Examination

TENTAMEN I:	Production and Logistics Planning
DATE:	2011-08-16
NUMBER OF HOURS:	5 Hours
GROUP:	Freestanding course
COURSE CODE:	KPP227
EXAMINATION CODE:	TEN1
HELPMEANS:	Calculator, Dictionary
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OBS: Rutat papper (Some Graph Paper)

Max points: 100
Point number for every task is within parenthesis.
For grade 3 at least 50 is required; grade 4 at least 65 and grade 5 at least 85

1 (4)
If operated around the clock under ideal conditions, the fabrication department of an engine manufacturer can make 100 engines per day. Management believes that a maximum output rate of only 45 engines per day can be sustained economically over a long period of time. Currently the department is producing an average of 50 engines per day. What is the utilization of the department, relative to design capacity? Effective capacity?

2 (5)
A toy manufacturer uses 48,000 rubber wheels per year for its popular truck series. The firm makes its own wheels, which it can produce at a rate of 800 per day. The toy trucks are assembled uniformly over the entire year. Carrying cost is $1 per wheel a year. Setup cost for a production run of wheels is $45. The firm operates 240 days per year. Determine the:

a. Optimal run size.
b. Minimal total annual cost for carrying and setup.
c. Cycle time (or TBO) for the optimal run size.
d. The production time per lot (Run time)

3 (3)
a."Because organizations in the service sector do not manufacture products from raw materials, materials management concepts do not apply to them." Do you agree or disagree with this statement? Why?
b. Few, if any, products or services fit the EOQ assumption (e.g. no variation in demand, lead time, or supply) so how can the EOQ model provide guidance in managing real-world inventories?

4 (6)
An assembly line involves 9 tasks that require a total assembly time of 66 minutes (see Table below).

Task	Performance time(m)	Predecessor(s)
A	10	-
B	11	A
C	5	B
D	4	B
E	12	A
F	3	C, D
G	7	F
H	11	E
I	3	G, H

a. Draw a precedence Diagram.
b. What cycle time results in the desired output rate?
c. Balance the line as best as you can.
d. What is the efficiency of your solution?

5 (12)

Customers arrive one at a time, completely random, at an ATM at the rate of 6 per hour. Customers take an average of 4 minutes to complete their transactions, and historical data have shown that the service time closely follow the negative exponential distribution. Customers queue up on FIFO basis. Assume that there is only one ATM.

a. Find the following expected measures of performance for this system: The expected number of customers in the system, the expected number of customers waiting for service, the expected time in the system, and the expected time in the queue.
b. What is the probability that there are more than 5 people in the system at any random point in time?
c. What is the probability that the waiting time in the queue exceeds 10 minutes?
d. Given these results, do you think that management should consider adding another ATM?

6 (6)

Consider the following job times for a three-machine problem. Assume that the jobs are processed in the sequence A-B-C. Find the optimum sequence for processing the jobs below and show it on a Gantt chart for all three machines.

	Machines		
Job	A	B	C
1	4	5	8
2	9	6	10
3	8	2	6
4	6	3	7
5	5	4	11

7 (8)

A manufacturer of automobile carburetors is considering three locations Akron, Bowling Green, and Chicago for a new plant. Cost studies indicate that fixed costs per year at the sites are \$30,000, \$60,000, and \$100,000 respectively; and variable costs are \$75, \$45, and \$25 per unit respectively. The expected selling price of carburetors produced is \$120. The company wishes to find the most economical location for an expected volume of 2000 per year. Which location would that be? Over what range of annual production level would each process be least costly?

8 (5)

Demand for an item is normally distributed with a mean of 18 units per week and a standard deviation in weekly demand of 5 units. The lead-time is 2 weeks, and business operates 52 weeks per year. What P (time between intervals) approximates a 75 unit EOQ? What T is needed for a 90 percent cycle-service level? Answers are to be rounded to the nearest integer.

9 (4)

Three operations, A, H, and C are arranged in series. For an eight-hour shift, the effective capacities are 24, 18, and 20 units per day, respectively. What is the effective capacity of the system? To increase production, 33% overtime was authorized at operation H and 20% at operation C. Soon after the overtime was authorized, the average output rate for the system rose to 21 units per day, which is less than 24 units per day expected. Explain three likely reasons the average output rate fell below expectations.

10 (14)

A corporation has developed a unique new product. Because of its uniqueness, the corporation does not know how well it will sell. Based on some surveys, the corporation estimates there is a 10% chance that the product will sell extremely well and be a big success; a 60% chance that it will sell moderately well and make a modest profit; and a 30% chance that it will have no sales and will be a flop. If the corporation immediately introduces the product nationwide, it estimates that the lifetime present values of profits (losses) from the product will be $20 million profit if sales are high, $6 million profit if sales are moderate and a loss of $5 million if sales are low.

An alternative to introducing the product nationwide immediately is to introduce it in a test market first. If sales do not look promising it can be discontinued, and if sales look promising it can then be introduced nationwide.

The delay in introducing the product nationwide, however, will hurt lifetime sales and profits. If the product is introduced in a test market, the profit from the test market only will be $1million if the sales in the test market are high, $0.2 million if test market sales are moderate, and a loss of $0.5 million if test market sales are low. If the product is introduced nationwide after test marketing, the additional profit will be $15 million if nationwide sales are high, $5 million if they are moderate, and a loss of $5 million if they are low.

Although the test market will help in estimating nationwide sales, the test is not perfect. If test market sales are low, there is a 90% chance that nationwide sales will be low and a 10% chance that they will be moderate. If test market sales are moderate, there is a 5% chance that nationwide sales will be high, a 5% chance that they will be low, and a 90% chance that they will be moderate. If test market sales are high, there is a 70% chance that nationwide sales will be high and a 30% chance that they will be moderate.

The corporation must decide whether or not to introduce the product to test market or introduce nationwide now. If it uses a test market, then it must later decide whether to introduce it nationwide or discontinue it.

11 (8)

A General Motors Buick plant manufactures several Buick models. The company has forecast its quarterly demands during the next four quarters, which are listed below. The plant can produce approximately 25 autos per quarter for each worker on staff. Workers receive an average of $15,000 per quarter in wages and benefits, and it costs $7,000 to hire and train a new worker and $10,000 to lay off a worker. Workers can be hired or laid off at the beginning of any quarter. GM expects to have 480 workers on staff and 2000 autos in inventory at the end of the current quarter. Any auto held in inventory at the end of a quarter incurs a holding cost of $1,000. Construct an aggregate plan for the next four quarters using the chase and level strategies and compute their total costs.

Quarter	Aggregate Demand
1	10,000
2	12,000
3	9,000
4	11,000

12 (5)

a. Explain in detail how customer service standards, transportation, inventories, and facility location play an important role in logistics.
b. How does the product life cycle and product characteristics influence logistics decisions? Explain in detail.

13 (10)

A power generating company has three electric power plants that supply the needs for four cities. Each power plant can supply the following number of kilowatt-hours (kwh) of electricity: plant 1, 35 million; plant 2, 50 million; plant 3, 40 million (see Table below where the entries represent the cost in dollars). The peak power demands in these cities, which occur at the same time (2 P.M.), are as follows in (kwh): city 1, 45 million; city 2, 20 million; city 3, 30 million; city 4, 30 million. The costs of sending 1 kwh of electricity from plant to city depends on the distance the electricity must travel. Solve the problem using the transportation method (modi) to find the optimal solution.

		City				
		1	2	3	4	Supply
Plant	1	8	6	10	9	35
	2	9	12	13	7	50
	3	14	9	16	5	40
Demand		45	20	30	30	

14 (10)

The BOMs for products A and B are shown in Table 1. Data from inventory records are shown in Table 2. The MPS calls for 85 units of product A to be completed in week 4 and 100 units to be completed in week 7 (the lead time is one week). The MPS for product B calls for 180 units to be completed in week 7 (the lead time is two weeks). Develop the material requirement plan for the next six weeks for items C, D, E, and F.

Item	Made of Number*Item	Item	Made of Number *Item
A	2*C 1*D	B	1*D 2*E
D	2*F 1*E	D	2*F 1*E
E	1*F	E	1*F

Table 1

Inventory Record Data

Data Category	Item C	Item D	Item E	Item F
Lot sizing rule	FOQ =220	L4L	FOQ = 300	POQ = (P=2)
Lead time	3 weeks	2 weeks	3 weeks	2 weeks
Safety stock	20	0	0	80
Scheduled receipts	280 (week 1)	None	300 (week 3)	None
On-hand inventory	25	0	150	600

Table 2

Good Luck
Sabah Audo

If operated around the clock under ideal conditions, the fabrication departme
of an engine manufacturer can make 100 engines per day. Management believ
that a maximum output rate of only 45 engines per day can be sustained ec
nomically over a long period of time. Currently the department is producing a
average of 50 engines per day. What is the utilization of the department, relati
to design capacity? Effective capacity?

Solution The two utilization measures are

$$\text{Utilization}_{\text{design}} = \frac{\text{Average output rate}}{\text{Design capacity}} = \frac{50}{100} \times 100\% = 50\%$$

$$\text{Utilization}_{\text{effective}} = \frac{\text{Average output rate}}{\text{Effective capacity}} = \frac{50}{45} \times 100\% = 111\%$$

Even though fabrication department operations fall well short of the design ca
pacity, they are beyond the output rate judged to be the most economical. They
could be sustained at that level only through the use of considerable overtime.

2.

A toy manufacturer uses 48,000 rubber wheels per year for its popular dump truck series. The firm makes its own wheels, which it can produce at a rate of 800 per day. The toy trucks are assembled uniformly over the entire year. Carrying cost is $1 per wheel a year. Setup cost for a production run of wheels is $45. The firm operates 240 days per year. Determine the:

a. Optimal run size

b. Minimum total annual cost for carrying and setup

c. Cycle time for the optimal run size

d. Run time

D = 48,000 wheels per year
S = $45
H = $1 per wheel per year
p = 800 wheels per day
u = 48,000 wheels per 240 days, or 200 wheels per day

a. $$Q_0 = \sqrt{\frac{2DS}{H}}\sqrt{\frac{p}{p-u}} = \sqrt{\frac{2(48{,}000)45}{1}}\sqrt{\frac{800}{800-200}}$$

$$= 2{,}400 \text{ wheels}$$

b. $$TC_{min} = \text{Carrying cost} + \text{Setup cost} = \left(\frac{I_{max}}{2}\right)H + (D/Q_0)S$$

Thus, you must first compute I_{max}:

$$I_{max} = \frac{Q_0}{p}(p-u) = \frac{2{,}400}{800}(800-200) = 1{,}800 \text{ wheels}$$

$$TC = \frac{1{,}800}{2} \times \$1 - \frac{48{,}000}{2{,}400} \times \$45 = \$900 + \$900 = \$1{,}800$$

Note again the equality of cost (in this example, setup and carrying costs) at the EOQ.

c. $$\text{Cycle time} = \frac{Q_0}{u} = \frac{2{,}400 \text{ wheels}}{200 \text{ wheels per day}} = 12 \text{ days}$$

Thus, a run of wheels will be made every 12 days.

d. $$\text{Run time} = \frac{Q_0}{p} = \frac{2{,}400 \text{ wheels}}{800 \text{ wheels per day}} = 3 \text{ days.}$$

Thus, each run will require three days to complete.

3. a. Materials management concepts apply to service organizations in the same way as to manufacturing organizations. The materials management decisions such as staffing plan, work-force schedule, inventory control (44 percent of the economy's inventory is held by wholesalers and retailers alone), operations scheduling, and purchasing are as important for the efficient management of service organizations as they are for manufacturing organizations.

b. It is true that very few actual situations are simple and well behaved enough to comply with the *EOQ* assumptions. Nevertheless, *EOQ* is often a reasonable first estimate of average lot size. Also, by adjusting the *EOQ* model to reflect the various changes in the basic assumptions, a planner can make more realistic decisions in managing inventories. Most of all, the *EOQ* concept provides valuable information about the structural relationships among the related variables. It provides a means to estimate the directions in which inventories will change in response to various changes in the cost and demand parameters.

5. The statement that customers arrive one at a time completely at random implies that the input process is a Poisson process. The arrival rate is $\lambda = 6$ per hour. The mean service time is 4 minutes $= 1/15$ hour, so that the service rate is $\mu = 15$ per hour. The utilization rate is $\rho = \lambda/\mu = 6/15 = 2/5 = .4$.

a. $L = \rho/(1 - \rho) = (2/5)/(3/5) = 3/4$ $(= 0.6667)$.
$L_q = \rho L = (2/5)(2/3) = 4/15$ $(= 0.2667)$.
$W = L/\lambda = (2/3)/6 = 2/18 = 1/9$ hour (6.6667 minutes).
$W_q = L_q/\lambda = (4/15)/6 = 4/90 = 2/45$ hour (2.6667 minutes).

b. Here we are interested in $P\{L > 5\}$.
In general,

$$P\{L > k\} = \sum_{n=k+1}^{\infty} P_n = \sum_{n=k+1}^{\infty} (1-\rho)\rho^n = (1-\rho)\sum_{n=k+1}^{\infty} \rho^n$$

$$= (1-\rho)\rho^{k+1}(1/(1-\rho)) = \rho^{k+1}.$$

Hence, $P\{L > 5\} = \rho^6 = (0.4)^6 = 0.0041$.

c. Here we are interested in $P\{W_1 > 1/6\}$.

$$P\{W_q > t\} = \rho e^{-(\mu-\lambda)t} = 0.4e^{-(15-6)(1/6)} = 0.4e^{-1.5} = 0.0892.$$

d. The answer is not obvious. Looking at the expected measures of performance, it would appear that the service provided is reasonable. The expected number of customers in the system is lessΩ than one and the average waiting time in the queue is less than 3 minutes. However, from part (*c*) we see that the proportion of customers having to wait more than 10 minutes for service is almost 10 percent. This means that there are probably plenty of irate customers, even though on average the system looks good. This illustrates a pitfall of only considering expected values when evaluating queuing service systems. ■

6.

Checking the conditions, we find

min $A_i = 4$, Max $B_i = 6$, Min $C_i = 6$

We now form the two columns A' and B'

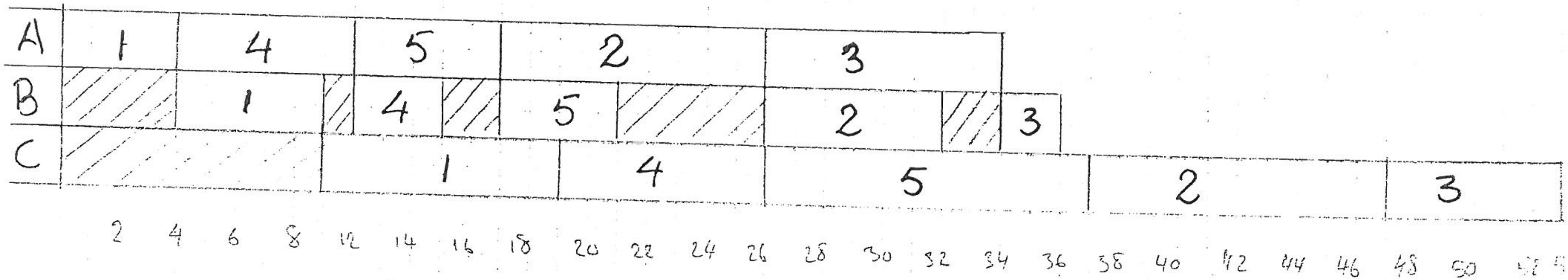
Job	Machines A'	B'
1	9	13
2	15	16
3	10	8
4	9	10
5	9	15

WRONG!

Using Johnson's Rule, we get

1 – 4 – 5 – 2 – 3

other solutions may be possible giving the same time span



7.

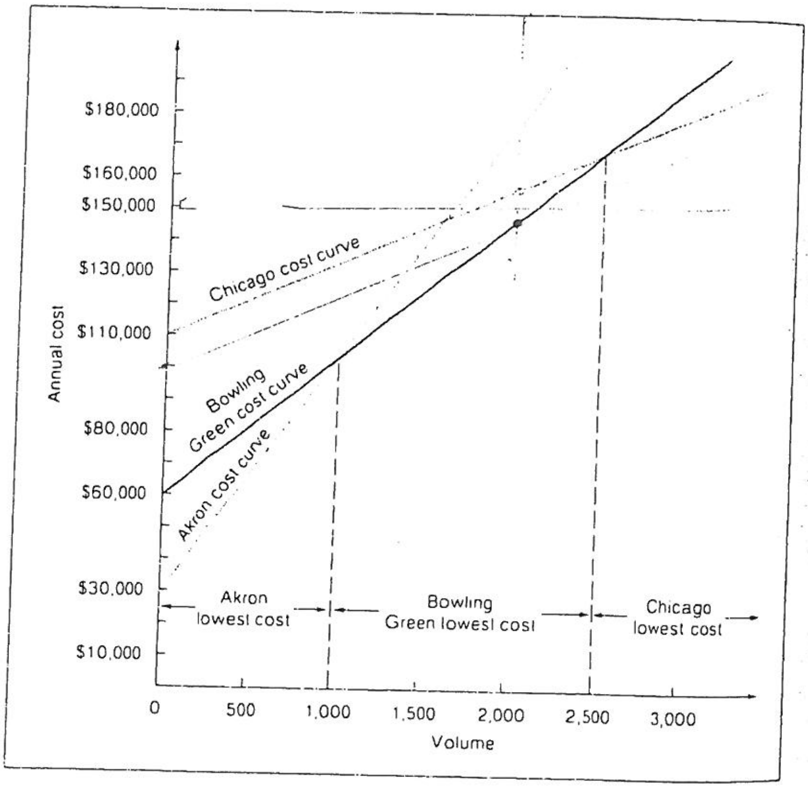
A manufacturer of automobile carburetors is considering three locations—Akron, Bowling Green, and Chicago—for a new plant. Cost studies indicate that fixed costs per year at the sites are $30,000, $60,000, and $110,000, respectively; and variable costs are $75 per unit, $45 per unit, and $25 per unit, respectively. The expected selling price of the carburetors produced is $120. The company wishes to find the most economical location for an expected volume of 2,000 units per year.

For each of the three, we can plot the fixed costs (those at a volume of zero units) and the total cost (fixed costs + variable costs) at the expected volume of output. These lines have been plotted in Figure 8.3.

Facit

baseval på

Fixed cost Chicago = 110 000



For Akron,

$$\text{Total cost} = \$30{,}000 + \$75(2{,}000) = \$180{,}000$$

For Bowling Green,

$$\text{Total cost} = \$60{,}000 + \$45(2{,}000) = \$150{,}000$$

For Chicago,

100' = 150'

$$\text{Total cost} = \$110{,}000 + \$25(2{,}000) = \$160{,}000$$

With an expected volume of 2,000 units per year, Bowling Green provides the lowest cost location. The expected profit is:

$$\text{Total revenue} - \text{Total cost} = \$120(2{,}000) - \$150{,}000 = \$90{,}000 \text{ per year}$$

The chart also tells us that for a volume of less than 1,000, Akron would be preferred, and for a volume greater than 2,500, Chicago would yield the greatest profit. The crossover points are 1,000 and 2,500.

8.

Solution We first define D and then P. Here, P is the time between reviews, expressed as a multiple (or fraction) of time interval t ($t = 1$ week because the data are expressed as demand *per week*):

$$D = (18 \text{ units/week})(52 \text{ weeks/year}) = 936 \text{ units}$$

$$P = \frac{\text{EOQ}}{D}(52) = \frac{75}{936}(52) = 4.2, \quad \text{or} \quad 4 \text{ weeks}$$

With $d = 18$ units per week, we can also calculate P by dividing the EOQ by d to get $75/18 = 4.2$, or 4 weeks. Hence we would review the birdfeeder inventory

:very 4 weeks. We now find the standard deviation of demand over the protection nterval ($P + L = 6$):

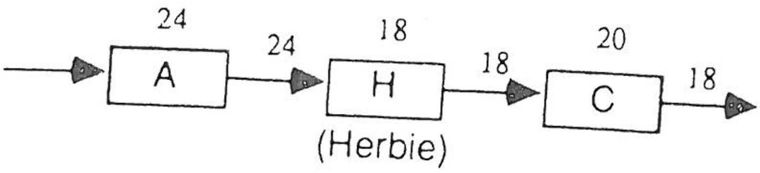
$$\sigma_{P+L} = \sigma_t\sqrt{P + L} = 5\sqrt{6} = 12 \text{ units}$$

Before calculating T, we also need a z value. For a 90 percent cycle-service level, $z = 1.28$ (see the Normal Distribution appendix). We now solve for T:

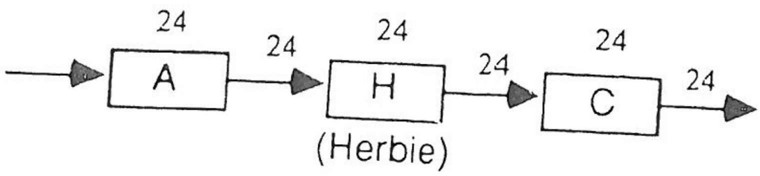
$$\begin{aligned} T &= \text{Average demand during the protection interval} + \text{Safety stock} \\ &= d(P + L) + z\sigma_{P+L} \\ &= (18 \text{ units/week})(6 \text{ weeks}) + 1.28(12 \text{ units}) = 123 \text{ units} \end{aligned}$$

Every four weeks we would order the number of units needed to bring inventory position IP (counting the new order) up to the target inventory level of 123 units. The safety stock for this P system is $1.28(12) = 15$ units, compared to only 9 units for the Q system.

9. The effective capacity of the system is limited by the bottleneck operation, H, to 18 units per day. If operation A produces 24 units per day, a large WIP inventory will build in front of operation H, but throughput will still be limited to 18 units per day.

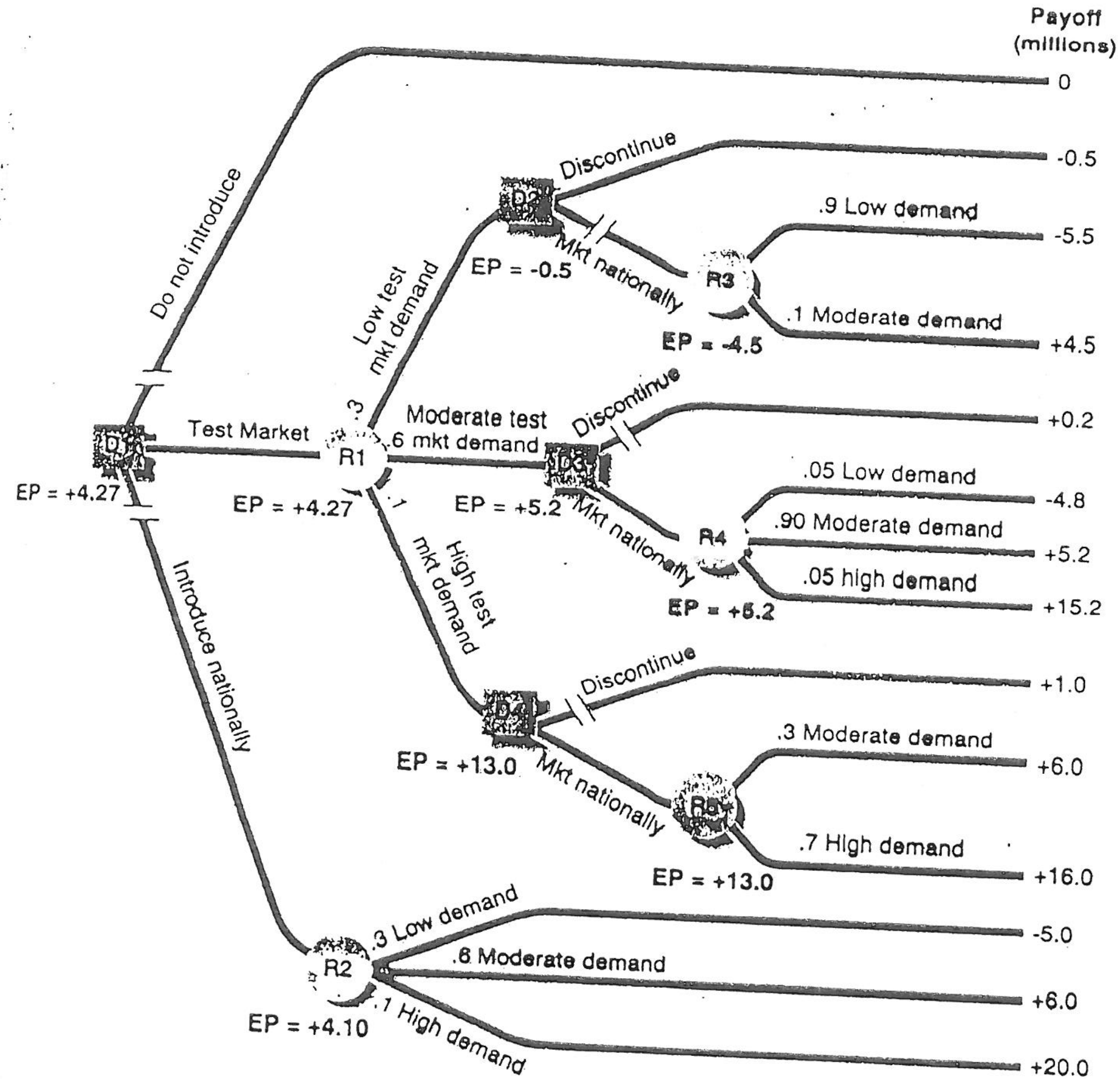


With overtime, the daily capacities are:



We would expect the throughput to increase to 24 units per day. However, the output increased to only 21 units per day. Possible causes include 1) fatigue from overtime, 2) material shortages, and 3) the loss of throughput that always occurs when variable operations are closely linked. The outpu rates are *average rates*, meaning that at any particular time the production rate at one of the operations could be less than the 24 units per day rate and cause a temporary bottleneck. When the operations are closely linked, (no WIP) throughput is always determined by the (momentary) weakest link. The system can not take advantage of favorable conditions at one operation unless those favorable conditions occur simultaneously at all operations. The upshot of all this is that the average throughput of closely linked operations will almost always be less than would be expected from just looking at average capacities. For a thorough discussion of bottlenecks, see *The Goal*, by Eli Goldratt.

15.


Payoff (millions)
Do not introduce
Test Market
Introduce nationally
EP = +4.27
R1
EP = +4.27
.3
Low test mkt demand
Moderate test
.6 mkt demand
.1
High test mkt demand
EP = -0.5
Discontinue
Mkt nationally
R3
EP = -4.5
.9 Low demand
.1 Moderate demand
EP = +5.2
Discontinue
Mkt nationally
R4
EP = +5.2
.05 Low demand
.90 Moderate demand
.05 high demand
EP = +13.0
Discontinue
Mkt nationally
EP = +13.0
.3 Moderate demand
.7 High demand
R2
EP = +4.10
.3 Low demand
.6 Moderate demand
.1 High demand
0
-0.5
-5.5
+4.5
+0.2
-4.8
+5.2
+15.2
+1.0
+6.0
+16.0
-5.0
+6.0
+20.0

11.

Quarter	Aggregate Demand
1	10,000
2	12,000
3	9,000
4	11,000

Solution:

(a) *Chase Demand Strategy* For each quarter we determine the number of workers needed to meet the demand in that quarter exactly Then we adjust the workforce accordingly

Qt	Aggregate Demand (units)	Planned Output (units)	Workers on Staff	Workers Hired	Workers Laid Off	Inventory (units)
0			480			2000
1	10,000	8,000	320	0	160	0
2	12,000	12,000	480	160	0	0
3	9,000	9,000	360	0	120	0
4	11,000	11,000	440	80	0	0
Totals	(Qts. 1–4)		1600	240	280	0

Salaries	1600 workers × $15,000/Qt	= $24,000,000
Hiring cost	240 workers × $7,000	= $ 1,680,000
Layoff cost	280 workers × $10,000	= $ 2,800,000
Inventory cost	0 units × $1,000/unit =	0
Total cost		$28,480,000

(b) *Level Strategy* For each quarter we compute the net cumulative requirements and the number of workers needed to make the cumulative requirements

Qt	Net Cumulative Requirements	Workers Needed to Make Cum. Req.
1	8,000	320 00
2	20,000	400 00
3	29,000	386 67
4	40,000	400.00

The largest number of workers ever needed is 400, so we will reduce the workforce to 400 and keep it there

Qt	Aggregate Demand (units)	Planned Output (units)	Workers on Staff	Workers Hired	Workers Laid Off	Inventory (units)
0			480			2000
1	10,000	10,000	400	0	80	2000
2	12,000	10,000	400	0	0	0
3	9 000	10,000	400	0	0	1000
4	11,000	10,000	400	0	0	0
Totals	(Qts 1–4)		1600	0	80	3000

Salaries	1600 workers × $15,000/Qt	= $24,000,000
Hiring cost	0 workers × $7,000	= $ 0
Layoff cost	80 workers × $10,000	= $ 800,000
Inventory cost	3000 units × $1,000/unit =	$ 3,000,000
Total cost		$27,800,000

Transportation and inventories are the primary cost-absorbing logistics activities. Experience has shown that each will represent one-half to two-thirds of total logistics costs.
It is *Transportation* **that adds place value to the products and services,** whereas *Inventory* **adds time value.**

Transportation is essential because no modern firm can operate without providing for the movement of its raw materials and/or finished products

Inventories are essential to logistics management because it is usually not possible or practical to provide instant production or sure delivery times to the customers. They serve as buffers between supply and demand so that needed product availability may be maintained for customers while providing flexibility for production and logistics to seek more efficient methods for manufacturing and distributing the products

Logistics is about creating value – value for customers and suppliers of the firm, and value for the firm's stakeholders. Value in logistics is expressed in terms of *time and place.*

Products and services have no value unless they are in the possession of the customers when (time) and where (place) they wish to consume them.

Logistics revolves around a primary decision triangle of ***Location, Inventory,*** and ***Transportation***, with ***Customer Service*** being the result of these decisions.

Customer Service Goals
Low levels of service allow centralized inventories at few locations and the use of less expensive forms of transport. High service levels generally require just the opposite. However, when service levels are pressed to their upper limits, logistics costs rise at a rate disproportionate to the service level.

Customer service broadly includes inventory availability, speed of delivery, and order filling speed and accuracy. The cost associated with these factors increase at a higher rate as customer service levels is raised.

Reformulating the logistics strategy is usually needed when service levels are changed due to competitive forces, policy revisions, or arbitrary service goals different from those on which the logistics strategy was based originally.

Facility Location Strategy
The geographic placement of the stocking points and their sourcing points create an outline for the logistics plan. Fixing the number, location, and size of the facilities and assigning market demand to them determines the path through which products are directed to the market place. The proper scope for the facility location problem is to include all product movements and associated costs as they take place from plant,

vendor, or port location through the intermediate stocking points and to the customer locations.

Assigning customer demand to be served directly from plants, vendors, or ports, or directing it through selected stocking points, affects total distribution costs. Finding the lowest cost assignments, or alternatively the maximum profit assignments is the essence of facility location strategy.

Inventory Decisions

Refer to the manner in which inventories are managed. Allocating (pushing) inventories to the stocking points versus pulling them into stocking points through inventory replenishment rules represents two strategies.
Selective location of various items in the product line in plant, regional or field warehouses or managing inventory levels by various methods or inventory control are others.

Transportation Decisions

Transport decisions can involve mode selection, shipment size, and routing or scheduling. These decisions are influenced by the proximity of warehouses to customers and plants, which in turn, influence warehouse location. Inventory levels also respond to transport decisions through shipment size.

Customer service levels, facility location, inventory, and transportation are major planning areas because of the impact that decisions in these areas have on the profitability, cash flow, and return on investment of the firm.

Another way to look at logistics planning problem is to view it in the abstract as a network of links and nodes, as shown in.
The links of the network represent the movement of goods between various inventory storage points. These storage points – retail stores, warehouses, factories, or vendors – are the nodes. There may be several links between any pair of nodes, to represent alternative forms of transportation service, different routes, and different products. Nodes represent points where the flow of inventories is temporarily stopped, for example, at a warehouse, before moving onto a retail store and to the final customer.
In addition there is a flow of information flows. Information is derived from sales revenues, product costs, inventory levels, warehouse utilization, forecasts, transportation rates and the like. Links in the information network usually consists of the mail or electronic methods for transmitting information from one geographical point to another. Nodes are the data collection and processing points, such as a clerk who handles order processing and prepares bills of laden or computer that updates inventory records.
A major difference in the network is that product mainly flows "down" the distribution channel (toward the final customer), whereas information mainly, but not entirely, flows "up" the channel (toward raw material sources).

Product Characteristics

Logistics costs are sensitive to such characteristics as product ***weight***, ***volume*** (cube), ***value***, and ***risk***.

In the logistics channel, these characteristics can be altered through package design or finished state of the product during shipment and storage. For example, shipping a product in a knocked-down form can considerably affect the weight-bulk ratio of the product and the associated transportation and storage costs.

A firm producing high valued goods (such as machine tools and computers) with logistics costs being a fraction of total costs will likely give little attention to the optimality of logistics strategy.

However, when logistics costs are high, as they can be in the case of packaged industrial chemicals and food products, logistics strategy is a key concern.

Classifying Products

Consumer Products are those that are directed to ultimate consumers.

A three-fold consumer classification has been suggested

Convenience Products are those goods and services that consumers purchase frequently, immediately, and with limited comparative shopping. Typical products are banking services, tobacco items, and many foodstuffs.

These products generally require wide distribution through many outlets. Distribution costs are typically high but more than justified by the increased sales potential that is brought about by this wide and extensive distribution.

Customer service levels are expressed in terms of product availability and accessibility. (Examples are vending machines for Pepsi-cola etc., and telephone kiosks all over the place).

Shopping Products are those for which customers are willing to seek and compare: shopping many locations, comparing price and quality, performance, and making a purchase only after careful deliberation. Typical products in this category are fashion clothes, automobiles, and home furnishings.

Because of the customer's willingness to shop around, the number of stocking points is substantially reduced as compared with convenience goods and services. Distribution costs for such suppliers are somewhat lower than convenience goods.

Specialty Products are those for which buyers are willing to expend a substantial effort and often to wait a significant amount of time in order to require them. Buyers seek out particular types and brands of goods and services. Examples can be almost any type of good ranging from fine foods to custom made automobiles or a service such as management consultancy advice. Because buyers insist on particular brands, distribution is centralized and customer service levels are not as high as for convenience and shopping products. Physical distribution costs can be the lowest of any product category. Because of this, many firms will attempt to create a brand preference for their product line.

Industrial Products are those that are directed to individuals or organizations that use them to produce other goods or services. Their classification is quite different from consumer products.

Traditionally, industrial goods and services have been classified according to the extent to which they enter the production process. For example, there are goods that are part of the finished product, such as raw materials and component parts; there are goods that are used in the manufacturing process, such as buildings and equipment; and there are goods that do not enter the process directly, such as supplies and business services. Although this classification is valuable in preparing a selling strategy, it is not clear if it is useful in planning a physical distribution strategy.

Industrial buyers do not seem to show preferences for different service levels for different product classes. This simply means that traditional product classification for industrial products may not be useful for identifying typical logistics channels, as is the classification of consumer products.

The Product Life Cycle

Products do not generate their maximum sales volume immediately after being introduced, nor do they maintain their peak sales volume indefinitely. The physical distribution strategy differs for each stage. During the introductory stage, the strategy is a cautious one, with stocking restricted to relatively few locations. Product availability is limited.

If the product receives market acceptance, sales are likely to increase rapidly. Physical distribution is particularly difficult at this stage. Often there is not much of a sales history that can guide inventory levels at stocking points or even the number of stocking points to use.

The growth stage may be fairly short, followed by a longer stage called maturity. Sales growth is slow or stabilized at a peak level. The product volume is no longer undergoing rapid change, and therefore can be assimilated into the distribution pattern of similar existing products. At this time the product has its widest distribution. Many stocking points are used with good control over product availability throughout the market place. Eventually the sales volume declines for most products as a result of technological change, competition, or waning consumer interest. To maintain efficient distribution, patterns of product movement and inventory deployment have to be adjusted. The number of stocking points is likely to be decreased and the product stocking reduced to fewer, and more centralized location.

The 80 -20 Curve

The product line of a typical firm is made up of individual products at different stages of their respective life cycles and with different degrees of sales success. At any point in time, this creates a product phenomenon known as the 80- 20 curve.

The bulk of the sales are generated from relatively few products in the product line and from the principle known as Pareto´s law. That is, 80 percent of a firm's sales are generated by 20 percent of the product line items. Each category of items could be distributed differently. For example, A items might receive wide geographical distribution through many warehouses and high levels of stock availability, where C items might be distributed from a single stocking point (e.g. the plant) with lower total stocking levels than for A items. B items would have an intermediate distribution strategy where a few regional warehouses are used.

Product Characteristics

The most important characteristics of the product that can influence logistics strategy are the attributes of the product itself – weight, volume, value, perishability, flammability, and substitutability. When observed in various combinations, they are an indication of the need for warehousing, inventories, materials handling, and order processing.

Weight–Bulk Ratio The ratio of weight to bulk (volume) is a particularly meaningful measure, as transportation and storage costs are directly related to them. Products that are dense, i.e. have a high weight-bulk ratio (rolled steel, printed materials, and canned foods) show good utilization of transportation equipment and storage facilities, with the costs of both tending to be low. However, for products with low density (inflated beach balls, boats, potato chips, and lamp shades), the bulk capacity of transportation equipment is not fully realized before the weight-carrying limit is reached. Also the handling and space costs, which are weight-based, tend to be high relative to the product's sales price.

Value-Weight Ratio Storage costs are particularly sensitive to value. When value is expressed as a ratio to weight, some of the obvious cost trade-offs emerge that are useful in planning the logistics system.

Products that have low value-weight ratios (coal ore, and sand) have low storage costs but high movement costs as a percentage of their sales price.
Inventory carrying costs are computed as a percentage of the product's value. Low product value means low storage cost because inventory-carrying cost is the dominant factor in storage cost.
Transportation costs on the other hand, are pegged to weight. When the value of the product is low, transportation costs represent a high proportion of the sales value.

High value- weight ratio products (electronic equipment, jewelry, and musical instruments) show the opposite pattern with higher storage and lower transport costs. If the product has a high value-weight ratio, minimize the amount of inventory maintained is a typical reaction.

Risk Characteristics Product risk characteristics refer to such patterns as perishability, flammability, value, tendency to explode, and ease of being stolen. When a product shows high risk in one or more of these features, it simply forces more restrictions on the distribution system. Both transport and storage costs are higher in absolute dollars and as a percentage of the sales price.

Logistics Customer Service

Customers view the offerings of any company in terms of price, quality, and service, and they respond with their patronage.

1.

	45	20	30	30	u_i
35	35 [8]	(-5) [6]	(-2) [10]	(4) [9]	0
50	10 [9]	− 20 [12]	+ 30 [13]	(5) [7]	1
40	(2) [14]	+ (-6) [9]	− 10 [16]	30 [5]	4
v_j	8	11	12	1	

	45	20	30	30	u_i
35	− 35 [8]	+ (-5) [6]	(-2) [10]	(2) [9]	0
50	+ 10 [9]	− 10 [12]	30 [13]	(-1) [7]	1
40	(8) [14]	10 [9]	(6) [16]	30 [5]	-2
v_j	8	11	12	7	

	45	20	30	30	u_i
35	− 25 [8]	10 [6]	+ (-2) [10]	(7) [9]	0
50	+ 20 [9]	(5) [12]	− 30 [13]	(4) [7]	1
40	(3) [14]	10 [9]	(1) [16]	30 [5]	3
v_j	8	6	12	2	

	45	20	30	30	u_i
35	(2) [8]	10 [6]	25 [10]	(7) [9]	0
50	45 [9]	(3) [12]	5 [13]	(2) [7]	3
40	(5) [14]	10 [9]	(3) [16]	30 [5]	3
v_j	6	6	10	2	

405
60
90
250
65
+150
―――
1020

Final Tableau gives the opt. solution

14.

Item: A	Week	1	2	3	4	5	6	7	8
MPS Quantity (due)					85			100	
MPS Quantity (release)				85			100		

Item: B	Week	1	2	3	4	5	6	7	8
MPS Quantity (due)								180	
MPS Quantity (release)						180			

Item: C | **Lot Size:** FOQ = 220
Description: | **Lead Time:** 3 weeks
Safety Stock: 20 units

Week		1	2	3	4	5	6	7	8
Gross requirements				170			200		
Scheduled receipts		280							
Projected on hand	25	305	305	135	135	135	155	155	155
Planned receipts							220		
Planned order releases				220					

Item: D | **Lot Size:** L4L
Description: | **Lead Time:** 2 weeks
Safety Stock: 0 units

Week		1	2	3	4	5	6	7	8
Gross requirements				85		180	100		
Scheduled receipts									
Projected on hand	0	0	0	0	0	0	0	0	0
Planned receipts				85		180	100		
Planned order releases		85		180	100				

Item: E | **Lot Size:** FOQ = 300
Description: | **Lead Time:** 3 weeks
Safety Stock: 0 units

Week		1	2	3	4	5	6	7	8
Gross requirements		85		180	100	360			
Scheduled receipts				300					
Projected on hand	150	65	65	185	85	25	25	25	25
Planned receipts						300			
Planned order releases			300						

Item: F | **Lot Size:** POQ = 2
Description: | **Lead Time:** 2 weeks
Safety Stock: 80 units

Week		1	2	3	4	5	6	7	8
Gross requirements		170	300	360	200				
Scheduled receipts									
Projected on hand	600	430	130	280	80	80	80	80	80
Planned receipts				510					
Planned order releases		510							