#1 – A small charged particle of mass $m$ is launched upward in a uniform electric field ($3.80 \times 10^3 \, j \, N/C$) with an initial speed of 2.12 m/s. The particle will travel 6.48 cm in 0.250 s. What is the particle’s charge to mass ratio ($q/m$)? Gravity needs to be considered in this problem.

First use kinematics to find the acceleration of the particle. Use kinematic equation #2.

$$y_f = y_i + v_{yi} \Delta t + \frac{1}{2} a \Delta t^2 \Rightarrow 0.0648 = 0 + (2.12)(0.250) + \frac{1}{2} a(0.250)^2 \Rightarrow a = -14.8864 \, m/s^2$$

-9.8 m/s$^2$ of that acceleration is due to gravity. The rest (-5.0864) can be attributed to the electric field.

$$qE = ma \Rightarrow \frac{q}{m} = \frac{a}{E} = \frac{5.0864}{3.80 \times 10^3} = 1.34 \times 10^{-5} \, C/kg$$

#2 – A small particle of mass $m$, charge $q$, and initial speed $v_0$ is projected into a uniform electric field $E$ that is generated by a parallel plate capacitor of length $a$ as shown in the figure below. The separation distance between the plates is unimportant however it is large enough such that the particle will not collide with the bottom plate. After passing through the field, it is deflected downward a vertical distance $d$ and hits a collecting screen that is a horizontal distance $b$ away. What is the particle’s charge to mass ratio ($q/m$) in terms of the given variables? Gravity does not need to be considered in this problem.

The particle will experience a downward acceleration while traveling in the capacitor. $a_y = \frac{q}{m} E$.

The particle will spend time, $\Delta t_0$, crossing through the capacitor and the kinematics equations during that motion are as follows:

$$a = v_o \Delta t_0 \quad \Delta y_0 = \frac{1}{2} a_y \Delta t_0^2 \quad v_{yf}^2 = 2a_y \Delta y_0$$

The particle will spend time, $\Delta t_1$, while in region b and the kinematics equations during that motion are as follows:

$$b = v_o \Delta t_1 \quad \Delta y_1 = v_{yf} \Delta t_1$$
Eliminate the time variables via substitution and formulate equations for $\Delta y_0$ and $\Delta y_1$.

$$\Delta y_0 = \frac{qEa^2}{2mv_0^2} \quad \Delta y_1 = \frac{qEab}{mv_0^2}$$

Note: $\Delta y_0 + \Delta y_1 = d$ so add up the equations given above and solve for the quantity $q/m$

$$\frac{q}{m} = \frac{2dv_o}{E(a^2 + 2ab)}$$

#3 – An electric dipole with dipole moment $\mathbf{p}$ is in a uniform electric field $\mathbf{E}$.

A) Find the orientations of the dipole for which the torque on the dipole is zero.

B) Which of those orientations are stable? Meaning if the dipole is nudged slightly does it return back to the original orientation or does it flip. Explain.

C) Show that for the stable orientation the dipole’s own electric field opposes the external field.

Part A

Part B – The top one is stable since a small perturbation of the dipole will return it to the original configuration. The bottom one is unstable since a small perturbation of the dipole will cause it to flip and become the top one.

Part C – The dipole’s electric field in and around the dipole opposes the external electric field (see figure)
#4 — Consider the figure on the left. If a positive charge is inside, what condition must be placed on the strength and direction of the electric field on the top? Consider the figure on the right. What electric field strength and direction must be present through the front if the box contains no net charge?

For the left picture
Field into box: $15 + 20 = 35 \text{ N/C}$
Field out of box: $10 + 10 + 20 = 40 \text{ N/C}$
Net field is 5 N/C out. So the electric field on the top must be out of the box or less than 5 N/C into the box so that the net field remains out.

For the right picture
Field into box: $15 + 20 = 35 \text{ N/C}$
Field out of box: $10 + 15 + 15 = 40 \text{ N/C}$
Net field is 5 N/C out. So the electric field on the front must be exactly 5 N/C into the box so that the net field is zero.