LINE BALANCING

The most common assembly-line is a moving conveyor that passes a series of workstations in a uniform time interval called the **workstation cycle time** (which is also the time between successive units coming off the end of the line).

The total work to be performed at a workstation is equal to the sum of the tasks assigned to that workstation. The line-balancing problem is one of assigning all tasks to a series of workstations so that each workstation has no more than can be done in the workstation cycle time, and so that the unassigned (idle) time across all workstations is minimized.

The steps in balancing an assembly line are:

1. Specify the sequential relationships among tasks using a precedence diagram.

2. Determine the required workstation cycle time C, using the formula

$$C = \frac{\text{Production time per day}}{\text{Required output per day (in units)}}$$

3. Determine the theoretical minimum number of workstations (N_t) required to satisfy the workstation cycle time constraint using the formula

$$N_t = \frac{\text{Sum of task times (T)}}{\text{Cycle time (C)}}$$

4. Select a primary rule by which tasks are to be assigned to workstations, and a secondary rule to break ties.

5. Assign tasks, one at a time, to the first workstation until the sum of the task times is equal to the workstation cycle time, or no other tasks are feasible because of time or sequence restrictions. Repeat the process for workstation 2, workstation 3, and so on until all tasks are assigned.

6. Evaluate the efficiency of the balance derived using the formula

$$\text{Efficiency} = \frac{\text{Sum of task times (T)}}{\text{Actual number of workstations } (N_a) \times \text{Workstations cycle time (C)}}$$

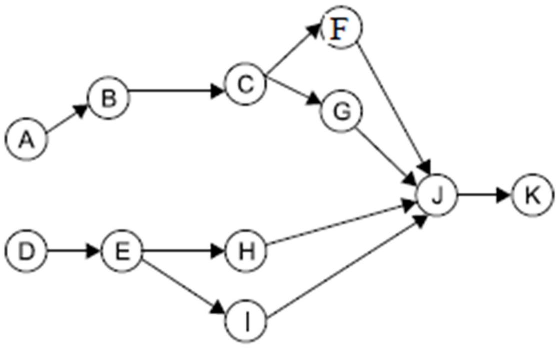
7. If efficiency is unsatisfactory, rebalance using a different decision rule.

Example. The MS 800 car is to be assembled on a conveyor belt. Five hundred cars are required per day. Production time per day is 420 minutes, and the assembly steps and times for the wagon are given below. Find the balance that minimizes the number of workstations, subject to cycle time and precedence constraints

Task	*Task time (in seconds)*	*Description*	*Tasks that must precede*
A	45	Position rear axle support and hand fasten	-
B	11	Four screws to nuts	A
C	9	Insert rear axle	B
D	50	Tighten rear axle support screws to nuts	-
E	15	Position front axle assembly and hand	D
F	12	Fasten with four screws to nuts	C
G	12	Tighten front axle assembly screws	C
H	12	Position rear wheel 1 and fasten hubcap	E
I	12	Position rear wheel 2 and fasten hubcap	E
J	8	Position front wheel 1 and fasten hubcap	F, G, H, I
K	9	Position front wheel 2 and fasten hubcap	J

SOLUTION:

1. Draw a precedence diagram as follows



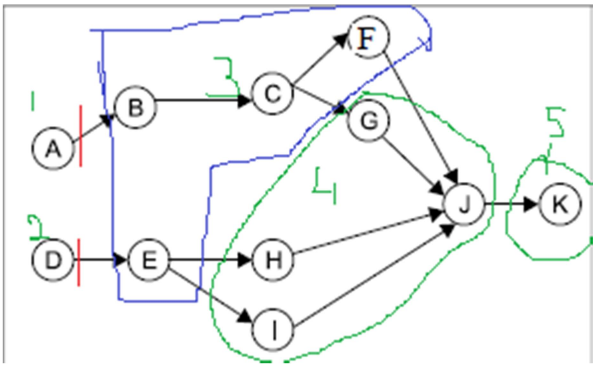
2. Determine workstation cycle time

$C = 420 \text{ min} \times 60 \text{ s} / 500 \text{ cars} = 50.4 \text{ s}$

3. Determine the theoretical min. number of workstations required (the actual number may be greater)

$N_t = T / C = 195 \text{ s} / 50.4 \text{ s} = 3.87 = 4$

3. Allocation of workstation



4. Make task assignments to form workstation 1, workstation 2, and so forth until all tasks are assigned. It is important to meet precedence and cycle time requirements as the assignments are made.

Station	*Task*	*Task time (in sec)*	*Remaining unassigned time (in sec)*	*Feasible remaining tasks*	*Task with most followers*	*Task with longest operation time*
Station 1	A	45	5.4	Idle	None	
Station 2	D	50	0.4	Idle	None	
Station 3	B	11	39.4	C, E	C, E	E
	E	15	24.4	C, H, I	C	
	C	9	15.4	F, G, H, I	F, G, H, I	F, G, H, I
	F	12	3.4 idle	None		
Station 4	G	12	38.4	H, I	H, I	H, I
	H	12	26.4	I		
	I	12	14.4	J		
	J	8	6.4 idle	None		
Station 5	K	9	41.4 idle	None		

6. Calculate the efficiency.

$$\text{Efficiency} = \frac{T}{N_a C} = \frac{195}{5 \times 50.4} = .77 \text{ or } 77\%$$

7. Evaluate the solution. An efficiency of 77 per cent indicates an imbalance or idle time of 23 per cent (1.0 – .77) across the entire line.