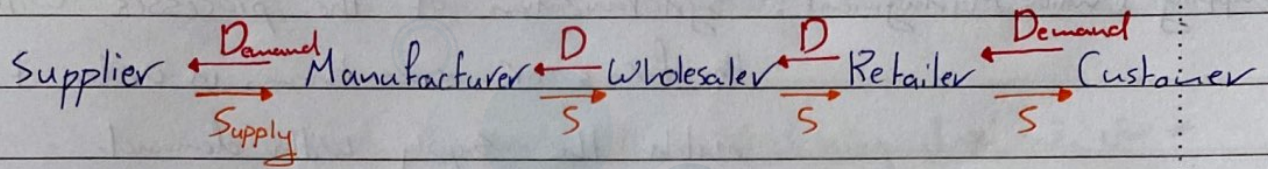
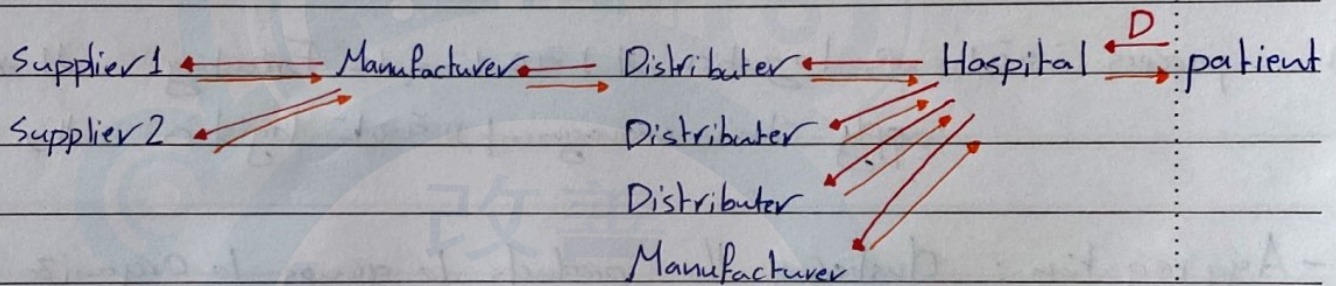


**Supply chain:** Typical supply chain (very general) :



echelon ~~but~~ ~~reio~~ ~~to~~ ~~is~~ \*

السلوكيات السلوكيات supply chain الى الى الى \*



**Supply chain:** Interrelated processes within and across the firms that produce a service or a product according to the customer needs.

**Functions or departments of Manufacturer:** HR, Q, Design, logistics, production, marketing, finance ....

\* there are multi processes within the firm

To make supply matching the demand we need management



- Supply Chain Management: Synchronization of the processes within the firms or across them, in order to match the supply with demand.

- logistics: Transporting or storing of materials in supply chain  
[كل ما يتعلق بنقل أو تخزين المواد خلال ال S. Chain]

\* ال Forecasting عملية تامة ال logistics  
وال logistics عملية ال supply chain management

- Aggregation: clustering the products to groups to organize them.

\* لحي نتج ال supply chain لاني نتج كل ال echelans

\* أي خطا لأي echelon يتطابق كل ال chain



**Forecasting** تَوَقُّعٌ → Activity: Estimating demand in the future

\* حتى تقرّر Level Matching بين ال supply وال demand فيحتاج فهم ال demand

\* حتى اعد Forecasting لازم آخذ في الحسبان decisions:

1] What to forecast?

\* level of aggregation

\* Units of measurements

2] Choosing the forecasting system.

3] Choosing the forecasting technique.



مثال : - على مصنع ينتج الأشياء التالية :-

$g_1$  { حلب فاكه الاسم 1L  
حلب كامل الاسم 1L

حتى نجد ال level of aggregation :

$g_2$  { حلب فراولة 250ml  
حلب نوتولا 250ml

$1g$

[ اعتبر كل كلمة مجموعة وحدة :  $1g$

\* long-term-planning (All/year)  
Items

\* highest level of aggregation

$g_3$  { حلب برتقال 250ml  
حلب تفاح 250ml

[ اعتبر كل كم نوعي مجموعة :  $g_1, g_2, g_3$

\* Medium-term-planning (each/month/quarter)  
group

[ كل item الى demand لحاله :

\* short-term-planning

(each item / shift / hour / day / weeks)

\* lower level of aggregation

\* ما ينطبق على ال products ينطبق على ال Services



اختيار البرنامج المناسب للـ S. chain

## Choosing Forecasting Technique

No historical data  
about actual demand

### Judgemental method

- Market research
- executive Opinion
- Delphi method
- Sales force estimates

Historical data about  
actual demand available

### Quantitative methods

#### Causal method

- \* independent variable  
affects the demand
- simple linear regression
- multiple linear "

#### Time series analysis

- Naive approach
- simple moving average
- Weighted moving average
- exponential  
smoothing
- trend
- multiplicative seasonal  
method



- Market research: Analysis of given surveys used to know how forecasting the demand will be.
- Executive Opinion: Based on Experience and opinion of the management
- Delphi method: " " opinions of coordinator + Analyst + Expert  
تقدير من قبل منسق بين أخصائى التسويق
- Sales Force Estimate: تقدير المبيعات بالجملة
- Judgmental method: \* تقدير منسق منها من حالة من data من قبل  
أو من



## Causal Methods :

- 1] Simple linear regression.  $\rightarrow$  ispl
- 2] multiple " " " " " "

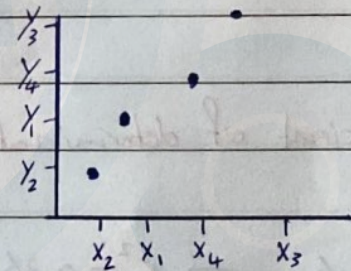
In Simple linear regression: dependent variable related to Independent variable by a linear equation.

We will assume that there is a relationship between the demand and other independent variable.

dependent variable: Demand  $\rightarrow$  a linear

Independent variable: # of competitors / Marketing expenditures / position of product (life cycle) / price / quality.

linear regression:



| Period         | independent variable<br>$X$ | dependent variable<br>$Y$ |
|----------------|-----------------------------|---------------------------|
| 1              | $x_1$                       | $y_1$                     |
| 2              | $x_2$                       | $y_2$                     |
| 3              | $x_3$                       | $y_3$                     |
| ...            | ...                         | ...                       |
| $n$            | $x_n$                       | $y_n$                     |
| مجموع<br>$n=5$ | $\sum x$                    | $\sum y$                  |

$$y = a + bx$$

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

$$\sum xy = x_1y_1 + x_2y_2 + \dots + x_ny_n$$

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

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

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

$$\sum x^2 = x_1^2 + x_2^2 + x_3^2 + \dots + x_n^2$$



\* نشو الأشياء يلي تتباعد عن بعضها انه ال Model يلي كذا متباعد

للإستخدام أولاً : يعني هل ال assumption تابع لأولاً :

1] Correlation Coef.  $r$  انما طرقت  $r$  في معادلات linear من ماعني بالترتيب relationship

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

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

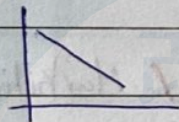
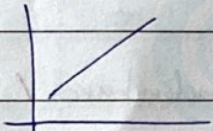
تعبيرنا :

Strength between relationship  $x$  and  $y$  [1]

direction of relationship (+/-) [2]

+ve relationship

-ve relationship



\* كلما جعد  $r$  عن الصفر تكون

ال relation أقوى سواء بالسالب

أو الموجب

كلما زادت  $x$  تنزى  $y$

كلما زادت  $x$  تنقل  $y$

2] Coefficient of determination  $r^2$

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

if  $r=0.6 \rightarrow r^2=0.36 \rightarrow 36\%$  changes in  $y$  caused by the changes in  $x$

\* بعمقنا معلومات اكبر نسبة تغير  $x$  الحالة بسبب تغير  $x$



### 3] Standard error of estimate. (S)

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

\* كل ما كانت قيمة S أكبر  
معناؤ النقاط أبعد عن line  
يعني Variability أكبر

\* كل ما قلت Variability أصحت ، يعني النقاط أقرب لـ line

\* محتاج S لما يكونه في آخر من Model وبيننا فرق بين الأضرب  
ياك هو يكونه أقل S



## Time Series method :

We have 5 Basic patterns here:

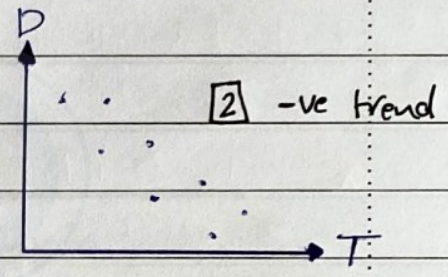
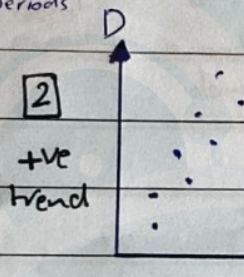
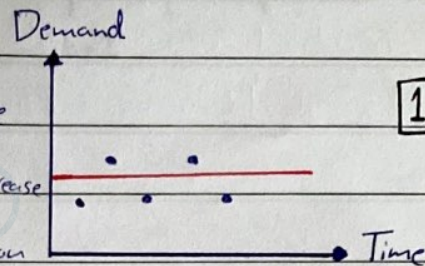
1] Horizontal → observations cluster about horizontal line

2] Trend (+ve/-ve) → demand consistently increase or decrease

3] Seasonal → Repeated peaks and valleys in the same season for different periods

4] Cyclical

5] Random

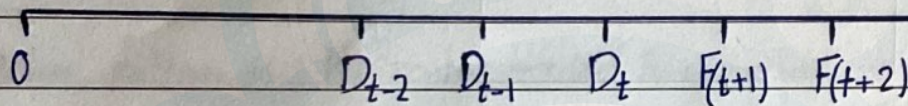
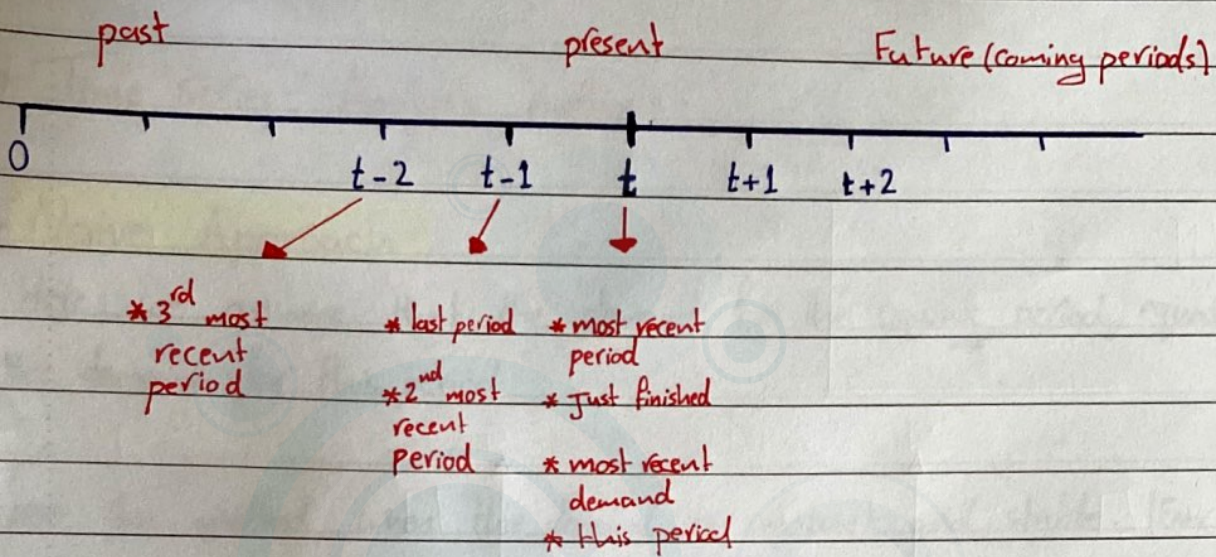


- Time series Analysis: The repeated observations of the demand of a certain product or service as they occur in their order of occurrence in the past.

الطلب يتكرر في نفس الفترة الزمنية ← seasonal \*  
في التوقيت

demand shows gradual decrease or increase ← cyclical \*  
over long periods





D: demand

F: Forecast → التوقع

\* The difference between actual and forecast to specific time is ( $E_t$ )

$$E_t: \text{Forecast Error} = D_t - F_t$$

Annotations:

- +ve →  $D_t > F_t$
- ve →  $D_t < F_t$
- ↙ ↘ last period forecast

+ve → under-estimating

-ve → over-estimating



## \* Time Series Analysis methods:

### - Naive Approach

# Here we assume that the demand for the coming period equals the demand for this period

# use this method when the demand is constant and stable. (Error is minimum)

# When pattern is Horizontal → use this method → very stable demand

### - Simple Moving Average :

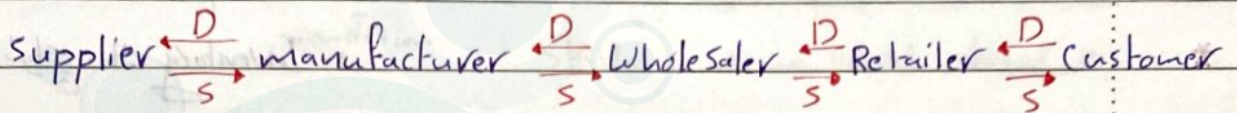
# لازم نحدد حجم ال (n) يعني ال periods اللي بنا اخذها بداية من  $D_t$  وارجع .

# General Formula : 
$$F_{t+1} = \frac{D_t + D_{t-1} + D_{t-2} \dots \dots + D_{t-(n-1)}}{n}$$

# لنرى هيك سيمبلا ؟ لأنه عم نعمل Averaging ال periods وحم نأخذها نفس ال Weight و Moving لأنه عم ناخذ فترات متتالية وبتحرك فيهم مثلا "  $F_{t+1}$  أخنا لما قبلها وبتحركنا



# INVENTORY : MANAGEMENT



Inventory → الخزانة → the stock } To match related  
 Warehouse → مكان التخزين

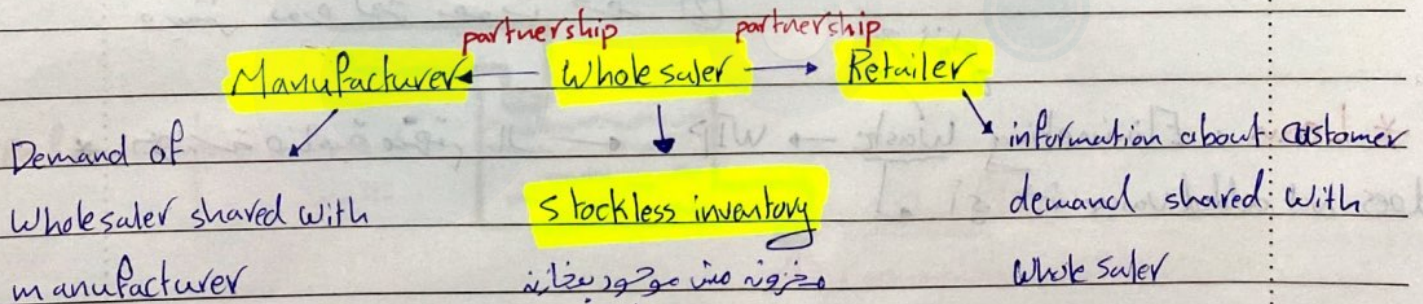
\* الفرق أميز بين inventory و warehouse لأنه :  
 - ال decisions في management ال inventory تختلف عن تحت ال warehouse  
 لها related لها

\* الأشياء التي يطلبها ال Customer و shipping يكونه التفاضل بين التاجر :

\* minimum delivery time      \* heighest quality      \* lowest Cost

حتى نحققها لازم يكونه ال inventory  
 لها أهمية ال inventory

\* لازم يكونه ال inventory في معلوم ال echelons حتى نفهمه أقل وقت توفيل .





\* متطلبات لازم نعرفها :

\* **Stock-Keeping-unit (SKU)**: any item has a unique code and stacked somewhere in the supply chain

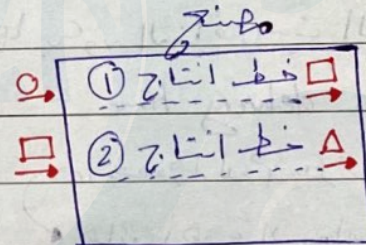
\* أنواع ال Inventory :

1] **Finished Goods Inventory**: ال SKU بتكون بصورتها النهائية يا بيع تكون  
تروح له next echelon

2] **Raw material Inventory**: ال SKU لها بنا فعل عليها processes لحتى نغير  
Finished goods

\* معنى نوع ال Inventory يكونوا بنفس العنصره عادي وممكن يكونوا متماثلين

3] **Work-in-process (WIP)**:



\* لما يكونه خط انتاج رقم 2 أبدأ من خط 1 راجع يتاخم على □□□ ويستمر دوره لحتى ينفوت خط 2

سبع أنواع

\* **Lean**: Eliminating Waste → WIP  
does Not added value أي



\* منحتي عنه ال Finished goods انما Independent demand  
SKU's

- يعني ال demand انما بشونه بيعته على ال Market انتم بده ولا بيعته على  
ال demand لغيره من ال SKU's condition

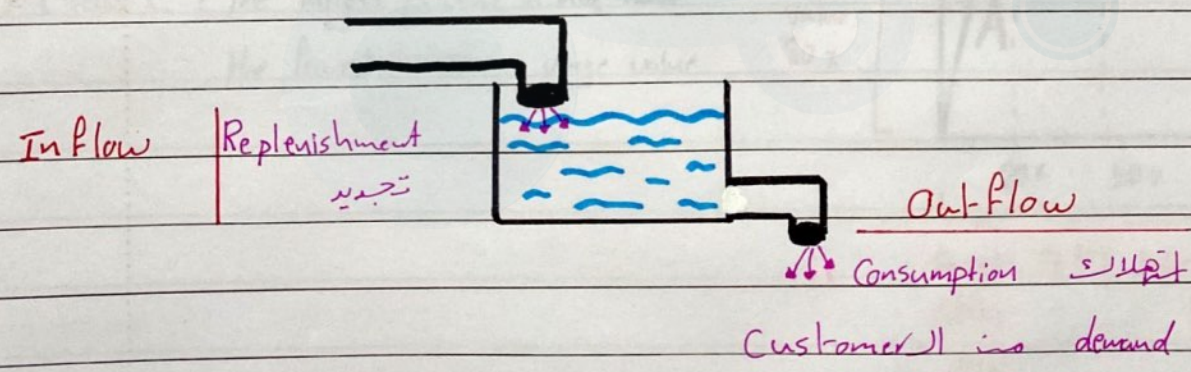
\* منحتي عنه ال Raw material انما Dependent Demand  
SKU's

- ال demand انما بيعته على ال demand ل another SKU's

\* لازم أميز بين ال Finished goods وال Raw material لأنه ال techniques  
المتبعة To manage ال Independent demand SKU's  
ال dependent demand SKU's

\* في ال Inventory كأنه Bath tub العي ال Inventory وال دخول  
كأنه Warehouse

\* الهدف من ال Inventory To supply the demand to customers





\* What is the decisions of Inventory Management?

1] How much to order?

قدريش افترج الصنفية؟

2] When to order?

كل قدريش افترج الصنفية؟

3] How often to review Inventory position?

كل قدريش افترج مستوى العري؟

## INVENTORY MANAGEMENT

Classification of SKU,

- ABC classification

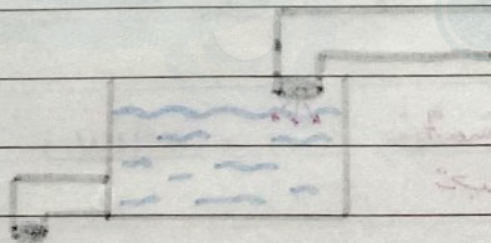
Choosing inventory Control system

وبناء عليه مزجود

- how much to order

- when ...

- how ...





\* Inventory management process

\* Inventory control approach

\* Classification of SKU, choosing inventory control approach

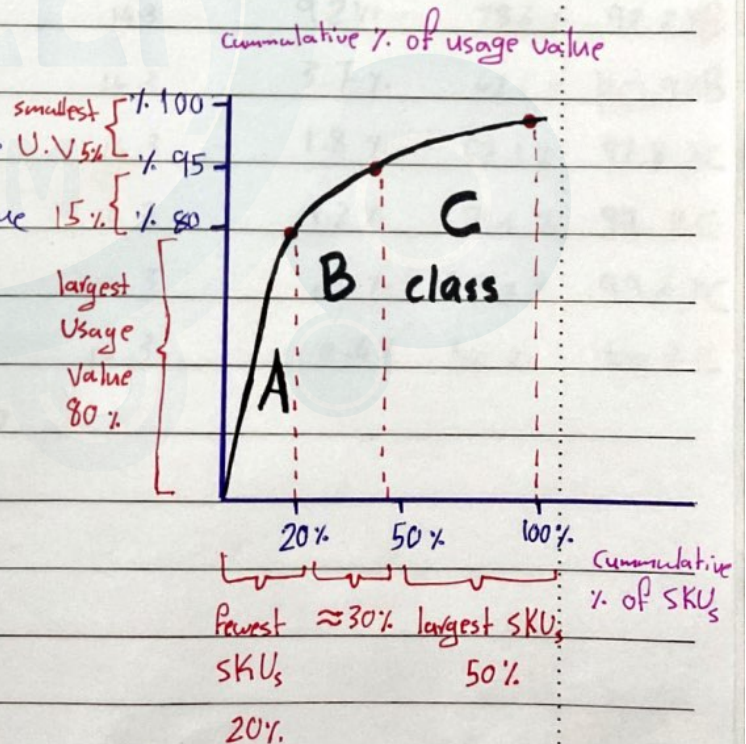
## ABC CLASSIFICATION

|           | Cost C  | Annual demand D | Usage Value (dollar usage) $C \times D$ |
|-----------|---------|-----------------|-----------------------------------------|
| product x | 1 \$    | 1000 000        | 1000 000 \$/Year                        |
| product y | 1000 \$ | 1               | 1000 \$/Year                            |

\* In ABC classification we will classify the SKUs into 3 class A, B, and C in terms of usage value.

\* class A : Few percent of SKUs that have the largest percent of usage value

\* class C : The largest Percent of SKUs have the fewest " " usage value



N O T E B O O K



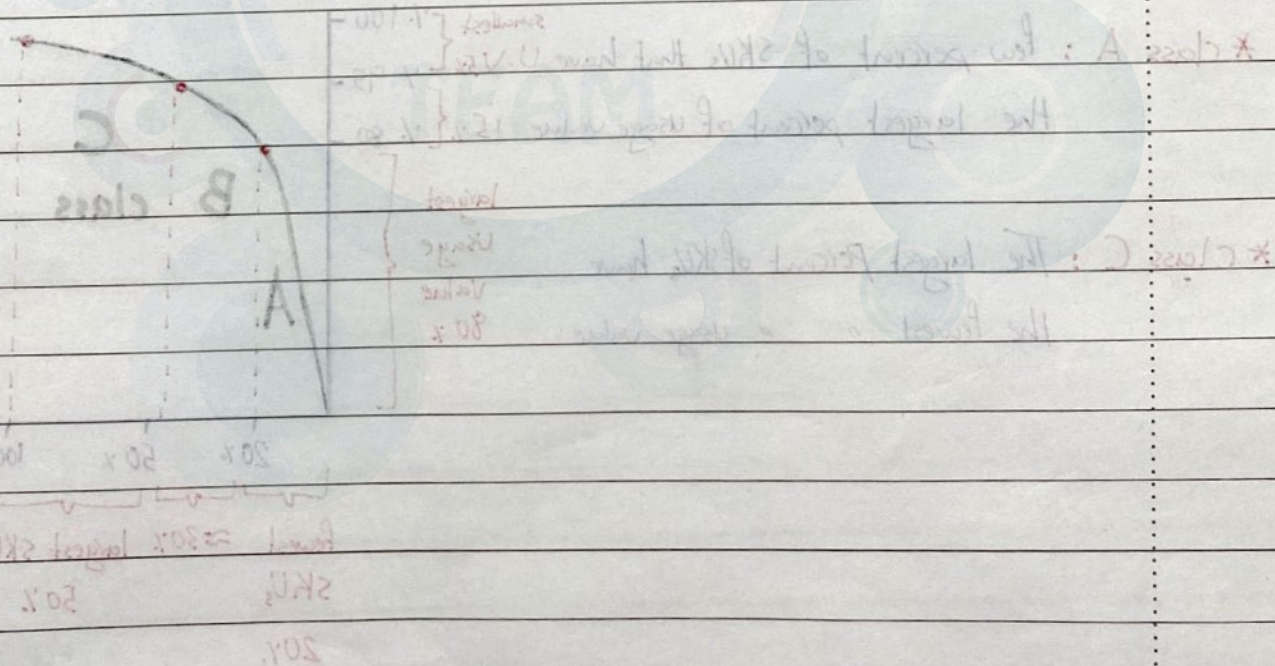
\* (80-20 Rule) (Pareto) → few → largest effect → critical  
many → small effect → trivial (useful)

\* تصنيف ال SKUs لـ ABC لمتى تعرف ايش ال SKUs ونقسم فيهم  
أكثر بياقي القارات المتعلقة بال Inventory management

\* لازم يكون عدد ال SKUs في A أقل من B أقل من C

| Product   | Cost (C) | Annual quantity (D) | Usage/Value (Dollars/yr) (C*D) |
|-----------|----------|---------------------|--------------------------------|
| Product X | \$1      | 1000                | 1000                           |
| Product Y | \$1000   | 1                   | 1000                           |

$A < B < C$





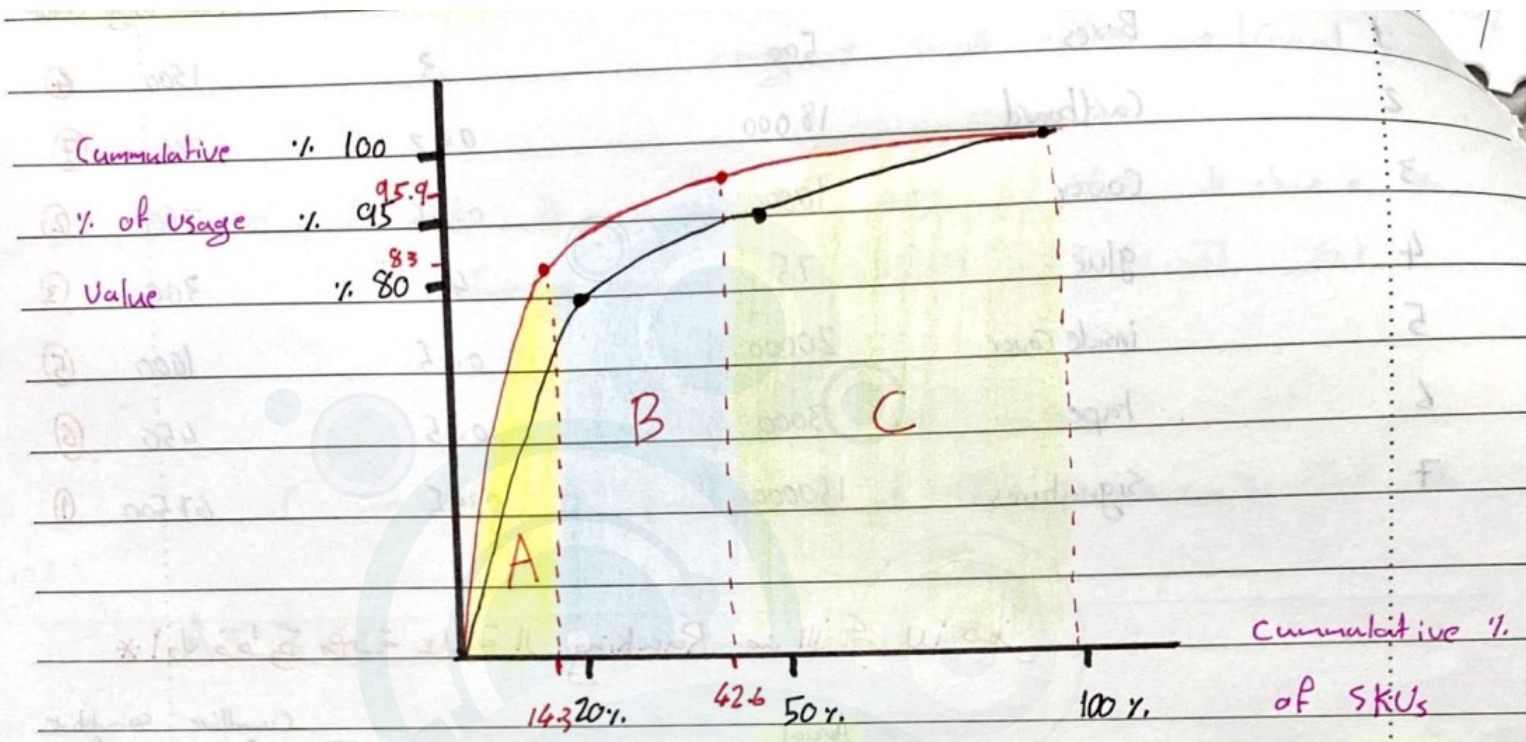
| SKU # | Description  | Quantity used/Year | Unit Value \$ | (Annual dollar usage)<br>Annual Usage Value |
|-------|--------------|--------------------|---------------|---------------------------------------------|
| 1     | Boxes        | 500                | 3             | 1500 (4)                                    |
| 2     | Cardboard    | 18000              | 0.02          | 360 (7)                                     |
| 3     | Cover        | 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)                                   |

\* أول خطوة مرتبة على الـ Ranking من الأكبر إلى الأصغر

| SKU # | Description  | Annual usage value | % of SKUs            | % of Usage Value     | Cumulative % of SKUs | Cumulative % of U.V |
|-------|--------------|--------------------|----------------------|----------------------|----------------------|---------------------|
| 7     | signatures   | 67500              | $\frac{1}{7} = 14.3$ | $67500/81310 = 83\%$ | 14.3 %               | 83% A               |
| 3     | cover        | 7500               | 14.3                 | 9.2 %                | 28.6 %               | 92.2 % B            |
| 4     | Glue         | 3000               | 14.3                 | 3.7 %                | 42.6 %               | 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 = 81310





\* في طرق ثانية لتقسيم الـ SKUs مثل  
 ABC من حيث criticality / slow fast



نقسم أنواع ال Cost لتكاليف متعلقة بال holding وتكاليف ال Replenishment  
 order setup

## INVENTORY COST

Inventory holding Cost

$H$ : unit holding cost \$/unit/year

Ordering/setup Cost

$S$ : \$/order

Cost of Capital

Storage and handling Cost

Taxes, insurance, shrinkage

\* التكلفة المرتبطة على فني

\* توفير مكان للتخزين / توفير

\* حساب ال Taxes  $\rightarrow$  as percent of unit cost

فرصة استثمار ال Capital

رفوف

\* تأمين ضد الحريق

في مجال ثاني وتجميعه

\* كل ما زاد ال unit cost يزيد

\* يجب ال insurance cost  $\rightarrow$  % of unit cost

على الرف بينا لو

الاهتمام بتوفير ظروف أفضل

استقرته كانه يجب

فيمرتفع هاي التكلفة

مرجع

\* عادة يتعلق بال unit cost

لحسابه

\* as percent of the unit cost منحصه

\* as percent of unit cost

\* كل ما زادت ال unit cost

يكونه ال Cost of capital

زاد

\* مفر عنه ال Holding cost ب \$/unit/year معناه حد المنتج الحصة الوحدة لو قدرت  
 سنة وحدة عايرى حالقه من الدولارات بتكلفنا

\* عادة منحصه ال  $H \leftarrow$  as a % of unit cost

مثلا قلم ال unit cost ال = \$10  $\leftarrow$  مفرح منحصه ال Cost تافه ومثلا طلع رقم

معنا نسبه بالنسبة ال unit cost 20% فنحاصل  $H = 20\%$  of unit cost



shrinkage

pilferage

(theft)

obsolescence

(out dated)

deterioration

(expired / damaged)

\* التكاليف المفقودة على سرقة

\* أشياء راحت موفتها فينظف

\* كلما كان ال unit cost

نسبة من العنونة

تبعها سعر أقل مثل تلفواك

\* كلما زاد ال Cost

\* كل ما كانت حالة Control

أدوى العنونة

\* كل ما عالت هاي التكاليف

\* أقل مقدار الربح عن العنونة

\* كلما زاد ال unit cost

بالوضع الطبيعي بسبب خلاص

\* بنيد هاي ال Cost

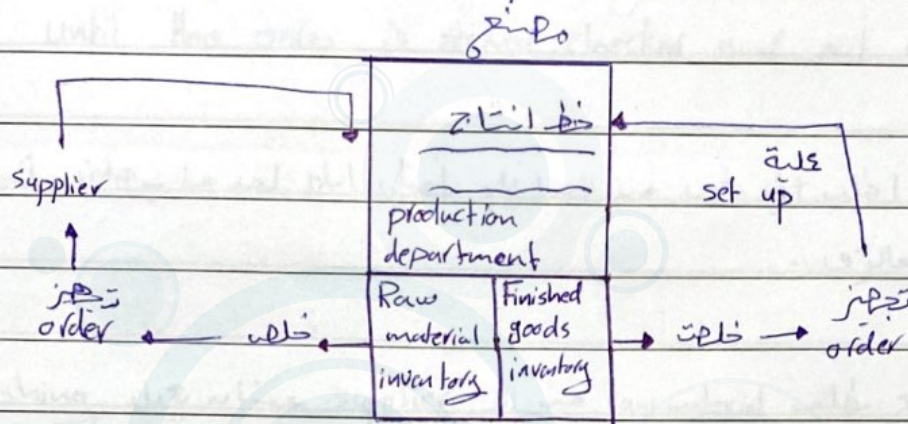
العنونة

\* يحسب ال % of unit cost

Total holding cost =  $H^*$  as average \* مع يكون في العنونة بالسنة



Replenishment (setup / order cost) :



\* Order cost : order الإرتبة كلفة الطلب : The cost related to Raw material  
 $S : \$ / \text{order}$  (Replenishing Raw material)

\* Setup cost : The cost of replenishing Finished goods  
 $S : \$ / \text{order}$

$$TP = OH + SR - BO$$

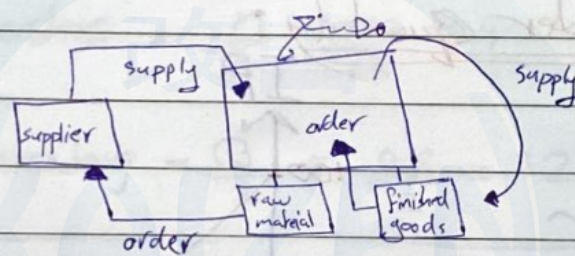


أو منتج

\* **lead time**: The time from the moment we send the order to (supplier) until this order is received, checked and put on shelves

\* الوقت من لما اطلب فيه معين من الجاي بالاضائي ايام اعد ما يوصلني وتيك عليه  
ويهر عندي عالف

\* ممكن المنتج يطلب raw material من supplier و line عمل replenishing  
و ينطلب من المنتج يوفر Goods Finished لا Warehouse



\* **Inventory position**: **On-hand** + **Scheduled receipt** - **Back Order**  

$$IP = OH + SR - BO$$

\* **On hand quantity** = الكمية الي موجودة عندي عالف لا Warehouse

\* **Scheduled receipt** = وصول الال Order و موجودين حالي بس لسا ما وصلت

\* **Back order** = معلقة من ال Customers و موجود الال confirmed و لسا لا لال الال

\* **Back order** لا Warehouse



## كيف أعرف كمية ال On-hand inventory

### Manually

يشوفكم عارف العترة  
يسألكم ربح يوناني  
يسألكم order مطلوب من  
ال Customer ولما ولما  
موافق عليه

### By using Technology

\* Barcodes

\* Scanning

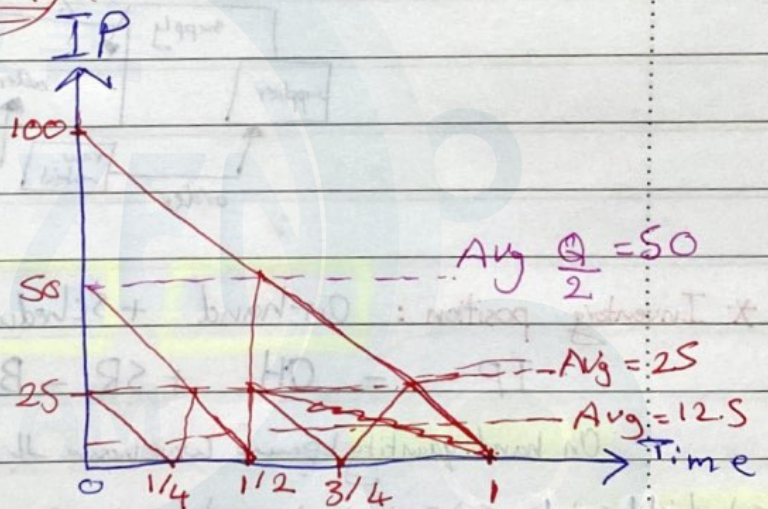
\* soft wave

$$IP = OH + SR - BO$$

### Economic order Quantity:

$D = \text{unit / year}$

$d = \text{unit / week}$   
month  
quarter  
day  
Shift



product X

$$D = 100$$

Case ①  $Q = 100$

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

$$\text{Avg. inventory} = \frac{Q}{2} = \frac{100}{2} = 50$$



$S$ : order cost \$/order

$H$ : unit holding cost \$/unit/year

Case (2)  $Q = 50$

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

$$\text{Avg. inventory} = \frac{Q}{2} = \frac{50}{2} = 25$$

Case (3)  $Q = 25$

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

$$\text{Avg. inventory} = \frac{Q}{2} = \frac{25}{2} = 12.5$$

Avg. inventory  $\leftarrow$  no. of orders  $\leftarrow$   $\frac{D}{Q}$   $\leftarrow$   $\frac{100}{Q}$   $\leftarrow$   $\frac{100}{25} = 4$



أنواع الـ Inventory

① Cycle inventory Cost

\* cycle inventory : الجزء من الـ inventory يزيد عن طريق Replenishment ويقل عن طريق الاستهلاك



② Pipe line inventory

الكمية التي لاسه عاي عن الطريق

③ Anticipation inventory



\* Total annual cycle inventory cost = التكلفة المترتبة على الاستهلاك

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

وإعادة التزويد

Annual holding cost + Annual ordering cost

↓  
Avg. cycle inventory \* H

↓  
# of ordering per year \* Ordering/setup cost

H : unit holding cost \$/unit/year

Avg. cycle inventory :  $\frac{Q}{2}$

Q : الكمية المطلوبة بكل اوريد

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

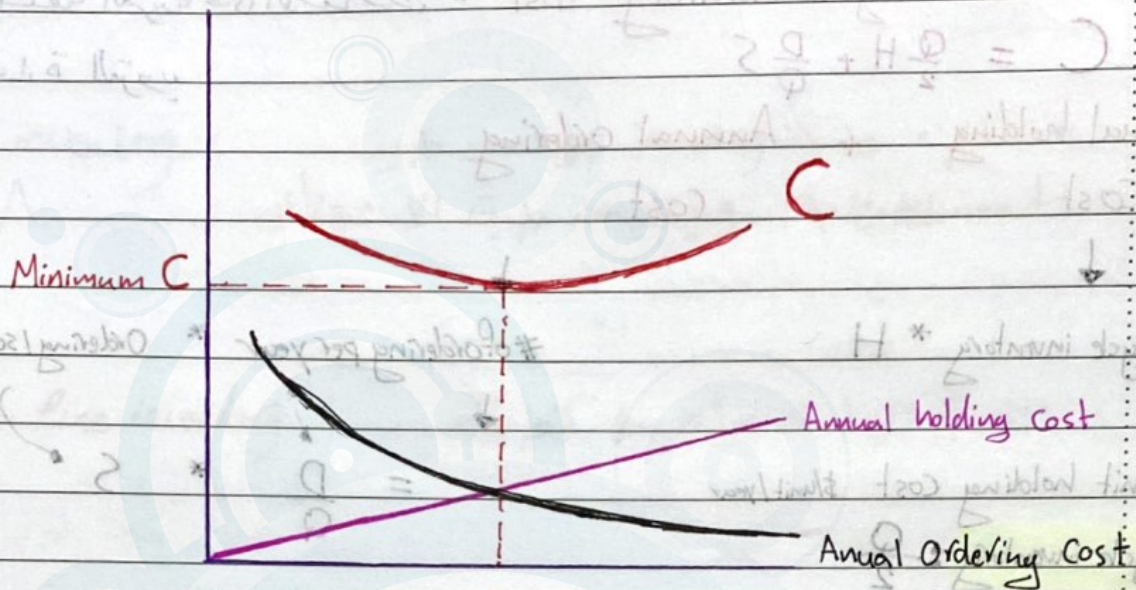
$$C = \frac{Q}{2} H + \frac{D}{Q} S$$

تناسب Q مع C طردياً  
Holding Cost

تناسب Q مع C عكسياً  
Ordering Cost

لو بدأ نرسم العلاقة :





قيمة  $Q$  التي تحقق أقل  $C$

وتمثل  $EOQ$  ← Economic Order quantity

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

\* كيف يمكننا حساب الوقت بين الطلب والطلب؟  
Time between Ordering

$$* TBO = \frac{Q}{D} \rightarrow \text{number of Orders}$$

$$\frac{Q}{D} \dots \text{(year)}$$

$$\frac{Q}{D} * 365 \dots \text{(days)}$$

$$\frac{Q}{D} * 52 \dots \text{(weeks)}$$

$$\frac{Q}{D} * 12 \dots \text{(months)}$$



\* Example: 52 weeks

SKU: bird feeder

d: 18 units / week

S: \$45 / order

unit cost: \$60 / unit

H: 25% of unit cost  $\rightarrow 0.25 * 60 = 15 \$ / \text{unit/year}$

$Q_{\text{currently}}$ : 390 unit

\*  $C_{\text{current}}$ : الحالي

\* EOQ

\*  $C_{\text{EOQ}}$

$$\rightarrow \text{solution} \rightarrow C_{\text{current}} = \frac{Q}{2} H + \frac{D}{Q} S = \frac{390}{2} * 15 + \frac{(18 * 52)}{390} * 45$$

$$= 3033 \$$$

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

$$= 76.94 \approx 75 \text{ unit}$$

$$C_{\text{EOQ}} = \frac{75 * 15}{2} + \frac{(18 * 52) * 45}{75}$$

$$= 1124 \$$$



## Inventory management

Choosing inventory control system

- How much to order?
- When to order?
- How often to review IP?

Independent demand SKU.

dependent demand SKU.

Traditional Control methods

materials requirement planning MRP

Continuous  
Review  
system

periodic  
Review  
system

Hybrid  
system

Optimal Replenishment

Base-stock system

1] Continuous Review System - ROP system - Q system - Fixed Order quantity system

Each Time we make a withdrawal → we check the inventory position.

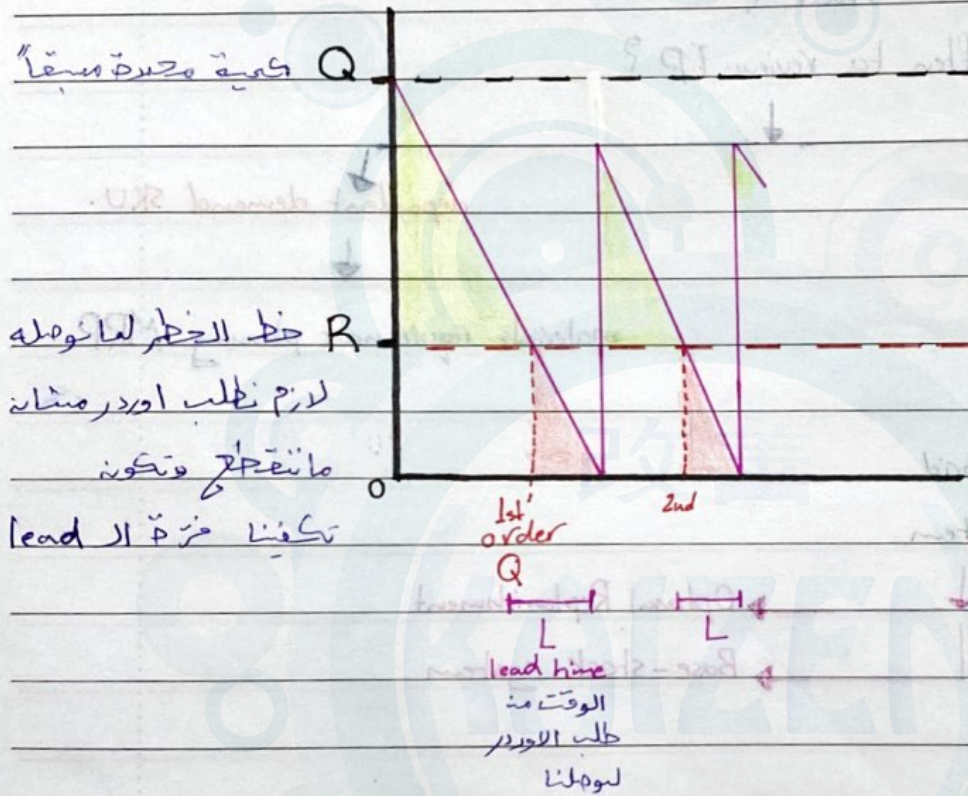
كل مرة بسحب من المخزن عني بحسب كم قل عني ومو في حالتها بسحب

[1] في حال كانه قليل عني مخزونه يساوي قيعه انا محسبها من قبل عني وكذا آخر

R لـ R ← يكون لازم اعل Order بقية Q و Q بتكون ثابتة



\*  $IP = OH + SR - BO$  :  $IP$  من قبل انه : بنا فترتها  $IP$  انه ما على  $SR$  ولا  $BO$  يعني ان  $IP$  مساوي  $OH$  فقط



\*  $R, Q, L$  :  $R$  : demand rate,  $Q$  : order quantity,  $L$  : lead time

1] How often check  $IP$ ? ... Continuously each time we make **Withdrawal**.

2] When to Order? ... When  $IP$  reach **R level**.

3] How much to Order? ... a fixed quantity **Q**



\* Now → How to choose ....

**Q Fixed quantity**

**EOQ**

Container  
size  
quantity

quantity  
selected

Discount price-Break quantity

\* نه لاجية

اقتصادية

\* مرات بكمية

Constrains

في EOQ لا يمكن

تأخذها قبل

الخزينة

By

\$ 20

management

\$ 18

\$ 15

price

80 100 120

price-break quantity

purchasing cost

100

120

\* لا يمكن طلب 120 بدل 100، فترية C

ونقل ال purchasing cost

\* في حال كان نقولانه في ال purchasing cost أكثر من الزيادة في C بأخذ 120 أذا

العكس بأخذ 100



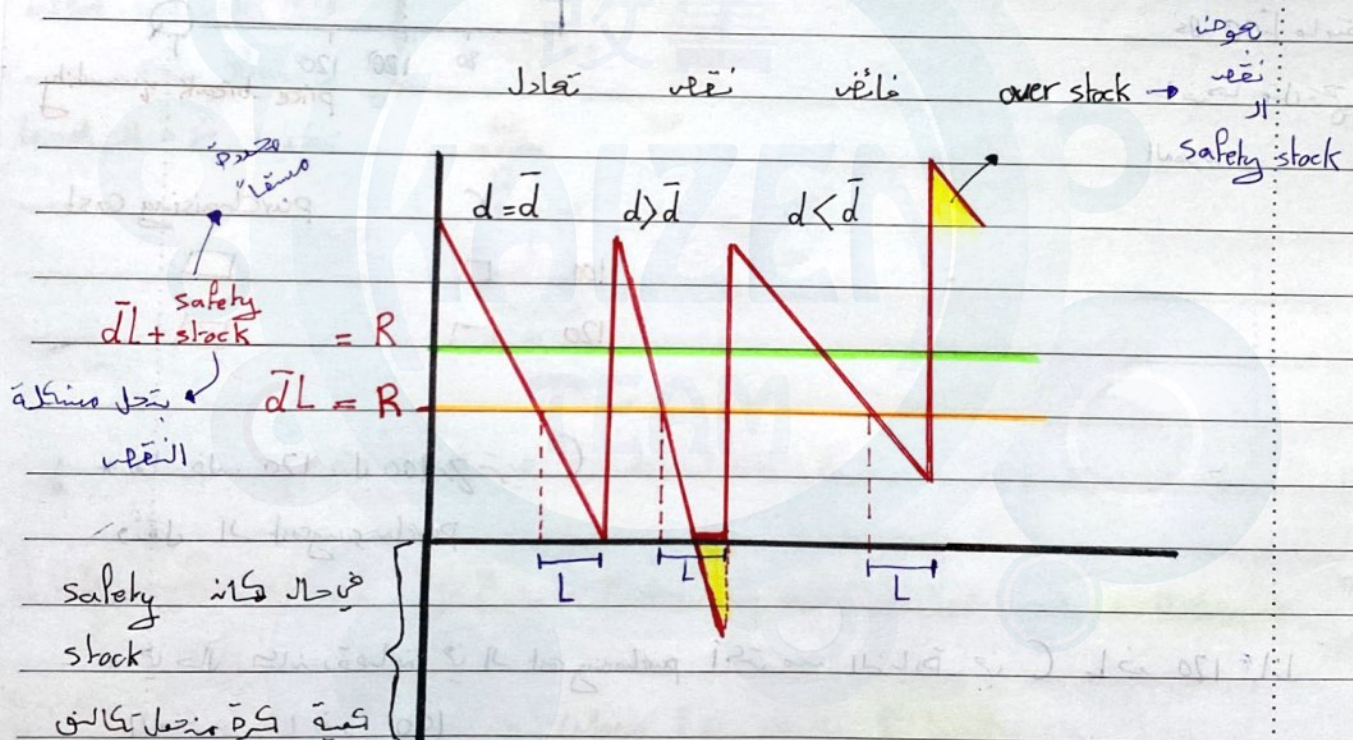
## How to choose... $R$

1] If Demand Constant (d) + lead time Constant (L)

$$R = dL$$

2] If Demand Variable + lead time Constant

\*  $\mu$  ist die Varianz,  $\sigma^2$  die Kovarianzmatrix



holding

اكثر

فلازم تعرف اسم نكوه



\* لازم نوازن ما بين اني اوفر عندي zero stock وبين تكاليف ال holding  
 ← safety stock ← service level

\* **Service level** : probability of having No stock out situation

100 % service level → يتطلب كمية جرد من ال safety stock وبالتالي  
 كمية تكاليف جرد ال holding

\* ممكن نزل نسبة ال service level على حسب الاشياء اذا كانت critical اولاً  
 اذا مستنصر مثلاً لازم 100 %

\* يسمى فترة ال lead time + protection interval لأنه في الفترة ياي ممكن  
 عندها stock out

$$R = \bar{d}L + \text{Safety stock} = \bar{d}L + Z * \sigma_d * \sqrt{L}$$

$$\text{Safety stock} = Z * \sigma_d \sqrt{L}$$

$Z$  : number of standard deviation needed to achieve the requirerment service level.

$$\sigma_{dLT} : \sigma_d * \sqrt{L}$$



Example: bird feeder,  $EOQ = 75$  unit,  $H = \$15$  /unit/year,  $S = \$45$  /order

suppose the avg demand 18 units/week  $\rightarrow \bar{d} = 18$  units/week

standard deviation 5 units...  $\rightarrow L = 2$  weeks,  $\sigma_d = 5$  units

$C, R, S.S \leftarrow 90\%$  service level (الطلب)

من جدول آيزنباي

$$* S.S = Z^* \sigma_{dLT} = \boxed{Z}^* \sigma_d * \sqrt{L} = 1.28 * 5 * \sqrt{2} = 9.05 \approx 9 \text{ units}$$

$$* R = \bar{d}L + S.S = 18 * 2 + 9 = 45 \text{ unit}$$

$$* C = \frac{Q}{2} H + \frac{D}{Q} S + S.S H = \frac{75}{2} 15 + \frac{(18 * 52) * 45}{75} + 9 * 15 = 1259 \$$$

..... الـ

Recently the OH = 60 units and NO SR or R BO, we make a withdrawal of 20 units. Is it time to order? How much?

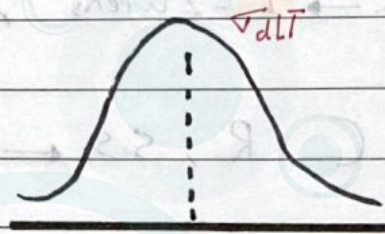
$$IP_{new} = (60 - 20) + 0 - 0 = 40 \rightarrow R = 45 \rightarrow \text{time to order} \rightarrow \text{order } Q$$

$$\rightarrow Q = 75 \text{ unit}$$



3] If Demand Variable  $[\bar{d}, \sigma_d]$  + lead time Variable  $[\bar{L}, \sigma_{LT}]$

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



\* distribution of demand during the lead time (protection interval)

$$z_{0.99} = 2.33 = \frac{R - \bar{d}\bar{L}}{\sigma_{dLT}} \Rightarrow R = \bar{d}\bar{L} + z_{0.99} \sigma_{dLT}$$

$$R = \bar{d}\bar{L} + z_{0.99} \sigma_{dLT}$$

$$z_{0.99} = 2.33 = \frac{R - \bar{d}\bar{L}}{\sigma_{dLT}} \Rightarrow R = \bar{d}\bar{L} + z_{0.99} \sigma_{dLT}$$

$z$  = no. of standard deviations needed to achieve required service level

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

\* Safety stock is the extra amount of inventory held to protect against uncertainty in demand during the lead time.

lead time demand



No.

Date

Date

No.

Subject

Example :  $\bar{d} = 12000 \text{ pen}$  $\sigma_d = 3000 \text{ pen}$  $Q = 156000 \text{ pen}$  $\bar{L} = 5 \text{ weeks}$  $\sigma_{LT} = 2 \text{ weeks}$ 

Service level = 95%.

الطلب  $R$  $Z = 1.65$  For 95% service level  $\rightarrow$  من الجدول

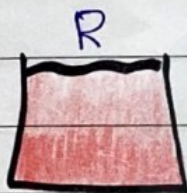
$$S.S = Z \sigma_{dLT} = Z * \sqrt{\bar{L} \sigma_d^2 + \bar{d}^2 \sigma_{LT}^2} = 1.65 * \sqrt{5 * 3000^2 + 12000^2 * 2^2}$$

$$= 4117.79 \approx 4118 \text{ pen}$$

$$R = \bar{d} \bar{L} + S.S = 12000 * 5 + 4118 = 101118 \text{ pens}$$

\* منقول فقط ال IP ! أو Manually أو By Technology أو بطريقة تالفة  
تسمى Visually يعني تشييد بالنظر لاحت عرف OH

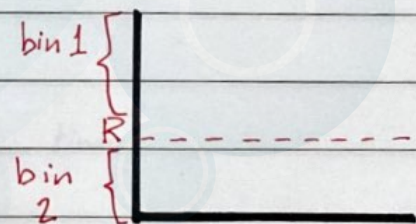
\* Visual Q system - (two-bin system)



bin 2



bin 1



بمجرد أن يمتلئ bin 1، آتخذ بغير مفرق طائر ب order لل supplier  
ولمجرد ما يجرى ال order يستخدم من bin 2 وفيه يوجد ب bin 2  
أول مرة في bin 1



## 2] Periodic Review System / Fixed-interval / Period Re-Order / P-System

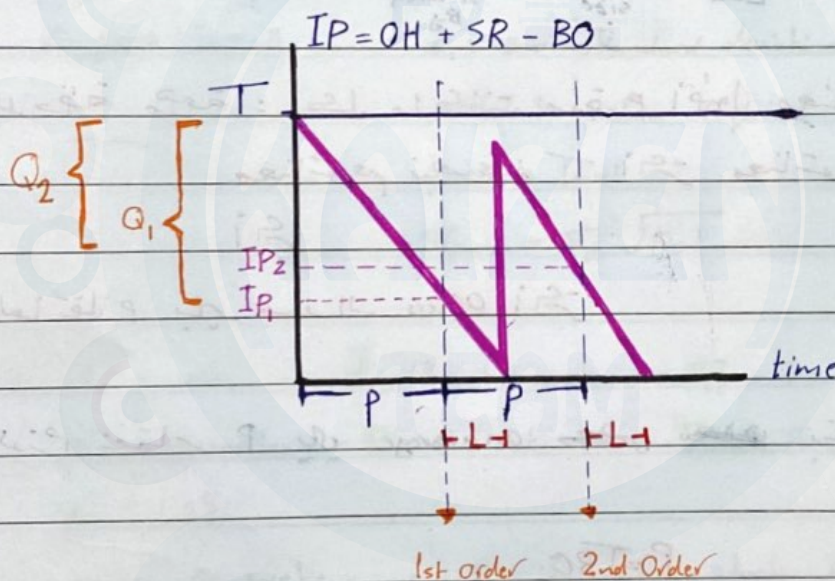
Re-Order system      system

\* الفكرة ← - بعد كل period "P" لنرجع أعمل check على الـ IP ونجيب  
أعمل Order يرجع على الـ Target level "T" ياكه اهلك  
بقيت فيه

- قيمة P و T ثابتة ونجيب من قبل

- مرج نفترض إنه الـ demand rate والـ lead time ثوابت Constants

وإنه لما الـ time يكون Zero يكون الـ  $IP = T$



So,

$$Q = T - IP_1 \quad Q = T - IP_2$$

- How often to review IP? Periodically at the end of each review period (P)
- When to Order? at the end of review period (P)
- How much to Order?  $Q = T - IP$



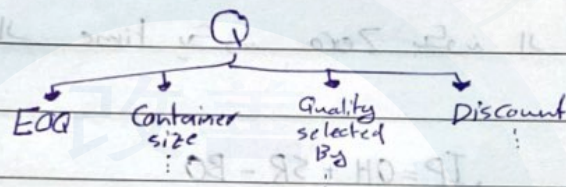
\*  $P = \text{Time between orders}$  ال

\*  $P$  بنا فرق على أي أساس من حيث كمية  $P$  و  $T$

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

$D$  و  $Q$  بتغير على  $P$

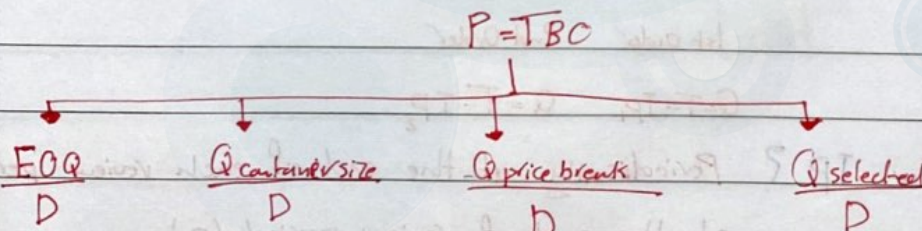
واحد قبل انه  $Q$  مقدارنا خدنا بالاعتبار على أي  $T$  من



\* ملاحظة مهمة: كل ما كانت مدة  $P$  أقول معناوعم نستطك أكثر  
معناوعم نبع كنز  $T$  أكثر معناوعم كمية  $Q$  يال مع نعلها

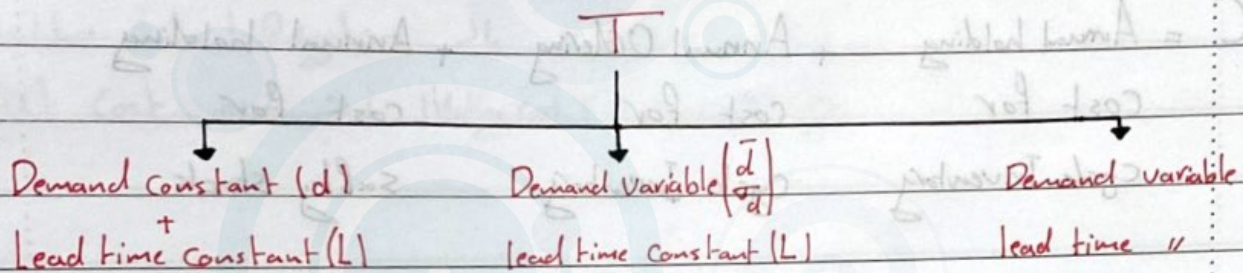
\* لما قلنا  $P$  بغير عدد ال Orders أكثر

\* لازم نقتار  $P$  يال on average  $Q$  يال بنا ال LPL





- \* لازم  $T$  تكون في الاصل خلال  $P$  وخلال ال lead time  
 \* تحدد  $T$  كل طبيعة ال demand في ال lead time و الفترة  $P$



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

\* لازم  $L$  و  $P$  يكونوا نفس

الوحدة (ايو، نمر، رسوم...)

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

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

$Z$  : # of standard deviations

needed to achieve required

service level

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

لأنه ال protection interval

بكرة لا نقدر نغيره انه

Normal dist.

Use simulation to estimate

the demand during  $P$ .

So as to use it to

select  $T$  under desired S.L

Example: 52 weeks -  $\bar{d} = 18$  units/week -  $\sigma_d = 5$  units -  $H = \$15$  /unit/year

$S = \$45$  /order -  $L = 2$  weeks -  $EOQ = 75$  units - 90% Service level

$$z = 1.28$$

Using P-system → what is safety stock / T / C

$$\text{Solution: } p = TBO = \frac{EOQ \times 52}{D} = \frac{75 \times 52}{118/(52)} = 4.2 \approx \boxed{4 \text{ weeks}}$$

$$S.S = Z \sigma_d \sqrt{P+L} = 1.28 \times 5 \times \sqrt{4+2} = 15.68 \approx \boxed{16 \text{ units}}$$



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

$$C = \begin{array}{c} \text{Annual holding} \\ \text{cost for} \\ \text{cycle Inventory} \end{array} + \begin{array}{c} \text{Annual Ordering} \\ \text{cost for} \\ \text{cycle Inventory} \end{array} + \begin{array}{c} \text{Annual holding} \\ \text{cost for} \\ \text{safety stock} \end{array}$$

$$= \frac{\bar{d} P H}{2} + \frac{D}{\bar{d} P} S + (S.S.)(H)$$

$$= \frac{18 \times 4 \times 15}{2} + \frac{18 \times 52 \times 45}{18 \times 4} + 16 \times 15$$

$$= 1365 \$$$

Now, it is the end of review period. The OH inventory is 45 and No SR, NBO, is it time to Order? and how much

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



\* ملاحظة مهمة ← ملاحظة انوار Cost لنفس الحالة والمعطيات في حال استخدام الـ P-system يطلع آخر من لو استخدمنا

الـ Q-system

السبب ← الـ protection Interval الـ P-system (P+L) اقول

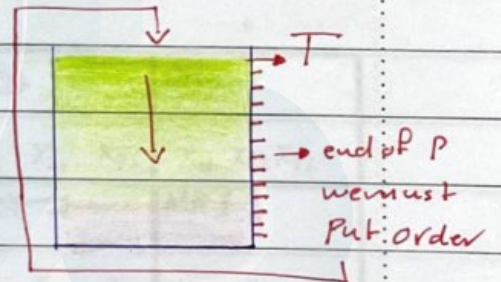
من الـ " " الـ Q-system (L) فالتالي

مع تقنية الـ Holding Cost S.S آخر فان Cost آخر

Now, How To check The IP in P-system?

- Manually → check OH, SR and BO
- By Technology → Scanners, barcoding and software
- Visually → Called One-bin system

\* لما نعلم مقدار مع الخازن أو السوائل  
لازم نستخدم P-system





## \*\* مقارنة بين Q-system Vs P-system \*\*

Q-system

P-system

- \* less cost
- \* Fixed Q (discount)
- يتم طلبهم للكمية الثابتة

- \* Ordering periodically → you can  
Combine orders → نقل ال  
Transportation Cost

- \* IP checked periodically → يتم إذا كان  
معدل مستوى ال IP عن طريقه ال Manually

|       |       |          |
|-------|-------|----------|
| $X_1$ | $X_5$ | $X_8$    |
| $X_2$ | $X_6$ | $X_9$    |
| $X_3$ | $X_7$ | $X_{10}$ |
| $X_4$ |       |          |

|                            |                            |
|----------------------------|----------------------------|
| X-Var                      | OR                         |
| $X_{11}$ $X_{21}$ $X_{31}$ | $X_{12}$ $X_{22}$ $X_{32}$ |
| Emergency                  | MRI                        |
| $X_{13}$ $X_{23}$ $X_{33}$ | $X_{14}$ $X_{24}$ $X_{34}$ |

\* في نظام كمية الأمانة كما ال Warehouse

تتميز وال IP وال Ordering

\* ما وراء كل ال Warehouse

- مثل ان طلب احسن Q-system

\* في حال كان  $X_7$  مثلا يطلب من نفس

ال supplier من نظام P-system

\* المسؤول عن تقدير IP غالباً العميل

\* يتم الاشارة العميل بالانوية ال IP

يعني مثل خايفنا كل ما يصعب ان

يقعدوا يحسبوا كل ال دهم راح

مثل ان طلب احسن P-system

\* في حال كان في item مهم وضروري لازم

نشير اننا من نظام Q-system

N O T E B O O K

لها ر ال item



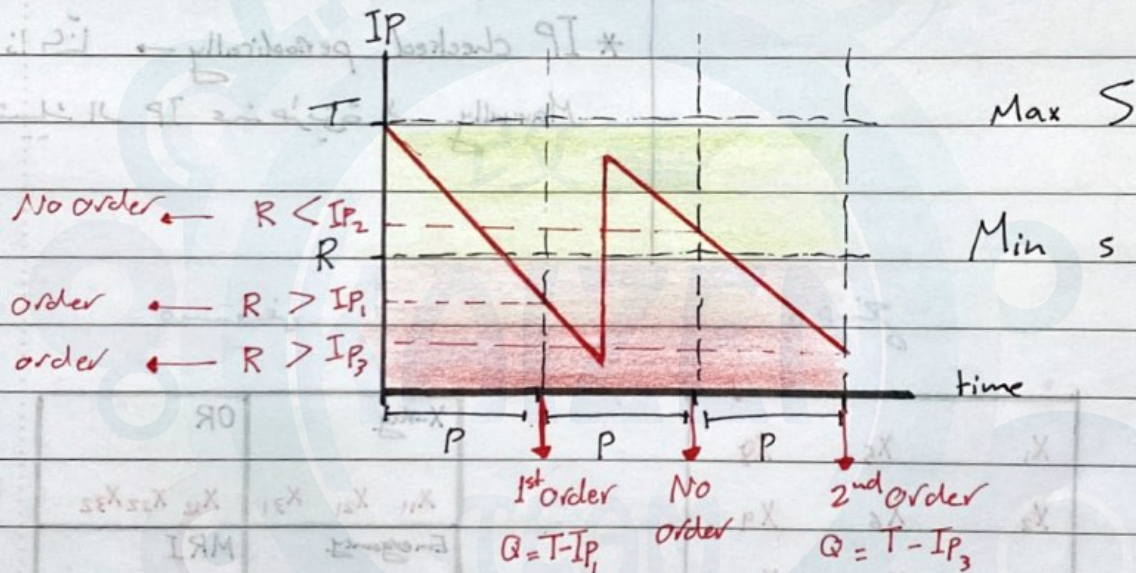
### 3] Hybrid system :

\* Optional replenishment (Max-Min system) (S.S system)

Simple & complex Q-systems are also in P-systems  $\downarrow$  PL \*

\* نهاية العمل  $x$  منسك على الـ  $JP$  من حال كان داخل قبة مصدرة قبل

all the microorganisms  $Q = T - IP$  and  $T$  is the order and  $R$  is the



\* ملاحظة مهمة : كونه ممكن يفرقنا وأكثر ما يدل Order ←

الـ protection interval يتكون من أطول سبب زيادة احتمالية

→ Stock out فلازم نزيد قيمة ال Safety Stock ←

low unit cost / Cheap items      هيا البضاعة المناسبة لـ



## \* Base-Stock system

\* النظام Q-system من حيث هو P-system بطريقة معينة

\* ال Target بالنسبة الى  $T=R$   $\leftarrow$   $R$  هو يتساوى  $R$

كمية بتكفي الاستهلاك خلال  $L$

\* يحاول تكون الكمية التي عندي أقل ما يمكنه عنده أقل ال Annual holding Cost

\* كل ما اذهب من  $IP$  جعل Order يتساوى القيمة التي سيجعلها  $Q$

\* هي الطريقة مناسبة للسلع الغالية High unit cost / expensive item



## EFFICIENT RESOURCE PLANNING :

\* مخطط حاد يندرج تحت إدارة المخزون Inventory management  $\rightarrow$  SKU dependent demand

\* في إطار إدارة Enterprise resource planning (ERP) يتم إتاحة مواد Materials requirement planning

\* هو عبارة عن Integrated information system يربط كل الـ Functions تحت المؤسسة مع بعض بحيث أي حركة لأي Function ينعكس في update كل الـ system مثله بالقياس إلى الـ Functions المعنية تكون على دراية بالتحركات التي تتم فقط

\* الهدف من الـ ERP  $\rightarrow$  يعمل كـ information  $\rightarrow$  streamlining وبالتالي تظهر القرارات نتائجها الإيجابية على معلومات حديثة مما يبرهن ذلك

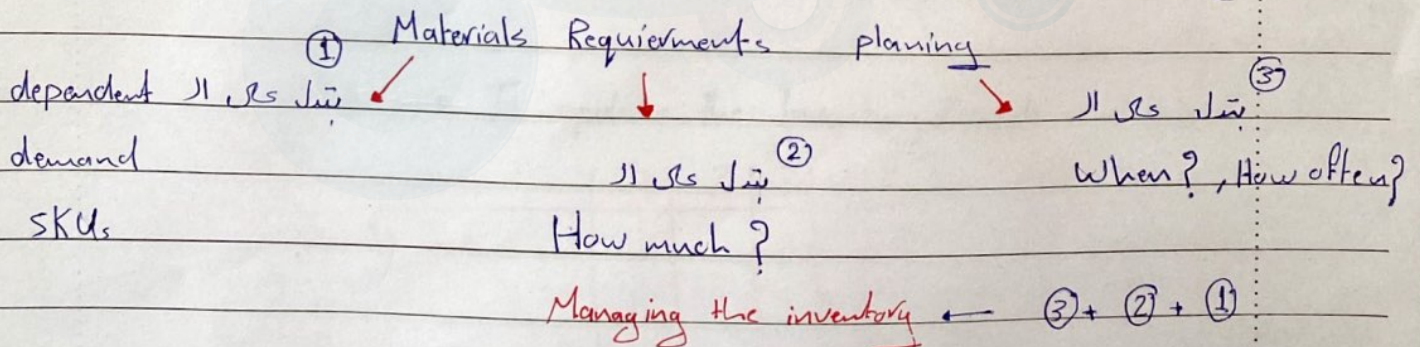
\* أن الـ ERP يتم زججه مع الـ MRP

## MATERIALS REQUIREMENTS PLANING (MRP)

\* عبارة عن Integrated / Computerized information system

\* الهدف منه  $\rightarrow$  To manage the inventory of dependent demand  $\rightarrow$  SKUs

\* مخطط يستخدم في إدارة informations تحت إدارة MRP explosion تحت إدارة الـ





|           | 1 | 2 | 3 | 4 | 5  | 6 |
|-----------|---|---|---|---|----|---|
| MPS start |   |   |   |   | 10 |   |

Authorized Master

For final product

For dependent

Production schedule

(independent demand sku)

demand sku,

Inventory  
TransactionInventory  
Records

MRP explosion

Bills of  
materialsEngineering  
and  
process  
design

1 - 0 - 2 - 2

Material requirements  
planning

2 1 2

MRP also find out how much? when? time

\* Bills of materials → Graph show you the main components and sub components of the final product and the quantity relationship

\* Authorized master production schedule → show you what you will produce of final product in the coming period (when + how much)

\* Inventory Records → What the value of OH, SR, BO, lead time, ordering policy

\* Inventory Transaction → To update the Inventory Records and keep it updated

| Weeks              | 1 | 2 | 3  | 4 | 5  |
|--------------------|---|---|----|---|----|
| Gross requirements |   |   |    |   | 20 |
| When? How much?    |   |   | 15 |   |    |

OH: 5

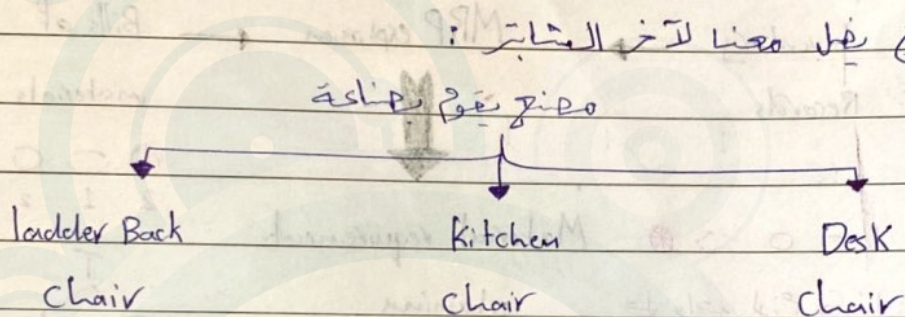
LT: 2 weeks

 $20 - 5 = 15$ 

N O T E B O O K



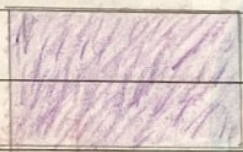
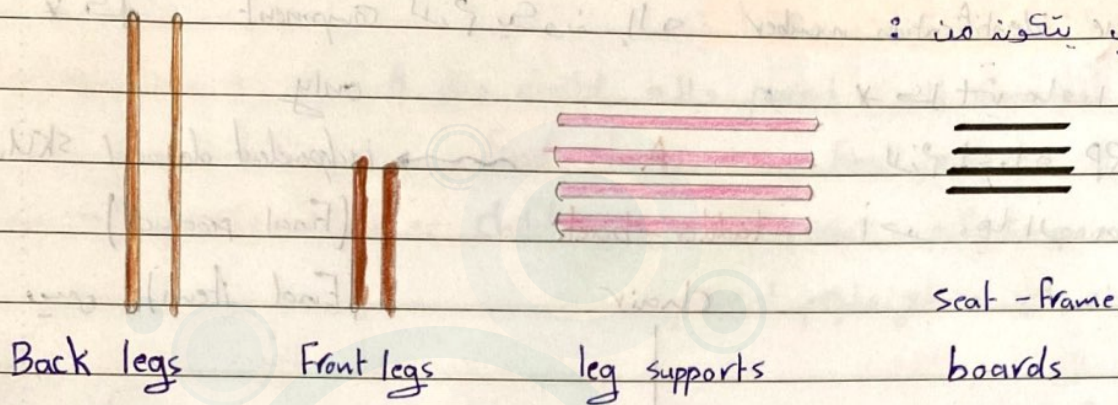
1] Bills of materials : graph that shows the main components and sub components of the final product also the quantity relationship between the parent and child independent demand ← Final product  $\leftarrow$  sku<sub>s</sub> Bills of materials



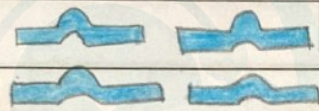
\* آخر تعديل ال Bills of material معينا لآخر تعديل ال Final product design



\* کرسی بنساخته می شود :



Seat cushion

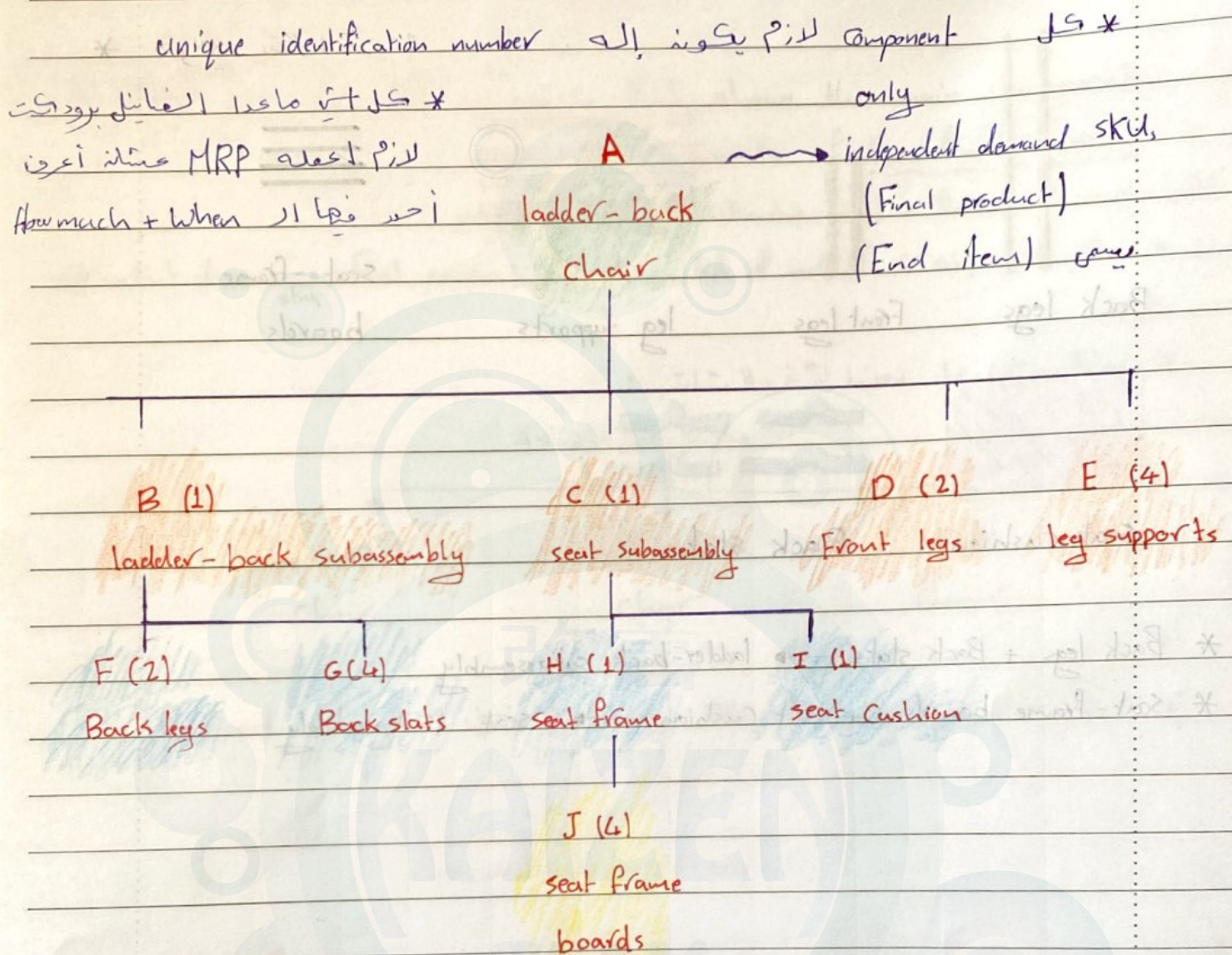


Back slats

\* Back legs + Back slats → ladder-back subassembly

\* Seat-frame boards + seat cushion → seat subassembly





● Level 0      ● Level 1      ● Level 2      ● Level 3

A, B, C, D, E, F, G, H, I and J  $\rightarrow$  Identification numbers

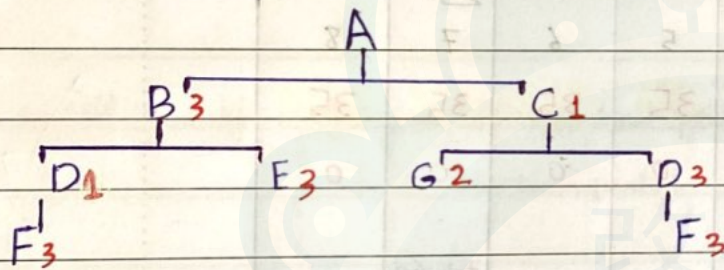
A, B, C and H  $\rightarrow$  parents  $\rightarrow$  components  $\rightarrow$  child  $\rightarrow$  parent



## \* معلومات و مسقيات بتقينا :

- أي component إلى parent وإلى child مثل H, C, B Intermediate items
- أي إلى Final product End item
- أي component إلى parent وإلى child purchased items لأنه من خارج

\* Example → We need to produce 5 A, How much we need of other items?



\* أول خطوة لازم أعرف ال Gross requirements

الـ Components أحسن كم بي فيه

Gross requirements → المطلوب الإجمالي

A = 5 quantity relation ship between A and B

$$B = 5 * 3 = 15$$

$$C = 5 * 1 = 5$$

$$D = \underbrace{1 * 15}_B + \underbrace{3 * 5}_C = 30$$

$$E = 3 * 15 = 45$$

$$F = 3 * 30 = 90$$

$$G = 2 * 5 = 10$$



## 2] Master Production Schedule :

- \* Tell us how much and when to produce from the final product at the coming period

كمية الإنتاج ووقت الإنتاج shortage ليس له

Item: ladder back chair

order policy : 150 units

lead time : 1 week

|                          | April |                                   |        |    |    | May |                                 |    |
|--------------------------|-------|-----------------------------------|--------|----|----|-----|---------------------------------|----|
| * OH → 55                | 1     | 2                                 | 3      | 4  | 5  | 6   | 7                               | 8  |
| * Forecast               | 30    | 30                                | 30     | 30 | 35 | 35  | 35                              | 35 |
| * Customer orders booked | 38    | 27                                | 24     | 8  | 0  | 0   | 0                               | 0  |
| * projected OH inventory | 55-38 | 17-30-13<br>shortage<br>150+17-30 | 137-30 |    |    |     | 7-35-28<br>shortage<br>7+150-35 |    |
| * MPS quantity           | 0     | 150                               | 0      | 0  | 0  | 0   | 150                             | 0  |
| * MPS start              | 150   |                                   |        |    |    | 150 |                                 |    |
| * Available - to -       | 5-38  | 150-27-26<br>-8-0-0               |        |    |    |     | 150-0-0                         |    |
| Promise (ATP) inventory  | 17    | 91                                |        |    |    |     | 150                             |    |

إذا احتاج  
طلب إقلا أو يساوي

\* الكمية التي يتوقع عني وقدر أودع فيها الزبائن بعد ما أرسلت  
\* من نحب منها لازم نغوي نعمل إيديت

\* من نحب من ال MPS لازم نعمله Freezing (يعني لا يغير بعد ال)

Authorized Master production schedule



\* **Item:** تعريف مادة ال MPS لذي item تابع / اتم ال item

\* **Order policy:** The quantity needed to be produced from final product to overcome the shortage

\* **Lead time:** Amount of time from the moment we put the order until this product is on shelf

\* **OH quantity:** الكمية التي علينا اياها من ال Final product قبل ان ياتي  
اول تبويع من الفترة التي هي قبل ال MPS schedule

\* **Forecast:** The predicted demand in the coming period

\* **Customer orders booked:** الكميات المطلوبة منه الزبونه وموافق عليها خلال الفترة التي هي ميعت فيها

\* **projected OH inventory:** كم متوقع يكون لنا OH في نهاية كل تبويع  
↓  
ما نلتي ال demand سواء كان ال demand حاسر كانه  
Forecast او Customer Orders booked  
منه هو ميزون لنا shortage

\* **MPS quantity:** كمية مطلوبة لدرت نغطي ال shortage الذي هو

\* **MPS start:** بتوطينا من لازم نبلش بتببيع ال MPS quantity الذي يكون قبل  
ال lead time



### 3] How we use the Inventory record in MRP :

MRP : Material requirement plan : خطة تخطيط متطلبات المواد (when how much) dependent demand SKU

Inventory records : سجلات المخزون MRP : خطة متطلبات المواد

MRP for item C seat subassembly

Item: C → ladderback Kitchen  
parents 2

Description: Seat subassembly

lot size: FOQ = 230

lead time: 2 weeks

When ever there is shortage order 230

OH = 37

week Safety stock: zero

Gross requirements

Scheduled Receipts

Projected OH

inventory 37

planned receipts

planned order

releases \*

| week                                                                   | 1              | 2   | 3   | 4                          | 5   | 6       | 7                          | 8   |
|------------------------------------------------------------------------|----------------|-----|-----|----------------------------|-----|---------|----------------------------|-----|
| Gross requirements                                                     | 150            |     |     | 120                        |     | 150     | 120                        |     |
| Scheduled Receipts                                                     | 230            | 0   | 0   | 0                          | 0   | 0       | 0                          | 0   |
| Projected OH                                                           | 230+37<br>-150 |     |     | 117-120<br>=-3<br>shortage |     | 227-150 | 77-120<br>=-43<br>shortage |     |
| inventory <span style="border: 1px solid red; padding: 2px;">37</span> | 117            | 117 | 117 | 230+117<br>-120<br>227     | 227 | 77      | 187                        | 187 |
| planned receipts                                                       | 0              | 0   | 0   | 230                        | 0   | 0       | 230                        | 0   |
| planned order releases *                                               |                | 230 |     |                            | 230 |         |                            |     |

tell us  
When  
+  
How much

Current OH, Gross requirements, Scheduled Receipts, lot size, lead time

Inventory record



- \* **lot size** : period أي shortage لما نقص انه في
- 1- Fixed Order quantity  $Q$  (FOQ) : lot size
  - 2- periodic Order quantity
  - 3- Lot for lot (L4L)

- \* نحتاج أعرف شو بيدي أدينج منه **item C** (when + HM) لازم أعرف : **lot size**
- [1] شو ال parents لل لولاء **Bills of material** من ال
- [2] كم وقع بيدي أدينج منه وصول ال parents من **parent MPS start**
- [3] شو العلاقة بين ال parent وال child يعني كم بيدي منه C حة ادينج A أو B
- مثالنا اقدر احدد ال **Gross requirement**

\* ال **MRP** من غير انه عن shortage لما يبر الا في أقل منه ال **Safety stock**



Now: MRP with FOG for item A:

|                        |                          |    |    |    |    |    |    |    |    |    |
|------------------------|--------------------------|----|----|----|----|----|----|----|----|----|
| item A                 | lot Size: FOG = 80 units |    |    |    |    |    |    |    |    |    |
| description            | lead time: 1 week        |    |    |    |    |    |    |    |    |    |
|                        | S.S = zero               |    |    |    |    |    |    |    |    |    |
|                        | 31                       | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| Gross Requirement      |                          | 60 |    | 25 |    | 35 |    | 45 |    | 60 |
| Scheduled Receipts     |                          |    |    |    |    |    |    |    |    |    |
| Projected OH           | 0                        | 20 | 20 | 75 | 75 | 40 | 40 | 75 | 75 | 15 |
| planned Receipts       | 0                        | 80 | 0  | 80 | 0  | 0  | 0  | 80 | 0  | 0  |
| planned Order releases | 80                       |    | 80 |    |    |    | 80 |    |    |    |

FOG →

Q = shortage time to lead

Remnant →

Holding cost

Order is the demand

S.S is the safety stock

Ordering cost is the cost of placing an order



Now: MRP for item A with POQ lot size:

|                        |                    |    |    |    |    |    |    |    |    |    |
|------------------------|--------------------|----|----|----|----|----|----|----|----|----|
| Item A                 | lot size POQ (P=4) |    |    |    |    |    |    |    |    |    |
| Description            | lead time 1 week   |    |    |    |    |    |    |    |    |    |
|                        | S.S = zero         |    |    |    |    |    |    |    |    |    |
|                        | 31                 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| Gross requirement      |                    | 60 |    | 25 |    | 35 |    | 45 |    | 60 |
| Scheduled receipt      |                    |    |    |    |    |    |    |    |    |    |
| projected OH           | 0                  | 25 | 25 | 0  | 0  | 45 | 45 | 0  | 0  | 0  |
| planned receipts       | 0                  | 85 | 0  | 0  | 0  | 80 | 0  | 0  | 0  | 60 |
| planned order releases | 85                 |    |    |    | 80 |    |    |    | 60 |    |

$$Q = 80$$

$$\begin{aligned} \text{Avg} &= 60 \\ D &= 138 \\ \text{Per week} &= 138 \\ &= 138 \\ &= 138 \\ &= 138 \end{aligned}$$

$$= 22.5$$

$$\begin{aligned} \text{TBO} &= 80 \div 52 \\ &= 1.54 \\ &= 1.54 \approx 2 \end{aligned}$$

$$P =$$

$$=$$

$$S.S$$

when  
+  
HM

$$P = \text{TBO at suitable } Q = \frac{Q}{D} \rightarrow \text{Avg demand per week} \times 52$$

POQ : shortage في كل فترة من P periods  
shortage في كل فترة من P periods

POQ : Matching مع Requirements مع demand بالزمن وبالتالي  
في نهاية P من ال periods قيمة projected OH لازم نغير مساوي قيمة S.S  
لأنه مع طلب كل ال



Now: MRP for item A with lot size L4L:

|                                                                               |                         |    |    |    |    |    |    |    |    |    |
|-------------------------------------------------------------------------------|-------------------------|----|----|----|----|----|----|----|----|----|
| item <b>A</b>                                                                 | lot size <b>L4L</b>     |    |    |    |    |    |    |    |    |    |
| description                                                                   | lead time <b>1 week</b> |    |    |    |    |    |    |    |    |    |
|                                                                               | S.S = zero              |    |    |    |    |    |    |    |    |    |
|                                                                               | 31                      | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| Gross Requirement                                                             |                         | 60 |    | 25 |    | 35 |    | 45 |    | 60 |
| Scheduled Receipts                                                            |                         |    |    |    |    |    |    |    |    |    |
| projected onh <span style="border: 1px solid black; padding: 0 2px;">0</span> | 0                       | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |
| planned Receipts                                                              | 0                       | 60 | 0  | 25 | 0  | 35 | 0  | 45 | 0  | 60 |
| planned order releases                                                        | 60                      |    | 25 |    | 35 |    | 45 |    | 60 |    |

**L4L** →

(P=1) ← POQ

shortage is 1 period

projected onh

S.S

Matching requirement with demand



### \* معيّنات و سلیبیت : F.O.Q

- وجود ال  $\text{reminant}$  و  $\text{حاجات}$  سلیبیت  $\leftarrow$  تحقّق تکالیف ال  $\text{Holding cost}$
- وجود ال  $\text{reminant}$  و  $\text{حاجات}$  ایجابی  $\leftarrow$  تعیل کبیل ال  $\text{Safety stock}$  (سّور امان)
- کل ما زدا ال  $\text{F.O.Q}$   $\leftarrow$  بزیر ال  $\text{TBO}$   $\leftarrow$  بقل ال  $\text{no. of orders}$   $\leftarrow$  بقل ال

Annual  
ordering  
Cost

کل ما زدا ال  $\text{F.O.Q}$   $\leftarrow$  زار ال  $\text{Avg inventory}$   $\leftarrow$  زار ال  $\text{Holding Cost}$

$\text{F.O.Q} \uparrow \rightsquigarrow \text{Holding Cost} \uparrow \rightsquigarrow \text{Ordering Cost} \downarrow$   
 زار                      زار                      قل

Conclusion  $\rightarrow$  مناسب ال  $\text{SKU}$  (cheap - low unit cost)

$$\text{Holding Cost} = \text{Avg inventory} * H \rightsquigarrow \left( \frac{0+20+20+75+75+40+40+75+75+15}{10} \right) * H$$

$$\text{Ordering Cost} = \text{no. of orders} * S \rightsquigarrow 3 * S$$

### \* معيّنات و سلیبیت : L4L

- وجود  $\text{Matching}$  دائم بین ال  $\text{requirement}$  و ال  $\text{planned receipts}$  (demand)
- تکالیف ال  $\text{Holding}$  فقط ال  $\text{safety stock}$   $\leftarrow$   $\text{Holding Cost}$  قلی
- $\text{no. of orders}$  غیر لایسای تکالیف ال  $\text{Ordering Cost}$  سیر

Conclusion  $\rightarrow$  مناسب ال  $\text{expensive SKU}$

$$\text{Holding Cost} = 0 * H = \text{Zero}$$

$$\text{Ordering Cost} = 5 * S = 5S$$



Safe

\* معيرات و سليات POQ : : EoD , اوقات و تاريخات \*

FOQ  $\leq$  ordering cost  $\leq$  L4L

$L\&L < \text{Holding Cost} < \text{FOQ}$

- Lo هي على remnant ← تحالف Holding أقل ← عدم وجود سلع أو خدمات S.S

Matching - دائم بين ال requirement و ال demand

Conclusion  $\rightarrow$   $14L$  اور  $FOQ$  میں

Holding Cost = Avg inventory \* H  
Ordering Cost = No. of orders \* Z

\* *anythin' possible* : *hell* :

Ordering Cost =  $F_0 \times 2 = 25$   
Holding Cost =  $0 \times 11 = 5.50$



\* مثال في حال وجود قيمة أكبر من Zero و Safety stock

Item : A

lot size: POQ (P=4)

Description :

Lead time: 1 week

Safety stock = 20

Gross requirements

scheduled receipts

Projected OH inventory

Planned receipts

Planned Order releases

|                        | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|------------------------|----|----|----|----|----|----|----|----|----|----|
| Gross requirements     |    | 60 |    | 25 |    | 35 |    | 45 |    | 60 |
| scheduled receipts     |    |    |    |    |    |    |    |    |    |    |
| Projected OH inventory | 20 | 45 | 45 | 20 | 20 | 65 | 65 | 20 | 20 |    |
| Planned receipts       | 0  | 85 | 0  | 0  | 0  | 80 | 0  | 0  | 0  |    |
| Planned Order releases | 85 |    |    |    | 80 |    |    |    |    |    |

نهاية P=4  
لزم يكون  
ال OH  
يساوي  
قيمة S.S

\* مثال في حالة وجود OH قبلها أكبر من S.S عند إنشاء POQ

Item : C

lot size: POQ (3=P)

Description: Seat subassembly

Lead time: 2 weeks

Safety stock = zero

Gross requirements

scheduled receipts

Projected OH inventory

Planned receipts

Planned Order releases

|                        | 31  | 32  | 33  | 34  | 35  | 36  | 37  | 38 | 39 | 40 |
|------------------------|-----|-----|-----|-----|-----|-----|-----|----|----|----|
| Gross requirements     | 150 |     |     | 120 |     | 150 | 120 |    |    |    |
| scheduled receipts     | 230 |     |     |     |     |     |     |    |    |    |
| Projected OH inventory | 117 | 117 | 117 | 150 | 150 | 0   | 0   | 0  | 0  | 0  |
| Planned receipts       | 0   | 0   | 0   | 153 | 0   | 0   | 120 | 0  | 0  | 0  |
| Planned Order releases |     | 153 |     |     | 120 |     |     |    |    |    |

نهاية P=3  
OH = S.S  
= zero

لزم نطلب قيمة ترجعنا ال S.S نهاية P  
مثال ذلك نقول ال 117  
→ To match order with demand



\* مثال في حال وجود OH قبله في S.S. مع اختيار ال 144 :

|                                      |                     |     |     |     |     |     |     |   |
|--------------------------------------|---------------------|-----|-----|-----|-----|-----|-----|---|
| item : C                             | lot size : 144      |     |     |     |     |     |     |   |
| description : seat subassembly       | lead time : 2 weeks |     |     |     |     |     |     |   |
|                                      | S.S = zero          |     |     |     |     |     |     |   |
|                                      | 1                   | 2   | 3   | 4   | 5   | 6   | 7   | 8 |
| Gross requirements                   | 150                 |     |     | 120 |     | 150 | 120 |   |
| scheduled Receipts                   | 230                 |     |     |     |     |     |     |   |
| projected OH inventory <sup>37</sup> | 117                 | 117 | 117 | 0   | 0   | 0   | 0   | 0 |
| planned Receipts                     | 0                   | 0   | 0   | 3   | 0   | 150 | 120 | 0 |
| planned Order Receipts               |                     | 3   |     | 150 | 120 |     |     |   |

→ To match the demand with order

|                                      |                     |     |     |     |     |     |     |   |
|--------------------------------------|---------------------|-----|-----|-----|-----|-----|-----|---|
| item : C                             | lot size : 144      |     |     |     |     |     |     |   |
| description : seat subassembly       | lead time : 2 weeks |     |     |     |     |     |     |   |
|                                      | 1                   | 2   | 3   | 4   | 5   | 6   | 7   | 8 |
| Gross requirements                   | 150                 |     |     | 120 |     | 150 | 120 |   |
| scheduled Receipts                   | 230                 |     |     |     |     |     |     |   |
| projected OH inventory <sup>37</sup> | 117                 | 117 | 117 | 0   | 0   | 0   | 0   | 0 |
| planned Receipts                     | 0                   | 0   | 0   | 3   | 0   | 150 | 120 | 0 |
| planned Order Receipts               |                     | 3   |     | 150 | 120 |     |     |   |



\* مثال في حالة استخدام POQ وجود S.S أكبر من Zero وجود OH صافي :

|                                                                                     |                     |     |     |                                  |     |     |     |    |
|-------------------------------------------------------------------------------------|---------------------|-----|-----|----------------------------------|-----|-----|-----|----|
| Item : C                                                                            | lot size : POQ P=3  |     |     |                                  |     |     |     |    |
| Description: seat subassembly                                                       | lead time : 2 weeks |     |     |                                  |     |     |     |    |
|                                                                                     | S.S = 80            |     |     |                                  |     |     |     |    |
|                                                                                     | 1                   | 2   | 3   | 4                                | 5   | 6   | 7   | 8  |
| Gross requirements                                                                  | 150                 |     |     | 120                              |     | 150 | 120 |    |
| Scheduled receipts                                                                  | 230                 |     |     |                                  |     |     |     |    |
| projected OH inventory <span style="border: 1px solid red; padding: 2px;">37</span> | 117                 | 117 | 117 | 230                              | 230 | 80  | 80  | 80 |
| Planned Receipts                                                                    | 0                   | 0   | 0   | $\frac{120+150}{2} = 135$<br>233 | 0   | 0   | 120 | 0  |
| Planned Order releases                                                              |                     | 233 |     |                                  | 120 |     |     |    |

قيمة طلبنا لا نرمزها لـ S.S وتكفي

فترة طولها يساوي P

$$120 + 150 - 117 + 80$$

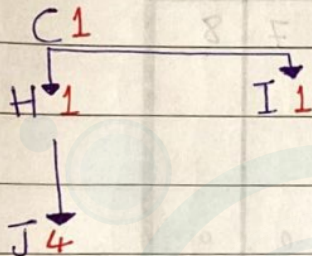
عشيرة تكفي P=3  
بالزبط لفترة تحمل

لغة  
ترجع لقيمة  
S.S

matching demand  
with order



4] MRP Explosion : MRP explosion \*  
 C → Final product H, I, J, C \*  
 MRP explosion



|                                                                              |                        |     |     |     |     |     |     |     |
|------------------------------------------------------------------------------|------------------------|-----|-----|-----|-----|-----|-----|-----|
| item                                                                         | C                      |     |     |     |     |     |     |     |
| description                                                                  | Seat Subassembly       |     |     |     |     |     |     |     |
|                                                                              | lot size : $FOQ = 230$ |     |     |     |     |     |     |     |
|                                                                              | lead time : 2 weeks    |     |     |     |     |     |     |     |
| S.S = zero                                                                   | 1                      | 2   | 3   | 4   | 5   | 6   | 7   | 8   |
| Gross requirement                                                            | 150                    |     |     | 120 |     | 150 | 120 |     |
| scheduled receipts                                                           | 230                    |     |     |     |     |     |     |     |
| projected OH <span style="border: 1px solid black; padding: 2px;">371</span> | 117                    | 117 | 117 | 227 | 227 | 77  | 187 | 187 |
| planned receipts                                                             | 0                      | 0   | 0   | 230 | 0   | 0   | 230 | 0   |
| planned order releases *                                                     |                        | 230 |     |     | 230 |     |     |     |

when + how much  
 we will produce  
 from C

|                                                                             |                        |     |     |     |     |     |     |     |
|-----------------------------------------------------------------------------|------------------------|-----|-----|-----|-----|-----|-----|-----|
| item                                                                        | H                      |     |     |     |     |     |     |     |
| description                                                                 | Seat Frame             |     |     |     |     |     |     |     |
|                                                                             | lot size : $FOQ = 300$ |     |     |     |     |     |     |     |
|                                                                             | lead time : 1 week     |     |     |     |     |     |     |     |
| S.S = zero                                                                  | 1                      | 2   | 3   | 4   | 5   | 6   | 7   | 8   |
| Gross requirement                                                           |                        | 230 |     |     | 230 |     |     |     |
| scheduled receipts                                                          |                        | 300 |     |     |     |     |     |     |
| projected OH <span style="border: 1px solid black; padding: 2px;">40</span> | 40                     | 110 | 110 | 110 | 180 | 180 | 180 | 180 |
| planned receipts                                                            | 0                      | 0   | 0   | 0   | 300 | 0   | 0   | 0   |
| planned order releases                                                      |                        |     |     | 300 |     |     |     |     |

when + how much  
 H we will produce

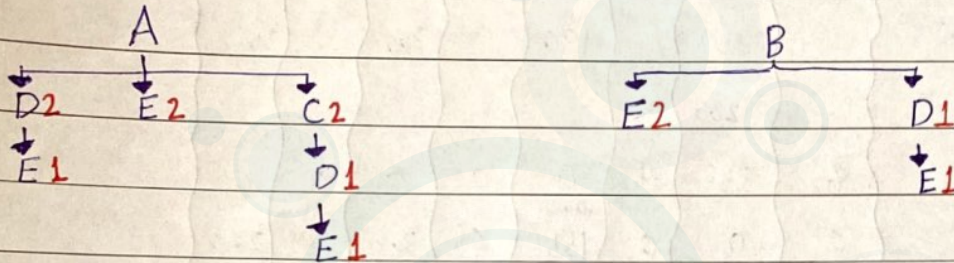


|                                                                            |              |                   |     |   |     |     |   |   |   |
|----------------------------------------------------------------------------|--------------|-------------------|-----|---|-----|-----|---|---|---|
| item                                                                       | I            | lot size: 444     |     |   |     |     |   |   |   |
| description                                                                | seat cushion | lead time: 1 week |     |   |     |     |   |   |   |
| S.S. = zero                                                                |              | 1                 | 2   | 3 | 4   | 5   | 6 | 7 | 8 |
| Gross requirement                                                          |              |                   | 230 |   |     | 230 |   |   |   |
| Scheduled Receipts                                                         |              |                   |     |   |     |     |   |   |   |
| projected OH <span style="border: 1px solid red; padding: 0 2px;">0</span> |              | 0                 | 0   | 0 | 0   | 0   | 0 | 0 | 0 |
| planned receipts                                                           |              | 0                 | 230 | 0 | 0   | 230 | 0 | 0 | 0 |
| planned order releases                                                     |              | 230               |     |   | 230 |     |   |   |   |

|                        |                     |                     |     |      |                 |     |     |     |     |
|------------------------|---------------------|---------------------|-----|------|-----------------|-----|-----|-----|-----|
| item                   | J                   | lot size FOQ = 1500 |     |      |                 |     |     |     |     |
| description            | Seat - frame boards | lead time 1 week    |     |      |                 |     |     |     |     |
|                        |                     | 1                   | 2   | 3    | 4               | 5   | 6   | 7   | 8   |
| Gross requirement      |                     |                     |     |      | 300 * 4<br>1200 |     |     |     |     |
| S. R                   |                     |                     |     |      |                 |     |     |     |     |
| projected OH           | 200                 | 200                 | 200 | 500  | 500             | 500 | 500 | 500 | 500 |
| planned Receipts       |                     | 0                   | 0   | 0    | 1500            | 0   | 0   | 0   | 0   |
| planned Order releases |                     |                     |     | 1500 |                 |     |     |     |     |



\* مسألة في الكتاب لا يتعلق بال MRP explosion



MPS start Dates :

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

Inventory Records DATA :

| Data Category       | C            | D       | E            |
|---------------------|--------------|---------|--------------|
| lot sizing Rule     | L4L          | POQ P=3 | FOQ=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 : L4L

description

lead time : 3 weeks

S.S = 0

Gross requirement

Scheduled Receipts

Projected OH

planned Receipts

planned order releases

|                        | 1   | 2   | 3   | 4   | 5   | 6   | 7 | 8   |
|------------------------|-----|-----|-----|-----|-----|-----|---|-----|
| Gross requirement      |     | 250 |     | 190 |     | 300 |   | 260 |
| Scheduled Receipts     |     | 200 |     |     |     |     |   |     |
| Projected OH           | 85  | 35  | 35  | 0   | 0   | 0   | 0 | 0   |
| planned Receipts       | 0   | 0   | 0   | 155 | 0   | 300 | 0 | 260 |
| planned order releases | 155 |     | 300 |     | 260 |     |   |     |

item D

lot size : POQ P=3

description

lead time : 2 weeks

S.S = 0

Gross Requirement

S.R

Projected OH

planned Receipts

planned order releases

|                        | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   |
|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Gross Requirement      | 155 | 250 | 80  | 190 | 250 | 300 |     | 260 |
| S.R                    |     |     | 300 |     |     | 70  |     |     |
| Projected OH           | 470 | 220 | 450 | 260 | 0   | 260 | 260 | 0   |
| planned Receipts       | 0   | 0   | 610 | 0   | 0   | 630 | 0   | 0   |
| planned order releases | 610 |     |     | 630 |     |     |     |     |

for A

lot size : FOQ = 800

lead time : 1 week

item : E

description :

S.S = 0

Gross requirement

S.R

OH

planned Receipts

planned order releases

|                        | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   |
|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Gross requirement      | 610 | 250 | 190 | 190 |     | 300 |     | 260 |
| S.R                    |     |     |     | 630 |     | 700 |     |     |
| OH                     | 540 | 290 | 130 | 110 | 110 | 470 | 470 | 210 |
| planned Receipts       | 0   | 0   | 0   | 800 | 0   | 800 | 0   | 0   |
| planned order releases |     |     | 800 |     | 800 |     |     |     |



## CH : PLANNING OF SCHEDULING OPERATIONS

\* أساسيات التخطيط :

\* التخطيط :

\* التخطيط :

1- Corporate strategies

- demand Forecast

- demand Forecast

2- policies

product family

for each SKU

3- Economics, political, ...

- per month

per week

4- Forecast (highest level)

- per quarter

for all product - per year

Capacity  
Planning

Aggregate  
Planning

Master schedule  
Planning

short term  
Scheduling

\* long term → years

\* intermediate term → monthly  
quarterly

\* per week

\* per day, hour, shift.

\* التخطيط طويل المدى :

\* MPS start

\* match specific

1- location of facility

\* Utilization Facility

tasks to specific

2- Size of facility

\* personal (HR)

people and

3- Equipments - production  
Lines

like → part-timers  
over time

machines

\* تحديد الأشياء المطلوب

تغيير كل شئ

|      | April | May |
|------|-------|-----|
| Bike | 800   | 850 |

\* Aggregate plan

من بيك إلى بيك

|          | April |    |    |    | May |    |    |    |
|----------|-------|----|----|----|-----|----|----|----|
|          | 1     | 2  | 3  | 4  | 1   | 2  | 3  | 4  |
| Bike M22 | 20    | 20 | 20 | 20 | 20  | 20 | 20 | 20 |
| Bike M24 | 10    | 10 | 10 | 10 | 10  | 10 | 10 | 10 |
| Bike M26 | 10    | 10 | 10 | 10 | 10  | 10 | 10 | 10 |



\* أنواع short time scheduling :

Facility jobs

1] Job of Facility Scheduling → مثل توزيع المكاتب والعمليات على غرف العمليات

2] Work Force scheduling → مثل توزيع عدد موظفين على شفتان نظام تشغيل لمدة 24 ساعة

3] Sequencing Jobs at work stations → مثل العنبرة التي فيها عدة آلات وحدة طلبات يشترك بالفتح بالآلات

\* شرح أنواع short time scheduling :

1] Job of Facility Scheduling :

1- أقل فائدة طويلة الأجل فيها كل job أي Facility not practical

2- أقل جدول

| Job    | slot 1 | slot 2    | slot 3  |
|--------|--------|-----------|---------|
| KIA    |        | 8-8:30 am |         |
| Toyota |        |           | 9-10 am |
| ...    |        |           |         |

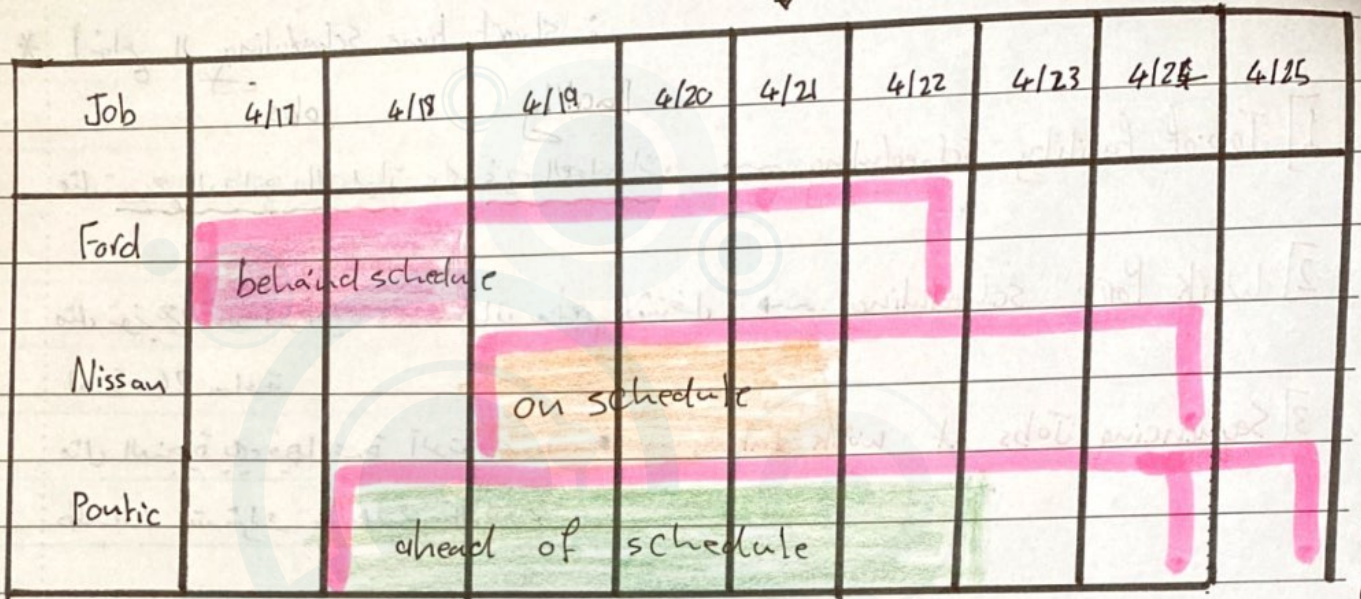
3- أقل Gantt chart وهو في نوعين :

1- Job of activity progress Gantt chart

2- Workstation Gantt chart



↓ Current date



Gantt Chart progress for Auto parts company

┌ start ┐ end ┐ scheduled time

▨ Actual progress ▨ Nonproductive time



| Work station | 7       | 8 | 9 | 10 | 11        | 12 | 1 | 2pm | 3pm | 4pm    | 5pm | 6pm |
|--------------|---------|---|---|----|-----------|----|---|-----|-----|--------|-----|-----|
| Room A       | Dr Aden | X | X | X  | dr Aubrey | X  | X | X   | X   | Alaina |     |     |
| Room B       | X       | X | X | X  | X         | X  | X | X   | X   | X      | X   | X   |
| Room C       | X       | X | X | X  | X         | X  | X | X   | X   | X      | X   | X   |

Gantt workstation chart for operating Rooms at Hospital



## 2] Work Force Schedule

\* فقط للدوام ياتي فيه shifts زي دوام ال nursing staff أو مطعم بدارم  
11 ساعة بس كل أيام الاسبوع

\* Constraints بتحددنا ال schedule

1- Technical Constraints

2- legal and behavioral Constraints

أي من ال behavioral

3- psychological needs of workers

+ psychological

The manager needs a work force schedule that provides two consecutive days off and minimizes the amount

\* Example :

أقل عدد موظفين  
نحتاجه

| Day      | M | T | W | Th | F  | S | Su |
|----------|---|---|---|----|----|---|----|
| Required | 6 | 4 | 8 | 9  | 10 | 3 | 2  |

of total slack capacity.  
To break ties in the selection of off days, the scheduler gives preference to Su, S if it is one of the tied pairs.

| M | T | W | Th | F  | S | Su | Employ | Comments                                    | Employ | M   | T   | W | Th | F | S   | Su  | Comments |
|---|---|---|----|----|---|----|--------|---------------------------------------------|--------|-----|-----|---|----|---|-----|-----|----------|
| 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      |                                             | 7      | X   | X   | X | X  | X | off | off |          |
| 1 | 0 | 1 | 2  | 3  | 1 | 0  | 8      | (S, Su) (M, T)<br>(T, W)                    | 8      | X   | X   | X | X  | X | off | off |          |
| 0 | 0 | 0 | 1  | 2  | 1 | 0  | 9      | (M, T) (T, W)<br>(Su, M)                    | 9      | off | X   | X | X  | X | X   | off |          |
| 0 | 0 | 0 | 0  | 1  | 0 | 0  | 10     | (M, T) (T, W)<br>(W, Th) (S, Su)<br>(Su, M) | 10     | X   | X   | X | X  | X | off | off |          |



Capacity, C

7

8

10

10

10

3

2

Requirements, R

6

4

8

9

10

3

2

Slack, C-R

1

4

2

1

0

0

0

$$\text{Total slack} = 1 + 4 + 2 + 1 + 0 + 0 + 0 = 8$$

\*  $\frac{\text{slack}}{\text{total slack}} = \frac{1}{8} = 0.125$  (الوقت 10)  $\frac{\text{وقت}}{\text{وقت}} = 10$

| Day | M | T | W | Th | F | Sa | Su | Comments |
|-----|---|---|---|----|---|----|----|----------|
| 1   |   |   |   |    |   |    |    |          |
| 2   |   |   |   |    |   |    |    |          |
| 3   |   |   |   |    |   |    |    |          |
| 4   |   |   |   |    |   |    |    |          |
| 5   |   |   |   |    |   |    |    |          |
| 6   |   |   |   |    |   |    |    |          |
| 7   |   |   |   |    |   |    |    |          |
| 8   |   |   |   |    |   |    |    |          |
| 9   |   |   |   |    |   |    |    |          |
| 10  |   |   |   |    |   |    |    |          |
| 11  |   |   |   |    |   |    |    |          |
| 12  |   |   |   |    |   |    |    |          |
| 13  |   |   |   |    |   |    |    |          |
| 14  |   |   |   |    |   |    |    |          |
| 15  |   |   |   |    |   |    |    |          |
| 16  |   |   |   |    |   |    |    |          |
| 17  |   |   |   |    |   |    |    |          |
| 18  |   |   |   |    |   |    |    |          |
| 19  |   |   |   |    |   |    |    |          |
| 20  |   |   |   |    |   |    |    |          |
| 21  |   |   |   |    |   |    |    |          |
| 22  |   |   |   |    |   |    |    |          |
| 23  |   |   |   |    |   |    |    |          |
| 24  |   |   |   |    |   |    |    |          |
| 25  |   |   |   |    |   |    |    |          |
| 26  |   |   |   |    |   |    |    |          |
| 27  |   |   |   |    |   |    |    |          |
| 28  |   |   |   |    |   |    |    |          |
| 29  |   |   |   |    |   |    |    |          |
| 30  |   |   |   |    |   |    |    |          |
| 31  |   |   |   |    |   |    |    |          |
| 32  |   |   |   |    |   |    |    |          |
| 33  |   |   |   |    |   |    |    |          |
| 34  |   |   |   |    |   |    |    |          |
| 35  |   |   |   |    |   |    |    |          |
| 36  |   |   |   |    |   |    |    |          |
| 37  |   |   |   |    |   |    |    |          |
| 38  |   |   |   |    |   |    |    |          |
| 39  |   |   |   |    |   |    |    |          |
| 40  |   |   |   |    |   |    |    |          |
| 41  |   |   |   |    |   |    |    |          |
| 42  |   |   |   |    |   |    |    |          |
| 43  |   |   |   |    |   |    |    |          |
| 44  |   |   |   |    |   |    |    |          |
| 45  |   |   |   |    |   |    |    |          |
| 46  |   |   |   |    |   |    |    |          |
| 47  |   |   |   |    |   |    |    |          |
| 48  |   |   |   |    |   |    |    |          |
| 49  |   |   |   |    |   |    |    |          |
| 50  |   |   |   |    |   |    |    |          |
| 51  |   |   |   |    |   |    |    |          |
| 52  |   |   |   |    |   |    |    |          |
| 53  |   |   |   |    |   |    |    |          |
| 54  |   |   |   |    |   |    |    |          |
| 55  |   |   |   |    |   |    |    |          |
| 56  |   |   |   |    |   |    |    |          |
| 57  |   |   |   |    |   |    |    |          |
| 58  |   |   |   |    |   |    |    |          |
| 59  |   |   |   |    |   |    |    |          |
| 60  |   |   |   |    |   |    |    |          |
| 61  |   |   |   |    |   |    |    |          |
| 62  |   |   |   |    |   |    |    |          |
| 63  |   |   |   |    |   |    |    |          |
| 64  |   |   |   |    |   |    |    |          |
| 65  |   |   |   |    |   |    |    |          |
| 66  |   |   |   |    |   |    |    |          |
| 67  |   |   |   |    |   |    |    |          |
| 68  |   |   |   |    |   |    |    |          |
| 69  |   |   |   |    |   |    |    |          |
| 70  |   |   |   |    |   |    |    |          |
| 71  |   |   |   |    |   |    |    |          |
| 72  |   |   |   |    |   |    |    |          |
| 73  |   |   |   |    |   |    |    |          |
| 74  |   |   |   |    |   |    |    |          |
| 75  |   |   |   |    |   |    |    |          |
| 76  |   |   |   |    |   |    |    |          |
| 77  |   |   |   |    |   |    |    |          |
| 78  |   |   |   |    |   |    |    |          |
| 79  |   |   |   |    |   |    |    |          |
| 80  |   |   |   |    |   |    |    |          |
| 81  |   |   |   |    |   |    |    |          |
| 82  |   |   |   |    |   |    |    |          |
| 83  |   |   |   |    |   |    |    |          |
| 84  |   |   |   |    |   |    |    |          |
| 85  |   |   |   |    |   |    |    |          |
| 86  |   |   |   |    |   |    |    |          |
| 87  |   |   |   |    |   |    |    |          |
| 88  |   |   |   |    |   |    |    |          |
| 89  |   |   |   |    |   |    |    |          |
| 90  |   |   |   |    |   |    |    |          |
| 91  |   |   |   |    |   |    |    |          |
| 92  |   |   |   |    |   |    |    |          |
| 93  |   |   |   |    |   |    |    |          |
| 94  |   |   |   |    |   |    |    |          |
| 95  |   |   |   |    |   |    |    |          |
| 96  |   |   |   |    |   |    |    |          |
| 97  |   |   |   |    |   |    |    |          |
| 98  |   |   |   |    |   |    |    |          |
| 99  |   |   |   |    |   |    |    |          |
| 100 |   |   |   |    |   |    |    |          |



### 3] Sequencing jobs at Workstations:

\* توزيع الطلبات على الآلات المشترجة بشكل مناسب (يعني أليس؟ على أي آلة أعمل؟)

\* العلماء خطوا Rules لحتى نحدد ترتيب الأشياء فيها :

1] First Come, First served (FCFS) : days ago since order

(- ياي ويلي قبل او درم بيلش فيه)

2] Earliest due date (EDD):

(- ياي وعدنا الزبون فيه اول بيلش فيه)

3] Shortest processing time (SPT):

(- ياي بياخذ وقت اقل بيلش فيه)

\* بجور مين أحسن طريقة على حسب وبناء على توقيت :

1] Flow Time : Finish time + days ago since order arrived

2] Past days due : Finish time - due date



Example: Currently a consulting company has 5 jobs in its backlog.

The time since the order was placed, processing time, and promised due dates are given in the following table. Determine the schedule by using the **FCFS Rule**, and calculate the Avg. days past due and Flow time. How can the schedule be improved, if average flow time is the most critical?

| Customer | (days ago)<br>Time Since order Arrived | Processing Time<br>(days) | Due Date<br>(days from now) |
|----------|----------------------------------------|---------------------------|-----------------------------|
| A        | 15                                     | 25                        | 29                          |
| B        | 12                                     | 16                        | 27                          |
| C        | 5                                      | 14                        | 68                          |
| D        | 10                                     | 10                        | 48                          |
| E        | 0                                      | 12                        | 80                          |

| Customer sequence | start time (days) | processing Time(days) | Finish Time(days) | Due Date | Days past Due | Days ago since order | Flow Time |
|-------------------|-------------------|-----------------------|-------------------|----------|---------------|----------------------|-----------|
| 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        |

$$\text{Avg Flow time} = (40 + 53 + 61 + 70 + 77) / 5 = 60.2 \text{ days}$$

$$\text{days past due} = (0 + 14 + 3 + 0 + 0) / 5 = 3.4 \text{ days}$$

FCFS Rule



| Customer<br>Sequence | start<br>Time<br>(days) | processing<br>Time<br>(days) | Finish<br>Time<br>(days) | Due<br>Date | Days<br>past<br>Due | Days ago<br>since order<br>Arrived | Flow time<br>(days) |
|----------------------|-------------------------|------------------------------|--------------------------|-------------|---------------------|------------------------------------|---------------------|
| 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                  |

avg Flow time :  $(20+22+41+64+92)/5 = 47.8$  days

avg days past due :  $(0+0+0+25+48)/5 = 14.6$  days

improve ← Flow time 11 15