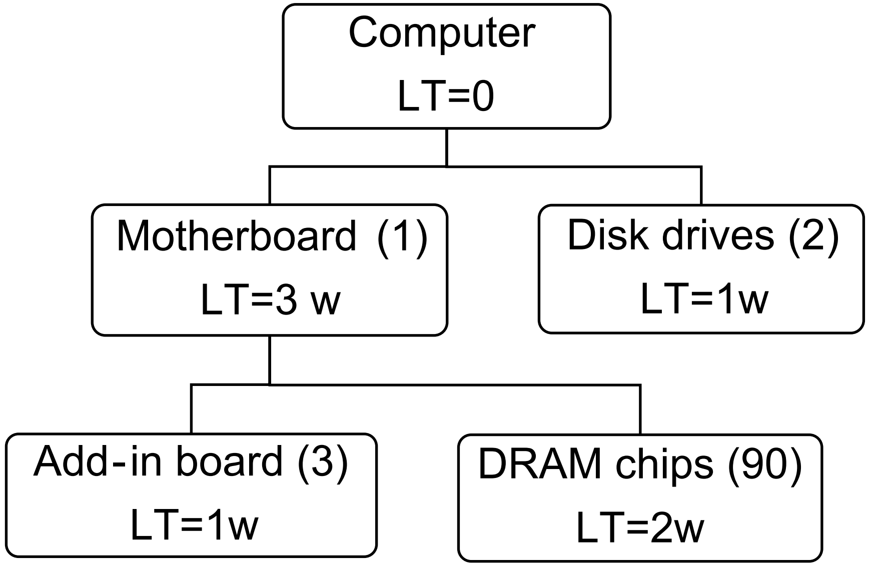
Exercise questions

MRP & Operations Scheduling

Q1. Noname computer company

Suppose that the forecasted demands for the computer for weeks 6 to 11 are 220, 165, 180, 120, 75, 300.

The starting inventory of assembled computers in week 6 will be 75, and the production manager anticipates returns of 30 in week 8 and 10 in week 10.



- (A) Determine the MPS for computers
- (B) Execute the MRP calculations:
  - (i) for motherboards assuming a lot-for-lot scheduling rule
  - (ii) for add-in boards assuming a lot size of 300.
  - (iii) for the motherboards assuming that one uses the EOQ formula to schedule production . K=SEK1800 and h=0,40 (correction 4 SEK).
- (C) Find the order quantities of add-in boards using silver-metal heuristic. Assume K=SEK 1800 and h=0,30 (correction 3 SEK).

Noname computer company …

A. Determine the MPS for computers

Item:Computer Lead t=0wk L4L	WEEKS	1	2	3	4	5	6	7	8	9	10	11
Gross requirement							220	165	180	120	75	300
Scheduled receipts									30		10	
On hand inventory						75						
Net predicted demand							145	165	150	120	65	300
Planned order receipts							145	165	150	120	65	300
Planned order releases							145	165	150	120	65	300

Noname computer company …

B i) Execute the MRP calculations for motherboards assuming a lot-for-lot scheduling rule

Item: Motherboard / Lead t=3wk / L4L	WEEKS 1	2	3	4	5	6	7	8	9	10	11
Gross requirement						145	165	150	120	65	300
Scheduled receipts						0	0	0	0	0	0
On hand inventory						0	0	0	0	0	0
Net predicted demand						145	165	150	120	65	300
Planned order receipts						145	165	150	120	65	300
Planned order releases			145	165	150	120	65	300			
Ending inventory						0	0	0	0	0	0

Noname computer company …

B ii) Execute the MRP calculations for add-in boards assuming a lot size of 300.

Item: Add-in board Lead t=1wk Q=300	WEEKS	1	2	3	4	5	6	7	8	9	10	11
Gross requirement				435	495	450	360	195	900			
Scheduled receipts				0	0	0	0	0	0			
On hand inventory				0	0	0	0	0	0			
Net predicted demand				435	495	450	360	195	900			
Planned order receipts				600	600	300	300	300	900			
Planned order releases			600	600	300	300	300	900				
Ending inventory				165	270	120	60	165	165			

Noname computer company …

B iii) Execute the MRP for the motherboards assuming that one uses the EOQ formula to schedule production .

K=SEK 1800 and h=4 SEK.

- $\lambda = (145 + 165 + 150 + 120 + 65 + 300)/6 = 157.5$
- EOQ = 377

Item: Motherboard Lead t=3wk EOQ WEEKS	1	2	3	4	5	6	7	8	9	10	11
Gross requirement						145	165	150	120	65	300
Scheduled receipts						0	0	0	0	0	0
On hand inventory						0	0	0	0	0	0
Net predicted demand						145	165	150	120	65	300
Planned order receipts						377		377			377
Planned order releases			377		377			377			
Ending inventory						232	67	294	174	109	186

Noname computer company …

C. Find the order quantities of add-in boards using silver-metal heuristic. Assume K=SEK 1800 and h=3 SEK.

- For the add-in boards net predicted demand matrix is,
- r=(435, 495, 450, 360, 195, 900)

C(1) = 1800
C(2) = (1800 + 3*495) / 2 = 1643 (<1800)
C(3) = (1800 + 3*495 + 2*3*450)/3 = 1995 (>1643) STOP

Order1=435+495=930

C(1) = 1800
C(2) = (1800 + 3*360) / 2 = 1440 (<1800)
C(3) = (1800 + 3*360 + 2*3*195)/3 = 1350 (<1440)
C(4) = (1800 + 3*360 + 2*3*195+3*3*900)/4 = 3038 (>1350) STOP

Order2=450+360+195=1005

Order3=900

Total cost =3*1800+3*(495+360+ 2*195)= 9135 SEK

Q2. A machine

- Seven jobs are to be processed through a single machine.

(A) Determine the sequence of the jobs in order to minimize

  - Mean flow time
  - Number of tardy jobs
  - Maximum lateness

(B) What is the makespan for any sequence?

Job	1	2	3	4	5	6	7
Processing time	3	6	8	4	2	1	7
Due date	4	8	12	15	11	25	21

A machine …

A SPT minimizes mean flow time!

- Sequence is 6-5-1-4-2-7-3.

B Moore's Alg. Minimizes number of tardy jobs.

-First order by EDD which is 1-2-5-3-4-7-6.

-Then find the first tardy job.

Job	Processing time	Due date	Completion time
1	3	4	3
2	6	8	9

Eliminate the job with the longest processing time among the jobs before the first tardy job.

-Place job 2 at the end of the current sequence.

Job	Processing time	Due date	Completion time
1	3	4	3
5	2	11	5
3	8	12	13

Place job 3 at the end of the current sequence.

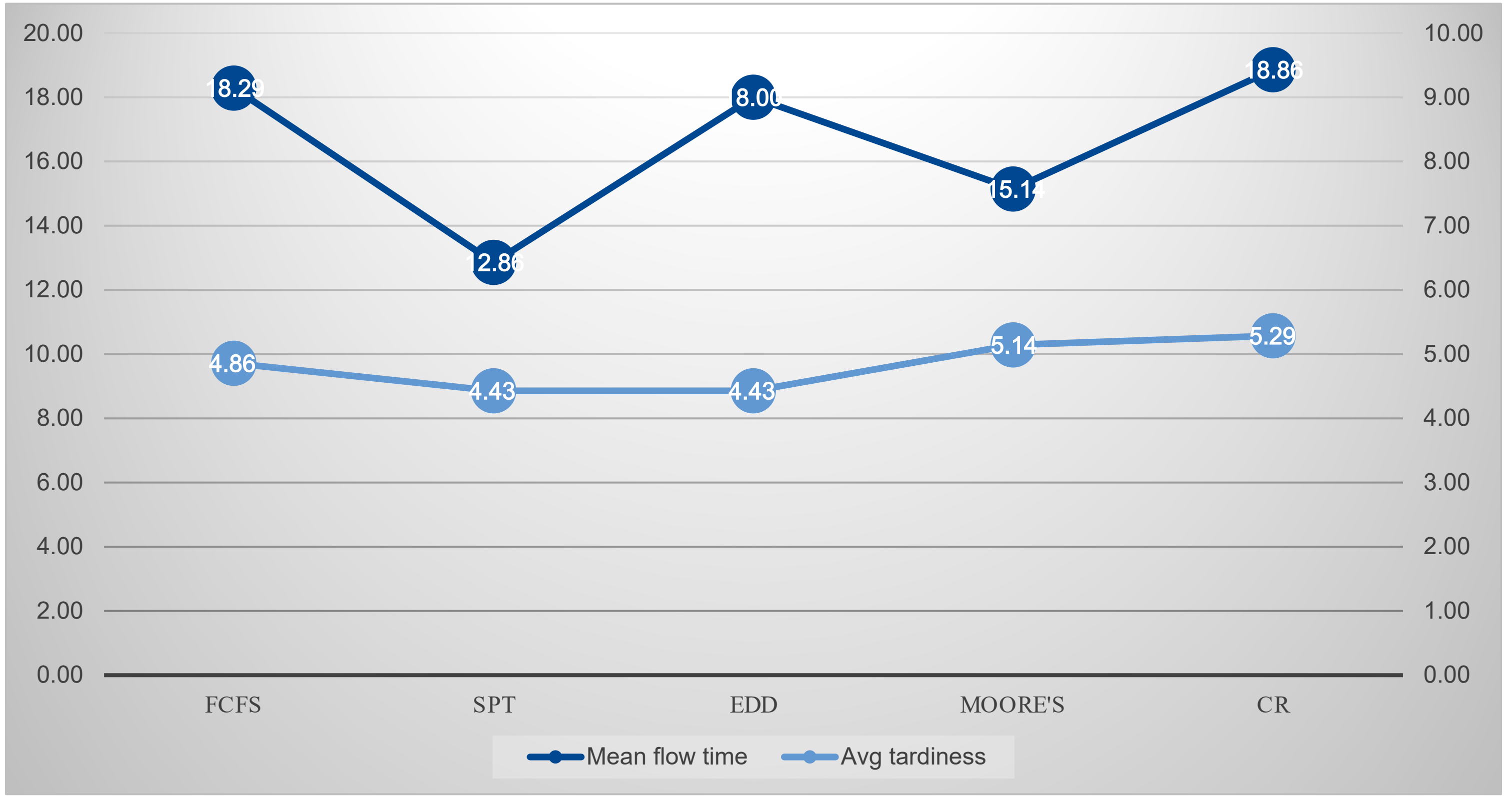
Job	Processing time	Due date	Completion time
1	3	4	3
5	2	11	5
4	4	15	9
7	7	21	16
6	1	25	17

No tardy job left at this step.
The optimal sequence is 1-5-4-7-6-2-3
(or 1-5-4-7-6-3-2).
Jobs 2 and 3 are tardy in either sequence.

A machine …

- EDD minimizes maximum lateness (and so does CR)
- The maximum lateness is minimized by EDD which is 1-2-5-3-4-7-6.
- What is the makespan for any sequence?
    - Makespan is the sum of the processing times for a single machine scheduling problem which is 31 for this problem.

	Mean flow time	No of tardy jobs	Max. tardiness	Max. lateness	Min. tardiness	Min. lateness	Avg tardiness
FCFS	18.29	5	12	12	0	-1	4.86
SPT	12.86	4	19	19	0	-24	4.43
EDD	18.00	5	9	9	0	-1	4.43
Moore's	15.14	2	23	23	0	-8	5.14
CR	18.86	6	9	9	0	-1	5.29



Q3. Machine flow shop

- The following four jobs must be processed through a three -machine flow shop.
- Find the optimal sequencing of the jobs in order to minimize the makespan. What is the makespan in the optimal solution? Draw a gant chart.

	MACHINE		
Job	A	B	C
1	4	2	6
2	2	3	7
3	6	5	6
4	3	4	8

Machine flow shop …

- Check if the Johnson's rule condition for three machine is satisfied.

Condition is; $\min A_i \geqslant \max B_i$ or $\min C_i \geq \max B_i$

$\min A_i = 2$
$\max B_i = 5$
$\min C_i = 6$

- $\min C_i \geq \max B_i$ is satisfied. We can apply johnson's rule.
- A'i=Ai+Bi; B'i=Bi+Ci and apply 2 mchine scheduling

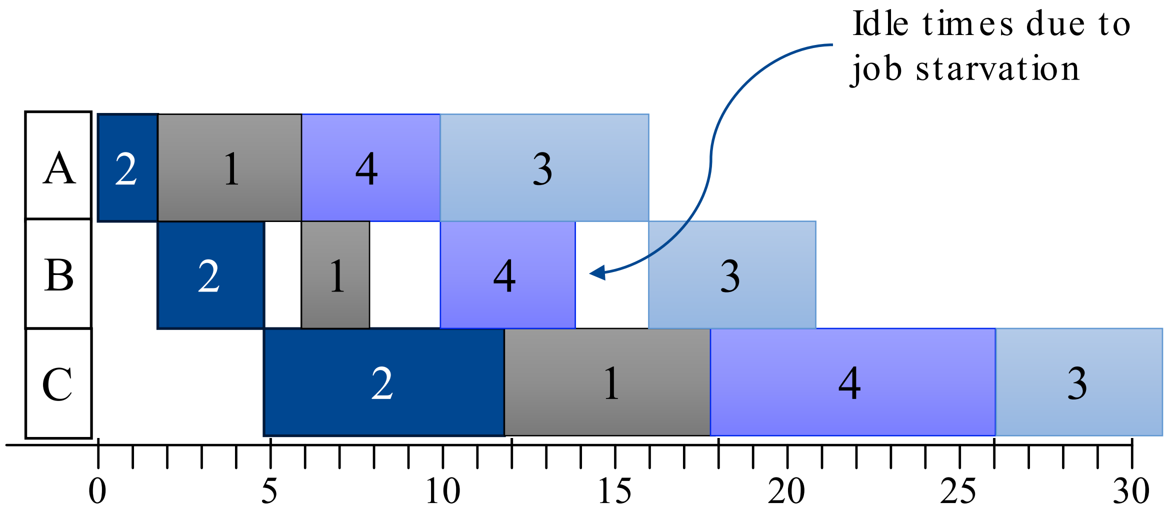
	MACHINE	
Job	A'	B'
1	6	8
2	5	10
3	11	11
4	7	12

The optimal sequence is.

2	1	4	3

Machine flow shop …

- The optimal sequence is 2-1-4-3. Machine sequence respected: A-B-C
- The Gantt chart showing the optimal schedule is as shown below:
- From the chart, we see that the flow times for jobs are respectively 12, 18, 26, and 32. The mean flow time is 22.



Q4. Silicon wafer

A purchasing agent for a particular type of silicon wafer used in the production of semiconductors must decide among three sources. Source A will sell the silicon wafers for 25 SEK per wafer, independently of the number of wafers ordered. Source B will sell the wafers for 24 SEK each but will not consider an order for fewer than 3 000 wafers. Source C will sell the wafers for 23 SEK each but will not accept an order fewer than 4 000 wafers. Assume an order setup cost of SEK 1 000 and an annual requirement of 20 000 wafers. Assume a 20% annual interest rate for holding cost.

- Which source should be used, and what is the size of the standing order?
- What is the optimal value of the holding and setup costs for wafers when the optimal sources is used?
- If the replenishment lead time for wafers is 3 months, determine the reorder point based on the on-hand level of inventory wafers.

Silicon wafer …

- Typical all units discount case

$\lambda = 20\ 000$

$K = 100$

$i = 0.20$

$c_A = 25 \quad q_A = 0$

$c_B = 24 \quad q_B = 3000$

$c_C = 23 \quad q_C = 4000$

$$Q = \sqrt{\frac{2K\lambda}{ic}}$$

- **Q_A=2828**
- Q_B=2887
- Q_C=2949

➔Only Q_A is realizable using EOQ; for all others, the min. quantity for price is considered

Silicon wafer …

Total cost=price + avg. inventory cost + order (setup) costs

Supplier A: Cost at Q = Q^0 = 2828

$$=20000 * 25 + \frac{0.2*25*2828}{2} + 1000 * \frac{20000}{2828} = 514\ 142$$

Supplier B: Cost at Q = 3000

$$=20000 * 24 + \frac{0.2*24*3000}{2} + 1000 * \frac{20000}{3000} = 493\ 867$$

Supplier C: Cost at Q = 4000

$$= 20000 * 23 + \frac{0.2*23*4000}{2} + 1000 * \frac{20000}{4000} = 474\ 200$$

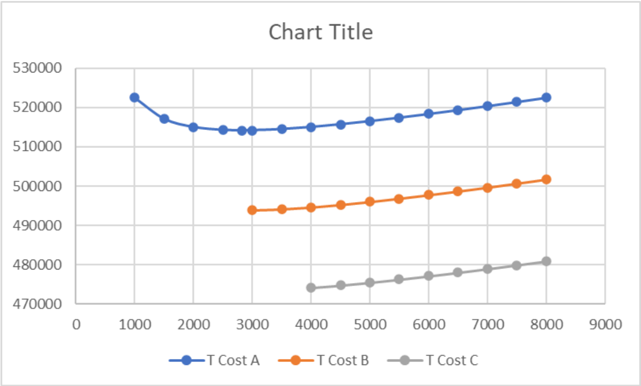
➔The optimal order size based on cost is Q = 4000 from supplier C

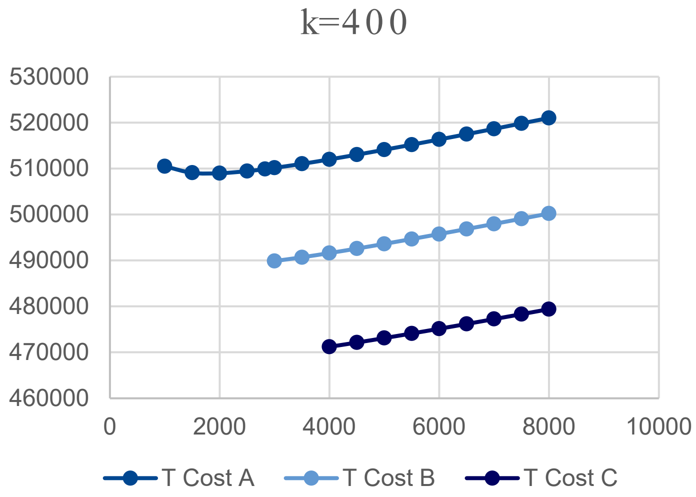
What is the optimal value of the holding and setup costs for wafers when the optimal sources is used?

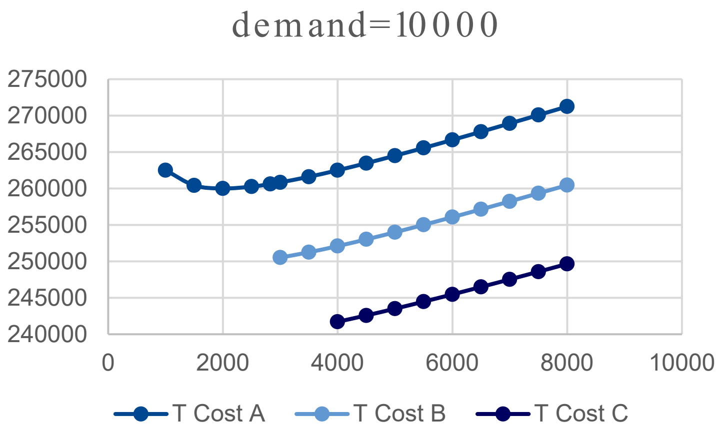
$$=\frac{0.2*23*4000}{2} + \frac{1000*20000}{4000} = 14\ 200$$

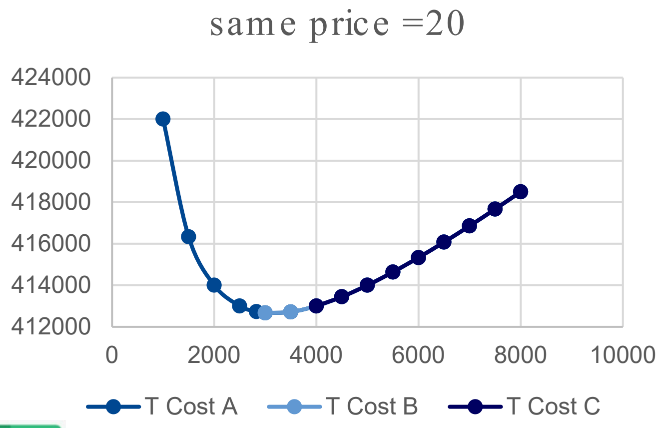
>>>>Explore: to what cost component do you think is the overall result most sensitive to?

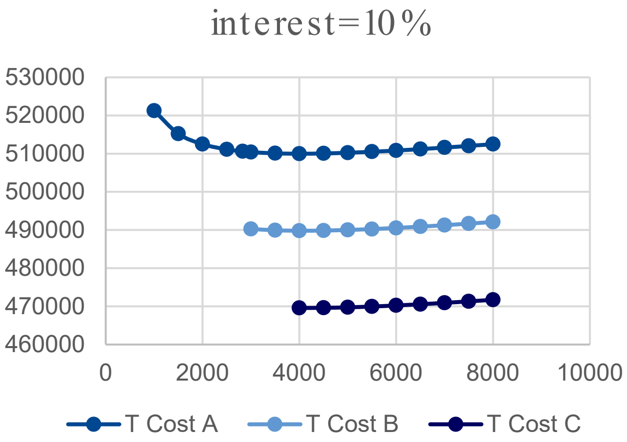
Silicon wafer …

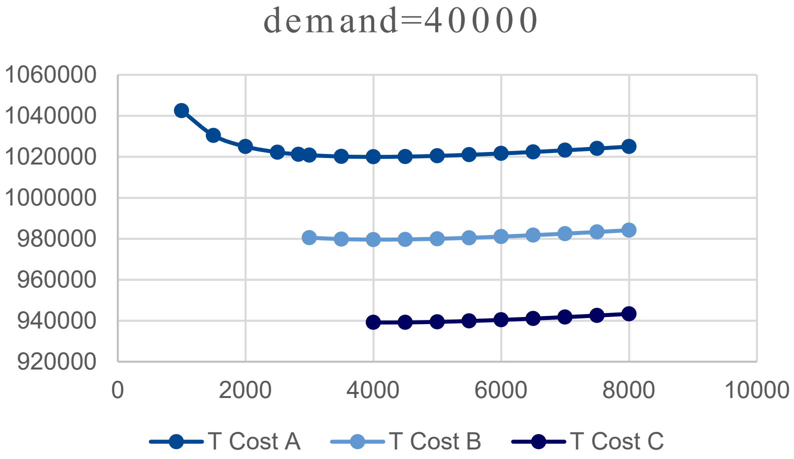












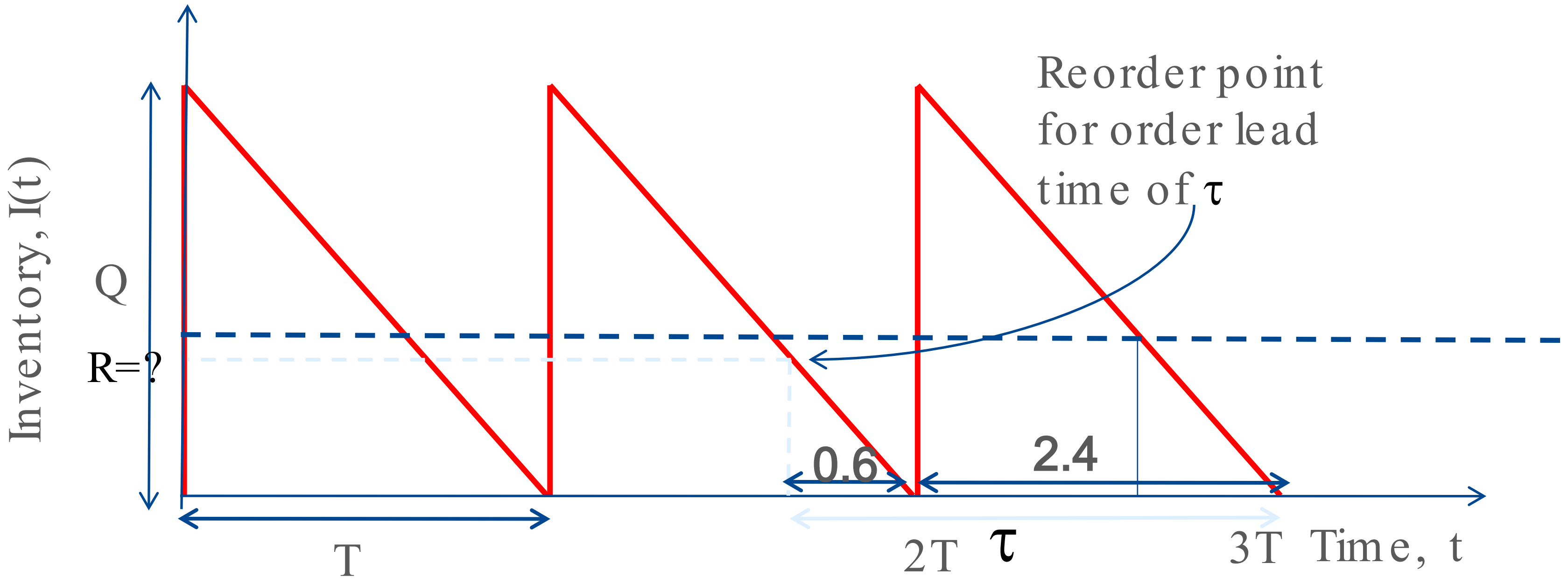
Silicon wafer …

If the replenishment lead time for wafers is 3 months, determine the reorder point based on the on-hand level of inventory wafers.

$\tau = 3$ months

$T = Q/\lambda = 4000 / 20000 = 0.2$ years $= 2.4$ months

$\tau > \lambda \Rightarrow \lambda(T * m) = (20{,}000/12)(0.25)(2.4) = 1{,}000$



Q5. A procrastinating student

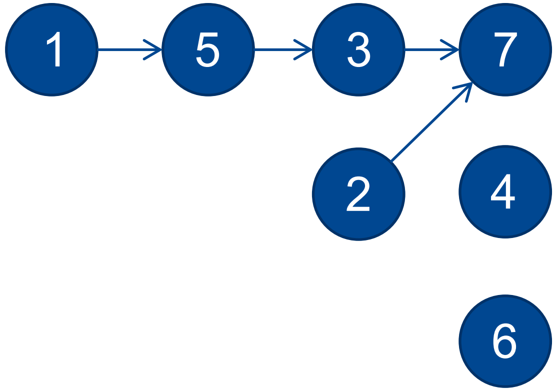
On May 1st, aprocastinating student suddenly realizes that he has done nothing on seven different homework assignments and projects that are due in various courses. He estimates the time required to complete each project and also notes their due dates.

Because projects 1, 3 and 5 are from the same class, he decides to do those in the sequence that they are due. Furthermore, project 7 requires results from project 2 and 3. Determine the sequence in which he should do the projects in order to minimize the maximum lateness.

Project	1	2	3	4	5	6	7
Time (days)	4	8	10	4	3	7	14
Due date (mm/dd)	4/20	5/17	5/28	5/28	5/12	5/7	5/15

A student …

Lawler's algorithm



Job	Due date	Processing time
1	-10	4
2	16	8
3	27	10
4	27	4
5	11	3
6	6	7
7	14	14

A student …

Candidate jobs = {4, 6, 7}

Completion time of unasssigned jobs,

$\tau = 4+8+10+4+3+7+14 = 50$

$\min[50-27, 50-6, 50-14] = \min[23, 44, 36] = 23$ at job 4

Candidate jobs = {6, 7}

$\tau = 50 - 4 = 46$

$\min[46-6, 46-14] = 32$ at job 7

					7	4

A student …

Candidate jobs = {2, 3, 6}

$\tau = 46 - 14 = 32$

min[32-16, 32-27, 32-6] = 5 at job 3

Candidate jobs = {2, 5, 6}

$\tau = 32 - 10 = 22$

min[22-16, 22-11, 22-6] = 6 at job 2

			2	3	7	4

A student …

Candidate jobs = {5, 6}

$\tau = 22 - 8 = 14$

$\min[14-11, 14-6] = 3$ at job 5

Candidate jobs = {1, 6}

$\tau = 14 - 3 = 11$

$\min[11-10, 11-6] = 5$ at job 6

1	6	5	2	3	7	4

On your own

- You are encouraged to further try to solve the end of chapter problems from the text book (chapter 8 on MRP and chapter 9 on operations scheduling

KTH

VETENSKAP OCH KONST