Examination

TENTAMEN I:	Production and Logistics Planning
DATE:	2012-01-12
NUMBER OF HOURS:	5 Hours
GROUP:	Freestanding course
COURSE CODE:	KPP227
EXAMINATION CODE:	TEN1
HELPMEANS:	Calculator, Dictionary
TEACHER:	Sabah Audo
TELEPHONE:	016-15 36 27

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 (6)
Use the longest work-element rule to balance the assembly line described in the table below so that it will produce 40 units per hour.

Work Element	Time (sec)	Immediate predecessor(s)
A	40	None
B	80	A
C	30	A
D	25	B
E	20	C
F	15	B
G	60	B
H	45	D
I	10	E,G
J	75	F
K	15	H, I, J
Total	415	

a. Draw a precedence diagram.
b. What is the cycle time?
c. What is the theoretical minimum number of work workstations?
d. Which work elements are assigned to each workstation?
e. What are the resulting efficiency and balance of delay percentages?

2 (5)
A manager is trying to decide whether to buy one machine or two. If only one is purchased and demand proves to be excessive, the second machine can be purchased later. Some sales will be lost, however, because the lead-time for producing this type of machine is six months. In addition, the cost per machine will be lower if both are purchased at the same time. The probability of low demand is estimated to be 0.25, and of high demand, 0.75. The net present value of the benefits from purchasing the two machines together is $94,000 if demand is low and $165,000 if demand is high.

If one machine is purchased and demand is low, the net present value is $115,000. If demand is high, the manager has three options. Doing nothing has a net present value of $115,000; subcontracting, $140,000; and buying the second machine, $126,000.

a. Draw a decision tree for this problem.
b. How many machines should the company buy initially? What is the expected payoff for this alternative?

3 (6)
A discount store stocks toy race cars. Recently, the store has been given a quantity discount schedule for these cars as shown below.

Quantity	Price
0 to 999	\$5.00
1000 to 1,999	\$4.80
2000 and over	\$4.75

Furthermore, ordering cost is \$49.00 per order, annual demand is 5,000 racecars, and inventory carrying charge, as a percentage cost, is 20%. What order quantity will minimize the total inventory cost?

4 (10)
A mechanic shop is able to install new mufflers at an average rate of 3 per hour according to a negative exponential distribution. Customers seeking this service arrive at an average rate of 2 per hour, following a Poisson distribution. They are served according to FIFO.

a. Find the following 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. The probability of zero cars in the system.
c. The probability of more than 0, 1, 2, 3, 4, 5, 6, and 7 cars in the system.

5 (7)
During the past eight quarters, a port has unloaded large quantities of grain from ships (see Table below). The port's manager wants to test the use of exponential smoothing to see how well the technique works in predicting tonnage unloaded. He guesses that the forecast of grain unloaded in the first quarter was 175. Two values of α are examined:
$\alpha = 0.1$ and $\alpha = 0.5$. Determine which value of α gives a better forecast based on the values of mean absolute deviation (MAD) and mean squared error (MSE).

Quarter	Actual tonnage
1	180
2	168
3	159
4	175
5	190
6	205
7	180
8	182

6 (12)
Use the least cost method (LCM), Vogel's approximation (VAM), and the modified transportation method to find the least cost of the following transportation problem where the costs per unit are shown in the matrix below.

	Warehouses				
Factories	1	2	3	4	Amount available
1	19	30	50	10	7
2	70	30	40	60	9
3	40	8	70	20	18
Amount required	5	8	7	14	

7 (7)

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	10	6	18
2	14	4	10
3	8	6	14
4	16	8	6
5	12	4	4
6	14	0	16

8 (12)

A company makes several models of compact disk players (CDPs), which form a product type at its facility. The predicted sales for these products for the next six months are as follows:

Month	Sales	Work Days
Oct.	200000	23
Nov	220000	21
Dec	310000	19
Jan	300000	21
Feb	240000	20
Mar	230000	23

Each unit of product requires approximately 1.5 person-hours of labor to make. Workers work an eight-hour day, and they receive an average of $2000 per month in wages and fringe benefits. It costs approximately $2500 to lay off or terminate an employee, and approximately $3000 to recruit and train a new employee. CDPs produced in one month can be held in inventory and shipped in subsequent months, but it costs $10 per month to hold the item in inventory.

For simplicity we assume that at the beginning of each month a decision to hire/dismiss workers is made. Then production occurs during the month and all shipments are made at the end of the month. Any item on hand at the end of the month that is not shipped incurs the $10 holding cost. The decisions facing the company are to select the number of production employees to have on staff each of the next six months (and the number to hire and dismiss). The number of CDPs to produce each month, and then indirectly how many to have in inventory at the end of each month.

The company expects to have 1850 production workers on staff during September, and it expects to end September with 5000 units of inventory available for use. In addition, the company wants to complete March with between 1800 and 1900 production workers on staff and with between 1800 and 2150 units of product in inventory.
Use both the level and the chase strategy to solve the problem and indicate which is best.

9 (4)
In a Q system, the demand for a certain product is normally distributed, with an average of 200 units per week. The lead-time is 4 weeks. The standard deviation of weekly demand is 15 units.

a. What is the standard deviation of demand during the 4-week lead-time?
b. What is the average demand during the 4-week lead-time?
c. What reorder point results in the cycle-service level of 99 percent?

10 (10)
The following information is available about three MPS items.
Item A: An 80 unit order is to be completed in week 4. A 55 unit order is to be completed in week 7.
Item B: A 125 unit order is to be completed in week 7.
Item C: A 60 unit order is to be completed in week 7.
The lead times are one week for A, two weeks for B, and three weeks for C. Develop the materials requirement plan for the next six weeks for items D, E, and F. The product structure is shown in the 1st table, and data from inventory record is shown in 2nd table.

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

Inventory Record Data

	Item		
Data category	D	E	F
Lot-sizing rule	FOQ = 150	L4L	POQ = (P = 2)
Lead time	3 weeks	1 week	2 weeks
Safety stock	40	0	30
Scheduled receipts	250 (week 1)	120 (week 2)	None
Beginning (on-hand) inventory	150	0	100

11 (6)
An automobile brake supplier operates on two eight-hour shifts, five days per week, 52 weeks per year. Table below shows the time standards, lot sizes, and demand forecast for three components. The manager believes a 20 percent capacity cushion is best.

	Time standard			
component	Processing hr/unit	Setup hr/lot	Lot Size units/lot	Demand forecast
A	0.05	1.0	60	25000
B	0.20	4.5	80	17000
C	0.05	8.2	120	40000

What is the minimum number of machines needed? If the operation currently has three machines and the manager is willing to expand capacity by 20 percent through-short term options, what is the capacity gap?

Use the following equation
$M = \{[Dp + (D/Q)s]_{product1} + \ldots\ldots + [Dp + (D/Q)s]_{product\ n}\}/N[1-(C/100)]$

Where M = number of machines required
D = number of units forecast per year
P = processing time
N = number of hours per year during which the process operates
Q = number of units in each lot
C = desired capacity cushion
s = setup time per lot

12 (9)
Management wants to locate two facilities to serve two groups of demand points. The following data were collected.

Demand Point	xy-Coordinates (miles)	Trips per Day (l)
A	(0, 10)	10
B	(15, 30)	15
C	(20, 15)	20
D	(30, 30)	30
E	(40, 45)	15

a. Draw a grid map showing the location of the demand points.
b. Divide the points into two groups, north and south. The north facility will serve B, D, and E, whereas the south facility will serve A and C. Let the facility locations be the centers of gravity of the two areas, rounded to the nearest whole numbers. What is the total load-distance score for the entire system, based on Euclidean distance?
c. Repeat part (b) for an east-west division. The west facility will serve A, B, and C, and the east facility will serve D, and E. Is this solution better or worse than the one in part (b)?

13 (6)
a. How do we classify products for logistics purposes and how can they be linked to the product life cycle and the 80-20 curve? Explain in details.
b. What are the most important product characteristics that can influence logistics? Explain in details.

1. Assembly-line balancing. Longest work element rule to produce 40 units per hour.

a. $c = \frac{1}{r} = \frac{1 \text{ hour}}{40 \text{ units}} = \frac{3600 \text{ sec}}{40 \text{ units}} = 90 \frac{\text{sec}}{\text{unit}}$

b. $TM = \left(\frac{\sum t}{c}\right) = \frac{415}{90} = 4.611 \text{ or } 5$

c. S1 = {A, C, E}, S2 = {B}, S3 = {G, D}, S4 = {H, F, I}, S5 = {J, K}

Station	Candidate(s)	Choice	Work Element time (sec)	Cumulative time (sec)	Idle time (c=90sec)
S1	A	A	40	40	50
	C	C	30	30	70
	E	E	20	90	0
S2	B	B	80	80	10
S3	D, F, G	G	60	60	30
	D, F, I	D	25	85	5
S4	F, H, I	H	45	45	45
	F, I	F	15	60	30
	I	I	10	70	20
S5	J	J	75	75	15
	K	K	15	90	0

d.

$$\text{Efficiency (\%)} = \frac{(\sum t)}{nc}(100\%) = \frac{415}{5(90)} = 92.2\%$$

$$\begin{aligned}\text{Balance delay (\%)} &= 100\% - \text{Efficiency} \\ &= 100\% - 92.2\% \\ &= 7.8\%\end{aligned}$$

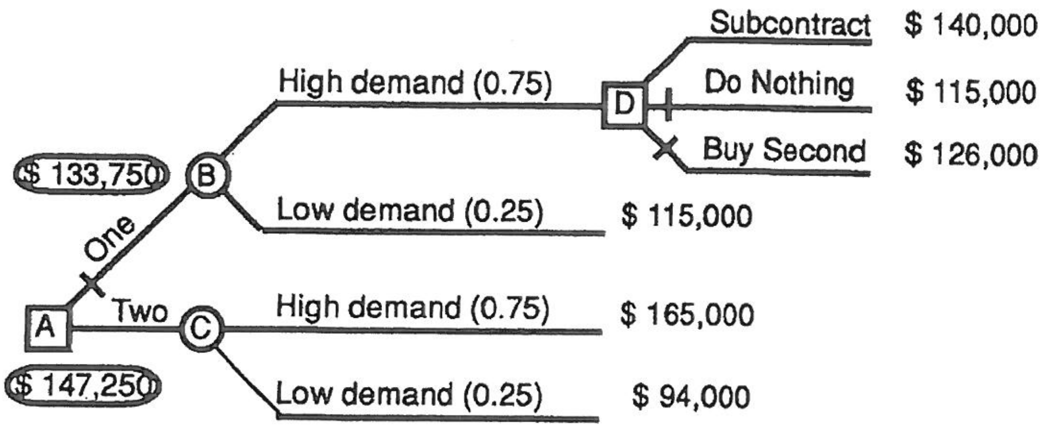
2) One machine or two. The decision tree is shown on the the next page. Working from right to left: Decision D is to subcontract because the upper branch has the highest expected value.

Event B [0.75 ($140,000) + 0.25 ($115,000)] = $133,750

Event C [0.75 ($165,000) + 0.25 ($ 94,000)] = $147,250

Decision A prunes Event B from the tree because the lower branch has a higher expected value. The indicated decision is purchase two machines now.

Review Problem 19, Decision Tree



3

Wohl's Discount Store stocks toy race cars. Recently, the store has been given a quantity discount schedule for these cars. This quantity schedule was shown in Table 12.2. Thus, the normal cost for the toy race cars is \$5.00. For orders between 1,000 and 1,999 units, the unit cost drops to \$4.80; for orders of 2,000 or more units, the unit cost is only \$4.75. Furthermore, ordering cost is \$49.00 per order, annual demand is 5,000 race cars, and inventory carrying charge, as a percentage of cost, I, is 20% or .2. What order quantity will minimize the total inventory cost?

The first step is to compute Q^* for every discount in Table 12.2. This is done as follows:

$$Q_1^* = \sqrt{\frac{2(5,000)(49)}{(.2)(5.00)}} = 700 \text{ cars order}$$

$$Q_2^* = \sqrt{\frac{2(5,000)(49)}{(.2)(4.80)}} = 714 \text{ cars order}$$

$$Q_3^* = \sqrt{\frac{2(5,000)(49)}{(.2)(4.75)}} = 718 \text{ cars order}$$

The second step is to adjust upward those values of Q^* that are below the allowable discount range. Since Q_1^* is between 0 and 999, it need not be adjusted. Because Q_2^* is below the allowable range of 1,000 to 1,999, it must be adjusted to 1,000 units. The same is true for Q_3^*: It must be adjusted to 2,000 units. After this step, the following order quantities must be tested in the total cost equation:

$$Q_1^* = 700$$

$$Q_2^* = 1,000\text{—adjusted}$$

$$Q_3^* = 2,000\text{—adjusted}$$

The third step is to use the total cost equation and compute a total cost for each order quantity. This step is taken with the aid of Table 12.3, which presents the computations for each level of discount introduced in Table 12.2.

TABLE 12.3 ■ Total Cost Computations for Wohl's Discount Store

Discount Number	Unit Price	Order Quantity	Annual Product Cost	Annual Ordering Cost	Annual Holding Cost	Total
1	\$5.00	700	\$25,000	\$350	\$350	\$25,700
2	\$4.80	1,000	\$24,000	\$245	\$480	\$24,725
3	\$4.75	2,000	\$23,750	\$122.50	\$950	\$24,822.50

The fourth step is to select that order quantity with the lowest total cost. Looking at Table 12.3, you can see that an order quantity of 1,000 toy race cars will minimize the total cost. You should see, however, that the total cost for ordering 2,000 cars is only slightly greater than the total cost for ordering 1,000 cars. Thus, if the third discount cost is lowered to \$4.65, for example, then this quantity might be the one that minimizes total inventory cost.

4.

λ = 2 cars arriving per hour

μ = 3 cars serviced per hour

$$L_s = \frac{\lambda}{\mu - \lambda} = \frac{2}{3 - 2} = \frac{2}{1}$$

= 2 cars in the system, on average

$$W_s = \frac{1}{\mu - \lambda} = \frac{1}{3 - 2} = 1$$

= 1-hour average waiting time in the system

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{2^2}{3(3 - 2)} = \frac{4}{3(1)} = \frac{4}{3}$$

= 1.33 cars waiting in line, on average

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{2}{3(3 - 2)} = \frac{2}{3} \text{ hour}$$

= 40-minute average waiting time per car

$$\rho = \frac{\lambda}{\mu} = \frac{2}{3}$$

= 66.6% of time mechanic is busy

$$P_0 = 1 - \frac{\lambda}{\mu} = 1 - \frac{2}{3}$$

= .33 probability there are 0 cars in the system

Probability of More Than k Cars in the System

k	$P_{n>k} = (2/3)^{k+1}$	
0	.667	← Note that this is equal to $1 - P_0 = 1 - .33 = .667$.
1	.444	
2	.296	
3	.198	← Implies that there is a 19.8% chance that more than 3 cars are in the system.
4	.132	
5	.088	
6	.058	
7	.039	

5

Quarter	Actual Tonnage Unloaded	Rounded Forecast with $\alpha = .10$	Absolute Deviation for $\alpha = .10$	Rounded Forecast with $\alpha = .50$	Absolute Deviation for $\alpha = .50$
1	180	175	5	175	5
2	168	176	8	178	10
3	159	175	16	173	14
4	175	173	2	166	9
5	190	173	17	170	20
6	205	175	30	180	25
7	180	178	2	193	13
8	182	178	4	186	4
	Sum of absolute deviations		84		100
	$MAD = \frac{\Sigma \lvert deviations \rvert}{n}$		10.50		12.50

On the basis of this analysis, a smoothing constant of $\alpha = .10$ is preferred to $\alpha = .50$ because its MAD is smaller.

Most computerized forecasting software includes a feature that automatically finds the smoothing constant with the lowest forecast error. Some software modifies the α value if errors become larger than acceptable.

Mean Squared Error The **mean squared error (MSE)** is another way of measuring overall forecast error. MSE is the average of the squared differences between the forecasted and observed values. Its formula is

$$MSE = \frac{\Sigma (\text{forecast errors})^2}{n} \quad (5.7)$$

Example 5 finds the MSE for the Port of Baltimore introduced in Example 4.

EXAMPLE 5

Quarter	Actual Tonnage Unloaded	Forecast for $\alpha = .10$	$(\text{Error})^2$
1	180	175	$5^2 = 25$
2	168	176	$(-8)^2 = 64$
3	159	175	$(-16)^2 = 256$
4	175	173	$2^2 = 4$
5	190	173	$17^2 = 289$
6	205	175	$30^2 = 900$
7	180	178	$2^2 = 4$
8	182	178	$4^2 = 16$
			Sum of errors squared = 1,558

$$MSE = \frac{\Sigma \text{ forecast errors}^2}{n} = 1{,}558/8 = 194.75$$

Is this MSE good or bad? It all depends on the MSEs for other values of a. As a practice exercise, find the MSE for $\alpha = .50$. (You should get MSE = 201.5.) The result indicates that $\alpha = .10$ is a better choice because we want to minimize MSE. Coincidentally, this confirms the conclusion we reached using MAD in Example 4.

6. Least Cost Method (LCM)

Supply	8 ~~7~~ 0	8 0	7 0	~~14~~ 7 0	
~~7~~ 0	19	30	50	7 [10]	–
~~9~~ 2	2 [70]	30	7 [40]	60	–
~~18~~ ~~10~~ 3 0	3 [40]	8 [8]	70	7 [20]	–
		–	–	–	

$2 \times 70 = 140$
$3 \times 40 = 120$
$8 \times 8 = 64$
$7 \times 40 = 280$
$7 \times 10 = 70$
$7 \times 20 = 140$

Total Cost = 814

VOGEL'S Approximation Method (VAM)

Supply	5 (0)	8 (10)	~~7~~ (0)	~~14~~ ~~4~~ (2)	1	2	3	4	5
~~7~~ ~~2~~ 0	5 [19]	30	50	2 [10]	9	9	40	40	–
~~9~~ ~~2~~ 0	70	30	7 [40]	2 [60]	10	20	20	20	20
~~18~~ ~~10~~ 0	40	8 [8]	70	10 [20]	12	20	50 ←	–	–
1	21	22 ↑	10	10					
2	21 ↑	–	10	10					
3	–	–	10	10					
4	–	–	10	50 ↑					
5	–	–	10	–					

$5 \times 19 = 95$
$2 \times 10 = 20$
$7 \times 40 = 280$
$2 \times 60 = 120$
$8 \times 8 = 64$
$10 \times 20 = 200$

Total Cost = 779

6.

1

	5	8	7	14	
7	[19] 5	[30] 2	[50] (10)	[10] (20)	0
9	[70] (51)	[30] 6⁻	[40] 3⁺	[60] (70)	0
18	[40] (-9)	[8] (52)⁺	[70] 4⁻	[20] 14	30
	19	30	40	-10	

5 X 19 = 95
2 X 30 = 60
6 X 30 = 180
3 X 40 = 120
4 X 70 = 280
14 X 20 = 280

Cost = 1015

2

	5	8	7	14	
7	[19] 5	[30] 2⁻	[50] (10)	[10] (32)⁺	0
9	[70] (51)	[30] 2	[40] 7	[60] (18)	0
18	[40] (43)	[8] 4⁺	[70] (52)	[20] 14⁻	-22
	19	30	40	42	

5 X 19 = 95
2 X 30 = 60
2 X 30 = 60
7 X 40 = 280
4 X 8 = 32
14 X 20 = 280

Cost = 807

3

	5	8	7	14	
7	[19] 5	[30] (32)	[50] (42)	[10] 2	0
9	[70] (19)	[30] 2	[40] 7	[60] (18)	32
18	[40] (11)	[8] 6	[70] (52)	[20] 12	10
	19	-2	8	10	

5 X 19 = 95
2 X 10 = 20
2 X 30 = 60
7 X 40 = 280
6 X 8 = 48
12 X 20 = 240

Cost = 743

7.

Job	M_1	M_2	M_3
1	10	6	18
2	14	4	10
3	8	6	14
4	16	8	6
5	12	4	4
6	14	0	16

$\min t_{i1} = \min\{t_{11}, t_{21}, t_{31}, t_{41}, t_{51}, t_{61}\} = 8$
$\max t_{i2} = \max\{t_{12}\ t_{22}, t_{32}, t_{42}, t_{52}, t_{62}\} = 8$

Since the condition of

$\min t_{i1} \geq \max t_{i2} \qquad i = 1, 2, \ldots, 6$

or $\min t_{i3} \geq \max t_{i2} \qquad i = 1, 2, \ldots, 6$

is satisfied, we can apply Johnson's algorithm

Job	M_1'	M_2'
1	16	24
2	18	14
3	14	20
4	24	14
5	16	8
6	14	16

$M_1' = t_{i1} + t_{i2}$
$M_2' = t_{i2} + t_{i3}$

7.

Upon applying Johnson's algorithm, it is found that the optimal job sequences are

3 - 6 - 1 - 2 - 4 - 5

3 - 6 - 1 - 4 - 2 - 5

6 - 3 - 1 - 2 - 4 - 5

6 - 3 - 1 - 4 - 2 - 5

8

Chase strategy for Example 1

The co.'s net requirements for Oct. are 200000 - 5000(in inv.) = 195000

The net requirements for later months equal the demand except for March,which requires an additional 2000 units for ending inv.

The no. of units that can be produced by an employee each month equals (8hr/day*no. of work days/month)/(1.5 person-hr/unit).

Assuming that all workers produce the max. no. of units each month.

Employee needed to make net equirements each month

Month	(A)Net requirements (units)	(B)Max. production/employee units/month	(C)=A/B employees
Oct	195000	122.67	1590
Nov	220000	112	1965
Dec	310000	101.33	3060
Jan	300000	112	2679
Feb	240000	106.67	2250
Mar	232000	122.67	1892

Aggregate Plan

Month	no.of workers	no. hired	no. dismissed	production	ending inv.
sep	1850				5000
oct	1590	0	260	195045	45
nov	1964	374	0	219968	13
dec	3060	1096	0	310070	83
jan	2678	0	382	299936	19
feb	2250	0	428	240007	26
mar	1892	0	358	232092	2118
apr	1892				
Totals (oct-mar)	13434	1470	1428		2304

The total production related cost of this strategy will be

wages cost = 13434 per-month*2000 = 26868000
hiring costs= 1470 workers*3000 = 4410000

dismissal costs = 1428 workers*2500 = 3570000
inventory costs= 2304 items*10 = 23040
total costs 34871040

TABLE 12.3 EMPLOYEES NEEDED TO MAKE NET CUMULATIVE REQUIREMENTS

Month	(A) Net Cumulative Requirements (units)	(B) Cumulative Production per Worker (units)	(C) = A/B No. of Workers Needed to Make (A)*
October	195,000	122.67	1590
November	415,000	234.67	1769
December	725,000	336.00	2158
January	1,025,000	448.00	2288
February	1,265,000	554.67	2281
March	1,497,000	677.33	2211

*The number of workers is rounded up to the next integer.

TABLE 12.4 STARLIGHT'S AGGREGATE PLAN USING THE LEVEL STAFFING STRATEGY

Month	No. of Workers	No. Hired	No. Dismissed	Production	Ending Inventory
September	1,850				5,000
October	2,288	438	0	280,669	85,669
November	2,288	0	0	256,256	121,925
December	2,288	0	0	231,843	43,768
January	2,288	0	0	256,256	24
February	2,250	0	38	240,007	31
March	1,892	0	358	232,092	2,123
April	1,892				
Totals (Oct.–Mar.)	13,294	438	496		253,540

The total production-related costs (October–March) for this level-workforce strategy will be as follows:

Wages costs = 13294 pers-months × \$2000 = \$26,588,000
Hiring costs = 438 workers × \$3000 = \$ 1,314,000
Dismissal costs = 496 workers × \$2500 = \$ 1,240,000
Inventory costs = 253,540 items × \$10 = \$ 2,535,400
Total cost \$31,677,400

Although this level strategy incurs \$2.5 million more in inventory costs, hiring and dismissal costs are \$5.5 million less than with the chase demand plan and total costs are \$3.2 million less.

9. A Q system (also known as a reorder point system).

$$d = 200\ \frac{\text{gizmos}}{\text{week}}$$

$$\sigma_t = 15 \text{ gizmos}$$

a. Standard deviation of demand during the protection interval:

$$\sigma_L = \sigma_t \sqrt{L}$$

$$\sigma_L = 15\sqrt{4} = 30 \text{ gizmos}$$

b. Average demand during the protection interval:

$$dL = 200\frac{\text{gizmos}}{\text{week}}(4 \text{ weeks}) = 800 \text{ gizmos}$$

c. Reorder point

R = demand during protection interval + safety stock

Safety stock = $z\sigma_L$

When the desired cycle-service level is 99%, $z = 2.33$.

Safety stock = 2.33 * 30 = 69.9 or about 70 gizmos

$R = 800 + 70 = 870$

10.

Item: A / Week	1	2	3	4	5	6	7	8	9	10
MPS Quantity (due)				80			55			
MPS Quantity (release)			80			55				

Item: B / Week	1	2	3	4	5	6	7	8	9	10
MPS Quantity (due)							125			
MPS Quantity (release)					125					

Item: C / Week	1	2	3	4	5	6	7	8	9	10
MPS Quantity (due)							60			
MPS Quantity (release)				60						

Item: D
Description:
Lot Size: FOQ = 150
Lead Time: 3 weeks
Safety Stock: 40 units

Week		1	2	3	4	5	6	7	8
Gross requirements				160	120	125	110		
Scheduled receipts		250							
Projected on hand	150	400	400	240	120	145	185	185	185
Planned receipts						150	150		
Planned order releases			150	150					

Item: E
Description:
Lot Size: L4L
Lead Time: 1 week
Safety Stock: 0 units

Week		1	2	3	4	5	6	7	8
Gross requirements				80	120	250	55		
Scheduled receipts			120						
Projected on hand	0	0	120	40	0	0	0	0	0
Planned receipts					80	250	55		
Planned order releases				80	250	55			

Item: F
Description:
Lot Size: POQ = 2
Lead Time: 2 weeks
Safety Stock: 30 units

Week		1	2	3	4	5	6	7	8
Gross requirements				160	500	110			
Scheduled receipts									
Projected on hand	100	100	100	530	30	30	30	30	30
Planned receipts				590		110			
Planned order releases		590		110					

11

a) The number of hours (H) provided per machine is
$H = (2 \text{ shifts/day} \times 8 \text{ hours/shift} \times 5 \text{ days/week} \times 52 \text{ week per year})(1.0 - 0.2) = 3328$

Total machine hour requirements (R)

$$25{,}000 \times 0.05 + \left(\frac{25000}{60}\right) \times 1 +$$
$$17{,}000 \times 0.2 + \left(\frac{17000}{80}\right) \times 4.5 +$$
$$40{,}000 \times 0.05 + \left(\frac{40000}{120}\right) 8.2$$

$= 10765.25$

$$M = \frac{10765.25}{3328} = 3.24 \text{ or } 4 \text{ machines.}$$

b) There is a gap of one machine
The gap drops to zero when the 20% increase from short-term options is included

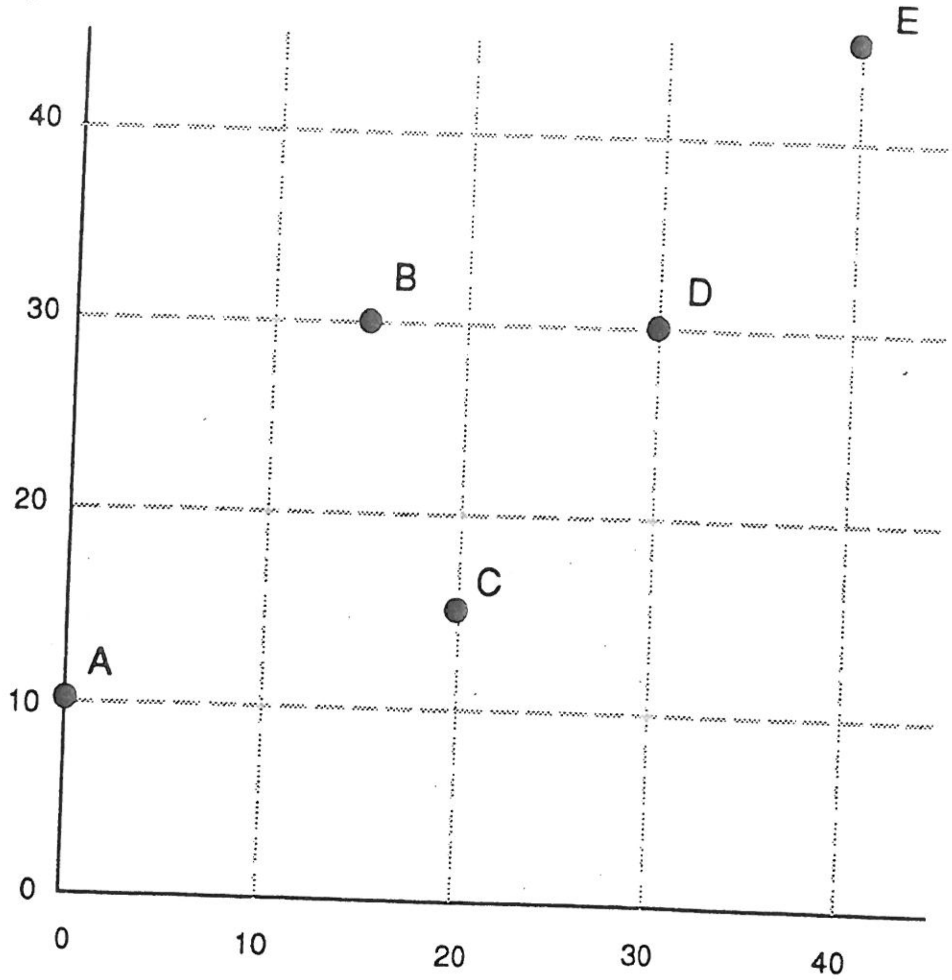
3 machines × 3328 h/machine × 1.2 = 11981. This is greater than 10765.25 hours required.

$3 \cdot 3328 = 9984.$

Two facilities to serve two groups of demand points.

a. Grid map.

12



b. For the north-south division, the center of gravity is:

North (Serving B, D, & E)

x^* = [15(15) + 30(30) + 15(40)] / (15 + 30 + 15)
= 28.75 or 29

y^* = [15(30) + 30(30) + 15(45)] / (15 + 30 + 15)
= 33.75 or 34

The center of gravity is (29, 34).

South (Serving A & C)

x^* = [10(0) + 20(20)] / (10 + 20)
= 13.33 or 13

y^* = [10(10) + 20(15)] / (10 + 20)
= 13.33 or 13

The center of gravity is at about (13, 13).

The load-distance score, assuming euclidean distance, is calculated in the following table.

Pair	Load (l)	d	ld
A to (13, 13)	10	13.34	133.4
B to (29, 34)	15	14.56	218.4
C to (13, 13)	20	7.28	145.6
D to (29, 34)	30	4.12	123.6
E to (29, 34)	15	15.56	233.4
			854.4

c. For the east-west division, the center of gravity is:

West (Serving A, B, & C)

x^* = [10(0) + 15(15) + 20(20)] / (10 + 15 + 20)
= 13.89 or 14

y^* = [10(10) + 15(30) + 20(15)] / (10 + 15 + 20)
= 19

The center of gravity is (14, 19).

East (Serving D & E)

x^* = [30(30) + 15(40)] / (30 + 15)
= 33

y^* = [30(30) + 15(45)] / (30 + 15)
= 35

The center of gravity is (33, 35).

The load-distance score for the entire system, assuming euclidean distance, is calculated in the table

Pair	Load (l)	d	ld
A to (14, 19)	10	16.64	166.4
B to (14, 19)	15	11.05	165.75
C to (14, 19)	20	7.21	144.2
D to (33, 35)	30	5.83	174.9
E to (33, 35)	15	12.21	183.15
			834.4

The east-west division (part c) results in a lower load-distance score.

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.

13 a

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.

13 .b. 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.