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%QUESTION 2.1%
%%%%%diagram (a)%%%%%%
%%%%%%%Electric Field%%%%%%

%constants
k = 9 * 10^9;

%charges
q1 = 2;
q2 = -3;
q3 = 3;

%creating grid
[x, y] = meshgrid(-6:0.5:6, -6:0.5:6);

%value of x and y component of Electric Field
Ex = k * q1 * x ./ (x.^2 + (y - 3).^2).^(3/2) + ...
     k * q2 * (x + 2) ./ ((x + 2).^2 + y.^2).^(3/2) + ...
     k * q3 * (x - 2) ./ ((x - 2).^2 + y.^2).^(3/2);

Ey = k * q1 * (y - 3) ./ (x.^2 + (y - 3).^2).^(3/2) + ...
     k * q2 * y ./ ((x + 2).^2 + y.^2).^(3/2) + ...
     k * q3 * y ./ ((x - 2).^2 + y.^2).^(3/2);

%plotting
figure;
quiver(x, y, Ex, Ey, 'Color', 'r');
xlabel('x');
ylabel('y');
title('Electric Field');

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%constants and charges
k = 9 * 10^9;
q1 = 2;
q2 = -2;
q3 = 3;
q4 = 2;

% Defining grid
[x, y] = meshgrid(-6:0.5:6, -6:0.5:6);

% Calculating electric field components
Ex = k * q1 * (x - 3) ./ ((x - 3).^2 + (y - 3).^2).^(3/2) + ...
     k * q2 * (x + 3) ./ ((x + 3).^2 + (y - 3).^2).^(3/2) + ...
     k * q3 * (x + 3) ./ ((x + 3).^2 + (y + 3).^2).^(3/2) + ...
     k * q4 * (x - 3) ./ ((x - 3).^2 + (y + 3).^2).^(3/2);

Ey = k * q1 * (y - 3) ./ ((x - 3).^2 + (y - 3).^2).^(3/2) + ...
     k * q2 * (y - 3) ./ ((x + 3).^2 + (y - 3).^2).^(3/2) + ...
     k * q3 * (y + 3) ./ ((x + 3).^2 + (y + 3).^2).^(3/2) + ...
     k * q4 * (y + 3) ./ ((x - 3).^2 + (y + 3).^2).^(3/2);
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% Plotting
figure;
quiver(x, y, Ex, Ey, 'Color', 'r');
xlabel('x');
ylabel('y');
title('Electric Field');
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%constants and charges
k = 9 * 10 ^ 9;
q1 = 2;
q2 = -3;
q3 = 3;

%initiating values of x and y
x = linspace(-6, 6, 100);
y = linspace(-6, 6, 100);

%creating grid
[X, Y] = meshgrid(x, y);

%distances
r1 = sqrt((X).^2+(Y-3).^2);
r2 = sqrt((X+2).^2+(Y).^2);
r3 = sqrt((X-2).^2+(Y).^2);

%potential formula
Z = k*(q1./r1 + q2./r2 + q3./r3);

% plotting
surf(X, Y, Z);
title('Potential');
xlabel('X');
ylabel('Y');
zlabel('Electric Potential');
colorbar();

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%charges and constants
k = 9 * 10 ^ 9;
q1 = 2;
q2 = -2;
q3 = 3;
q4 = 2;

%init. values of x and y
x = linspace(-6, 6, 100);
y = linspace(-6, 6, 100);

%creating grid
[X, Y] = meshgrid(x, y);

%distances
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r1 = sqrt((X-3).^2+(Y-3).^2);
r2 = sqrt((X+3).^2+(Y-3).^2);
r3 = sqrt((X+3).^2+(Y+3).^2);
r4 = sqrt((X-3).^2+(Y+3).^2);

%Potential formula
Z = k*(q1./r1 + q2./r2 + q3./r3 + q4./r4);

% Plotting
surf(X, Y, Z);
title('Potential');
xlabel('X');
ylabel('Y');
zlabel('Electric Potential');
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%charges, distances and constants
k = 9*10^9;
q1 = 2;
q2 = 3;
q3 = -3;
r1 = 4;
r2 = sqrt(13);
r3 = sqrt(13);

%electrostatic energy formula
Z = k*(q1*q2/r3 + q2*q3/r1 + q1*q3/r2);

% defining range of X and Y
[X, Y] = meshgrid(-6:0.1:6, -6:0.1:6);

%creating Z matrix
Z_matrix = ones(size(X)) * Z;

% Plotting
surf(X, Y, Z_matrix);
xlabel('X-axis');
ylabel('Y-axis');
zlabel('Electrostatic Energy');
title('Electrostatic Energy');

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%charges, distances, and constants
k = 9*10^9;
q1 = 2;
q2 = -2;
q3 = 3;
q4 = 2;
r1 = 4;
r2 = 4*sqrt(2);
r3 = 4;
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r4 = 4;
r5 = 4*sqrt(2);
r6 = 4;

% Electrostatic energy formula
Z = k*(q1*q2/r1 + q1*q3/r2 + q1*q4/r3 + q2*q3/r4 + q2*q4/r5 + q3*q4/r6);

% Defining range for X and Y
[X, Y] = meshgrid(-6:0.1:6, -6:0.1:6);

% creating Z matrix
Z_matrix = ones(size(X)) * Z;

% Plotting
surf(X, Y, Z_matrix);
xlabel('X-axis');
ylabel('Y-axis');
zlabel('Z-axis');
title('Simple 3D Plot with Constant Z Value');
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k = 9*10^9;
q = 1;
p = [0, 0, 0];

r = 1;
theta = linspace(0, pi, 100);
phi = linspace(0, 2*pi, 100);
[theta, phi] = meshgrid(theta, phi);
x = p(1) + r * sin(theta) .* cos(phi);
y = p(2) + r * sin(theta) .* sin(phi);
z = p(3) + r * cos(theta);

d = sqrt((x - p(1)).^2 + (y - p(2)).^2 + (z - p(3)).^2);
Ex = k * q * (x - p(1)) ./ d.^3;
Ey = k * q * (y - p(2)) ./ d.^3;
Ez = k * q * (z - p(3)) ./ d.^3;

dA = r^2 * sin(theta) * (2*pi/100) * (pi/100);
flux = sum(sum(Ex .* dA(1, :))) + sum(sum(Ey .* dA(1, :))) + sum(sum(Ez .* dA(1, :)));

qen = q;

figure;
quiver3(x, y, z, Ex, Ey, Ez);
hold on;

surf(x, y, z, 'FaceAlpha', 0.3);
shading interp;
axis equal;
xlabel('X');
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ylabel('Y');
zlabel('Z');
title('Gauss Law');

scatter3(p(1), p(2), p(3), 'filled', 'MarkerEdgeColor', 'k', 'MarkerFaceColor',
'r');
text(p(1), p(2), p(3), '   Charge', 'HorizontalAlignment', 'left');

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[x, y] = meshgrid(-2:0.2:2, -2:0.2:2);
v = sin(x).*cos(y);

[dx, dy] = gradient(v);

ex = -dx;
ey = -dy;

figure;
contour(x, y, v);
title('Potential');
xlabel('x');
ylabel('y');
colorbar;

figure;
quiver(x, y, ex, ey);
title('Electric Field e = -del v');
xlabel('x');
ylabel('y');
axis equal;
------
x = linspace(-6, 6, 2000);
y = linspace(-6, 6, 2000);
[X, Y] = meshgrid(x, y);
r = sqrt(X.^2 + Y.^2);
Ex = 9 * X ./ r.^3;
Ey = 9 * Y ./ r.^3;
[Curl_E,~] = curl(X, Y, Ex, Ey);
surf(x, y, Curl_E, "LineStyle", "none");
zlim([-1, 1]);
clim([-1, 1]);
colorbar;
xlabel('x');
ylabel('y');
zlabel("curl(E)");
```