8.25 λ = 57 per hour
μ = 60 per hour
ρ = 57/60 = 0.95

a) $E_{FCFS}(W) = 1/(\mu - \lambda) = 1/3$ hours (= 20 minutes)

Using Figure 8.13, it follows that for ρ = .95, the relative flow time is approximately .35. It follows that

$E_{SPT}(W) = (.35)(1/3) = .1167$ hours.

b) $P\{W > .5\} = e^{-(\mu - \lambda)t} = e^{-3/2} = .2231$

c) To answer this part, we need to compute the variance of the flow time under LCFS.

$E_{FCFS}(W^2) = 2[E_{FCFS}(W)]^2 = 2(1/3)^2 = 2/9$ hrs^2.

$E_{LCFS}(W^2) = (1/(1 - .95))(2/9) = 4.44$ hrs^2, giving $\mathrm{Var}(W) = 4.33$.

$P_{LCFS}\{W > 1/2\} \approx P\{Z > (1/2 - 1/3)/\sqrt{4.33}\} = P\{Z > .0801\} = .4681$.

8.26 a) Since there are two tasks requiring 12 minutes, the minimum cycle time is 12 minutes

The theoretical minimum number of stations is obtained from 70/12 = 5.833. Hence, the theoretical minimum is 6.

b)

Station	1	2	3	4	5	6	7
Tasks	1	2,3	6	4,5,7,9	8,10	11	12
Idle Time	0	0	0	0	3	6	5

Seven stations are required.

c) 1 Five stations result in 26.25 units per line per day so that 4 lines are required.

2 Six stations result in 32.3 units per line per day so that 3 lines almost gives 100 units per day

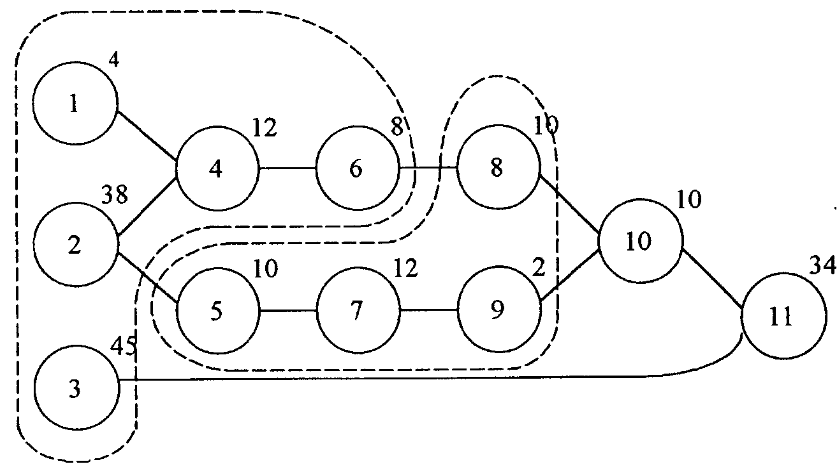
3. The 7-station balance above has C = 12 which gives 35 units a day. Three lines would result in more than 100 units per day.

Some further comments on Problem 8.26:

One can assess and compare the quality of the solutions obtained in cases (c1), (c2) and (c3), by considering (i) the total idleness that is incurred by each of them, and (ii) the proximity of the resulting total production capacity to the target capacity of 100 units per day. Regarding the second criterion, it can go either way depending on the anticipated future growth of the company; i.e., a solution that controls well the incurred idleness but results in considerable excess capacity than the targeted 100 units per day, may still be a competitive solution if the company anticipates significant future growth.

Also, one can consider a combination of the candidate configurations; e.g., two lines with 7 stations and one line with 6 stations would also satisfy the target daily production rate of 100 units per day, maybe more tightly than the other three options. Again, one has also to consider the idleness that is incurred by such a configuration.

8.42 a)



b) 45 ~~minutes~~ secs
Total time = 185 185/45 ≈ 4.11 → 5 stations.

c)

Task	Positional Weight	Task Rank	Task Time
1	78	3	4
2	136	1	38
3	79	2	45
4	74	4	12
5	68	5	10
6	62	6	8
7	58	7	12
8	54	8	10
9	46	9	2
10	44	10	10
11	34	11	34

C = 45

Stations	1	2	3	4	5
Tasks	2,1	3	4,5,6,7,9	8,10	11
Idle time	3	0	1	25	11

d) 185/4 = 46.25 ⇒ 47 is the smallest cycle time.

C = 47 – impossible
C = 48

Stations	1	2	3	4
Tasks	2,5	3	1,4,6,7,8,9	10,11
Idle time	0	3	0	4

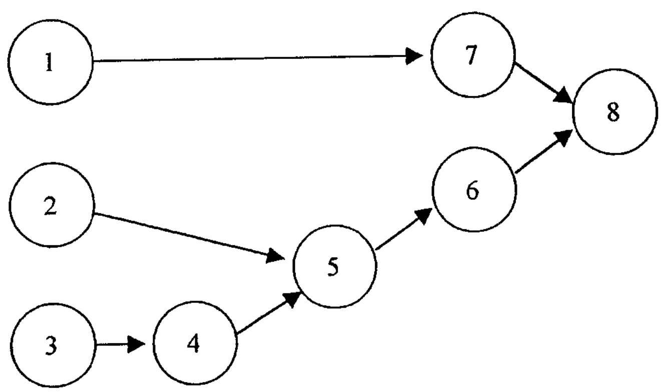
e) 60*6*60/45 = 480 units/day

To achieve a higher production rate, they would have to decrease the cycle time which would probably result in more stations.

8.43 C = 45

Stations	1	2	3	4	5
Tasks	2,1	3	~~1,~~ 4,6	5,7,8,9	10,11
Idle time	~~2~~ 3	0	~~21~~ 25	11	1

8.44 a)



b) 14 is the minimum cycle time that can be considered.

C = 14

Task	Weights
1	36
2	35
3	31
4	25
5	21
6	15
7	15
8	12

1-2-3-4-5-6-7-8

Homework 1 Solutions, Part B

2.1) WIP_s=25 jobs, λ = 4 jobs per hour, $E[T_s]$ = 14.5 minutes / (60 minutes/hour) = 0.2417 hr

By Little's Law, $WIP_s = \lambda * CT_s$, so $CT_s = WIP_s/\lambda$ = 25 jobs/4 jobs/hr = 6.25 hr.

$CT_s = CT_q + E[T_s]$, so $CT_q = CT_s - E[T_s]$ = 6.25 hr – 0.2417 hr = 6.008 hr.

2.2) $CT_{sys} = CT_{s1} + CT_{s2}$ for serial systems, so we get CT_{sys} = 4.2 hr + 5.3 hr = 9.5 hr.

Since $WIP_{sys} = \lambda*CT_{sys}$, WIP_{sys} = (10 jobs/day / 24 hr/day)*9.5 hr = 3.9583 jobs.

Solutions for Part C

a. What are the three primary attributes that define the modern corporate competition from a strategic standpoint? For each of these attributes, provide an example of a company that places its primary emphasis on that attribute (and explain your answer).

   See slide 17 in the introductory set of slides.

b. Discuss how the need to maintain a higher level of responsiveness to potential demand upsurges might lead to an increase of the company's operational costs. Also, consider how the effective deployment of modern information technology can help companies improve their responsiveness without experiencing the operational cost increases that were suggested above.

   A company attains high(er) levels of responsiveness to potential upsurges of its demand by providing a "buffer" either in the form of safety stock or in the form of excess capacity. Both of these elements come at a cost.

   Information technology enables a company to have better visibility of its own internal operations as well as of its broader operational environment, and in this way it reduces the uncertainty that must be faced by the company. Hence, the effective deployment of the modern IT capabilities can enable a company to increase its responsiveness to the experienced demand and at the same time reduce the aforementioned buffers.

   Of course, IT infrastructure comes with its own cost, and one must assess this additional cost against the gains that will be obtained by the deployment of this infrastructure.

c. Which of the layouts discussed in class would you choose for a discrete-part manufacturing company that experiences frequent changes in its product portfolio? How, in your opinion, could such a company control the operational complexities and the costs that might result from these changes?

   From the above description it seems that the quantities manufactured by this company w.r.t. the different (end-)products and their parts do not have the size and the stability that would justify the dedication of a separate production line to each of them. This remark, when combined with the flexibility that is necessitated by the indicated frequent changes of the product portfolio, would suggest a functional layout for the company shop-floor, and especially for the back-end operations that produce the various parts that go into the final assemblies.

   The company described above could try to deal with the complexities that result from the experienced frequent changes in the following ways:

   i. By making an effort to standardize and reuse the components that are going into the final assembly of its various products. In this way, even if the end products might change, the part of the system that produces some of the key components might not be impacted by these changes, and the company might even get the stability and the volumes to justify a product-flow layout for these items.

   ii. The company might also seek to outsource the production of those components that are produced in smaller quantities and/or in a less stable manner.

d. What is the meaning of *stability* for a manufacturing workstation?

A workstation is stable if the WIP and the cycle times of the jobs that go through this station do not grow to infinity. A necessary condition for stability is that the average rate with which work is brought to this workstation does not exceed the production capacity of this workstation.

e. Provide a mathematical argument, based on your IE3232 experience, to establish that at a workstation which is operated in a stable mode, long waiting times for the processed jobs imply a high concentration of material at the workstation buffer, and similarly, a high concentration of material in the station buffers implies long waiting times. Conclude that high WIP concentrations and long waiting times are essentially two different facets of the same basic concept, i.e., that of *congestion*!

   The above statement is just an implication of Little's law: WIP = TH x CT.

f. What is the primary motivation for a "pull" production control scheme?

   Pull production systems were introduced in the 80's in an effort to implement a "feedback mechanism" that (i) would prevent the production line to "clog" itself with WIP, especially in the case that certain contingencies at certain stations compromised the production capacity of those workstations, and (ii) it would be practically implementable with the limited IT capabilities of the time.

g. Consider a heuristic for the ALB problem that is similar to that of the ranked positional weights discussed in class, but instead of ranking the involved tasks in decreasing order of positional weights, it ranks them in decreasing order with respect to the number of their successors. Would this heuristic provide correct solutions? Explain your answer.

   As we discussed in class, if a task i is a predecessor of a task j, the successor set of i, S_i, is a superset of S_j, the successor set of j. Hence, the task ordering that is suggested above respects the precedence constraints among the various tasks, and the resulting heuristic would still provide correct solutions.

   A potential advantage of the RPW heuristic over this new one, is that the RPW heuristic tends to schedule tasks with larger times earlier, and this gives some more flexibility in packing the already started workstations with tasks that might appear later in the list (provided that these additions do not violate the precedence constraints).