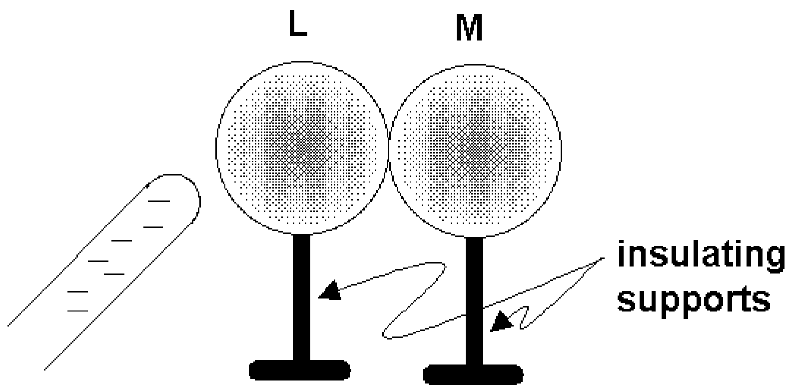
1. A neutral metal ball is suspended by a string. A positively charged insulating rod is placed near the ball, which is observed to be attracted to the rod. This is because:

   (a) the ball becomes net positively charged by induction
   (b) the ball becomes net negatively charged by induction
   (c) the number of electrons in the ball is more than the number in the rod
   (d) the string is not a perfect insulator
   (e) there is a rearrangement of the electrons in the ball

2. A positively charged insulating rod is brought close to an object that is suspended by a string. If the object is repelled away from the rod we can conclude:

   (a) the object is positively charged
   (b) the object is negatively charged
   (c) the object is an insulator
   (d) the object is a conductor
   (e) none of the above

3. Two uncharged metal spheres, L and M, are in contact. A negatively charged rod is brought close to L, but not touching it, as shown. The two spheres are slightly separated and the rod is then withdrawn. As a result:



(a) both spheres are neutral
(b) both spheres are positive
(c) both spheres are negative
(d) L is negative and M is positive
(e) L is positive and M is negative

4. A positively charged metal sphere A is brought into contact with an uncharged metal sphere B. As a result:

(a) both spheres are positively charged
(b) A is positively charged and B is neutral
(c) A is positively charged and B is negatively charged
(d) A is neutral and B is positively charged
(e) A is neutral and B is negatively charged

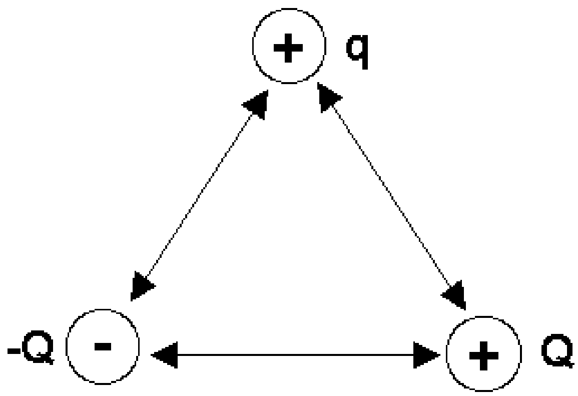
5. Two particles have charges Q and -Q (equal magnitude and opposite sign). For a net force of zero to be exerted on a third charge it must be placed:

   (a) midway between Q and -Q
   (b) on the perpendicular bisector of the line joining Q and -Q
   (c) on the line joining Q and -Q, to the side of Q opposite -Q
   (d) on the line joining Q and -Q, to the side of -Q opposite Q
   (e) at none of these places (there is no place)

6. Two particles A and B have identical charge Q. For a net force of zero to be exerted on a third charge it must be placed:

   (a) midway between A and B
   (b) on the perpendicular bisector of the line joining A and B but away from the line
   (c) on the line joining A and B, not between the particles
   (d) on the line joining A and B, closer to one of them than the other
   (e) at none of these places (there is no place)

7. Charges Q, -Q, and q are placed at the vertices of an equilateral triangle as shown. The total force exerted on the charge q is:



(a) the total force is zero

(b) at right angles to the line joining Q and -Q (up)

(c) at right angles to the line joining Q and -Q (down)

(d) parallel to the line joining Q and -Q (right)

(e) parallel to the line joining Q and -Q (left)

8. Choose the INCORRECT statement:

(a) Gauss' law can be derived from Coulomb's law

(b) Gauss' law states that the net number of lines crossing any closed surface in an outward direction is proportional to the net charge enclosed within the surface

(c) Coulomb's law can be derived from Gauss' law and symmetry

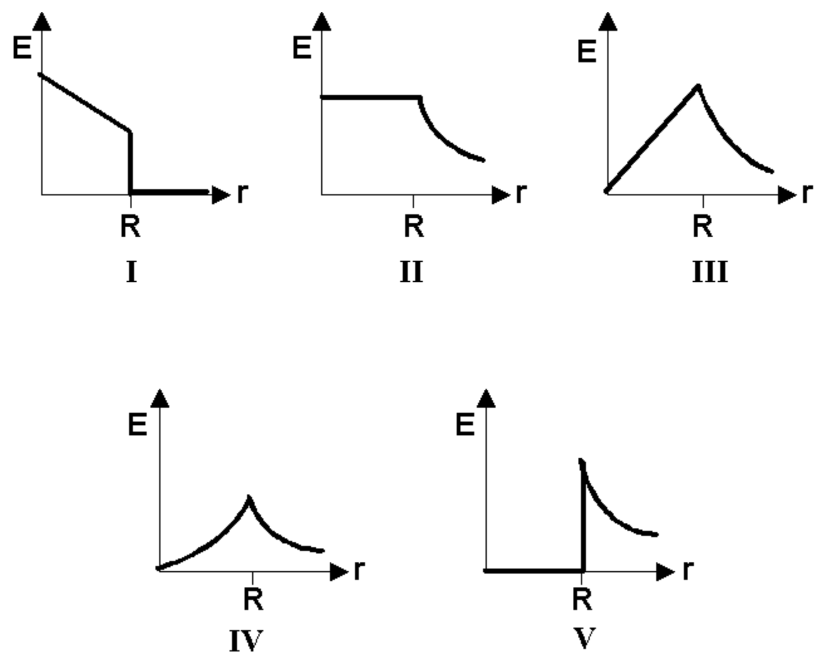
(d) Gauss' law applies to a closed surface of any shape

(e) According to Gauss' law, if a closed surface encloses no charge, then the electric field must vanish everywhere on the surface

9. A 5-cm radius conducting sphere is charged until the electric field just outside its surface is 2000 V/m. The electric potential of the sphere, relative to the potential far away, is:

(a) 0
(b) 5 V
(c) 100 V
(d) 4×10^4 V
(e) 8×10^5 V

10. A solid insulating sphere of radius R contains a uniform volume distribution of positive charge. Which of the graphs below correctly gives the magnitude E of the electric field as a function of r?



(a) I.
(b) II.
(c) III.
(d) IV.
(e) V.

BONUS Which of the preceeding graphs represents the magnitude of the electric field as a function of the distance from the center of a solid charged conducting sphere of radius R?

(a) I.

(b) II.

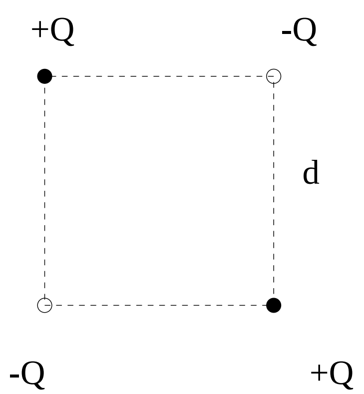
(c) III.

(d) IV.

(e) V.

Partial Credit Section (50 points)

Charges $+Q$ and $-Q$ are arranged at the corners of a square of side d as shown.



(a) What is the electric potential at the center of the square?

(b) What is the electric field (magnitude and direction) at the center of the square?

An infinitely long thin wire carries uniform linear charge density +8 μC/m. What is the difference in voltage between point A (1 meter from the wire) and point B (3 meters from the wire)?

Show that a volt/meter is the same as a newton/coulomb. What quantity is measured in these MKS units?

If C = 12 pF, determine the equivalent capacitance for the combination shown.