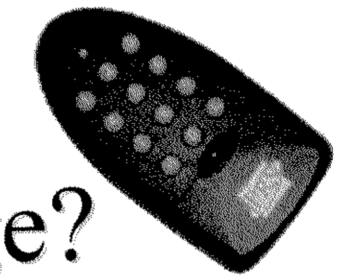
Lecture
3/3/05

STRAWS IN SERIES AND PARALLEL

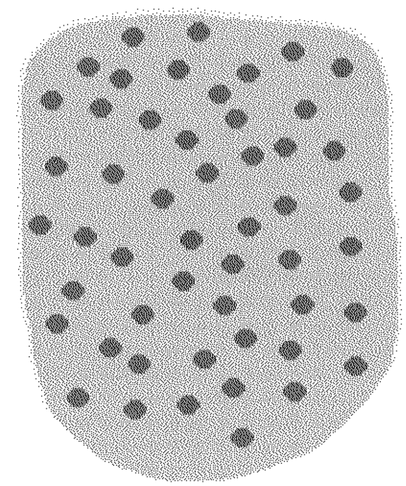
IN YOUR EXPERIMENT WITH 3 STRAWS IN SERIES AND IN PARALLEL, DO YOU EXPECT THE TIME REQUIRED TO EXHALE THROUGH THE SERIES SET TO BE:

1. ABOUT THE SAME
2. 3 TIMES LONGER
3. 6 TIMES LONGER
4. 9 TIMES LONGER

THAN FOR THE PARALLEL SET



Puzzle
What happens to excess charge?



- Suppose that I distribute a bunch of excess charges through the body of a conductor and release them. (The charges can move through the conductor but not off it.)
  - What will happen to the charges?
  - What if the conductor is pointy?

QUESTION 1

1. THE CHARGES WILL POSITION THEMSELVES UNIFORMLY THROUGHOUT THE CONDUCTOR

2. THE CHARGES WILL MOVE TO THE SURFACE OF THE CONDUCTOR

QUESTION 2

SUPPOSE THE CONDUCTOR IS A HOLLOW SHELL (LIKE A TIN CAN)

1. THE CHARGES WILL POSITION THEMSELVES OVER BOTH THE INNER AND OUTER SURFACES

2. THE CHARGES WILL POSITION THEMSELVES ONLY OVER THE OUTER SURFACE

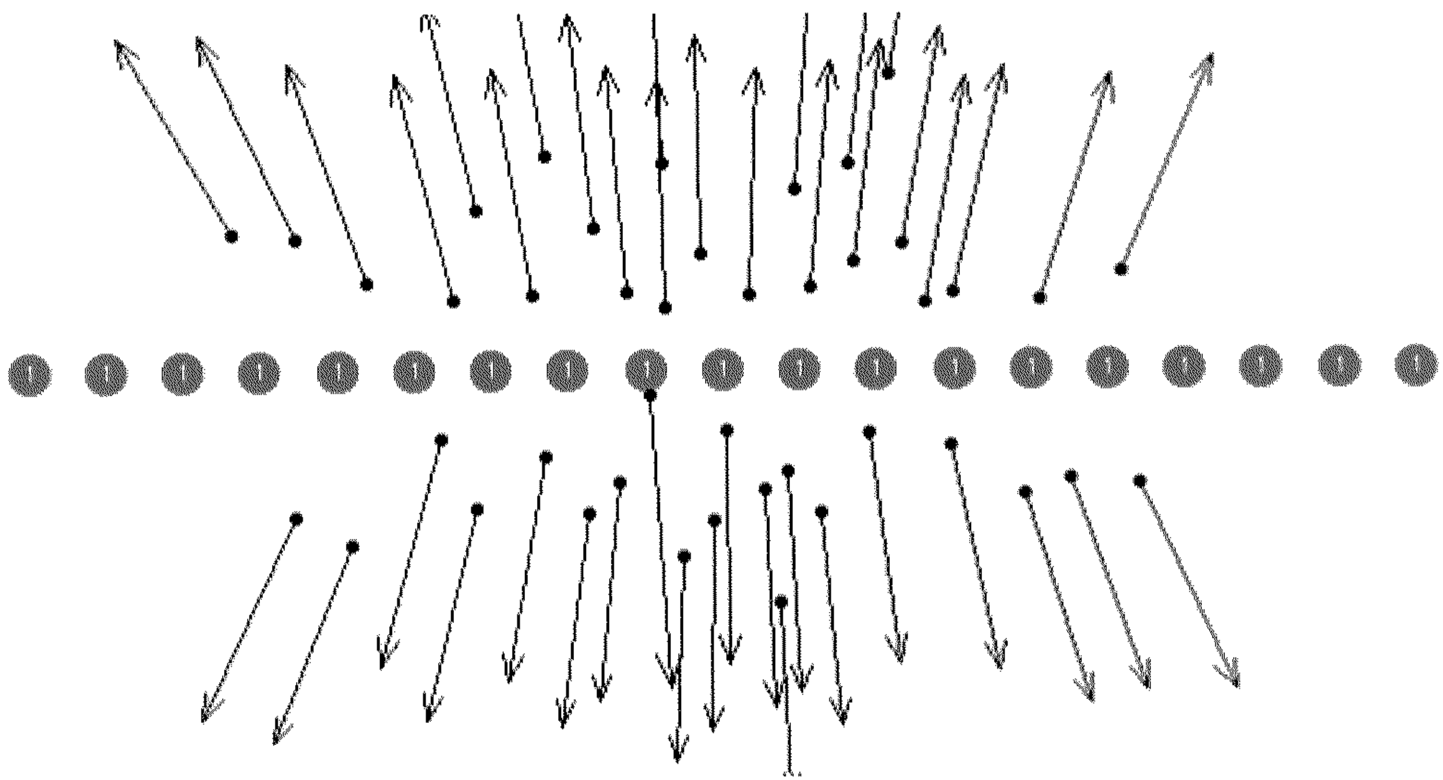
QUESTION 3

1. THE CHARGES WILL POSITION THEMSELVES UNIFORMLY ACROSS THE SURFACE, INCLUDING THE POINT

2. THE CHARGES WILL TEND TO CONCENTRATE AT THE POINT.

WHY?

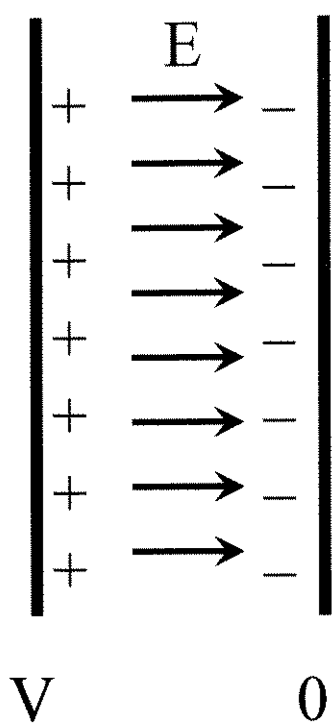
Field near a large uniform plate



$$E = \frac{Q}{2\varepsilon_0 A} = \frac{\sigma}{2\varepsilon_0}$$

Storing electrical energy: The capacitor

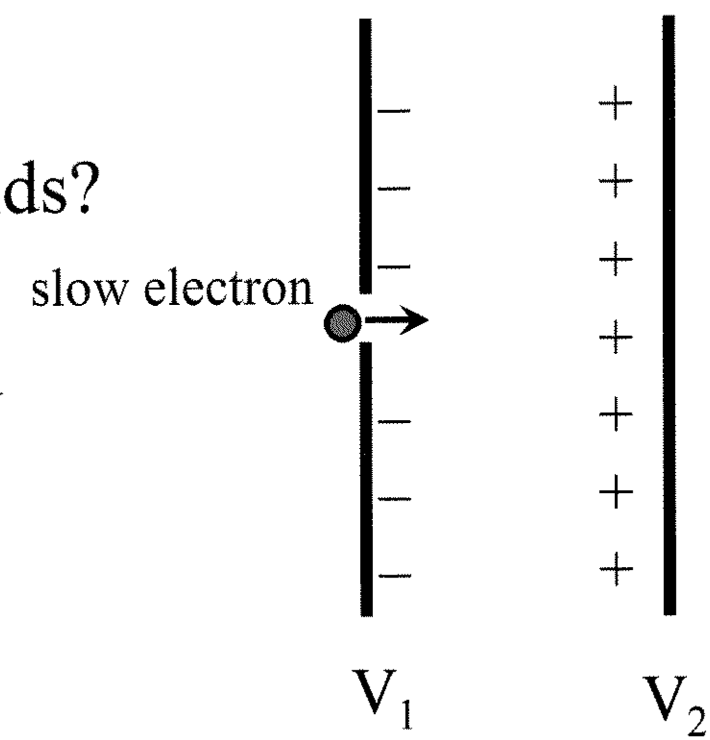
- Two parallel plates of area A separated by a distance d.
- Put $+Q$ on one plate, $-Q$ on the other.



Using the Work-Energy Theorem we can use potentials to find changes in KE or the work needed to carry a charge from one point to another.

- Where are the electric fields?

- How fast will the electron be going when it reaches the second plate?



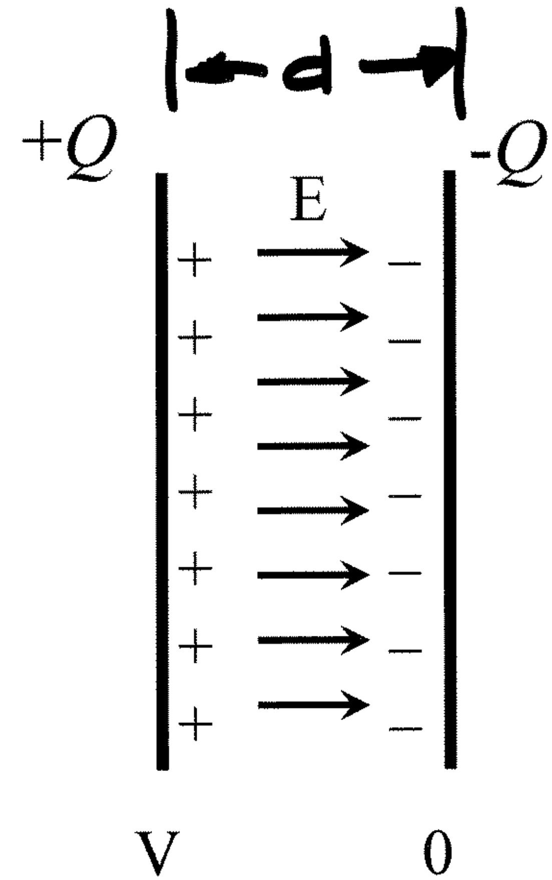
Capacitor Equations

$$E = \frac{\sigma}{\varepsilon_0} = 4\pi k_C \frac{Q}{A}$$

$$W = F\Delta s = qEd = q\Delta V$$

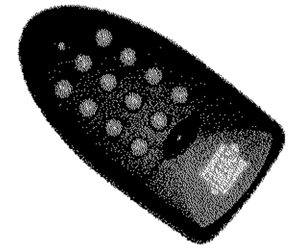
$$\Delta V = Ed$$

$$\Delta V = \frac{\sigma d}{\varepsilon_0} = \left(\frac{d}{A\varepsilon_0}\right)Q$$

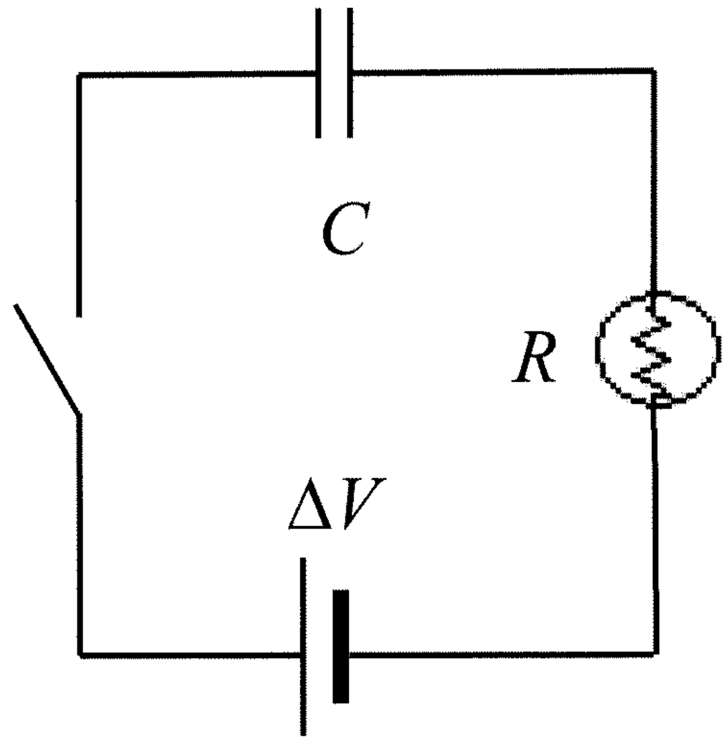


$$Q = C\Delta V$$

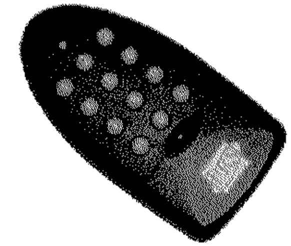
Puzzle



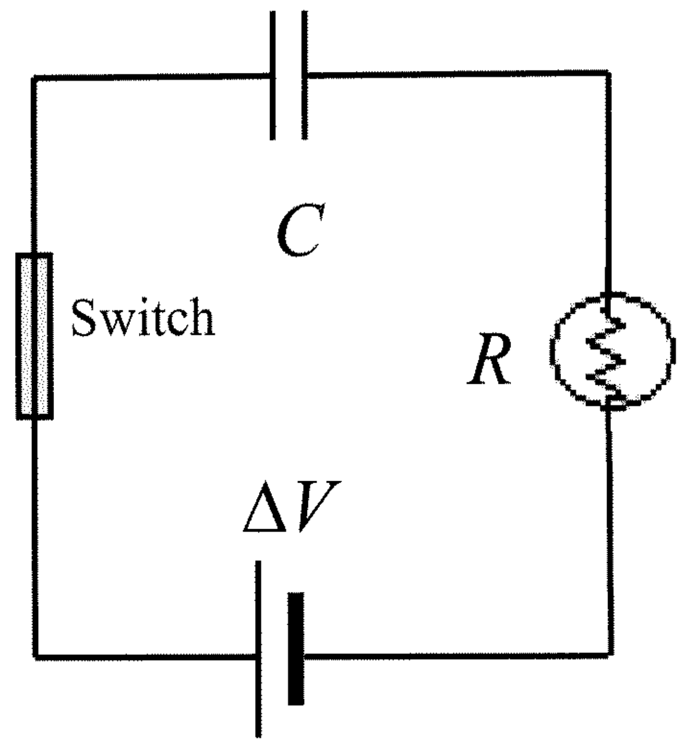
- A capacitor is connected to a battery in series with a bulb and a switch as shown. When the switch is closed the bulb
  - 1. stays unlit
  - 2. goes on and stays lit
  - 3. goes on briefly and then goes out
  - 4. stays out for a while, then goes on slowly and stays on.



Puzzle



- A capacitor is connected to a battery in series with a bulb and a switch closed as shown. When the switch is opened the bulb
  - 1. stays unlit
  - 2. goes on and stays lit
  - 3. goes on briefly and then goes out
  - 4. stays out for a while, then goes on slowly and stays on.



HOW LONG?

- IF R OR C IS INCREASED WHAT (IF ANYTHING) HAPPENS TO THE TIME OVER WHICH CHANGES OCCUR?

- THIS SUGGESTS A FUNCTIONAL RELATIONSHIP THAT MIGHT BE

$$\tau = aR + bC$$

or

$$\tau = RC$$

or

$$\tau = (RC)^2$$

CHECK UNITS

FROM OHM'S LAW

$$[R] = \frac{[V]}{[I]} = \frac{\text{volts}}{\text{coulombs/sec}}$$

FROM CAPACITOR EQ

$$[C] = \frac{[Q]}{[V]} = \frac{\text{coulombs}}{\text{volt}}$$

$$\Downarrow$$

$$[RC] = \text{seconds}$$

BINGO!!