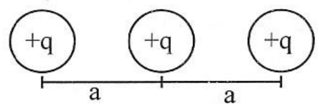
Electricity and Magnetism, Exam 2, 10/03/2017

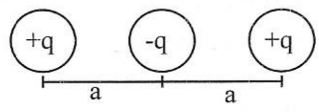
17 questions

This is a multiple-choice exam. Write your name and student number on the answer sheet. Clearly mark the answer of your choice on the answer sheet. Only a single answer is correct for every question. The score will be corrected for guessing. Use of a (graphing) calculator is allowed. You may make use of the formula sheet. The same notation is used as in the book, i.e. a bold-face **A** is a vector, T is a scalar.

1. Consider three charges in a row, separated by an equal distance a. What is the force on the middle charge, if all three charges are positive $+q$?
   A. zero
   B. $\frac{1}{4\pi\epsilon_0}\frac{q^2}{a}$
   C. $\frac{1}{4\pi\epsilon_0}\frac{2q^2}{a}$

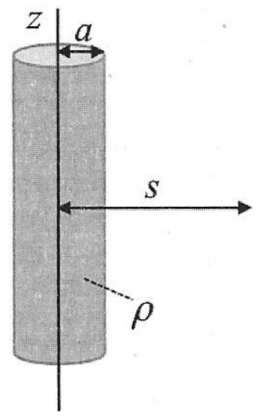


2. Consider three charges in a row, separated by an equal distance a. What is the force on the middle charge, if it is negative $-q$ while the outer ones are positive $+q$?
   A. zero
   B. $\frac{1}{4\pi\epsilon_0}\frac{q^2}{a}$
   C. $\frac{1}{4\pi\epsilon_0}\frac{2q^2}{a}$



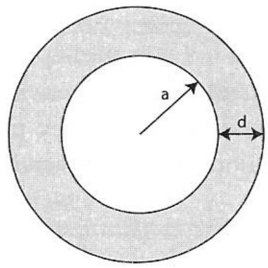
3. Consider the three charges from the previous question. Is the total work needed to place these three charges in this configuration
   A. positive
   B. negative
   C. zero

4. A very long non-conducting cylinder of radius a lies with its symmetry axis along the z-axis. It carries a uniform charge distribution ρ (in C/m^3). Edge effects may be neglected. Find the electric field $\vec{E}$ *outside* the cylinder at a distance s of the symmetry axis.
   A. $\mathbf{E} = \frac{a\rho}{\epsilon_0 s}\hat{\mathbf{s}}$
   B. $\mathbf{E} = \frac{s\rho}{2\epsilon_0}\hat{\mathbf{s}}$
   C. $\mathbf{E} = \frac{a^2\rho}{2\epsilon_0 s}\hat{\mathbf{s}}$



5. Suppose that the cylinder suddenly becomes conducting and all charge is allowed to move freely. How would that effect the electric field *outside* the cylinder?
   A. Nothing would change
   B. It would become zero
   C. It would increase

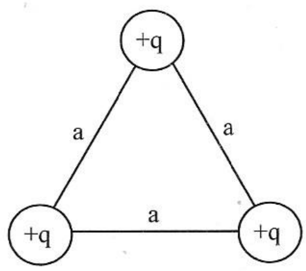
6. Consider a spherical shell of thickness d, with an inner radius a. It has a charge density $\rho(r) = kr$, where k is a constant. What is the electric field *inside* the shell, i.e. for $(a < r < a + d)$?
   A. $\mathbf{E} = \frac{1}{4\pi\epsilon_0}\frac{k}{2}(1 \mp \frac{a^2}{r^2})\hat{\mathbf{r}}$
   B. $\mathbf{E} = \frac{1}{4\pi\epsilon_0}\frac{k}{2}(1 \mp \frac{2a}{r})\hat{\mathbf{r}}$
   C. $\mathbf{E} = \frac{k}{4\epsilon_0}(r^2 \mp \frac{a^4}{r^2})\hat{\mathbf{r}}$



7. Given an empty spherical conducting shell with uniform surface charge density σ (no other charges anywhere else). What can you say about the potential V inside this shell? (Assume as usual, $V_\infty = 0$)
   A. $V = 0$ everywhere inside
   B. V is nonzero and constant everywhere inside
   C. V must vary with position, but is zero at the center

8. Given an empty spherical shell with uniform surface charge density σ (and some other charges somewhere outside). What can you say about the electric field $\mathbf{E}$ inside this shell?
   A. $\mathbf{E} = 0$ everywhere inside
   B. $\mathbf{E}$ is nonzero and constant everywhere inside
   C. $\mathbf{E}$ must vary with position, but is zero at the center

9. Three identical charges $+q$ sit on an equilateral triangle. What would be the final kinetic energy of the top charge if you released it (keeping the other two fixed)?
   A. $\frac{1}{4\pi\epsilon_0}\frac{q^2}{a}$
   B. $\frac{1}{4\pi\epsilon_0}\frac{2q^2}{a}$
   C. $\frac{1}{4\pi\epsilon_0}\frac{3q^2}{a}$



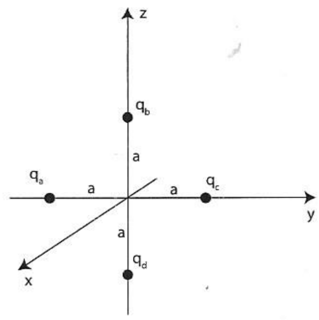
10. Consider the same arrangement of three charges as in the previous question. What would be the final kinetic energy of the top charge if you released all three charges simultaneously?
   A. $\frac{1}{4\pi\epsilon_0}\frac{q^2}{a}$
   B. $\frac{1}{4\pi\epsilon_0}\frac{2q^2}{3a}$
   C. $\frac{1}{4\pi\epsilon_0}\frac{2q^2}{a}$

11. Two charges, $+q$ and $-q$, are a distance r apart. As the charges are slowly moved together, the total field energy $\frac{\epsilon_0}{2}\int E^2 d\tau$
A. increases
B. decreases
C. remains constant

12. A parallel-plate capacitor has +Q on one plate, -Q on the other. The plates are isolated so the charge Q cannot change. As the plates are pulled apart, the total electrostatic energy stored in the capacitor
A. increases
B. decreases
C. remains constant

13. A parallel-plate capacitor has +Q on one plate, -Q on the other. The plates are connected to a battery, and are kept at constant voltage +V and -V. As the plates are pulled apart, the total electrostatic energy stored in the capacitor
A. remains constant
B. increases
C. decreases

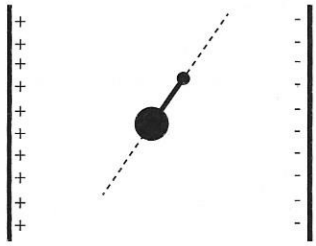
Consider the arrangement of four charges (q_a, q_b, q_c, q_d) as depicted on the right. They are in the y-z plane, all at a distance a from the center of the coordinate system.



14. For $q_a = -2q, q_b = +3q, q_c = -2q, q_d = +1q$, what is the electric field far away $(x \gg a)$ on the x-axis?
A. $\mathbf{E} = \frac{1}{4\pi\epsilon_0}\frac{qa}{x^2}\hat{\mathbf{z}}$
B. $\mathbf{E} \approx -\frac{1}{4\pi\epsilon_0}\frac{qa}{x^2}\hat{\mathbf{z}}$
C. $\mathbf{E} \approx -\frac{1}{4\pi\epsilon_0}\frac{2qa}{x^3}\hat{\mathbf{z}}$

15. Regarding the configuration of the four charges in the previous question, which charge configuration would give rise to an potential that, for $x \gg a$, drops of as $1/x$ on the x-axis?
A. $q_a = 2q, q_b = +1q, q_c = -1q, q_d = 0$
B. $q_a = -2q, q_b = +2q, q_c = -2q, q_d = +2q$
C. $q_a = -2q, q_b = 0, q_c = +2q, q_d = 0$

16. Consider a polar molecule (consisting of two atoms) in between two large metal plates. The internuclear axis is indicated by the dotted line. The polarizability parallel to the internuclear axis ($\alpha_{\|}$) is large compared to the polarizability perpendicular to the internuclear axis ($\alpha_{\perp}$). What will happen to the molecule when the plates are charged as indicated?
A. It will move towards one of the plates
B. It will rotate until it is perpendicular to the electric field
C. It will rotate until it is parallel to the electric field



17. A sphere of radius R carries a uniform polarization.
Which of the following statements is correct?
A. There is no volume bound charge ρ_b, and the surface bound charge σ_b produces a uniform electric field outside the sphere
B. There is no volume bound charge ρ_b, and the surface bound charge σ_b produces a uniform electric field inside the sphere
C. There is no surface bound charge σ_b, and the volume bound charge ρ_b produces the electric field of a dipole outside the sphere