Explanation: If the current reference is in the direction of the voltage drop across the terminals of the inductor as shown in Fig. 1, the power $p(t)$ is

$$p(t) = v(t)i(t), \tag{1}$$

where $v(t)$ is the voltage in Volts [V] and $i(t)$ is the current in Amperes [A]. The power $p(t)$ is in Watts [W]. Knowing that the power is the time rate of expending energy and assuming a reference for a zero energy corresponds to zero current in the inductor, the stored energy $w(t)$ in Joules [J] can be given as

$$w(t) = \int_0^t p(\tau)d\tau = \int_0^t v(\tau)i(\tau)d\tau. \tag{2}$$

Using the voltage-current relation of the inductor, the stored energy can also be found as

$$w(t) = \frac{1}{2}Li^2(t). \tag{3}$$

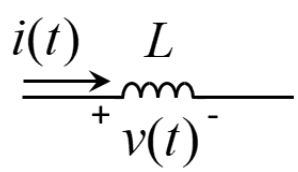

Figure 1: Current and voltage of an inductor.

Question: The current and voltage values of an inductor with $L = 100$ mH are measured for a time step size of $\Delta t = 25$ ms at the time interval $t \in [0, 1]$ s. In the measurement data file (**pr3data.dat**), the first column is the time in seconds (s), the second column is the current value in Amperes (A), and the third column is the voltage value in Volts (V).

Write a code to import the associated data and answer the following questions:

1. Plot the current $i(t)$ and voltage $v(t)$ data and comment on their consistency.
2. Determine and plot the power $p(t)$.
3. Determine the stored energy in the inductor by numerically integrating the equation (2) using
   (a) Composite Midpoint Rule,

(b) Composite Trapezoidal Rule,

(c) Composite Simpson's Rule.

4. Determine the stored energy in the inductor using equation (3).

5. Compare all results obtained in Question 3 with the result obtained in Question 4.

6. Comment on the stored energy, specify the important time instances.

Suggestions:

- You can use **importdata**, **load** or **dlmread** commands to import the data.
- Pay attention to the upper limit (t) of the integral in equation (2). This implies that you have to numerically integrate the data to a time instance. In other words, for different time step sizes, the integral in equation (2) should be re-calculated.
- Be careful on choosing the integration limits, you might require to define separate time steps (subintervals) to implement numerical integration rules.
- You can check the consistency of the voltage and the current using the current-voltage relation of the inductor.
- You can include separate figures that zoom in to specific regions to support your comments and analysis.
- If required, you can use **semilogy** command to plot in logarithmic scale.

Notes:

- A report should be prepared as explained in **Homework and Project Report Preparation Guideline**.
- The codes and the report should be student's own work.
- A single, ready to run MATLAB script (m) file should be uploaded along with the pdf and docx files of your report.
- The figures presented in your report should have proper axis labels, legends, as well as figure numbers with proper citation in the report.
- Presenting only the code and plots will be graded with zero points.