**Explanation:** In a circuit with impressed voltage $\mathcal{E}(t)$, inductance $L$, and resistance $R$, as shown in Figure 1, Kirchhoff's voltage law gives the relationship

$$\mathcal{E}(t) = L\frac{d}{dt}i(t) + Ri(t),$$

where $i(t)$ is the current. This is due to the voltage difference induces on an inductance is proportional to the inductance value and the time derivative of the current flows through the inductance, i.e. $V_L(t) = L\frac{d}{dt}i(t)$. On the other hand, the voltage difference on a resistance can be determined as $V_R(t) = Ri(t)$.

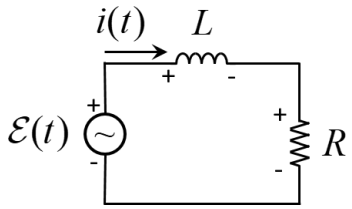


Figure 1: A RL circuit.

**Question:** The current values of the circuit, where $L = 0.98$ H (Henries) and $R = 14.2\ \Omega$ (Ohms), is measured using a current meter for different time step sizes at the time interval $t \in [0, 600]$ ms. The measured data sets of the current with time step sizes $\Delta t$ are plotted in Figure 2 for $t \in [0, 500]$ ms and relations are specified in Table 1. In the measurement data files, the first column is the time in seconds (s) and second column is the current value in Amperes (A).

Table 1: Data sets.

| Data File | Time Step Size $\Delta t$ |
|---|---|
| current1.dat | 75 ms |
| current2.dat | 50 ms |
| current3.dat | 25 ms |
| current4.dat | 10 ms |

Write a code to import the associated data using the given data files and determine the impressed voltage $\mathcal{E}(t)$ using

(a) Forward-difference formula,

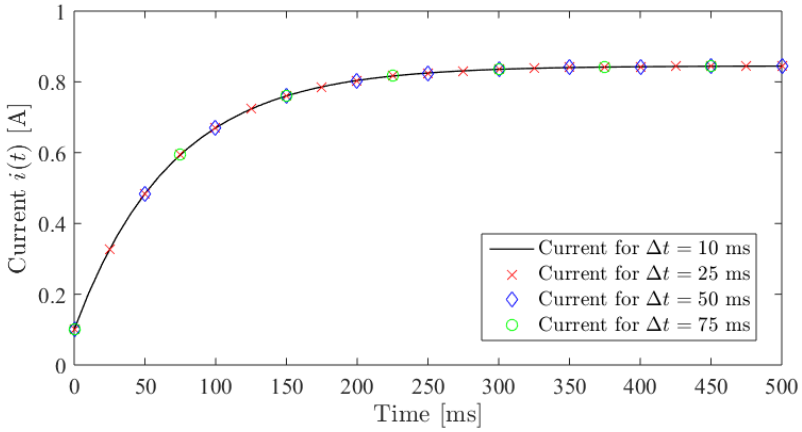


Figure 2: Measured currents.

(b) Backward difference formula,

(c) Three point midpoint formula (use three point endpoint formula for the first and last points)

for all data sets.

In your report,

(a) Include an analysis and comment on the convergence (error) orders with respect to the applied method,

(b) Include an analysis and comment on the convergence (error) orders of the applied methods with respect to the time step size $\Delta t$,

(c) Include a plot or plots to show the time derivative of the current for all the cases and compare them systematically,

(d) Include a plot or plots to show the impressed voltage $\mathcal{E}(t)$ for all the cases and compare them systematically and rationally,

(e) Do you have a guess for the actual impressed voltage $\mathcal{E}(t)$? If yes, specify the guessed $\mathcal{E}(t)$ function and try to include an error analysis using the guessed $\mathcal{E}(t)$.

**Notes:**

1. A report should be prepared as explained in **Homework and Project Report Preparation Guideline**.
2. The codes and the report should be student's own work.
3. A single, ready to run MATLAB script (m) file should be uploaded along with the pdf and docx files of your report.
4. Include the followings to your report:
   - Convergence analysis with respect to the step size $\Delta t$,
   - Convergence analysis with respect to order of the method,
   - Plots of time derivative of the current and the impressed voltage,
   - Show the convergence of the error after guessing the impressed voltage function,
   - Support your analysis with comments.

   **The convergence analysis does not have to be a mathematical analysis, it can be carried out using the plots and data.**
5. Try to answer the following questions and comment on the following issues:
   - Can you observe the expected convergence rates?
   - If the endpoint formula is not used, how is the accuracy affected?
6. The figures presented in your report should have proper axis labels, legends, as well as figure numbers with proper citation in the report.
7. Presenting only the code and plots will be graded with zero points.
8. You can use **importdata**, **load** or **dlmread** commands to import the data and **norm** command to analyze the error in the impressed voltage function.