commerce
undergraduate
society

COMM 204 (Tim Huh)
Midterm Exam Review Session

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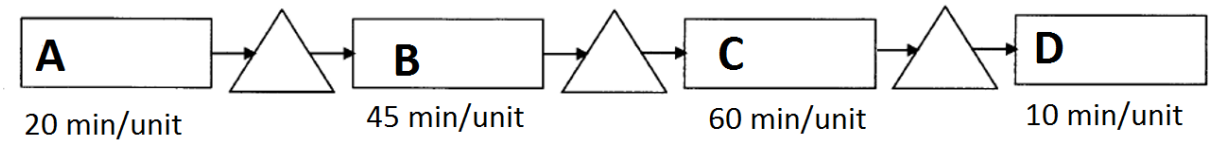
PROCESS FLOW ANALYSIS

Capacity Rates

Below is a flow diagram for the production process of CMP Brewery. Currently, the process is being used to make units of beer. Production times (per unit) are included on the diagram.



(a) What is the maximum throughput rate for CMP beer?

Capacity Rates for the Processes are as follows:

A: 3 units/hr B: 1.33 units/hr C: 1 unit/hr D: 6 units/hr

Bottleneck is Part C, therefore the maximum throughput rate (capacity rate) is 1 unit/hr.

(b) What is the cycle time of this process?

Since the capacity rate is 1 unit/hr, the cycle time is 60 minutes.

(c) What is the theoretical flow time?

Flow time is the sum of production times: 20+45+60+10=135 minutes

(d) Assume that the operator of part B has come up with an innovation that has reduced processing time from 45 minutes to 5 minutes. As a result, the throughput rate will (circle one)

i. increase ii. decrease **iii. remain the same**

Part C is the bottleneck, so a decrease in processing time in part B will have no effect on throughput

(e) Assume that the operator of part B has come up with an innovation that has reduced processing time from 45 minutes to 30 minutes. As a result, the flow time will (circle one)

i. increase **ii. decrease** iii. remain the same

Flow time is not the same as throughput time. Regardless, flow time always decreases whenever any process becomes more efficient. **Even if it is not the bottleneck.**

(f) When the demand rate = capacity rate of the process, what is the short run utilization of

i. Resource A: 33% = (20/60) ii. Resource B: 75% = (45/60)

iii. Resource C: 100% = (60/60) iv: Resource D: 17% = (10/60)

Utilization is based on bottleneck resource. Note how resource C has 100% short run utilization

Little's Law

Suppose you work on a metal compactor that processes 20 kilograms of metal per hour. Your current job is estimated to be completed in 3 hours. Using Little's Law how many kilograms of metal are waiting to be compacted at the beginning of your task?

$L=\lambda \cdot W$

$L=(20kg/hr)(3hr)=60kg$ of metal

How would you reduce the time scrap metal stays in the servicing queue?

- Increase throughput rate
- Decrease quantity of metal to be processed (inventory)

How would you increase throughput rate of the compactor?

- Decrease throughput time
- Increase "inventory"

Note On Asset Turnover in Little's Law

You are the operator of a very lucrative textbook selling service. On average, each textbook only stays in inventory for about 4 days. How often does your entire supply of textbook turnover?

Asset Turnover = 1/T = 1/4 = 0.25 times.

You check inventory and see that you currently have 300 textbooks in stock, based on your calculated asset turnover, at what rate are your textbooks being sold (on a daily basis)?

Asset Turnover = R/I

0.25 = R / 300 R = 75 books/day

Inventory Buildup

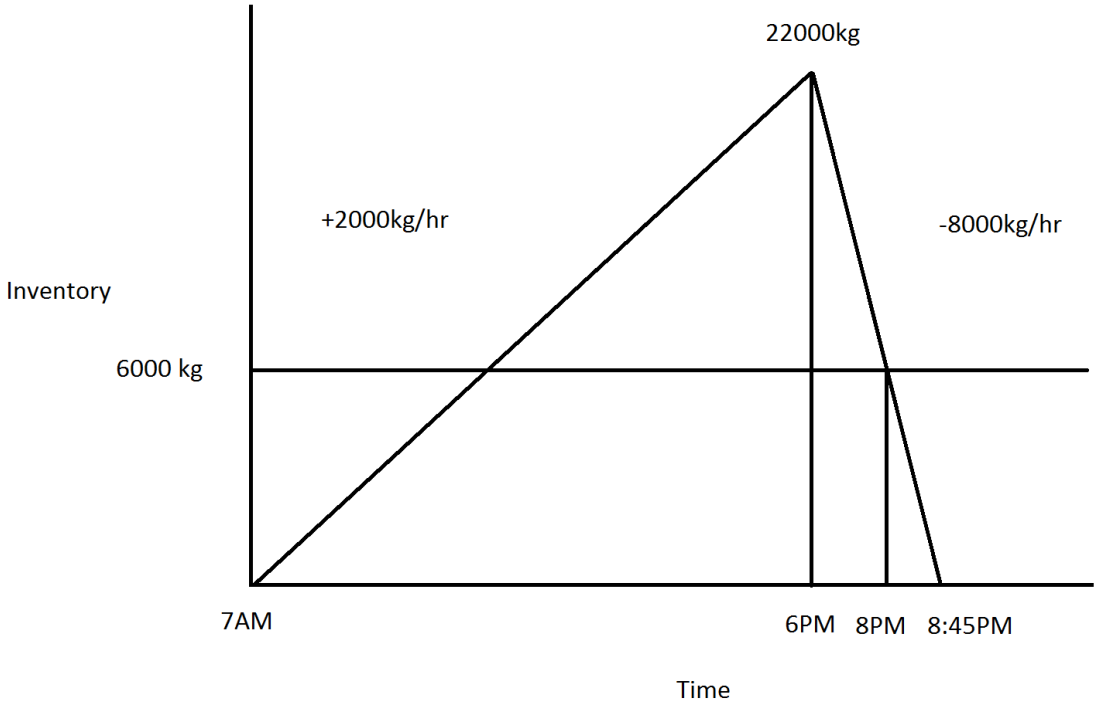
The National Cranberry Cooperative receives blueberries delivered by trucks each workday from 7am to 6pm. Each day, 10,000 kg of berries are delivered per hour. The trucks dump the berries in a bin that can hold 6000 kg of berries, and must wait if the bin is full. The plant pocesses 8,000 kg of berries per hour. Assume that the berries arrive continuously over time and each truck holds 1000kg of berries.

a) Draw a detailed inventory buildup diagram with time on the horizontal and inventory on the vertical axes. Calculate the time when:

i. Inventory reaches the peak (6PM)

ii. When the last waiting truck leaves (8PM)

iii. When the plant finishes processing all the berries (8:45PM)



b) Among the trucks that do wait, how long is the average wait?

Area = 80,000 kg waiting hours = 80000kg waiting hrs / (1000 kg/truck) = 80 truck waiting hrs

80 trucks arrive from 10am to 6pm (10 trucks/hr) and do wait. Hence the average waiting time among those trucks that do wait is 80 truck waiting hrs/ 80 trucks = **1 hour**

Multiple Units

Product A goes through the following workstations: V (25 min), Y (5 min), and X (30 min). Product B: Y (15 min) and X (25 min). Product C: W (20 min), Z (10 min), X (15 min) and Y (5 min). Product D: W (20 min), Z (5 min) and Y (30 min). Product E: V (20 min), W (30 min), Z (10 min). Product F: X (30 min) The weekly demand for the products is given by A: 70 units, B: 60 units, C: 75 units, D: 90 units, E: 80 units, F: 50 units. There are 5 workers (1 for each of the 5 work centers V, W, X, Y, Z)

(a) Which of the workstations has the highest total workload, and thus serves as the bottleneck?

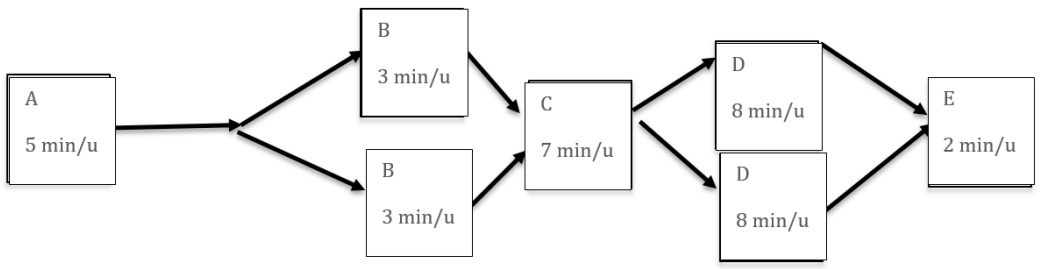
	A	B	C	D	E	F	70A+60B+75C+90D+80E+50F
V	25	0	0	0	20	0	3350
W	0	0	20	20	30	0	5700
X	30	25	15	0	0	30	6225
Y	5	15	5	30	0	0	4325
Z	0	0	10	5	10	0	3000

X is the bottleneck at 6225 minutes

(b) Can the firm meet the demand if the plant runs 3 shifts/day (=150 hours/week)?

Yes, it can: 6225 minutes = 103 hours and 45 minutes.

The following is a simple process



What is the capacity rate for each resource? Also determine the bottleneck

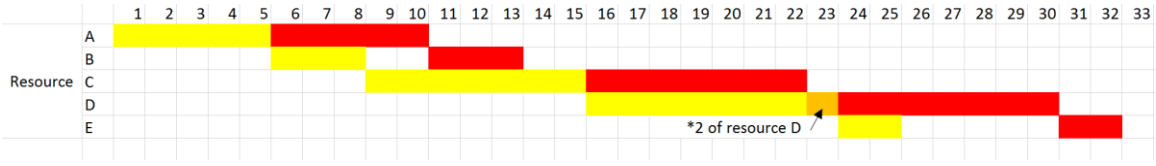
A: 12 units/hr B: 40 units/hr C: 8.6 units/hr D: 15 units/hr E: 30 units/hr

Bottleneck is C

How long does it take to produce 1 unit?

25 minutes (trick question, having 2 of resource B and D does not change the flow time)

How long does it take to produce 2 units? 32 minutes (note we could have added flow + cycle time)



PROCESS AND VARIABILITY

OM Triangle

Which of the following is/are not a tradeoff element in the OM Triangle?

A. Capacity B. Efficiency C. Information D. Inventory E. Performance

Queuing Analysis

The Sauder Undergraduate Office currently has 2 receptionists at the desk. Students arrive at the UGO at a rate of 10 per hour. Each receptionist can service 20 per hour if need be. What type of queue model is this?

M/M/2

Imagine that 1 of the 2 receptionists goes on his break so currently there is only 1 server. Answer the question i-v maintaining the same arrival and service rate as the previous question. What:

i. type of queue model is this?
ii. are the number of students in the system?
iii. are average time each student spends in the system?
iv. are number of students waiting in the queue?
v. are average time each student waits in the queue?
vi. is the probability that no students are waiting in the queue?

i. M/M/1
ii. L_s = 1 student
iii. W_s = 0.1 hours = 6 minutes
iv. L_q = 0.5 students
v. W_q = 0.05 hours = 3 minutes
vi. 1-(10/20) = 50%

Take the following parameters for a queue model:

- Average arrival rate: 15 minutes with standard deviation of 5 minutes
- Average service rate: 25 minutes with standard deviation of 7 minutes
- There are 7 operators

What is the average wait time for a customer in the queue?

Use the P-K formula

$\lambda = \frac{1}{15}$ =0.066 min/person

$\mu = \frac{1}{25}$ =0.04 min/person

$C_a = \frac{5}{15} = 0.333$

$C_b = \frac{7}{15} = 0.466$

$\rho = 0.238095$

$L_q = 6.936195 \times 10^{-4}$ people

$W_q = 0.0104$ minutes

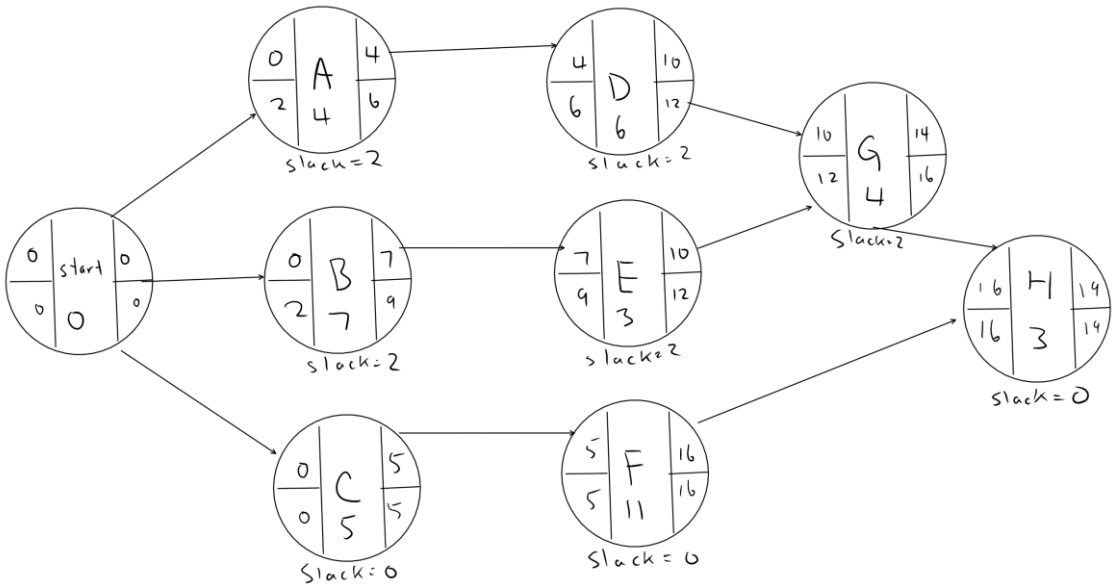
Project Management

Your company has just received an order for a specially designed electric motor. The contract states that if the project is not completed 12 days from now, then beginning on the 13th day, your firm will experience a penalty of $300 per day. The table below shows the activities that need to be completed for this project, along with data on direct costs and precedence relationships. (Crash Time represents the minimum time of each activity if it was completely crashed; the Crash Cost represents the cost of each activity if it is crashed to its minimum.)

Activity	Normal time	Normal cost	Crash time	Crash cost	Predecessor
A	4 days	$1000	3 days	$1300	-
B	7 days	$1400	4 days	$2000	-
C	5 days	$2000	4 days	$2700	-
D	6 days	$1200	5 days	$1400	A
E	3 days	$900	2 days	$1100	B
F	11 days	$2500	6 days	$3750	C
G	4 days	$800	3 days	$1450	D & E
H	3 days	$300	1 days	$500	F & G

a) Draw the network diagram: include ES, EF, LF, LS, and Slack on each node.
b) What completion date do you recommend for the project? (Hint: It will be better to incur the penalty cost, if the cost of reducing the duration of the project is greater than $300.) What is the project cost for that project length?

a) Critical Path C-F-H: 19 days



b)

Activity	Normal time	Normal cost	Crash time	Crash cost	Crashable Days	Crash Cost/Day
A	4 days	$1000	3 days	$1300	1	300
B	7 days	$1400	4 days	$2000	3	200
C	5 days	$2000	4 days	$2700	1	700
D	6 days	$1200	5 days	$1400	1	200
E	3 days	$900	2 days	$1100	1	200
F	11 days	$2500	6 days	$3750	5	250
G	4 days	$800	3 days	$1450	1	650
H	3 days	$300	1 days	$500	2	100

Crashable tasks: C, F, H (on critical path)

First, crash H (the lowest daily crash cost activity: $100/day). We crash H by 2 days (maximum amount that H can be crashed). This incurs additional cost: $100/day for 2 days = $200. But shortening 2 days reduces penalty by $600.

Paths: A-D-G-H = 15 days B-E-G-H = 15 days C-F-H = 17 days (critical path)

Crashable tasks: C, F (on critical path)

Secondly, we crash F, which costs $250/day, lower than crashing C.

Crash F by 2 days (maximum amount that critical path can be reduced before other paths become critical). This incurs additional cost: $250/day for 2 days = $500.

But shortening 2 days reduces penalty by $600. Paths: A-D-G-H = 15 days (critical path) B-E-G-H = 15 days (critical path) C-F-H = 15 days (critical path)

Crashable tasks: A, B, C, D, E, F, G

Reducing the duration of the project further requires crashing at least 2 of these activities simultaneously. By inspection, we see that combining any two activities will always cost more than the daily penalty $300. So we do not want to further reduce the project duration, and 15 days is the optimal length. Sum of normal costs = $10,100

Sum of crash costs = $200 + $500 = $700

Sum of penalty cost = $300 / day x (15-12) days = $ 900

Cost of project = $10,100 + $900 + $700 = $11,700.

The following is information regarding a construction project. Fill in the blanks and answer the questions that follow (Hint: questions build on one another):

Activity	Predecessor	Pessimistic Time	Most Likely Time	Optimistic Time	Slack	Mean	Variance
J	-	15	10	8	0	10.5	1.361
K	-	9	8	7	5.5	8	0.111
L	J	10	6	5	1.5	6.5	0.694
M	J	3	3	3	0	3	0
N	K & M	9	5	1	0	5	1.778
O	K & M	10	7	4	5.5	7	1
P	L & N	10	8	3	0	7.5	1.361

What is the critical path?

J-M-N-P

What is the expected (mean) and variance of the duration of the critical path?

10.5+3+5+7.5=26 days

Project variance = 1.361+0+1.778+1.361=4.5 *only count the variance of the critical path

What is the probability that the project will be completed in fewer than 30 days?

St. Dev = $\sqrt{4.5} = 2.121$ $Z = \frac{30-26}{2.121} = 1.8856$ P(t<30)=0.9699=97%

Alternatively: in excel =NORM.DIST(30,26,SQRT(4.5),TRUE) ~ 0.970327