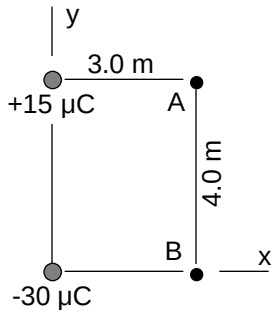
Name _____

Please work the problems on separate sheets of paper and staple this sheet to the front. Read each problem carefully. Show your work and/or give explanations for *all* answers. Make sure that your answers are given with a reasonable number of sig figs and that you have included appropriate units. Check your answers for physical *reasonableness* whenever possible. I do give partial credit, but *only* if I can follow your work, so be as clear as possible about what you are doing.

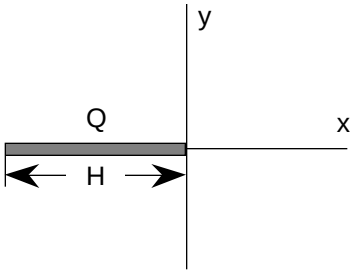
1. [35 pts] *Two* charges are placed as shown in the figure at right.



   a) [10] Find the *electric field vector*—magnitude and direction—*at* A.
   b) [5] Find the *potential difference* $V_B - V_A$ between points B and A.
   c) [5] *Now* I put a –5.0 μC charge at point A. What *force* —magnitude and direction—would be exerted on this charge?
   d) [5] How much *work* would it take to move the –5.0 μC charge from point A to point B?
   e) [5] What is the total electric *potential energy* of the three charges when the –5.0 μC charge is at point B?
   f) [5] How much *work* would it take to separate the three charges "to infinity"?

2. [35 pts] A spherical shell of inner radius a and outer radius b carries a total charge Q (>0) distributed uniformly throughout its volume.
   a) [5] Find the volume *charge density* in terms of the knowns—Q, a, and b.
   b) [5] Find the *electric field magnitude* E(r) for points lying a distance r < a from the center of the spherical shell.
   c) [5] Find E(r) for r > b.
   d) [5] Find E(r) for a < r < b.
   e) [5] Which is higher, the electric potential of a point on the *outer* surface of the spherical shell or that of a point on the *inner* surface? Explain!
   f) [5] How would your answers to parts b–d change if a point charge –Q were placed at the center of the spherical shell? Be specific about the change to each answer.
   g) [5] How would your answers to parts b–d change if the spherical shell had been made of a conducting material? (... with the necessary resulting redistribution of the charge Q.) Be specific about the change to each answer.

3. [30 pts] A uniformly charged rod with total charge Q (>0) and length H lies along the x-axis as shown at right.



   a) [5] Sketch the electric field lines (solid) and the equipotentials (dashed) in the vicinity of the rod out to a distance of several H away from it.
   b) [10] Find the electric *potential* V(x) at points on the x-axis for x > 0. (Leave your answer in terms of the knowns—Q and H—and the x-coordinate.)
   c) [5] What is the limit as x goes to infinity of V(x)?
   d) [5] Find the *magnitude of the electric field* E(x) on the x-axis for x > 0. (You may use the result of part b appropriately OR calculate the field from scratch.)
   e) [5] What point *charge*, placed at x = 2H would make the electric field at x = H vanish? (Express your answer in terms of Q.)