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.

Now that you have learned about hyperparameter optimization techniques such as Bayesian optimization (BO) you will implement this loop yourself.

1. **Bayesian Optimization for HPO** [14 points]
   We provide you with a rough structure of the BO loop using a Gaussian Process. You will implement the remaining parts to **minimize** a synthetic 1D function.
   (a) Implement the acquisition functions *Expected Improvement* as presented in the lecture. Keep in mind that you will use `optim()` to optimize the acquisition function. [4.pt]
   (b) Implement the acquisition functions *Lower Confidence Bound*[1] as presented in the lecture. Keep in mind that you will use `optim()` to optimize the acquisition function. [4.pt]
   (c) Implement Grid Search and Random Search. [4.pt]
   (d) Compare your implementations of BO against Random Search and Grid Search for 8, 16, 32 and 64 function evaluations[2] Bonus: Repeat all stochastic optimizations multiple times and compare the results using a Box-plot. [2.pt]

[1] Similar to *Upper Confidence Bound*, but for minimizing an objective value.
[2] Hint: Your implementations of BO should perform better than Random Search for few function evaluations.