chapter (2)

Scrap Estimate

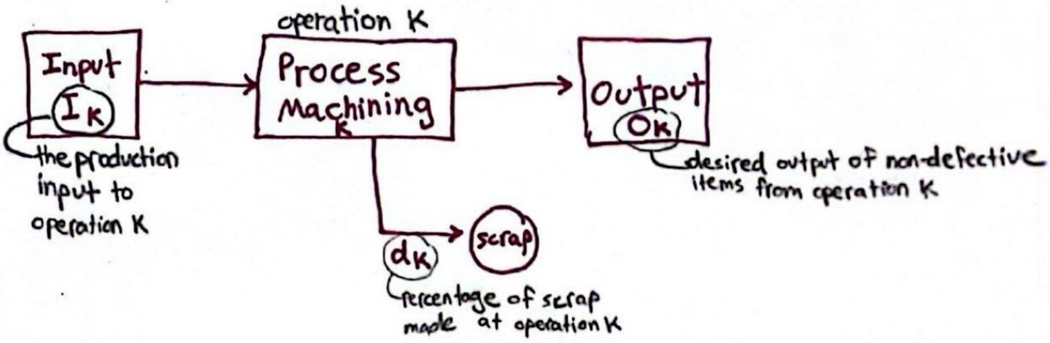
$$\boxed{I_K = O_K + d_K I_K}$$

or

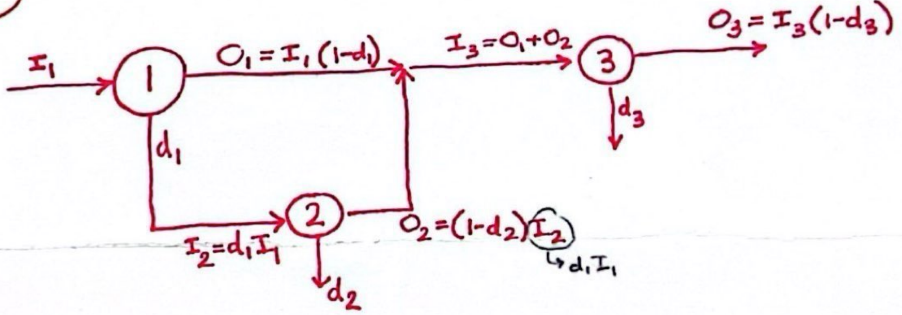
$$\boxed{O_K = I_K * (1-d_K)}$$

$$\boxed{I_K = \frac{O_K}{1-d_K}}$$

$$\boxed{I_1 = \frac{\text{final output}}{(1-d_1)(1-d_2)(1-d_3)\ldots\ldots}}$$



Scrap Estimate with Rework



$$\text{Input} = \frac{\text{Final Output}}{(1-d_3)\left[(1-d_1)+d_1(1-d_2)\right]}$$

*amount of scrap for process 3 → $(I_3 - O_3)$
input - output

Equipment Fraction

$$\text{Machine Fraction} = \frac{\text{Total required time to perform operation}}{\text{Total time available per machine.}}$$

$$F = \frac{SQ}{EHR}$$

#of machines required per shift
standard time per unit produced
#of units to be produced per shift
Actual performance expressed as a percent of standard time
amount of time available per machine
Reliability of machine (percent of up time)

$\boxed{F}$ can also be affec

- → #of shifts
- → set up time
- → degree of flexibility -
  small lots or large lo
- → Layout type - process or
  prod
- → Total productive ma

Chapter 3
(Method 1 + 2)
[cluster Identification is not her

Method (1) :- Direct clustering Algorithm (DCA)

① sum the 1s in each column and each row of the machine part matrix

② order the rows (top to bottom) in descending order of the number of 1s in the rows

③ order the columns (left to right) in ascending order of the number of 1s in the columns

④ Sort the columns, begining with the first row of the matrix, shift to the Left all columns having 1s in the firs ro continue row by row until no futher opportunity exits for shifting columns.

⑤ Sort the rows, begining with the Leftmost column, shift rows upward when opportunities exist to form b of 1s

⑥ Form cells such that all processing for each part occurs in a single cell.

Method (2) :- Rank Order Clustering Algorithm

① Assign binary weight $BW = 2^{\overset{\text{\# of machines}}{m} - \overset{\text{columns (\# of machines)}}{j}}$ to each column j of the part machine processing indicator matrix.

② Determine the decimal equivalent DE of the binary value of each row i using the formula

$$DE_1 = \sum_{j=1}^{m} 2^{m-j} a_{ij}$$

③ Rank the rows in decreasing order of their DE values. break ties arbitrarily.
Rearrange the rows based on this ranking, if no rearrangement is necessary → stop, otherwise go to step ④

④ For each rearranged row of the matrix, assign binary weight

$$BW_i = 2^{\overset{\text{\# of parts}}{n} - \overset{\text{number of row}}{i}}$$

⑤ Determine the decimal equivalent of the binary value of each column j using the formula

$$DE_j = \sum_{i=1}^{m} 2^{n-i} a_{ij}$$

⑥ Rank the columns in decreasing order of their DE values. break ties arbitrarily
Rearrange the columns based on this ranking, if no rearrangment is necessary → stop, otherwise go to step ①

Cluster Identification algorithm

1. Select any row and cross it
2. For each crossed 1 make a vertical line
3. For each crossed 1 make a horizontal line
4. Repeat until all the 1s are crossed by a vertical line or by a horizontal line
5. Form a cell from all the machines and components which were crossed
6. Remove all the crossed elements (machines and components) and start again

$6''_{(\text{inch})} \rightarrow 0.5'_{(\text{feet})}$

$\text{inch} \xrightarrow[\div 12]{} \text{in} = \text{feet}$

Chapter (4)

Personnel Requirements

+ Employee Parking

W1 (single Loaded wall to wall [with bumpers])
W2 (double Loaded wall to wall [with continuous concrete curb])
W3 (double Loaded wall to ~~wall~~ ℄ with sawtooth concrete curb])
W4 (double Loaded ℄ to ℄ [or ℄ to walkedge])

W4 ← No walking edge + No walls

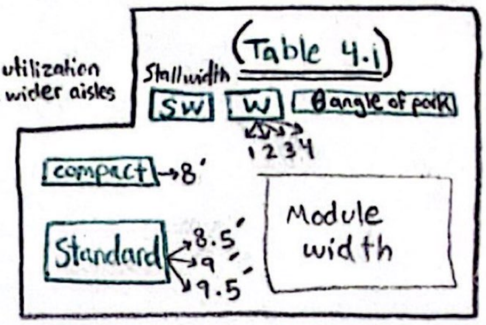
(Public Transportation is not available) 1 space for every 1.25 employees

(transportation available) 1 space for every 3 employees

[select the best Layout that best utilize space and maximize convenience]

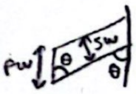
→ compact
→ standart
→ handicapped

→ 90° (perpendicular) → greater space utilization although it have wider aisles
→ other angle (with angle) → allows quicker turnover



in angular

$$\boxed{\underset{\text{parking width}}{PW} = \frac{\underset{\text{stall width}}{SW}}{\sin\theta}}$$



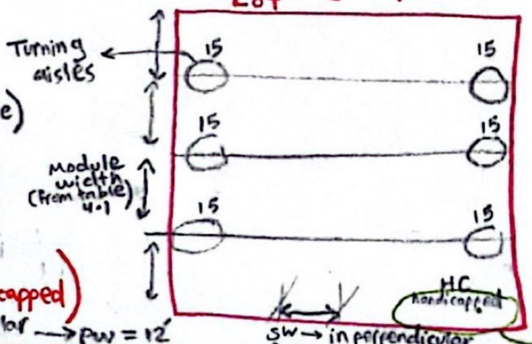
in angular

$$\boxed{Y = \underset{\text{stall depth}}{SD} \cos\theta}$$

Y → (distance lost due to parking at an angle)

$$\boxed{\underset{\text{Depth}}{\text{Module}} = Y + (\overset{\text{الجدول}}{\text{\# of stalls}} \times pw)}$$

Parking Space (Lot)



SW → in perpendicular
PW → in angular

$\frac{(\text{width})}{(\text{Module depth})}$ ← نفس بعض

→ ussually in first row handicapped SW → 12'

$$\text{Row}(1) \rightarrow \frac{\left(\text{Total width} - (\overset{\text{pw in angular}}{12'} \times \text{\# of handicapped})\right)}{SW}$$

12' → in angular → $pw = \frac{12'}{\sin\theta}$

SW → ussualy for standard

$$\text{Row}(2 \cdots \text{before the last row}) \rightarrow \left(\frac{\text{Total width} - \underset{\text{turning aisle}}{30}}{SW}\right)$$

SW → either for standard or for compact

$$\text{Last Row} \longrightarrow \frac{\text{Total width}}{SW}$$

SW → ussually for compact

Notes : ☺

- At least (2) handicapped spaces per (100) parking spaces
- employees are not required to walk more than (300-400) feet from their parking space place to the entrance of facility
- Percentage of compact cars is 33% if the question didn't determine it
- SW for handicapped = 12'
- Parking at an angle reduces Module width but have less parking spaces than perpendicular parking

* Storage for employees personal belongings

6 ft² → for each person using the Locker room

* Restrooms

→ should be Located within (200 ft) of every permanent workstation

smaller decentralized restrooms > Large centralized restrooms

more convenient than

Table 4.2 → water closets → Lavaratories → urinals

each Entrance → 15 ft²

each Toilet → 15 ft² or 12.5 ft²

each sink → 6 ft²

each urinal (for male) → 6 ft²

each water closet → 15 ft²

each Lavaratories → 6 ft²

each bed/cot (women) → 60 ft²

* of bed or cot	* of employees
1	< 100
2	100 < * of employees < 250
*	one additional bed should be Provided for each additional 250 female employees

في حل الأسئلة

	Male	Female
*	⋮	⋮
*		
*		
SubTotal	☐	من الجدول percentage ☐
Allowance	X% x Sub Total	X% x Sub Total
Total Area	Sub Total + Allowance	Sub Total + Allowance

- water fountains within 200 ft of workstation

* Food Services

→ firms views it as → necessity → convenience → luxury or

→ located within 1000 feet of permenant employee workstations

Four Main meal Options:

- Dinning Away
- Vending Machines and cafeteria → Commercial, Industrial, Banquet
  - Vending Machines ↓ 1 ft²
  - cafeteria ↓ from table
- 200 < * emp: Serving Line and cafeteria
  - Serving Line ↓ 300 ft²/line → (each line can serve 70 persons)
- 400 < * emp: Full Kitchen and cafeteria
  - Full Kitchen ↓ from table (I use total number of employees)
  - cafeteria ↓ Service line space + ~~[illegible]~~ cafeteria space

Table cafeteria 4.4

	16-18 13-15 10-11

بختار الـ Lower

Table Full Kitchen 4.5

لا يسوي interpolation

service line

$$\frac{\text{* of emp}}{70} = \bigcirc \text{ Round up}$$

$$300 \times \bigcirc = \boxed{\text{Service line}}$$

* Health Services

→ Minimum 100 ft² space

- waiting Room → (75 ft²) for the first nurse + (25 ft²) per additional nurse
- First Aid Room → (250 ft²) per nurse
- Examination Room → (150 ft²) per physician

حفظ
space for handicapped ⇒ 12′ each one

بعتبرها 33 % اذا ما حدد

- ◆ **Example 4.1:**
- ◆ 200 employees, 1 space for every 2 employees, 30% ~~40 %~~ compact cars, 5% for handicap, and available parking space 180X200ft
- ◆ Assuming no walls, and no walking edge. } → W_4
- ◆ Use SW of 8' 6" for standard cars
- ◆ Determine the best parking layout

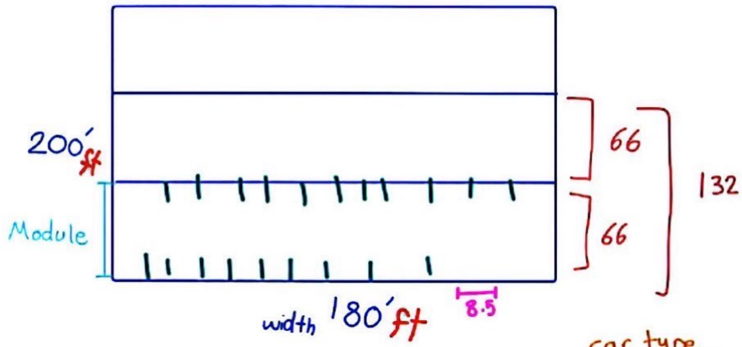
$(90°, W_4)$

$200 \cancel{\text{employee}} \times \frac{1 \text{ parking space}}{2\ \cancel{\text{employee}}} = 100$ parking space required

$\%40 \cdot 100 = \cancel{40}$ space for comp
30 space for compact

30 compact
70 standard

* The Parking Layout



car type
* compact $(90, 8') W_4 \longrightarrow 57' 2''$
* standard $(90) W_4 \longrightarrow 66$

* we need to see if the depth of the (200ft) can accomodate a parking Layout using 2 module ?? → (X) standard, (Y) compact ← عن طريق التجريب

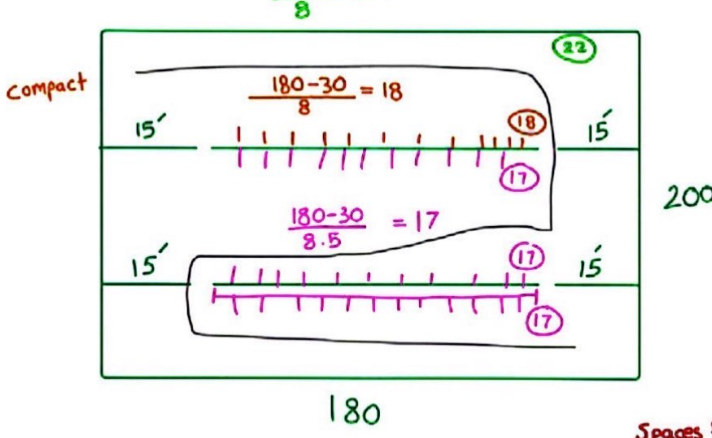
* the most important is to satisfy customer

$1S + 1C = 123 \ll 200$

$2S + 2C = 132 + 114 = 246 \gg 200$ X

$\boxed{2S + 1C} = 2(66) + 1(57' 22'') = 189' 2'' \lll 200$ ✓ the best

$\frac{180}{8} = 22$



* the suggested Layout is

$\frac{2 \text{ rows}}{\text{Module}} \times 2S + \boxed{\frac{2 \text{ rows}}{\text{Module}}} \times 1C = 6_{\text{Rows}}$

W_4

$\overset{C}{\uparrow}$ $\overset{S}{\uparrow}$
$44 + \boxed{84} = 128 > 100$ ✓

5% handicapped
$12' \longrightarrow$ handicapped
$12' \times 5 = 60'$

Spaces for Standard in row 1 $\rightarrow \frac{180-60}{8.5} = 14$ spaces for standard
5 spaces for handicapped

Angular parking

Monday, May 6, 2024 8:05 AM

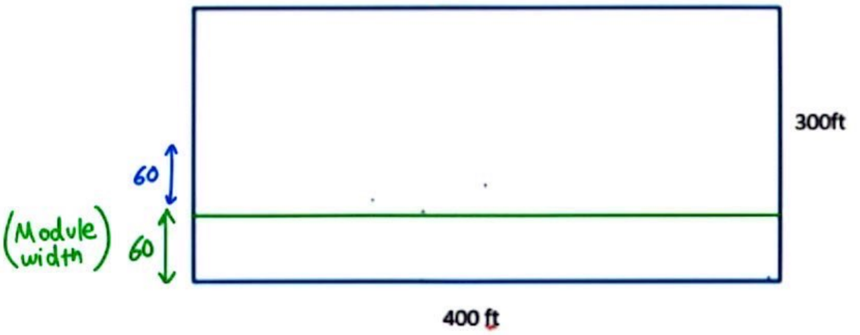
$\theta = 75$ $SD = 16'$

A parking lot is to be 400 feet wide and 300 feet deep. How may standard-sized cars fit in this lot? Use W4 Module, where the parking is angular with angle of 75, assume a stall depth of 16 feet. Determine the best parking layout using stall width, SW=8'6". + the managers wants exactly 10 stalls for handicapped and all are in the first row.

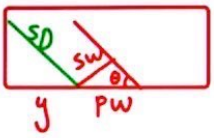
السؤال يريد
only standard cars

$SW = 8.5'$

Module for standard width (8.5') → 60'



$$\#\text{ of Modules} = \frac{300\text{ ft}}{60\text{ ft}} = 5\text{ modules} \rightsquigarrow \#\text{ of Rows} = \underset{\text{double Loaded}}{2} \times \underset{\#\text{ of Modules}}{5} = 10\text{ Rows}$$



$$\boxed{PW = \frac{SW}{\sin\theta}} = \frac{8.5}{\sin 75} = 8.799\text{ ft}$$

$$\boxed{y = SD \times \cos\theta} = 16 \times \cos 75 = 4.1411\text{ ft}$$

$$*\boxed{\text{Row }1} = \frac{\overset{\text{parking width}}{400} - \overset{\text{distance lost due to parking at angle}}{y} - (PW_{(HC)} \times \overset{\#\text{ of stalls for HC}}{10})}{PW}$$

$$= \frac{400 - \overset{y}{4.1411} - \overset{12.42}{\boxed{PW_{HC}}} \times 10}{8.8}$$

$$PW_{HC} = \frac{SW_{HC}}{\sin\theta} = \frac{12'}{\sin 75} = 12.42$$

$$= 30.87 \xrightarrow{\text{Rounddown}} 30 \text{ for row 1}$$

$$\boxed{\text{Row 2 — Row 9}} = \frac{400 - \overset{y}{4.1411} - \overset{\text{Turning aisles}}{(15)2}}{8.8} = 41.574 \underset{\text{Round down}}{\approx} 41$$

$$\boxed{\text{Row 10}} = \frac{400 - \overset{y}{4.1411}}{8.8} = 44.98 \approx 44$$

Row(1)	10 HC 30 SC
Row(2-9)	41 SC
Row (10)	44 SC

Chapter (5)

Efficiency of Containers

① container space utilization = $\frac{\text{inside dimension}}{\text{outside dimension}}$

② Container nesting Ratio = $\frac{\text{(overall container height)}}{\text{nested height}}$

③

* Trailer space utilization

determine how much containers are on $\left(\frac{\text{Trailer}}{\text{outside}}\right)$ → Length, width, height

Length → $\frac{T_{Length}}{O_{Length}}$

width → $\frac{T_{width}}{O_{height}}$

height → $\frac{T(height)}{O(height)}$

*total number o F $\overset{\text{full}}{\uparrow}$ containers = Length x width x height

→ * Trailer space utilization = $\frac{\text{total number of containers} \times \text{inside dimension}}{\text{Trailer inside dimension}}$

④

number of empty containers vertically in (height) = $1 + \frac{\text{Trailer height} - \text{outside height}}{\text{nested height}}$

number of empty containers = containers verticaly x Length x width

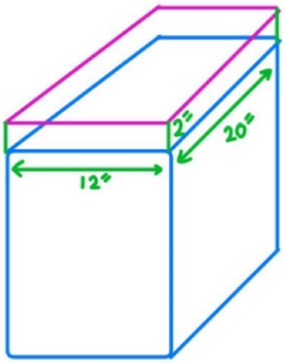
Trailer return Ratio = $\frac{\text{\# of empty containers fit in the trailer}}{\text{\# of full containers fit in the trailer}}$

شرح → https://youtu.be/xAyfk6MyvqI?si=3yAMrl1FltUGpcmh (نفس سؤال السلايدات)

Example:
Given the following dimensions of a particular type of plastic reusable containers:

- Inside dimensions 18”x 11”x11”
- Outside dimensions 20”x12”x12”
- Each nested container 20”x12”x2” → الارتفاع الظاهر لما ندخل two containers
- A trailer inside dimension 240”x120”x120”
- Containers are not palletized. Assume no clearance is needed between containers, and between containers and the walls of the trailer

يعني ← لا نضع تحتها pallete



Determine the following:
1. Container space utilization.
2. Container nesting ratio.
3. Trailer space utilization (if all containers stacked vertically in only one orientation).
4. Trailer return ratio.

① Container Space utilization = $\frac{\text{inside dimension}}{\text{outside dimension}} = \frac{18 \times 11 \times 11}{20 \times 12 \times 12} = 75.625 \approx \boxed{76\%}$

② Container nesting Ratio = $\frac{\text{container outside hieght}}{\text{nesting height}} = \frac{12}{2} = \boxed{6}$

(نهتم فقط بال Height)

كل ما كانت أقل كل ما كان أفضل ←

⟹ so (6) nested container use the same space as one closed container

③ Trailer Space Utilization =

→ ※of Loaded containers that the trailer can take

(we need to determine how much container are in the
and → Length → $\frac{240}{20} = \underline{12}$ containers along the Length
and → width → $\frac{120}{12} = \underline{10}$ containers along the width
height → $\frac{120}{12} = \underline{12}$ containers along the height

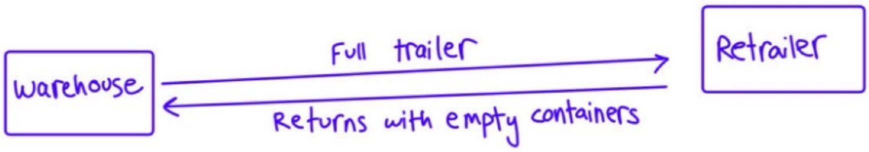
※ so Total number of containers = 12 x 10 x10 = 1200 full containers

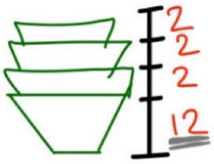
and now the trailer Utilization = $\frac{\text{※of container} \times \text{container inside dimension}}{\text{Trailer inside dimension}}$

$$= \frac{1200 \times (18 \times 11 \times 11)}{240 \times 120 \times 120} = \boxed{76\%}$$

④ Trailer Retail Ratio $= \dfrac{\text{\# of empty containers fit in the trailer}}{\left(\text{\# of full containers fit in the trailer}\right)}$

من الفرع القبل
1200





so number of containers stacked vertically $= \underset{\text{دائماً}}{1} + \left(\dfrac{\overset{\substack{\text{the height}\\ \text{of the trailer}}}{120} - \overset{\text{the first height}}{12}}{\underset{\text{the nested height}}{2}}\right) = 1 + \dfrac{108}{2} = \boxed{55}$ empty containers vertically

$*$so total # of empty containers $= 55 \times 12 \times 10 = 6600$ empty container

$*$Trailer Return Ratio $= \dfrac{\text{\# of empty containers fits in the trailer}}{\text{\# of full containers fits in the trailer}}$

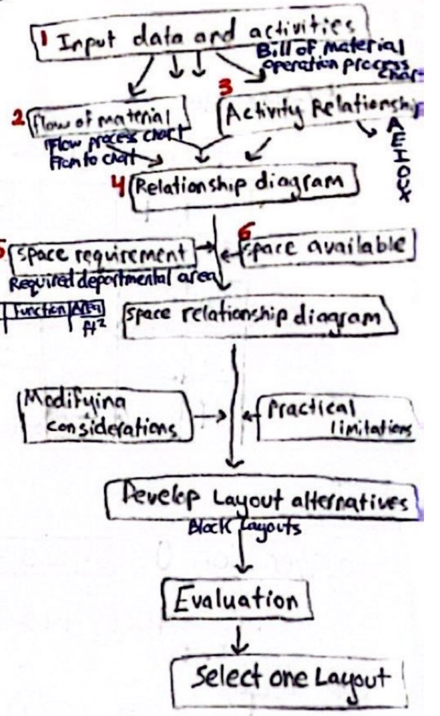
$$= \frac{6600}{1200}$$

$$= \boxed{5.5}$$

we want this number to be as high as possible

Systematic Layout planning procedure

(SLP)



(6.7) Develop a block Layout using SLP
Four departments are to be Located in a building of 600′ x 1000′
area requirements for departments are shown in Table below

(Develop from to chart)

Dep	A	B	C	D
A	0	375	125	365
B		0	400	620
C			0	400
D				0

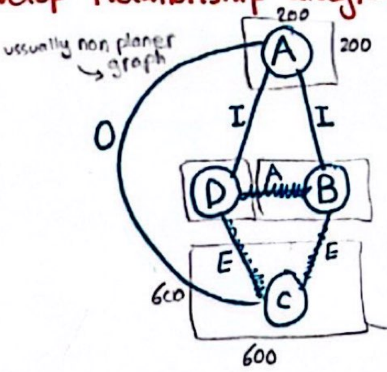
Dep	department dimension
A	200′ x 200′
B	400′ x 400′
C	600′ x 600′
D	200′ x 200′

try to make them adjacent
620] A → very bold
400
400] E
375
365] I
125] O

(Develop Activity Relationship Matrix)

Dep	A	B	C	D
A	–	I	O	I
B		–	E	A
C			–	E
D				–

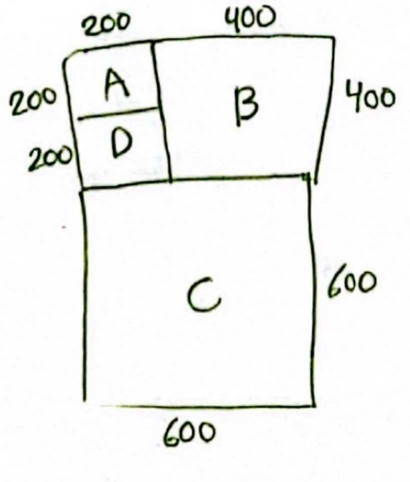
(Develop Relationship diagram)



طول الـ line يعتمد على الـ score

المربعات خطوة لحالها

(Develop ~~requirement~~ diagram)
space relationship



*Systematic Layout Planning (SLP)

6.7 Four departments are to be located in a building of 600′ × 1000′. The expected personnel traffic flows and area requirements for the departments are shown in the tables below. Develop a block layout using SLP.

Dept.	A	B	C	D
A	0	250	25	240
B	125	0	400	335
C	100	0	0	225
D	125	285	175	0

Department	Department Dimension
A	200′ × 200′
B	400′ × 400′
C	600′ × 600′
D	200′ × 200′

*Step ① Develop from to chart

(ما يهمني ال Direction)

	A	B	C	D
A	0	375	125	365
B		0	400	620
C			0	400
D				0

620]A
400
400]E
375
365]I
125]O

*step ② Develop Activity Relationship (Matrix)

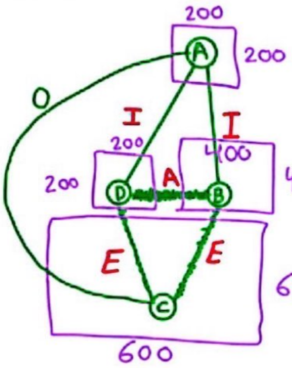
	A	B	C	D
A	—	I	O	I
B		—	E	A
C			—	E
D				—

من السؤال
B = 400 x 400
A = 200 x 200
D = 200 x 200
C = 600 x 600

→ square

*step ③ Relationship Diagram

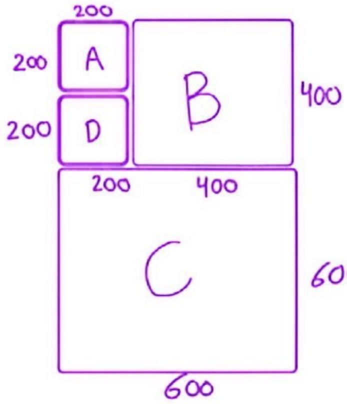
Proximity
line boolches



طول ال line
يعتمد على ال score

→ The purple color is for step ④

*step ④ space Relationship Diagram

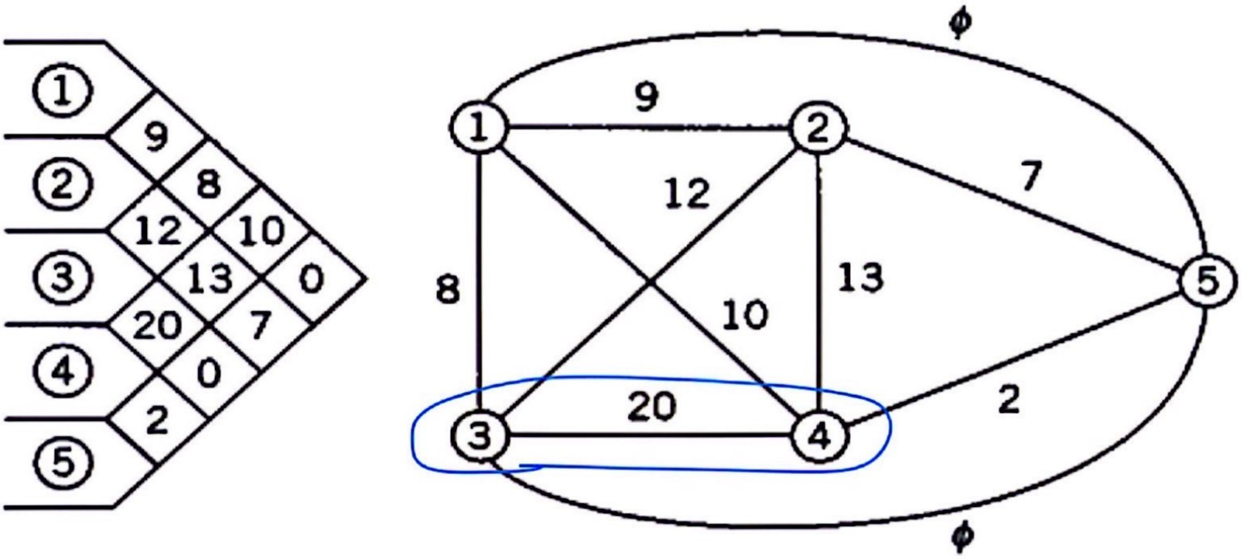


(Block Layout)

→ Dimension for the facility

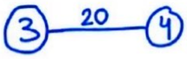
1000 x 600

Graph-based Method



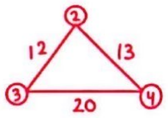
(*a*) Relationship Chart (*b*) Relationship Diagram

Figure 6.12 Relationship chart and relationship diagram for graph-based example.



	3	4	Sum
1	8	10	18
2	12	13	25
5	0	2	2

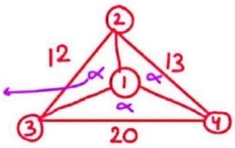
my goal is to maximize flow or maximize weight



	2	3	4	Sum
1	9	8	10	27
5	7	0	2	9

✓ the best

اذا بضيف الواحد

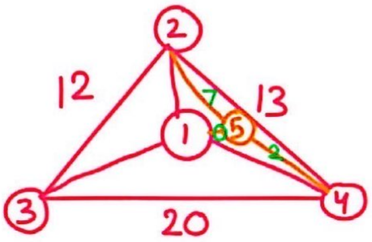


face
(بدي احدد وين احط 5)

	1	2	3	4	Sum
5	0	7	0	2	

Faces	
1-2-3	7
1-2-4	9 ✓
1-3-4	2
2-3-4	9

I have two alternatives (I choose any of them)



وآخر اشي بعمل
Block Layout

Pairwise Exchange Method

→ improvement type Layout

→ Leads to suboptimal solution

*Example

From to chart (without taking direction into consideration)

	1	2	3	4
1	–	10	15	20
2		–	10	5
3			–	5
4				–

Distance Matrix (based on existing Layout)

	1	2	3	4
1	–	1	2	3
2		–	1	2
3			–	1
4				–

phase(1) construct phase initial solution (1,2,3,4)

phase(2) Improvement pair-wise exchange

ⓐ exchange two departme

ⓑ if results in better solution

→ accept

→ back to ⓐ

a) iteration 0 $\boxed{1|2|3|4}$

original $\boxed{1234}$ $TC = 10\overset{1-2}{(1)} + 15\overset{1-3}{(2)} + 20\overset{1-4}{(3)} + 10\overset{2-3}{(1)} + 5\overset{2-4}{(2)} + 5\overset{3-4}{(1)} = 125$

1-2 $TC_{2134} = 10(1) + 15(1) + 20(2) + 10(2) + 5(3) + 5(1) = 105$

1-3 $TC_{3214} = 10(1) + 15(2) + 20(1) + 10(1) + 5(2) + 5(3) = \boxed{95}$ smallest value

1-4 $TC_{4231} = 10(2) + 15(1) + 20(3) + 10(1) + 5(1) + 5(2) = 120$

2-3 $TC_{1324} = 10(2) + 15(1) + 20(3) + 10(1) + 5(1) + 5(2) = 120$

2-4

3-4

1234

3214

→ 1-2
→ 1-3
→ 1-4
→ 2-3
→ 2-4
→ 3-4

---

iteration 1 $\boxed{3|2|1|4}$

Algorithm Classification

type of input
- Relationship chart
- or from to chart
- or both

the basis of Layout planning is the
- closeness ratings
- material flow intensities

(Avoid spliting departments)

(Avoid$^+$ void)

Helpful in comparing two or more alternate layo

but it disgards the distance or separation betwee non-adjacent departments

* Layout Algoprithms can be classified according to (their objective function):

① Minimize the Sum of flows times distance (Distance based scoring)

input data from from to chart

$$\text{Min } Z=\sum_{i=1}^{m}\sum_{j=1}^{m} f_{ij}\, c_{ij}\, d_{ij}$$

m → # of departments

f_{ij} → flow (from to chart)

c_{ij} → cost

d_{ij} → distance (Mallang Matrix)

② Maximize the closeness (adjacency) (Adjacency scoring)

$$\text{Max } Z=\sum_{i=1}^{m}\sum_{j=1}^{m} f_{ij}\,X_{ij}$$

f_{ij} → Relationship value between i and j

X_{ij} → Binary variable: 1 if adjacent, 0 not adj.

Efficiency Rating

$$Z=\frac{\sum_{i=1}^{m-1}\sum_{j=1}^{m} f_{ij}X_{ij}}{\sum_{i=1}^{m-1}\sum_{j=1}^{m} f_{ij}}$$

based on
- relationship chart
- relationship diagram

* Layout Algorithms can be classified according to (the format of Layout representation):

① Discrete Representation

② continuous Representation

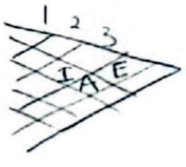
*Layout Algotithms can be also classified according to (their primary function):

① improvement type Algorithms

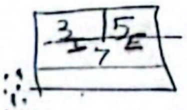
② Construction type Layout Algorithms

Adjacency based scoring

Relationship chart



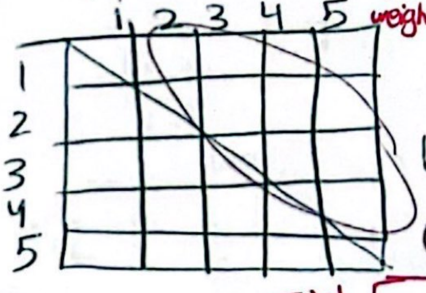
Layout



$Z = f_{ij}\,X_{ij}$

weights

adj: 1, 0



بمشي على كل dep adj وبحط رمزها

(كتبنا ال adjacent only)

Total score

(الوزن يلي حطيناها برجع اصله)

x → very large negative

Distance based Scoring

① * أول اشي نحدد ال centeroid for each department

② Distance Data (d_{ij}) احنا نحسبها

$|x_i-x_j|+|y_i-y_j|$

From to

	A	B	C	D
A	–			
B		–		
C			–	
D				–

③ Flow Data

بسويها upper Matrix

④ Total Score (cost) Z → $f_{ij}\, d_{ij}\, c_{ij}$

	A	B	C	D	Total
A	–				*
B		–			*
C			–		*
D				–	*

↓ +

Total

is an improvement method (computerized)

CRAFT

starts with
→ initial Layout
→ From to chart

1) determine departments centroids.

2) calculate rectilinear distance between centroids.

rectilinear distance ⇒ $D = |x_i - x_j| + |y_i - y_j|$

3) calculate transportation cost of the Layout.

↳ transportation cost = flow x unit cost x distance

$$\text{Min } z = \sum_{i=1}^{m} \sum_{j=1}^{m} f_{ij} c_{ij} d_{ij}$$

4) consider department exchanges of either ① equal area departments or ② departments sharing a common border.

5) determine the estimated change in transportation cost of each possible exchanges.

عندنا ما راح اغير ال centroid for the area

بس حبدل centroid dep B ⟺ centroid dep A

يعني نختار اقل transportation cost

6) select and implement the departmental exchange that offers the greatest reduction in transportation cost.

7) Repeat the procedure for the new Layout until no interchange is able to reduce the transportation cost.