Imagine you are the newly appointed Director of Operations Research for a major Public Hospital. This institution operates under the constant pressure of limited budgets, high patient demand (especially in critical departments like the Emergency Room and Intensive Care), and mandatory service delivery standards. The hospital management seeks to use analytical models to improve resource utilization, patient throughput, and overall service quality. Your task is to identify, define, and formulate a specific optimization problem that contributes to the enhanced efficiency, cost-effectiveness, or patient outcomes within this public hospital setting. In particular, the decision-making process must require the formulation of a **(continuous) linear** optimization model with at least 100 decision variables and 20 constraints. You should not use any of the models described in class or in the slides (but a significant modification of any of them might be acceptable).

a) (*1 points*) Formulate mathematically the problem as a linear optimization model (based on the general formulation of an LP). Identify the model sets, parameters, variables, objective function and constraints.

b) (*1 points*) Implement the model in Pyomo and solve it for a set of (parameter) values, either based on real-world or randomly generated data (make sure that the values you use are coherent with the model defined in a)). In both cases, include your model and the specific data you have used.

c) (*1 point*) Compute the sensitivities associated with each constraint, and interpret the values of those you may consider more important.

d) (*2 points*) Derive the dual problem associated with a) and solve it in Pyomo. Does the Strong Duality holds?

e) (*2 points*) Modify the problem in a) to impose some logical or conditional (linear) constraints that require the use of **binary or integer variables**. If needed, the model can be substantially different than a). Implement and solve this new model in Pyomo and interpret the results. Include the data used for the solution of the problem.

f) (*1 point*) Consider the relaxed problem corresponding to the one in e), that is, the linear optimization problem you would obtain if you do not take into account any integrality constraints on the variables. Compare the solutions for both problems and comment on them.

g) (*1 point*) For the integer problem in e), solve several instances with increasing sizes (different numbers of variables) using randomly generated data. Comment on the impact of the size of the problem on the time required to solve it.

h) (*1 point*) For the integer problem in e), solve several instances with the same data, using increasing values for one of the parameters in the model (choose a parameter you think may provide insights for the interpretation of the different solution values). Collect the resulting optimal values of the objective function, print and plot them. Comment on the resulting behavior.

IMPORTANT:

- Due date: **Wednesday, December 17, at 23:59 p.m.**
- Upload the code to Aula Global as a Jupyter notebook named as "Surname-Name-A1.ipynb".
- You are strongly advised to include descriptions for your formulations and comments in the same notebook, by using markdown cells.
- If this would prove too complicated, exceptionally you may present this information in a separate pdf file. In this case, name the file "Surname-Name-A1.pdf".
- Upload any datasets that might be required to reproduce your results (if not included with the models).