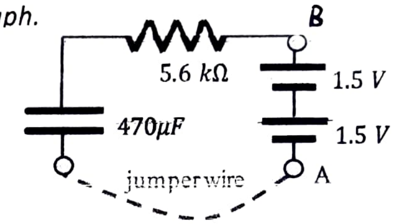
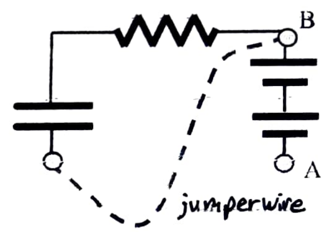
Section	Group	Name	Signature
Grade		Jacob H[illegible]	[illegible]

After this activity you should know: • *the time dependence of the voltage across the capacitor for charging and discharging capacitors* • *The time constant for RC circuits and how to obtain it from a graph.*

Experiment: A circuit is built with a 470 μF capacitor, a 5.6 $k\Omega$, and with two 1.5 V batteries. The capacitor can be charged through the resistor by connecting the jumper wire between the capacitor and point A. The charged capacitor can be discharged through the resistor by connecting the jumper wire to point B.





1. The voltage across the capacitor as it charges is

$$V_c(t) = \mathcal{E}\left(1 - e^{-t/\tau_c}\right)$$

where $\tau_c = RC$ and t is the time from when the capacitor started to be charged.

When $t = \tau_c$, the capacitor voltage is $V_c(\tau_c) = \mathcal{E}(1 - e^{-1}) = 0.63\,\mathcal{E}$. Therefore, we can determine the time constant by finding the time it takes for the voltage to reach 63% of the EMF.

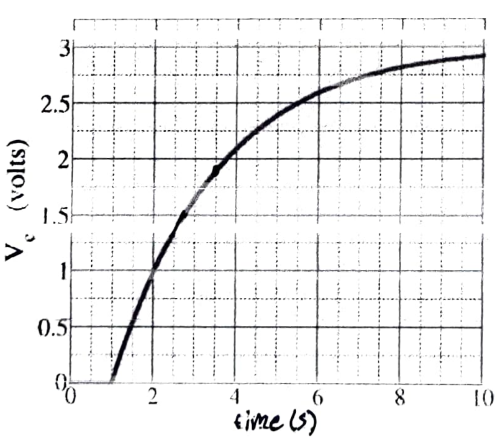
a. Use the graph of the charging capacitor below to determine the time constant for the circuit. Don't forget to subtract the time the charging starts. Check your answer is close to the expected value.

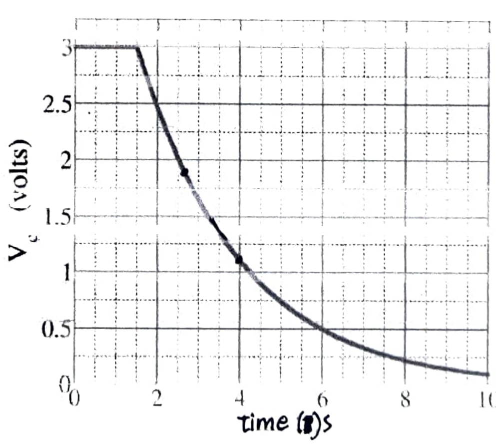
$3.5 - 1 = 2.5\,s$

b. Use the graph of the charging capacitor and the loop rule to determine the current at t = 2 sec.

$I = \cancel{25}\ 0.25\ ms$

c. For a discharging capacitor, the voltage across the capacitor is $V_c(t) = V_o\,e^{-t/\tau_c}$ where V_o is the initial voltage and $\tau_c = RC$. Since $V_c(\tau_c) = V_o e^{-1} = 0.37\,V_o$, the time constant is the time it takes for the voltage to decay 37% of the initial voltage. Use the graph of the discharging capacitor below to determine the time constant. Put your result in table on next page. Don't forget to subtract the time the discharging starts.

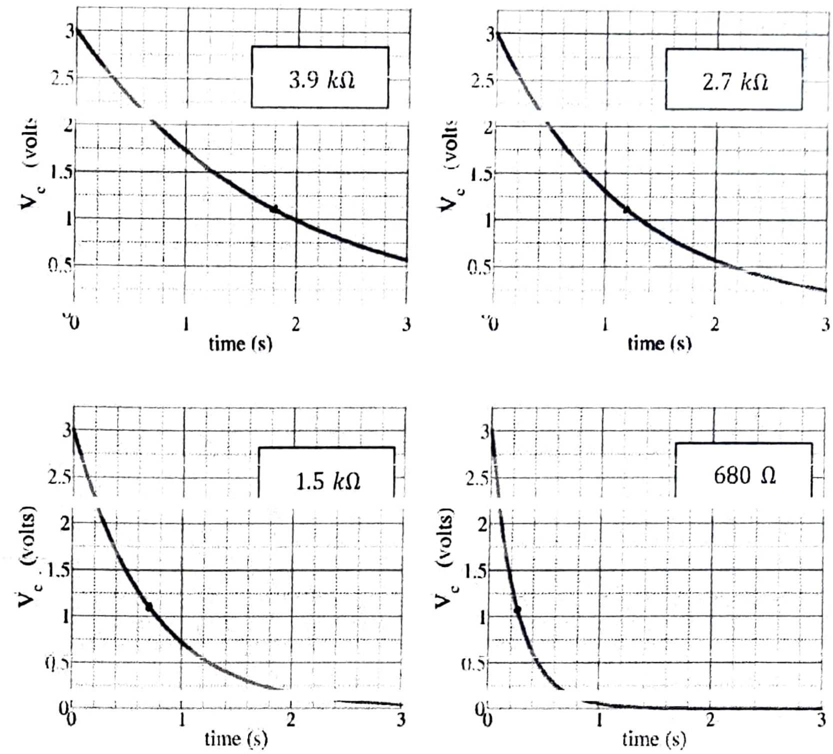




$4 - 1.5 = 2.5$

2. The experiment is repeated with the 5.6 $k\Omega$ resistor is replaced by a 3.9 $k\Omega$, 2.7 $k\Omega$, 1.5 $k\Omega$ and finally a 680 Ω resistor. The graphs of the voltage across the capacitor as the capacitor discharges is shown below. Use the graphs to determine the time constant for each case and fill in the table below.

   1.11 V



3. Calculate the expected time constant for each resistance and fill in table. Be reasonable with *significant digits, i.e., don't put in 8 digits of precision.*

Resistance	680 Ω	1.5 $k\Omega$	2.7 $k\Omega$	3.9 $k\Omega$	5.6 $k\Omega$
τ_c (measured)	0.320 s	0.705 s	1.269 s	1.83 s	2.63 s
τ_c *(expected)*	0.3 s	0.7 s	1.2 s	1.8 s	2.5 s

4. Use a software package such as EXCEL to make a graph of the time constant versus resistance (τ_c on the vertical scale and R on the horizontal). Include the graph in when you submit your report. Report the slope of the graph including units below.

   0.448 mF

5. Determine the %discrepancy between the capacitance you found from the slope of your graph and expected value of 470 μF. Show the numbers you used. *The % discrepancy is 100% x |measured-expected|/|expected|.*

$$\frac{|0.448 - 0.470|}{0.470} \cdot 100 \approx 4.7\%$$