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DM87 Scheduling, Timetabling and Routing
Study Plan for the Oral Exam

This is a list of questions that can be posed at the oral exam.

The exam will last 30 minutes and the questions will be extracted randomly from the list. It is allowed to bring hand written notes but not course material (slides, textbook, articles). The notes will lay on the table and can be consulted if needed.

1. **Present and explain your best learning** matching the goals of the course. You have a maximum of 10 minutes to address this question. The item can be chosen from the list below but it is possible to show creativity going out of the list (for example, by following a topic and developing it transversely to the arguments in the list).
2. **Classification scheme for scheduling problems**. Discuss:
   - Machine environment
   - Constraints (blocking, no-wait, etc.)
   - Objectives (in this case it might be further asked which standard objective might be used to achieve different goals, such as maximum throughput, balanced load, work-in-progress, just in time, etc).
   - Graham, Lawler, Lenstra, Rinooy Kan's notation.
3. **Single machine scheduling problem**. Define and discuss one of the cases below:
   - Heuristics for scheduling: Dispatching rules (mention few cases where they are optimal) and local search.
   - Consider the case $1|prec|h_{max}$. Describe the dynamic programming algorithm.
   - Consider the relevant case $1|r_i|L_{max}$. Describe the branch and bound algorithm for its solution.
   - Sketch the algorithm by Gilmore and Gomory for the special case of $1|s_{jk}|C_{max}$ with structured setup times.
   - Sketch the dynasearch by Congram, Potts and van de Velde for $1||\sum_j w_j T_j$.
   - Treat the details of local search for $1||\sum_j w_j T_j$: complexity and possible speedups for the most common neighborhoods.
4. **Flow shop scheduling problem**. Define it and describe the digraph representation and the procedure for obtaining the makespan from a permutation of jobs when changes at machines are not allowed. Moreover, choose and treat one of the cases below:
   - Johnson's rule for the case $F2||C_{max}$.
   - Tabu search for the case $Fm|perm|C_{max}$. Describe shortly: (i) the property used to prune the examination of the neighborhood, (ii) the evaluation of a move, (iii) the tabu status and (iv) the search strategy.
   - Consider the case $Fm|perm|C_{max}$. Describe the Navaz, Enscore and Ham heuristic and how this heuristic can be enhanced through the iterated greedy metaheuristic.
5. **Job shop scheduling problem**. Define it and describe the disjunctive graph model, the alternative graph model and one of the following:

- Disjunctive Programming Formulation for $Jm||C_{max}$.
- Consider the job shop case $Jm||C_{max}$. Describe the branch and bound procedure (page 404 of the text book).
- Consider the job shop case $Jm||C_{max}$. Describe the use of constraint programming as possible solution approach indicating the general principles of the constraint programming method.
- Consider the job shop case $Jm||C_{max}$. Describe a possible application of local search, by defining the candidate solutions, the solution representation, the neighborhood and possible pruning of the neighborhood.
- Consider the job shop and discuss how blocking, no-wait and perishability constraints can be modeled. Sketch the Roll-Out heuristic (without going into the details of the heuristic used, but focusing on the general framework).

6. **Shifting Bottleneck heuristic** for $Jm||C_{max}$. (Adams, Balas and Zawack 1988).
7. **Resource Constrained Project Scheduling Problem**. Define it and describe the solution approach with heuristic methods.
8. **Reservation timetabling problem with and without slack**. Define and mention solution approaches.
9. **Timetabling in transportation**. Discuss one of the following:
   - Tanker scheduling. Define the problem, give the integer programming formulation and sketch the branch and bound procedure.
   - Daily aircraft routing and scheduling. Define the problem, give the integer programming formulation and sketch the branch and price (or column generation) algorithm (a summary description of this method is sufficient).
   - Train timetabling. Define the problem treated in the lecture, illustrate the diagram time-space, and indicate the solution method that uses mixed integer programming as sub-procedure (the full model is not required, only the high level framework).
10. **Workforce timetabling**. Discuss one of the following:
    - Crew scheduling. Definition, mathematical programming formulation and possible solution methods.
    - Shift scheduling (rostering) problem. Definition, integer program formulation and observation on integrality of the linear relaxation.
    - Days-off scheduling problem. Definition, integer programming formulation, solution approach.
    - Operators scheduling in call centers and employee timetabling. General description of the problem and heuristic approaches: candidate solutions, construction heuristics, neighborhoods.
11. **Vehicle routing problems**. Define the entities, the constraints and the objectives. Describe the possible variants.
12. **Mathematical programming models for CVRP**. Define variables and constraints of the two index vehicle flow formulation, the three index vehicle flow formulation, the two commodity flow formulation, the set partitioning formulation.
13. **Heuristics for VRP**. Treat one of the following:
    - Give a general classification of construction heuristics for CVRP and describe two at choice.
    - Discuss local search procedures for CVRP and VRPTW.
    - Describe the large neighborhood search obtained combinaing local search and constraint programming.
14. **Rich Pick up and Delivery Vehicle Routing Problem**. Describe it and give examples of how it can be used to model various versions of VRP problems.