

OM 380.17 Bagchi & Gutierrez**Group Homework – 2 (worth 2.5% of your course grade)****Names of Group Members and Index Numbers**

Name (First, Last)	Index Number	Signature
Aditya Chawla	7	Aditya Chawla
Anvesh Karangula	19	Anvesh Karangula
Sanyam Jain	16	Sanyam Jain

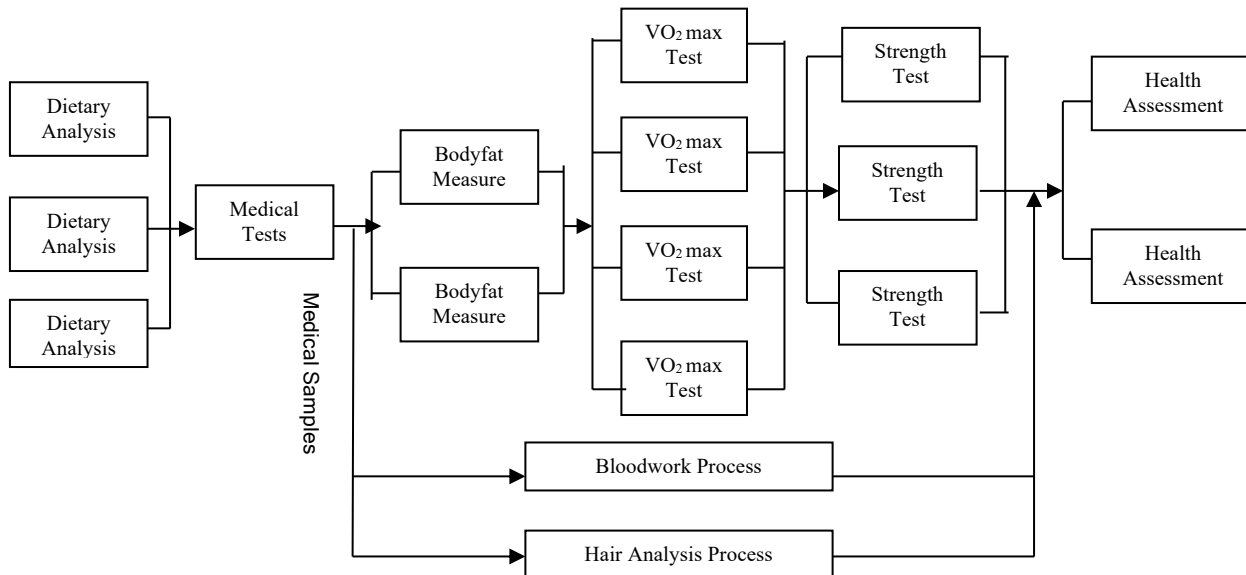
***** By signing my name, I am affirming that:**

- **I have read the course syllabus.**
- **I have contributed as expected toward the fulfillment of this assignment.**
- **The work our group is turning in is the work product of our group.**
- **Our group did not get outside help in fulfilling this assignment.**

This homework consists of two exercises requiring answers to twenty-five individual questions. Please place each of your answers inside the rectangular box that follows each question.

Your submission must have this page as the cover page. Please submit on Canvas by the beginning of class on the day the assignment is due.

Exercise 1. You are the owner of Total Health Clinic (THC), a new health-related clinic specializing in diet and fitness assessment. Clients, typically sponsored by their employer, arrive at the clinic and undergo a series of tests to assess their current overall health status. Upon completion of the tests, the client meets with a specialist for a detailed discussion of their current physical status along with specific recommendations for improvement. The layout of the process is shown below:



Please note that the potential buffer areas (triangles) are left out of the drawing for the sake of simplicity; however, there is the possibility of waiting before each stage. The client waits for the process to begin. The process starts with a “Dietary Analysis” followed by “Medical Tests” where blood is drawn and hair samples are collected. There is a split in the process at this point: blood samples are routed to the “Bloodwork Process”, hair samples are sent to the “Hair Analysis Process”, and the client continues with “Bodyfat Measure”, the “VO₂ max Test”, and a “Strength Test.” Finally, after all tests are complete and the results are available to the specialist, the process ends with a personalized “Health Assessment.” The equipment, labor and processing times on a per-workstation basis are shown below for each stage in the process. Note that there are multiple stations in many stages (e.g. three in Dietary Analysis). Of course, a client/order needs to be processed at just one station in each stage. **Note also that each of the two Bodyfat Measure stations employs 2 techs.**

Stage	Equipment per Station	Labor per Station	Processing Time (minutes)
Dietary Analysis	Computer	1 dietician	12 min
Medical Tests	Test Unit	1 nurse	5 min
Bodyfat Measure	Scanner	2 techs	10 min
VO ₂ max Test	Erg	1 tech	24 min
Strength Test	Mini Gym	1 tech	15 min
Bloodwork	Profiler	1 med-tech	5 min
Hair Analysis	Incinerator	1 med-tech	5 min
Health Assessment	Computer	1 MD	8 min

Assume that at the stated processing times, all equipment and labor resources are fully utilized.

THC is open to clients at 8 am on every working day but no client is admitted after 5 pm. The working day ends when the last client has been processed. Assume 5 days/week, 50 weeks/year, for a total of 250 days/year.

(a) Calculate (below) the capacity (in clients per hour) for each stage.

Stage	Capacity (clients per hour)
Dietary Analysis	Capacity per Dietary Analysis station = $60/12 = 5$ clients per hour Total capacity (3 stations) = $3*5 = 15$ clients/hour
Medical Tests	Capacity = $60/5 = 12$ clients per hour
Bodyfat Measure	Capacity per station = $60/10 = 6$ clients per hour Total capacity (2 stations) = $2*6 = 12$ clients per hour
VO ₂ max Test	Capacity per station = $60/24 = 2.5$ clients per hour Total capacity (4 stations) = $4*2.5 = 10$ clients per hour
Strength Test	Capacity per station = $60/15 = 4$ clients per hour Total capacity (3 stations) = $3*4 = 12$ clients per hour
Bloodwork	Capacity = $60/5 = 12$ clients per hour
Hair Analysis	Capacity = $60/5 = 12$ clients per hour
Health Assessment	Capacity per station = $60/8 = 7.5$ clients per hour Total capacity (2 stations) = $2*7.5 = 15$ clients per hour

(b) Where is the bottleneck in this process?

Bottleneck in the process is the one which takes most of the time and whose capacity is less. Here the bottleneck is **VO2 max test** whose capacity is 10 clients per hour

(c) What is the steady-state process capacity (in clients/hour)?

Steady-state process capacity = Bottleneck capacity = **10 clients per hour**

(d) What is the rush order flow time (in minutes)?

Total time taken for the rush order flow

= Dietary Analysis time + Medical tests time + **Max**(Bloodwork process time, Hair analysis time, (Bodyfat measure + VO2 max + Strength test)) + health assessment time

$$= 12 + 5 + \text{Max}(5, 5, 10+24+15) + 8 = 74 \text{ min}$$

(e) On a particular day, 25 clients from the same employer are the first to arrive at THC at 8 am. The employer will send a bus to pick up all 25 employees as soon as all of them have been processed by THC. Assuming a steady-state flow rate of 10 clients/hour, how many minutes past 8 am will it be before these 25 clients will have been processed?

Assuming a steady state flow rate of 10 clients/hour. Rush order time is 74 minutes.

$$\text{Time taken to process 25 clients} = 74 + (24/10) \times 60 = 74 + 144 = 218 \text{ minutes}$$

Hence, it takes a total of **218 minutes** past 8am to process 25 clients.

(f) Assuming a steady-state flow rate of 10 clients/hour, what is the steady-state utilization (in percentage) of the stations in the Dietary Analysis stage?

Capacity of Dietary Analysis stage = 15 clients per hour

$$\text{Steady-state utilization of the Dietary analysis stage} = 10/15 = 66.66\%$$

(g) Assuming a client arrival rate of 8 clients/hour and a steady-state process capacity of 10 clients/hour, what is the steady-state utilization (in percentage) of the stations in the Dietary Analysis stage?

Client arrival rate = 8 clients/hour

Capacity of Dietary Analysis stage = 15 clients /hour

Steady-state capacity = 10 clients /hour

$$\text{Steady-state utilization of the Dietary analysis stage} = \min(8, 10)/15 = 8/15 = 53.34\%$$

(h) Assuming a client arrival rate of 8 clients/hour and a steady-state process capacity of 10 clients/hour, what is the steady-state utilization (in percentage) of THC?

Client arrival rate = 8 clients/hour

Steady-state capacity = 10 clients /hour

$$\text{Steady-state utilization of THC} = 8/10 = 80\%$$

(i) Assuming a steady-state flow rate of 10 clients/hour, what is the steady-state labor utilization (in percentage) in this process?

Steady state flow rate = 10 clients/hour

Assume that the labor utilization is proportional to the stage utilization.

Labor utilization = (Stage utilization rate)* (total labor for the stage)

Total labor available = $3+1+4+4+3+1+1+2 = 19$

Stage	Labor utilization
Dietary Analysis	$(10/15)*3 = 2$
Medical Tests	$(10/12)*1 = 0.83$
Bodyfat Measure	$(10/12)*4 = 3.33$
VO ₂ max Test	$(10/10)*4 = 4$
Strength Test	$(10/12)*3 = 2.5$
Bloodwork	$(10/12)*1 = 0.83$
Hair Analysis	$(10/12)*1 = 0.83$
Health Assessment	$(10/15)*2 = 1.33$

Total labor utilized = $2+0.83+3.33+4+2.5+0.83+0.83+ 1.33 = 15.65$

Labor utilization = $15.65/19 = 0.8237 = \mathbf{82.37\%}$

Exercise 2. JiffyPhysical - a chain of small clinics - has contracted with NASA to conduct physical examination of prospective amateur astronauts. The table below lists the various tasks that need to be performed in a physical examination:

Task	Task Description	Duration (in minutes)
A	Review application	6
B	Health history	21
C	Lab procedure	26
D	Nurse's visit	16
E	Doctor's visit	16
F	Report preparation	15

Task F has to follow every other task and Task A has to precede every other task. Furthermore, Task E has to follow tasks A-D. Every task requires the presence of the client and the client can be in only one task at a time.

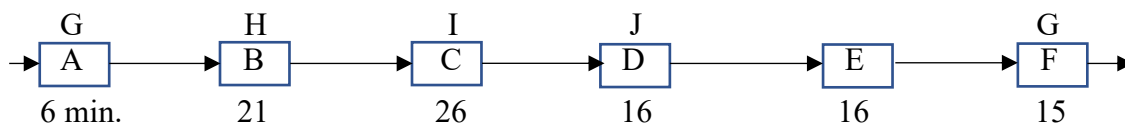
The current process is staffed with:

4 nurses (Glenda, Hedda, Isadore, and Janice) who collectively perform Tasks A-D and F;

1 doctor (Kristina) who performs Task E.

All nurses are cross-trained to perform each other's tasks. However, Task E can only be performed by the doctor who will perform no other task. In drawing process flow diagrams for this problem, we denote which nurse is assigned to which task by writing the initial of the nurse (G, H, I, and J) on top of the task notation.

(a) As the process flow diagram shows, currently, each client progresses through the six tasks in the sequence A-B-C-D-E-F. Glenda performs Tasks A and F, Hedda performs Task B, Isadore performs Task C, and Janice performs Task D.



(i) Which employee is the bottleneck?

Employee's capacity

Employee	Capacity (clients per hr)
G	$(60/(6+15)) = 2.86$
H	$60/21 = 2.86$
I	$60/26 = 2.31$
J	$60/16 = 3.75$
K	$60/16 = 3.75$

Employee Isadore is the bottleneck here with a capacity of 2.31 clients per hour.

(ii) What is the process capacity (in clients/hour)?

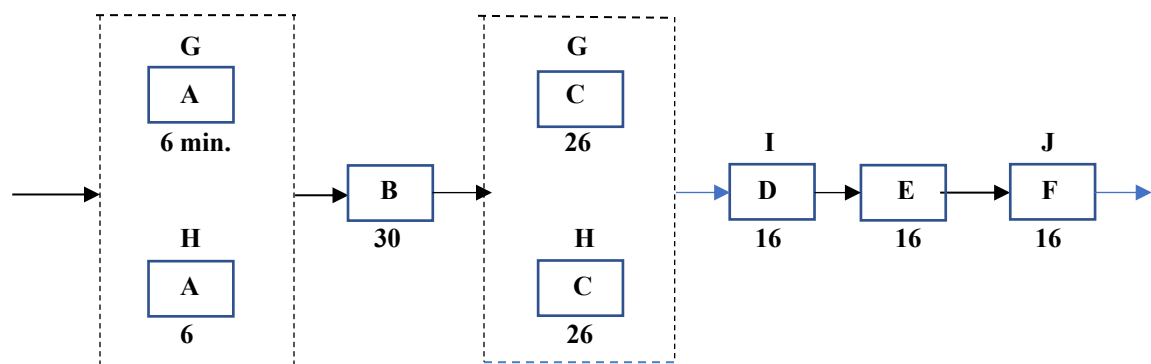
Process capacity = bottleneck capacity = **2.31 clients per hour**

(iii) What is the rush order flow time (in minutes)?

$$\text{Rush order flow time} = 6 + 21 + 26 + 16 + 16 + 15 = \mathbf{100 \text{ minutes}}$$

(b) You want to redesign the process to increase process capacity. On closer examination you find that Task B can be performed by the client without the presence of a nurse. However, if Task B is performed by the client then the task time of B will increase to 30 minutes and the task time of F will increase to 16 minutes. Union rules prohibit assigning more than two different tasks to a nurse.

Consider the redesigned process below where the client performs Task B, each client progresses through the six tasks in the sequence A-B-C-D-E-F, and for tasks A and C, Glenda and Hedda are alternative resources. (See if can you convince yourself that this redesigned process maximizes process capacity.)



(i) What is Glenda's capacity (in clients/hour)?

Employee's capacity

Employee	Capacity (clients per hr)
G,H	Time available = 120 min. $120/(6+26) = 120/32 = 3.75$
I	$60/16 = 3.75$
J	$60/16 = 3.75$
K	$60/16 = 3.75$
Client (task B)	$60/30 = 2$ (but clients can perform tasks in parallel. Hence this capacity is not the bottleneck)

Combined capacity of both Glenda and Hedda = 3.75 Clients/hour

Hence, Glenda's capacity = $3.75/2 = \mathbf{1.875 \text{ Clients/hour}}$

(ii) What is Isadore's capacity (in clients/hour)?

Isadore's capacity = **3.75 Clients/hour**

(iii) What is Kristina's capacity (in clients/hour)?

Krishna's capacity = **3.75 Clients/hour**

(iv) What is the process capacity (in clients/hour)?

Since task B cannot be considered as a bottleneck since it is performed by the clients themselves and can be performed in parallel, process capacity = **3.75 Clients/hour**

(v) What is the rush order flow time (in minutes)?

Rush order flow time = $6+30+26+16+16+16 =$ **110 minutes**

(vi) What would be the overall labor utilization (in percentage) if clients arrived at the rate of 3/hour?

Since all the employee's capacity is same and is 3.75 clients per hour , overall labor utilization = $3/3.75 = 0.8 =$ **80%**