	Examination
Course:	**Production and Logistics Planning**
Date:	**2014-01-14**
Number of hours:	**5 hours**
Group:	**Freestanding course**
Course code:	**KPP227**
Examination code:	**TEN1**
Help Means:	**Calculator, Dictionary**
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Please make your calculations on Graph paper.

Max points: 100

Number of points for each task is denoted within parenthesis.

For grade 3 at least 50 is required; grade 4 at least 65; and grade 5 at least 85.

1. (6p)

A manager is trying to decide whether to build a small, medium, or large factory. Demand can be low, average, or high, with the estimated probabilities being 0.25, 0.40, and 0.35 respectively.

A small facility is expected to earn $18,000 if demand is low. If demand is average, the small facility is expected to earn $75,000; it can be increased to average size to earn $60,000. If demand is high, the small facility is expected to earn $75,000 and can be expanded to average size to earn $60,000 or to large size to earn $125,000.

A medium sized facility is expected to lose an estimated $25,000 if demand is low, and earn $140,000 if demand is average. If demand is high, the medium-sized facility is expected to earn $150,000; it can be expanded to a large size to earn $145,000.

If a large facility is built and demand is high, earnings are expected to be $220,000. If demand is average for the large facility, it is expected to earn $125,000; if demand is low, the facility is expected to lose $60,000.

a) Draw the decision tree for this problem.
b) What should management do to achieve the highest expected payoff?

2. (6p)

A company is designing a new testing station for a product. The testing station is able to test products at an average rate of 5 products per hour according to a negative exponential distribution. Products for testing arrive at an average rate of 3 units per hour, following a Poisson distribution. They are served according to FIFO and each product requires 1.5 m^2 in storage space. A product is in this stage of the production process has a value of 1400 €.

a) How much floor space is required for storing products in queue for testing?
b) What's the average value of products within the testing system?

3. (6p)

A company wants to design a new assembly line for their latest products. The company wants to produce at least 270 units per day and they expect to operate the production line 450 minutes per day. The assembly requires 14 different tasks and the work element data is shown in the table below.

Work element	Time (seconds)	Immediate Predecessor(s)
A	10	None
B	25	None
C	10	None
D	35	A
E	65	B, C
F	35	A, E
G	30	None
H	20	D, G
I	45	A
J	50	None
K	20	None
L	40	J, K
M	30	A, L
N	70	F, H, I, M

a) Draw a precedence diagram.
b) What cycle time (in minutes) results in the desired output rate?
c) What is the theoretical minimum number of workstations and which work elements are assigned to which station?
d) What is the efficiency of your solution?

4. (6p)

The supply manager of a chemical plant must determine the lot size for a particular chemical that has a steady demand of 30 barrels per day. The production rate is 190 barrels per day, annual demand is 10,500 barrels, setup cost is \$200, annual holding cost is \$0.21 per barrel, and the plant operates 350 days per year. Determine the following:

a) The economic production lot size.
b) The total annual setup and inventory holding cost for this chemical.
c) The time between orders.
d) The production time per lot.

5. (10p)

The BOMs (Bill Of Materials) for products A is shown in Table 1 below. Data from inventory records are shown in Table 2. The MPS calls for 250 units of product A to be completed in week 8. The lead-time for production of product A is two weeks.

Item	Made of: Number x Item
A	1xB, 1xC, 2xD
B	2xC
D	1xB

Table 1

Inventory Record Data:

Data category	B	C	D
Lot sizing rule	L4L	FOQ = 1000	L4L
Lead time	2 weeks	1 week	3 weeks
Safety stock	0	100	0
Scheduled receipts	None	1000 (week 1)	None
On-hand inventory	0	200	0

Table 2

Develop the materials requirement plan for the next six weeks for items A, B, C, and D. An MRP template is included in the exam for your convenience.

6. (8p)

A manufacturing company has three factories that supply three major warehouses. The capacity of each factory, and the demand of each warehouse, is listed in the table below. Use the Modified Transportation Method (MODI) to optimize the distribution of goods from the factories to the warehouses.

	Warehouses			
Factories	1	2	3	Amount available
1	5	4	3	100
2	8	4	3	300
3	9	7	5	300
Amount required	300	200	200	

7. (6p)

Name, and explain the five steps, used when practically applying Theory of constraints.

8. (10p)

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 the first quarter was 175 tons. Two values of α are examined; α=0.1, and α=0.5. Determine which value of α gives the better forecast based on the values of MAD and MSE.

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

9. (6p)

a) Name four functions of inventory.
b) Name three reasons to keep low levels of inventory.

10. (6p)

As an inventory manager you must decide on the order quantity for an item that has an annual demand of 2000 units. Placing an order cost you €20 each time. Your annual holding cost, expressed as a percentage of average inventory value is 20%. Your supplier has provided the following price schedule:

Order size	Price per unit
1 – 199	€ 2:50
200 – 299	€ 2:40
300 – 999	€ 2:25
1000 -	€ 2:00

What is the best order policy from a cost perspective?

11. (9p)

Answer the three questions below in detail!

a) From a logistics point of view, what is the difference between *Convenience products*, and *Shopping products*?
b) How do the logistics strategy for a certain product change over the different phases of the product life cycle?
c) How do the Weight-Bulk ratio influence the two more important logistics costs; transportation and storage?

12. (5p)

In a Q system, the demand for a certain product is normally distributed, with an average of 520 units per week. The lead-time is 7 weeks. The standard deviation of weekly demand is 17 units.

a) What is the standard deviation of demand during the 7-week lead-time?
b) What is the average demand during the 7-week lead-time?
c) What reorder point results in the cycle-service level of 99%?

13. (8p)

Consider the following job times for a three-machine problem. Assume that the jobs are processed in the sequence M1-M2-M3. Find the optimum sequence for processing the five jobs below and show it in a Gantt-chart for all three machines, indicating the total processing time.

Job	M1	M2	M3
A	12	15	24
B	27	18	30
C	24	6	18
D	18	9	21
E	15	12	33

14. (5p)

A company produces 2 different gearbox models. Relevant data on a bottleneck operation in the plant for the upcoming year are given in the table below.

Pump model	Model A	Model B
Demand forecast	30,000 gearboxes/year	12,000 gearboxes/year
Lot size	50 units	30 units
Standard processing time	0.6 hour/unit	1.0 hour/unit
Standard setup time	3.0 hours/lot	3.0 hours/lot

The shop works 200 days per year, 2 shifts per day, eight hours per shift, and a 15% capacity cushion is desired. How many machines are needed to meet the upcoming year's demand without resorting to any short-term capacity solutions?

15. (3p)

Describe how the labor climate is affecting the decision for new manufacturing plants.

MRP

Item:	Week:	1	2	3	4	5	6	7	8
	Due:								
	Release:								

Item:	Week:	1	2	3	4	5	6	7	8
	Due:								
	Release:								

Item:							Lot size: Lead time: Safety stock:		
	Week:	1	2	3	4	5	6	7	8
Gross requirements									
Scheduled reciepts									
Projected on hand									
Planned reciepts									
Planned order releases									

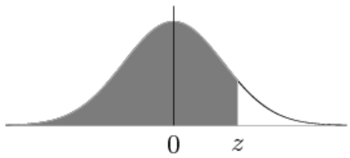
Item:							Lot size: Lead time: Safety stock:		
	Week:	1	2	3	4	5	6	7	8
Gross requirements									
Scheduled reciepts									
Projected on hand									
Planned reciepts									
Planned order releases									

Item:							Lot size: Lead time: Safety stock:		
	Week:	1	2	3	4	5	6	7	8
Gross requirements									
Scheduled reciepts									
Projected on hand									
Planned reciepts									
Planned order releases									

Item:							Lot size: Lead time: Safety stock:		
	Week:	1	2	3	4	5	6	7	8
Gross requirements									
Scheduled reciepts									
Projected on hand									
Planned reciepts									
Planned order releases									

Cumulative Normal Distribution Table

$$\Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-s^2/2}\, ds$$



z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

Capacity formulas

Capacity

Machine requirements for single products

$$M = \frac{Dp}{N[1-(C/100)]}$$

Machine requirements for multiple products

$$M = \frac{[Dp + (D/Q)s]_{product\ 1} + [Dp + (D/Q)s]_{product\ 2} + \cdots + [Dp + (D/Q)s]_{product\ n}}{N[1-(C/100)]}$$

M = Number of machines

D = Yearly demand

p = processing time per product

Q = Batch size

s = setup time per batch

N = Total operating time per year

C = Desired capacity cushion (expressed in %)

Break-even analysis

Total cost $$C = F + c \times Q$$

Total revenue $$R = p \times Q$$

Break even quantity $$Q = \frac{F}{(p - c)}$$

C = Total cost

F = Fixed cost

c = variable cost

Q = Quantity of sold products/services

R = Total revenue

p = revenue per sold unit

Forecasting formulas, KPP227

Linear regression:

$$Y = a + bX$$

$$b = \frac{\Sigma XY - n\bar{X}\bar{Y}}{\Sigma x^2 - n\bar{X}^2}$$

$$a = \bar{Y} - b\bar{X}$$

Forecast accuracy (Linear regression):

Correlation coefficient: $$r = \frac{n\sum XY - \sum X \sum Y}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}}$$

Coefficient of determination: $$r^2 = \frac{a\sum Y + b\sum XY - n\bar{Y}^2}{\sum Y^2 - n\bar{Y}^2}$$

Standard error of the estimate: $$\sigma YX = \sqrt{\frac{\sum Y^2 - a\sum Y - b\sum XY}{n-2}}$$

Weighted moving average

$$F_{t+1} = W_1 D_t + W_2 D_{t-1} + \cdots W_n D_{t-n+1}$$

Exponential smoothing

$$F_{t+1} = \alpha D_t + (1 - \alpha) F_t$$

$$F_{t+1} = F_t + \alpha (D_t - F_t)$$

Exponential smoothing with trend

$$A_t = \alpha D_t + (1 - \alpha)(A_{t-1} + T_{t-1})$$

$$T_1 = \beta (A_t - A_{t-1}) + (1 - \beta) T_{t-1}$$

$$F_{t+1} = A_t + T_t$$

A_t =exponential smoothed average of the series in period t

T_t =exponential smoothed average of the trend in period t

α = smoothing parameter for average (value 0-1)

β = smoothing parameter for trend (value 0-1)

T_{t+1} = Forecast for period t+1

Forecast errors

Forecast error $E_t = D_t - F_t$

Average forecast error $\bar{E} = \frac{CFE}{n}$

Mean square error $MSE = \frac{\sum E_t{}^2}{n}$

Mean absolute deviation $MAD = \frac{\sum |E_t|}{n}$

Standard deviation $\sigma = \sqrt{\frac{\sum (E_t - \bar{E})^2}{n-1}}$

Mean absolute percentage error $MAPE = \frac{\sum [|E_t|(100)]/D_t}{n}$

Tracking signal $Tracking\ Signal = \frac{CFE}{MAD}$

Inventory management

Holding cost

$$Holding\ cost = \frac{Q}{2}(H)$$

Ordering-/setup cost

$$Ordering\ or\ setup\ cost = \frac{D}{Q}(S)$$

Material handling cost

$$C = \frac{Q}{2}(H) + \frac{D}{Q}(S)$$

Economic order quantity

$$EOQ = \sqrt{\frac{2DS}{H}}$$

Time between orders

$$TBO_{EOQ} = \frac{EOQ}{D}$$

Q = Order quantity

H = Holding cost per item

D = Forecasted demand

S = Setup cost per order

Continuous review (Q) system

Inventory position

$$IP = OH + SR - BO$$

IP = Inventory Point

OH = On-hand inventory

SR = Scheduled receipts

BO = Back orders

Re-order point

$$R = \bar{d}L + Safety\ stock$$

$\bar{d}$ = Average demand per time unit

L = constant lead time In time units

Standard deviation of demand during lead time: $\sigma_{dLT} = \sqrt{\sigma_d^2 L} = \sigma_d \sqrt{L}$

Safety stock: $= z\sigma_{dLT}$

Periodic review (P) system

$$T = z\sigma_{(P+L)} = z\sigma_d \sqrt{P + L}$$

T = average demand during the protection interrval + safety stock for protection interval

P = length of time between reviews

Noninstantaneous replenishment

Maximum cycle inventory: $$I_{max} = \frac{Q}{p}(p - d) = Q\left(\frac{p-d}{p}\right)$$

p = production rate

d = demand rate

Q = lot size

Total annual handling cost: $$C = \frac{I_{max}}{2}(H) + \frac{D}{Q}(S)$$

Total annual handling cost: $$C = \frac{Q}{2}\left(\frac{p-d}{p}\right)(H) + \frac{D}{Q}(S)$$

Economic production lot size: $$ELS = \sqrt{\frac{2DS}{H}}\sqrt{\frac{p}{p-d}}$$

I = Inventory
D = annual demand
p = production rate
d = demand rate
Q = lot size
H = holding cost
S = ordering/setup cost

Quantity discounts

Total annual material cost: $$C = \frac{Q}{2}(H) + \frac{D}{Q}(S) + PD$$

Q = lot size

H = holding cost

D = annual demand

S = ordering/setup cost

P = Price/unit

D = Demand rate

One period decisions

Payoff: $$If\ Q \leq S \Rightarrow Payoff = pQ$$

$$If\ Q > S \Rightarrow Payoff = pD - ld$$

p = profit/unit

Q = Purchased quantity

D = actual demand

l = loss/unit

d = number of disposed items

Location formulas, KPP227

Location

Load distance $ld = \sum_i l_i d_i$

Euclidian distance $d_{AB} = \sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2}$

Rectilinear distance $d_{AB} = |X_A - X_B| + |Y_A - Y_B|$

Center of gravity

$X^* = \frac{\sum l_i X_i}{\sum l_i}$ $Y^* = \frac{\sum l_i Y_i}{\sum l_i}$

Waiting lines formulas, KPP227

Waiting lines

Interarrival times

$$P_n = \frac{(\lambda T)^n}{n!} e^{-\lambda T} \text{ for } n = 1,2,\ldots$$

P_n = Probability of n arrivals in T time periods

λ = Average numbers of cutomer arrivals per period

Service time distribution

$$P_{(t \leq T)} = 1 - e^{-\mu T}$$

μ = Average number of customers completing service per period

t = service time of the customer

T = target service time

Single server model

Average utilization of the system

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

Average number of customers in the system

$$L = \frac{\lambda}{\mu - \lambda}$$

Average number of customers in the waiting line

$$L_q = \rho L = \frac{\lambda^2}{\mu(\mu - \lambda)}$$

Average time spent in the system including service

$$W = \frac{1}{\mu - \lambda}$$

Average waiting time in line

$$W_q = \rho W = \frac{\lambda}{\mu(\mu - \lambda)}$$

Probability that n customers are in the system

$$P_n = (1 - \rho)\rho^n$$

Probability that 0 customers are in the system

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

Probability that less than *k* customers are in the system

$$P_{n<k} = 1 - \left(\frac{\lambda}{\mu}\right)^k$$

Probability of more than *k* customers are in the system

$$P_{n>k} = \left(\frac{\lambda}{\mu}\right)^{k+1}$$