# BUS 314

## Outline

1. Element of production & Production Design
2. Line Balancing
3. Network Analysis
4. Inventory Management
5. Facility Layout
6. Facility Location
7. Production Scheduling & Control

13/2/28

## Inventory

Components: - Raw Materials
- Work-in-Progress
- Finished Goods

Reasons for Inventory

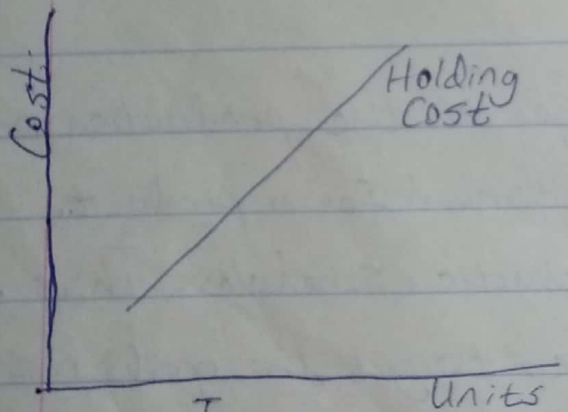
1. To prevent unexpected stoppages in the production process.
2. To meet discrepancies in the demand for a product.
3. It allows for flexibility in production schedules. Thus, reduces pressure on the production system to get the goods out by all means.
4. It allows for continuous production even when there's a delay or disruption in one stage or department of production organization
5. It prevents labour redundancy. This is achieved when there is

adequate inventory to keep workers on the job. Thus, improving labour relations.

6. It helps to guide against speculated and sudden hike in price in the future.
7. It provides for the ~~opportuni~~ organization to take advantage of ~~economic lot size~~ & gain quantity discounts.
8. It improves the wellness of the organization.

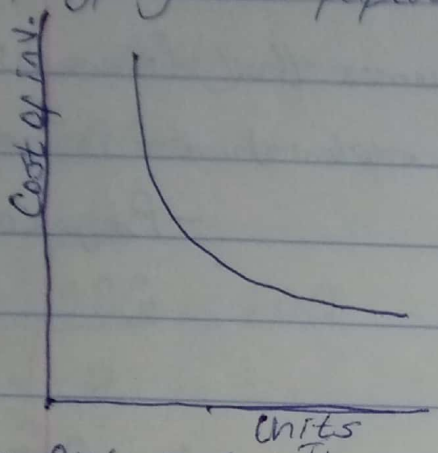
Costs in Inventory

1. Holding/Carrying cost: These are costs incurred when goods are kept in the store. Such costs include: ~~Cost~~ of storage facilities, handling, cost of insurance, thievery, breakage, obsolence, depreciation, taxes and opportunity cost of capital.




2. Set-up cost: These are costs incurred at the beginning of every production process. They are: Cost of oiling, retooling & Cost of overhauling.
3. Ordering cost: These are costs incurred when making an order. Such

Costs include: Cost of counting items & calculating order quantities, cost of typing order papers; telephoning & filing




4. Stock-Out costs: These are costs ~~incurred~~ incurred when goods are not available for sales. Such costs include: Loss of goodwill, loss of customers, loss of profits

## Inventory Models

These are useful approaches for solving inventory problems. The models allow us to operate within the various inventory decision variables in order to arrive at how effective they are in the inventory control management.

## Types of inventory models

1. Deterministic model
2. Stochastic model

1. Deterministic model: This model states that inventory demand

patterns are known and constant besides other relevant variables e.g the leadtime

2. Stochastic model: This model assumes that demand is not constant from period to period and replenishment is not instantaneous

—Banjoko 2009

* One model that depicts the deterministic model is the Economic Order Quantity (EOQ). This model was developed in 1915 by F.W Harris.

Assumptions of the EOQ model

1. Demand is known and constant.
2. There is no leadtime/Replenishment is instantaneous.
3. Stock-out is not allowed.
4. Order size could be varied
5. Cost of ordering is fixed
6. Unit price is also fixed

Calculus method

$$TC = \frac{DC_o}{Q} + \frac{Q - 0}{2}\left(\frac{Q}{2}\right)$$

(Ordering cost; Holding cost)

$$TC = \frac{DC_o}{Q} + \frac{Q_H}{2}$$ (only applies when there's no discount)

$$TC = \frac{Dco}{Q} + \frac{Qh}{2} + PD$$

(Purchase price; Demand)

$$\frac{Dco}{Q} = \frac{Q_H}{2}$$

$$\text{No. of Orders} = \frac{D}{Q}$$

$$2Dco = Q^2H$$

$$Q^2 = \frac{2DCo}{H}$$

$$Q = \sqrt{\frac{2DCo}{H}} = EOQ$$

Q → Quantity

D → Annual Demand

Co → Ordering cost

H → Holding Cost

* A company has an annual demand of 100,000 units and Ordering cost per order is ₦10. Carrying cost is ₦2.5 and Unit cost is ₦25

(i) What is the qty to order

(ii) " " " expected total cost

(i) $EOQ = \sqrt{\frac{2 \times 10 \times 100{,}000}{2.5}} = 894.43$ units

(ii) $TC = \frac{100{,}000 \times 10}{894.} + \frac{894 \times 2.5}{2}$

$= ₦2{,}236.07$

* Assume ~~that~~ 12% of the unit price to be the carrying cost. The company decided to give a discount of 6% to any purchase that is above 10,000 units. Also, a discount of 9% for any purchase above 20,000 units and discount of 12% for any purchase that is above 50,000 units. You are required to advise the company if it should take advantage of the discounts given.

Step 1: Determine EOQ for each price break

P = ₦25 (No discount)

~~EOQ~~ H = 0.12(25) = 3

$$EOQ = \sqrt{\frac{2 \times 100,000 \times 10}{3}} = 816 \text{ units}$$

$$TC = \left(\frac{100,000}{816} \times 10\right) + \left(\frac{816}{2} \times 3\right) + 25 \times 100,000$$

$$= ₦2,502,449.49$$

6% discount

94% × ₦25 = ₦23.5 → Purchase price

H = 0.12 × 23.5 = ₦2.82

$$EOQ = \sqrt{\frac{2 \times 100,000 \times 10}{2.82}} = 842 \text{ units}$$

$$TC = \left(\frac{100,000}{10,001} \times 10\right) + \left(\frac{10,001}{842} \times 2.82\right) + 23.5(100,000)$$

$$= ₦2,364,201.4$$

9% discount

91% × ₦25 = ₦22.75 → Purchase Price

H = 0.12 × 22.75 = 2.73

$EOQ = \sqrt{\frac{2 \times 100,000 \times 10}{2.73}} = 855.92 = 856 \text{ units}$

$TC = \frac{100,000 \times 10}{20,001} + \frac{20,001 \times 2.73}{2} + 22.75 \times 100,000$

= ₦2,303,351.35*

12% discount

88% × ₦25 = ₦22 → Purchase Price

H = 0.12 × 22 = ₦2.64

$EOQ = \sqrt{\frac{2 \times 100,000 \times 10}{2.64}} = 870 \text{ units}$

$TC = \frac{100,000 \times 10}{50,001} + \left(\frac{50,001 \times 2.64}{2}\right) + (22 \times 100,000)$

= ₦2,266,021.32

The Company should take the 12% discount because it gives the least Total Cost.

20/11/2023

# Project Management

A project is a task of considerable size that requires substantial investment in terms of time, money and effort. A project has a beginning and an ending point. The activities must follow a particular precedent relationship. The obvious distinction between project mgt and other types of management activity is that each project is a unique entity that occurs just once.

## Objectives of Project Planning

1. The determination of the shortest time to complete a project.
2. The identification of the critical or bottleneck activities with a view to give such activities extra attention.
3. Determination of how much flexibility or slack exists with the bottleneck activities.
4. The assessment of the effect of shifting resources from ordinary to critical activities.
5. The determination of the probability of completing the project on schedule should there be variation in the time requirement for the activities.

Terms in Project Planning (or Network) ~~activities~~

1. Activities: These are the various tasks that are meant to be performed. It can also be seen as tasks within the project that have a definite beginning and ending date at a point in time. The activities consume time. It is denoted by an arrow. However, the length of the arrow is of no significance. The activities could be Activities On Arc (AOA) or Activities on Node (AON). Activities on Arc can be described as network diagram principles in which an arrow depicts the activities while Activities on Node can be described as network diagram principles in which nodes depict the activities.
2. Network: This is a graphical display of the various activities, events and their precedent relationship. The sequence obeys the precedent requirement
3. ~~Dummy~~ ~~Starts~~ This is a non-existing or fictitious activity. It's a fictitious activity which consumes no time, but it is necessary to preserve the unique identification of activities. It is often denoted by a broken line (- - - - - -).
4. Event: This marks the beginning and ending point of an activity. Each project has a distinct project beginning and ending. It is designated as a node with its symbol (○). There are two types of events: (I) Merge events (II) Burst events

(I) Merge events: This is the node that marks the point

where two or more activities are jointly completed. 

(4) Burst event: This is the node that marks the point where two or more activities begin at the same time 

5. Slack: This is the difference between the latest and the earlie starting time. Therefore, Slack is LS - ES = 0. Every slack must be equal to 0. Otherwise,

## Network Models

A model represents what is real. Project mgt requires going through several steps in sequence to ensure the inciden of delay found in most other jobs that leads to non-delive on due dates. There are two types of models:

1. Deterministic model 2. Stochaostic model
= CPM I PERT

1. Deterministic

I Critical Path Method

II Programme Evaluation Review Technique

* Critical Path: This is a technique that is used in planning and controlling projects. It was developed in 1957 by J.E Kelly and Walker M.R to aid in scheduling maintenance shutdow of chemical processing plants. CPM is often referred to as deterministic in nature. Ie the duration for each activity in the network is known and constant, this make

the distinction between CPM and PERT

Features of CPM

1. It helps in the recognition of critical activities that must be given constant attention.
2. It helps to determine the project completion time
3. The critical path is the longest path and shortest route on the network
4. The CP always has its slack to be 0.

* For the critical path to be more applicable, it must have the following:

1. It must have well defined jobs whose completion time also ends the project.
2. The jobs are autonomous i.e different jobs in a network may begin, be completed and conducted separately within a cycle.
3. The jobs must follow a precedence relationship i.e it must be orderly.

1-3
2-5
2ty → Activities on Node

*Most optimistic, Pessimistic & Likely

→ Activity on Arc

| Activities | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Preceeding events | - | - | - | B | B | B | C | A,D | A,D | F,G | I,E,J | H,K |
| Time duration | 4 | 3 | 2 | 5 | 1 | 4 | 3 | 2 | 3 | 3 | 1 | 2 |

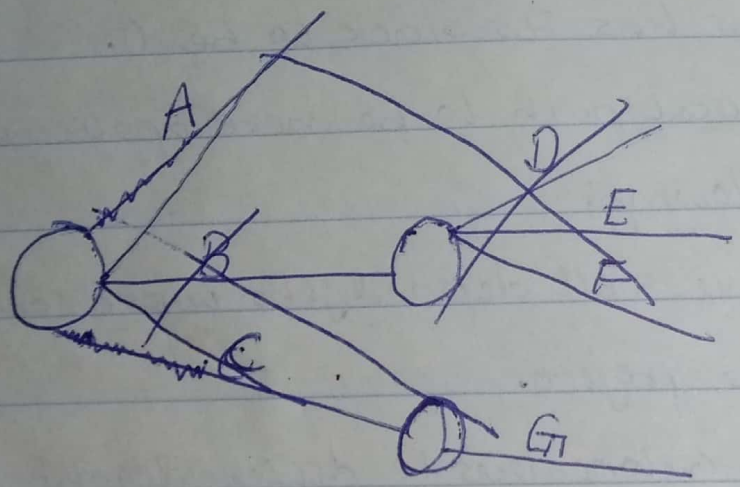
Requirement

(i) Draw the project network diagram.

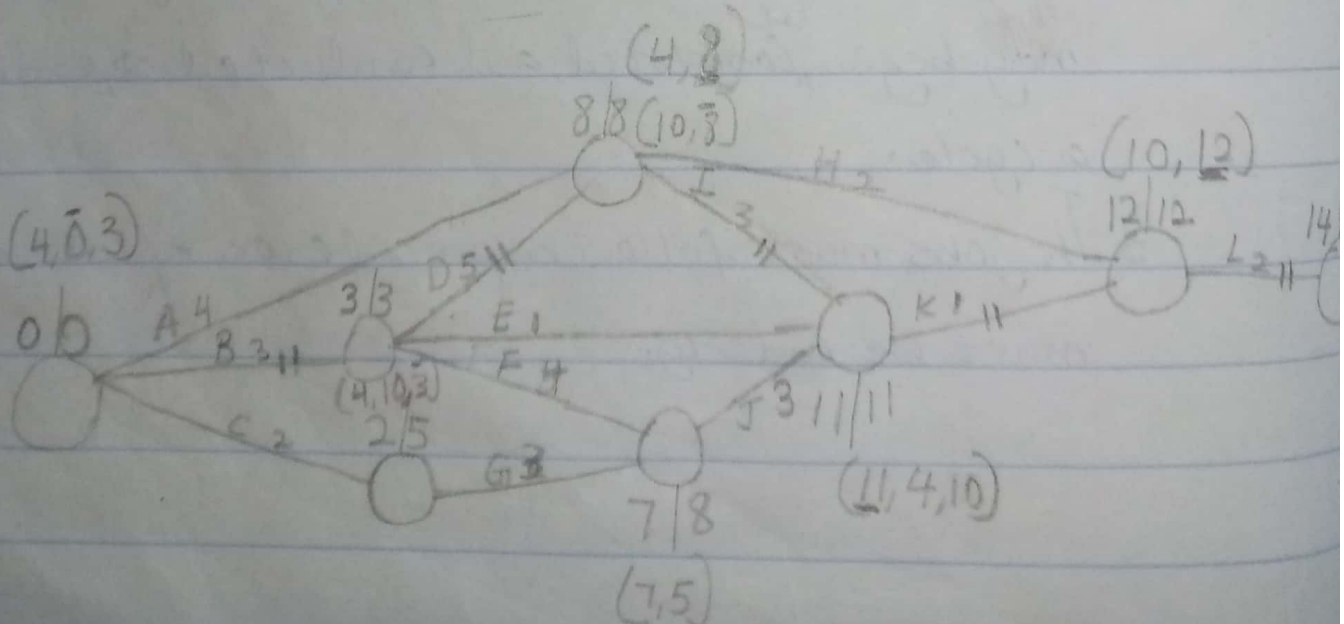
(ii) Determine the critical path and the project completion time

(iii) What are the features of the critical path?

(iv) In what way is the critical path difference btw CPM & PERT?




(1)



# Programme Evaluation Review Technique

I Most optimistic: It is denoted by "a"
II Most likely: It is denoted by "m"
III Most pessimistic: It is denoted by "b"

These are 3 PERT time estimates. ~~They are t~~

$$\Sigma t_i = \frac{a+4m+b}{6} \qquad \sigma^2 = \left(\frac{b-a}{6}\right)^2$$

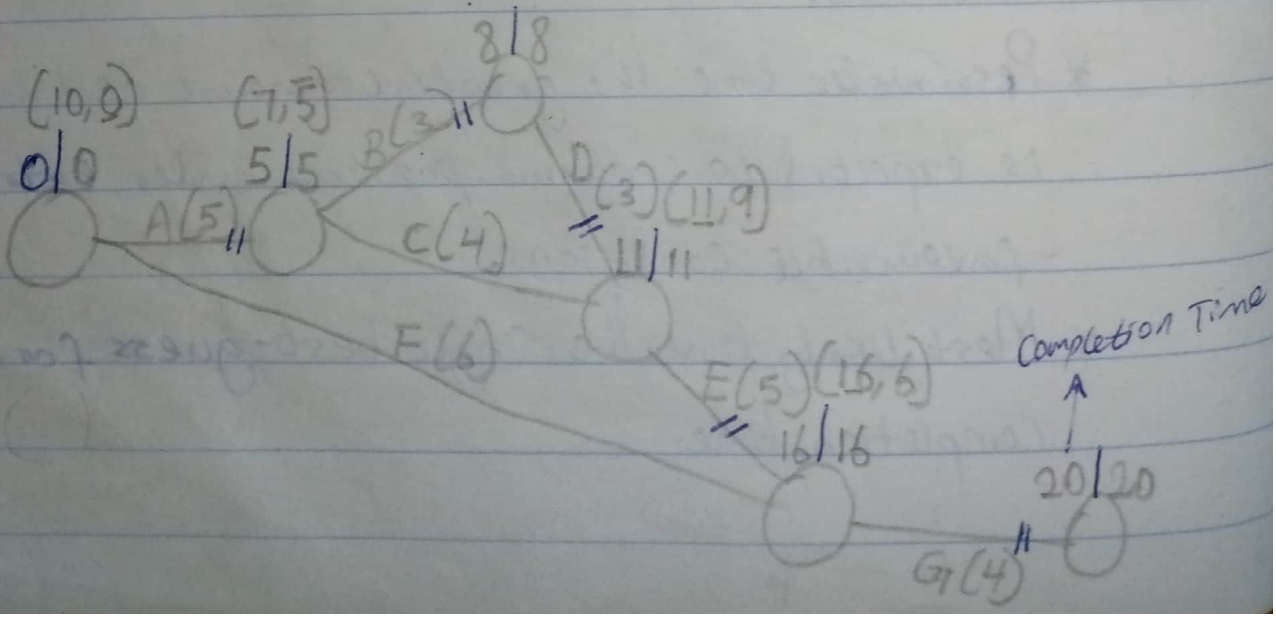
* Path: Any one unique portion of the project sequence, beginning with the first activity and ending with the last activity, for which each activity has a single immediate successor. Each node pair has a single arc,
* Critical path: This is the path whose activities are expected to consume the most time.
* Optimistic time: The least amount of time an activity is expected to consume, possible under extremely favourable conditions.
* Pessimistic time: The greatest amount of time an activity is expected to consume, possible under extremely unfavourable conditions.
* Most likely time: The single best-guess for activity completion time.

| Activity | Required Predecessor | a | m | b |
|---|---|---|---|---|
| A | – | 2 | 5 | 8 |
| B | A | 2 | 3 | 4 |
| C | A | 1 | 4 | 7 |
| D | B | 2 | 3 | 4 |
| E | C, D | 2 | 5 | 8 |
| F | – | 4 | 6 | 8 |
| G | E, F | 1 | 4 | 7 |

Required

1. Draw the network diagram for the project
2. Determine the expected duration for each job
3. Determine the critical path
4. What is the probability of completing the project 5 weeks behind schedule
5. Solution

1.



2. $\frac{a+4m+b}{6}$

$Et_A = \frac{2+4(5)+8}{6} = 5$

$Et_B = \frac{2+4(3)+4}{6} = 3$

$Et_C = \frac{1+4(4)+7}{6} = 4$

$Et_D = \frac{2+4(3)+4}{6} = 3$

$Et_E = \frac{2+4(5)+8}{6} = 5$

$Et_F = \frac{4+4(6)+8}{6} = 6$

$Et_G = \frac{1+4(4)+7}{6} = 4$

3. Critical path = A, B, D, E, G

Completion Time = 5+3+3+5+4 = 20

Variance of the critical paths

$\sigma^2 = \left(\frac{b-a}{6}\right)^2$

$\sigma_A^2 = \left(\frac{8-2}{6}\right)^2 = 1$

$\sigma_B^2 = \left(\frac{4-2}{6}\right)^2 = \frac{1}{9} = 0.11$

$\sigma_D^2 = \left(\frac{4-2}{6}\right)^2 = \frac{1}{9} = 0.11$

$\sigma_E^2 = \left(\frac{8-2}{6}\right)^2 = 1$

$\sigma_G^2 = \left(\frac{7-1}{6}\right)^2 = 1$

$\sigma^2 = 1 + 0.11 + 0.11 + 1 + 1$

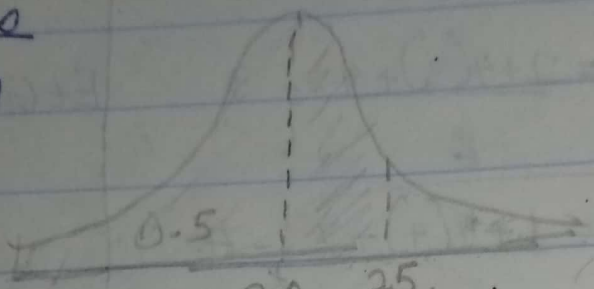
$= 3.22$

$\sigma = \sqrt{3.22} = 1.79$

4. $P \leq Z = \frac{T - ET}{\sqrt{\sigma^2}}$ 5 weeks behind schedule means they take an additional 5 weeks.

$= \frac{25 - 20}{1.79}$

$Z = 2.79$




$\therefore Q(z\ 2.79) = 0.49736$

## Line Balancing

Line balancing is defined as a technique which seeks to distribute tasks to each workstation in a way that will optimize some appropriate measures of line operation. A li balancing problem is one of assigning tasks to a series o workstations so that each workstation has no more than can be done in the workstation cycletime. So that the unassigned (idle) time accross all workstations is minimi

Terms in Line Balancing.

1. Task: These are the smallest groupings of work that ca be assigned to workstations. It can also be referred to t the smallest unit into which the total job content can be divided.

2. Assembly line: This is referred to as progressive assembly that is linked by some material handling devices

3. Precedence relationship: This specifies the order in which a task must be performed in the assembly process

4. Work station: The minimum allowable number of work stations is a function of two variables: the cycle time & the total work content of the job. If the cycle time is fixed at a value of C, then the number of workstations (N) must be equal to or greater than the integer value of the ratio of $\frac{T}{N}$ or if N ~~is the~~ equals the minimum number of workstations, the formula becomes

$N = \frac{\Sigma ti}{C}$ → Total work content

↓ Work stations

C → Cycle time

5. Cycle time: This is the maximum time allowable for a task or group of tasks to be completed at each work station. Usually, the total time taken by each workstation on the line must be equal to or less than the cycle time. This means no station overloading is allowed. The formula for cycle time

$$= \frac{\text{Available Working hours}}{\text{Desired Output}}$$

Heuristic → Wester & Kilbridge
Weighted

6. Balance Delay: This measures the degree of inefficiency in the system. It reflects the proportion of idle time over the total available work time. The closer the value of Balance Delay to zero, the more the balance in the line.

$$\therefore BD = \frac{NC - \Sigma ti}{NC} \times 100$$

Where N is the Number of Workstations
C is the Cycle time
$\Sigma ti$ is the Summation of task times

12/2023 Techniques

1 Heuristic Solution method. This method has been developed by many authors:

- Wester & Kilbridge (1962) made systematic use of the task precedence relationship in achieving near-optimum allocation of tasks to workstations
- Helgeson & Birnie (1961) also developed the rank positional weight technique for solving line balancing problems which require weights to be assigned tasks and at the same time, used as a source for allocating optimum tasks to workstations such that idleness would have been

reduced.

**Question**: The mgt. of an Oogonization wants to balance the line with the hope of minimizing idle time. The output required is 400 units & Operation is carried out in an 8-hour work day.

| Task | Task minutes | Predecessor |
|---|---|---|
| A | 0.2 | — |
| B | 0.2 | A |
| C | 0.8 | — |
| D | 0.6 | C |
| E | 0.3 | B |
| F | 1.0 | D, E |
| G | 0.4 | F |
| H | 0.3 | G |

Required:

I Draw the network diagram

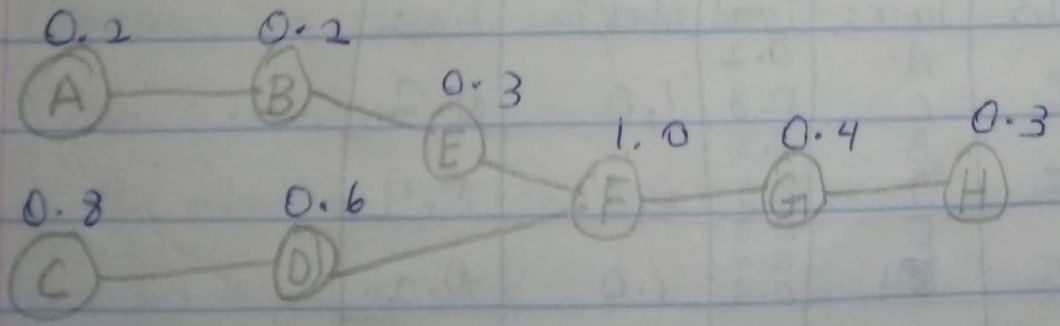
II Calculate the cycle time

III Calculate the number of workstations

IV Calculate the idle time

V Assign tasks to work stations

I



II $C = \frac{\text{Available working hours}}{\text{Desired Output}}$

$= \frac{8 \times 60}{400}$

$C = 1.2$ minutes

III $N = \frac{\sum ti}{C} = \frac{3.8}{1.2} = 3.16 \simeq 4$ workstations

IV Idle Time $= N \times C - \sum ti$

$= 4 \times 1.2 - 3.8$

$= 1$ minute

V.

| W.S | Tasks | Task Time | Cumm T.T | Idle Time |
|---|---|---|---|---|
| I | A | 0.2 | 1.2 | 0 |
| | B | 0.2 | | |
| | C | 0.8 | | |
| II | D | 0.6 | 0.9 | 0.3 |
| | E | 0.3 | | |
| III | F | 1.0 | 1.0 | 0.1 |
| IV | G | 0.4 | 0.7 | 0.5 |
| | H | 0.3 | | |
| | | | | 1 |

A .2
C .8 1
B .6
G .4
E

OR

| W.S | Tasks | Task Time | Cumm. Task Time | Idle Time |
|---|---|---|---|---|
| I | A | 0.2 | 1.0 | 0.2 |
| | C | 0.8 | | |
| II | B | 0.2 | 0.8 | 0.4 |
| | D | 0.6 | | |
| III | E | 0.3 | 1.0 | 0.1 |
| | G | 0.4 | | |
| | H | 0.3 | | |
| IV | F | 1.0 | 1.0 | 0.2 |
| | | | | 1 |

# Facilities Location

* Linear Assignment
* Transportation model - Northwest Corner Method
  - Least Cost method
  - Vogel Approximation method

Question

| | Sales Territories | | | |
|---|---|---|---|---|
| Salesperson | Ikorodu | Yaba | Ojo | Ikeja |
| Gilo | 62 | 58 | 49 | 42 |
| Alex | 58 | 72 | 57 | 71 |
| Rexo | 70 | 81 | 69 | 40 |
| Vinto | 30 | 52 | 51 | 62 |

1. Determine the opportunity cost by identifying the least value in each row & column and subtracting this smallest value from every other number in the row & column
2. Identify the rows & columns with unique 0
3. Cover the rows & columns with unique zeros with a line in an optimal manner
4. If the number of liner that cover the rows are equal to m or n where m = number of rows & n = number of columns.

5. If the number of lines that cover the zeros are not equal to m or n, do the following:

I Identify the smallest number that is not covered by any line, add the smallest number identified to the numbers at intersection and subtract the same number from any other number that are not covered by any line.

Solution

Row Reduction

| | Ik | Yaba | Ojo | Ikeja |
|---|---|---|---|---|
| Gilo | 20 | 16 | 7 | 0 |
| Alex | 1 | 15 | 0 | 14 |
| Rexo | 30 | 41 | 29 | 0 |
| Vinto | 0 | 22 | 21 | 32 |

Column Reduction

| | Ik | Yaba | Ojo | Ikeja | |
|---|---|---|---|---|---|
| Gilo | 20 | 1 | 7 | 0 | 1 |
| Alex | 1 | 0 | 0 | 14 | 2 |
| Rexo | 30 | 26 | 29 | 0 | 1 |
| Vinto | 0 | 7 | 21 | 32 | 1 |
| | 1 | 1 | 1 | 2 | |

The line over Vinto's 0 can be drawn either horizontally or vertically

Identify the smallest uncovered number (0). Subtract it from the uncovered numbers. The numbers not at intersections will be left as they are. 1 will be added to the numbers at intersections

| | IK | Yaba | Ojo | Ikeja |
|---|---|---|---|---|
| Gilo | ~~19~~ | 0 | 6 | 0 |
| Alex | ~~1~~ | 0 | 0 | 15 |
| Rexo | ~~19~~ | 15 | 28 | 0 |
| Vinto | 0 | 7 | 21 | 33 |

Gilo — Yaba ✓ ~~Ikeja~~

Alex — ~~Yaba~~ Ojo ✓

Rexo — Ikeja ✓

Vinto — Ikorodu ✓

Assign the locations to Salespeasons with only one. If it has been assigned, no one else can get that location. Since Gilo can't get Ikeja anymore, Yaba is automatically assigned to him. Since Yaba has gone to Gilo, Alex can't get it anymore so Alex gets Ojo.

Transportation Models

1. North-West Corner
2. Least-Cost
3. Vogel's Approximation method

Trans Transportation Cost

| From \ To | Benin | Port-Harcourt | Ilorin |
|---|---|---|---|
| Ijebu-Ode | ₦3 | ₦6 | ₦12 |
| Enugu | ₦5 | ₦7 | ₦6 |
| *Ibadan | ₦8 | ₦2 | ₦5 |
| *Jos | ₦2 | ₦8 | ₦7 |

*Estimated

Suppose the Obanta Breweries Nig Ltd. has two production facilities located at Ijebu-Ode & Enugu from where it supplies its warehouses located at Benin, PH & Ilorin. Assume further that current supply of beer from its two plants falls short of demand. Consequently, the company has decided to build a third brewery. Two possible locations are being considered: Ibadan & Jos.

Requirements: production capacity, estimated dealings. Variable production costs of the proposed facilities plus building & equipment costs are as shown above. The problem is to select a location which will minimize the sum of production & distribution costs for the entire production/distribution network.

(1)

Warehouse demand

| | |
|---|---|
| Benin | 400 |
| PH | 480 |
| Ilorin | 410 |
| | 1,290 |

(2)

Production Capacity

| | |
|---|---|
| Ijebu Ode | 300 |
| Enugu | 400 |
| | 700 |

(3)

Estimated Variable/unit Prod Cost

Ibadan: ₦0.95/unit of output

Jos: ₦0.85/unit of output

(4)

Building & Equipment Cost

Ibadan: ₦23,100 per year over the life of the plant

Jos: ₦21,200 per year over the life of the plant.

## Solution

1. For Ibadan

I North-West Corner Method

| From \ To | Benin | P/H | Ilorin | Supply |
|---|---|---|---|---|
| Ijebu Ode | 300 #3 | X #6 | X #12 | 300 |
| Enugu | 100 #5 | 300 #7 | X #6 | 400 |
| Ibadan | X #8 | 180 #2 | 410 #5 | 590 |
| Demand | 400 | 480 | 410 | 1,290 |

$M+N-1 = 3+3-1 = 5$

Number of cells that units are assigned to must be equal to 5 $(m+n-1)$

→ (1,290 − 700)

$TC = 300\times3 + 100\times5 + 300\times7 + 180\times2 + 410\times5$

$= ₦5,910$

II Least-Cost Method

| From \ To | Benin | PH | Ilorin | Supply |
|---|---|---|---|---|
| Ijebu Ode | 300 ₦3 | X ₦6 | X ₦12 | 300 |
| Enugu | 100 ₦5 | X ₦7 | 300 ₦6 | 400 |
| Ibadan | X ₦8 | 480 ₦2 | 110 ₦5 | 590 |
| Demand | 400 | 480 | 410 | 1,290 |

$TC = 300\times3 + 100\times5 + 480\times2 + 300\times6 + 110\times5$

$= ₦4,710$

III Vogel Approximation Method

| From \ To | Benin | PH | Ilorin | Supply | Penalties |
|---|---|---|---|---|---|
| Ijebu Ode | ₦3 | X ₦6 | ₦12 | 300 | 3 |
| Enugu | ₦5 | X ₦7 | ₦6 | 400 | 1 |
| Ibadan | ₦8 | 480 ₦2 | ₦5 | 590 | 3 |
| Demand | 400 | 480 | 410 | 1,290 | |
| Penalties | 2 | (4) | 1 | | |

| From \ To | Benin | Ilorin | Supply | Penalties |
|---|---|---|---|---|
| Ijebu Ode | 300 ₦3 | X ₦12 | 300 | (9) |
| Enugu | ₦5 | ₦6 | 400 | 1 |
| Ibadan | ₦8 | ₦5 | 110 | 3 |
| Demand | 400 | 410 | 810 | |
| Penalties | 2 | 1 | | |

| From / To | Benin | Ilorin | Supply | Penalties |
|---|---|---|---|---|
| Enugu | 100 (₦5) | 300 (₦4) | 400 | 1 |
| Ibadan | X (₦8) | 110 (₦5) | 190 | (B) |
| Demand | 100 | 410 | 510 | |
| Penalties | 3 | 1 | | |

(3)

* Either of them can be chosen

| From / To | Benin | P/H | Ilorin | Supply |
|---|---|---|---|---|
| Ijebu Ode | 300 (₦3) | (₦6) | (₦12) | 300 |
| Enugu | 100 (₦5) | (₦7) | 300 (₦6) | 400 |
| Ibadan | (₦8) | 480 (₦2) | 110 (₦5) | 590 |
| Demand | 400 | 480 | 410 | 1,290 |

$TC = 300 \times 3 + 100 \times 5 + 480 \times 2 + 300 \times 6 + 110 \times 5$

$= ₦4,710$

2. For Jos

I North-West Corner Method

| From / To | Benin | P/H | Ilorin | Supply |
|---|---|---|---|---|
| Ijebu Ode | 300 (₦3) | X (₦6) | X (₦12) | 300 |
| Enugu | 100 (₦5) | 300 (₦7) | X (₦6) | 400 |
| Jos | X (₦2) | 180 (₦8) | 410 (₦7) | 590 |
| Demand | 400 | 480 | 410 | 1,290 |

Cost = $300 \times 3 + 100 \times 5 + 300 \times 7 + 180 \times 8 + 410 \times 7 = ₦7,810$

II Least Cost Method

| From \ To | Benin | P/H | Ilorin | Supply |
|---|---|---|---|---|
| Ijebu Ode | X ₦3 | 300 ₦6 | X ₦12 | 300 |
| Enugu | X ₦5 | X ₦7 | 400 ₦6 | 400 |
| Jos | 400 ₦2 | 180 ₦8 | 10 ₦7 | 590 |
| Demand | 400 | 480 | 410 | 1,290 |

Cost = 400x2 + 300x6 + 180x8 + 400x6 + 10x7

= ₦6,510

III Vogel Approximation Method

| From \ To | Benin | P/H | Ilorin | Supply | Penalties |
|---|---|---|---|---|---|
| Ijebu Ode | ₦3 | ₦6 | ₦12 | 300 | 3 |
| Enugu | ₦5 | ₦7 | ₦6 | 400 | 1 |
| Jos | 400 ₦2 | ₦8 | ₦7 | 590 | (5) |
| Demand | 400 | 480 | 410 | 1,290 | |
| Penalties | 1 | 1 | 1 | | |

| From \ To | P/H | Ilorin | Supply | Penalties |
|---|---|---|---|---|
| Ijebu Ode | 300 ₦6 | ₦12 | 300 | (6) |
| Enugu | ₦7 | ₦6 | 400 | 1 |
| Jos | ₦8 | ₦7 | 190 | 1 |
| Demand | 480 | 410 | 890 | |
| Penalties | 1 | 1 | | |

| From \ To | P/H | Ilorin | Supply | Penalties |
|---|---|---|---|---|
| Enugu | X ₦7 | 400 ₦6 | 400 | 1 |
| Jos | 180 ₦8 | 10 ₦7 | 190 | 1 |
| Demand | 180 | 410 | 590 | |
| Penalties | 1 | 1 | | |

| From \ To | Benin | P/H | Ilorin | Supply |
|---|---|---|---|---|
| Ijebu Ode | ₦3 | 300 ₦6 | ₦12 | 300 |
| Enugu | ₦5 | ₦7 | 400 ₦6 | 400 |
| Jos | 400 ₦2 | 180 ₦8 | 10 ₦7 | 590 |
| Demand | 400 | 480 | 410 | 1,290 |

$$\text{Cost} = 400 \times 2 + 300 \times 6 + 180 \times 8 + 400 \times 6 + 10 \times 7$$

$$= ₦6,510$$

## Facility Layout

Layout is simply defined as the grouping & organization of equipment and employees within a facility. Deciding where to put facilities, equipments and staff within a facility is what is called layout.

Facility layout can be defined as the physical arrangement of the facility that'll allow for efficient & effective production. It refers to the configuration of

departments, work centres & equipments with particular emphasis on the movement of work (customer & materials) through the system.

Facility location is closely related to facility layout. However, there are three basic reasons why we ~~are~~ make layout decisions:

1. To have a significant impact on the course & efficiency of operations.
2. It involves long term commitments which make mistakes difficult to overcome.
3. It ~~involves~~ requires substantial investment of money & efforts

## Needs for facility layout

The need for layout planning has become increasingly important based on the following points:

1. To maximize the efficient flow of man & materials through the facility floor.
2. To ensure safe movement of personnel
3. To minimize distance travelled between one work unit and another.
4. To ease the process of designing and redesigning the

existing facility.

Reasons for redesigning an existing facility.

1. Changes in the volume of output
2. Changes in the method of production or equipment.
3. Changes in environmental and legal requirements.
4. Inefficient operation.
5. Accident
6. Changes in design of products or services.

Poor layouts can adversely affect system performance. Thus, in toying to find optimal solution to layout problems, the operation manages is guarded by two cardinal objectives:

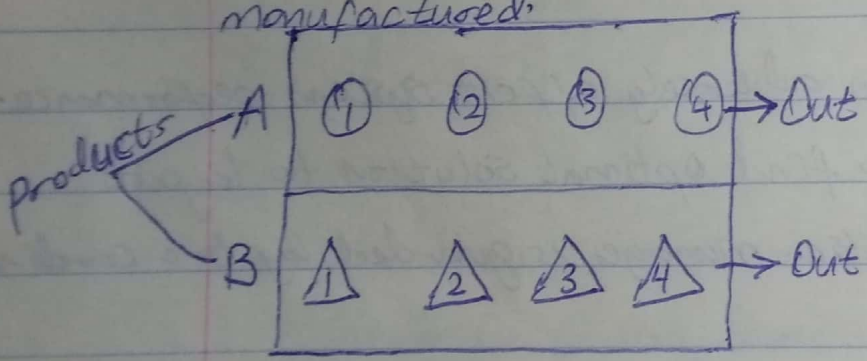
1. Minimization of total distance travelled and each associated cost
2. The creation of production systems that can meet the capacity of a firm and maximize the operation efficiently.

In a manufacturing business, the first 3 are the basic layout designs

Basic Layout designs

1. Product Layout 2. Process Layout 3. Fixed position Layout
4. Service oriented Layout

1. Product Layout: This is the configuration of machines and other support facilities arranged in accordance with the sequential manufacturing requirement of products. The unique characteristic of this design is that work centres and equipments follow a specialized sequential order as required by the nature of the product being manufactured.




Conditions that favour Product Layout Design

1. High product standardization
2. Mass production
3. When there is limited product variety

Advantages

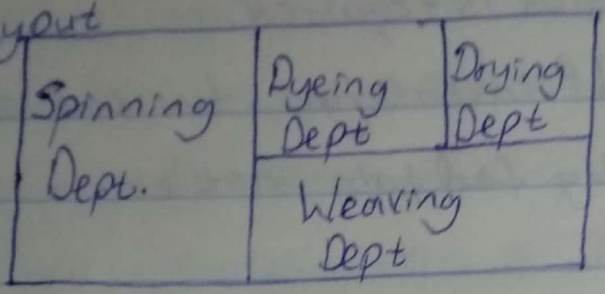
1. There is smooth & logical flow of production line since the layout follows a sequence of production.
2. There is relatively shorter production time.

3. It enhances maximum use of space since materials or WIP move from one process to another
4. Production planning, scheduling & control are simplified & very little supervision is required
5. Investment in WIP inventory is limited since one product is directly fed into another.

Disadvantages

1. A breakdown in one machine may disrupt the entire production process.
2. Once there is a change in product design, the entire layout may have to be revised.
3. Boredom and other psychological problems may be experienced by workers due to highly simplified & repetitive work.
4. There is need for greater investment in identical machines if disruption due to breakdown of one machine is to be avoided.
5. The speed of production line can be held back by one of the machines in the production line.

2. Process Layout: This is featured by a situation in which similar machines and services are located together. This type of layout is sometimes referred to as functional layout




Conditions that favour process layout

1. They have to be largely unstandardized products
2. A jobshop situation exists where products or services vary in nature & in size according to customer specification

Advantages

1. There is better & maximum use of machines.
2. Breakdown in one machine cannot disrupt production since other identical machines can be put to immediate use.
3. There is greater diversity of tasks.
4. Since identical machines are grouped together, specialized supervision is possible.

Disadvantages

1. The total production time is much longer.
2. There is greater space usage than product layout.

3. There is need for more control & supervision of each respective department
4. Comparatively larger amount of WIP is kept.
5. The movement of WIP → process from one department to another will likely result in higher material handling & movement cost.

3. Fixed Position Layout: This layout is unique in the sense that the product remains in a single location while all productive & support facilities are brought to this central location. For example, for ship & aircraft building, all tools, raw materials and other essential equipments are brought to the shipyard or where the aircraft is being constructed.

Advantage

1. There is little or no movement of materials from one workstation to another

Disadvantages

1. Production time is usually long
2. It requires higher labour or material cost

4. Service Oriented Layout: This is a situation whereby the Service Organizations are designed based on the needs of the final consumers. Service oriented Organizations such as hospitals, for example, the layout design must give sufficient consideration to such facilities as patient waiting room and consultancy room.

Criteria for effective Layout

1. Ease of future expension: This refers to
2. Material handling effectiveness
3. Safety and housekeeping
4. Ease of supervision & control
5. Fit into existing plant structure
6. Cost minimization.

22/01/2024

Production Scheduling & Control

Job Scheduling & Sequencing

Problems relating to scheduling & Sequencing confron operation managers from time to time. Hence, operation managers are expected to maximize the limited resources available in order to maximize profit. Apart from limitation of resources, operations

managers are also confronted with time limitation.

The term scheduling refers to the process of determining when certain jobs are to be processed on given facilities or when the facilities are to be allocated to a given set of jobs.

On the other hand, job sequencing refers to the order in which jobs are to be processed through the system or the order of processing the jobs through the facility.

In job scheduling & sequencing, the operation managers have certain objectives expected to be achieved. Some of those objectives may include optimizing facility utilization through minimizing machine idle time and also minimizing late completion of jobs.

## Assumptions of Job Scheduling & Sequencing

1. No machine can process more than one job at a time.
2. The processing time on various machines are independent of order of processing the jobs
3. Each job once started on one machine is continued

till its completed on jo without any interruption.
4. The order of routing/scheduling a job through the machine is maintained.
5. The time taken to move a job from one machine to anoth is small.
6. A job would start on a machine as soon as the job and the machine on which it is to be processed are free.
7. There's no machine breakdown all through the process -ng period.
8. All the jobs to be processed are available in the shop at time 0
9. The release time is small. (time taken by the operations managed to release the job for processing

## Types of Scheduling

1. Forward Scheduling
2. Backward Scheduling

1. Forward Scheduling: This involves starting a job as soo as it arrives (as soon as the job requirements are thou and the job has arrived, processing the job starts.

Advantages of Forward Scheduling

1. High Labour Utilization i.e No idle time.
2. It reduces shop congestion.
3. Machine downtime is assumed to be absent, but if it occurs, it may not undermine timely delivery of jobs.
4. There is high flexibility in the operations.

Disadvantages of

1. It may require holding inventory in anticipation of jobs instead of acquiring them only when they're really needed.
2. Schedule changes by customers may not be accom-modated.

2. Backward Scheduling: This involves scheduling by working backwards from the due date.

Advantages

1. It is less exposed to risk in case of Schedule changes by customers (or finished goods)
2. Cost of carrying inventory is lower
3. It tends to focus operation on customer's due date.

4. There is possibility of enjoying lower material cost.

Disadvantages

1. Lower utilization of Labour
2. Shop may be congested as jobs are left till the last minute.
3. Any work disruption such as machine breakdown will most likely result to tardiness of jobs.

Sequencing rules used in Scheduling Procedure

1. First Come First Served (FCFS): Priority is given to the processing of that job that arrives at the machine first (not in the shop).
2. Shortest Processing Time: Priority is given to that job with the shortest processing time on the machine.
3. Earliest Due Date: Priority is given to that job with the earliest due date.
4. First In the System, First Served: Priority is given to the processing of the job that arrives in the shop first that was received first from the customers (not the one that gets to the machine first).
5. Longest Processing Time:

C.T – Completion Time
F.T → Flow Time

Scheduling of Jobs on One Machine

| JOB | Processing Time (Days) | Due Date (Days) |
|---|---|---|
| 1 | 5 | 7 |
| 2 | 8 | 10 |
| 3 | 3 | 20 |
| 4 | 9 | 18 |
| 5 | 6 | 16 |

(a) First In the System, First Served

| Job | Processing Time (Days) | D.D (Days) | C.T (Days) | F.T (Days) | Tardiness (Days) (CT - DD) |
|---|---|---|---|---|---|
| 1 | 5 | 7 | 5 | 5 | – |
| 2 | 8 | 10 | 13 | 13 | 3 |
| 3 | 3 | 20 | 16 | 16 | – |
| 4 | 9 | 18 | 25 | 25 | 7 |
| 5 | 6 | 16 | 31 | 31 | 15 |
| | | | | 90 | |

Total Tardiness → 25 days

Number of Late Jobs → 3 jobs

Mean Tardiness $\left(\frac{25}{5}\right)$ → 5 days

Mean Flow Time $\left(\frac{90}{5}\right)$ → 18 days

(6) Using Earliest Due Date:

| Job | P.T (Days) | D.D (Days) | C.T (Days) | F.T (Days) | Tardiness (CT − DD) (Days) |
|---|---|---|---|---|---|
| 1 | 5 | 7 | 5 | 5 | 0 |
| 2 | 8 | 10 | 13 | 13 | 3 |
| 5 | 6 | 16 | 19 | 19 | 3 |
| 4 | 9 | 18 | 28 | 28 | 10 |
| 3 | 3 | 20 | 31 | 31 | 11 |

I Total Tardiness = 27 days

II Mean Tardiness = 5.4 days

III Number of Late jobs = 4 jobs

IV Mean Flowtime = $\frac{96}{5}$ = 19.2 days