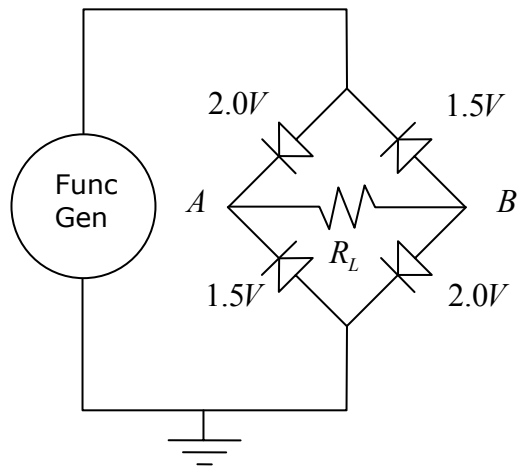


SP.764, Practical Electronics
Dr. James A. Bales
Lecture 3: Capacitors

Topics:

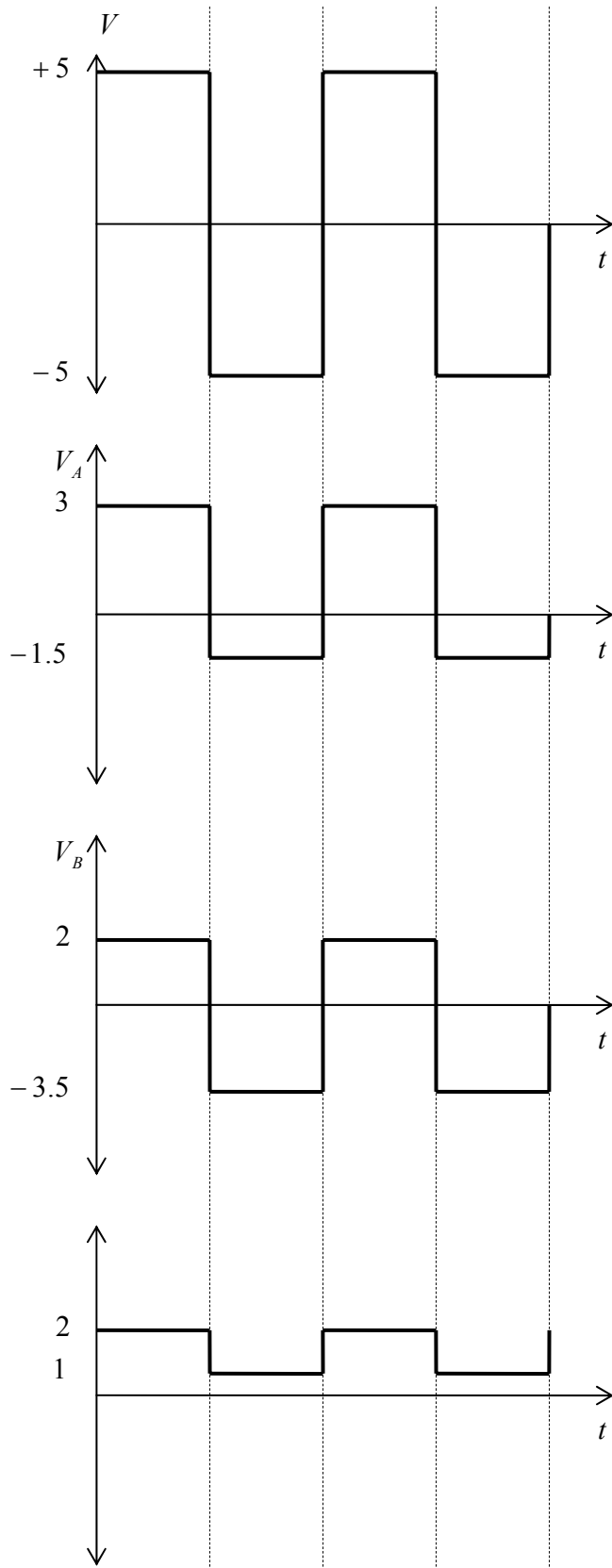
- 1) Review Homework
- 2) Capacitors
 - Time varying systems
 - Water analogy
 - What capacitors are
 - How they work
 - Constitutive systems
 - RC circuits

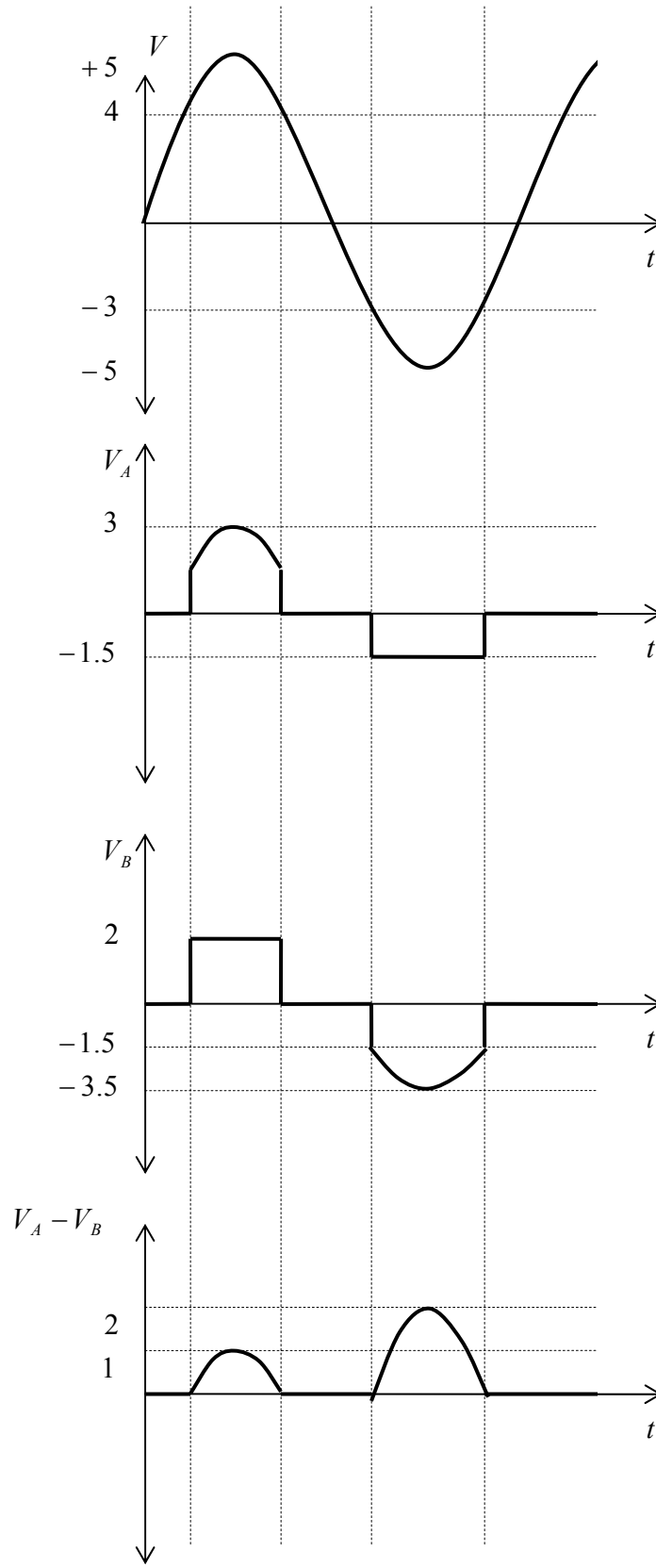
Homework Review:



For "positive" part of cycle:
 $V_A = 3V, V_B = 2V$

For "negative" part of cycle:
 $V_A = -1.5V, V_B = -3.5V$





Capacitors:

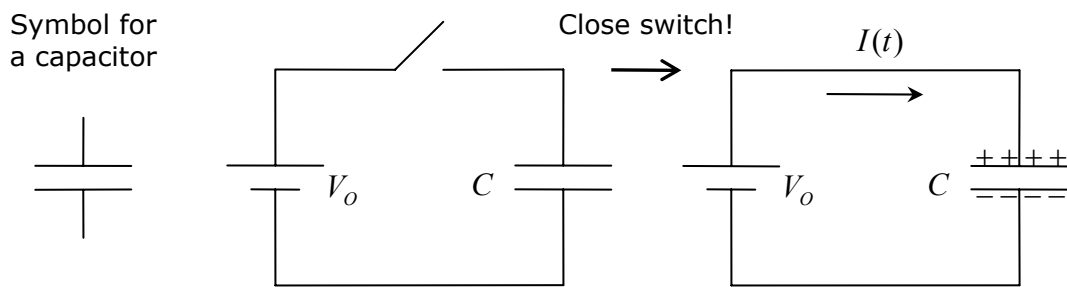
Water Analogy

Voltage \Leftrightarrow Pressure

Current \Leftrightarrow Volumetric Flow Rate

A capacitor is a bucket for charge!

In the fluid system, voltage is equivalent to pressure. Current maps to the volumetric flow rate of water. Looking inside a pipe, one would say water is flowing at a rate of gallons per second. The water analogy is used because the easiest way to think about this is that the capacitor is a bucket for charge. That is, the capacitor can store charge and can release charge as needed.

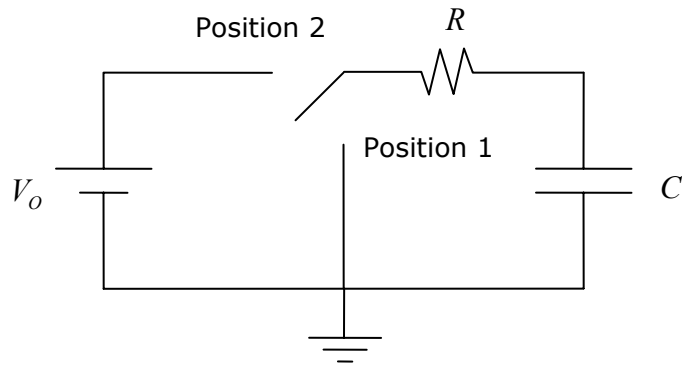


The symbol for a capacitor is two metal plates (two pieces of metals separated by air). If a battery is added with voltage V_0 and a switch, then current will flow if the switch is closed.

How is I related to q ?

- For a resistor, $I = V/R$. Since I is the flow rate of charge, then $I = dq/dt$.
- For a capacitor, the amount of charge "q" on a plate obeys: $q = CV$. Therefore when the switch is closed, current starts flowing until $q = CV_0$.

Resistor	Capacitor
$I = \frac{V}{R} = \frac{dq}{dt}$	$I = \frac{dq}{dt} = C \frac{dV}{dt}$



The switch starts at position 1, and at time $t = 0$, the switch goes instantaneously to position 2.

Question: What is V_{CAP} as a function of time?

For $t \leq 0$, V_{CAP} ?

For $t \leq 0$, $q = 0$, so $V_{CAP} = 0$.

At $t = 0$, flip switch:

$$q(t) = CV_{CAP}(t)$$

ΔV across resistor is $\Delta V(t = 0) = V_0$

$$I(t = 0) = \frac{V_0}{R}$$

$$V_{CAP}(t) = V_0 \left(1 - e^{-\frac{t}{RC}} \right)$$

$$I(t) = \frac{V_0}{R} e^{-\frac{t}{RC}}$$

$RC = \text{time constant}$

