PHYS102 - Gauss's Law.

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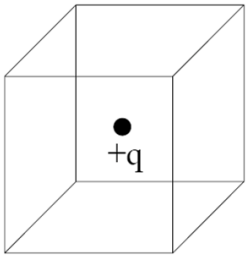
PRS Questions slide 2

0.1 Flux - General

Question #1

Consider the Gaussian surface of a cube which encloses a charge of +q that is located in the exact middle of the cube. What is the electric flux through one side of the cube?



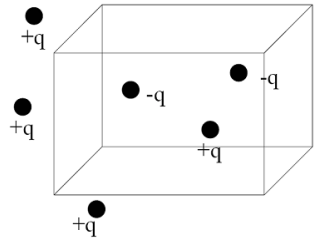
1. 0.
2. q/ε_0
3. $q/6\,\varepsilon_0$
4. There is enough information, but none of the above are correct.
5. There is not enough information.

Answer to Question #1

- The electric flux is given by $\Phi = \frac{Q_{enclosed}}{\varepsilon_0}$.
- Q is the amount of charge contained inside the closed surface (in this case $Q_{enclosed} = +q$).
- Since the charge q is located in the center of the cube, then each face of the cube will have the same number of field lines passing through its surface.
- Each face will contribute the same of amount of electric flux (and there are 6 faces to the cube).
- The answer is 3.

Question #2

What is the total flux through the rectangular prism surface due to the charge configuration below?



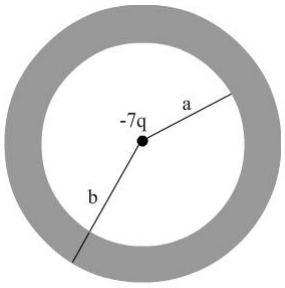
1. 0.
2. $-q/\varepsilon_0$
3. q/ε_0
4. $2q/\varepsilon_0$
5. There is not enough symmetry to answer the question.

Answer to Question #2

- The electric flux is given by $\Phi = \frac{Q_{enclosed}}{\varepsilon_0}$.
- Q is the amount of charge contained inside the closed surface (in this case $Q_{enclosed} = -2q + q$).
- The answer is 2.

Question #3

A net charge of $+Q$ is transferred to a spherical ***conducting*** shell of inner radius a and outer radius b. A charge ($-7q$) is placed in the center of the shell. What is the charge on the inside of the conducting shell?



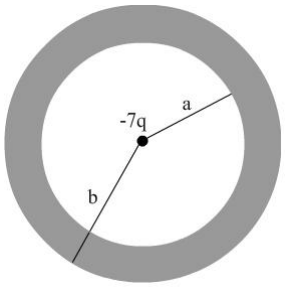
1. $-7q$.
2. $-Q$.
3. $7q$.
4. Q.
5. $Q - 7q$.
6. $Q + 7q$.
7. $7q - Q$.

Answer to Question #3

- The charge located in the center ($-7q$) will attract positive (repel negative) charges within the conductor.
- A total charge of $+7q$ will be attracted to the center charge to try to "neutralize" its presence.
- The answer 3.

Question #4

A net charge of $+Q$ is transferred to a spherical ***conducting*** shell of inner radius a and outer radius b. A charge ($-7q$) is placed in the center of the shell. What is the charge on the outside of the conducting shell?



1. $-7q$.
2. $-Q$.
3. $7q$.
4. Q.
5. $Q - 7q$.
6. $Q + 7q$.
7. $7q - Q$.

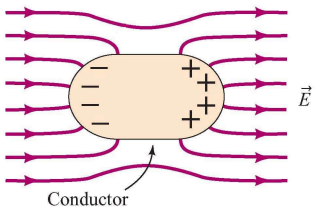
Answer to Question #4

- From the previous question, we know that the inner surface of the conductor has a charge $7q$.
- The net charge on the conductor is Q, but $7q$ is already distributed to the inner surface so the outer surface must have a charge of $Q - 7q$.
- The answer 5.
  NOTE: The sum of charges over the inner surface and the outer surface of the conductor must be equal to the total net charge on the conductor.

0.2 Equilibrium

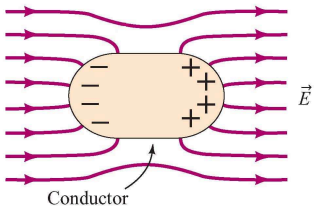
Conductors in Electric Fields

- A conductor allows electrons to flow quasi-freely throughout it whereas an insulator restricts the flow of electrons.
- Placing a metal in an external electric field causes the charges throughout the metal to redistribute themselves as in the figure to the right. (NOTE: The time taken to redistribute is much less than one microsecond.)
  - No net motion of charge implies that the conductor is in electrostatic equilibrium.



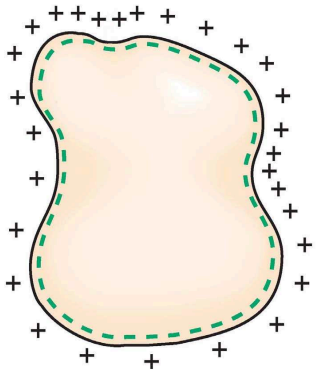
Conductors in Electric Fields II

- The charges within the conductor arrange in such a way as to produce no electric field within the conductor.
  - The electric field generated by the separation of charges adds against the external field yielding no net electric field within the conductor.
- Question: *What happens when a net charge is deposited on a neutral conductor?*



Charging a Conductor

- The excess charge placed on the conductor will experience a repulsive Coulomb force.
  - The charges will experience an acceleration (causing the charges to move).
  - After a very short ($t \approx 10^{-9}$s) time, the charges will push each other as far as possible and stop moving.
    - How far can the charges move?Answer: to the surface of the conductor.



Conductors - Summary

- Any net excess charge on a conductor will reside on its surface.
- The electric field within a conductor is zero.
- The electric field immediately outside a conductor must be perpendicular to the conductor's surface.
  - If there exists an electric field component parallel to the conductor's surface, then the charges on the surface will experience a force.