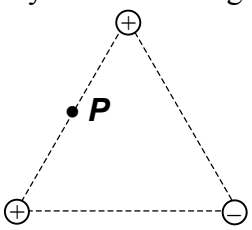
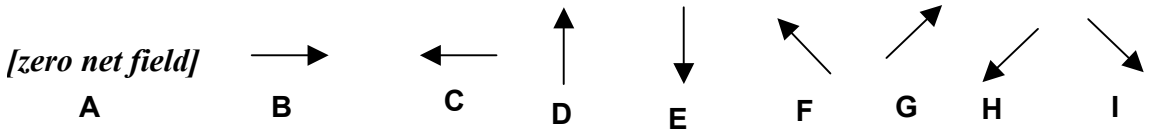
Physics 112
Exam #1
September 15, 2000
Name: _____

YOU MUST RECORD <u>ALL</u> ANSWERS ON THE ANSWER SHEETS!! NOTHING WRITTEN ON THE QUESTION SHEETS WILL BE GRADED!!

#1-6 are NO PARTIAL CREDIT; 4 points each. #7-12 have multiple parts, or require diagrams or explanations. Record everything on the answer sheet. Points indicated for each question.
Total: 50 points

1. Two positive charges and a negative charge, all of equal magnitude, are arranged on the corners of an equilateral triangle as shown in the diagram. Which choice most closely represents the ***net*** electric field at point *P* that is produced by the three charges?





2. A small charged object (a "source" charge) is located in the center of a room. When a test charge is located 63 meters from the charged object, it experiences a force of magnitude 4 N. If that same test charge is moved to a distance 20 ***centimeters*** from the charged object, which of these values will be ***closest*** to the magnitude of the force on it now?

   A. 0.004 N
   B. 0.04 N
   C. 0.4 N
   D. 4 N
   E. 40 N
   F. 400 N
   G. 4000 N
   H. 40,000 N
   I. 400,000 N

3. A –2-C charge is located at (–1 m, 0 m) and two +2-C charges are located at (+2 m, 0 m). A proton is located at the origin.

What is the magnitude of the net electric ***field*** experienced by the proton at the origin, produced by the three charges described above?

A. 9.0×10^{9} N/C
B. 1.8×10^{10} N/C
C. 2.7×10^{10} N/C
D. 3.6×10^{10} N/C
E. 5.4×10^{10} N/C
F. 1.44×10^{-9} N/C
G. 2.88×10^{-9} N/C
H. 4.32×10^{-9} N/C
I. 5.76×10^{-9} N/C
J. 8.64×10^{-9} N/C

4. Source charge Q is fixed in position, and charge q is 5 m away from Q. The initial potential energy of q is 40 J. How much energy is required for you to push the charge q to a final distance of 4 m from Q, starting from the original location? (The charge q starts at rest, and ends up at rest.)

A. 10 J
B. 20 J
C. 30 J
D. 40 J
E. 50 J
F. 60 J
G. 90 J
H. 120 J
I. 180 J

5. A proton is fixed at the origin; there are no other "source" charges present. Which of these is ***true*** about the electric field at a point "*P*" 3 m from the origin?

A. If there is no particle located at point *P* — if it is just vacuum, i.e., "empty space" — then there is no electric field there.
B. A test charge q and a test charge $3q$ placed at point *P* will detect ***different*** magnitudes of the electric field at that point.
C. A test charge q and a test charge $3q$ placed at point *P* will experience ***different*** magnitudes of electrical force at that point.
D. The electric field at point *P* is a measure of how much area is in the neighborhood of the proton.
E. The electric field at point *P* will have the same magnitude as the electric field at a point 1 m from the origin.

6. The electron and the proton in a hydrogen atom are separated by a distance of around 5×10^{-11} m. What is the magnitude of the electrical force that they exert on each other? *[No partial credit. Your answer must be within 10% of the correct answer to receive credit. Units missing or incorrect: –1 point.]*

7. *[4 points]* A test charge, initially at rest, is released and allowed to move freely in a region in which a uniform electric field is present. During the period that the charge is moving in this region,

   A. which quantities will always ***increase?*** List ***all*** that apply.

   B. which quantities will always ***decrease?*** List ***all*** that apply.

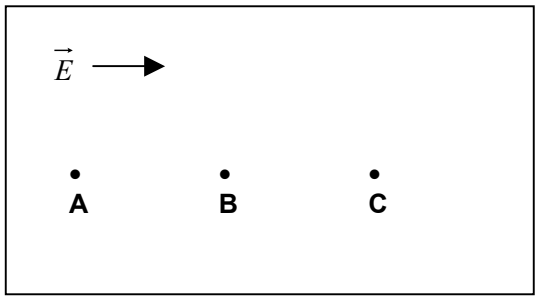
   C. which quantities will remain ***constant?*** List ***all*** that apply.

   Select from the following list to answer A, B, and C above:

   1. *magnitude of force on the charge*
   2. *speed of the charge*
   3. *magnitude of acceleration of the charge*
   4. *work done on the charge by the electrical force*
   5. *kinetic energy of the charge*
   6. *potential energy of the charge*
   7. *total energy of the charge*

8. *[4 points]* The region below contains a uniform electric field as shown. A charge q is placed at rest at point A, and then allowed to move freely; it passes through B, and then through C. Later, a charge $4q$ is placed at A, and it follows the same path. Both q and $4q$ have the same mass.

   On the answer sheet are shown the velocity vector and the acceleration vector of charge q when it is located at point B. Draw (a) the acceleration vector of charge $4q$ at point B; (b) the acceleration vector of charge $4q$ at point C; (c) the velocity vector of charge $4q$ at point B.



9. *[4 points]* Suppose you are sent into an empty room in which an electric field is present and told to determine its magnitude and direction at the center of the room. You are supplied with a +3 C test charge and a spring scale to attach to the charge, to determine the force acting on the charge.

   When you put your test charge at the center of the room, you find that it experiences an 18-N force in the "down" direction.

   Based on this observation, what is:

   A. the direction (up or down) of the electric field you measure with your charge;
   B. the magnitude of the electric field you measure with your charge;
   C. the direction of the force you would observe on a –12 C test charge, if you had used it instead.
   D. the magnitude of the force you would observe on a –12 C test charge, if you had used it instead.
   E. the direction of the electric field you would observe with a –12 C test charge, if you had used it instead.
   F. the magnitude of the electric field you would observe with a –12 C test charge, if you had used it instead.

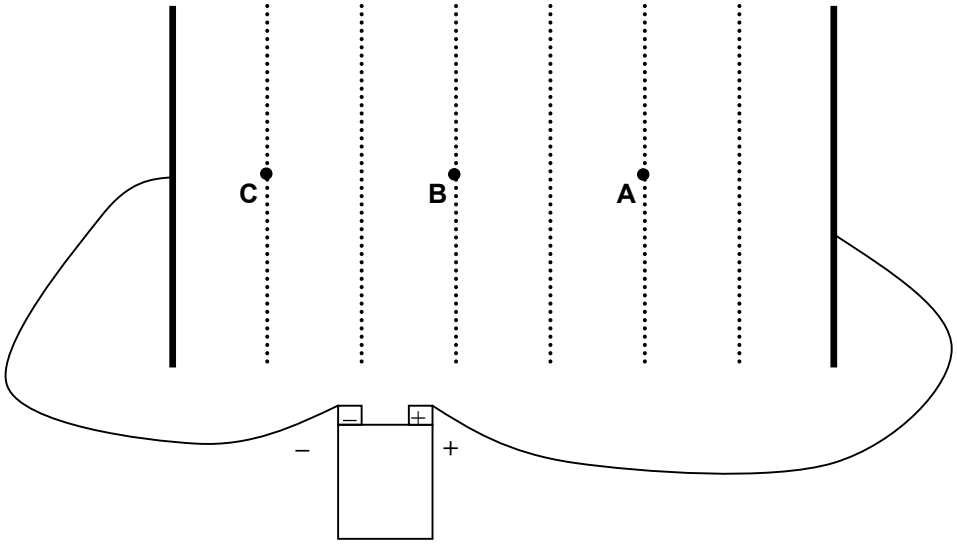
10. *[4 points]* A charge $-q$ and a charge $+4q$ are located as shown on the answer sheet.

    A. Where will the net electric field be zero? Choose from this list (List all that apply):
       1. to the left of $-q$
       2. between $-q$ and $+4q$
       3. to the right of $+4q$

    B. Explain your answer to A.

    C. Mark a dot or an "X" at the exact location (or locations) where the net field is zero.

11. *[4 points]* Two large parallel conducting plates are connected to a battery as shown. The parallel dashed lines shown are all equally spaced (i.e., distances between adjacent lines are the same). Suppose a positively charged particle is shot from a gun that is located on the left-side plate, but is pointed toward the right side.



After leaving the gun, the particle heads toward the right side, passing first through position C, then position B, and then position A. On the Answer Sheet, complete the bar graph to show the kinetic energy (KE) of the particle at A, B, and C, and the electric potential energy (PE) of the particle at A, B, and C. The kinetic energy at C (KE_C) and at A (KE_A), and the electric potential energy at C (PE_C) are already shown; you need to draw three additional bars.

12. *(six points)* Two positive source charges of equal magnitude are shown. Draw arrows on the figure to represent the ***net*** electric field at points A, B, and C. (There are no charges at these points, just empty space.) Make sure the arrows correctly represent the relative magnitudes of the three electric field vectors (not ***exactly,*** but enough to see which is larger than which). If the electric field at a point is zero, write "***zero***" at that point. ***IMPORTANT: ONLY*** DRAW ARROWS REPRESENTING THE ***NET*** ELECTRIC FIELD AT THOSE POINTS!!

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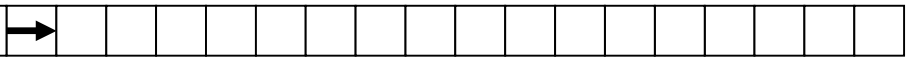
1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

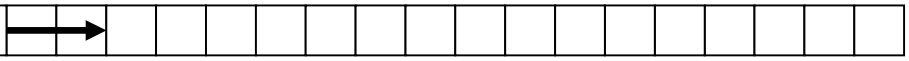
7. A. _____ B. _____ C. _____

8.

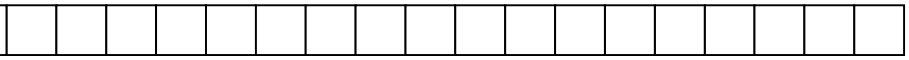
velocity of q at B



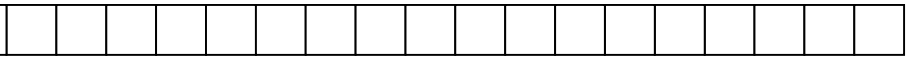
acceleration of q at B



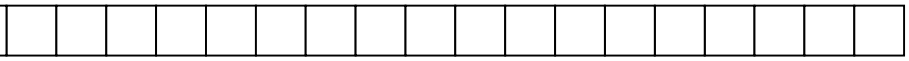
a) acceleration of 4*q* at *B*



b) acceleration of 4*q* at *C*



c) velocity of 4*q* at *B*



9.

A. _____
B. _____
C. _____
D. _____
E. _____
F. _____

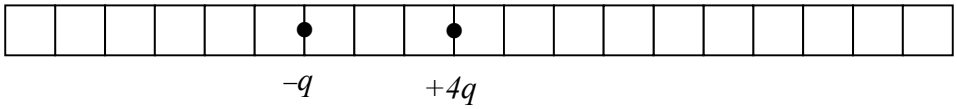
10.

A. _____

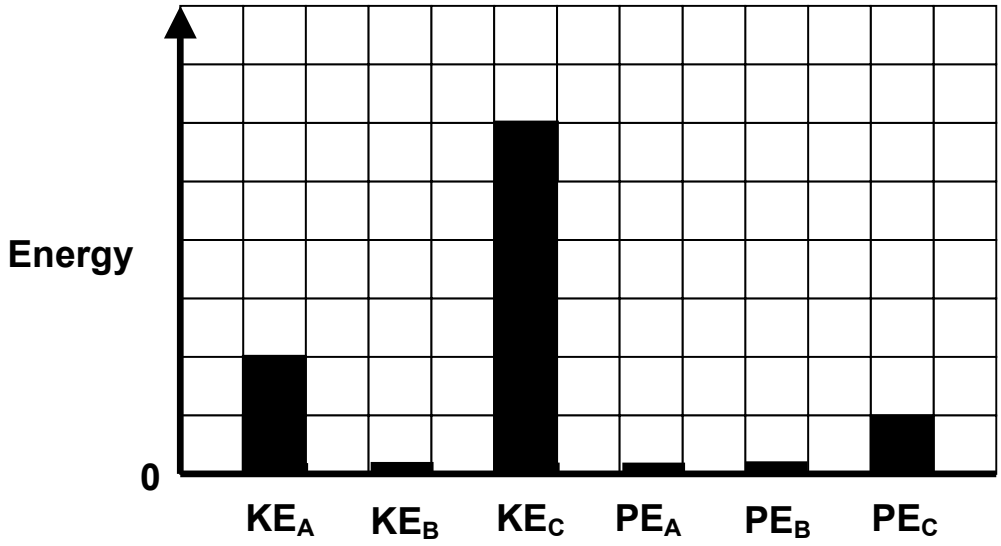
B.

_____
_____
_____
_____
_____

C.



11.



12.