Study Guide for the Final Exam

ISE 453: Design of PLS Systems **Spring 2020**

The Final Exam will consist of a 24-hour "take-home" portion worth 60% of the exam grade and an online assessment worth 40% of the grade. The take-home portion will be posted 24 hours before the start of the scheduled online assessment and can be submitted anytime during this period. You can submit any computer files or scanned worksheets used. The 75-minute online assessment portion will be completed any time during the regularly scheduled exam time: Thu, 30 Apr, 8–11 a.m. EDT. The assessment will a Moodle quiz along with a handout, you will be able to submit all of your answers online and will not have to upload any files. Time will be extended for those students with DSO accommodation. Both portions of the exam are individual, open computer, and open notes.

Study pp 85–99, 113–175 of the Lecture Notes, ICA 16–20, Project 2 (Problems 1 and 2, only), HW 6, and the following problems (solutions provided at the end of the guide):

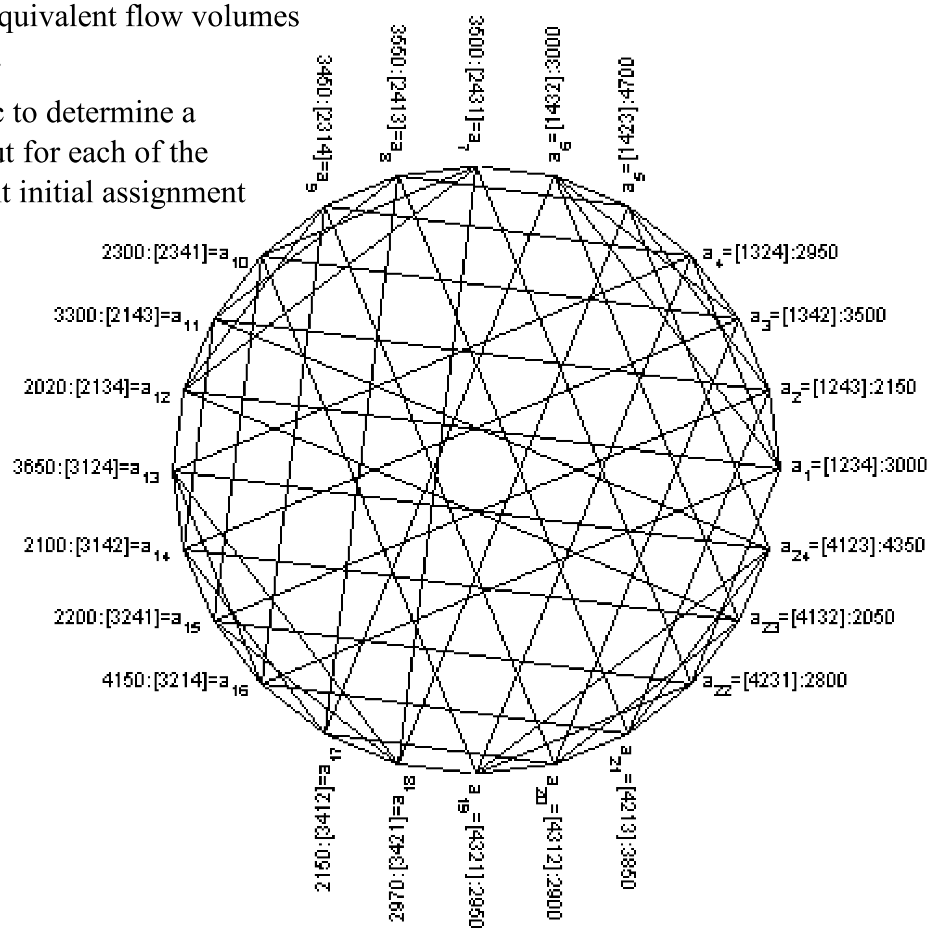
Online Assessment Study Problems

1. Products A and B are to be produced using four different machines, Machines 1–4. The routings for the products are A: 1–2–3–4–1 and B: 1–3–4–1. The material handling effort for each unit of each product is expected to be proportional to each unit's overall volume. Each unit of Product A has dimensions of 2 by 3 by 2, and each unit of Product B has dimensions of 3 by 4 by 2. Assuming that there is no scrap, that a unit's volume does not change during production, and that 10 and 15 units of A and B, respectively, are to be produced, determine equivalent flow volumes between the machines.

2. Use the SDPI heuristic to determine a (locally) optimal layout for each of the following two different initial assignment vectors (please list the intermediate nodes used at each iteration):

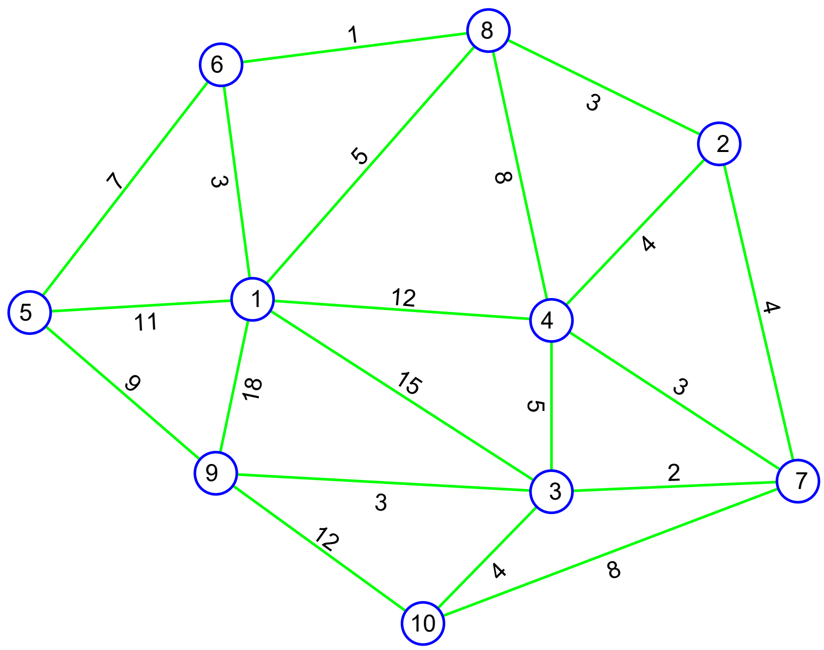
   (a) $a = a_{21}$

   (b) $a = a_{15}$



3. Describe one advantage and one disadvantage of a U-shaped material flow pattern as compared to a straight-line material flow pattern.

4. The cost of each arc is shown in the network below. Use Dijkstra's algorithm to determine the least cost path from node 1 to node 10.



5. List the type(s) of pallet racks that will never result in honeycomb loss.

6. Explain why drive-in and drive-through storage racks might have greater potential for honeycomb loss as compared to other types of racks.

7. Why is a deep-reach pallet rack not appropriate when a FIFO retrieval policy is required?

8. What type of rack would likely be the most appropriate for the storage of 20-foot-long bar stock?

9. What storage alternative is both the storage medium and the transport mechanism?

10. How can a product be stored so that FIFO retrieval is possible even though not every load is always accessible?

11. What type of rack would likely be the most appropriate for the temporary outdoor storage of pallet loads of eggs?

12. What type of storage medium would likely be the most appropriate if each item in storage needs to be accessible at all times and space for storage is very expensive due to high land costs?

13. What type of storage medium would likely be the most appropriate to store a very large number of identical pallet loads of a single type of fragile and perishable item?

14. Explain the difference between zone and batch picking.

15. Why is lines-per-item usually a better measure of piece picking activity than the number of units picked?

16. Why is the cube of each item listed in the item master file, instead of just calculating its value using the product of the item's dimensions that are listed in the file?

17. Explain why multi-level pick to pallet is likely to be more appropriate for picking a large number of slow moving items as compared to floor-level pick to pallet.

18. List three different means of communicating piece-pick information to a picker.

19. Explain the difference between picking and putting.

20. Determine the cube per order and cube movement for the following item master and order dataset: (*Answer:* Cube per order = 2540 and cube movement = 1260, 384, 5400, and 576 for A–D)

SKU	Length	Width	Depth	Cube	Weight
A	5	3	4	60	7.45
B	6	4	5	48	8.05
C	8	6	5	180	12.50
D	4	4	3	32	9.75

Order	SKU	Qty	UOM	Order	SKU	Qty	UOM
1	A	3	EA	2	C	12	EA
1	B	4	EA	2	D	6	EA
1	C	6	EA	3	A	6	EA
2	A	12	EA	3	C	12	EA
2	B	4	EA	3	D	12	EA

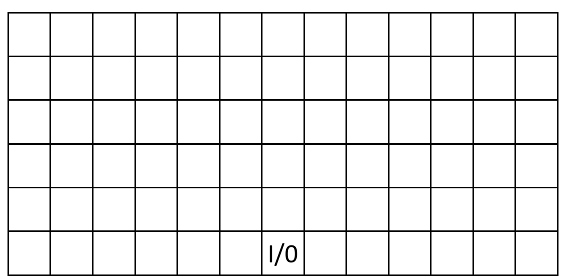
21. Determine the demand correlation distribution for the four SKUs in the following order dataset:

Order	SKU	Order	SKU	Order	SKU	Order	SKU
1	A	2	C	5	A	7	D
1	B	2	D	5	C	8	A
1	C	3	A	6	D	9	A
2	A	3	C	7	B	9	C
2	B	4	D	7	C	10	D

22. The inventory levels of the products A, B, and C are listed in the table below. How many storage locations are required if a dedicated storage policy is used? How many locations are required if a randomized policy is used? How many are required if a class-based policy is used where Products A and C together form Class I and Product B forms Class II?

	Product		
Period	A	B	C
1	10	12	7
2	8	9	8
3	9	20	7
4	15	8	3
5	11	5	2
6	8	2	18

23. Consider the storage area shown below. The I/O port is used for all S/R operations. Products A, B, and C each require 8, 4, and 12 slots, respectively, and have throughput requirements of 25, 13, and 38. Use the DSAP to determine the slot assignments for each product that minimizes the total distance traveled (label the product assigned to each slot). You can assume Assumptions 1–4 of DSAP are satisfied and that the same material handling equipment is used for all S/R operations. Rectilinear travel is used and is measured between the centroids of the slots and the I/O port.



“Take-Home” Portion Study Problem

24. A new public warehouse is being designed. It is expected to store 4,800 different items, and each item can be assumed to belong to a different customer of the warehouse. The average maximum inventory level of each item is two hundred and fifty units, six percent of which is safety stock. The average unit cost of each item in storage is \$46.75, and is expected to increase 3% per year for each of the next ten years. Randomized block stacking will be used to store 40 × 42 × 42 in. two-way pallet loads, one unit per pallet, and all of the slots in the warehouse are equally likely to be used. There is no limit on stacking pallets, but the clear height available for stacking is 18 feet. The warehouse will have a rectangular shape with a single I/O point located along its perimeter. The investment costs for the building are \$15.50 per square foot of area, and it will have a salvage value equal to 100% of its original cost at the end of ten years. The area required for cross aisles, offices, and shipping/receiving docks equals 15% of the total storage area. A narrow-aisle reach truck will be used for all storage and retrieval operations. Each truck requires seven-foot-wide down aisles, requires 35 seconds for loading or unloading, has an investment cost of \$35,000, and will have a salvage value equal to 25% of its original cost at the end of ten years. Riding speed is 7 mph and fuel cost is \$2.75 per hour of operation. The fully burdened labor rate of all direct labor is \$15.00 per hour. One operator is assigned to each truck for an entire shift, and there are twelve additional workers that perform the other move-related tasks. The annual demand is expected to be constant at two-million single-command moves. There should be enough trucks to handle a peak loads that are 25% above the average demand rate. If there are two eight-hour shifts per day, five days a week, fifty weeks per year and the real cost of capital is 5% per year with annual compounding, what is the minimum cost that can be charged for (a) each single-command move and (b) the time each pallet load spends in the warehouse? Also, (c) what are other costs that should be added to each charge to better reflect the true costs of each activity? (*Answer:* (a) \$2.10 per move, (b) \$2.70 per slot-year, (c) most significant missing costs are the facility non-move-related operating costs, which should be added to the slot-year charge)

Solution:

1.

								1	2	3	4
Routing : 1	1	2	3	4	1		1	0	120	360	0
2	1	3	4	1			2	0	0	120	0
3							3	0	0	0	480
4							4	480	0	0	0

Item :	1	2	3	4	5	6
Flow :	10	15				
Handling Cost :	12	24				

2. (a) $a_{21} \rightarrow a_2$, (b) $a_{15} \rightarrow a_{14} \rightarrow a_{23} \rightarrow a_{12}$

3. Adv: Can load/unload at same side using same equipment/operator/dock. Easier operator access to all MC. Disadv: Congestion due to load/unload at same side if high volume. Longer, more difficult operator access to all MC. Possible difficulty of WIP making turns along line.

4.

```
Node:    1    2    3    4    5    6    7    8    9   10

   S:   1*    0    0    0    0    0    0    0    0    0
   d:    0  Inf  Inf  Inf  Inf  Inf  Inf  Inf  Inf  Inf
pred:    0    0    0    0    0    0    0    0    0    0

   S:    1    0    0    0    0   1*    0    0    0    0
   d:    0  Inf   15   12   11    3  Inf    5   18  Inf
pred:    0    0    1    1    1    1    0    1    1    0

   S:    1    0    0    0    0    1    0   1*    0    0
   d:    0  Inf   15   12   10    3  Inf    4   18  Inf
pred:    0    0    1    1    6    1    0    6    1    0

   S:    1   1*    0    0    0    1    0    1    0    0
   d:    0    7   15   12   10    3  Inf    4   18  Inf
pred:    0    8    1    1    6    1    0    6    1    0

   S:    1    1    0    0   1*    1    0    1    0    0
   d:    0    7   15   11   10    3   11    4   18  Inf
pred:    0    8    1    2    6    1    2    6    1    0

   S:    1    1    0   1*    1    1    0    1    0    0
   d:    0    7   15   11   10    3   11    4   18  Inf
pred:    0    8    1    2    6    1    2    6    1    0

   S:    1    1    0    1    1    1   1*    1    0    0
   d:    0    7   15   11   10    3   11    4   18  Inf
pred:    0    8    1    2    6    1    2    6    1    0

   S:    1    1   1*    1    1    1    1    1    0    0
   d:    0    7   13   11   10    3   11    4   18   19
pred:    0    8    7    2    6    1    2    6    1    7

   S:    1    1    1    1    1    1    1    1   1*    0
   d:    0    7   13   11   10    3   11    4   16   17
pred:    0    8    7    2    6    1    2    6    3    3
```

```
   S:    1    1    1    1    1    1    1    1    1    1*
   d:    0    7   13   11   10    3   11    4   16   17
pred:    0    8    7    2    6    1    2    6    3    3

d =
    17
p =
   1     6     8     2     7     3    10
```

5. Single deep, sliding racks
6. They have the greatest storage depth per lane (except for block stacking, which is not actually a rack)
7. Pallets that are input first in a lane are blocked by later pallets, making them less accessible and FIFO more difficult.
8. Cantilever rack
9. AS/RS, A-frame, vertical lift module, or storage carousel
10. Loading and unloading occurs at opposite ends of a one-level lane of storage
11. Stacking frame
12. Sliding racks
13. Drive through
14. Zone picking uses multiple pickers for a single order, while batch picking uses a single picker for multiple orders
15. Most of the cost of piece picking us getting to/from the storage location, which is proportional to the number of different SKUs picked in an order and corresponds to the number of lines in the order.
16. The total cubic volume (cube) of an item may be less than the product of its dimensions, which may affect packing
17. More pick locations are available, but it takes longer to pick from locations above floor level.
18. Any three of: Paper (Pick-to-Paper), PDT display (Bar Code Scanning), spoken commands (Pick-to-Voice), LED display (Pick-to-Light)
19. In picking, containers of many items are used to form each order, while in putting, one container of an item is put into many orders.

20.

	Order									
Item	1	2	3	Cube				Cube Movement		
A	3	12	6	60	180	720	360	1260		
B	4	4	0	48	192	192	0	384		
C	6	12	12	180	1080	2160	2160	5400		
D	0	6	12	32	0	192	384	576		
					1452	3264	2904	2540	= cube per order	

21. A-B,C,D = 0.2,0.5,0.1, B-C,D = 0.3,0.2, C-D = 0.2

22. Dedicated = 15 + 20 + 18 = 53 locations, Randomized = 36 locations, Class-based = 26 + 20 = 46 locations

Period	A	B	C	ABC	AC	Total
1	10	12	7	29	17	
2	8	9	8	25	16	
3	9	20	7	36	16	
4	15	8	3	26	18	
5	11	5	2	18	13	
6	8	2	18	28	26	
	15	20	18	36	26	
Ded	15	20	18			53
Rand				36		36
AC-B		20			26	46

23. Given flow densities of 3.125, 3.25, and 3.167 for A, B, and C, respectively:

						A						
					A	C	A					
				A	C	C	C	A				
			A	C	C	B	C	C	A			
		C	C	B	B	I/0	B	C	C	A		

24.

r		0.05
N	(yrs)	10
IV	($)	35,000
SV	(%)	25
SV	($)	8,750
IVeff	($)	29,628
CcrTr	($/yr/veh)	3,837
A		7
M		636,000
N		4,800
x		3.50
y		3.33
z		3.50
H		5
D		7
L(D)		20,503
TA(2-D)		1,925,573
Cross Aisle %		15%
CS(2-D)		288,836
TS = TS + CS		2,214,409
Perimeter Cost		0
Perimeter		6,313
Area Cost		15.50
Bldg Cost	($)	34,323,346
CcrBldg	($/yr)	1,716,167

sft/yr		500	
hr/sft		8	
Speed	(mph)	7	
	(ft/min)	616	
TA	(ft^2)	2,214,409	
d_Slots,0	(ft)	2104	
d_I/O,0	(ft)	0	
d_SC	(ft/mov)	2104	
L/U time	(s)	35	
T(SC)	(min/mov)	4.583023664	
Annual Demand	(mov/yr)	2,000,000	
Operating Hours	(hr/yr)	152767	
Fuel	($/hr)	2.75	
Annual Hours	(hr/yr)	4000	
Labor	($/yr)	15.00	
Other Move Workers		12	
Oper Cost	($/yr)	4,020,111	
Annual Demand	(mov/hr)	500	
Peak Demand	(mov/hr)	625	
T(SC)	(hr/mov)	0.076383728	
No. vehicles	(m)	48	
Peak Util	(u)	0.994579788	
Avg Util	(u)	0.795663831	
CcrTr * m	($/yr)	184,175.76	
Total Move Cost	($/yr)	4,204,286.27	
Average Move Cost	($/mov)	2.102143134	(a)
Total Bldg Cost (CcrBldg)	($/yr)	1,716,167	
No. of Slots (M)		636,000	
Average Storage Cost	($/slot-yr)	2.69837627	(b)

Demand assumed uncorrected since it belongs to different customers