Q1.

Two **neutral** identical metallic spheres, separated by 1.0 m (center to center distance), are connected by a very thin conducting wire. An 8.0 μC charge is placed on one of the spheres. Then, after a long time, the two spheres are disconnected from each other. Find the magnitude of the electrostatic force of one sphere on the other after they are disconnected. (Consider the radii of the spheres small compared to their separation)

A) 0.14 N
B) 0.070 N
C) 0.58 N
D) 0.29 N
E) 0 N

Q2.

Experimenter A uses a test charge q_o and experimenter B uses a test charge $-2q_o$ to determine the electric field in a region having a uniform electric field. Experimenter A finds an electric field that is

A) Identical to the field found by experimenter B.
B) greater in magnitude than the field found by experimenter B.
C) less in magnitude than the field found by experimenter B.
D) opposite in direction to the field found by experimenter B.
E) dependent on the accelerations of the test charges.

Q3.

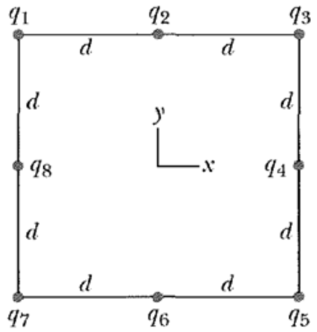
How much work is done by an external agent to turn an electric dipole by an angle of 20^o in a uniform electric field of magnitude 700 N/C if the dipole moment has a magnitude of 4.0×10^{-9} C.m and the initial angle is 0^o?

A) $+ 1.7 \times 10^{-7}$ J
B) $- 1.7 \times 10^{-7}$ J
C) $+ 2.8 \times 10^{-6}$ J
D) $- 2.8 \times 10^{-6}$ J
E) $- 5.6 \times 10^{-6}$ J

Q4.

In **Figure 1**, eight particles form a square in which the distance d = 4.0 cm. The charges are $q_1 = -4e$, $q_2 = -e$, $q_3 = -5e$, $q_4 = +2e$, $q_5 = -4e$, $q_6 = -e$, $q_7 = -5e$, and $q_8 = -e$. In unit-vector notation, what is the net electric field at the center of the square?
(e is the magnitude of the charge of the electron)

Fig#



A) $-2.7 \times 10^{-6}\ \hat{i}$ N/C
B) $+2.7 \times 10^{-6}\ \hat{i}$ N/C
C) $-1.0 \times 10^{-6}\ \hat{i}$ N/C
D) $+1.0 \times 10^{-6}\ \hat{j}$ N/C
E) $-7.1 \times 10^{-6}\ \hat{i}$ N/C

Q5.
Two point charges, Q_1 = 1.0 μC and Q_2 = 2.0 μC, are separated by 12 cm. At what distance from charge Q_1 should a third charge Q_3 be placed, between Q_1 and Q_2, so that it stays stationary?

A) 5.0 cm
B) 6.0 cm
C) 1.0 cm
D) 2.0 cm
E) 3.0 cm

Q6.
A long straight thin wire is surrounded by a hollow metallic cylinder whose axis coincides with the wire. The wire has a charge per unit length of λ, and the cylinder has a charge per unit length of 2λ. What is the charge per unit length on the outer surface of the cylinder?

A) +3 λ
B) –3 λ
C) –2 λ
D) –λ
E) +2 λ

Q7.
A particle, with a mass of 10 g and a charge of – 0.70 μC, is suspended in equilibrium above the center of a large, horizontal, insulating uniformly charged sheet. What is the surface charge density on the sheet?

A) –2.5 μC/m²
B) +2.5 μC/m²
C) –1.2 μC/m²
D) +1.2 μC/m²
E) –4.6 μC/m²

Q8.

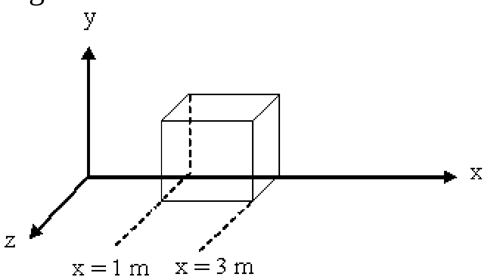
A solid insulating sphere of radius 5.0 cm carries a charge + 3.0 µC. Concentric with this sphere is a conducting spherical shell of inner radius 20 cm and outer radius 25 cm. The electric field at a distance of 50 cm from the center of the sphere is 3.6×10^4 N/C and points radially outward. What is the net charge on the spherical shell?

A) –2.0 µC
B) +4.0 µC
C) +2.0 µC
D) –4.0 µC
E) –3.0 µC

Q9.

An electric field given by $\vec{E} = 2.0\hat{i} + 4.0(y^2 + 2.0)\hat{j}$ (N/C) pierces (passes through) the Gaussian cube shown in **Figure 2**. What is the electric flux through the **top** face of the cube?

Fig#



A) 96 $N.m^2/C$
B) 8.0 $N.m^2/C$
C) 32 $N.m^2/C$
D) 72 $N.m^2/C$
E) zero

Q10.

A particle of charge + 4.0 nC moves from point (3.0, 0) m to point (0, 3.0) m in a region where there is a uniform electric field that points in the positive *x* direction. If the electric potential energy of the particle increases by 18 µJ, what is the magnitude of the electric field?

A) 1.5 kN/C
B) 6.5 kN/C
C) 11 kN/C
D) 4.3 kN/C
E) 3.7 kN/C

Q11.

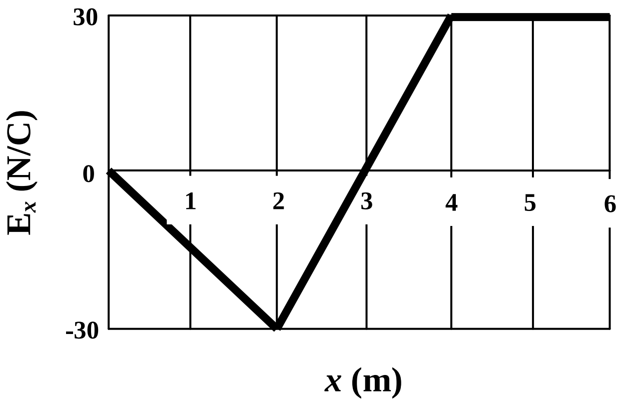
Two protons are initially held fixed at a separation of 1.0 m. If the protons are released from rest, what is the speed of each proton when they are infinitely separated? (Assume V at infinity = 0)

A) 0.37 m/s
B) 0.51 m/s

C) 0.25 m/s
D) 0.19 m/s
E) 0.44 m/s

Q12.
The graph of the x component of the electric field as a function of position x in a region of space is shown in **Figure 3**. The y and z components of the electric field are zero in this region. If the electric potential is 20 V at the origin, what is its value at x = 3.0 m?

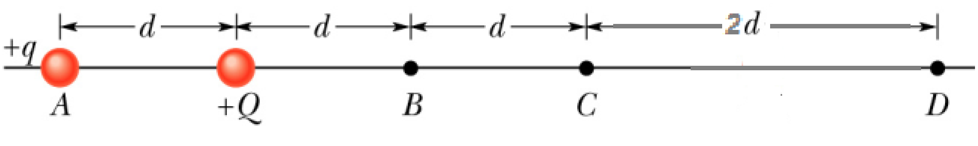
Fig#



A) + 65 V
B) – 65 V
C) + 25 V
D) – 25 V
E) + 60 V

Q13.
Figure 4 shows a system of two charged particles. Let W_{AB}, W_{AC}, W_{AD} be the work done by an external agent to move the charge +q from A to B, from A to C, or from A to D, respectively. Which of the following statements is true?

Fig#



A) $W_{AB} > W_{AC} > W_{AD}$
B) $W_{AB} < W_{AC} < W_{AD}$
C) $W_{AB} > W_{AC} = W_{AD}$
D) $W_{AB} = W_{AC} < W_{AD}$
E) $W_{AB} < W_{AC} = W_{AD}$

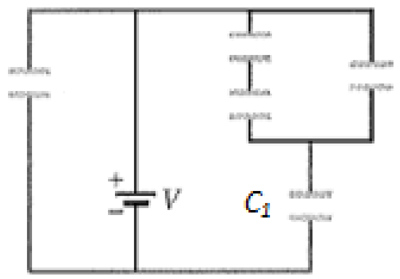
Q14.
Point A is inside a charged conducting sphere and is a distance of 5.0 cm from the center of the sphere. Point B is outside the sphere at a distance of 15 cm from the center. If

$V_\infty = 0$, $V_A = 150$ V, and $V_B = 80$ V, what is the radius of the sphere?

A) 8.0 cm
B) 11 cm
C) 5.0 cm
D) 15 cm
E) 4.0 cm

Q15.
Figure 5, the battery has a potential difference of V = 20 V and the five capacitors each has a capacitance of 30 μF. What is the voltage across capacitor C_1?

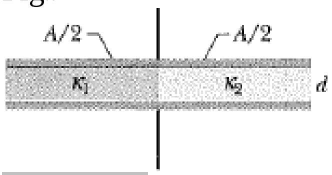
Fig#



A) 12 V
B) 8.0 V
C) 20 V
D) 10 V
E) 5.0

Q16.
Figure 6 shows a parallel-plate capacitor with a plate area A = 5.56 cm^2 and a separation d = 5.56 mm. The left half of the gap is filled with material of dielectric constant $\kappa_1 = 7.00$. The right half is filled with material of dielectric constant $\kappa_2 = 12.0$. What is the capacitance of this configuration?

Fig#



A) 8.41 pF
B) 2.04 pF
C) 3.10 pF
D) 4.21 pF
E) 7.47 pF

Q17.
A 100 V battery is connected across a combination of n capacitors connected in series. The capacitance of each capacitor is 5.00 µF. If the total stored energy is 50 µJ, what is n?

A) 500
B) 100
C) 200
D) 300
E) 600

Q18.
A parallel plate capacitor is connected to a battery. The capacitor has a certain energy density. While the battery is still connected to the capacitor, and the distance between the capacitor plates is doubled, the capacitor energy density

A) decreases by a factor of four.
B) increases by a factor of four.
C) increases by a factor of two.
D) decreases by a factor of two.
E) does not change.

Q19.
Two cylindrical wires, 1 and 2 are made of the same material. The resistance of wire 1 is 3 times the resistance of wire 2. If the length of wire 2 is two times the length of wire 1, what is the ratio of their cross-sectional areas, A2/A1?

A) 6.0
B) 0.17
C) 0.25
D) 0.50
E) 4.0

Q20.
A flashlight bulb has a resistance of 1.1 Ω at 20 ^{0}C. The temperature of the filament is 1800 ^{0}C when the bulb is operated at 2.9 V. What is the power dissipated when the bulb is operational at that voltage? The temperature coefficient of resistivity of the filament is $4.5 \times 10^{-3}/^0$C. (Assume no change in the dimensions of the filament).

A) 0.85 W
B) 1.4 W
C) 0.46 W
D) 2.5 W
E) 3.2 W

$$F = k\frac{q_1 q_2}{r^2}$$

$$U = -\vec{P}\cdot\vec{E}$$

$$\vec{\tau} = \vec{P}\times\vec{E}$$

$$\Phi = \int_{Surface} \vec{E}.d\vec{A}$$

$$\Phi_c = \oint \vec{E}.d\vec{A} = \frac{q_{in}}{\varepsilon_0}$$

$$E = \frac{\sigma}{2\varepsilon_o}$$

$$E = \frac{\sigma}{\varepsilon_o}$$

$$E = k\frac{q}{r^2}$$

$$E = k\frac{q}{R^3}r$$

$$E = \frac{2k\lambda}{r}$$

$$\Delta V = V_B - V_A = -\int_A^B \vec{E}.d\vec{S} = \frac{\Delta U}{q_0}$$

$$V = k\frac{q}{r}$$

$$E_x = -\frac{\partial V}{\partial x},\quad E_y = -\frac{\partial V}{\partial y},\quad E_z = -\frac{\partial V}{\partial z}$$

$$U = k\frac{q_1 q_2}{r_{12}}$$

$$C = \frac{q}{V}$$

$$C = \kappa C_{air}$$

$$U = \frac{1}{2}CV^2$$

$$U = \frac{1}{2}\varepsilon_o E^2$$

$$I = \frac{dQ}{dt}$$

$$I = JA$$

$$R = \frac{V}{I} = \rho\frac{L}{A}$$

$$J = \sigma E$$

$$\rho = \rho_0\,[1 + \alpha(T - T_0)]$$

$$P = IV$$

$v = v_o + at$

$x - x_o = v_o t + \frac{1}{2}a t^2$

$v^2 = v_o^2 + 2a(x - x_o)$

<u>Constants:</u>

$k = 9.00 \times 10^9$ N.m^2/C^2
$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N.m^2
$e = 1.60 \times 10^{-19}$ C
$m_e = 9.11 \times 10^{-31}$ kg
$m_p = 1.67 \times 10^{-27}$ kg
$g = 9.8$ m/s^2

μ = micro = 10^{-6}
n = nano = 10^{-9}
p = pico = 10^{-12}