1.) A small charged sphere of charge $q$ and mass $m$ hangs from a cord of length $L = 1.5$ m in an electric field $E$ that points to the right (positive $x$-direction). The charged sphere experiences a deflection 3 cm to the right of the vertical dashed line. If $q = 3.2$ nC, $m = 1$ g, what is the magnitude of the electric field? (Acceleration due to gravity is $9.8$ m/s$^2$) [10 points]
2.) (a) The surface charge density on a circular disk of radius R is \( \sigma \). Without using Gauss’ law, calculate the electric field \( (E_x, E_y, E_z) \) at a point P on the axis of the disk, a distance \( x \) away from its center. [15 points]

(b) Using the differential form of the voltage \( V = \int \frac{dq}{r} \), calculate the electric potential located at this point P. [10 points]

(c) Using \( V \) in part (b), calculate the electric field \( (E_x, E_y, E_z) \) at the point P. Show that it is the same thing you found in part (a). [5 points]
3.) Two charges \( q_1 = 6 \text{ mC}, \ q_2 = -3 \text{ mC} \) are separated by distance equal to 4 m. Taking \( q_1 \) as located at the origin, at what point on the line will the electric potential be zero? [10 points]
4.) (a) You have two thin concentric conducting shells of radius $r_1$ and $r_2$ (as shown below). The outer shell contains $-Q$ uniformly spread over its surface. The inner shell contains $+Q$ uniformly spread over its surface. What is the capacitance of the two shells? [15 points]

(b) Suppose now you have four thin concentric conducting spheres. (Each of a different radius as noted above.) Current flows radially outward from the center and there is a vertical metal strip that connects the shell of radius $r_3$ with the shell of radius $r_2$. Assume that the charge on each sphere is given by: $-Q$ on $r_1$, $+Q$ on $r_2$, $-Q$ on $r_3$, $+Q$ on $r_4$. What is the capacitance of the system? (Hint: The metal strip means that you can consider the system as two spherical capacitors in series.) [10 points]
5.) What is the equivalent resistance of the following circuit? (Assume each resistor has a resistance R) [5 points]
6.) Determine the magnitudes and directions of the currents in each resistor for the circuit below. [20 points]
Extra Credit) Suppose you have a nonconducting sphere of radius $r_0$ with an interior cavity of radius $r_1$. Assume that the charge $Q$ is uniformly spread throughout the volume of this nonconducting spherical shell. Assume now we place a point charge $q$ at the center of the sphere. Calculate the electric field for the following regions: (a) $0 < r < r_1$ (b) $r_1 < r < r_0$ (c) $r > r_0$ [10 points for entire problem]

Extra Extra Credit) Name every actor who has ever played the role of Batman in a non cartoon tv/movie production. (Hint: There are eight) [2 points]