PPC

Notebook

للدكتورة: لينا القطاونة

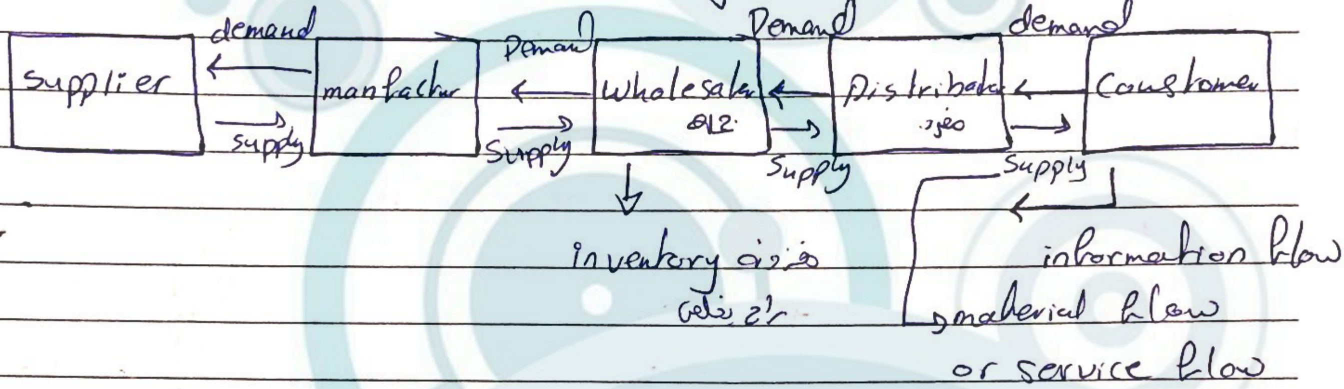
المادة كاملة

إعداد الزميلة:
نيفين الجعافرة

OR ← رزبانا
اناليس ← رهن

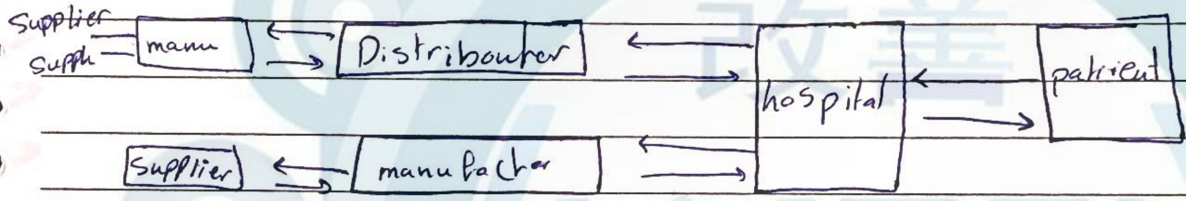
* Supply chain *

for product and survaces. In general ⇓

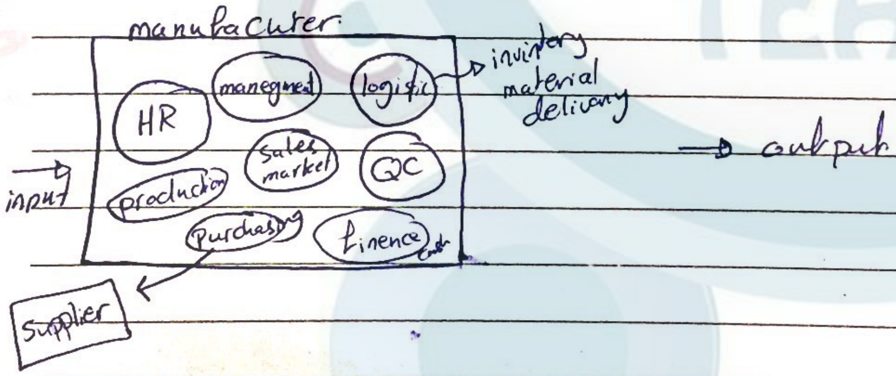


EX

supply chain for hospitale:-



supply chain:- interrelated processes ↑ Seriese across the farmes and within farmes to produce a product or servise for the end costomer.



* Best ⇒ matching between Demand and supply. (logistics)

- sicrunaZation all prosses in ordera to match flow with demand.
تعريف قصير

↗ S.C. mangment

Forcasting: estimate in future. → chart next page.
out put of forcasting is Number.

* aggregation → تجميع → clustring → put in groups g_1, g_2 ---

for example مثل حليب

- highest level of aggregation → F = 10000 units
  ↓
- lower " " " →
  - Fg_1 = 5000 unit
  - Fg_2 = 1000 unit
  - Fg_3 = 2000 unit
  - Fg_4 = 2000 unit
  ↓
- lowest level " "

كل نوع لحال.

g_1	حليب كامل الدسم	1L
g_1	" منزوع "	1L
g_1 / g_2	" شوكولاته	1L
	" فراولة	1L
g_2	" "	250 ml
	" [illegible]	250 ml
g_3	عصير برتقال	1L
	" [illegible]	1L
g_4	" برتقال	250
	" جوافة	250

* unit of mesurment

unit ---- علبة ، كرتونة ،

او مثلاً كل قرش

unit / year

unit / month.

- salesforce (بياع.) → they have clear infor. about demand.
salesforce estimate.

* disadvantage of Jugment method :- rough estimation. اراء ابني عليه
1- different opinion.

*2 ـر

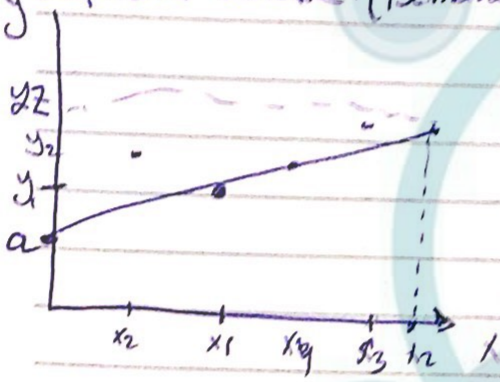
Forcasting

- What to forcast
  - level of aggregation *
  - unit of measurments *
- Choosing forcasting system
  - ↳ to use softwear.
- Choosing forcasting technique
  - ↓ How to use softwar.
  - No Historical Demand
    - Judgement method gained by experance.
      - sales force estimate عمال
      - executive opinion
      - market research
      - Delphi method.
  - Historical data about actual demand to predect future demand.
    - ↓ quantitiative techniques.
      - Causal method
        - simple Linear regression
        - multiple linear regression
      - time-series analysis
        - naive approach
        - simple moving avg
        - weighted moving avg
        - exponential smoothing
        - trend
        - multiplicative seasonal method.

→ we can use multipule . L.R.

- Simple Linear regression : use to develope any relationship.
* demand depend on a certain variable

y dependent variable . (Demand / sales)



→ draw line : y, x
$y = a + bx$ ↳ historical data

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

intersection line with y axis ↶ $a = \bar{y} - b\bar{x}$

independent variable. (expendiusure)

① بافترض ... النقط x وحطينا D, a بعد y .

period	x	y	xy	x^2	y^2
1	x_1	y_1	x_1y_1	x_1^2	
2	x_2	y_2	x_2y_2	x_2^2	
3			⋮	⋮	
⋮			⋮	⋮	
n	x_n	y_n	x_ny_n	x_n^2	
	Σ	Σ	Σ	Σ	Σ

↑ plot the data for each pair.

unique line = min sum of square diviation.

$\bar{x} = \frac{\sum x}{n}$ $\bar{y} = \frac{\sum y}{n}$

* We need some measure
① correlation coefficient (r)

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

$-1 \leq r \leq 1$

direction of relation.

-1 — 0 — 1

indirect (r) ⇒ -ve $-1 \leq r \leq 0$

direct (r) ⇒ +ve. $0 \leq r \leq 1$

كل ما كانت r اقرب لل 1 , -1 يتكون

Strength of relashion is big.

No relashion. ⇐ بس اذا اقرب للصفر r=0 no relation at all

when r=1 or -1 that mean that all point will be at the line.
(Perfect relashion).

r — strength (اقرب للصفر اقل) (اقرب للواحد اقوى)
r — direction -ve , +ve

Cluster of point near to line hard relation

" → → far any of line weak reration.

strength درجات
indication يحتاج
افرض اقرب احدد
strength درجة

② coefficient of determination r^2

$0 \leq r^2 \leq 1$

amount of change in the dep.V that is caused by change in Independent variable

Ex	r^2	r	
	0.81	0.9	→ strong
	0.64	0.8	→ madricate.
	0.36	0.6	→ weak.
	0.16	0.4	

Five Apple

③ Standard error of estimate S (never -ve)

قانون S =

S = 0
كل النقاط على الخط

Ex:- *hint:- نحدد مين X ومين y.

Month	Sales thousend of unit (Y)	Advertis expediture thous of $ (X) الأداة	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			

$\bar{X}$

$\bar{y}$

b = 109.229 a = -8.135

① y = -8.135 + (109.229) X ← L.R. M ⇒ developing

① we have to test modle befor forcasting by fin r, r^2, S

② r = 0.98 direct, strong.

r^2 = 0.96

S = 15.6

The company will spend $1750 next month, what is the forcast next month??

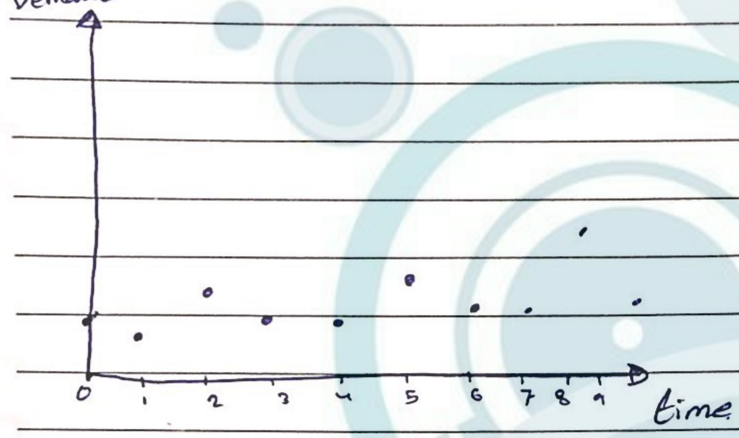
$X_{next\ month}$ = 1.75

$y_{next\ month}$ = -8.135 + (109.229)(1.75) = 183.01575

Forcast next month = 183010 unit.

time series:-

Demand.

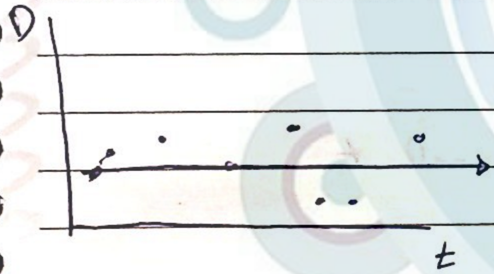


Demand behavior over time

- Time series patterns:-

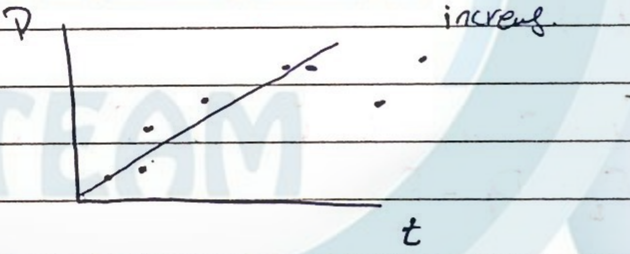
* Horizontal
* Trend.
* seasonal
* cyclical
* Random

*Horizontal



*Trend → const decrease or increase.

increase.

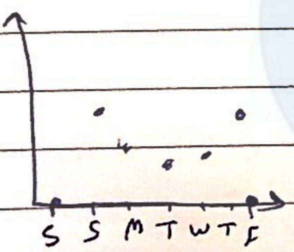


* seasonality

for example Ice cream or Bank { Summer Peak / winter vary.

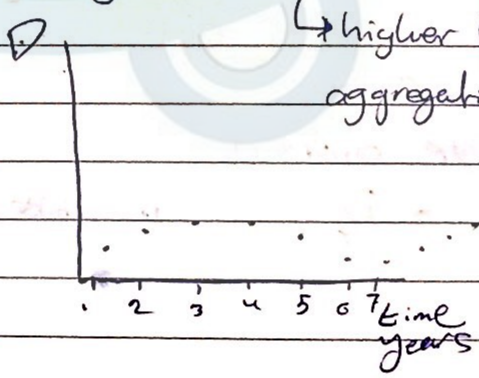
week → period

seson → days

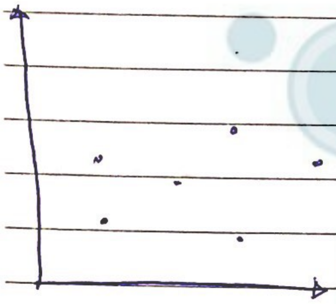


* cyclical increase followed by decrease.

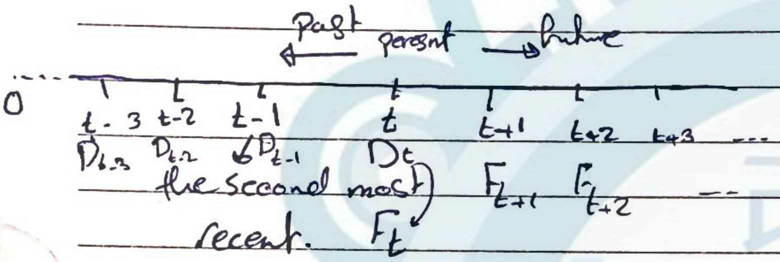
↳ higher level of aggregation.



* Random



*



t most ~~resont~~ recent period.
or current period.

real data about demand ← t

* F_t : forcast of t period that we forcast when we was at (t-1)

* E_t :- Error of forcast for certen period t

$E_t = D_t - F_t$

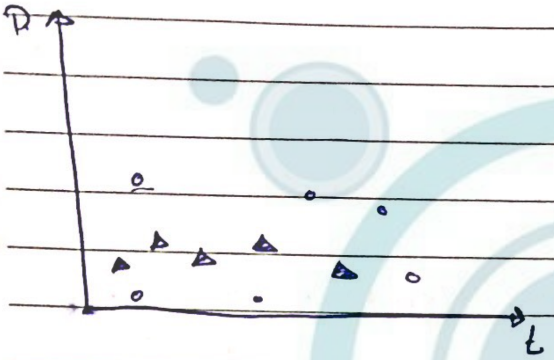
\+ under estimated $F_t < D_t$

\- over estimated $F_t > D_t$

* Methods:-

- Naive approach:-

$F_{t+1} = D_t$ it suitable for horizontal.



▲ → Naive → cluster ↓

o → unstable.

* Simple moving average:-

$$F_{t+1} = \frac{D_t + D_{t-1} + D_{t-2} + D_{t-(n)+1}}{n}$$

$t(-3+1)$ → -2 → $t-2$

most recent.

* three-periods moving. avg ⇒ $F_{t+1} = \frac{D_t + D_{t-1} + D_{t-2}}{3}$

* Four - " " " ⇒ $F_{t+1} = \frac{D_t + D_{t-1} + D_{t-2} + D_{t-3}}{4}$

For example

... t t+1 t+2 t+3

o F_{t-2} F_{t-1} D_t F_{t+1} F_{t+2} F_{t+3}

F_t

E_t

Sun M Tu W

↑

P

Forcast$_M$ ⊛ اذا انطلب احسب

ال الفائت وصو لته ل

Tu , W

اذا اجا يوم M صار عنا

actual Demand

فلا Forcasting بتغير

ليوم Th هو نفسه يكون

(Moving) W ل + simple = avg مجرد

Example:-

	Week	Demand. patient arrival
t-2	1	400
t-1	2	380
t	3	411
	4	415

Forcast week 4 ?
so week 3 present

$F_4 = \frac{411 + 380 + 400}{3} = 397$ patient

round up or down depend on value or more than 5 rounding up less than 5 rounding down

$E_4 = 415 - 397 = 18$
+ve/underestimate demand.

$t, t-1, t-2$

$F_5 = \frac{415 + 411 + 380 + (400) \to out}{3}$

= 402 patient

3 most recent

* Error

3 through 10

* weighted moving avg:-

$F_{t+1} = W_1 D_t + W_2 D_{t-1} + W_3 D_{t-2} + \cdots + W_n D_{t-n+1}$

where $\sum_{i=1} w$ must equal (1)

also $w_1 > w_2 > w_3 > \cdots > w_n$

. Forcast 4 1,2,3,4

* three-period wighted moving avg

$F_t = W_1 D_{t-1} + W_2 D_{t-2} + W_3 D_{t-2}$

$W_1 + W_2 + W_3 = 1$

$W_1 > W_2 > W_3$ or equal

Simple-avg , w_1 , $w_2 = w_3$

week	Demand. customer arrival
1	800
t-2 2	740
t-1 3	810
t 4	790
5	865

IF 5 finish

F_5 IF $w_1 = 0.5$, $w_2 = 0.3$, $w_3 = 0.2$

most three recent

$F_5 = 0.5(790) + 0.3(810) + 0.2(740)$

$= 786$ customer.

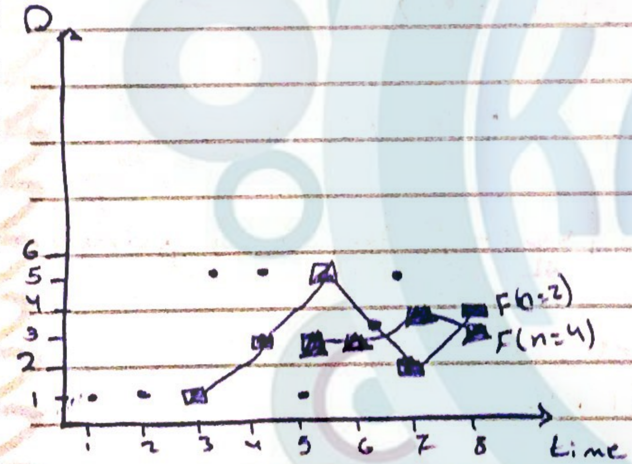
$E_5 = 805 - 786 = 19$ customer

under estimated.

$F_6 = (0.5)(805) + (0.3)(790) + (0.2)(810)$

$= 801.5 = 802$ customer

using simple moving average.



* D

* F (n=2)

● → actual demand

☐ → forecast

* F (n=4)

$\frac{5+5+1+1}{4} = 3$

more smoother when n↑ (n=4)

more responsive when n↓ (n=2)

If Demand stable.

طالع بدو فرق بال

Forcasting behavior.

* Exponential Smoothing technique.

$F_{t+1} = \alpha D_t + (1-\alpha) F_t$ most recent period.

$= F_t + \alpha (D_t - F_t)$

α = Smoothing parameter $0 \leq \alpha \leq 1$

Example:-

using $\alpha = 0.1$

week	Patient arrival (D) actual	F
1	400	$F_1 = 400$ (نفترضها)
2	380	$F_2 =$
3	411	$F_3 =$
4	415	

$F_4 = (0.1)(411) + (1-0.1)(390)$

$= 392.1 = 392$

F_t (طريقة D)

$F_3 = \frac{400+380}{2}$ using Simple moving avg.

$E_4 = 415 - 392 = 23$

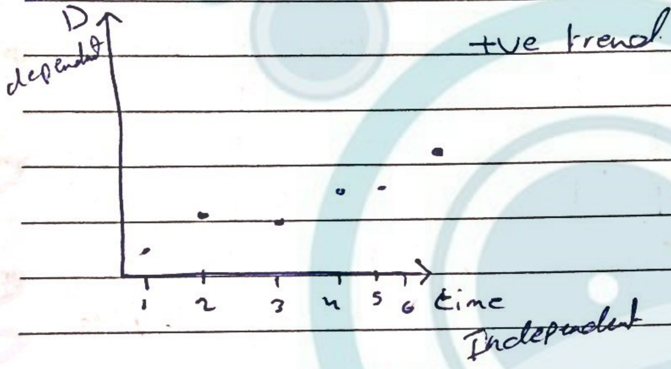
* تأثير α (small α , large α)

resonce [illegible]

infeces اكثر

$(1-\alpha)F_t$

* Trend :- constant decreas or increas based on time.

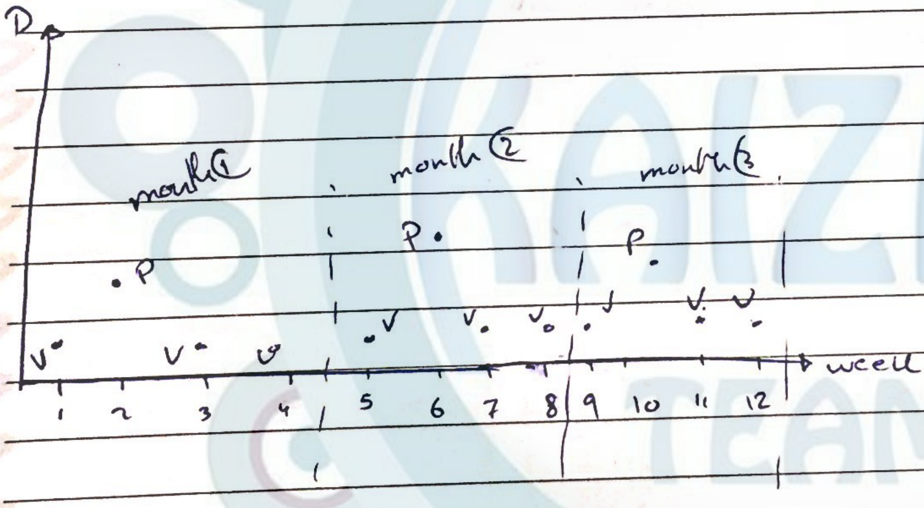


→ Simple linear regretion

* we can use any tech to any data

بس، نشوف بال %Error

* How to know if it seasonality Demand. (plot Demand)
- collect data (hourly, daily, weekly, monthly, yearly)



2^{nd} week every month
→ peak
Season → month.
period →

*

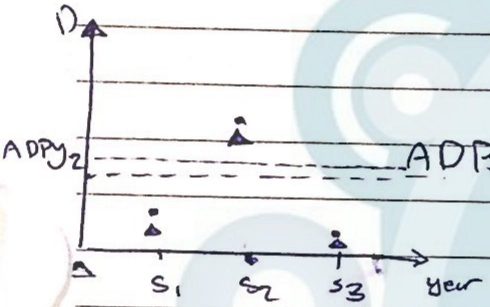
Season	D	year (1)	D	year (2)	avg seasonal index
S_1	$D_{y_1 s_1}$	$S.I_{y_1 s_1} = \frac{D_{y_1 s_1}}{ADPS_{y_1}}$	$D_{y_2 s_1}$	$S.I_{y_2 s_1} = \frac{D_{y_2 s_1}}{ADPS_{y_2}}$	$A.S.I_{s_1} = \frac{S.I_{y_1 s_1} + S.I_{y_2 s_1}}{\text{no of period}}$
S_2	$D_{y_1 s_2}$	$S.I_{y_1 s_2} = \frac{D_{y_1 s_2}}{ADPS_{y_1}}$	$D_{y_2 s_2}$	$S.I_{y_2 s_2} = \frac{D_{y_2 s_2}}{ADPS_{y_2}}$	$A.S.I_{s_2} = \frac{S.I_{y_1 s_2} + y_2 s_2}{\text{no of period}}$
S_3	$D_{y_1 s_3}$	$S.I_{y_1 s_1} = \frac{D_{y_1 s_3}}{ADPS_{y_1}}$	$D_{y_2 s_3}$	$S.I_{y_2 s_3} = \frac{D_{y_2 s_3}}{AP PS_{y_2}}$	$A.S.I_{s_3} = \frac{S.I_{y_1 s_3} + y_2 s_3}{\text{no of period}}$

- Total Demand $y_1 = D_{y_1 s_1} + D_{y_1 s_2} + D_{y_1 s_3}$

  Avg D per season $= \frac{T.D_{y_1}}{\text{no of seasons}}$

- $T.D_{y_2} = D_{y_2 s_1} + D_{y_2 s_2} + D_{y_2 s_3}$

  $ADPS_{y_2} = \frac{T.D_{y_2}}{\text{no of seson}}$



Seasonal Index $= \frac{\text{actual}}{\text{avg}}$

S.F < 1

كل ما كانت اقل يعني

Vale أكتر

S.F > 1

كل ما كانت اقرب لل 1

peak.

→ year (3)

$F_{y_3 s_1} = A.SI_{s_1} \times EADPS_{y_3}$

$F_{y_3 s_2} = A.SI_{s_2} \times EADPS_{y_3}$

$F_{y_3 s_3} = A.SI_{s_3} \times EADPS_{y_3}$

Estimated total demand y_3 (using any previous technique)

∴ avg Demand per sea. $y_3 = \frac{ETD_{y_3}}{\text{no of season}}$

Q	D	Year ① S.I	D	S.I year ②
1	45	$S.I_{y_1 s_1} = \frac{45}{250} = 0.18$	70	$S.I_{y_2 s_1} = \frac{70}{300} = 0.23$
2	335	$S.I_{y_1 s_2} = \frac{335}{250} = 1.34$	370	$S.I_{y_2 s_2} = \frac{370}{300} = 1.23$
3	520	$S.I_{y_1 s_3} = \frac{520}{250} = 2.08$	590	$S.I_{y_2 s_3} = \frac{590}{300} = 1.96$
4	160	$S.I_{y_1 s_4} = \frac{100}{250} = 0.4$	170	$S.I_{y_2 s_4} = 0.56$

$T.D_{y_1} = \boxed{1000}$ (200) $T.D_{y_2} = \boxed{1200}$ (600)

$ADPs_{y_1} = \frac{1000}{4} = 250$ $ADPs_{y_2} = \frac{1200}{4} = 300$

D	Year ③ S.I	D	Year ④ S.I
160	$S.I_{y_3 s_1} = 0.22$	160	$S.I_{y_4 s_1} = 0.18$
585	$SI_{y_3 s_2} = 1.3$	725	$S.I_{y_4 s_2} = 1.318$
830	$SI_{y_3 s_3} = 1.84$	1160	$S.I_{y_4 s_3} = 2.1$
285	$SI_{y_3 s_4} = 0.63$	215	$S.I_{y_4 s_4} = 0.39$

(400)

$T.D_{y_4} = \boxed{2200}$

$ADPs_{y_4} = 550$

$TD_{y_3} = \boxed{1800}$

$ADPs_{y_3} = \frac{1800}{4} = 450$

A.S.I	Forcast
$A.S.I_{s_1} = \frac{0.18 + 1.34 + 2.08 + 0.4}{4}$	$F_{s_1} = (0.2643)(650) = 132.79$
$= 0.2043$	$F_{s_2} = (1.2979)(650) = 843.63$
$A.SI_{s_2} = 1.2979$	$F_{s_3} = (2.0001)(650) = 1300.06$
$A.S.I_{s_3} = 2.0001$	$F_{s_4} = (0.4977)(650) = 323.5$
$A.S.I_{s_4} = 0.4977$	

Const ~~ct~~ increas   *Linear regretion * or naiev.

$\frac{200 + 600 + 400}{3} = 400$ on averge ع بزيد   trend ع

↳ Estimated total $D = 2200 + 400 = 2600$

$EADPs_{y_5} = \frac{2600}{4} = 650$

error — random → مشروعة
error — Biased → caused by technique

method ①

Period	D	F	E
1	D_1	F_1	E_1
2	D_2	F_2	E_2
3	⋮	⋮	⋮
4			
5			
⋮			
n	D_n	F_n	E_n

① cumulative sum of forcast error

$$CFE = \sum_{i=1}^{i=n} E_i$$

+ve → bias to under estimate Demand
-ve → bais to over estimate

② Mean bias $\bar{E} = \frac{CFE}{n}$

③ mean absolute deviation $MAD = \frac{\sum_{i=1}^{i=n} |E_i|}{n}$

كل ما صغرت MAD بكون احسن

④ Mean squared error $MSE = \frac{\sum_{i=1}^{i=n} E^2}{n}$

لـ اذا قيمه كبيرة يعني اسوأ.

← اخذنا E^2 عشان نقدر نحدد مين الطريقة الاحسن*

Ex.

P	method ① Error	E^2	method ② Error	E^2
1	1	1	4	
2	1	1	0	
3	1	1	0	
4	1	1	0	
MAD	1	1	1	4

method 2 → اسوأ

Example

Product	D	E
X	10	1
Y	10000	1

نسبة الخطأ من actual Demand.

⑤ Mean absolute percent errors $MAPE = \frac{(\sum |E_i| / D_i)(100)}{n}$

↳ كل ما كبرت بتكون أسوأ.

(هاي مش ∑) ↑

$\frac{\sum (|E_i| / D_i)(100)}{n}$. * نحفظ القانون ع

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

↳ try to reduce variability.

Example

P	D	F	E	|E|	E^2	$\frac{\|E\|}{D} \times 100$
1	200	225	-25	25	625	$\frac{25}{200} \times 100$
2	240	220	20	20	400	.
3	360	285	15	15	225	.
4	270	290	-20	20	⋮	.
5	230	250	-20	20	⋮	
6	260	240	20	20		$\sum = 81.3\%$
7	210	250	-40	40		
8	275	240	35	35	$\sum E^2 = 5275$	

$CFE = -15$ (Sum ال...)

$\bar{E} = \frac{-15}{8} = -1.878$

$MAD = \frac{195}{8} = 24.4$ on avg (بالمتوسط)

$MSE = \frac{5275}{8}$

مش زيادة ولا أقل.

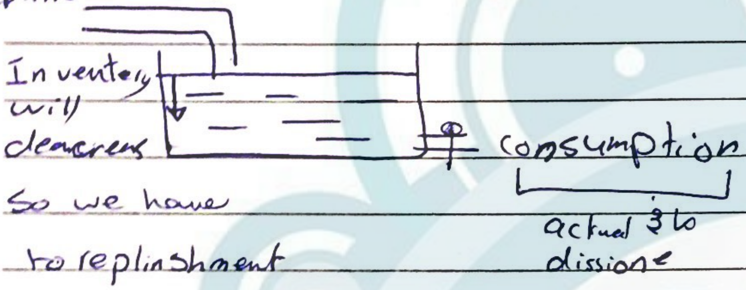
Inventory (mangment.)

Interferes ظروف

. مخزون (material stocked) (مادة.)

wherehouse → مخزن ((مكان) actual activity. (size, material, ظروف ----)

replinshment ⇐ main dission.



replinshment
1. How much to order
2. when to order
3. How often to reviwe.
} manging inventory.

4. How to calssifay.

Stock keeping unit (SKU) → any Item have a code stocked somewhere in the supply chine

Chart.

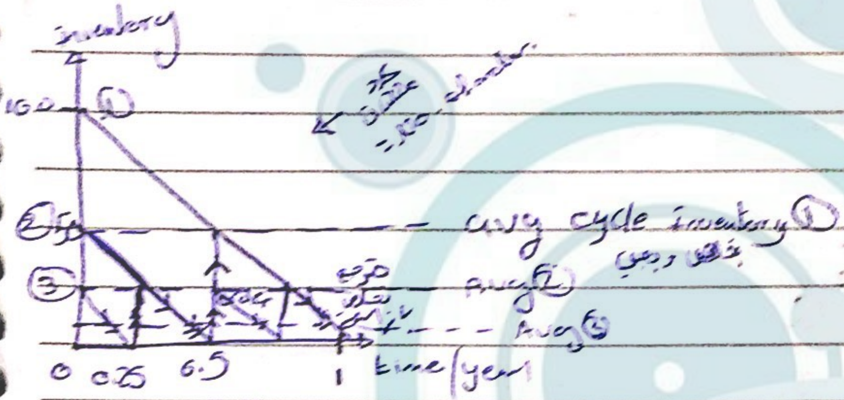
ABC calssolocatoon

SKU	cost		D (annual demand item/year)	usage value.
A (more efficient inventory control sys.)	$1	cost not enough	1000 000	1000 000 $/year
B	$1000		10	10000 $/year.

to say which is more Imp. to control it very will

Inventory mangement

- Classification of SKUs
  - ABC classification
  - [class A, class B, class C]
  - in term on usage value
  - * 2√
- Choosing Inventory control sys.
  - * How much to order
  - * when to order
  - * How often to review Inventory posi...
  - Independent demand SKU
    - Continous Review Sys
    - Periodic Review Sys
    - Hybrid sys
      - optiond Replenishment
      - base-stock sys.
  - dependent
    - MRP sys
    - materials requirements planning



Ex. D = 100 unit.
Consumption Rate = const
ordering → once.

* Case ① :-
Q. quantity ordering = 100
No. of orders = 1 = $\frac{D}{Q}$
Avg. C.I = $\frac{Q}{2}$ = 50

cycle, pipe, stock, ... inventory

* Case ② :-
Q = 50
No. of orders = $\frac{100}{50}$ = 2
→ (Avg ... No. of orders ... Q ...)
Avg cycle inventory = $\frac{Q}{2}$
$\frac{50}{2}$ = 25

* Case ③
Q = 25
no. of order = $\frac{100}{25}$ = 4
Avg. cycle Inventory = $\frac{25}{2}$ = 12.5

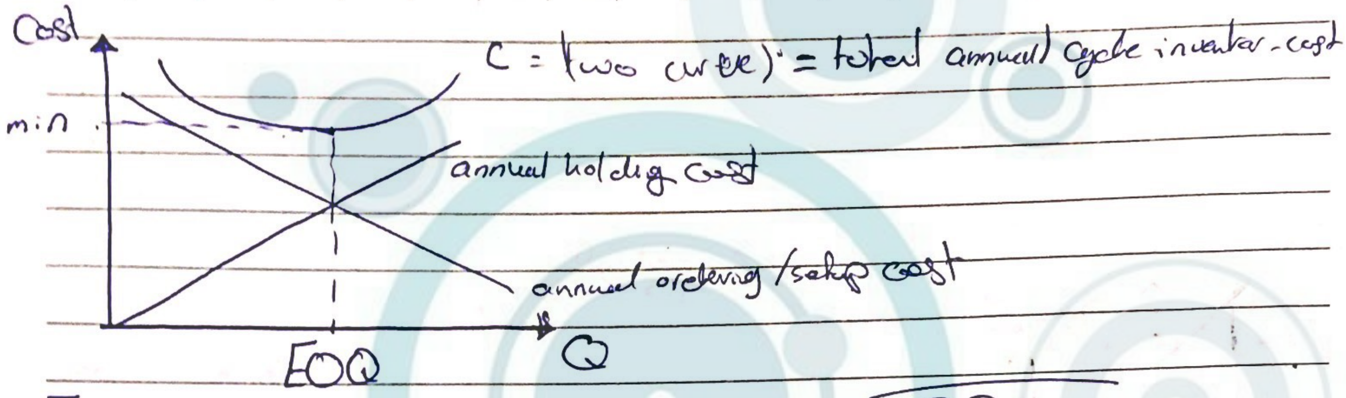
Cost total annual cycle-inventory cost = annual holding cost + Annual ordering/setup cost

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

*Annual holding cost = Avg * unit holding cost = $\frac{Q}{2}$ H

H: unit holding cost = $ unit / year

* Annual ordering cost setup = Number of order/year × order/setup
S:- ordering/setup
$\frac{D}{Q}$ S



EOQ: Economic ordering Quantity. $= \sqrt{\frac{2DS}{H}}$

Small el capital بنقلل ال

time btween order $= \frac{Q}{D} =$ year.

⇓

month. $\frac{Q}{D} * 12$

⇓

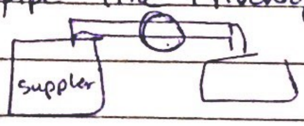
week $\frac{Q}{D} * 52$

⇓

Days $\frac{Q}{D}$ 365

Inventory:- □ → next etshilone → □ - - -

* Finished goods Inventory.
* raw material Inventory.
* work in process Inventory (WIP)
* pipe line inventory.



next etshilone

we try to elimenate (wast → space, cost, time -) work in process
Solve it By (Canban, Just in time) - - -

* On-hand Inventory (الكمية الفعلية الموجودة عندنا)
* Sceduled-receival Inventory (اطلبت order من ال لسه موصلش [illegible])

Independent demand Items SKU
[(Finished goods inventory] ← Demand يعتمد على market condition.

dependent demand items. depend on another
(raw material inventory) SKU

} عشان نعرف نعمل control.

(lead time) put order on (production line) till we recived order.
F.g.I (production line) or to supplier. r.m.I

* Back-order Inventory. (لما العميل custom order 13 مثلا بالنسبة ليه [illegible])

— Inventory position = on-hand + schedual Receipt − Back order.

$$I.P = OH + SR - BO$$

* Continous Review sys. / ROP sys / Fixed order quantity sys

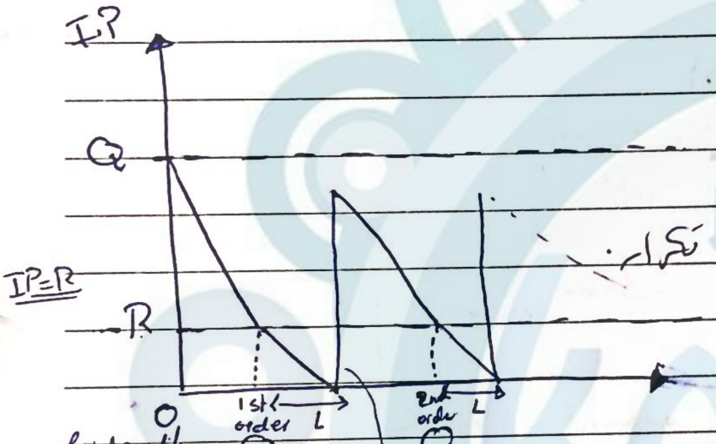
- inventory position is review
↓
if reaches pre determin level r → put an order (we)

I.P → check it continously

Q → fixed quantity of Q.

Simpliest case

Cycle - Inventory.



fixed quantity ← Q

below R → order

L → lead time

ما يوصل لـ Q بالزبط

عشان بنفترض انو بأخد الـ Q استهلاكها

const. rate.

(1)
* When to order

(3)
* How much to order.

(2)
* How often to review inventory position

① When the inventory position reaches a predetermined level (R)

Ⓐ
- Demand constant (d)
- lead time constant (L)

$R = dL$

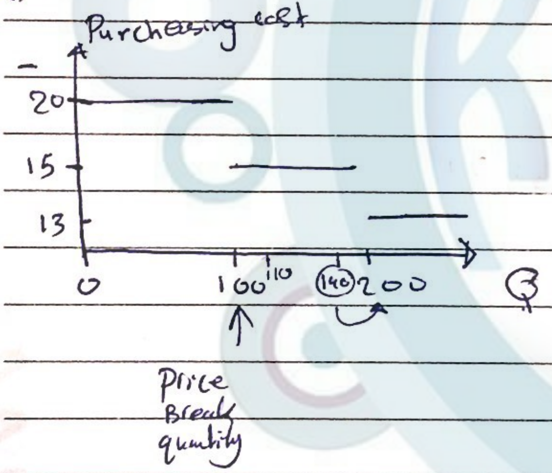
Ⓑ Demand variable $(\bar{d}, \sigma_d)$
lead time constant (L)

Ⓒ Demand $(\bar{d}, \sigma_d)$
lead time variable $(\bar{L}, \sigma_L)$

② continuously, each time we make a withdrawal

③ fixed Quantity

- Economic order quantity $\sqrt{\frac{2DS}{H}}$ / p.B.Q



← discount chart

- Continuous size ⎡ truck (delivery)
⎣ مخزن

- Expairy date

- any quantity selected by mangment

52 weeks

d = 18 unit / week

unit cost = $60

S = $45

H = 0.25 unit cost = (0.25)(60) = 15 unit/year.

E.O.Q = ?!   R?!

annual total cost ?!   Time between order ?!

$$EOQ = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{(2)(18)(52)(45)}{15}} = 74.94 \approx 75$$

R = dL = (18)(2) = 36 unit.

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

$$\frac{72}{2}(15) + \frac{(18)(52)}{75}(45) = \$1124$$

$$\cdot\ TBO_{EOQ} = \frac{EOQ}{D} = \frac{75}{(18)(52)} = 0.08 \text{ year.}$$

= (0.08)(52) = 4.1 week

OH = 50 unit

S.R = 0

B.O = 0

withdrawal = 20 unit

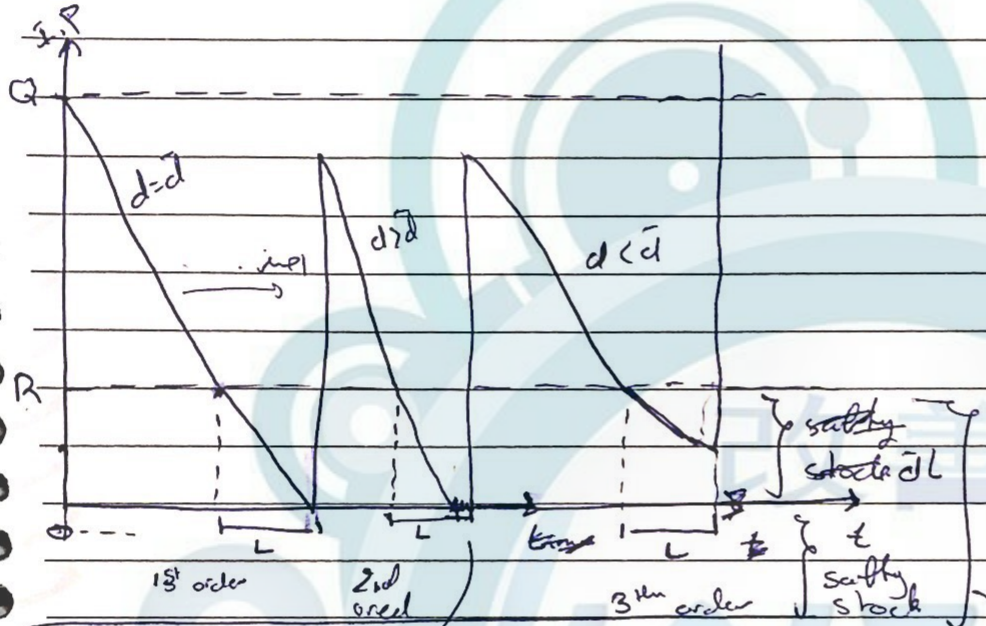
do we need to order.

if yes, how much?

$I.P = (50-20) + 0 - 0 = 30$

$I.P < R \Rightarrow$ we ~~much~~ make order

$Q = 75$



Demand variable $\begin{pmatrix} \bar{d} \\ \sigma_d \end{pmatrix}$

lead time contant (L)

$R = L\bar{d}$

case ① $d = \bar{d}$

case ② $d > \bar{d}$

case ③ $d < \bar{d}$

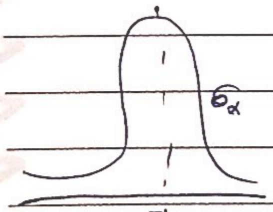
ما حصلتش طول فترة lead stock out situation.

↑ as a service level.

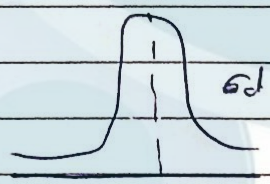
$R = \bar{d}L + S.S$

* service level

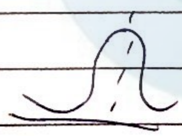
$S.S(z)$ = No of standard devetion Needed to achive service level.



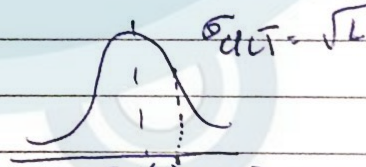
day ①



day ②



day ③



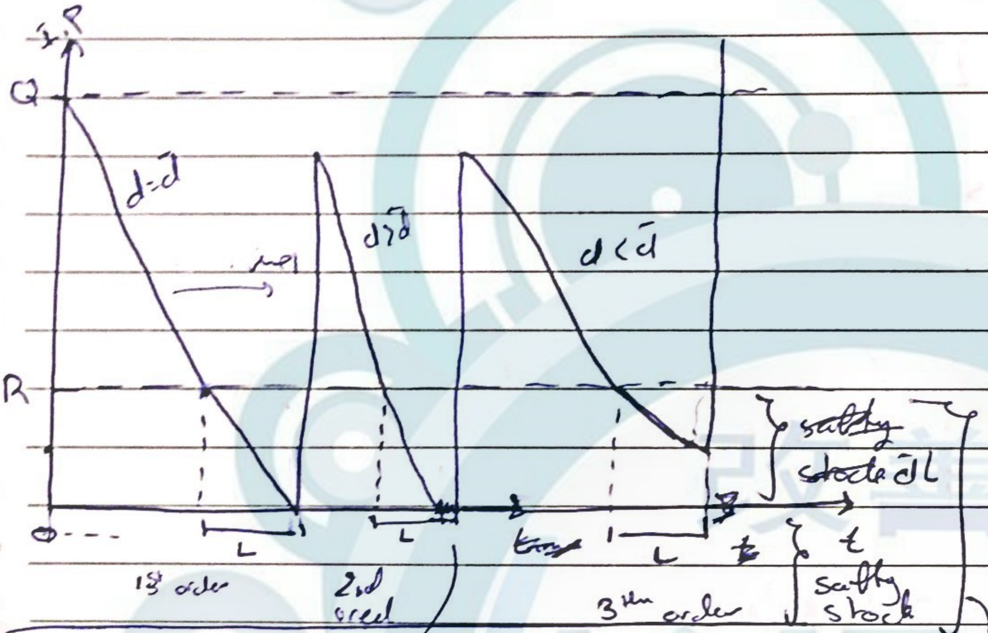
$S.S = z\,\sigma_{dLT}$

distribution of demand during protection interval (L)

$I.P = (50-20) + 0 - 0 = 30$

$I.P < R \rightarrow$ we ~~must~~ make order

$Q = 75$



Demand variable $\begin{pmatrix} \bar{d} \\ \sigma_d \end{pmatrix}$

lead time constant (L)

$R = L\bar{d}$

case ① $d = \bar{d}$

case ② $d > \bar{d}$

case ③ $d < \bar{d}$

ما تكفي طول فترة lead

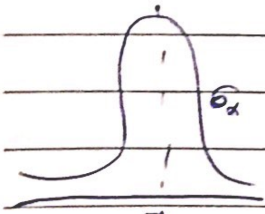
بيكون خلال lead time [Stock out situation.

↑ as a service level.

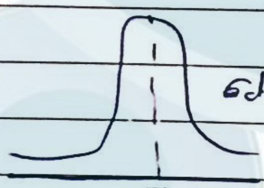
$R = \bar{d}L + S.S$

* service level

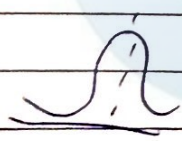
$S.S(z)$ = No of standard devetion needed to achive service level.



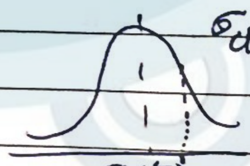
day ①



day ②



day ③



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

$S.S = z\,\sigma_{dLT}$

distribution of demand during protection interval (L)

① Q / L ⇒ constant.

② * variable demand. / constant lead time.
$\begin{pmatrix} \bar{d} \\ \sigma_d \end{pmatrix}$

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

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

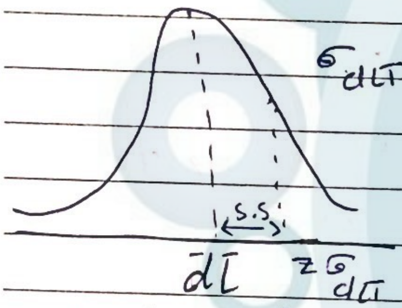
$$\sigma_{dLT} = \sigma_d \sqrt{L}$$

Z: Number of standard deviation need to achive the required service level.

③ * variable demand / variable lead time. $\begin{pmatrix} \bar{L} \\ \sigma_{LT} \end{pmatrix}$
$\begin{pmatrix} \bar{d} \\ \sigma_d \end{pmatrix}$

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

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



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

Distribution of demand during lead time (proteciton interval)

*Example:- 52 week.

EOQ = 75 unit

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

σ_d = 5 unit.

L = 2 weeks

S = $45

H = $15

S.S = ?? R = ?? 90% service level

C = ??

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

Normal table +ve ②

$(1.28)(5)\sqrt{2} = 9.05 = 9$ unit

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

$(18)(2) + 9 = 45$ units

I.P = 50 unit ← assume
S.R = 0
B.O = 0

withdrawal = 15 unit

I.P = 50 − 15 + 0 − 0 = 35

I.P < R → yes.

Q = 75

Safety stock inventory → Holding cost.

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

$\frac{(75)}{2}(15) + \frac{(18)(52)}{(75)}(45) + (9)(15)$

$= 1259.1$

Example:-

$\bar{d} = 12000$ pens

$\sigma_d = 3600$ pens

$Q = 156\,000$ pens

$\bar{L} = 5$ weeks

$\sigma_{LT} = 2$ weeks

95% service level. Find R = ??

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

$= (1.65)\sqrt{(5)(3000)^2 + (12000)^2\,(2)^2}$

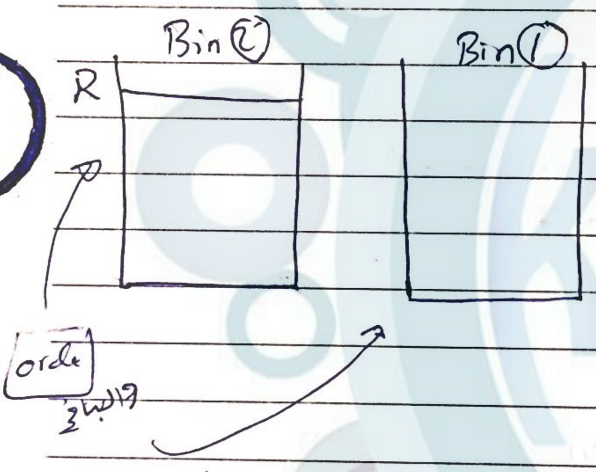
= ~~24920~~ 41118 pcs.

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

$(12000)(5) + 24920 = 101118$

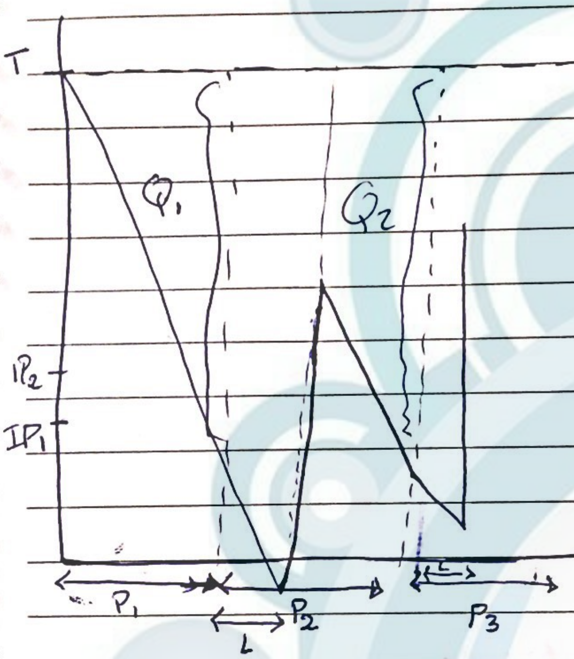
~~101118 pcs.~~

* visual Q sys. → 2-bin sys.



Cheep items.

periodic Review sys. / fixed interval reorder sys. / P sys / periodic reorder sys.



withdrawal [illegible] How often to review / when to order

① we check it → at end of period P

② Q → Target level − Inventory position (How much to order)

→ Find P / T ?!

لما تجيب P تجيب Q

P → Tim between order.

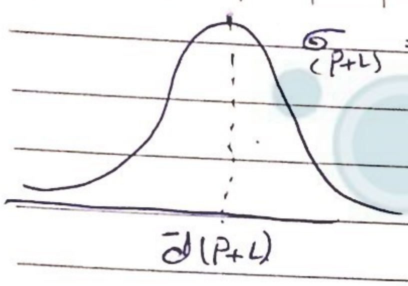
P

- TBO = EOQ / D ($TBO_{EOQ} = \frac{EOQ}{D}$)
- $TBO_Q = \frac{Q}{D}$
- any convenient period ⇓ بيعطيك فترة يشيلك عليهم.

* protection Interval ⇓ الفترة يلي ممكن يصير فيها Shortage

$T = d\,(P + L)$ (constant demand / Lead time)

T (variable demand / constant L).



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

normal dist.

distribution of demand
during protection interval (P+L)

$T = \bar{d}(P+L) + S.S$

$S.S = z\,\sigma_{P+L}$

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

z :- # of standard deviation needed to achive the required service level

Variable demand ($\bar{d}$, σ_d) / variable lead time.
→ we use simulation to estimate the demand during protection interval so as to use it to select value of T (under desired service level)

52 weeks

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

σ_d = 5 units

L = 2 weeks

H = \$15

S = \$45

EOQ = 75 unit

9% service level → Z = 1.28

P = ??

T = ??

C = ??

Sol :-

$P = TBO_{EOQ} = \frac{EOQ}{D} = \frac{(75)}{(18)(52)} = 4.2 \approx 4$ weeks

$T = \bar{d}\,(P + L) + S.S$

$= (18)(4 + 2) + 16 = 124$ unit

$S.S = Z\,\sigma_{dLT} = Z\,\sigma_d\,\sqrt{P + L} = (1.28)(5)\sqrt{4 + 2} = 15.68 \approx 16$

at the time of review, I.P = 60 unit (SR = zero) B.O zero)

$Q = T - I.P$

$= 124 - 60 = 64$

$C = \frac{\bar{d}P}{2} H + \frac{D}{\bar{d}P} S + S.S\,H = \frac{(18)(4)}{2}(15) + \frac{(18)(52)}{(18)(4)} 45 + (16)(15)$

= \$1365   P.sys.

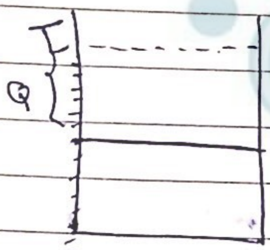
↑ عالي S.S = 16

سؤال بيجي C = \$1259

S.S = 9   Q sys.

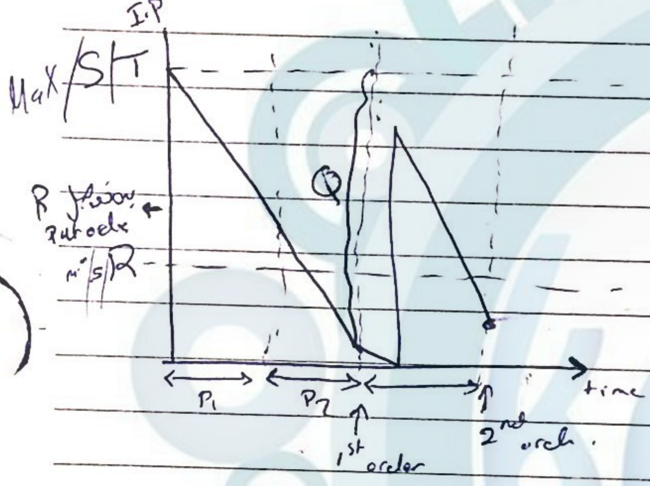
→ Items. مائعة، نعد (gas, liquid, tiny things)

* visual P sys (one-bin-sys)



Scaled Bin

* optional replenishment sys. or (S,s syst), (max,min sys)



≠ Holding cost سيء

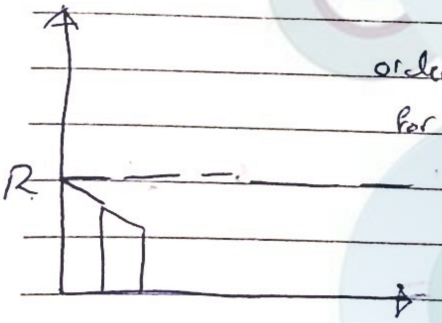
S.S ~~std~~, T

(L+P) لازم يغطيها فترة

very chop items and small item.

* base stock sys.

IP → at level (R) R = Target



كل مرة بنجيب بنحط order

مناسب for very expensive items.

Adv. / dis adv. for → P-sys / Q sys

S.S → أقل → H cost ↓ → cost ↓ Adv Q sy. بعكس P-sys

checking invent. with every drawal dis Q-sys / P-sys Adv.

Q order متغير dis P / بينما Q ثابت بال Q sys.

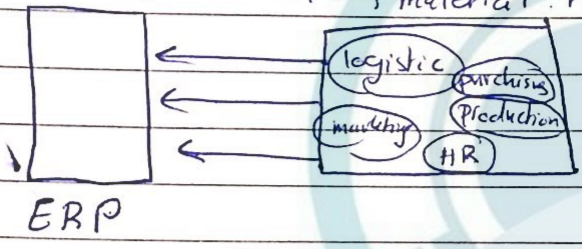
P-sys. الفترة ثابتة
TBO وعادا احسن انه Q
يكون متغير.

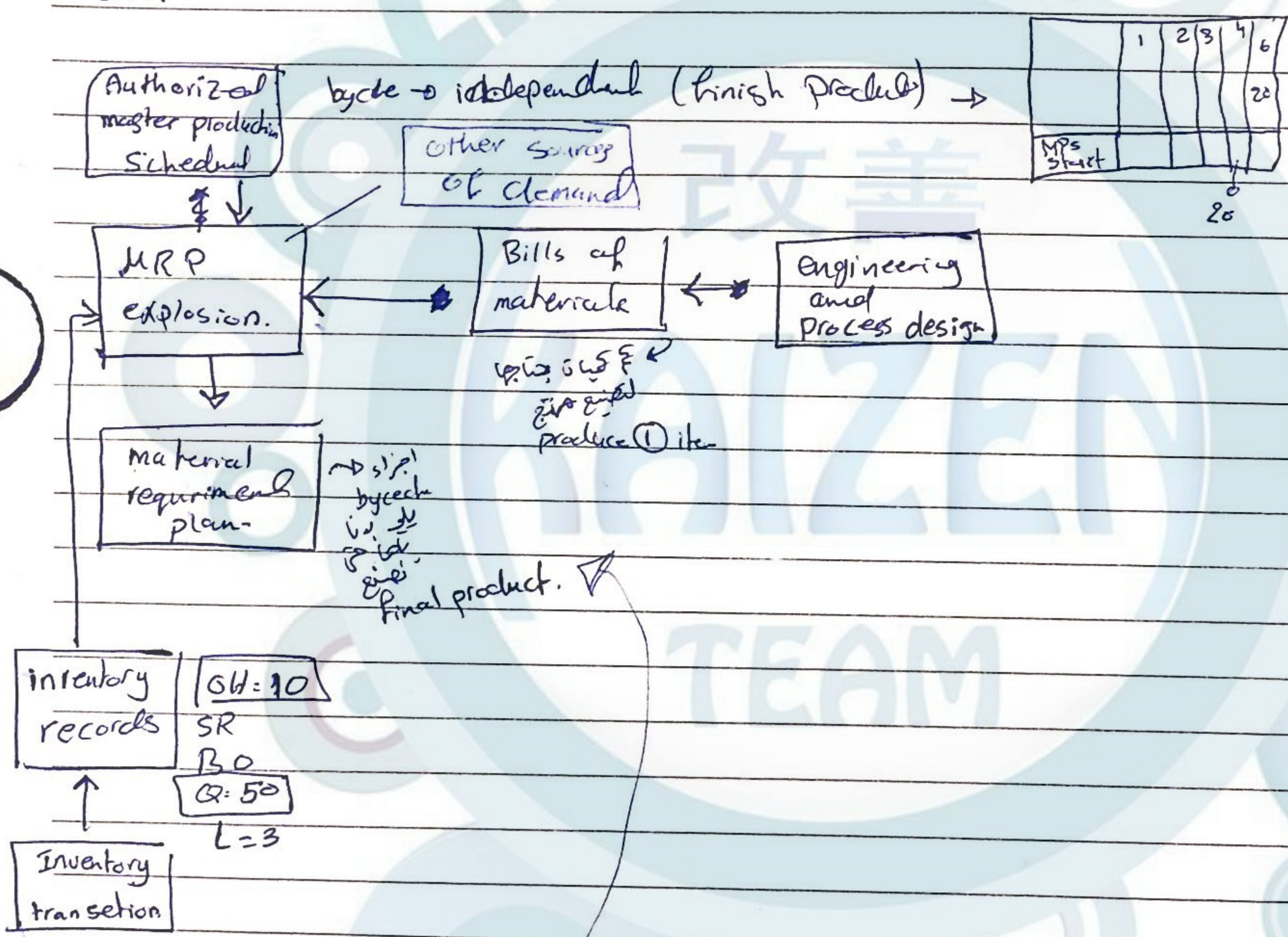
manage dependant demand item

ERP

dependent sku's

MRP → material requirements planing.



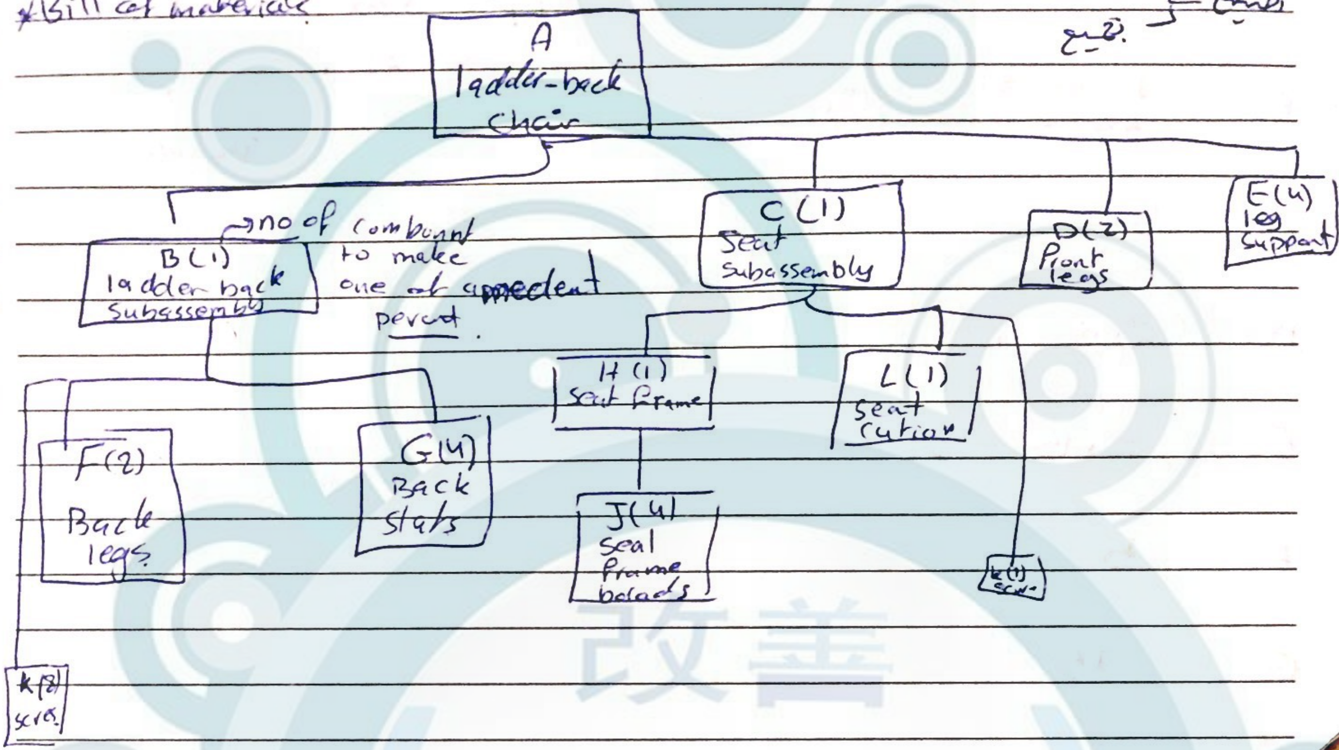


.10	⊗	1	2	3	4	5	6	
				10	20 50			← Gross requirments
		50						released order quantity

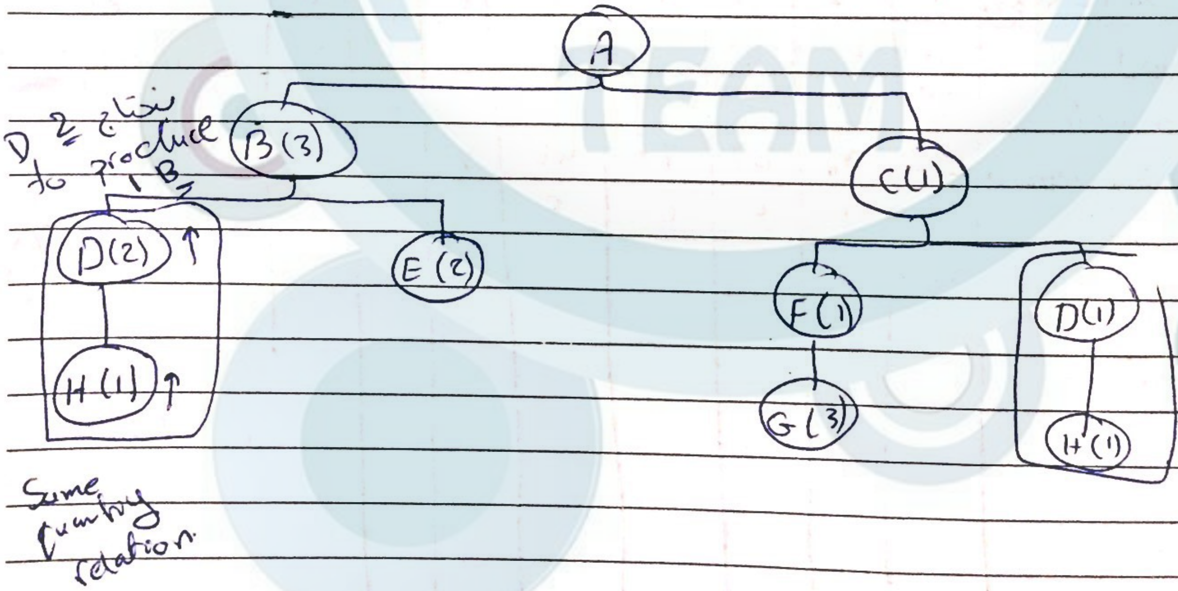
*Bill of materials

.Chiar.

تصنيع ← تشكيل / تجميع



Screws :- ظاهرتين بال Bill او ال Bill diff اذا نفس
component
بيعطي نفس code ونفس
requirment plane.



Gross requirment.

→ الكمية من كل component

← Inventory / الموجود في المخزن

Final product / المنتج النهائي

A = 5

B = 1A → 3B, 5A → ; B = 15

C = 5

D = (2x15) + (1x5) = 35

E = 2x15 = 30

F = 5

G = 15

H = 35

* master production scheduling (mps) → final product.

Item: lather back chair

order policy: 150 unit

lead time = 1 week

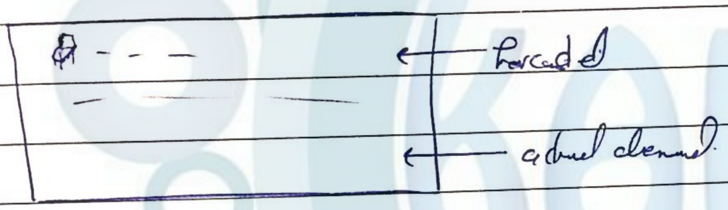
Quality on hand [55]	1 (april)	2 (april)	3 (april)	4 (april)	5 (may)	6 (may)	7 (may)	8 (may)
Forcast	30	30	30	30	35	35	35	35
customer order books	38	27	24	8	0	0	0	0
Projected on-hand inventory	[17]	1~~37~~ [illegible]	107	77	42	7	122	87
MPS quantity (no shortage)	[0]	150	0	0	0	0	150	0
MPS Start	150					150		
Available-to-promise (ATP) inventory								

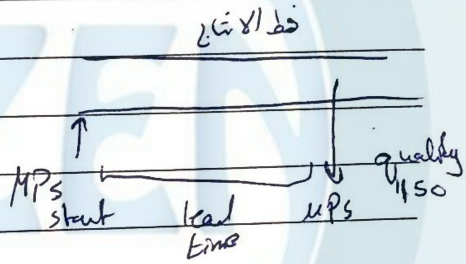
150 + 17 − 30 = (137)

150 + 7 − 35

explosion.

finished goods inventory





Item:- C
Seat - [illegible]

Fixed order quantity → lot size:- 230 unit
lead time:- 2 week
Safthy stock: zero

3 [Fixed order q
lot for long

	April 1	April 2	April 3	April 4	May 1	May 2	May 3	May 4
Gross Requirments	150			120		150	120	
Schedual Receipts	230							
37 Projected-on-hand invatory	117	117	117	227	227	77	187	187
Planned Receipts	0	0	0	230	0	0	230	0
Planned order release		230			230			

معمول order [illegible] (Schedual Receipts)
يوم [illegible] (Planned Receipts)
تغطي النقص (Planned order release)
لما نعمل order [illegible] اوامر ال

* هو بتعطينا المعلومات [illegible] لازم [illegible] ال order

بدأ التصنيع [illegible] باسبوعين حتى [illegible] الاسبوع الرابع

Master production Schedual

Shortage if less than Safthy stock.

* Kitche chair

1	2	3	4	1	2	3	4

وقت الوصول Planned Receipts	0	0	0	230	0	0	230	0
وقت التصنيع Planned order release (لو مواعيد order التصنيع)		230			230			

* هي بتعطيا معلومات متى وكم لازم نبعث الـ order

← نبدأ التصنيع بأسبوعين حتى يصل بالأسبوع الرابع

Shortage if less than Saftey stock.

Master production Schedual

* Kitche chair

	1	2	3	4	1	2	3	4
MPS start				120			120	

* ladder Back Chair

	1	2	3	4	1	2	3	4
MPS start	150					150		

Item C — seat subassembly

lot size: FOQ = 230 | lead time: 2 week | SS: zero

	1	2	3	4	5	6	7	8
Gross requirements	150			120		150	120	
Scheduled Receipts	230							
projected on hand inventory [37]	117	117	117	227	227	77	187	187
planned receipts	0	0	0	230	0	0	230	0
planned order release		230			230			

Item C — seat subassembly

lot size: (POQ) (P=3) | lead time = 2 | SS: zero

1	2	3	4	5	6	7*	8*	9* [37]
150			120		150	120		
230								
117	117	117	150	150	0	0	0	
0	0	0	153	0	0	120	0	
	153			120				

step تحويل

TBO P

step

150 + 120 − 117

= 153

لـ اخر ٣ مراحل حيكون مقدار S.S

Item c — seat subassembly

lot size L4L (lot 4 lot) | lead time: 2 | SS. zero

	1	2	3	4	5	6	7	8
	120			120		150	120	
	230							
[37]	117	117	117	0 (S.S)	0	0	0	0
	0	0	0	3	0	150	120	0
				150	120			

ord. = gross requirement for this period

120 − 117

S.S — خطوة التحويل

تحول

II S.S ≠ Zero

Same Example **S.S = 80**

1	2	3	4	5	6	7	8
150			120		150	120	
230							
117	117	117	207	227	307	187	187
0	0	0	230	0	230	0	0
	230						

Shortage → if [ ] < S.S

2 tabel

[illegible]

بيكون بدل 37

معناه SS = 80 ما

وبعد يعني بمقدار 80

عن طول ال on-hand

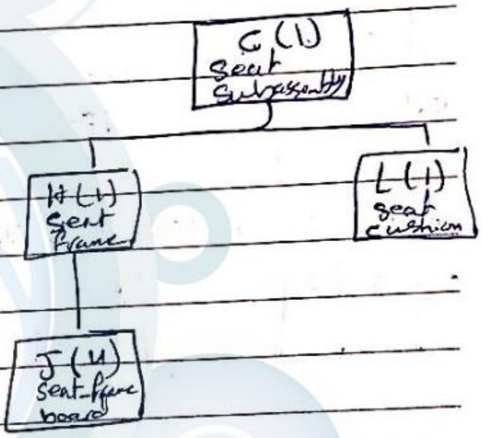
on hand < S.S
Shortage.

lot size :- FOQ = 230
Item C lead time :- 2 week S.S :- Zero

	1	2	3	4	5	6	7	8
Gross req.	150			120		150	120	
Scheduled Receipt	230							
Projected on hand	117	117	117	227	227	77	187	187
planned	0	0	0	230	0	0	230	
planned order		230			230			

37

لازم نبدأ بال parent then child.

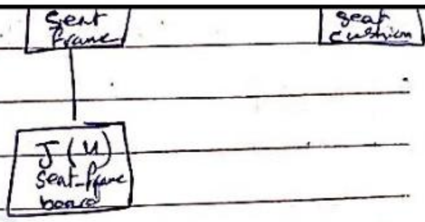


lot size FOQ = 300
item H lead time = 1 week
S.S = Zero

depend on quantity relation between C, H
بناخد من planned order

	2	3	4	5	6	7	8
	230			230			

order		230			230			



item H

lot size FOQ = 300

lead time = 1 week

S.S - Zero

↑ depend on quantity relation between C, H
planned order jo 3alebl relace

	1	2	3	4	5	6	7	8
		230			230			
		300						
	40	110	110	110	180	180	180	180 (40)
	0	0	0	0	300	0	0	0
				300				

item L

lot size LUL = Gross req for that week

lead time = 1 week

S.S - Zero

C, L

	1	2	3	4	5	6	7	8
		230			230			
	0	0	0	0	0	0	0	0
	0	230	0	0	230	0	0	0 (0)
	230			230				

1	2	3	4	5	6	7	8
			1200				
200	200	200	500	500	500	500	500
0	0	0	1500	0	0	0	0
		1500					

200

Item J

lot size = FOQ = 1500

lead time = 1 week

S.S = Zero

H, J

1 : 4

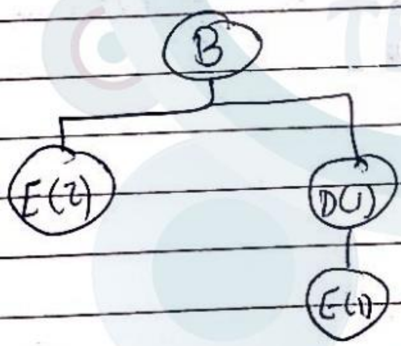
300

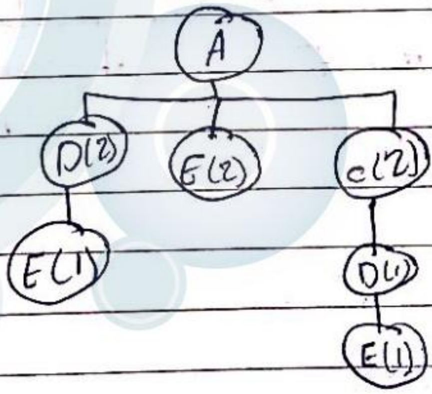
في
الأسبوع
الرابع

300 x4

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=3)	FOQ=800
lead time	3week	2week	1week
Schedule-Recipt	200 (week2)	None	800 (w.1)
Begining inventory	85	625	350
Safty stock	Zero	Zero	Zero





Item: C

lot size L4L
lead time 2week
S.S Zero.

	1	2	3	4	5	6	7	8
Gross requirement		250		190		300		260
scheduled Re		200						
projected on hand 85	35	35	0	0	0	0	0	0
planned Recpts	0	0	0	155	0	300	0	260
planned order release			300		260			

[85]

190 - 35 = 155

MPS start [illegible]

Item D

lot size:- POQ =(P=3)
lead time 2week

projection on hand	85	35	35	0	0	0	0	0
planned receipts	0	0	0	155	0	300	0	260
planned order release			300		260			

190 - 35 = 155

Item D lot size :- POQ = (P = 3)

lead time 2 week

SS Zero.

1	2	3	4	5	6	7	8
155	250	300+80	190	260	300		260
470	220	450	260	0	650	260	0
0	0	610	0	0	0	0	0
610		[illegible]	630				

for A and B. C

625

order ① 300+80+190+260-220 = 610

order ② : 300+70+0+260 = 630

Item E lot size : FOQ = 800

lead time : 1 week

SS Zero.

1	2	3	4	5	6	7	8
610	250	160	190		140 300		260
800							
540	290	130	110	110	470	470	210
0	0	0	800	0	800	0	0
		800		800			

350

one D → E

[illegible] E

A → E

B → E

when we change S.S = 30. for Item C

1	2	3	4.	5	6	7	8
	250		190		300		260
	200						

✓ level [illegible]

85 S.S [illegible] 35 − 30 = 185

1	2	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
610	250	160	190		140 300		260
800							
540	290	130	110	110	470	470	210
0	0	0	800	0	800	0	0
		800		800			

[350]

[illegible]

Ⓐ → Ⓔ

Ⓑ → E

when we change S.S = 30. for Item C

1	2	3	4	5	6	7	8
	250		190		300		260
	200						
85	35	35	30				
0	0	0	185				
185							

[85] S.S ✓ level

190 - 35 + 30 = 185

details

	1	2	3	4
Bike 1	100	100	200	200
Bike 2	50	50	50	50

*Scheduling :-

- intermediate planning (weekly)
- master production schedule
- materials requirement plans

Business plan → capacity planning → aggregate planning → Master schedule planning → scheduling

Business plan:
↳ long term planning (10 - 15 years)
→ corporate strategies and policies.
→ Economic political and competitive conditions.
→ Aggregate demand forcast

capacity planning:
↳ long. t. P (5.10 years)
→ Facilities requirements
→ Facilities location
→ machine requirements

aggregate planning:
↳ intermediate planning (quarterly monthly)
- Facility utilization.
- subcontracting.

scheduling:
- short planning (days, hrs, mins)
- specific task to specific people and machine.
- tools :-
① Job and Facility scheduling
② work force scheduling

→ Corporate strategies and policies.
→ Economic political and competitive conditions
→ Aggregate demand forecast

(5-10 years)
→ Facilities requirements
→ Facilities location
→ machine requirements

planning (quarterly, monthly)
- facility utilization
- subcontracting

- specific task to specific people and machine
- tools:
① Job and facility scheduling
② work force scheduling
③ Sequencing Job at a work station.

* aggregate plane

Bikes	1	2	3	
	800	850		not much of details

months

* Job and facilities scheduling:

⌐ start activity.

¬ Finish activity.

☐ scheduled activity time

☑ actual progress.

بالسؤال بعطينا شروط والجدول

rules → to take dicision → schedul → mesure

عبارة عن موظف ومعلومات بنحطها بعين الاعتبار

اذا اعتبرنا انه عملناه good or not

Work force schedule

	M	T	W	Th	F	S	Su
Required # of employees	6	4	8	9	10	3	2

① Day off (two consecutive)

② min tot slack capacity

M	T	W	Th	F	S	Su	Employee	Comments
6	4	8	9	10	3	2	①	S/Su off M-F work
5	3	7	8	9	3	2	②	s/su off
4	2	6	7	8	3	2	③	s/su off
3	1	5	6	7	3	2	④	M/T off
3	1	4	5	6	2	1	⑤	S/Su

نطرح واحد من 3 ايام off ما عدا

If there's choises

Employee	M	T	W	Th	F	S	Su	total
1	✓	✓	✓	✓	✓	off	off	
2	✓	✓	✓	✓	✓	off	off	
3	✓	✓	✓	✓	✓	off	off	
4	off	off	✓	✓	✓	✓	✓	
5	✓	✓	✓	✓	✓	off	off	

If there's choises rules:-

1. fixed pairs (Su,S) prefrence.
if not we can select arbitrarity

هنبدأ ول نعطي Day off
بالأيام الأقل
requirment
فبجمع لكل يومين
وباخد أقل قيمة.
S/Su.=5
لأنهم تاني Su/M

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

[illegible] FCFS

W1	W2	W3
~~B~~ A C	B A	

[illegible] نحقق الأولوية (Sequence)

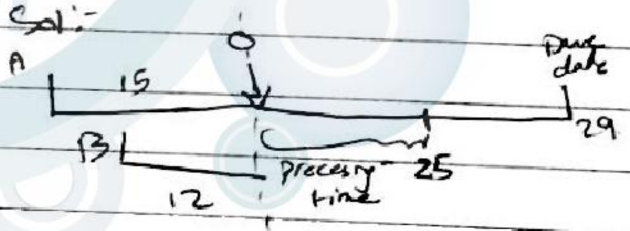
1. FCFS
2. Earliest due Date EDD
3. shortes ~~duration~~ processis time.

Job A $W_2 \to W_3 \to W_1$

Job B $W_2 \to W_1 \to W_3$

Job C $W_1 \to W_3 \to W_2$

Sol:-



First come First serv.

① FCFS

[illegible]

Customer sequance	Start time days	processing time (days)	Finish time days	Due Date	Days past due	Days ago since order arrived	Flow time (days)
A							

FCFS

B A C	B A	
W_1	W_2	W_3

شرط نعطي الأولوية (Sequence)

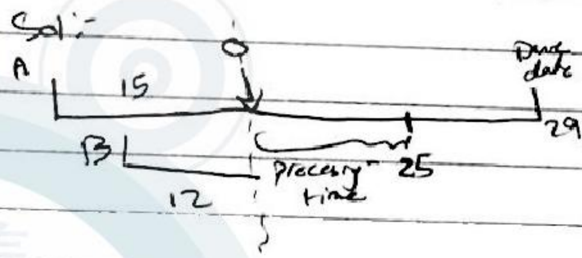
1. FCFS
2. Earliest due Date EDD
3. shortes ~~duration~~ processis time.

Job A $W_2 \rightarrow W_3 \rightarrow W_1$

Job B $W_2 \rightarrow W_1 \rightarrow W_3$

Job C $W_1 \rightarrow W_3 \rightarrow W_2$

Sol:-



First come First serv.

1. FCFS

Customer sequance	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	53
D	41	10	51	48	3	10	61
C	51	14	65	68	0	5	70
E	65	12	77	80	0	0	77

$$\text{Average days past due} = \frac{0+14+3+0+0}{5} = 3.5$$

$$\text{Averge flow time} = \frac{40+53+61+70+77}{5} = 60.2 \leftarrow \text{on avg}$$

Job بتقعد معنا.

② S.P.T

D	0	10	10	48	0	10	20
E	10	12	22	80	0	0	22
C	22	14	36	68	0	5	~~[illegible]~~ 41
B	36	16	(52)	27	~~[illegible]~~ 25	12	64
A	52	25	77	29	48	15	92

Avg (تأخير) delay $= \frac{0+0+0+25+48}{5} = 14.6$

Avg flow time $= \frac{20+22+41+64+92}{5} = 47.8$