**I.P.(P.G) College Campus-2 Bulandshahr**
**Department of Computer Science**
**Software Engineering (BCA-403)**

## SECTION A (Multiple Choice Questions)

1. What is the first step in the software development lifecycle?
a) System Design b) Coding c) System Testing **d) Preliminary Investigation and Analysis**
2. What does RAD stand for?
a) Rapid Application Document **b) Rapid Application Development**
c) Relative Application Development d) None of the above
3. What are the features of Software Code?
a) Simplicity b) Accessibility c) Modularity **d) All of the above**
4. _____ is a software development activity that is not a part of software processes.
a) Validation b) Specification c) Development **d) Dependence**
5. Which of the following word correctly summarized the importance of software design?
**a) Quality** b) Complexity c) Efficiency d) Accuracy
6. Software is considered to be collection of
a) Programming code b) associated libraries c) Documentations **d). All of the above**
**7.** The process of developing a software product using software engineering principles and Methods are referred to as_____.
a) Software Engineering **b) Software Evolution** c) System Models d). Software Models
8. Which of the following are the Characteristics of good software?
a) Transitional b) Operational c) Maintenance **d) All of the above**
9. Which one of the following models is not suitable for accommodating any change?
a) Build & Fix Model b). Prototyping Model c). RAD Model **d). Waterfall Model**
10. RAD Model has
a) 2 phases b) 3 phase **c) 5 phases** d). 6 phases
11. The spiral model was originally proposed by..
**a) Barry Boehm** b) Pressman c) Royce d) Pressman
12. Which of the following is also known as Verification and Validation Model?
**a) V-Model** b) Waterfall Model c) Prototype Model d) Evolutionary Mode
13. The SRS document is also known as _____ specification.
**a) Black box** b) white box c) grey box d) None
14. COCOMO stands for _____
a) Consumed Cost Model **b) Constructive Cost Model**
c) Common Control Model d) Composition Cost Model
15. Name of the programming technique which emphasizes breaking large and complex problem into small
a) Scrambling **b) Structure Programming**
**c**) micro-programming d) subprogramming
16.SRS stands for
**a) Software Requirement Specification** b) Software Requirement System
c) Software Requirement Software d) Software Requirement Series
17. The tools that support different stages of SDLC called
**a)CASE tools** b) CAME tools c) CAQE tools d) CARE tools
18.Requirement Engineering Process include which of these steps
a) Feasibility study b) Requirement Gathering c) Testing and coding d**) All OF the above**
19. Which coupling is also known as "Module Coupling"?
a) Content Coupling b) Stamp Coupling c) Data coupling **d) Common Coupling**
20.What is the aim of software engineering?
a) Reliable software b) cost Effective software **c) Reliable and cost Effective software** d) none
21.In OOD,the attribute (data variables)and methods (operation on data) are bundled together is called
a) class b) object **c) Encapsulation** d) Inheritance
22.Which design define the logical structure of each module and their interface that is used to communicate with the m
a) High level design b) Archietectural design **c) Detailed design** d) All of the above

23. Model selection is based on _____.

a)Requirements b) Development team & users

c) Project type & associated risk **d)All of the above**

24. Software maintenance costs are expensive in contrast to software development.

**a)True** b) False

25. Who is the father of software Engineering ?

a) Margaret Hamilton **b) Watts S,Humpey** c) Alan Turing d) Boris Biexer

26.CASE stands for

**a)Computer-Aided Software Engineering** b)Control Aided Science and Engineering

c) Cost Aided System Experiments d) none of the mentioned

27. Modifying the software to match changes in the ever changing environment is called _____ .

**a)Adaptive maintenance** b) Corrective maintenance c). Perfective maintenance d). Preventive maintenance

28. ER model shows the _____ .

**a) Static view** b). Functional view c). Dynamic view d). All the above

29. The worst form of module cohesion is_____.

**a) Coincidental Cohesion** b) Functional Cohesion c) Temporal Cohesion d) Logical Cohesion

30. _____is not a direct measure of SE process.

a) Effort b) Cost **c) Efficiency** d) All of the above

## SECTION B (Short Questions)

1. Explain Difference between
   (i) Top down and bottom up approach in designing software
   (ii) Differentiate top-down and bottom up approach
2. What is Verification & Validation and why it is required?
3. Describe 'Rapid Application Development (RAD) model in details.
4. Differentiate Black Box and White Box Testing.
5. (i) Describe the relationship between design and implementation.
   (ii) How is the cost of software estimated? Discuss in details
6. Describe SCM? What are four major activities of SCM.

## SECTION C (Long Questions)

1. (i).What is the limitation of waterfall model?
   (ii) How some of the limitation of waterfall model is overcome by iterative model
2. What are the CASE tools and their usage in software engineering? Discuss
3. Explain the types of maintenance in details. Also explain the maintenance activities
4. (i) Define module coupling and explain different types of coupling in details
   (ii)Explain cohesion and its different types.
5. Discuss various components of Good Programming Style, also explain its Importance in Software development.
6. What is Software design process? Explain it with the help of principles and concept

# SE Notes By Bhavy Sharma

## Short Questions

**Q1. Explain Difference between**
**(i) Top down and bottom up approach in designing software**
**(ii) Differentiate top-down and bottom up approach**
Ans. **(i) Explanation:**

**Top-Down Approach:**

- In this approach, **system design starts from the highest level** of abstraction and breaks down into smaller sub-systems or components.
- Think of it as going from the **big picture to details**.
- Focus is on understanding the complete system first and then dividing it into modules.

**Bottom-Up Approach:**

- In this method, **design starts from the lower-level components**, and then these components are integrated to form a complete system.
- Think of it as going from **details to the big picture**.
- It emphasizes developing and testing low-level modules first.

### (ii) Difference Between Top Down and Bottom Up Approach

| S.No | Top Down | Bottom Up |
|---|---|---|
| 1. | Begins from the main system or overall design | Begins from individual components or modules |
| 2. | From general to | From specific to |

| | specific | general |
|---|---|---|
| **3.** | **Focuses on system design first** | **Focuses on module development first** |
| **4.** | **Integration tested after all modules are developed** | **Modules are tested individually before integration** |
| **5.** | **Less reuse, more custom design** | **Encourages code/module reuse** |
| **6.** | **Centralized control system** | **Distributed control** |
| **7.** | **Traditional Software Development** | **Object-oriented Programming** |

**Q2. What is Verification & Validation and why it is required?**
**Ans.**

**Verification:**

- Verification is the process of **checking whether the software meets the specified requirements and design specifications**.
- It answers the question:
  *"Are we building the product right?"*

**Validation:**

- Validation is the process of **evaluating the final product to ensure it meets the user's needs and expectations**.
- It answers the question:
  *"Are we building the right product?"*

| Aspect | Verification | Validation |
|---|---|---|
| **Purpose** | Checks if software is built correctly | Checks if the right software is built |
| **Focus** | Process-oriented | Product-oriented |
| **When** | During development (before execution) | After development (during/after testing) |
| **Examples** | Reviews, walkthroughs, inspections | Testing, user acceptance, beta testing |

**Q3. Describe 'Rapid Application Development (RAD) model in details.**
**Ans.**
**Rapid Application Development (RAD)** is a **software development model** that focuses on **quick development and delivery** of a high-quality system with **minimal planning**.
It emphasizes **rapid prototyping**, **frequent user feedback**, and **quick iterations** instead of long drawn-out development cycles.

🛠️ **Key Characteristics:**

- Quick development and delivery.
- User involvement is **continuous** throughout the project.
- Focus on building **prototypes** instead of full product upfront.
- Changes are welcomed even late in development.
- Small teams are preferred for flexibility and speed.

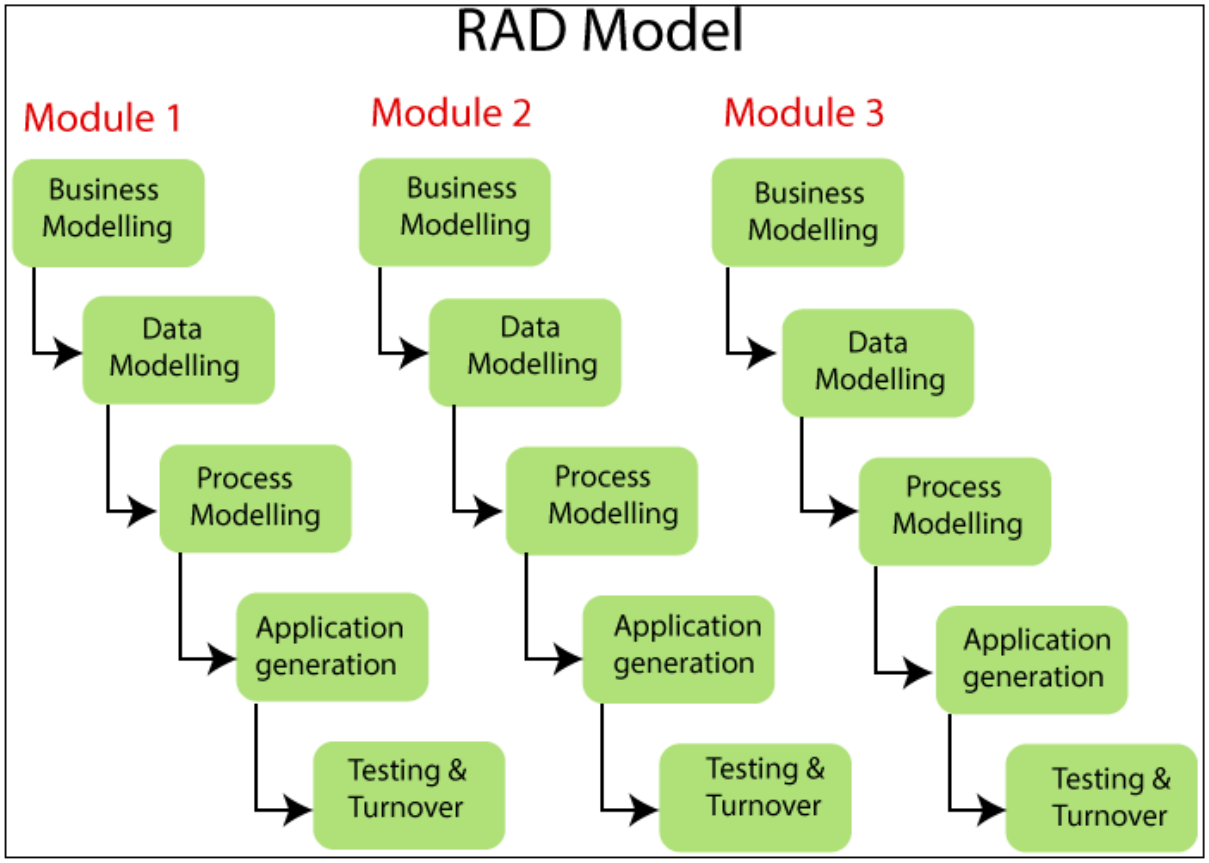
| Phase | Description |
| --- | --- |
| 1. Requirements Planning | Define project scope, identify business needs, and gather initial requirements with clients. |
| 2. User Design | Users and developers work together to design prototypes and system features interactively. |
| 3. Rapid Construction | Actual development happens by refining the prototypes into working models quickly. |
| 4. Cutover (Deployment) | Final testing, implementation, and user training take place before delivery. |

**Advantages:**

- Fast delivery of working systems.
- High user satisfaction because of continuous involvement.
- Easier to incorporate changes during the project.
- Reduced development time compared to traditional models.

**Disadvantages:**

- Not suitable for large, complex, or high-risk projects.
- Requires strong and committed user involvement.
- Depends heavily on skilled developers and designers.
- Poor design might occur if rushed without proper understanding.




**Q4. Differentiate Black Box and White Box Testing.**
**Ans.**

**Black Box Testing:**

- Black Box Testing is a **software testing method** in which the **internal structure, code, or logic of the program is not known** to the tester.
- The tester only focuses on **inputs and expected outputs**, without worrying about how the system internally processes them.

*It answers: "Does the software do what it is supposed to do?"*

**White Box Testing:**

- White Box Testing is a **software testing method** in which the **internal structure, design, and coding** are known to the tester.
- The tester **examines the internal logic, code paths, conditions, and flow** to verify the correctness of the program.

*It answers: "Is the software built correctly from inside?"*

| **Aspect** | **Black Box Testing** | **White Box Testing** |
|---|---|---|
| Knowledge of Code | Not required | Required |
| Focus | Focuses on functionality (what the system does) | Focuses on internal structure (how it works) |
| Test Basis | Based on requirements and specifications | Based on design, structure, and code |
| Tester Role | Tests input/output without knowing internal code | Tests by analyzing the actual code |
| Techniques Used | Functional Testing, System Testing, Acceptance Testing | Unit Testing, Path Testing, Code Coverage Testing |
| Advantages | Easier for non-programmers; user perspective testing | Ensures deeper code coverage and optimization |
| Disadvantages | Cannot test all possible paths in the software | Requires high technical skills and more time |

**Q5. (i) Describe the relationship between design and implementation.**
**(ii) How is the cost of software estimated? Discuss in details.**
**Ans. (i)**

**Design and Implementation Relationship:**

- **Design** is the **blueprint** of the software.
- **Implementation** is the **construction** of the software according to that blueprint.

**In simple terms:**

Design decides **what to build and how to build it**, Implementation **actually builds** the system based on that plan.

**Key Points:**

- In the **Design phase**, software engineers create models like system architecture, database designs, user interface layouts, etc.
- During **Implementation**, developers **translate the design into actual code** using programming languages.
- A **good design** makes implementation **easier and more error-free**.
- If the **design is poor or unclear**, implementation will be **difficult, time-consuming**, and may lead to **many bugs**.
- **Feedback loops** often exist — if developers find issues during implementation, they may suggest **modifications in the design**.

**Simple Example:**

- Designing a house = **Architectural Design**
- Building the house = **Implementation/Construction**

(ii)

**Software Cost Estimation:**

Software cost estimation means **predicting** the **amount of effort, time, and money** required to build a software project.

**Major Factors Considered:**

- **Project size and complexity**
- **Skills and experience** of the team
- **Development tools** and technologies used
- **Risk factors** and uncertainties
- **Customer requirements clarity**
- **Quality requirements** (how perfect the software must be)

**Popular Cost Estimation Model — COCOMO (Constructive Cost Model):**

- Developed by **Barry Boehm**.
- Estimates the effort (person-months) based on the size of the software measured in **Kilo Lines of Code (KLOC)**.
- Three models:
  - **Basic COCOMO** (simple)
  - **Intermediate COCOMO** (considers more factors like experience, reliability)
  - **Detailed COCOMO** (most accurate, considers project phases separately)

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**Why is Software Cost Estimation Important?**

- To plan **budget and resources** correctly.
- To set **realistic timelines**.
- To avoid **overruns** (spending more time/money than expected).
- To **improve customer trust** by giving clear expectations.

**Q6. Describe SCM? What are four major activities of SCM. Ans.**

**What is SCM? (Software Configuration Management)**

- **SCM** stands for **Software Configuration Management**.
- It is a process of **systematically managing changes** in software to maintain **integrity**, **traceability**, and **quality** throughout the software development lifecycle.
- SCM ensures that **all changes** made to a software system are **properly documented, controlled, and tracked**.

In simple words:
**SCM manages the "versions" and "changes" of a software project so that nothing is lost or confused.**

**Main Goals of SCM:**

- Control **changes** to software systems.
- Keep **track of versions** and **history** of changes.
- Prevent **confusion** and **conflicts** in software development (especially when many people are working together).

- Make sure that **right versions** are delivered to the customer.

| Activity | Description |
|---|---|
| **1. Configuration Identification** | Identifying and defining the **items** (code files, documents, data) that need to be controlled and managed. |
| **2. Configuration Control** | Managing changes to the configuration items. Changes are **reviewed**, **approved**, and **implemented** properly. |
| **3. Configuration Status Accounting** | Keeping records of the **current status** of all configuration items — what versions exist, what changes are made, etc. |
| **4. Configuration Audits and Reviews** | Checking and verifying that the software product and its configurations are **complete**, **correct**, and **meet requirements**. |

# Long Questions

**Q1. (i).What is the limitation of waterfall model?**
**(ii) How some of the limitation of waterfall model is overcome by iterative model**
**Ans.** (i)

## Limitations of Waterfall Model:

1. **No Flexibility for Changes:**
    - Once a phase is completed, it is difficult to go back and make changes.
    - Customers often realize new requirements only after seeing a working product, but by then, it's too late.
2. **Late Testing:**
    - Testing is done **only after the development** is complete.
    - Errors and bugs found at this stage are expensive and time-consuming to fix.
3. **Customer Feedback Comes Too Late:**
    - Users can only see the final product after full development, leading to dissatisfaction if the product doesn't meet expectations.
4. **High Risk and Uncertainty:**
    - If the project requirements are unclear or if technology changes during development, the Waterfall model fails badly.
5. **Not Suitable for Complex or Long Projects:**
    - Large projects require frequent changes and better risk management, which Waterfall cannot handle properly.
6. **Assumes Requirements are Fixed:**
    - The model assumes that all requirements can be gathered at the start, which is unrealistic in real-world projects.
7. **Difficult to Measure Progress:**
    - Until the last stage (testing), it's hard to know if the project is truly on track.

(ii)

## What is the Iterative Model?

- In the **Iterative Model**, software is developed and delivered **in small parts (iterations)**.
- Each iteration **improves** the software based on **feedback** and **changing requirements**.

| Waterfall Limitation | How Iterative Model Solves It |
|---|---|
| No flexibility for changes | Iterative model allows **changes after each iteration.** Requirements can evolve. |
| Late testing | Testing is done **after each iteration**, not at the end, making bug detection early and cheaper. |
| Customer feedback comes too late | Customer can **review** and **give feedback** after every iteration. |
| High risk and uncertainty | Risks are **identified and handled early** in small steps instead of waiting till the end. |
| Not suitable for complex projects | Complex systems are **broken into manageable parts**, developed step-by-step. |
| Assumes requirements are fixed | Iterative model **accepts changing requirements** as part of the process. |
| Difficult to measure progress | After every iteration, a **working product** is delivered, making progress clear and visible. |

**Q2.What are the CASE tools and their usage in software engineering? Discuss.**
**Ans.**

## What are CASE Tools?

- **CASE** stands for **Computer-Aided Software Engineering**.
- CASE Tools are **software programs** that help software engineers to **develop, maintain, and manage** software projects more efficiently.
- They provide **automated support** for various software development activities like **designing, coding, testing, documentation**, and **project management**.

In simple words:
**CASE tools are like helping hands for software**

**developers** that make their work faster, more accurate, and more organized.

## Objectives of CASE Tools:

- Increase the **quality** of software.
- Reduce **errors** and **bugs** during development.
- **Speed up** the development process.
- Make software **more maintainable** and **reliable**.
- Ensure **proper documentation** and **version control**.

| Type of CASE Tool | Usage / Purpose |
|---|---|
| Upper CASE Tools | Help in the **early stages** of software development like **planning**, **analysis**, and **design**. |
| Lower CASE Tools | Help in the **later stages** like **coding**, **testing**, and **maintenance**. |
| Integrated CASE Tools (I-CASE) | Support **both upper and lower** stages, providing a **complete environment** for software development. |

## Benefits of Using CASE Tools:

- Faster development with **automation**.
- Improved **accuracy** and **consistency**.
- Better **team collaboration**.
- Helps in **tracking** and **controlling** project progress.
- Supports **standardization** across all development activities.
- Easy to handle **complex and large-scale projects**.

**Q3. Explain the types of maintenance in details. Also explain the maintenance activities.**
**Ans.**

## What is Software Maintenance?

- **Software Maintenance** is the process of **modifying** a software system after it has been delivered to correct faults, improve performance, or adapt it to a changed environment.

- It is an essential part of the **Software Development Life Cycle (SDLC)**.
- Maintenance ensures the software remains **useful**, **secure**, and **efficient** over time.

| Activity | Description |
|---|---|
| 1. Analysis of the Problem | Understand the issue or requirement reported by the user or team. |
| 2. Impact Analysis | Study how the change will affect other parts of the software system. |
| 3. Design and Planning | Plan how the change will be implemented (design, resources, time). |
| 4. Implementation of Changes | Modify the software code and integrate the changes. |
| 5. Testing the Modified Software | Test the system to ensure the change is working correctly and hasn't affected other functionality. |
| 6. Documentation Update | Update all related documents (e.g., user manual, system documentation). |
| 7. Release and Deployment | Deliver the updated version to users. |

**Q4. (i) Define module coupling and explain different types of coupling in details**

**(ii)Explain cohesion and its different types.**

**Ans.**

## What is Module Coupling?

- **Coupling** refers to the **degree of dependency** between two modules.
- It shows **how closely connected** two modules are.
- **Low coupling** is preferred because it means modules are **independent** and **easier to maintain, test, and reuse**.

| | |
|---|---|
| **1. Content Coupling (Highest)** | One module **directly accesses** or modifies the internal data or logic of another module. 🚫 Very bad! |
| **2. Common Coupling** | Multiple modules share the **same global data.** If one changes the data, it affects all. Risky. |
| **3. External Coupling** | Modules depend on **external systems**, like file formats or hardware protocols. |
| **4. Control Coupling** | One module controls another by passing **control flags or commands.** |
| **5. Stamp Coupling (Data-structured Coupling)** | Modules share **common data structures**, but don't use all data inside them. |

(ii)

## What is Cohesion?

- **Cohesion** refers to how **strongly related and focused** the responsibilities of a single module are.
- **High cohesion** means a module performs **a single, well-defined task**.
- **Low cohesion** means a module is trying to do **too many unrelated things**.

| | |
|---|---|
| **1. Coincidental Cohesion (Worst)** | Random functions grouped in one module. No meaningful connection. 🚫 Avoid this. |
| **2. Logical Cohesion** | Functions are related logically but selected based on a control flag. Example: `open(file)`, `read(file)`, `write(file)` in one module. |
| **3. Temporal Cohesion** | Functions grouped because they are done at the same time. Example: initialization tasks. |
| **4. Procedural Cohesion** | Functions grouped because they follow a sequence of steps. |
| **5. Communicational Cohesion** | Functions operate on the same data. Example: fetch and display employee details. |
| **6. Sequential Cohesion** | Output of one function becomes input for the next in the module. |

**Q5. Discuss various components of Good Programming Style, also explain its Importance in Software development.**

**Ans.** Bhavy

## What is Good Programming Style?

- **Good Programming Style** refers to the use of practices, conventions, and patterns that make code more **readable**, **maintainable**, and **efficient**.
- It involves following certain **standards** to write clean, understandable, and error-free code.

## Components of Good Programming Style:

### 1. Clarity

- Code should be **easy to read** and **understand**.
- Use **descriptive variable and function names** that clearly convey the purpose of that element.
- Avoid **obfuscated code**. Your code should read like a **story**.

### 2. Consistent Naming Conventions

- Consistent naming helps in recognizing the **purpose** of variables, functions, and classes.
- **CamelCase** for variables and functions, **PascalCase** for class names.

### 3. Indentation and Spacing

- Consistent **indentation** makes the structure of the code clear. Typically, use **4 spaces** for indentation.
- **White spaces** should be used for readability, but not excessive.

### 4. Commenting and Documentation

- Proper comments help other developers (or even future you) understand what the code does.

- **Explain the 'why'**, not the 'what' (the code itself should explain the what).
- Use **docstrings** for functions and classes to provide clear documentation.

**5. Modularity**

- Break down the code into smaller, **manageable functions** and modules.
- Each function should have a **single responsibility** (Single Responsibility Principle).
- **Example**: A function should only do **one thing**, like calculating the area of a circle, not both calculating and displaying it.

**6. Error Handling**

- Always handle **errors and exceptions** gracefully.
- Use **try-except blocks** (in languages like Python) or **error codes** (in C/C++).

**7. Code Reusability**

- Avoid **redundancy** by creating reusable functions or methods.
- Use **DRY** (Don't Repeat Yourself) principle, meaning no duplicate code.
- **Modularize your code** so that you can **reuse** common logic in multiple places.

**8. Appropriate Use of Libraries and Frameworks**

- Utilize existing libraries or frameworks rather than **reinventing the wheel**.
- This will make your code more efficient and leverage best practices from experts in that area.

**9. Code Structure and Organization**

- Organize your code in **logical sections**: grouping similar functions together, separating them by their role (e.g., utility functions, data functions).

- Use proper directory structures in large projects (e.g., separating logic, tests, assets).

**10. Testing**

- Always write **tests** for your code, including **unit tests** and **integration tests**.
- Writing testable code makes debugging and maintenance easier.

## Importance of Good Programming Style in Software Development

**1. Improves Readability**

- Code readability is **critical** for maintenance and collaboration.
- Good style allows **team members** or **future developers** to quickly understand and work on the code.

**2. Eases Debugging and Troubleshooting**

- With well-organized, readable code, debugging becomes **faster** and **more efficient**.
- If a developer can **easily read the code**, identifying issues becomes much simpler.

**3. Enhances Collaboration**

- In **team projects**, good programming style helps developers **collaborate effectively**.
- When everyone follows the same style, it reduces conflicts, confusion, and misunderstandings.

**4. Increases Maintainability**

- Code that follows best practices is **easier to modify** over time.
- Maintenance and future upgrades are more straightforward with clean, well-documented code.

**5. Promotes Reusability**

- Properly structured code promotes **modular design** and **reuse**.
- Writing reusable functions and modules helps reduce duplication and lowers the chances of introducing bugs.

**6. Improves Code Quality and Performance**

- Good programming practices often lead to **more efficient**, optimized, and **error-free code**.
- It forces developers to think carefully about design, performance, and correctness.

**7. Supports Scaling**

- Well-structured code is easier to scale as your project grows.
- It ensures that your software can **accommodate new features** or **handle more users** without breaking down.

**8. Facilitates Future Enhancements**

- With clear and clean code, adding new features, fixing bugs, or modifying code becomes **easier** in the future.
- This is crucial in software systems that need to **evolve** over time.

**Q6. What is Software design process? Explain it with the help of principles and concept.**

**Ans.** Bhavy

## What is Software Design?

- **Software Design** is the process of defining the architecture, components, interfaces, and data for a software system to satisfy specific requirements.
- It is a critical phase in the **Software Development Life Cycle (SDLC)** that focuses on converting **requirements** into a blueprint for development.

## Software Design Process:

The software design process typically follows these steps:

### 1. Requirement Analysis

- The first step is to understand and analyze the **requirements** of the system.
- These requirements come from stakeholders, end-users, or business needs.
- The goal is to clarify what the software needs to achieve.

### 2. High-Level Design (Architectural Design)

- This phase defines the **overall structure** of the system.
- It focuses on breaking the system into **modules** or **components** and establishing how they will interact.
- Decisions about **software architecture** (e.g., layered architecture, client-server architecture, etc.) are made here.

### 3. Low-Level Design (Detailed Design)

- After high-level design, each **module** or **component** is broken down into **smaller sub-components**.
- Detailed algorithms, data structures, and interfaces for each part are designed.
- This step focuses on the **implementation details** (e.g., classes, methods, and their interactions).

### 4. Design Verification

- In this step, the design is checked against the **requirements** to ensure correctness.
- **Design reviews** and **walkthroughs** may be performed with stakeholders to confirm the design is feasible and meets the goals.
- **Prototypes** or **models** might be created to validate the design.

### 5. Design Documentation

- The final design is documented in detail for developers to refer to during implementation.

- Diagrams, flowcharts, data models, and code snippets are included to clearly express the design.
- **UML diagrams** (e.g., class diagrams, sequence diagrams) are often used to visualize the design.

## Principles of Software Design:

The software design process is guided by several key principles, which help in creating high-quality software. These principles are:

### 1. Modularity

- **Decompose** the system into smaller, manageable modules or components.
- Each module should perform a **specific function** and interact with other modules in a defined manner
- **Benefits**: Easier to maintain, understand, test, and extend.

### 2. Abstraction

- Focus on **high-level functionality** and hide unnecessary details.
- Use abstraction to provide a **simplified interface** for complex functionality.
- **Example**: Using **APIs** to interact with complex systems without knowing their internal workings.

### 3. Cohesion

- Ensure that components or modules have a **single responsibility** and are internally **focused** on a specific task.
- A module with high cohesion performs a well-defined set of operations.
- **Benefits**: Makes the system easier to maintain and understand.

### 4. Coupling

- Minimize **dependencies** between modules.
- **Loose coupling** (where modules communicate but are not highly dependent on each other) is preferred, as it promotes flexibility.

- **Benefits**: Makes the system more adaptable and reduces the impact of changes.

**5. Reusability**

- Design components that can be **reused** in other parts of the system or even in other projects.
- This helps reduce redundancy and effort in coding.
- **Example**: Developing reusable **libraries**, **functions**, or **modules**.

**6. Separation of Concerns**

- Break the system down into distinct **parts** where each part addresses a specific concern (e.g., user interface, business logic, data storage).
- **Benefits**: Simplifies the design, making it easier to manage and modify.

**7. Scalability**

- Ensure the design can **grow** and **handle increasing load** or more features over time.
- Design the system in such a way that **new modules** can be added with minimal disruption.

**8. Maintainability**

- Design software so that it can be **easily updated** and **maintained** as requirements change over time.
- This includes clear documentation, modularization, and easy-to-understand code.

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# OT Solution By Kratakshi Bhardwaj

# I. P. (P.G.) College, Campus – 2, Bulandshahr

## Department of Computer Science

## Internal Question Bank (2024-25)

## Optimization Techniques (BCA - 404)

**Section – A**

**(Objective type Questions)**

1. Which of the following relationship is not true?
   a) $W_s = W_q + 1/\mu$ b) $L_s = \lambda W_s$ c) $\boldsymbol{L_s = L_q + 1/\lambda}$ d) $L_q = \lambda W_q$
2. For maximization LP model, the simplex method is terminated when all values-
   a) $\boldsymbol{C_j - Z_j \leq 0}$ b) $C_j - Z_j \geq 0$ c) $C_j - Z_j = 0$ d) $Z_j \leq 0$
3. A BFS of a LPP is said to be _____ if at least one of the basic variable is zero
   a) **Degenerate** b) Non-degenerate c) Infeasible d) Unbounded
4. Graphic method can be applied to solve a LPP when there are only _____variable.**(Two)**
5. Once the initial basic feasible solution has been computed, the next step in the problem is optimality test. **(T/F) T**
6. Balanced transportation problem is one in which the total supply is not equal to the total requirements. **(T/F) F**
7. Every LPP is associated with another LPP is called Primal? **(T/F) F**
8. The abbreviation for EOQ is Economic Order Quantity. **(T/F) T**
9. Objective functions are expressed in the form of inequities. **(T/F) F**
10. Operations Research is primarily concerned with optimizing complex systems using mathematical models. **(T/F) T**
11. Linear programming assumes that all relationships in the model are nonlinear. **(T/F) F**
12. The Simplex Method is used to solve linear programming problems with equality constraints only. **(T/F) F**
13. The dual of a linear programming problem always has the same number of variables as the primal problem. **(T/F) F**
14. The Hungarian method is used to solve assignment problems efficiently. **(T/F) T**
15. A feasible solution to a linear programming problem must satisfy all constraints. **(T/F) T**
16. MODI method is applied to check the optimality of solution. **(T/F) T**
17. Expected waiting time of customer in the system is $W_q = L_q + (\lambda/\pi)$. **(T/F) F**
18. If there are more than one optimum solution in graphical method then there is infinitely many solutions for given problem. **(T/F) T**
19. Operations Research is most closely associated with –
    a) **Mathematics** b) Physics c) Literature d) Chemistry
20. Which of the following method is used to solving LPP?
    a) Hungarian method b) Decision Tree c) **Simplex method** d) CPM
21. If any value in XB column of final simplex table is negative, then the solution is _____.
    a) **Infeasible** b) Optimum c) Bounded d) No solution
22. The calling population is considered to be infinite when _____.
    a) All customers arrive at once c) **Capacity of the system is infinite**
    b) Service rate is faster than arrival rate d) Arrivals are independent of each other
23. In marking assignments, which of the following should be preferred?
    a) Only row having single zero c) Only column having single zero
    b) **Only row/column having single zero** d) Column having more than one zero
24. In a Linear Programming Problem functions to be maximized or minimized are called _____.
    a) **Objective function** b) Constraints c) Basic solution d) Feasible solution

# OT Solution By Kratakshi Bhardwaj

**25.** If the primal problem has n constraints and m variables, then the number of constraints in the dual problem is _____.

a) **m** b) n c) m-n d) m/n

**26.** Key element is also known as _____.

a) Slack b) Surplus c) Artificial d) **Pivot**

**27.** The solution to a transportation problem with m-sources and n-destinations is feasible if the numbers of allocations are _____.

a) m+n b) mn c) m-n d) **m+n-1**

**28.** The allocation cells in the transportation table will be called _____ cell.

a) **Occupied** b) Unoccupied c) Constraints d) Finite

**29.** The coefficient of slack\surplus variables in the objective function are always assumed to be _____.

a) **0** b) 1 c) M d) -1

**30.** The assignment problem is always a _____matrix.

a) Circle b) **Square** c) Rectangle d) Triangle

## Section B (Short Question)

**Q1. Write a linear programming problem in matrix form.**
**Ans.**

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# OT Solution By Kratakshi Bhardwaj

Optimize (maximize or minimise) $Z = \sum_{j=1}^{n} c_j x_j$

(Objective Function)

Subject to the constraints

$$\sum_{j=1}^{n} a_{ij} x_j \ (\leq, =, \geq) \ b_i, \quad i = 1, 2, \ldots, m$$

(constraints)

and

$$x_j \geq 0; \quad j = 1, 2, \ldots, n$$

(Non-negativity restrictions)

In matrix notation, we can write the above problem as -

$$\text{Maximise (or minimise) } Z = \begin{bmatrix} c_1 & c_2 & \cdots & c_n \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$$

Subject to linear constraints

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \begin{matrix} \geq \\ \leq \\ \\ \\ \end{matrix} \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_m \end{bmatrix}$$

**Q2. Customers arrive at a sales counter manned by a single person according to a poison process with a mean rate at 20 per hour. The time required to serve a customer has an exponential distribution with a mean of 100 seconds. Find the average waiting time of a customer.**

# OT Solution By Kratakshi Bhardwaj

**Ans.**

Given → • Customers arrive at mean rate of 20 per hour which means 20 customer per hour

∴ Arrival mean time ($\lambda$) = 20 per hour

Given → • Time required to serve a customer is 100 seconds

⇒ 1 customer → 100 seconds

1 seconds → $\frac{1}{100}$ customer

3600 sec → $\frac{1}{100} \times 3600$ customer

1 hr → 36 customer

which means

$\mu = 36$ per hour

(mean servicing Rate)

⇒ Average waiting time of a customer = ?

So, we have to find $W_q$ (Mean average waiting time of a customer in the queue) and $W_s$ (Mean average waiting time of a customer in the system

$$W_q = \frac{\lambda}{\mu(\mu-\lambda)} = \frac{20}{36(36-20)} = \frac{\cancel{20}^{\cancel{10}\,5}}{36 \times \cancel{16}_{\cancel{8}\,4}} \text{ hour}$$

$$= \frac{5}{\cancel{36}_{\cancel{6}\,3} \times 4} \times \cancel{60}_{\cancel{10}\,5} \text{ min} = \frac{5 \times 5}{3 \times 4} \text{ min} = 2.084 \text{ minute}$$

$$= 2.084 \times 60 \text{ sec} = \underline{125.04 \text{ sec}}$$

$$W_s = \frac{1}{\mu-\lambda} = \frac{1}{36-20} \text{ hr} = \frac{1}{16} \times 60 \text{ min} = 3.75 \text{ min}$$

$$= 3.75 \times 60 \text{ sec} = \underline{225 \text{ sec}}$$

# OT Solution By Kratakshi Bhardwaj

**Q3. Solve the following linear programming problem graphically: Maximize Z = 60$x$ + 15$y$ Subject to constraints $x$ + $y$ ≤ 50, 3$x$ + $y$ ≤ 90, and$x$ ≥ 0, $y$ ≥ 0.**

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# OT Solution By Kratakshi Bhardwaj

**Ans.**

Max $Z = 60x + 15y$ (Objective Function)

Subject to constraints -

$x + y \leq 50$, $3x + y \leq 90$, and $x \geq 0, y \geq 0$

Step1- Convert the inequality equation into equality equation and find their respective points.

(i) $x + y = 50$ -(i)

when $x = 0$, $y = 50$ $\Rightarrow$ Points $\rightarrow$ $(0, 50)$, $(50, 0)$

when $y = 0$, $x = 50$

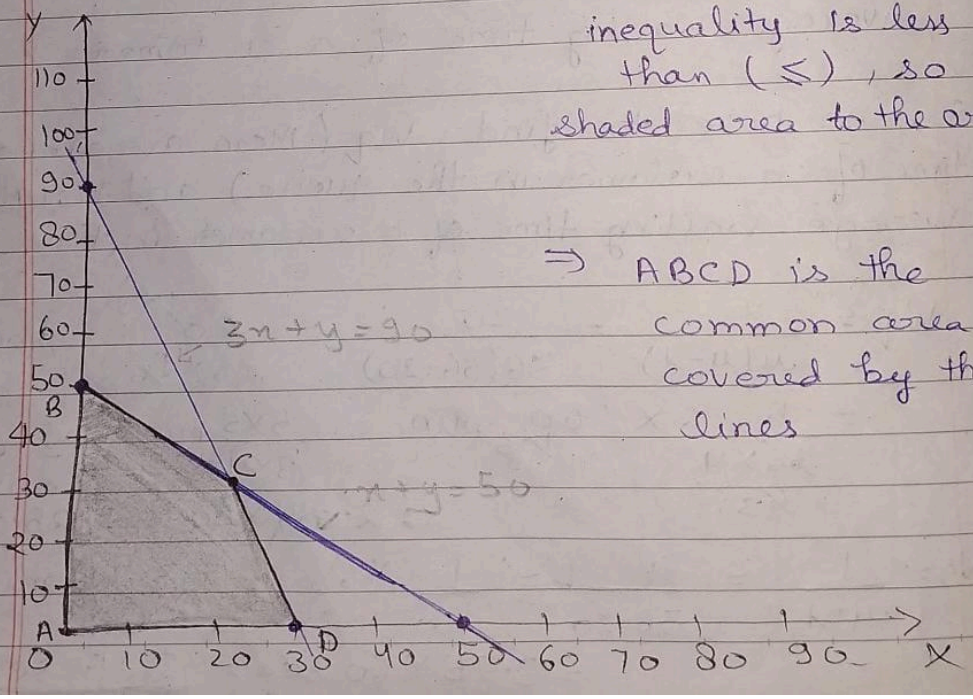
(ii) $3x + y = 90$ - (ii)

when $x = 0$, $y = 90$ $\Rightarrow$ Points $\Rightarrow$ $(0, 90)$, $(30, 0)$

when $y = 0$, $x = 30$

Step2-

Now, plot all the coordinates on the graph and shade the respective area the line holds




inequality is less than ($\leq$), so shaded area to the origin

$\Rightarrow$ ABCD is the common area covered by the lines

# OT Solution By Kratakshi Bhardwaj

Step 3 → A (0,0) , B (0,50) , C ( ) ,
D (30,0)

For finding the coordinates of C point we have to solve the equations.

* Subtract equation (ii) from equation (i)

$$x + \cancel{y} = 50$$
$$-\ 3x \pm \cancel{y} = -90$$
$$\pm 2x = \pm 40$$
$$x = \frac{40}{2} \quad \boxed{x = 20}$$

Now, put the value of $x$ in equation (i)

$$20 + y = 50 \Rightarrow y = 50 - 20$$
$$\boxed{y = 30} \Rightarrow C\ (20, 30)$$

Step 4 →
Now, we calculate value of objective function at A, B, C and D points.

At point A (0, 0)

$$Z = 60x + 15y$$
$$Z = 60 \times 0 + 15 \times 0$$
$$Z = 0 + 0 \Rightarrow \boxed{Z = 0}$$

At point B (0, 50)

$$Z = 60 \times 0 + 15 \times 50$$
$$Z = 0 + 750$$
$$Z = 750$$

**OT Solution By Kratakshi Bhardwaj**

At point C (20, 30)

$Z = 60 \times 20 + 15 \times 30$

$Z = 1200 + 450$

$Z = 1650$

At point D (30, 0)

$Z = 60 \times 30 + 15 \times 0$

$Z = 1800 + 0$

$Z = 1800$

In given problem, the objective function is maximum.

At Point D (30, 0), value of objective function is maximum

**4)** Solve the following assignment problem: -

| | | SUBORDINATES | | | |
|---|---|---|---|---|---|
| | | I | II | III | IV |
| TASKS | A | 8 | 26 | 17 | 11 |
| | B | 13 | 28 | 4 | 26 |
| | C | 38 | 19 | 18 | 15 |
| | D | 19 | 26 | 24 | 10 |

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# OT Solution By Kratakshi Bhardwaj

**Ans.**

Subordinates

| Tasks | I | II | III | IV |
|---|---|---|---|---|
| A | 8 | 26 | 17 | 11 |
| B | 13 | 28 | 4 | 26 |
| C | 38 | 19 | 18 | 15 |
| D | 19 | 26 | 24 | 10 |

(4 × 4)

This problem is balanced

Step 1 → find the smallest elements from all the rows and subtract the smallest element from all elements of that row.

| Tasks | I | II | III | IV |
|---|---|---|---|---|
| A | 0 | 18 | 9 | 3 |
| B | 9 | 24 | 0 | 22 |
| C | 23 | 4 | 3 | 0 |
| D | 9 | 16 | 14 | 0 |

Step 2 → Now, find the smallest elements from all columns and subtract the smallest element from all elements of that column.

| Tasks | I | II | III | IV |
|---|---|---|---|---|
| A | 0 | 14 | 9 | 3 |
| B | 9 | 20 | 0 | 22 |
| C | 23 | 0 | 3 | 0 |
| D | 9 | 12 | 14 | 0 |

Step 3 - Now, firstly put a □ on a zero where only one zero in a row, if more than one zero exist then put □ on one row and cut (X) all other zeroes in that row and column.

# OT Solution By Kratakshi Bhardwaj

| | I | II | III | IV |
|---|---|---|---|---|
| A | 0 | 14 | 9 | 3 |
| B | 9 | 20 | 0 | 22 |
| C | 23 | 0 | 3 | 0 |
| D | 9 | 12 | 14 | 0 |

Step 4- Now draw lines to cover all zeroes

Step 5- We can see every row and every column has an assignment, So we can find a optimise solution.

A – I – 8
B → III – 4 (write original value)
C → II – 19
D – IV – 10

Min Cost = 8 + 4 + 19 + 10 = 41

**Q5. The cost of a machine is Rs. 6100 and its resale value is only Rs. 100. The maintenance costs are found from experience to be as under:**

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Maintenance Cost (Rs.) | 100 | 250 | 400 | 600 | 900 | 1250 | 1600 | 2000 |

**Ans.**

# OT Solution By Kratakshi Bhardwaj

To find the year of replacement of machine we have to make a table.

| Year (n) | Maintenance Cost | Cummulative Maintenance Cost | * Depreciation Cost | * Total Cost | * Average Cost |
|---|---|---|---|---|---|
| 1 | 100 | 100 | 6000 | 6100 | 6100 |
| 2 | 250 | 350 | 6000 | 6350 | 3175 |
| 3 | 400 | 750 | 6000 | 6750 | 2250 |
| 4 | 600 | 1350 | 6000 | 7350 | 1837.5 |
| 5 | 900 | 2250 | 6000 | 8250 | 1650 |
| 6 | 1250 | 3500 | 6000 | 9500 | 1583.3 |
| 7 | 1600 | 5100 | 6000 | 11100 | 1585.7 |
| 8 | 2000 | 7100 | 6000 | 13100 | 1637.5 |

Cummulative → 100
100 + 250 = 350
350 + 400 = 750

⇒ Cost of machine = ₹6100
Resale value = ₹ 100

* Depreciation Cost = Cost of machine − resale value / scrap value
= 6100 − 100
= 6000

* Total Cost = Cummulative Maintenance Cost + Depreciation Cost

* Average Cost = $\frac{\text{Total Cost}}{\text{Year}}$

⇒ From the above table, the Average Cost per year is minimum during 6th year (1583.3).
Hence, the machine should be replaced after every 6th year

**Q6. We have five jobs each of which must go through two machines A and B in the order AB. Processing times in hours are given below:**

# OT Solution By Kratakshi Bhardwaj

| Jobs | I | II | III | IV | V |
|---|---|---|---|---|---|
| Machine A | 5 | 1 | 9 | 3 | 10 |
| Machine B | 2 | 6 | 7 | 8 | 4 |

**Determine sequence for the five jobs that will minimize the elapsed time T also calculate the value of T and idle time for both the machines.**

2024, 2013

| Job | Machine A | Machine B |
|---|---|---|
| 1 | 5 | 2 |
| 2 | 1 | 6 |
| 3 | 9 | 7 |
| 4 | 3 | 8 |
| 5 | 10 | 4 |

Machine A - smallest (starting) ⇒

Machine B - Smallest (Ending)

⇒ Job Sequence ⇒ | 2 | 4 | 3 | 5 | 1 |

| Job sequence | A In | A Out | B In | B Out | Idle time (Difference) B |
|---|---|---|---|---|---|
| 2 | 0 | 1 | 1 | 7 | 1 |
| 4 | 1 | 4 | 7 | 15 | 0 |
| 3 | 4 | 13 | 15 | 22 | 0 |
| 5 | 13 | 23 | 23 | 27 | 1 |
| 1 | 23 | 28 | 28 | 30 | 1 |
| | | | | | 3 |

Total elapsed time = 30

Ideal time for machine A = Total eclapsed time - Out time of machine A

= 30 - 28 = 2

Ideal time for machine B = difference + (Total eclapsed time - Out time of machine B)

= 3 + (30 - 30)

= 3

**OT Solution By Kratakshi Bhardwaj**

# Section C

**Q1. 1) Solve the following LPP: Maximize Z = 5$x$ + 3$y$ Subject to $x$ + $y$ ≤ 2, 5$x$ + 2$y$ ≤ 10, 3$x$ + 8$y$ ≤ 12 and $x$ , $y$ ≥ 0**
**Ans.**

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# OT Solution By Kratakshi Bhardwaj

Max $Z = 5x + 3y$

Subject to - $x + y \leq 2$ , $5x + 2y \leq 10$,

$3x + 8y \leq 12$ & $x, y \geq 0$

Step 1 → Convert the inequality equation into equality equation and find their respective points.

(i) $x + y = 2$

when $x = 0$, $y = 2$ ⇒ Points - $(0, 2)$, $(2, 0)$

when $y = 0$, $x = 2$

(ii) $5x + 2y = 10$

when $x = 0$, $y = 5$ ⇒ Points - $(0, 5)$, $(2, 0)$

when $y = 0$, $x = 2$

(iii) $3x + 8y = 12$

when $x = 0$, $y = \frac{\cancel{12}\,\cancel{6}\,3}{\cancel{8}\,\cancel{4}\,2}$ , $y = \frac{3}{2}$

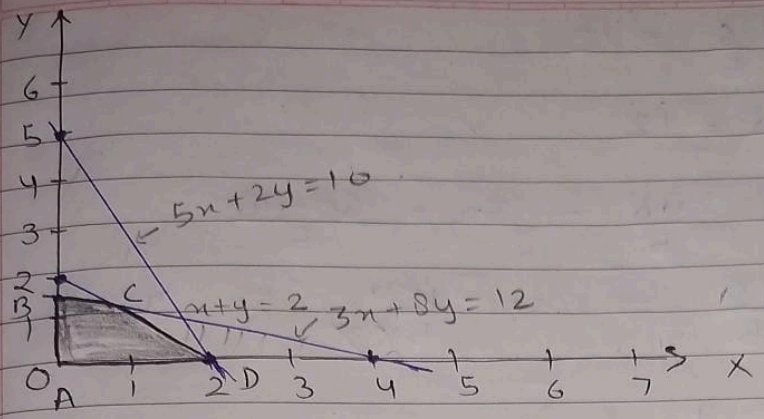
when $y = 0$, $x = \frac{12}{3} \Rightarrow x = 4$

Points → $(0, 3/2)$ , $(4, 0)$

Step 2 - Put all the points on a graph and shade the respective area the line holds.

⇒ inequality is less than ($\leq$), so shaded area to the origin.

# OT Solution By Kratakshi Bhardwaj




Step 3 → A ( 0, 0 ), B ( 0, 3/2 ),
C ( ), D ( 2, 0 )

For finding the coordinate of C, we have to solve the (i) & (iii) equation Because (i) & (iii) equation intersect point is C.

⇒ Multiply eq (i) by 3

$$3x + 3y = 6 \quad — (i)$$

~~Multiply eq (iii) by 2~~

~~3x +~~

Now, subtract eq (iii) from (i)

$$\begin{array}{r} 3\cancel{x} + 3y = 6 \\ -\ \cancel{3x} \pm 8y = \pm 12 \\ \hline \cancel{+}5y = \cancel{+}6 \end{array}$$

$$y = \frac{6}{5}$$

Put the value of y in eq (iii)

# OT Solution By Kratakshi Bhardwaj

$3x + 8 \times \frac{6}{5} = 12$

$3x + \frac{48}{5} = 12$

$3x = 12 - \frac{48}{5} \Rightarrow 3x = \frac{60-48}{5}$

$3x = \frac{12}{5} \Rightarrow x = \frac{\cancel{12}\,4}{5 \times \cancel{3}} \Rightarrow x = \frac{4}{5}$

$\Rightarrow C\left(\frac{4}{5}, \frac{6}{5}\right)$

Step 4:- Now, put all the Points coordinate in Objective function one-by-one to find maximum objective function value

At A $(0, 0)$

$Z = 5x + 3y \Rightarrow Z = 5 \times 0 + 3 \times 0$

$Z = 0$

At B $\left(0, \frac{3}{2}\right)$

$Z = 5 \times 0 + 3 \times \frac{3}{2} \Rightarrow Z = 0 + \frac{9}{2}$

$Z = 4.5$

At C $\left(\frac{4}{5}, \frac{6}{5}\right)$

$Z = \cancel{5} \times \frac{4}{\cancel{5}} + 3 \times \frac{6}{5} \Rightarrow Z = 4 + \frac{18}{5}$

$Z = \frac{20+18}{5} \Rightarrow Z = \frac{38}{5} \Rightarrow Z = 7.2$

At D $(2, 0)$

$Z = 5 \times 2 + 3 \times 0 \Rightarrow Z = 10 + 0$

$Z = 10$

# OT Solution By Kratakshi Bhardwaj

As we know, our objective function is maximum, so we select the maximum value which is 10
So, At point D (2,0), our objective function is maximum.

**Q2. On average 96 patients per 24 Hour day require the service of an emergency clinic. Also on average a patient requires 10 mints of active attention. Assume that the facility can handle only one emergency at a time. Suppose that it costs the clinic ₹100 per patient treated to obtain an average serving time of 10 patients & that each minutes of decrease in the average time would cost by ₹10 per patient treated. How much would be budgeted by the clinic to decrease the average size of the queue from one & one third patients to half (1/2) a patient?**
**Ans.**

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# OT Solution By Kratakshi Bhardwaj

Given → * 96 patients per 24 Hour day require the service of an emergency clinic

* Each patient require 10 minutes of active attention ( service time)

$\Rightarrow \lambda = 96$ per day

$\lambda = \frac{96}{24}$ per hour

$\lambda = 4$ per hour

$\Rightarrow$ 10 min - 1 patient

1 min - $\frac{1}{10}$ patient

60 min - $\frac{1}{10} \times 60$ patient

1 hr - 6 patient

$\mu = 6$ per hr

Average patient in the queue

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)}$$

$$L_q = \frac{4 \times 4}{6(6-4)}$$

$$L_q = \frac{4 \times \cancel{4}\,\cancel{2}}{\cancel{6}_{3} \times \cancel{2}} \Rightarrow L_q = \frac{4}{3}$$

$$L_q = 1.333$$

# OT Solution By Kratakshi Bhardwaj

Now, when the average queue size decreases from $\frac{4}{3}$ to $\frac{1}{2}$ patient, so the value of $\mu'$

$$L'_q = \frac{\lambda^2}{\mu'(\mu'-\lambda)}$$

$$\frac{1}{2} = \frac{4 \times 4}{\mu'(\mu'-4)}$$

$$\frac{1}{2} = \frac{4 \times 4}{\mu'^2 - 4\mu'}$$

$$\mu'^2 - 4\mu' = 2 \times 4 \times 4$$

$$\mu'^2 - 4\mu' = 32$$

$$\mu'^2 - 4\mu' - 32 = 0$$

$$\mu'^2 - 8\mu' + 4\mu' - 32 = 0$$

$$\mu'(\mu' - 8) + 4(\mu' - 8) = 0$$

$$(\mu' + 4)(\mu' - 8) = 0$$

$$\mu' = -4, \quad \mu' = 8$$

$\mu'$ cannot be negative, so

~~$\mu' = 8$ per hour~~ $\mu' = 8/\text{hr}$

$\mu' = \frac{1}{8}$ per hr

Average rate of treatment require

$= \frac{1}{8} \times 60$ min

$= 7.5$ minute

# OT Solution By Kratakshi Bhardwaj

Decreasing in average rate of treatment

$= 10 - 7.5$

$= 2.5$ minute

Budget / patient $= 100 + 2.5 \times 10$

$= 100 + 25$

$= ₹\ 125$

**Q3. Solve the following transportation problem:**

| From \ To | 1 | 2 | 3 | Supply |
|---|---|---|---|---|
| 1 | 16 | 19 | 12 | 14 |
| 2 | 22 | 13 | 19 | 16 |
| 3 | 14 | 28 | 8 | 12 |
| Demand | 10 | 15 | 17 | |

**Ans.**

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# OT Solution By Kratakshi Bhardwaj

| To / From | 1 | 2 | 3 | Supply |
|---|---|---|---|---|
| 1 | 16 | 19 | 12 | 14 |
| 2 | 22 | 13 | 19 | 16 |
| 3 | 14 | 28 | 8 | 12 |
| Demand | 10 | 15 | 17 | |

Step 1 - $\Sigma$(Demand) = 10 + 15 + 17
= 42

$\Sigma$(Supply) = 14 + 16 + 12
= 42

Check it is balanced or not
$\Sigma$(Demand) = $\Sigma$ Supply
$\therefore$ It is balanced.

Now, we find Initial solution of this problem.
(By Vogel's Approximation Method)

Step 2 → ~~find~~ Calculate penalties for each row / column by taking the diff$^n$ b/w the smallest and next smallest unit transpotation ~~problem~~ cost in that row / column.

# OT Solution By Kratakshi Bhardwaj

①

| from \ To | 1 | 2 | 3 | Supply | P |
|---|---|---|---|---|---|
| 1 | 16 | 19 | 12 | 14 | 4 |
| 2 | 22 | 13 | 19 | 16 | 6 |
| 3 | 14 | 28 | 8 [12] | ~~12~~ 0 | 6 ⇐ |
| Demand | 10 | 15 | ~~17~~ 5 | 42 | |
| P | 2 | 6 | 4 | | |

②

| from \ To | 1 | 2 | 3 | Supply | P |
|---|---|---|---|---|---|
| 1 | 16 | 19 | 12 [5] | ~~14~~ 9 | 4 |
| 2 | 22 | 13 | 19 | 16 | 6 |
| Demand | 10 | 15 | ~~5~~ 0 | 30 | |
| P | 6 | 6 | 7 ⇑ | | |

③

| from \ To | 1 | 2 | Supply | P |
|---|---|---|---|---|
| 1 | 16 | 19 | 9 | 3 |
| 2 | 22 | 13 [15] | ~~16~~ 1 | 9 ⇐ |
| Demand | 10 | ~~15~~ 0 | 25 | |
| P | 6 | 6 | | |

④

| from \ To | 1 | Supply |
|---|---|---|
| 1 | 16 [9] | 9 |
| 2 | 22 [1] | 1 |
| Demand | 10 | 10 |

# OT Solution By Kratakshi Bhardwaj

| From \ To | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 16 [9] | 9 | 12 [5] |
| 2 | 22 [1] | 13 [15] | 19 |
| 3 | 14 | 28 | 8 [12] |

Step-3 - MODI METHOD

⇒ ① $m+n-1 \Rightarrow 3+3-1 = 6-1 = 5$

we have 5 occupied cells, it is non-degenerate.

② Consider occupied cells

$T.C = 16\times9 + 22\times1 + 13\times15 + 12\times5 + 8\times12$

$= 144 + 22 + 195 + 60 + 96$

$= ₹517$

⇒ Occupied Cells Table

| From \ To | 1 | 2 | 3 | |
|---|---|---|---|---|
| 1 | 16 | | 12 | $u_1 = 0$ |
| 2 | 22 | 13 | | $u_2 = 6$ |
| 3 | | | 8 | $u_3 = -4$ |

$v_1 = 16 \quad v_2 = 7 \quad v_3 = 12$

⇒ $C_{ij} = u_i + v_j$

* $C_{11} = u_1 + v_1$
  $16 = 0 + v_1$
  $v_1 = 16$

* $C_{13} = u_1 + v_3$
  $12 = 0 + v_3$
  $v_3 = 12$

* $C_{21} = u_2 + v_1$
  $22 = u_2 + 16$
  $u_2 = 22 - 16$
  $u_2 = 6$

* $C_{22} = u_2 + v_2$
  $13 = 6 + v_2$
  $v_2 = 13 - 6$
  $v_2 = 7$

# OT Solution By Kratakshi Bhardwaj

* $C_{33} = u_3 + v_3$

$8 = u_3 + 12$

$u_3 = 8 - 12$

$u_3 = -4$

Unoccupied Cells Table

| From \ To | 1 | 2 | 3 | $u_i$ |
|---|---|---|---|---|
| 1 | | 19 | | 0 |
| 2 | | | 19 | 6 |
| 3 | 14 | 28 | | -4 |
| $v_j$ | 16 | 7 | 12 | |

⇒ Now we find $\Delta_{ij}$ for unoccupied cells.

$\Delta_{ij} = C_{ij} - (u_i + v_j)$

$\Delta_{12} = 19 - (0 + 7)$

$= 19 - 7$

$= 12$

$\Delta_{23} = 19 - (6 + 12)$

$= 19 - 18$

$= 1$

$\Delta_{31} = 14 - (-4 + 16)$

$= 14 - 12$

$= 2$

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$\Delta_{32} = 28 - (-4+7)$

$= 28 - 3$

$= 25$

Hence, $\Delta_{ij} > 0$, then the solution is unique or ultimate optimal

T.C = ₹ 517

**Q4. We have five jobs each of which must go through the machines A, B and C in the order ABC, processing times are as follows: -**

| Jobs | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Processing times in hours | A | 4 | 9 | 8 | 6 | 5 |
| | B | 5 | 6 | 2 | 3 | 4 |
| | C | 8 | 10 | 6 | 7 | 11 |

**Determine the sequence for five jobs that will minimize the total elapsed time and also calculate T.**

**Ans.**

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Job

Processing time in hours

| Jobs | A | B | C |
|---|---|---|---|
| 1 | 4 | 5 | 8 |
| 2 | 9 | 6 | 10 |
| 3 | 8 | 2 | 6 |
| 4 | 6 | 3 | 7 |
| 5 | 5 | 4 | 11 |

⇒ For 3 Machines n jobs → 3 machine into 2 machine

Minimum Processing time of Machine A = 4

Minimum Processing time of Machine C = 6

Maximum Processing time of Machine B = 6

Condition → $M(B) \geq M(C)$

$6 = 6$

condition satisfied

Now we take two machines G and H

* $G = A + B$ and * $H = B + C$

| Job | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| G | 9 | 15 | 10 | 9 | 9 |
| H | 13 | 16 | 8 | 10 | 15 |

Job Sequence = | 1 | 4 | 5 | 2 | 3 |

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| Jobs | M(A) In | M(A) Out | M(B) In | M(B) Out | M(C) In | M(C) Out | Idle time for M(B) | Idle time for M(C) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 4 → | 4 | 9 → | 9 | 17 | 4 | 9 |
| 4 | 4 | 10 | 10 | 13 | 17 | 24 | 1 | 6 |
| 5 | 10 | 15 | 15 | 19 | 24 | 35 | 2 | 0 |
| 2 | 15 | 24 | 24 | 30 | 35 | 45 | 5 | 0 |
| 3 | 24 | 32 | 32 | 34 | 45 | 51 | 2 | 0 |
| | | | | | | | 14 | 9 |

Total elapsed time = 51

Idle time for M(A) = 51 - 32 = 19

Idle time for M(B) = 14 + (51 - 34)
= 14 + 17
= 31

Idle time for M(C) = 9

**Q5. Explain the following: -**
**a) Busy period, idle period and mean arrival rate.**
**b) Slack variables and surplus variables.**
**Ans.**

## a) Busy period, Idle period and Mean arrival rate

These terms are commonly used in **queuing theory** or **operating systems**, particularly when studying **CPU scheduling** or **network traffic**.

**Busy Period:**

- The **busy period** is the **time duration** during which the server (or CPU) is continuously **busy** serving requests without being idle.

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- It starts when a request arrives at an idle server and ends when the server becomes idle again.

- Example: If the CPU starts processing jobs at 10:00 AM and finishes the last job at 10:30 AM without any idle time in between, the busy period is **30 minutes**.

**Idle Period:**

- The **idle period** is the time during which the server is **not processing any jobs** because there are no requests in the queue.

- This typically happens when the system is underutilized.

- Example: If no processes are running on a CPU between 9:00 AM and 9:10 AM, then that 10-minute span is an idle period.

**Mean Arrival Rate (λ):**

- This refers to the **average number of requests/jobs arriving per unit time**.

- It's denoted as **λ (lambda)** in queuing theory.

- Example: If 10 jobs arrive in 2 minutes, the mean arrival rate = 10 / 2 = **5 jobs per minute**.

**b) Slack Variables and Surplus Variables**

These are terms used in **Linear Programming (LP)**, particularly to **convert inequalities into equalities** for solving using methods like the **Simplex Method**.

**Slack Variables:**

- Added to a **"less than or equal to" (≤)** constraint to convert it into an equation.

- Represents **unused resources**.

- Example:
  Constraint: `x + y ≤ 10`
  Add slack variable `s`: `x + y + s = 10`, where `s ≥ 0`

**Surplus Variables:**

- Subtracted from a **"greater than or equal to" (≥)** constraint to convert it into an equation.

- Represents **excess above a minimum requirement**.

- Example:
  Constraint: `x + y ≥ 10`
  Add surplus variable `s`: `x + y - s = 10`, where `s ≥ 0`

**Q6. Define: -**
**a) Linear programming problem**
**b) Sequencing problem**
**c) Degeneracy in LPP**
**Ans.**

**a) Linear Programming Problem (LPP):**

A **Linear Programming Problem** is a mathematical technique used to **maximize or minimize** a **linear objective function**, subject to a set of **linear equality or inequality constraints**.

**Standard Form:**

Maximize or Minimize:

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$$Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n$$

Subject to:

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n &\leq b_1 \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n &\leq b_2 \\ &\vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n &\leq b_m \\ x_1, x_2, \ldots, x_n &\geq 0 \end{aligned}$$

**b) Sequencing Problem:**

A **Sequencing Problem** involves determining the **optimal order** in which tasks or jobs should be performed to **minimize total time, cost, or other resources**.

**Common goals:**

- Minimize **total completion time**
- Minimize **waiting time**
- Minimize **idle time** on machines

**c) Degeneracy in LPP:**

**Degeneracy** occurs in a Linear Programming Problem when the **basic feasible solution** has **one or more basic variables equal to zero**.

**Why it matters:**

- Degeneracy can cause **cycling** in the Simplex Method (i.e., the algorithm goes in loops without progressing).
- It can also **delay convergence** to the optimal solution.

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**I.P. (P.G) College Campus-2, Bulandshahr**
**Department of Computer Science**
**Sessional Exam May -2025**
**Mathematics-III (BCA-406)**

**SECTION A (Quiz questions)**

1. Modulus of $\frac{1+i}{1-i}$:
   a) -1 b) 0 c) 1 d) 1/2
2. If $z = x + iy$, then $|z|$ is given by
   a) $\sqrt{x^2 - y^2}$ b) $\sqrt{y^2 - x^2}$ c) $\sqrt{x^2 + y^2}$ d) $\sqrt{x + y}$
3. If $z_1$ and $z_2$ are any two complex numbers ,then value of $\left|\frac{z_1}{z_2}\right|$ is :
   a) $|z_1|.|z_2|$ b) $\frac{|z_1|}{|z_2|}$ c) $\frac{|z_2|}{|z_1|}$ d) $|z_1| + |z_2|$
4. If $z_1$ and $z_2$ are any two complex numbers ,then value of $\arg\left(\frac{z_1}{z_2}\right)$ is :
   a) $\arg(z_1) - \arg(z_2)$ b) $\arg(z_2) - \arg(z_1)$ c) $\arg(z_1) + \arg(z_2)$ d) $\frac{argz_1}{argz_2}$
5. The Fourier series of an even function of period $2\pi$ is a :
   a) Fourier cosine series b) Fourier sine series c) Fourier complex series d) none of these
6. The Fourier series of an odd function of period 2L is a :
   a) Fourier cosine series b) Fourier sine series c) Fourier complex series d) none of these
7. In Fourier series $f(x) = \frac{a_0}{2} + \sum_1^\infty (a_n cosnx + b_n sinnx)$, Euler formula is :
   a) $a_0 = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)dx$ b) $a_0 = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)cosnxdx$ c) $a_0 = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)sinnxdx$ d) none
8. In Fourier series $f(x) = \frac{a_0}{2} + \sum_1^\infty (a_n cosnx + b_n sinnx)$, Euler formula is :
   a) $a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)dx$ b) $a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)cosnxdx$ c) $a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)sinnxdx$ d) none
9. In Fourier series $f(x) = \frac{a_0}{2} + \sum_1^\infty (a_n cosnx + b_n sinnx)$, Euler formula is :
   a) $b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)dx$ b) $b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)cosnxdx$ c) $b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)sinnxdx$ d) none
10. For exact differential equation of the form $Mdx + Ndy = 0$-
    a) $\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$ b) $\frac{\partial M}{\partial x} = \frac{\partial N}{\partial y}$ c) $\frac{\partial M}{\partial y} + \frac{\partial N}{\partial x} = 0$ d) none of these
11. The order of differential equation is always –
    a) Positive integer b) negative integer c) irrational number d) none of these
12. The number of arbitrary constants in the particular solution of a differential equation of third order is :
    a) 3 b) 2 c) 1 d) 0
13. The vector field $\vec{F}$ is solenoidal if
    a) $\nabla \times \vec{F} = 0$ b) $\nabla.\vec{F} = 0$ c) $\nabla^2\vec{F} = 0$ d) none of these
14. Divergence and curl of a vector field are respectively
    a) Vector and scalar b) scalar and scalar c) vector and vector d) scalar and vector
15. A vector field $\vec{F}$ is irrotational if
    a) $\nabla \times \vec{F} = 0$ b) $\nabla.\vec{F} = 0$ c) $\nabla^2\vec{F} = 0$ d) none of these
16. For a vector field $\vec{F}$ if $\vec{F} = \nabla\emptyset$ then $\emptyset$ is called –
    a) Curl of $\vec{F}$ b) scalar potential function of $\vec{F}$ c) div$\vec{F}$ d) solenoidal
17. If $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ , then $\nabla.\vec{r}$ = ?
    a) 0 b) 3 c) -3 d) 1
18. If $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ , then $\nabla \times \vec{r}$ = ?
    a) 0 b) 3 c) -3 d) 1
19. Which is the I.F. for the differential equation $\frac{dy}{dx} + py = q$ ?
    a) $e^{-\int pdx}$ b) $e^{\int qdx}$ c) $e^{\int pdx}$ d) $e^{-\int qdx}$
20. The order and degree of $\left(\frac{d^3y}{dx^3}\right)^2 + \left(\frac{d^2y}{dx^2}\right)^3 + y = 0$ are :
    a) 3,2 b) 2,3 c) 3, not defined d) none of these
21. The complete solution can be obtained by :
    a) C.F. b) P.I. c) C.F.+ P.I. d) none of these

22. An equation of the type $\frac{dy}{dx} + Py = Qy^n$

a) linear b) homogeneous c) exact d) Bernoulli's differential equation

23. $\frac{1}{D}\sin x =$.....

a) Sinx b) 0 c) cosx d) −cosx

24. Infinite series $1 + \frac{1}{2} + \frac{1}{2^2} + \frac{1}{2^3} + \cdots$ ..... is

a) Divergent b) convergent c) Oscillatory d) none of these

25. The general solution of a differential equation includes arbitrary constants. T True/False

26. All bounded sequences are convergent. F True/False

27. Gradient is a vector Quantity. T True/False

28. Fourier series can be used to represent non-periodic functions. F True/False

29. Every first order linear differential equation can be solved using an integrating factor. F True/False

30. Cauchy's Integral test can be applied to any series without restriction . F True/False

## SECTION-B (Short Type questions)

1. If $Z_1$ and $Z_2$ are complex numbers then prove that: $|Z_1 + Z_2|^2 + |Z_1 - Z_2|^2 = 2\{ |Z_1|^2 + |Z_2|^2 \}$
2. Compute square root of Z = -1-i.
3. Show that $\nabla r^{-3} = -3r^{-5}\vec{r}$ .
4. Solve : $(x\log x)\frac{dy}{dx} + y = 3x^3$ .
5. Solve : $\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 3y = e^{-3x}$.
6. Solve : $x(e^y + 4)dx + e^{x+y}dy = 0$ .

## SECTION-C (Long Type questions)

1. Express $\tan^{-1}(x + iy)$as the sum of real and imaginary parts .
2. Find the directional derivative of $f(x, y, z) = x^2 + y^2 + z^2$ at the point (1,2,3) in the direction of the vector $3\hat{\imath} + 4\hat{\jmath} + 10\hat{k}$ .
3. Obtain the Fourier series for the function $f(x) = \frac{\pi - x}{2}$, in the interval $(0,2\pi)$ and hence deduce that

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} \ldots\ldots\ldots\ldots\ldots\ldots$$

4. Solve : $(1 + y^2)dx - (\tan^{-1}y - x)dy = 0$ .
5. Solve : $\frac{d^3y}{dx^3} + 2\frac{d^2y}{dx^2} + \frac{dy}{dx} = e^{2x} + x^2 + x$ .
6. If $\vec{f} = \frac{x\hat{\imath} + y\hat{\jmath} + z\hat{k}}{\sqrt{x^2+y^2+z^2}}$, find the value of $\nabla.\vec{f}$and $\nabla \times \vec{f}$

Page No.
Date

## Section-B

**Q1-** If $z_1$ and $z_2$ are complex number, prove that $|z_1+z_2|^2 + |z_1-z_2|^2 = 2\{|z_1|^2+|z_2|^2\}$

prove →

**Solve →** $|z_1+z_2|^2 + |z_1-z_2|^2 = 2\{|z_1|^2+|z_2|^2\}$

L.H.S ⇒ $|z_1+z_2|^2 + |z_1-z_2|^2$

$= (z_1+z_2)(\overline{z_1+z_2}) + (z_1-z_2)(\overline{z_1-z_2})$

$[\because |z|^2 = z\bar{z}]$

$= (z_1+z_2)(\bar{z}_1+\bar{z}_2) + (z_1-z_2)(\bar{z}_1-\bar{z}_2)$

$[\because (\overline{z_1+z_2}) = \bar{z}_1+\bar{z}_2]$

$= z_1\bar{z}_1 + \cancel{z_1\bar{z}_2} + \cancel{z_2\bar{z}_1} + z_2\bar{z}_2 + z_1\bar{z}_1 - \cancel{z_1\bar{z}_2}$
$- \cancel{z_2\bar{z}_1} + z_2\bar{z}_2$

$= 2z_1\bar{z}_1 + 2z_2\bar{z}_2$

$= 2(z_1\bar{z}_1 + z_2\bar{z}_2)$

$= \boxed{2\{|z_1|^2 + |z_2|^2\} = \text{R.H.S} = \text{proved}}$

Page No.
Date

**Q2-** Compute Square root of $z = -1-i$

**Solve-** $\sqrt{z} = w = a + ib$ $\quad [(a+b)^2 = a^2 + b^2 + 2ab]$

We want:

$(a+ib)^2 = -1-i$

$a^2 + 2abi + (bi)^2 = a^2 + b^2 + 2abi$

Compare it from right side

$a^2 - b^2 = -1$ —— (I)

$2ab = -1$ —— (II)

from eqn (II)

$2ab = -1$

$b = \frac{-1}{2a}$

Put the value of b in eqn (I)

$a^2 - \left(\frac{-1}{2a}\right)^2 = -1$

$a^2 - \frac{1}{4a^2} = -1$

Multiply by $4a^2$

$4a^4 - 1 = -4a^2$

$4a^4 + 4a^2 - 1 = 0$

let $x = a^2$

$4x^2 + 4x - 1 = 0$

Solve it using quadratic formula

Page No.
Date

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-4 \pm \sqrt{4^2 - 4(4)(-1)}}{2(4)}$$

$$x = \frac{-4 \pm \sqrt{32}}{8}$$

$$x = \frac{-4 \pm 4\sqrt{2}}{8}$$

$$x = \frac{\cancel{4}(-1 + \sqrt{2})}{\cancel{8}\ 2}$$

$$x = \frac{-1 + \sqrt{2}}{2}$$

$a^2$ must be positive so we take positive root

$$a^2 = \frac{-1 + \sqrt{2}}{2}$$

$$a = \pm \sqrt{\frac{-1 + \sqrt{2}}{2}}$$

$$a = \sqrt{\frac{\sqrt{2} - 1}{2}}$$ then,

$$b = \frac{-1}{2\sqrt{\frac{\sqrt{2} - 1}{2}}}$$ [∵ The square root of 4 is 2]

Page No.
Date

$$b = -\sqrt{\frac{1}{\cancel{4}_{2}\left(\frac{\sqrt{2}-1}{\cancel{2}}\right)}}$$

$$b = -\sqrt{\frac{1}{2(\sqrt{2}-1)}}$$

$$b = -\sqrt{\frac{1}{2(\sqrt{2}-1)} \times \frac{(\sqrt{2}+1)}{(\sqrt{2}+1)}}$$

$$b = -\sqrt{\frac{\sqrt{2}+1}{2 \times (\sqrt{2}-1)(\sqrt{2}+1)}}$$

$$[\because (a+b)(a-b) = a^2 - b^2]$$

$$b = -\sqrt{\frac{\sqrt{2}+1}{2 \times (\sqrt{2}-1)(\sqrt{2}+1)}}$$

$$b = -\sqrt{\frac{\sqrt{2}+1}{2\{(\sqrt{2})^2 - 1^2\}}}$$

$$b = -\sqrt{\frac{\sqrt{2}+1}{2(2-1)}}$$

$$b = -\sqrt{\frac{\sqrt{2}+1}{2}}$$

The square root is

$$\boxed{\sqrt{\frac{\sqrt{2}-1}{2}} - i\sqrt{\frac{\sqrt{2}+1}{2}}}$$

Page No.
Date

Q3- Show that $\nabla r^{-3} = -3 r^{-5} \vec{r}$.

Solve → L.H.S ⇒ $\nabla r^{-3}$

$$= \nabla \frac{1}{r^3} \qquad \boxed{\because \nabla = i\frac{\partial}{\partial x} + j\frac{\partial}{\partial y} + k\frac{\partial}{\partial z}}$$

$$= \left(i\frac{\partial}{\partial x} + j\frac{\partial}{\partial y} + k\frac{\partial}{\partial z}\right)\frac{1}{r^3}$$

$$= i\frac{\partial}{\partial x}\left(\frac{1}{r^3}\right) + j\frac{\partial}{\partial y}\left(\frac{1}{r^3}\right) + k\frac{\partial}{\partial z}\left(\frac{1}{r^3}\right)$$

$$= i\left(\frac{-3}{r^4}\frac{\partial r}{\partial x}\right) + j\left(\frac{-3}{r^4}\frac{\partial r}{\partial y}\right) + k\left(\frac{-3}{r^4}\frac{\partial r}{\partial z}\right) \quad \text{—— (1)}$$

$$= \frac{-3}{r^4}\left(i\frac{\partial r}{\partial x} + j\frac{\partial r}{\partial y} + k\frac{\partial r}{\partial z}\right)$$

$$\because \vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \quad \text{—— (2)}$$

$|\vec{r}|$ or $r$ →

$$r = \sqrt{x^2 + y^2 + z^2}$$

Square on Both side

$$r^2 = x^2 + y^2 + z^2$$

Diff w.r.t $x$ —

$$2r\frac{\partial r}{\partial x} = 2x$$

$$\frac{\partial r}{\partial x} = \frac{x}{r}$$

Similary → $\frac{\partial r}{\partial y} = \frac{y}{r}$

Page No.
Date

$$\frac{\partial r}{\partial z} = \frac{z}{r}$$

from eqn (1)

$$= \frac{-3}{r^4}\left(i\frac{x}{r} + j\frac{y}{r} + k\frac{z}{r}\right)$$

$$= \frac{-3}{r^5}\left(xi + yj + kz\right)$$

from eqn (2)

$$= \frac{-3}{r^5}\vec{r}$$

$$= \boxed{-3r^{-5}\vec{r} = R.H.S}$$ proved

$$x \log x \frac{dy}{dx} + y = 3x^3$$

divide by $x \log x$

$$\frac{dy}{dx} + \cancel{x\log x}\ \frac{1}{x\log x} y = \frac{3x^3}{x\log x}$$

on comparing with general Equation we get

$$P = \frac{1}{x\log x} \qquad Q = \frac{3x^2}{\log x}$$

$$I.f = e^{\int P dx} = e^{\int \frac{1}{x\log x} dx}$$

let $u = \log x$

$$\frac{du}{dx} = \frac{1}{x} dx$$

$$e^{\int \frac{1}{u} du} = \int e^{\log u} = u \Rightarrow \log x$$

The solution is

$$y \cdot I.f = \int I.F \times Q\, dx + C$$

$$y \cdot \log x = \int \cancel{\log x} \times \frac{3x^2}{\cancel{\log x}} dx$$

$$y \log x = \frac{\cancel{3}x^3}{\cancel{3}} + C$$

$$\boxed{y = \frac{x^3 + C}{\log x}}$$

Page No.
Date

Q5- Solve → $\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 3y = e^{-3x}$

Solu → $\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 3y = e^{-3x}$

$D^2y + 4Dy + 3y = e^{-3x}$

$(D^2 + 4D + 3)y = e^{-3x}$

Auxiliary equation → $(D = m, y = 1, B = 0)$

$m^2 + 4m + 3 = 0$

$m^2 + 3m + m + 3 = 0$

$m(m+3) + 1(m+3) = 0$

$(m+1)(m+3) = 0$.

$m = -1, -3$

$C.F = C_1e^{-x} + C_2e^{-3x}$ — (1)

$P.I = \frac{1}{D^2+4D+3} e^{-3x}$

$\boxed{\because \frac{1}{f(D)} e^{ax} = \frac{e^{ax}}{f(a)}}$

$= \frac{e^{-3x}}{(-3)^2 + 4\times(-3) + 3}$

$= \frac{e^{-3x}}{9 - 12 + 3 = 0}$

→ Denominator is 0 we can'not apply this

$= \frac{1}{(D+1)(D+3)} e^{-3x}$

$= \frac{1}{(-3+1)(D+3)} e^{-3x}$

$$= -\frac{1}{2}\left(\frac{1}{D+3}e^{-3x}\right)$$

$$= \frac{-e^{-3x}}{2}\left(\frac{1}{D-3+3}\right)$$

$$= \frac{-e^{-3x}}{2}\left(\frac{1}{D}\cdot 1\right)$$

$$P.I = \frac{-xe^{-3x}}{2} \quad \text{--- (ii)}$$

from eqn (i) and (ii)

$$y = C.F + P.I$$

$$\boxed{y = c_1e^{-x} + c_2e^{-3x} - \frac{xe^{-3x}}{2}}$$

Page No.
Date

**Q6-** Solve :- $x(e^y+4)\,dx + e^{x+y}\,dy = 0$

**Solve →** $x(e^y+4)\,dx + e^{x+y}\,dy = 0$

$$x(e^y+4)\,dx = -e^{x+y}\,dy$$

$$\frac{dy}{dx} = -\frac{x(e^y+4)}{e^{x+y}}$$

$$\frac{dy}{dx} = \frac{-x(e^y+4)}{e^x \cdot e^y}$$

$$\frac{e^y}{e^y+4}\,dy = -\frac{x}{e^x}\,dx$$

Integration on both side

$$\int \frac{e^y}{e^y+4}\,dy = \int -\frac{x}{e^x}\,dx$$

$$\log(e^y+4) = \int \underset{I}{-x}\,\underset{II}{e^{-x}}\,dx$$

$$\left[\because \int \frac{f'(x)}{f(x)}\,dx = \log\{f(x)\}\right]$$

$$\left[\int I\,II\,dx = I\int II - \int\left\{\left(\frac{d}{dx}(I)\right)\int II\right\}dx\right]$$

$$\log(e^y+4) = -\left[-xe^{-x} - \int (1)(-e^{-x})\,dx\right] + c$$

$$\boxed{\log(e^y+4) = xe^{-x} + e^x + c}$$

Page No.
Date

## Section - C

**Q1-** Express $\tan^{-1}(x+iy)$ as the sum of real and imaginary parts.

**Solu →** let $\tan^{-1}(x+iy) = A + iB$ — (I)

then $\tan^{-1}(x-iy) = A - iB$ — (II)

add eqⁿ (I) and (2),

$$2A = \tan^{-1}(x+iy) + \tan^{-1}(x-iy)$$

$$2A = \tan^{-1}\left[\frac{x+\cancel{iy}+x-\cancel{iy}}{1-(x+iy)(x-iy)}\right]$$

$$\boxed{\because \tan^{-1}A + \tan^{-1}B = \tan^{-1}\left(\frac{A+B}{1-AB}\right)}$$

$$\boxed{A = \frac{1}{2}\tan^{-1}\left(\frac{2x}{1-x^2-y^2}\right)}$$

Subtract eqⁿ (II) from (I),

$$2iB = \tan^{-1}(x+iy) - \tan^{-1}(x-iy).$$

$$2iB = \tan^{-1}\left(\frac{x+iy-x+iy}{1+(x+iy)(x-iy)}\right)$$

$$\boxed{\because \tan^{-1}A - \tan^{-1}B = \tan^{-1}\left(\frac{A-B}{1+AB}\right)}$$

$$2iB = \tan^{-1}\left(\frac{2iy}{1+x^2+y^2}\right)$$

$$\tan(2iB) = \frac{2iy}{1+x^2+y^2}$$

Page No.
Date

$$i\tan(2B) = \frac{2iy}{1+x^2+y^2}$$

$$\tan(2B) = \frac{2y}{1+x^2+y^2}$$

$$\boxed{B = \frac{1}{2}\tanh^{-1}\left(\frac{2y}{1+x^2+y^2}\right)}$$

$\tan^{-1}(x+iy)$ as the sum of real and imaginary parts

$$= A + iB$$

$$= \boxed{\frac{1}{2}\tan^{-1}\left(\frac{2x}{1-x^2-y^2}\right) + i.\ \frac{1}{2}\tanh^{-1}\left(\frac{2y}{1+x^2+y^2}\right)}$$

Page No.
Date

Q2- find the directional derivative of $f(x, y, z) = x^2 + y^2 + z^2$ at the points $(1, 2, 3)$ in the direction of the vector $3\hat{i} + 4\hat{j} + 10\hat{k}$.

Solu→ $f = x^2 + y^2 + z^2$

$$\nabla f = \left(i\frac{\partial}{\partial x} + j\frac{\partial}{\partial y} + k\frac{\partial}{\partial z}\right) f$$

$$\nabla f = i\frac{\partial f}{\partial x} + j\frac{\partial f}{\partial y} + k\frac{\partial f}{\partial z}$$

$$\nabla f = 2xi + 2yj + 2zk$$

At point $(1, 2, 3)$

$$\nabla f = (2 \times 1)i + (2 \times 2)j + (2 \times 3)k$$

$$\boxed{\nabla f = 2i + 4j + 6k}$$

$$\vec{a} = 3\hat{i} + 4\hat{j} + 10\hat{k}$$

$$|\vec{a}| = \sqrt{3^2 + 4^2 + 10^2}$$

$$|\vec{a}| = \sqrt{9 + 16 + 100}$$

$$|\vec{a}| = \sqrt{125}$$

$$|\vec{a}| = 15$$

$$\hat{a} = \frac{\vec{a}}{|\vec{a}|} \Rightarrow \hat{a} = \frac{3\hat{i} + 4\hat{j} + 10\hat{k}}{15}$$

Page No.
Date

Directional derivative of f in the direction of $\vec{a}$ at the point (1, 2, 3) =

$$\nabla f \cdot \hat{a}$$

$$= (2i + 4j + 6k) \cdot \frac{(3i + 4j + 10k)}{15}$$

$$= \frac{1}{15}(6 + 16 + 60)$$

$$= \frac{82}{15} \text{ Ans.}$$

2022 Q3 → Obtain the Fourier series of $f(x) = \left(\frac{\pi - x}{2}\right)$ in the interval $(0, 2\pi)$ and hence deduce $\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots$

Solve → fourier series of $f(x)$ is given by →

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos nx + \sum_{n=1}^{\infty} b_n \cos nx$$

$$a_0 = \frac{1}{\pi}\int_0^{2\pi} f(x)\,dx$$

$$a_0 = \frac{1}{\pi}\int_0^{2\pi} \left(\frac{\pi - x}{2}\right) dx$$

$$a_0 = \frac{1}{2\pi}\int_0^{2\pi} (\pi - x)\,dx$$

$$a_0 = \frac{1}{2\pi}\left(\pi x - \frac{x^2}{2}\right)_0^{2\pi}$$

$$a_0 = \frac{1}{2\pi}\left[\left(2\pi^2 - \frac{4\pi^2}{2}\right) - (0 - 0)\right]$$

$$a_0 = \frac{1}{2\pi} \times 0 \Rightarrow \boxed{a_0 = 0}$$

$$a_n = \frac{1}{\pi}\int_0^{2\pi} f(x)\cos nx\,dx$$

$$a_n = \frac{1}{\pi}\int_0^{2\pi}\left(\frac{\pi - x}{2}\right)\cos nx\,dx$$

$$a_n = \frac{1}{2\pi}\int_0^{2\pi}\underset{I}{(\pi - x)}\,\underset{II}{\cos nx}\,dx$$

$$\boxed{\int I\cdot II\,dx = I\int II - \int\left(\frac{dI}{dx}\int II\,dx\right)}$$

$$a_n = \frac{1}{2\pi}\left[\left[(\pi - x)\frac{\sin nx}{n}\right]_0^{2\pi} - \int_0^{2\pi}(-1)\frac{\sin nx}{n}\,dx\right]$$

$$a_n = \frac{1}{2\pi}\left[\left[\frac{\pi\sin nx}{n} - \frac{x\sin nx}{n}\right]_0^{2\pi} + \frac{1}{n}\left[-\frac{\cos nx}{n}\right]_0^{2\pi}\right]$$

$$a_n = \frac{1}{2\pi}\left[[0 - 0] + \frac{-1}{n^2}(\cos 2n\pi - \cos 0)\right]$$

$$\boxed{\begin{aligned} &\because \sin 2n\pi = 0 \\ &\because \cos 2n\pi = 1 \end{aligned}}$$

$$a_n = \frac{1}{2\pi}\left[\frac{-1}{n^2}(1-1)\right]$$

$$\boxed{a_n = 0}$$

$$b_n = \frac{1}{\pi}\int_0^{2\pi} f(x)\sin nx\,dx$$

$$b_n = \frac{1}{\pi}\int_0^{2\pi}\left(\frac{\pi - x}{2}\right)\sin nx\,dx$$

$$b_n = \frac{1}{2\pi}\int_0^{2\pi} \underset{I}{(\pi - x)}\ \underset{II}{\sin nx}\,dx$$

Page No.
Date

$$b_n = \frac{1}{2\pi}\left[\left\{(\pi - x)\frac{-\cos nx}{n}\right\}_0^{2\pi} - \int_0^{2\pi}(-1)\left(\frac{-\cos nx}{n}\right)dx\right]$$

$$b_n = \frac{1}{2\pi}\left[\frac{-1}{n}\left(-\pi\cos 2n\pi - \pi\cos 0\right) - \frac{1}{n}\left(\frac{\sin nx}{n}\right)_0^{2\pi}\right]$$

$$b_n = \frac{1}{2\pi}\left[\frac{-1}{n}\left(-\pi\times 1 - \pi\times 1\right) - \frac{1}{n}(0-0)\right]$$

$$b_n = \frac{1}{2\cancel{\pi}}\left[\frac{-1}{n}(-2\cancel{\pi})\right]$$

$$b_n = \frac{1}{n}$$

The required Fourier series is -

$$f(x) = \sum_{n=1}^{\infty}\frac{1}{n}\sin nx$$

$$\frac{1}{2}(\pi - x) = \frac{1}{1}\sin x + \frac{1}{2}\sin 2x + \frac{1}{3}\sin 3x + \cdots$$

$$\boxed{\text{Put } x = \frac{\pi}{2}}$$

$$\frac{1}{2}\left(\pi - \frac{\pi}{2}\right) = \frac{1}{1}\sin\frac{\pi}{2} + \frac{1}{2}\sin 2\times\frac{\pi}{2} + \frac{1}{3}\sin 3\times\frac{\pi}{2} + \cdots$$

$$\frac{1}{2}\left(\frac{\pi}{2}\right) = 1 + 0 - \frac{1}{3} + 0 \cdots$$

$$\boxed{\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} + \cdots}$$ proved

Page No.
Date

Q4→ Solve $(1+y^2)dx - (\tan^{-1}y - x)dy = 0$

$\Rightarrow (1+y^2)dx - (\tan^{-1}y - x)dy = 0$

$$\frac{dx}{dy} = \frac{\tan^{-1}y - x}{1+y^2}$$

$$\frac{dx}{dy} = \frac{\tan^{-1}y}{1+y^2} - \frac{x}{1+y^2}$$

$$\frac{dx}{dy} + \frac{x}{1+y^2} = \frac{\tan^{-1}y}{1+y^2}$$

Compare with $\frac{dx}{dy} + Px = Q$

$$P = \frac{1}{1+y^2}, \quad Q = \frac{\tan^{-1}y}{1+y^2}$$

$$I.F = e^{\int P\,dy}$$

$$I.F = e^{\int \frac{1}{1+y^2}dy}$$

$$I.F = e^{\tan^{-1}y}$$

The solution is –

$$x \times I.F = \int I.F \times Q \, dy + c$$

$$x \times e^{\tan^{-1} y} = \int e^{\tan^{-1} y} \frac{\tan^{-1} y}{1+y^2}\, dy + c$$

let $\tan^{-1} y = t$

$$\frac{1}{1+y^2} \frac{dy}{dt} = 1$$

$$\frac{1}{1+y^2}\, dy = dt$$

$$x \times e^{\tan^{-1} y} = \int \underset{II}{e^t} \cdot \underset{I}{t}\, dt + c$$

$$\boxed{\int I\, II\, dx = I \int II - \int \left\{ \left\{ \frac{d}{dx} I \right\} \int II \right\} dx}$$

$$x \times e^{\tan^{-1} y} = e^t t - \int (1) e^t\, dt + c$$

$$x \times e^{\tan^{-1} y} = e^t t - e^t + c$$

$$\boxed{\text{put } t = \tan^{-1} y}$$

$$x e^{\tan^{-1} y} = e^{\tan^{-1} y} \tan^{-1} y - e^{\tan^{-1} y} + c$$

$$x e^{\tan^{-1} y} = e^{\tan^{-1} y} (\tan^{-1} y - 1) + c$$

Divide by $e^{\tan^{-1} y}$

$$\boxed{x = \tan^{-1} y - 1 + \frac{c}{e^{\tan^{-1} y}}}$$

Page No.
Date

Q5- Solve $\frac{d^3y}{dx^3} + 2\frac{d^2y}{dx^2} + \frac{dy}{dx} = e^{2x} + x^2 + x$

Solve A/E is $\frac{d^3y}{dx^3} + 2\frac{d^2y}{dx^2} + \frac{dy}{dx} =$

$m^3 + 2m^2 + m$

$(D^3 + 2D + D)y = e^{2x} + x^2 + x$

A E is -

$m^3 + 2m^2 + m = 0$

$m(m^2 + 2m + 1) = 0$

$m(m+1)^2 = 0$

$m = 0, -1, -1$

$C.F = c_1 e^{0 \cdot x} + [c_2 + x c_3]e^{-x}$ — (1)

$P.I = \frac{1}{D^3 + 2D^2 + D} e^{2x} + x^2 + x$

$= \frac{1}{D^3 + 2D^2 + D} e^{2x} + \frac{1}{D^3 + 2D^2 + D}(x^2 + x)$

$= \frac{1}{D^3 + 2D^2 + D} e^{2x} + \frac{1}{D(1 + D^2 + 2D)}(x^2 + x)$

$= \frac{e^{2x}}{2^3 + 2 \times 2^2 + 2} + \frac{1}{D}[1 + (D^2 + 2D)]^{-1}(x^2 + x)$

$= \frac{e^{2x}}{18} + \frac{1}{D}[1 - (D^2 + 2D) + (D^2 + 2D^2) + \dots](x^2 + x)$

$= \frac{e^{2x}}{18} + \frac{1}{D}[(x^2 + x) - (D^2 + 2D)(x^2 + x) + (D^4 + 4D^2 + 4D^3)(x^2 + x) + \dots$

$= \frac{e^{2x}}{18} + \frac{1}{D}[(x^2 + x) - \{2 + 2 \cdot (2x + 1)\} + \{0 + 4(2) + 0\} + 0]$

$$= \frac{e^{2x}}{18} + \frac{1}{D}\left[x^2 + x - (2 + 4x + 2) + 8\right]$$

Page No.
Date

$$= \frac{e^{2x}}{18} + \frac{1}{D}\left[x^2 - 3x + 4\right]$$

$$P.I = \frac{e^{2x}}{18} + \frac{x^3}{3} - \frac{3x^2}{2} + 4x$$

$$y = C.F + P.I$$

$$\boxed{y = c_1 e^{0 \cdot x} + [c_2 + x c_3] e^{-x} + \frac{e^{2x}}{18} + \frac{x^3}{3} - \frac{3x^2}{2} + 4x}$$

Q 6 If $\vec{f} = \dfrac{x\hat{i} + y\hat{j} + z\hat{k}}{\sqrt{x^2+y^2+z^2}}$, find the value of $\nabla\cdot\vec{f}$ and $\nabla\times\vec{f}$

Solu→ let $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

$$r = |\vec{r}| = \sqrt{x^2+y^2+z^2}$$

$$\vec{f} = \frac{\vec{r}}{r}$$

(i) $\nabla\cdot\vec{f} = \nabla\cdot\left(\frac{1}{r}\vec{r}\right) = \frac{1}{r}(\nabla\cdot\vec{r}) + \left(\nabla\frac{1}{r}\right)\cdot\vec{r}$

$$= \frac{1}{r}(3) + \left[\frac{-1}{r^2}\nabla r\right]\cdot\vec{r} \qquad [\because \nabla\cdot\vec{r} = 3]$$

$$= \frac{3}{r} - \frac{1}{r^2}\left[i\frac{\partial r}{\partial x} + j\frac{\partial r}{\partial y} + k\frac{\partial r}{\partial z}\right]\cdot\vec{r}$$

$$= \frac{3}{r} - \frac{1}{r^2}\left[\frac{xi + yj + zk}{r}\right]\cdot\vec{r}$$

$$= \frac{3}{r} - \frac{1}{r^3}\vec{r}\cdot\vec{r}$$

$$= \frac{3}{r} - \frac{1}{r^3}r^2 = \frac{3}{r} - \frac{1}{r} = \frac{2}{r}$$

$$\boxed{\nabla\cdot\vec{f} = \frac{2}{r}}$$

(ii) $\nabla\times\vec{f} = \nabla\times\left(\frac{1}{r}\vec{r}\right)$

$$= \frac{1}{r}(\nabla\times\vec{r}) + \left(\nabla\frac{1}{r}\right)\times\vec{r}$$

$$= \frac{1}{r}[0] - \frac{\vec{r}}{r^3} \times \vec{r}$$

$$\left[\because \nabla \times \vec{r} = 0 \text{ and } \nabla \frac{1}{r} = \frac{-\vec{r}}{r^3}\right]$$

$$= 0 - \frac{1}{r^3}(\vec{r} \times \vec{r})$$

$$\boxed{\nabla \times \vec{f} = 0}$$

# OS Notes By Fazal Ali

**1. An operating system is the interface between**

a) user and software b) user and CPU

**c) user and hardware** d) CPU and monitor

**2. A program in execution is called a__**

**a) process** b) procedure

c) instruction d) function

**3. A binary semaphore has a value of**

a) 0 b) 1

**c) 'a' or 'b'** d) 2

**4. Which of the following is not an OS?**

a) Linux b) DOS

**c) Oracle** d) Windows

**5. The most optimal CPU scheduling algorithm is_____**

**a) SJF** b) FCFS

c) Round Robin d) None

**6. The example of Input device**

a) Joystick b) keyboard

c) Magnetic stripe reader **d) all of above**

**7. Thread is a__**

**a) light-weight process** b) heavy-weight process

c) Multi-process d) I/O process

**8. What does FAT mean?**

a) File format attribute b) Font allocation tree

**c) File allocation table** d) Font attribute table

**9. The SUSPEND service is called as:-**

a) SLEEP b) BLOCK

**c) ‘a’ and ‘b’ both** d) none of them

**10. Who needs a BIOS to function properly?**

a) A mobile device **b) An operating system**

c) Hardware device d) All of the above

**11. CPU performance is measured through____**

**a) Throughput** b) MHz

c) Flaps d) none of the above

**12. PCB stand for___**

a) Program Control Block **b) Process Control Block**

c) Process Communication Block d) none of the above

**13. The Operating System manages___**

a) Memory b) Processor

c) Disk and I/O devices **d) all of the above**

**14. Virtual Memory is commonly implemented by_____**

a) Segmentation b) Swapping

**c) Demand Paging** d) none of the above

**15. ___page replacement algorithm suffers from Belady's anamoly.**

a) LRU b) MRU

**c) FIFO** d) LIFO

**16. Whole part of the operating system dealing with files is known as:**

a) a file b) file naming

**c) file system** d) none of them

**17. A major problem with priority scheduling is___**

a) definite blocking **b) Starvation**

c) low priority d) none of the above

**18. It is not the layer of the operating system.**

a) kernel b) shell

c) application program **d) critical section**

**19. The section of code which accesses shared variables is called as___**

**a) Critical section** b) Block

c) Procedure d) Semaphore

**20. Which is not the state of the process ?**

a) Blocked b) Running

c) Ready **d) Privileged**

**21. The number of processes completed per unit time is known as__**

a) Output **b) Throughput**

c) Efficiency d) Capacity

**22. Who is the supervisor of computer activity?**

a) CPU **b) Operating System**

c) Control Unit d) Application Program

**23. Device driver required in?**

a) register b) main memory

**c) disk** d) cache

**24. FIFO scheduling is a type of:**

a) Pre-emptive scheduling **b) Non-pre-emptive scheduling**

c) Deadline scheduling d) None of the above

**25. Is mutual exclusion required for shareable resources?**

a) Yes **b) No**

c) Maybe d) None

**26. Main memory of a computer system is?**

a) Non-volatile **b) Volatile**

c) Restricted d) Unrestricted

**27. Semaphore can be used for solving___**

a) Wait & Signal b) Deadlock

**c) Synchronization** d) Priority

**28. The Banker's algorithm is used**

a) to rectify deadlock b) to detect deadlock

c) to prevent deadlock **d) to avoid deadlock**

**29. The operating system is the most common type of__ software.**

a) Communication b) Application

**c) System** d) Word processing software

**30. Running multiple programs at the same time is called:**

**a) Multitasking** b) Foreground tasking

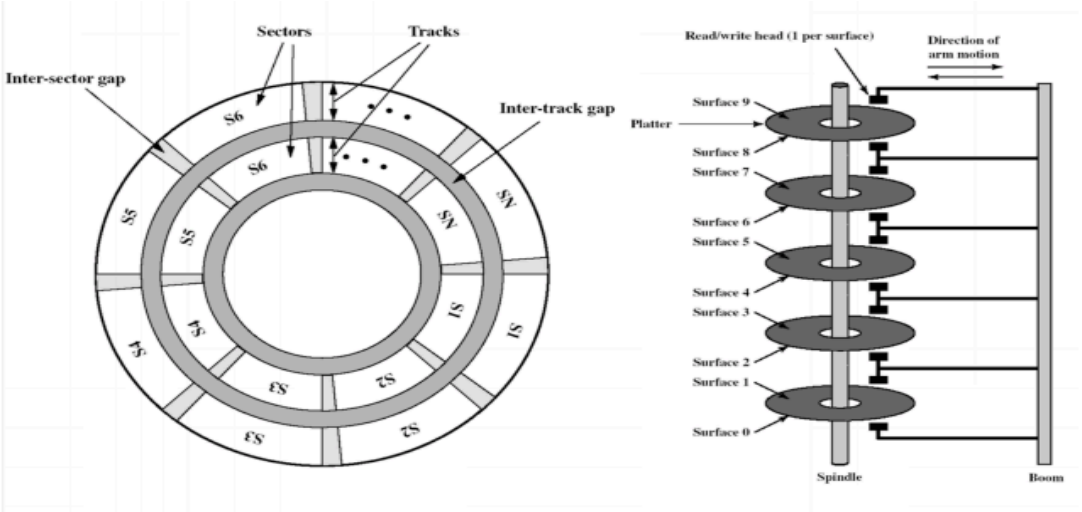
c) Single tasking d) Symmetric

## Section B

**1 .What is fragmentation problem? Describe the external and internal fragmentation**
**.**
**Ans Fragmentation is a memory management issue that occurs when free memory blocks are divided into small, non-contiguous parts, making them inefficient for allocation. It leads to wasted memory and reduces system performance.**
**There are two main types of fragmentation: 1. External Fragmentation 2. Internal Fragmentation**
**External fragmentation occurs when free memory is available, but it is scattered in small, non-contiguous blocks, preventing processes from being allocated even though enough memory exists. Example: Assume a system has total free memory of 400 KB, but it is divided into non-contiguous blocks: ● 100 KB free ● 50 KB free ● 150 KB free ● 100 KB free**
**Now, a process requiring 250 KB cannot be allocated, even though the total free memory is 400 KB, because no single continuous block of 250 KB is available.**

**Internal fragmentation occurs when allocated memory is larger than required, leading to unused space within allocated blocks. Example: If a system allocates fixed memory blocks of 100 KB for processes: ● Process A (Needs 80 KB) → Allocated 100 KB → 20 KB wasted ● Process B (Needs 60 KB) → Allocated 100 KB → 40 KB wasted**

**2. Show disk structure pictorially. Find the total capacity of a disk bared on the disk parameters.**
**Ans :**

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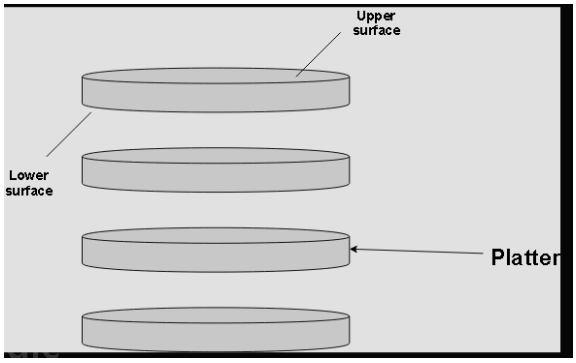
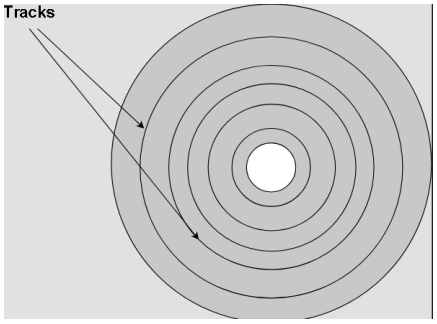
# Disk Structure (Pictorial Overview)

**A typical magnetic hard disk consists of the following physical components and organization:**

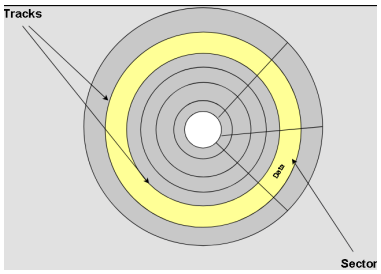



- **Platters: Circular disks coated with magnetic material where data is stored. A disk may have multiple platters stacked vertically.**

- **Surfaces: Each platter has two surfaces (top and bottom) for data storage.**

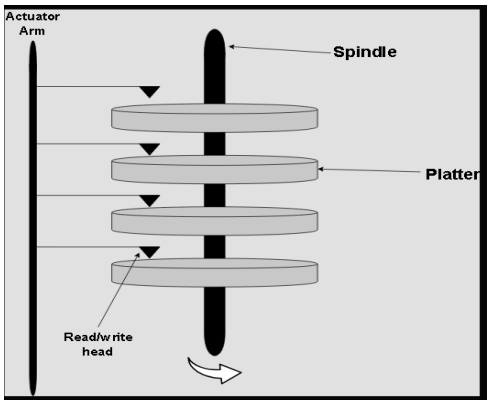



**Tracks: Each surface is divided into concentric circular bands called tracks, numbered from the outer edge inward.**

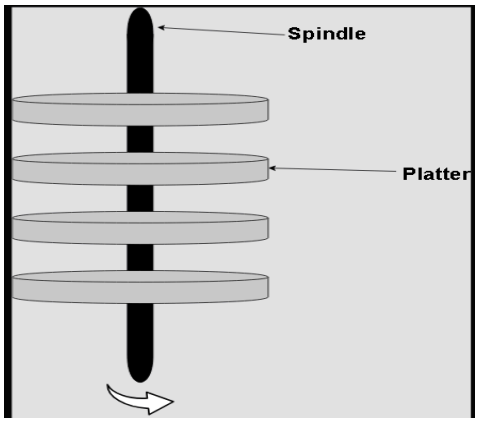



**Sectors: Each track is further divided into pie-shaped segments called sectors, which are the smallest physical storage units (usually 512 bytes each).**

- **Cylinders: A set of tracks with the same track number on all platters forms a cylinder.**




- **Read/Write Heads: Mechanical arms that move across platters to read or write data on the sectors.**




- **Spindle Motor: Rotates the platters at high speed.**

## Calculating Total Disk Capacity Based on Disk Parameters

The total capacity of a disk can be calculated using the following parameters:

- Number of platters (P)
- Number of surfaces per platter (usually 2)
- Number of tracks per surface (T)
- Number of sectors per track (S)
- Number of bytes per sector (B)

Formula:

$$\text{Total Capacity} = P \times \text{Surfaces per platter} \times T \times S \times B$$

**3. What are the basic functions does an OS perform as resource manager?**

**Ans Important functions of an operating System:**
**1. Security – The operating system uses password protection to protect user data and simila other techniques. it also prevents unauthorized access to programs and user data**

**2. Control over system performance –**
**Monitors overall system health to help improve performance. records the response time between service requests and system response to having a complete view of the system health. This can help improve performance by providing important information needed to troubleshoot problems.**

**3. Job accounting – Operating system Keeps track of time and resources used by various tasks and users, this information can be used to track resource usage for a particular user or group of users.**

**4. Error detecting aids – The operating system constantly monitors the system to detect errors and avoid the malfunctioning of a computer system**

**5. Coordination between other software and users – Operating systems also coordinate and assign interpreters, compilers, assemblers, and other software to the various users of the computer systems.**

**6. Memory Management –The operating system manages the Primary Memory or Main Memory. For a program to be executed, it should be first loaded in the main memory. An Operating System performs the following activities for memory management:**
**• It keeps track of primary memory, i.e., which bytes of memory are used by which user program.**
**• The memory addresses that have already been allocated and the memory addresses of the memory that has not yet been used.**
**• In multiprogramming, the OS decides the order in which processes are granted access to memory, and for how long.**
**• It Allocates the memory to a process when the process requests it and deallocates the memory when the process has terminated or is performing an I/O operation.**

**7. Processor Management – In a multi-programmin genvironment, the OS decides the order in which processes have access to the processor, and how much processing time each process has. This function of OS is called process scheduling. An Operating System performs the following**
**activities for processor management.**
**• Keeps track of the status of processes. The program which performs this task is known as a traffic controller.**
**• Allocates the CPU that is a processor to a process.**
**• De-allocates processor when a process is no more required.**

**8. Device Management – An OS manages device communication via their respective drivers. It performs the following activities for device management.**
**• Keeps track of all devices connected to the system.**

**• designates a program responsible for every device known as the Input/Output controller.**
**• Decides which process gets access to a certain device and for how long.**
**• Allocates devices in an effective and efficient way. Deallocates devices when they are no longer required.**

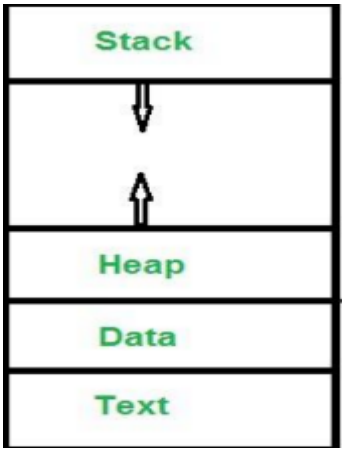
**9. File Management –**
**A file system is organized into directories for efficient or easy navigation and usage. These directories may contain other directories and other files. An Operating System carries out the following file management activities.**

**• It keeps track of where information is stored, user access settings and status of every file, and more... These facilities are collectively known as the file system.**

10. Handling Input/Output Operations: The Operating System is responsible for handling all sorts of inputs, i.e, from the keyboard, mouse, desktop, etcThe Operating System does all interfacing in the most appropriate manner regarding all kinds of Inputs and Outputs.
For example, there is a difference in the nature of all types of peripheral devices such as mice or keyboards, the Operating System is responsible for handling data between them.

**Q4. Explain the different process states with the help of statediagram.**

**Ans :**




**Process**
**A process is basically a program inexecution. When a program is loaded into the memory and it becomes a process, it can be divided into four sections — stack, heap, text and data. The following image shows a simplified layout of a process inside main memory —**

**Stack**
**The process Stack contains the temporary data such as method/function parameters, return address and local variables.**

**Heap**
**This is dynamically allocated memory to a process during its run time.**

**Text**
**This includes the current activity represented by the value of Program Counter and the contents of the processor's registers.**

**Data**
**This section contains the global and static variables. A process is an ‘active’ entity, instead of a program, which is considered a ‘passive’ entity.**

**States of Process:**
**A process is in one of the following states:**

**Start**
**This is the initial state when a process is first started/created.**

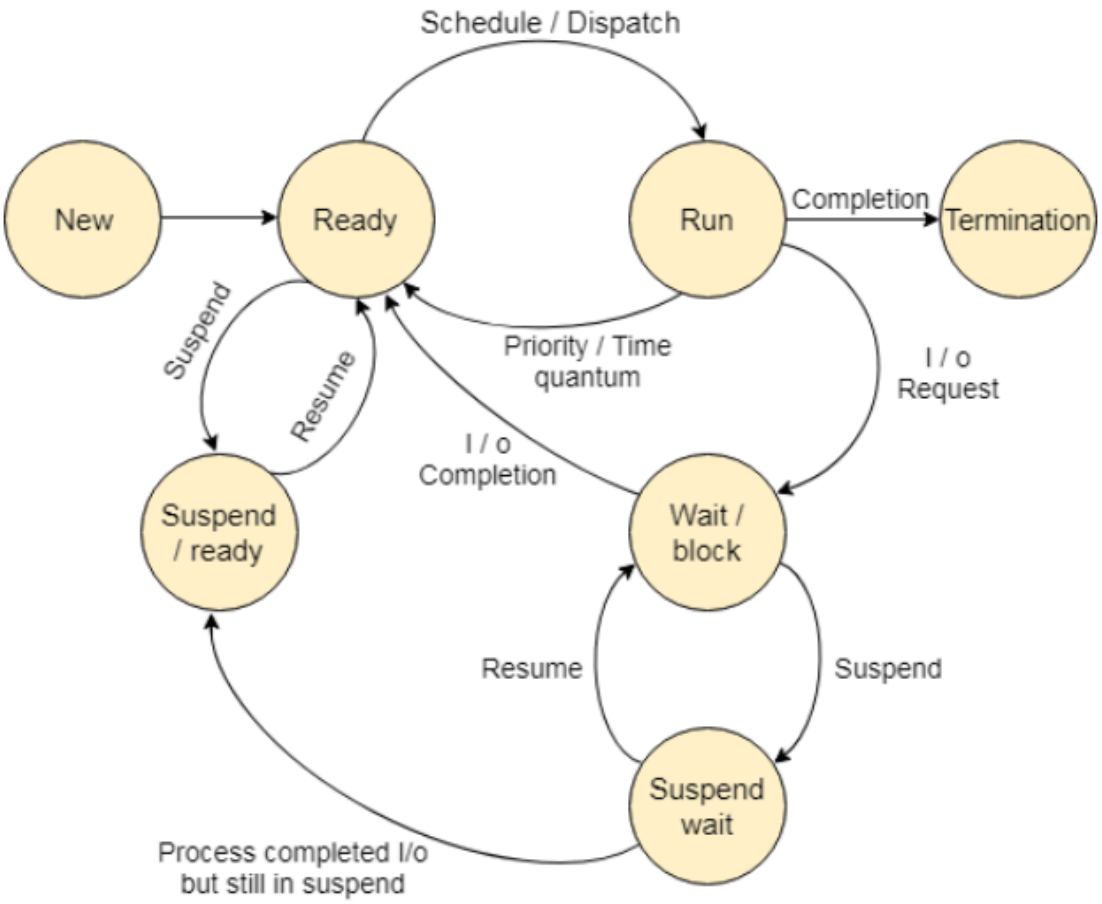
**Ready**

**The process is waiting to be assigned to a processor. Ready processes are waiting to have the processor allocated to them by the operating system so that they can run**

**Running**
**Once the process has been assigned to a processor by the OS scheduler, the process state is set to running and theprocessor executes its instructions.**

**Waiting**
**Process moves into the waiting state if it needs to wait for a resource, such as waiting for user input, or waiting for a file to becom available.**

**Terminated or Exit**
**Once the process finishes its execution, or it is terminated by the operating system, it is moved to the terminated state where it waits to be removed from main memory.**



**Q5. Explain how memory can dynamically allocated using first-fit, best-fit, worst-fit strategies.**

**Ans :**

**1. First Fit:**

**The first-fit algorithm allocates the first available memory block that is large enough to accommodate the process. It starts searching from the beginning of the memory and selects the first suitable block encountered. This algorithm is simple and provides fast allocation, but it may result in relatively larger leftover fragments.**

**2. Best Fit:**

**The best-fit algorithm searches for the smallest available memory block that is large enough to accommodate the process. It aims to minimize leftover fragments by choosing the most optimal block. This algorithm can lead to better overall memory utilization, but it may involve more time consuming searches.**

**3. Worst Fit:**

**The worst-fit algorithm allocates the largest available memory block to the process. This approach intentionally keeps larger fragments to accommodate potential future larger processes. While it may seem counterintuitive, it can help reduce fragmentation caused by small processes and improve overall memory utilization.**

**Q6. Describe the critical section problem with suitable example**

## Introduction

**The critical section problem is a fundamental concept in operating systems related to the management of concurrent processes. When multiple processes access and manipulate shared resources (such as variables, files, or databases) concurrently, it can lead to inconsistent or unpredictable results if not properly synchronized. The critical section refers to the part of the code where the shared resource is accessed. The primary challenge is to design a protocol**

that ensures that only one process enters the critical section at a time, maintaining data consistency and system reliability.

```
do {
    entry section
        critical section
    exit section
        remainder section
  } while (TRUE);
```

In the entry section, the process requests for entry in the Critical Section.

Any solution to the critical section problem must satisfy three requirements:

•Mutual Exclusion :

If a process is executing in its critical section,then no other process is allowed to execute in the critical section.

•Progress :

If no process is executing in the critical section and other processes are waiting outside the critical section, then only those processes that are not executing in their remainder section can participate in deciding which will enter in the critical section next, and the selection can not be postponed indefinitely.

•Bounded Waiting :

A bound must exist on the number of times that other processes are allowed to enter their critical sections after a process has made a request to enter its critical section and before that request is granted.

To solve critical section problem :

1. Peterson solution

Peterson's Solution is a classical software based solution to the critical section problem.

In Peterson's solution, we have two shared variables:

```
do {

    flag[i] = TRUE ;
    turn = j ;
```

**•boolean flag[i] :Initialized to FALSE, initially no one is interested in entering the critical section**

**• int turn : The process whose turn is to enter the critical section.**

**Peterson's Solution preserves all three conditions :**

**•Mutual Exclusion is assured as only one process can access the critical section at any time.**

**•Progress is also assured, as a process outside the critical section does not block other processes from entering the critical section.**

**•Bounded Waiting is preserved as every process gets a fair chance.**

**Disadvantages of Peterson's Solution**

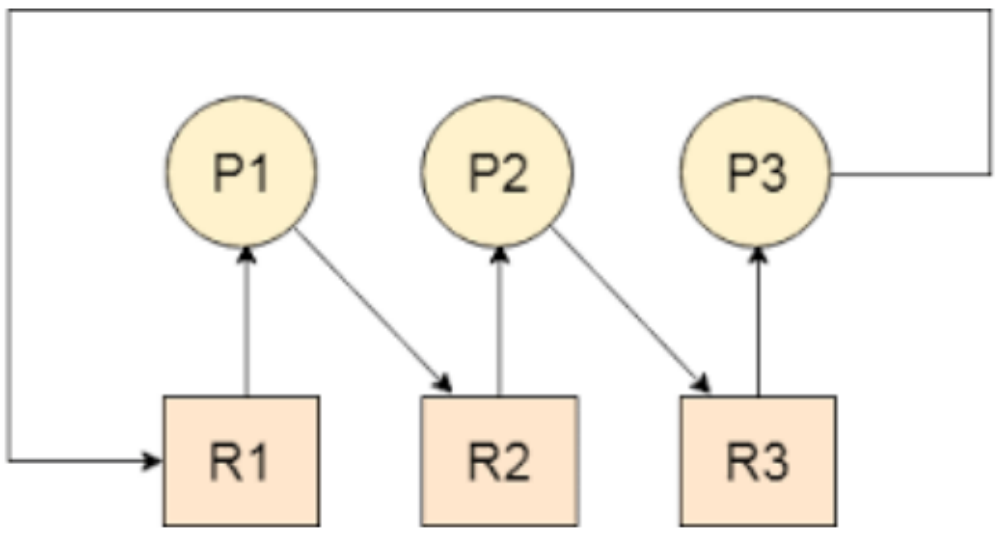
**o It involves Busy waiting**

**o It is limited to 2 processes.**

**Long Question**

**Q1. What is deadlock ? Explain four necessary conditions for deadlock to occur. Describe the different methods for preventation of deadlock.**

**Ans : A Deadlock is a situation where each of the computer processes waits for a resource that is being assigned to another process. In this situation, none of the process gets executed since the resource it needs, is held by some other process that is also waiting for some other resource to be released**




**Necessary conditions for Deadlocks**

**1. Mutual Exclusion**

**Two or more resources are non- shareable (Only one process canuse at a time) A resource can only be shared in mutually exclusive manner. It implies, if two process cannot use the same resource at the same time**

**2. Hold and Wait**
**A process is holding at least one resource and waiting for resources.**

**3. No preemption**

**A resource cannot be taken from a process unless the process releases the resource. The process which once scheduled will be executed till the completion. No other process can be scheduled by the scheduler**
**meanwhile.**

**4. Circular Wait**

**All the processes must be waiting for the resources in a cyclic manner so that the last process is waiting for the resource which is being held by the first process.**

## Deadlock Prevention

**The possibility of deadlock is excluded before making requests, by eliminating one of the necessary conditions for deadlock.**
**Example: Only allowing traffic from one direction, will exclude the possibility of blocking the road**

### Eliminate Mutual Exclusion

**A mutual exclusion means that unshareable resources cannot be accessed simultaneously by processes. Shared resources do not cause deadlock but some resources can't be shared among processes, leading to a deadlock. It is not possible to dis-satisfy the mutual exclusion because some resources, such as the tape drive and printer, are inherently non-Shareable.**

### Eliminate Hold and wait

**1. Allocate all required resources to the process before the start of its execution, this way hold and wait condition is eliminated but it will lead to low device utilization. for example, if a process requires printer at a later time and we have allocated printer before the start of its execution printer will remain blocked till it has completed its execution.**

**2. The process will make a new request for resources after**

**releasing the current set of resources. This solution may lead to starvation.**

**Eliminate No Preemption**

**There are two ways to eliminate this condition by preemption: If a process is holding some**

**1. resources and waiting for other resources, then it should release all previously held resources and put a new request for the required resources again. The process can resume once it has all the required resources.**

**2. If a process P1 is waiting for some resource, and there is another process P2 that is holding that resource and is blocked waiting for some other resource. Then the resource is taken from P2 and allocated to Pl. This way process P2 is preempted and it requests again for its required resources to resume the task.**

**The above approaches are possible for resources whose states are easily restored and saved, such as memory and Registers.**

**Eliminate Circular Wait**

**Each resource will be assigned with a numerical number. A process can request the resources increasing/decreasing. order of numbering.**
**For Example, if P1 process is allocated R5 resources, now next time if P1 ask for R4, R3 lesser than R5 such request will not be granted, only request for resources more than R5 will be granted.**

**3. Discuss in detail the file allocation methods with suitable diagram.**

**Ans :**

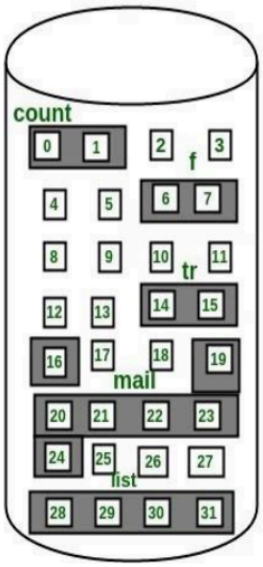
## File Allocation Methods

**The allocation methods define how the files are stored in the disk blocks. There are three main disk space or file allocation methods:-**

**1. Contiguous Allocation**

**In this scheme, each file occupies a contiguous set of blocks on the disk. For example, if a file requires n blocks and is given a block b as the starting location, then the blocks assigned to the file will be: b, b+1, b+2,.....b+n-1.**
**This means that given the starting block address and the length of the file (in terms of blocks required), we**

**can determine the blocks occupied by the file. The directory entry for a file with contiguous allocation contains**




Directory

| file | start | length |
|---|---|---|
| count | 0 | 2 |
| tr | 14 | 3 |
| mail | 19 | 6 |
| list | 28 | 4 |
| f | 6 | 2 |

**• Address of starting block**
**• Length of the allocated portion.**
**The file 'mail' in the following figure starts from the block 19 with length = 6 blocks. Therefore, it occupies 19, 20, 21, 22, 23, 24 blocks.**

**Advantages:**

**•Both the Sequential and Direct Accesses are supported by this.**

**•For direct access, the address of the kth block of the file which starts at block b can easily be obtained as (b+k).**

**•This is extremely fast since the number of seeks are minimal because of contiguous allocation of file blocks.**

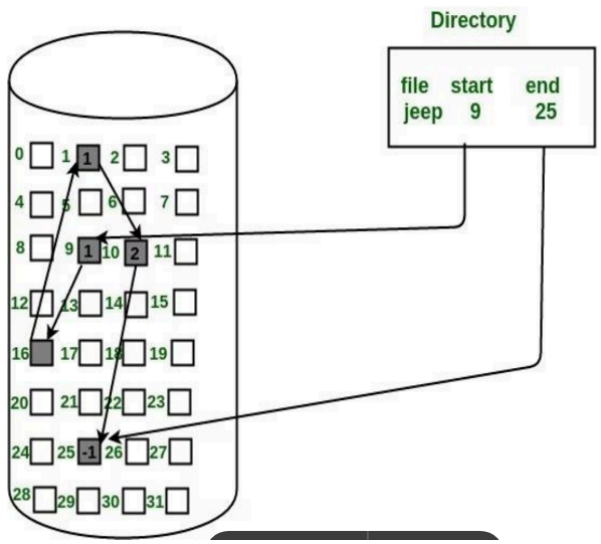
**Disadvantages:**

**•This method suffers from both internal and external fragmentation. This makes it inefficient in terms of memory utilization.**

**• Increasing file size is difficult because it depends on the availability of contiguous memory at a particular instance.**

**2. Linked List Allocation**

**In this scheme, each file is a linked list of disk blocks which need not be contiguous. The disk blocks can be scattered anywhere on the disk.The directory entry contains a pointer to the starting and the ending file block. Each block contains a pointer to the next block occupied by the file.**




**The file 'jeep' in following image shows how the blocks are randomly distributed. The last block (25) contains -1 indicating a null pointer and does not point to any other block.**

**Advantages:**

**•This is very flexible in terms of file size. File size can be increased easily since the system does not have to look for a contiguous chunk of memory.**

**•This method does not suffer from external fragmentation. This makes it relatively better in terms of memory utilization.**

**Disadvantages:**

**•Because the file blocks are distributed randomly on the disk, a large number of seeks are needed to access every block individually. This makes linked allocation slower.**

**• It does not support random ordirect access. We can not directly access the blocks of a file. A block k of a file can be accessed by traversing k blocks sequentially (sequential access ) from the starting block of the file via block pointers.**

**•Pointers required in the linked allocation incur some extra overhead.**

**3. Indexed Allocation**

**In this scheme, a special block known as the Index block contains the pointers to all the blocks occupied by a file. Each file has its own index block. The ith entry in the index block contains the disk address of the ith file block.**

**The directory entry contains the address of the index block as shown in the image:**

**Advantages:**

**•This supports direct access to theblocks occupied by the file andtherefore provides fast access to the file blocks.**

**• It overcomes the problem ofexternal fragmentation.**

**Disadvantages:**

**•The pointer overhead for indexed allocation is greater than linked allocation.**

**•For very small files, say files that expand only 2-3 blocks, the indexed allocation would keep one entire block (index block) for the pointers which is inefficient i terms of memory utilization.**

**However, in linked allocation we**

**lose the space of only 1 pointer per block.**

**Q4. What is demand paging? Under what circumstances does page fault occur? Describe the action taken by the OS when page fault occurs with the help of suitable diagram.**

**Ans : Demand paging** is a memory management technique where **pages of a program are loaded into RAM only when they are needed**, not in advance.

This helps save memory and makes programs run even when **not all pages fit in RAM**.

## Page Fault

A **page fault** happens when a program tries to access a **page that is not currently in RAM**.

This means the OS must bring that page from **secondary storage (disk)** to **main memory (RAM)**.

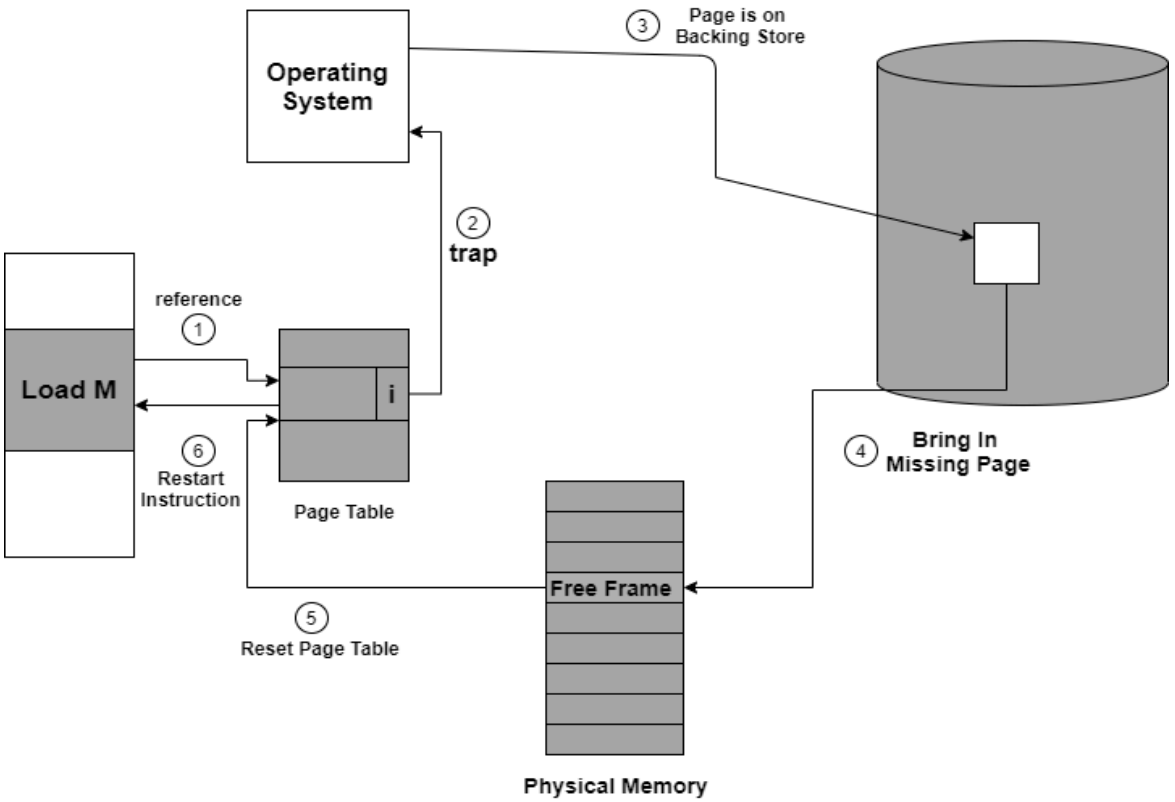
#### When Does a Page Fault Occur?

- A page fault occurs **when a process accesses a page** that is:
  - Not currently in memory

- But exists in the virtual memory (on disk)

## Steps Taken by the OS When a Page Fault Occurs:

1. **Check the Memory Reference:**
   - OS checks if the memory access is **valid or invalid**.
   - If invalid → **Segmentation Fault (error)**
   - If valid → continue
2. **Locate the Page:**
   - OS finds the **page on disk** (in the page table).
3. **Find a Free Frame:**
   - OS finds a **free space** in RAM.
   - If no space, it uses a **page replacement algorithm** (like FIFO, LRU) to remove a page.
4. **Read Page from Disk to RAM:**
   - The required page is **copied into RAM**.
5. **Update Page Table:**
   - OS updates the page table to show that the page is now in memory.
6. **Resume the Program:**
   - The instruction that caused the page fault is **executed again**.



**Q6. Write short note on any four:-**

**(i) Swapping (ii)Threads**

**(iii)Real Time System (iv)Multiprocessor system**

**(v)File system structure**

**Ans.**

**(i) Swapping:**

Swapping is a memory management technique where a **process is temporarily moved from RAM to disk** (called the swap space) and brought back when needed.
This helps the OS handle **more processes** than the available RAM.

**(ii) Threads:**

A thread is the **smallest unit of execution** in a process.
Multiple threads in a process share the **same memory** but run **independently**.

**(iii) Real-Time System:**

A Real-Time System is one where **correctness** depends not only on output but also on the **time it is produced**.
These systems are used in environments where **timely response** is critical (like medical, military, robotics).

**(iv) Multiprocessor System:**

A Multiprocessor System has **two or more CPUs** sharing the same memory and working **in parallel** to increase speed and reliability.

**(v) File System Structure:**

The **File System Structure** refers to **how data is organized and managed** on storage devices like hard drives or SSDs.

It allows users and applications to **store, access, and manage files** efficiently.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Ques-2

| Process | B.T | A.T | C.T | T.A.T | W.T |
|---|---|---|---|---|---|
| $P_1$ | 10 | 0 | 10 | 10 | 0 |
| $P_2$ | 29 | 0 | 39 | 39 | 10 |
| $P_3$ | 3 | 0 | 42 | 42 | 39 |
| $P_4$ | 7 | 0 | 49 | 49 | 42 |
| $P_5$ | 12 | 0 | 61 | 61 | 49 |

By FCFS

gantt chart:-

| $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ |
|---|---|---|---|---|

0, 10, 10+29, 39, 42, 49, 61

~~A.A.T~~ =

T.A.T = CT − A.T

W.T = T.A.T − B.T

Average Waiting Time = $\frac{0+10+39+42+49}{5}$

$= \frac{140}{5} = 28$ ms.

By S.J.F

| | P. | B.T | A.T | C.T | T.A.T. | W.T |
|---|---|---|---|---|---|---|
| 3 | $P_1$ | 10 | 0 | 20 | 20 | 10 |
| | $P_2$ | 29 | 0 | 61 | 61 | 32 |
| 1 | $P_3$ | 3 | 0 | 3 | 3 | 0 |
| 2 | $P_4$ | 7 | 0 | 10 | 10 | 3 |
| 4 | $P_5$ | 12 | 0 | 32 | 32 | 20 |

gantt chart -

| $P_3$ | $P_4$ | $P_1$ | $P_5$ | $P_2$ |
|---|---|---|---|---|

0, 3+7, 10+10, 20+12, 32, 61

Average Waiting Time $= \frac{10+32+0+3+20}{5}$

$= \frac{65}{5} = 13ms$

By RR (quantum = 10ms)

| PROCESS | B.T | A.T | C.T | T.A.T | W.T |
|---|---|---|---|---|---|
| $P_1$ | 10 | 0 | 10 | 10 | 0 |
| $P_2$ | 29 (19) (9) | 0 | 61 | 61 | 32 |
| $P_3$ | 3 | 0 | 23 | 23 | 20 |
| $P_4$ | 7 | 0 | 30 | 30 | 23 |
| $P_5$ | 12 (2) | 0 | 52 | 52 | 40 |

gantt chart:

| $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ | $P_2$ | $P_5$ | $P_2$ |
|---|---|---|---|---|---|---|---|

0, 10+10, 20+3, 23+7, 30+10, 40+10, 50+2, 52+9, 61

Average W.T $\Rightarrow \frac{0+32+20+23+40}{5} \Rightarrow \frac{115}{5} = 23ms$

Average Waiting Time of SJF = 13ms

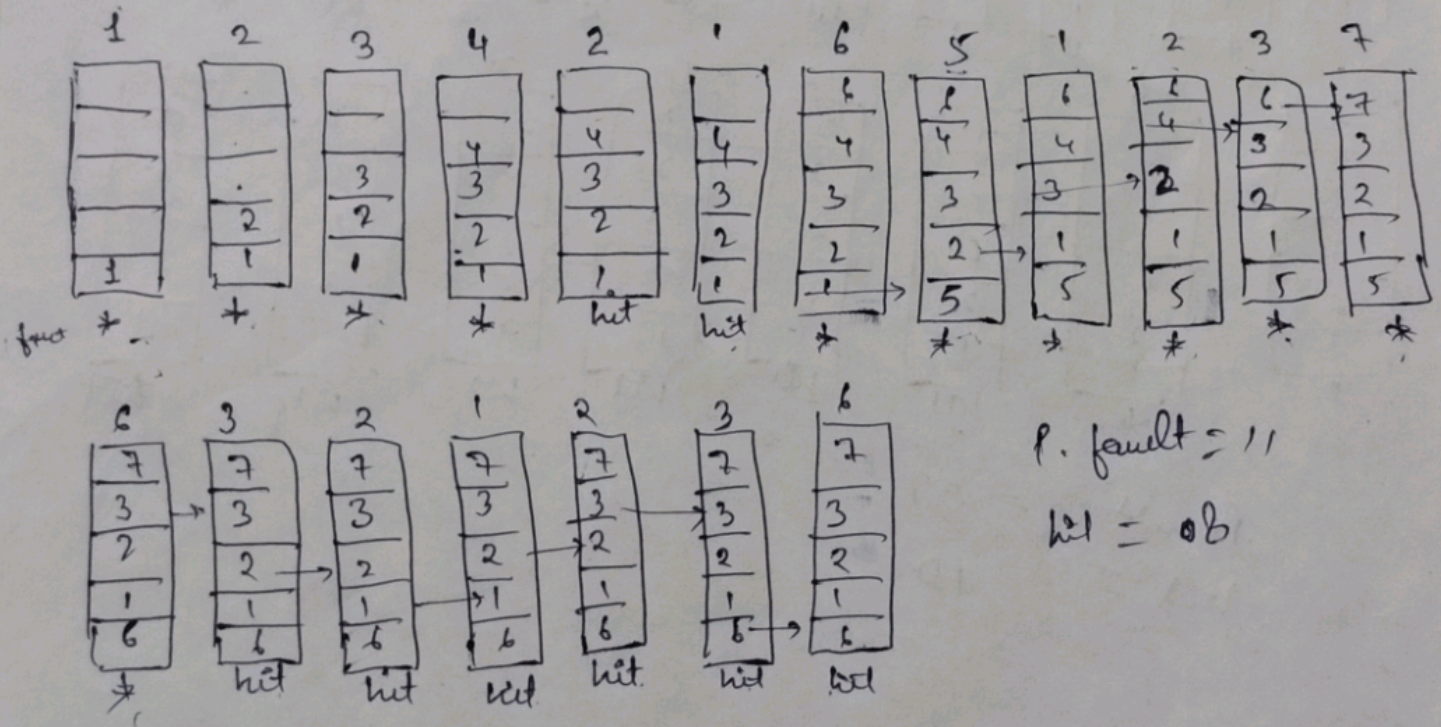
" " " FCFS = 28ms

" " " RR = 23 ms

Ref String → 1, 2, 3, 4, 2, 1, 6, 5, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6

5 frames. (FIFO, LRU, Optimal

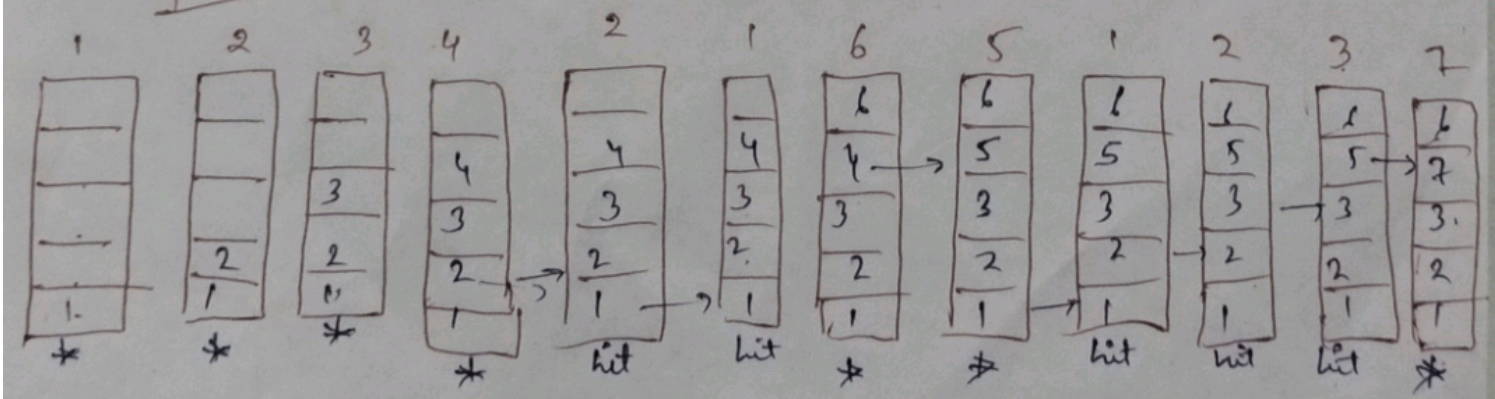
FIFO -

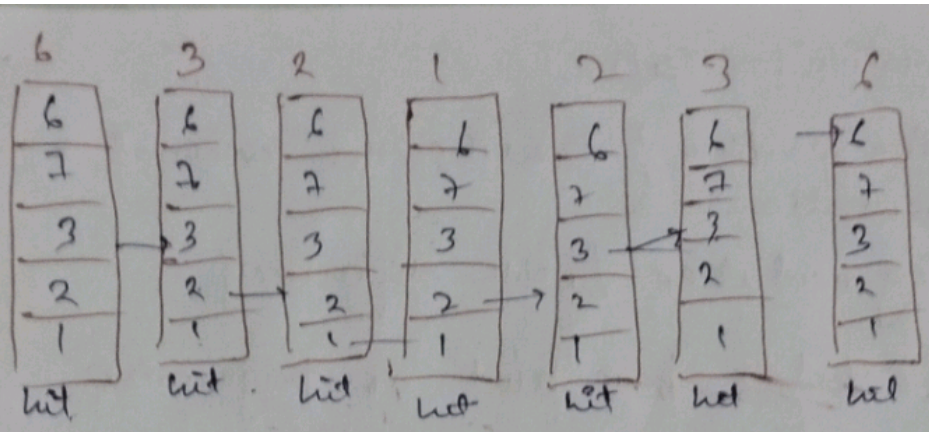



P. fault = 11

hit = 08

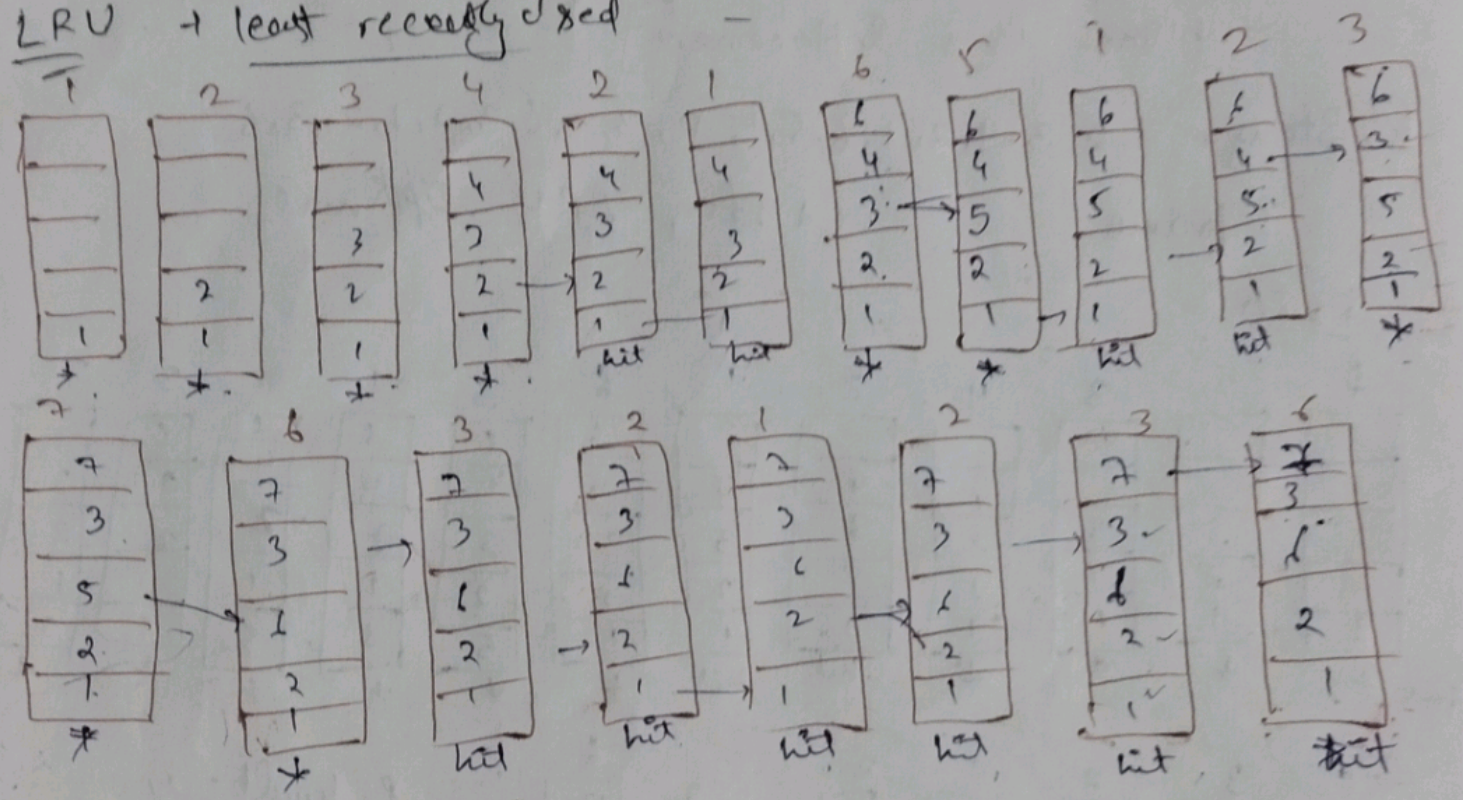
Optimal longest future






p. fault = 07
hit = 12

LRU → least recently used




fault = 09
hit = 10

# CG Internal By Bhavy Sharma

**1. Coordinates of viewport are known as .....**

a) World coordinates b) Polar coordinates c) **Screen coordinates** d)Cartesian coordinates

**2. Beam penetration method is usually used in .....**

a) LCD b) Raster Scan display c) **Random scan display** d) DVST

**3. DTP means:**

a) Draw top publishing b) **Desktop Publishing** c) Dask town publishing d) None of these

**4. Which of the following is a Computer Graphics Curve?**

a) Bezier Curves b) Implicit Curves c) Explicit Curves d) **All of the above**

**5. Shadow mask method is used in**

a) Random scan system b) **Raster scan system** c) Both (a) and (b) d) None of these

**6. Which of the following is a Computer Graphics type?**

a) **Raster and Vector** b) Raster and Scalar c) Scalar only d) All of the above

**7. Graphics output devices are:**

a) Mouse b) Keyboard c) Light pen, joystick d) **none of these**

**8. In beam penetration method of color CRT, two layers of phosphorus coated are:**

a)Red & Blue b) **Red & Green** c) Blue & Green d) None

**9. The basic geometric transformations are:**

a)Rotation b) Translation c) Scaling d) **All of the above**

**10. The major contents of multimedia services are:**

a) Multimedia Hardware b) Operating System c) Multimedia software d) **All of the above**

**11. The area of computer that is captured by an application is called:**

a) **View port** b) Window c) Display d) none of these

**12. CAD means;**

a) Car aided design b) **Computer aided design** c) Computer art design d) none of these

**13. Cohen Sutherland line clipping algorithm divides 2D-space into:**

a) 8 parts b) **9 parts** c) 10 parts d) 12 parts

**14. Which of the following is the purpose for using clipping in computer graphics?**

a) copying b) zooming c) adding graphics d) **removing objects and lines**

**15. Which of the following statements define Computer Graphics?**

a) **It refers to designing plans** b) It means designing computers

c) It refers to designing images d) None of these

**16. Which of the following is defined as the number of pixels stored in the frame buffer of a graphics system?**

a) Resalution b) **Resolution** c) Depth d) None of the mentioned

**17. Which of the following operations can be used to zoom in or out around any axis on a three-dimensional object from its original position?**

a) Rotation b) Shearing c) **Scaling** d) Translation

**18. Which of the following algorithm is a faster method for calculating pixel positions?**

a) Parallel line algorithm b) Mid-point algorithm c) **DDA line algorithm** d) Bresenham's line algorithm

**19. Viewing transformation is the process of mapping a world window in world coordinates to the viewport.**

a) False b) **True**

**20. Higher the number of pixels, … ……the image quality**

a)Bad b) **Better** c) Smaller d) Larger

**21. How many axis do 3D graphics consist of?**

a) Two axis b) **Three axis** c) Five axis d) One axis

**22. Which of the following is a correct abbreviation of DDA algorithm?**

a) Data differential analyzer b) Direct differential analyzer

c) Digital difference analyzer d) **Digital differential analyzer**

**23.A video consists of a sequence of**

a) **frames**. b) signals. c) packets. d) slots.

**24. Which of the following device is designed to minimize the background sound?**

a) Joystick b) Data glove c) **Microphone** d) Digitizers

**25. Which of the following equation is used in 2D translation to move a point(x,y) to the new point (x',y')?**

a) x' = x + ty and y' = y + tx b) x' = x - tx and y' = y - ty

c) **x' = x + tx and y' = y + ty** d) x' = x + tx and y' = y - ty

**26. Random Display system produces real and shadow images.** T/**F**

**27. A positive value of the rotation angle rotates an object in the clockwise direction.** T/**F**

**28. The 4-bit code of the centre-region among the nine regions divided using the Cohen-Sutherland algorithm.**

a) **0000** b) 0010 c) 0110 d) 0101

**29. How many phosphor color dots at each pixel position in a shadow mask CRT?**

a) 1 b) 7 c) 2 d) **3**

**30. Sutherland Hodgeman is a Polygon clipping algorithm. T**/F

# Section B

**Q1. What do you mean by Multimedia? What are the different types of Hardware and Software Requirement to make Good Multimedia?**

**Ans. Multimedia** refers to the integration of multiple forms of media such as text, images, audio, video, animation, and interactivity to convey information or provide entertainment. It is widely used in areas like education, entertainment, advertising, and web development.

## Hardware Requirements for Multimedia:

**Processor (CPU):** A fast processor to handle heavy multimedia tasks.
**High-Resolution Monitor:** For accurate color and visual representation.
**Storage:** SSDs are preferred for fast read/write speed.
**Input Devices:** Microphone, digital camera, scanner, and graphic tablet for capturing media.
**Output Devices:** High-quality speakers, printer, or projector.

## Software Requirements for Multimedia:

1. **Operating System:** Windows, macOS, or Linux.
2. **Editing Software:**

    - Image: Adobe Photoshop
    - Audio: Audacity
    - Video: Adobe Premiere Pro
    - Animation: Blender, After Effects

3. **Web Development Tools:** HTML5, CSS, JavaScript, and frameworks like React for web-based multimedia.

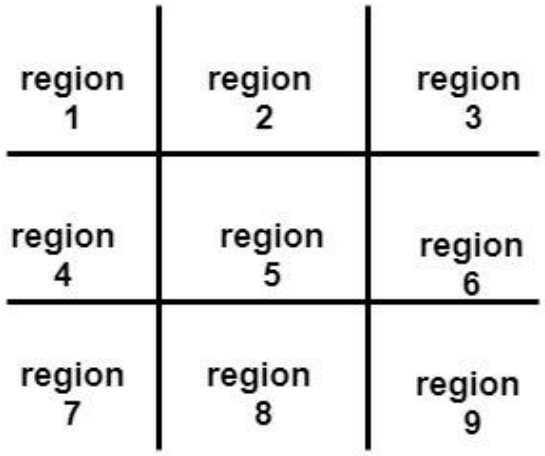
**Q2. Discuss the Cohen Sutherland Line Clipping Algorithm.**

**Ans.** The **Cohen-Sutherland Line Clipping Algorithm** is a computer graphics algorithm used to clip a line segment to a rectangular clipping window. It helps determine which portion of a line lies inside the visible region and which portion should be discarded.

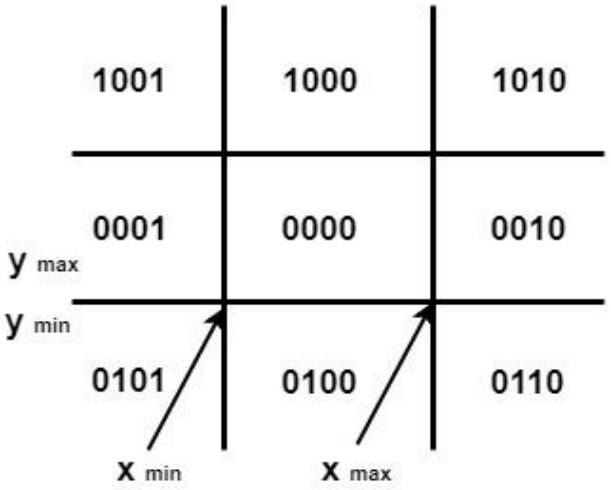
The algorithm divides the 2D space into **9 regions** (inside + 8 outside regions) based on the position of the line relative to the clipping window.

Each endpoint of the line is assigned a **4-bit region code** (also called an *outcode*) that tells us where the point is relative to the clipping window.

## Region Code (4-bit):
## TBRL – Top, Bottom, Right, Left




9 region




bits assigned to 9 regions

**Advantages:**

- Fast and efficient for rectangular clipping regions.
- Reduces unnecessary drawing operations.

**Disadvantages:**

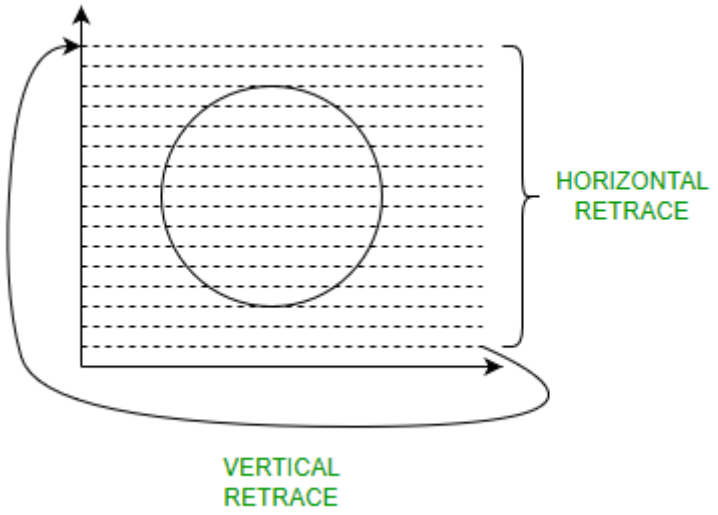
- Works only for **rectangular** clipping windows.
- Might require several iterations for partially visible lines.

## Q3. Discuss the main difference between Raster scan system and Random scan system.

## Ans. Raster Scan:

**Raster Scan** is a method used in display systems (like monitors and TVs) where the **electron beam scans the screen row by row**, from **top to bottom** and **left to right**.

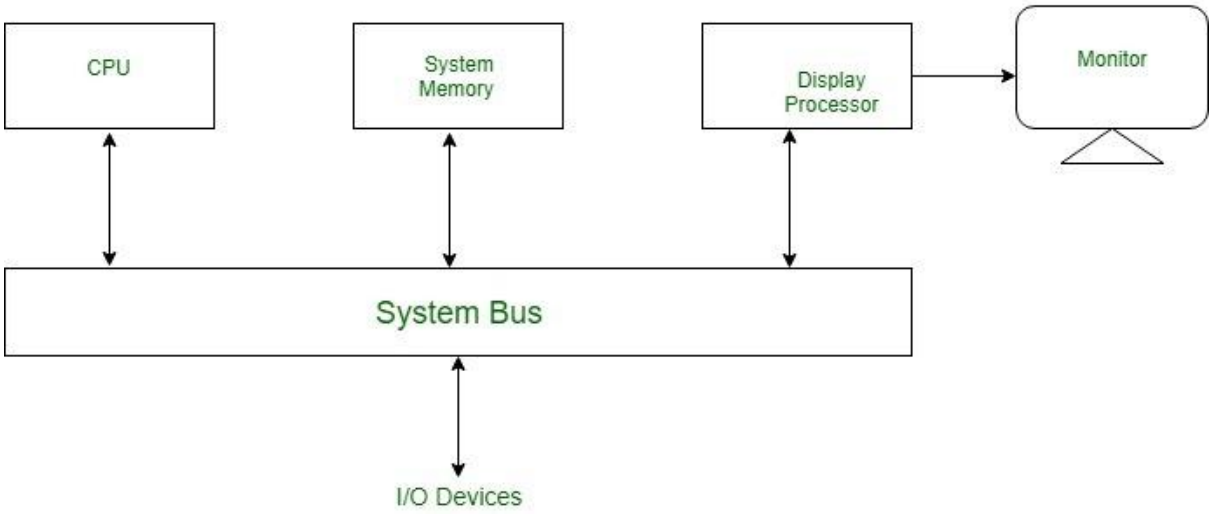
After reaching the end of a row, it **moves to the next row**, and after finishing all rows, it goes back to the top.




## Random Scan:

**Random Scan** is a display method where the electron beam is directed only to **draw the lines or shapes** needed for the image, instead of scanning every pixel row by row like in raster scan.

It is also called a **Vector Display** or **Line Drawing Display**.



## Differentiate between Random and Raster Scan Display

| Random Scan | Raster Scan |
|---|---|
| 1. It has high Resolution | 1. Its resolution is low. |
| 2. It is more expensive | 2. It is less expensive |
| 3. Any modification if needed is easy | 3.Modification is tough |
| 4. Solid pattern is tough to fill | 4.Solid pattern is easy to fill |
| 5. Refresh rate depends or resolution | 5. Refresh rate does not depend on the picture. |
| 6. Only screen with view on an area is displayed. | 6. Whole screen is scanned. |
| 7. Beam Penetration technology come under it. | 7. Shadow mark technology came under this. |
| 8. It does not use interlacing method. | 8. It uses interlacing |
| 9. It is restricted to line drawing applications | 9. It is suitable for realistic display. |

**Q4. What is animation and write the different types of functions available for computer animation?**

**Ans. Animation** is the process of creating the illusion of motion by displaying a series of static images (frames) one after the other. In **computer animation**, this is done using digital graphics and software tools to move objects, characters, or scenes over time.

---

## Types of Functions Used in Computer Animation:

1. **Morphing:** Morphing is an animation function which is used to transform object shape from one form to another is called Morphing. It is one of the most complicated transformations. This function is commonly used in movies, cartoons, advertisement, and computer games.

2. **Wrapping:** Wrapping function is similar to morphing function. It distorts only the initial images so that it

matches with final images and no fade occurs in this function.

3. **Tweening:** Tweening is the short form of 'inbetweening.' Tweening is the process of generating intermediate frames between the initial & last final images. This function is popular in the film industry.

4. **Panning:** Usually Panning refers to rotation of the camera in horizontal Plane. In computer graphics, Panning relates to the movement of fixed size window across the window object in a scene. In which direction the fixed sized window moves

5. **Zooming:** In zooming, the window is fixed an object and change its size, the object also appear to change in size. When the window is made smaller about a fixed center, the object comes inside the window appear more enlarged. This feature is known as Zooming In.

**Q5. Write a short note on (any Three):**

- **Boundary Fill Algorithm**
- **Frame Buffer**
- **Aspect Ratio**
- **Output Primitive**
- **Scan Conversion**

**Ans. Boundary Fill Algorithm**

The boundary fill algorithm uses polygon boundaries. It is also called an edge fill algorithm. In this method, aseed point is taken in the polygon boundary and checks whether the adjacent or neighboring pixel is colored or not. If the adjacent pixel is not colored then, fill it. This can be done using two approaches: 4-connected or 8-connected.

1. **Four connected approaches:** In this approach, left, right, above, below pixels are tested.

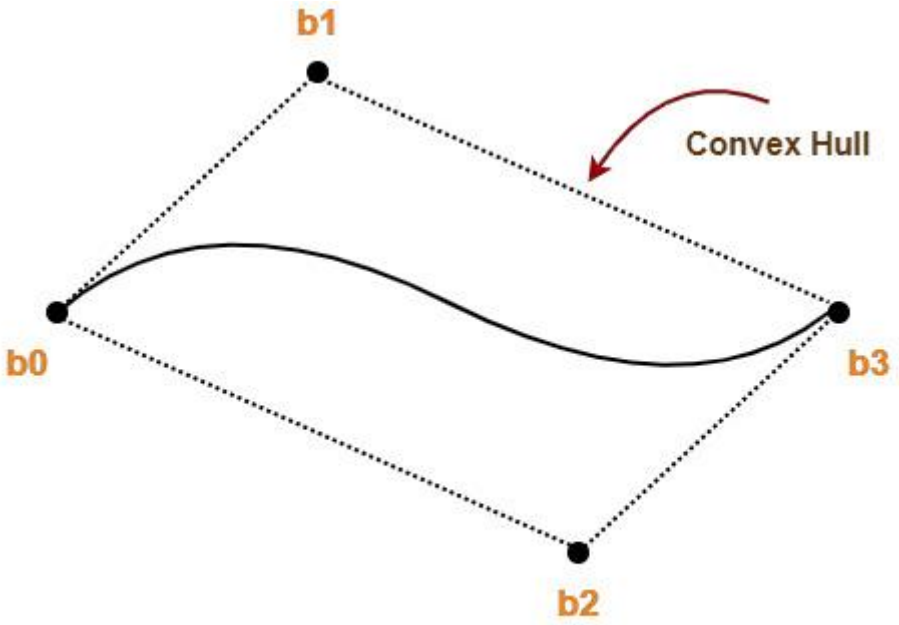
**2. Eight connected approaches:** In this approach, left, right, above, below and four diagonals are selected.
Boundary can be checked by seeing pixels from left and right first. Then pixels are checked by seeing pixels from top to bottom. The algorithm takes time and memory because some recursive calls are needed.

For Better Understanding Check >>>
https://drive.google.com/file/d/1RnleiHq8wpkYJpoyXd7oUX5YcAzu_en3/view?usp=sharing

**Q6. Write the Properties of Bezier Curve and B-Spline Curve.**
**Ans. Bézier Curve Properties:**

**Property-01:**

Bezier curve is always contained within a polygon called as convex hull of its control points.




Bezier Curve With Convex Hull

**Property-02:**

- Bezier curve generally follows the shape of its defining polygon.
- The first and last points of the curve are coincident with the first and last points of the defining polygon.

**Property-03:**

The degree of the polynomial defining the curve segment is one less than the total number of control points.

Degree = Number of Control Points – 1

## Property-04:

The order of the polynomial defining the curve segment is equal to the total number of control points.

**Property-05:**

- Bezier curve exhibits the variation diminishing property.

- It means the curve do not oscillate about any straight line more often than the defining polygon.

$$P(t) = \sum_{i=0}^{n} B_i J_{n,i}(t)$$

Bezier Curve Equation

**B-Spline Curve Properties:**

1. A B-spline curve is made by joining **small curve pieces** together smoothly.
2. If you move one control point, **only a small part** of the curve changes — not the whole curve.
3. The curve usually **goes near** the control points, not exactly through them (except the start and end in some cases).
4. The curve is **very smooth** at the joints where segments meet. It follows **C1 and C2 continuity** (means no sharp turns).

## Section C

**Q1. Digitize a line from (10,12) to (15,15) on a raster screen using Bresenham's straight line Algorithm. What are the Various line drawing algorithms?**

Ans.

Sec-C

① (10,12) to (15,15) using Bresenham's straight line algorithm

$x_1 = 10$, $x_2 = 15$

$y_1 = 12$, $y_2 = 15$

Step1→ Calculate $\Delta x$ & $\Delta y$

$\Delta x = x_2 - x_1 = 15 - 10 = 5$

$\Delta y = y_2 - y_1 = 15 - 12 = 3$

Step2→ Calculate decission Parameter

$P_K = 2\Delta Y - \Delta X$

$= 2 \times 3 - 5$

$= 6 - 5 = 1$

Step3- Current point $(x_K, y_K) = (10, 12)$

next point $(x_{K+1}, y_{K+1})$

As $P_K > 0 \Rightarrow 1 > 0$

So, for the first step in table

$P_{K+1} = P_K + 2\Delta y - 2\Delta x$

$x_{K+1} = x_K + 1$

$y_{K+1} = y_K + 1$

and if $P_K < 0$, $P_{K+1} = P_K + 2\Delta y$

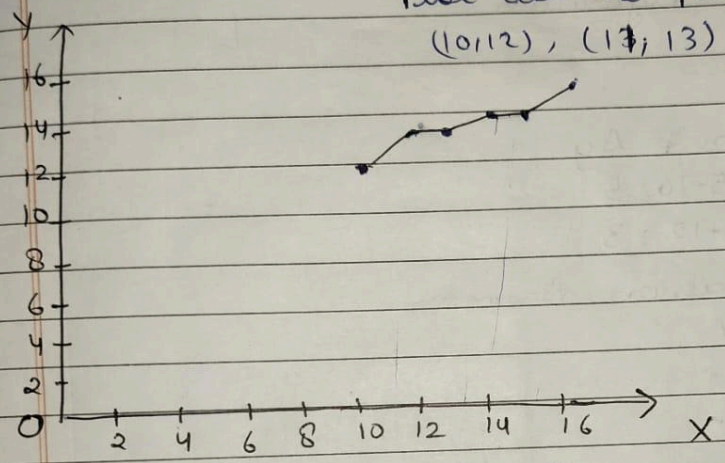
$x_{K+1} = x_K + 1$

$y_{K+1} = y_K$

| $x_k$ | $y_k$ | $P_k$ | $P_{k+1}$ | $x_{k+1}$ | $y_{k+1}$ | $(x_{k+1}, y_{k+1})$ |
|---|---|---|---|---|---|---|
| 10 | 12 | 1 | -3 | 11 | 13 | (11, 13) |
| 11 | 13 | -3 | 3 | 12 | 13 | (12, 13) |
| 12 | 13 | 3 | -1 | 13 | 14 | (13, 14) |
| 13 | 14 | -1 | 5 | 14 | 14 | (14, 14) |
| 14 | 14 | 5 | 1 | 15 | 15 | (15, 15) |

Plot all the points on graph

(10,12), (11, 13) (12,13) (13,14) (14,14) (15,15)




Other line drawing Algorithm →

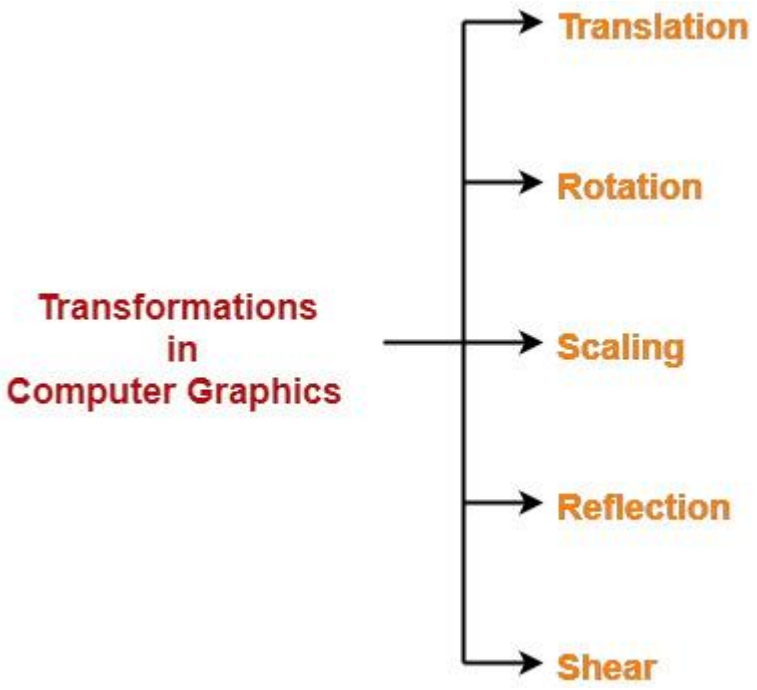
(i) Midpoint line Algorithm

(ii) DDA

**Q2. What is 2D transformation? Explain the basic 2D transformation with an example.**

**Ans. 2D Transformation** refers to the process of changing the position, size, orientation, or shape of 2D objects in a **two-dimensional plane** using mathematical operations.

There are Different Types of 2D Transformation :




Rotating >>>
https://drive.google.com/file/d/1FG9Ya9MgkXhgrmZKI3Nu3OsqvNzg4ICp/view?usp=sharing

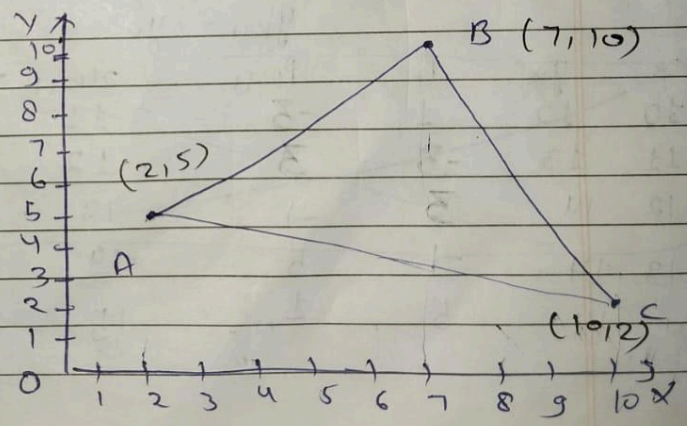
Scaling, Reflecting, Shearing >>>
https://drive.google.com/file/d/1bYsShB6Bwca7w406ktAbpnZ7G_SHJObd/view?usp=sharing

**Q3. Translate the Polygon with coordinates A(2,5), B(7,10) and C(10,2) by 3 units in x direction 4 units in y direction.**
**Ans.**

3. Translate the Polygon with co-ordinates A(2,5), B(7,10), C(10,2) by 3 units in x direction and 4 units in y direction.

Given → A (2,5), B(7,10), C(10,2)

$$T = \begin{bmatrix} 3 \\ 4 \end{bmatrix}$$



For Translating this polygon, we have to find $A'$, $B'$, $C'$

$\Rightarrow A = \begin{bmatrix} 2 \\ 5 \end{bmatrix}$, $B = \begin{bmatrix} 7 \\ 10 \end{bmatrix}$, $C = \begin{bmatrix} 10 \\ 2 \end{bmatrix}$

$\Rightarrow A' = A + T$

$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 2 \\ 5 \end{bmatrix} + \begin{bmatrix} 3 \\ 4 \end{bmatrix} \Rightarrow \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 5 \\ 9 \end{bmatrix}$

$A'(5, 9)$

$\Rightarrow B' = B + T$

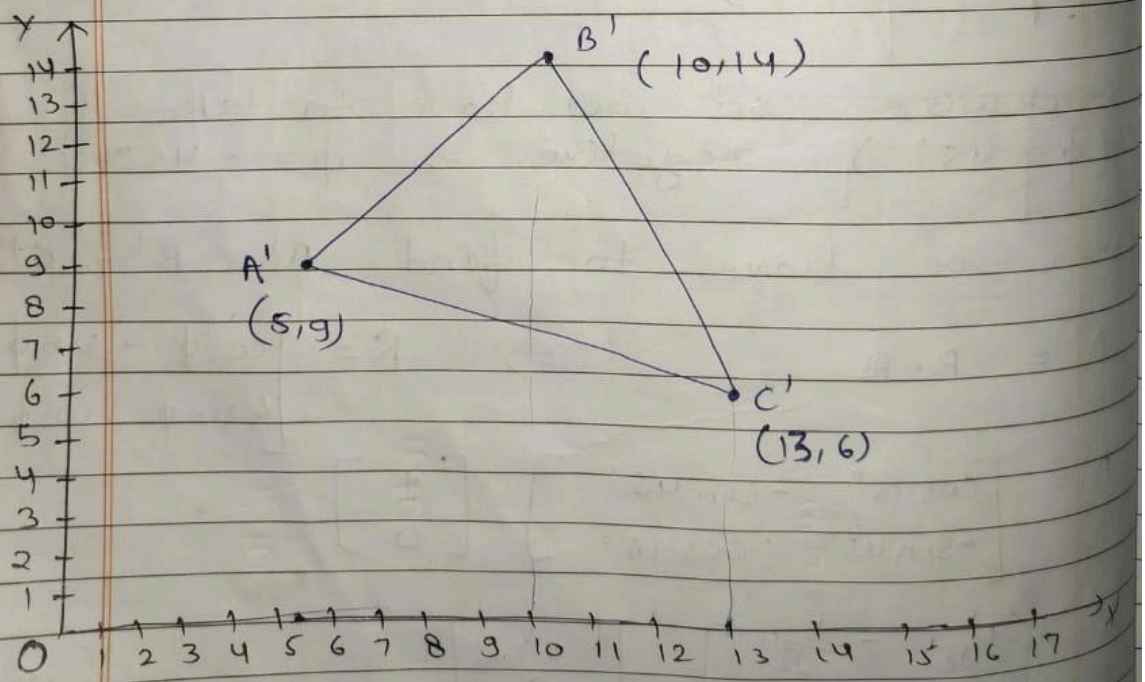
$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 7 \\ 10 \end{bmatrix} + \begin{bmatrix} 3 \\ 4 \end{bmatrix} \Rightarrow \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 10 \\ 14 \end{bmatrix}$

$B'(10, 14)$

$\Rightarrow C' = C + T$

$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 10 \\ 2 \end{bmatrix} + \begin{bmatrix} 3 \\ 4 \end{bmatrix} \Rightarrow \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 13 \\ 6 \end{bmatrix}$

$C'(13, 6)$



**Q4. Write a short note on any three of following .**
**a) Projection**
**b) CRT**
**c). Interactive computer graphics**
**d) DDA**
**Ans.**

**a) Projection:** Projection is the method of displaying a 3D object on a 2D screen. It helps in visualizing 3D scenes in computer graphics. There are two main types:

**1. Parallel Projection:**

- The **lines of sight are parallel**.
- **No perspective effect** (objects don't look smaller as they go far).

  **Example:** Used in **engineering drawings**, CAD, architecture.

**2. Perspective Projection:**

- **Lines of sight converge** at a point (called the **center of projection**).
- Gives a **realistic view**, as **distant objects appear smaller**.

**Example:** Used in **games**, simulations, 3D movies.

---

**b) CRT (Cathode Ray Tube):**

CRT is a display device used in older monitors and TVs. It works by firing electron beams onto a phosphor-coated screen to create images.

- Uses **electron guns**, **deflection coils**, and **phosphor**.
- Was commonly used in early computer graphics for displaying images and animations.

---

**c) Interactive Computer Graphics:**

This refers to graphics where the user can interact with the system in real-time.

- Examples: Drawing applications, video games, CAD software.
- It uses input devices like a mouse, keyboard, or touchscreen to control and modify graphics on the screen.

---

**d) DDA (Digital Differential Analyzer):**

DDA is an algorithm used to draw lines on a pixel-based screen.

- It calculates intermediate points between two given endpoints.
- Works by incrementing one coordinate and calculating the other using the line equation.
- Simpler but slower than Bresenham's Line Algorithm.

**Q5. Find a transformation of triangle A(1,0), B (0,1), C(1,1) by .**
**(a) Rotating 45o about the origin and the translating one unit in X and Y direction.**
**(b) Translating one unit in X and Y directing and then rotating 45o about the origin.**
**Ans.**

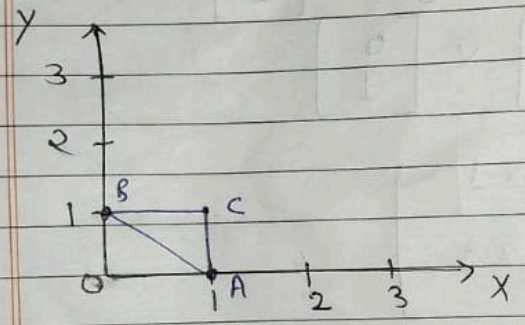
**Solve Questions Below and We are Try to make the Whole Video Solution For You >>>>**

5. Find the transformation of triangle A(1,0), B(0,1), C(1,1) by-

a) Rotating 45° about the origin and translating one unit in X and Y direction-

b) Translating one unit in X and Y directly then rotating 45° about the origin.

Sol$^n$ → Given A(1,0), B(0,1) & C(1,1)
Plot these points on graph.




a) First we have to it about 45° about the origin which means in anti-clockwise direction ($\phi = 45°$)

Then, $R = \begin{bmatrix} \cos\phi & -\sin\phi \\ \sin\phi & \cos\phi \end{bmatrix}$

$\Rightarrow A = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $C \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

Now, we have to find A', B' & C'

$A' = R \cdot A$

$A' = \begin{bmatrix} \cos 45° & -\sin 45° \\ \sin 45° & \cos 45° \end{bmatrix} \times \begin{bmatrix} 1 \\ 0 \end{bmatrix}$

$$A' = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$A' = \begin{bmatrix} \frac{1}{\sqrt{2}} \times 1 - \frac{1}{\sqrt{2}} \times 0 \\ \frac{1}{\sqrt{2}} \times 1 + \frac{1}{\sqrt{2}} \times 0 \end{bmatrix}$$

$$A' = \begin{bmatrix} 1/\sqrt{2} \\ 1/\sqrt{2} \end{bmatrix}$$

$\Rightarrow$ $B' = R \cdot B$

$$B' = \begin{bmatrix} \cos 45^\circ & -\sin 45^\circ \\ \sin 45^\circ & \cos 45^\circ \end{bmatrix} \times \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$B' = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \times \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$B' = \begin{bmatrix} 1/\sqrt{2} \times 0 - 1/\sqrt{2} \times 1 \\ 1/\sqrt{2} \times 0 + 1/\sqrt{2} \times 1 \end{bmatrix}$$

$$B' = \begin{bmatrix} -1/\sqrt{2} \\ 1/\sqrt{2} \end{bmatrix}$$

$\Rightarrow$ $C' = R \cdot C$

$$C' = \begin{bmatrix} \cos 45^\circ & -\sin 45^\circ \\ \sin 45^\circ & \cos 45^\circ \end{bmatrix} \times \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$C' = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \times \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$C' = \begin{bmatrix} 1/\sqrt{2} \times 1 - 1/\sqrt{2} \times 1 \\ 1/\sqrt{2} \times 1 + 1/\sqrt{2} \times 1 \end{bmatrix} \Rightarrow C' = \begin{bmatrix} 0 \\ 2/\sqrt{2} \end{bmatrix}$$

Date: __/__/____
Page: _____

Now, we have to translate it one-one unit in both X, Y direction.

So, $T = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

Now, we have to find new points after translation A'', B'' & C''

$A'' = A' + T$

$A'' = \begin{bmatrix} 1/\sqrt{2} \\ 1/\sqrt{2} \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} \Rightarrow A'' = \begin{bmatrix} 1/\sqrt{2} + 1 \\ 1/\sqrt{2} + 1 \end{bmatrix}$

$B'' = B' + T$

$B'' = \begin{bmatrix} -1/\sqrt{2} \\ 1/\sqrt{2} \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} \Rightarrow B'' = \begin{bmatrix} -1/\sqrt{2} + 1 \\ 1/\sqrt{2} + 1 \end{bmatrix}$

$C'' = C' + T$

$C'' = \begin{bmatrix} 0 \\ 2/\sqrt{2} \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} \Rightarrow C'' = \begin{bmatrix} 1 \\ 2/\sqrt{2} + 1 \end{bmatrix}$

b) First we have to translate it in one unit in both X and Y direction.

Find A', B' and C'

$\Rightarrow T = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, A = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

$\Rightarrow A' = A + T$

$A' = \begin{bmatrix} 1 \\ 0 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} \Rightarrow A' = \begin{bmatrix} 2 \\ 1 \end{bmatrix}$

$B' = \begin{bmatrix} 0 \\ 1 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} \Rightarrow B' = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$

$$C' = C + T$$

$$C' = \begin{bmatrix} 1 \\ 1 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} \Rightarrow C' = \begin{bmatrix} 2 \\ 2 \end{bmatrix}$$

⇒ Now, we have rotate it 45° about the origin which means in anti-clockwise direction ($\phi = 45°$)

$$R = \begin{bmatrix} \cos 45° & -\sin 45° \\ \sin 45° & \cos 45° \end{bmatrix}$$

Now, find $A''$, $B''$ & $C''$

$$A'' = R \cdot A$$

$$A'' = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \times \begin{bmatrix} 2 \\ 1 \end{bmatrix}$$

$$A'' = \begin{bmatrix} 1/\sqrt{2} \times 2 - 1/\sqrt{2} \times 1 \\ 1/\sqrt{2} \times 2 + 1/\sqrt{2} \times 1 \end{bmatrix} \Rightarrow A'' = \begin{bmatrix} 2/\sqrt{2} - 1/\sqrt{2} \\ 2/\sqrt{2} + 1/\sqrt{2} \end{bmatrix}$$

$$A'' = \begin{bmatrix} 1/\sqrt{2} \\ 3/\sqrt{2} \end{bmatrix}$$

$$B'' = R \cdot B$$

$$B'' = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \times \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$

$$B'' = \begin{bmatrix} 1/\sqrt{2} \times 1 - 1/\sqrt{2} \times 2 \\ 1/\sqrt{2} \times 1 + 1/\sqrt{2} \times 2 \end{bmatrix} \Rightarrow B'' = \begin{bmatrix} 1/\sqrt{2} - 2/\sqrt{2} \\ 1/\sqrt{2} + 2/\sqrt{2} \end{bmatrix}$$

$$B'' = \begin{bmatrix} -1/\sqrt{2} \\ 3/\sqrt{2} \end{bmatrix}$$

$$\cancel{C'' = C' \cdot R}$$

$$C'' = R \cdot C'$$

$$C'' = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \times \begin{bmatrix} 2 \\ 2 \end{bmatrix}$$

$$C'' = \begin{bmatrix} 1/\sqrt{2} \times 2 - 1/\sqrt{2} \times 2 \\ 1/\sqrt{2} \times 2 + 1/\sqrt{2} \times 2 \end{bmatrix}$$

$$C'' = \begin{bmatrix} 2/\sqrt{2} - 2/\sqrt{2} \\ 2/\sqrt{2} + 2/\sqrt{2} \end{bmatrix}$$

$$C'' = \begin{bmatrix} 0 \\ 4/\sqrt{2} \end{bmatrix}$$

**Q6. Explain the following Algorithm:**
**a) Ellipse Generating Algorithm**
**b) Cyrus – Beck Algorithm**
**Ans.**

---

**a) Ellipse Generating Algorithm** The **Ellipse Generating Algorithm** is used to draw an ellipse on a pixel-based display using **midpoint logic**, similar to the midpoint circle algorithm.

**Midpoint Ellipse Algorithm**

1. The ellipse is symmetric in both x and y axes, so only one quadrant is calculated and mirrored.
2. The algorithm divides the ellipse drawing into **two regions**:
   - **Region 1 (slope < 1)**: x is incremented, and y is calculated.
   - **Region 2 (slope > 1)**: y is decremented, and x is calculated.
3. A **decision parameter (p)** is used to decide the next pixel, avoiding floating-point calculations.

**Advantages:**

- Uses only integer arithmetic.
- Efficient for raster-based graphics systems.

---

**b) Cyrus–Beck Line Clipping Algorithm**

The **Cyrus–Beck Algorithm** is a **parametric line clipping** algorithm used for clipping a line segment against a **convex polygonal window** (not just rectangles).

- Represents the line segment parametrically:

$$P(t) = P_0 + t(P_1 - P_0), \quad 0 \le t \le 1$$

- It calculates values of `t` where the line intersects with the polygon edges.

**Steps:**

1. For each edge of the polygon, compute:
    - The **normal vector** to the edge.
    - The **dot product** of the normal with the direction of the line.
2. Based on the sign of the dot product, decide:
    - **Entering point**: where the line enters the polygon.\
    - **Leaving point**: where the line exits the polygon.
3. Clip the line segment between the values of **t_enter** and **t_leave**.

**Advantages:**

- Works for **convex polygons** (not just rectangles).
- More general than Cohen-Sutherland.

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https://chat.whatsapp.com/CLKQ7tzYfl2200sOrED9xl