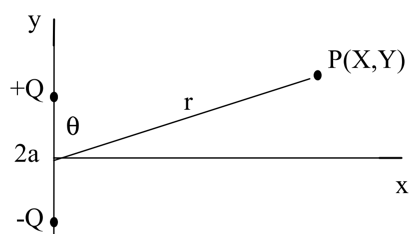
Finding E and V Using a Spreadsheet

Purpose: To gain experience using spreadsheets to calculate potential and electric fields
To gain experience calculating the electric field from the potential field.

Equipment: PC computer with Excel software

Procedure:

1. Set up a spreadsheet that calculates the electric potential at some point P(X,Y) due to 10 (or less) point charges located anywhere in the XY plane. Create columns headings as follows: Charge #, charge (μC), x(m), y(m), r(m), V(volts). Put appropriate formulae under the last two column headings to calculate for each charge the distance r from the point P and the potential at P due to each charge. Place enough text near the top of your spreadsheet to explain what it is calculating. A sample of what the finished spreadsheet might look like is given on the next page.
2. Put all given quantities and results in individual cells at the left side of your spreadsheet in the usual way. One of these cells should of course be the resultant potential at P due to all of the individual charges. You can test out the calculations in the potential part of your worksheet by comparing the numbers given with the sample spreadsheet. Make a sketch of the charges and their positions along with the point P for this example.



3. Show, analytically, that for distant points, r>>a, the potential due to a dipole as given in the figure is

$$V = (p/4\pi\varepsilon_o r^2)\cos\theta = (p/4\pi\varepsilon_o)\, y/(x^2 + y^2)^{3/2},\ \ p = 2aQ$$

4. Test out your spreadsheet by finding the potential due to this dipole at the points P(2,1), P(1,0), and P(0,1) and comparing it with the values obtained from the above equation at these same three points. Use a = 0.01 m, Q = 1 μC.
5. Solve analytically for the electric field at distant points (r>>a) from the dipole above. Base your solution on the method outlined in class where one first finds the potential function, V(x,y) and then determines the components of the electric field by taking partial derivatives of the potential function. From your solution find both the magnitude and direction of the electric field at the same three points as given in Part 4 above.
6. Use your spreadsheet to find the electric field at P(X,Y) by calculating

$$E_x = -\Delta V/\Delta x = [V(X+\Delta x,Y) - V(X-\Delta x,Y)]/\Delta x$$

and

$$E_y = -\Delta V/\Delta y = [V(X,Y+\Delta y) - V(X,Y-\Delta y)]/\Delta y$$

for $\Delta x \ll X$ and $\Delta y \ll Y$. Explain in your report how you calculate the size of Δx and Δy in your spreadsheet. Have your spreadsheet calculate the magnitude of E and its direction and compare with the analytic result calculated in part 5 above using the same three points as given in part 4. Place these results in cells at the left of your spreadsheet with enough text to make the results clear. **Hint**: You'll have to use an IF statement to properly determine the direction of E.

Electric and Potential Field Calculations--An Example

Electric Potential calculations:

$k = 8.99E+09\ Nm^2/C^2$

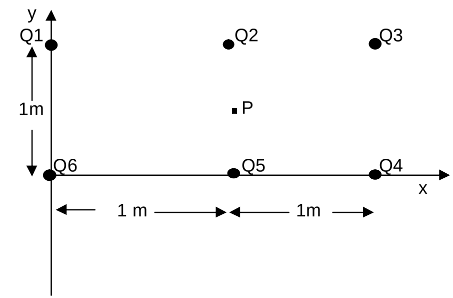
Location of P:

X = 1 m

Y= 0.5 m

V_T = 8489.004 volts

Charge #	Charge(C)	x(m)	y(m)	r(m)	V(X,Y)(volt)
1	5.00E-06	0	1	1.11803399	40204.502
2	-2.00E-06	1	1	0.5	-35960
3	-3.00E-06	2	1	1.11803399	-24122.7
4	5.00E-06	2	0	1.11803399	40204.502
5	-2.00E-06	1	0	0.5	-35960
6	3.00E-06	0	0	1.11803399	24122.701
7					
8					
9					
10					



Electric Field calculations:

Δx = 0.001

X + Δx/2 = 1.0005

X - Δx/2 = 0.9995

Δy = 0.001

Y+Δy/2 = 0.5005

Y-Δy/2 = 0.4995

Charge #	r(X+Δx/2,Y)	V(X+Δx/2,Y)	r(X-Δx/2,Y)	V(X-Δx/2,Y)	r(X,Y+Δy/2)	V(X,Y+Δy/2)	r(X,Y-Δy/2)	V(X,Y-Δy/2)
1	1.118481225	40188.42606	1.1175868	40220.59	1.11781047	40212.542	1.1182577	40196.46
2	0.50000025	-35959.98202	0.5000002	-35959.982	0.4995	-35996	0.5005	-35924.08
3	1.117586798	-24132.3538	1.1184812	-24113.056	1.11781047	-24127.52	1.1182577	-24117.88
4	1.117586798	40220.58967	1.1184812	40188.426	1.11825768	40196.46	1.1178105	40212.542
5	0.50000025	-35959.98202	0.5000002	-35959.982	0.5005	-35924.08	0.4995	-35996
6	1.118481225	24113.05564	1.1175868	24132.354	1.11825768	24117.876	1.1178105	24127.525
7								
8								
9								
10								
V total(volts)		8469.753525		8508.3499		8479.2803		8498.5784

$E_x = -\Delta V/\Delta x = -[V(X+\Delta x,Y) - V(X-\Delta x,Y)]/\Delta x =$ 38596.32601 V/m

$E_y = -\Delta V/\Delta y = -[V(X,Y+\Delta y) - V(X,Y-\Delta y)]/\Delta y =$ 19298.15721 V/m

E total = 43152.0017 V/m

Direction = 26.5650443 degrees wrt +x-axis