

NUMERISCHE METHODEN DER PHYSIK

WiSE 2023-2024 – PROF. MARC WAGNER

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Exercise sheet 13

To be handed in on 24.01.2024 and discussed on 26.01.2024 and 29.01.2024.

Exercise 1 [*Arctic expedition*] (3 + 8 + 9 (+2) = 20 (22) pts.)

To increase the impact of your groundbreaking theoretical research even further, you plan an Arctic expedition to find evidence for magnetic monopoles. Unfortunately, the airplane pilot imposes a strict weight limit on your expedition backpack of 20 kg. The total weight of the items you have planned to bring with you exceeds this limit by far. You now have to find the optimal subset of items, thus, you assign to each item I_j a value v_j , characterizing its importance. The optimal subset is then given by the maximum of

$$F = \sum_{I_j \in \text{backpack}} v_j,$$

with the condition

$$\sum_{I_j \in \text{backpack}} m_j \leq 20 \text{ kg},$$

where m_j is the mass of item I_j . You can download the itemlist on the web page

<https://itp.uni-frankfurt.de/~mwagner/teaching/numerik/items.dat>.

The first, second and third column list the item name, its weight m_j in kg and its usability value v_j , respectively.

- (i) How many subsets of items exist? Estimate, how long it would take for each subset to check the weight limit of 20 kg and compute F , assuming 10^{-9} s for each subset.
- (ii) Develop a strategy which uses simulated annealing to find the optimal subset of your equipment. In particular, discuss your update steps, e.g. why did you choose the updates in your particular way? What was your conceptual idea and did you do numerical tests with different update strategies?
- (iii) Implement the strategy you developed in task (ii) and list the items of your optimized subset. What is the total weight and total value F of that subset? Compare your results with those of your friends and colleagues.
- (iv) (optional) Challenge: One maximum has been found, corresponding to $F_{\text{ref.}} = 215.35$. Find a subset, which corresponds to $F > F_{\text{ref.}}$.