Instructions: In this session, we will learn some more mathematical modeling. We will consider some scenarios where linear programming may be applied to solve a practical problem. Use these exercises to become more comfortable with writing optimisation models and solving them using AMPL.

Answer all the questions in this assignment. Only the questions marked [**R**] need to be answered in a lab-report. Do not include AMPL commands in your report. Write the report in your lab notebook after answering all such questions. Upload your models and code files on moodle. Also save all your files in the server in a new folder lab02. Show all your work to TA/instructor before leaving.

Exercise 1: Fitting. (Adapted from Bradley, Hax, and Magnanti, Addison-Wesley, 1977)
The selling prices of a number of warehouses in Powai overlooking the lake are given in the following table, along with the size of the lot and its elevation.

Warehouse i	Selling price P_i	Lot size (sq. ft.) L_i	Elevation (feet) E_i
1	155000	12000	350
2	120000	10000	300
3	100000	9000	100
4	70000	8000	200
5	60000	6000	100
6	100000	9000	200

You have been asked by Laxmi Warehousing Company to construct a model to forecast the selling prices of other warehouses in Powai from their lot sizes and elevations. The company feels that a linear model of the form $P = b_0 + b_1 L + b_2 E$ would be reasonably accurate and easy to use. Here b_1 and b_2 would indicate how the price varies with lot size and elevation, respectively, while b_0 would reflect a base price for this section of the city. You would like to select the "best" linear model in some sense. If you knew the three parameters b_0, b_1 and b_2, the six observations in the table would each provide a forecast of the selling price as follows:

$$\hat{P}_i = b_0 + b_1 L_i + b_2 E_i \quad i = 1, 2, \ldots, 6.$$

However, since b_0, b_1 and b_2 cannot, in general, be chosen so that the actual prices P_i are exactly equal to the forecast prices $\hat{P}_i$ for all observations, you would like to minimize the absolute value of the residuals $R_i = P_i - \hat{P}_i$.

(a) **[R]** Formulate another mathematical program to find the "best" values of b_0, b_1 and b_2 by minimizing the linear absolute residual $\sum_{i=1}^{6} \left| P_i - \hat{P}_i \right|$. Write the model in the report.

(b) Model the problem in AMPL and solve using Gurobi solver.

(c) **[R]** Report the solution.

Exercise 2: It is the beginning of monsoon semester at IIT Bombay, and our department needs a system adminstrator to be working every weekday (Mon-Fri) from 8AM to 10PM. There are six candidates available who can do this job, but they are also busy doing other activities during the week. Their availability and wage-rate is listed in the table below

	Wage-rate	Mon	Tue	Wed	Thu	Fri
K.C.	150	6	0	6	0	6
D.H.	152	0	6	0	6	0
H.B.	148	4	8	4	0	4
S.C.	146	5	5	5	0	5
K.S.	166	3	0	3	8	0
N.K.	176	0	0	0	6	2

Each candidate has a different qualification and hence they have a different wage-rate. According to the contract, K.C., D.H., H.B. and S.C., must work at least 8 hours every week. K.S. and N.K. must work at least 7 hours every week. There should be exactly one administrator on duty at any time during the work hours.

(a) You are required to find number of hours each candidate must be alloted each day so that the cost of running the facility is minimized. Write a linear optimization model to solve this problem.

(b) Solve this problem using Gurobi.

(c) **[R]** Report the number of variables, constraints and nonzeros in the constraints of your model.

(d) **[R]** Report the solution and the total cost.

Exercise 3: Gulmohar Cheese produces two types of cheese: Swiss cheese and sharp cheese. The firm has 60 experienced workers and would like to increase its working force to 90 workers during the next eight weeks. Each experienced worker can train three new employees in a period of two weeks during which the workers involved produce nothing. A worker takes one hour to produce 10 KG Swiss cheese and one hour to produce 6 KG sharp cheese. A work week is 40 hours. The weekly demands (in 1000 KG) are as follows

	WEEK							
CHEESE TYPE	1	2	3	4	5	6	7	8
Swiss cheese	12	12	12	16	16	20	20	20
Sharp cheese	8	8	10	10	12	12	12	12

Suppose that a trainee receives full salary equal to that of an experienced worker. Further suppose that extra cheese not sold can be kept in inventory for at most one week. You may assume that demand in each week must be met.

(a) **[R]** How should the company hire and train its new employees so that the labor cost is minimized? Formulate a linear program that can be solved to find the answer. Clearly explain what each variable and constraint means. Also clearly mention the assumptions you made.

(b) **[R]** Solve the problem using CPLEX (or GUROBI) solver. Report how many new workers start training in each week. Also report the inventory available in each week.