General hints for code submissions To make it easier for us and others to understand your solutions please follow these guidelines:

- If available use the template file to create your solution.
- Please add comments so we can understand your solution.
- Please make sure to load all required packages at the beginning of your code.
- Only use relative file paths for `source()`, `load()`, etc.
- Each exercise directory contains a `skeleton` folder where preliminary `R` files are located.
- Use these `R` files as a basis for creating your solution which should be contained in a main `R` file named as the content of the exercise, e.g., `evaluation.R`.
- You can (and sometimes have to) reuse code from previous exercises.
- The points indicate the difficulty of the task.
- If not stated otherwise, we will use exclusively R 4.0 or greater.

As you learned in the last lecture we can use Grey-Box Optimization to make the hyperparameter search more efficient. For this we assume that we have some information directly from the optimization process. These could be for example:

- Early stopping poorly performing configurations
- Cheap-to-evaluate proxies
- Gradients

In this exercise you will implement a straight-forward early stopping algorithm commonly used in practice called Successive Halving and its popular extension Hyperband.

1. **Grey-Box Optimization for HPO** [14 points]

   We provide you with a rough structure of Successive Halving and Hyperband. You will implement the remaining parts to **minimize** an objective function.

   (a) Implement Successive Halving based on the algorithm you have seen in the lecture. [5.pt]

   (b) Create a plot of the Successive Halving results that plots all evaluated configurations. On the x-axis plot the budget parameter and on the y-axis plot the outcome. Connect points that were evaluated on the same input configuration (not including the budget parameter) [2.pt]

   (c) Implement Hyperband by reusing the Successive Halving implementation based on the algorithm discussed in the lecture. [4.pt]

   (d) Create a plot of the Hyperband results similarly as above. [2.pt]

   (e) What are the advantages/disadvantages of Successive-Halving/Hyperband compared to Bayesian Optimization? [1.pt]