

# Physics 12

## Electricity Retest Solutions

- |        |                                     |    |                                     |    |                                     |    |                                     |
|--------|-------------------------------------|----|-------------------------------------|----|-------------------------------------|----|-------------------------------------|
| 1. a.  | <input type="checkbox"/>            | b. | <input checked="" type="checkbox"/> | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |
| 2. a.  | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input type="checkbox"/>            | d. | <input checked="" type="checkbox"/> |
| 3. a.  | <input type="checkbox"/>            | b. | <input checked="" type="checkbox"/> | c. | <input type="checkbox"/>            | d. | <input type="checkbox"/>            |
| 4. a.  | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |
| 5. a.  | <input checked="" type="checkbox"/> | b. | <input type="checkbox"/>            | c. | <input type="checkbox"/>            | d. | <input type="checkbox"/>            |
| 6. a.  | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |
| 7. a.  | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |
| 8. a.  | <input checked="" type="checkbox"/> | b. | <input type="checkbox"/>            | c. | <input type="checkbox"/>            | d. | <input type="checkbox"/>            |
| 9. a.  | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |
| 10. a. | <input type="checkbox"/>            | b. | <input checked="" type="checkbox"/> | c. | <input type="checkbox"/>            | d. | <input type="checkbox"/>            |
| 11. a. | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |
| 12. a. | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |
| 13. a. | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |
| 14. a. | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |
| 15. a. | <input type="checkbox"/>            | b. | <input type="checkbox"/>            | c. | <input checked="" type="checkbox"/> | d. | <input type="checkbox"/>            |

**1. Problem**

Which of the following are vector quantities? **Select all that apply.**

- a. Electric potential.
- b. Electric field.
- c. Electric force.
- 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 neutral object?

- a. It has more neutrons than protons or electrons.
- b. It is made up of neutrons only.
- c. It is repelled by charged objects.
- d. It is attracted to charged objects.

**Solution**

An charged object would induce a charge in the neutral object causing the neutral object to be attracted to the charged object.

**3. Problem**

Electric field lines

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

**Solution**

Electric field lines radiate outward from positive charges.

**4. Problem**

The electron-volt (eV) is a unit of

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

**Solution**

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

**5. Problem**

What is the magnitude of the coulomb force a  $+9.1 \mu\text{C}$  charge exerts on a  $+7 \mu\text{C}$  charge 34 cm away?

- a. 5 N
- b. 24 N
- c. 43 N
- d. 19 N

**Solution**

The coulomb force is

$$F = \frac{kq_1q_2}{r^2} = \frac{(9.0 \times 10^9 \text{ N m}^2/\text{C}^2)(9.1 \times 10^{-6} \text{ C})(7 \times 10^{-6} \text{ C})}{(34 \times 10^{-2} \text{ m})^2} = 5 \text{ N}$$

**6. Problem**

The magnitude of the electric field at a distance of 14 m from a point charge is 1 N/C. What is the magnitude of the electric field at a distance of 3 m from the point charge?

- a.  $(3/14) \text{ N/C}$
- b.  $(3/14)^2 \text{ N/C}$
- c.  $(14/3)^2 \text{ N/C}$
- d.  $(14/3) \text{ N/C}$

**Solution**

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

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

Let  $r_1 = 14 \text{ m}$  and  $r_2 = 3 \text{ m}$ . The ratio between the electric field at  $r_1$  and  $r_2$  is

$$\frac{E_2}{E_1} = \frac{kq/r_2^2}{kq/r_1^2} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{14}{3}\right)^2$$

Since  $E_1 = 1 \text{ N/C}$ , the electric field at 3 cm is  $(14/3)^2 \text{ N/C}$ .

**7. Problem**

Two point charges are separated by a distance of 17 cm. Their electric potential energy is 1 J, relative to infinity. What would their electric potential energy be if the separation is changed to 2 cm?

- a.  $(2/17) \text{ J}$
- b.  $(17/2)^2 \text{ J}$
- c.  $(17/2) \text{ J}$
- d.  $(2/17)^2 \text{ J}$

**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  $r_1 = 17$  cm and  $r_2 = 2$  cm. The ratio between the potential energy at  $r_1$  and  $r_2$  is

$$\frac{E_{p,2}}{E_{p,1}} = \frac{kq_1q_2/r_2}{kq_1q_2/r_1} = \frac{r_1}{r_2} = \frac{17}{2}$$

Since  $E_{p,1} = 1$  J, the coulomb force when the separation is 2 cm is  $(17/2)$  J.

**8. Problem**

The electric potential at a distance of 2 m from a point charge is 1 V. What is the electric potential at a distance of 1 m from the point charge?

- a.  $(2/1)$  V
- b.  $(2/1)^2$  V
- c.  $(1/2)^2$  V
- d.  $(1/2)$  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  $r_1 = 2$  m and  $r_2 = 1$  m. The ratio between the potential energy at  $r_1$  and  $r_2$  is

$$\frac{V_2}{V_1} = \frac{kq/r_2}{kq/r_1} = \frac{r_1}{r_2} = \frac{2}{1}$$

Since  $V_1 = 1$  V, the potential at 1 m is  $(2/1)$  V.

**9. Problem**

Two charged objects repel each other with a force  $F$ . What is the force between them if one of the charges is multiplied by 9, the other charge is multiplied by 7, and the distance between them is reduced to  $1/6$  its original value?

- a.  $(63/6)$   $F$
- b.  $(63/36)$   $F$
- c.  $2268$   $F$
- d.  $378$   $F$

**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  $9 \times 7 \times 6^2 F = 2268 F$ .

**10. Problem**

What is the force on a  $+7.3 \text{ mC}$  charge when placed in a uniform electric field of strength  $682 \text{ N/C}$ ?

- a.  $6.4 \text{ N}$
- b.  $5 \text{ N}$
- c.  $3.7 \text{ N}$
- d.  $3.1 \text{ N}$

**Solution**

The force on a charge in an electric field is

$$F = qE = (7.3 \times 10^{-3} \text{ C})(682 \text{ N/C}) = 5 \text{ N}$$

**11. Problem**

It takes  $25 \text{ J}$  of energy to move  $1.9 \text{ C}$  of charge from point  $A$  to point  $B$ . What is the potential difference between points  $A$  and  $B$ ?

- a.  $48 \text{ V}$
- b.  $22 \text{ V}$
- c.  $13 \text{ V}$
- d.  $0.08 \text{ V}$

**Solution**

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

$$V = \frac{E}{Q} = \frac{25 \text{ J}}{1.9 \text{ C}} = 13 \text{ V}$$

**12. Problem**

Consider a uniform electric field of  $47.0 \text{ N/C}$  pointing toward the east. If the voltage measured relative to ground at a given point in the field is  $318 \text{ V}$ , what is the voltage  $6.00 \text{ m}$  directly south of the point?

- a.  $-23.7 \text{ V}$
- b.  $-388 \text{ V}$
- c.  $318 \text{ V}$
- d.  $142 \text{ V}$

**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

$$V = 318 \text{ V} + (0 \text{ m})(47 \text{ N/C}) = 318 \text{ V}$$

**13. Problem**

What is the electric field strength 37 cm away from a +5 nC point charge?

- a. 1300 N/C
- b. 95 N/C
- c. 330 N/C
- d. 2800 N/C

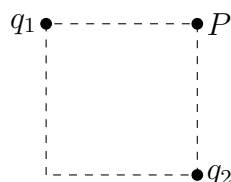
**Solution**

The electric field from a point charge is

$$E = \frac{kq}{r^2} = \frac{(9.0 \times 10^9 \text{ N m}^2/\text{C}^2)(5 \times 10^{-9} \text{ C})}{(37 \times 10^{-2} \text{ m})^2} = 330 \text{ N/C}$$

**14. Problem**

Two point charges,  $q_1 = -2.0 \mu\text{C}$  and  $q_2 = -6.0 \mu\text{C}$ , are fixed at opposing corners of a square of side length 3.0 m as shown in the figure. What is the electric field strength at one of the unoccupied corners of the square (point  $P$  in the figure)?



- a. 9200 N/C
- b. 7100 N/C
- c. 6300 N/C
- d. 8500 N/C

**Solution**

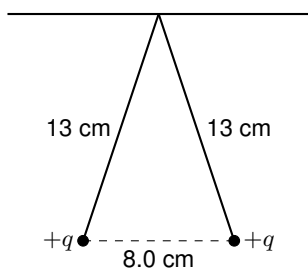
At point  $P$ , the electric field from  $q_1$  will be at a right angle to the electric field from  $q_2$ . Therefore, the net electric field strength can be calculated using the Pythagorean theorem.

$$E = \sqrt{E_1^2 + E_2^2} = \frac{k}{s^2} \sqrt{q_1^2 + q_2^2} = 6300 \text{ N/C}$$

**15. Problem**

Two balls, each of mass 0.99 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 8.0 cm. The length of the string from the point of support to the centre of a ball is 13 cm.

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



- a.  $0.07\text{ }\mu\text{C}$
- b.  $1.1\text{ }\mu\text{C}$
- c.  $1.5\text{ }\mu\text{C}$
- d.  $0.37\text{ }\mu\text{C}$

**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

$$q = \sqrt{\frac{r^2 mg \tan \theta}{k}} = 1.5\text{ }\mu\text{C}$$