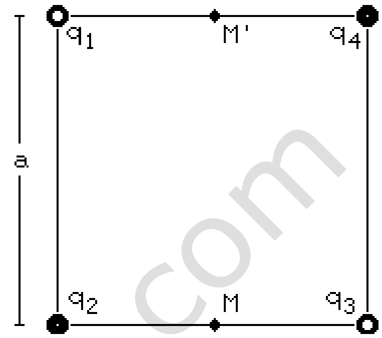
Q- Four charges $q_1 = q_3 = -q$ and $q_2 = q_4 = +q$, where q = 7 μC, are fixed at the corners of a square with sides a = 2.2 m.
(a) Calculate the x- and y-components of the net electric field at the midpoint M of the bottom side of the square.



The charges q_1 and q_4 constitutes a dipole of dipole moment P = q*a and M is on the perpendicular bisector of it, hence the magnitude of the field at M due to this dipole will be given by the formula

$$E_1 = \frac{1}{4\pi \in_0} . \frac{qa}{\left[a^2 + (a/2)^2\right]^{3/2}} = \frac{8*q}{4\pi \in_0 a^2 * 5\sqrt{5}}$$

Or $$E_1 = . \frac{(9*10^9)*8(7*10^{-6})}{(2.2)^2 * 5\sqrt{5}} = 9.314*10^3 \text{ N/C}$$

This field is in negative x direction.
The field due to q_2 and q_3 will be equal in magnitude and both are in positive x direction and their resultant will be

$$E_2 = 2* \frac{q}{4\pi \in_0 (a/2)^2} . = \frac{8q}{4\pi \in_0 a^2} = \frac{(9*10^9)*8(7*10^{-6})}{(2.2)^2} = 1.04*10^5 \text{ N/C}$$

This field will be in positive x direction.
As fields E_1 and E_2 both are in x direction the x component of the total field at M will be

$104.1*10^3 - 9.314*10^3 = 94.79*10^3$ N/C

And y component of the field at M will be zero.

(b) Find the total force exerted on q_4 by the charges q_1, q_2, and q_3:
Force on q_4 due to q_1 will be

$$\vec{F}_1 = \frac{q^2}{4\pi \in_0 a^2}\left(-\hat{i}\right)$$

Force on q_4 due to q_2 will be

$$\vec{F}_2 = \frac{q^2}{4\pi \in_0 2a^2}\left(\cos 45^0\, \hat{i} + \sin 45^0\, \hat{j}\right) = \frac{q^2}{4\pi \in_0 2\sqrt{2} * a^2}\left(\hat{i} + \hat{j}\right)$$

Force on q_4 due to q_3 will be

$$\vec{F}_3 = \frac{q^2}{4\pi \in_0 a^2}\left(-\hat{j}\right)$$

Hence the total force will be

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \frac{q^2}{4\pi \in_0 a^2}\left(\frac{1}{2\sqrt{2}} - 1\right)\left(\hat{i} + \hat{j}\right)$$

Or $$\vec{F} = \frac{(9*10^9)(7*10^{-6})^2}{2.2^2}(-0.6464)\left(\hat{i} + \hat{j}\right) = -0.0589\left(\hat{i} + \hat{j}\right)$$

Hence the magnitude of the force F = 0.589*$\sqrt{2}$ = N and its direction will bisect the angle between negative x and negative y axes.