

Consider a parallel-plate capacitor consisting of two circular disks of radius $R = 0.10$ m. When a 2-volt battery is connected to the plates, 2.510^{-11} coulombs builds up on the right plate. An equal negative charge builds up on the left plate. When solving this problem, do not look up any formulas from the "parallel plate capacitor" section of your textbook, other than the definition of capacitance.

- (a) If we hooked this same capacitor to a 4-volt battery, what charge would build up on the right plate?
- (b) What is the capacitance of this capacitor? $s \rightarrow \sigma$
- (c) The electric field between two parallel plates is $E = \sigma/\epsilon_0$, where σ denotes the surface charge density of the positive plate. Using your part (b) answer, find the distance s separating the two plates. Remember, don't look up any textbook formulas about parallel plates.
- (d) When the uncharged capacitor was connected to the 2-volt battery, how much work did the battery do while charging the capacitor? In other words, how much chemical energy did the battery "use up" while charging the capacitor?

a) $Q = CV$ If $V' = 2V$ $Q' = 2Q$ } \Rightarrow charge doubles
↑
const
for this
configuration

b) $C = \frac{Q}{V} = \frac{2.5 \times 10^{-11} \text{ C}}{2 \text{ V}} = 12 \text{ pF}$

c) $E = \frac{\sigma}{\epsilon_0}$ between plates

$$V = - \int_{-}^{+} \vec{E} \cdot d\vec{s} = \frac{\sigma}{\epsilon_0} s = \frac{Q}{\epsilon_0 A} s$$

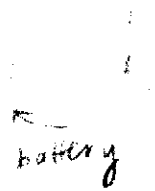
$$C = \frac{Q}{V} = \frac{Q}{\frac{Q}{\epsilon_0 A} s} = \frac{\epsilon_0 A}{s}$$

$$\Rightarrow s = \frac{C}{\epsilon_0 A} = \underline{\underline{0.022 \text{ m}}}$$

d) $U = qV$? wrong

(2)

Actually $U = \frac{1}{2} qV$



At first, when V is low,
it's easy to move charge

Later, as charge builds up,
it's harder to move the same
charge, because there's more
repulsion

Cut into small pieces of chg:

$$dW = V dq$$

↳ potential while charge dq
is being pushed

$$dW = \frac{q}{C} dq$$

$$\int dW = \int_0^Q \frac{q dq}{C} = \frac{q^2}{2C} \Big|_0^Q = \frac{Q^2}{2C}$$

Energy stored in a capacitor

$$U = \frac{Q^2}{2C} = \frac{1}{2} CV^2$$