1 Modeling

Exercise 1. Given binary variables $b_1, b_2, b_3 \in \{0, 1\}$ and continuous variables $x_1, x_2 \in [0, K]$, linearize the following products:

a) $b_3 = b_1 \cdot b_2$, [1 pt]

b) $x_2 = b_1 \cdot x_1$. [1 pt]

Exercise 2. Nurses at the St. Charles hospital work 8-hour shifts starting at 0:00, 4:00, 8:00, 12:00, 16:00 or 20:00. Find an integer linear programming model to determine the minimum number of nurses needed to satisfy the following requirements:

Time	Required number of nurses
00:00–04:00	3
04:00–08:00	8
08:00–12:00	10
12:00–16:00	12
16:00–20:00	14
20:00–00:00	8

[2 pts]

Exercise 3. Express the following requirements as integer linear programming constraints:

a) If Charles takes k or more classes from the set $\{c_1, \ldots, c_n\}$, then he also has to take classes d_1 and d_2. [2 pts]

b) Charles can take c_3 only if he also takes c_1 or c_2, but not both. [1 pts]

Exercise 4. Propose an integer programming model for scheduling classes at a university. Decide what constraints should be included and what data are needed. [3 pts]