1. Which one of the following represents correct units for electric field strength?
   A. T  
   B. N/C  
   C. J / C  
   D. N \cdot m^2 / C^2

2. The diagram below shows two positive charges of magnitude \( Q \) and \( 2Q \).

Which vector best represents the direction of the electric field at point \( P \), which is equidistant from both charges?

A.  
B.  
C.  
D.  

3. A \( 6.0 \times 10^{-6} \) C charge is located 4.0 m from a \( -3.0 \times 10^{-6} \) C charge.

What is the electric potential at \( P \), halfway between the charges?

A. \(- 4.1 \times 10^{-2} \) V  
B. \( 6.8 \times 10^3 \) V  
C. \( 1.4 \times 10^4 \) V  
D. \( 4.1 \times 10^4 \) V
4. The diagram below shows the electric field near two point charges L and R.

![Diagram of electric field with arrows pointing towards L and away from R.]

What is the polarity of each charge?

<table>
<thead>
<tr>
<th>CHARGE L</th>
<th>CHARGE R</th>
</tr>
</thead>
<tbody>
<tr>
<td>positive</td>
<td>positive</td>
</tr>
<tr>
<td>positive</td>
<td>negative</td>
</tr>
<tr>
<td>negative</td>
<td>positive</td>
</tr>
<tr>
<td>negative</td>
<td>negative</td>
</tr>
</tbody>
</table>

5. The electric field 2.0 m from a point charge has a magnitude of $8.0 \times 10^4$ N/C. What is the strength of the electric field at a distance of 4.0 m?

A. $2.0 \times 10^4$ N/C  
B. $4.0 \times 10^4$ N/C  
C. $1.6 \times 10^5$ N/C  
D. $3.2 \times 10^5$ N/C

6. When a charge is accelerated through a potential difference of 500 V, its kinetic energy increases from $2.0 \times 10^{-5}$ J to $6.0 \times 10^{-5}$ J. What is the magnitude of the charge?

A. $4.0 \times 10^{-8}$ C  
B. $8.0 \times 10^{-8}$ C  
C. $1.2 \times 10^{-7}$ C  
D. $1.6 \times 10^{-7}$ C
7. What is the electric potential energy of an electron located \(5.3 \times 10^{-11}\) m from the proton in a hydrogen atom?
   A. \(-8.2 \times 10^{-8}\) J
   B. \(-4.3 \times 10^{-18}\) J
   C. \(-2.2 \times 10^{-18}\) J
   D. \(-1.6 \times 10^{-19}\) J

8. A negative charge in an electric field experiences a force accelerating it due south. What is the direction of the electric field?
   A. east
   B. west
   C. north
   D. south

9. A \(-2.3 \times 10^{-6}\) C charge exerts a repulsive force of magnitude 0.35 N on an unknown charge 0.20 m away. What are the magnitude and polarity of the unknown charge?

<table>
<thead>
<tr>
<th>MAGNITUDE</th>
<th>POLARITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 6.8 \times 10^{-7} C</td>
<td>Negative</td>
</tr>
<tr>
<td>B. 6.8 \times 10^{-7} C</td>
<td>Positive</td>
</tr>
<tr>
<td>C. 1.2 \times 10^{-6} C</td>
<td>Negative</td>
</tr>
<tr>
<td>D. 1.2 \times 10^{-6} C</td>
<td>Positive</td>
</tr>
</tbody>
</table>

10. Two point charges, \(2.5 \times 10^{-6}\) C and \(-5.0 \times 10^{-6}\) C, are placed 3.0 m apart as shown below.

\[
\begin{array}{c}
\text{2.5} \times 10^{-6}\text{C} \\
\text{P} \\
\text{\text{-5.0} \times 10^{-6}\text{C}}
\end{array}
\]

\(\text{1.5 m} \quad \text{1.5 m} \quad \text{1.5 m}\)

What is the magnitude of the electric field at point P, midway between the two charges?

A. 0 N/C
B. \(1.0 \times 10^{4}\) N/C
C. \(2.0 \times 10^{4}\) N/C
D. \(3.0 \times 10^{4}\) N/C
11. A $4.0 \times 10^{-9}$ C charge is initially located 3.0 m from a stationary $6.0 \times 10^{-8}$ C charge. How much work is required to move the $4.0 \times 10^{-9}$ C charge to a point 0.50 m from the stationary charge?

![Diagram of two charges](image)

A. $6.0 \times 10^{-7}$ J  
B. $8.6 \times 10^{-7}$ J  
C. $3.6 \times 10^{-6}$ J  
D. $4.3 \times 10^{-6}$ J

12. Two parallel plates $4.0 \times 10^{-2}$ m apart have a potential difference of 1000 V. An electron is released from the negative plate at the same instant that a proton is released from the positive plate. Which of the following best compares their speed and kinetic energy as they strike the opposite plate?

<table>
<thead>
<tr>
<th>SPEED OF ELECTRON AND PROTON</th>
<th>KINETIC ENERGY OF ELECTRON AND PROTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. same</td>
<td>same</td>
</tr>
<tr>
<td>B. same</td>
<td>different</td>
</tr>
<tr>
<td>C. different</td>
<td>same</td>
</tr>
<tr>
<td>D. different</td>
<td>different</td>
</tr>
</tbody>
</table>

13. Two long, parallel plates are separated by 0.028 m and have a potential difference between them of 80 V, as shown below.

![Diagram of two plates](image)

Point P is located midway between the plates. What is the potential difference between point P and one of the plates?

A. 0 V  
B. 40 V  
C. 80 V  
D. 160 V
14. A particle with a charge of $2.4 \times 10^{-5} \text{ C}$ is accelerated from rest through a potential difference of $6.2 \times 10^{4} \text{ V}$. If the final speed of this particle is $9.3 \times 10^{3} \text{ m/s}$, what is the mass of the particle?

A. $7.7 \times 10^{-10} \text{ kg}$  
B. $5.2 \times 10^{-9} \text{ kg}$  
C. $3.4 \times 10^{-8} \text{ kg}$  
D. $1.5 \times 10^{-1} \text{ kg}$

15. Two positive charges, equal in magnitude, are separated as shown below.

In which location would the electric field strength be zero?

A. 1  
B. 2  
C. 3  
D. 4

16. An electron is positioned in an electric field. The force on the electron due to the electric field is equal to the force of gravity on the electron. What is the magnitude of this electric field?

A. $8.93 \times 10^{-30} \text{ N/C}$  
B. $5.69 \times 10^{-12} \text{ N/C}$  
C. $5.58 \times 10^{-11} \text{ N/C}$  
D. $1.44 \times 10^{-9} \text{ N/C}$

17. Two $3.0 \times 10^{-6} \text{ C}$ point charges are placed 5.0 m apart as shown below.

What is the potential at point $P$ due to the two charges?

A. 0 V  
B. $5.4 \times 10^{3} \text{ V}$  
C. $7.6 \times 10^{3} \text{ V}$  
D. $1.1 \times 10^{4} \text{ V}$
18. Which of the following diagrams best shows the electric field between two equal negative charges?

A. ![Diagram A]

B. ![Diagram B]

C. ![Diagram C]

D. ![Diagram D]

19. In a hydrogen atom, the electron and proton are separated by a distance of \(5.3 \times 10^{-11}\) m. What is the electric force exerted on the proton by the electron?

A. 0 N

B. \(4.4 \times 10^{-18}\) N

C. \(8.2 \times 10^{-8}\) N

D. \(1.0 \times 10^{12}\) N

20. A 2.5 C charge is moved from a point with a potential of 12 V to another point of potential 75 V. How much work was done on this charge?

A. 30 J

B. 160 J

C. 180 J

D. 220 J
21. An electron is travelling in an electric field as shown.

Describe the electrostatic force acting on the electron while in the field.

<table>
<thead>
<tr>
<th>MAGNITUDE OF FORCE</th>
<th>DIRECTION OF FORCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Changing</td>
<td>Upward</td>
</tr>
<tr>
<td>B. Changing</td>
<td>Downward</td>
</tr>
<tr>
<td>C. Constant</td>
<td>Upward</td>
</tr>
<tr>
<td>D. Constant</td>
<td>Downward</td>
</tr>
</tbody>
</table>

22. A proton initially at rest is accelerated between parallel plates through a potential difference of 300 V.

What is the maximum speed attained by the proton?

A. $7.5 \times 10^3$ m/s
B. $1.7 \times 10^5$ m/s
C. $2.4 \times 10^5$ m/s
D. $1.2 \times 10^6$ m/s
23. An electron experiences an electric force of $1.8 \times 10^{-11} \text{ N}$ at a distance of $5.0 \times 10^{-9} \text{ m}$ from the nucleus of an ion. The electron is moved farther away, to a distance of $2.0 \times 10^{-8} \text{ m}$ from the ion. What is the new electric force on the electron?

A. $1.1 \times 10^{-12} \text{ N}$
B. $4.5 \times 10^{-12} \text{ N}$
C. $7.2 \times 10^{-11} \text{ N}$
D. $2.9 \times 10^{-10} \text{ N}$

24. What is the magnitude of the electric field at point $P$ due to the two fixed charges as shown?

A. $3.0 \times 10^3 \text{ N/C}$
B. $9.4 \times 10^3 \text{ N/C}$
C. $1.3 \times 10^4 \text{ N/C}$
D. $3.9 \times 10^4 \text{ N/C}$

25. Which of the following is an equivalent unit for the volt?

A. $\frac{\text{C}}{\text{s}}$
B. $\frac{\text{J}}{\text{C}}$
C. $\frac{\text{N}}{\text{C}}$
D. $\text{J}$
26. An object with a charge of $+4.0 \times 10^{-18}$ C and a mass of $1.1 \times 10^{-15}$ kg is held stationary by balanced gravitational and electric forces midway between horizontal charged plates as shown. What is the applied voltage $V$?

A. $16$ V  
B. $32$ V  
C. $65$ V  
D. $2.7 \times 10^2$ V

27. What are the magnitude and direction of the electric force on the $+2.0 \times 10^{-6}$ C charge shown below?

$q = +2.0 \times 10^{-6}$ C  
$Q_1 = -6.0 \times 10^{-6}$ C  
$Q_2 = -7.0 \times 10^{-6}$ C

<table>
<thead>
<tr>
<th>MAGNITUDE OF FORCE</th>
<th>DIRECTION OF FORCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. $1.1 \times 10^{-3}$ N</td>
<td>Left</td>
</tr>
<tr>
<td>B. $1.1 \times 10^{-3}$ N</td>
<td>Right</td>
</tr>
<tr>
<td>C. $1.5 \times 10^{-3}$ N</td>
<td>Left</td>
</tr>
<tr>
<td>D. $1.5 \times 10^{-3}$ N</td>
<td>Right</td>
</tr>
</tbody>
</table>
28. Which diagram shows the electric field between a pair of charged parallel plates?

A. 

B. 

C. 

D. 

29. In the diagram below, a \(2.0 \times 10^{-6}\) C charge experiences forces of 3.0 N and 8.0 N at its location between charges \(Q_1\) and \(Q_2\).

\[Q_1 \quad 2.0 \times 10^{-6} \text{ C} \quad Q_2\]

\(F_1 = 3.0\) N \(F_2 = 8.0\) N

Find the magnitude of the net electric field strength at the location of the \(2.0 \times 10^{-6}\) C charge.

A. \(2.5 \times 10^6\) N/C
B. \(2.8 \times 10^6\) N/C
C. \(5.5 \times 10^6\) N/C
D. \(1.2 \times 10^7\) N/C

30. How much work is done moving the \(-2.0 \times 10^{-6}\) C charge, \(Q_1\), from S to T in the diagram shown below?

\(Q_2 = 8.0 \times 10^{-6}\) C \(Q_1 = -2.0 \times 10^{-6}\) C

\(S\) \(T\)

5.0 m \(2.0\) m

A. \(5.6 \times 10^{-3}\) J
B. \(8.2 \times 10^{-3}\) J
C. \(1.2 \times 10^{-2}\) J
D. \(7.2 \times 10^{-2}\) J
31. A $1.60 \times 10^{-19}$ C ion is accelerated from rest through a potential difference of 750 V reaching a maximum speed of $8.50 \times 10^4$ m/s. What is the mass of this ion?

A. $9.11 \times 10^{-31}$ kg  
B. $1.67 \times 10^{-27}$ kg  
C. $3.32 \times 10^{-26}$ kg  
D. $4.84 \times 10^{-20}$ kg

32. Which of the following shows the electric field between two opposite charges of unequal magnitude?

A.  
B.  
C.  
D.  

33. Three point charges of equal magnitude but opposite sign are arranged as shown in the diagram below.

Which of the diagrams below best represents the electric forces acting on $Q_3$ due to the other two charges?

A.  
B.  
C.  
D.
34. What is the acceleration of a proton in a uniform \( 2.5 \times 10^5 \) \( \text{N/C} \) electric field as shown below?

\[ E \]

\[ \text{proton} \]

<table>
<thead>
<tr>
<th>MAGNITUDE OF ACCELERATION</th>
<th>DIRECTION OF ACCELERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ( 2.4 \times 10^{13} ) m/s(^2)</td>
<td>Right</td>
</tr>
<tr>
<td>B. ( 2.4 \times 10^{13} ) m/s(^2)</td>
<td>Left</td>
</tr>
<tr>
<td>C. ( 1.5 \times 10^{32} ) m/s(^2)</td>
<td>Right</td>
</tr>
<tr>
<td>D. ( 1.5 \times 10^{32} ) m/s(^2)</td>
<td>Left</td>
</tr>
</tbody>
</table>

35. How much work is needed to move a \( -2.0 \times 10^{-6} \) C charge from position S to position T as shown below?

\[ \text{8.0} \times 10^{-6} \text{ C} \quad \text{fixed} \quad \text{S} \quad \text{T} \quad \text{2.0 m} \quad \text{3.0 m} \]

A. \( 4.3 \times 10^{-2} \) J  
B. \( 4.8 \times 10^{-2} \) J  
C. \( 9.1 \times 10^{-2} \) J  
D. \( 1.1 \times 10^{-1} \) J

36. An electron, initially at rest, is accelerated through a potential difference of \( 600 \) V as shown.

\[ \begin{array}{c}
\text{600 V} \\
\text{4.2} \times 10^{-2} \text{ m}
\end{array} \]

What is the maximum kinetic energy of the electron?

A. \( 3.7 \times 10^{-31} \) J  
B. \( 9.6 \times 10^{-17} \) J  
C. \( 6.0 \times 10^{2} \) J  
D. \( 1.4 \times 10^{4} \) J
37. A cathode ray tube is adjusted so as to deflect the beam as shown.

If the deflecting voltage is held constant and the accelerating voltage is then decreased, which diagram displays the new deflection?

A.  

B.  

C.  

D.
38. A cathode ray tube beam deflects to the location as shown in Diagram I when a certain voltage is applied to the deflecting plates.

![Diagram I and Diagram II]

The connections to the deflecting plates are then reversed and the deflecting voltage is reduced. Which location in Diagram II best represents the new beam position?

A. Location 1  
B. Location 2  
C. Location 3  
D. Location 4

39. Two $2.0 \times 10^{-6}$ C charges are positioned as shown in the diagram below.

![Diagram with X and Y]

What work must be done to move a $1.2 \times 10^{-7}$ C charge from location X to location Y?

A. $3.6 \times 10^{-3}$ J  
B. $1.5 \times 10^{-2}$ J  
C. $1.8 \times 10^{-2}$ J  
D. $3.9 \times 10^{-2}$ J
40. An electron orbits the nucleus of an atom with velocity $v$. If this electron were to orbit the same nucleus with twice the previous orbital radius, its orbital velocity would now be

A. $\frac{v}{2}$
B. $\frac{v}{\sqrt{2}}$
C. $v$
D. $2v$

41. In a cathode ray tube,

A. protons are accelerated from anode (positive) to cathode (negative).
B. protons are accelerated from cathode (negative) to anode (positive).
C. electrons are accelerated from anode (positive) to cathode (negative).
D. electrons are accelerated from cathode (negative) to anode (positive).

42. Which pair of values will cause the greatest deflection of an electron beam in a cathode ray tube?

<table>
<thead>
<tr>
<th>ACCELERATING VOLTAGE</th>
<th>DEFLECTION (PLATE) VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 400 V</td>
<td>20 V</td>
</tr>
<tr>
<td>B. 400 V</td>
<td>40 V</td>
</tr>
<tr>
<td>C. 800 V</td>
<td>20 V</td>
</tr>
<tr>
<td>D. 800 V</td>
<td>40 V</td>
</tr>
</tbody>
</table>

43. Which diagram shows the electric field near a negative point charge?

A. [Diagram A]
B. [Diagram B]
C. [Diagram C]
D. [Diagram D]
44. In an experiment, a positively charged oil droplet weighing $6.5 \times 10^{-15}$ N is held stationary by a vertical electric field as shown in the diagram.

If the electric field strength is $5.3 \times 10^3$ N/C, what is the charge on the oil droplet?

A. $1.2 \times 10^{-18}$ C  
B. $3.4 \times 10^{-11}$ C  
C. $4.1 \times 10^{4}$ C  
D. $8.2 \times 10^{17}$ C

45. A proton with kinetic energy of $2.1 \times 10^{-17}$ J is moving into a region of charged parallel plates. The proton will be stopped momentarily in what region?

![Diagram of charged parallel plates with voltage differences.]

A. Region K  
B. Region L  
C. Region M  
D. Region N

46. A moving proton has $6.4 \times 10^{-16}$ J of kinetic energy. The proton is accelerated by a potential difference of 5 000 V between parallel plates.

The proton emerges from the parallel plates with what speed?

A. $8.8 \times 10^5$ m/s  
B. $9.8 \times 10^5$ m/s  
C. $1.3 \times 10^6$ m/s  
D. $1.8 \times 10^6$ m/s
1. a) A $2.5 \times 10^{-7}$ C charge is initially located 7.0 m from a fixed $8.0 \times 10^{-6}$ C charge. What is the minimum amount of work required to move the $2.5 \times 10^{-7}$ C charge 2.0 m closer as shown? (5 marks)
b) If the $2.5 \times 10^{-7}$ C charge is moved a further 2.0 m closer to the $8.0 \times 10^{-6}$ C charge, will the additional work required be less than, the same as or greater than the work required in (a)?

Using principles of physics, explain your answer. (4 marks)

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________
2. A proton is located at A, 1.0 m from a fixed $+2.2 \times 10^{-6}$ C charge.

a) What is the change in potential energy of the proton as it moves to B, 10 m from the fixed charge?  

b) If the proton started from rest at A, what would be its speed at B?
3. A $-4.2 \times 10^{-6}$ C charge is placed between two stationary charges, $Q_1$ and $Q_2$, as shown below.

\[ Q_1 = 2.5 \times 10^{-6} \text{C} \quad -4.2 \times 10^{-6} \text{C} \quad Q_2 = 7.3 \times 10^{-6} \text{C} \]

What is the magnitude and direction of the net force on the $-4.2 \times 10^{-6}$ C charge due to the two stationary charges? (7 marks)
4. An electron passing between parallel plates 0.025 m apart experiences an upward electrostatic force of $5.1 \times 10^{-16}$ N.

a) What is the magnitude of the electric field between the plates? (3 marks)

b) What is the potential difference between the plates? (2 marks)

c) On the diagram below draw in the connections to the power supply necessary for the electron to experience this upward force. (2 marks)
5. Two charges are positioned as shown in the diagram below.

\[
\begin{align*}
Q_1 &= 8.0 \, \mu\text{C} \\
Q_2 &= -2.0 \, \mu\text{C}
\end{align*}
\]

A

\[
\begin{array}{c}
\text{4.0 m} \\
\text{2.0 m}
\end{array}
\]

a) Find the magnitude and direction of the electric field at A. (Note: 1.0 \( \mu\text{C} = 1.0 \times 10^{-6} \, \text{C} \) )

(4 marks)

b) A charge placed at A experiences a force of \( 4.0 \times 10^{-3} \, \text{N} \) towards the right. What are the magnitude and polarity of this charge?

(3 marks)
6. A charge $q$ of 30.0 $\mu$C is moved from point X to point Y.

How much work is done on the 30.0 $\mu$C charge? \(1 \mu C = 1 \times 10^{-6} C\) \(\text{(7 marks)}\)
7. A small $4.0 \times 10^{-3}$ kg charged sphere is suspended by a light thread between parallel plates, as shown in the diagram below. When the plates are connected to a $500$ V source, the thread makes a $15^0$ angle with the vertical.

What is the charge on the sphere? (9 marks)
8. Two small, indentically-charged conducting spheres each of mass $2.5 \times 10^{-4}$ kg hang from the same point on insulating threads of length 0.50 m as shown in the diagram below. If the enclosed angle between the threads is $90^\circ$, what is the charge on each sphere? (9 marks)
9. In a cathode-ray tube, electrons are accelerated from the cathode towards the anode by an accelerating voltage $V_a$. After passing through the anode, the electrons are deflected by the two oppositely-charged parallel plates.

If the accelerating voltage $V_a$ is increased, will the deflection increase, decrease, or remain the same? Using principles of physics, explain your answer. **(4 marks)**