ISyE 3104 Exam 1 – Part I of II
Instructor: Damon P. Williams, Ph.D.

Name (Print Neatly): At Solutions

Point values are indicated next to each problem – please take these into consideration as you budget your time during the exam. If you are having difficulty with a question, sometimes it is beneficial to work on another question, and then come back.

You must show your work in order to receive full credit. Clearly identify your final answers (with a box, etc.) A lack of neatness and legibility can result in a reduction of your grade.

This is a closed book, closed notes exam; you are permitted to use the following in the exam:

- Calculator
- Pencil & erasers

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Points Summary

Question	Points	Out of
True/False		14
Multiple Choice		14
Short Answer #1		26
Part I Subtotal		**54**

I. **True/False – Please circle either T for 'TRUE' or F for 'FALSE'. (2 points each)**

1. T -or- F If the raw process time is halved, then the worst case throughput is doubled.
2. T -or- F Sojourn time of a given routing or line is the time allotted for production of a part on that routing or line
3. T -or- F If you speed up the bottleneck workstations, when the WIP level is smaller than the critical WIP level, then the cycle time will increase.
4. T -or- F Limiting buffers reduces cycle time at the cost of decreasing throughput.
5. T -or- F A machine operator daily lunch break is considered as a preemptive outage.
6. T -or- F At low utilization levels, the flow variability is determined largely by the variability of the process times at the station.
7. T -or- F The availability of a machine is directly proportional to the mean time to failure (MTTF) the machine.

II. Multiple Choice - Please circle ONE response. (2 points each)

1. In the worst case scenario, the worst cycle time (TH_{worst}) is:

   a. T_0
   b. $w\ T_0$
   c. $\frac{w}{T_0}$
   d. r_b

2. For an M/M/1 queue, the average cycle time for a process is:

   a. $\frac{t_e}{1-u}$
   b. $\frac{u\ t_e}{1-u}$
   c. $\frac{u}{1-u}$
   d. $\frac{u^2}{1-u}$

3. The turnover ratio is defined as the ratio of the throughput and ____

   a. the average inventory
   b. the utilization
   c. cycle time
   d. lead time

4. A station with three machines operating in parallel with 20-minute process times at each station, what is the capacity in parts per hour for the following system

   a. ~1 part
   b. ~3 parts
   c. ~6 parts
   d. ~9 parts

5. Process changeovers can be regarded as ___

   a. natural variability

   b. variability from preemptive outages

   c. variability from nonpreemptive outages

   d. variability from rework

6. If the mean is doubled, then the CV is

   a. doubled
   b. halved
   c. quadrupled
   d. quartered

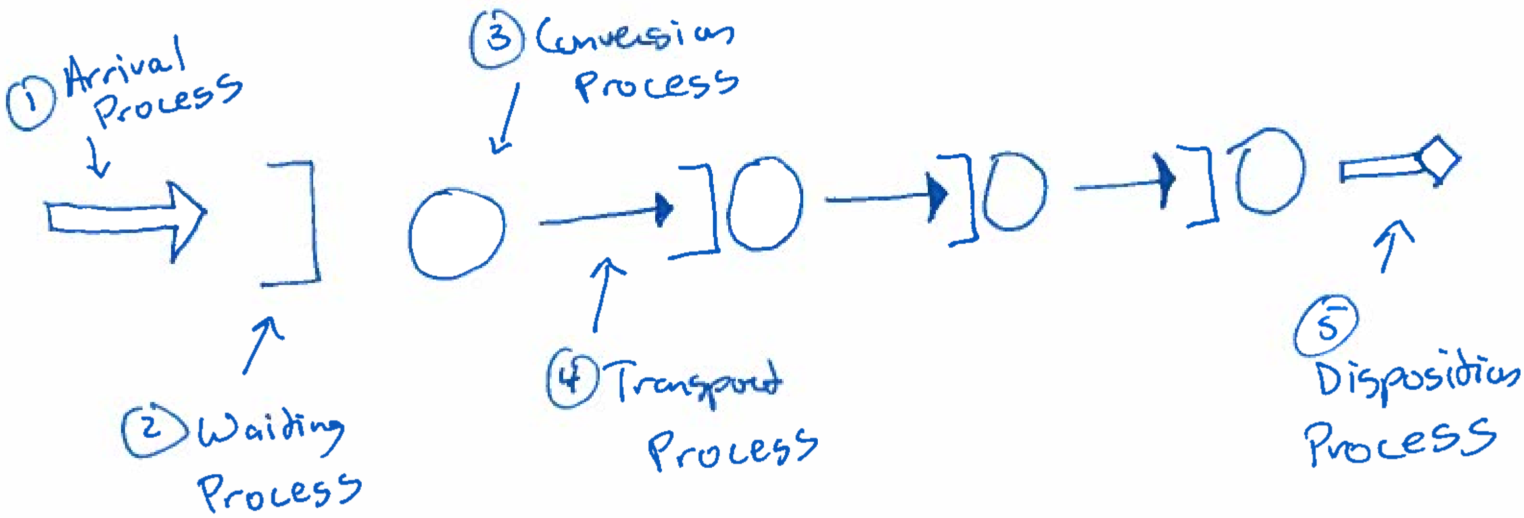
7. A machine with one failure per day, and 4 hours mean time to repair it (the machine operates 20 hours in average daily), and a natural capacity of 6 jobs per day, has an effective capacity of:

   a. 3.33 jobs per day
   b. 5.14 jobs per day
   c. 5 jobs per day
   d. 3.42 jobs per day

III. Short Answer – Solve the following. Show all of your work. Write neatly and legibly. Place a box around your final answers.

1. Consider the Penny Fab 1 model. [26 pts]

   a. Draw the process map and label the five processes on the map. [10 pts]



   b. What triggers an arrival for this model? [4 pts]

The disposition process

c. Assume each work station has a process time of 2 hours. Complete the following table [12 pts]

WIP	TH	CT
1	0.125	8
2	0.250	8
3	0.375	8
4	0.500	8
5	0.500	10
6	0.500	12

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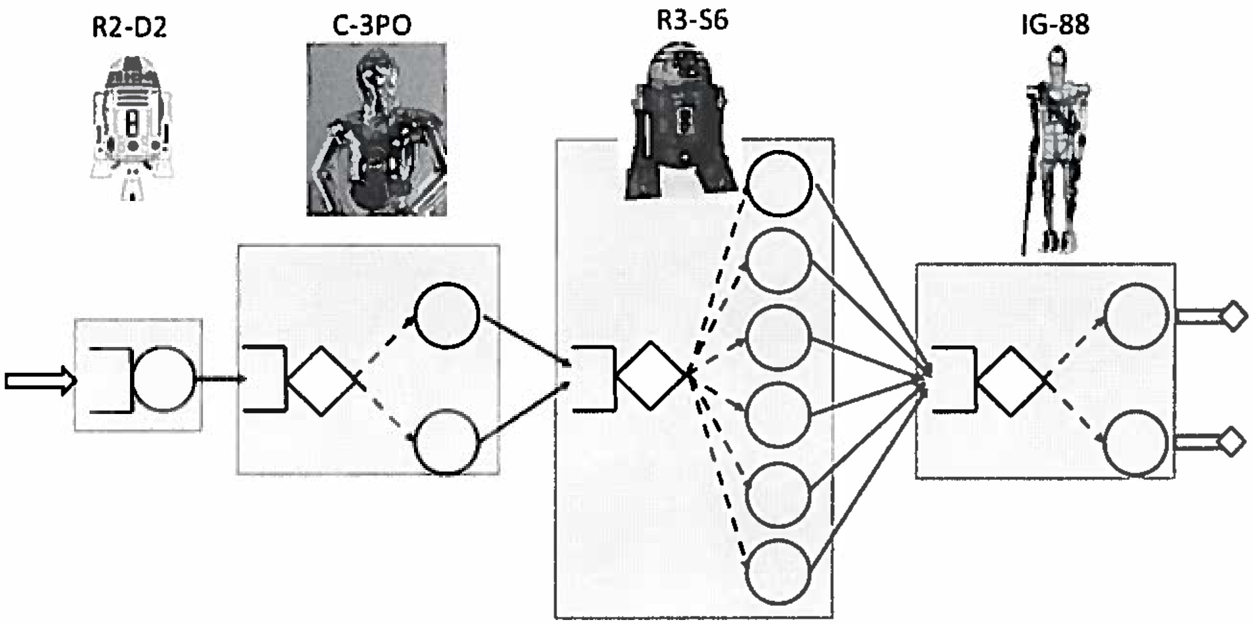
Point Summary

Question	Points	Out of
Short Answer # 2		25
Short Answer # 3		15
Short Answer # 4		18
Part II Subtotal		**58**

I. **Short Answer (Cont'd) – Solve the following. Show all of your work. Write neatly and legibly. Place a box around your final answers.**

2. The figure below shows the process map of the Wramblin' Wreck Top Flow Line for which parts are in heavy demand. Jobs arrive to R2-D2 at a rate of 10 jobs per hour. R2-D2 has an average process time of 5 minutes per job, C-3PO's average process time is 10 minutes, R3-S6's average process time is 30 minutes, and IG-88's is 10 minutes per job. There is plenty of buffer space for items to wait in front of C-3PO after they have been processed by R2-D2. It is reasonable to assume that the interarrival and process times are exponentially distributed. [25 pts]



(a) What is T_0? [5 pts]

$T_0 = 5 + 10 + 30 + 10 = 55$ mins

(b) Which station is the bottleneck and why? [5 pts]

The line is balanced.

(c) What is the capacity of the line? [5 pts]

$1/5$ jobs/min

(d) Suppose C-3PO undergoes a preemptive failure on average every 110 hours with a repair time that lasts an average of 2 hours with a standard deviation of 2 hours. What is the capacity of the line? [5 pts]

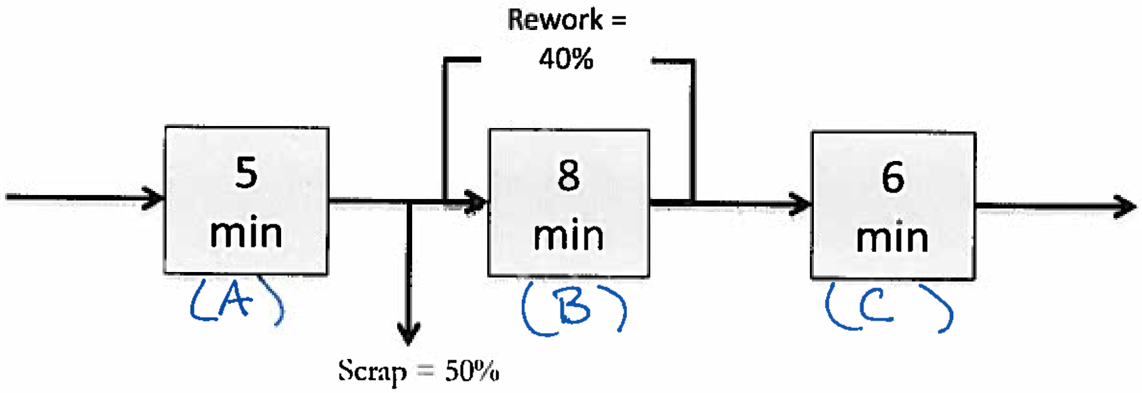
$r_{C3PO} = \left(\frac{1}{5}\right)(A)$ where $A = \frac{110}{112} = 98.2\%$

$= (1/5)(.982)$

$= .1964$ jobs/min

(e) Given the conditions in (d) what is the line throughput? [5 pts]

$1/6$ jobs/min (Note: It doesn't change)



3. Consider the line above with three workstations and a 6 units per hour arrival rate. [15 pts]
   a. Is the line balanced? Why or why not? [4 pts]

No, the differing process times will create different amounts of work at each station.

   b. What is the utilization of each workstation? [6 pts]

(A) (6)(5) = 30 minutes ⇒ 50% utilization

(B): (6)(.5)(1.4)(8) = 33.6 mins ⇒ 56% utilization.

(C): (3)(6) = 18 minutes ⇒ 30% utilization.

   c. What is the capacity of the line? [5 pts]

The line finishes 3 units per hour at a max utilization of 56%

$\frac{3}{.56}$ = 5.357 units per hour

4. Consider a balanced stable line with five identical stations in series, each consisting of a single machine with low variability process times and infinite buffers. Suppose the arrival rate is r_a, utilization of all machines is 85%, and the arrival SCV is $c_a^2 = 1$. What happens to WIP, CT, and TH when we do the following, one at a time? [18 pts]

a. Decrease the arrival rate. [6 pts]

Cycle time decreases because utilization will decrease. Throughput will be equal to the arrival rate so it will decrease. Since WIP = (TH)(CT), WIP will decrease.

$\boxed{\text{WIP} \downarrow \quad \text{CT} \downarrow \quad \text{TH} \downarrow}$

b. Increase the variability of station 1(assume that the system remains stable). [6 pts]

If c_e^2 for station 1 increases the cycle time will increase. The arrival constrains throughput so it will stay the same. Since cycle time increased and WIP = (CT)(TH) ~~c~~ WIP will increase.

$\boxed{\text{WIP} \uparrow \quad \text{CT} \uparrow \quad \text{TH (same)}}$

c. Decrease the capacity of station 5 (assume that the system remains stable). [6pts]

If r_e for station 5 decreases then utilization will increase thus increasing cycle time. The arrival rate constrains TH so it will stay the same. WIP will increase with cycle time since WIP = (CT) x (TH)

$\boxed{\text{WIP} \uparrow \quad \text{CT} \uparrow \quad \text{TH (same}}$

Summary of Formulas for computing Effective Process Time Parameters

Situation	Natural	Preemptive	Nonpreemptive
Examples	**Reliable Machine**	**Random Failures**	**Setups; Rework**
Parameters	t_0, c_0 (basic)	Basic plus m_f, m_r, c_r^2	Basic plus N_s, t_s, c_r^2
t_e	t_0	$\frac{t_0}{A}, A = \frac{m_f}{m_f + m_r}$	$t_0 + \frac{t_s}{N_s}$
σ_e^2	$t_0^2 c_0^2$	$\frac{\sigma_0^2}{A^2} + \frac{(m_r^2 + \sigma_r^2)(1-A)t_0}{A m_r}$	$\sigma_0^2 + \frac{\sigma_s^2}{N_s} + \frac{N_s - 1}{N_s^2} t_s^2$
c_e^2	c_0^2	$c_0^2 + (1 + c_r^2)A(1-A)\frac{m_r}{t_0}$	$\frac{\sigma_e^2}{t_e^2}$