

IENG 471 Facilities Planning – Assignments for Fall 2017 (so far...)

HW 1: In teams of 4 persons, find a way to work with MS Excel to do the following:

- a.) determine at least five items/activities that should be housed in the facility; and...
- b.) list at least five criteria for deciding if the assigned facility design is a good one, and five quantitative measures for assessing the design (one for each criterion);
- c.) create a layout for the assigned facility.

Turn in one spreadsheet (divided into tabs) for each team. Construct a cover sheet tab for this assignment, with all team member's names on it.

HW 2: In teams of 4 persons, reverse engineer the assigned product, and ...

- a.) create an indented Bill Of Materials, estimating and rolling up cost data; and
- b.) create an Operations Process Chart for the product, assuming the structural starting materials are in a bulk state (bars of aluminum/zinc, barrel of uncolored LDPE), and the non-structural components are purchased (decals, paint)
- c.) create a Precedence Diagram for the operations in (b).
- d.) convert your Precedence Diagram from (c) into a PERT chart. Assume that each operation in the first level of your OPC takes 1 minute, that each operation in the second level of your OPC takes 2 minutes, and add an additional minute for each additional level in your OPC. Analyze your PERT chart and answer the following:
 - i. What is the makespan of your product?
 - ii. What operations are on the Critical Path?
 - iii. What is the slack time for each of the Non-Critical operations?

Turn in one set of combined sheets, with each person's contribution noted. Construct a cover sheet for this set, with all team member's names on the front.

HW 3: In teams of either 4 or 5 persons, use the data below to answer (a. – h.):

The seven step Casting and Paint Line process is to be modelled. The process characteristics are given in the table (bottom) for each workstation. The process steps are:

1. Input raw material for a variety of tractor models enters the CM (casting machine). The scrap is re-cast (RC) similar to a re-work station, and both the CM and RC output is sent on to the trim station (TS). RC scrap is lost.
2. The output from CM and RC goes into the trim station (TS). Output from TS goes to de-grease & de-burr (DD). TS scrap is lost.
3. The output from TS goes into de-grease & de-burr (DD). Output from DD is sent to base paint (BP), scrap from DD is usually found in the de-burring media within another cycle (treat as a rework station called FM) and can be sent on to BP as well. Scrap that is not found within one cycle is usually lost (giving us the FM scrap rate).
4. The output from DD (and recovered scrap from FM) goes into the base paint (BP) station. The output from the BP goes to a drying oven (DO), but the scrap is lost.
5. The painted output from BP goes into the drying oven (DO), which dries the paint before sending the parts onto the mask paint (MP) station. Sometimes parts fall off the paint hooks inside the oven, which results in a few incomplete part sets at the end of the shift – accounting for the scrap rate – and those short sets are lost.
6. The output from DO may be mask painted, which two-tones the colors, at the MP station. Output is sent through a drying oven (DO). Poorly painted parts are lost scrap,.
7. If there is output from mask paint (MP), it must also go through a drying oven (DO), with the same process characteristics as before (see 5.). Output from DO goes to meet the Quota (at a sub-assembly line).

	MC	RC	TS	DD	FM	BP	DO	MP	DO		
Scrap Rate:	1.00%	5.00%	1.00%	1.00%	0.05%	0.01%	1.00%	0.50%	1.0%		
Footprint Length:	8	8	4	6	6	8	20	6	20	feet	
Footprint Width:	3.5	3.5	6	6	6	4	3	4	3	feet	
Efficiency:	400%	400%	100%	100%	100%	400%	100%	200%	100%		
MTTF:	103,680	103,680	8,640	1,440	1,440	7,200	311,040	7,200	311,040	minutes	
Diagnosis Time:	240	240	4	2	2	1	12	1	12	minutes	
Repair Time:	336	336	0.5	5	5	72	26	72	26	minutes	
Replacement Time:	1104	1104	0	0	0	2	4	2	4	minutes	
Return to Service Time:	105	105	0.2	0.2	0.2	0.2	15	0.2	15	minutes	
Operator Hourly Rate:	\$ 25.50	\$ 25.50	\$ 25.50	\$ 19.00	\$ 19.00	\$ 22.00	\$ 17.00	\$ 25.00	\$ 17.00		
Operator Overhead:	52%	52%	52%	52%	52%	52%	52%	52%	52%		
Machine Hourly Rate:	\$ 29.00	\$ 29.00	\$ 7.00	\$ 2.00	\$ 2.00	\$ 1.00	\$ 12.00	\$ 4.00	\$ 12.00		
Concurrent Time:	10	10	25	25	25	15	40	15	40	seconds	
Autonomous Machine Time:	68	120	0	6	12	20	10	20	10	seconds	
Operator Ind. Tasks Time:	42	50	5	25	25	30	45	30	45	seconds	
Operator Travel Time:	15	15	8	4	4	8	10	8	10	seconds / machine assigned	
Machine Assignment:	1.25	0.5	4	1	1	4	1	2	1	machines/operator	

Put together a spreadsheet model for this system, with the table (above) as an input sheet (tab), along with the following information:

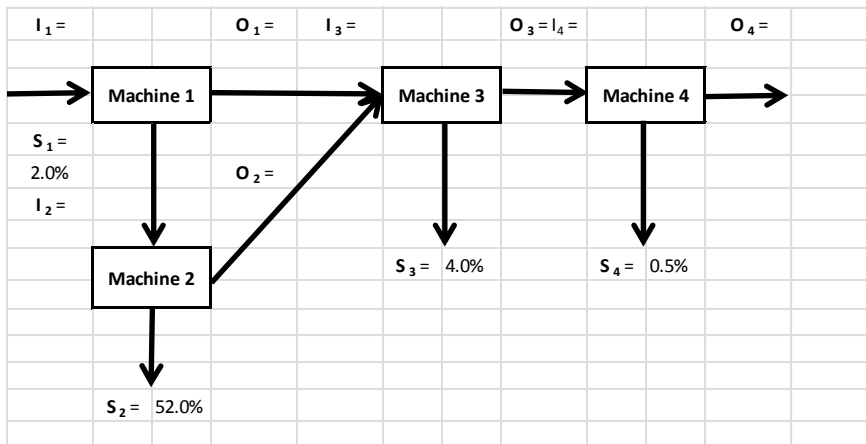
- Quota for the line per day
- Shifts per day
- Hours per shift
- And any other values that need to be assumed ...

(problem continues, next page)

Set up a second sheet (tab) that calculates and displays the following information:

	MC	RC	TS	DD	FM	BP	DO	MP	DO		
Input at Station:											units/day
Output from Station:											units/day
Ideal Assignment:											machines/operator
Cycle Time (Steady State):											seconds
Machine Idle Time:											seconds
Operator Idle Time:											seconds
Cost per Unit:											Total Cost/Unit
Quota per Shift:											units/shift
Time per Shift:											seconds per shift
Availability:											
Equipment Fraction:											
Equip Fraction Ceiling:											Total Space
Space Required (Mass Prod):											sq feet
Space Required (Job Shop):											sq feet
Station Total Cost/ Good Unit:											Total Cost/Good Unit

and diagrams the process, similar to:



(Bonus points if the correct OPC symbols are used!)

Then, use your model to do the following if the daily quota is 600 units/day, and if the daily quota is 1270 units/day; assuming 1 shift of 8 hours each day, and assuming 2 shifts of 10 hours/day under both quotas:

- compute the required input for each of the workstations
- compute the equipment necessary for each machine
- compute the steady state cycle time for each machine
- compute the ideal machine assignment for each machine
- compute the idle time for the operator and machine at each station, if the given machine assignments are implemented
- compute the unit cost at each workstation, if the given assignments are used
- compute the total cost per good unit using (f)
- estimate the square footage required for mass production for each workstation and the total space required for the entire system

Add a cover sheet tab and turn in one Excel spreadsheet for each team, with all team member's names listed. A starting format spreadsheet is linked [here](#).

HW 4: Use the Group Technology spreadsheet application to complete the following two exercises.

These are individual problems – you may still work together – but you must turn in one spreadsheet of problem solutions per individual. Put these in three tabs, one problem per tab, with a cover sheet tab in the first tab position. Use the highlighter tool to highlight the cells in your matrix AND type your answer to each problem (which families contain which components) in the cells below the matrix.

- a.) The following table of products and machines must be used to formulate work cells. Which products and machines should form each cell?

Product	Machines
A	2, 4, 6
B	1, 3, 5, 7, 9
C	1, 5
D	1, 7, 9
E	2, 4, 8
F	3, 5, 9
G	6, 5, 7
H	2, 8

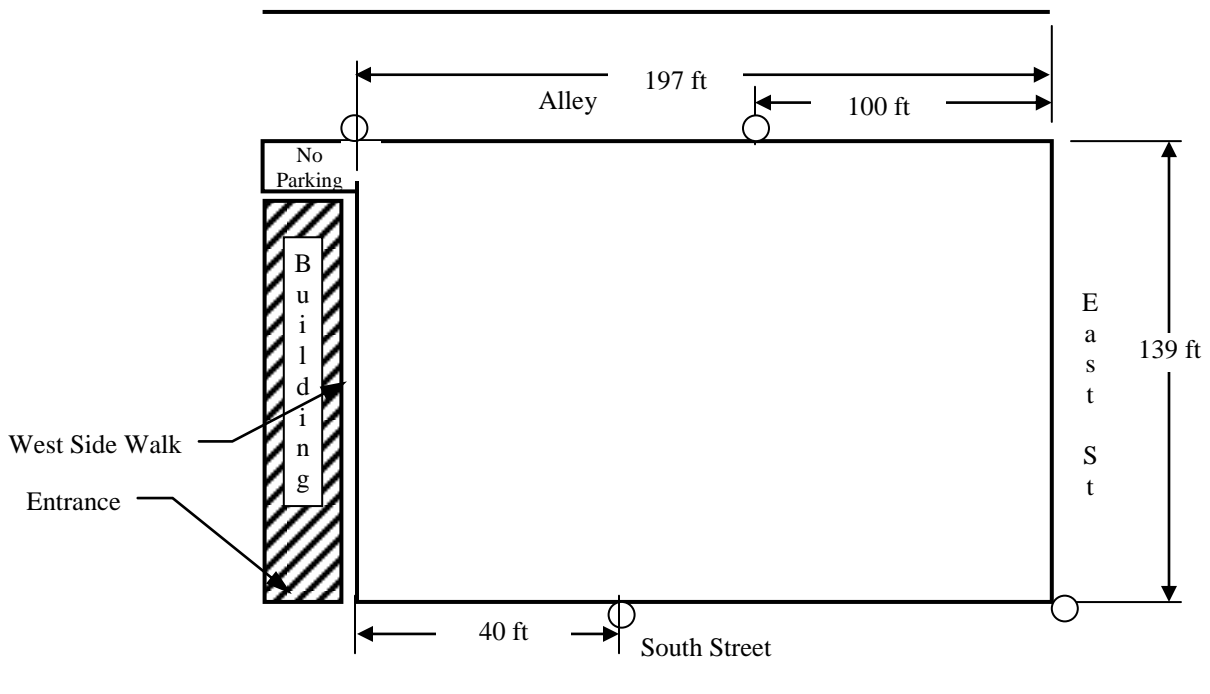
- b.) The following table of Departments shows the employee position Skill Classifications needed for the operation of a large hospital. How should the hospital organize the wings of its' facility? Which Skill Classes should be formed into Departments in the same wings?

Dept.	Skills Classes
1	A, F, H
2	F, G, H
3	D, E
4	B, D
5	A, C, H
6	B, E
7	A, G

HW 5: In teams of 2 persons, design a parking lot for the space (below), and subject to the listed constraints. Assume that the objective is to maximize number served in the space available, and subject to the following constraints:

- The alley and side streets at the South and East ends of the lot could serve as cross-aisles for the lot.
- 90° parking must use the stall width midpoints, other angles can use the smallest stall widths in a class.
- 2% of the stalls are handicapped accessible (use 12' stall width, regardless of angle)
- 14 - 20% of the stalls are for compact vehicles.
- 10 - 14% of the stalls are for large vehicles (see (b.), above).
- Bumpers can overhang the sidewalks to the South and East, but not the West.
- Bumpers cannot encroach on the alley, or the garbage truck will hit them!
- The remainder of the parking lot is to be used for standard car stalls (see (b.), above).
- Any cross aisles in the lot are to be at least 10 ft wide.
- Watch for obstructions that would prevent stall use – like 2' diam. utility poles ... ○
- Each individual car must be able to leave the lot without moving another vehicle.

Fully document the design of your parking lot (module type, parking angle, module width, rows per module, and number of cars per row). Show the row directions in the lot diagram (next page, and give the number of vehicles accommodated:



Turn in one set of combined sheets, with each person's design noted. Construct a cover sheet for this set, with both team member names on the front.

HW 6: Use the Personnel Space Handouts to complete the following two exercises.

You may work in teams of 2 persons, turn in one assignment set per team on EP paper, with a cover page. Document your work professionally for full consideration.

- A. Restrooms are to be designed for an electronics manufacturing facility that employs 285 employees. Assume that 40% are male, and separate facilities are needed. At least 1/3 of all water closets are to be sized for handicapped access (15 ft², each), and space must be allotted for cots, urinals, entrances, and sinks as well. What is the **minimum** allowable total space for each sex?
- B. An industrial company is interested in providing on-site food service for its 400 employees. To maintain production near steady state, overlapping lunch shifts will serve 100 employees each shift. A cafeteria will be required for seating, but options are needed for both a vending-machine and a catering approach. Answer the following:
- What is the minimum time needed to serve all employees for a single meal?
 - What is the minimum space needed for vending machine service?
 - What is the minimum space needed for serving line service?
 - What is the minimum space required for the cafeteria?
- C. Assume that one dimension of a cafeteria is 62 ft, and that seated diners are considered “stationary”. Select standard-sized tables and lay them out to provide seating for 100 persons while minimizing the overall space. **Show your layout and give the important dimensions.**

HW 7: Work in teams of 3 or 4 persons, turn in one assignment set per team.

E-mail one spreadsheet per team to the instructor **and cc all team members** by the deadline with the ***Subject Line: IENG 471 HW7***. Make sure that the first tab on the spreadsheet has all team member names listed **and** your answers to each of the part of each of the questions **neatly summarized**. (i.e. use the remaining tabs for your calculations, **neatly detailed**.) Answer the following:

- Dr. Jensen’s downtown office was 151 inches in length, 144 inches in width, and 96 inches in height. He could fill it with four types of boxes.

In each of the four scenarios below (I – IV), compute:

- the usable cube;
- the container space utilization;
- the total number of boxes if using the best stacking pattern to fit them into his office (boxes can be stacked, but not if they are laid on their sides, and boxes can be turned 90° to better fit the room); and ...
- the storage space efficiency for the best stacking pattern.

- I. The standard book box is rectangular in shape, with dimensions of 16 “ x 13” x 10.5” tall. When really packed tight, it can contain the following:

		Length	Width	Height
1	Project Management Books	8.25	1	10.25
1	Facilities Planning Books	7.25	1.5	10.25
1	Engineering Economics Books	7.5	1.75	9.5
2	Manufacturing Processes Books	8.25	2	10.25
1	Statistical Quality Control Books	8.25	1.5	10.25
1	Engineering AI Applications Books	7.25	1	9.5
5	Engineering Notebooks	7.5	0.25	9.75
1.375	Standard Stacks of Paper Handouts	11	2	8.5

- II. The half-sized book boxes are almost the same shape, but the dimensions change to 7.5” x 13” x 10.5” tall. When stuffed full, they can contain:

		Length	Width	Height
1	Project Management Books	8.25	1	10.25
1	Facilities Planning Books	7.25	1.5	10.25
1	Engineering Economics Books	7.5	1.75	9.5
0	Manufacturing Processes Books	8.25	2	10.25
1	Statistical Quality Control Books	8.25	1.5	10.25
1	Engineering AI Applications Books	7.25	1	9.5
1	Engineering Notebooks	7.5	0.25	9.75
0	Standard Stacks of Paper Handouts	11	2	8.5

- III. The BankersBox™ has dimensions of 12.5” x 12.5” x 10.5” tall. Crammed full, they can hold:

		Length	Width	Height
1	Project Management Books	8.25	1	10.25
1	Facilities Planning Books	7.25	1.5	10.25
1	Engineering Economics Books	7.5	1.75	9.5
2	Manufacturing Processes Books	8.25	2	10.25
1	Statistical Quality Control Books	8.25	1.5	10.25
1	Engineering AI Applications Books	7.25	1	9.5
5	Engineering Notebooks	7.5	0.25	9.75
0	Standard Stacks of Paper Handouts	11	2	8.5

- IV. The Dr. J Box has dimensions of 9.75” x 13” x 10.5”. Most efficiently packed, it holds:

		Length	Width	Height
1	Project Management Books	8.25	1	10.25
1	Facilities Planning Books	7.25	1.5	10.25
1	Engineering Economics Books	7.5	1.75	9.5
2	Manufacturing Processes Books	8.25	2	10.25
1	Statistical Quality Control Books	8.25	1.5	10.25
1	Engineering AI Applications Books	7.25	1	9.5
5	Engineering Notebooks	7.5	0.25	9.75
0.5	Standard Stacks of Paper Handouts	11	2	8.5

2. The interior dimensions of the standard “professor moving trailer” are 53’ x 8’ x 9.5’. You may use any one of the standard pallet sizes to stack standard book boxes upon, but book boxes may NOT hang over the edge of any of the pallets. Note that a pallet adds 6” to the height of the stack when loading/unloading the truck.
 - a. Find the optimum size standard pallet to use when loading the truck;
 - b. Find the total number of optimum size pallets and the total number of palletized standard book boxes that may be loaded on the truck;
 - c. Find the trailer space utilization under these optimal conditions; and...
 - d. If Dr. Jensen is a “standard professor”, how many standard professor moving trailer trips would have been necessary to move 6 faculty to the basement of the library?
3. Go to the following address on the MHIA-CICMHE website: <http://www.mhia.org/industrygroups/cicmhe/resources/guidelines> and use the Material Handling Taxonomy link to answer the following questions:
 - a. What is the difference between a narrow-aisle straddle truck and a narrow-aisle reach truck?
 - b. What is the difference between a counter-balanced lift truck and a turret truck?
 - c. Which of the first seven types of Storage Equipment can be accessed Last-In, First-Out;
 - d. Which of the first seven types of Storage Equipment can be accessed First-In, First-Out
 - e. Which of the first seven types of Storage Equipment can be accessed Randomly (in any order)?

HW 8: Use your notes from the Facility Layout Lecture to complete the following three exercises.

You may work in teams of 2 persons, turn in one assignment set per team on EP paper, with a cover page. Document your work professionally for full consideration.

- Use the From/To chart (below) to perform a Pareto Analysis and assign appropriate affinity relationships to each department pair:

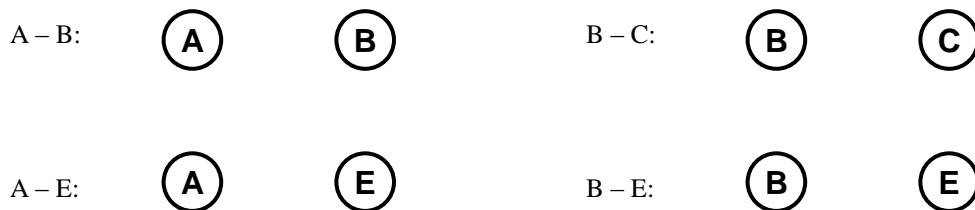
<i>To</i> <i>From</i>	Dept A	Dept B	Dept C	Dept D	Dept E
Dept A		10	5		
Dept B			25		
Dept C				8	6
Dept D			2		10
Dept E	4			5	

Note that there should be no more than 10% “A” pairs, 10% “E” pairs, 20% “I” pairs, and 30% “O” pairs.

- Assume that the following matrix resulted from the conversion to relationships. Illustrate the following relationships *using the standard Affinity diagram connections* between each department pair listed:

	Dept B	Dept C	Dept D	Dept E
Dept A	I	O	O	O
Dept B		A	U	X
Dept C			I	O
Dept D				E

Dept. Pairs



- Assume that the following matrix resulted from the conversion and combination of quantitative and qualitative relationships. Further, assume that the table below lists the estimated size of each department. Construct a reasonably workable, *scaled* Affinity Diagram *using the standard diagram connections* between each department:

	<i>Affinity Relationship</i>			
	Dept B	Dept C	Dept D	Dept E
Dept A	I	O	O	O
Dept B		A	U	X
Dept C			I	O
Dept D				E

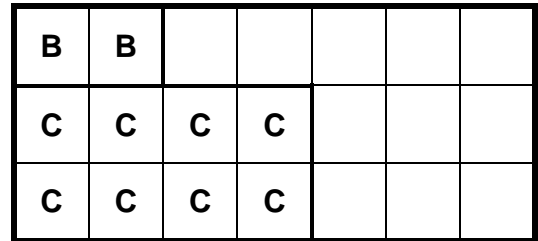
	<i>Estimated Size (sq. ft.)</i>
Dept A	300
Dept B	200
Dept C	800
Dept D	300
Dept E	500

HW 9: Use the information from HW 8 to complete the following three exercises.

You may work in teams of 2 persons, turn in one assignment set per team on EP paper, with a cover page. Document your work professionally for full consideration.

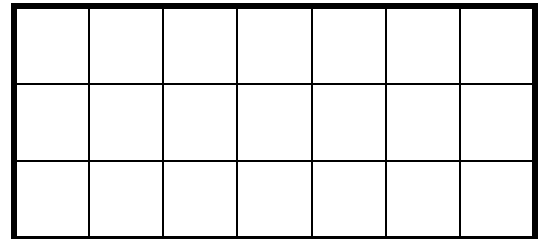
1. Assume that the following partial layout resulted from fitting the Affinity Diagram and department size data to a scaled diagram of the rectangular building. Complete the departmental layout for this alternative (each \square represents 100 FT²), and compute the Flow Weighted Adjacency.

Estimated Size (sq. ft.) & Flow (E.L.U.s)					
Size	Dept	Total Flow to Dept			
		B	C	D	E
300	A	500	250	200	150
200	B		900		400
800	C			300	100
300	D				700
500	E				



2. In the second building (below), construct an improved, alternative layout based on the affinity diagram (each \square represents 100 FT²), and compute the improved Flow Weighted Adjacency.

Estimated Size (sq. ft.) & Flow (E.L.U.s)					
Size	Dept	Total Flow to Dept			
		B	C	D	E
300	A	500	250	200	150
200	B		900		400
800	C			300	100
300	D				700
500	E				



3. The distance between the exterior wall of a warehouse and the property line is 95 feet. The facility must be able to load/unload four semi-trailer trucks simultaneously, and the trucks are 60 – 65 feet in length. Assuming that the docks are 14 feet in width, what is the minimum length exterior wall that will accommodate the truck bays and docks? (Be careful – it is NOT just the sum of the bay widths!) Sketch your final design and dimensions, and show your work.)

