Explanation: The voltage-versus-current characteristic of a practical diode at forward biased region ($v_D > 0$) can be approximated by the Shockley diode equation:

$$i_D = I_S(e^{v_D/(nV_T)} - 1), \tag{1}$$

where

- i_D is the current [A] through the diode,
- v_D is the diode voltage [V],
- I_S is the leakage (or reverse saturation) current, typically in the range of 10^{-6} A to 10^{-15} A,
- n is the empirical constant known as the emission coefficient or the ideality factor, whose value varies from 1 to 2,
- V_T is a constant called the thermal voltage.

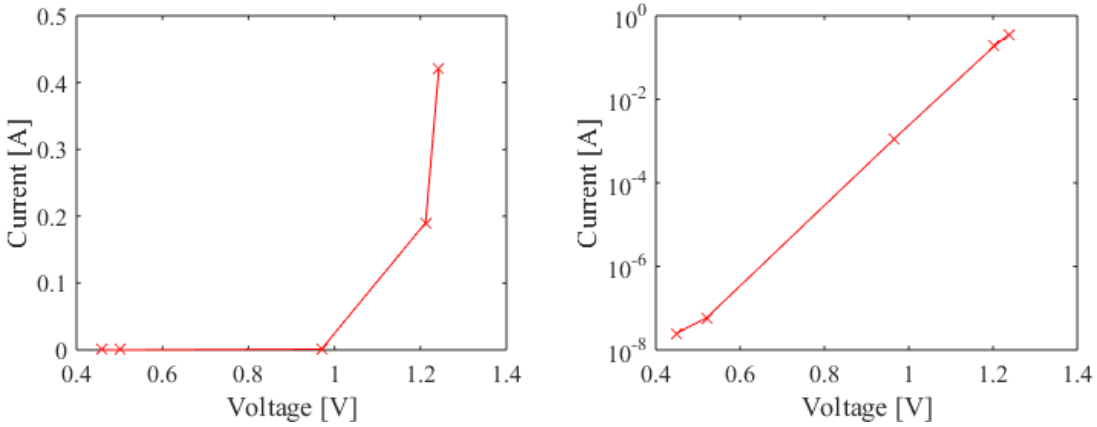
The diode current i_D will be very small if the diode voltage v_D is less than a specific value V_{TD}, known as the *threshold voltage* or the *cut-in voltage* or the *turn-on voltage* (typically 0.7 V). The diode conducts fully if v_D is higher than V_{TD}. Thus, the threshold voltage is the voltage at which a forward-biased diode begins to conduct fully. For $v_D > 0.1$ V, which is usually the case, $i_D \gg I_S$, and Eq. (1) can be approximated by

$$i_D = I_S(e^{v_D/(nV_T)} - 1) \approx I_S e^{v_D/(nV_T)}. \tag{2}$$

Question: The voltage-versus-current characteristic of a diode at forward biased region ($v_D > 0$) is measured at a junction temperature of 25 °C and the measured values are plotted in Figure 1 and given in the data file (**fprdata.dat**), where the first column is the voltage in V and the second column is the measured current in A. This diode is used in the RL circuit shown in Figure 2, where the switch is closed at $t = t_0$. Formulate and write a code to calculate the current $i(t)$, voltages $v_1(t)$, $v_2(t)$, and $v_D(t)$ for $V_S = 2$ V, $L = 0.98$ H, $R = 14.2\ \Omega$, $t_0 = 0$ s, and $i_0 = 0$ A for the time interval $t \in [0, 600]$ ms using the step sizes $\Delta t = 25$ ms and $\Delta t = 2.5$ ms. Assume that $v_D(0) = 0$ V for $t = 0$ s.

Followings should be included to your report:

- Formulation for the initial value problem.
- Formulation of the method used to handle the diode characteristic.



(a) (b)

Figure 1: The measured voltage-current characteristic of a diode at forward biased region: (a) linear, (b) logarithmic scales.

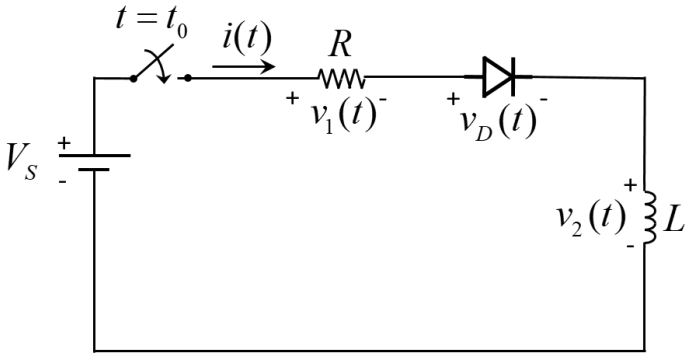


Figure 2: Circuit for the final project.

- Plots of the current $i(t)$, voltages $v_1(t)$, $v_2(t)$, and $v_D(t)$ versus time t.
- Which methods are used? Explain why they are chosen.
- Include all necessary values and figures (depending on the used methods).
- Include your comments and if possible your analysis to your report in a **separate section**.

Notes:

- A report should be prepared as explained in **Homework and Project Report Preparation Guideline**. The percentages are applicable if all your results/formulation/implementations are correct.
- File naming for the final project report should be in the following format:
  studentnumber_surname_FPR_MATH214.pdf
  studentnumber_surname_FPR_MATH214.docx
  m_studentnumber_surname_FPR_MATH214.m
- 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.