Physics 12
Electricity Test Solutions

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

1. **Problem**
   Which of the following is a scalar? **Select all that apply.**
   a. Electric force.
   b. Electric charge.
   c. Electric potential.
   d. Electric potential energy.

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

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

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 $+5.6\,\mu$C charge exerts on a $+7.5\,\mu$C charge $33\,\text{cm}$ away?
   a. 20 N
   b. 2.8 N
   c. 3.5 N
   d. 16 N

Solution
The coulomb force is

$$F = \frac{kq_1q_2}{r^2} = \frac{(9.0 \times 10^9\,\text{N m}^2/\text{C}^2)(5.6 \times 10^{-6}\,\text{C})(7.5 \times 10^{-6}\,\text{C})}{(33 \times 10^{-2}\,\text{m})^2} = 3.5\,\text{N}$$

6. **Problem**
The magnitude of the electric field at a distance of $17\,\text{m}$ from a point charge is $1\,\text{N}/\text{C}$. What is the magnitude of the electric field at a distance of $12\,\text{m}$ from the point charge?
   a. $(17/12)^2\,\text{N}/\text{C}$
   b. $(17/12)\,\text{N}/\text{C}$
   c. $(12/17)^2\,\text{N}/\text{C}$
   d. $(12/17)\,\text{N}/\text{C}$

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

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

Let $r_1 = 17\,\text{m}$ and $r_2 = 12\,\text{m}$. The ratio between the electric field at r_1 and r_2 is

$$\frac{E_2}{E_1} = \frac{kq/r_2^2}{kq/r_1^2} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{17}{12}\right)^2$$

Since $E_1 = 1\,\text{N}/\text{C}$, the electric field at $12\,\text{cm}$ is $(17/12)^2\,\text{N}/\text{C}$.

7. **Problem**
Two point charges are separated by a distance of $1\,\text{cm}$. Their electric potential energy is 1 J, relative to infinity. What would their electric potential energy be if the separation is changed to $4\,\text{cm}$?
   a. $(1/4)$ J
   b. $(4/1)$ J
   c. $(4/1)^2$ J
   d. $(1/4)^2$ 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 $r_1 = 1$ cm and $r_2 = 4$ cm. The ratio between the potential energy at r_1 and r_2 is

$$\frac{E_{p,2}}{E_{p,1}} = \frac{kq_1q_2/r_2}{kq_1q_2/r_1} = \frac{r_1}{r_2} = \frac{1}{4}$$

Since $E_{p,1} = 1$ J, the coulomb force when the separation is $4\,\text{cm}$ is $(1/4)$ J.

8. **Problem**
   The electric potential at a distance of $13\,\text{m}$ from a point charge is $1\,\text{V}$. What is the electric potential at a distance of $12\,\text{m}$ from the point charge?

   a. $(13/12)^2\,\text{V}$
   b. $(12/13)\,\text{V}$
   c. $(13/12)\,\text{V}$
   d. $(12/13)^2\,\text{V}$

   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 $r_1 = 13\,\text{m}$ and $r_2 = 12\,\text{m}$. The ratio between the potential energy at r_1 and r_2 is

$$\frac{V_2}{V_1} = \frac{kq/r_2}{kq/r_1} = \frac{r_1}{r_2} = \frac{13}{12}$$

   Since $V_1 = 1\,\text{V}$, the potential at $12\,\text{m}$ is $(13/12)\,\text{V}$.

9. **Problem**
   Two charged objects repel each other with a force F. What is the force between them if one charge multiplied by 9, the other charge is multiplied by 5, and the distance between them is reduced to $1/3$ its original value?

   a. $(45/9)\,F$
   b. $135\,F$
   c. $405\,F$
   d. $(45/3)\,F$

   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 $9 \times 5 \times 3^2\,F = 405\,F$.

10. **Problem**
What is the force on a $+5.7\,\mathrm{mC}$ charge when placed in a uniform electric field of strength $491\,\mathrm{N/C}$?

    a. 4.2 N
    b. 3.1 N
    c. 3.4 N
    d. 2.8 N

    Solution
    The force on a charge in an electric field is

$$F = qE = (5.7 \times 10^{-3}\,\mathrm{C})(491\,\mathrm{N/C}) = 2.8\,\mathrm{N}$$

11. **Problem**
It takes $10\,\mathrm{J}$ of energy to move $9.1\,\mathrm{C}$ of charge from point A to point B. What is the potential difference between points A and B?

    a. 0.91 V
    b. 45 V
    c. 1.1 V
    d. 91 V

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

$$V = \frac{E}{Q} = \frac{10\,\mathrm{J}}{9.1\,\mathrm{C}} = 1.1\,\mathrm{V}$$

12. **Problem**
Consider a uniform electric field of $14.0\,\mathrm{N/C}$ pointing toward the east. If the voltage measured relative to ground at a given point in the field is $803\,\mathrm{V}$, what is the voltage at a point $4.00\,\mathrm{m}$ directly west of the point?

    a. -1270 V
    b. 1060 V
    c. 741 V
    d. 859 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

$$V = 803\,\mathrm{V} + (4\,\mathrm{m})(14\,\mathrm{N/C}) = 859\,\mathrm{V}$$

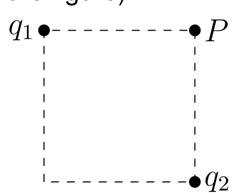
13. **Problem**
What is the magnitude of the electric field $30\,\text{cm}$ away from a $+4.7\,\text{nC}$ point charge?

   a. 85 N/C
   b. 420 N/C
   c. 150 N/C
   d. 470 N/C

Solution
The electric field from a point charge is

$$E = \frac{kq}{r^2} = \frac{(9.0 \times 10^9\,\text{N}\,\text{m}^2/\text{C}^2)(4.7 \times 10^{-9}\,\text{C})}{(30 \times 10^{-2}\,\text{m})^2} = 470\,\text{N}/\text{C}$$

14. **Problem**
Two point charges, $q_1 = 9.0\,\mu\text{C}$ and $q_2 = -2.0\,\mu\text{C}$, are fixed at opposing corners of a square of side length $7.0\,\text{m}$. What is the electric field strength at one of unoccupied corners of the square (point P in the figure)?



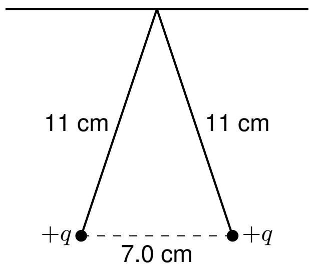
   a. $1700\,\text{N}/\text{C}$
   b. $2500\,\text{N}/\text{C}$
   c. $2100\,\text{N}/\text{C}$
   d. $1100\,\text{N}/\text{C}$

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.

$$E = \sqrt{E_1^2 + E_2^2} = \frac{k}{s^2}\sqrt{q_1^2 + q_2^2} = 1700\,\text{N}/\text{C}$$

15. **Problem**
Two balls, each of mass $1.0\,\text{kg}$, 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 $7.0\,\text{cm}$. The length of the string from the point of support to the centre of a ball is $11\,\text{cm}$.

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



a. $2\,\mu$C
b. $0.88\,\mu$C
c. $2.4\,\mu$C
d. $1.3\,\mu$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

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