Engineering Models II
Homework Assignment #1

Problem 1: Capacitor Charging in RC Circuit

In Models I, you did some experiments with a capacitor charging in a series RC circuit.

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

$$V_c(t) = E(1 - e^{-t/\tau})$$

$V_c(t)$ = 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:

$$\tau = R \cdot C$$

τ = RC time constant (s)
R = Resistance in ohms (Ω)
C = Capacitance in farads (F)

The time it takes for the capacitor to charge is five time constants, 5*τ.

(a) Create a MATLAB ***function*** that meets the following specifications:

- Has three input arguments, resistance, R, (in ohms), capacitance, C (in farads), and source voltage, E (in volts).
- Has two output arguments, 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)**

(b) Run your function 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.

(c) Submit your function with this assignment.

Problem 2: Chemical Reaction Rate

In Models I you did some plots and curve fitting for chemical reaction rates. Quick review:

First order chemical reactions can be modeled using exponential functions. Hydrogen Peroxide (H_2O_2) decomposes as a 1st order reaction into water and oxygen gas:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The concentration of hydrogen peroxide decreases exponentially according to the following equation:

$$C(t) = C_0 e^{-kt}$$

C(t) = Concentration at time t (M or mols/L)
C_0 = Initial Concentration (M)
k = Reaction rate (s^{-1})

The reaction rate, k, depends on the temperature according to Arrhenius' Equation (also exponential):

$$k = Ae^{-E_a/(RT)}$$

A = Frequency Factor (s^{-1})
E_a = Activation Energy (J/mol)
R = Ideal Gas Constant = 8.314 (J/(mol*K))
T = Absolute Temperature (K)

(a) Create a MATLAB ***function*** that meets the following specifications:

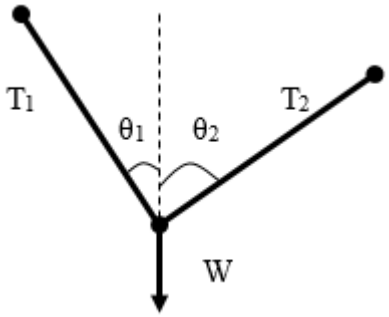
- Has four input arguments, Frequency Factor (A), Activation Energy (Ea), Absolute Temperature (T), and Initial Concentration (Co). Assume the user will enter values in the units indicated above.
- Has two output arguments, Reaction Rate (k), and Decomposition Time (5/k).
- The function should calculate the reaction rate (k) and decomposition time (5/k) using the input arguments and Arrhenius' Equation. The reaction rate and decomposition time should be sent to the command window via the output arguments (no fprintf or disp statements)
- The function should also produce a plot of the concentration (C) vs. time with time on the x-axis starting at 0 and ending at the decomposition time. Include labels and title on plot.

(b) Run your function for A = 10^{11} (s^{-1}), Ea = 7.5*10^4 , T = 300 (K), and Co = 5 M. 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.

(c) Submit your function with this assignment.

Problem 3: Tension in Cables

Last semester in Models I, we solved a simple statics problem to find the tension in two cables for a given weight, W.



(a) Create a MATLAB ***function*** that meets the following specifications:

- Has three input arguments, the Weight, W, and the two angles, θ_1 and θ_2.
- Your function should have two output arguments, the ***magnitude*** of the tension in each cable.
- Your function should first check to make sure the Weight, W entered by the user is non-negative and the two angles are between 0 and 90^o. If these conditions are not met, your function should simply terminate with an error statement. (Use the ***error*** command)
- Assuming valid inputs are entered by the user, the function should calculate the magnitude of the tension in each cable and send the values to the command window via the output arguments (not fprintf or disp statements).

(b) Run your function for Weight, W = 25 lbs, and angles, $\theta_1 = 20^o$ and $\theta_2 = 50^o$. Paste the MATLAB command you used to run the function and the resulting output in the space below.

(c) Run you function for some invalid input argument. Paste the MATLAB command you used to run the function and the resulting output (should be your error statement) in the space below.

(c) Submit your function with this assignment.