Manufacturing Systems I
SMA6304 / MIT 2.853 / 2.854 Fall 2004

Homework #5: Line Design and MRP

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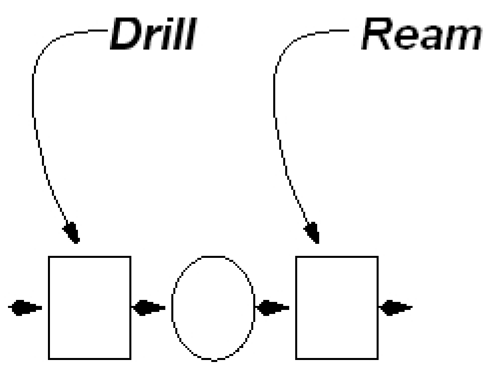
To do these problems, you must use the tools available on http://cell1.mit.edu/.

(Total 110 points)

1. **Line Design Example** (30 points)

   The Tech Manufacturing Company is contemplating the acquisition of a transfer line to make its highly successful Tech-o-Tronic brand of desktop widgets.

   The making of widgets is a two-step process. It requires rough drilling and finished reaming. Several different vendors have been invited to submit bids for the machines and buffer that will make up the line.

   It is your job to pick the least expensive combination of machines and buffers that produces the required production rate of 5.5 parts per hour. Which of the following machines should the company purchase, and what size buffer should it have to minimize cost?

   The following is a summary of the information supplied by the vendors

   - The ALPHA Machine Tool Company has a rough drilling machine that costs \$25,000 that can do 0.11 operations per minute on the average and has a mean time to fail of 40 working hours and a mean time to repair of 2 hours.
   - The ALPHA Machine Tool Company has a final reaming machine that costs \$50,000 that can do 6.3 operations per hour on the average and has a mean time to fail of 50 working hours and a mean time to repair of 2 hours.

- The BETA Machine Tool Company has a rough drilling machine that costs \$20,000 that can do an average of 1 operation per 10 minutes and has a mean time to fail of 15 hours of operation and a mean time to repair of 180 minutes.
- The BETA Machine Tool Company has a final reaming machine that costs \$45,000 that can do an average of 6 operations per hour and has a mean time to fail of 200 operations and a mean time to repair of 2 hours.
- The GAMMA Machine Tool Company has a machine that can do both rough drilling and final reaming. It costs \$80,000 and can process (perform both operations on) an average of 1 part per 10 minutes and has a mean time to fail of 40 hours and a mean time to repair of 2 hours.

Assume that the buffer space is free but the inventory cost between the drilling and reaming stages is \$1,000 per part per year. The investment period is one year and there is no depreciation and salvage capital on the machines.

In the optimal line, what is the average lead (cycle) time?

2. **Production Line Behavior** (50 points)

   Consider a production line that has four machines with the same parameters: $\mu_i =$ 100.0 (parts/day), $r_i = .075$, $p_i = .009$, i = 1, 2, 3, 4.

   (a) Variation of N_i

   1. Assume $N_1 = 30$ and $N_2 = 30$. Let N_3 range from 3 to 300, and plot the resulting values of $\overline{n_1}, \overline{n_2}$,and $\overline{n_3}$ on the same set of axes. Explain the shapes of the graphs, especially why numbers are increasing or decreasing, and their limits.
   2. Now assume that $N_3 = 30$, and let N_1 vary from 3 to 300. Again, plot $\overline{n_1}, \overline{n_2}$,and $\overline{n_3}$. Explain again the graphs, and especially how they differ from the last set of graphs.

   (b) Reliability optimization

   Suppose the sales price of an item produced is \$1,000. The revenue is therefore \$1000P, where P is the production rate (unit: parts/day). With all buffer sizes set to 30, consider the effect of varying the mean time to repair of Machine 1. It costs money to make Machine 1 easier to repair; in fact, it costs \$100/MTTR_1(\$/day). Consider the following expression for profit for running the line for one day:

   $$\$1000P - \$2(N_1 + N_2 + N_3) - \$10(\overline{n_1} + \overline{n_2} + \overline{n_3}) - \frac{\$100}{MTTR_1}$$

   1. Is this function reasonable? Explain what each of the terms means, and why it belongs there.
   2. What is the most profitable value of $MTTR_1$?
   3. Does the answer make intuitive sense?

3. **MRP Example** (30 points)

You are the Head Production Scheduler for a new startup, called SingaMIT.com. (It has spent hundreds of millions of its investors' dollars in its flagship product, the *Runninglater*, a high tech running shoe with internet access, which allows you to check your portfolio or send e-mail while you are jogging. As soon as the designers can figure how people can run and use the keyboard at the same time, they will all be rich. But that is not your problem.) Your problem is involved with the Heel Flange subassembly which is produced by assembling one A subassembly and two B subassemblies. (The two Bs are identical and interchangeable.) The gross requirements for the Heel Flange are given in Table 1.

Before the start of Week 1, there are 25 heel flanges, 12 As, and 20 Bs available. Assume that the heel flanges are made in batches of 35. Any multiple of 35 items may be made in a week, and the lead time for the heel flange is one week.

Assume that the As are made in batches of 100, and that they may be made only in even numbered weeks. They have a one week lead time. The Bs can be made in batches of size 1, but they have a 3 week lead time.

Assume that the production of the components can start earlier than week 1. For example, the first batch of subassembly components, part As and Bs, will be required at the beginning of week 0. In the following, start production of components as early as necessary (week 0, week -1, etc.).

(a) Graph the gross requirements of the heel flanges. Schedule the production of the heel flanges. Graph the gross production of the heel flanges.

(b) Determine and graph the gross requirements of the type As. Schedule the production of the type As. Graph the gross production of the type As.

(c) Determine and graph the gross requirements of the type Bs. Schedule the production of the type Bs. Graph the gross production of the type Bs.

Week	1	2	3	4	5	6	7	8	9	10
Requirements	20	20	40	10	70	10	35	10	5	60

Table 1: Heel Flange requirements