RC Circuits and Timing

Dov Kruger

Department of Electrical and Computer Engineering
Rutgers University

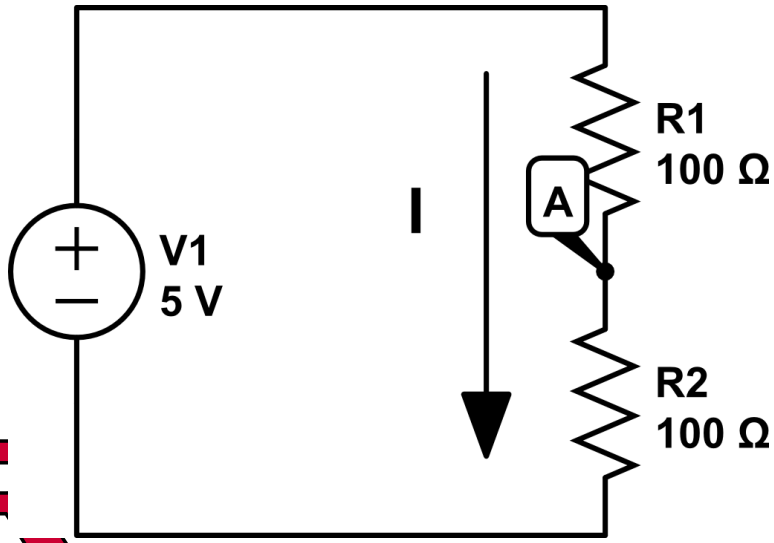
November 5, 2024

RC Circuits

- Lab 6 includes a timing circuit
- You are supposed to research a 555 timer circuit
- This lesson is designed to give you the background you need to understand how it works
- Two concepts you will need:
- Voltage dividers
- RC time constants

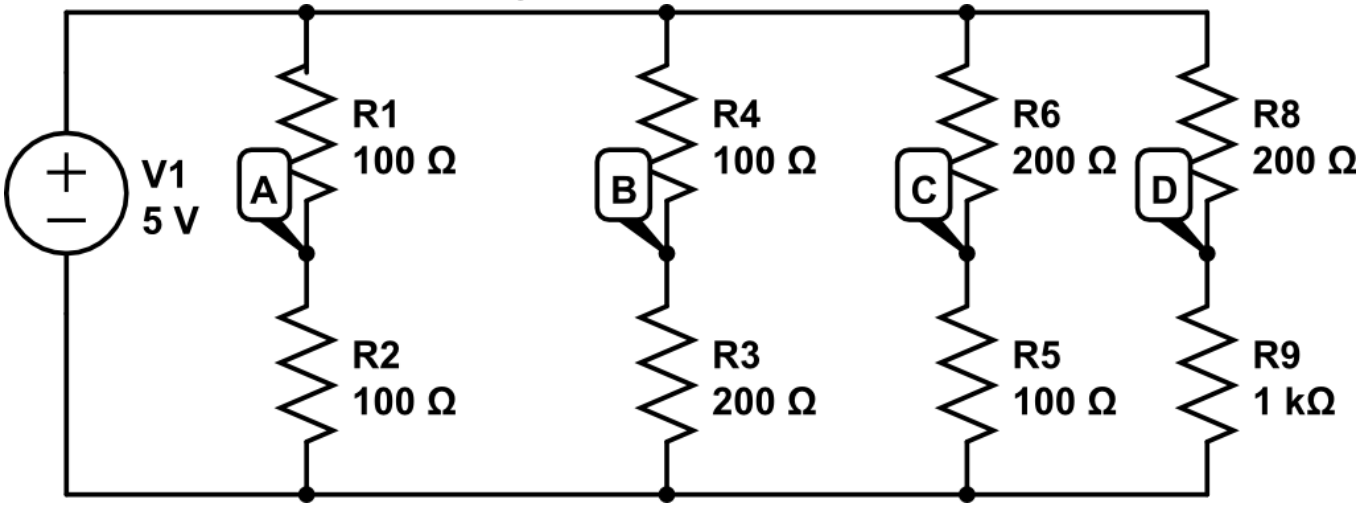
Voltage Dividers

- A voltage divider is a simple circuit that takes a higher voltage and converts it to a lower voltage
- It is a series circuit with two or more resistors
- Current is the same through all resistors in a voltage divider
- Sum of the voltages must equal the total voltage
- $V_1 = V_{total}\frac{R_1}{R_{total}} = 5\frac{100\Omega}{100\Omega+100\Omega} = 2.5V$
- $V_2 = V_{total}\frac{R_2}{R_{total}} = 5\frac{100\Omega}{100\Omega+100\Omega} = 2.5V$
- $A = 0 + 2.5V = 5V - 2.5V = 2.5V$



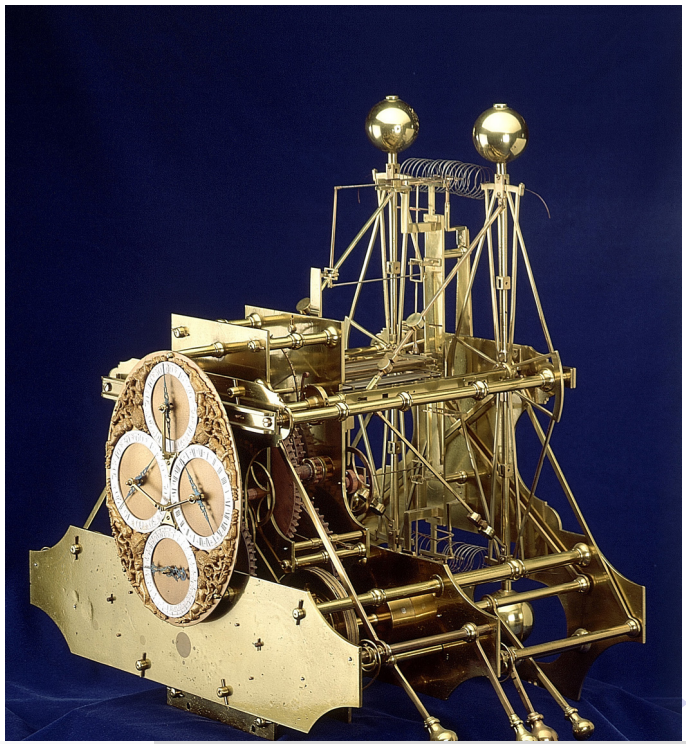
Voltage Dividers

Determine the voltages at points A,B,C,D



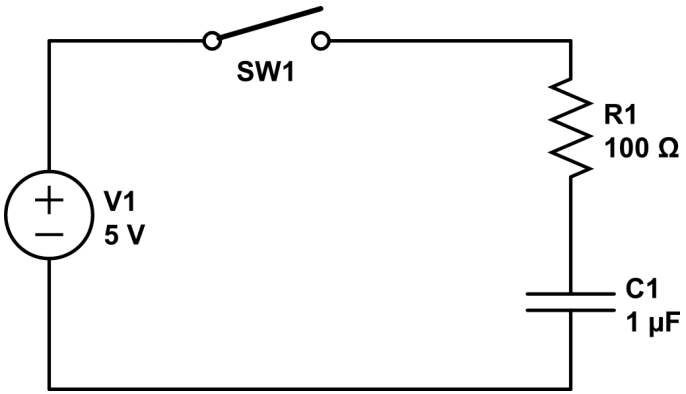
Clocks and Timing Elements

- Mechanical clocks depend on something with a resonant frequency: Pendulum
- Fun reading: Dava Sobel, *Longitude* `https://www.amazon.com/Longitude-Genius-Greatest-Scientific-Problem/dp/080271529X`



RC Circuit Time Constants

- Electronic clocks depend on a circuit element that has a time: RC circuit
- We will use an RC circuit to create a timing element
- RC circuits have a time constant $\tau = RC$
- Charging: $V = V_0 e^{-t/RC}, t = RC, 2RC, 3RC, ...$
- Discharging: $V = V_0(1 - e^{-t/RC}), t = RC, 2RC, 3RC, ...$



Examples

Charging: $V = V_0(1 - e^{-t/RC}), t = RC, 2RC, 3RC, ...$

V_0	R	C	τ	$V(RC)$	$V(2RC)$	$V(3RC)$	$V(4RC)$
10V	1kΩ	$1\mu F$	1ms	6.32V	8.65V	9.50V	9.82V
5V	4.7kΩ	$33\mu F$	.15s	3.16V	4.32V	4.75V	4.91V

Discharging: $V = V_0 e^{-t/RC}, t = RC, 2RC, 3RC, ...$

V_0	R	C	τ	$V(RC)$	$V(2RC)$	$V(3RC)$	$V(4RC)$
8V	22kΩ	$470\mu F$	10.3s	2.94V	1.08V	.398V	.146V

Graphical Visualization

Charging: 0%, 63%, 86%, 95%, 98% 99.5%

Discharging: 100%, 95%, 86%, 63%, 37%, 0%