24.01.2023
Wednesday

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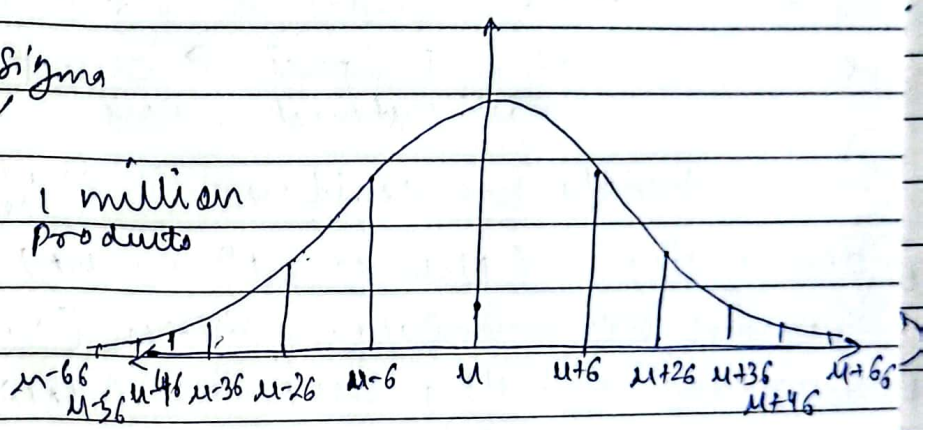
67%	One Sigma	1σ	B+	Extraordinary
Q	Two Sigma	2σ	95%	A	(100 − 99.73)% =
	Three Sigma	3σ	99.73%	A+	0.27% of the products are not as per the quality products
	Four Sigma	4σ		
	Five Sigma	5σ		
	Six Sigma	6σ		

→ Asian Heart Hospital → Best hospital situated in Mumbai
Six Sigma Certified

3 Sigma → 1 million → 2700 deaths
$\frac{0.27}{100}$ 1,000,000
No compromise should be there

4 Sigma 5 Sigma 6 Sigma
↓
3 defects in 1 million products



TQM:- Total Quality Management

Mumbai Dabbawala → 6 Sigma
To achieve 6 Sigma –
follow TQM
→ Demin

Quality is not an act but a habit

Compromising Quality
1. Toyota cars
2. bp ⇌ Transocean US
3. Rocket

Quality means doing it right when no one is looking

→ ~~Dabbawala~~ :-
- Leader no extra salary (Bonus even)
- Customer is God. work is worship.
- No strike
- No legal
- Passionate
- Retention
- Value added services (Salary, match, mobile)
- zero attrition rate

Work

30.01.2024
Tuesday

Dr. Pawan Agrawal

Coding system : Responsibility of work
Business ethics Time consistent.

Factors to determine plant location –
Gurgaon + ~~Foo~~ Industrial area (Automobile) → Reason; Delhi connectivity

Banglore (IT hub) – connectivity { Easy to develop other company at same area (easy availability of man power) }

Wallmart takes orders from Bangladesh [
BPOs culture in India & China
Global service तो Tier-1 की जरूरत नहीं।
Nemuch, Nagda & Shripuri → cement industry
Raw material = Rock

1. NTPC electricity in Hairidwar (Source of operating power near)
2. Tier-1 city (Near to port market) (Labour)
3. Transport & communication facilities (Tier-1 IIT Indore)
4. Integration with other companies (TATA + suppliers)

Price Minus system : price of product decided (Tyre ~~[illegible]~~ IC Engine change)
or cost Minus system (Auxiliary units) Ex: TATA Nano in Bengal

Gift City : Gujarat
Trading ~~city~~ cost ↓↓↓ Singapore, Hong Kong की तरह।
~~Dholera City~~ ↳ Foreign Exchange
Financial Hub

6. Land & climate (Banglore)
7. Govt. benefits (tax benefit, etc) → Uttarakhand SEZs Rudrapur
Honda units, ← excise duty nominal

Operation Management
by Barrish Taylor.

(8) Availability of housing & services
(9) Political situation, Mamta Banerjee.

Types of Facilities -
(1) Heavy manufacturing - NTPC Bhel
(2) Light Industry facilities - Biscuits — Proximity to customer location
(3) Retail & service - Bank,

Location Analysis Techniques, (Management)
(1) Location Rating factor
(2) Centre of gravity factor
(3) Load Distance Technique.

Location Rating factor
(1) (i) Identify impo factors.
(ii) Weight factor (0.00 - 1.00)
(iii) Subjectively score each factor (0 - 100)
(iv) Sum weighted score.

Q) Location factor

	wt.	score (0 to 100) Site 1	Site 2	Site 3
Labour	0.3	80.	65	90
Proximity to supplier	0.2	100		

Subjectively लिखना है।

$\Sigma w_i (f_i)_{site_1}$ <

$\Sigma = 1$

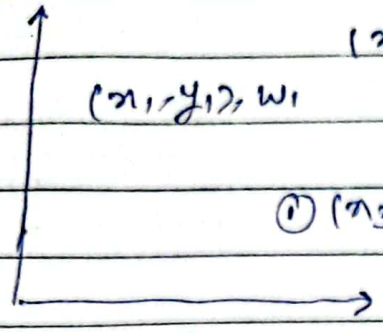
City1 - 77.5
City2 - 80.8
City3 - 82.05

Problem:
(i) कोई factor miss (TATA Nano - Political factor miss)
(ii) Weights गलत assign.

(2) Centre of gravity
(i) Locate facility at centre of geographic area
(ii) Based on wt & dist travelled establish grid map of area.
(iii) Identify coordinates & weights shipped for each location

OEM: Original Equipment Manufacturer.

If you know where are your suppliers (OEMs) or market.
[How much load you are transporting]



$$x = \frac{\sum x_i w_i}{\sum w_i}$$

$$y = \frac{\sum y_i w_i}{\sum w_i}$$

x, y : coordinates of new facility at COG

x_i, y_i : coordinates of existing facility i

w_i : annual wt. shipped from facility i.

$x = 238$
$y = 444$
COG (Centre of Gravity)

	A	B	C	D
x	200	100	250	500
y	200	500	600	300
w	75	105	135	60

75
105
135
60
375

COG = If say is parliament then management helps to decide the location

Load Dist. Technique

i) Compute (Load × Distance) for each site.
ii) Choose site with lowest (load × distance)
iii) dist. can be actual or straight line.

$$\boxed{LD = \sum_{i=1}^{n} l_i d_i}$$

Load Dist value

Load expressed as a wt., number of trips or units being shipped from proposed

360

01.02.2

Tuesday

Fit	Site X	Site Y
1	300	180
2		
3		

	A	B	C	D
X	200	100		
Y				

Wt → Load

Site 1 $d_A = \sqrt{(x_A - x_1)^2 + (y_A - y_1)^2}$

$200 - 360$ $200 - 180$

Method.

1 Where to locate based on factors
2 Based on supplies/markets locate.
3 Selection among sites + locations info

420

A	B	C
$X_a = 150$	$X_b = 300$	$X_c = 400$
$Y_a = 250$	$Y_b = 100$	$Y_c = 500$
$Wt = 140$	110	170

COG $\begin{cases} x = 290.47 \\ y = 311.90 \end{cases}$

Facility layout Decisions

05.03.2024
Tuesday

Project scheduling

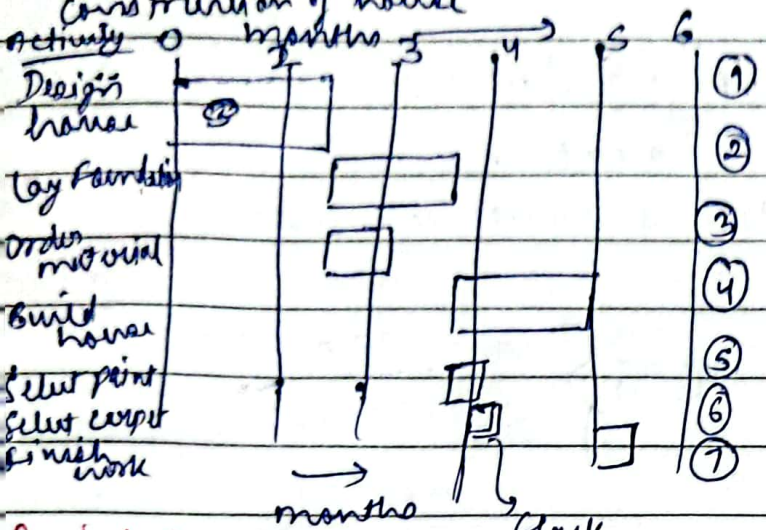
Steps
- Define activities
- Sequence activities
- Estimate time
- Develop schedule

Techniques
- Gantt chart
- CPM
- PERT
- Microsoft Project
- Project Evaluation & Review Technique

critical path length

Gantt Chart

Construction of house



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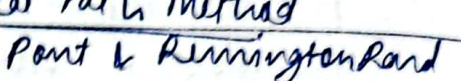
Critical Path Method

Du Pont & Remington Rand
Deterministic task times
Activity on node n/w construction (AON)

Project Evaluation & Review Technique (PERT)

Activity on Arrow (AOA)



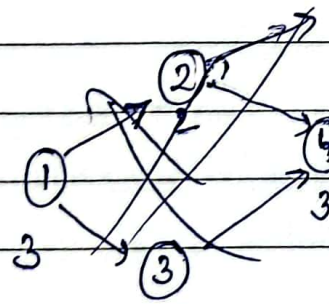
AON
- Nodes → Activities
- Arrow → precedence relationship

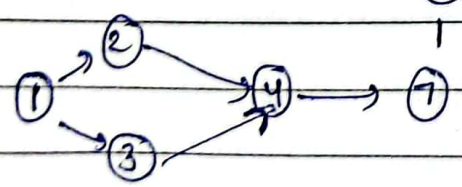
AOA
- Arrows → Activities
- Nodes → event for points in time

Event → project starts & ends here

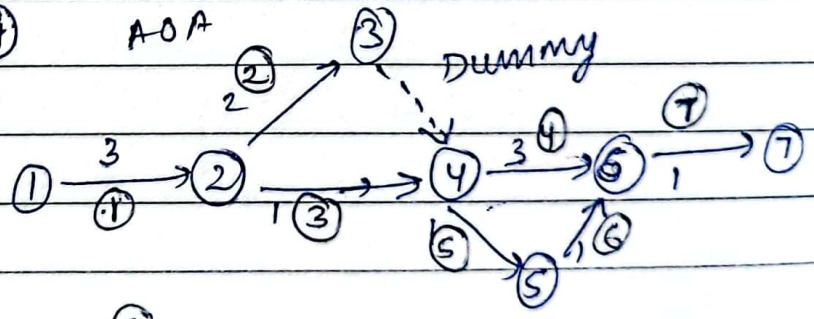
Project Report
Q7 Last Page 42 |.

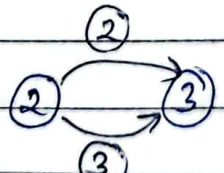
	months
1	3 ~~months~~
2	2
3	1
4	3
5	1
6	1
7	1



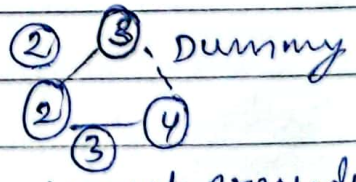


AOA





Incorrect precedence rel



correct precedence rel

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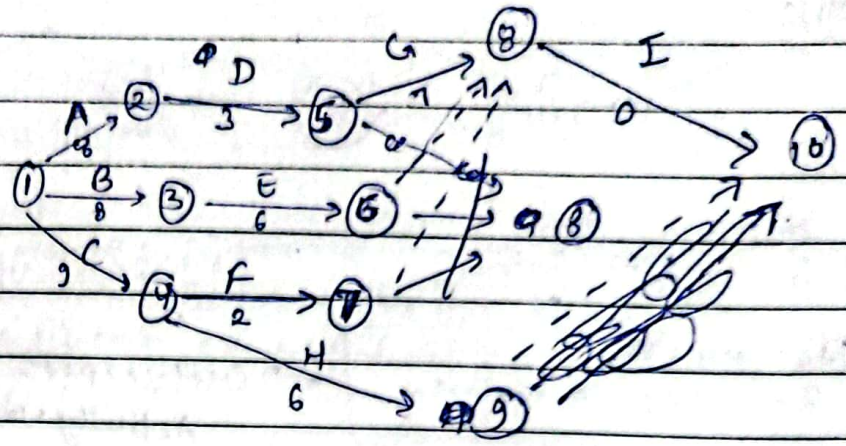
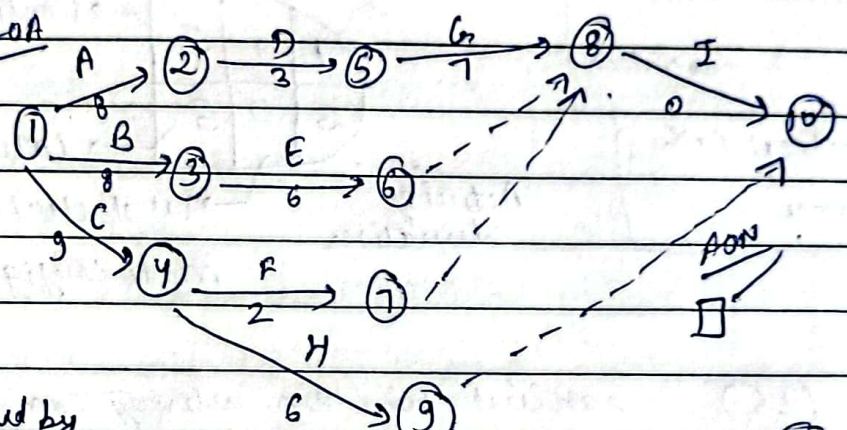
Activity	Duration	Precedency
A	8	–
B	8	–
C	9	–
D	3	A
E	6	B
F	2	C
G	7	D, E, F
H	6	C
I	0	G, H



AOA

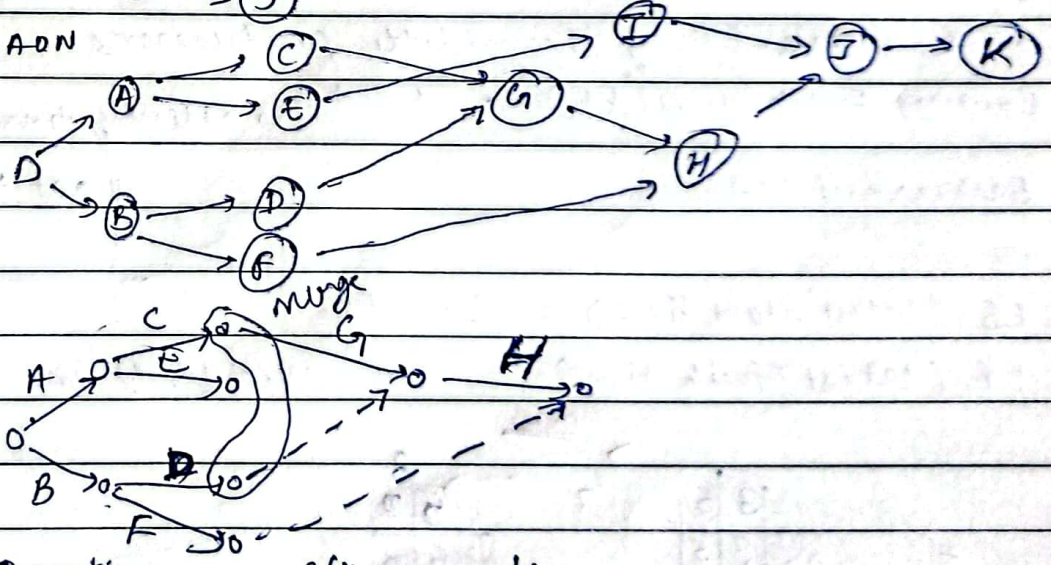


Dummy Arrow.

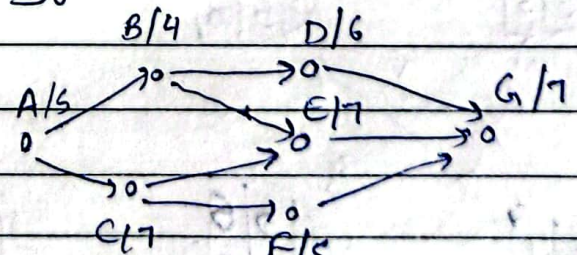
AON

Activity	Preceded by
A	–
B	–
C	A
D	B
E	A
F	B
G	C, D
H	G, F
I	E
J	H, I
K	J

AON



Activity	Immediate predecessor	Duration
A	–	5
B	A	4
C	A	7
D	B	6
E	B, C	6
F	C	5
G	D, E, F	7



AON

Activity : A
Duration : D

(A/D)

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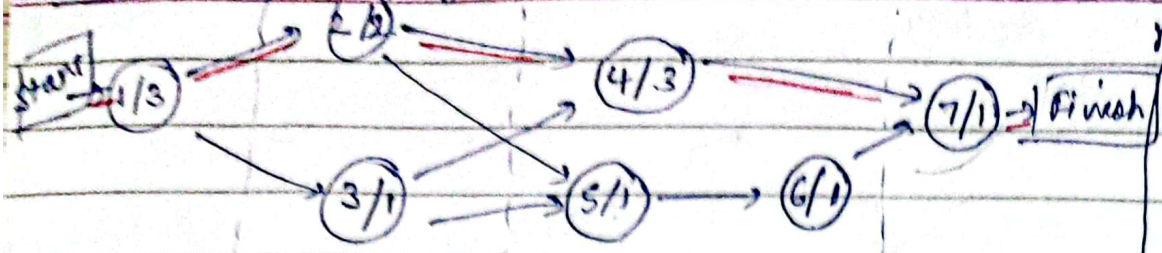
Project N/W

AON House Building



Find critical path

If any time change on this path
Then path of whole project changes.

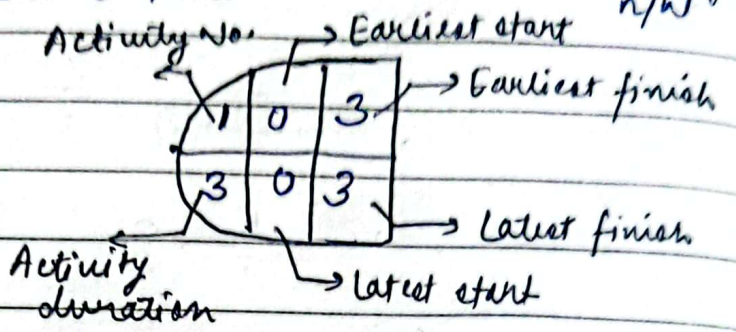
① Minimum time to complete the project
② Longest path of the n/w

3 | max (2, 1) = 2 | max (3, 2) = 3 | 1 = 9

1 + 2 + 4 + 7
3 + 2 + 3 + 1 = 9 months → Critical path

1 + 2 + 5 + 6 + 7
3 + 2 + 1 + 1 + 1 = 8 months

Activities on Critical Path have 0 slack time



Node configuration

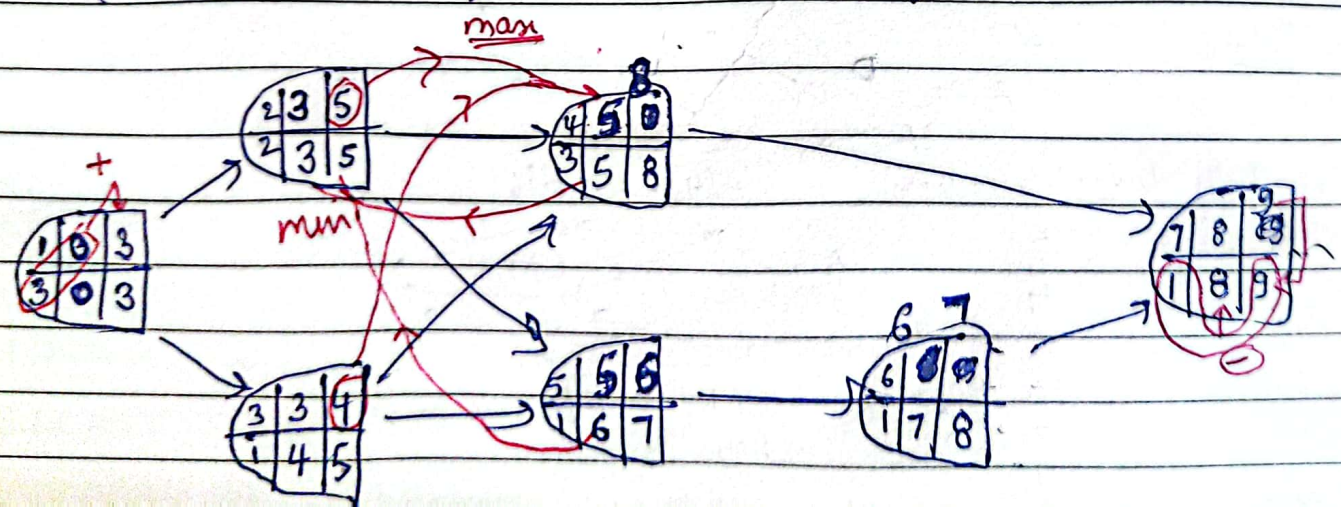
Forward Pass

Earliest Start time (ES) earliest time an activity can start
ES = max. EF of immediate predecessors
Earliest Finish time (EF) = ES + t ↳ activity time

Backward Pass

Last Node & First Node
LS = ES
& LF = EF

LS (Latest Start time) = LF − t
LF (Latest Finish time) = minimum LS of immediate predecessors



12.03.2024
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Russell & Taylor Operation Management

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1 → 2 → 4 → 7 → Critical Path (EF = LF & ES = LS on this path)

Slack = LS − ES
= LF − EF
→ 2 तो ही Time

PERT (Project Evaluation & Review Technique)

CPM → Does not account uncertainity in estimating activity times

PERT → provides confidence limits,

Features :-

1. Draw the n/w for the project
2. 3 time estimates → optimistic time (shortest time) = OT = a
→ Normal time (most likely time) = NT = m
→ Pessimistic time (Abnormal delay) = PT = b
3. Expected time = f (OT, NT, PT)
4. Critical Path & Slack

Normal distributed

$$\text{Mean (expected time)} = \frac{a + 4m + b}{6}$$

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

$\sigma = \sqrt{\text{variance}}$
= Standard deviation

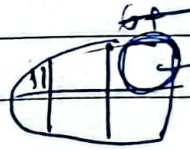
$$\text{Probability (that project is completed within specific time)} = Z = \frac{x - \mu}{\sigma}$$

Activity	Time estimates a	m	b	Mean time t	Variance σ^2
1	6	8	10	8	0.44
2					

t_p

$\frac{1}{a, m, b}$

2 - 5 - 8 - 11



Last Node → time of completion

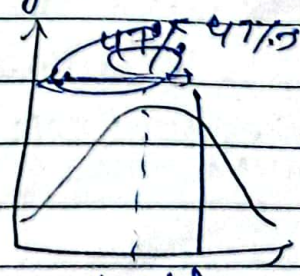
$\sigma^2 = \sigma_2^2 + \sigma_5^2 + \sigma_8^2 + \sigma_{11}^2 = 6.89$

↳ variance of project

$\mu = \mu_2 + \mu_5 + \mu_8 + \mu_{11}$

↳ Mean of project = 25

$$P(\text{completing project 'x' weeks}) = \frac{x - \mu}{\sigma}$$



P(completing within 30 weeks) = P(Z)

<= 30

$Z = \frac{30 - 25}{\sqrt{6.89}}$

= ~~0.72~~ 1.91

25 days
[ही रहे]

P(Z) = 0.47119 (from Z-table)

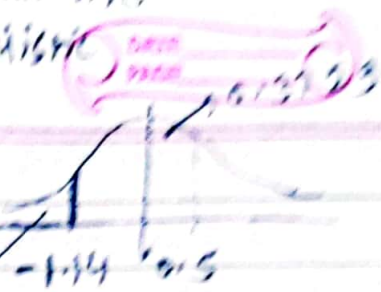
0.5 + 0.47119 = 0.97119

02.04.2024
Tuesday

Project Scheduling
- Gantt → simple bar chart
- CPM → Deterministic
- PERT → Probabilistic

$$\frac{22-25}{\sqrt{6.89}} = -\frac{3}{2.6} = -1.14$$

$P = 12.71\% \approx 0.1271$



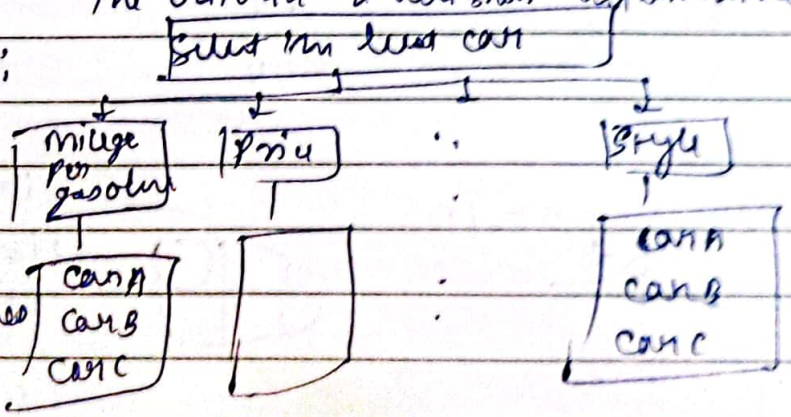
control → periodical checks & monitoring
Add machines & people to avoid late → Resource Allocation
project crashing
↳ cost ↑

4MS add
man power
Machine
money
add

Multi Criteria Decision Making

Different MDCM methods:-

AHP : ① graphical represent^n of problem in terms of overall goal, the criteria & decision alternatives.



(DFMA)
Design for manufacture & Assembly
② ③

DFM Guidelines
(i) minimize parts & subassemblies
(ii) Avoid tools & separate fasteners & adjustments
(iii)

15000/- without service

25000/- with maintenance

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Function reliability parameter –

Reliability

MTBF → length of time a product or service is in operation
(Mean time Betn Failures)

Maintainability (serviceability)

MTTR → Mean time to Repair कितने जल्दी सही हो रहा है।

System Availability $= \frac{MTBF}{MTBF + MTTR}$

	MTBF (Hr)	MTTR (Hr)
A	60	4
B	36	2
C	24	1
	Reliability	Maintain

$SA_A = \frac{60}{64} = 0.9375$ $SA_B = \frac{36}{38} = 0.9473$ $SA_C = \frac{24}{25} = 0.96$

high ∴ C

Usability of
→ easy learning
easy fast
~~ease of remembering how to use~~

OS : windows पसंद आता है।

Production Design

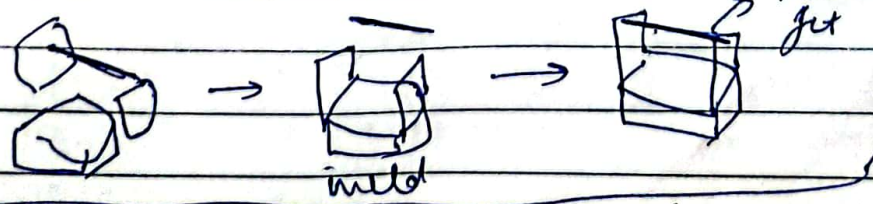
① Standardization
Interchangeability
Standard products → economy of scale

Nut → Internal threading

Daewoo & Korean
Service not available

② Modularity
→ components merge करके एक module बना दो।
→ ज्यादा parts तो Reliability कम।

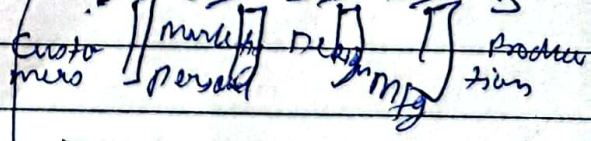
③ Simplification
→ ज्यादा Nut Bolt मत लगाओ (Fasteners)
Reduce no. of parts



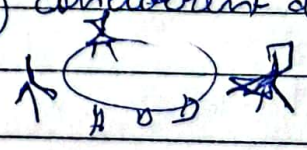
Concurrent design → Price - Mining System
Nano 1 lakh

Design Team

① Sequential design
(walls low functional areas)



② Concurrent design



BLOCK DIAGRAMMING

Unit load - qty. in which material is normally moved

Non adjacent load - dist. farther than the next load.

ex: mach. to clinic via Electric.

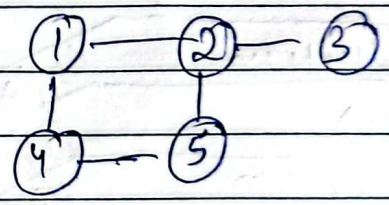
STEPS:-

1. create load summary chart.
2. Calculate composite (two way) movements.
3. Develop trial layouts minimizing no. of non adjacent loads.
4. Add information about the space required for each dept.

2x3 Matrix

1. Load Summary Chart → कितने लोग goes from Dept. x to Dept. y

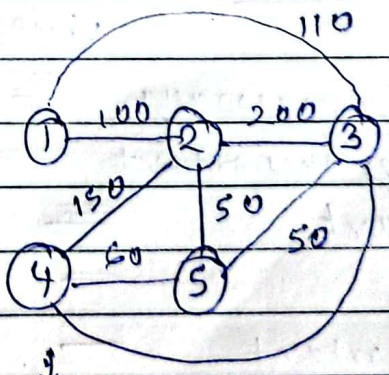
From/to Dept.	1	2	3	4	5
1	-	100	50		
2		-	200	50	
3	60		-	40	50
4		100		-	60
5		50			

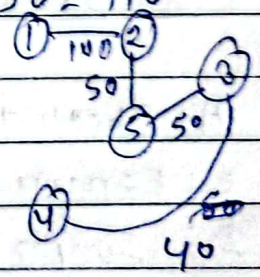


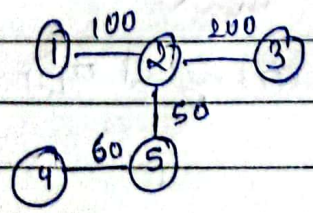
2. Two way movements 1→3 to 3→1 = 60 + 50 = 110

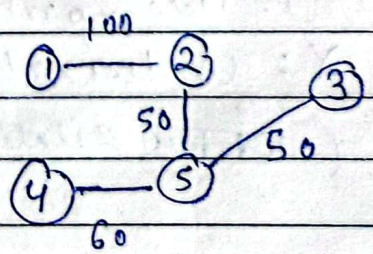
1-2	100
1-3	50+60=110
1-4	0
1-5	0
2-3	200
2-4	150 (50+100)
2-5	50
3-4	40
3-5	50
4-5	60

(2x3 Matrix)

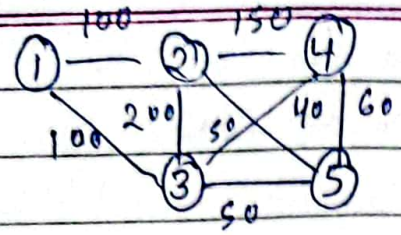


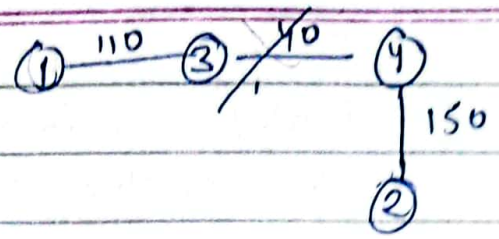




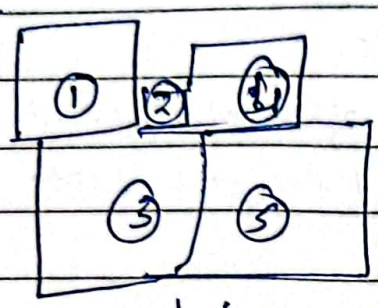


27.02.2024
Wednesday

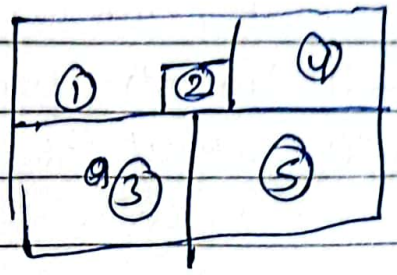




Nonadjacent layouts
= 0

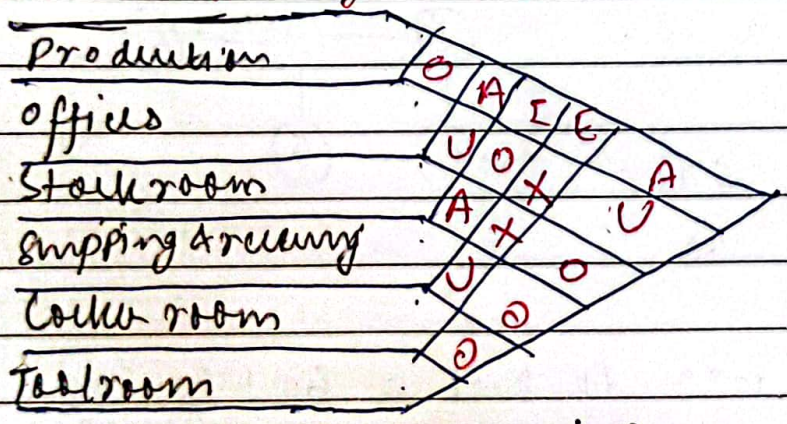


Function →



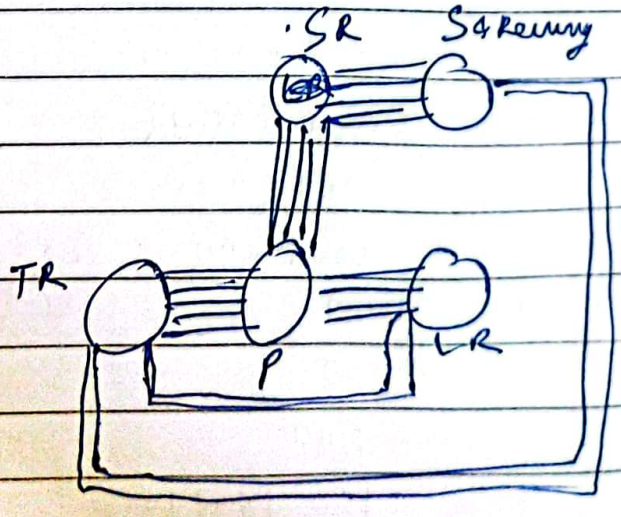
company ने information
दे दी है की What is size of dept. required.

Relationship diagramming (Muther's diagram)



Uses

A: Absolutely necessary
E: Especially important
I: Important
O: Okay
U: Unimportant
X: Undesirable
(जिनकी Relationship strong हो पास)

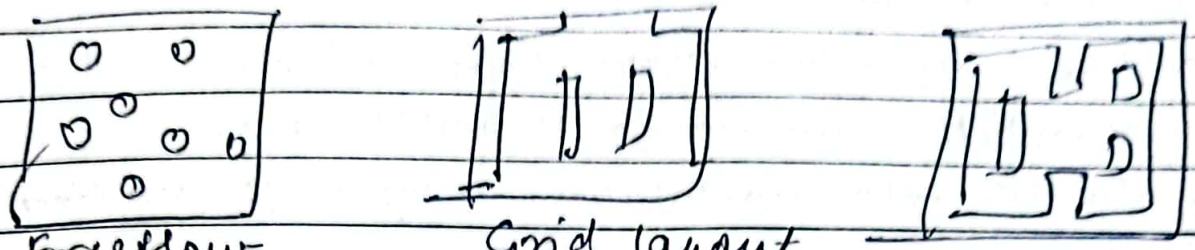


S/W:
CRAFT
(computer aid. Relation Allocation Facility)

28.02.2024
Wednesday

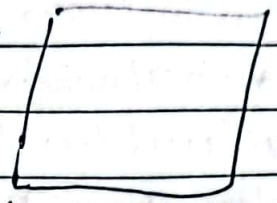
DATE
PAGE

Designing service layouts



Freeflow layout — Grid layout — Loop layout

Spiral layout



Designing Product layouts:

Obj. Balance the assembly line

① Line Balancing : tries to equalize the amt. of work at each workstation

② Precedence requirements : Order of operations

③ Cycle time : max. time ~~in~~ allowed at each workstation.

$$C_d = \frac{\text{production time available}}{\text{desired units of output}} = \frac{(8\text{hrs} \times 60\text{min./hour})}{(120\text{ min})}$$

$$\therefore C_d = \frac{480}{120} = 4 \text{ minutes}$$

Flow time: time to complete all stations

determine no. of products (ZMP)

$\frac{480}{4} = 120$

$\frac{480}{6} = 80$

[1] — [2] — [3]

4 4 4 (in minutes)

Flow time = 4+4+4 = 12 min.

cycle time = max({4, 4, 4}) = 4 min.

$$\text{Efficiency } E = \frac{\sum_{i=1}^{j} t_i}{n C_a}$$

$$\text{Minimum no. of workstations } N = \frac{\sum_{i=1}^{j} t_i}{C_d}$$

C_a : actual cycle time (result from balancing approach)

C_d : desired cycle time

t_i : completion time for element i

j : No. of work elements

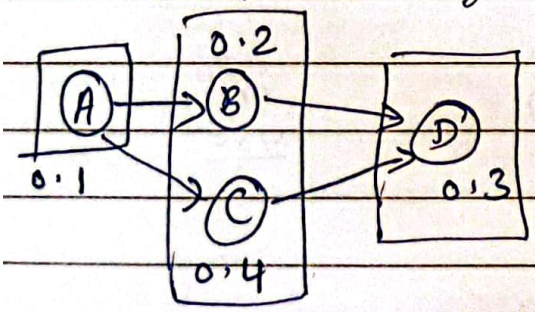
n : actual ~~no~~ work station

Line Balancing Procedure

1) Draw & label a precedence diagram (order)
2) Calculate desired cycle time required for the line.
3) Calculate theoritical minimum no. of workstations.
4) Group elements into workstations recognizing cycle time & precedence.
5) Calculate efficiency of the line.
6) Determine if the theoritical minimum no. of workstations or an acceptable efficiency level has been reached. If not go back to step 4.

[Innovations can reduce time]

	Work element	Precedence	Time (min)
A	Press out sheet of fruit	—	0.1
B	Cut into strip	A	0.2
C	Outline fun shapes	A	0.4
D	Roll up & package	B, C	0.3



$$N = \frac{0.1+0.2+0.4+0.3}{0.4} = \frac{1}{0.4} = \frac{10}{4} = 2.5 = 3$$

To produce 6000 units ~~per~~ in every 40 hours week

$$C_d = \frac{6000}{40 \times 60} = \frac{2}{5} = 0.4 \text{ min.}$$

$$N = \frac{0.1+0.2+0.3+0.4}{0.4} = \frac{1}{0.4} = 2.5$$

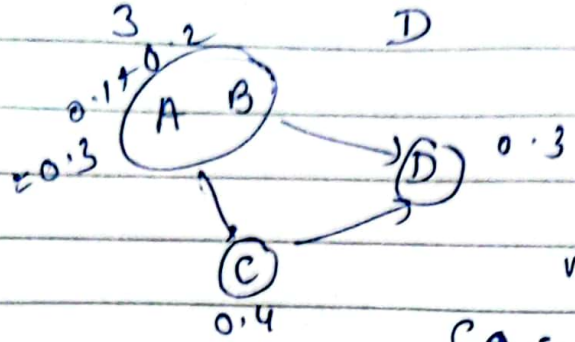
3 workstations

Workstation	Element	Remaining time	Remaining elements
1	A	0.3	B, C
	B	0.1	C, D

(A B) combine (precedence & C_d) rule

05.03.2024
Tuesday

2	C	0.4	D
3	D	0.1	next (done)



$E = \frac{0.3 + 0.4 + 0.3}{3 \times (0.4)}$

n = 3 workstations

$= 83.33\%$

$C_a = \max(\{0.3, 0.4, 0.3\}) = 0.4$

Phases of Project Management:-

1) Project Planning:-

(i) Setting the objectives of the project & the assumption to be made

(ii) Development of work Breakdown structure (Total project & activities & breakdown structure)

(iii) Estimating the activity duration, their resource requirements & costs (Time & cost imp.)

(iv) Establishing the interdependency relationships b/w activities

2) Project Scheduling:-

(i) Start & finish time of each activity

(ii) Critical path in which the activities require special attention.

(iii) Slack & float for the non-critical path

→ No free time / slack time available (max. amt of time required on this path)

3) Project Control:-

(i) Making periodical progress report.

(ii) Reviewing the progress.

(iii) Analyzing the status of the project.

(iv) Management decision regarding updating, crashing & resource allocation etc. → time reduction

Project team — Matrix organization — Project Manager

Project Scope → Scope statement, Statement of work

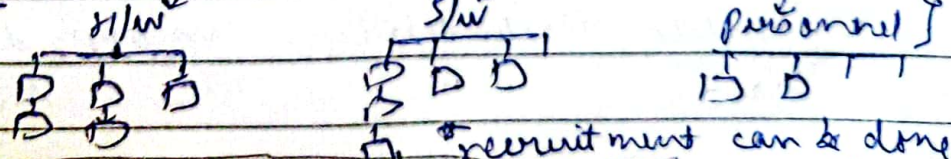
computerized order processing system

Work Breakdown Structure

We know the activities & skills required but not the order.

Responsibility Assign new notion

Activities { H/W, S/W, Personnel } Elements



	Activity 1	Activity 2
H/W engineering	3	1
S/W engineering	1	0
Vendor	2	0

*recruitment can be done

Level of Responsibility
1 = overall responsible
2 = performance responsibility
3 = support

08.02.2024
Thursday
Sumit Sir

→ Sibling & nepheews.

Deletion in RBT

Single child parent → parent = black, child = red

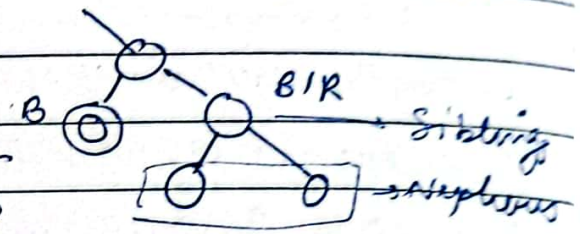
leaf node red black case

Case-1:
Replace till you reach leaf.
leaf == red ⇒ directly delete

Case-2:
black:

make it double black. (Node को delete करना है)
(If root पर double black आ ~~जाए~~ directly हटा दो)

Case-3:
Double black + Not root



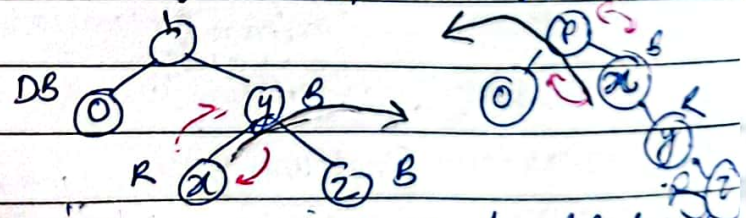
Case3: sibling color: Black
Nepheews → {BB, BR, RB, RR}

2 blacks confirm ∴ Right ही confirm sibling.

~~2.~~ Sibling: B, Nephew - BB
(i) Remove the double black.
(ii) Make sibling red
(iii) Add Black to its parents.

R ⇒ B
B ⇒ Double B & Reapply the suitable cases.

Case 4:
If double black sibling is B & far nephew is B
& near nephew is R



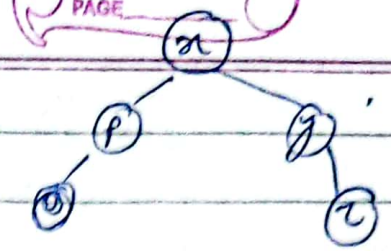
(i) Swap the colour of double black sibling & near nephew.
(ii) Rotate double black sibling in opp. dirn of double black node.
(iii) Apply case 5.

Case 5:
If double black sibling is B & far nephew is red.
(i) Swap the colour of DB parents & DB siblings.

(ii) Rotate DB parent in ~~DB~~ DB dir^n.

(iii) change color of far red nephew to black

(iv) Remove DB.

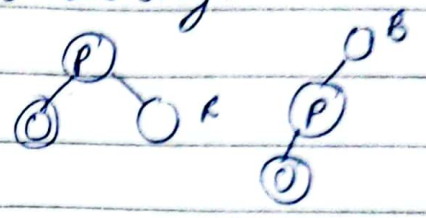


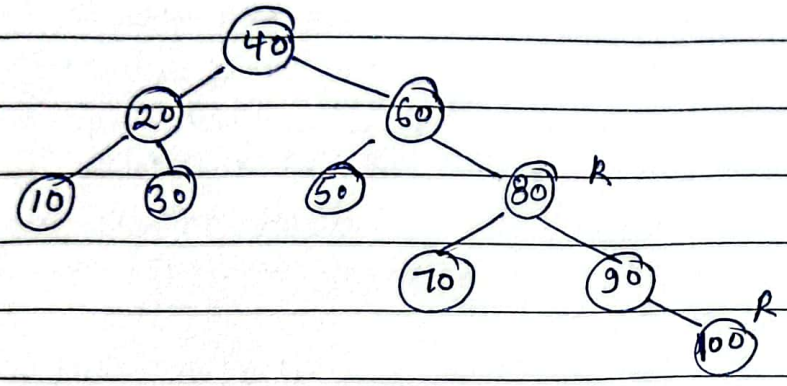
Case: If DB's sibling is red in colour

(i) Swap colour of DB parent & DB sibling.

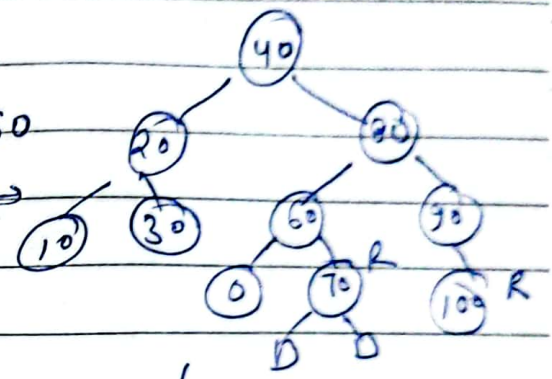
(ii) Rotate parent in DB direction

(iii) we apply suitable case as DB still exist.

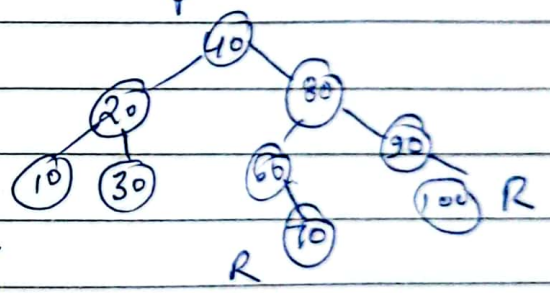




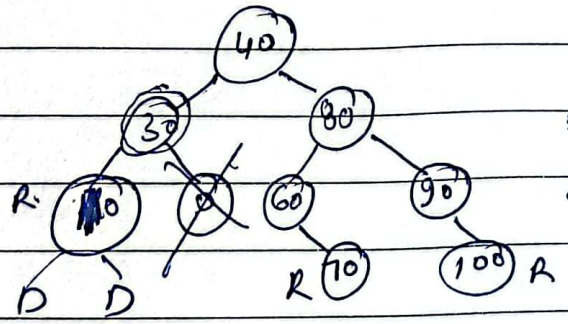
del. 50 $\xrightarrow{\text{case 5}}$



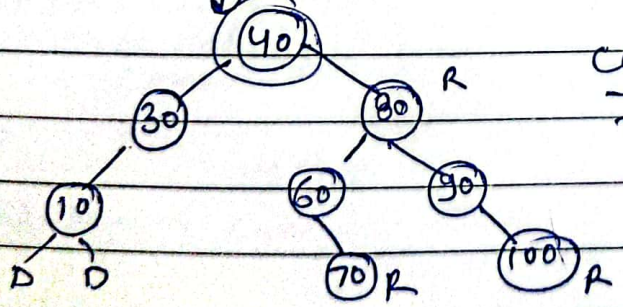
$\downarrow$ Case 3



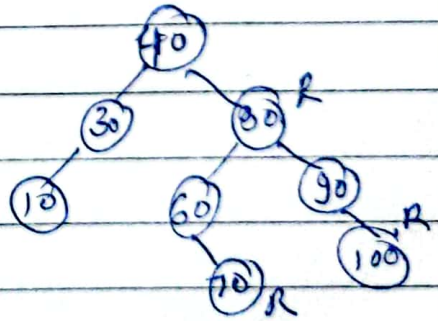
Delete 20 $\leftarrow$ Case 2 + 3



$\downarrow$ Case ~~2~~ + Case 3



$\xrightarrow{\text{case 2}}$ root, DB directly removed



$x^T y - x^T \hat{y}$

DATE
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$$J = \sum_{i=1}^{m} (y_i - \hat{y}_i)^2 + \lambda \sum_{i=1}^{m} w_i^2$$

$$\Rightarrow J = \sum_{i=1}^{m} (y_i - w_0 - w_1 x)^2 + \lambda \sum_{i=1}^{m} w_i^2$$

$$\frac{dJ}{dw_0} = 2$$

01.02.2024
Thursday

SWOT
internal: poor competition, s/w skill
external: Medical (Doctor)

S	W
O	T

10 points

DATE
PAGE

Facility layout

Arrangement of machines, dept., workstations

Emphasis why?

Comfort, easy movement, expansion possibility (practical), interconnectivity with dept., automation (conveyer belt), html

movement ↓ cost ↓ ∴ efficient

Imp. of layout decisions – Long term commitments

Need of layout decisions –

1. Bottlenecks → Inefficient { CSE में mech. नहीं है
2. Changes in design of products / services : (Mech में Audi है
3. New Product or service
4. Safety purpose (मरचंट tiger)
5. Morale problems
6. Space utilize & labour utilize.
7. Facilitate interactions & communication [Director office के पास Dean office]
8. Cycle time reduction
9. Customer service time ↓

Bottle neck: 5 min, 4 min, 6 min. (non-time)

Cycle time = 6 min (+ 8) very small ignore

Basic layout types (LFSC)

1. Line / Product layouts
2. Functional
3. Stationary
4. Comb^n

(1) In → [S-1] → [S-2] → [S-3] → [S4] → Finishes

Material or labour

Repetitive & continuous processing

S-i → Station-i

In → [ ] → [ ] → [ ]

worker

Out ← [ ] ← [ ]

Only one in & one out

Advantage:-

1. Fast production
2. Low unit cost.
   economy of scale → Bulk purchases + than discount.
3. High utilization of labour & equipment

Workbalancing synchronization

Fairly inflexible to changes in volume & variety.

Disadvantage:-

1. Difficult to supervise and incentivise (raw material)
2. Assembly line breakup
3. Inflexible to change
4. Repetitive jobs, volume. (Poorly skilled workers)
5. synchronization problem
6. Modification & updation of product.

No Flexibility

Job shop & shop processing

(2) Process layout :

Dept. A	Dept. C	Dept. E
Dept. B	Dept. D	Dept. F

Advantage :
1. Flexible
2. Equipment is not less costly
3. Lower capital investment
4. Effective supervision. (incentivised)

4 operational strategies
- Flexible
- Cost
- Quality
- On time fast delivery / Speed

Garage
↑
General purpose machine
or
Special purpose machine
↓
Big showroom

Disadvantage :-
1. Movement (21%) (Conveyor belt ↓) (Inprocess inventory)
2. Challenging routing & scheduling
3. Equipment utilization rates are low.
4. Personalised att^n.
5. Accounting more.
6. Span of supervision

(5) Stationary layout :
Construction of bridge, heavy machines, aeroplanes.
High skilled labour, costly

Coca cola plant
Example of automation
(1) Efficient utilization of space.
Modularity
Effective design (speed)

Three containers { Plastic, glass, can

excursion machine } moulding → Pryform
Special purpose machines

air rayon → space utilization

Vertical conveyor →

Factors affecting choice of layout —
1. Nature of product.
2. Size of o/p.
3. Nature of manufacturing system.

→ Process Facility layout

customers unique requirements ~~in~~

Types of PS :- (Production System) - -

→ Hospital, Flyovers

1. Job / Project Production System — IIT Jodhpur vs IIT Indore
2. Batch Production System → Ecell के T-shirts, Price अलग है। — customised T-shirt
3. Mass Productions → EM class के tshirts, Maruti
4. Process / Continuous PS → Full college के T-shirts.

→ depends on single customer. — does not depends on single customer

→ A B C ... यहाँ काम होता है। — Red colour की light, ~~orange~~ Red color की diesel 24 ~~hours~~ hours चलती है। Rarely बंद होती है।

→ product facility layout.

	Product	Process
Layout decision	Line Balancing	Machine Loading
Goal	Equalize work at each station	Minimize material handling cost.

Designing Process layouts :-

Block Diagramming

- minimize nonadjacent loads
- use when quantitative data is available

Relationship Diagramming

- based on location preferences b/w area
- when quantitative data is not available.

Productivity = (o/p)/(i/p) Total productivity = sales / (i/p)
labour, materials, capital

Productivity growth = Current Period Productivity − Prev. Prod.
Prev. Period Productivity

Reasons of low productivity −

① Poor product design.
② Poor plant design,
③ Shortage of i/p material, tools, jigs & fixtures
④ Poor preventive maintainence
− Breakdown maintainence
↳ जैसे के ऐसे Check
⑤ Poor working cond^n & env.
⑥ Absenteeism of worker without prior permission.
⑦ Poor employee − employer relationship.
⑧ less participation of worker in management.

Capital Quality Technology & management
↳ ways to improve productivity.

Right person right job. flexible org., determine bottleneck problem area.

Competitiveness (of Indians) Productivity Industrial term. dot com burst

Term used for nation (Group) Japan

Productivity = o/p / i/p

Ways −

	o/p	i/p	
①	o/p ↑	i/p	Efficient
②	o/p ↑↑↑	i/p ↑	Expand
③	o/p ↑	i/p ↓	Breakthrough (Innovation) USA
④	o/p	i/p ↓	Downsize
⑤	o/p ↓	i/p ↓↓↓	Retrench

Kaizen
daily improvements in workplace

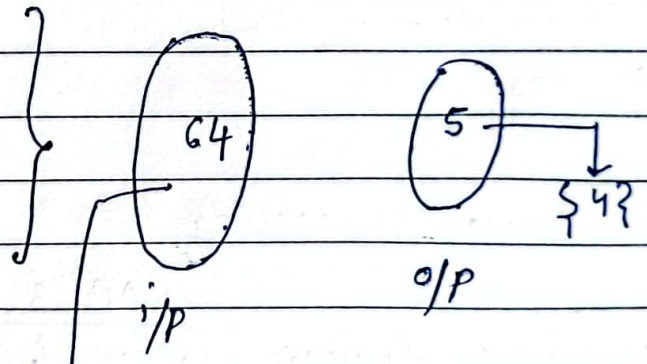
DATE
PAGE

Gift City :- Gujarat International Finance Tec-City → Tax benefits, Water, Electricity

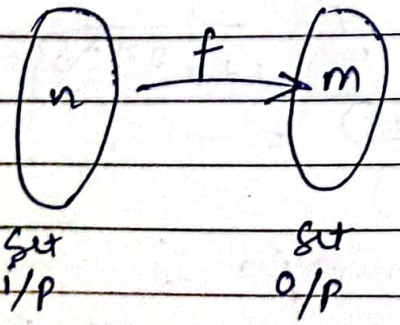
Tata Nano. 2006, 997.11 acres land in Singur by Left Front govt.
2008 Protests (Land with Tata)
2011 Legal battle betn Mamta Banerjee & Tata
Aug 2016 SC return land.
Oct 2016 Plant structure demolished
Feb 2017 Potato main cash crop harvest.
[Backed by govt]

mini ②

Feature	Values
1	4
2	4
3	4
4	5 (output)



Formula



→ Possible instances $= 4 \times 4 \times 4$
{1} {2} {3}
$= 64$

No. of functions / hypothesis space $= m^n$
$= 5^{64}$