Last Name: First Name:

Physics 102 Spring 2005: Exam 1—Free Response and Instructions

- Print your LAST and FIRST name on the front of your blue book, on this question sheet, the multiple-choice question sheet and the multiple-choice answer sheet.
- TIME ALLOWED 90 MINUTES
- The test consists of two free-response questions and ten multiple-choice questions.
- The test is graded on a scale of 100 points; each free-response question accounts for 35 points, and the multiple-choice questions account for 30 points.
- Answer the two free-response questions in your blue book. Answer the multiple-choice questions by marking a dark X in the appropriate column and row in the table on the multiple-choice answer sheet.
- Consult no books or notes of any kind. You may use a hand-held calculator in non-graphing, non-programmed mode.
- Do NOT take test materials outside of the class at any time. Return this question sheet along with your blue book and multiple-choice question sheet.
- Write and sign the Pledge on the front of your blue book.

Show your work for the free-response problems, including neat and clearly labelled figures, in your blue book. Answers without explanation (even correct answers) will not be given credit.

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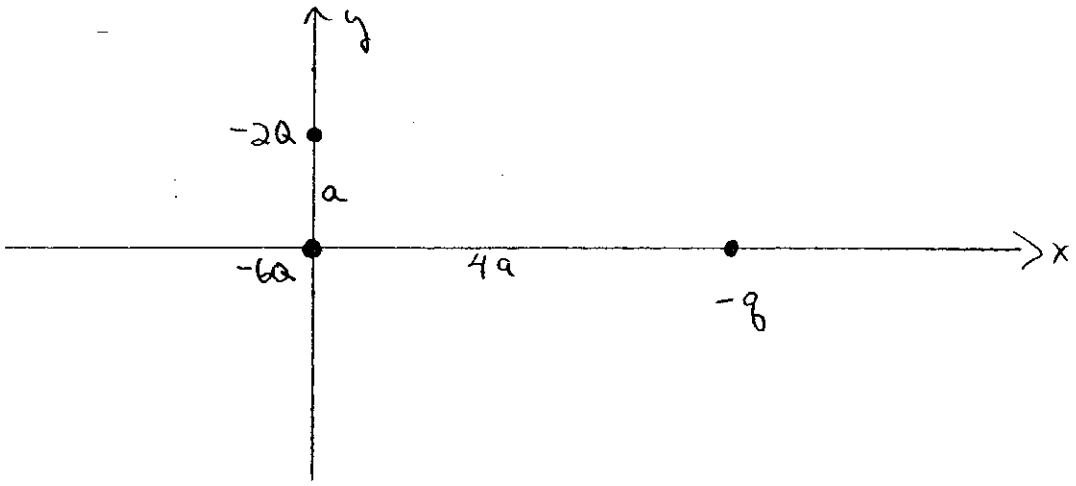
I. As shown in the figure below, three point charges are arranged as follows: a negative charge $-6Q$ is located at the origin; a second negative charge $-2Q$ is located on the y-axis, a distance a from the origin; a third negative charge $-q$ is located on the x-axis, a distance $4a$ from the origin. The electrostatic potential energy is zero when the charges are infinitely far from each other. The electrostatic potential is zero at infinity.

5 (a) Determine the total electrostatic potential energy of this charge system.

10 (b) The charge $-q$ is released and moves off to infinity. What is its kinetic energy when it is infinitely far from the origin? The other two charges remain fixed.

(c) Determine an expression for the electrostatic potential $V(x, y)$ at an arbitrary point $P(x, y)$ in the x-y plane due to the two remaining charges.

(d) Determine an expression for the the x-component of the electric field E_x due to the two remaining charges, as a function of x for an arbitrary point on the x-axis.



35 II. An insulating sphere of radius R is centered at the origin. It carries a positive uniform volume charge density ρ. In addition, a very long, thin insulating rod runs parallel to the y-axis at $x = 4R$. The rod carries a negative uniform linear charge density $-\lambda$. Express your answers in terms of ρ, R, λ, and possibly other constants.

7 (a) Determine the electric field $\vec{E}$ at the point $x = 2R, y = 0$.

7 (b) Determine the electric field $\vec{E}$ at the point $x = 0, y = 3R$.

8 (c) Determine the contribution to the x-component of the electric field, E_x, due to the rod only, as a function of position x on the x-axis. Sketch this contribution to E_x.

8 (d) Determine the contribution to the x-component of the electric field, E_x, due to the sphere only, as a function of position x on the x-axis. Sketch this contribution to E_x.

5 (e) Determine the electric flux Φ_E through a cube of side $\frac{1}{3}R$ centered at $x = 0, y = 2R$.