Factory Production Optimization

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Table of Contents

Company Overview

In the heart of an industrial town, a bustling factory stands as a hub of productivity and innovation. This factory specializes in manufacturing seven products (Glassware, Home Decor,Plumbing, Automotives,Kitchen Appliances,Electronics, Furnitures) using a range of 5 different types of machines including:

- Four grinders
- Two vertical drills
- Three horizontal drills
- One borer
- One planer

These seven products are brought to life through the combined efforts of **five types of machines** within the factory.

The profit of each product per unit sold are included in the table below:

	Glassware	Home Decor	Plumbing	Automotive	Kitchen Appliances	Electronics	Furniture
Profit	$10	$6	$8	$4	$11	$9	$3

Project Statement:

To determine the **optimal production and maintenance plans** for a factory that manufactures seven different products using various machines. The goal is to **maximize the profit** while satisfying the constraints on machine maintenance, product sales limitations, and inventory requirements.

Production Time Requirements (in hours)

	Glassware	Home Decor	Plumbing	Automotive	Kitchen Appliances	Electronics	Furniture
Grinder	0.5	0.7	/	/	0.3	0.2	0.5
Vertical Drill	0.1	0.2	/	0.3	/	0.6	/
Horizontal Drill	0.2	/	0.8	/	/	/	0.6
Borer	0.05	0.03	/	0.07	0.1	/	0.08
Planner	/	/	0.01	/	0.05	/	0.05

Maximum Products Sold

Months	Glassware	Home Decor	Plumbing	Automotive	Kitchen Appliances	Electronics	Furniture
January	500	1000	300	300	800	200	100
February	600	500	200	0	400	300	150
March	300	600	0	0	500	400	100
April	200	300	400	500	200	0	100
May	0	100	500	100	1000	300	0
June	500	500	100	300	1100	500	60

Sets ,Indices and Decision Variables

Sets and Indices

$n \in \text{Months} = \{\text{Jan, Feb, Mar, Apr, May, Jun}\}$: Set of months.

$p \in \text{Products} = \{\text{" } Glassware \text{ ", " } HomeDecor \text{ ", } \ldots \text{ , " } Furniture \text{ "}\}$: Set of products.

$m \in \text{Machines} = \{\text{Grinder, VertDrill, horiDrill, Borer, Planer}\}$: Set of machines.

Decision Variables

$\text{Produce}_{n,p} \in \mathbb{R}^+$: Number of units of product p to manufacture at month n.

$\text{Inventory}_{n,p} \in [0, \text{max\_inventory}] \subset \mathbb{R}^+$: Number of units of product p to store at month n.

$\text{Sold}_{n,p} \in [0, \text{max\_sales}_{n,p}] \subset \mathbb{R}^+$: Number of units of product p to sell at month n.

$\text{Maintenance}_{n,m} \in \{0, 1, \ldots, \text{down\_req}_m\} \subset \mathbb{N}$: Number of machines of type m scheduled for maintenance at month n.

Objective Function

The objective function is formulated according to the goal which is maximizing profit.

Profit: Maximize the total profit (in USD).

$$\text{Maximize} \quad T = \sum_{n \in \text{Months}} \sum_{p \in \text{Products}} (\text{Profit}_p * \text{Produce}_{n,p} - \text{Inventory\_cost} * \text{Inventory}_{n,p})$$

The above function means Sum of profit achieved from each product in all 6 months minus sum of inventory expense for each product in all 6 months.

Different Constraints

- **Initial Balance:** For each product p, the number of units produced should be equal to the number of units sold plus the number stored (in units of product).

$$\text{Produce}_{\text{Jan},p} = \text{Sold}_{\text{Jan},p} + \text{Inventory}_{\text{Jan},p} \quad \forall p \in \text{Products} \tag{1}$$

- **Balance:** For each product p, the number of units produced in month n and previously stored should be equal to the number of units sold and stored in that month (in units of product).

$$\text{Inventory}_{n-1,p} + \text{Produce}_{n,p} = \text{Sold}_{n,p} + \text{Inventory}_{n,p} \quad \forall (n,p) \in \text{Months} \setminus \{\text{Jan}\} \times \text{Products}$$

- **Inventory Target:** The number of units of product p kept in inventory at the end of the planning horizon should hit the target (in units of product).

$$\text{Inventory}_{\text{Jun},p} = \text{store\_target} \quad \forall p \in \text{Products} \tag{3}$$

- **Maintenance**: The number of machines of type m scheduled for maintenance should meet the requirement.

$$\sum_{n \in \text{Months}} \text{Maintenance}_{n,m} = \text{down\_req}_m \quad \forall m \in \text{Machines} \tag{4}$$

- **Machine Capacity:** Total time used to manufacture any product at machine type m cannot exceed its monthly capacity (in hours).

$$\sum_{p \in \text{Products}} \text{time\_req}_{m,p} * \text{Produce}_{n,p} \leq \text{hours\_per\_month} * (\text{installed}_m - \text{Maintenance}_{n,m}) \quad \forall (n,m) \in \text{Months} \times \text{Machines} \tag{5}$$

Optimal Solution

Optimal Result: The result of the optimization model shows that the maximum profit we can achieve is **$108,855.00**

	Glassware	Home Decor	Plumbing	Automotive	Kitchen Appliances	Electronics	Furniture
Jan	500	1000	300	300	800	200	100
Feb	600	500	200	0	400	300	150
Mar	400	700	100	100	600	400	200
Apr	0	0	0	0	0	0	0
May	0	100	500	100	1000	300	0
Jun	550	550	150	350	1150	550	110

References

https://colab.research.google.com/github/Gurobi/modeling-examples/blob/master/factory_planning_1_2/factory_planning_2_gcl.ipynb#scrollTo=vRQPrTIxUeUB