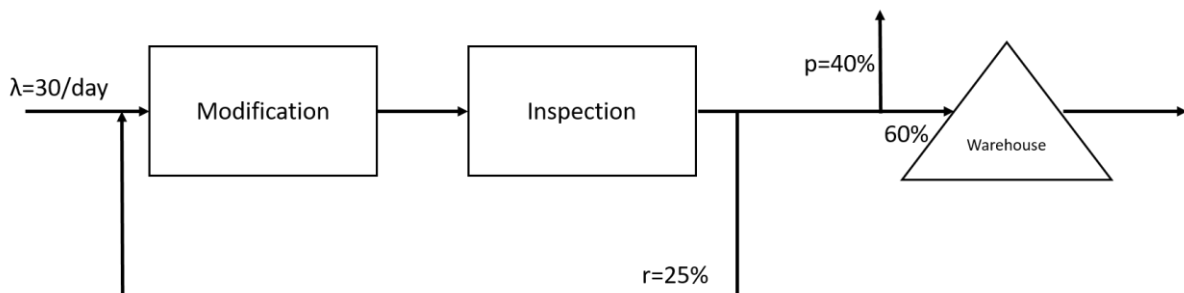


## MSBA 7004 Operations Analytics

### Practice Final

#### Question 1 (12 points)

An automobile custom modification company faces new modification orders of 30 cars per day. Assume the company has enough capacity to handle the input. There are three steps in the company's process: two value adding steps—modification and inspection—and a warehouse where they store the finished cars before dispatching to some customers. The modification step takes 12 days on average for a car while the inspection takes 1 day on average. Due to the nature of each order being highly customized, the company sets a high standard for a completed car. Hence, 25% of the cars going through the inspection step are rejected and are returned to the start of the process to go through the modification step again. The remaining 75% are qualified to be delivered to the customers. This 25% rework rate is consistent for the initial work and subsequent reworks. The company charges extra for fast delivery and this counts for 40% of orders which are dispatched immediately after passing the inspection, while the remaining 60% will be stored at the warehouse for 3 days on average before being released to the customers. The process flow diagram is shown below.



- (a) What is the throughput at the inspection step? (4 points)

Throughput at inspection step:

- (b) What is the total number of cars within the process? (4 points)

Total number of cars:

- (c) What is the average flow time of a car going through the process? (4 points)

Average flow time:

## Question 2 (14 points)

A company has the capability to produce three products A, B, and C. However, product B and C are complementary products to the main product A. Hence, production of B and C are done in combination with product A. Since, product B and C serve similar purposes, the company wants to rather focus and produce only one of them in conjunction with product A. The company wants to decide whether to produce B or C based on overall profitability. The profit margin for A, B, and C is \$2, \$1, \$0.5 respectively.

When producing A and B, the production of A requires step 1, 2, and 3 which involves resources R1, R2, and R3 respectively. Production of B requires step 2 involving resource R2 and step 4 involving both resources R2 and R3. The production mix of A and B is 1:2. There are only one of each resource type. The process flow diagram is shown below with time required by the corresponding resource(s) for each step.

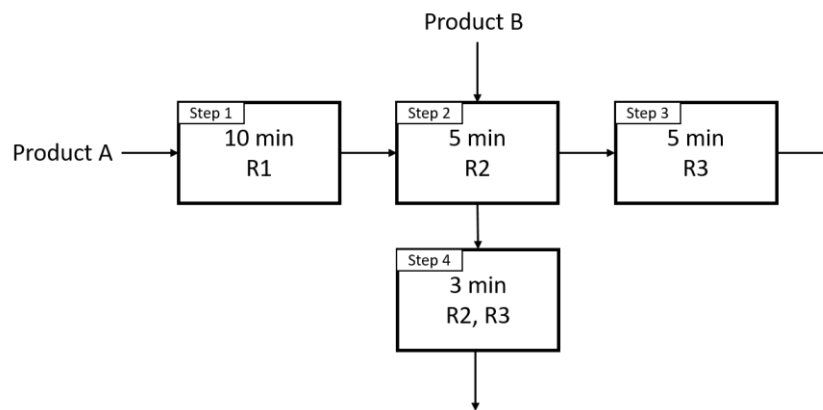


Figure 2-1: Process flow diagram for production of A and B.

When producing A and C, the production of A requires step 1, 2, and 3 which involves resources R1, R2, and R3 respectively. Production of C requires step 1 involving resource R1, step 4 involving both resources R1 and R2, and step 5 involving resource R4. The production mix of A and C is 1:3. There are only one of each resource type. The process flow diagram is shown below with time required by the corresponding resource for each step.

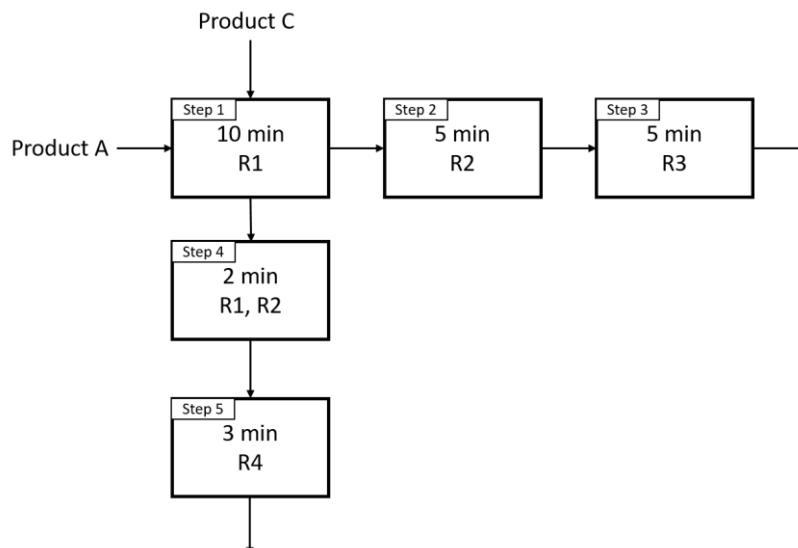


Figure 2-2: Process flow diagram for production of A and C.

(a) What is the capacity of the process for each option (in units/hr)? (8 points)

Producing A and B  
Capacity for product A:

Capacity for product B:

Producing A and C  
Capacity for product A:

Capacity for product C:

(b) Which option should the company choose? What is the profitability of each option (in \$/hr)? (6 points)

Profitability of producing A  
and B:

Profitability of producing A  
and C:

Between B and C, which  
product should the company  
produce in conjunction with  
product A?

**Question 3 (10 points)**

Customers enter the camera department of a store at the average rate of six per hour. The department is staffed by one employee who takes an average of six minutes to serve a customer. Assume this is a situation with a simple Poisson arrival, and exponentially distributed service time for the staff employee.

- (a) As a casual observer, how many people, on average, would you expect to see in the camera department (excluding the staff) (2 points)?

Average number of customers  
in the camera department:

- (b) What is the average waiting time (in minutes) of the customer? (2 points)

Average waiting time:

- (c) The manager wants the average customer waiting time to be less than 4 minutes. How fast should the staffed employee be able to serve a customer on average (in minutes)? (6 points)

Average service time:

**Question 4 (10 points)**

The R&D department of Smart Electronics is investigating the feasibility of a new product development project. The following table provides all the necessary information about this project: the precedence of activities, normal and crash activity times, and normal and crash costs.

Activity	Predecessors	Normal time (weeks)	Normal costs (\$)	Crash time (weeks)	Crash costs (\$)
A	None	16	1100	10	2300
B	None	12	3200	10	3500
C	None	25	4000	19	4600
D	A	10	2500	5	2750
E	A and B	20	1400	Not applicable	Not applicable
F	C	18	4100	15	5000
G	D, E and F	15	2700	14	3000

- (a) What is the duration of the project (using normal times)? What is the critical path(s)? (4 points)

Duration of project:

Critical path(s):

- (b) If we want to shorten the duration of the whole project by 5 weeks while minimizing the total costs, which activities will you crash and by how many weeks? (6 points)

Activities to crash (also say by how many weeks you crash each activity):

**Question 5 (10 points)**

Joe is a Christmas tree vendor serving his own neighbourhood. He purchases trees for \$10 each and sells for \$25 each. At the end of the holiday season, the unsold trees can be salvaged at \$3 each. From past experience, Joe is sure that the number of trees demanded is equally likely between 1 and 9 (inclusive).

- (a) What is the optimal number of trees that Joe should purchase? (5 points)

Optimal # of trees to purchase:

- (b) If Joe purchases 4 trees, what is the expected number of trees sold? (5 points)

Expected number of trees sold:

**Question 6 (10 points)**

Each year the admission committee at a top business school receives a large number of applications for admission to the MSBA program and they have to decide on the number of offers to make. Since some of the admitted students may decide to pursue other opportunities, the committee typically admits more students than the ideal class size of 216 students. You were asked to help the admission committee estimate the appropriate number of people who should be offered admission. It is estimated that in the coming year the number of people who will not accept the admission offer is normally distributed with mean 30 and standard deviation 10. Suppose that the school does not maintain a waiting list, that is, all students are accepted or rejected.

- (a) Suppose 230 students are offered admission. What is the probability that the class size will be at least 216 students? (5 points)

Probability that the class size  
will be at least 216 students:

- (b) It is hard to associate a monetary value with admitting too many students or admitting too few. However, there is a mutual agreement that having a student in excess of the ideal 216 is twice as expensive as having a student short of this ideal number. What is the appropriate number of students to admit? (5 points)

Number of students to admit:

### Question 7 (34 points)

After graduation, you decide to go into a partnership in an office supply store that has existed for a number of years. Walking through the store and stockroom, you find a great discrepancy in service levels. Some spaces and bins for items are completely empty; others have supplies that are covered with dust and have obviously been there a long time. You decide to take on a project of establishing consistent levels of inventory to meet customers' demands. Most of your supplies are purchased from just a few distributors that call on your store once every two weeks.

You choose, as your first item for study, computer printer paper. You examine the sales records and purchase orders and find that demand for the past 12 months was 5,000 boxes. Using your calculator, you sample some days' demands and estimate that the standard deviation of daily demand is 10 boxes. Also, you assess that the normal distribution reasonably describes demand. You also find these figures:

- Cost per box of paper: \$11
- Desired service level: 97.7%
- Store is open every day
- Salesperson from the distributor visits every two weeks (once in two weeks) to take orders
- The office supply store pays the distributor when the order is placed (pays for inventory in stock and in transit)
- The distributor dispatches orders the same day they are placed
- Delivery time from the distributor to the supply store is three days from dispatch
- Assume 365 days in a year
- Cost of carrying inventory is 25% of the inventory value per year
- Cost of placing an order is \$50 per order

(a) What is the average inventory holding cost per year? (6 points)

Average inventory holding cost:

(b) What is the average ordering cost per year? (4 points)

Average ordering cost:

(c) Using your procedure, how many boxes of paper would be ordered if, on the day the salesperson visits, 60 boxes are on hand? (4 points)

Number of boxes to order:



Your manager wants you to analyze whether the store can save cost in managing computer printer paper inventory. While chatting with the salesperson from the distributor, you learned that the distributor is flexible in the order taking schedule. You want to assess whether you should propose to your manager to change the current ordering cycle of once every two weeks.

- (d) The manager is concerned with the ordering cost and inventory holding cost of computer printer paper. How would you model the decision? Express the decision variable and the objective function (in cost per year). Every other condition remains the same besides the decision variable. (6 points)

Decision variable:

Objective function (\$/year):

- (e) If the salesperson visits your store every 28 days, how much cost is the office supply store saving per year? (6 points)

Cost saving per year:

- (f) If the salesperson can visit anytime you want to place an order, and the cost of placing an order is still \$50 per order, what is the optimal order quantity every time the salesperson visits your store? (6 points)