

PPC lecture 1

inter-related processes within the firms value chain

Process across the firms $\rightarrow$ internally across the



PPC lecture 2

Forecasting

what to forecast?

- level of aggregation
- unit of measurement

Num#

highest level of aggregation unit/year

lower level of aggregation unit/month

lowest level of aggregation unit/week shift

SKU: Stock Keeping unit

choosing forecasting system

choosing forecasting technique

no data about previous actual demand

↓

4 judgemental methods

2 quantitative methods

data available about actual demand

↓

Executive opinion

Sales force estimates

Delphi method

Market research

Causal method

Time series method

levels of aggregation

1/ highest level of aggregation

- دہائی اسکا ایگريگیشن ہوتا ہے SKU کے لئے ہر سال

per year کے لئے ہر سال

unit / year

for all products together

2/ lower level of aggregation

- ہفتہ وار اسکا ایگريگیشن ہوتا ہے medium term کے لئے ہر گروپ کے لئے

low term

unit / month

quarter

each group

3/ lowest level of aggregation

- ہر ایک اسکا ایگريگیشن ہوتا ہے " item " کے لئے ہر گروپ کے لئے

item

Stack Keeping unit → SKU

مستند

unit / day

hour

week

each SKU

g₁ [12 pull down
12 pull down

g₂ [250ml 12 pull down
250ml 12 pull down

g₃ [12 pull down
12 pull down

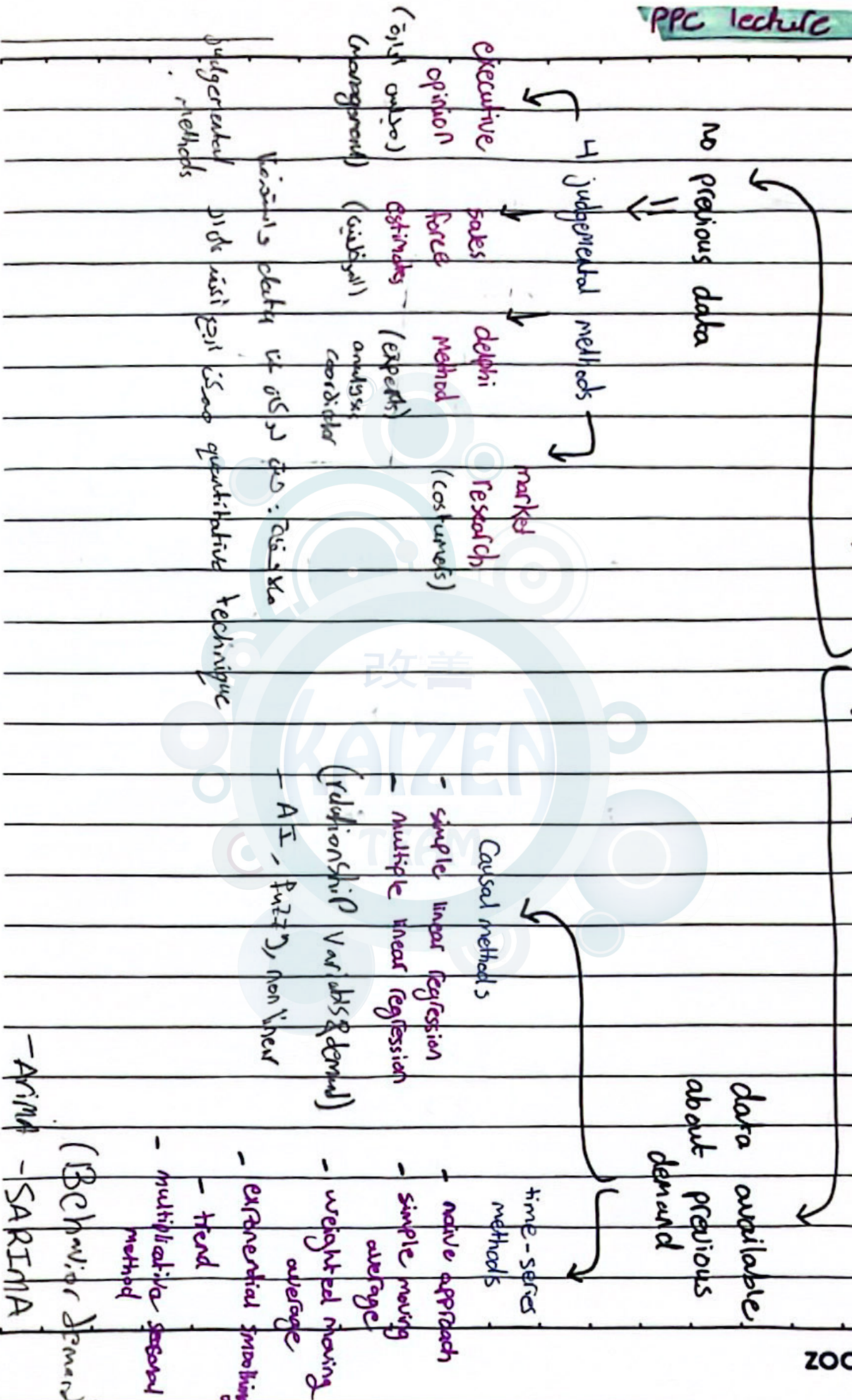
g₄ [250ml 12 pull down

highest need to pull

lower need to pull

highest need to pull

Choosing forecasting technique



Simple linear regression

$$\text{dependent Variable } y = \overset{\substack{\text{intercept} \\ a}}{a} + \overset{\substack{\text{slope} \\ b}}{b}x \rightarrow \text{ind}$$

dependent y
 variable
 demand
 sales
 number of
 patients

assumed to cause the results observed in first

x
 independent
 Variable
 cost
 number of
 population
 quality

Period	x	y	xy	x ²
1	x ₁	y ₁	x ₁ y ₁	x ₁ ²
2	x ₂	y ₂	x ₂ y ₂	x ₂ ²
3	x ₃	y ₃	x ₃ y ₃	x ₃ ²
⋮	⋮	⋮	⋮	⋮
n	x _n	y _n	x _n y _n	x _n ²
	Σx	Σy	Σxy	Σx ²

$$\bar{x} = \frac{\Sigma x}{n}$$

$$\bar{y} = \frac{\Sigma y}{n}$$

$$b = \frac{\Sigma xy - n \bar{x} \bar{y}}{\Sigma x^2 - n \bar{x}^2}$$

$$a = \bar{y} - b \bar{x}$$

to draw the best line :

→ least squared method

الخط الأفضل هو الذي يقلل مجموع مربعات البعديتين عن الخط
least squared.

(i) Correlation Coefficient r

$$r = \frac{n \sum xy - \sum y \sum x}{\sqrt{(n \sum x^2 - (\sum x)^2)(n \sum y^2 - (\sum y)^2)}}$$

$$-1 \leq r \leq 1$$

الارتباط سالب إذا كان r سالباً و موجباً إذا كان r موجباً
negative relationship
positive relationship

الارتباط ضعيف إذا كان r قريباً من 0
weak relationship
الارتباط قوي إذا كان r قريباً من 1 / -1
strong relationship

PPC lecture 4

[2] coefficient of determination r^2

$$0 \leq r^2 \leq 1$$

→ it shows me the amount of changes in the dependent variable due to the independent one.

$$r = 0.9 \quad r^2 = 0.81 \quad \therefore 81\%$$

فان r^2 ان نسبة التغير في demand
بسبب التغير في independent var.

[3] standard error of estimate

$$S = \sqrt{\frac{\sum y^2 - a \sum y - b \sum xy}{n-2}}$$

→ this gives me the amount of actual data variation about the line

هذا هو التغير في y بسبب التغير في x

example for the 3 indicators.

1/ cost & demand Adv. exp & demand

model (1)

model (2)

$$r = 0.9$$

$$r = 0.9$$

$$r^2 = 0.81$$

$$r^2 = 0.81$$

$$S = 12$$

$$S = 18$$

↳ this model is better

2/ cost & demand

Adv. exp & demand

model (1)

model (2)

$$r = 0.8$$

$$r = -0.8$$

$$S = 18$$

$$S = 19$$

↳ multiple linear regression

example

month	Sales ^{demand} y (thousands of units)	Advertising x (thousands of \$)	xy	x ²	y ²
1	264	2.5			
2	116	1.3			
3	165	1.4			
4	101	1.0			
5	209	2.0			
	Σy	Σx	Σxy	Σx^2	Σy^2

$$\bar{x} =$$

$$\bar{y} =$$

$$y = a + bx$$

$$b = 109.229$$

$$a = -8.135$$

$$\therefore \text{regression model } y = -8.135 + 109.229x$$

$$r = 0.98$$

next month

$$r^2 = 0.96$$

$$S = 15.6$$

From r^2 we will accept the model because it's close

ZOOM PRO

the company will spend 1750 \$ next month $\rightarrow$ given
on advertising daily

$$\rightarrow \therefore x = 1.750$$

$$y = -8.135 + 109.229 (1.750)$$

$$y = 183.01575$$

$$\therefore \text{sales next month} = 183015.7 \text{ unit}$$

$$\approx 183016 \text{ unit (door hinges)}$$

- Positive correlation $x \uparrow \quad y \uparrow$

- Negative $\therefore \quad x \uparrow \quad y \downarrow$

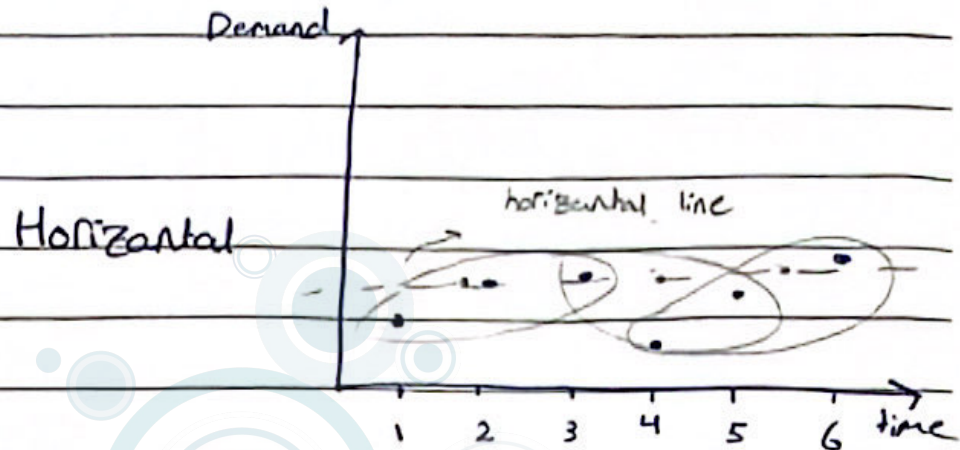
- Strong correlation when it's close to 1 or -1
weak close to 0

$r = 1 \Rightarrow$ all points on the line

~~error~~ error $s \Rightarrow s \uparrow$ cluster around line $\downarrow$
variation $\uparrow$

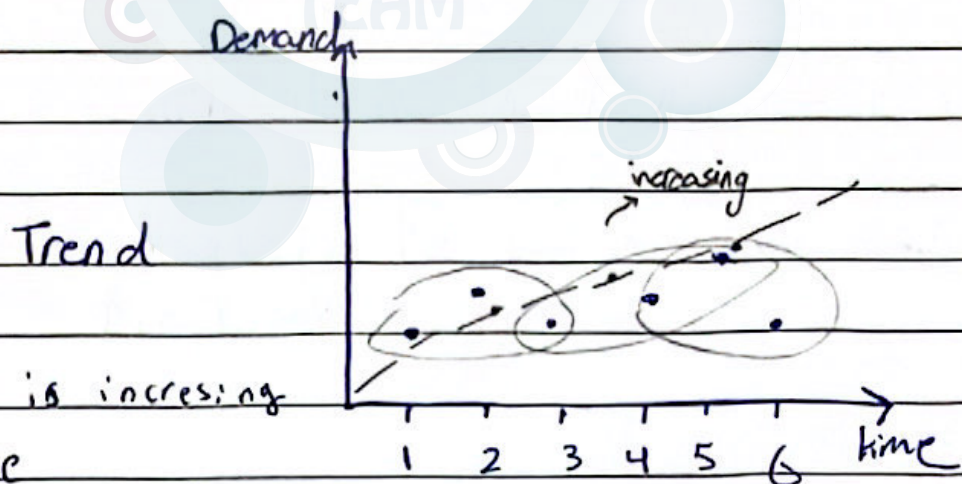
PPC lecture 5

time-series methods (in order of their occurrence)



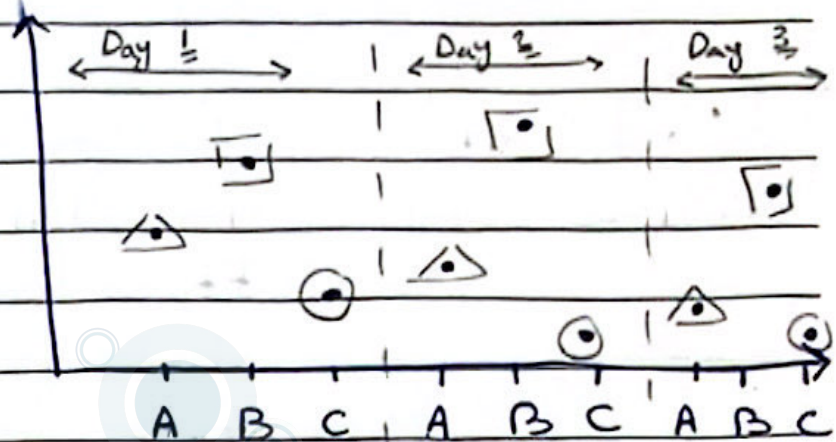
Patterns:

- Horizontal demand clusters ^{around} over a horizontal line
- Trend consistent obvious increasing or decreasing
- Seasonal re occurrence For Peak and Valley is each
- Cyclical small increases and decrease in a pattern over the year
- Random



The average is increasing with time

Seasonal

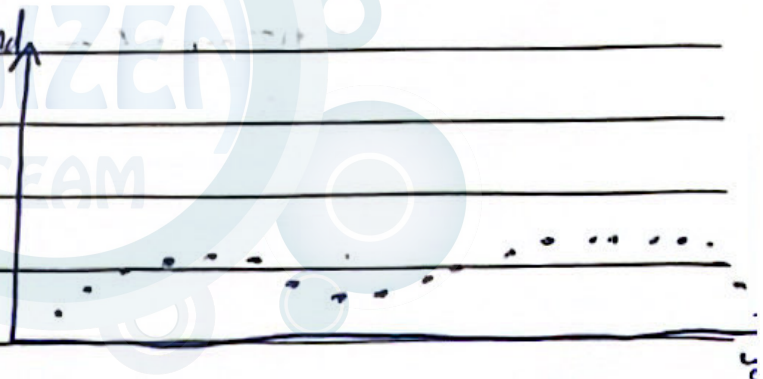


∴ seasonal : (Days) periods side $\frac{\text{Period}}{\text{Shifts}}$ seasons $\rightarrow$

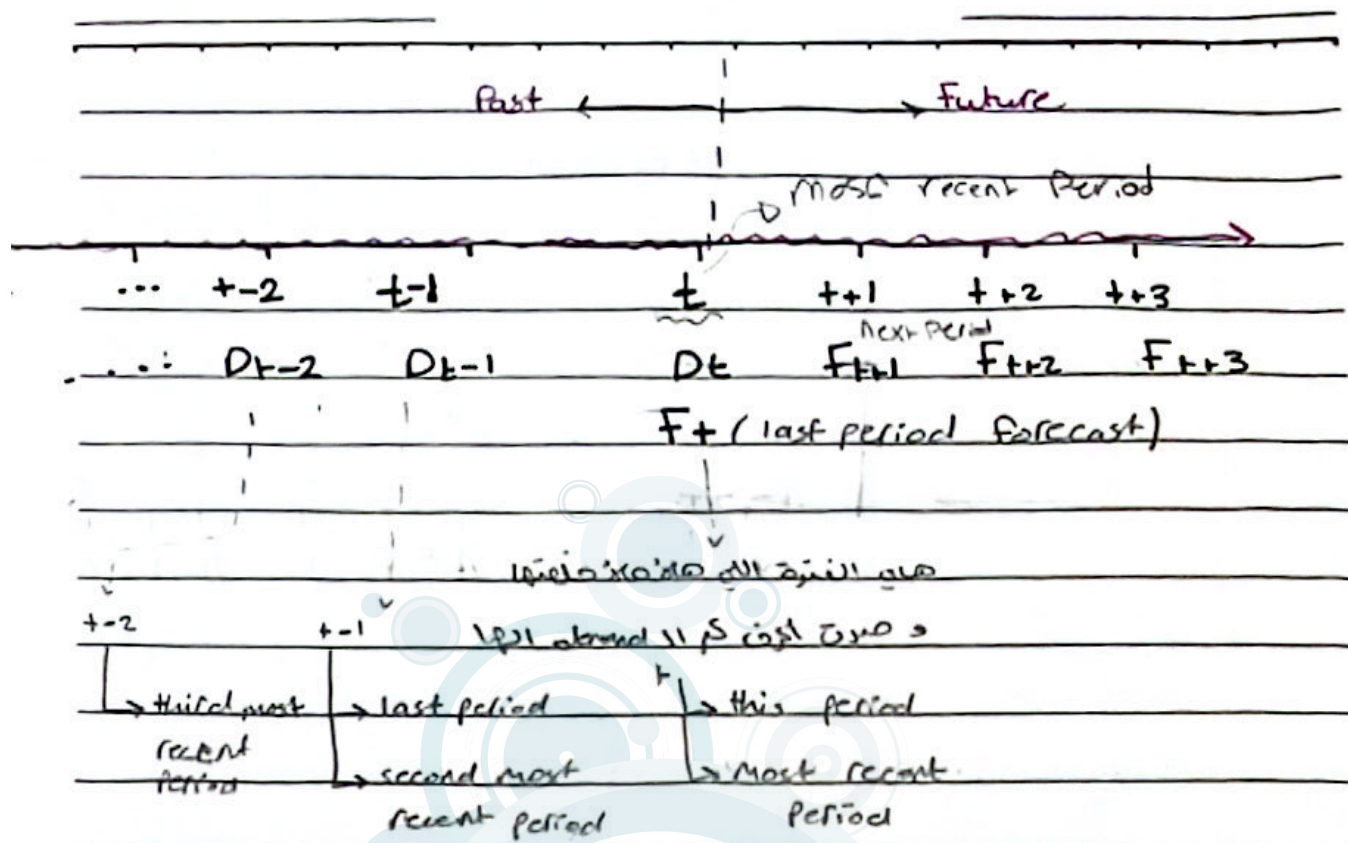
Peaks $\rightarrow$ season $\rightarrow$ (high period) is in $\rightarrow$ $\frac{\text{Period}}{\text{Shifts}}$
 Valley $\rightarrow$ season $\rightarrow$ (low period) is in $\rightarrow$ $\frac{\text{Period}}{\text{Shifts}}$

cyclical

demand



choosing the right technique $\rightarrow$ $\frac{\text{Pattern}}{\text{Shifts}}$ $\rightarrow$ Note



$$\rightarrow E_t = D_t - F_t$$

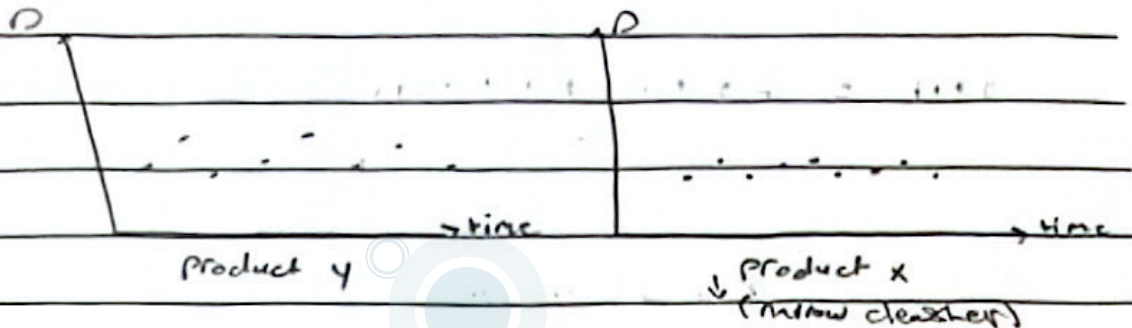
error
of F_t

= +ve (underestimated demand)

= -ve (overestimated demand)

I naive approach (if horizontal pattern)

$$\rightarrow F_{t+1} = D_t$$



more horizontal stable data exists in product X than trend data exists in product Y. Naive forecast works well in increasing demand trend data. increasing demand trend data is not suitable for naive forecast.

$\therefore$ naive approach $\rightarrow$ the forecast for the next period is the demand of this period

PPC lecture 6

[2] simple moving average (if horizontal)

periods = all periods in the past

$$F_{t+1} = \frac{D_t + \dots + D_{t-n+1}}{n} \quad n = \text{periods}$$

3-periods simple moving average

$$F_{t+1} = \frac{D_t + D_{t-1} + D_{t-2}}{3}$$

example :- using 3-periods simple moving average

week patients arrival

$t-2 \leftarrow 1$	400
$t-1 \leftarrow 2$	380
$t \leftarrow 3$	411

$$F_{w4} = \frac{400 + 380 + 411}{3} = 397 \text{ patients}$$

week 4 actual patients arrival = 415 given

$$E_{w4} = D_{w4} - F_{w4} = 415 - 397 = 18 \text{ patients}$$

we under
estimated
the demand

⊕ one we choose number of periods we do not change it till its not valid

week	Patients arrived
1	400
$t-2 \leftarrow 2$	380
$t-1 \leftarrow 3$	411
$t \leftarrow 4$	415

$$FWS = \frac{415 + 411 + 380}{3} = 402 \text{ Patients}$$

naive approach is a special case of simple moving average when $n=1$

[3] weighted moving average

(1:50) Most recent N weight given to periods $t-1$ to $t-N+1$

$$F_{t+1} = w_1 D_t + \dots + w_N D_{t-N+1}$$

$$w_1 + \dots + w_N = 1$$

$$w_1 > \dots > w_N$$

$w \rightarrow$ is the fraction $\rightarrow$ fraction most recent

3-period weighted moving average

$$F_{t+1} = \underline{w_1 D_t} + \underline{w_2 D_{t-1}} + \underline{w_3 D_{t-2}}$$

More in phases $w_1 + w_2 + w_3 = 1$ $\otimes$

$$w_1 > w_2 > w_3$$

assigned to 3 periods, i.e. 3 periods

PPC lecture 7

example

month

customer arrival

1

800

2

740

3

810

4

790

$$w_1 = 0.5$$

$$w_2 = 0.3$$

$$w_3 = 0.2$$

$$w_2 = 1 - w_1 - w_3$$

Forecast the demand for next month
using 3-period weighted moving average

$$F_{m5} = 0.5 \cdot 790 + 0.3 \cdot 810 + 0.2 \cdot 740 = 786 \text{ customer}$$

given by the question

month

customer arrival

(5)

805

$$E_{m5} = 805 - 786 = 19 \text{ customer}$$

$$F_{m6} = 0.5 \cdot 805 + 0.3 \cdot 790 + 0.2 \cdot 810 = 801.5$$

$$\approx 802 \text{ customer}$$

special case of weighted

[4] exponential smoothing (if horizontal pattern)

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

D_t : demand for this period

F_t : last period forecast

α : smoothing parameter

$$\textcircled{4} \rightarrow F_{t+1} = F_t + \alpha (D_t - F_t)$$
$$\alpha D_t + (1-\alpha) F_t$$

$$\underline{0 \leq \alpha \leq 1} \quad \alpha: 0.1 / 0.3 / 0.7 / 0.9$$

Note: exponential smoothing is a special case of weighted moving average

Note: exponential smoothing when $\alpha=1$ is naive approach

Note: α is emphasis (less) is an exponential

also all of most recent

most recent α emphasis (less) (this weighted)

example

week

patient arrival

1

400

2

380

3

411

$$\alpha = 0.1$$

using exponential smoothing

$$Fw_4 = 0.1 D_{w3} + 0.9 Fw_3$$

← فرضية لبيبي Fw_3

using 2-periods moving average ← متوسط متحرك

$$Fw_3 = \frac{D_{w2} + D_{w1}}{2} = 390$$

$$Fw_4 = 0.1 \cdot 411 + 0.9 \cdot 390 = 392.1 \approx 392 \text{ patient}$$

given by the question

week	patient arrival
4	415

$$Fw_4 = 415 - 392 = 23 \text{ patient}$$

$$Fw_5 = 0.1 \cdot 415 + 0.9 \cdot 392.1 = 394.4 \approx 394$$

تقريب Patient

L.5

FW3 actual - actual - actual ✓

	week	Patient arrival	De Paul
	1	400	$Dw_1, Fw_1 = D$
expo	2	380	Dw_2, Fw_2
expo	3	411	Dw_3, Fw_3
expo	4		

α is fixed

the initial forecast

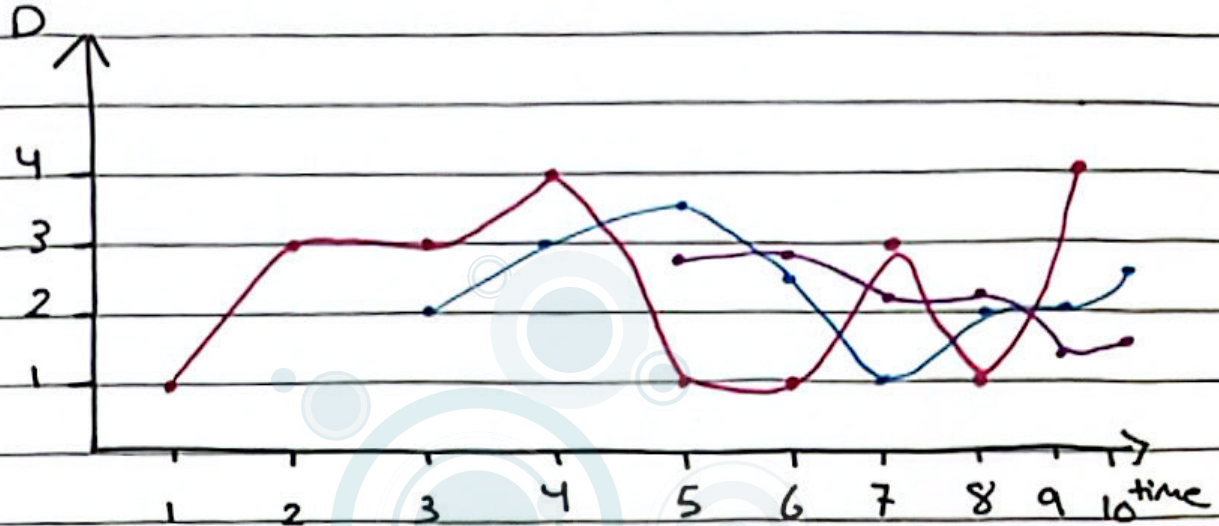
we go back forward

⊗ when we calculate we substituted the actual value not the rounding

Horizontal time-series

PPC lecture 8

responsive & smooth forecast



- actual data Demand

fore cast $n=2$ 2-periods simple moving average
 - fore cast $n=4$ 4-periods simple moving average

$$\text{simple} = D_t + \dots + D_{t-n+1}$$

$$\text{weighted} = w_1 D_t + \dots + w_n D_{t-n+1}$$

$$\text{exponential} = \alpha D_t + (1 - \alpha) F_t$$

• smaller n (with lag)

responsive forecast

fore cast $n=2$, $n=4$ etc

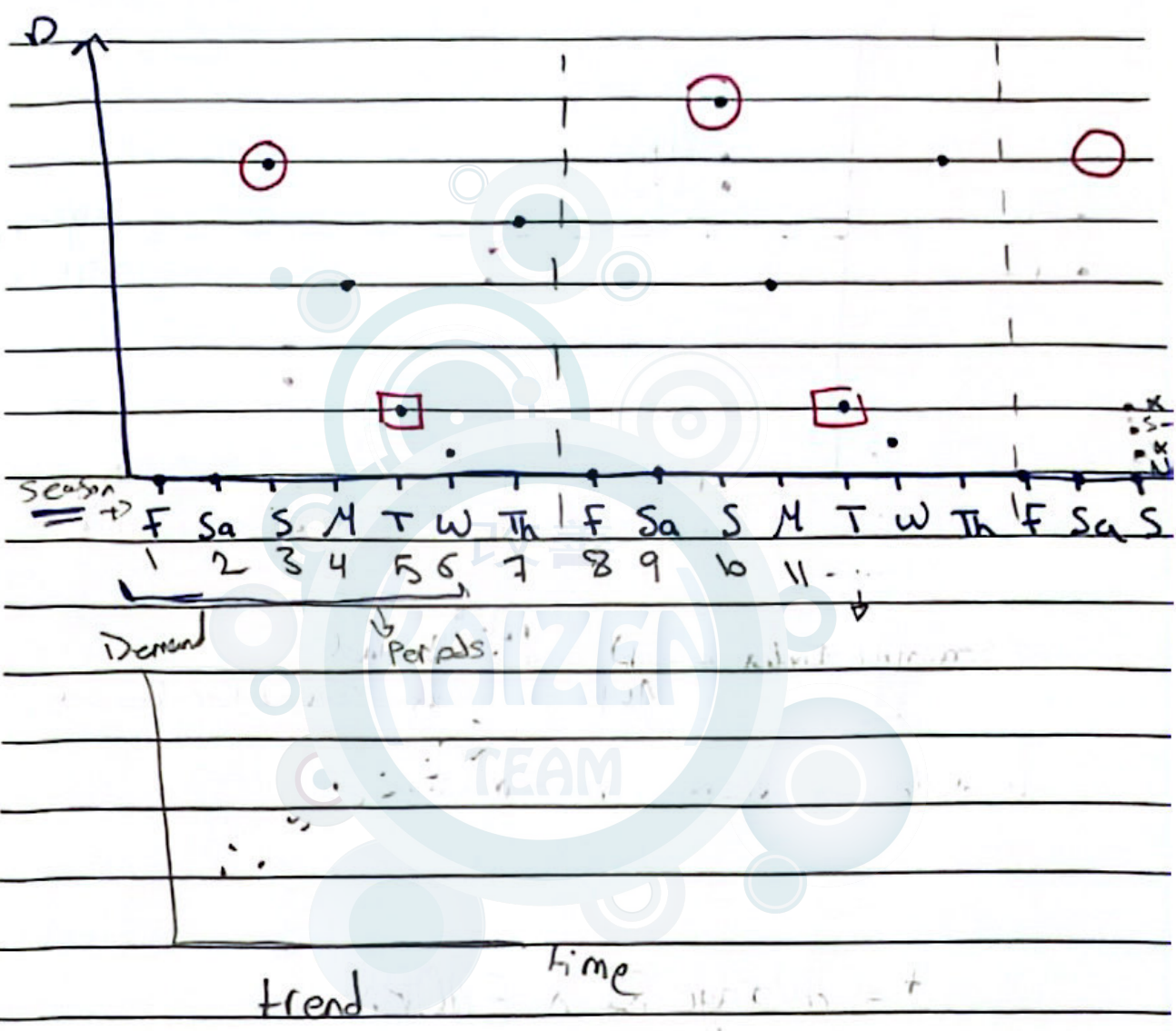
larger α

larger n

smoothed forecast

smaller α

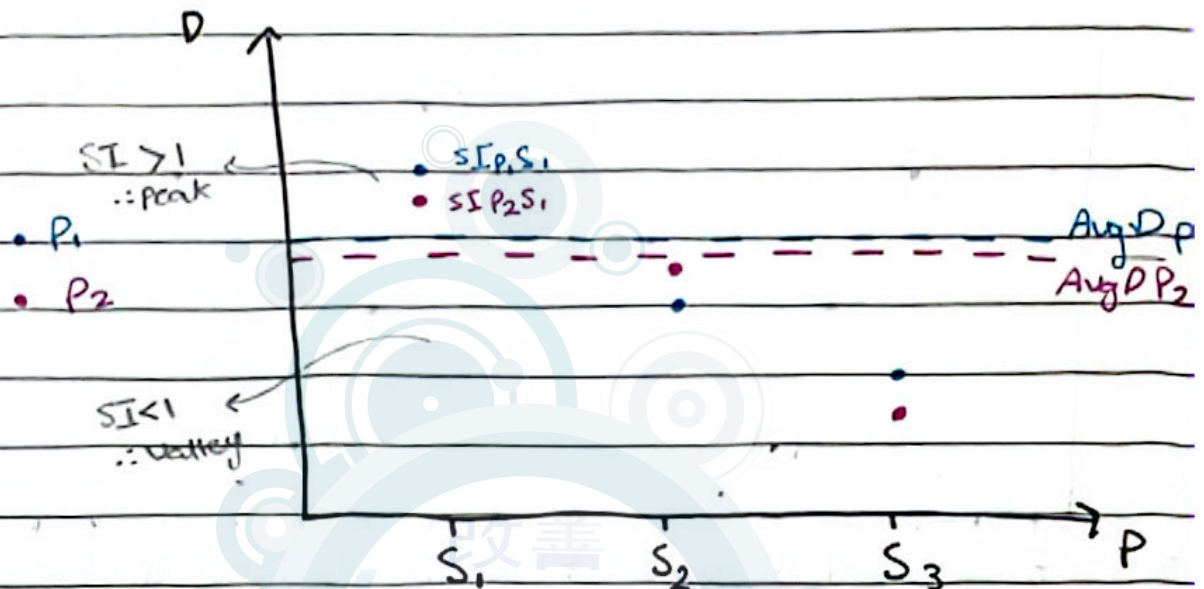
Note: simple linear regression - Trend is inc or dec
 or, Collection is in 2019 is in



PPC lecture 9

[5] multiplicative seasonal method (more than two)

data available for each season is also reqd -



$$\text{Seasonal Index} = \frac{D}{ADPS} = \frac{\text{Actual Demand}}{\text{Average Demand Per Season}}$$

SI > 1 :: peak, SI < 1 :: valley

SI > 1 :: peak, SI < 1 :: valley

SI < 1 :: valley

$$F = \text{Average SI} \times \text{EADPS}$$

$$F = \text{ASI} \times \text{EADPS}$$

↓
estimated

ZOOM

Season	D	Seasonal Index SI	0	Seasonal Index SI	(Average seasonal Index) ASI	Forecasted Period
S ₁	$SI_{PS1} = \frac{DP_{S1}}{ADPS_1}$ (3)	DP_{S1}	$SI_{PS1} = \frac{DP_{S1}}{ADPS_1}$	(4) $ASI_{S1} = \frac{SI_{PS1} + SI_{PS1}}{\text{no. of Periods}}$	(5) $FP_{S1} = ASI_{S1} \times EADPS_1$	
S ₂	$SI_{PS2} = \frac{DP_{S2}}{ADPS_1}$	DP_{S2}	$SI_{PS2} = \frac{DP_{S2}}{ADPS_2}$	$ASI_{S2} = \frac{SI_{PS2} + SI_{PS2}}{\text{no. of Periods}}$	$FP_{S2} = ASI_{S2} \times EADPS_2$	
S ₃	$SI_{PS3} = \frac{DP_{S3}}{ADPS_1}$	DP_{S3}	$SI_{PS3} = \frac{DP_{S3}}{ADPS_2}$	$ASI_{S3} = \frac{SI_{PS3} + SI_{PS3}}{\text{no. of Periods}}$	$FP_{S3} = ASI_{S3} \times EADPS_3$	
① →	Total Demand = $DP_{S1} + DP_{S2} + DP_{S3}$ (TDP)		$TDP_2 = DP_{S1} + DP_{S2} + DP_{S3}$	Estimated	Estimated total demand using an appropriate technique (ETDP ₃)	
② →	Average demand per season $AOSR_1 = \frac{TDP_1}{\text{no. of seasons}}$ (ADPS ₁)		$ADPS_2 = \frac{TDP_2}{\text{no. of seasons}}$		$EADPS_3 = \frac{ETDP_3}{\text{no. of seasons}}$	

linear regression

LPX 1 year - time

ETD_{y5} لا يبي اوله

proper technique
عن طريق

تحت شفت TD وسنة او

في trend :: يلبس اوله
linear regression

years = x
1, 2, 3, 4

TD = y

1000, 1200, 1800, 2200

لكين اوله correlation

ويستوي اذا قولى او لا

⇒ ETD_{y5} وصلها بطه

عن طريق اتي الوقت x=5

Author 11-2020

ETD_{y5}

Average increase

in total demand

each year

$$= \frac{200 + 600 + 400}{3}$$

$$= 400$$

$$\therefore ETD_{y5} = 2200 + 400 = 2600$$

PPC lecture 10

example on seasonality

Quarter	year 1	year 2	year 3	year 4	Average seasonal index	forecast
1	45 SI 0.18 45 / 250	70 SI 0.23	100 SI 0.22	100 SI 0.18	$\frac{\sum SI}{\text{no. of periods}} = 0.2$	130
2	335 SI 1.34	370 SI 1.23	585 SI 1.3	725 SI 1.32	1.29×1650	843.7
3	520 SI 2.08	590 SI 1.96	830 SI 1.84	160 SI 2.1	2	1300
4	100 SI 0.4	170 SI 0.56	285 SI 0.63	215 SI 0.39	0.498	323.7
					$\frac{\sum SI}{\text{no. of periods}}$	ASIKEMAS
	$TD_{y1} = 1000$ $ADPS_{y1} = 250$	$TD_{y2} = 1200$ $ADPS_{y2} = 300$	$TD_{y3} = 1800$ $ADPS_{y3} = 450$	$TD_{y4} = 2200$ $ADPS_{y4} = 550$	constant index	$ETD = 2200 + 400 = 2600$ $EAPRS = 650$
	Week 1 (200)	(600)	(400)	Avg index = 400		

ZOOM PRO

⊗ PPC lecture II

period	DE	FE	E _t
1	D ₁	F ₁	E ₁
2	D ₂	F ₂	E ₂
3	D ₃	F ₃	E ₃
⋮	⋮	⋮	⋮
n	D _n	F _n	E _n

So fix n
at least 5 periods

$$E = D - F = +ve \text{ (underestimated demand)}$$

$$= -ve \text{ (overestimated demand)}$$

1 Cumulative sum of Forecast error $CFE = \sum_{t=1}^n E_t$

Method (1)	Method (2)	Method (3)
E	E	E
-3	+3	+2
-5	+5	-1
+2	-3	-1
-1	+1	-2
→ CFE -7	+7	-2

overestimate is underestimate ← bias is in the direction of the error
underestimate is overestimate ← bias is in the direction of the error

-10 & +10 → are the same

We prefer less bias

[2] Mean Bias $\bar{E} = \frac{CFE}{n}$

average bias

- هو نقشه ار CFE بالزبط as idea

3 Mean absolute deviation

$$\text{MAD} = \sum_{t=1}^{t=n} |E_t|$$

Average deviation or Actual

- $\frac{1}{2} \times 100 = 50\%$

	Method 1		Method 2	
Revised	E	$ E $	E	$ E $
	-1	1	-5	5
	+3	3	+8	8
	-2	2	-4	4
	+1	1	0	0
CFE =	+1		-1	
MAD =	$\frac{7}{4}$		$\frac{17}{4}$	

we want MAD to be less. also

= The Logn. has a bias to t Demand $\rightarrow$ answer

[4] Mean squared error

$$MSE = \frac{\sum E^2}{n}$$

inot is is is is is is is is -

Method 1

E E²

5 25

5 25

4 16

3 9

MAD

17

4

MSE

75

4

Method 2

E E²

12 144

2 4

1 1

2 4

← large

error

to improve

17

4

153

4

[5] Mean absolute percent error

$$MAPE = \frac{\sum \left(\frac{|E|}{D} \times 100 \right)}{n}$$

actual is deviation is is is is is -

inot is is is is is is is -

Method

E

D

|E|

→ product x

1

10

1

→ product y

1

10000

1

10000

we need to know the actual demand

inot is

$$\sum \left[\frac{|E|}{D} \times 100 \right]$$

n

ZOOM PRO

central tendency // measures of central tendency // Methods 5 // 5 -

6 standard deviation of error σ
$$\sigma = \sqrt{\frac{\sum (E_t - \bar{E})^2}{n-1}}$$

measures of error // 5 -

5 Measures of error

Sum up $\rightarrow$

Measures of error

- bias of method $\rightarrow$ CFE, $\bar{E}$
- deviation from actual $\rightarrow$ MAD
- large error in certain periods $\rightarrow$ MSE
amount of deviation as a percent.
- of actual demand $\rightarrow$ MAPE
- variability of error $\rightarrow$ σ_E

PPC lecture 12

- Measures of error -

2 strategies to decide of 2 good techniques

↓
Combination forecast

↓
Focus forecast

- Combination forecast

Period	Method 1	Method 2	Forecast for the decision
	$F_{p10} M_1$	$F_{p10} M_2$	$F_1 + F_2$
			2
			↓ any of 2 technique

How to decide that this technique is better to use?

find error of the combination and for each technique then compare

- focus forecasting

Method 1			Method 2			decision
time						
DA0	F_{10/M_1}	E_{10/M_1}	DA0	F_{10/M_1}	E_{10/M_2}	✓ MAPS
Per 10	fill 9					Per 11
✓ MAD						fill 10
Period 10 skip						

→ we will choose the technique that gave the least error
for the last period

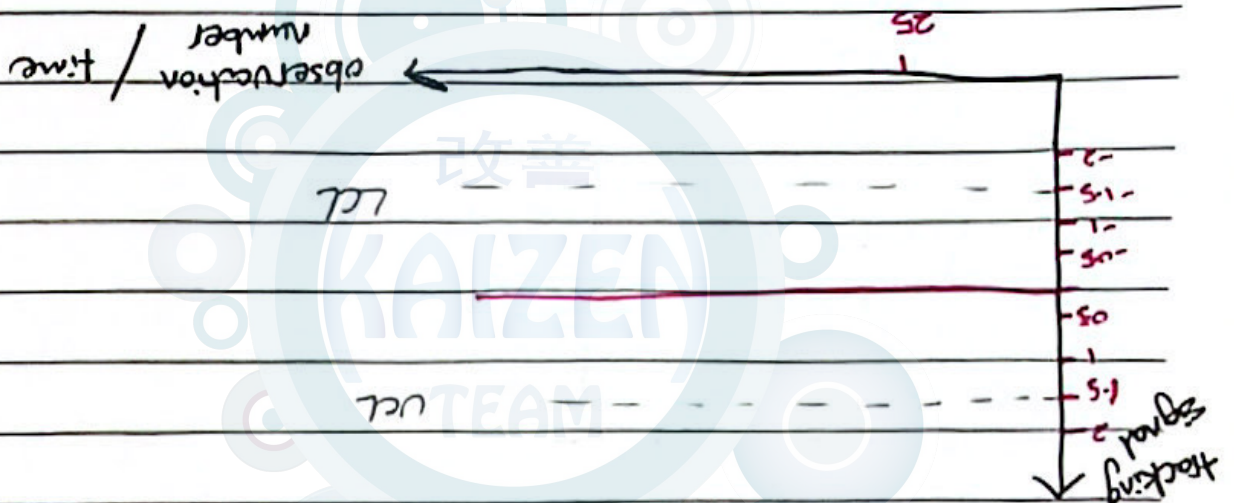
~~Forgetting using the chosen technique is within~~

6] Tracking signal: It is the process of

60:47 T201 1:25N am @ (4)

10/1/2021 11:45 AM

The plot T_{25} is between UCL & LCL

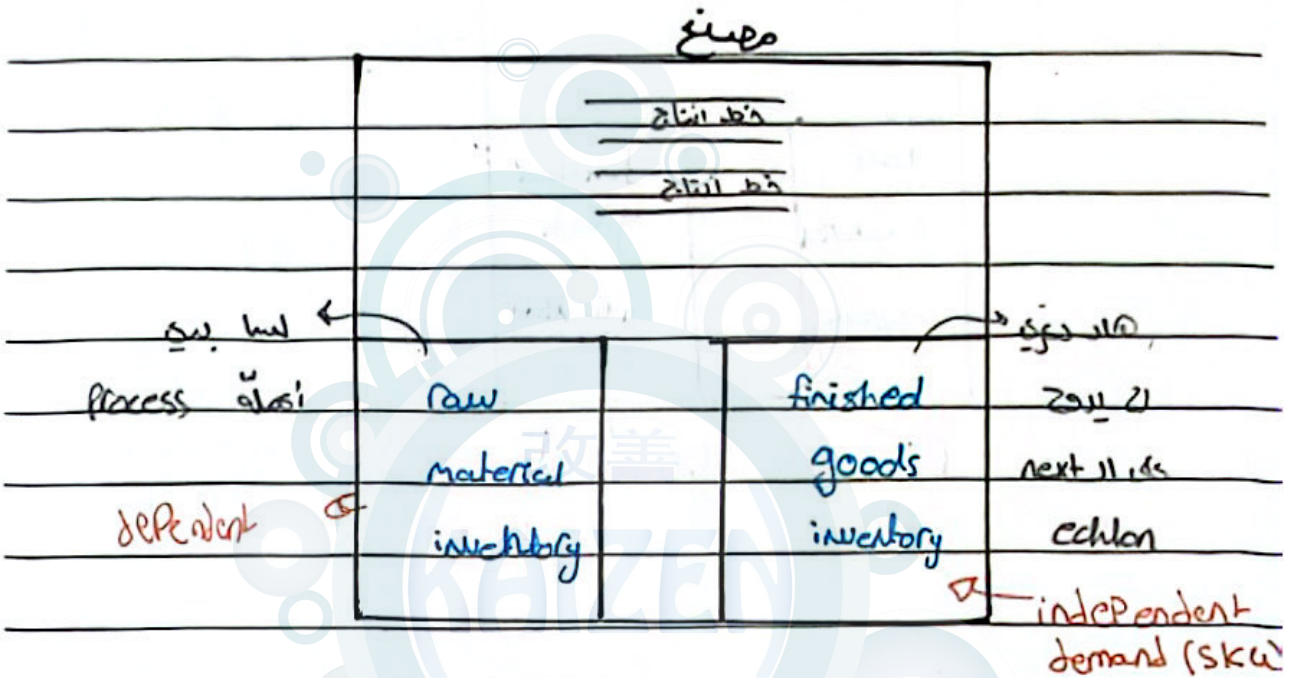


my to decide if the forecasting is still under control or not

~~$$\text{Control charts of tracking signal} = \frac{\text{CFE}}{\text{MAD}}$$~~

PPC lecture 13

Inventory $\rightsquigarrow$ The stock itself warehouse $\rightsquigarrow$ the place of the inventory



work-in-process inventory $\leftarrow$ "waste"

elimination of waste

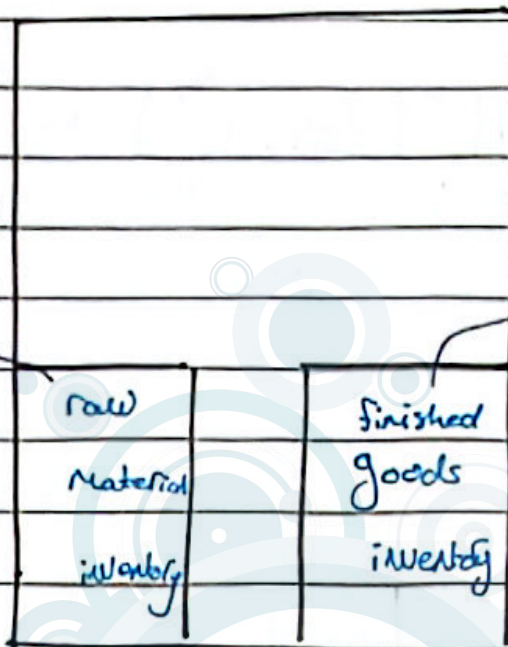
Management view

Lean Management practices

$\therefore$ For this course I'm gonna focus on managing $\hat{=}$ Raw Material $\hat{=}$ Finished goods

dependent demand (SKU)

SKU ke saath hi iske
sare SKU ki demand
pata chalti hai



independent demand (SKU)

Iske demand apni hi hai
bina kisi aur SKU ke



عجلہ



پسکیت

iske demand apni hi hai

finished goods (SKU)

iske demand apni hi hai

raw material (SKU)

iske demand apni hi hai
bina kisi aur SKU ke

SKU: Stock-Keeping-unit (SKU)

Inventory management

Classification of SKU
ABC classification

Choosing inventory control systems

(کیسے؟) - how much to order?
(کیسے؟) - when to order?
(کیسے؟) - how often to review inventory position?



PPC lecture 14

Classification of SKU's

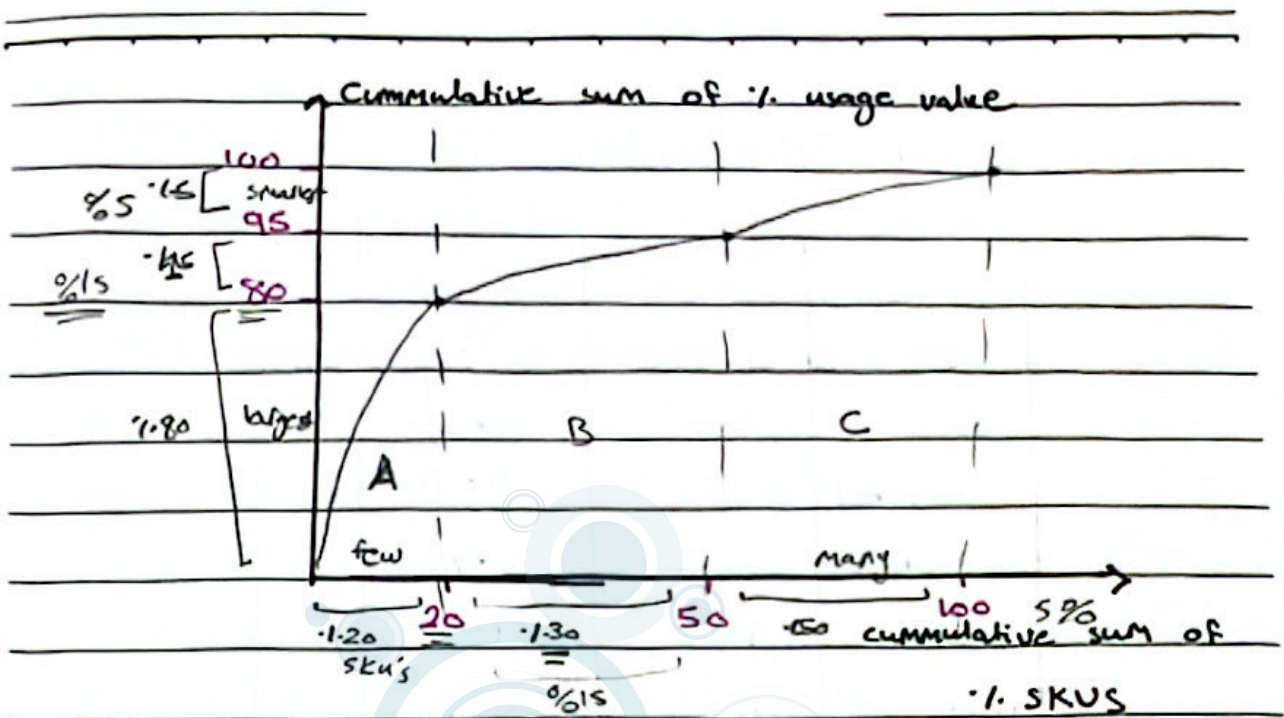
1.1 ABC classification → most common technique

(classification based on usage value (Dollar usage))

	cost	Annual demand	Annual usage value $\text{cost} \times \text{demand}$
Product x	\$1	100,000 unit	100,000 \$/year
Product y	\$100	1 unit	100 \$/year

Assignment → Find other classifications of SKU's

in terms of what like speed...



Ranking SKU in terms of usage order is desirindg

"Pareto principle (80/20 rule)"

A :: 7.80 ppl 1.20 ppl 1.50 ppl

B :: 1.15 ppl 1.30 ppl 1.50 ppl

C :: 1.5 ppl 1.50 ppl 1.50 ppl

relative value ::

Critical < A :: largest value ppl few J

trivial < C :: smallest value ppl many J
useful

• Pareto principle < two in 80 ABC J

(80/20 rule)

few < largest effect (critical few) *

many < smallest effect (trivial many)
useful many

PPC lecture 15

example on ABC classification

- First Step

# SKU	Description	Quantity used per year	unit value (\$)	Annual usage value \$/year
1	Boxes	500	3	1500 (4)
→ 2	cardboard	18000	0.02	360 (7)
5 3	cover stock	10000	0.75	7500 (2)
4	glue	75	40	3000 (3)
5	inside cover	20000	0.05	1000 (5)
6	tape	3000	0.15	450 (6)
→ 7	signatures	150000	0.45	67500 (1)

2nd step

→

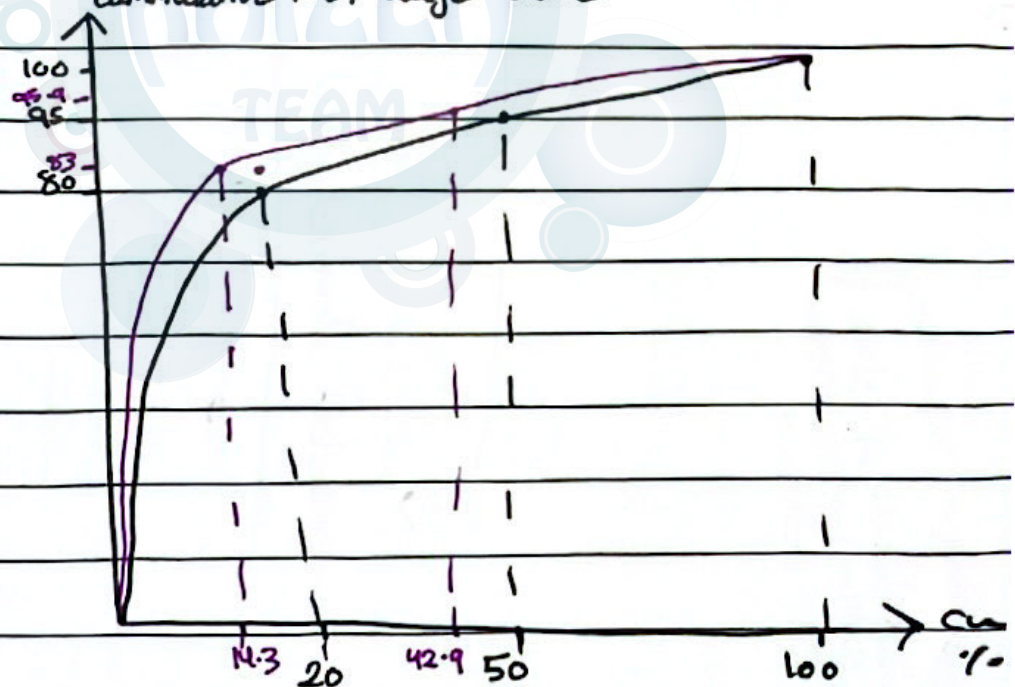
Ranking is the first step to class. f i

skt#	Description	Annual usage value \$/year	% of SKUs	% of usage value	Cumulative % of SKUs	Cumulative % of usage value	class
7	signature	67500	$\frac{1}{7} \times 100 = 14.3\%$	$\frac{67500}{81130} \times 100 = 83.2\%$	14.3%	83.2%	A
3	cover stock	7500	14.3%	$\frac{7500}{81130} \times 100 = 9.2\%$	28.6%	92.2%	B
4	glue	3000	14.3%	3.7%	42.9%	95.9%	B
1	boxes	1500	14.3%	1.8%	57.1%	97.8%	C
5	inside cover	1000	14.3%	1.2%	71.4%	99.0%	C
6	tape	450	14.3%	0.6%	85.7%	99.6%	C
2	card board	360	14.3%	0.4%	100%	100%	C

Total: 81,130

C: should be more

Cumulative % of usage value



classification of SKUs

- ABC classification

choosing inventory control system

- when to order?
- how much to order?
- how often to review TP?

Inventory Position

independent demand SKU

continuous review system

periodic review system

"traditional systems"
"demand review on a fixed interval"

hybrid system

optional replenishment system

base stock system

dependent demand SKU

raw material
materials requirements planning (MRP)

inventory cost

H: unit holding cost
\$/unit/year

as a percent of unit cost

Order/setup cost

Purchasing cost

holding cost

Cost of capital

strategizing & handling cost

Taxes, insurance, shrinkage

Pilferage (theft)

obsolescence (outdated)

deterioration (expired, damaged)

Purchasing cost:

ordering cost:

setup cost:

S: order/setup cost

\$/order

\$/setup

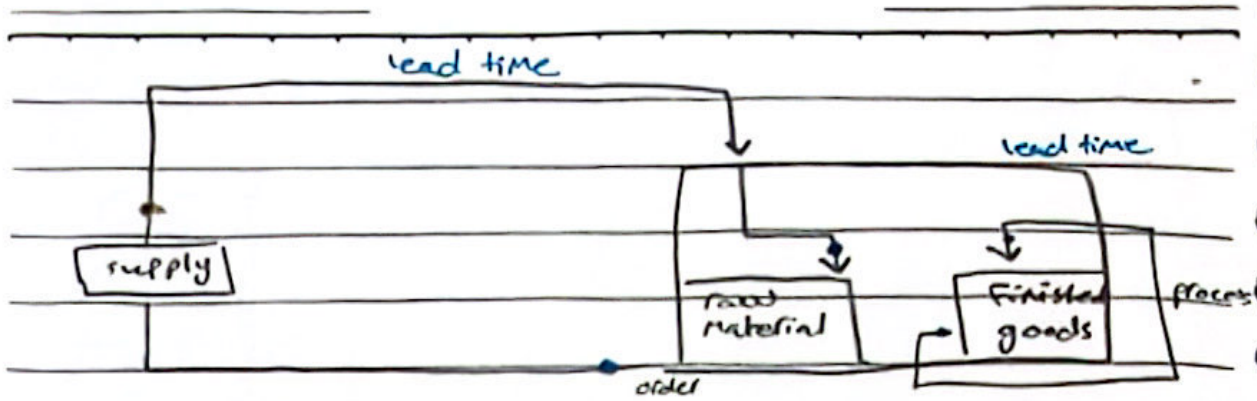
unit cost

H: unit holding cost

as a percent

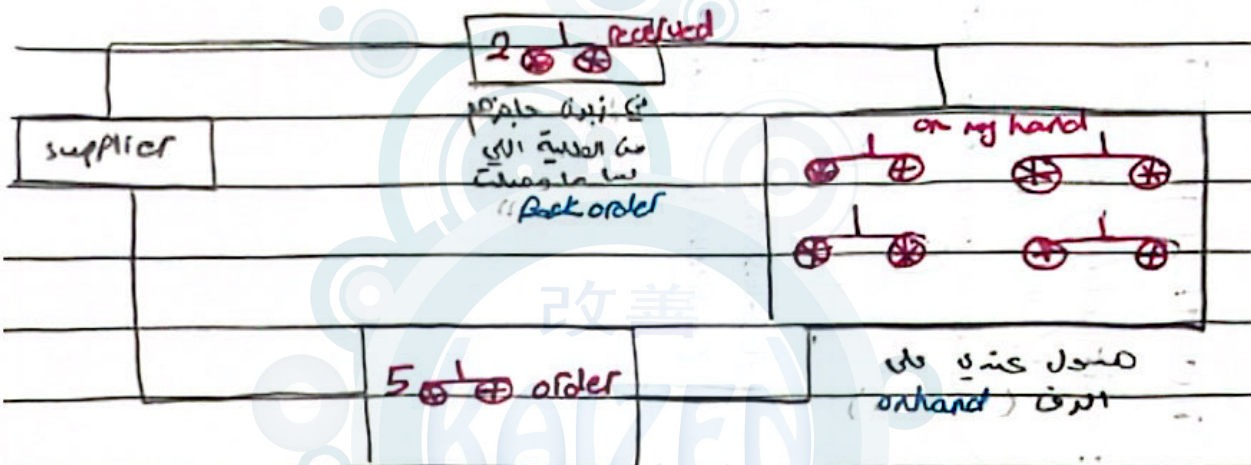
PPC lecture 15

ZOOM



lead time:
(L)

time to get order till it is in your hand
time to get order till it is



is this is on hand
order
Scheduled Receipts

$$\text{Inventory position (IP)} = \text{On-hand Inventory (OH)} + \text{Scheduled Receipts (SR)} - \text{Backorder (BO)}$$

and already ordered
but not shipped
yet

PPC lecture 17

d: unit/hour

unit/shift

unit/day

unit/month

unit/week

unit/year

annual

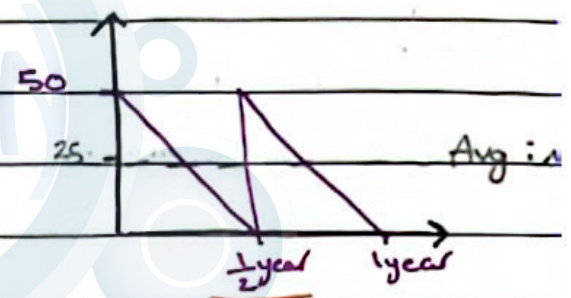
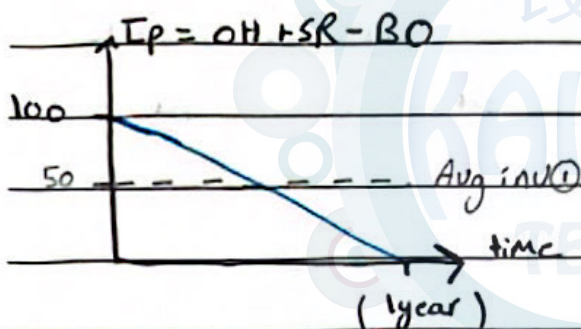
D : ~~annual~~ demand

product x $D = 100$ unit/year $\rightarrow$

Q = quantity we order

Case (1) $Q = 100$ unit

Case (2) $Q = 50$ unit



$$Avg\ inv = \frac{Q}{2} = \frac{100}{2} = 50 \text{ unit}$$

$$Avg\ inv = \frac{Q}{2} = \frac{50}{2} = 25 \text{ unit}$$

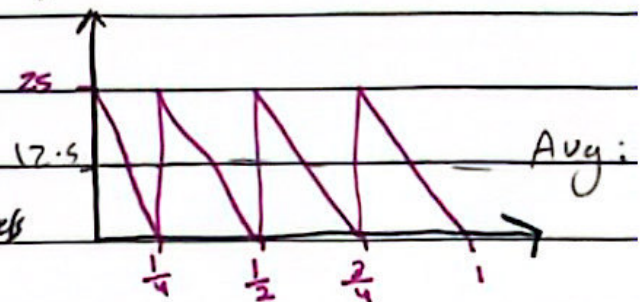
$$\text{no. of orders} = \frac{D}{Q} = \frac{100}{100} = 1 \text{ order}$$

$$\text{no. of orders} = \frac{D}{Q} = \frac{100}{50} = 2 \text{ or}$$

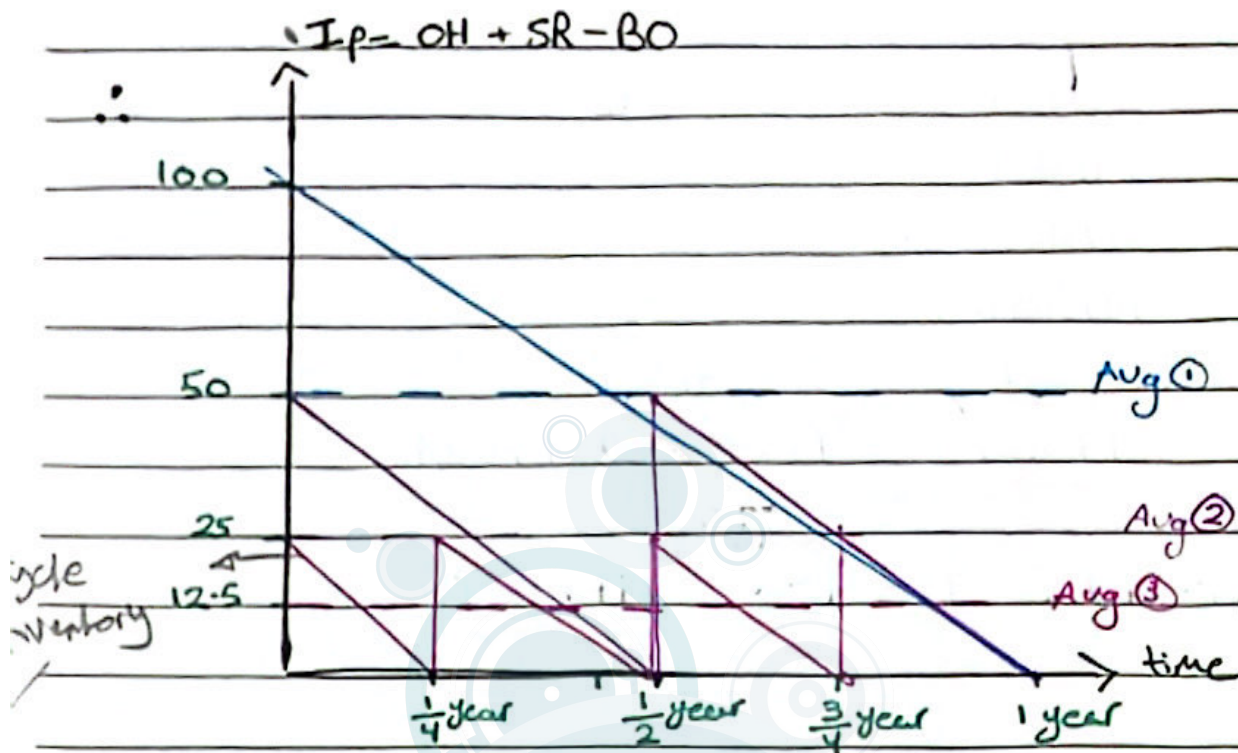
Case (3) $Q = 25$

$$Avg\ inv = \frac{Q}{2} = \frac{25}{2} = 12.5 \text{ unit}$$

$$\text{no. of orders} = \frac{D}{Q} = \frac{100}{25} = 4 \text{ orders}$$



ZOOM



Law tooth pattern and case 3. 4. This also is pattern 11. Note
 traditional inventory control system also has 11. This also is
 "cycle inventory"

Total Annual cycle inventory cost $C = \text{Annual holding cost} + \text{Annual ordering cost}$

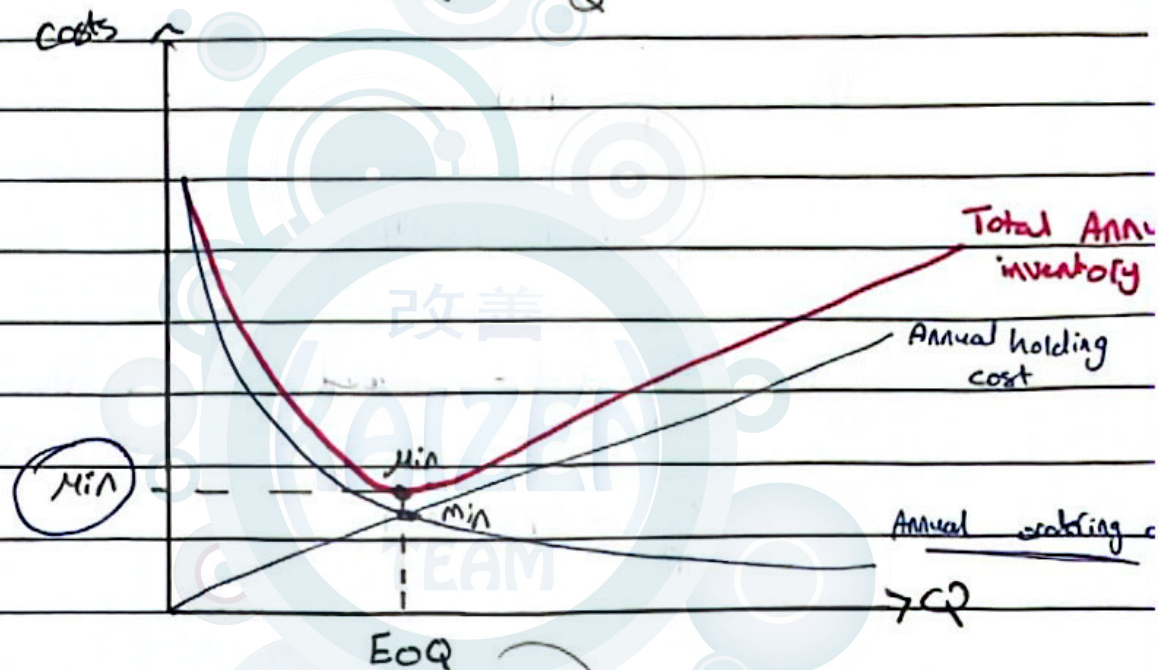
$$C = \frac{Q}{2} H + \frac{D}{Q} S$$

Annual holding cost = Average cycle inventory $\times$ unit holding cost

$$\frac{Q}{2} H$$

Annual ordering/setup cost = number of orders $\times$ unit setup/order cost

$$\frac{D}{Q} S$$



EOQ = economic order quantity

1 unit at a time
cost is less

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

Note "EOQ" answers the question "How much to order"



Time between orders

$$TBO = \frac{Q}{P} \dots \text{year}$$

$= 1$
Number of orders

Note TBO answers the question "when to order"

$$TBO = \frac{Q}{P} \text{ year}$$

$$= \frac{Q}{P} \times 12 \text{ month}$$

$$= \frac{Q}{P} \times 52 \text{ week}$$

$$= \frac{Q}{P} \times 365 \text{ day}$$

PPC lecture 18

example

operates 52 weeks in year

$d = 18$ unit/week

unit cost = \$60

$S = 45$ \$/order - Order Placing cost

$H = 25\%$ of unit cost

$\sim 0.25 \times 60 = 15$ \$/unit/year

$Q_{current} = 390$ unit

lot size

1/ Total annual cycle inventory cost (C_i)

$$C = \frac{Q}{2} H + \frac{DS}{Q}$$

$$C_{current} = \frac{390}{2} (15) + \frac{(18)(52)(45)}{390} = \$3033$$

2/ EOQ $\sqrt{\frac{2DS}{H}} = \sqrt{\frac{(2)(18)(52)(45)}{15}} = 74.94$

$$EOQ = 75 \text{ unit}$$

3/ $C_{EOQ} = \frac{75}{2} \times 15 + \frac{(18)(52)(45)}{75} = \1124

4) $TBO = \frac{Q}{D} = \frac{75}{(18)(52)} = 0.08 \text{ Year}$

$$\times 12 = 0.96 \text{ Month}$$

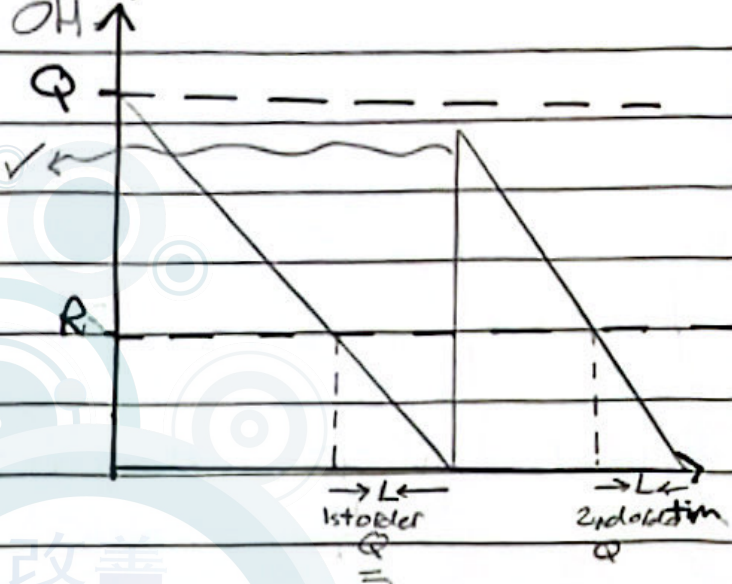
$$\times 52 = \text{Week}$$

Continuous Review system

ROP system

"Fixed Quantity Q"

$$I_p = OH + SR - BO$$



Q, Fixed

Continuous Review System / Fixed-order quantity system / ROP system / Q system

How often to review inventory position?

continuously, after each withdrawal

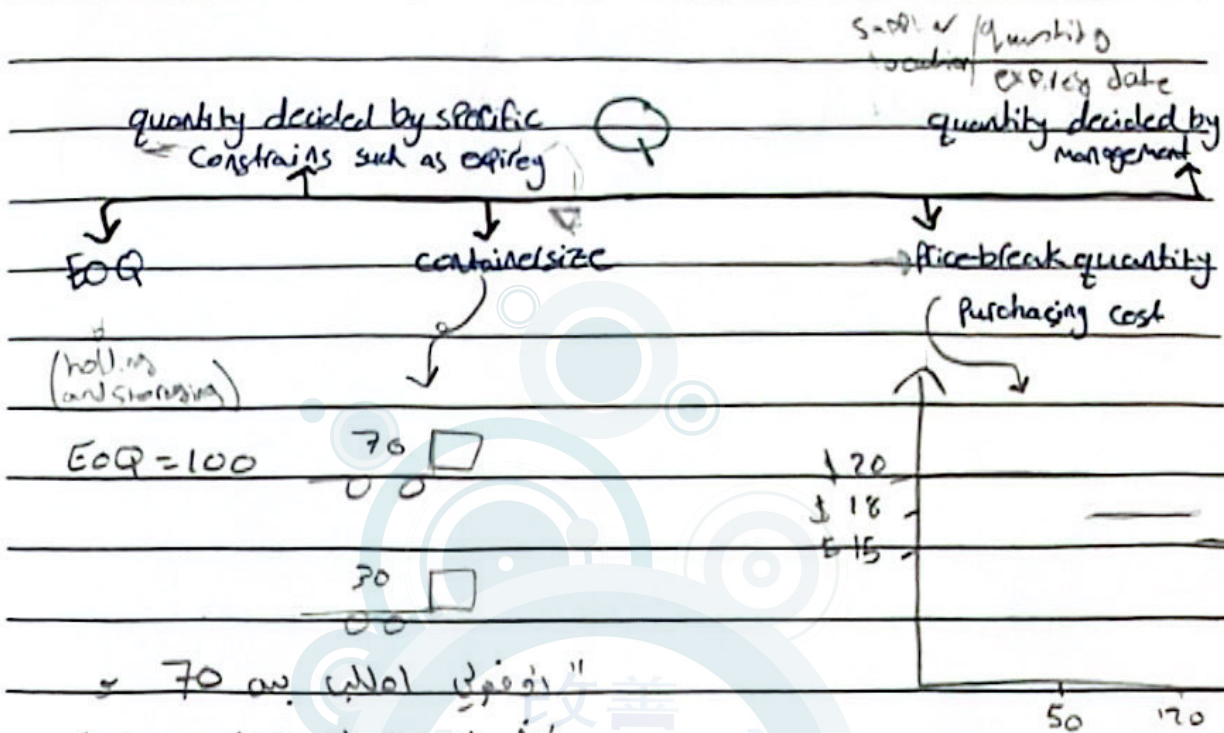
When to order?

when I_p reaches a pre determined quantity R

How much to order?

a fixed quantity Q

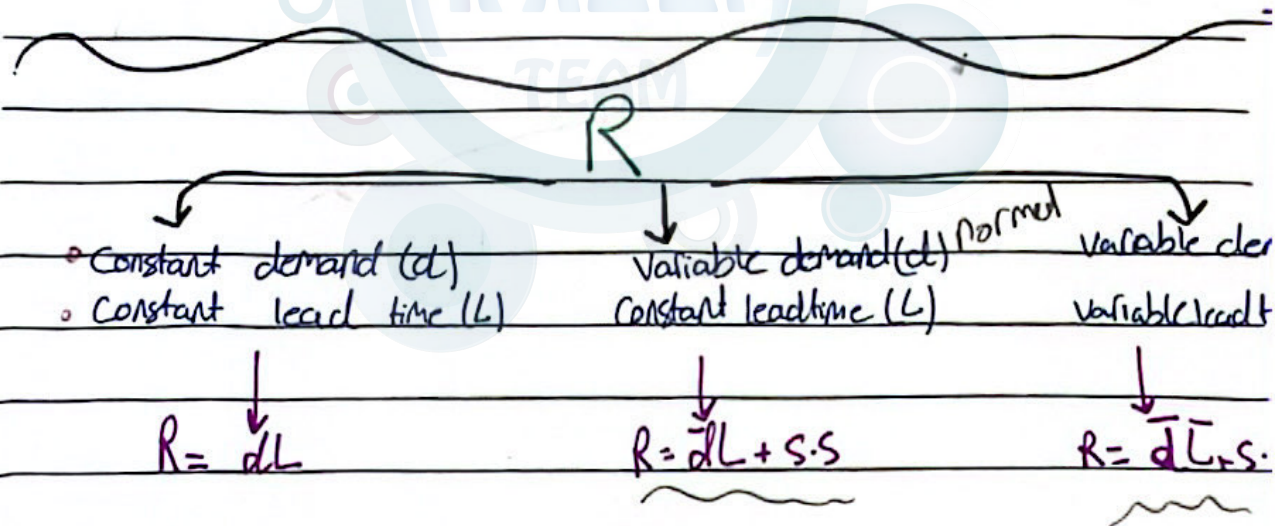
→ Now I have to choose Q/R



70 au. qalal (purchasing)

qalal 30 au. qalal

qalal 30 au. qalal



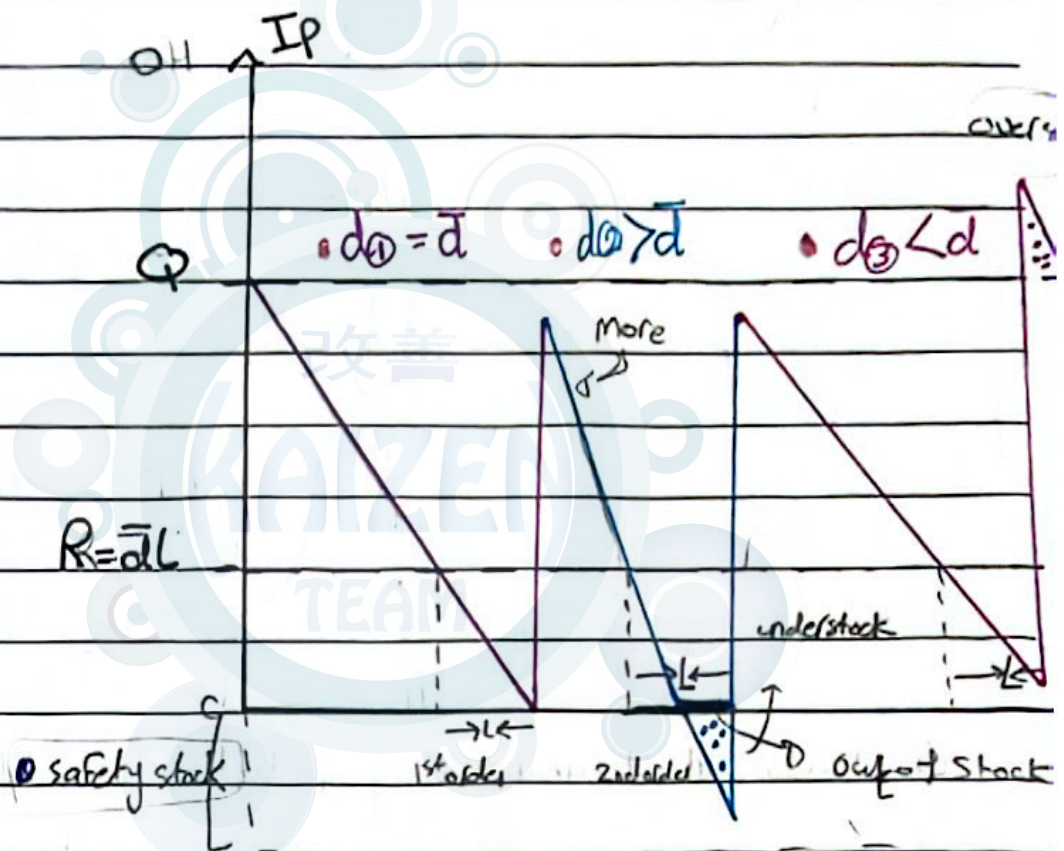
$$S.S = Z \sigma_{\bar{d}\bar{L}T}$$

PPC lecture 19

R
↓

normal dist. ← variable demand ($\bar{d}$)
constant leadtime (L)

let's assume that the variable demand is normally distributed



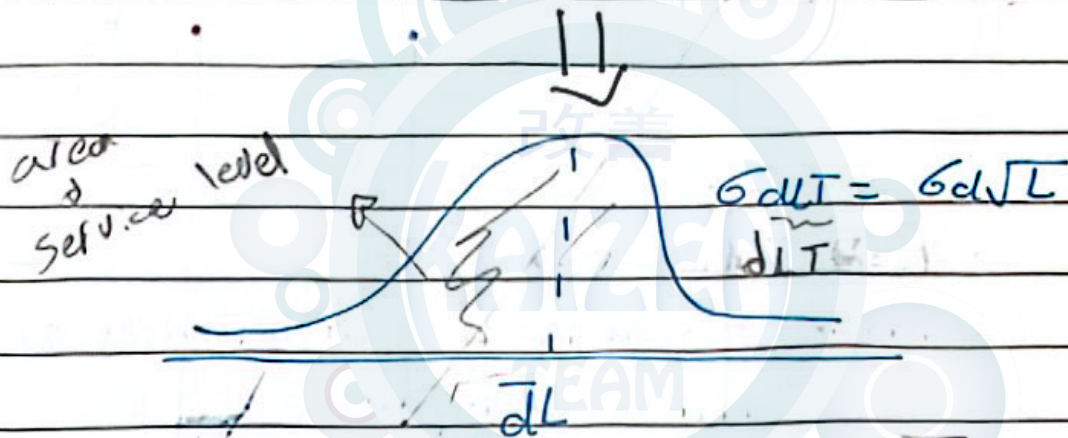
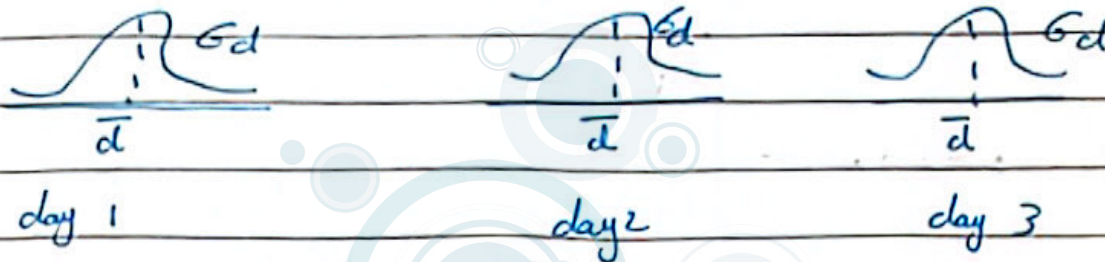
$$\therefore R = \bar{d}L + S.S$$

الطلب المتغير في مستوى المخزون Safety stock هو المستوى الذي يحمي من نقص المخزون في حالة الطلبات العالية أو منخفضة.

$$P(\text{overstock}) = P(\text{understock}) \leftarrow \text{Normally distributed}$$

This is the effect of lead time on the probability to stock out due to variable demand
 Protection interval is the time in which the demand is expected to occur

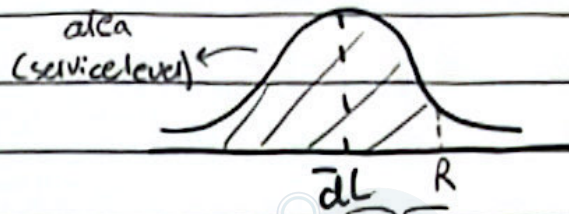
lead time for 3 days



distribution of demand during protection interval (ie lead time)
 (*) $\downarrow$
 lead time

Note: If $R = \bar{d}L \rightarrow$ 100% service level is used

Safety stock - extra inventory held to protect against uncertainty in demand



$$S.S = Z \sigma_{dLT}$$

area to the right of $\bar{d}L$ is the service level value used

Safety stock is extra

Summary for

R

Variable demand ($\bar{d}$)

constant leadtime (L)

$$R = \bar{d}L + S.S$$

$$S.S = Z \sigma_{dLT} \rightarrow \text{demand during lead time}$$

Z = number of standard deviations needed to achieve required service level

$$\sigma_{dLT} = \sigma_d \sqrt{L}$$

$$\sigma_{dLT} = \sigma_d \cdot \sqrt{L}$$

example

operates 52 weeks

$d = 18$ unit/weeks $\leadsto$ Note: d varies

$Gd = 5$ units

$L = 2$ weeks

service level = 90%

$CP = EOQ = 75$ unit $\leadsto$ Note: Eq. value of Q is whole no.

$R = ??$

$$Z = 1.28 \leftarrow \alpha = 0.9 = 0.91$$

$$S.S = Z \sigma_{dLT}$$

$$\sigma_{dLT} = 5\sqrt{2} = 7.07$$

$$S.S = 1.28 * 7.07 = 9.05$$

$$= 9 \text{ unit}$$

$$R = dL + S.S$$

$$R = 45 \text{ unit}$$

Recently, the inventory position is 60 units (no SR and no RO). Today a withdrawal of 20 units is done. Is it time to order? If yes, how much?

$$IP_{\text{now}} = 60 - 20 = 40 \leadsto \underline{IP < R}$$

$\downarrow$
Reached R

yes its time to order a fixed quantity 75

Fixed quantity (as continuous is required)

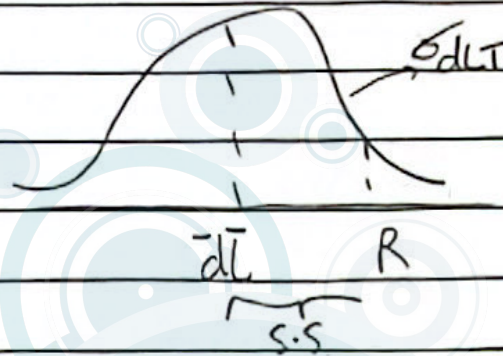
PPC lecture 20

R

variable demand ($\bar{d}$)
 σ_d

leadtime variable ($\bar{L}$)
 σ_{LT}

assuming that they are both normally distributed



$$R = \bar{dL} + S.S.$$

$$S.S. = Z \sigma_{dLT}$$

Z: number of standard deviations needed to achieve required service level

$$\sigma_{dLT} = \sqrt{\bar{L} \sigma_d^2 + \bar{d}^2 \sigma_{LT}^2}$$

example

$$\bar{d} = 12000 \text{ pens}$$

$$Gd = 3000 \text{ pens}$$

$$Q = 156000 \text{ pens}$$

$$\bar{L} = 5 \text{ weeks}$$

$$GLT = 2 \text{ weeks}$$

service level = 95%

using Q system, R?

∴ JSI

$$R = \bar{d}\bar{L} + S.S$$

$$S.S = Z \sigma_{dLT} \rightarrow \text{area} = 0.95$$

$$Z = 1.65$$

$$\sigma_{dLT} = \sqrt{\bar{L} \sigma_d^2 + \bar{d}^2 \sigma_L^2}$$

$$S.S = 1.65 \sigma_{dLT}$$

$$S.S = 41117.7 \approx 41118 \text{ pens}$$

$$R = \bar{d}\bar{L} + S.S$$

$$R = 101118 \text{ pens}$$

ZOOM PRO

continuous Review System relies on checking I_p after each withdrawal
how it's done

$$I_p = OH + SR - BO$$

Manually

Technology

scanners

1 and code

software application

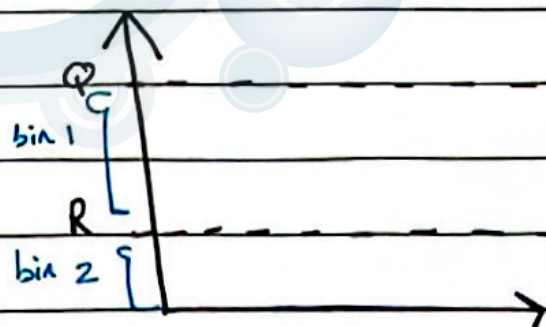
Visual Q system

(two-bin system)



يقوم النظام بمتابعة مستوى المخزون في bin (1) وإذا كان
مستوى المخزون في bin (1) قد انخفض إلى مستوى R
فحينئذٍ يتم طلب كمية Q من المورد. وعندما يصل
الطلب إلى bin (2) يتم طلب كمية R من المورد. وعندما
يصل الطلب إلى bin (2) يتم طلب كمية R من المورد.

capacity = R



Note: we usually use visual Q systems when we have very small and very cheap items

ZOOM

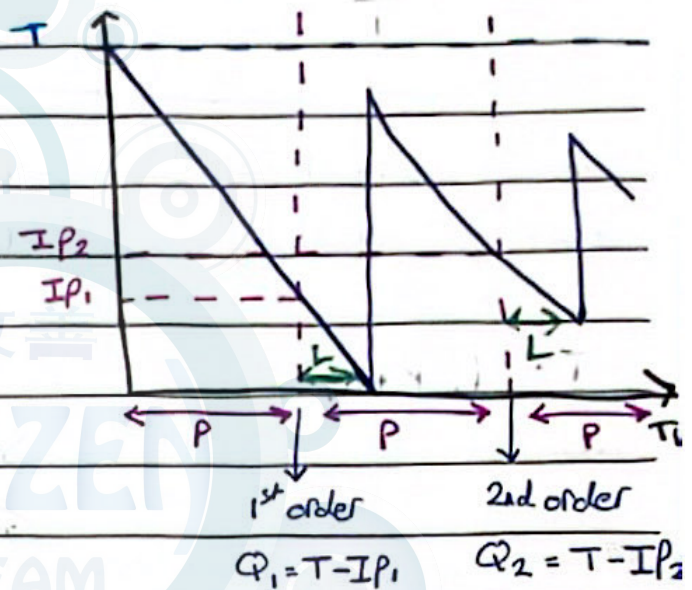
PPC lecture 21

Tuesday 26/11

Periodic Review System

Periodic Review system - Fixed interval reorder system - Periodic reorder system - P system

$$IP = OH + SR - BO$$



How often to review
 IP ?

Periodically, at the end
of each review period (P)

When to
order?

at the end
of each review
period (P)

How much
to order?

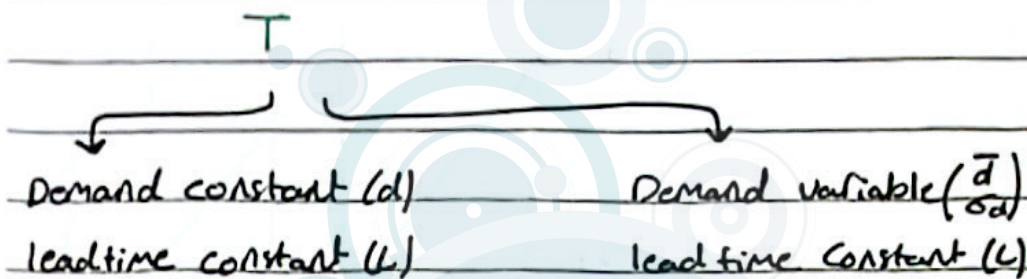
order - Target - inv
quantity inventory pos

$$Q = T - IP$$

$$P = TBO = \frac{Q}{D}$$

$$TBO_{\text{selected}} = \frac{Q_{\text{selected}}}{D}$$

$$TBO = \frac{EOQ}{D} \quad TBO = \frac{Q_{\text{container size}}}{D} \quad TBO = \frac{Q_{\text{price break quantity}}}{D}$$



$$T = d(P+L)$$

unit 21

unit 21

$$T = \bar{d}(P+L) + \text{safety stock}$$

$$S.S. = Z \sigma_{P+L}$$

$$\sigma_{P+L} = \sigma_d \sqrt{P+L}$$

Z: Number of standard deviations needed

Use simulation to estimate the demand during protection interval (P+L) So as to use it to determine value of T to achieve required service level

desired service level

example

52 weeks

$$\bar{d} = 18 \text{ unit/week}$$

$$\sigma_d = 5 \text{ units}$$

$$H = \$15/\text{unit/year}$$

$$S = \$45/\text{order}$$

$$EOQ = 75 \text{ unit}$$

$$L = 2 \text{ weeks}$$

$$90\% \text{ service level} \rightarrow Z = 1.28$$

p-system

SS?

T?

C?

solution:

$$p = TBO_{EOQ} = \frac{EOQ}{D} = \frac{75}{52 \times 18} \times 52 = 4.2 \approx 4 \text{ weeks}$$

$$S.S = Z \sigma_p \sqrt{L} = Z \sigma_d \sqrt{p \cdot L} = 1.28 \cdot 18 \cdot \sqrt{4 \cdot 2} = 15.68 \approx 16 \text{ unit}$$

$$T = \bar{d}(p+L) + S.S = 18(4+2) + 16 = 124 \text{ units}$$

$$C = \frac{\bar{d}^2 p}{2} H + \frac{D}{\bar{d} p} S + S.S H = 1365 \$$$

note that the same example in Q-system

It is the end of review period and I have

OH = 45 units, is it time to order & how much?

SS = 9 C = 1259
∴ Q-system would be

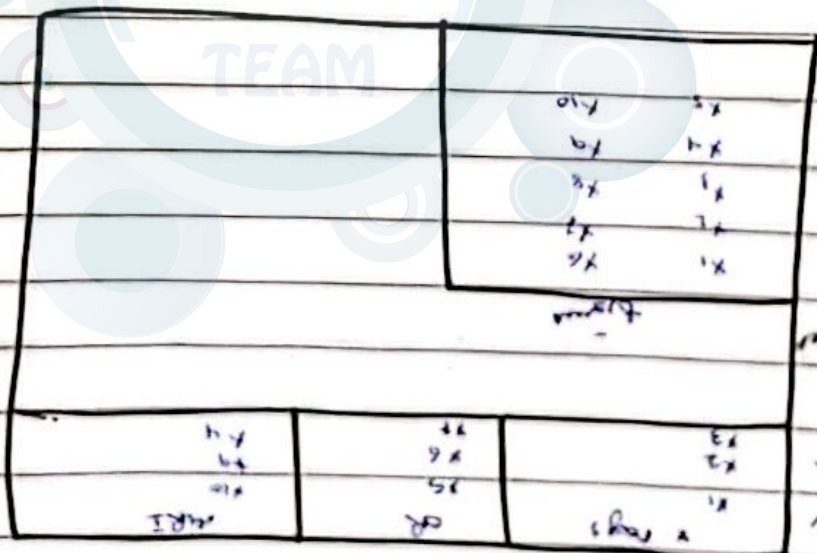
$$\text{Yes } Q = T - IP = 124 - 45 = 79 \text{ units}$$

ZOOM

This Page belongs to leg22
ZOOMPRO

For Visual P-system
One bin system

X6 & X3 I order it from the same supplier → P-system
X9 is really expensive → base stock system
X5 is not really important and it's cheap → optional replenishment



APC lecture 22

Thursday 28/11

↓ T
variable demand

Variable lead time

for given μ and σ of (P+L) protection interval is

Normally distributed

So?

→ use simulation to estimate the demand distribution during the protection interval (P+L) so as to use it to determine the value of T (achieving required service level)

Minimise the cost of stock



Q system

less cost

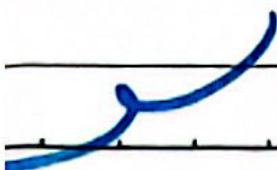
(for given μ and σ of PI stock)

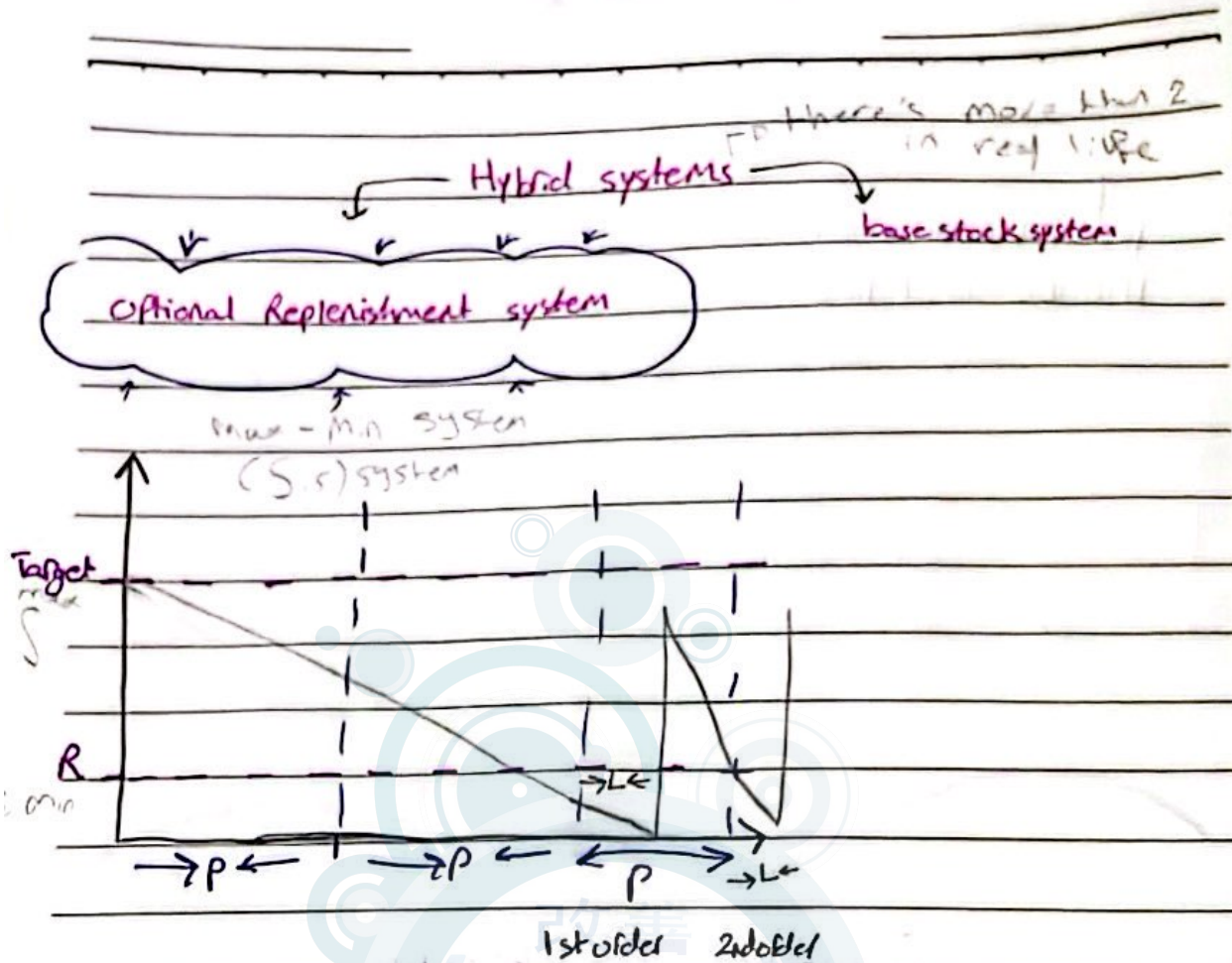
fixed Q

P system

order → fixed intervals (TBO)

Note: Q system → Holding cost not in effect





The idea: R is the reorder point, P is the period between orders.

$2P+1$ = protection interval (the time between orders plus the lead time).

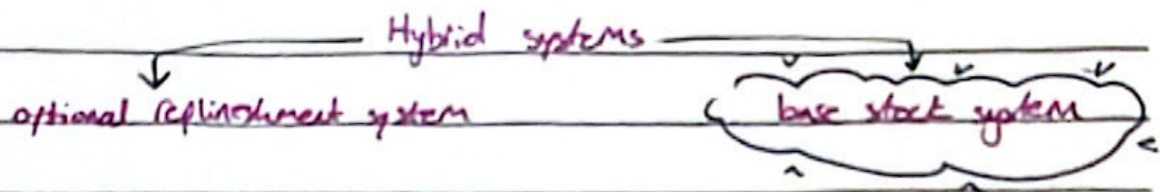
skills of the system is the safety stock level.

the holding cost is the cost of the inventory.

For not very important items

adv of Q more than P is SIS

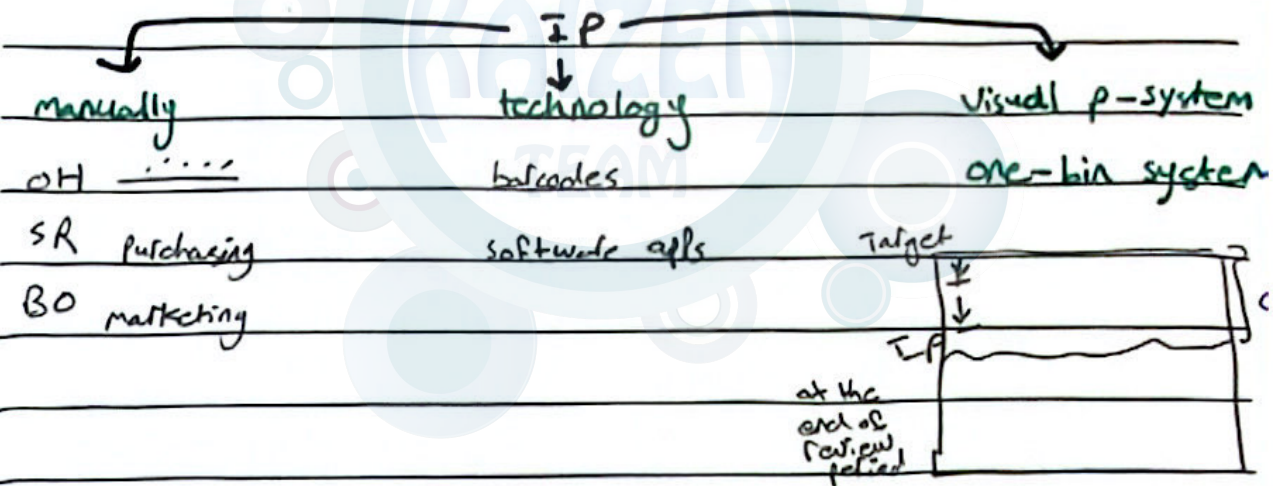
P is more convenient



The idea:

ISO is better than the other system
 this is the idea of the system
 ordering cost is the cost of placing an order
 holding cost is the cost of holding inventory
 - Minimal cost is holding it in the system

Now I want to check IP



⊗ Inventory position system

ward inventory → an inventory in the department (small inv)

Monday 1/12

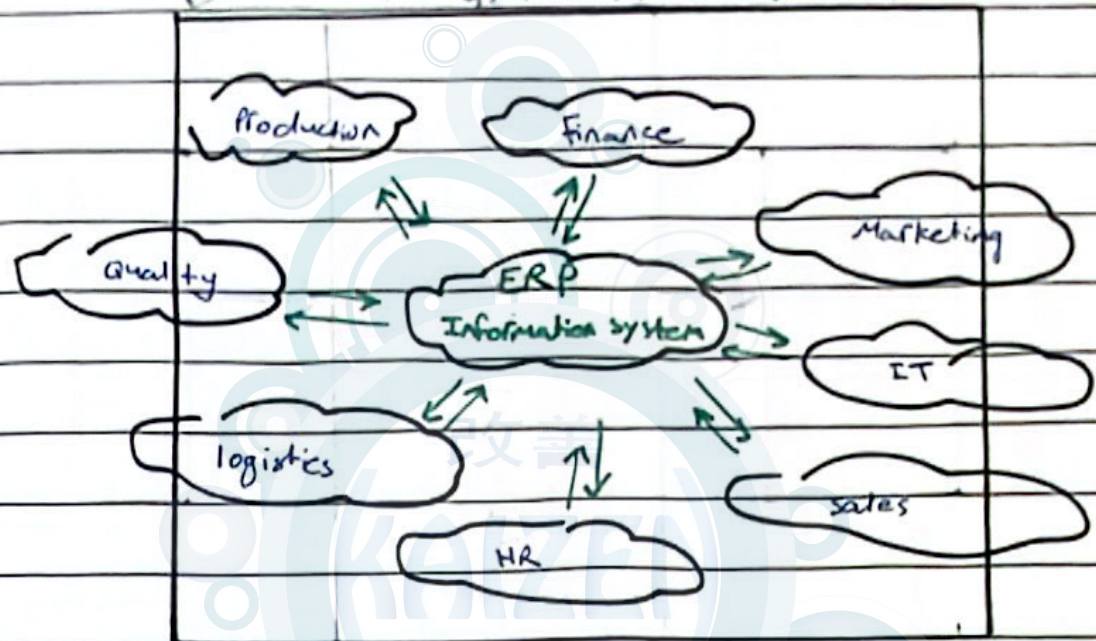
dependent demand

New chapter

ERP: Enterprise resource planning

(Information system)

Human, capital, materials, equipments



how much to order / when to order

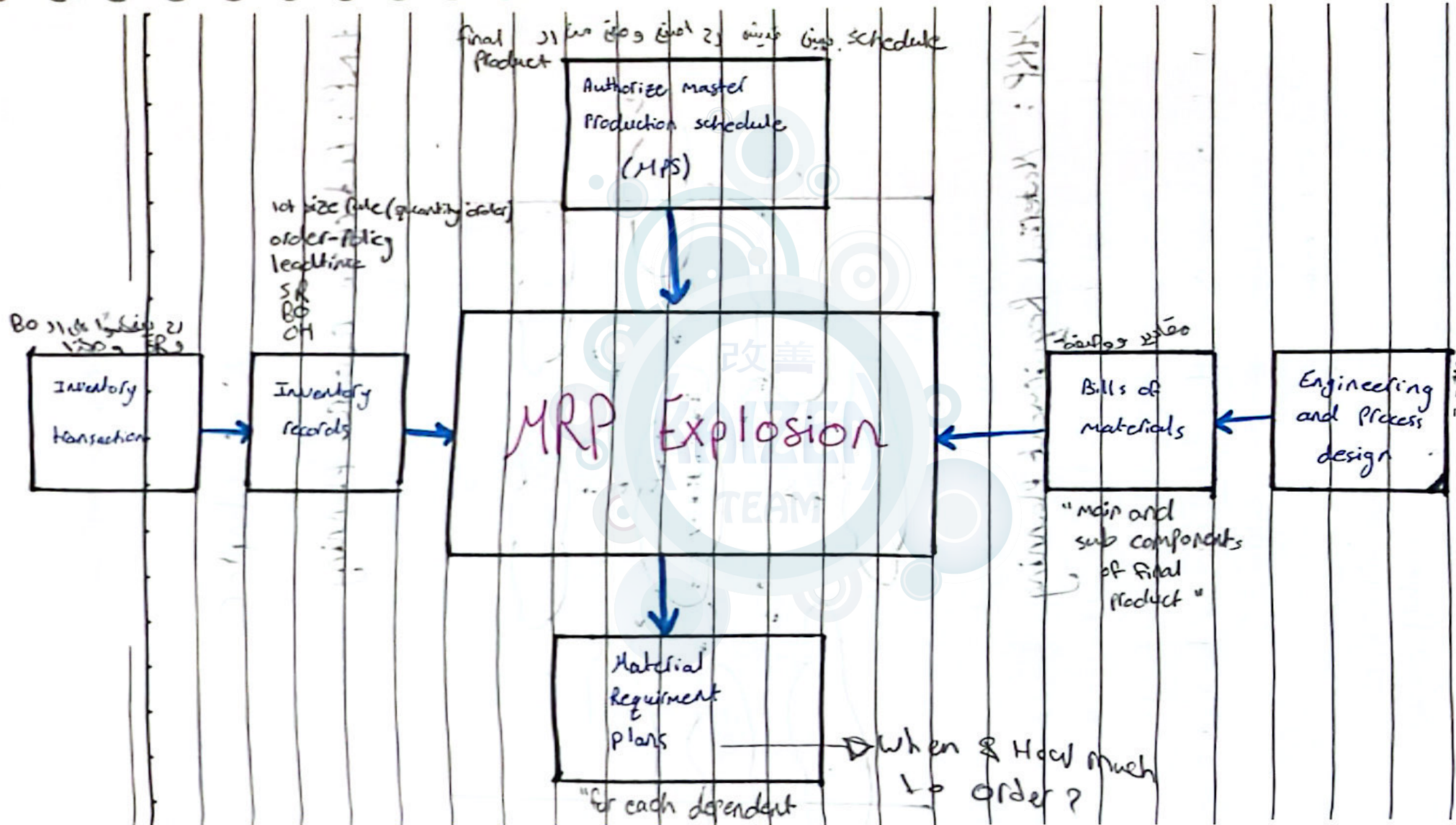
MRP: Material Requirement planning

→ For dependent stocks
integrated information system used to manage the inventory
of spare parts/accessories for a product is a dependent stock: no direct demand
BUT! its demand depends on the demand for that product so dependent.
dependent stock is raw material and components.

Most transaction actions is automated
checked and it's continuously reviewed

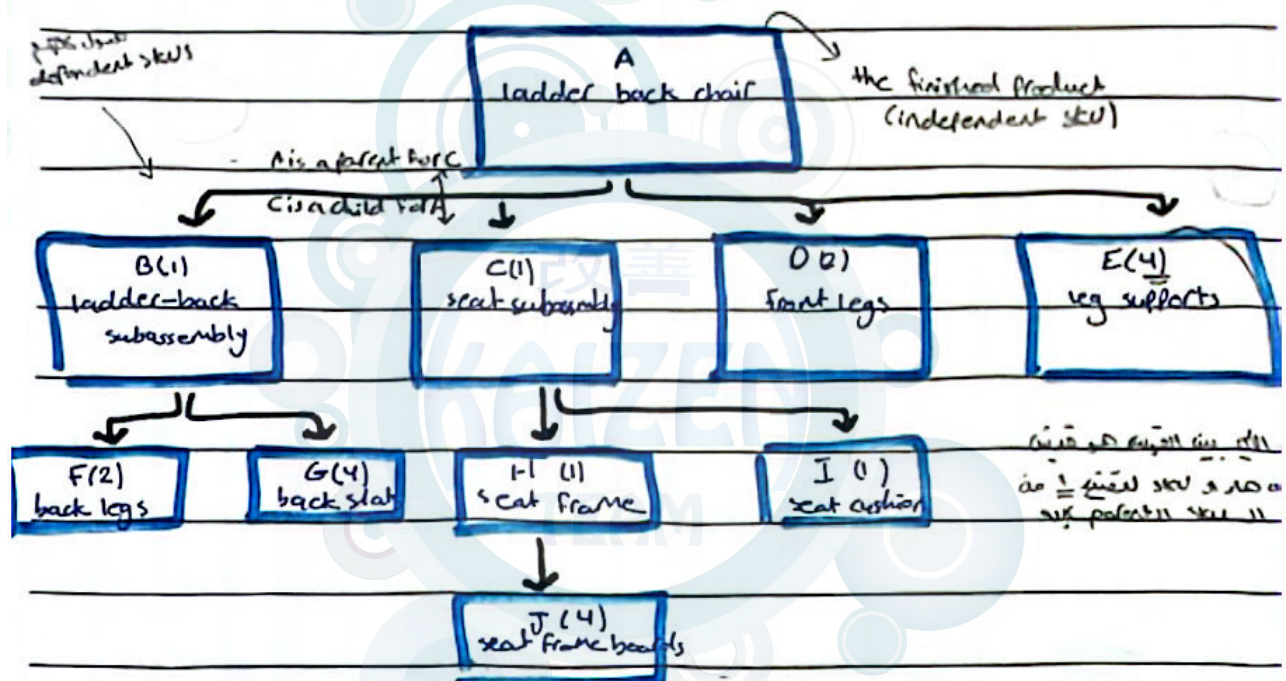
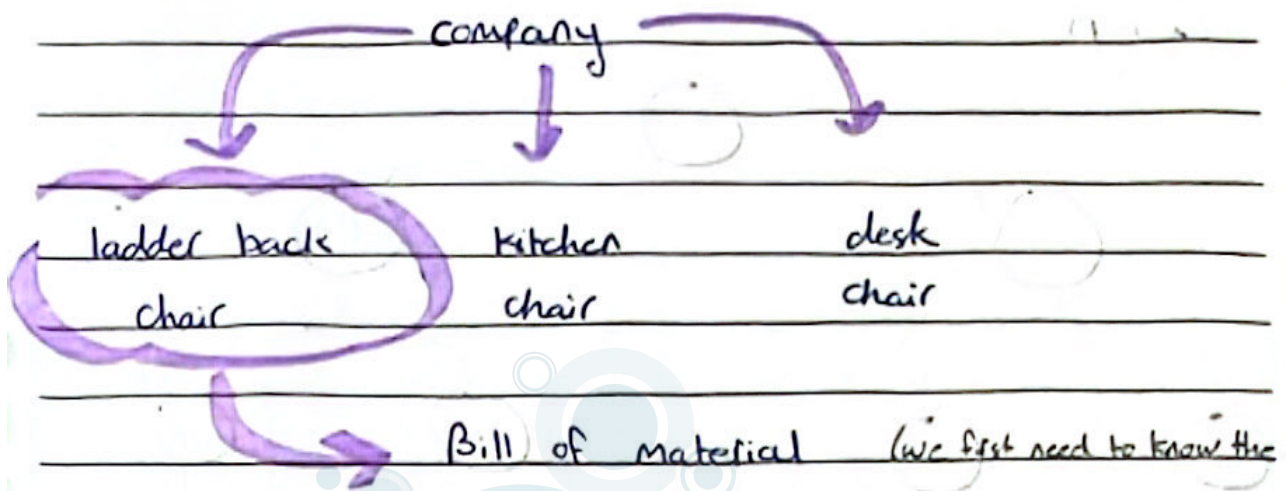
How often to review inventory position?

سؤال: كيف يتم مراقبة المخزون؟
جواب: يتم مراقبة المخزون باستمرار



Thursday 3/12

PPC lecture 24



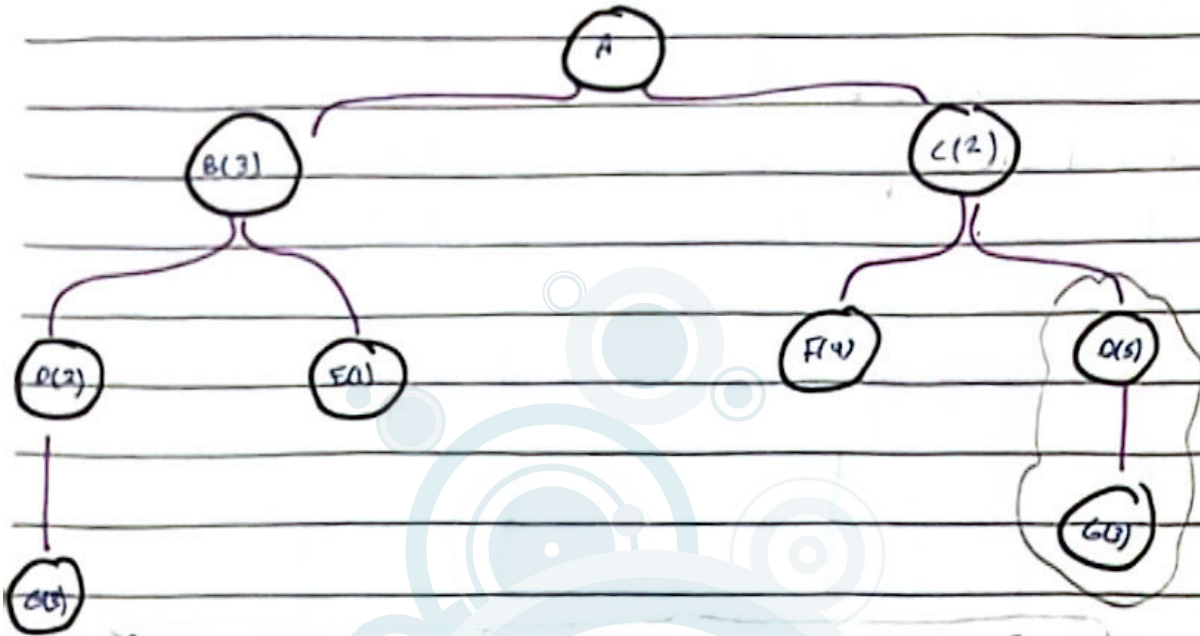
"any sku that is a parent and a child (like B, C, H) is intermediate component"

"any component that has no child (like F, G, J, I, D, E) is ready to purchase"

"any parent that is its parent of the child is immediate parent"

2001

example



Note: 1 unit of A is 1 unit

we want 5 units of A

$$3 = 3 \times 5 = 15 \text{ unit}$$

$$= 2 \times 5 = 10 \text{ unit}$$

$$= 2 \times 15 + 5 \times 10 = 80 \text{ unit}$$

$$= 1 \times 15 = 15 \text{ unit}$$

$$= 4 \times 10 = 40 \text{ unit}$$

$$= 3 \times 80 = 240 \text{ unit}$$

الكمية

Parent 11 unit 1

Quantity (relations) unit 1e

ZOOM PRO

PPC lecture 25

sunday 8/12

when & How much

11-May → Master production schedule (MPS) ~ (for final product)

Item: ladder back chair

order policy: 150 units → to the production line

Demand

lead time: 1 week

Forecast customer order booked

Final Product → inventory level

re-order point 100 units

	April				May			
Quantity on hand (55)	1	2	3	4	5	6	7	8
Forecast	30	30	30	30	35	35	35	35
customer orders	38	27	24	8	0	0	0	0
booked (confirmed) orders							28	
projected on-hand inventory at the end of week	$55 - 38 = 17$	$17 - 30 + 27 = 14$	$14 - 30 + 24 = 8$	$8 - 30 + 8 = -14$	$-14 - 35 + 0 = -49$	$-49 - 35 + 0 = -84$	$-84 - 35 + 0 = -119$	$-119 - 35 + 0 = -154$
MPS Quantity	0	150	0	0	0	0	150	0
MPS start	150					150		
Available to Promise (ATP) inventory for new customer	$55 - 38 = 17$	$17 - 27 + 150 = 140$					$140 - 0 + 150 = 290$	

Customer	Qty	week	Freezing → Authorized (we don't know more)
1	50	4	accept ATP = $17 + 91 = 108 > 50$ ✓ $91 - 50 = 41$
2	60	3	$41 + 17 = 58 < 60$ X
3	47	5	$58 > 47$ ✓

accept all or rejected all

ZOOM PRO

Item Product A

order policy 50 units

lead time 1 week

Quantity on hand [5]	1	2	3	4	5	6	7	8	9	10
Forecast	20	10	40	10	0	0	30	20	40	20
customer's order booked	30	20	5	8	0	2	0	0	0	0
	<u>30</u>	<u>20</u>								
Projected on hand inventory	25	5	15	5	5	3	23	13	13	13
MPS Quantity	50	0	50	0	0	0	50	0	50	50
			<u>50</u>							
MPS start 50		50				50		50	50	
Available to promise (ATP) inventory	55-30-20=5	50-5-8-0-2=35	35			50	50	50		

tuesday 10/11

PPC lecture 26

Material Requirement Plan

MRP

Item C Lot size FOC = 230 unit

Item C

lot size FOC = 230 unit

Description seat assembly

lead time 2 weeks

from the MPS table of the parent safety stock 800

	1	2	3	4	5	6	7	8
gross requirement	150			120	0	150	120	
from MPS sub								
scheduled receipts	230							
inventory record								
projected on hand	117	117	117	227	227	77	157	157
inventory								
planned receipts	0	0	0	230	0	0	230	0
(like MPS quantity)								
planned order release		230			230			
no short		✓			✓			

MRP

Material Requirement Plan for dependent demand items

when and how much to order from component C

1

ZOOM

Item C

description seat subassembly

Lot size POQ (P=3)

lead time 2 week

safety stock 200

month

	1	2	3	4	5	6	7	8
Gross requirement	150			120		150	120	
scheduled receipts	230							
Projected on hand inventory	117	117	117	150	150	0	0	0
Planned receipts	0	0	0	153	0	0	120	0
Planned order release		153			120			

Week 4 week 5 week 6 CH			
$120 + 0 + 150 + 0 - 117$	$120 + 0 + 0 - 0$		
$= 153$	$= 120$		
VI			
5/28			
$3 + 117 - 120$	$120 + 0 - 120 = 0$		

ZOOM PRO

Thursday 12/12

PPC lecture 27

SP, Lead Cost, etc.

Item C

Lot size L4L



PB

description seat subassembly

lead time 2 weeks

safety stock zero

	1	2	3	4	5	6	7	8
Gross Requirement	150			120		150	120	
scheduled receipts	230							
Projected on hand inventory	117	117	117	-3	0	-150	-120	0
planned receipts	0	0	0	3	0	150	120	0
planned release order		3		150	120			

120 to -117

150 to -0

120 to -0

3

2001

0. A safety stock is an extra unit

Item C

Lot size POQ (P=3)

Description 1st subassembly

Lead time 2 weeks

Safety stock 20

	1	2	3	4	5	6	7	8
Gross requirement	150			120		150	120	
Scheduled receipts	230							
Projected ending inventory	117	117	117	170	170	20	120	20
Planned receipts	0	0	0	173	0	0	120	0
Planned order release		173			120			

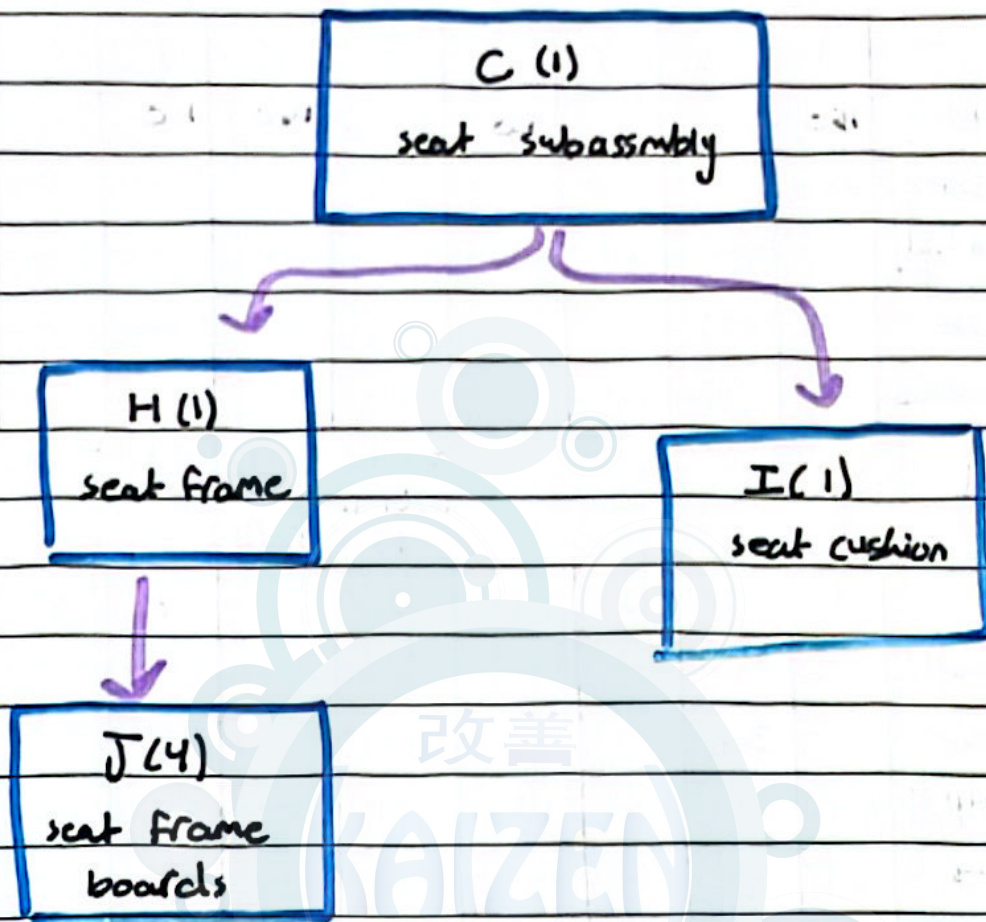
ZOOM PRO

Sunday 15/12

[illegible]

Tuesday 17/12

PPC lecture 29



Item C

lot size FOQ = 230
lead time 2 weeks

SS zero

	1	2	3	4	5	6	7	8
Gross requirements	150			120		150	120	
Scheduled receipts	230							
Projected on-hand 37	117	117	117	227	227	77	187	167
Planned receipts	0	0	0	230	0	0	230	0
Planned order release		230			230			

Item H

lot size FOQ 300 units

lead time 1 week

SS zero

	1	2	3	4	5	6	7	8
Gross requirement		230			230			
Scheduled receipts		300						
Projected on-hand 40	40	110	110	110	180	180	180	180
Planned receipts	0	0	0	0	300	0	0	0
Planned order release				300				

Item I

lot size L4L

lead time 1 week

SS zero

	1	2	3	4	5	6	7	8
Gross requirement		230			230			
Scheduled receipts								
Projected on-hand 0	0	0	0	0	0	0	0	0
Planned receipts	0	230	0	0	230	0	0	0
Planned order release	230			230				

ZOOM PRO

Item J

lot size $FOQ = 1500$ units

lead time 1 week

SS zero

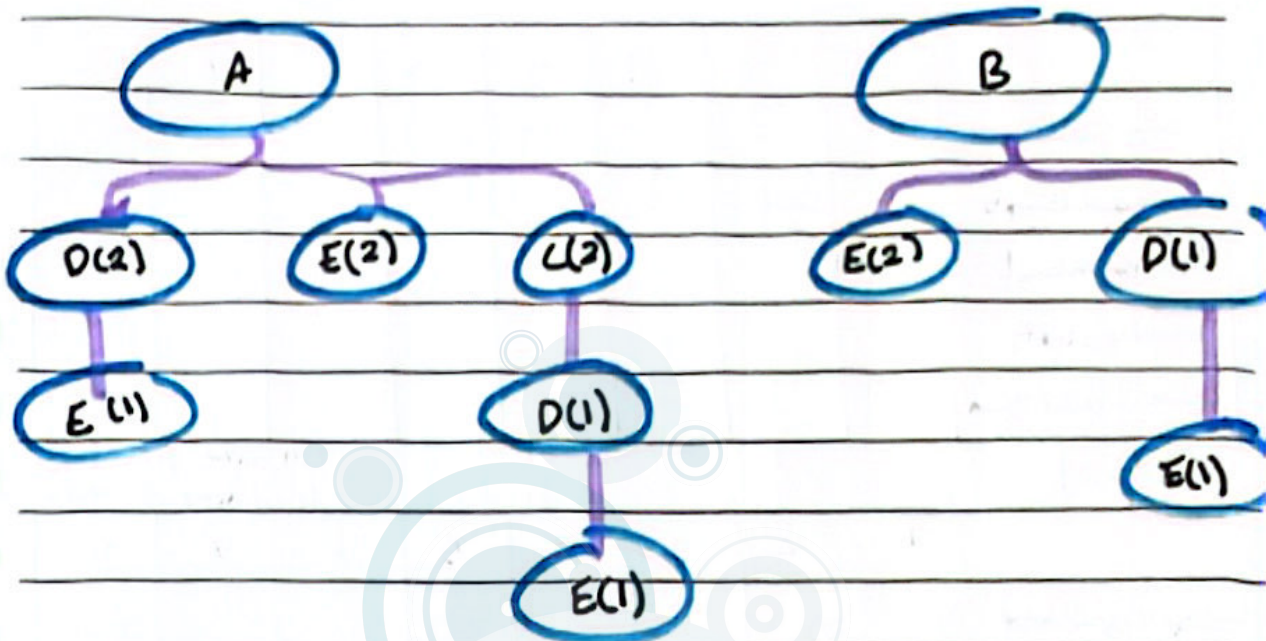
	1	2	3	4	5	6	7	8
Gross requirement				1200				
Scheduled receipts								
Planned on-hand 200	200	200	200	500	500	500	500	500
Planned receipts	0	0	0	1500	0	0	0	0
Planned order release			1500					

改善

KAIZEN

TEAM

Ex 25



MPS start

	1	2	3	4	5	6	7	8
A		125		95		150		130
B			80			70		

	C	D	E
lot sizing rule	L4L	POQ(P=2)	EOQ=800
lead time	3 weeks	2 weeks	1 week
scheduled receipts	200 (week 2)	None	800 (week 1)
beginning inventory	85	625	350
safety stock	Zero	Zero	Zero

Item C

Lot size 140

Lead time 3 weeks

SS zero

	1	2	3	4	5	6	7	8
Gross requirement		250		140		300		260
Scheduled receipts		200						
Projected on hand [85]	85	35	35	0	0	0	0	0
Planned receipts	0	0	0	155	0	300	0	260
Planned order release	155		300		260			

Item D

Lot size 600 (P=3)

Lead time 2 weeks

	1	2	3	4	5	6	7	8
Gross requirement	155	250	380	190	260	370		260
Scheduled receipts								
Projected on hand [625]	470	220	450	260	0	260	260	0
Planned receipts	0	0	610	0	0	630	0	0
Planned order release	610			630				

Item E

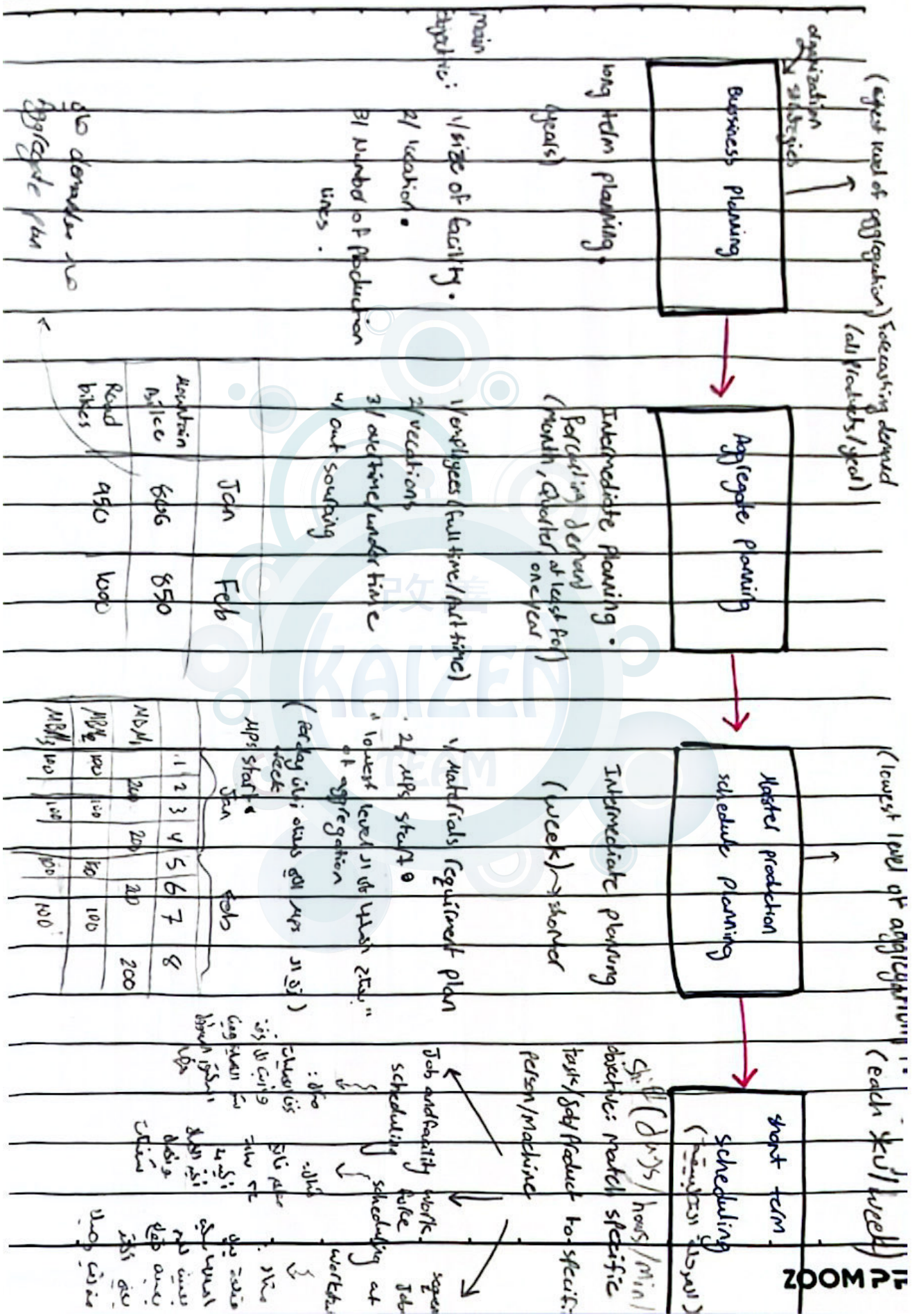
Lot size 800 (P=1)

Lead time 1 week

	1	2	3	4	5	6	7	8
Gross requirement	610	250	160	820		440		260
Scheduled receipts	800							
Projected on hand [350]	540	290	130	110	110	470	470	210
Planned receipts	0	0	0	800	0	800	0	0
Planned order release			800		800			

ZOOM PRO

PPC lecture 31



كازم بالقریب الدور



26/12/2024 Thursday

PPC lecture 32

Final workshop

Short term scheduling

Job & facility
scheduling

workforce
scheduling

Sequencing
jobs at workstation

Job & facility scheduling

- write

- list

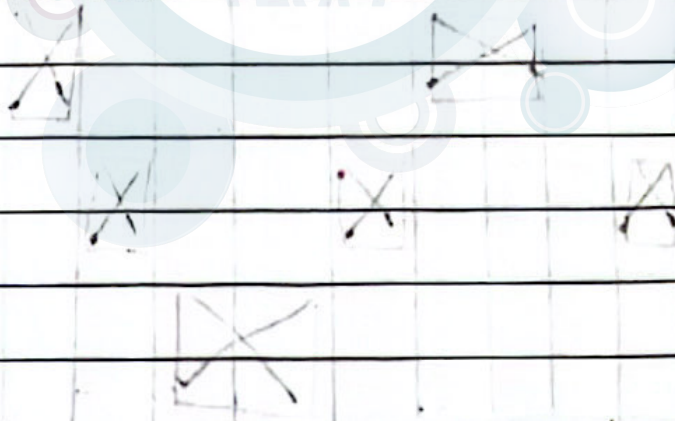
Job	sta 1	sta 2	sta 3
(Job 1)	8-10		

Final workshop

Gantt chart

1- Job or activity chart

2- workstation chart



ZOOM PRO

Job or activity chart

current date
↓

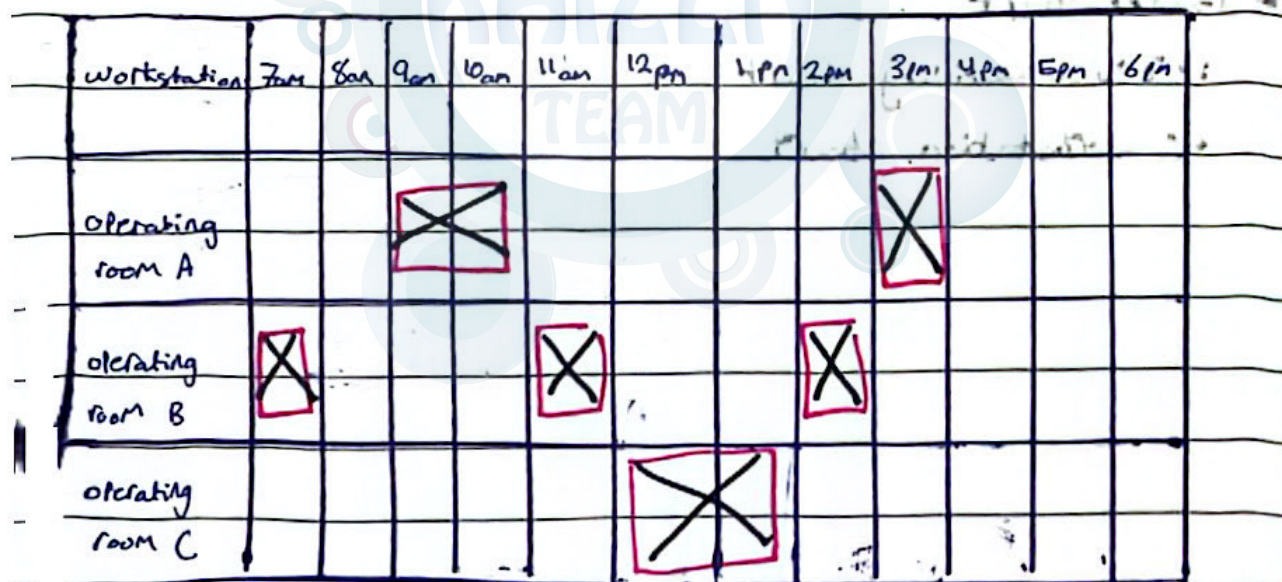


car service center - behind schedule st1

- on schedule st2

- ahead of schedule st3

Workstation chart



ZOOM PRO

Work force scheduling

we have **constraints**

Technical constraints

legal and behavioral constraints

Psychological needs of workers

改善

KAIZEN

TEAM

PPC lecture 33

example

Day	M	T	W	Th	F	S	Su
<u>Required Number of employees</u>	6	4	8	9	10	3	2

The manager needs a workforce schedule that provides two consecutive days off and minimizes the amount of total stock capacity. To break ties in the selection of off days, the scheduler gives preference to Saturday and Sunday if it is one of the tied pairs. If not, she selects one of the tied pair arbitrarily.

Total



Technical
Requirements
(constraints)
Psychological
Needs of
workers
Legal
Constraints

M	T	W	Th	F	S	Su	employee	Comment	capable	M	T	W	Th	F	S	Su
6	4	8	9	10	3	2	1	S/Su	1	X	X	X	X	X	off	off
5	3	7	8	9	3	2	2	S/Su	2	X	X	X	X	X	off	off
4	2	6	7	8	3	2	3	S/Su	3	X	X	X	X	X	off	off
3	1	5	6	7	3	2	4	M/T	4	off	off	X	X	X	X	X
3	1	4	5	6	2	1	5	S/Su	5	X	X	X	X	X	off	off
2	0	3	4	5	2	1	6	M/T	6	off	off	X	X	X	X	X
2	0	2	3	4	1	0	7	S/Su	7	X	X	X	X	X	off	off
1	0	1	2	3	1	0	8	M/T, T/W, S/Su, Su	8	X	X	X	X	X	off	off
0	0	0	1	2	1	0	9	M/T, T/W, Su/M	9	off	X	X	X	X	X	off
0	0	0	0	1	0	0	10	M/T, T/W, W/Th, S/Su, Su	10	X	X	X	X	X	off	off
0	0	0	0	0	0	0		Capacity C	7	8	10	10	10	3	2	
								Regul mnts R	6	4	8	9	10	3	2	
								Slack = (C - R)	1	4	2	1	0	0	0	

total slack = 1+4+2+1 = 8

Tuesday 31/12

PPC lecture 34

Sequencing jobs at workstations

Rules of thumb $\rightarrow$ schedule jobs in order of priority

1) First come, first served (FCFS)

$J_2 \rightarrow J_1 \rightarrow J_3$

2) Earliest due date (EDD)

$J_1 \rightarrow J_3 \rightarrow J_2$

3) shortest processing time (SPT)

$J_3 \rightarrow J_1 \rightarrow J_2$

Due date (days from arrival) Processing time (days) Time since order arrived (days)

16	16	10	16	3	J_1
15	11	11	15	5	J_2
12	3	3	11	18	J_3

M1

$J_1 \rightarrow J_2 \rightarrow J_3$

EDD

$J_1 \rightarrow J_3 \rightarrow J_2$

6 schedules

$J_2 \rightarrow J_1 \rightarrow J_3$

FCFS

$J_2 \rightarrow J_3 \rightarrow J_1$

$J_3 \rightarrow J_1 \rightarrow J_2$

SPT

$J_3 \rightarrow J_2 \rightarrow J_1$

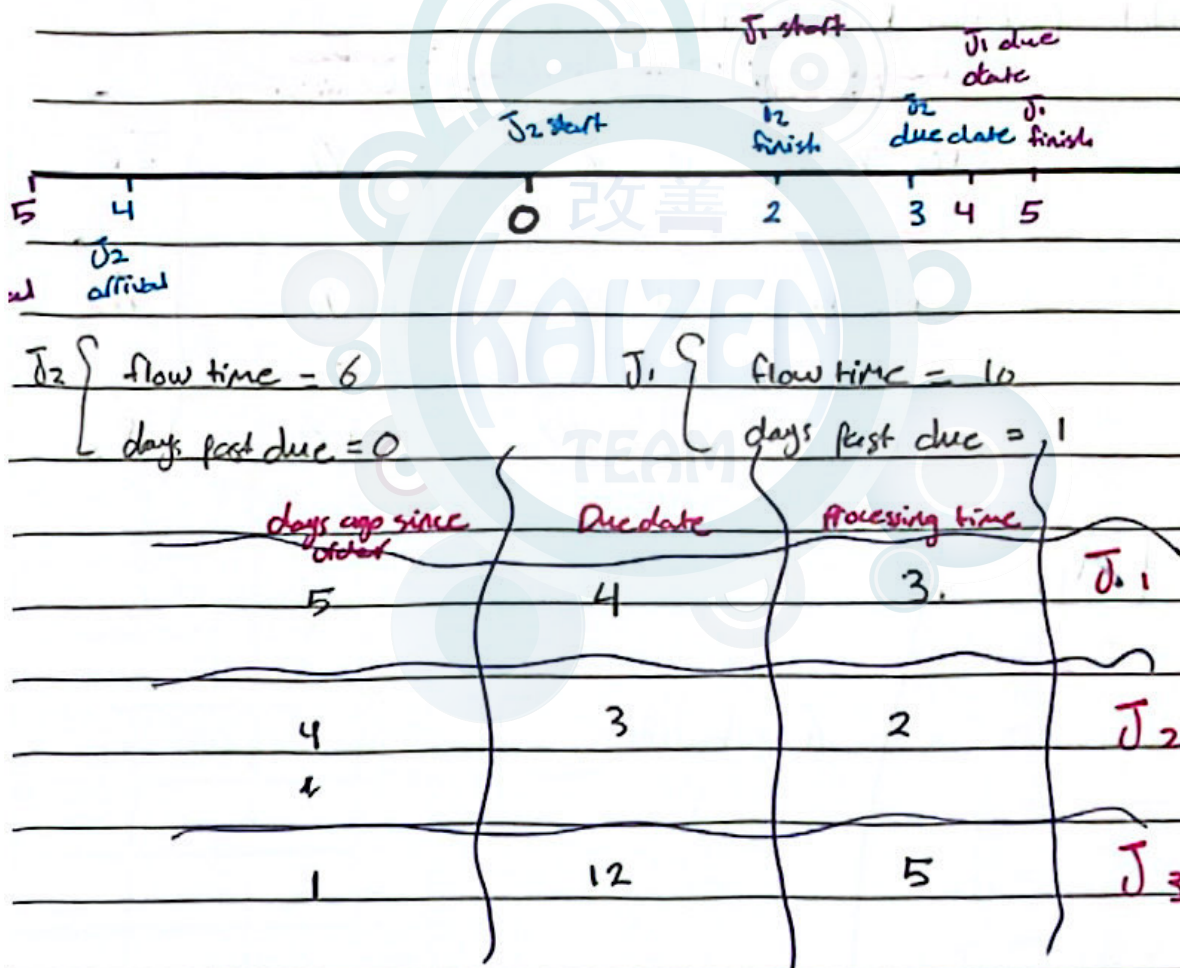
السؤال الثاني: scheduler will rank the jobs according to the following criteria:

1. Rules of thumb for

performance evaluation Methods are as follows ←

- **Flow time** = finish time + days ago since order arrived

- **days past due** = finish time - due date



SPT: J₂ → J₁ → J₃

Thursday 2/11/2025

PPC lecture 35

example

Customer	Time since order arrived (days ago)	Processing time (days)	Due date (days from now)
A	15	25	29
B	12	16	27
C	5	14	68
D	10	10	48
E	0	12	80

determine the schedule by using FCFS rule, and calculate the average days past due and flow time. How can the schedule be improved, if average flow time is the most critical?

FCFS

A → B → D → C → E

customer sequence	start time (days)	Processing time (days)	Finish time (days)	Due date	Days past due	Days ago since order arrived	Flow time + days
A	0	25	25	29	0	15	40
B	25	16	41	27	14	12	57
D	41	10	51	48	3	10	61
C	51	14	65	68	0	5	70
E	65	12	77	80	0	0	77

$$\text{Average Flow time} = \sum \text{Flow time} / 5 = 60.2 \text{ days}$$

$$\text{Average days past due} = 3.4 \text{ days}$$

don't found up there

ZOOM PRO

PT

D → E → C → B → A

order sequence	start time (days)	Processing time (days)	Finish time	Due date	Days past due	Days ago since order received	Flow time
D	0	10	10	48	0	10	20
E	10	12	22	80	0	0	22
C	22	14	36	68	0	5	41
B	36	16	52	27	25	12	64
A	52	25	77	29	48	15	92

Average Flow time = 47.8 days

Average days past due = 14.6 days