YOUR NAME

Turn in scantron
You keep these question sheets
1) Electric flux through a spherical surface of radius 1m due to a charge inside [which is the only charge in this problem] is 100 Nm²/C.

The flux through the surface of a cube with sides equal to the diameter would then be:

   a) > 100 Nm²/C.
   b) < 100 Nm²/C.
   c) = 100 Nm²/C.

2) 2 Charges: one positive of unknown magnitude and one negative of -1 C are a distance R apart.
   At the point marked “x”, a distance R to the right of –Q, the net electric field is zero.
   Where, among the points given, is the net electric potential zero?
   [using the –Q charge as origin, thus all points to the right of the neg. charge]

   A. + R/4
   B. + R/3
   C. + R/2
   D. + R [that would be at the x]
   E. + 2R
Three charges are placed at the corners of an equilateral triangle as shown. The charges are equal in magnitude, but differ in sign as shown. Rank the magnitude of the net electrostatic potential at each of the three points on the midpoint of each side of the triangle.

1: left side; 2: right side; 3: bottom side

(a) 1 < 2 < 3  
(b) 1 = 2 < 3  
(c) 1 < 2 = 3  
(d) 1 = 3 < 2  
(e) Something else

A negative charge is shot into an electric field in the –x direction and slowing down. From this we can conclude that the electric potential

a) Is higher on the left than on the right.

b) Is higher on the right than on the left.

c) is constant

d) none of these
5) A **conductive** spherical shell is concentric with a solid **conductive** sphere. The charges on the sphere and on the shell are unknown, they could be anything.

Electrostatic potential
- \( V_0 \) (at the center)
- \( V_1 \) (at the surface of the sphere)
- \( V_2 \) (at the inner surface of the shell)
- \( V_3 \) (at the outer surface of the shell)

Which of these statements is **correct**?

A) If the electric field between sphere and shell points outwards, the potential \( V_2 \) of the inside surface of the shell must be negative.
B) If the sphere has a charge of \( Q \), then the outside surface of the shell must have the same charge \( Q \)
C) If the electric field between sphere and shell points outwards, the inside surface of the shell must have a negative charge.
D) The charges on the inner and outer surface of the shell must always be equal in magnitude and opposite in sign.
E) If the sphere has no charge, then the inner surface of the shell must be positively charged.

6) The work related to a -2 C charge moving from point A to point C in the voltage landscape shown is:

a) 2 J Work input is needed
b) 2 J Work flows out
c) 4 J Work input is needed
d) 4 J Work flows out
e) Work is zero
7) 2 Charges: one positive of unknown magnitude and on negative of -1 C are a distance R apart. At the point marked “x”, a distance R to the right of –Q, the net electric potential is zero.

Then the net electric field at that point X points:

A. ←  
B. →  
C. ↑  
D. ↓  
E. Is zero

8) The capacitors (6 F and 1 F) are connected in series and got charges by a battery. How do the charges stored on the 2 capacitors compare?

a. $Q_{6F} = Q_{1F}$  
b. $Q_{6F} = 6 Q_{1F}$  
c. $Q_{6F} = \frac{1}{6} Q_{1F}$  
d. $Q_{6F} = 36 Q_{1F}$  
e. $Q_{6F} = \frac{1}{36} Q_{1F}$

9) The capacitors (2 F and 1 F) were connected in series to and got charged by a battery. If the voltage across the 1 F capacitor is $\Delta V_{1F} = 5$ V, the battery voltage must be:

a. $\Delta V_{BAT} = 2.5$ V  
b. $\Delta V_{BAT} = 5$ V  
c. $\Delta V_{BAT} = 7.5$ V  
d. $\Delta V_{BAT} = 10$ V  
e. $\Delta V_{BAT} = 15$ V
10) You have two identical capacitors. They can be connected in series or in parallel or you can use just one of them. If you want the smallest capacitance for the combination, how do you use them?

   a) 2 in series
   b) 2 in parallel
   c) use only one of them
   d) either way; all combinations have the same capacitance

11) In the circuit, what is the charge on $C_3$ if $C_1 = 1 \text{ F}; C_2 = 1 \text{ F}; C_3 = 2 \text{ F}$ and $\Delta V_{\text{Bat}} = 5 \text{ V}$

   a) None of these
   b) $Q_3 = 10 \text{ C}$
   c) $Q_3 = 5 \text{ C}$
   d) $Q_3 = 2 \text{ C}$
   e) $Q_3 = 1 \text{ C}$

12) In the circuit, what is the energy stored in $C_2$ if $C_1 = 1 \text{ F}; C_2 = 2 \text{ F}; C_3 = 3 \text{ F}$ and the voltage across $C_1$, $\Delta V_{C_1} = 6 \text{ V}$

   a) $U_2 = 6 \text{ J}$
   b) $U_2 = 18 \text{ J}$
   c) $U_2 = 36 \text{ J}$
   d) $U_2 = 54 \text{ J}$
   e) None of these
Given a radially symmetric charge distribution, the graph below compares electric flux vs radial distance from the origin.

Which of the following correctly describes the corresponding arrangement of charges?

a) There is a positive point charge at the origin and a thin layer of a smaller negative charge at $R = A$ and no charge further outside, $R > A$.
b) There is a continuous positive charge distribution between origin and $R = A$ and a continuous, smaller negative charge distribution between $R = A$ and $R = B$ and no charge further outside, $R > B$.
c) There is a positive point charge at the origin and a thin layer of a larger negative charge at $R = A$ and a thin layer of a small positive charge at $R = B$.
d) There is a continuous positive charge distribution between origin and $R = A$ and a continuous, larger negative charge distribution between $R = A$ and $R = B$ and no charge further outside, $R > B$.
e) None of these.
14) To each of the following 3 circuits is the same total battery voltage $\Delta V = 10$ V applied. All capacitors have $C = 1$ F.

Rank the 3 circuits with respect to the total charge stored [charges of the capacitors added] from largest to smallest.

a) $Q_1 > Q_2 > Q_3$
b) $Q_2 > Q_3 > Q_1$
c) $Q_3 > Q_2 > Q_1$
d) $Q_1 > Q_3 > Q_2$
e) $Q_2 > Q_1 > Q_3$

15) The capacitors got connected as shown to the battery with voltage $\Delta V$ and charged up. If the voltage drop across $C_1$ came out to be 10 V,

Then the voltage drop across $C_5$ must be:

a) 40 V
b) 20 V
c) 10 V
d) 5 V
e) 2.5 V
16) A solid metal sphere is at the center of a hollow metal shell. The radius of the sphere is 0.5 cm and the inner and outer radii of the hollow shell are 1 cm and 2 cm.

The net charge on the sphere is +20 μC and the electric field at r = 30 cm is 10^7 N/C pointing inwards.

The net charge on the shell is:

a) - 100 μC  
b) − 120 μC  
c) + 120 μC  
d) - 80 μC  
e) none of these

17) The amount of work related to a +2 C charge moving from bottom to top in the voltage landscape shown.

- 20 V  
- 40  
- 60  
- 80  
- 100

a) Work flows out to the amount of 200 J  
b) Work input of 160 J is needed  
c) Work flows out to the amount of 160 J  
d) Work input of 80 J is needed  
e) Work flows out to the amount of 80 J
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 charge 1, keep charge 2 unchanged and cut their distance in half. Let \( F_1 \) be the magnitude of the force particle 1 experiences and \( F_2 \) the magnitude of the force particle 2 experiences.

Now we have:

1. \( F_1 = 4 \, F_{\text{original}} \); \( F_2 = 4 \, F_{\text{original}} \)
2. \( F_1 = F_{\text{original}} \); \( F_2 = \frac{1}{2} \, F_{\text{original}} \)
3. \( F_1 = 8 \, F_{\text{original}} \); \( F_2 = 8 \, F_{\text{original}} \)
4. \( F_1 = 8 \, F_{\text{original}} \); \( F_2 = 4 \, F_{\text{original}} \)
5. \( F_1 = 2 \, F_{\text{original}} \); \( F_2 = 4 \, F_{\text{original}} \)

A conducting spherical shell and a conducting solid sphere are concentric. The charge \(-Q\) is placed on the inner surface of the outer shell and the total charge on the inner sphere is zero. 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) \( q_1 = +Q \) \hspace{1cm} q_2 = \text{zero} \hspace{1cm} q_3 = \text{zero}
(b) \( q_1 = \text{zero} \) \hspace{1cm} q_2 = -Q \hspace{1cm} q_3 = +Q
(c) \( q_1 = -Q \) \hspace{1cm} q_2 = 2Q \hspace{1cm} q_3 = \text{zero}
(d) \( q_1 = \text{zero} \) \hspace{1cm} q_2 = \text{zero} \hspace{1cm} q_3 = -Q
(e) \( q_1 = +Q \) \hspace{1cm} q_2 = -Q \hspace{1cm} q_3 = \text{zero}
20) A spherical conductor has a radius of 12.0 cm and charge of 24.0 µC. The electric field and the electric potential at a distance of 6 cm from the center are:

- E = 60 MV/m  V = 3.6 MV
- E = 0 MV/m  V = 3.6 MV
- E = 15 MV/m  V = 1.8 MV
- E = 0 MV/m  V = 1.8 MV
- None of these

21) The surface potential of a conducting sphere of radius r = 3 cm is 2 MV. The strength of the electric field at a radius of 2 cm from the center is:

- 42 MV/m
- 100 MV/m
- 150 MV/m
- 0 MV/m
- None of these

22) A uniform electric field of magnitude 320 MV/m is directed in the negative y direction. How much work is required to move a charge of q = 20 µC from the origin to the right to a point at x = 5 cm; y = 0?

- 320,000 J
- -320,000 J
- 320 J
- -320 J
- Zero
| Kinematics                      | \( \mathbf{v} = \mathbf{v}_0 + \mathbf{a} \cdot t \)  \\
|                               | \( \mathbf{x} = \mathbf{x}_0 + \mathbf{v}_0 \cdot t + \frac{1}{2} \mathbf{a} \cdot t^2 \)  \\
|                               | \( \mathbf{v}^2 = \mathbf{v}_0^2 + 2 \mathbf{a} \cdot (\mathbf{x} - \mathbf{x}_0) \)  \\
|                               | \( \mathbf{v} = \frac{(\mathbf{v} + \mathbf{v}_0)}{2} \)  \\
| Newton’s Law                   | \( \mathbf{F} = m \cdot \mathbf{a} \)  \\
|                               | \( \mathbf{F}_{\text{gravity}} = m \cdot \mathbf{g} \quad \mathbf{g} = 9.80 \text{ m/s}^2 \)  \\
| Conservation of Energy        | \( \text{KE}_1 + \text{U}_1 + W_{\text{in/out}} = \text{KE}_2 + \text{U}_2 \)  \\
| Energy                         | Kinetic (linear): \( \text{KE}_{\text{lin}} = \frac{1}{2} m \mathbf{v}^2 \)  \\
|                               | Potential (gravity): \( \text{U}_g = m \mathbf{g} \mathbf{y} \)  \\
| Work                           | \( W = \mathbf{F} \cdot \mathbf{d} = \mathbf{F} \mathbf{d} \cos \theta \)  \\
| Power                          | \( P = \frac{W}{t} = \frac{E}{t} \)  \\
|                               | \( P = I \Delta V = I^2 R = \frac{(\Delta V)^2}{R} \)  \\
| Coulomb force                  | \( \mathbf{F} = \frac{k_e q_1 q_2}{r^2} \) along the connecting line  \\
| Electric field                 | \( \mathbf{E} = \frac{\mathbf{F}}{q} = \frac{k_e}{\text{volume}} \int \frac{dq}{r^2} \)  \\
|                               | \( \mathbf{E} = \frac{k_e q}{r^2} \) for a point charge / pointing radially  \\
|                               | \( E = -\text{gradient}(V) = -\frac{dV}{dx} \)  \\
| Electric flux                  | \( \Phi_E = \int_{\text{surface}} \mathbf{E} \cdot d\mathbf{A} \)  \\
| Gauss Law                      | \( \Phi_E = \int_{\text{closed surface}} \mathbf{E} \cdot d\mathbf{A} = \frac{q_{\text{inside}}}{\varepsilon_0} = 4\pi k_e \cdot q_{\text{inside}} \)  \\
| Potential energy               | \( \Delta U = U_B - U_A = -q \int_B^A \mathbf{E} \cdot d\mathbf{s} = q \Delta V \)  \\
| Potential                      | \( \Delta V = \Delta U / q = -\int_A^B \mathbf{E} \cdot d\mathbf{s} \)  \\
|                               | \( V = k_e q / r \) for a point charge  \\
| Capacitance                    | \( C = \frac{Q}{\Delta V} \quad \left[= \varepsilon_0 \frac{A}{d \kappa} \right \text{ parallel plate C} \)  \\
|                               | \( C_{\text{eq}} = C_1 + C_2 + C_3 + \ldots \) \quad \left[\text{parallel combination} \right \)  \\
|                               | \( 1/C_{\text{eq}} = 1/C_1 + 1/C_2 + 1/C_3 + \ldots \) \quad \left[\text{series combination} \right \)  \\
|                               | \( U = \frac{1}{2} Q^2/C = \frac{1}{2} Q \Delta V = \frac{1}{2} C (\Delta V)^2 \) \quad \left[\text{energy stored in C} \right \)  \\
| electron mass                  | \( m_e = 9 \times 10^{-31} \text{ kg} \)  \\
| proton mass                    | \( m_p = 2 \times 10^{-27} \text{ kg} \)  \\
| elementary charge              | \( e = 1.6 \times 10^{-19} \text{ C} \) \quad \left[\text{electron: -e ; proton: +e} \right \)  \\
| Coulomb constant               | \( k_e = 9 \times 10^9 \text{ Nm}^2/\text{C}^2 \)  \\
| Permittivity of free space     | \( \varepsilon_0 = 9 \times 10^{-12} \text{ C}^2/\text{Nm}^2 \) \quad \left[\text{ke} = 1/4\pi\varepsilon_0 \right \)