MODA 2022 Brief Exam Briefing

- Open book: you can bring annotated lecture slides, exercises, tutorial article (Emmerich, Deutz). Pen and paper exam. Bring colored pens /ruler
- Topics MOO: Try to understand these parts of the lecture; there might be short questions related to them to test your general understanding:
  - Mathematical Programming Formulations and Problem Difficulty: be able to formulate optimization problems with decision variables and use the techniques we used and discussed in the lecture and exercises; Solve linear programming tasks graphically; know terms such as active constraints, minimizer, conflicting objectives. Classify mathematical programming models
  - Orders and Pareto Dominance Understand the axiomatic and geometric definition of different types of orders and the properties of orders; understand the Pareto dominance order and weak componentwise order; Hasse Diagram; order extension; and minimal element. Polyhedral cone equations;
  - Landscape Analysis: Understand how to identify efficient points based on level curves (contours); understand weakly dominated solutions; Know how to classify pareto front shapes into concave, convex, etc.
  - Optimality Conditions: Understand partial derivatives and how to compute them for simple analytical functions; Know gradient and second derivative (Hessian matrix) and how to compute it and check optimality of unconstrained problems; know the Lagrange multiplier theorem and rule; and how to use it to solve problems with equality constraints; know how to check whether a point satisfies the KKT conditions; understand the meaning of the different parts in the KKT condition; know the Fritz John conditions; in particular also in the bi-objectice unconstraint case.
  - Single point methods: Understand single point methods discussed in the lecture (see also tutorial article) and know their limitation. Epsilon constraint method. Disadvantages of linear weighting.
  - Population based methods: Know the general pseudocode of a $(\mu + \lambda)$-Evolutionary algorithm, know the 2-D hypervolume indicator, non-dominated/crowding-distances/ hypervolume-contributions
  - Bayesian Multiobjective Optimization: Understand how to use a linear predictor to make a prediction and how to compute the weights of the linear predictor of simple kriging (lambda values). Understand what is the expected improvement (of hypervolume) and what are its two monotonicity properties; Know the basic loop of Bayesian global optimization .
  - MCDA: Understand difference between a priori, a posteriori and progressive methods, what is a indifference curve, know the difference between Derringer Suich and Harrington Desirability functions, LP formulation of robust ordinal regression;
  - Hillclimbing methods: Understand the pseudocode of simulated annealing and understand how to compute a search direction in Gradient based and Newton Raphson method. Understand the idea of set-scalarization, memetic algorithm, single point methods to use hillclimbing for Pareto front approximation.
  - Design optimization: understand different ideas of parameterizing shapes. What means innovization.

Tasks to practice:

- Linear Programming graphical: single- and multi-objective
- Model optimization problems using decision variables and mathematical programming:: similar to the techniques used in lecture
- Lagrange Multiplier Rule to solve a constrained problem.
- Interpreting contour plots to identify efficient solutions
- Analysing an order for its axiomatic properties and type; whether it extends another order. Draw Hasse diagrams and identify minimal/maximal points
- Sorting populations using non-dominated sorting, crowding distance; hypervolume contributions; Computing the hypervolume indicator in 2-D
- Compute gradients, steepest descent directions; check optimality conditions (KKT, Fritz John) for given points.

Practicing material will be made available on bright space; consider also Assignment 1 and 2 and the epsilon-constraint example for preparation; next to the lecture slides. We will try to keep the algebra and functions simple, so no advanced calculus skills are expected but some simple algebraic transformation and differentiation rules will be used.