Fall 2022-23

IE 251 – LINEAR PROGRAMMING

CASE STUDY I

Due date: Dec. 12, 2022 until 17:30

MHT Defense Industry Ltd. manufactures two types of bullets for Turkish Air Forces, namely, the incendiary bullets and the explosive bullets. Since the bullets are sensitive and dangerous products, the regulations require the workers to be experts in Occupational Safety and Health (OSH) protocols on explosives and flammables. This means that whenever a new worker is hired, s/he should complete a 1-week training on OSH and manufacturing processes before taking part in bullet production. The training must be given by the expert workers who demonstrate the implementation of the OSH protocols and manufacturing processes on the production line. After one week of training, a newly hired worker becomes an expert worker knowing all manufacturing processes and OSH protocols on explosives and flammables (i.e., thereafter, s/he can take part in production and training as a trainer).

Currently, the company has 60 expert workers. In each week, an expert worker can train at most 5 newly hired workers. Besides, each expert worker can produce 100 units of incendiary bullets or 200 units of explosive bullets per week. However, if an expert worker trains newly hired workers on-line, his/her weekly production rate decreases to one fifth of his/her regular weekly production rate, regardless of the number of trainees assigned to him/her. For the following 5-week, the weekly demands of each bullet type are provided in Table 1.

Table 1. Weekly Demand for Each Bullet Type

	Demand (in units)				
Bullet Type	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**
Incendiary (1)	3,000	6,000	8,000	2,000	8000
Explosive (2)	4,000	6,000	8,000	2,000	1000

The wage rate of each worker is $500/week. Moreover, whenever hiring and/or firing a worker, the company is obliged to incur legal costs enforced by the current Labor Protection Act. Accordingly, the cost of hiring a new worker is $100/worker and firing an existing worker is $200/worker. Moreover, considering the firm's reputation, the HR Department of MHT Defense Industry Ltd. has set a weekly budget for hiring and firing activities as $2,000 in total (note that the wages to be paid for the newly hired workers are not included in this budget). Also, the management wants to have at least 40 and at most 70 expert workers available at the end of the last week.

If the bullet production is more than the demand of the current week, the excess production amount can be held in the inventory to be used to satisfy future demands in the following weeks. Nonetheless, the company has a limited storage area corresponding to an inventory capacity of

5,000 bullets (note that this capacity is accounted for the total of incendiary and explosive bullets). Currently, there are 1000 units of incendiary bullets but no explosive bullets in the company's inventory. The weekly inventory holding costs are $1/unit and $2/unit for the incendiary and explosive bullets, respectively. Due to the foregoing operational and financial limitations, it is possible that some portion of the demand may not be satisfied in some weeks. However, this unmet demand is considered as a lost-sale. In case of such a situation, the lost-sale penalty cost of $20/bullet is incurred.

The management of MHT Defense Industry Ltd. would like to determine a 5-week workforce plan for the weekly production of the incendiary bullets and explosive bullets while minimizing the total operational cost. Your team is hired as consultants by the company. At the end of the consultancy, you are expected to complete the following tasks:

a) You should formulate this problem as an LP.

b) You should solve the LP model using Excel Solver only because the company does not have any other optimization package.

c) You should perform several sensitivity analyses and report them as suggestions to be presented to the management.