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Analytcial Calculations:

MatLab 3°

- $\rho_L = 4\ nC/m$
- point charges of 8nC each located at (0,1,1) and (0,-1,1)

Find E at (0,0,0)

$$E_{point} = \frac{Q}{4\pi\varepsilon_0 |R^2|} R$$

Point charge at Q_1°

$$R_1 = (0a_x + 0a_y + 0a_z) - (a_y + a_z)$$

$$= -1a_y - 1a_z$$

$$E_1 = \frac{Q_1}{4\pi\varepsilon_0 |R_1|^3} R_1$$

$$= \frac{8\times10^{-9}}{4\pi \times \frac{1}{36\pi}\times10^{-9} \times \left(\sqrt{(-1)^2+(-1)^2}\right)^3} (-1a_y - 1a_z)$$

$$= \frac{8\times10^{-9}}{8.888\times10^{-10}} (-1a_y - 1a_z)$$

$$E_1 = -25.4614\ a_y - 25.4614\ a_z$$

Point charge at Q_2°

$$R_1 = (0a_x + 0a_y + 0a_z) - (-a_y + a_z)$$

$$= 1a_y - 1a_z$$

$$E_1 = \frac{Q_1}{4\pi\varepsilon_0 |R_1|^3} R_1$$

$$= \frac{8\times10^{-9}}{4\pi \times \frac{1}{36\pi}\times10^{-9} \times \left(\sqrt{(1)^2+(-1)^2}\right)^3} (1a_y - 1a_z)$$

$$= \frac{8\times10^{-9}}{3.142\times10^{-10}} (1a_y - 1a_z)$$

$$E_2 = 25.4614\ a_y - 25.4614\ a_z$$

$dE_x = dE\sin\theta \qquad dE_y = dE\cos\theta$ } E split into 2 components

↳ $E = E_x + E_y$

$\sin\theta = \frac{x}{\sqrt{x^2+y^2}} \qquad \cos\theta = \frac{y}{x^2+y^2}$

$$dE = \frac{dQ}{4\pi\varepsilon_0 |R|^2} = \frac{\rho\, dL}{4\pi\varepsilon_0 |R|^2}$$

$$dE_x = \frac{\rho_L\, dL}{4\pi\varepsilon_0 (x^2+y^2)} \cdot \frac{x}{\sqrt{x^2+y^2}}$$

$$dE_x = \int_0^7 dE_x = \frac{\rho x}{4\pi\varepsilon_0} \int_0^7 \frac{dy}{(x^2+y^2)^{3/2}}$$

↳ $\frac{\rho x}{4\pi\varepsilon_0} \cdot \left[\frac{y}{x^2\sqrt{x^2+y^2}} \right]_0^7 \Rightarrow E_x = \frac{7\rho}{4\pi\varepsilon_0 x^2\sqrt{x^2+49}}$

(structure for y ↓)

$$E_y = \frac{7\rho}{4\pi\varepsilon_0 y^2\sqrt{y^2+49}}$$

$$E_x = \frac{7 \times 4 \times 10^{-9}}{(4\pi)\left(\frac{1}{36\pi} \times 10^{-9}\right)\left(7 \cdot \sqrt{7^2+49}\right)}$$

$E_x = 3.6365$

$$E_y = \frac{7 \times 4 \times 10^{-9}}{(4\pi)\left(\frac{1}{36\pi} \times 10^{-9}\right)\left(7 \cdot \sqrt{7^2+49}\right)}$$

$E_x = 3.6365$

$E = E_x + E_y$

$= 7.273$

$\underline{R} = (0-x)\,a_x + (0-y)\,a_y + (0-0)\,a_z$

$E_L = (7.273)(-1\,a_x - 1\,a_y)$

$E_L = (-7.273, -7.273, 0)$

Total E:

$E_T = E_1 + E_2 + E_3$

$= (-25.4614\, a_y - 25.4614\, a_z) + 25.4614\, a_y - 25.4614\, a_z + (-7.273 a_x - 7.273\, a_y)$

$E_T = (-7.273, -7.273, -50.9228.$

MATLAB CODE:

```
Q1=8e-9;%charges on Q1
Q2=8e-9;%charges on Q2

pL=4e-9;%charge density of the line
Epsilono=8.8419e-12;%Permitivity of free space

P=[0 0 0];%coordinates of observation point
A=[0 1 1];%coordinates of Q1
B=[0 -1 1];%coordinates of Q2
C=[3.5 3.5 0];%coordinates of the center of the line charge

Number_of_L_Steps=100000;%the steps of L
R1=P-A; %the vector pointing from Q1 to the observation point
R2=P-B; %the vector pointing from Q2 to the observation point
R1Mag=norm(R1);%the magnitude of R1
R2Mag=norm(R2);%the magnitude of R1

E1=Q1/(4*pi*Epsilono*R1Mag^3)*R1;%the electric field generated by Q1
E2=Q2/(4*pi*Epsilono*R2Mag^3)*R2;%the electric field generated by Q2
%%the following routine calculates the electric field at the
%%observation point generated by the line charge
% the following routine calculates the electric field at the
% observation point generated by the line charge

D = norm(P-C); % the distance from the observation point to the center of the line
L = sqrt(98)*D; % the length of the line

length = sqrt(98);
dir_vec = [-7/sqrt(98) 7/sqrt(98) 0];

dL = length/Number_of_L_Steps;
dL_Vector = dL*dir_vec;

EL = [0 0 0]; % initialize the electric field generated by EL


C_segment = C - (Number_of_L_Steps/2 * dL_Vector - dL_Vector/2);% the center of the first segment


for i = 1:Number_of_L_Steps
   R = P - C_segment;
   RMag = norm(R); % the magnitude of the vector R
   EL = EL + dL * pL / (4 * pi * Epsilono * (RMag)^3) * R; % get contribution from each segment
   C_segment = C_segment + dL_Vector; % the center of the i-th segment
end

E = E1 + E2 + EL; % the electric field at P
disp('ETotal: ');
disp(E);
```

Output:

```
>> assignment3
E:
   -7.2731   -7.2731  -50.9119
```