

1 Solved Exercises

1.1 Statement of Exercises

1. [Deducing Demand] Cindy and Mindy were in the same student group while studying for their MBA at UTD. They graduated together but started working as inventory managers in different but competing retailers selling air conditioners in Dallas. While in school, they learned only the economic order quantity model for finding the optimal order sizes. Now they are both purchasing air conditioners from Trane to sell at their stores. Cindy knows that the order setup cost with Trane is \$200 and the annual inventory holding cost is \$400. Cindy expects that Mindy has the same cost figures. Cindy has accidentally learned that Mindy is ordering 10 air conditions every time she orders. Show how Cindy can use this information to deduce the demand Mindy faces. Explain why would competitors way want to know each other's demand.

2. [Spring Water] The demand for spring water at the Plano WalMart is 600 litres per week. The setup cost for placing an order to replenish inventory is \$25. The order is delivered by the supplier which charges WalMart \$0.10/liter for the cost of transportation from the Ozark mountains to Plano. This transportation cost increases the cost of water to \$1.25/liter. The water loses its freshness while stored at the Plano WalMart. To account for this, the WalMart charges an annual holding cost of \$2.6/liter. Determine how often the WalMart should order for water and what size each order should be.

3. [Shoe Assembly] A shoe assembly plant buys leather tops and soles from its suppliers. The leather tops have no color on them when bought. The assembly plant first dyes the leather with colors like black, beige, brown and cream. Then it sews the colored leather tops to the soles. Finally leather tops are polished with an agent that depends on the color of the shoe. Basically there are three operations in the shoe plant: Coloring, Sewing and Polishing. The activity times and set up times for these operations are given in minutes as follows:

Operation	Coloring	Sewing	Polishing
Activity time	0.25	0.20	0.15
Set up time	30	20	45

Soles and the leather top-sole assemblies are processed in batches in all operations. The batch sizes are kept the same at all operations. Before a batch goes through an operation, the shoe plant must set up the machines for that operation.

- a) How many leather tops can be colored in an hour with a batch size of 40?
 - b) Explain why sewing cannot be the bottleneck operation under any batch size.
 - c) For which batch sizes is coloring the bottleneck operation? Here your answer can be an interval of batch sizes rather than a single number because there are many batch sizes which make coloring the bottleneck.
4. [EPROM] A local company produces a programmable EPROM (erasable programmable read-only memory) for several industrial clients. They have experienced a relatively flat demand of 2500 units per year for the product. The EPROM is produced at a rate of 10000 units per year. The accounting department has estimated that it costs \$50 to initiate a production run, each unit costs the company

\$2 to manufacture, and the cost of holding is based on a 30% annual interest rate. Determine the optimal size of a production run, the length of each production run, and the average annual cost of holding and setup. What is the maximum level of on-hand inventory of the EPROMs?

5. Textbook 5.4.

1.2 Solutions

ANSWER for Exercise 1:

Since Cindy knows that Mindy learned only the EOQ model during her MBA, Cindy safely assumes that Mindy uses the EOQ formula which yields

$$R = \frac{Q^2 h}{2K} = \frac{10^2 * 400}{2 * 200} = 100/\text{year}.$$

Competitors can use each other's demand information while formulating sales strategies such as price discounts, sales campaigns. It also helps a retailer, while negotiating with a supplier, to know whether that retailer is selling significantly more than the others. The retailers which sell significantly more are given "preferred retailer" status. These retailers can buy items at a lower cost from the supplier because the volume of the sales that they generate makes them strong while negotiating prices with the supplier. \square

ANSWER for Exercise 2:

From the question, we deduce that $K = 25$, $h = 2.6/52 = 0.05$ per week, $R = 600$ per week. Note that the transportation cost and the cost of water are irrelevant for our analysis. Then the optimal order quantity is

$$Q = \sqrt{\frac{2KR}{h}} = \sqrt{\frac{2 * 25 * 600}{0.05}} = 774.6 \text{ liters}.$$

The WalMart places an order of size 774.6 liters in each order cycle. Length of such a cycle is

$$\frac{Q}{R} = \frac{774.6}{600} = 1.29 \text{ weeks} \approx 9 \text{ days}.$$

Every 9 days, the WalMart should order for 774.6 liters of spring water. \square

ANSWER for Exercise 3:

a) With $B = 40$, $S = 30$ mins, $t = 0.25$ mins. It takes $S + tB$ minutes to color B leather tops. Then $B/(S + tB)$ tops can be colored in a minute:

$$\text{Coloring capacity} = \frac{B}{S + tB} = \frac{40}{30 + 0.25 * 40} = 1 \text{ top per minute}.$$

Equivalently, the capacity is 60 tops per hour.

b) It takes $30 + 0.25B$ to complete the coloring of B units. The same number is $20 + 0.2B$ for sewing. For all $B \geq 0$, we have $30 + 0.25B \geq 20 + 0.2B$. In words, it always takes more time to color than sew. Hence, sewing is never the bottleneck.

c) The capacity for coloring and polishing are equal when

$$\frac{B}{30 + 0.25B} = \frac{B}{45 + 0.15B},$$

or when $B = 150$. Polishing is the bottleneck when

$$\frac{B}{30 + 0.25B} > \frac{B}{45 + 0.15B} \implies 30 + 0.25B < 45 + 0.15B \implies 0.1B < 15 \implies B < 150.$$

That is, for batches smaller than 150 shoes, polishing is the bottleneck. Otherwise, coloring is the bottleneck. \square

ANSWER for Exercise 4:

First, we compute $h = 0.3 * 2 = 0.6$ per unit per year. $K = 50$, $R = 2500$ per year, $P = 10,000$ per year. Then

$$EPQ = \sqrt{\frac{2KR}{(1 - R/P)h}} = \sqrt{\frac{2 * 50 * 2500}{(1 - 2500/10000)0.6}} = \sqrt{\frac{250000}{0.45}} = 745.$$

The time between production runs is $T = EPQ/R = 745/2500 = 0.298$ years. The working time in each cycle is $Q/P = 745/10000 = 0.0745$ years, which is the duration of time that is spent to produce 745 EPROMs. The average annual cost of holding and setup is

$$\begin{aligned} C(Q = EPQ; P) &= \frac{K * R}{EPQ} + \frac{1}{2} \frac{EPQ}{P} (P - R)h = \frac{50 * 2500}{745} + \frac{1}{2} \frac{745}{10000} (7500)0.6 = 167.785 + 167.625 \\ &= 335.41. \end{aligned}$$

The maximum level of on-hand inventory happens exactly at the end of the working time which lasts for 0.0745 years, during which the inventory increases at the rate of 10000-2500 per year. That is the maximum inventory that our storage must accommodate is 559 ($\approx 0.0745 * 7500$). \square

ANSWER for Exercise 5:

a) The desheller works for 3.45 hours and it is cleaned for 15 mins. While it is working, it produces 400+400+400+300 lbs in 3.45 hours. Since it does not produce anything while being cleaned, the capacity of desheller is 1500 lbs per 4 hours, or 375=1500/4 lbs/hr.

b) A day has 12 hours, so deveiner's daily capacity is 4320=12(360) lbs.

c) Since the system is not decoupled by the inventory, for every 15 mins the desheller stops, every other process also stops for 15 mins. That is the system works only for 11.25 hours per day, during which the deveiner is the bottleneck process. Hence, the process capacity is 11.25(360)=4050 lbs/day.

d) 5 trucks bring in 5000 lbs while only 4050 lbs can be processed, so 950 lbs of shrimp is wasted every day. \square

2 Homework Questions

- An online computer store sells 1000 computers per month and keeps the inventory turnover rate at 12 per year. Once a customer places an order, computer will be shipped directly from a warehouse. Each warehouse worker can ship 2 computers per hour, and works 8 hours/day, 250days/year.
 - What is the average time a computer spends at the warehouse? b) How many workers are needed for shipping?
 - How many computers should be ordered in a batch to keep the inventory turnover rate at 12 per year? For example, if $B = 12,000$, warehouse will be ordering once a year. Some computers in this batch are sold immediately, so they spend 0 months in the warehouse. The others are sold towards the end of the year, so they spend 12 months in the warehouse. Average time spent in the warehouse then is 6 months, which corresponds to an inventory turnover rate of 2.
- [Stankree Cookies] Stankree is an undergraduate student at UTD and sells cookies to UTD students. His operation involves mixing ready-to-cook dough in a bowl, shaping the dough into cookies, cooking in an oven, cooling the cookies, packing the cookies in boxes and receiving the payment from the

students. The orders for cookies come in dozens. Cycle time for cooking operations are as follows. Mixing: 6 minutes independent of the number of cookies upto 4 dozen cookies; Shaping: 2 min/dozen; Cooking: 20 min/dozen; Cooling 7 min/dozen; Packing: 2 min/dozen; Payment 2 min/order. Mixing and shaping operations must be done back to back without any delay between them. Because of this, we think of them as a single operation Mixing&Shaping, whose set up time is 6 minutes and cycle time is 2 min/dozen.

- a) With a single oven, the cooking operation would be the bottleneck. Stankree installs 4 ovens to reduce the cycle time for cooking down to 5 min/dozen. If the orders always are for 1 dozen, what is the bottleneck operation? What is the cycle time of the bottleneck operation?
- b) If the orders always are for 4 dozens, what is the bottleneck operation? What is the cycle time of the bottleneck operation?
- c) If your answers to a) and b) differ, explain how they can be different. Otherwise, explain why the size of orders does not change the bottleneck operation.