Conceptual Questions

$+Q$ $+q$ $+Q$ $-q$
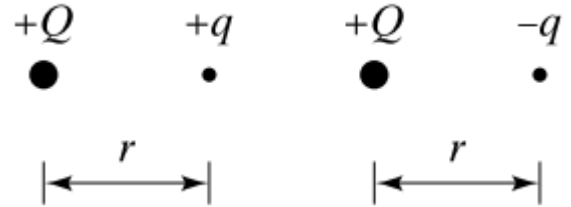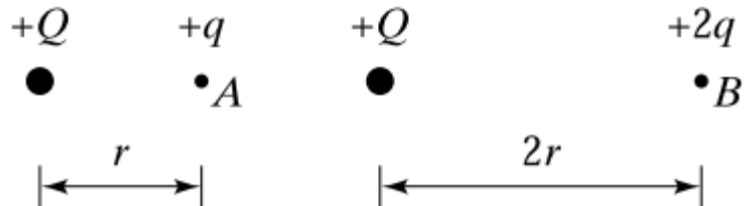
1. Two test charges are brought separately into the vicinity of a charge **+Q**. First, test charge **+q** is brought to a point a distance r from **+Q**. Then this charge is removed and test charge **–q** is brought to the same point. The electrostatic potential energy of which test charge is greater:[1]
   a) **+q**   b) **–q**   c) it is the same for both

2. Draw two equal positive point charges and connect them with a line.[2]
   a) Is there a point on the line at which the electric field is zero?
   b) Is there a point on the line at which the electric potential is zero?
   c) Explain the difference between the two answers.

3. The electric potential at a point is zero. Is it possible for the electric field at that point to be nonzero? If "yes," give an example. If "no," explain why not.[3]

4. Two test charges are brought separately into the vicinity of a charge **+Q**. First, test charge **+q** is brought to point **A**, a distance **r** from **+Q**. Next, **+q** is removed and a test charge **+2q** is brought to point **B** a distance **2r** from **+Q**. Compared with the electrostatic potential of the charge **+Q** at **A**, that of the charge **+Q** at **B** is [4]
   a) greater.   b) smaller.   c) same.

$+Q$ $+q$ $+Q$ $+2q$
         $\bullet A$ $\bullet B$

5. If two points are at the same potential, does this mean that no work is done in moving a test charge from one point to another? Does this imply that no force need be exerted? Explain.[5]

6. If a negative charge is initially at rest in an electric field, will it move toward a region of higher potential or lower potential? What about a positive charge? How does the potential energy of the charge change in each instance?[6]

7. What point charges, all having the same magnitude, would you place at the corners of a square (one charge per corner), so that both the electric field and the electric potential are zero at the centre of the square? Account for the fact that the charge distribution gives rise to *both* a zero field and a zero potential. [7]

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[1] Peer Instruction – A User's Guide, Mazur, Electrostatics CT 11
[2] Physics 12, Nelson Education, Section 7.4 Questions, #3
[3] Physics 12, Nelson Education, Section 7.4 Questions, #5
[4] Peer Instruction – A User's Guide, Mazur, Electrostatics CT 10
[5] Physics 6th Edition, Giancoli, Chapter 17 Questions, #1
[6] Physics 6th Edition, Giancoli, Chapter 17 Questions, #2
[7] Physics, 7th Edition, Cutnell & Johnson, Chapter 19 Conceptual Questions, #4

Problems

+4.0 μC

8. Three charges are placed at the corners of an equilateral triangle
    with sides
    of length 2.0 m, as shown.[8]
    a) Calculate the total electric potential energy of the group of
    charges.
    b) Determine the electric potential at the midpoint of each side of
    the triangle.

    -4.0 μC   +2.0 μC
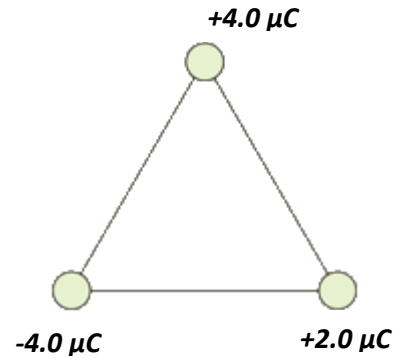
9. A charge of 1.2×10^{-3} C is fixed at each corner of a rectangle 30.0 cm wide and 40.0 cm long. What is the
    electric potential at the centre of the rectangle?[9]

10. A 1.0×10^{-6} C test charge is 40.0 cm from a 3.2×10^{-3} C charged sphere. How much work was required to
    move it there from a point 1.0×10^{2} cm away from the sphere?[10]

11. Two alpha particles, separated by an enormous distance, approach each other. Each has an initial speed
    of 3.0×10^{6} m/s. Calculate their minimum separation, assuming no deflection from their original path. [11]

12. How much work must be done to bring three electrons from a greaat distance apart to 1.0×10^{-10} m from
    one another (at the corners of an equilateral triangle)?[12]

13. The potential at location **A** is 452 V. A positively charged particle is released there from rest and arrives
    at location **B** with a speed v_B. The potential at location C is 791 V, and when released from rest from this
    spot, the particle arrives at **B** with twice the speed it previously had, or **$2v_B$**. Find the potential at **B**.[13]

14. In the Bohr model of the hydrogen atom, an electron orbits a proton (the nucleus) in a circulat orbit of
    radius 0.53×10^{-10} m. [14]
    a) What is the electric potential a the electron's orbit due to the proton (in joules and eV)?
    b) What is the kinetic energy of the electron (in joules and eV)?
    c) What is the total energy of electron in its orbit (in joules and eV)?
    d) What is the ionization energy – that is, the energy required to remove the electron from the atom and
    take it to $r = \infty$, at rest (in joules and eV)?

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[8] Physics 12, Nelson Education, Section 7.4 Questions, #8
[9] Physics 12, Nelson Education, Chapter 7 Review, #18 (modified)
[10] Physics 12, Nelson Education, Chapter 7 Review, #20
[11] Physics 12, Nelson Education, Chapter 7 Review, #34
[12] Physics 6th Edition, Giancoli, Chapter 17 Problems, #24
[13] Physics, 7th Edition, Cutnell & Johnson, Chapter 19 Problems, #9
[14] Physics 6th Edition, Giancoli, Chapter 17 Problems, #27