UGBA 141
Discussion 2

Agenda

- Review and practice problems covering : flow rate, utilization, cycle time, time to produce x items, labor content/cost/utilization

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Recap

- Process capacity

  bottleneck smallest capacity.

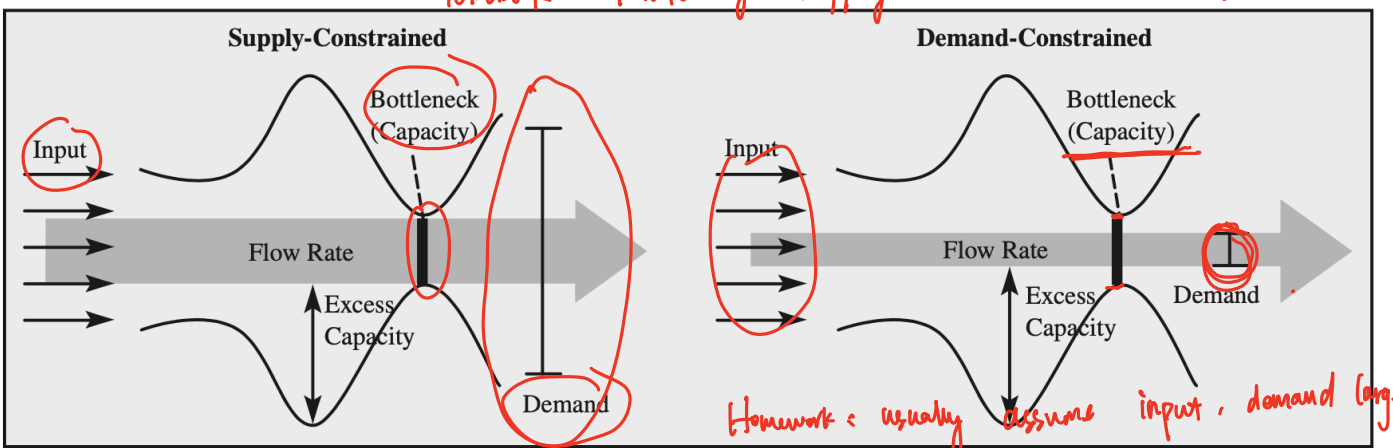
  Process capacity = Minimum {Capacity of resource 1, …, Capacity of resource n }

  units / time

- Flow rate

  Flow rate = Minimum { Available input, Demand, Process capacity }

Textbook : Matching supply Demand (MSD)



Homework : usually assume input, demand large

X → flow rate ≤ process capacity

Review: Utilization and Implied Utilization

- Utilization

$$\text{Utilization} = \frac{\text{Flow rate}}{\text{Capacity}} \leq 1$$

$= 100\%$. percentage.

- Implied utilization

$$\text{Implied utilization} = \frac{\text{Demand}}{\text{Capacity}}$$

implied utilization can be larger than 1

- It always holds that utilization $\leqslant$ implied utilization

if implied utilization > 1

Demand $>$ Capacity

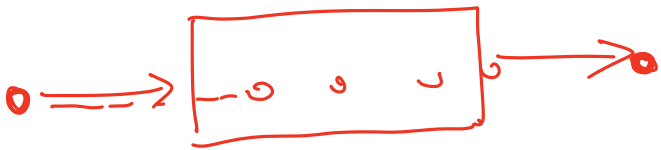
Review: Time to Fulfill Units

- Time to fulfill X units (with steady state)

$$\text{Time to fulfill } X \text{ units} = \frac{X}{\text{Flow rate}}$$

- Time to fulfill X units (starting with an empty system)

$$\text{Time to fulfill } X \text{ units starting with an empty system} = \text{Time though an empty process} + \frac{X-1}{\text{Flow rate}}$$



Practice Problem

(Yoggo Soft Drink) A small, privately owned Asian company is producing a private-label soft drink, Yoggo. A machine-paced line puts the soft drinks into plastic bottles and then packages the bottles into boxes holding 10 bottles each. The machine-paced line is comprised of the following four steps: (1) the bottling machine takes 1 second to fill a bottle, (2) the lid machine takes 3 seconds to cover the bottle with a lid, (3) a labeling machine takes 5 seconds to apply a label to a bottle, and (4) the packaging machine takes 4 seconds to place a bottle into a box. When a box has been filled with 10 bottles, a worker tending the packaging machine removes the filled box and replaces it with an empty box. Assume that the time for the worker to remove a filled box and replace it with an empty box is negligible and hence does not affect the capacity of the line. At step 3 there are two labeling machines that each process alternating bottles; that is, the first machine processes bottles 1, 3, 5, . . . and the second machine processes bottles 2, 4, 6, ... Problem data are summarized in the table following.

Process Step	Number of Machines	Seconds per Bottle
Bottling	1	1
Applying a lid	1	3
Labeling	2	5
Packaging	1	4

Practice Problem: Solution

Process Step	Number of Machines	Seconds per Bottle
(1) Bottling	1	1
(2) Applying a lid	1	3
(3) Labeling	2	5
(4) Packaging	1 → 2	4

bottleneck

Capacity
3600
1200
1440
900.

a. What is the process capacity (bottles/hour) for the machine-paced line? What is the bottleneck in the process?

(1) $\frac{1}{1} \times 3600\ s/hr = 3600$ (3) $\frac{2}{5} \times 3600 = 1440$

(2) $\frac{1}{3} \times 3600 = 1200$ (4) $\frac{1}{4} \times 3600 = 900$ packaging

b. If one more identical packaging machine is added to the process, how much is the increase in the process capacity going to be (in terms of bottles/hour)?

after adding packaging. $\frac{2}{4} \times 3600 = 1800$

3600, 1200, 1440, 1800..

Applying a lid.

1200 bottles/hour.

1200 − 900 = 300

c. How long does it take to produce 20 boxes if there is no drinks in the beginning? Recall that a box consists of 10 bottles.

20 box × 10 bottle/box = 200 bottles

Time to produce 200 bottles (hours) = $(1_5 + 3_5 + 5_5 + 4_5)/3600 + \frac{200-1}{900} = \ldots$

d. What is the implied utilization of the packaging machine if the demand rate is 60 boxes/hour?

60 × 10 = 600 bottles/hour

implied utilization = $\frac{\text{Demand}}{\text{capacity}} = \frac{600}{900} = 66.67\%$

Review: Labor Productivity

- Labor content

Labor content = Sum of processing times with labor

- Cycle time

$$\text{Cycle time} = \frac{1}{\text{Flow rate}}$$

- Cost of direct labor

$$\text{Cost of direct labor} = \frac{\text{Total wages}}{\text{Flow rate}}$$

Review: Labor Productivity (Cont.)

- Average labor utilization

$$\text{Average labor utilization} = \frac{\text{Labor content} \times \text{Flow rate}}{\text{Number of workers}}$$

- Idle time across all workers at resource i

$$\text{Idle time across all workers at resource } i = \text{Cycle time} \times (\text{Number of workers at resource } i) - \text{Processing time at resource } i$$

- Idle time

$$\text{Idle time for a single worker} = \text{Cycle time} - \text{Processing time of the single worker}$$

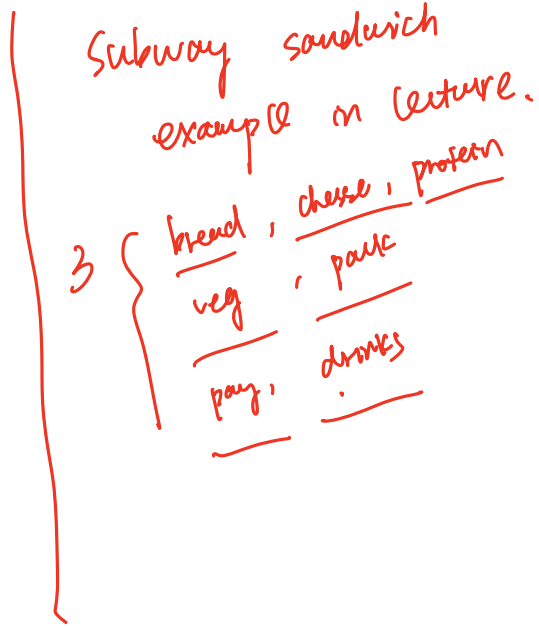
Practice Problem

(12 Tasks to 4 Workers) Consider the following tasks that must be assigned to four workers on a conveyor-paced assembly line (i.e., a machine-paced line flow). Each worker must perform at least one task. There is unlimited demand.

	Time to Complete Task (seconds)
Task 1	30
Task 2	25
Task 3	15
Task 4	20
Task 5	15
Task 6	20
Task 7	50
Task 8	15
Task 9	20
Task 10	25
Task 11	15
Task 12	20

The current conveyor-paced assembly-line configuration assigns the workers in the following way:

- Worker 1: Tasks 1, 2, 3
- Worker 2: Tasks 4, 5, 6
- Worker 3: Tasks 7, 8, 9
- Worker 4: Tasks 10, 11, 12



Practice Problem: Solution

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- Worker 1: Tasks 1, 2, 3
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a. What is the direct labor content?

$30 + 25 + 15 + 20 + 15 + 20 + 50 + 15 + 20 + 25 + 15 + 20 = 270$

b. What is the flow rate and what is the cycle time?

$\frac{1}{70}, \frac{1}{55}, \frac{1}{85}, \frac{1}{60}$.

flow rate $\frac{1}{85}$ cycle time 85 s

c. What is the idle time of each worker?

cycle time 85.

worker 1 $85 - 70 = 15$ s

worker 2 $85 - 55 = 30$ s

worker 3 $85 - 85 = 0$ s

worker 4 $85 - 60 = 25$ s

d. What is the average labor utilization (do not consider any transient effects such as the line being emptied before breaks or shift changes)?

$$= \frac{\text{Labor content} \times \text{flow rate}}{\text{number of workers}} = \frac{270 \times \frac{1}{85}}{4} = \frac{270}{340}$$