IEOR 130 Final Examination
Spring, 2002
Prof. Leachman

Open book and notes. Work all problems. 120 points total.

1. (10 points) The following table shows the customer commitments and the projected supply of a particular product over the next 9 days.

Day	1	2	3	4	5	6	7	8	9
Commitments	40	40	20	10	40	40	10	10	0
Supply	100	10	20	20	20	30	20	10	30

(a) A new customer calls asking for delivery of 10 units on each of days 2, 3 and 4. Calculate the best delivery schedule that may be offered to this prospective customer without impacting the previous customer commitments.

(b) A previous customer calls and cancels his order for delivery of 5 units on day 3 and 5 units on day 8. Does this cancellation affect the best schedule that may be offered the prospective customer in part (a)? If so, calculate the revised best delivery schedule for the prospective customer.

2. (15 points) The process flow for making an advanced DRAM device requires the use of a DUV stepper at the photo steps in layers 1, 5 and 9. The cycle times from fab start to the photo steps in layers 1, 5 and 9 are 0 weeks, 1 week and 2 weeks, respectively. The fab line yield is 100%. The UPH factors at the photo steps in layers 1, 5 and 9 are 60, 50 and 45, respectively.

There are 3 DUV steppers in service. The CEE of the DUV steppers is 75%. The fab operates 24 hours a day, 7 days per week. The DUV stepper is believed to be the fab bottleneck equipment type.

It is desired to develop a capacity constraint on weekly fab starts for the purposes of production planning.

(a) Let x_t denote the fab starts in week *t*. Express the DUV capacity constraint on x_t, x_{t-1} and x_{t-2}.

(b) In steady-state, how many wafers may be started per week?

(c) Suppose 5,000 wafer starts were made last week, and 9,000 wafer starts were made the week before that. How many wafers may be started this week without extending cycle times?

3. (20 points) An I Line stepper is the bottleneck of a small fabrication facility, and management desires to maximize its output rate. When equipped with a brand new bulb, the lamp intensity of the stepper is approximately 1,000 mW/cm2. The intensity declines after every wafer exposure until the bulb is replaced. The photo engineer has estimated the lamp intensity function to be $LI(n) = 1{,}000(0.9994)^n$, where n refers to the nth wafer exposed since the bulb was replaced and $LI(n)$ is the lamp intensity realized for the nth wafer. The total machine down time to replace the bulb and re-qualify the stepper is four hours. Other stepper data: wafer exchange time XT = 13 seconds, initial alignment time AT = 27.5 seconds, and move and align time MT = 0.5 seconds. There is only one exposure step performed by the stepper, with NE = 60 and EE = 1,000 mJ. No blading is required.

Consider three possible frequencies for changing the bulb: once every 100 wafers, once every 1,000 wafers, or once every 5,000 wafers. Which frequency would maximize stepper output rate? Explain. (Useful fact from algebra: $\sum_{i=1}^{n} a^i = a\frac{1-a^n}{1-a}$.)

4. (20 points) A process flow includes six steps that contribute significant amounts of contaminating particles. Engineering investigations have been completed to determine the potential reduction in particle counts and the engineering time required to achieve such reductions at each of the six steps, with the following results:

Step	Average defects Per sq cm	Fraction Fatal	Potential average Defects per sq cm	Engineering time Required (days)
1	0.9	0.1	0.4	16
2	0.8	0.2	0.6	15
3	0.8	0.3	0.6	18
4	0.2	0.2	0.0	16
5	0.6	0.2	0.3	10
6	0.5	0.3	0.3	15

The fraction of defects that are fatal at each step is not expected to change after the engineering work is completed. The engineering work must be completed one step at a time. For example, while the engineering work is being performed to reduce particles at step 3, no particle-reduction work can be performed on steps 1, 2, 4, 5 or 6.

(a) In what order of steps would you recommend undertaking the engineering work? Explain.

(b) The die yield of the principal product in the process flow is currently 72%. This product has a die area of 0.5 cm^2. What is the minimum time required to raise its die yield above 80%?

5. (15 points) A film thickness is subject to statistical process control. The USL is 7,000 angstroms and the LSL is 4,500 angstroms. On the X-bar chart, the UCL is 6,300 angstroms, and the LCL is 5,300 angstroms. The process performance index is 1.073.

(a) What is the sample size?

(b) What are the limits on the Range chart?

6. (20 points) Two alternative process machines are under consideration. Statistics about machine performance and maintenance are as follows:

Machine	Rework Rate	Scrap Rate	Avg. PM Hours/Week	Avg. Machine Failures (Hours) MTBF	MTTR	Avg. Process time (Hours/lot-pass)
A	0.01	0.001	16	200	8	0.55
B	0.02	0.006	18	100	6	0.50

Assume the fab operates 168 hours per week. The machines processes one lot at a time. When rework is required, the lot must be processed a second time. The average process time for the second pass is the same as for the first pass. The chance of a third pass is negligible.

(a) What is the average availability of each machine type?

(b) The two machines have the same price. From a productivity point of view, which one would you recommend? Explain.

7. (20 points) A fabrication process includes 4 visits to the photo bottleneck, one each at the end of layers 1, 2, 3 and 4. A simulation of the fabrication process produced the following statistics:

Layer	Avg. cycle time (shifts)	Standard deviation of cycle time (shifts)	Avg. number of active lots
1	8	1.0	60
2	10	1.5	75
3	12	1.5	95
4	8	1.0	55
5	2	0.5	15

The simulated average production rate was 10 lots per shift. No line yield losses were simulated.

(a) Recommend target cycle times by layer assuming line yields are 100% and the target cycle time is 40 shifts.

(b) The fab outs at the end of the simulation had achieved the target output. The WIP status at the end of the simulation was as follows. Data concerning the photo steps also is displayed.

Layer	Actual WIP (lots)	WIP at Photo (lots)	Photo process time (hours/lot)	Qualified Machines
1	80	10	0.4	A, B, C
2	120	20	0.5	B, C
3	108	5	0.6	A, B
4	87	8	0.8	C
5	15			

Assume the simulation ended at the start of a shift. Calculate the IPQ for each photo step for that shift.

(c) Assume one shift lasts 8 hours. Using the data in part (b), determine an efficient shift schedule for the steppers. Assume only the WIP at photo may be scheduled and assume all 3 steppers will be available for all 8 hours. (An efficient schedule has the following properties: as much of the IPQs is completed as possible, steppers are utilized as much as possible, and changeovers of the steppers are minimized.)

Have a nice summer!