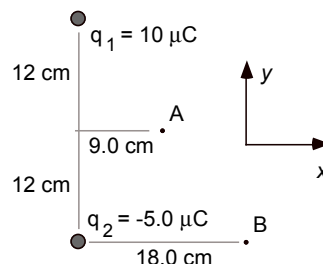


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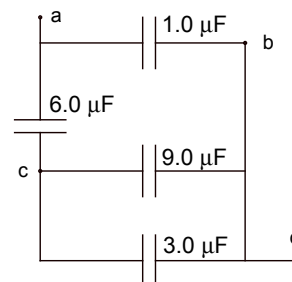
PLEASE READ THIS FIRST: Work the problems on separate sheets of paper and staple *this* sheet to the front. Read each problem *carefully*. The credit you receive on each problem will depend at *least* as much on how you get your answer as on what answer you get. There is *no* need to be as “wordy” as I ask you to be on homework, but you must show your work or give at least a brief explanation for *every* answer. I give *no* credit for unsupported answers. I give partial credit for partially correct solutions, but *only* when I can figure out what you are doing, so am as clear as possible. Make *certain* that all numerical answers are given with a reasonable number of significant digits (when in doubt, three is almost *always* a good compromise!) and that you have included *appropriate* and *simplified* units. Check your answers for physical *reasonableness* whenever possible; I do deduct points for obviously ridiculous answers that go uncommented upon.

1. [30 pts total] Two small objects with charges as shown are located as shown.
 - a) [7] Find the electric potential at position A.
 - b) [8] Find the amount of work that would be required to move a small object carrying a charge of $-2.0 \mu\text{C}$ from position A to position B.
 - c) [15] Find the *direction* of the electric field at position A. (Express your answer by referring to the indicated coordinate directions.)



EXTRA CREDIT [5 pts] With only the *original* two objects in the vicinity, what charge, when placed at position A, would cause the total potential energy of the three charge system to be zero?

2. [25 pts total] In the capacitor network shown at right, $V_a - V_d = 30 \text{ V}$.
 - a) [10] Find the equivalent capacitance between points a and d.
 - b) [5] Find the charge on the $6.0\text{-}\mu\text{F}$ capacitor.
 - c) [5] Find the potential difference $V_c - V_b$.
 - d) [5] Find the energy stored by the $9.0\text{-}\mu\text{F}$ capacitor.

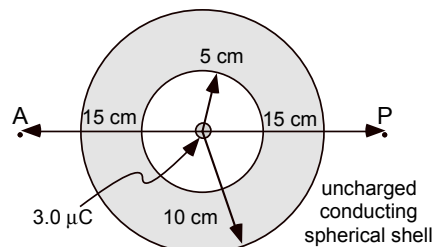


EXTRA CREDIT [5 pts] What is the equivalent capacitance between points a and c?

3. [15 pts total]
 - a) [10] Find the electric field (a vector!) at the position P due to the thin, uniformly charged rod. [Hints: I suggest that you use the distance from position P as your variable of integration. Your answer should, of course, be expressed in terms of "the givens."]
 - b) [5] Suppose that all of the charge on the rod is gathered and placed at the midpoint of the rod. How would the electric field at position P change? That is, does it get larger, smaller, or remain the same? [Hint: The easiest thing to do here is simply to calculate the new electric field and compare it with your answer to part a.]



4. [15 pts total] As shown at right, a small object carrying a charge of $+3.0 \mu\text{C}$ is located at the center of an uncharged conducting spherical shell with inner and outer radii 5.0 cm and 10 cm . There is nothing at positions A and P, both of which lie 15 cm from the center of the spherical shell.



- a) [8] Find the amount of charge on the inner and outer surfaces of the spherical shell.
 - b) [7] Find the magnitude of the electric field at position P.

EXTRA CREDIT [5 pts] Suppose a charge of $-12 \mu\text{C}$ is now placed at position A. Tell me what happens to the electric field at position P. (Be as precise as you can in explaining what happens.)

5. [15 pts] Three small identical objects each with mass $m = 1.0 \text{ g}$ and charge $q = 1.0 \mu\text{C}$ are placed in a line as shown at right. The objects are then released simultaneously from rest. How *fast* does the leftmost object eventually move?

