Chapter 4 Electric Potential

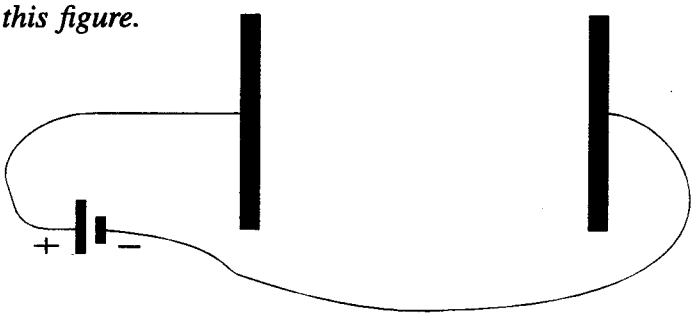
In-Class Questions

Prerequisite Concepts:

- **Electric potential energy**
- **Definition of electric potential: V = EPE/q**
- **Conductor is an equipotential volume**
- **Electric potential in neighborhood of a point charge Q: $V \propto Q/r$**

[Note: All gravitational forces may be ignored in this chapter]

In this figure, two parallel metal plates are connected to the positive and negative terminals of a battery as shown. A 2-Coulomb positive charge is held at rest on the left-hand plate, and then released and allowed to move freely. When it strikes the right-hand plate, its kinetic energy is 12 joules. *Questions #1–5 refer to this figure.*



1. As the 2–Coulomb charge moved between the plates, how did its electric potential energy change?

   A. increased by 6 joules
   B. increased by 12 joules
   C. remained constant
   D. decreased by 6 joules
   E. decreased by 12 joules
   F. not enough information to answer

2. What is the potential difference between the terminals of the battery?

   A. 0 volts
   B. 3 volts
   C. 6 volts
   D. 12 volts
   E. 24 volts
   F. not enough information to answer

3. Assume that the negative terminal of the battery is at a potential of 0 volts. What is the electric potential ***midway*** between the plates?

   A. 0 volts
   B. 1.5 volts
   C. 3 volts
   D. 6 volts
   E. 12 volts
   F. not enough information to answer

4. Suppose a different positively charged particle, starting from rest on the left-hand plate, moves across and strikes the right-hand plate with a kinetic energy of 24 joules. What is the charge on this particle?

   A. 1 C
   B. 2 C
   C. 3 C
   D. 4 C
   E. 6 C
   F. 12 C

5. What is the electric potential energy of this charge when it is midway between the plates?

   A. 3 joules
   B. 6 joules
   C. 12 joules
   D. 18 joules
   E. 24 joules
   F. 48 joules

In this figure, two parallel metal plates are connected to a 4-V battery as shown. (The vertical lines divide the space between the plates into four equal segments.) The electric potential at point #1 is 0 volts. Choose your answers for questions #6–10 from this list:

A. 0 V

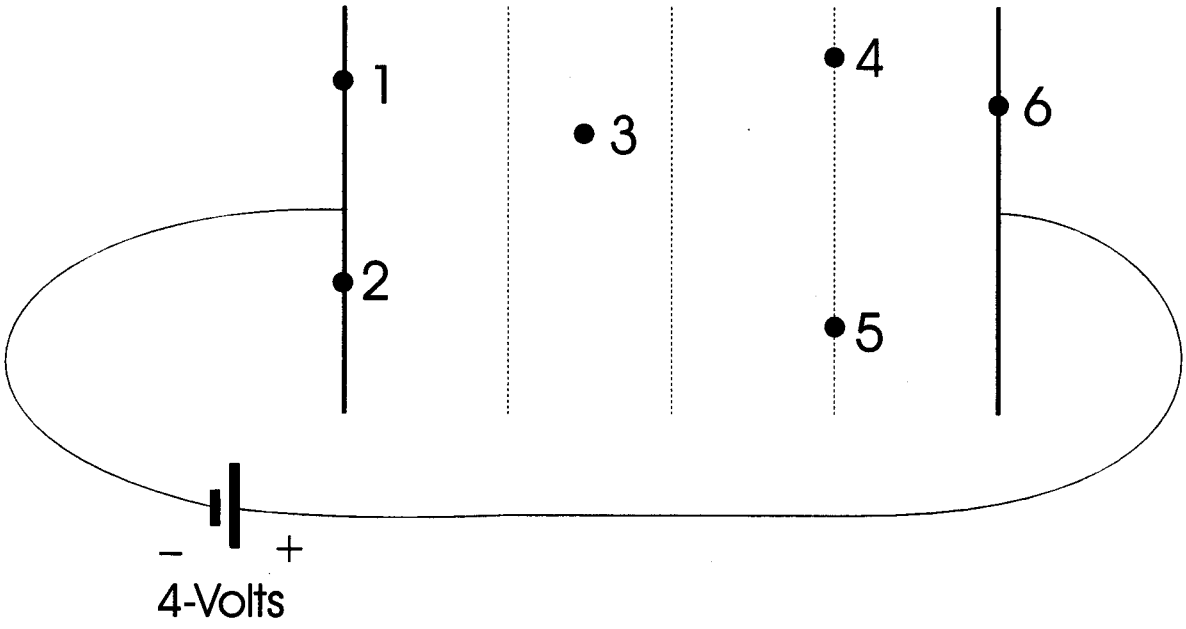
B. 1 V

C. 2 V

D. 3 V

E. 4 V

F. none of the above



6. What is the electric potential at point #2?

7. What is the electric potential at point #4?

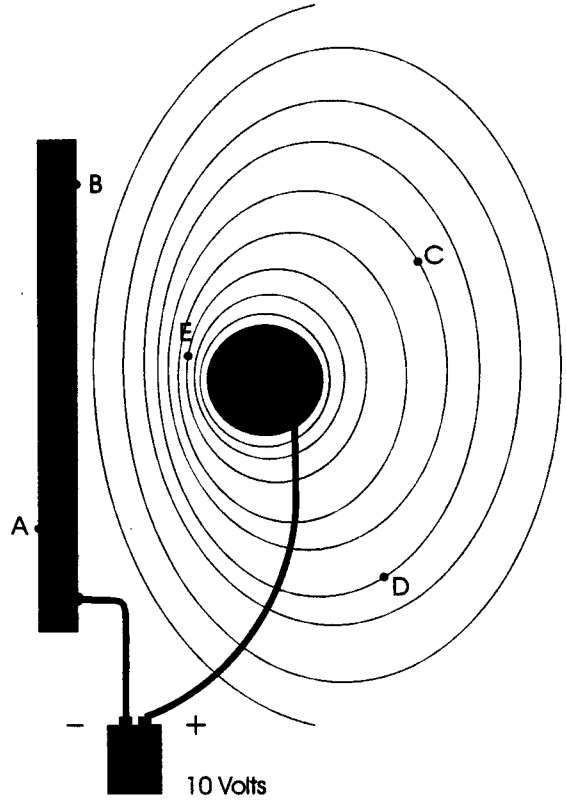
8. What is the electric potential at point #5?

9. What is the electric potential at point #6?

10. What is the electric potential at point #3?

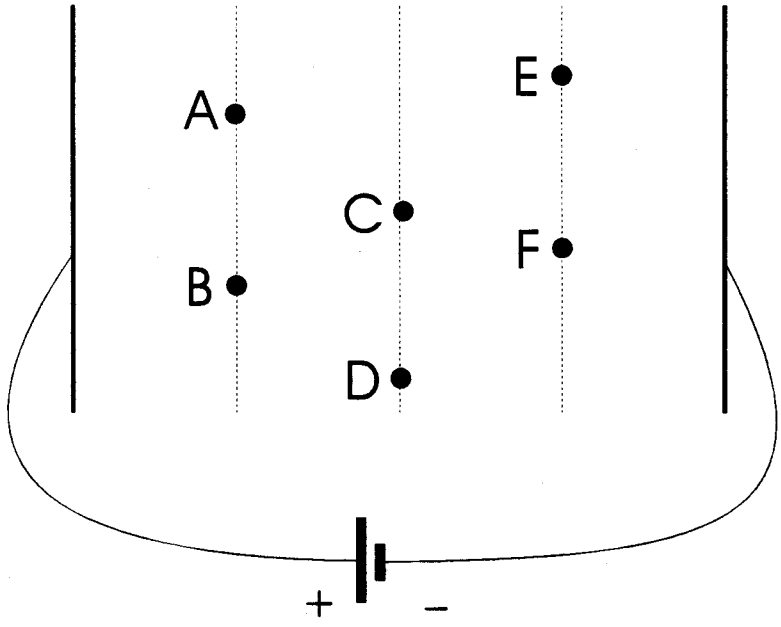
In-Class Exercises

In this figure, a metal strip (points "A" and "B" are located on this strip) and a metal disc (shaded) are connected to the terminals of a ten-volt battery as shown. The lines that are drawn are equipotential lines, drawn at one-volt intervals. The electric potential at point "A" is zero volts.



1. What is the electric potential at a point on the metal disc?_____
2. What is the electric potential at point B?_____
3. What is the electric potential at point C?_____
4. What is the difference in electric potential between points D and C?
5. At which of the following points does the electric potential vary ***most rapidly*** as a function of distance? Circle one: C D E

In this figure, two parallel metal plates are connected to the terminals of a battery as shown. (The vertical lines divide the space between the plates into four equal segments.) *Questions #6–12 refer to this figure.*



6. Rank, in order, the following values:

   A. The electric potential at point "A"
   B. The electric potential at point "B"
   C. The electric potential at point "C"
   D. The electric potential at point "D"
   E. The electric potential at point "E"
   F. The electric potential at point "F"

   Rank A, B, C, D, E, and F, starting with largest value; if two or more are the same, put an "equals" sign ["="] between them; e.g., [A, B=C, D, E, F] means: A is largest, F is smallest, and B is equal to C, but is larger than D]:

   Ranking: (largest)_____(smallest)

7. Rank, in order, the following magnitudes:

   A. The electric field magnitude at point "A"
   B. The electric field magnitude at point "B"
   C. The electric field magnitude at point "C"
   D. The electric field magnitude at point "D"
   E. The electric field magnitude at point "E"
   F. The electric field magnitude at point "F"

   Rank A, B, C, D, E, and F, starting with largest magnitude; if two or more are the same, put an "equals" sign ["="] between them; e.g., [A, B=C, D, E, F] means: A is largest, F is smallest, and B is equal to C, but is larger than D]:

   Ranking: (largest)_____(smallest)

8. If V_A represents the electric potential at A, and so forth, rank the following magnitudes (absolute values of the quantities indicated):

   A. $| V_A - V_C |$
   B. $| V_D - V_F |$
   C. $| V_B - V_C |$
   D. $| V_B - V_E |$
   E. $| V_B - V_F |$

   Rank A, B, C, D, and E, starting with largest magnitude; if two or more are the same, put an "equals" sign ["="] between them; e.g., [A, B=C, D, E] means: A is largest, E is smallest, and B is equal to C, but is larger than D]:

   Ranking: (largest)_____(smallest)

9. Suppose a proton is placed at point A, initially at rest, and allowed to drift out to the line on which points C and D lie. Then, another proton, also initially at rest, is placed at point B and allowed to drift out to the line on which points E and F lie. A third proton, initially at rest, is placed at point C, and allowed to drift out to the line on which points E and F lie. Rank the velocities of these three particles:

   A. The velocity of the proton that started at point A
   B. The velocity of the proton that started at point B
   C. The velocity of the proton that started at point C

   Ranking: (largest)_____(smallest)

10. Suppose you have to push a proton in (at constant speed) from point E to point A, and then you have to push another proton in from point C to point B (also at constant speed). Finally, you have to push another proton in (at constant speed) from point F to point C. Rank the magnitude of the amount of work you have to do:

    A. The work needed to push from E to A
    B. The work needed to push from C to B
    C. The work needed to push from F to C

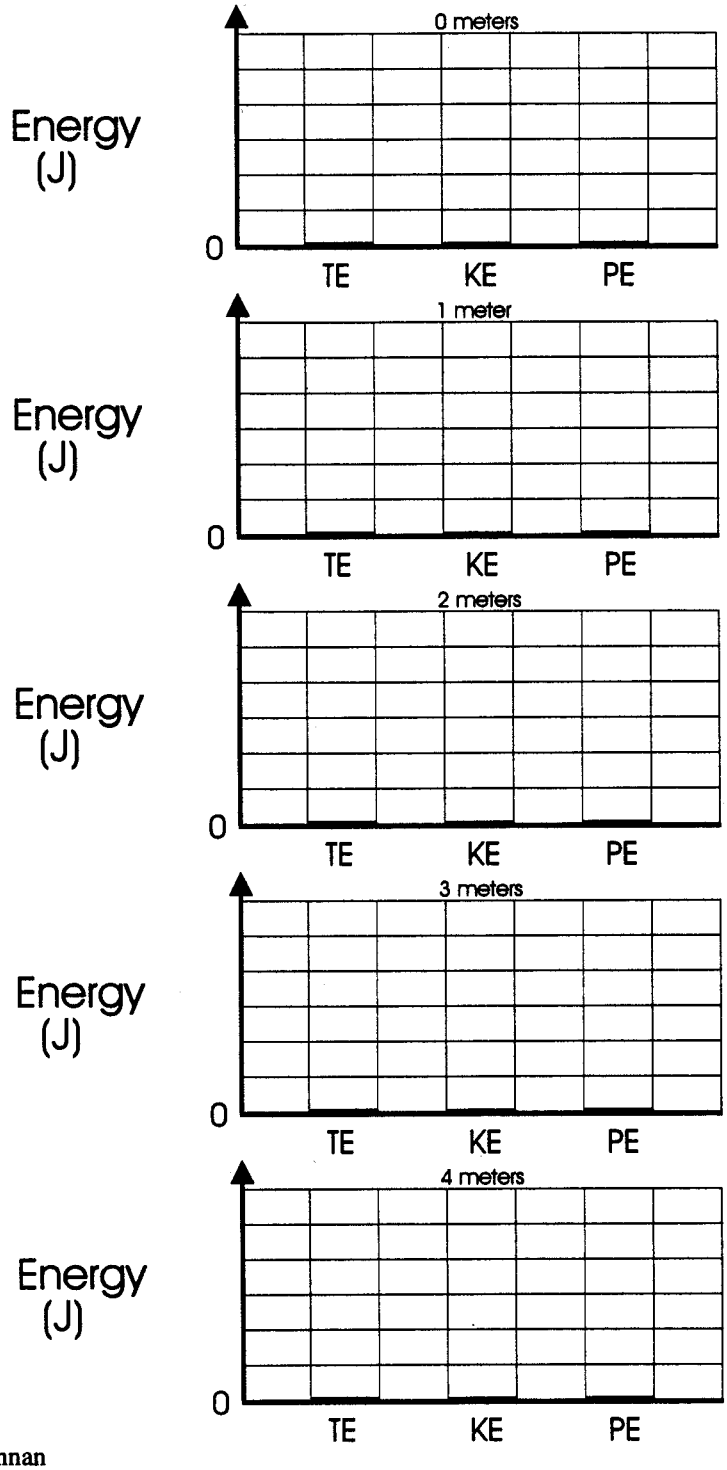
    Ranking: (largest)_____(smallest)

11. If a charge moves at constant velocity from point A to point B, is the amount of external work required positive, negative, or zero?

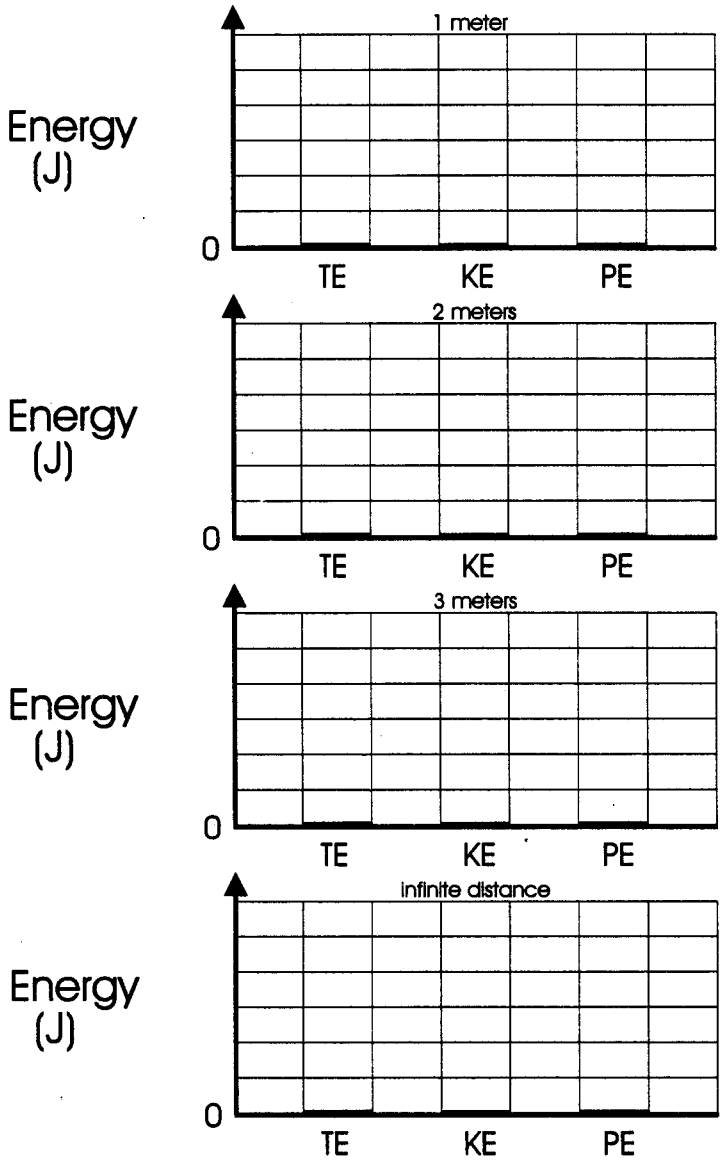
12. As a proton drifts from one plate to the other, the electrical force on it: increases, decreases, or remains the same?

Homework Exercises

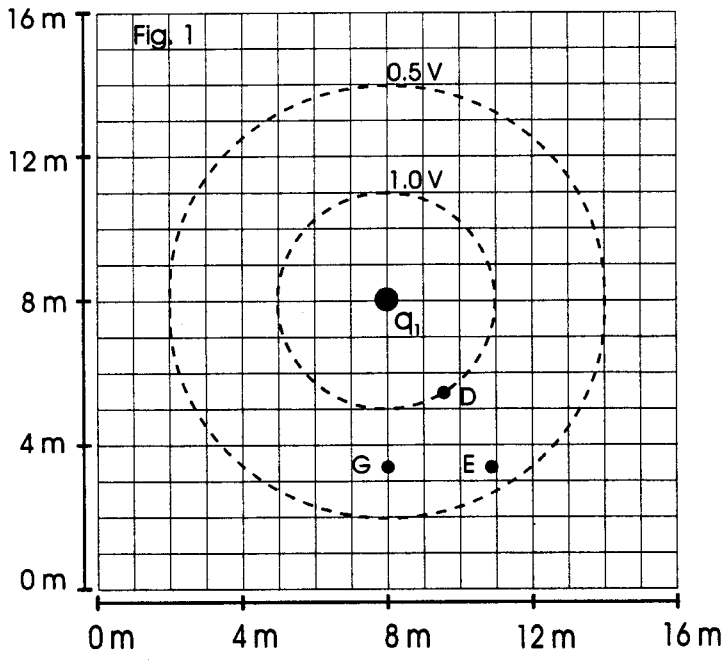
1. Two parallel metal plates separated by 4 m are connected to a 10 V battery; the negative battery terminal has a potential of 0 volts. A 2-C charge is released from the positive plate; initially the charge is at rest. Draw ***five*** bar graphs, one each corresponding to the situation when the charge is 0 m, 1 m, 2 m, 3 m, and 4 m from the positive plate. Each bar graph should have three bars, one corresponding to the total energy (TE), one to the kinetic energy (KE), and one to the electric potential energy (PE) of the charge. ***(Label the energy axis with appropriate numbers.)***

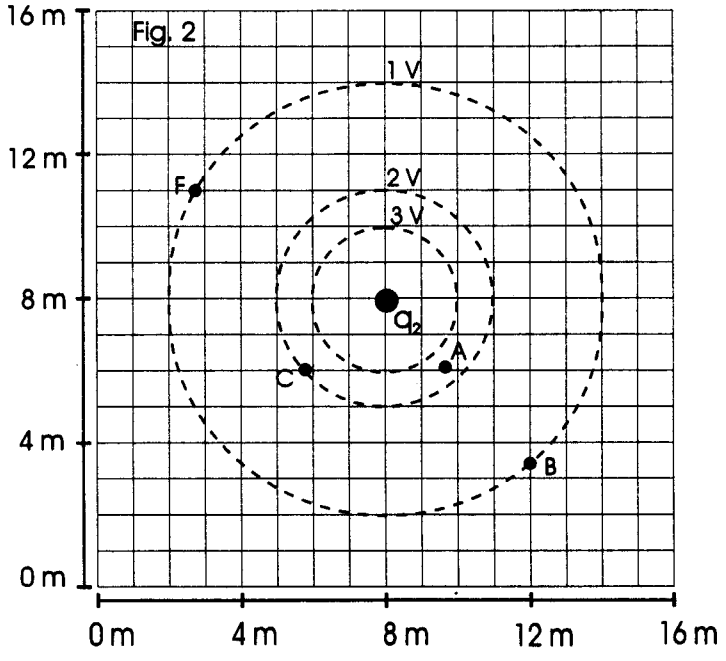


2. A 3-C charge is fixed at the origin. The electric potential infinitely far away from this charge is zero volts. A 2-C charge is released from rest at a point 1 m from the origin. Draw ***four*** bar graphs, one each corresponding to the situation when the charge is 1 m, 2 m, 3 m, and an infinite distance from the origin. Each bar graph should have three bars, one corresponding to the total energy (TE), one to the kinetic energy (KE), and one to the electric potential energy (PE) of the charge. ***(Label the energy axis with appropriate numbers.)***



In Figure 1 below (left), a charge q_1 is at the center of the circle; In Figure 2 (right), a charge q_2 is at the center of the circle. The dashed lines represent equipotential lines. The electric potential infinitely far away from the charges is, in both cases, zero volts.





3. Are the charges positive or negative? Explain your answer._____

4. Which charge has the largest magnitude? Explain your answer._____

5. What is ratio of q_1/q_2? q_1/q_2 = _____.

6. Rank in order the following values:

   A. The electric potential at point "A"
   B. The electric potential at point "B"
   C. The electric potential at point "C"
   D. The electric potential at point "D"
   E. The electric potential at point "E"
   F. The electric potential at point "F"
   G. The electric potential at point "G"

   Rank A, B, C, D, E, F and G starting with largest value; if two or more are the same, put an "equals" sign ["="] between them; e.g., [A, B=C, D, E, F, G] means: A is largest, G is smallest, and B is equal to C, but is larger than D, etc.]:

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7. Rank, in order, the following magnitudes:

   A. The electric field magnitude at point "A"
   B. The electric field magnitude at point "B"
   C. The electric field magnitude at point "C"
   D. The electric field magnitude at point "D"
   E. The electric field magnitude at point "E"
   F. The electric field magnitude at point "F"
   G. The electric field magnitude at point "G"

   Ranking: (largest)_____(smallest)

8. If V_A represents the electric potential at A, and so forth, rank the following magnitudes (absolute values of the quantities indicated):

   A. $| V_A - V_B |$
   B. $| V_D - V_F |$
   C. $| V_B - V_C |$
   D. $| V_B - V_E |$
   E. $| V_B - V_F |$

   Ranking: (largest)_____(smallest)

9. Consider the following three protons:

   A. Proton "A" is placed at point A, initially at rest, and allowed to drift out to point B.
   B. Proton "B" is placed at rest at point D, and allowed to drift out to point E.
   C. Proton "C" is placed at rest at point D, and allowed to drift out 100 km from the origin.

   Rank the speeds of these three protons.

   Ranking: (largest)_____(smallest)

10. Consider the following three quantities of work:

    A. The work you must supply to push a proton in (at constant speed) from point B to point A;
    B. The work you must supply to push another proton in from point E to point D (also at constant speed);
    C. The work you must supply to push another proton in (at constant speed) from 100 km away from the origin, to point D.

    Rank the three magnitudes of work.

    Ranking: (largest)_____(smallest)