E2-1

Given an electric potential, I can calculate the electric field at an arbitrary point

1. To do so, I will use the equation

$$\vec{E} = \frac{1}{4\pi\epsilon_0} * \frac{q}{|r|^2} * \hat{r}$$

This equation provides the electric field observed at any location away from the source point chaarge. In such case, we requires the following information:

q - the electric potential, or the charge of the source point

$\vec{r}$ - the vector of distance between the source charge and the point of observation

We then require the magnitude of the distance r, and the unit vector associated with r. (calculating the electric field without the unit vector resutls in the magnitude of the electric field, we use the unit vector to determine the direction)

Scenario

An electron is placed at a location <0.004, -0.026, -0.402>m from the origin. What is the vector form of the electric field produced by this electron at the origin, and at an observed location A = <0.062, 0.033, -0.402>m

An electric field is generated from a source point charge. This electried field will radiate arround the source.

We start by designating the appropriate distance vectors I will ommit the steps for calculating the distance, magnitude, and unit vector.

Distance, magnitude, and unit vector between the electron and the Origin:

$$\vec{r_{eo}} =< -0.004, 0.026, 0.402 > m$$

$$|r_{eo}| = 0.4028m$$

$$\hat{r}_{eo} =< -0.0099, 0.0645, 0.9978 > m$$

Distance between electron and point A:

$$\vec{r_{ea}} =< 0.058, 0.059, 0 > m$$

$$|r_{ea}| = 0.0827m$$

$$\hat{r}_{ea} =< 0.7010, 0.7131, 0 > m$$

Then we are ready to calculate the electric field:

For the origin:

$$k = \frac{1}{4\pi\epsilon_0}$$

$$\vec{E_{eo}} = \frac{-1k * e}{|r_{eo}|^2} * \hat{r}_{eo}$$

$$\vec{E_{eo}} = \frac{-1.44e-09}{(0.4028m)^2} * < -0.0099, 0.0645, 0.9978 > m$$

$$=< 8.81e-11, -5.73e-10, -8.85e-09 > \frac{C}{m}$$

for the observed location:

$$\vec{E_{ea}} = \frac{-1k * e}{|r_{ea}|^2} * \hat{r}_{ea}$$

$$\vec{E_{ea}} = \frac{-1.44e-09}{(0.0827m)^2} * < 0.7010, 0.7131, 0 > m$$

$$=< -1.47e-07, -1.5e-07, 0 > \frac{C}{m}$$

In [7]:
```
import numpy as np
import scipy.constants as const

# Constants
e0= const.epsilon_0
```

```python
e = const.elementary_charge
k = 1/(4*np.pi*e0)


def vectorize(final, initial):
    # Input variables are not vectorized. This function puts them in vector format, then calculates
    # The distance between the points, with the first entry as the final location.
    # Then will calculate the magnitude and unit vector for that distance
    # Returns the distance vector, magnitude, and unit vector

    f = np.array([final])
    i = np.array([initial])
    distance = f - i
    magnitude = np.linalg.norm(distance)
    hat = distance/magnitude
    return distance, magnitude, hat

def e_calc(charge, rmag, rhat):
    # Calculate electric field, EQN: (kq/|r|^2)*rhat

    e = (k*charge/rmag**2)*rhat
    return e

electron = -1*e

# Inputting the coordinates of each point of interest.
origin = [0,0,0]                    # Origin location
e_loc = [0.004, -0.026, -0.402]    # Electron location
a_loc = [0.062, 0.033, -0.402]     # Observed location


# Vector, magnitude, and unit for distance from electron to origin
r_e_origin, r_eo_mag, r_eo_hat = vectorize(origin, e_loc)

# Vector, magnitude, and unit for distance from electron to observed point
r_e_a, r_ea_mag, r_ea_hat = vectorize(a_loc, e_loc)

# Calculating the electric field at the origin due to the electron
e1 = e_calc(electron, r_eo_mag, r_eo_hat)

# Calculating the electric field at the observed location due to the electron
e2 = e_calc(electron, r_ea_mag, r_ea_hat)
```

```python
# Outputs
print("Electric Field at Origin: ", e1)
print("Electric Field at Observed Location: ", e2)
```

```
Electric Field at Origin:  [[ 8.80947580e-11 -5.72615927e-10 -8.85352318e-09]]
Electric Field at Observed Location:  [[-1.47475411e-07 -1.50018090e-07 -0.00000000e+00]]
```