Use Excel to calculate the electric field due to the effect of a series of A) 10 individual charges and B) due to a line element of charge.

A)

(1.1)

$$\vec{E}_{total} \text{at the point P(x,y,z)} = k_e \sum_{i=1}^{n} \frac{q_i}{r_i^2} \vec{u}_{ri} =$$

$$= k_e \sum_{i=1}^{n} \frac{q_i}{(x-x_i)^2 + (y-y_i)^2 + (z-z_i)^2} \cdot \frac{\langle x-x_i, y-y_i, z-z_i \rangle}{\sqrt{(x-x_i)^2 + (y-y_i)^2 + (z-z_i)^2}} =$$

$$\vec{E}_{total}(x,y,z) = k_e \sum_{i=1}^{n} \frac{q_i \langle x-x_i, y-y_i, z-z_i \rangle}{\left[(x-x_i)^2 + (y-y_i)^2 + (z-z_i)^2\right]^{\frac{3}{2}}}$$

$$E_{total,x}(x,y) = k_e \sum_{i=1}^{n} \frac{q_i (x-x_i)}{\left[(x-x_i)^2 + (y-y_i)^2\right]^{\frac{3}{2}}}$$

$$E_{total,y}(x,y) = k_e \sum_{i=1}^{n} \frac{q_i (y-y_i)}{\left[(x-x_i)^2 + (y-y_i)^2\right]^{\frac{3}{2}}}$$

Calculate the resultant field at the following xy coordinates (0.10,0.05). Units are in meters.
1 m corresponds to 1cm on mm-paper. k=8.98E9 in SI units.
The charges are arranged in the columns as: charge in Coulombs, x coordinate in cm, y coordinate in cm:

qi	xi	yi
-5.00E-06	0	0
1.00E-05	0.07	0.06
-3.00E-06	-0.035	0.03
6.00E-06	-0.015	0.02
1.00E-06	0.04	-0.07
-2.00E-06	-0.045	0.08
-3.00E-06	-0.03	0.035
1.50E-06	-0.01	-0.02
-1.00E-06	-0.03	-0.03
2.00E-06	0.06	-0.05

(1.2)

Find the x and y components of the resultant field, its magnitude and its direction.
Use mm paper and draw the resultant field vectors with magnitude and direction. Indicate the charges and show all the distance vectors $\vec{r} - \vec{r}_i$ (the vectors pointing from the charges to the point where you calculate the electric fields.) Use a scale of 10megavolts/m =1cm. Use a straight edge to draw your lines.

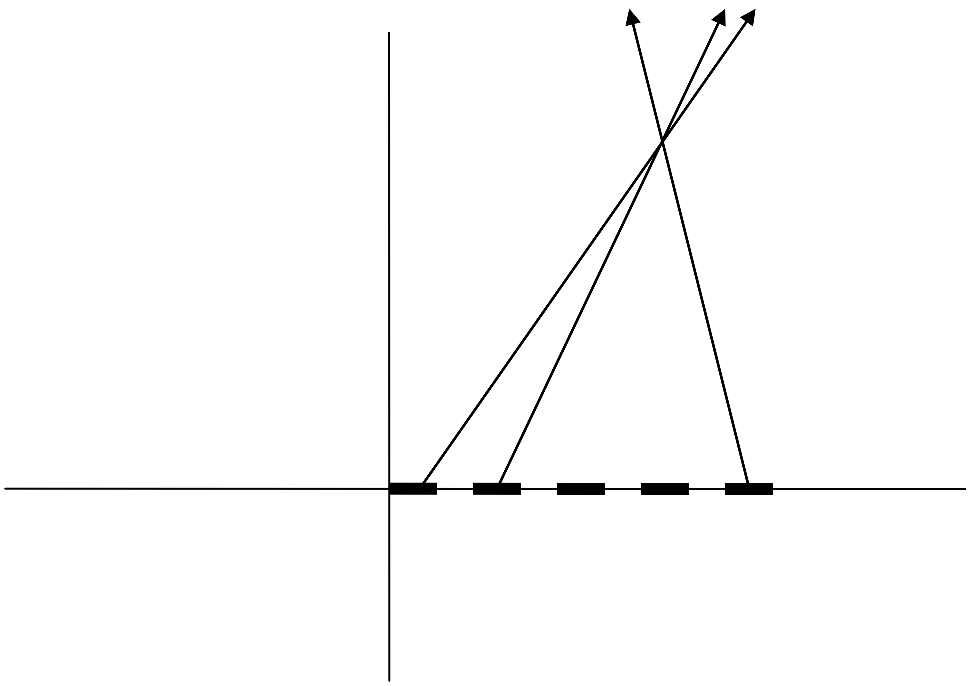
B) A 5.0 cm long line of charge (placed along the x-axis) carries a total charge of 10.0E-9C. Calculate the resultant field at a point (7cm,5cm) and (-4cm, 6cm) by summing up the field contributions of 2 mm long segments of charge. Place the beginning of the line charge at (0,0). Center the origin of the distance vector at the center of the line segments. This means that the first charge dq is located at x=0.10 cm, the second at 0.30 … the last at 4.9 cm. The sum of the line segments must add up to L=5 cm.

$$\vec{E}_{total}\text{at the point P(x,y,z)} = k_e \sum_{i=1}^{n} \frac{q_i}{r_i^2}\vec{u}_{ri} =$$

$$\vec{E}_{total}(x,y,z) = k_e \sum_{i=1}^{N=25} \frac{dq\langle x-x_i, y\rangle}{\left[(x-x_i)^2+y^2\right]^{\frac{3}{2}}}; dq=\lambda\Delta x_1; \lambda=\frac{Q}{L}; \Delta x_1=\frac{L}{N}$$

$$E_x(x,y) = k_e \int_0^L \frac{\lambda(x-x_1)dx_1}{\left[(x-x_1)^2+y^2\right]^{\frac{3}{2}}}; (x-x_1)^2+y^2=z; dz=-2(x-x_1)dx_1$$

$$E_x(x,y) = k_e\lambda\int -\frac{dz}{2z^{\frac{3}{2}}} = k_e\lambda\frac{1}{z^{\frac{1}{2}}} = E_x = k_e\lambda\left(\frac{1}{\sqrt{(x-L)^2+y^2}} - \frac{1}{\sqrt{x^2+y^2}}\right)$$



(1.3) $$E_y(x,y) = k_e \int_0^L \frac{\lambda y dx_1}{\left[(x-x_1)^2+y^2\right]^{\frac{3}{2}}} = \frac{k_e\lambda}{y}\left(\frac{x}{\sqrt{(x^2+y^2)}} - \frac{x-L}{\sqrt{(x-L)^2+y^2}}\right)$$

Find the x and y components of the resultant electric field, its magnitude and its direction. In addition (see formulas above), find the result through integration and compare it to your numerical approximation.

Draw the line charge and the resultant field at the two locations on a second sheet of mm paper. Use a scale of 1 cm for 500 V/m .