Physics 212 Test 1A

Chap. 23-26

Dr. Gladden, Feb. 23, 2012

NAME: KEY　　　　**UM ID#:**__________

Conceptual Multiple Choice (*2 points each*): Clearly write the letter corresponding to the BEST possible answer in the space provided. You may also circle the answer to be sure.
Some Constants: $k_e = 9 \times 10^9 Nm^2/C^2$, $\epsilon_0 = 8.85 \times 10^{-12} C^2/(m^2N)$

1. B How can a negatively charged rod charge an electroscope positively?
   A) by conduction
   B) by induction
   C) by deduction
   D) It cannot.

2. D Can electric field lines intersect in free space?
   A) Yes, but only at the midpoint between two equal like charges.
   B) Yes, but only at the midpoint between a positive and a negative charge.
   C) Yes, but only at the centroid of an equilateral triangle with like charges at each corner.
   D) No.

3. A For a negative charge moving from an electric potential of 0 V to 10 V, the potential energy will:
   A) decrease
   B) increase
   C) remain unchanged
   D) we would need to know the magnitude of the charge

4. B One joule per coulomb is a
   A) newton.
   B) volt.
   C) electron-volt.
   D) farad.

5. B An equipotential surface must be
   A) parallel to the electric field at any point.
   B) perpendicular to the electric field at any point.
   C) there is no connection between their orientation.
   D) they must be in opposite directions

6. C A surface on which all points are at the same potential is referred to as
A) a constant electric force surface.
B) a constant electric field surface.
C) an equipotential surface.
D) an equivoltage surface.

7. A Materials in which the electrons are bound very tightly to the nuclei are referred to as
A) insulators.
B) conductors.
C) semiconductors.
D) superconductors.

8. C An imaginary Gaussian surface surrounding charges of +Q and -Q has a net electric field flux which is
A) outward
B) inward
C) zero
D) not enough information to determine

9. B Two point charges each with charge +Q lie on the x axis. In what region is there a point where the net electric field can be 0?
A) to the right of both charges
B) between both charges
C) to the left of both charges
D) it is not 0 anywhere for these charges

10. B When gravitational, magnetic and any forces other than static electric forces are not present, electric field lines in the space surrounding a charge distribution show
A) the directions of the forces that exist in space at all times.
B) only the directions in which static charges would accelerate when at points on those lines
C) only the directions in which moving charges would accelerate when at points on those lines.
D) tangents to the directions in which either static or moving charges would accelerate when passing through points on those lines.

11. B The electric potential can be defined as the
A) potential energy per unit mass.
B) potential energy per unit charge.
C) kinetic energy per unit charge.
D) work done.

18. D Which of the following statements is incorrect?

A) Capacitance is always positive.

B) The symbol for potential difference between the plates of a capacitor is ΔV.

C) When a dielectric is placed in a capacitor it serves to reduce the electric field.

D) Nonpolar molecules cannot be used for dielectric material in a capacitor.

19. B An electric dipole having dipole moment of magnitude p is placed in a uniform electric field having magnitude E. What is the magnitude of the greatest change in potential energy that can happen for this dipole in this field?

a. pE

b. $2pE$

c. $4pE$

d. $\sqrt{2}pE$

20. B A parallel plate capacitor is charged with a battery and then disconnected from the battery. If the plates are moved apart, the voltage

A) decreases

B) increases

C) remains constant, but the charge increases

D) remains constant, but the charge decreases

Test B Solns

1. B	7. C	13. B	18. D
2. B	8. B	14. B	19. A
3. C	9. B	15. B	20. B
4. A	10. B	16. D	
5. D	11. C	17. B	
6. D	12. B		

12. C Starting from a position A near a point charge and traversing a path around the point charge back to point A will result in a
A) potential gain
B) potential drop
C) potential change of 0
D) too little information to tell.

13. B An uncharged metal sphere is placed on an insulating puck on a frictionless table. While being held parallel to the table, a rod with a charge q is brought close to the sphere, but does not touch it. As the rod is brought in, the sphere
A) remains at rest.
B) moves toward the rod.
C) moves away from the rod.
D) moves perpendicular to the velocity vector of the rod.

14. B An uncharged spherical conducting shell surrounds a charge -q at the center of the shell. The charges on the inner and outer surfaces of the shell are respectively
A) -q, -q.
B) -q, +q.
C) +q, -q.
D) +q, +q.

15. D A student has made the statement that the electric flux through one half of a Gaussian surface is always equal and opposite to the flux through the other half of the Gaussian surface. This is
A) never true.
B) never false.
C) true whenever enclosed charge is symmetrically located at a center point, or on a center line or centrally placed plane.
D) true only when no charge is enclosed within the Gaussian surface.

16. B The electric potential inside a charged solid spherical conductor in equilibrium
A) is always zero.
B) is constant and equal to its value at the surface.
C) decreases from its value at the surface to a value of zero at the center.
D) increases from its value at the surface to a value at the center that is a multiple of the potential at the surface.

17. D When introduced into a region where an electric field is present, an electron with initial velocity will eventually move
A) along an electric field line, in the positive direction of the line.
B) along an electric field line, in the negative direction of the line.
C) to a point of decreased potential.
D) to a point of increased potential.

Problems: Work each of the following problems. Make sure to **show your work** and put a box around your final answer.

1. (*15 points*) (a) Calculate the work required to bring a $Q_1 = +10.0m\text{C}$ charge from very far away to a point 3.0 cm from a $Q_2 = +5.0m\text{C}$ charge that is fixed in space.

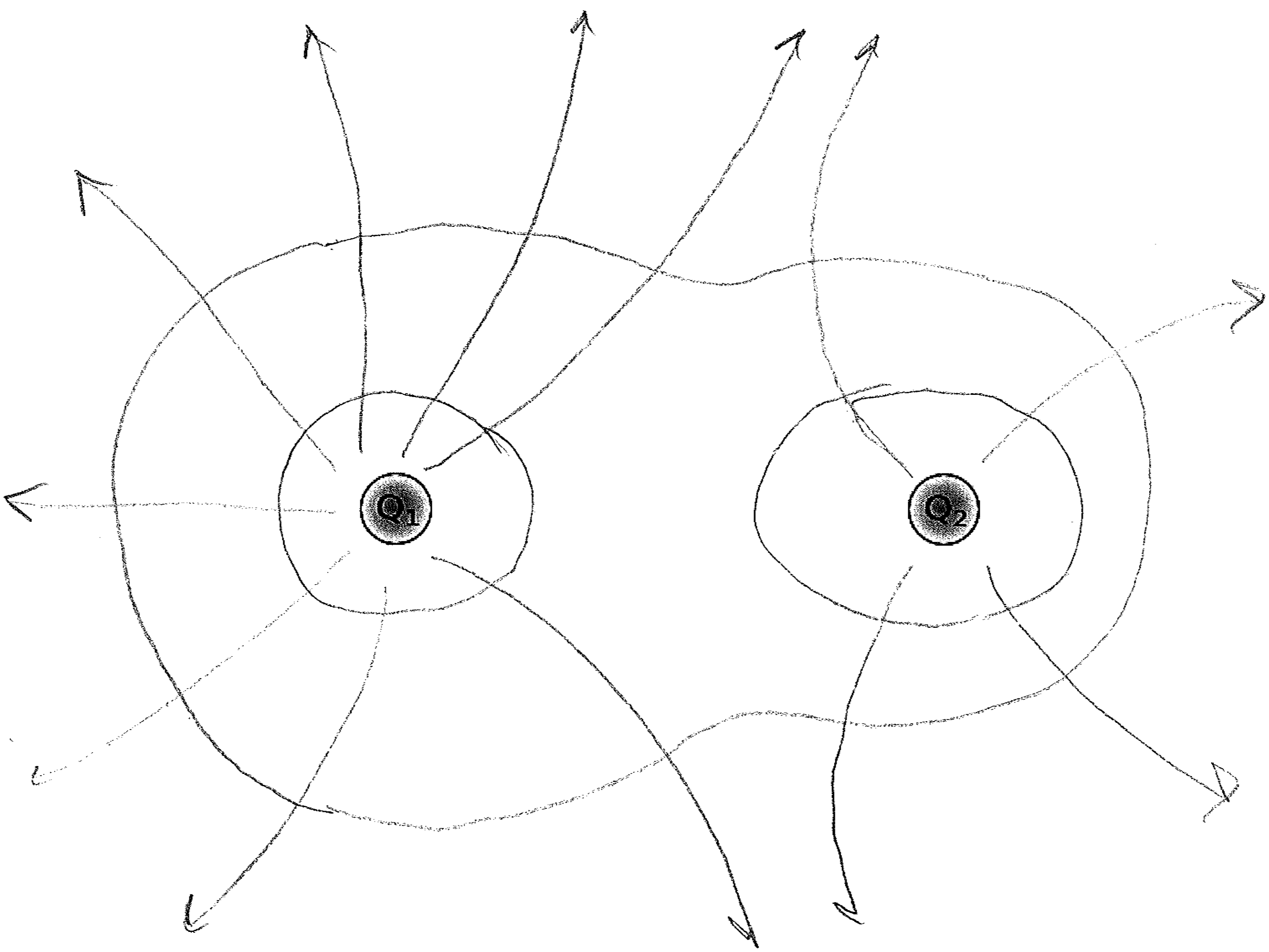
Assume $V=0$ at $r=\infty$

$W = q_2 \Delta V$

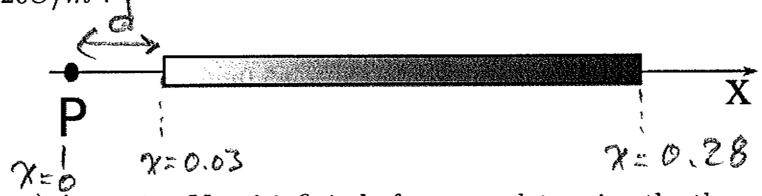
$\Delta V = k \frac{q_1}{r}$ ← for a point charge

so $W = k \frac{q_1 q_2}{r} = 9\times10^9 \frac{(10\times10^{-3})(5\times10^{-3})}{0.03} = \boxed{15\times10^6 \text{J}}$

(b) (5 points) Sketch the electric field and equipotential lines around the 2 (+) charges once they are 3.0 cm apart.



2. A line charge has a **non-uniform** charge density of $\lambda(x) = \beta x^2$ and total length of 25 cm. $\beta = +20 C/m^2$.



(a) (*15 points*) Assuming $V = 0$ infinitely far away, determine the the potential 3.0 cm away from the $x = 0$ end of the rod along the axis of the rod (as shown in the figure).

$$V = K \int \frac{dq}{x} \quad , \text{ but } \quad dq = \lambda\, dx = \beta x^2 dx$$

$$= K\beta \int_{x_1}^{x_2} (x-d)\, dx = K\beta \left[\tfrac{1}{2}(x_2^2 - x_1^2) - d(x_2 - x_1) \right]$$

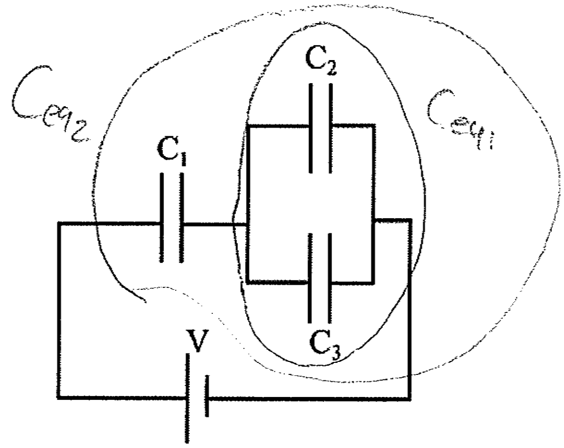
$$= K\beta \left[\tfrac{1}{2}(0.28^2 - 0.03^2) - (0.03)(0.28 - 0.03) \right]$$

$$= k(20 \tfrac{C}{m^2})[0.03875 - 0.0075] = \boxed{5.6 \times 10^9\ V}$$

(b) (*5 points*) Would the potential be larger, smaller, or the same at a point the same distance away from the other end of the rod? Justify your answer.

It would be larger because a higher concentration of charge is closer to that point.

3. The diagram shows a circuit of parallel plate capacitors. The capacitances are $C_1 = 5.0$ mF, $C_2 = 3.2$ mF, and $C_3 = 10.9$ mF. The voltage of the battery is 10 V.



a) (*10 points*) Determine the equivalent capacitance of the circuit.

$C_{eq_1} = C_3 + C_2$

$\frac{1}{C_{eq_2}} = \frac{1}{C_1} + \frac{1}{C_2 + C_3} = \frac{1}{5mF} + \frac{1}{3.2mF + 10.9mF}$

$\Rightarrow C_{eq} = 3.69\ mF$

b) (*5 points*) If a slab of mica with dielectric constant of $\kappa = 5.5$ were inserted into each of the capacitors, how much would the total energy stored in the capacitors change?

The total energy would increase by 5.5 So

$C = \kappa C_{eq} = 5.5(3.69\ mF) = 20.30\ mF$

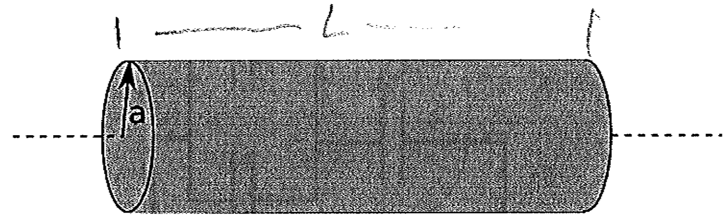
$U = \frac{1}{2} C V^2 = \frac{1}{2}(20.30\ mF)(10V)^2 = 1,015\ J$

(c) (*5 points*) As the mica was inserted would the total charge on the capacitors increase, decrease, or remain the same? Explain your answer!

Increase. The dielectric becomes polarized as it is inserted which partially cancels the E field. The nearby oppositely charged surfaces on the dielectric allow more charge from the battery to be built up on the plates,

Extra Credit (5 points)

An infinite length cylinder of charge has a uniform volume charge density of ρ, and radius of a. Use Gauss' Law to find an equation for the magnitude of the electric field between $r = 0$ and $r = a$



$$\oint \vec{E} \cdot d\vec{a} = \frac{q_{in}}{\epsilon_0}$$

$E \perp da$ at end caps so $\vec{E} \cdot d\vec{a} = 0$ there

now $q_{in} = \rho V = \rho \pi r^2 L$

and at walls of cylindrical Gaussian surface $\vec{E} \parallel d\vec{a}$, so $\vec{E} \cdot d\vec{a} = E\,da$ and E is constant

so $\oint \vec{E} \cdot d\vec{a} = E A$ → area of walls $A = 2\pi r L$

so

$$E (2\pi r L) = \frac{\rho \pi r^2 L}{\epsilon_0}$$

so $\boxed{E = \frac{\rho}{2\epsilon_0} r}$ for $r < a$