PHY102E MIDTERM EXAM

PART-II: MULTIPLE CHOICES

1) Two negatively charged particles, q_1 and q_2 , are of a distance r apart with $q_1=2q_2$. Compare the forces they exert on each other when $\boldsymbol{F_{21}}$ is the force q_2 exerts on q_1 and $\boldsymbol{F_{12}}$ is the force q_1 exerts on q_2. Which of the followings is true?

a)$2\overrightarrow{F_{21}} = \overrightarrow{F_{12}}$ **b)** $\boldsymbol{\overrightarrow{F_{21}} = -\overrightarrow{F_{12}}}$ c) $\overrightarrow{F_{21}} = -2\overrightarrow{F_{12}}$ d) $\overrightarrow{F_{21}} = 2\overrightarrow{F_{12}}$ e) $\overrightarrow{F_{21}} = \overrightarrow{F_{12}}$

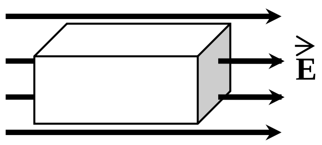
2) The electric field in some region of space is uniform in magnitude and direction. Which one of the following statements best describes the volume charge density, ρ, in this region of space?

a) ρ is uniform throughout the region.

b) ρ decreases linearly in the direction of the electric field

c) ρ increases linearly in the direction of the electric field

d) It is not possible to say anything about ρ from the information given



e) ρ=0

3) If we double each side of a cube which contains positively charged particles, what will be flux ratio for the initial to the final case?

a) 1 b) 1/8 c) 2 d) 1/ 2 e) 8

4) For an electron moving in a direction opposite to the electric field

a. its potential energy increases and its electric potential increases

b. its potential energy decreases and its electric potential increases

c. its potential energy increases and its electric potential decreases

d. its potential energy decreases and its electric potential decreases

e. both the potential energy and the electric potential remain constant

5) If a conductor is in electrostatic equilibrium near an electric charge

a. the total charge on the conductor must be zero

b. any charge on the conductor must be uniformly distributed

c. the force between the conductor and the charge must be zero

d. the total electric field of the conductor must be zero

e. the electric field of the conductor is perpendicular to the surface

6) An electric dipole is centered at the origin. What is the ratio of the magnitudes of electric field at a distance y and 3y from the origin of the dipole where y >> d and d is the separation between the charges forming the dipole?

a) 27 b) 1/9 c) 1/3 d) 9 e) 3

7) A circular ring of radius R=2.0m has a charge Q=2.0μC uniformly distributed along it. A test charge q=1.0μC is placed at the center of the ring. What is the magnitude of the force on the test charge?

F=0, per argument of symmetry

A. 0 B. 2.25 mN C. 4.5 mN D. 9.0 mN

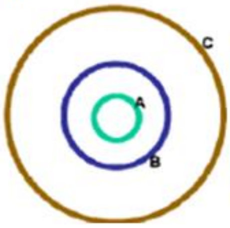
8) Three concentric thin **conducting** spherical shells A,B,C, have radius $r_A=R$, $r_B=2R$, and $r_C=4R$ and charges $Q_A=Q$, $Q_B=-Q$, and $Q_C=3Q$, respectively. (Q>0). Rank the electric potentials of the shells.

A. $V_A>V_B>V_C$

B. $V_A<V_B<V_C$

C. $V_A=V_B>V_C$

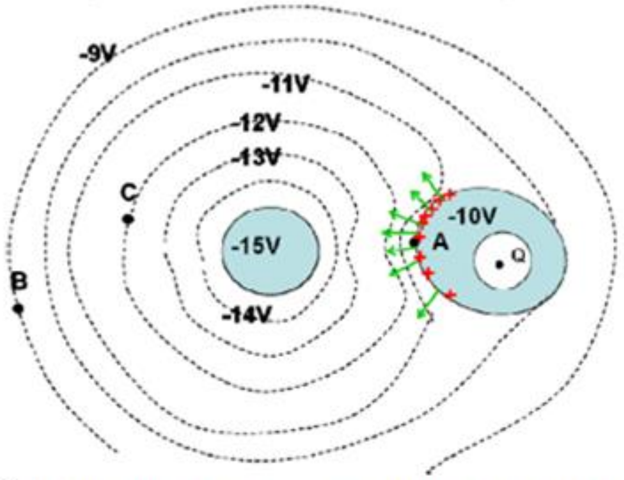
D. $V_A>V_B=V_C$



Per argument of symmetry and per Gauss's Law:

- Between sphere A and B, electric field points outwards, →lower V as r increases $V_A>V_B$
- Between sphere B and C, E=0 → Same potential $V_B=V_C$

** The figure below is referred to in the next three questions



9) In figure above, the surface charge at point A, which is on the surface of the conductor at -10 V, is

✓ A. positive
B. negative
C. zero
D. can not be determined

See fig above, first draw electric field line, noting that they shall always point to lower potential. Then use argument that electric field always pointing away from positive charges.

10) In the figure above, a test charge q of charge 1.0μC is placed at point C, the magnitude of the electric force on q is

A. +1.0μN B. - 1.0μN C. zero ✓ D. can not be determined

Without distance information, Electric field strength can not be determined by potential alone

11) In the above figure, a test charge q of charge 1.0μC is moved from point C to point A. Ignoring the effect of the test charge q on the field, what is the work done to q by the electric field in the process?

A. 2.0 μJ ✓ B. - 2.0 μJ C. zero D. none of above or con not be determined.

$W_{electric\ field}$= $-(U_f-U_i)=-q(V_f-V_i)=-2\mu J$
Review Phy201 if in question of the – sign.

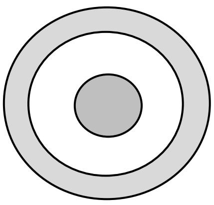
12) A fully charged parallel-plate capacitor remains connected to a battery while a dielectric is inserted between the plates. Which of the following is true about the capacity and the electric field between the plates?

A) Both the capacity and the electric field increase.
✓ B) The capacity increases and the electric field remains the same.
C) The capacity remains the same and the electric field decreases.
D) Both the capacity and the electric field remain the same.

$C = K\varepsilon_0 \frac{A}{d}$ $C\uparrow$

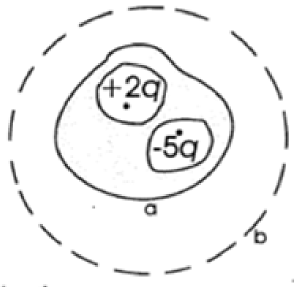
$E = \frac{\Delta V}{d}$

13) The figure shows the cross-section through a pair of concentric, spherical conductors. The inner conductor carries charge –Q and the outher conductor carries charge +3Q. What is the charge on the outher surface of the outher conductor?



a) impossible to calculate b) +4Q **c) +2Q** d) Zero e) +3Q

14) An **UNCHARGED** conducting object *a* contains two cavities. One cavity contains a point charge of $+2q$ and the other contains a point charge of $-5q$. Which of the following statements **IS TRUE**?



A. The total electric flux through a spherical surface *b* completely enclosing the object is $\frac{+3q}{\varepsilon_0}$.

√B. The total electric flux through a spherical surface *b* completely enclosing the object is $\frac{-3q}{\varepsilon_0}$.

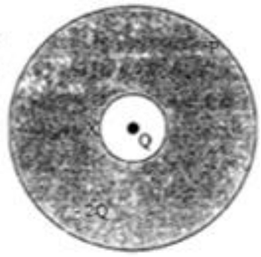
C. The total electric flux through a spherical surface *b* completely enclosing the object is 0.

D. The total electric flux through a spherical surface *b* completely enclosing the object depends on the area of the surface.

15) The electric potential V in a region of space is given by $V(x, y, z) = A(-3x^2 + 2y^2 - 3z^2)$ where A is a constant. Derive an expression for the electric field **E** at any point in this region.

a) $A(6x\,\hat{i} - 4y\,\hat{j} + 6z\,\hat{k})$ b) $A(-6x\,\hat{i} + 4y\,\hat{j} - 6z\,\hat{k})$) c) $A(3x\,\hat{i} - 2y\,\hat{j} + 3z\,\hat{k})$
d) $A(-3x\,\hat{i} + 2y\,\hat{j} - 3z\,\hat{k})$ e) $A(-6x\,\hat{i} + 4y\,\hat{j} - 3z\,\hat{k})$

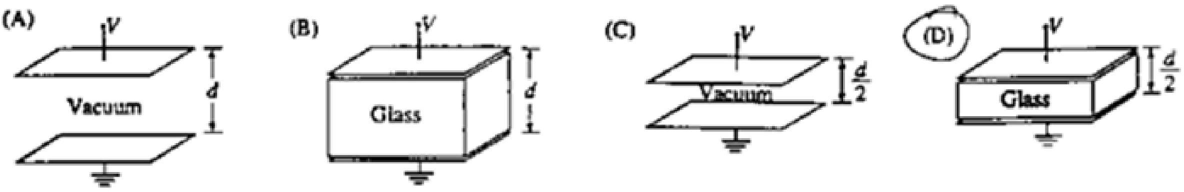
16) A point charge, +Q, is located at the center of a hollowed out conducting shell of inner radius 10 cm and outer radius 50 cm. The shell itself carries a net charge of −2Q. If the electric potential is taken to be zero at an infinite distance, and the potential at point P, very near the outer surface, is measured as −300 V, then the potential at point X, very near the inner surface of the shell, is approximately



√ a) −300 V
b) −100 V
c) +100 V
d) +300 V
e) none of the above are even approximately correct

A conductor is an equipotential – all points in and on it are at the same potential so $V_P = V_X = -300\,V$

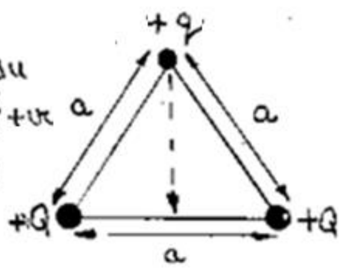
17) Which of the following capacitors, each of which has plates of area A, would store the most charge on its top plate for a given potential difference V?



18) Two charges $+Q$ are fixed at the vertices of an equilateral triangle with sides of length *a* as shown. The work required to move a third charge $+q$ from the other vertex to the midpoint of the line joining the charges $+Q$ is:

$W_E = -\Delta U$

$-U_E$ $+U_E$



a) 0 b) $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{a}$ c) $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{a^2}$ d) $\frac{1}{4\pi\varepsilon_0}\frac{2Qq}{a}$ e) $\frac{1}{4\pi\varepsilon_0}\sqrt{2}\frac{Qq}{a}$

$W_{external} = q(V_f - V_i) = \frac{q}{4\pi\varepsilon_0}\left\{\frac{2Q}{a/2} - \frac{2Q}{a}\right\}$

19) Which of the following statements is **NOT TRUE?**

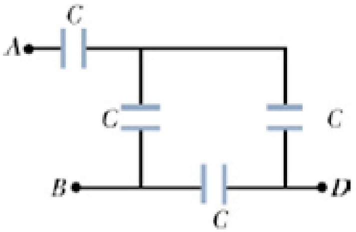
A. Electric field lines can never cross.

B. Electric field lines represent the direction of the force on a positive test charge.

C. Electric field lines start on positive charges and end on negative charges.

√D. The separation of electric field lines increases with increasing magnitude of the electric field.

20) **What is the total capacitance, in units of μF, between points A and D in the section of the circuit shown? All three capacitors have C= 1μF.**



a) 3/5

b) 6/7

c) 1/4

d) 4

e) 3/4

Solution:

One can start with the 2 capacitors in series at the bottom left: they are in series with equivalent capacitance C/2. That is in parallel with another capacitor, so the equivalent capacitance of the 3 capacitors to the right is 3C/2. Add the first capacitor in series and you get $\frac{1}{C_{eq}} = \frac{1}{C} + \frac{2}{3C} = \frac{5}{3C} \Rightarrow C_{eq} = \frac{3}{5}C$

21) A parallel plate capacitor with an air dielectric is attached to a voltage source and charged. The voltage source is removed, and then the plates are separated to double their previous distance.

I- What happens to the electric field between the plates when they are separated?

a) It doubles. b) It quadruples. c) It halves. d) It is diminished by a factor of 4.

e) It stays the same.

II- What happens to the energy stored by the capacitor when the plates are separated?

a) It doubles. b) It quadruples. c) It halves. d) It is diminished by a factor of 4.

e) It stays the same.

III- When an insulator with dielectric constant 5.0 is inserted between the plates, what happens to the electric field strength if the surface charge density does not change?

a) It increases by a factor of 5. b) It increases by a factor of 25. **c) It decreases by a factor of 5.** d) It decreases by a factor of 25. e) It stays the same.

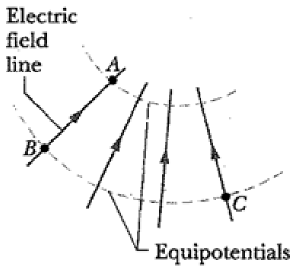
IV- If the electric field in the dielectric between the plates of a capacitor is E, what is the charge density on the plates?

a) $E \cdot V$ b) $E^2 \varepsilon_0$ c) $V^2 \cdot E$ d) $\varepsilon_0 E$ **e)** $\kappa \varepsilon_0 E$

V- If the plate area, plate separation, and dielectric constant all are doubled, what happens to the capacitance?

a) It stays the same. **b) It doubles.** c) It quadruples. d) It halves. e) It quarters

24) When an electron moves from A to B along the electric field line in the figure below. the electric field does $+3.20 \times 10^{-19}$ J of work on it.



(i) What is the electric potential difference $V_B - V_A$?

a) 0 V
b) 2 V
c) –2 V
d) None of the above are even approximately correct

V decreases in direction of $\vec{E}$

$$\Delta V = \frac{\Delta U}{q} = \frac{-W_{field}}{q} = \frac{-3.2 \cdot 10^{-19}\ J}{-1.6 \cdot 10^{-19}\ C} = +2V$$

(ii) What is the electric potential difference $V_B - V_C$?

a) 0 V   B, C on same equipotential surface
~~b) 2 V~~
c) –2 V
d) None of the above are even approximately correct

(iii) What is the electric potential difference $V_A - V_C$?

a) 0 V
b) 2 V $V_A - V_C = V_A - V_B = -(V_B - V_A)$
c) –2 V

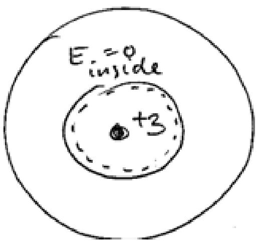
26) An isolated conductor of arbitrary shape has a net charge of +10 μC. Inside the conductor is a cavity within which is a point charge q = +3.0 μC.

(i) What is the charge on the wall of the cavity? Circle the right answer.

a) +3.0 μC   √b) –3.0 μC   c) +10 μC   d) –10 μC   e) +13 μC

(ii) What is the charge on the outer surface of the conductor? Circle the right answer:

a) +3.0 μC   b) –3.0 μC   c) +10 μC   d) +7 μC   √e) +13 μC



(i) Use Gauss' law, with surface just inside conducting material

$q_{encl} = \varepsilon_0 \oint \vec{E} \cdot d\vec{A} = 0$ since E = 0 inside metal.

So $q_{encl} = q_{point} + q_{inner} = 0$

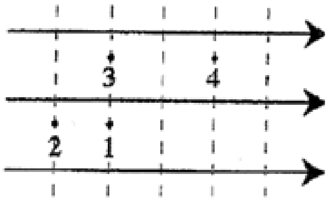
$\Rightarrow q_{inner} = -q_{point} = \underline{-3\ \mu C}$

(ii) By charge conservation $q_{TOT,\ SHELL} = 10\ \mu C = q_{inner} + q_{outer}$

$\Rightarrow q_{outer} = 10\ \mu C - q_{inner} = 10\mu C - (-3\mu C) = \boxed{+13\ \mu C}$

27) Which of the following statements is true?
a)Electric field lines stay inside equipotent surfaces. b) equipotent surfaces intersect in straight lines. b) equipotent surfaces intersect in curved lines **d) Electric field lines are perpendicular to equipotentail surfaces** e) equipotent surfaces are parallel to each other.

28) The figure shows a uniform electric field, pointing to the right. The equipotential surfaces are indicated with dashed lines.
There are four points indicated on the figure (1, 2, 3, and 4). We define V = 0 at point 3 ($V_3 = 0$).



a) What is the electric potential at the three other points?
Circle the right answer for each V.

i) $V_1 < 0$ $V_1 = 0$ $V_1 > 0$
ii) $V_2 < 0$ $V_2 = 0$ $V_2 > 0$
iii) $V_4 < 0$ $V_4 = 0$ $V_4 > 0$

$V_1 = V_3 = 0$

V DECREASES ALONG FIELD LINES

b) What is the work done by the electric field on an electron if it is moved from point 2 to point 4? Circle the correct answer.

Positive Zero Negative Not enough information to tell

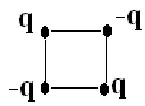
$e < 0$

c) What is the work done by the electric field on an electron if it is moved from point 1 to point 3? Circle the correct answer.

Positive Zero Negative Not enough information to tell

$V_1 = V_3$

30) Charges +q and –q are arranged at the corners of a square as shown. When the electric field E and the electric potential V are determined at P, the center of the square, we find that



a) E≠ and V>0 **b) E=0 and V=0** c) E=0 and V>0 d)E≠0 and V<0 e) none of these is correct