A. Motivation:

Through the proposed exercises students are invited to gain sensivity to the several approaches that can be followed in order to determine device model parameters.
For the initial study, three different approaches will be addressed:

A. Fully optimization based
B. Mixed- optimization + model Knowledge
C. Model-based

Python will be used for the code development.

B. Case study

The Mosfet Schokley's model is considered, where the current flowing through the transistor drain may be obtained with:

$$Id = \begin{cases} 0 & \Leftarrow \quad v_{gs} < v_t \\ K\left((v_{gs} - v_t)v_{ds} - 0.5{v_{ds}}^2\right)^2 (1 + \lambda v_{ds}) & \Leftarrow \quad v_{gs} \geq v_t \wedge v_{ds} < v_{gs} - v_t \\ 0.5\, K\left(v_{gs} - v_t\right)^2 (1 + \lambda v_{ds}) & \Leftarrow \quad v_{gs} \geq v_t \wedge v_{ds} \geq v_{gs} - v_t \end{cases}$$

Given files containing "noisy" characteristics of Mosfets, the values for v_t, K and λ that will enable the given model to more accurately represent the transistor behaviour.

C. Fully optimization-based Approach

Consider the transistor $Id_{meas}(V_{gs})$ characteristic in file "*MeasuredIdVg1.csv*".
Using Python proceed as follows

1. Read the file content and obtain the corresponding graphic.
2. Write a function that given the Mosfet differential terminal voltages (V_{gs} and V_{ds}), as well as the model parameters, returns the value for the drain current.
3. Using python *curve_fit* function, without establishing any boundary values determine the values for the model parameters.
4. Using the obtained parameter values, generate $Id_{model1}(V_{gs})$ using the model and compare it with $Id_{meas}(V_{gs})$
5. Drive conclusions regarding the accuracy of results (based on relative error plot)
6. Using the model obtain $Id(V_{ds})$ for Vgs=0.4, 0.6, 0.8, 1.0, an 1.2 ; Consider $0<V_{ds}<1.2$ with a step of 0.1.
7. From file "Idvds.csv" obtain the real characteristic (for VGs=1.2) and plot it against the values obtained in 6.
8. Drive conclusions whether the values obtained make sense for an actual Mosfet
9. Repeat 3-7 using bounds for the parameters

D. Mixed- Optimization + Model Knowledge

In this approach, we "help" the optimization with "some knowledge" we have from the model. The knowledge we use may be obtained in different ways, but we are going to consider a particular case.
Let us consider two transistor characteristics we have obtained for V_{ds}=1.2V and V_{ds}=0.7V, in files *MeasuredIdVg1.csv* and *MeasuredIdVg2.csv*. We will refer to them as $Id_{meas1}(V_{gs})$ and $Id_{meas2}(V_{gs})$, respectively.

1. Based on the analytical expression for $Id(V_{gs})$ in saturation, obtain the expression representing the ratio between the values of the currents for different values of v_{ds}.
2. From 1. Obtain the analytical expression for λ
3. Given the two characteristics, obtain the vector containing their ratio, and obtain the value for λ.
4. Using the already obtained values for λ, and considering any of the initial characteristic, use curve-fit for determining the value for Vt and K.
5. Repeat points 4. to 8 from Section C.