Micron NUS-ISE Business Analytics Case Competition 2024 Question

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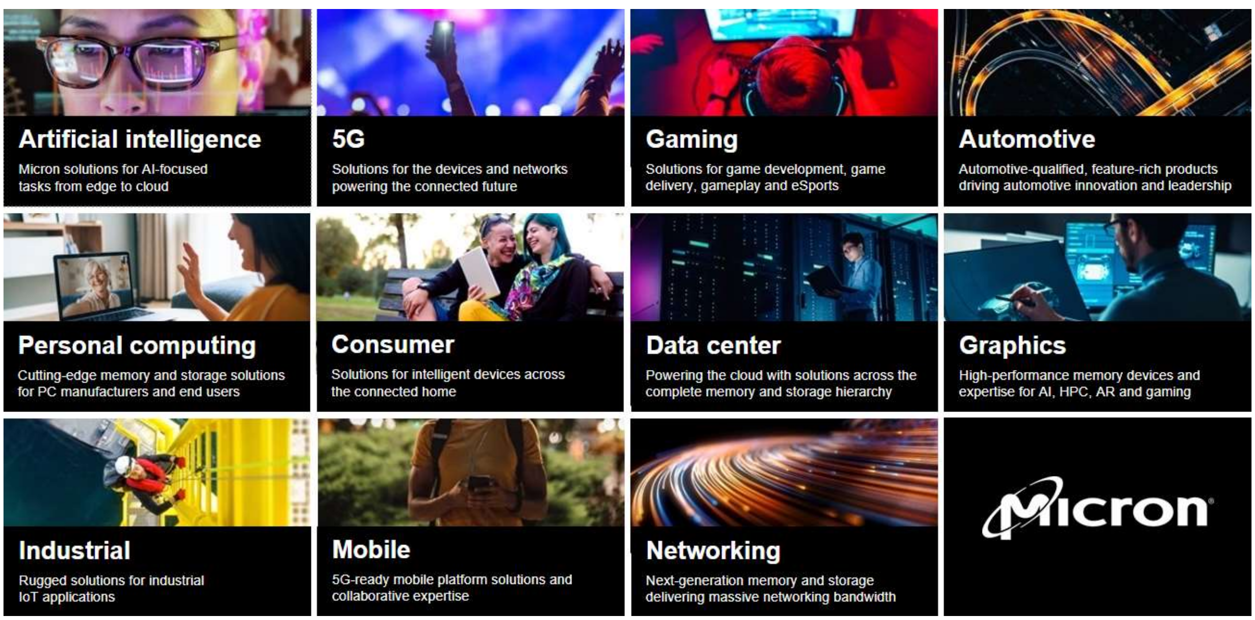
Introduction

Digital technologies such as Smart Devices, Internet of Things (IOT) and Artificial Intelligence (AI) are changing the world we live in from the way we connect with each other, how we make purchases, and even how we commute. Data is the new currency, and it is all around us, in our connected devices, machines, and gadgets. It is captured in data centers, stored in the cloud, and surged through networks. 330 quintillion (10^{18}) bytes of data created per day, and it is growing exponentially year by year. And memory chips are the key enablers in moving, processing, collecting, storing, and sharing data, empowering many of the cutting-edge digital devices we use today and the technologies that are changing our life.

Micron is a world leader in innovative memory solutions that transform how the world uses information to enrich life. Backed by more than 45 years of technology leadership, Micron offers the industry's broadest and most cutting-edge technologies in Memory and Storage, enabling disruptive trends in key market segments like mobile, data center, client, consumer, industrial, graphics, automotive, and networking. Singapore is home to Micron's largest manufacturing footprint with three facilities and a technology center supporting innovation globally for the company. Micron continues to expand its presence here in Singapore, serving as the base of worldwide operations.



Applications of Micron Memory Chips

From 5G smartphones to the AI-enabled cloud, memory fuels everything that computes and is essential to growing the data economy. To address 2030-era demand for memory, Micron plans to invest more than $150 billion globally in manufacturing and R&D over the next decade.

Micron Semiconductor, as one of major suppliers of Memory and Storage solutions, has invested heavily in expanding its own capacity through building new plants. Micron Semiconductor have also expanded its existing plants, including a two-time expansion in Singapore in 2016 and 2019, and a recent announcement to expand in Boise, US, to accelerate the production ramp of advanced memory technology. In 2022, Micron Semiconductor has also announced to invest up to $100 billion to build a brand new Mega-fab in Central New York, US.

Background

Among the many infrastructures that are required to support Micron's manufacturing operations and expansion, one of them is to manage huge variety of material usage requirement that are used in processing Micron chips at every single processing step across varying products. This complex and constantly evolving usage needs to be planned and managed with changing production plans to provide material forecast to suppliers. The challenge to Micron's team is optimize the planning and cost of materials by creating an accurate material forecast to ensure just in time delivery with optimal inventory level onsite that will not incur any material excess that can lead to high cost incurred or worse, shortages that cause production disruption.

In this Business Analytics Case Competition, we will take a deeper dive into the material planning to strategically meet the increasing demands of our production expansions.

Disclosure

In this challenge, all materials, figures, and numbers used are strictly arbitrary and have no reference to actual production in Micron Technology, Inc.

Challenge

Question 1:

As a Material Planning Engineer, you are tasked to provide material forecast for supply management team to negotiate and purchase necessary materials for production. The high complexity of the processes in semiconductor wafer production often causes the forecasting of material requirement to be challenging. Equipped with your knowledge in planning and forecasting, you are tasked to come up with a model to forecast the material usage, by utilizing data including but not limited to the process and/or material specifications given by process team, and historical actual usage of the material.

Your answers will be judged based on its Accuracy, Insights, and Creativity. Please provide all written answers in a report document in PDF format.

Table 1.1: Definition of Terms

Attribute	Definition
Lot	1 lot refers to 1 unit of product
Wafer	1 wafer refers to 1 unit of silicon disc within a lot
Load size	Number of wafers in a batch
Usage	Amount of material used to process a lot in a Step
Inventory	Amount of material stored on site to standby for production use
Batch Life	Number of batches that can be processed before the chemicals have to be replenished with fresh chemical
Reclaim %	Proportion of materials that can be reclaimed and reused
Chemical Life	The elapsed time before chemicals must be replenished with fresh chemicals
Wafer Projection	Projection of wafer demand in the production plan
Forecast	Total amount of material required by all steps in a specified period

Wafer Cleaning Process

One of the materials required for production is Sulphuric Acid (H_2SO_4). Sulphuric Acid (H_2SO_4) is used in the wafer cleaning process, where batch of wafers are "rinsed" in a tank. To put it simply, you can think of it like washing plates in the kitchen sink, where the Sulphuric Acid (H_2SO_4) acts as the water. This process is sensitive to the concentration of the chemicals in the tank. When the concentration falls below acceptable level, the chemicals must be discarded. The batch life and chemical life of the material determine when the chemical must be discarded and replenished with fresh chemical. Before replenishment, a portion of the chemicals can be reclaimed in a container and get recycled to be mixed with fresh chemicals to top up the tank (this is determined by the reclaim efficiency).

** **Chemicals in the tank must be dumped and replaced upon reaching batch life or chemical life, whichever earlier, except for the reclaimed portion of the chemicals that is collected and can be reused to top up the next tank.** Either batch life or chemical life will determine how much chemical is required in a week, with the assumption that the wafer processing is evenly distributed across 24 hours a day, 7 days a week.

Figure 1.1 Simple illustration of wafer cleaning process in the tank

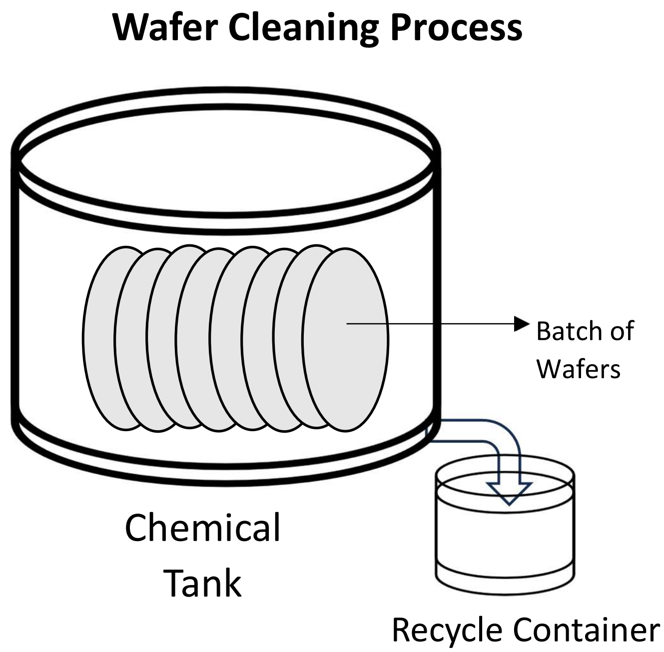
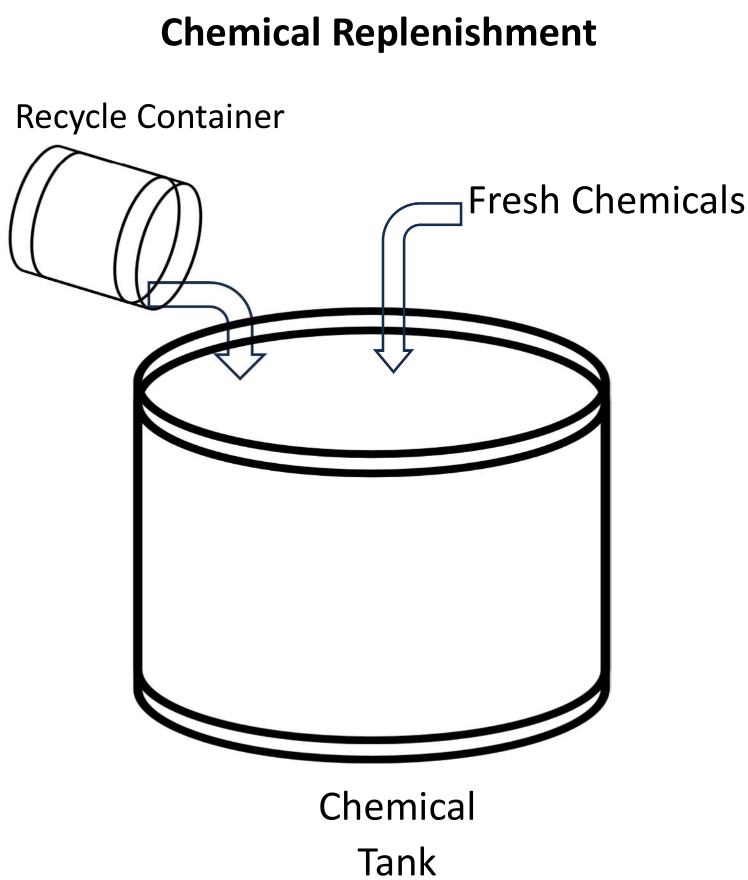


Figure 1.2 Illustration of Chemical Replenishment



Part a)

You managed to gather additional information from the Process team, Equipment team, and Production Planning team to help you with the forecasting of the Sulphuric Acid (H_2SO_4) usage.

Table 1.2: The current H_2SO_4 needed to produce 1 batch of product A and B.

Product	Batch Life	Loadsize (wafers)
A	5 to 7	35 to 38
B	7 to 8	45 to 52

Table 1.3: Wafer Projection for the next 10 weeks

Product	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10
A	3289	3566	2358	2951	2152	973	2453	2314	2347	2765
B	2100	2409	4090	1874	3893	3973	3615	3541	2900	2602

The equipment has a tank size of 80L and can be used to produce both product A and B. Historical data shows that the **reclaim efficiency of Sulphuric Acid (H_2SO_4) ranges from 4% to 9%,** and the **chemical life for Sulphuric Acid (H_2SO_4) is 500 minutes.**

Formulate a method to forecast Sulphuric Acid (H_2SO_4) and provide the forecast on the requirement for Sulphuric Acid usage in the next 10 weeks by studying the sets of data. The forecast will help the team to negotiate with the suppliers and ensure Micron has sufficient supply of the chemical for production. On top of the final forecast number for each week, please also share the approach that you take to tackle this challenge (Max 300 words).

Part b)

After running the production for the 5 weeks, you manage to obtain the information of the actual usage of Sulphuric Acid for the first 5 weeks.

Table 1.4: Actual Usage after the first 5 weeks

	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5
Actual Usage (L)	1686	1998	1858	1870	1894

With the actual usage data and given a chance to regenerate the forecast for the remaining 5 weeks, share how you would adjust your forecast by utilizing the historical usage data (Max 200 words)

Part c)

Given your experience in planning and forecasting for the usage in the short term, you are now tasked to model for the longer-term planning for the Sulphuric Acid material.

With some of the lesson learnt through the experience in part 1a and 1b and through your own research, **share what are the key factors that should be considered for the long term planning and inventory management of this material and how would you model in these factors** (Max 500 words)

Question 2:

As a Production Planning Engineer, you are tasked to develop a strategy to optimize the production plan while considering multiple constraints and challenges in the line. Consider the scenario below:

For lot production, the fab can run different recipes, and each recipe will have a different processing time, steps compatibility, and will require different materials combination and quantity. The fab has 3 equipments (Alpha, Beta, and Gamma) to process the lots. Below is the list of recipes that the fab can choose to run on each equipment, its required processing time, and the steps compatibility.

There are multiple recipes to choose from to run each of the steps as shown in the table below.

Table 2.1: Recipe Selection

Step	Recipe Selection
Step 1	A or B or D
Step 2	C or E
Step 3	B or D or E
Step 4	B or C
Step 5	A or C or D

Below is the list of recipe requirements, including its processing time and material usage.

Table 2.2: Recipe Processing Time Information

Recipe	Processing Time
A	4 hrs
B	3 hrs
C	5 hrs
D	2 hrs
E	6 hrs

Each of the equipment has different capabilities to run different recipes, and any recipe switch within the same equipment will require equipment downtime for chemical cleaning as shown below.

Table 2.3 Equipment Recipe Compatibility

Equipment	Recipe
Alpha	A, B, D, E
Beta	B, C, E
Gamma	A, C, D

Table 2.4 Recipe Switch Equipment Downtime (in hours)

Recipe Switch	A	B	C	D	E
A	-	1	1	3	1
B	1	-	1	1	2
C	1	1	-	1	2
D	3	1	1	-	2
E	1	2	2	2	-

Table 2.5: Recipe Material Usage (per run)

Recipe	Material	X Usage (L)	Y Usage (L)	Z Usage (L)
A	X	24	0	0
B	Y	0	22	0
C	X and Y	6	9	0
D	X and Y and Z	20	15	6
E	Y and Z	0	8	4

** Usage of materials X, Y and Z in table 2.5 are for 1 time process use and not per hour use. Materials are consumed during the process.

Table 2.6: Material Supply Information per week (assume that unused material will expire and need to be discarded each week)

Material	Pricing Tier ($/L)		
	0-50 L	51-500 L	>500 L
X	$200	$190	$175
Y	$300	$275	$250
Z	$240	$220	$205

Below is an illustration example of lots processing across 24 hours based on the recipe that the equipment is running.

Table 2.7: Illustration Example of Lots Processing

	Equipment Alpha			Equipment Beta			Equipment Gamma		
Recipe Capability	A,B,D,E			B,C,E			A,C,D		
Hours	**Lot**	**Recipe**	**Step**	**Lot**	**Recipe**	**Step**	**Lot**	**Recipe**	**Step**
1	1	A	1	2	B	1	3	A	1
2	1	A	1	2	B	1	3	A	1
3	1	A	1	2	B	1	3	A	1
4	1	A	1	SWITCH	SWITCH	SWITCH	3	A	1
5	SWITCH	SWITCH	SWITCH	1	C	2	SWITCH	SWITCH	SWITCH
6	SWITCH	SWITCH	SWITCH	1	C	2	SWITCH	SWITCH	SWITCH
7	SWITCH	SWITCH	SWITCH	1	C	2	2	C	2
8	4	D	1	1	C	2	2	C	2
9	4	D	1	1	C	2	2	C	2
10	SWITCH	SWITCH	SWITCH	SWITCH	SWITCH	SWITCH	2	C	2
11	SWITCH	SWITCH	SWITCH	IDLE	IDLE	IDLE	2	C	2
12	1	B	3	2	B	3	3	C	2
13	1	B	3	2	B	3	3	C	2
14	1	B	3	2	B	3	3	C	2
15	1	B	4	SWITCH	SWITCH	SWITCH	3	C	2
16	1	B	4	SWITCH	SWITCH	SWITCH	3	C	2
17	1	B	4	4	E	2	2	C	4
18	SWITCH	SWITCH	SWITCH	4	E	2	2	C	4
19	SWITCH	SWITCH	SWITCH	4	E	2	2	C	4
20	1	D	5	4	E	2	2	C	4
21	1	D	5	4	E	2	2	C	4
22	5	D	1	4	E	2	2	C	5
23	5	D	1	IDLE	IDLE	IDLE	2	C	5
24	IDLE	IDLE	IDLE	IDLE	IDLE	IDLE	2	C	5

Your answer should strictly adhere to the following constraints:

- A lot is required to run from Step 1 to Step 5 sequentially, after which it will be a finished product.
- Each recipe must run to completion for each lot for each step in the same equipment.
- A lot that has not completed the full Step 1-5 sequence will not count as a completed product and thus will not be sellable at the end of the 168 hours.

Part a)

List down all the constraints and restrictions that you need to adhere to before building the optimal production plan.

Part b)

Assume the selling price of each completed lot to be $40,000.

Using the above information, propose an optimal production plan for 7 days (168 hours) that is most profitable for the company (**<u>Do fill in the necessary answers that you obtained in the excel sheet named "Answer Sheet" provided in the question folder)</u>**

Briefly explain your answers/approach (max 200 words)

<u>Instructions when filling up Excel:</u>

1. Input your solution with only "Lot Number", "Recipe Letter", "Step Number", "SWITCH", OR "IDLE".

2. Unused hours in equipment to be filled with "IDLE" for all "Lot", "Recipe" and "Step" respectively.

3. Do not merge the cells and fill it with any other letters or words.

4. Fill in the yellow cells with the usage of each Recipe and Material, number of completed Lots, and calculate your revenue, cost, and profit over the 168 hours.