



Subject: Production and Operation Management Module 03

CHAPTER 01

OPERATION

SEQUENCING

❖ INTRODUCTION

- One of the planning functions of an operations manager
- Most important function in job shop processing
- In continuous and semi-continuous production processes scheduling is automatically done at the time of designing the facility,
 - as the product has almost no variety and production volumes are large
- Operations scheduling in job shop involves the following activities:
 - Assigning job orders to different machines or work centers
 - Deciding the sequence of processing on different machines on basis of some priority rule (called sequencing or prioritization)
 - Planning the route of movement of material from one to the other department (called routing)
 - Issuing dispatch lists to various work centers containing information about the work centers a customer order should be processed at first, the amount of time the processing should take and so on (called dispatching)
- Tracking the progress of various scheduled jobs and the implementation of schedules, revising the schedules in case of delays, and expediting the completion of certain jobs (called expediting)



- The absence of proper scheduling may lead to various problems
 - High work -in- process inventory
 - Low utilization of workers
 - Higher set-up time of machines
 - Higher cost of production/ operations
 - No accurate information available for current status of a job
 - High average completion time of jobs
 - Delays in meeting due dates of customer orders

❖ ROUTING, PRIORITIZING, DISPATCHING & EXPEDITING

- In job shop, the Operation Manager designs a product according to customer requirements, and decides the order of work centers or departments through which the product should be processed- this is called **routing**
- Which specifies the route to be followed by a semi-finished good from one to the other department
- The operations manager must send information about the detailed schedule of various orders to the production supervisor in form of dispatch lists- this is called **dispatching**
- Determining the priority or importance of each customer order for processing is another important task in scheduling- this is called **prioritization** of orders or **sequencing**
- After processing the order, the worker informs the supervisor, who in turn informs the operations manager, who issues a move ticket to the material handlers



- The operations manager has to keep track of the progress of various jobs but practically there can be certain situations where there are deviations from the schedule
- In such situations the schedule may have to be revised by the manager and some jobs handled on a special priority basis- this is called **expediting**

❖ FORWARD AND BACKWARD SCHEDULING

- **Forward Scheduling:** It means assigning customer orders or jobs to various work centers based on the ‘as early as possible’ approach
 - Thus, a job is scheduled at a work center as soon as it is free to process a job
 - The job is then finished as soon as possible
 - This approach is based on the assumption that a customer is ready to receive the goods as soon as these are produced
 - This scheduling approach may result in to high WIP inventory if the subsequent work center in the processing sequence of the product is busy with some other jobs
- **Backward Scheduling:** Another way of scheduling, which is based on ‘as late as possible’ approach, with the condition that the jobs are finished by their due dates for delivery to the customer
 - Thus, the planning process starts with assigning job to the last work centre in the processing sequence
 - Then, according to the processing time of the job at the various work centers, the schedule is worked out towards the beginning of the processing sequence
 - The lead time of the earlier processes have to be accurate enough to support this scheduling approach
 - This approach results in a significant reduction of WIP



❖ FINITE AND INFINITE LOADING

- Loading means assigning tasks to work centers or machines
- Gantt charts are very useful tools in this process
- These centers were originally developed by Henry Gantt
- Every machine or work center has a maximum production capacity for a normal working day
- Keeping in view this maximum capacity when loading is called finite loading
- Thus, finite loading involves assigning tasks to work centers such that the maximum capacity of the work center is not exceeded at any time
- Infinite loading means overlooking the maximum capacity of a machine or work center while assigning tasks to it
- Infinite loading is done when the operations manager knows that the excess work scheduled during some time periods can be shifted to other work centers or time periods
- Another option is to do over time or subcontracting of work during such times
- This is terms as capacity expansion of machines or work centers

❖ SEQUENCING OR PRIORITIZATION

- Sequencing or prioritization is deciding the order or sequence of various jobs to be performed on the given machines or work centers on basis of some priority rule
- Based on different situations there can be different methods for sequencing
- Sequencing n jobs on one machine problems can be solved using different priority rules



❖ SEQUENCING n JOBS

- Sequencing n jobs on one machine- in sequencing n jobs on one machine the processing time of each job and their due dates of delivery are required
- A priority rule is then decided upon in order to sequence the various jobs accordingly
- The priority rules are First Come First Serve (FCFS), Last Come First Serve (LCFS), Due Date Method,
- Random Method, Shortest Processing Time (SPT) Method

❖ FIRST COME FIRST SERVE (FCFS) METHOD

- First Come First Serve (FCFS)- in this method, the top priority of assignment is given to the job whose order was placed the earliest
- Jobs are sequenced according to the dates of arrival
- The job order received the latest is scheduled at the end of the sequence

❖ LAST COME FIRST SERVE (LCFS) METHOD

- In this method the job order received in the end is scheduled at the beginning of the sequence
- Jobs are sequenced according to their dates of arrival
- The job order received at the earliest is scheduled at the end of the sequence



❖ DUE DATE METHOD

- In this method jobs are sequenced according to their due dates of delivery
- The job with the earliest due date is scheduled at the beginning of the sequence

❖ RANDOM METHOD

- As the name suggests, jobs are selected for processing at random by the workers
- The processing sequence may vary from individual to individual

❖ SHORTEST PROCESSING TIME (SPT) METHOD

- In this method the priority rule of sequencing is based on the processing time of various jobs
- The job with the shortest processing time is scheduled first
- The remaining jobs are sequenced according to their processing time lengths
- The job with the maximum processing time is scheduled at the end of the sequence
- It has been established that the Shortest Processing Time is the best method in terms of all comparison criteria
- The most common comparison criteria for the methods or priority rules are total flow time, mean flow time, and average lateness



❖ **PROBLEM**

- Ganapati Typesetting Solution is a major typesetter of printing material based at Indore. It has recently received six orders for typesetting printing material.
- The six jobs are in the order of arrival, their processing time, and due dates of delivery are given.
- Sequence the jobs according to the priority rules of FCFS, LCFS, Due Date, random and SPT method

Jobs in order of arrival	Processing time (days)	Due date (days from the start)
A	3	9
B	7	10
C	4	7
D	2	4
E	5	8
F	8	12



CHAPTER 02

PROJECT

MANAGEMENT

❖ INTRODUCTION

- Operations manager must plan, organize, and control a variety of manufacturing and service operations.
- Some of them are one-time activities and others are repetitive
- Besides, some activities might be continuous or intermittent
- The requirements of all of them are based on the nature of operations, i.e. job shop requires scheduling, continuous requires line balancing techniques and so on
- Project and project management has been defined in various ways. Munns and Bjeirmi define a project as
 - The achievement of a specific objective which involves a series of activities and tasks that consumes resources, and project management as the process of controlling the achievement of project objectives
- Managers have to handle various projects during their careers. A software consultant may need to implement a database management project, a construction manager may have to handle the construction project of a building, a scientist in the Research and Development department may be given a research project, and similarly, for an entrepreneur, starting a new business or a manufacturing unit is a project
- Planning a project requires identification of the various activities involved in the project and the sequence in which these activities have to be performed
- A well-planned project leads to completion in the scheduled time, thus avoiding unnecessary delays and extra costs.

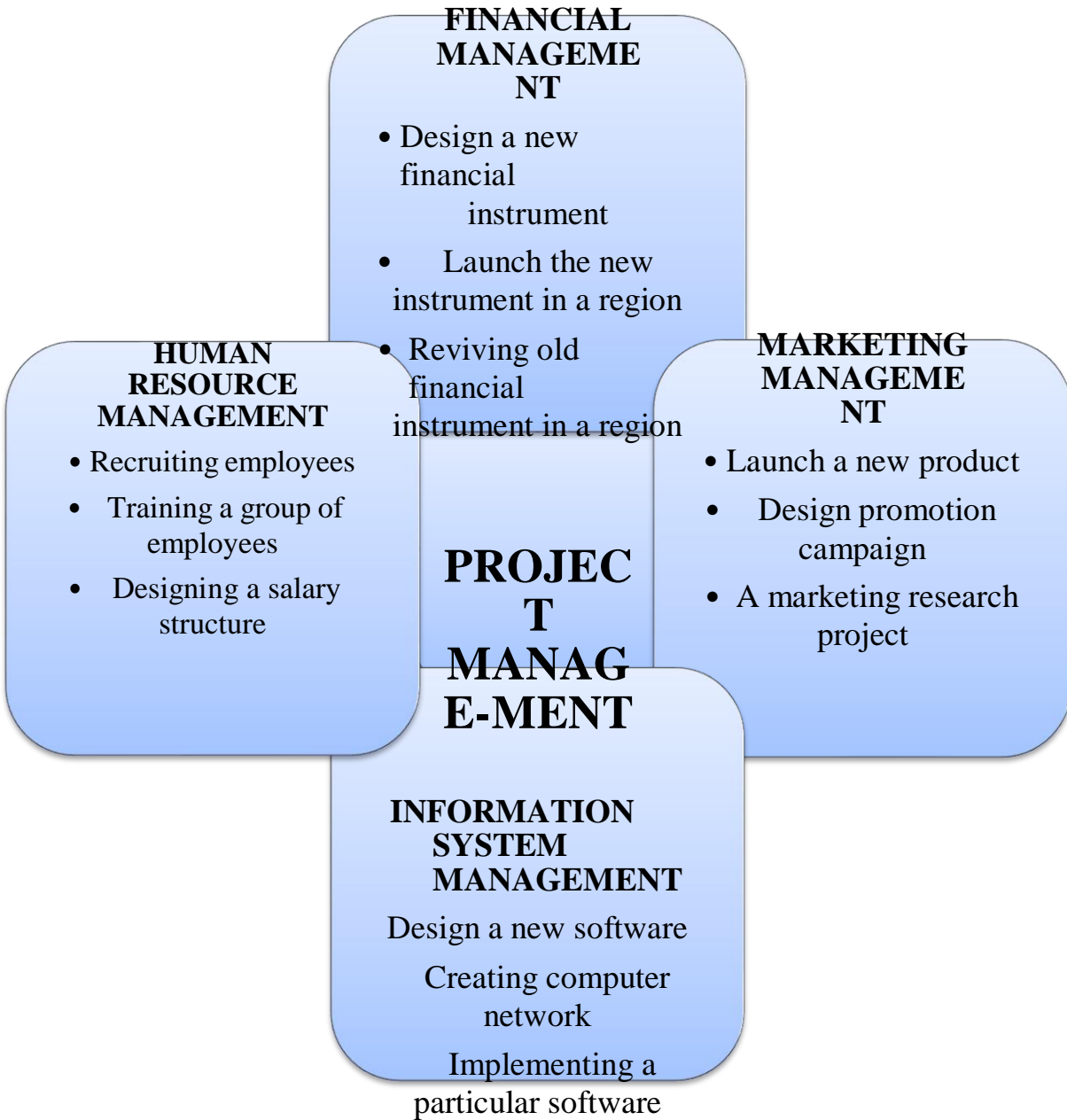


❖ PROJECT MANAGEMENT

- A project is a non-routine or low volume task
- Although projects are not repetitive, they take significant amount of time to complete and are large-scale or complex enough to be recognized and managed as separate undertakings
- Unique one-time operations designed to accomplish a specific set of objectives in a limited time frame
- Management of project differs in several ways from management of a typical business
- Manager must often organize project team to plan and control projects
- The team must ordinarily work to tight time schedules,
- Adhere to strict budgets,
- Report to top management persons,
- Temporarily removed from their regular jobs
- Rest of the employees continuous to produce the products, and services
- The type of techniques required to manage the projects depends on the complexity of the project
- For small projects Gantt charts are adequate whereas for large and complex projects, Critical Path Method (CPM) or Program Evaluation and Review Technique(PERT)

❖ ROLE OF PROJECT MANAGEMENT IN OTHER FUNCTIONAL AREAS OF MANAGEMENT

- All the functional areas of management involve projects of different types as shown in the following graph
- Project management skills are thus required by all managers- be it a manager, a marketing manager, an HRD manager, or an information systems manager





❖ NETWORK DIAGRAM

- It is a model that uses small circles - nodes, connected by lines to represent precedence relationship
- CPM and PERT are network diagram techniques for analyzing system in terms of activities and events that must be completed in specified sequence
- An activity is represented by an arrow, preferably straight line
- There can be only one activity between any two nodes
- The situation can be represented by a special activity called dummy activity
- It is a hypothetical activity i.e. it does not exist practically, not require any time , resources
- It is an imaginary event

- A network diagram represents the various activities of a project.
- An event or node marks the beginning or end of an activity and is represented by an arrow, preferably a straight-line arrow
- There can be only one activity between any two nodes
- Therefore, the representation of two activities X and Y between two events 1 and 2

❖ CRITICAL PATH METHOD

- In construction projects, project managers can accurately predict how much time a particular activity will take based on past experience with similar projects
- Such projects, in which the duration of various activities can be determined with great accuracy, can be planned with the help of a technique called the critical path method
- The following table shows the various tasks in a project, their duration, and required predecessors



TASK	TIME (DAYS)	REQUIRED PREDECESSOR (S)
A	2	-
B	3	-
C	4	-
D	1	A
E	2	B
F	5	B
G	7	C
H	2	D, E
I	3	F, G
J	1	H, I

❖ CRITICAL PATH

- Critical path is defined as the longest duration path between the first and the last nodes of a project
- Find out first all the possible paths and then decide whichever the longest path, it becomes the critical path
- While tracing a path from the first to last node, always move along the direction of the arrows
- The duration of a path is simply the sum of the duration of all the activities on the path
- Once you find the critical path mark the path with a double line
- The duration of a project is always the same as the duration of its critical path



❖ EARLIEST START (ES) AND FINISH (EF) TIME

- Earliest start and finish time of an activity are based on the condition that every activity will be started and finished as early as possible
- Assume that the first event of the project takes place immediately at time instant 0
- Earliest start and finish time of an activity are shown in square brackets adjacent to the name of the activity
- First number represents the earliest start time & second number earliest finish time

❖ LATEST START (LS) AND FINISH TIME (LF)

- The latest start and finish time of an activity are based upon the condition that every activity will be started and finished as late as possible, but the project will still get completed in the scheduled time

❖ FLOAT OF AN ACTIVITY

- The total float of an activity is the maximum amount of delay that can be permitted in its execution without introducing any delay in the completion of the project
- It helps the project manager to have some flexibility in implementing the project
- By calculating the project, he can know how much delay an activity can be allowed without disturbing the project completion schedules

❖ TOTAL FLOAT

- The formula for calculating the total float (TF) of an activity is $TF = LS_{I-j} - ES_{I-j}$
- The total float can also be calculated as

$$TF = LF_{I-j} - EF_{I-j}$$

- Total float of a critical activity will be always zero.



❖ SLACK OF AN EVENT

- The slack of an event is equivalent to the float of an activity
- It is defined as the maximum possible delay in the occurrence of an event
- Slack of an event = (latest occurrence time of the event) - (earliest occurrence time of the event)
- The latest occurrence (LO) and earliest occurrence (EO) times of an event are always dependent upon the activities ending at this event
- Slack values of all events lying on the critical path is always zero

❖ INTERFERING AND FREE FLOATS

- The total float of an activity is composed of two parts interfering float-(IF) and free float- (FF)
$$TF = IF + FF$$
- The TF of an activity is defined as that part of TF which when used affects the floats of the following activities
- Similarly, FF of an activity is defined as that part of TF which when used does not affect the floats of the following activities
- Head slack or IF means slack of the head event (event touching the head of arrows representing the activity)



❖ PROGRAM EVALUATION AND REVIEW TECHNIQUES

(PERT)

- PERT is applied in projects where the duration of various activities cannot be predicted with certainty
- CPM and PERT are very similar in application after the time estimates have been arrived at
- PERT is especially suitable for research and development projects
- Researchers are usually not sure as to how much time a particular research activity will take
- Researcher have to arrive at three time estimates for each activity based on their past experience
- Optimistic time estimate (a)- the shortest possible time estimate of an activity
 - It is based up on the premise that everything will go right for the earliest completion of the activity
- Pessimistic time estimate (b)- this is the longest possible time estimate of an activity
 - It is based upon the premise that there may be hindrances in the completion of the activity
- Most likely time estimate (m)- this is the time estimate that has the highest probability of occurrence
 - This is based up on the gut feeling of the project manager
- The three-time estimates are clubbed together into a single time estimate by taking a weighted average
- The combined estimate is called the expected time estimate (t_e) of the activity
- A weight of 4 is attached to m and weights of 1 each are attached to a and b
- t_e can thus be found by using the following formula:

$$t_e = \frac{a + 4m + b}{6}$$



❖ BETA CURVE

- The probability distribution curve of the duration of an activity is represented by a curve known as beta curve
- The beta curve is dispersed around the average value t_e . It means that when this activity is actually implemented, it may take any time between a and b
- The dispersion of the curve as measured by its standard deviation is given by:

$$\sigma = \frac{b - a}{6}$$

- and the variance is:

$$\sigma_2 = \frac{b - a^2}{6}$$

- For a project the expected duration (T) is the sum of expected duration t_e of all the critical activities
- Let us assume that a project has critical activities 1, 2, 3, .., k
- Then $T = t_{e1} + t_{e2} + \dots + t_{ek}$
- Similarly, the variance (σT) of the expected duration (T) is the sum of the variances of all the critical activities $\sigma T^2 = \sigma_1^2 + \sigma_2^2 + \dots + \sigma_k^2$
- The central limit theorem of statistics states that for a large number of critical activities (30 or more) in a project, the expected duration (T) of the project may be assumed to follow a normal distribution curve for all practical purposes

❖ Limitations of PERT and CPM

- It is difficult to identify the various activities in complex projects
 - To clearly define the start and end points of activities is not easy
 - In complex projects a network diagram made during the planning stage may require
 - new/modified activities due to changes in project over time



- In certain types of projects, it is not possible to sequence all the activities according to precedence requirement
- The critical path is focused only on to control the duration of the project.
- Durations of the activities in PERT follows the beta curve, and variance of the project duration is equal to the sum of the variances of all the critical values

❖ CRASHING OF A PROJECT

- All projects have two types of costs direct and indirect costs
- Direct costs are the costs involved in all the activities of the project (materials, labor, and machine, equipment)
- Indirect cost is mainly the cost of supervision during the implementation of the project (salaries paid to supervisor, miscellaneous costs due to delays, rewards to team member etc.)
- Project indirect cost is dependent on the length of duration of the project, hence the project having a longer duration will have a higher indirect cost
- Crashing of a project means intentionally reducing the duration of a project by allocating more resources to it
- A project can be crashed by crashing its critical activities as duration of the project is dependent on the duration of its critical activities
- We know that duration of a project can be reduced by adding more resources to it,
- e.g. an activity gets completed in 10 days with 5 men, the same activity can be finished say in 6 days with 10 men. Initial direct cost was 50 man-days and now it is 60 man-days
- Direct cost has increased by 10 man-days, at the same time because of the decrease in duration of the activity by 4 days indirect cost decreases
- So, we observe that direct and indirect costs have inverse relationship
- An activity can be crashed by adding more resources only up to a definite limit



- Beyond that limit the duration of the activity does not decrease by adding more resources
- The reason is decreased efficiency of labor and confusion of having large number of resources
- The limit beyond which the duration of the activity does not decrease is called crash time and the corresponding direct cost is called crash cost
- The normal time can be defined as duration of an activity when the minimum possible resources required for its performance are deployed, the corresponding cost is called normal cost
- In the actual time-cost curve, note that for crashing an activity from 10 to 9 days the incremental cost is approximately 2rs.
- It is proportionately increasing as we crash the activity time from 6 to 5 days it becomes 20rs.
- It means that cost of crashing keeps on increasing as the crash time is approached
- For the sake of simplicity in the problems of crashing, assume that the linear approximation curve is followed
- This linear approximation curve has a constant slope representing constant incremental cost of crashing.

$$INCREMRNTAL COST OF CRASHING = \frac{CRASH COST - NORMAL COST}{NORMAL TIME - CRASH TIME}$$

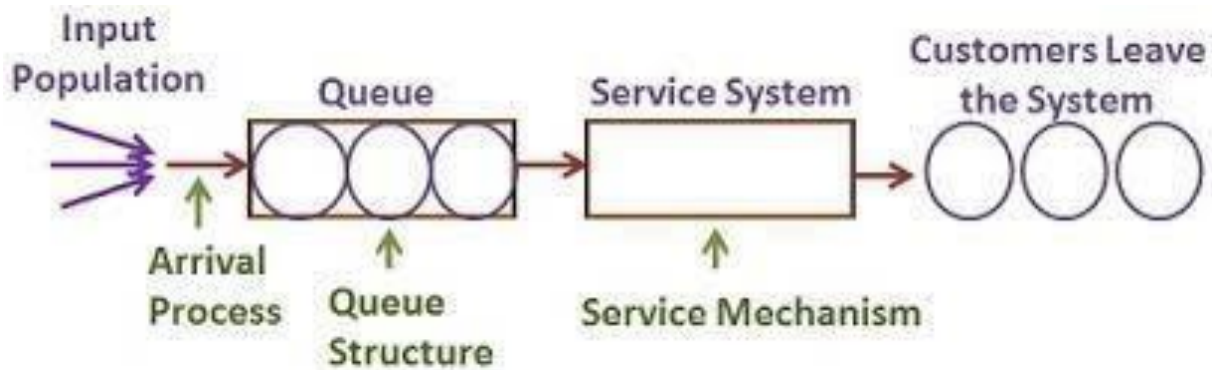
- During the process of crashing a project, the critical path may get changed
- At some stage of crashing, there may even be two or more critical paths simultaneously.
- In such situation one activity is chosen from each of the critical paths and these activities are crashed by unit time to reduce the duration of the project by unit time.



CHAPTER 03

QUEUING SYSTEM & LINE BALANCING

General Structure of Queuing System



❖ ELEMENTS OF A SYSTEM

1) Arrival Process:

- According to source
- According to numbers
- According to time

2) Service System

A. Structure of service system

B. Speed of service

3) Queue structure

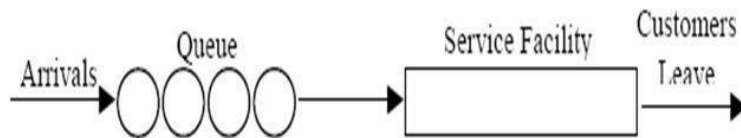
- FCFS
- LCFS
- Service in random order
- Priority service



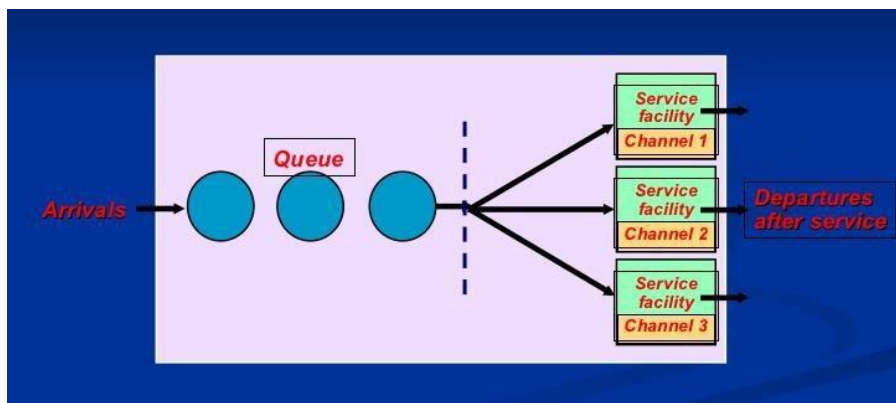
❖ SERVICE SYSTEM

A. Structure of Service System

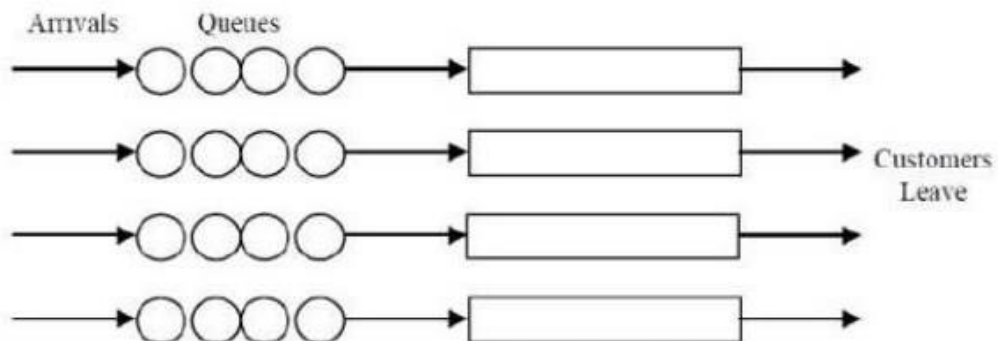
a. A Single Service Facility



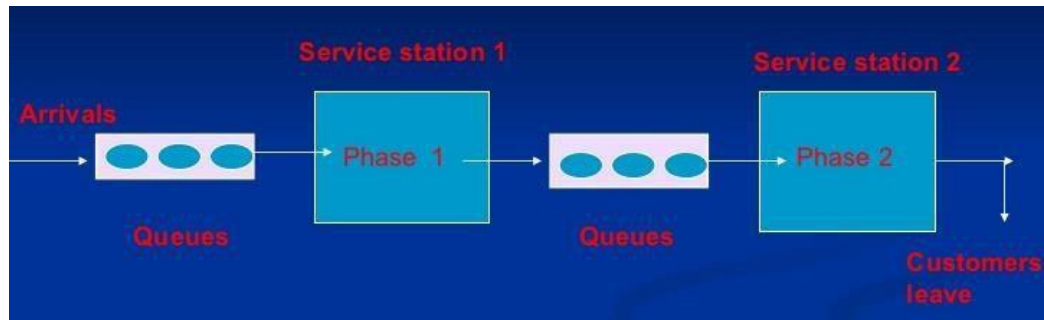
b. Multiple, Parallel Facility with Single Queue



c. Multiple, Parallel Facility with Multiple Queues



d. Service Facilities in a Series



B. Speed of Service

- **Service Rate:** The number of customers serviced during a particular time period.
- **Service Time:** Amount of time needed to service a customer.

❖ OPERATING CHARACTERISTICS OF QUEUING SYSTEM

- 1) **Queue Length:** Customer in the queue waiting to get service.
- 2) **System Length:** Customer in system, those waiting to be and those being serviced.
- 3) **Waiting time in queue:** Customer has to wait in a queue to get service.
- 4) **Total time in system:** Customer spends in the system, from entry in the queue to completion of service.
- 5) **Service idle time:** The relative frequency with which the service system is idle.

❖ QUEUING MODELS

- If service rate of customer is denoted by: μ and arrival rate of customer is denoted by: λ then queuing will form if,
- $\lambda > \mu$: The waiting line shall be form.



- $\lambda \leq \mu$: No waiting line will be formed; The proportion of time the service facility would be idle is $1 - \lambda / \mu$.
- The ratio $\lambda / \mu = p$ is called average utilization rate.
- If $p > 1$ the system would ultimately fail.
- If $p < 1$ the system works & p is proportion of time it is busy.

❖ PROBABILISTIC QUEUING MODELS

- Of the numerous queuing models available, we shall consider the following models:
 - a) Poisson exponential, single server model-infinite population;
 - b) Poisson exponential, single server model-finite population; and
 - c) Poisson exponential, Multiple server model-infinite population;

❖ LINE BALANCING

- The assembly line can be efficient only when tasks are assigned to different workstations in such a way that, as far as possible, the total processing times at the workstations are equal
- This is so because the conveyor moves at regular intervals of time and, therefore, the time available for each workstation to complete its set of assigned tasks is the same
- This is achieved by line balancing.



❖ HEURISTIC METHOD FOR LINE BALANCING

- The time for which a basic structure of the product is available before a work station is called the cycle time
- In fact, it is the time after which the conveyor moves
- Cycle time is defined as the time period after which completed units come off the assembly line
- Note that completed units will be available after each movement of the conveyor, as the basic structure being worked up on at the last work station will become a completed unit in that time
- Let us try to understand the steps in assembly line balancing by an example:

Steps to follow while balancing an assembly line

- Step- 1- Find the bottleneck operation and the minimum cycle time
 - Step-2 – Find the theoretical minimum number of workstations required for the assignment of tasks
 - Step-3 – Apply a heuristic to assign tasks to work stations
 - Step-4 – Find the efficiency of the assembly line
-
- **Example:**

World Star appliances Ltd. Is based at New Delhi and manufactures the blue ink range of mixer/ grinders for household use. It sources the outer plastic bodies of mixers, electric wires, electric plugs etc. from external suppliers. The assembly line of this factory has a number of tasks to be performed according to the precedence requirement given in the table:



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TASK	DESCRIPTION	PRECEDENCE REQUIRE D	TASK TIME (MIN.)
A	Fixing electric motor over plastic base	-	4
B	Inserting the rubber blocks in the slot below plastic base	-	2
C	Connecting electric lead to electric motor assembly	-	5
D	Attaching the outer plastic cover over motor assembly	A, C	3
E	Fixing electric on/off switch over the plastic cover	D	4
F	Attaching plastic circular rotator on the top of mixer	D	2
G	Final inspection of mixer	B, E, F	3
H	Packing mixer unit with jar attachments	G	2



ONE WORD QUESTION-ANSWER (MCQ)

Sr. No.	Question	Answer
1.	What is the Most important function in job shop processing?	Operation sequencing
2.	In continuous and semi-continuous production processes scheduling is automatically done at the time of designing the facility. True/False?	True
3.	Operation sequencing is what kind of Function OF an Operation Manager?	One of the planning functions of an operations manager
4.	If the product has almost no variety and production volumes will be Large or Small?	Large
5.	What is prioritization?	Deciding the sequence of processing on different machines on basis of some priority rule called sequencing or prioritization.
6.	What is Routing?	Planning the route of movement of material from one to the other department called w.
7.	What is dispatching?	Issuing dispatch lists to various work centers containing information about the work centers a customer



		order should be processed at first, the amount of time the processing should take and so on called dispatching.
8.	What is expediting?	Tracking the progress of various scheduled jobs and the implementation of schedules, revising the schedules in case of delays, and expediting the completion of certain jobs called expediting.
9.	Who has to keep track of the progress of various jobs but practically there can be certain situations where there are deviations from the schedule?	The operations manager
10.	What is Forward Scheduling?	It means assigning customer orders or jobs to various work centres based on the 'as early as possible' approach
11.	If a job is scheduled at a work centre as soon as it is free to process a job then The job is then finished as soon as possible.	Yes
12	Forward Scheduling approach is based on what?	The assumption that a customer is ready to receive the goods as soon as these are produced



13	What is the result of Forward scheduling approach?	High WIP inventory if the subsequent work center in the processing sequence of the product is busy with some other jobs
14	What is Backward Scheduling?	Another way of scheduling, which is based on ‘as late as possible’ approach, with the condition that the jobs are finished by their due dates for delivery to the customer.
15	What is finite loading?	Keeping in view this maximum capacity when loading is called finite loading
16	What is the most useful tools in this FINITE AND INFINITE LOADING process?	Gantt charts are very useful tools in this process
	Every machine or work center has a maximum production capacity for a normal working day. True/False?	True
17	Finite loading involves what?	assigning tasks to work centers such that the maximum capacity of the work center is not exceeded at any time
18	What do you mean by Infinite loading?	Infinite loading means overlooking the maximum



		capacity of a machine or work center while assigning tasks to it
19	When Infinite loading can be done?	Infinite loading is done when the operations manager knows that the excess work scheduled during some time periods can be shifted to other work centers or time periods
20	Based on different situations there can be different methods for sequencing. True/False?	
21	What is Sequencing or prioritization?	Sequencing or prioritization is deciding the order or sequence of various jobs to be performed on the given machines or work centers on basis of some priority rule
22.	How Sequencing n jobs on one machine problems can be solved?	Sequencing n jobs on one machine problems can be solved using different priority rules
23.	What is Sequencing n jobs on one machine?	Sequencing n jobs on one machine- in sequencing n jobs on one machine the processing time of each job and their due dates of delivery



		are required
24.	What is FCFS?	First Come First Serve (FCFS)
25	What is LCFS?	Last Come First Serve (LCFS),
26.	What is SPT?	Shortest Processing Time (SPT)
27.	What is First Come First Serve (FCFS)?	in this method, the top priority of assignment is givento the job whose order was placed the earliest
28.	How Jobs are sequenced?	Jobs are sequenced according to the dates of arrival
29.	The job order received the latest is scheduled at the end of the sequence. True/False	True
30.	What is LAST COME FIRST SERVE (LCFS) METHOD?	In this method the job order received in the end is scheduled at the beginning of the sequence
31.	In LCFS how job order can received?	At the earliest is scheduled at the end of the sequence
32.	What is Due-Date Method?	In this method jobs are sequenced according to their due dates of delivery, The job with the earliest due date is scheduled at the beginning



		of the sequence
33.	What is RANDOM METHOD?	As the name suggests, jobs are selected for processing at random by the workers, The processing sequence may vary from individual to individual
34.	What is SPT method?	In this method the priority rule of sequencing is based on the processing time of various jobs.
35.	It has been established that the Shortest Processing Time is the best method interms of all comparison criteria. True/False?	True
36.	What is the most common comparison criteria in STP method?	Priority rules are total flow time, mean flow time, and average lateness.
37	What do Operation Manager do?	Operations manager must plan, organize, and control a variety of manufacturing and service operations.
38.	What is Project as Munns and Bjeirmi?	The achievement of a specific objective which involves a series of activities and tasks



		that consumes resources, and project management as the process of controlling the achievement of project objectives
39.	A software consultant need to implement which kind of project?	A software consultant may need to implement a database management project
40.	Planning a project requires identification of the various activities involved in the project and the sequence in which these activities have to be performed. True/False?	True
41.	A well-planned project leads where?	A well-planned project leads to completion in the scheduled time, thus avoiding unnecessary delays and extra costs.
42.	A project is a non-routine or low volume task. True/False?	True
43.	Why projects are not repetitive?	They take significant amount of time to complete and are large-scale or complex enough to be recognized and managed as separate undertakings.



44.	How unique one-time operations designed?	Unique one-time operations designed to accomplish a specific set of objectives in a limited time frame
45.	Do Management of project differs in several ways from management of a typical business?	Yes
46.	Manager must often organize project team to plan and control projects. True/False?	True
47.	The type of techniques required to manage the projects depends on what?	The complexity of the project.
48.	For small projects Gantt charts are adequate. True/False?	True
49.	What is CPM?	Critical Path Method (CPM)
50.	What is PERT?	Program Evaluation and Review Technique (PERT)
51.	What is Network Diagram?	It is a model that uses small circles - nodes, connected by lines to represent precedence relationship
52.	How CPM and PERT network diagram techniques can be use?	For analyzing system in terms of activities and events that must be completed in specified sequence
53.	There can be only one activity between any two nodes. True/False?	True



54.	What is Dummy activity?	It is a hypothetical activity i.e. it does not exist practically, not require any time , resources
55.	Do Dummy Activity is an Imaginary event?	Yes
56.	What do A network diagram represents?	A network diagram represents the various activities of a project.
57.	An event or node marks the beginning or end of an activity and is represented by what?	An arrow, preferably a straight-line arrow
58.	There can be only one activity between any two nodes. True/False?	True
59.	What is Critical path?	Critical path is defined as the longest duration path between the first and the last nodes of a project
60.	How to find out Critical Path?	Find out first all the possible paths and then decide whichever the longest path, it becomes the critical path.
61	While tracing a path from the first to last node, always move along the direction of the arrows. True/ False?	True
62.	Earliest start and finish time of an activity are based on what?	The condition that every activity will be started and finished as early as possible



63.	How Earliest start and finish time of an activity can be shown?	in square brackets adjacent to the name of the activity
64.	What is The latest start and finish time?	An activity based upon the condition that every activity will be started and finished as late as possible, but the project will still get completed in the scheduled time
65.	What is The total float of an activity?	It is the maximum amount of delay that can be permitted in its execution without introducing any delay in the completion of the project
66.	What helps the project manager to have some flexibility in implementing the project?	Total float of an activity
67.	What is the formula for calculating the total float (TF) of an activity?	The formula for calculating the total float (TF) of an activity is $TF = LS_{I-j} - ES_{I-j}$
68.	What is another mathematical formula for calculating the total float (TF) of an activity?	$TF = LF_{I-j} - EF_{I-j}$
69.	Total float of a critical activity will be always zero. True/False?	True
70.	The slack of an event is equivalent to the float of an activity. True/False?	True
71.	What is The slack of an event?	It is defined as the maximum possible delay in the occurrence of an event



72.	What is the Mathematical formula of Slack of an event?	Slack of an event = (latest occurrence time of the event) - (earliest occurrence time of the event)
73.	The latest occurrence (LO) and earliest occurrence (EO) times of an event are always dependent upon what?	the activities ending at this event
74.	Slack values of all events lying on the critical path is always zero. True/False?	True
75.	What is Head Slack?	Head slack or IF means slack of the head event
76.	PERT is applied in which kind of project?	PERT is applied in projects where the duration of various activities cannot be predicted with certainty
77.	CPM and PERT are very similar in application after the time estimates have been arrived at. True/False?	True
78.	PERT is especially suitable for which kind of project?	PERT is especially suitable for research and development projects
79.	Researchers are usually not sure as to how much time a particular research activity will take. True/False?	True
80.	What is Optimistic time estimate?	The shortest possible time estimate of an activity. It is based up on the premise that everything will go right for the



		earliest completion of the activity
81.	What is Pessimistic time estimate?	This is the longest possible time estimate of an activity. It is based upon the premise that there may be hindrances in the completion of the activity
82.	What is Most likely time estimate?	This is the time estimate that has the highest probability of occurrence. This is based up on the gut feeling of the project manager
83.	Three-time estimates are clubbed together into a single time estimate by taking a weighted average. True /False?	True
84.	What do The combined estimate called?	The combined estimate is called the expected time estimate (t_e) of the activity
85.	What is the formula of expected time estimate (t_e)?	$t_e = a + 4m + b/6$
86.	What is beta curve?	The probability distribution curve of the duration of an activity is represented by a curve, known as beta curve
87.	For a project the expected duration (T) is the sum of expected duration t_e of all the critical activities. True/False?	True
88.	To clearly define the start and end points of activities is not easy True/False?	True



89.	In complex projects when a network diagram made?	In complex projects a network diagram made during the planning stage may require
90.	In certain types of projects, it is not possible to sequence all the activities according to precedence requirement. True/False?	True
91	Where the critical path is focused only on?	To control the duration of the project.
92	What are Direct costs?	Direct costs are the costs involved in all the activities of the project (materials, labor, and machine, equipment)
93	What is Indirect cost?	Indirect cost is mainly the cost of supervision during the implementation of the project (salaries paid to supervisor, miscellaneous costs due to delays, rewards to team member etc.)
94	Where do Project indirect cost is dependent on?	the length of duration of the project,
95	The project having a longer duration will have a higher indirect cost. True/False?	True
96	What do you know by Crashing of a project?	Crashing of a project means intentionally reducing the duration of a project by allocating more resources to it



97.	When A project can be crashed?	A project can be crashed by crashing its critical activities as duration of the project is dependent on the duration of its critical activities
98.	Do duration of a project can be reduced by adding more resources to it?	Yes
99.	Direct and indirect costs have which relation between each other?	inverse relationship
100.	Do corresponding direct cost is called crash cost?	Yes
101.	During the process of crashing a project do the critical path may get changed?	Yes
102.	What is Service Rate?	The number of customers serviced during a particular timeperiod.
103.	What is Service Time?	Amount of time needed to service a customer
104.	What is Queue Length?	Customer in the queue waiting to get service.
105.	What is System Length?	Customer in system, those waiting to be and those being serviced
106.	The assembly line can be efficient only when tasks are assigned to different workstations in such a way that, as far as possible, the total processing times at the workstations are equal. True/False?	True
107.	What is cycle time?	The time for which a basic structure of the product is



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		available before a work station is called the cycle time.
108.	Cycle time is defined as the time period after which completed units come off the assembly line. True/False?	True
109.	What is the Step- 1 in balancing an assembly line?	Find the bottleneck operation and the minimum cycle time
110.	What is the Step- 2 in balancing an assembly line?	Find the theoretical minimum number of workstations required for the assignment of tasks.
111.	What is the Step- 3 in balancing an assembly line?	Apply a heuristic to assign tasks to work stations
112.	What is the Step- 4 in balancing an assembly line?	Find the efficiency of the assembly line