AP PHYSICS 2: ELECTROSTATICS

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and place the letter of your choice in the corresponding box on the student answer sheet.

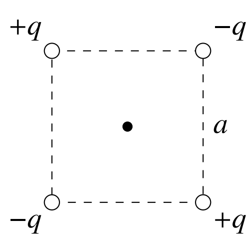
1. Two electric objects experience a repulsive force. What happens to that force if the distance between the objects is doubled?

(A) It decreases to one-fourth its value.
(B) It decreases to one-half its value.
(C) It stays the same.
(D) It doubles.
(E) It quadruples.

2. An electron and a proton are separated by 1.50×10^{-10} m. If they are released, which one will accelerate at a greater rate, and what is the magnitude of that acceleration?

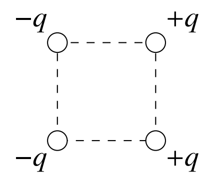
(A) The electron; 1.12×10^{22} m/s^2
(B) The proton; 1.12×10^{22} m/s^2
(C) The electron; 6.13×10^{18} m/s^2
(D) The proton; 6.13×10^{18} m/s^2
(E) They both accelerate at the same rate; 1.02×10^{-8} m/s^2

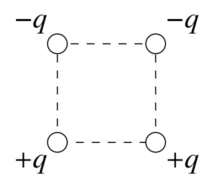
3. Four charges are arranged at the corners of a square of side a as shown. Which of the following is true of the electric field and the electric potential at the center of the square?



	Electric Field	Electric Potential
(A)	zero	zero
(B)	$\frac{kQ}{a\sqrt{2}}$	zero
(C)	$\frac{kQ^2}{2a^2}$	$\frac{kQ}{2a}$
(D)	zero	$\frac{kQ}{\sqrt{2}a}$
(E)	$\frac{kQ^2}{2a}$	$\frac{kQ}{a\sqrt{2}}$

4. Which of the following diagrams best represents how you might rearrange the charges so that the electric field at the center would point directly toward the top of the page?

(A)


(B)


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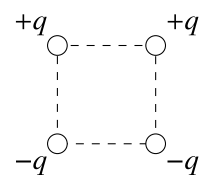

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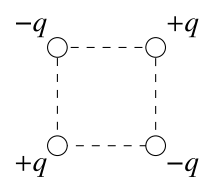
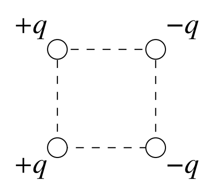
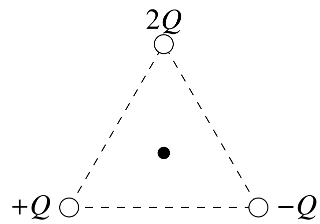


(E)


5. Three charges, $+Q$, $-Q$, and $+2Q$, are arranged in an equilateral triangle as shown. Which of the arrows below best represents the direction of the electric field at the center of the triangle?



(A) $\downarrow$
(B) $\uparrow$
(C) $\searrow$
(D) $\swarrow$
(E) $\nearrow$

6. A non-conducting sphere does not have a uniform charge density, but the density ρ varies with the distance r from the center of the sphere according to the equation $\rho = \beta r$ where β is a positive constant. The electric field inside the sphere ($r < R$) at a distance r from the center of the sphere is

(A) $\dfrac{\beta r^2}{12\epsilon_0}$
(B) $\dfrac{\beta r^3}{3\epsilon_0}$
(C) $\dfrac{\beta r}{2\epsilon_0}$
(D) $\dfrac{\beta r^2}{2\epsilon_0}$
(E) $\dfrac{\beta r^2}{4\epsilon_0}$

7. The electric potential at the surface of the sphere from the last question is

(A) $\dfrac{\beta R^3}{12\epsilon_0}$
(B) $\dfrac{\beta R}{2\epsilon_0}$
(C) $\dfrac{\beta R^3}{3\epsilon_0}$
(D) $\dfrac{\beta R^2}{2\epsilon_0}$
(E) $\dfrac{\beta R^2}{4\epsilon_0}$

8. According to Gauss's law, the net electric flux passing through a closed surface is

(A) positive if the flux is entering the surface
(B) negative if the flux is exiting the surface
(C) positive if the net charge inside the surface is zero
(D) negative if the net charge inside the surface is zero
(E) zero if the net charge inside the surface is zero

9. According to Gauss's law, which of the following statements is true?

(A) It is possible to have a nonzero electric field, but zero electric flux.
(B) It is possible to have a nonzero electric flux, but zero electric field.
(C) It is possible to have a nonzero electric flux through a closed surface even if the enclosed charge in a surface is zero.
(D) If a surface is not closed (such as a sheet of paper), the flux through it must be zero.
(E) It is possible for charges located outside a closed surface to produce a net positive flux through the surface.

10. Electric potential

(A) is a vector quantity that depends on the direction of the electric field
(B) is a scalar quantity that depends on the magnitude and sign of charges in the vicinity
(C) is a scalar quantity that depends on the square of the distance from the charges in the vicinity
(D) is a vector quantity that depends on the sign of the charges in the vicinity
(E) is a vector quantity that must point from high to low potential

11. Gauss's law is most convenient to use when calculating an electric field due to

(A) charges outside a closed surface
(B) charges inside a closed surface that has high symmetry
(C) charges inside a closed surface that has low symmetry
(D) a potential difference that is negative
(E) a potential difference that is positive

Question 12-13

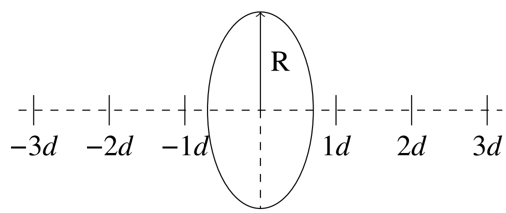
12. A cube has sides of length a. The cube rests so that one side rests on the x-axis as shown. An electric field is established in the x-direction according to the function $E_x = bx^2$, where b is a positive constant. Which of the following statements is true?
    (A) There is a net charge inside the cube.
    (B) There is no net charge inside the cube.
    (C) The flux passing through the cube is negative.
    (D) The flux passing through the cube is zero.
    (E) The flux diminishes while passing through the cube.

13. The charge inside the cube can be expressed by the equation
    (A) $\epsilon_0 ba$
    (B) $\epsilon_0 ba^2$
    (C) $\epsilon_0 ba^3$
    (D) $\epsilon_0 ba^4$
    (E) $\epsilon_0 b^2 2a^2$

14. Which of the following statements is true of electric field and equipotential lines?
    (A) The electric field vector always points in the same direction as the equipotential lines.
    (B) The electric field always points in the opposite direction of the equipotential lines.
    (C) The electric field always points perpendicular to the equipotential lines.
    (D) The electric field is always equal to the equipotential lines.
    (E) Equipotential lines always form a circle around electric field lines.

15. The potential V as a function of distance r for a particular charge distribution is given by the equation $V = ar^{-1}$. The electric field as a function of distance r from the charge distribution is
    (A) $1/3\ ar^{-3}$
    (B) $2ar^{-1}$
    (C) ar^2
    (D) $a(\ln r)$
    (E) ar^{-2}

16. A positively charged ring of radius R is made of conducting material and has a charge Q distributed uniformly around it. The center of the ring is located at point 0 on the x-axis. The potential V at a distance $3d$ from point 0 on the x-axis is



    (A) $V = \dfrac{kQ}{9d^2}$
    (B) $V = \dfrac{kQ}{3d^2}$
    (C) $V = \dfrac{kQ}{R^2 + 9d^2}$
    (D) $V = \sqrt{\dfrac{kQ}{R^2 + 9d^2}}$
    (E) $V = \dfrac{kQ}{\sqrt{R^2 + 9d^2}}$

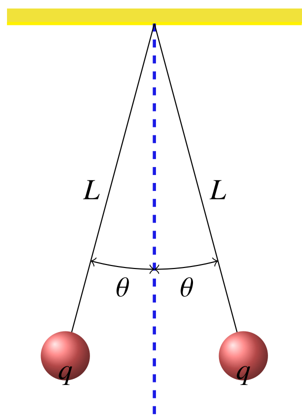
AP PHYSICS 2: ELECTROSTATICS
SECTION II
6 Questions

Directions: Answer all questions. The suggested time is about 10 minutes for answering each of the questions. The parts within a question may not have equal weight. All final numerical answers should include appropriate units. Credit depends on the quality of your solutions and explanations, so you should show your work. Credit also depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should clearly indicate which part of a question your work is for.

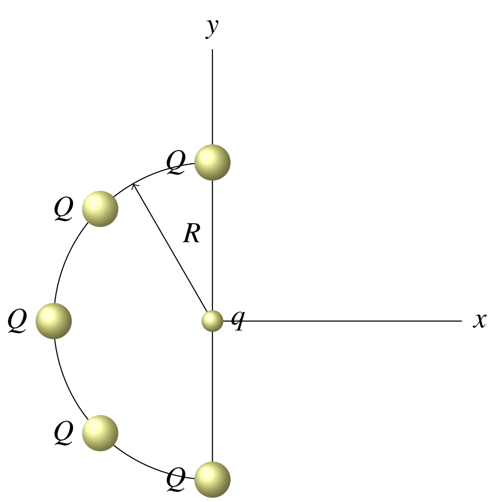
1. Two identical small spheres of mass m are suspended from a common point by threads of length L. When each sphere carries a charge q, each thread makes an angle θ with the vertical as shown in the figure below.

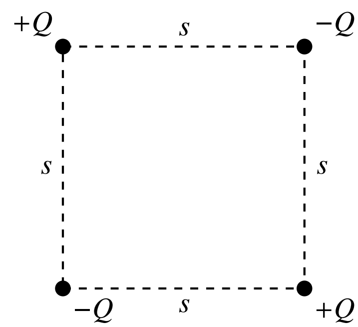
   (a) Express charge q in terms of θ, m, L and any other relevant constants, and

   (b) Compute q if $m = 10\,\text{g}$, $L = 50\,\text{cm}$ and $\theta = 10°$.



2. Five equal charges Q are equally spaced on a semicircle or radius R as shown in the figure below. Find the force on a charge q located at the center of the semi-circle. (Hint: Take advantage of symmetry.)





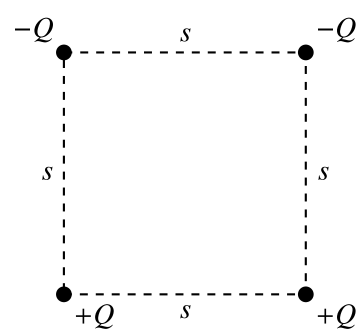
Arrangement 1

3. Four charged particles are held fixed at the corners of a square of side s. All the charges have the same magnitude Q, but two are positive and two are negative. In Arrangement 1, shown above, charges of the same sign are at opposite corners. Express your answers to parts (a) and (b) in terms of the given quantities and fundamental constants.

   (a) For Arrangement 1, determine the following.

      i. The electrostatic potential at the center of the square

      ii. The magnitude of the electric field at the center of the square



Arrangement 2

   The bottom two charged particles are now switched to form Arrangement 2, shown above, in which the positively charged particles are on the left and the negatively charged particles are on the right.

   (b) For Arrangement 2, determine the following.

      i. The electrostatic potential at the center of the square

      ii. The magnitude of the electric field at the center of the square

   (c) In which of the two arrangements would more work be required to remove the particle at the upper right corner from its present position to a distance a long way away from the arrangement?

   ____Arrangement 1 ____Arrangement 2

   Justify your answer.