat{r}_1$$

Here: $\vec{R}_1 = (X, Y) - (10m, 0)$

$$\hat{r}_1 = \frac{\vec{R}_1}{|\vec{R}_1|} = \frac{(X - 10m, Y)}{\sqrt{(X-10m)^2 + Y^2}}$$

so $$\vec{F}_1 = \frac{kQ^2}{((X-10m)^2 + Y^2)^{3/2}} \cdot (X - 10m, Y)$$

Similarly, we find

$$\vec{F}_2 = \frac{-kQ^2}{((X-10m)^2 + (Y-12)^2)^{3/2}} (X - 10m, Y - 12m)$$

Mario's acceleration at time t can then be determined using Newton's 2nd Law:

$$\vec{a} = \frac{1}{m} \vec{F}_{NET}$$

$$a_x = \frac{kQ^2/m}{((X-10m)^2 + Y^2)^{3/2}} (X-10m) - \frac{kQ^2/m}{((X-10m)^2 + (Y-12m)^2)^{3/2}} (X-10m)$$

$$a_y = -g + \frac{kQ^2/m}{((X-10m)^2 + Y^2)^{3/2}} Y - \frac{kQ^2/m}{((X-10m)^2 + (Y-12m)^2)^{3/2}} (Y-12m)$$

To find the trajectory, we can then solve for (X, Y) and (V_x, V_y) using

$$\frac{dV_x}{dt} = a_x \quad \frac{dV_y}{dt} = a_y \quad \frac{dX}{dt} = V_x \quad \frac{dY}{dt} = V_y$$

We can employ Euler's method to find that when $X = 10m$, $Y = 10.3335m$, so Mario gets 4603 points.