

Physics 12

Electricity Test Solutions

1. a. b. c. d.
2. a. b. c. d.
3. a. b. c. d.
4. a. b. c. d.
5. a. b. c. d.
6. a. b. c. d.
7. a. b. c. d.
8. a. b. c. d.
9. a. b. c. d.
10. a. b. c. d.
11. a. b. c. d.
12. a. b. c. d.
13. a. b. c. d.
14. a. b. c. d.
15. a. b. c. d.

1. Problem

Which of the following is a scalar? **Select all that apply.**

- a. Electric charge.
- b. Electric force.
- c. Electric field.
- d. Electric potential difference (voltage).

Solution

Vectors: Electric (coulomb) force and electric field.

Scalars: Electric charge, electric potential, electric potential difference (voltage), electric potential energy.

2. Problem

What is always true of an electrically charged object?

- a. It has more protons than electrons.
- b. It has no neutrons.
- c. It has an unequal number of protons and electrons.
- d. It has more electrons than protons.

Solution

An electrically charged object has an unequal number of protons and electrons.

3. Problem

Electric field lines

- a. Circle clockwise around positive charges.
- b. Radiate outward from positive charges.
- c. Circle clockwise around negative charges.
- d. Radiate outward from negative charges.

Solution

Electric field lines radiate outward from positive charges.

4. Problem

The electron-volt (eV) is a unit of

- a. Power.
- b. Voltage.
- c. Current.
- d. Energy.

Solution

The electron-volt (eV) is a unit of energy.

5. Problem

What is the magnitude of the coulomb force a $+8.9 \mu\text{C}$ charge exerts on a $+6 \mu\text{C}$ charge 43 cm away?

- a. 1.1 N
- b. 1.5 N
- c. 2.6 N
- d. 2.1 N

Solution

The coulomb force is

$$F = \frac{kq_1q_2}{r^2} = \frac{(9.0 \times 10^9 \text{ N m}^2/\text{C}^2)(8.9 \times 10^{-6} \text{ C})(6 \times 10^{-6} \text{ C})}{(43 \times 10^{-2} \text{ m})^2} = 2.6 \text{ N}$$

6. Problem

The magnitude of the electric field at a distance of 4 m from a point charge is 1 N/C. What is the magnitude of the electric field at a distance of 1 m from the point charge?

- a. $(4/1) \text{ N/C}$
- b. $(1/4)^2 \text{ N/C}$
- c. $(1/4) \text{ N/C}$
- d. $(4/1)^2 \text{ N/C}$

Solution

The formula for the electric field magnitude shows that it is inversely proportional to the distance squared:

$$E = \frac{kq}{r^2}$$

Let $r_1 = 4 \text{ m}$ and $r_2 = 1 \text{ m}$. The ratio between the electric field at r_1 and r_2 is

$$\frac{E_2}{E_1} = \frac{kq/r_2^2}{kq/r_1^2} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{4}{1}\right)^2$$

Since $E_1 = 1 \text{ N/C}$, the electric field at 1 cm is $(4/1)^2 \text{ N/C}$.

7. Problem

Two point charges are separated by a distance of 7 cm. Their electric potential energy is 1 J, relative to infinity. What would their electric potential energy be if the separation is changed to 6 cm?

- a. $(7/6)^2 \text{ J}$
- b. $(6/7)^2 \text{ J}$
- c. $(6/7) \text{ J}$
- d. $(7/6) \text{ J}$

Solution

The formula for the electric potential energy shows that it is inversely proportional to the distance:

$$E_p = \frac{kq_1q_2}{r}$$

Let $r_1 = 7 \text{ cm}$ and $r_2 = 6 \text{ cm}$. The ratio between the potential energy at r_1 and r_2 is

$$\frac{E_{p,2}}{E_{p,1}} = \frac{kq_1q_2/r_2}{kq_1q_2/r_1} = \frac{r_1}{r_2} = \frac{7}{6}$$

Since $E_{p,1} = 1 \text{ J}$, the coulomb force when the separation is 6 cm is $(7/6) \text{ J}$.

8. Problem

The electric potential at a distance of 1 m from a point charge is 1 V. What is the electric potential at a distance of 4 m from the point charge?

- a. $(4/1) \text{ V}$
- b. $(4/1)^2 \text{ V}$
- c. $(1/4)^2 \text{ V}$
- d. $(1/4) \text{ V}$

Solution

The formula for the electric potential from a point charge shows that it is inversely proportional to the distance:

$$V = \frac{kq}{r}$$

Let $r_1 = 1 \text{ m}$ and $r_2 = 4 \text{ m}$. The ratio between the potential energy at r_1 and r_2 is

$$\frac{V_2}{V_1} = \frac{kq/r_2}{kq/r_1} = \frac{r_1}{r_2} = \frac{1}{4}$$

Since $V_1 = 1 \text{ V}$, the potential at 4 m is $(1/4) \text{ V}$.

9. Problem

Two charged objects repel each other with a force F . What is the force between them if one charge multiplied by 6, the other charge is multiplied by 2, and the distance between them is reduced to $1/3$ its original value?

- a. $36F$
- b. $(12/3)F$
- c. $(12/9)F$
- d. $108F$

Solution

The formula for the coulomb force shows that it is proportional to both charges and inversely proportional to the distance squared:

$$F = \frac{kq_1q_2}{r^2}$$

Therefore, the answer is $6 \times 2 \times 3^2 F = 108F$.

10. Problem

What is the force on a $+7.0\text{ mC}$ charge when placed in a uniform electric field of strength 868 N/C ?

- a. 6.1 N
- b. 3.4 N
- c. 4.3 N
- d. 7.9 N

Solution

The force on a charge in an electric field is

$$F = qE = (7 \times 10^{-3}\text{ C})(868\text{ N/C}) = 6.1\text{ N}$$

11. Problem

It takes 22 J of energy to move 2.4 C of charge from point *A* to point *B*. What is the potential difference between points *A* and *B*?

- a. 5.1 V
- b. 9.2 V
- c. 33 V
- d. 53 V

Solution

The electric potential difference (voltage) is the energy per charge:

$$V = \frac{E}{Q} = \frac{22\text{ J}}{2.4\text{ C}} = 9.2\text{ V}$$

12. Problem

Consider a uniform electric field of 78.0 N/C pointing toward the east. If the voltage measured relative to ground at a given point in the field is 522 V , what is the voltage at a point 1.00 m directly south of the point?

- a. 522 V
- b. -897 V
- c. -784 V
- d. -220 V

Solution

The voltage changes with distance in a uniform electric field following the formula

$$V = Ed$$

The potential decreases moving in the same direction as the electric field and increases moving in the opposite direction. When moving perpendicular to the electric field, the potential does not change. Therefore, for this question, the voltage is

$$V = 522\text{ V} + (0\text{ m})(78\text{ N/C}) = 522\text{ V}$$

13. Problem

What is the magnitude of the electric field 23 cm away from a +4.8 nC point charge?

- a. 6200 N/C
- b. 820 N/C
- c. 600 N/C
- d. 2900 N/C

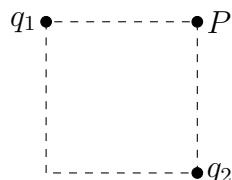
Solution

The electric field from a point charge is

$$E = \frac{kq}{r^2} = \frac{(9.0 \times 10^9 \text{ N m}^2/\text{C}^2)(4.8 \times 10^{-9} \text{ C})}{(23 \times 10^{-2} \text{ m})^2} = 820 \text{ N/C}$$

14. Problem

Two point charges, $q_1 = 5.0 \mu\text{C}$ and $q_2 = -5.0 \mu\text{C}$, are fixed at opposing corners of a square of side length 5.0 m. What is the electric field strength at one of unoccupied corners of the square (point P in the figure)?



- a. 3800 N/C
- b. 3200 N/C
- c. 2500 N/C
- d. 2900 N/C

Solution

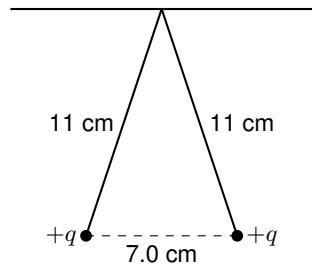
At point P , the electric field from q_1 will be at a right angle to the electric field from q_2 . Therefore, the net electric field strength can be calculated using the Pythagorean theorem.

$$E = \sqrt{E_1^2 + E_2^2} = \frac{k}{s^2} \sqrt{q_1^2 + q_2^2} = 2500 \text{ N/C}$$

15. Problem

Two balls, each of mass 0.9 kg, acquire the same electric charge. Each charge is suspended from the same point by a massless, electrically insulating string. They repel each other and hang with a separation of 7.0 cm. The length of the string from the point of support to the centre of a ball is 11 cm.

What is the charge on each ball? (The figure is not drawn to scale.)



- a. $2.5 \mu\text{C}$
- b. $1.6 \mu\text{C}$
- c. $1.4 \mu\text{C}$
- d. $1.3 \mu\text{C}$

Solution

The answer can be calculated by balancing the three forces on each ball:

- The force of gravity, $F_g = mg$, which acts straight down.
- The coulomb force, $F_q = kq^2/r^2$, which acts horizontally, pushing the charges apart.
- The tension force, which acts along the same angle as the string.

The answer is

$$q = \sqrt{\frac{r^2 mg \tan \theta}{k}} = 1.3 \mu\text{C}$$