**Capacitor Charging in RC Circuit**

Many physical processes can be modeled using the exponential function. Some examples include charging or discharging a capacitor, population growth or decay, heating and cooling, radioactive decay, and chemical reaction rates.

***Part A: Graphing and Time Constants***

The equation that describes how a capacitor charges over time in an RC circuit is:

Vc(t) = Capacitor voltage at time t (V)

E = Voltage of the battery or source (V)

τ is the RC time constant (s)

The time constant, τ, is simply the product of the resistance and the capacitance:

τ = RC time constant (s)

R = Resistance in ohms (Ω)

C = Capacitance in farads (F)

1. Calculate the time constant for each of the resistances shown in the table below.

Note: To calculate τ in seconds, capacitance must be in farads (F) and resistance must be in ohms (Ω). 1 µF = 10-6 F and 1 kΩ = 103 Ω.

Hint: In MATLAB, you can enter the value 4.7\*10-6 as 4.7\*10^-6 or as 4.7e-6

|  |  |  |
| --- | --- | --- |
| **Resistance** | **Capacitance** | **τ (s)** |
| 1 kΩ | 4.7µF |  |
| 2 kΩ | 4.7µF |  |
| 10 kΩ | 4.7µF |  |

1. Assume the battery voltage is 5V. On the same graph in MATLAB, plot the capacitor voltage for all three resistance values. Determine a good time range.
2. Add the following to your plot then copy and paste your plot into this document.

* Label the x-axis as time (s)
* Label the y-axis as Capacitor Voltage (V)
* Add a title: Capacitor Charging in RC Circuit
* Add a legend that shows the three resistance values

1. Using the data cursor tool, determine how long it takes the capacitor voltage to reach 63.2% and 98.2% of its final value (final value is battery voltage). Enter results in the table below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Resistance** | **Capacitance** | **Time to Reach**  **63.2% of 5V** | **Time to Reach**  **98.2% of 5V** |
| 1 kΩ | 4.7µF |  |  |
| 2 kΩ | 4.7µF |  |  |
| 10 kΩ | 4.7µF |  |  |

**Questions:**

1. How is the time required to reach 63.2% of the final voltage related to the time constant, τ?
2. Approximately how many time constants does it take the capacitor to reach 98.2% of its final voltage?

***Part B: Writing a Program***

1. Create a MATLAB programthat meets the following specifications:

* Has three user input, resistance, R, (in ohms), capacitance, C (in farads), and source voltage, E (in volts).
* Has two outputs, time constant, τ, (in seconds) and charge time, 5τ (in seconds)
* The function should calculate the time constant and charge time using the input arguments and output these values to the command window via the output arguments (not fprintf or disp statements)
* The function should also produce a plot of the capacitor voltage vs time with time on the x-axis starting at 0 and ending at the charge time. Include labels and title on plot.
* **Remember, in MATLAB the exponential function is exp. Example: exp( -t / tau )**

2. Run your program for R = 470 Ω, C = 2.2µF (2.2e-6) and E = 9 volts. Paste the MATLAB command you used to run the function and the resulting output in the space below. Also paste the plot in the space below.