YOUR NAME

Turn in scantron
You keep these question sheets
1) This is to identify the exam version you have - IMPORTANT
Mark the A

2) This is to identify the exam version you have - IMPORTANT
Mark the B

3) Three charges [1,2,3] are placed at the corners of an equilateral triangle as shown.
The charges are equal in magnitude, but differ in sign as not shown.
The net electrostatic potential at the center of the triangle is negative and
The E-field points down $\downarrow$ on the midpoint of the bottom side of the triangle [marked x].

The charges must be:
(a) 1: -, 2: -, 3: -
(b) 1: +, 2: -, 3: +
(c) 1: -, 2: +, 3: -
(d) 1: -, 2: -, 3: +
(e) 1: +, 2: -, 3: -

4) A positive charge is shot with velocity pointing in the $\leftarrow$ direction into an electric field
and slowing down due to the field.
From this we can conclude that the electric field vector points

  a) $\leftarrow$
  b) $\rightarrow$
  c) $\uparrow$
  d) $\downarrow$
  e) Is zero
5) Two charges: one positive of unknown magnitude and one negative of -1 C are a distance R apart.

The magnitude of the positive charge is such that at a point a distance R to the right of -Q, at marker "X", the net electric field is zero.

\[ E_{\text{NET}} = 0 = E^+ + E^- \]

\[ E^+ = k \frac{q^+}{(2R)^2} \]

\[ E^- = k \frac{Q}{R^2} \]

Then the net electric potential at that point X is:

- A. Positive
- B. Negative
- C. Zero
- D. The E-field cannot be zero at point X.

6) A conducting spherical shell and a conducting solid sphere are concentric.

A charge -Q is placed on the outer shell and a charge -Q on the inner sphere.

A second later, how much charge will you find on the surface of the inner sphere \([q_1]\) and the inside surface of the outer shell \([q_2]\) and the outside surface of the outer shell \([q_3]\)?

- (a) \( q_1 = -Q \) \quad \( q_2 = \text{zero} \) \quad \( q_3 = -Q \)
- (b) \( q_1 = -Q \) \quad \( q_2 = +Q \) \quad \( q_3 = -2Q \)
- (c) \( q_1 = \text{zero} \) \quad \( q_2 = \text{zero} \) \quad \( q_3 = -Q \)
- (d) \( q_1 = -Q \) \quad \( q_2 = -Q \) \quad \( q_3 = \text{zero} \)
- (e) \( q_1 = -Q \) \quad \( q_2 = +Q \) \quad \( q_3 = -Q \)
The figure shows three pairs of parallel plates with the same separation of 1 m, and the electric potential of each plate. The electric field between the plates is uniform and perpendicular to the plates.

Rank the pairs according to the magnitude of the electric field between the plates,

a) $|E_1| > |E_2| > |E_3|$
b) $|E_2| > |E_3| > |E_1|$
c) $|E_2| > |E_1| = |E_3|$
d) $|E_1| > |E_3| > |E_2|$
e) Something else

8) You move a negative charge from point A towards B in an electric field pointing right-istr, as shown. Talking about changes in electric potential energy or the related work input/output by you ...

1. This requires you putting work into relocating the charge
2. This delivers work to you
3. Requires zero work
4. None of these

9) 4 charges are placed as shown. The charges are equal in magnitude, but differ in sign as shown. Vertical and horizontal distances between adjacent charges are 1 m.

What direction is the force on the charge at the top?

(a) ↑
(b) →
(c) ↓
(d) ←
(e) F = 0.
A positive +1 C and a negative -1 C charge are located on the x-axis at x = -1 and x = 1 respectively.

Rank the value of the net electric potential at the following points A, B, C, D:
A: (-2,0); B: (0,0); C: (0,1); D: (+2,0);

(not just magnitudes but also sign, like: +1 > -4)

A) C > A = B = D
B) A = B > C > D
C) A = D > B > C
D) A > B = C > D
E) A > B > C > D

The figure below gives the electric potential $V$ as a function of $x$.

An electron placed into this voltage landscape would feel the strongest force to the left in region:

a) 1
b) 2
c) 3
d) 4
e) 5
12) A uniform electric field of magnitude 30 V/m is directed in the negative y direction as shown. Point $A$ is at (-2, -3) m, and point $B$ is at (4, 5) m. Calculate the amount of work you have to either put into or receive out of moving a negative charge of -2 C from point $A$ to point $B$.

- a) 480 J work output
- b) 480 J work input
- c) 600 J work output
- d) 600 J work input
- e) None of these

13) An ball with mass = 2 kg and -1 C negative charge is moving parallel to the x axis with an initial speed of $+10^2$ m/s [in the +x direction] at the origin. Its speed is reduced to zero at the point x = 2 cm. Calculate the potential difference between the origin and that point. Which direction does the electric field point?

- 1. $\Delta V = 10,000$ V; E points left
- 2. $\Delta V = 10,000$ V; E points right
- 3. $\Delta V = 200$ V; E points left
- 4. $\Delta V = 200$ V; E points right
- 5. something else

14) Two charged particles, originally with equal charge, are a distance $r$ apart and exert a force of $F_{\text{original}}$ on each other, same magnitude of force on each charge.

Now we double both charges. If we wanted to still have the same magnitude of electric force we would have to set the distance to

- 1. $r_{\text{new}} = 4 \times r_{\text{original}}$
- 2. $r_{\text{new}} = 2 \times r_{\text{original}}$
- 3. $r_{\text{new}} = r_{\text{original}}$
- 4. $r_{\text{new}} = \frac{1}{2} \times r_{\text{original}}$
- 5. $r_{\text{new}} = \frac{1}{4} \times r_{\text{original}}$
2 charges are located on the x-axis.
A -3C charge at x = -1 and
A +1C charge at x = +1.
Looking for places on the x-axis where the net electric potential is zero, where could we find it?
We exclude “infinitely far away”, instead looking for place a finite distance from the charges!
Considering these 3 regions:
Left = to the left of the left charge [finite distance]
Middle = between the two charges
Right = to the right of the right charge [finite distance]
In which of these regions could one find a place of zero electric potential?

A) Only somewhere left
B) Only somewhere middle
C) Only somewhere right
D) Both, somewhere middle and somewhere right
E) Both somewhere left and somewhere right
The charges of the inner sphere $Q_1$ and the outer shell $Q_2$ must be:

a) $Q_1$: positive; $Q_2$: positive; $|Q_1| = |Q_2|$  
   ($Q_1$ positive obviously)

b) $Q_1$: positive; $Q_2$: negative; $|Q_1| = |Q_2|$  
   ($Q_2$ negative probably)

c) $Q_1$: positive; $Q_2$: negative; $|Q_1| > |Q_2|$  
   $|Q_1| > |Q_2|$

For a metal sphere [radius = 1] surrounded by a concentric metal shell [inner radius = 2; outer radius = 3] the electric field varies as a function of radius as shown [positive E-filed pointing outwards, negative inwards].

The charges of the inner sphere $Q_1$ and the outer shell $Q_2$ must be:

For a metal sphere [radius = 1] surrounded by a concentric metal shell [inner radius = 2; outer radius = 3] the electric field varies as a function of radius as shown [positive E-filed pointing outwards, negative inwards].

A spherical conductor has a radius of 18 cm and charge of 200.0 $\mu$C. The electric field and the electric potential at a distance of 9 cm from the center are:

a) $E = 55.6$ MV/m $V = 10$ MV  
   $E = 0 =$ ZERO

b) $E = 222$ MV/m $V = 20$ MV

c) $E = 0$ MV/m $V = 10$ MV

d) $E = 0$ MV/m $V = 20$ MV

e) None of these

$V_{surface} = V_{9cm}$

$V_{surface} = k \frac{q}{4\pi\epsilon_0} = 10$ MV
### Kinematics

<table>
<thead>
<tr>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( v = v_0 + a \cdot t )</td>
</tr>
<tr>
<td>( x = x_0 + v_0 \cdot t + \frac{1}{2}a \cdot t^2 )</td>
</tr>
<tr>
<td>( v^2 = v_0^2 + 2a \cdot (x - x_0) )</td>
</tr>
<tr>
<td>( v = \frac{(v + v_0)}{2} )</td>
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</tbody>
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### Newton’s Law

<table>
<thead>
<tr>
<th>Equation</th>
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<tbody>
<tr>
<td>( F = m \cdot a )</td>
</tr>
<tr>
<td>( F_{\text{gravity}} = m \cdot g )</td>
</tr>
<tr>
<td>( g = 9.80 , \text{m/s}^2 )</td>
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</table>

### Conservation of Energy

<table>
<thead>
<tr>
<th>Equation</th>
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<tbody>
<tr>
<td>( KE_1 + U_1 + W_{\text{in/out}} = KE_2 + U_2 )</td>
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</table>

### Energy

<table>
<thead>
<tr>
<th>Type</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinetik (linear)</td>
<td>( KE_{\text{lin}} = \frac{1}{2}mv^2 )</td>
</tr>
<tr>
<td>Potential (gravity)</td>
<td>( U_g = mg , y )</td>
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</table>

### Work

<table>
<thead>
<tr>
<th>Equation</th>
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<tbody>
<tr>
<td>( W = F \cdot d = F \cdot d \cos \theta )</td>
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</table>

### Power

<table>
<thead>
<tr>
<th>Type</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(electrical)</td>
<td>( P = W/t = E/t )</td>
</tr>
<tr>
<td>( P = 1 \Delta V = l^2 , R = (\Delta V)^2 / R )</td>
<td></td>
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</tbody>
</table>

### Coulomb force

<table>
<thead>
<tr>
<th>Equation</th>
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<tbody>
<tr>
<td>( F = k_e , q_1q_2 / r^2 ) along the connecting line</td>
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</table>

### Electric field

<table>
<thead>
<tr>
<th>Equation</th>
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<tbody>
<tr>
<td>( E = F/q = k_e \int \frac{dq}{r^2} )</td>
</tr>
<tr>
<td>( E = k_e , q / r^2 )</td>
</tr>
<tr>
<td>for a point charge / pointing radially</td>
</tr>
<tr>
<td>( E = -\text{gradient}(V) = -\frac{dV}{dx} )</td>
</tr>
</tbody>
</table>

### Electric flux

<table>
<thead>
<tr>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Phi_E = \int \vec{E} \cdot d\vec{A} )</td>
</tr>
<tr>
<td>( \Phi_E = \oint \vec{E} \cdot d\vec{A} = q_{\text{inside}} / \varepsilon_0 = 4\pi k_e \cdot q_{\text{inside}} )</td>
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</tbody>
</table>

### Gauss Law

<table>
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<tr>
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<tr>
<td>( \oint \vec{E} \cdot d\vec{A} = q_{\text{inside}} / \varepsilon_0 = 4\pi k_e \cdot q_{\text{inside}} )</td>
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</table>

### Potential energy

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<tbody>
<tr>
<td>( \Delta U = U_B - U_A = -q \int_{A} \vec{E} \cdot d\vec{s} = q \Delta V )</td>
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</table>

### Potential

<table>
<thead>
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<tbody>
<tr>
<td>( \Delta V = \Delta U / q = -\int_{A} \vec{E} \cdot d\vec{s} )</td>
</tr>
<tr>
<td>( V = k_e q / r ) for a point charge</td>
</tr>
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</table>

### Physical Constants

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron mass</td>
<td>( m_e = 9 \times 10^{-31} , \text{kg} )</td>
</tr>
<tr>
<td>Proton mass</td>
<td>( m_p = 2 \times 10^{-27} , \text{kg} )</td>
</tr>
<tr>
<td>Elementary charge</td>
<td>( e = 1.6 \times 10^{-19} , \text{C} )</td>
</tr>
<tr>
<td>Coulomb constant</td>
<td>( k_e = 9 \times 10^9 , \text{Nm}^2/\text{C}^2 )</td>
</tr>
<tr>
<td>Permittivity of free space</td>
<td>( \varepsilon_0 = 9 \times 10^{-12} , \text{C}^2/\text{Nm}^2 )</td>
</tr>
<tr>
<td>[ k_e = 1/4\pi \varepsilon_0 ]</td>
<td></td>
</tr>
</tbody>
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