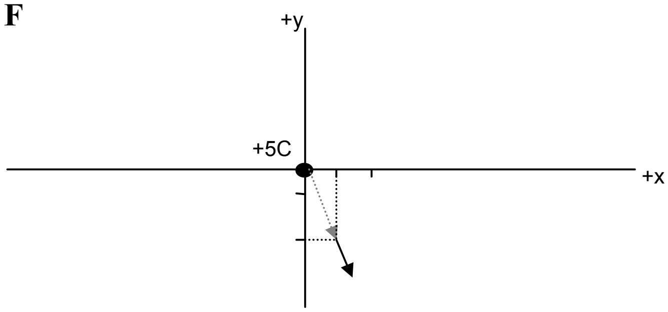
Answers to Sample Exam Questions #1

1. At the origin, the electric field due to the negative charge points in the same direction as the electric field due to the two positive charges. Therefore, to get the magnitude of the net field, we just have to *add* the magnitudes of the three individual fields. This gives $E_{net} = [k(2)/1] + [k(2)/4] + [k(2)/4] = 3k$ N/C = 2.7×10^{10} N/C. **Answer: C**

2. The force on a charge in an electric field is given by $F = |\,q\,|\,E$. Since the magnitude of the charge on the electron is the same as that on a proton, the magnitude of the forces on them would be the same. However, the *direction* of the force would be opposite, since the electron has negative charge and the proton has positive charge. **Answer: D**

3. The direction of the electric field (solid arrow) at the point (1 m, –2 m) is the same as the direction of the *displacement vector* (dashed arrow) from the origin to that point (since both the field and the displacement are along the straight line path from the origin to that point). The diagram shows that the x component of the displacement vector is positive, since a line drawn perpendicular to the x axis from the tip of this vector meets the *positive*-x axis (at a point with x > 0). However, the y component of the field is larger in magnitude than the x component, since the displacement vector has a larger-magnitude y component than x component. [Starting from the origin, you have to walk a greater distance along the y axis than you do in the x direction, in order to arrive at the point (1 m, –2 m).] **Answer: F**

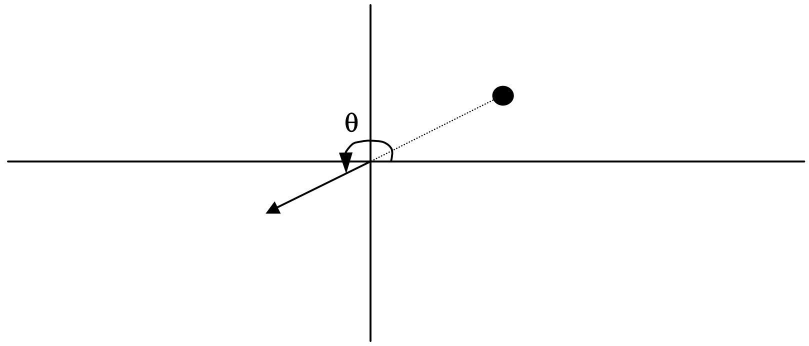


4. The net electric field due to the –1-C charge and the +2-C charge is $[k(1)/4] + [k(2)/16] = 3k/8$ N/C, pointing toward the left (toward negative x). To get a field of the same magnitude pointing toward the *right*, we have to put the 6-C charge at the x = –4 m position; then it produces a field with magnitude $k(6)/16 = 3k/8$ N/C, which cancels out the field due to the other two charges. **Answer: I**

5. The initial total energy equals the final total energy: KE(initial) + PE(initial) = KE(final) + PE(final). We know that KE(initial) = ½ mv^2 = (0.5)(2)(9) = 9 J, and KE(final) = 0 J. PE(initial) is nearly zero, since PE = kQq/r and r(initial) = 2×10^4 m. Then we have TE(initial) = TE(final) ⇒ 9 J + 0 J = 0 J + PE(final), so PE(final) = 9 J. Then kQq/r = 9 J, or r = kQq/9 J = $(9 \times 10^9)(0.001)(4 \times 10^{-6})/9 = 4$ m. **Answer: D**

6. If the separation between the charges is doubled (from R to 2R), then the force between the charges is reduced, *not* by a factor of two, but by a factor of ***4*** (since F(new)/F(old) = $[r(old)/r(new)]^2$ = ¼). Then the new force on Q will be (1/4) (12 N) = 3 N, and that will also be the force on the 3Q charge. **Answer: C**

7. The diagram shows the electric field vector at the origin. You can see right away that the angle is greater than 180° and less than 225°. If you work out the trigonometry, you can find the exact angle. **Answer: H**



8. The electric field is ***uniform***, so it doesn't matter where we put our 3-C test charge. We find that the magnitude of the electric field is 6 N/C (since F/q = 18 N/3C), and it points north, since that is the direction of the force on our positive charge. If someone brings in another test charge, they must find the exact same magnitude and direction of electric field (although the force on their test charge may be different). **Answer: E**

9. $F = kq_1q_2/r^2 = ke^2/r^2 = (9 \times 10^9)(1.6 \times 10^{-19})^2/(0.65)^2 = 5.45 \times 10^{-28}$ N.

10. With your test charge, you find the magnitude of the field to be $E = F/q = (3\text{ N}) / (2 \times 10^{-6}\text{ C}) = 1.5 \times 10^6$ N/C. Also, since the force on your positive charge is up, the direction of the field is up. The same field is detected by the electron, which experiences a force given by $F = qE = (1.6 \times 10^{-19}\text{ C})(1.5 \times 10^6\text{ N/C}) = 2.4 \times 10^{-13}$ N; the force on the electron is ***down***, since the electric field points ***up.***