FACILITY LOCATION & LAYOUT

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Facility location

- Facility/Plant location refers to the choice of region and the selection of a particular site for setting up a business or factory.
- Facility location is the process of determining geographic sites for a firm's operations.

Factors influencing plant/facility location

Controllable Factors

- Proximity to markets
- Supply of materials
- Transportation facilities
- Infrastructure availability
- Labour and wages
- Capital

Factors influencing plant/facility location

Uncontrollable Factors

- Government policy
- Climate conditions
- Supporting industries and services
- Community and labour attitudes

Factors influencing plant/facility location

Specific Factors for service industry

- Favourable labour climate
- Proximity to markets
- Quality of life
- Proximity to suppliers and resources
- Utilities, taxes, and real estate costs

Models to decide ideal location

- Factor rating method
- Weighted factor rating method
- Load-distance method
- Centre of gravity method
- Break even analysis

Factor rating method

- Identify the important location factors.
- Rate each factor according to its relative importance, (*i.e., higher the ratings is indicative of prominent factor*).
- Assign each location according to the merits of the location for each factor.
- Calculate the rating for each location by multiplying factor assigned to each location with basic factors considered.
- Find the sum of product calculated for each factor and select best location having highest total score.

Factor rating method: Example

- Let us assume that a new medical facility is to be located in Ajmer. The location factors, factor rating and scores for two potential sites are shown in the following table. Which is the best location based on factor rating method?

Location factor	Factor rating	Score	
		Location 1	Location 2
Facility utilization	8	2	5
Patient per month	5	4	3
Employee preferences	5	5	3

Factor rating method: Example

Location factor	Factor rating	Score			
		Location 1		Location 2	
Facility utilization	8	2	16	5	40
Patient per month	5	4	20	3	15
Employee preferences	5	5	25	3	15
Total score			61		70

Weighted factor rating method

- Let us assume that a new medical facility is to be located in Ajmer. The location factors, factor rating and scores for two potential sites are shown in the following table. Which is the best location based on factor rating method?

Location factor	Factor rating	Score	
		Location 1	Location 2
Facility utilization	0.44	2	5
Patient per month	0.28	4	3
Employee preferences	0.28	5	3

Weighted factor rating method

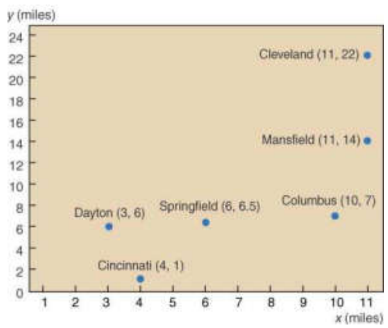
Location factor	Factor rating	Score			
		Location 1		Location 2	
Facility utilization	0.44	2	0.88	5	2.20
Patient per month	0.28	4	1.12	3	0.84
Employee preferences	0.28	5	1.40	3	0.84
Total score			3.40		3.88

Load-distance method

- The load-distance method is a mathematical model used to evaluate locations based on **proximity factors.**
- The objective is to select a location that **minimizes the total weighted loads moving into and** out of the facility.
- The distance between two points is expressed by assigning **the points to grid coordinates** on a map.
- An alternative approach is to use time rather than distance.

Load-distance method: Example

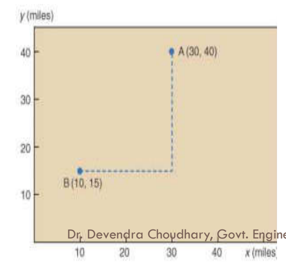
- Matrix Manufacturing is considering where to locate its warehouse in order to service its four Ohio stores located in Cleveland, Cincinnati, Columbus, Dayton. Two sites are being considered; Mansfield and Springfield, Ohio. Use the load-distance model to make the decision.



Load-distance method: Example

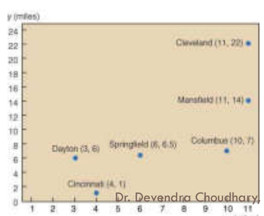
- Calculate the rectilinear distance :

  $d_{AB} = |30 - 10| + |40 - 15| = 45$ miles
- **Load** : no of trip from origin to destination in certain period (week, month , year)
- LDS = Load distance score = Load* d_{AB}



Load-distance method: Example

	Springfield			Mansfield		
	Load	Distance	LDS	Load	Distance	LDS
Cleveland	15	20.5	307.5	15	8	120
Columbus	10	4.5	45	10	8	80
Cincinnati	12	7.5	90	12	20	240
Dayton	4	3.5	14	4	16	64
Total load distance score			456.5			504



The load distance score for Mansfield > Springfield.
The Warehouse should be located in Springfield

Centre of gravity method

- **Determine the *x and y coordinates of different locations either in the form of the*** longitude and latitude of the locations, or by creating an (*x*, *y*) *grid*.
- The center of gravity's *x-coordinate, denoted x*, is found by multiplying* ***each point's x coordinate*** (either the longitude of the location or the x coordinate on a grid), **by its load (l_i), *summing these products ($\Sigma l_i x_i$), and then dividing by the sum of the loads (Σl_i).***
- The *y-coordinate, denoted y*, is found the same way.*

Centre of gravity method

S. No.	Location	(X, Y)	Load/Population (L)
1	A	(2.5, 4.5)	2
2	B	(2.5, 2.5)	5
3	C	(5.5, 4.5)	10
4	D	(5, 2)	7
5	E	(8, 5)	10
6	F	(7, 2)	20
7	G	(9, 2.5)	14

Centre of gravity method

S. No.	Location	(X, Y)	Load/Population (L)	Lx	Ly
1	A	(2.5, 4.5)	2	5	9
2	B	(2.5, 2.5)	5	12.5	12.5
3	C	(5.5, 4.5)	10	55	45
4	D	(5, 2)	7	35	14
5	E	(8, 5)	10	80	50
6	F	(7, 2)	20	140	40
7	G	(9, 2.5)	14	126	35
	Total		68	453.5	205.5

Cx = 453.5/68 = 6.67   **Cy = 205.5/68 = 3.02**

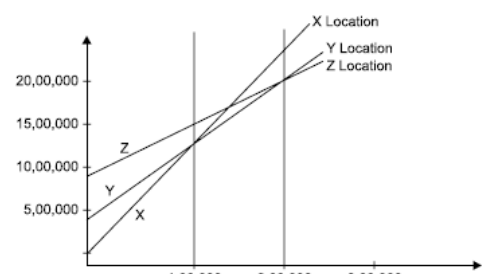
The centre of gravity is (6.67, 3.02).

Break even analysis

- For each location, determine the fixed and variable costs
- Plot the total costs for each location on one graph
- Identify ranges of output for which each location has the lowest total cost
- Solve algebraically for the break-even points over the identified range

Break even analysis

	Location X	*Location Y*	*Location Z*
Fixed Costs	Rs. 150,000	Rs. 350,000	Rs. 950,000
Variable Costs	Rs. 10	Rs. 8	Rs. 6



Facility layout

- The disposition of various facilities and services of the plant within the area of the location/site which has been selected previously is known as layout.
- Layout begins with the design of the new building and goes upto the placement, construction, errection and orientation of work place.

Facility layout

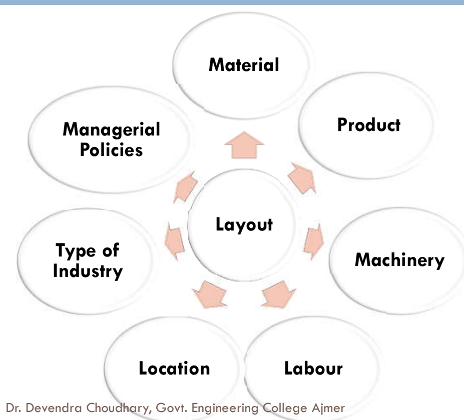
Facility layout is a plan of an optimum arrangement of facilities including

- Personnel
- operating equipment
- storage space
- material handling equipment and
- all other supporting services along with the design of best structure to contain all these facilities.

Objectives of Plant Layout

- Minimizes:
  - Material handling costs.
  - Movement of people and material
  - Hazards to personnel
  - Accidents
- Maximizes:
  - Production capacity
  - Labour efficiency
  - Employee morale
  - Space utilization
  - Ease of Supervision and Maintenance

Factors affecting Layout



Principles of Plant Layout

- Principle of integration (man, m/c and material in a balanced way)
- Principle of minimum movement (man, material and handling equipment)
- Principle of cubic space utilization (ground floor plus upper space)
- Principle of smooth and continuous flow
- Principle of maximum flexibility (Easy to rearrange or expand at minimum cost and least inconvenience)
- Principle of safety, security and satisfaction

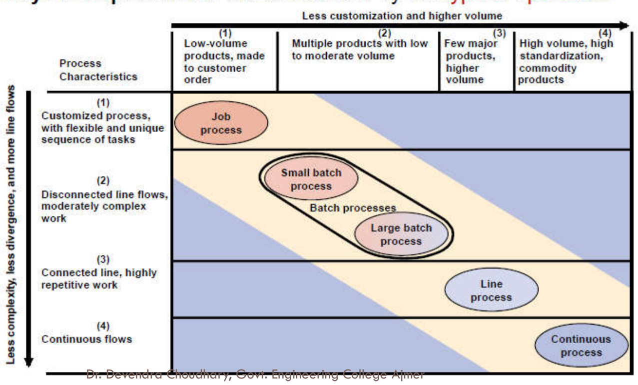
Classification of layout

Basic
- Process layout
- Product layout
- Fixed-position

Hybrid
- Cellular layouts
- Flexible manufacturing systems
- Mixed-model assembly lines

Classification of layout

Layout requirements are determined by the type of operation.



Classification of layout

- ***Fixed position layout***
  - Used in projects for large products e.g., airplanes, ships and rockets
- ***Process layout***
  - Used in a job shop for a low volume, customized products
- ***Product layout***
  - Used in a flow shop for a high volume, standard products
- ***Cellular layout***
  - A cell contains a group of machines dedicated for similar parts
  - Suitable for producing a wide variety parts in moderate volume

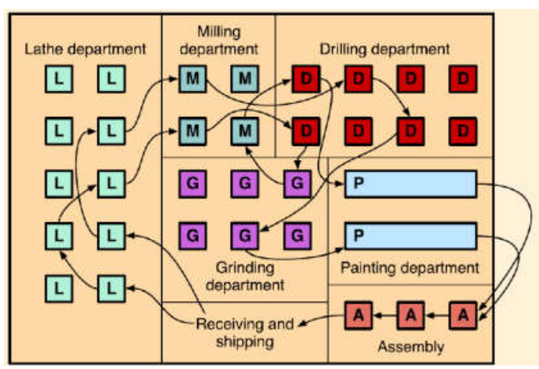
Fixed position layout

- Used for large, heavy/bulky and fragile products such as ships and buildings.
- The machines implementing the operation must come to the product, rather than the product moving to the machines.
- In this layout, the product remains stationary for the entire manufacturing cycle.
- Equipment, workers, materials, and other resources are brought to the production site.
- Here scheduling of operations is important rather than the layout of machines.

Fixed position layout

- Advantage
  - Interest and pride in doing the job
  - Enlargement and upgrades the skills
  - Flexibility
  - Layout capital investment is lower.
- Disadvantage
  - Equipment utilization is low because it is often less costly to leave equipment idle at a location.
  - The variable costs would be high (due to high labour rates and the cost of leasing and moving equipment)

Process/Job-shop layout



Process/Job-shop layout

- Deals with low-volume, high-variety production
- Machines are grouped according to function into machine centers (also called functional layout).
- The sequence of operations required to complete a customer's order can vary considerably
- Manage varied material flow for each product
- Machines are general purpose
- A relatively low level of automation
- Workers will be highly skilled
- A process layout provides flexibility

Process/Job-shop layout

- Production scheduling is difficult with this type of arrangement because the level and type of work is highly variable.
- This results in large amounts of work-in-process, long product lead times, and high levels of management interaction.
- The costs for setting up machines to produce the various products will be high because of the variety of different products and small lot sizes.

Process layout

- Advantages of process Layout
  - Flexibility
  - Increase knowledge of supervisors
- Limitation of process Layout
  - Large Storage space is required to accommodate the large amount of in-process inventory.
  - Reduce material handling efficiency (flexible material handling equipment (such as forklifts) that can follow multiple paths, move in any direction)
  - Decrease productivity due to large setup time

Product/Assembly line layout

- Deals with the high volume of production of a single product, or a few similar products.
- Arrange activities in a line according to the sequence of operations that need to be performed to assemble a particular product.
- Special purpose machines on the line can be designed with a high level of fixed automation, with very little manual labour.

Product/Assembly line layout

- Setup costs and work-in-progress will be low for this arrangement.
- Facilitates optimal utilization of personnel and machines.
- Equalize the task time at each workstation.
- A product layout provides efficiency and ease of use.

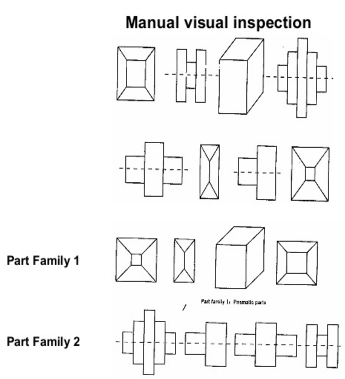
Product/Assembly line layout

- Advantages of product Layout
  - efficiency and ease of use
  - In-process inventory is less
  - Decrease handling cost
  - Mechanized handling systems
  - Unskilled workers can learn and manage the production.
  - Manufacturing cycle is short due to uninterrupted flow of materials.
- Limitation of product Layout
  - Stop entire production (very sensitive to failures that cause the entire line to shut down)
  - Difficult to change product design
  - Required high investment
  - Lack of flexibility (not flexible to product or volume changes)

Comparison of process and product layouts

	Product Layout	Process Layout
1. Description	Sequential arrangement of activities	Functional grouping of activities
2. Type of process	Continuous, mass production, mainly assembly	Intermittent, job shop, batch production, mainly fabrication
3. Product	Standardized, made to stock	Varied, made to order
4. Demand	Stable	Fluctuating
5. Volume	High	Low
6. Equipment	Special purpose	General purpose
7. Workers	Limited skills	Varied skills
8. Inventory	Low in-process, high finished goods	High in-process, low finished goods
9. Storage space	Small	Large
10. Material handling	Fixed path (conveyor)	Variable path (forklift)
11. Aisles	Narrow	Wide
12. Scheduling	Part of balancing	Dynamic
13. Layout decision	Line balancing	Machine location
14. Goal	Equalize work at each station	Minimize material handling cost
15. Advantage	Efficiency	Flexibility

Cellular/Group Technology layout



- Cellular layouts attempt to combine the flexibility of a process layout with the efficiency of a product layout.
- Products are grouped into classes that have some similarity with respect to processing (Identify a product family).

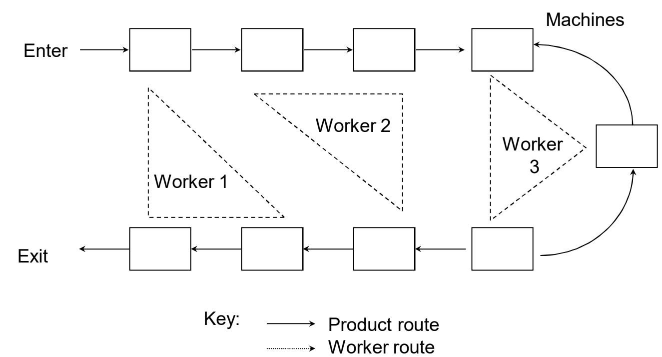
Cellular/Group Technology layout

- Dissimilar machines are grouped into work centers, called *cells*, to process parts with similar shapes or processing requirements.
- The cells are arranged in relation to each other so that material movement is minimized.
- Large machines that cannot be split among cells are located near to the cells that use them.
- The layout of machines within each cell resembles a product layout.
- The layout between cells is a process layout.

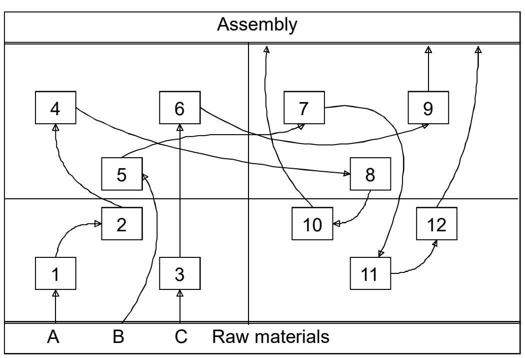
Cellular/Group Technology layout

- Because the range of products manufactured by each cell is less than that for the job shop, the machines and workers can be more specialized (build teams, cross train team members).
- The group technology arrangement requires less setup time and cost than the job shop because of the greater specialization of function.

Cellular/Group Technology layout



Converting a process layout into cellular layout: an example



Cellular layout example

	Machines											
Parts	1	2	3	4	5	6	7	8	9	10	11	12
A	x	x		x				x		x		
B					x		x				x	x
C			x			x			x			
D	x	x		x				x		x		
E					x	x						x
F	x			x				x				
G			x			x			x			x
H							x				x	x

Cellular layout example

	Machines											
Parts	1	2	4	3	5	6	7	8	9	10	11	12
A	x	x	x					x		x		
B					x		x				x	x
C				x		x			x			
D	x	x	x					x		x		
E					x	x						x
F	x		x					x				
G				x		x			x			x
H							x				x	x

Cellular layout example

	Machines											
Parts	1	2	4	3	5	6	7	8	9	10	11	12
A	x	x	x					x		x		
D	x	x	x					x		x		
B					x		x				x	x
C				x		x			x			
E					x	x						x
F	x		x					x				
G				x		x			x			x
H							x				x	x

Cellular layout example

	Machines											
Parts	1	2	4	8	3	5	6	7	9	10	11	12
A	x	x	x	x						x		
D	x	x	x	x						x		
B						x		x			x	x
C					x		x		x			
E						x	x					x
F	x		x	x								
G					x		x		x			x
H								x			x	x

Cellular layout example

	Machines											
Parts	1	2	4	8	3	5	6	7	9	10	11	12
A	x	x	x	x						x		
D	x	x	x	x						x		
F	x		x	x								
B						x		x			x	x
C					x		x		x			
E						x	x					x
G					x		x		x			x
H								x			x	x

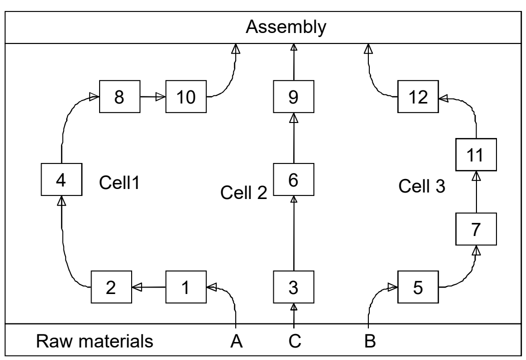
Cellular layout example

	Machines											
Parts	1	2	4	8	10	3	5	6	7	9	11	12
A	x	x	x	x	x							
D	x	x	x	x	x							
F	x		x	x								
B							x		x		x	x
C						x		x		x		
E							x	x				x
G						x		x		x		x
H									x		x	x

Cellular layout example

	Machines											
Parts	1	2	4	8	10	3	6	9	5	7	11	12
A	x	x	x	x	x							
D	x	x	x	x	x							
F	x		x	x								
C						x	x	x				
G						x	x	x				x
B									x	x	x	x
E							x		x			x
H										x	x	x

Cellular layout example



Each of A, B, C now visits only one area, minimizing jumping.

Cellular layout

- Advantages
  - Reduced material handling and transit time
  - Reduced setup time
  - Reduced work-in-process inventory
  - Better use of human resources
  - Better scheduling, easier to control and automate
- Disadvantages
  - Some cells may have a high volume of production and others very low.
  - workers must be multi-skilled and cross-trained

Design of product layout

- **Assembly Line Balancing**
- Assembly line balancing is the process of assigning tasks to workstations so that idle time is minimized. This will,
  - distribute the total workload on the assembly line as evenly as possible
  - ensure a smooth flow of products through the layout, with all resources used as fully as possible
  - Balancing the line gives the minimum amount of stations for a determined output rate, still satisfying all precedence requirements

Design of product layout

- The **goal is to match the output rate to the** production plan.
  - The work is separated into **work elements** **(the smallest** units of work that can be performed independently)
  - A **precedence diagram** **is constructed, which shows** which work elements that must be performed before the next can begin.
  - Determine the desired **output rate.**
  - Calculate the **cycle time** **(the maximum time allowed for** work on a unit at each station) = 1/output rate
  - Assign work elements to **stations.**

Design of product layout

- *Cycle time* is the maximum time allowed at each workstation to complete its set of tasks on a unit.

  Why is this important?
  - Consider the following process, with cycle times given:

A – 6 minutes → B – 7 minutes → C – 3 minutes

- Process cycle time is determined by the work station taking the **longest** time. Here, stations A and C will experience idle time.

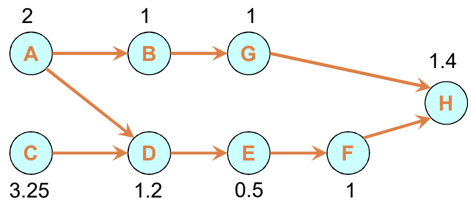
Assembly Line Balancing Example

- Consider a fan assembly line with the tasks below. 100 fans are to be assembled per day (production time of 420 minutes). How would you set up the workstations?

Task	Time (minutes)	Description	Predecessors
A	2	Assemble frame	None
B	1	Mount switch	A
C	3.25	Assemble motor housing	None
D	1.2	Mount motor housing in frame	A, C
E	0.5	Attach blade	D
F	1	Assemble and attach safety grill	E
G	1	Attach cord	B
H	1.4	Test	F, G

Assembly Line Balancing Example

- Draw flow diagram



Cycle time of the line cannot be smaller than the time for task C, the maximum possible production is:

$$Max\ Production = \frac{Total\ Time}{Bottleneck\ Rate} = \frac{420\ min}{3.25\ min/unit} = 129\ units$$

Assembly Line Balancing Example

- Determine cycle time $C = \frac{Daily\ Production\ Time}{Required\ Daily\ Ouput}$

$$C = \frac{Production\ time\ per\ period}{Required\ \ output\ per\ period} = \frac{420\ mins/day}{100\ units/day} = 4.2\ mins/unit$$

- Determine minimum number of workstations needed

$$N_t = \frac{Sum\ of\ Task\ Times\ (T)}{Cycle\ Time\ (C)}$$

$$N_t = \frac{Sum\ of\ task\ times\ (T)}{Cycle\ time\ (C)} = \frac{11.35\ mins}{4.2\ mins} = 2.702 \quad (round\ up\ to\ 3)$$

Assembly Line Balancing Example

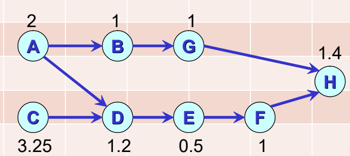
- Determine positional weight (PW) of each work element

Elements	Time	A	B	C	D	E	F	G	H	PW
A	2									
B	1									
C	3.25									
D	1.2									
E	0.5									
F	1									
G	1									
H	1.4									

Assembly Line Balancing Example

- Determine positional weight (PW) of each work element

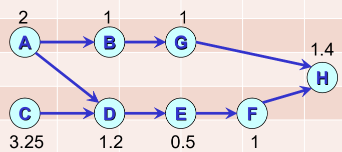
Elements	Time	A	B	C	D	E	F	G	H	PW
A	2	2	1	-	1.2	0.5	1	1	1.4	8.1
B	1									
C	3.25									
D	1.2									
E	0.5									
F	1									
G	1									
H	1.4									



Assembly Line Balancing Example

- Determine positional weight (PW) of each work element

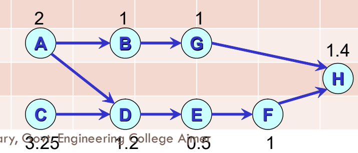
Elements	Time	A	B	C	D	E	F	G	H	PW
A	2	2	1	-	1.2	0.5	1	1	1.4	8.1
B	1	-	1	-	-	-	-	1	1.4	3.4
C	3.25									
D	1.2									
E	0.5									
F	1									
G	1									
H	1.4									



Assembly Line Balancing Example

- Determine positional weight (PW) of each work element

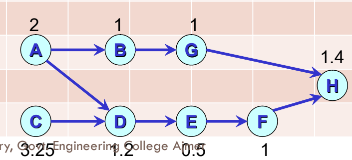
Elements	Time	A	B	C	D	E	F	G	H	PW
A	2	2	1	-	1.2	0.5	1	1	1.4	8.1
B	1	-	1	-	-	-	-	1	1.4	3.4
C	3.25	-	-	3.25	1.2	0.5	1	-	1.4	7.35
D	1.2									
E	0.5									
F	1									
G	1									
H	1.4									



Assembly Line Balancing Example

- Determine positional weight (PW) of each work element

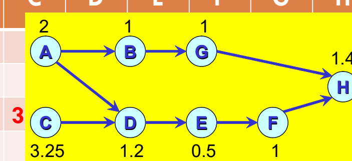
Elements	Time	A	B	C	D	E	F	G	H	PW
A	2	2	1	-	1.2	0.5	1	1	1.4	8.1
B	1	-	1	-	-	-	-	1	1.4	3.4
C	3.25	-	-	3.25	1.2	0.5	1	-	1.4	7.35
D	1.2	-	-	-	1.2	0.5	1	-	1.4	4.1
E	0.5									
F	1									
G	1									
H	1.4									



Assembly Line Balancing Example

- Determine positional weight (PW) of each work element

Elements	Time	A	B	C	D	E	F	G	H	PW
A	2	2	1							8.1
B	1	-	1							3.4
C	3.25	-	-	3						7.35
D	1.2	-	-							4.1
E	0.5	-	-	-	-	0.5	1	-	1.4	2.9
F	1	-	-	-	-	-	1	-	1.4	2.4
G	1	-	-	-	-	-	-	1	1.4	2.4
H	1.4	-	-	-	-	-	-	-	1.4	1.4



Assembly Line Balancing Example

- Arrange elements in decreasing order of positional weight (PW)

Elements	Time	PW
A	2	8.1
B	1	3.4
C	3.25	7.35
D	1.2	4.1
E	0.5	2.9
F	1	2.4
G	1	2.4
H	1.4	1.4

Elements	Time	PW
A	2	8.1
C	3.25	7.35
D	1.2	4.1
B	1	3.4
E	0.5	2.9
F	1	2.4
G	1	2.4
H	1.4	1.4

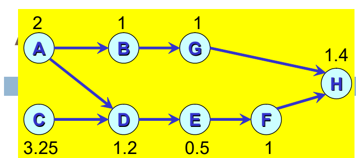
Assembly Line Balancing Example

- Assign elements to workstations, one at a time in order of decreasing positional weights and without violating precedence constraints and cycle time constraints.

Assign tasks to workstations such that,

No. of workstations = 3

Cycle time ≤ 4.2



Elements	Time	PW
A	2	8.1
C	3.25	7.35
D	1.2	4.1
B	1	3.4
E	0.5	2.9
F	1	2.4
G	1	2.4
H	1.4	1.4

No. of workstations = 3

Cycle time ≤ 4.2

Station 1
A – 2 min
B – 1 min
G – 1 min
4 min

Station 2
C – 3.25 min
3.25 min

Station 3
D – 1.2 min
E – 0.5 min
F – 1 min
H – 1.4 min
4.1 min

Assembly Line Balancing Example

- Calculate the line efficiency:

$$Efficiency = \frac{Sum\ of\ Task\ Times\ (T)}{Actual\ \#\ Workstations\ (N_a) \times Workstation\ Cycle\ Time\ (C)}$$

= 11.35*100/(3*4.2) = 90.07%

The new bottleneck is workstation 3, at 4.1 minutes:

$$Max\ Production = \frac{Total\ Time}{Bottleneck\ Rate} = \frac{420\ min}{4.1\ min/unit} = 102\ units$$

Assembly Line Balancing Example

Task	Imm. predecessor	Task time (sec)
A	None	55
B	A	30
C	A	22
D	B	35
E	B, C	50
F	C	15
G	F	5
H	G	10
	TOTAL	222

- Draw precedence diagram
- Determine cycle time—demand = 50 units/hr
- Theoretical minimum no. of work stations
- Assign tasks to workstations using cycle time
- Efficiency and balance delay of line?
- Bottleneck?
- Maximum output?

Assembly Line Balancing Example

The manager of a computer assembly line plans to produce 100 assembled computers per 10-hour workday. Work element data for the assembly is shown in the table below.

- Draw precedence diagram
- What cycle time (in minutes) results in the
- Theoretical minimum no. of work stations
- Assign tasks to workstations using cycle time
- Efficiency and balance delay of line?
- Bottleneck?
- Maximum output?

Task	Imm. predecessor	Task time (minutes)
A	None	2
B	A	3
C	B	1
D	B	5
E	C, D	5
F	E	4
G	D, E	1
H	F	2
I	G	6
J	H	4
K	I, J	2
L	K	6

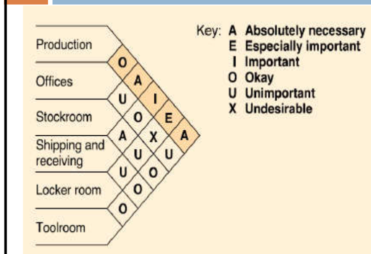
Design of process layout

- Step 1: Gather information
  - **Space requirements of each center**
  - **Available space in the facility**
  - **Closeness factor indicates which centers** need to be located next to each other (using **activity relation chart**)
- Step 2: Develop *current block plan (allocates space* and indicates placement of each department by trial and error)
- Step 3: Develop *proposed block plan*
- Step 4: Compare the two (e.g. using load-distance method, Cost matrix analysis or CRAFT) and make choice!

Activity Relation Chart (ARC)

- An **activity relationship chart is a graphical tool used to represent importance of** locating pairs of operations near each other.
- Importance is described using letter codes defined below:
  - A - absolutely necessary
  - E - especially important
  - I - important
  - O - ordinarily important
  - U - unimportant
  - X - undesirable

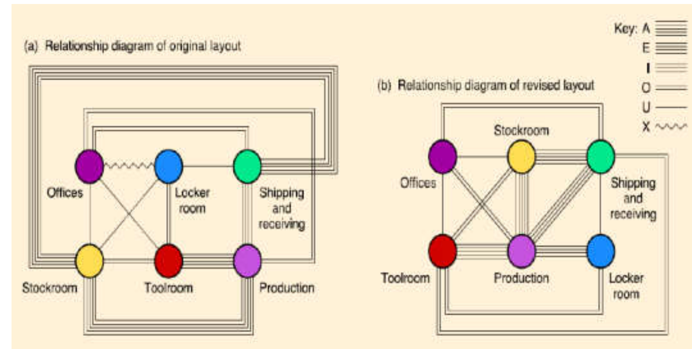
Activity Relation Chart (ARC)



Mother's grid displays preferences for departmental locations and used to construct a relationship diagram

It is *okay* if the offices are located next to production, *absolutely necessary* that the stockroom be located next to production, *important* that shipping and receiving be located next to production, *especially important* that the locker room be located next to production, and *absolutely necessary* that the tool room be located next to production.

Activity Relation Chart (ARC)



The best solution would show short heavy lines and no zigzagged lines

COMPUTERIZED LAYOUT TECHNIQUE

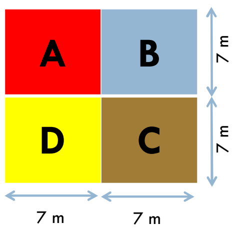
- **CRAFT**
  - Computerized Relative Allocation of Facilities Technique
  - A Layout Improvement Procedure
- **CORELAP**
  - Computerized Relationship Layout Planning
- **ALDEP**
  - Automated Layout Design Program
  - A Layout Construction Procedure

CRAFT

- CRAFT takes a load summary chart and block diagram as input and then makes pair-wise exchanges of departments until no improvements in cost or non-adjacency score can be found.
- The output is a revised block diagram after each iteration for a rectangular-shaped building, which may or may not be optimal.
- CRAFT is sensitive to the initial block diagram used; that is, different block diagrams as input will result in different layouts as outputs.
- For this reason, CRAFT is often used to improve upon existing layouts or to enhance the best manual attempts at designing a layout.

Designing process layout: Ex. 1

- Consider the following layout and flow matrix with unit cost matrix. Use **CRAFT algorithm** to obtain improved layout.

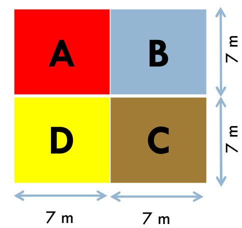


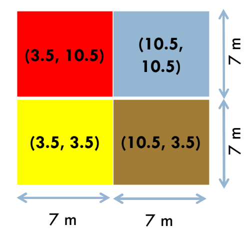
Dept	A	B	C	D
A	-	30	25	45
B	21	-	15	20
C	10	20	-	10
D	100	10	5	-

Flow matrix

Designing process layout: Ex. 1

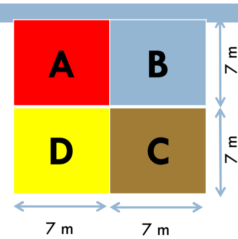
- **Step 1:** Determine centroids of each department



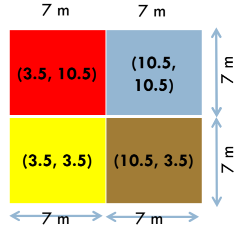


Designing process layout: Ex. 1

- **Step 2:** Draw distance matrix using rectilinear distances



Dept	A	B	C	D
A	0	7	14	7
B	7	0	7	14
C	14	7	0	
D	7	14	7	0



$d_{AB} = |10.5 - 3.5| + |10.5 - 10.5| = 7$

$d_{AC} = |10.5 - 3.5| + |3.5 - 10.5| = 14$

Designing process layout: Ex. 1

- **Step 3:** Determine total load distance or total cost matrix

Total load distance = Flow * Distance

Total cost = Flow * Distance * Cost of unit distance

Dept	A	B	C	D
A	-	30	25	45
B	21	-	15	20
C	10	20	-	10
D	100	10	5	-

Flow matrix

Dept	A	B	C	D
A	0	7	14	7
B	7	0	7	14
C	14	7	0	
D	7	14	7	0

Distance matrix

Designing process layout: Ex. 1

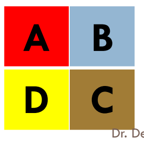
- **Step 3:** Determine total load distance or total cost matrix

Total load distance = Flow * Distance

Total cost = Flow * Distance * Cost of unit distance

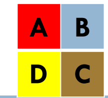
Dept	A	B	C	D
A	-	30	25	45
B	21	-	15	20
C	10	20	-	10
D	100	10	5	-

Dept	A	B	C	D
A	0	7	14	7
B	7	0	7	14
C	14	7	0	7
D	7	14	7	0



Dept	A	B	C	D	Cost
A	-	210	350	315	875
B	140	-	105	280	525
C	140	140	-	70	350
D	700	140	35	-	875
Total cost					2625

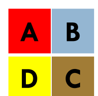
Designing process layout: Ex. 1



- **Step 4: Propose new layouts by interchanging departments which have common boundary or equal area or both.**

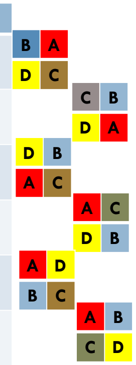
Interchange	Reason
A – B	Common boundary and equal area
A – C	Equal area
A – D	Common boundary and equal area
B – C	Common boundary and equal area
B – D	Equal area
C - D	Common boundary and equal area

Designing process layout: Ex. 1



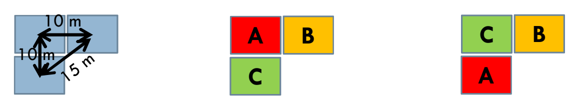
- **Step 5: Using Step 1 – 4, calculate total cost for each possible interchange and select the layout that gives least total cost.**

Interchange	Reason
A – B	Common boundary and equal area
A – C	Equal area
A – D	Common boundary and equal area
B – C	Common boundary and equal area
B – D	Equal area
C - D	Common boundary and equal area



Designing process layout: Ex. 2

- A facility that will be used to produce a single product has three departments (A, B, C) that must be housed in the configuration shown below:



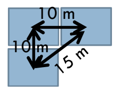
- The interdepartmental work load between work station is shown in table. Identify the best layout of two options given above. Assume that the cost of transportation is Rs. 4 per load.

Department	A	B	C
A	-	30	25
B	20	-	40
C	15	50	-

Designing process layout: Ex. 2

Flow matrix

Dept	A	B	C
A	-	30	25
B	20	-	40
C	15	50	-



A B
C

Distance matrix

Dept	A	B	C
A	-	10	10
B	10	-	15
C	10	15	-

Load Distance matrix

Dept	A	B	C
A	-	300	250
B	200	-	600
C	150	750	-

C B
A

Dept	A	B	C
A	-	15	10
B	15	-	10
C	10	10	-

Dept	A	B	C
A	-	450	250
B	300	-	400
C	150	500	-

Designing process layout: Ex. 2

A B
C

Load Distance matrix

Dept	A	B	C
A	-	300	250
B	200	-	600
C	150	750	-

Total cost matrix

Dept	A	B	C	Cost
A	-	1200	1000	2200
B	800	-	2400	3200
C	600	3000	-	3600
Total cost				9000

C B
A

Dept	A	B	C
A	-	450	250
B	300	-	400
C	150	500	-

Dept	A	B	C	Cost
A	-	1800	1000	2800
B	1200	-	1600	2800
C	600	2000	-	2600
Total cost				8200

Designing process layout: Ex. 2

A B
C

Total cost matrix

Dept	A	B	C	Cost
A	-	1200	1000	2200
B	800	-	2400	3200
C	600	3000	-	3600
Total cost				9000

C B
A

Dept	A	B	C	Cost
A	-	1800	1000	2800
B	1200	-	1600	2800
C	600	2000	-	2600
Total cost				8200

Total cost of the second layout is less than that of the first layout. So, the second layout will be preferred.

Designing process layout: Ex. 2

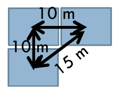
Assume that **a second product**, whose flow matrix is given below, is also to be produced in the same plant. Identify the best layout of two options.

Flow matrix of second product

Dept	A	B	C
A	-	40	8
B	35	-	12
C	10	8	-

Designing process layout: Ex. 2

Second product



Flow matrix

Dept	A	B	C
A	-	40	8
B	35	-	12
C	10	8	-

Layout 1:

A B
C

Distance matrix

Dept	A	B	C
A	-	10	10
B	10	-	15
C	10	15	-

Load Distance matrix

Dept	A	B	C
A	-	400	80
B	350	-	180
C	100	120	-

Layout 2:

C B
A

Dept	A	B	C
A	-	15	10
B	15	-	10
C	10	10	-

Dept	A	B	C
A	-	600	80
B	525	-	120
C	100	80	-

Designing process layout: Ex. 2

Second product

Layout 1:

A B
C

Load Distance matrix

Dept	A	B	C
A	-	400	80
B	350	-	180
C	100	120	-

Total cost matrix

Dept	A	B	C	Cost
A	-	1600	320	1920
B	1400	-	720	2120
C	400	480	-	880
Total cost				4920

Layout 2:

C B
A

Dept	A	B	C
A	-	600	80
B	525	-	120
C	100	80	-

Dept	A	B	C	Cost
A	-	2400	320	2720
B	2100	-	480	2580
C	400	320	-	720
Total cost				6020

Designing process layout: Ex. 2

Total cost matrix

Layout 1:

A B
C

First product

Dept	A	B	C	Cost
A	-	1200	1000	2200
B	800	-	2400	3200
C	600	3000	-	3600
Total cost				9000

Second product

Dept	A	B	C	Cost
A	-	1600	320	1920
B	1400	-	720	2120
C	400	480	-	880
Total cost				4920

Layout 2:

C B
A

First product

Dept	A	B	C	Cost
A	-	1800	1000	2800
B	1200	-	1600	2800
C	600	2000	-	2600
Total cost				8200

Second product

Dept	A	B	C	Cost
A	-	2400	320	2720
B	2100	-	480	2580
C	400	320	-	720
Total cost				6020

Designing process layout: Ex. 2

Total cost matrix for both products

Layout 1:

A B
C

Dept	A	B	C	Cost
A	-	2800	1320	4120
B	2200	-	3120	5320
C	1000	3480	-	4480
Total cost				13920

Layout 2:

C B
A

Dept	A	B	C	Cost
A	-	4200	1320	5520
B	3300	-	2080	5380
C	1000	2320	-	3320
Total cost				14220

Total cost of the first layout is less than that of the second layout. So, the first layout will be preferred for two products.

Designing process layout: Ex. 3

Use the following data for **ALDEP algorithm**, and design the layout.

- Number of departments = 5
- Minimum closeness preference = I = 4
- Sweep width = 2
- Areas of depts. And relationship chart

Dept	Area(m^2)
1	2500
2	3000
3	1200
4	1300
5	2000

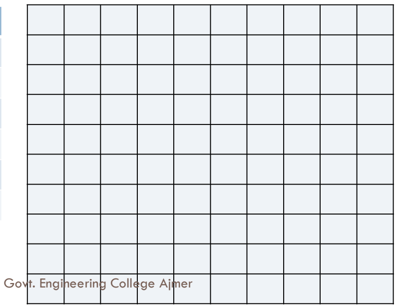
Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

Designing process layout: Ex. 3

Assume one square in the layout to be equal to 100 sq. meter.

- Let the size of layout be 10*10 and sweep width be 2 (this means that we will fill two columns simultaneously.

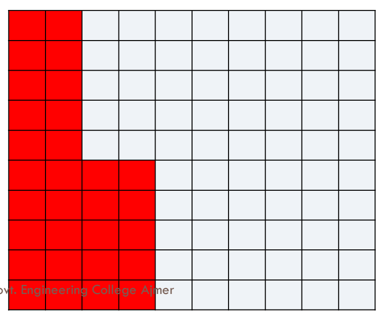
Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

- Randomly select the first department in the layout. Let department be 2.
- Number of unit squares in Dept. 2 be 30
- Place the first department in the upper left corner and extend it downward to fill 30 squares.

Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

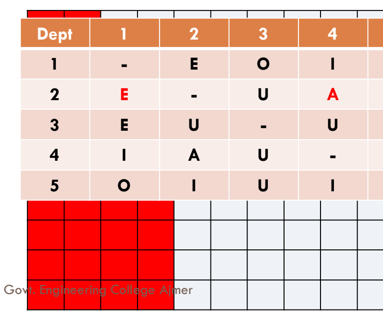


Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department.
- Select department having more close relationship requirement. Let it be 4
- The department 4 begins where the department 2 ended and follows the serpentine sweep pattern.

Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

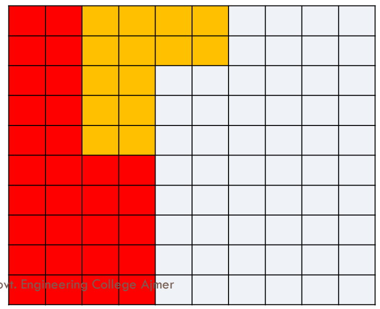
Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department.
- Select department having more close relationship requirement. Let it be 4
- The department 4 begins where the department 2 ended and follows the serpentine sweep pattern.

Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

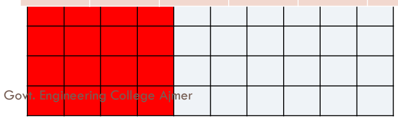


Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department.
- Select department having more close relationship requirement. Let it be 1
- The department 1 begins where the department 4 ended and follows the serpentine sweep pattern.

Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

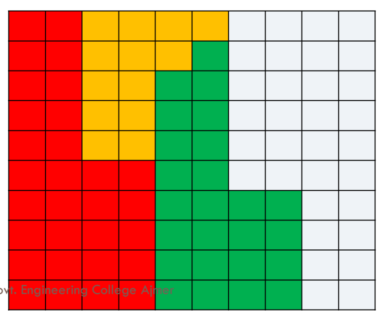
Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department.
- Select department having more close relationship requirement. Let it be 1
- The department 1 begins where the department 4 ended and follows the serpentine sweep pattern.

Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

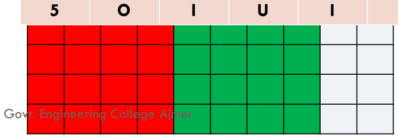


Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department. Depts 4 and 2 already assigned.
- Select any department from remaining. Let it be 3
- The department 3 begins where the department 1 ended and follows the serpentine sweep pattern.

Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

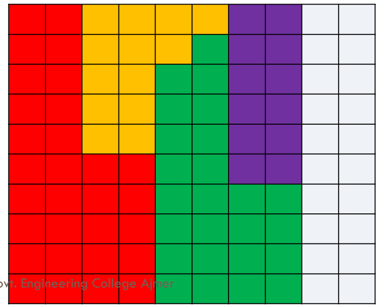
Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department. Depts 4 and 2 already assigned.
- Select any department from remaining. Let it be 3
- The department 3 begins where the department 1 ended and follows the serpentine sweep pattern.

Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

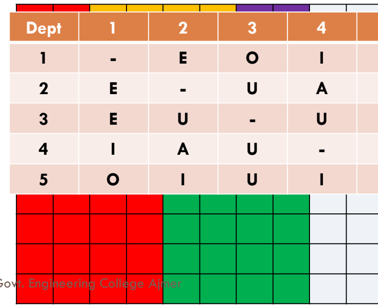


Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department. Dept 3 is already assigned.
- Unassigned dept. is 5
- The department 5 begins where the department 3 ended and follows the serpentine sweep pattern.

Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

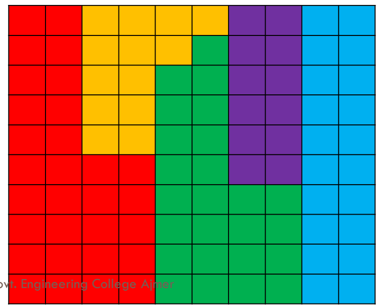
Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department. Dept 3 is already assigned.
- Unassigned dept. is 5
- The department 5 begins where the department 3 ended and follows the serpentine sweep pattern.

Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

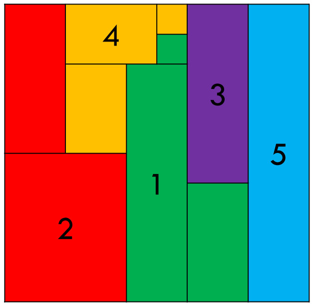


Designing process layout: Ex. 3

- Find total closeness rating

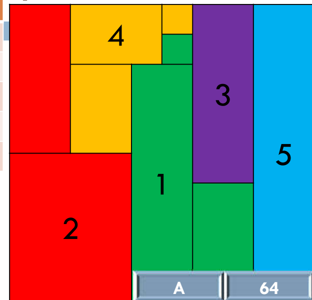
Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20

A	64
E	16
I	4
O	1
U	0
X	-1021



Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



A	64
E	16
I	4
O	1
U	0
X	-1021

Pair	Closeness rating
1, 2	16
1, 3	
1, 4	
1, 5	
2, 4	
3, 4	
3, 5	
Total	

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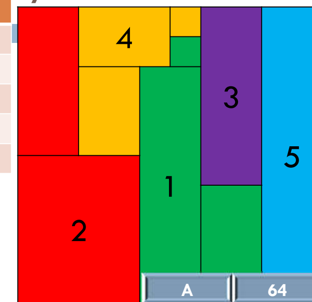
Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



A	64
E	16
I	4
O	1
U	0
X	-1021

Pair	Closeness rating
1, 2	16
1, 3	1
1, 4	
1, 5	
2, 4	
3, 4	
3, 5	
Total	

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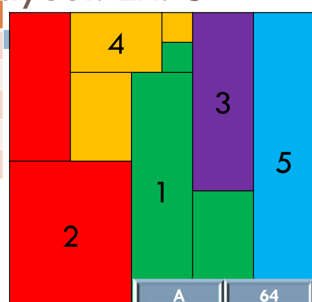
Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



A	64
E	16
I	4
O	1
U	0
X	-1021

Pair	Closeness rating
1, 2	16
1, 3	1
1, 4	4
1, 5	
2, 4	
3, 4	
3, 5	
Total	

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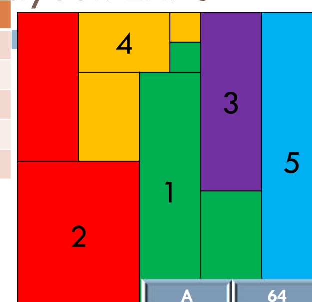
Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



A	64
E	16
I	4
O	1
U	0
X	-1021

Dept. Pair	Closeness rating
1, 2	16
1, 3	1
1, 4	4
1, 5	1
2, 4	64
3, 4	0
3, 5	0
Total	86

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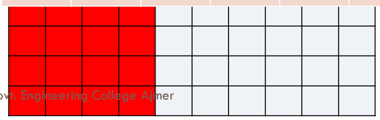
Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department.
- Select department having more close relationship requirement. Let it be 5 instead of 1
- The department 5 begins where the department 4 ended and follows the serpentine sweep pattern.

Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

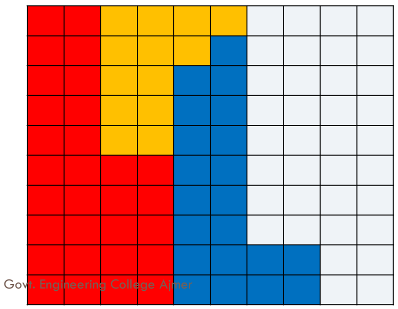
Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department.
- Select department having more close relationship requirement. Let it be 5 instead of 1
- The department 5 begins where the department 4 ended and follows the serpentine sweep pattern.

Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

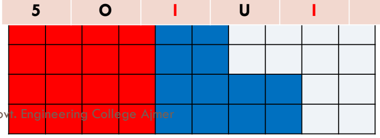


Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department. . Depts 4 and 2 already assigned.
- Select any department from remaining. Let it be 1
- The department 1 begins where the department 5 ended and follows the serpentine sweep pattern.

Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	

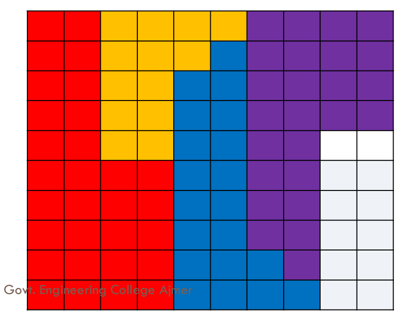
Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



Designing process layout: Ex. 3

- Since the minimum closeness between departments is I = 4, scan the relationship chart to find next department. . Depts 4 and 2 already assigned.
- Select any department from remaining. Let it be 1
- The department 1 begins where the department 5 ended and follows the serpentine sweep pattern.

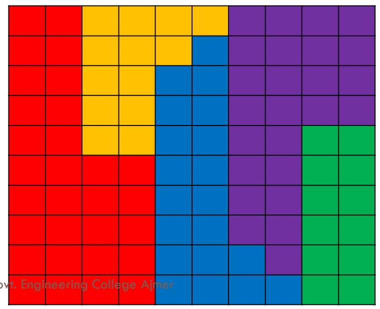
Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

- Finally, assign department 3

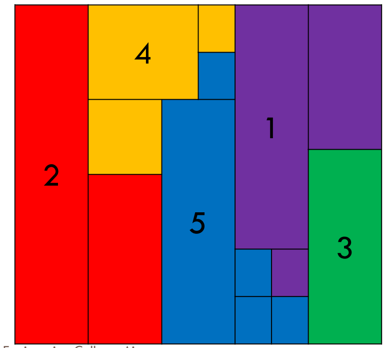
Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

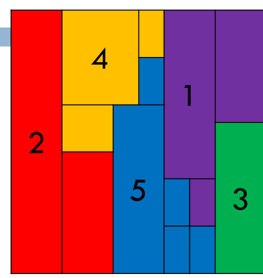
- Finally, assign department 3

Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

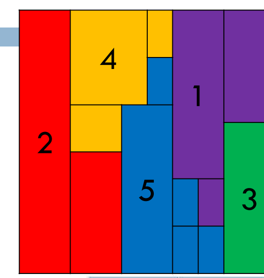
- Find total closeness rating



Dept. Pair	Closeness rating
2, 4	
2, 5	
4, 1	
4, 5	
5, 1	
5, 3	
1, 3	
Total	

Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

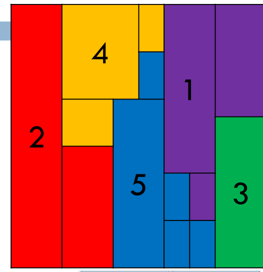


Dept. Pair	Closeness rating
2, 4	64
2, 5	
4, 1	
4, 5	
5, 1	
5, 3	
1, 3	
Total	

A	64
E	16
I	4
O	1
U	0
X	-1021

Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

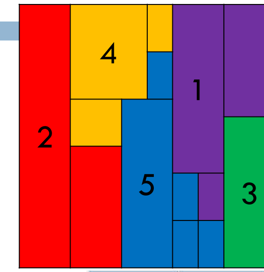


Dept. Pair	Closeness rating
2, 4	64
2, 5	4
4, 1	
4, 5	
5, 1	
5, 3	
1, 3	
Total	

A	64
E	16
I	4
O	1
U	0
X	-1021

Designing process layout: Ex. 3

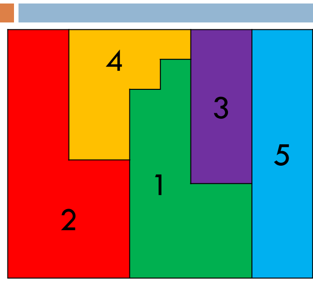
Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



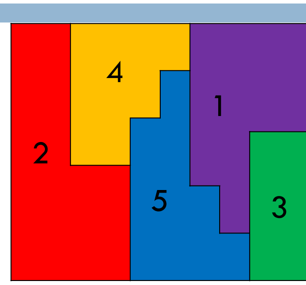
Dept. Pair	Closeness rating
2, 4	64
2, 5	4
4, 1	4
4, 5	4
5, 1	1
5, 3	0
1, 3	1
Total	78

A	64
E	16
I	4
O	1
U	0
X	-1021

Designing process layout: Ex. 3



Closeness rating = 86



Closeness rating = 78

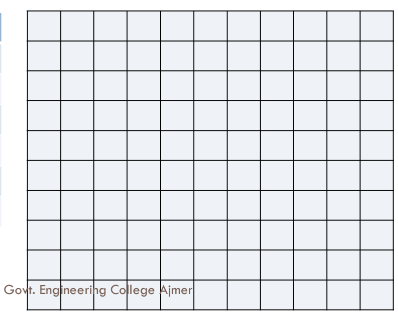
A layout with better closeness rating is preferred.

Designing process layout: Ex. 3

Assume one square in the layout to be equal to 100 sq. meter.

- Let the size of layout be 10*11 and sweep width be 2 (this means that we will fill two columns simultaneously.

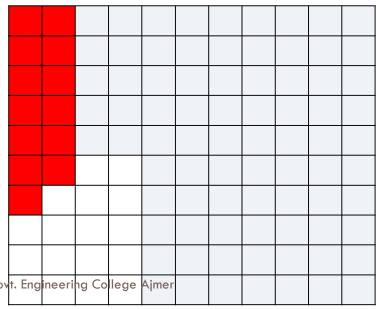
Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

- Randomly select the first department in the layout. Let department be 4.
- Number of unit squares in Dept. 4 be 13
- Place the first department in the upper left corner and extend it downward to fill 12 squares.

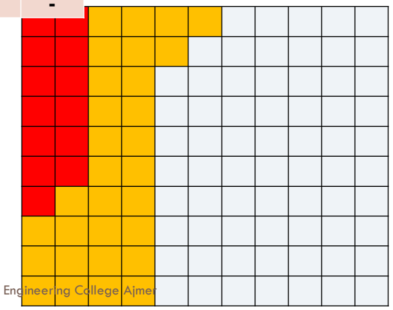
Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

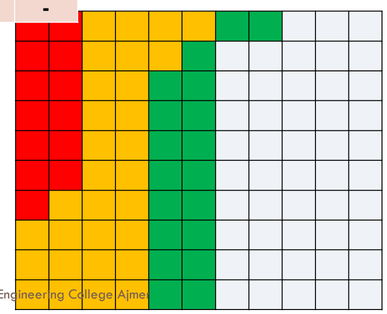
Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

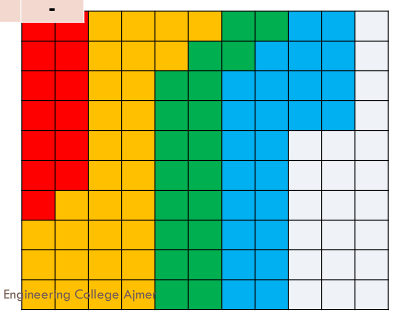
Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

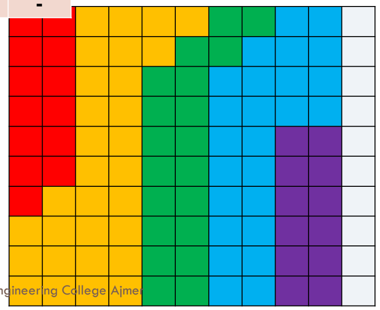
Dept	Area(m²)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

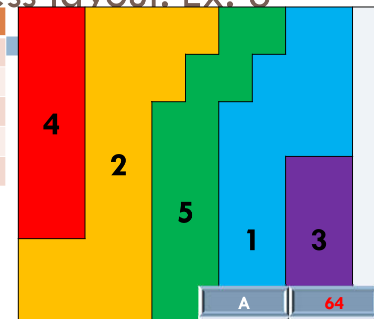
Dept	Area(m^2)	#Square
1	2500	25
2	3000	30
3	1200	12
4	1300	13
5	2000	20
Total	10000	



Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

Dept. Pair	Closeness rating
4, 2	64
2, 5	
5, 1	
1, 3	
Total	

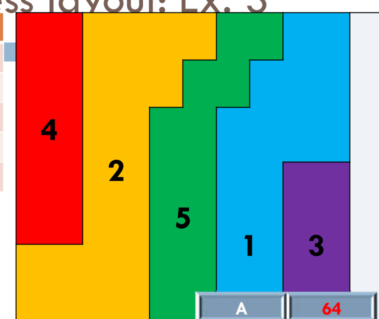


A	64
E	16
I	4
O	1
U	0
X	-1021

Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

Dept. Pair	Closeness rating
4, 2	64
2, 5	4
5, 1	
1, 3	
Total	

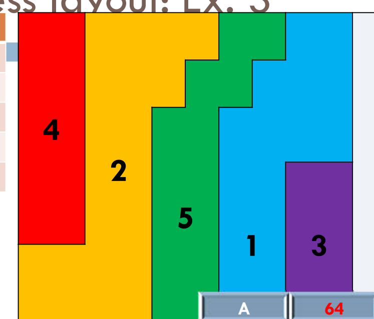


A	64
E	16
I	4
O	1
U	0
X	-1021

Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-

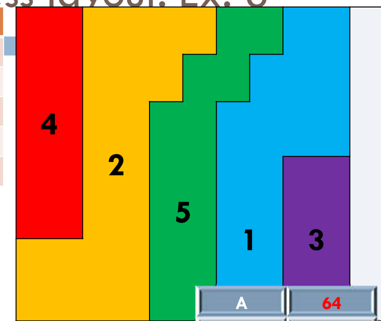
Dept. Pair	Closeness rating
4, 2	64
2, 5	4
5, 1	1
1, 3	1
Total	70



A	64
E	16
I	4
O	1
U	0
X	-1021

Designing process layout: Ex. 3

Dept	1	2	3	4	5
1	-	E	O	I	O
2	E	-	U	A	I
3	E	U	-	U	U
4	I	A	U	-	I
5	O	I	U	I	-



Dept. Pair	Closeness rating
4, 2	64
2, 5	4
5, 1	1
1, 3	1
Total	70

A	64
E	16
I	4
O	1
U	0
X	-1021

Not better than previous two layouts

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