

## 1 Solved Exercises

### 1.1 Statement of Exercises

1. Textbook 4.4.

### 1.2 Solutions

*ANSWER* for Exercise 1:

Worker - task assignment is below:

Worker	Tasks	Activity Time in sec	Capacity in units/hour
1	1,2,3	70	51.43=3600/70
2	4,5,6	55	65.45=3600/55
3	7,8,9	85	42.35=3600/85
4	10,11,12	60	60.00=3600/60
	Cycle Time	85	

- a) The capacity of the line is  $\min\{51.43, 65.45, 42.35, 60\} = 42.35$ .
- b) The direct labor content is  $70+55+85+60$  secs.
- c) It takes 4 workers  $340=4(85)$  seconds to finish a product while only  $270=70+55+85+60$  of 340 is used for production. The productivity is  $0.79=270/340$ .
- d) The first unit takes 340 secs because the system is empty to begin with. Each of the remaining 99 units will take 85 seconds. The total time to produce 100 units is  $340+99(85)$ . Here we are assuming that a worker passes a product to the next worker at the end of a cycle. That is why it takes 340 seconds for the first product to be completed. Another way to obtain the same total time is to use the capacity of  $3600/85$  per hour or  $1/85$  per second, 100 units are completed in  $340+99(1/(1/85))$  secs.
- e) This question can only be answered with an Integer Programming formulation. You are welcome to try couple worker-task assignment to compute the capacity of a given assignment. Here is an example below.

Worker	Tasks	Activity Time in sec	Capacity in units/hour
1	1,2	55	65.45=3600/55
2	3,4,5	50	72.00=3600/50
3	6,7	70	51.43=3600/70
4	8,9	35	102.86=3600/35
5	10,11,12	60	60.00=3600/60
	Cycle Time	70	

- f) This question can only be answered with an Integer Programming formulation whose objective is to minimize the cycle time. Note that minimizing the cycle time is equivalent to maximizing the capacity.
- g) 72 unit per hour is achievable with a cycle time of 50 secs= $3600/72$ . Start loading tasks one by one to the workers making sure that no worker is given tasks whose total activity time is more than 72 secs. This yields the following assignment: W1: 1; W2: 2,3; W3: 4,5; W4: 6; W5: 7; W6: 8,9; W7: 10,11; W8: 12. Thus, 8 workers suffice. □