Name KEY

Homework Questions

Potential + Capacitance #1

1. A positive electric charge is moved at a constant speed between two locations in an electric field, with no work done by or against the field at any time during the motion. This situation can occur only if the:

(A) charge is moved in the direction of the field

(B) charge is moved opposite to the direction of the field

(C) charge is moved perpendicular to an equipotential line

(D) charge is moved along an equipotential line

(E) electric field is uniform

D

2. Calculate the speed of a proton that is accelerated from rest through a potential difference of 134 V.

[160] km/s

$U_E = E_k$

$-qEd = \frac{1}{2}mv^2$

$-q\Delta V = \frac{1}{2}mv^2$

$\Delta V = -134\,V$

$m = 1.67\times10^{-27}\,kg$

$q = 1.60\times10^{-19}\,C$

$v = ?$

160 km/s

3. Calculate the speed of an electron that is accelerated through the same potential difference.

[6.86] Mm/s

$U_E = E_k$

$-qEd = \frac{1}{2}mv^2$

$m = 9.11\times10^{-31}\,kg$

$q = -1.60\times10^{-19}$

$\Delta V = 134\,V$

$V = 6.86$ Mm/s

4. Given two 2.20 μC charges at +/- 0.800 m and a positive test charge $q = 1.33 \times 10^{-18}$ C at the origin (as shown at the bottom of the page):

a. What is the net force exerted by the two 2.20 μC charges on the test charge *q*?

[0] N Equal & Opposite

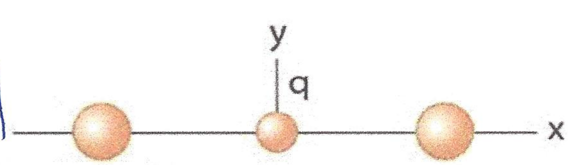
b. What is the electric field at the origin due to the two 2.20 μC charges?

[0] N/C Electric Fields are also equal and opposite

c. What is the electrical potential at the origin due to the two 2.20 μC charges?

[49.4] kV

$V = \frac{kQ}{r} + \frac{kQ}{r} = 49.4\,kV$



5. How many electrons should be removed from an initially uncharged spherical conductor of radius 0.400 m to produce a potential of 4.00 kV at the surface?

[1.11e+12] electrons

$r = 0.4\,m$

$V = 4000\,V$

$Q = ?$

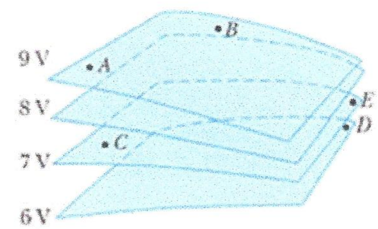
$V = \frac{kQ}{r}$

$Q = 1.77\times10^{-7}\,C$

$\frac{1.77\times10^{-7}}{1.60\times10^{-19}} = 1.11\times10^{12}$ electrons

6. The labeled points shown below are on a series of equipotential surfaces associated with an electric field. Rank (from greatest to least) the work done by the electric field on a positively charged particle that moves from *A* to *B*; from *B* to *C*; from *C* to *D*; from *D* to *E*.

Rank	From ____ to ____	
1 (Greatest)	From B → C	+2V
2	From C → D	+1V
3	From A → B	0V
4 (Least)	From D → E	−1V



7. On planet Tehar, the free-fall acceleration is the same as that on Earth but there is also a strong downward electric field that is uniform close to the planet's surface. A 2.00 kg ball having a charge of 6.00 μC is thrown upward at a speed of 29.4 m/s and it hits the ground after an interval of 4.30 s. What is the potential difference between the starting point and the top point of the trajectory?

[40,800] kV

qE, mg

$m = 2\,kg$

$q = 6\times10^{-6}\,C$

$v = 29.4\,m/s$

$t_{total} = 4.30\,s$

$t_{top} = 2.15\,s$

$g = -9.8\,m/s^2$

Acceleration

$V = at + V_0$

$0 = a(2.15s) + 29.4\,m/s$

$a = -13.67\,m/s$

Δx

$2a\Delta x + V_0^2 = V^2$

$2(-13.67)(d) + (29.4\,m/s)^2 = 0$

$d = 31.6\,m$

Electric Field & ΔV

$ma = qE + mg$

$E = -1290000\,N/C$

$\Delta V = -Ed$

$\Delta V = 40764\,V$

Hints:
#1 - Charge refers to the magnitude on each plate, not the total which would be zero.
#4 - 1 fF=1x10^-15 F
#5 - Watch units carefully.

Name KET

Homework Questions

Potential + Capacitance #2

1. How much charge is on each plate of a 4.00 μF capacitor:

   a. when it is connected to a 18.0 V battery?

   72 μC

   $C = \frac{Q}{\Delta V}$

   b. when it is connected to a 1.50 V battery?

   6 μC

   $C = \frac{Q}{\Delta V}$

2. Two conductors having net charges of +16.0 μC and -16.0 μC have a potential difference of 16.0 V between them.

   a. Determine the capacitance of the system.

   1.00e-6 F

   $C = \frac{Q}{\Delta V}$

   b. What is the potential difference between the two conductors if the charges on each are increased to +256 μC and -256 μC?

   $Q = 256 \times 10^{-6} C$

   256 V

   $C = \frac{Q}{\Delta V}$

3. When a potential difference of 138 V is applied to the plates of a parallel-plate capacitor, the plates carry a surface charge density of 35.0 nC/cm². What is the spacing between the plates?

   $3.5 \times 10^{-12} C/m^2 = \frac{Q}{A}$ = surface charge density

   3.49 μm

   $C = \frac{A\varepsilon_0}{d} = \frac{Q}{\Delta V} \rightarrow \frac{Q}{A} = \frac{\Delta V \varepsilon_0}{d}$

   $\frac{Q}{A}$

   $\frac{Q}{A} = 3.5 \times 10^{-12} C/m^2$

   $\Delta V = 138 V$

   $\varepsilon_0 = 8.85 \times 10^{-12} C^2/m^2$

   Solve for d

   $3.49 \times 10^{-6} m$

4. An air-filled capacitor consists of two parallel plates, each with an area of 7.60 cm^2, separated by a distance of 1.50 mm.

   a. If a 21.0 V potential difference is applied to these plates, calculate the electric field between the plates.

   $\Delta V = Ed \qquad d = \frac{\Delta V}{E}$

   [14] kV/m

   b. What is the surface charge density?

   Use charge from d $\qquad \frac{Q}{A}$

   [124] nC/m^2

   c. What is the capacitance?

   $C = \frac{A\varepsilon_0}{d} = 4.48 \times 10^{-12} F$

   [4.48] pF

   d. Find the charge on each plate.

   Use capacitance from C

   $C\Delta V = q = 94.2 \times 10^{-12} C$

   [94.2] pC

5. A 1 megabit computer memory chip contains many 62.0 fF capacitors. Each capacitor has a plate area of 23.0 ×10^{-12} m^2. Determine the plate separation of such a capacitor (assume a parallel-plate configuration). The characteristic atomic diameter is 10^{-10} m = 0.100 nm. Express the plate separation in nanometers.

   [3.28] nm

   $A = \pi r^2$

   $\frac{Q}{\Delta V} = \frac{A\varepsilon_0}{d}$

   $\frac{Qd}{\varepsilon_0 \Delta V} = \pi r^2$ Sove for r

6. When a potential difference of 152 V is applied to the plates of a parallel-plate capacitor, the plates carry a surface charge density of 30.0 nC/cm^2. What is the spacing between the plates?

   [4.49] µm

   $\frac{Q}{\Delta V} = \frac{A\varepsilon_0}{d}$

   $d = \frac{A\varepsilon_0 \Delta V}{Q}$

   $d = 4.49 \times 10^{-6} m$