1. Topic and History

**KNOWLEDGE**
- Understand what a conflicting pair of objective functions is, distinguish between minimizer and minimum.
- Know examples of different applications of multiobjective optimization, e.g. machine learning. What are objective functions, search or decision space? Why is there a conflict? what is a trade-off curve?

2 Formal Problem Definitions

**TASKS**
- Formulation of mathematical programming problems in standard form
- Classification of mathematical programming problems
- Being able to solve a linear programming problem graphically in 2-D

**KNOWLEDGE**
- Systems analysis tasks: modeling, simulation, and optimization
- Problem difficulties: discrete and continuous optimization
- Decision problems vs. optimization. What means NP complete? NP hard?

3 Multiattribute Decision Analysis

**TASKS:**
- Visualize and compare solutions using indifference curves (2-D) and Parallel Coordinate diagram. Graphically determine Pareto front (2-D)

**KNOWLEDGE:**
- Desirability functions: Definition Derringer-Suich and Harrington type.
- Steps in building utility functions?
- Definitions: A priori, A posteriori and Progressive approach
- Definitions: Incomparability, indifference, and Pareto dominance.

4 Orders and Dominance

**TASKS:**
- Drawing Hasse diagrams, identify minimal set.
- Checking cone dominance for polyhedral cones.
- Comparing orders on basis of isomorphism, extension, equality and
- Analyzing orders for geometric and axiomatic properties

**KNOWLEDGE:**
- Know the axiomatic properties of different types of orders and ordered sets
- Know what is a chain, antichain, minimal set, topological sorting, pointed and convex cone, polyhedral cone, cone order

5 Level Sets and Landscape Analysis

**TASKS:**
- Condition of efficiency in 2-D diagram, in particular in linear case (with and without constraints) in 2-D

**KNOWLEDGE:**
- Definition: level set, strict level set and level curve and be able to identify
these for simple 2-D functions.
- Different shapes of the Pareto front (concave, convex, disconnected, 3-D Pareto front)
- Special points: Nadir Point, Maximal point, Ideal Point
- Understand what it means for a point to be weakly non-dominated or weakly efficient.

6 Optimality Conditions and KKT Theorem
TASKS:
- Computing gradients and partial derivatives.
- Find optimum analytically for simple unconstrained problems.
- Using lagrange multiplier rule for problems with equality constraints.
- Identifying optimal points in single and multiobjective optimization using the KKT theorem based on contour plots in 2-D.
KNOWLEDGE:
- Necessary and sufficient conditions for local optimality.

7 Single Point Methods
TASKS
- Being able to graphically determine the solution found by a single point method, given a drawing of the 2-D Pareto front.
KNOWLEDGE
- Being able to discuss the pro’s and con’s of different single point methods, when being used for approximating the Pareto fronts and as utility functions.

8 KLP Algorithm, Complexity, and Skyline Operators
TASKS:
- Being able to use the Landau Symbols (Big O, Theta, Omega).
- Know and visualize steps in the 2-D and 3-D KLP algorithms.
KNOWLEDGE
- Know complexity results: Pareto order, general partial order
- Main idea of N-D KKT algorithm. Complexity results.
- Understand why simple divide and conquer strategies lead to computational time complexity \(O(n \log n)\).
- Understand the main steps of the N-D algorithm (not complexity proof).

9 Evolutionary Multi-criterion Optimization
TASKS:
- Rank individuals using the principles of NSGA-II and SMS-EMOA selection schemes: Crowding distance, hypervolume, dominance rank (non-dominated sorting)
KNOWLEDGE:
- Being able to distinguish: Exact algorithm, heuristic, and metaheuristic
- Know the main operators in an evolutionary algorithm, and the concept of a \((\mu+\lambda)\) selection.
- Complete probabilistic convergence: What does it mean? Theorem for EA.
- Why makes evolutionary multicriterion optimization a flexible framework? (What is generic, what needs to be done to instantiate an EMO algorithm?)
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