1-A. Describe three differences between an electric field and a gravitational field.

B. As shown below, an object is suspended from a string in a region of space having a constant electric field (its y-comp. is given). The angle that the string makes with the horizontal and the mass and charge of the object are also given.

\[ \vec{E} = (E_x \hat{i} - 540 \hat{j}) \text{N/C} \]
\[ \vec{g} = -9.81 \text{ N/kg} \hat{j} \]
\[ \theta = 56.0^\circ \quad m = 72.0 \text{ mg} \]
\[ q = 360. \text{ nC} \]

1. Draw a FBD for the object.

2. Assuming that the object is held in static equilibrium determine the tension in the string.

3. Determine the x-component of the electric field.

4. If the string is now cut (at t = 0.0 s) describe or determine (use a coordinate system as shown to the right with origin located at the initial position of the object);
   a. the trajectory of the object.
   b. when and where (x-value) the object reaches a point that is 2.00 m below its initial location (i.e. \( y = -2.00 \text{ m} \)).
2-A. Compare the advantages and/or disadvantages of using (a) Coulomb's law vs (b) Gauss's law to calculate:

1. the electric field produced by an uniformly charged disk of radius R at a distance z above the center of the disk.

2. the electric field produced by uniformly charged sphere of radius R.

B. An "infinite" sheet with uniform charge density \( \sigma \) lies in the xy plane (at \( z = 0 \)) of a three dimensional space. \( \sigma = -78.0 \text{ nC/m}^2 \)

An object, with given charge and mass, has the indicated velocity at point A (\( z_A = 6.00 \text{ m} \) \( y_A = 0.0 \text{ m} \))

\[ m = 150. \mu\text{g} \quad q = -420. \text{ pC} \quad \vec{v}_A = \{ 6.00 \hat{j} - 4.60 \hat{k} \} \text{ m/s} \]

1. Use Gauss's law to determine the electric field at points for which \( z \geq 0.0 \text{ m} \).

2. Draw a FBD of the object and use with the 2nd law to determine the acceleration of the object.

3. Since the acceleration is constant, use constant acceleration kinematics to determine;

   i. the minimum separation between the object and the charged sheet (and the time it reaches this position) during the motion.

   ii. the time (and y-location) when the object returns to its initial z-position above the charged sheet.

4. Compare the work done by the gravitational field to the work done by the electric field on the object as it moves from the initial position until it reaches the minimum position above the charged sheet.
3-A. Describe three differences between the concepts of (1) electric potential and (2) electric potential energy.

B. In the diagram shown to the right there exists a constant electric field (given). I have chosen the point Q to have an electric potential of 0.00 Volts.

\[ E = (-3.00 \hat{i} - 2.00 \hat{j}) \text{kN/C} \]

1. Determine the electric potential at points P and R.

2. An object (mass and charge are given) is given the indicated initial velocity at point R. Determine; \( m = 20.0 \text{ mg} \)
\( q = -300. \mu\text{C} \)
(neglect the effect of the earth's grav. field)

\[ \vec{v}_R = (-500 \hat{i} - 200 \hat{j}) \text{m/s} \]

a. The velocity of the object (and its location (x-value)) when it reaches the x-axis using a FBD and kinematics.

b. The work done on the object by the electric field as the object moves from point R to the point where it crosses the y-axis.
4-A. An ideal parallel plate capacitor is charged by being connected to a battery. After the capacitor has been charged, it is disconnected from the battery and a dielectric slab is inserted between the plates. Describe what happens to (1) the charge on the plates, (2) the net electric field between the plates, (3) the potential difference across the plates, and (4) the energy stored in the capacitor due to the insertion of the dielectric material between the capacitor plates.

B. A capacitor is constructed using two concentric cylindrical shells. The surface charge density on the outer cylindrical shell is given as well as the radius of the two shells and their length. (neglect end effects)

\[ r_1 = 10.0 \text{ cm} \quad r_2 = 15.0 \text{ cm} \]

\[ \sigma_2 = 84.0 \mu\text{C/m}^2 \quad L = 2.00 \text{ m} \]

1. Determine the charge on the outer shell.

2. Use Gauss's law to determine the electric field at a point halfway between the two shells.

3. Determine the potential difference between the two shells by integrating the electric field along a path that connects the two shells.

4. Determine the capacitance of the capacitor using the definition of capacitance.

5. Determine the energy stored in the capacitor by integrating the electric field energy density over the volume contained between the two shells. Check by using \( U = Q^2/(2C) \).
5-A. Describe what is meant by the "temperature coefficient of resistivity" ($\alpha$). Why is $\alpha$ positive for conductors and negative for semiconductors?

B. A piece of a cylindrical copper conductor is shown to the right. The resistivity and length of the conductor as well as the current and the power dissipated in the conductor are all given below.

$\rho = 1.72 \times 10^{-8} \, \Omega m$ \quad $L = 52.0 \, m$

$I = 4.00 \, A$ \quad $P_d = 36.0 \, W$

1. Determine the potential difference between the ends of the conductor.

2. Determine the resistance of the conductor.

3. Determine the diameter of the conductor.

4. Determine the total amount of energy dissipated in the conductor in 2.00 hours.

5. Determine how long it will take, on average, for a conduction electron to move from one end (which one?) of the conductor to the other. (use the number density for conduction electrons in copper found in example 25.1 in text)
6-A. In the RC circuit, shown to the right, the capacitor is charged before the switch is closed. After the switch is closed discuss the energy transformations taking place in the battery, the resistor, and the capacitor. \(0 < q_0 < \varepsilon C\).

\[
\begin{array}{c}
\text{E} \\
\text{I(t)} \\
\text{C} \\
\text{q(t)} \\
\end{array}
\]

A. For the RC circuit which is shown above, use the indicated values for R, C, and \(\varepsilon\). Also use for the initial capacitor charge (at \(t = 0\) s) \(q_0 = -500. \mu\text{C}\) \(\varepsilon = 20.0\) Volts

\[
\begin{array}{c}
R = 250 \Omega \\
C = 40.0 \mu\text{F} \\
\end{array}
\]

1. Write down the loop equation for this circuit going around the circuit counter clockwise from point A.

2. Determine;
   
   a. the capacitive time constant for the circuit.
   
   b. the initial current in the circuit (give sense).
   
   c. the "final" charge on the capacitor

3. At \(t = 18.0\) ms determine the charge on the capacitor and the rate of energy storage in the capacitor.

4. Determine the time, after the switch is closed, that the rate of energy storage in the capacitor is equal to the rate of energy dissipated in the resistor.