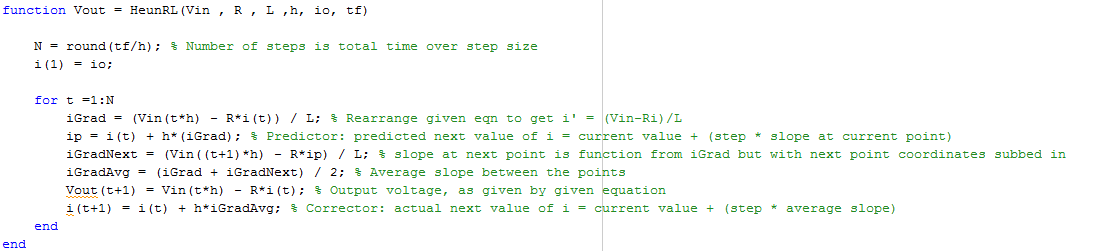
**EE2-08C: Numerical Analysis of ODEs/PDEs using Matlab**

1. **RL Circuit**

The following is the script HeunRL.m, which implements the Heun method for a function, Vin, passed to it:



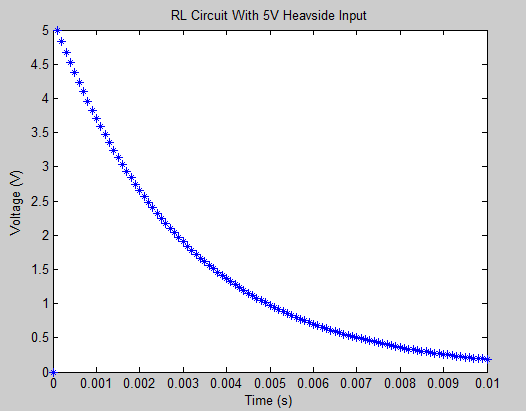
The function implements the improved Euler method as so:

1. Find the number of steps we will need to take by dividing the total length of x-axis we will be working on (i.e. time) by the step size
2. Rearrange the ODE given to us to get an equation for the gradient at the current point
3. Get a predicted next y-axis value corresponding to our next time point using the Euler method
4. Use the equation from **ii.** to get a prediction of the gradient at the next point using the next time value and our predicted y-axis value from **iii.**
5. A better estimate for the gradient between the current and next values is the average of their gradients
6. The voltage across the inductor is the input voltage minus the voltage across the resistor
7. The next y-axis value is the current value plus the step size multiplied by the average gradient from **v.**

I tested this function with various different input signals. These are the results:

**Input: Heaviside – h = 0.001, tf = 0.01**

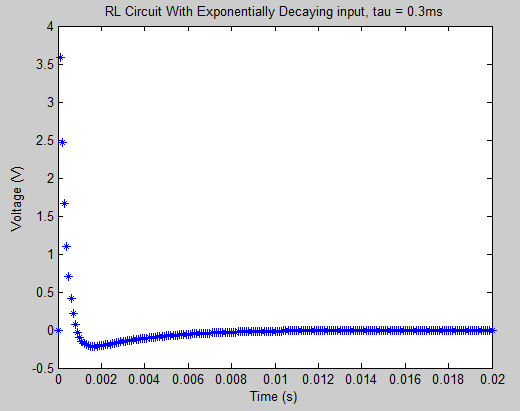
With a 5V Heaviside input to the RL circuit, the output voltage varies as shown in the graph:



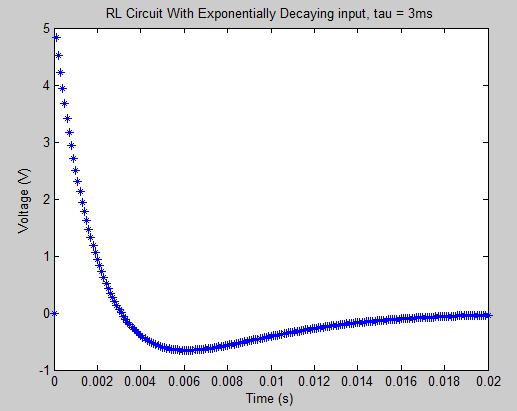
Since the inductor resists changes in voltage, at the start of the input it provides a lot of resistance, which causes lots of current to be generated and therefore the voltage across it to be high. As time goes on, the resistance decreases and the inductor gradually becomes equivalent to a short circuit, which is why the voltage across it tends to zero.

**Input: Exponential Decay – h = 0.001, tf = 0.02**

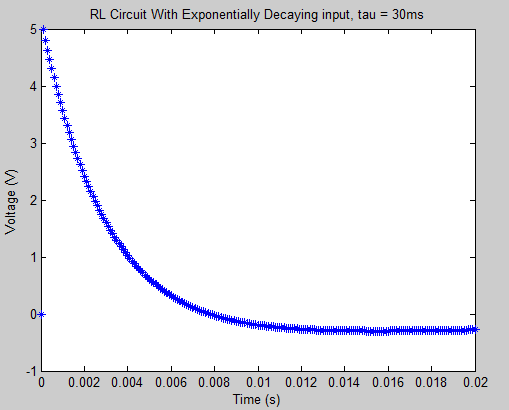
* **τ = 0.3ms**

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* **τ = 3ms**

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* **τ = 30ms**

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We can see that as τ gets smaller, the response tends to a horizontal line at y = 0. This is because a small τ value causes the exponent to be very negative, so the exponential term becomes very small and significantly outweighs whatever constant factor it is being multiplied by (in this case 5). The zero input response of this circuit gives zero output, and that is what the graph portrays.

If τ is larger, the absolute value of the exponent becomes small, and the exponential term tends to 1, meaning it is insignificant in comparison to the constant factor, so our input essentially becomes equivalent to the Heaviside input shown earlier, which is why the graphs are similar.

The reason the graph dips below the 0V mark for a short time with exponential input is **some reason I don’t know**

**Input: Sine Wave -**