Prep 1

*Suggested finish date:* Monday, April 8

The formats (type, length, scope) of these Prep problems have been purposely created to closely parallel those of a typical exam (indeed, these problems have been taken from past exams). *To get an idea of how best to approach various problem types (there are three basic types), refer to these sample problems.*
1. a. Evaluate each statement (T/F/N). *As always, you must fully explain your reasoning and answers.*
   (i) An electrically charged object can exert a net electrical force on an electrically neutral object.

   (ii) An electrically neutral object can exert an electrical force on another electrically neutral object.

   (iii) An electrically neutral insulator can be polarized.

   (iv) If you place a charged object near to (but not touching) an unknown object, and there is a repelling force exerted by each on the other, the unknown object could be electrically neutral.

   (v) A proton exerts a positively directed force on another proton.

   (vi) A proton exerts a positively directed force on an electron.

b. X and Y are two uncharged metal spheres sitting at rest on adjacent insulating stands. The spheres are initially in contact with each other. A positively charged rod, R, is then brought close to X (without touching it). Sphere Y is then moved away from X. Then R is moved far away from both X and Y. What are the final net charges (positive, negative or neutral) of X and Y?

   *As always, explain your answers — use drawings as needed to help you reason and explain.*
2.  
a. *Explain briefly but fully:* How does an object usually acquire a net positive charge?

b. If a metal object becomes positively charged, does the mass of the object increase, decrease, or stay the same? *Explain briefly but fully.*

c. *Explain briefly but fully:* If a conductive object carries a net charge, how is the excess charge distributed on the object—and *why is this so?* Use one or more sketches if necessary.

d. *Explain briefly but fully:* How can an electrically neutral object be attracted to a charged object? Use one or more sketches if necessary.

e. *Explain briefly but fully:* How can an initially neutral object acquire a positive charge without touching any charged object? Use one or more sketches if necessary.

f. How many electrons would you need in order to have 1.50 nC of negative charge? *As always, show all work, reasoning, and calculations.*
3. a. Evaluate the following statement (T/F/N), and as always, fully explain your reasoning:
   If you reduce by half the distance between two point charges, you double the magnitude of electrical force
   that each exerts on the other.

   b. Two point charges were previously 18.0 cm apart. Then they were moved so that the force on each has
   become three times what it was before. How far apart are the charges now?

   c. A point charge \( q_1 = +2e \) is located at \((0, 0)\). Another point charge \( q_2 = -3e \) is located at \((-2,0)\). A third
   point charge \( q_3 = -6e \) is located at \((3,0)\). Find the direction of the total electrical force exerted on \( q_1 \).

   d. Let \( q > 0 \) and \( d > 0 \).
   A particle with charge \(+q\) is stationary and
   located at the point \((0, d)\).
   A particle with charge \(-q\) is stationary and
   located at the point \((0, -d)\).
   In which direction would an electron accelerate
   if it were located at \((L, 0)\), where \(L > 0\)?

   e. Evaluate (T/F/N) the following statement. Justify your answer fully with any valid mix of words, drawings and
   calculations. Three protons are located in the \(x\)-\(y\) plane: \( q_A \) is at \((0, 0)\); \( q_B \) is at \((1, 0)\); \( q_c \) is at \((0, d)\). If the
   net force on \( q_A \) is in the \(\angle 150^\circ\) direction (angle measured conventionally), then \(d \approx -1.32\).

   f. A point charge, \( q_1 \), is located at the origin, \((0, 0)\). It exerts a force of known magnitude \( F_{12} \) on an electron,
   \( q_2 \), located at the point \((4,0)\). Write an expression for the magnitude \( F_{13} \) of the force that \( q_1 \) exerts on
   another charge, \( q_3 = +2e \), located at \((0, 2)\).

   g. A point charge is located at the origin. It exerts a force of known magnitude \( F_{12} \) on an electron \( (q_s) \) located
   at the point \((4,0)\). Write an expression for the magnitude \( F_{13} \) of the force it exerts on a charge \( q_3 = -3e \),
   located at \((0,1)\).
4. a. Four identical particles of charge +\(Q\) are equally spaced along a horizontal line. The distance between adjacent charges is \(d\). What is the magnitude of the electric force on the charge on the far left end?

b. Three point charges, \(q_1\), \(q_2\) and \(q_3\), are located along the x-axis, with the same distance \(d\) between \(q_1\) and \(q_2\) as between \(q_2\) and \(q_3\). \(q_2 = -3.40\) nC. Find the value of \(q_1\) that will put \(q_3\) into static equilibrium.

c. Three charged particles are positioned along a line. Particle B is positioned a distance \(d\) to the right of particle A. Particle C is positioned an equal distance \(d\) to the right of particle B. Particles A and C are electrons. Particle B is a proton. If the magnitude of the net electrical force on particle C is \(5.00 \times 10^{-25}\) N, calculate \(d\).

d. Point charges are fixed at the corners of an equilateral triangle, as shown. \(q_B\) is located at \(x = 2.50\) cm. The value of \(q_c\) is known: \(q_c = +1.80\) \(\mu\)C, and the net electrical force on \(q_c\) is in the negative y-direction and has a magnitude of 450 N. Find the magnitudes and signs of \(q_A\) and \(q_B\).
e. The current standard model of particle physics states that a proton is comprised of two “up” quarks, each of charge \((2/3)e\), and one “down” quark, of charge \(-(1/3)e\). Assume that all three quarks are equidistant from each other at the distance of \(1.50 \times 10^{-15}\) m.

(i) What is the total force magnitude exerted on one of the “up” quarks by the other two quarks?

(ii) What is the total force magnitude exerted on the “down” quark by the other two quarks?
5. a. Evaluate each statement (T/F/N). *As always, you must fully explain your reasoning and answers.*

   (i) Assuming no other charges (or fields) in the area, the electric field midway between a proton and electron is zero.

   (ii) The magnitude of the electric field caused by a point charge is the same at any point on a circle whose center is occupied by that charge.

   (iii) The electric field is uniform in the region surrounding a single point charge.

b. An electron is located at the origin. Another electron is located at (3,0). Find the E-field direction at (1,0), using the positive x-axis as 0°.

c. An electron is located at the origin. A proton is located at (2,0). Find the E-field direction at (−1,0).

d. An electron is located at the origin. A proton is located at (2,0). Find the electric field direction at (1,1).

e. What’s the direction of the electric field caused at the point (−2,3) by an electron located at the origin?
6. a. The net electric field produced by two charges is shown to the right. Fully explain your reasoning and answer for each of the following:
   
   (i) What can you conclude about each of the two charges, \( P \) and \( Q \)?
   \( (P \) is the charge on the left; \( Q \) is on the right, and each charge’s field lines emerge from it. Sorry for the poor resolution here.)
   
   (ii) Where in the diagram is the electric field magnitude strongest—and where it is weakest?
   
   (iii) How does the force of \( P \) on \( Q \) compare to the force of \( Q \) on \( P \)?

b. In the drawing, \( q_1 \) is located at point A, and \( q_2 \) is located at point B. Let \( E_{1B} \) mean “the electric field caused at point B by charge 1;” and let \( E_{2A} \) means “the electric field caused at point A by charge 2.”
   
   Evaluate each statement (T/F/N). As always, you must fully explain your reasoning and answers.
   
   (i) If both \( q_1 \) and \( q_2 \) are negative, the direction of \( E_{2A} \) is the same as the direction of \( F_{12} \).

   (ii) Regardless of their signs (±), if \( q_1 \) and \( q_2 \) are of equal magnitude, then \( E_{2A} = -E_{1B} \), always.


   c. Write an expression for the E-field magnitude midway between an electron and proton that are a distance \( d \) apart.
6. d. Two electrons are located along the y-axis at points (0, s) and (0, −s). 
You may consider the following as known values (so they may be included in your answers): k, ε0, e, s

(i) Write an expression for the electric force magnitude exerted on one electron by the other.

(ii) Write an expression for the net electric field (magnitude and direction) at the point (r, 0) on the positive x-axis. (You may consider r as a known value, too, so your answer may include r, k, ε0, e, s.) Be sure to use diagrams if they help!

(iii) Referring to the field expression from part b, how you would calculate the value of r where (along the x-axis) that field strength is a maximum? You do not have to actually do the calculation; just fully explain your reasoning and the procedure.