

# Quiz 1 solutions

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1. What is the relationship between the number of Electric field lines per unit area and the field strength?

Directly proportional

Please look at properties of electric field lines on textbook.

2. Two charges exert a force on each other. How does that force change if their separation is increased by a factor of 4?

Decrease by factor of 16

$$k_e \frac{q_1 q_2}{(4r)^2} = \frac{1}{16} k_e \frac{q_1 q_2}{r^2}$$

3. A  $2.83 \times 10^{-6}$  C charge is uniformly distributed on the surface of a conducting sphere of radius 1.12 m. What is the surface charge density, in  $C/m^2$ ?

$1.80 \times 10^{-7}$

$$\sigma = \frac{Q}{S} = \frac{2.83 \times 10^{-6} C}{4\pi(1.12m)^2} = 1.80 \times 10^{-7} C/m^2$$

4. What happens to the net electric flux through the surface of a sphere when the charge inside the sphere is doubled?

It is doubled.

In this case,  $\Phi = \oint \vec{E} \cdot d\vec{S} = \frac{q_{in}}{\epsilon_0}$ , so  $\Phi$  is proportional to  $q_{in}$ .

5. An electron and a proton are separated by  $5.31 \times 10^{-11}$  m. The mass of the proton is  $1.67 \times 10^{-27}$  kg, the mass of the electron is  $9.11 \times 10^{-31}$  kg. What electric force does the electron exert on the proton, in N?

$8.16 \times 10^{-8}$

$$|F_e| = k_e \frac{e^2}{r^2} = k_e \frac{(1.6 \times 10^{-19} C)^2}{(5.31 \times 10^{-11} m)^2} = 8.16 \times 10^{-8} N$$

6. A thin, square conducting plate 50.0 cm on a side lies in the xy plane. A total charge of  $4.00 \times 10^{-8}$  C is uniformly distributed across the plate. What is the E-field just below the plate, in N/C?

$9.04 \times 10^3$  in negative z direction

$$E = \frac{\sigma}{\epsilon_0} = \frac{4.00 \times 10^{-8} C}{2 \times (0.5m)^2 \times 8.85 \times 10^{-12} C^2/(Nm^2)} = 9.04 \times 10^{-3} N/C,$$

and it's pointing away from the plate.

7. Two charges exert a force on each other. How does that force change if both charges are doubled?

increase by factor of 4

$$k_e \frac{2q_1 \times 2q_2}{r^2} = 4 \times k_e \frac{q_1 q_2}{r^2}$$

8. Two cork balls are hung from insulating strings. Charges on the balls create a force pushing them apart. What can we say about those charges?

Both are positive, or both are negative.

Charges repel each other if they have the same sign, otherwise they will attract each other.

9. Two charges, a positive one of  $1.1 \times 10^{-10} C$  and a negative one of equal magnitude, are  $2.0 \times 10^{-6} m$  apart. A 3rd charge of  $1.0 \times 10^{-16} C$  is midway between them. What is the magnitude of the force on the 3rd charge, in N?

$2.0 \times 10^{-4}$

The 3rd charge feels two forces. These two forces have the same magnitude and the same direction.

$$F_3 = F_{13} + F_{23} = k_e \frac{1.1 \times 10^{-10} C \times 1.0 \times 10^{-16} C}{(1.0 \times 10^{-6} m)^2} + k_e \frac{1.1 \times 10^{-10} C \times 1.0 \times 10^{-16} C}{(1.0 \times 10^{-6} m)^2} = 2.0 \times 10^{-4} N$$

10.  $q_1$  is 2 C;  $q_2$  is -4 C. They are spaced so that  $q_1$  pulls on  $q_2$  with 5 N. What is the force of  $q_2$  on  $q_1$ ?

pulls with 5 N

Because two charges have different signs, they pull each other with same amount of force.

$$\vec{F}_{12} = k_e \frac{q_1 q_2}{r^2} \hat{r}_{12} = -5N \hat{r}_{12}$$

$$\vec{F}_{21} = k_e \frac{q_1 q_2}{r^2} \hat{r}_{21} = -5N \hat{r}_{21}$$