## 6. Exercise Optimization in Engineering Summer Term 2025
Transforming constrained optimization problems into unconstrained problems

A box-shaped packaging of a birthday gift is to be designed in such a way that the surface area A of the packaging is minimized. The volume of the package is supposed to be 25,000 cm³ and a label with the dimensions of 30 cm x 20 cm should be placed on the front surface of the package (as displayed in the sketch)
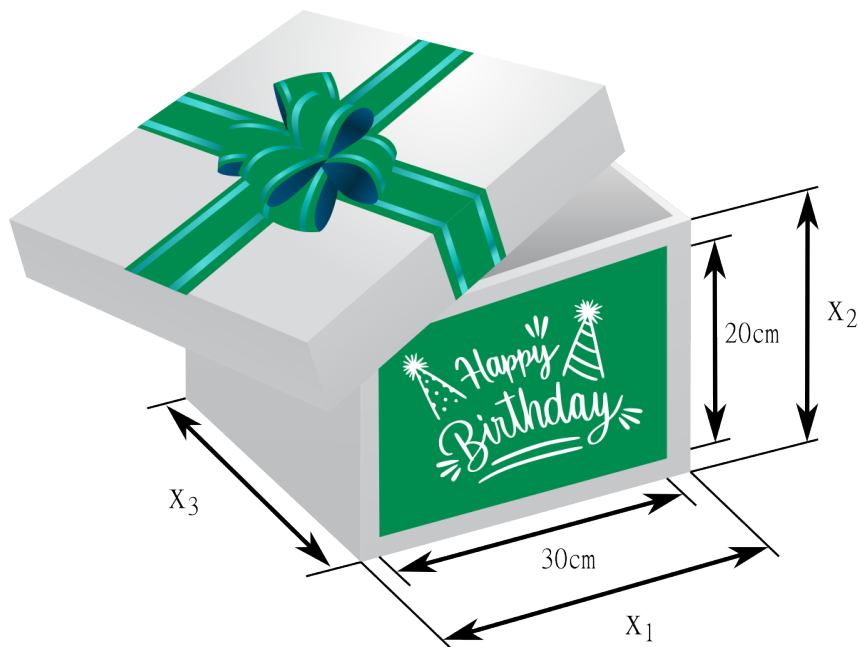
Tasks:

a) Formulate the corresponding optimization problem including all constraints using the notation from the sketch. Give the complete mathematical formulation!

b) Solve the equality constraint (EQC) for x_3, and substitute the obtained equation into the optimization problem of task a).

c) Transform the constrained optimization problem of task b) into an unconstrained optimization problem by using quadratic penalty functions! Solve the reformulated problem with weighting factors of $\sigma = 1$, 10, and 100, and plot the curves of the reformulated objective functions. How do you explain the differences?

d) Solve the optimization problem of task a) by using a built-in solver for constrained optimization problems. In MATLAB you may use `fmincon`. Python users may apply `scipy.minimize`. Formulate your objective function in such a way that it returns the packaging surface A for any vector $x = [x_1, x_2, x_3]^T$. Use the SQP algorithm to solve the problem.

e) Compare the methods of tasks c) and d) regarding accuracy, efficiency and applicability. Discuss your optimized packaging dimensions critically.

Bonus Task

Transform the optimization problem of task a) into an unconstrained problem by suitable variable substitutions and transformations! Solve this problem with a built-in solver for unconstrained problems and again plot the course of the objective function.

Lecturer

Lukas Gottheil, M.Sc.
gottheil@icvt.tu-clausthal.de

Submission per .zip file on Stud.IP
Till: 25.06.2024 23:59