

15-Phys-202

S 2002

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Quiz 2

Name _____

1. Four charges of equal magnitude q are placed in the corners of a square with sides of length a .

- (a) Calculate the electric force \vec{F} on a charge $5q$ at the midpoint of one of the square's sides, as shown in the Figure. (Be sure to specify both the magnitude and the direction of \vec{F}).

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4 = \vec{F}_2 + \vec{F}_3$$

The force is directed outside the square, along the perpendicular to the side. The magnitude of the force is

$$F = 2F_2 \cos \theta$$

where

$$F_2 = \frac{1}{4\pi\epsilon_0} \frac{5q^2}{d^2}$$

d is the distance between the charges

$$d = \sqrt{a^2 + \left(\frac{a}{2}\right)^2} = \frac{\sqrt{5}a}{2}$$

and

$$\cos \theta = \frac{a}{d}$$

Combining the above

$$F = 2 \frac{1}{4\pi\epsilon_0} \frac{5q^2}{d^2} \frac{a}{d} = \frac{1}{4\pi\epsilon_0} \frac{16q^2}{\sqrt{5}a^2}$$

- (b) A charge Q is now placed in the center of the square. Find Q such that the force on the charge $5q$ will be zero.

$$\frac{1}{4\pi\epsilon_0} \frac{16q^2}{\sqrt{5}a^2} = \frac{1}{4\pi\epsilon_0} \frac{(-Q)(5q)}{(a/2)^2}$$

whereof

$$Q = -\frac{4}{5\sqrt{5}}q$$