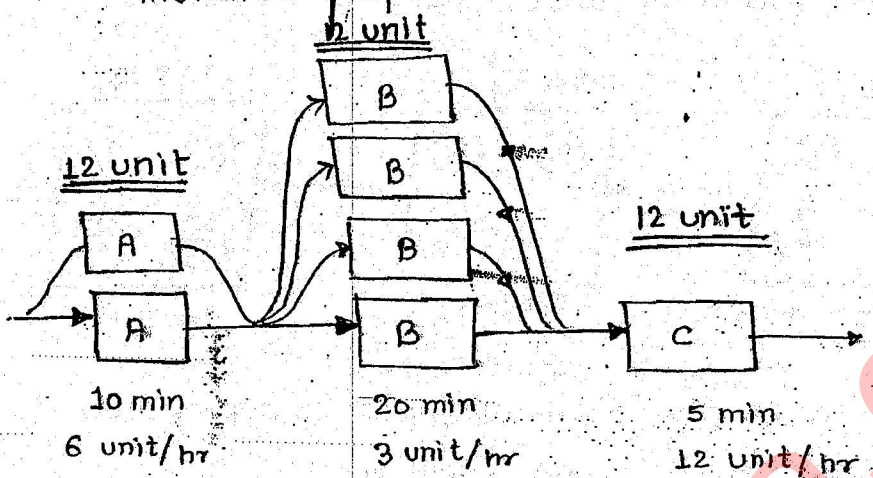
LINE BALANCING

$$\eta_{system} = \frac{\text{Actual output}}{\text{Installed output}}$$



Assem

The aim of assembly line is to group diff facilities and equipment in diff workstation in such a manner that idle time is minimised and utilisation is optimised.

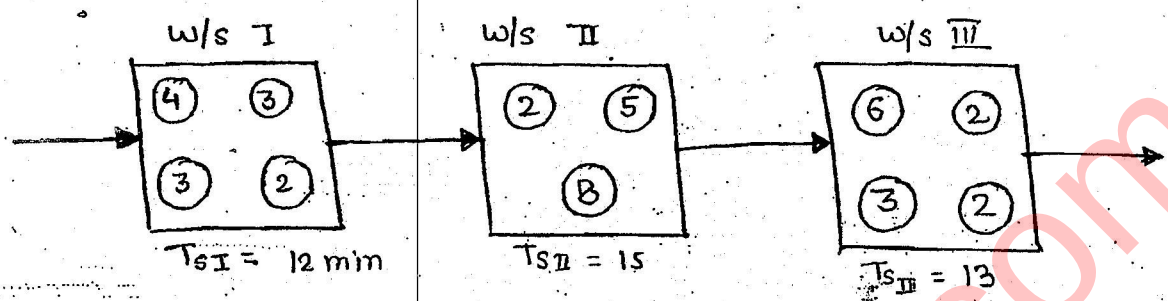
Advantage :

1) Reduction in work in progress inventory
2) dec. in material handling
3) effective utilisation of man power and m/c
4) easy production control
5) uniform rate of production

Terms :-

1) **Work element** : Every job is completed by a set of operat^{n} and each operation which is performed on the job is termed as work element.
2) **Task time** : It is the standard time required to complete work element.

3) Workstation :- It is the specific location on the assembly line where given amount of work element are completed within the fixed period of time.



4) Station time :- It is the time req. to complete work element assigned in a work station.

5) Total work content :- It is the time required to complete one set of job. It is given by either the submission of all the station time or the submission of all the elemental task time.

$$TWC = \Sigma T_{si} = \Sigma T_i = 40 \text{ min}$$

6) Cycle Time :-

$$T_c \geq (T_{si})_{max}$$

It is the amount of time for which a job that is to be assemble remains in the workstation. It is the time gap b/w two sucessive product comming out from the assembly line.

7) Balance Delay :- It is the ratio of total idle time of the job on the assembly line to the total time spend by the job on the assembly line.

$$BD\ \% = \left(\frac{nT_c - TWC}{nT_c}\right) \times 100$$

represents ineffectiveness

n → no. of workstation

TWC → total work content

T_c → cycle time

eg - $n = 3$, $T_c = 16$ min, $T_{WC} = 40$ min

$$B.D\ \% = \frac{3 \times 16 - 40}{48} \times 100 = \frac{8}{48} \times 100$$

8) Line efficiency :-

represent effectiveness

$$\eta_L = \frac{T_{WE}}{n T_c} \times 100$$

$$\eta_L = 100 - BD\ \%$$

9) Smoothness Index (SI) :- It is the term use to represent load distribution b/w the different w/s compared to the station consuming maximum time.

$$SI = \sqrt{\sum_{i=1}^{n} (\text{Max station time} - \text{Station time})^2}$$

$$SI = \sqrt{\sum_{i=1}^{n} \left[(T_{si})_{max} - T_{si} \right]^2}$$

eg - $SI = \sqrt{(15-12)^2 + (15-15)^2 + (15-13)^2}$

10) Minimum number of workstation required :-

$$n_{min} = \frac{T_{WC}}{T_c}$$

eg - $n_{min} = \frac{40}{16} = 2.5 \approx 3$

Method of line balancing :-

1) Largest Candidate Rule :-

Steps involved are -

i) List all the element in decreasing order of their task time

ii) To assign an element in a workstation start from the beginning of the list moving downward, searching first feasible element which can be placed in a workstation. A feasible element is one which satisfy precedence requirement, when that element is placed in workstation, the total time of w/s should not exceed the cycle time.

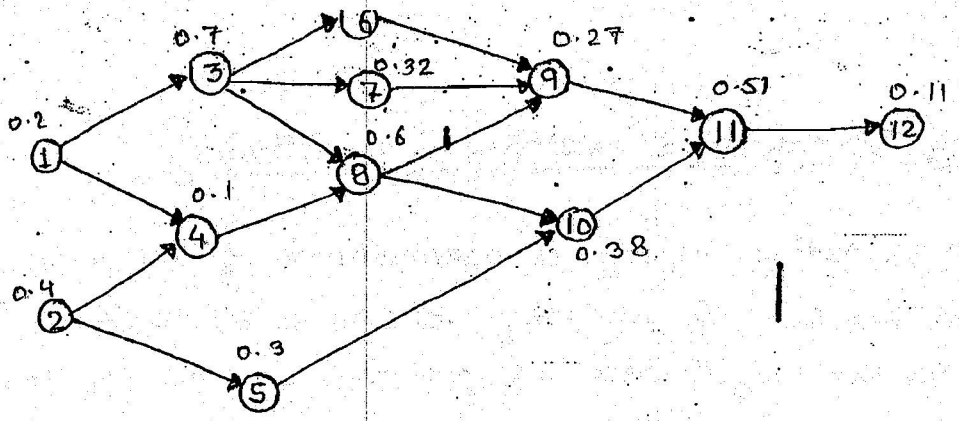
iii) Strike off the element which is assigned so that it cannot be considered again.

iv) Continue in the similar manner untill all the elements are assigned to different w/s.

Q- For the following set of element, draw the precedence diag, balance the line and determine balance delay, line efficiency and smoothness index. Take cycle time as 1 min.

Element	Ti (min)	Precedence
1	0.2	-
2	0.4	-
3	0.7	1
4	0.1	1,2
5	0.30	2
6	0.11	3
7	0.32	3
8	0.60	3,4
9	0.27	6,7,8
10	0.38	5,8
11	0.51	9,10
12	0.11	11

Element	Ti (min)	Preced
3	0.7	1
8	0.6	3,4
11	0.51	9,8
2	0.4	-
10	0.38	5,8
7	0.32	3
5	0.30	2
9	0.27	6,7,8
1	0.2	-
6	0.11	5
12	0.11	11
4	0.1	1,2



WS	Element	T_i	T_{si}	Idle time
1	1	0.24	0.24	
	5	0.3	0.7	0
	1	0.2	0.9	
	4	0.1	1	
2	3	0.7	0.81	0.19
	6	0.11		
3	8	0.6	0.98	0.02
	10	0.38		
4	7	0.32	0.59	0.41
	9	0.27		
5	11	0.51	0.62	0.38
	12	0.11		

no. of w/s = n = 5

TWC = 4

T_c = 1 min

i) $BD = \frac{5 \times 1 - 4}{5} \times 100 = \frac{1}{5} \times 100 = 20\%$

ii) $\eta_L = 80\%$

iii) SI = 0.59