Explore | Expand | Enrich

<Codemithra />™

MERN STACK HANDOUT NOTES

MERN Full-Stack

Full Stack Development

Fullstack development refers to the practice of building both the front-end (client-side) and back-end (server-side) components of a web application. Fullstack developers are skilled in a wide range of technologies that enable them to handle the complete lifecycle of an application, from designing the user interface to managing databases and server logic.

Key Components of Fullstack Development

1. **Front-End Development**
    - **Purpose**: Focuses on the user interface (UI) and user experience (UX).
    - **Technologies**:
        - **Languages**: HTML, CSS, JavaScript.
        - **Frameworks/Libraries**: React.js, Angular, Vue.js, Bootstrap.
    - **Responsibilities**:
        - Designing responsive and interactive web pages.
        - Ensuring cross-browser compatibility.
        - Implementing designs from UI/UX wireframes.
2. **Back-End Development**
    - **Purpose**: Focuses on server-side logic, database management, and API integration.
    - **Technologies**:
        - **Languages**: Node.js, Python, Java, PHP, Ruby.
        - **Frameworks**: Express.js, Django, Spring Boot, Flask.
        - **Databases**: MySQL, MongoDB, PostgreSQL, Firebase.
        - **APIs**: RESTful APIs, GraphQL.
    - **Responsibilities**:
        - Managing server-side logic and database queries.
        - Developing and maintaining APIs.
        - Ensuring application security and performance.
3. **DevOps and Deployment**

- **Purpose**: Focuses on deploying and maintaining applications in a production environment.
- **Technologies**: Docker, Kubernetes, AWS, Azure, CI/CD pipelines.
- **Responsibilities**:
  - Automating deployment processes.
  - Monitoring application performance.
  - Ensuring scalability and reliability.

Popular Fullstack Tech Stacks

1. **MERN Stack**: MongoDB, Express.js, React.js, Node.js.
2. **MEAN Stack**: MongoDB, Express.js, Angular, Node.js.
3. **LAMP Stack**: Linux, Apache, MySQL, PHP.
4. **Django Stack**: Django, Python, PostgreSQL.
5. **Spring Boot Stack**: Spring Boot, Java, MySQL.

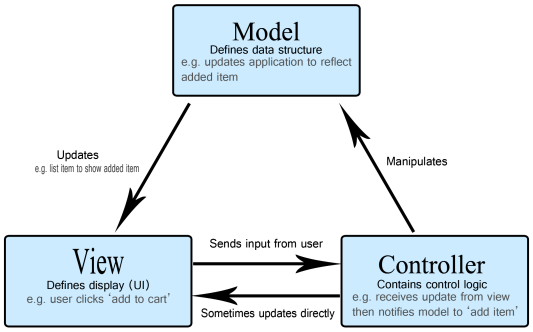
Challenges in Fullstack Development

1. **Continuous Learning**: Keeping up with the rapid evolution of technologies.
2. **Workload Management**: Balancing front-end and back-end responsibilities.
3. **Depth vs. Breadth**: Achieving expertise in both areas can be challenging.

Applications of Fullstack Development

1. **E-Commerce Platforms** (e.g., Amazon, Flipkart).
2. **Social Media Platforms** (e.g., Instagram, Facebook).
3. **Content Management Systems** (e.g., WordPress, Wix).
4. **Business Management Tools** (e.g., CRM software).

Model-View-Controller (MVC) Architecture



1. **Model**
    - **Purpose**: Represents the application's data and business logic.
    - **Responsibilities**:
        - Manages the data, logic, and rules of the application.
        - Communicates with the database or external APIs to fetch and store data.
        - Notifies the view of any changes in the data.
    - **Example**:
        - In a blog application, the Model might handle blog posts and user data, including fetching posts from the database.
2. **View**
    - **Purpose**: Represents the user interface (UI) of the application.
    - **Responsibilities**:
        - Displays data to the user as provided by the Model.
        - Sends user inputs to the Controller.
    - **Example**:
        - The web page displaying a list of blog posts with titles, authors, and timestamps.
3. **Controller**
    - **Purpose**: Acts as an intermediary between the Model and the View.
    - **Responsibilities**:
        - Handles user inputs and routes them to the appropriate Model methods.
        - Updates the View with data from the Model.
    - **Example**:

- In a blog application, the Controller processes a user request to add a new post by passing the data to the Model and refreshing the View.

How MVC Works

1. **User Interaction**: The user interacts with the View (e.g., clicks a button or submits a form).
2. **Controller Handling**: The Controller processes the input, interprets it, and calls the appropriate Model method.
3. **Model Update**: The Model performs the required operations, such as updating the database or retrieving data.
4. **View Update**: The View is updated with new data from the Model and re-rendered for the user.

Applications of MVC

1. **Web Development**
   - Frameworks like **Django**, **Ruby on Rails**, and **Spring MVC** follow this architecture.
2. **Desktop Applications**
   - Used in frameworks like **JavaFX** or **Microsoft's .NET Framework**.
3. **Mobile Applications**
   - Adopted in **iOS (Cocoa MVC)** and **Android development**.

Client-Server Model

The **client-server model** is a network architecture where two types of entities—clients and servers—communicate with each other to perform tasks. The server provides resources or services, and the client requests them. This model underpins the design of most modern networked systems, including web applications, email systems, and file-sharing platforms.

Key Components of the Client-Server Model

1. **Client**
   - **Purpose**: A client is a device or application that initiates a request for resources or services from a server.

- **Characteristics**:
  - Typically runs on end-user devices like PCs, smartphones, or tablets.
  - Sends requests to the server and processes the responses.
  - Examples: Web browsers, email clients, mobile apps.

2. **Server**
   - **Purpose**: A server is a system or application that provides resources, services, or data to clients.
   - **Characteristics**:
     - Typically hosted on powerful machines or cloud platforms.
     - Waits for client requests and responds to them.
     - Examples: Web servers, database servers, file servers.
3. **Network**
   - **Purpose**: Connects clients and servers to facilitate communication.
   - **Characteristics**:
     - Can be a local network (LAN) or the internet (WAN).
     - Uses protocols like HTTP, FTP, or SMTP for communication.

How the Client-Server Model Works

1. **Request**: The client sends a request to the server using a specific protocol.
2. **Processing**: The server processes the request using its resources or services.
3. **Response**: The server sends the requested data or an appropriate response back to the client.

Examples of the Client-Server Model

1. **Web Browsing**
   - **Client**: Web browsers like Chrome or Firefox.
   - **Server**: Web servers like Apache or Nginx serve websites.
2. **Email Systems**
   - **Client**: Email applications like Outlook or Gmail.
   - **Server**: Email servers using protocols like SMTP, IMAP, or POP3.
3. **Online Gaming**
   - **Client**: Gaming consoles or apps.
   - **Server**: Game servers handle multiplayer interactions.
4. **Database Access**
   - **Client**: Applications or software requesting data.
   - **Server**: Database servers like MySQL or PostgreSQL

Client-Server Protocols

1. **HTTP/HTTPS**
    - Used for web applications to exchange data between web clients and servers.
2. **FTP**
    - Used for file transfer between a client and a server.
3. **SMTP, IMAP, POP3**
    - Used in email systems for sending and retrieving messages.
4. **SQL**
    - Used for querying and managing databases on database servers.

Frontend Development

Frontend development involves building the part of a web application that users interact with directly—the user interface (UI). It focuses on creating visually appealing, responsive, and user-friendly designs while ensuring seamless functionality and compatibility across devices and browsers.

Key Aspects of Frontend Development

1. **Structure and Layout (HTML)**
    - **HTML (HyperText Markup Language)**: The backbone of web pages, used to structure content such as text, images, and links.
2. **Styling and Design (CSS)**
    - **CSS (Cascading Style Sheets)**: Controls the appearance of web pages, including colors, fonts, layouts, and responsiveness.
3. **Interactivity and Logic (JavaScript)**
    - Adds dynamic behaviors to web pages, such as animations, form validation, and interactive menus.

Frontend Development Frameworks and Libraries

1. **Frameworks**
    - **React.js**: A library for building dynamic user interfaces with reusable components.
    - **Angular**: A complete framework for building single-page applications (SPAs).
    - **Vue.js**: A lightweight and versatile framework for building UIs.
2. **Styling Frameworks**
    - **Bootstrap**: A framework for responsive and mobile-first design.
    - **Tailwind CSS**: A utility-first CSS framework for custom designs.

Key Frontend Skills

- HTML5 and CSS3
- JavaScript (ES6 and beyond)
- Knowledge of responsive design principles
- Understanding of API integration

Hypertext Markup Language

HTML (HyperText Markup Language):

- The standard language used to create and design the structure of web pages.
- It defines elements like headings, paragraphs, images, links, and more.

Basic Structure of an HTML Document

```
<!DOCTYPE html>
<html>
<head>
    <title>Document Title</title>
</head>
<body>
    <h1>Welcome to HTML</h1>
    <p>This is a paragraph.</p>
</body>
</html>
```

Explanation:

- `<!DOCTYPE html>`: Declares the document as HTML5.
- `<html>`: Root element containing all HTML content.
- `<head>`: Contains metadata (e.g., title, styles, links).
- `<body>`: Contains visible content of the web page.

Commonly Used HTML Tags

Tag	Description
<h1> to <h6>	Headings, <h1> is the largest.
<p>	Paragraph text.
<a>	Hyperlink.
<img>	Displays images.
	Unordered list.
	Ordered list.
	List item for or .
	Generic container for block content.

	Generic container for inline content.
<table>	Creates a table.
<form>	Creates an input form.

Attributes

- Attributes provide additional information about an element.
- **Syntax**: `<tag attribute="value">`

  Example:
  ```
  <a href="https://example.com">Visit Example</a>
  <img src="image.jpg" alt="Sample Image" width="300" height="200">
  ```

Types of Lists

- **Unordered List**:
  ```
  <ul>
      <li>Item 1</li>
      <li>Item 2</li>
  </ul>
  ```

- **Ordered List**:

  ```
  <ol>

      <li>First Item</li>

      <li>Second Item</li>

  </ol>

  ``>

  ---

  ### **6. Images**

  ```html

  <img src="path/to/image.jpg" alt="Description" width="300"
  height="200">
  ```

- `src`: Path to the image file.
  ```

- `alt`: Alternative text for accessibility.

Links

```
<a href="https://example.com" target="_blank">Click Here</a>
```

`href`: URL of the link.
`target="_blank"`: Opens link in a new tab.

Tables

```
<table border="1">
    <tr>
        <th>Heading 1</th>
        <th>Heading 2</th>
    </tr>
    <tr>
        <td>Data 1</td>
        <td>Data 2</td>
    </tr>
</table>
```

- `<table>`: Creates a table.
- `<tr>`: Table row.
- `<th>`: Table header.
- `<td>`: Table data.

Forms

```
<form action="/submit" method="POST">
    <label for="name">Name:</label>
    <input type="text" id="name" name="name">
    <button type="submit">Submit</button>
</form>
```

`action`: URL to send the form data.
`method`: HTTP method (`GET or POST`).

Semantic HTML

Semantic tags clearly describe their purpose:

- `<header>`: Page or section header.
- `<footer>`: Page footer.
- `<article>`: Independent content.

- `<section>:` Thematic grouping of content.
- `<nav>:` Navigation links.

Inline vs Block Elements

- **Inline**: Does not start a new line (e.g., `<span>, <a>`).
- **Block**: Starts a new line and takes full width (e.g., `<div>, <p>`).

Comments in HTML

Comments are not displayed on the webpage.
`Example: <!-- This is a comment -->`

Cascading Style Sheets

CSS (Cascading Style Sheets): A language used to style HTML elements, controlling the appearance and layout of web pages.
CSS allows you to change colors, fonts, spacing, layouts, and more.

Basic CSS syntax:

The CSS Syntax consists of a set of rules

```
selector{
	property:value;
}
```

Example:

```
h1{
	color:blue;  font-size: 12px;
}
```

In the example, h1 is a selector, colour and font size are properties, blue and 12px are values, property and value together known as declaration and each declaration will be separated by semicolon

The selector points to the HTML element(tag) you want to style

A selector is an HTML tag at which style will be applied. This could be any tag like h1, li, p etc.

- The declaration block contains one or more declarations separated by semicolon

The property is a type of attribute of HTML tag, values are assigned to property.

- For example, color property can have values either blue or red

Multiple CSS declarations are separated with semicolon and declaration blocks are surrounded by curly braces

Levels of stylesheet

There are three levels of stylesheet used to associate CSS styles with your HTML document

- Inline
- Internal(document)
- External

Inline CSS - The style attribute

- Inline style sheet rules will be applied to the content of the one element or tag.
- Inline style sheet rules are specified as the value of the style attribute.
- Syntax: <element style = "style rule" >
- Example: `<h1 style="color: red;">This is inline</h1>`

```
    <p style="color: blue; font-size: 18px;">This is a styled
paragraph.</p>
```

Document Level or Internal CSS- The Style element

- Document level style sheet rule will be applied to all the elements available in the document. The Internal style is defined in the <style> element, inside the head section.

```
<style>
    p {
        color: green;
        font-size: 16px;
    }
</style>
```

External stylesheet

- With an external style sheet, you can change the look of an entire website by changing just one file!
- Each HTML page must include a reference to the external style sheet file inside the <link> element, inside the head section.

```
<link rel="stylesheet" href="styles.css">
```

CSS Selectors

- **Universal Selector**: * (Applies to all elements)

```
    * { margin: 0; padding: 0; }
```

- **Type Selector(Element selector)**: Targets a specific tag (e.g., p, h1)

```
p {
    font-size: 14px;
}
```

- **Class Selector**: Targets elements with a specific class (`.`)

```
.highlight { background-color: yellow; }
```

- **ID Selector**: Targets an element with a specific ID (#)

```
#header { color: blue; }
```

- **Group Selector**: Targets multiple elements

```
h1, h2, h3 { font-family: Arial, sans-serif; }
```

- **Descendant Selector :** Targets elements within a parent

```
div p {
    color: gray;
}
```

Common Properties

Property	Description	Example
color	Text color	color: red;
background-color	Background color	background-color: yellow;
font-size	Size of text	font-size: 20px;
font-family	Font style	font-family: Arial;
margin	Space outside an element	margin: 10px;
padding	Space inside an element	padding: 5px;
border	Border around an element	border: 1px solid black;
text-align	Text alignment	text-align: center;
width	Width of an element	width: 100%;
height	Height of an element	height: 300px;

Box Model

- Describes the layout and spacing of elements, including:
    1. **Content**: The actual content inside the element.
    2. **Padding**: Space between content and border.
    3. **Border**: The boundary around padding.
    4. **Margin**: Space outside the border.

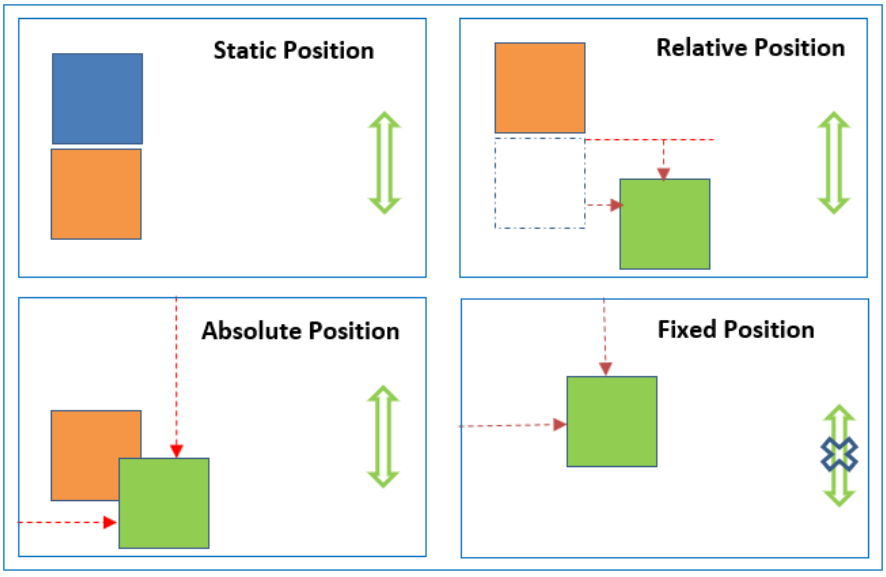
    Example:

```
div {
    width: 200px;
    padding: 10px;
    border: 2px solid black;
    margin: 20px;
}
```

Positioning

Controls the placement of elements:

- **Static**: Default positioning.
- **Relative**: Positioned relative to its normal position.
- **Absolute**: Positioned relative to its nearest positioned ancestor.
- **Fixed**: Positioned relative to the viewport.
- **Sticky**: Toggles between relative and fixed.



CSS Flexbox

Flexbox (Flexible Box Layout) is a CSS layout model designed to align and distribute items efficiently in a container, even when the size of the items is unknown or dynamic.
Useful for creating responsive designs and handling spacing/alignment issues.

Key Concepts

1. **Flex Container**: The parent element with `display: flex;` or `display: inline-flex;`.
2. **Flex Items**: The child elements of the flex container.

Properties for Flex Containers

Property	Description	Values
flex-direction	Defines the direction of flex items.	row (default), row-reverse, column, column-reverse
justify-content	Aligns items along the main axis.	flex-start, flex-end, center, space-between, space-around, space-evenly
align-items	Aligns items along the cross axis.	stretch (default), flex-start, flex-end, center, baseline
align-content	Aligns multiple lines of content (if wrapping is enabled).	stretch, flex-start, flex-end, center, space-between, space-around
flex-wrap	Specifies whether items wrap or stay on one line.	nowrap (default), wrap, wrap-reverse

Properties for Flex Items

Property	Description	Values
order	Controls the order of the items.	Integer (default is 0)
flex-grow	Specifies how much a flex item should grow relative to the others.	Number (default is 0)
flex-shrink	Specifies how much a flex item should shrink relative to the others.	Number (default is 1)
flex-basis	Sets the initial size of the flex item before growing or shrinking.	auto, <length>
align-self	Overrides align-items for a specific item.	auto, flex-start, flex-end, center, baseline, stretch

Example

```
<!--- html–>
<div class="container">
    <div class="item">1</div>
    <div class="item">2</div>
    <div class="item">3</div>
</div>

.container {
    display: flex;
    flex-direction: row; /* Items arranged horizontally */
    justify-content: space-around; /* Space around items */
    align-items: center; /* Items centered vertically */
    height: 200px;
}

.item {
    background-color: lightblue;
    padding: 20px;
    border: 1px solid blue;
}
```

CSS z-index

The **`z-index`** property in CSS determines the **stacking order** of elements along the **z-axis** (visual depth).
It defines which elements appear in front of or behind others.
Works only on elements that have a **position** other than `static` (e.g., `relative`, `absolute`, `fixed`, or `sticky`).

Values of `z-index`

Value	Description
auto	Default value. The stack order of the element is determined by its order in the DOM.
Positive Integers (1, 10, 100)	Places the element above elements with lower values.
Negative Integers (-1, -10)	Places the element below elements with higher values or 0.

0	Places the element at the default stacking context.

How z-index Works

- Higher Values Appear on Top:
  - Elements with a higher z-index value are rendered above elements with a lower value.
- Stacking Context:
  - A stacking context is created in the following cases:
    - When an element has a z-index and a positioned property (relative, absolute, etc.).
    - CSS properties like opacity (< 1), transform, or filter also create a stacking context.
  - Elements within the same stacking context only compare their z-index values within that context.

Example

```
<div class="box1">Box 1</div>
<div class="box2">Box 2</div>
<div class="box3">Box 3</div>

.box1 {
    position: relative;
    z-index: 1;
    background: lightblue;
    width: 100px;
    height: 100px;
}

.box2 {
    position: relative;
    z-index: 2;
    background: lightgreen;
    width: 100px;
    height: 100px;
    margin-top: -50px;
}

.box3 {
    position: relative;
    z-index: 0;
    background: lightcoral;
    width: 100px;
    height: 100px;
```

```
    margin-top: -50px;
}
```

CSS Grid

What is CSS Grid?

- **CSS Grid** is a powerful layout system that allows you to create complex two-dimensional layouts (both rows and columns) in a flexible and efficient way.
- It provides more control over the arrangement of items in a grid than traditional layout methods (like flexbox or floats).

Basic Terminology

- **Grid Container**: The element that defines the grid layout. It is the parent element with `display: grid;`.
- **Grid Items**: The direct child elements of the grid container, which are placed within the grid cells.
- **Grid Lines**: The horizontal and vertical lines that divide the grid into rows and columns.
- **Grid Tracks**: The space between two grid lines (i.e., rows or columns).
- **Grid Cells**: The individual spaces within the grid formed by intersecting grid lines.

Defining Rows and Columns

- **`grid-template-columns`**: Specifies the width of each column.
- **`grid-template-rows`**: Specifies the height of each row

Creating Gaps Between Rows and Columns

- **`grid-gap`**: Defines the space between grid items.
- **`grid-column-gap`**: Defines space between columns.
- **`grid-row-gap`**: Defines space between rows.

Justify and Align Content in the Grid

- **`justify-content`**: Aligns the entire grid container's content horizontally.
- **`align-content`**: Aligns the entire grid container's content vertically.

Example:

```
<div class="container">
    <div class="item1">Item 1</div>
    <div class="item2">Item 2</div>
```

```
    <div class="item3">Item 3</div>
    <div class="item4">Item 4</div>
</div>

.container {
    display: grid;
    grid-template-columns: 1fr 1fr 1fr;
    grid-template-rows: 100px 100px;
    grid-gap: 10px;
}

.item1 {
    background: lightblue;
    grid-column: 1 / 3; /* Spans columns 1 to 3 */
}

.item2 {
    background: lightgreen;
}

.item3 {
    background: lightcoral;
}

.item4 {
    background: lightyellow;
}
```

Responsive Grid Layouts

```
.container {
    display: grid;
    grid-template-columns: 1fr 1fr 1fr;
    grid-gap: 10px;
}

@media (max-width: 600px) {
    .container {
        grid-template-columns: 1fr; /* Single column on small screens */
    }
}
```

Benefits of Using CSS Grid

1. **2D Layouts**: Grid allows both row and column alignment, unlike flexbox, which is one-dimensional.
2. **Precision**: Grid allows you to create precise, complex layouts with less effort.
3. **Responsiveness**: Easily create responsive designs using `fr` units, `auto`, and `media queries`.
4. **Align Items and Content**: Aligning both grid items and the entire grid content becomes much easier.

CSS Responsive Design

- **Responsive Web Design (RWD)** ensures that web pages adapt to different screen sizes and orientations. It aims to provide an optimal viewing experience across a wide range of devices, from desktop monitors to smartphones.
- It uses flexible layouts, images, and media queries to create a fluid, adaptable design.

Key Principles of Responsive Design

1. **Fluid Layouts**:
    - Use flexible units like percentages (%), `vw` (viewport width), and `vh` (viewport height) to set widths, margins, and padding. This allows the layout to scale according to the size of the viewport.
2. **Flexible Images**:
    - Images should scale with the size of the container. Use CSS to set `max-width: 100%` to make images responsive.
3. **Media Queries**:
    - Media queries are key to responsive design. They apply CSS styles based on specific conditions like screen width, height, or device orientation.

Fluid Layouts

A fluid layout in CSS adapts to the screen size, allowing the design to adjust as the window is resized. You can achieve this by using relative units like percentages or `vw` (viewport width), rather than fixed pixel values.

- Use **percentages**, **vw**, **vh**, and **em**/rem units instead of fixed pixel values.

```
<!DOCTYPE html>
<html lang="en">
<head>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1.0">
  <title>Fluid Layout Example</title>
  <style>
```

```
    body {
      margin: 0;
      font-family: Arial, sans-serif;
    }

    .container {
      width: 100%;
      margin: 0 auto;
      padding: 20px;
    }

    .header, .footer {
      background-color: #333;
      color: white;
      text-align: center;
      padding: 20px;
    }

    .main {
      display: flex;
      flex-wrap: wrap;
      justify-content: space-between;
    }

    .main > .box {
      width: 48%; /* Fluid width, taking up half of the container */
      background-color: #f4f4f4;
      padding: 20px;
      margin-bottom: 20px;
      box-sizing: border-box;
    }

    @media (max-width: 768px) {
      .main > .box {
        width: 100%; /* Stack the boxes on smaller screens */
      }
    }
  </style>
</head>
<body>

  <div class="container">
    <div class="header">
```

```
      <h1>Fluid Layout Example</h1>
    </div>

    <div class="main">
      <div class="box">
        <h2>Box 1</h2>
        <p>This box will take up 48% of the width on larger screens.</p>
      </div>
      <div class="box">
        <h2>Box 2</h2>
        <p>This box will also take up 48% of the width on larger screens.</p>
      </div>
    </div>

    <div class="footer">
      <p>&copy; 2025 Fluid Layout Example</p>
    </div>
  </div>

</body>
</html>
```

Flexible Images

To make images flexible in CSS, you can use the `max-width` property along with `height: auto;`. This ensures that the images scale appropriately while maintaining their aspect ratio

- **`max-width: 100%`** ensures images scale with their parent container, preventing overflow.

```
<!DOCTYPE html>
<html lang="en">
<head>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1.0">
  <title>Flexible Images Example</title>
  <style>
    body {
      margin: 0;
      font-family: Arial, sans-serif;
    }

    .container {
```

```
      width: 80%;
      margin: 0 auto;
      padding: 20px;
      text-align: center;
    }

    img {
      max-width: 100%; /* Makes the image scale to the container's width */
      height: auto;    /* Maintains aspect ratio */
      display: block;  /* Removes space below the image */
      margin: 0 auto;  /* Centers the image */
    }
  </style>
</head>
<body>

  <div class="container">
    <h1>Flexible Image Example</h1>
    <img src="https://via.placeholder.com/1200x800" alt="Placeholder Image">
    <p>The image will resize automatically according to the container size
while maintaining its aspect ratio.</p>
  </div>

</body>
</html>
```

Explanation:

- The `img` tag has a `max-width: 100%;` property, which ensures the image will not exceed the width of its parent container (in this case, `.container`).
- The `height: auto;` property maintains the image's aspect ratio as it scales up or down.
- `display: block;` is used to remove any unwanted space beneath the image (which is typically caused by inline-block behavior of images).
- `margin: 0 auto;` centers the image within its container.

Media Queries

- Media queries allow you to apply CSS styles based on conditions such as viewport width, height, orientation, and more.

Common Conditions:

- `max-width`: Applies styles when the viewport is smaller than the specified width.
- `min-width`: Applies styles when the viewport is larger than the specified width.
- `orientation`: Detects the screen's orientation (`portrait` or `landscape`).

Breakpoints

- **Breakpoints** are specific widths at which the layout should adjust.
- Common breakpoints:
  - `320px`: Small mobile devices.
  - `600px`: Medium-sized devices (tablets).
  - `768px`: Tablet-sized screens.
  - `1024px`: Desktop-sized screens.
  - `1200px`: Large desktop screens.

Mobile-First Design

- **Mobile-first** approach involves designing for smaller screens (mobile devices) first, then using media queries to adjust styles for larger screens.
- This ensures that mobile users get a faster-loading, optimized experience.

Viewport Meta Tag (For Mobile)

- To control the viewport's size and scaling on mobile devices, use the `<meta>` tag inside the `<head>` of the HTML document.

`width=device-width`: Makes the width of the page match the width of the device.
`initial-scale=1.0`: Sets the initial zoom level when the page is loaded.

Example:

```
<!DOCTYPE html>
<html lang="en">
<head>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1.0">
  <title>Responsive Design Example</title>
  <style>
    /* Mobile-first base styles */
    body {
      margin: 0;
      font-family: Arial, sans-serif;
      padding: 0;
    }
```

```
.container {
  width: 100%;
  padding: 10px;
  box-sizing: border-box;
}

.header, .footer {
  background-color: #333;
  color: white;
  text-align: center;
  padding: 10px;
}

.main {
  text-align: center;
  margin-top: 20px;
}

.main > .box {
  width: 100%;  /* Full width on small screens */
  background-color: #f4f4f4;
  padding: 20px;
  margin-bottom: 20px;
  box-sizing: border-box;
}

/* Tablet */
@media (min-width: 600px) {
  .main {
    display: flex;
    justify-content: space-around;
  }

  .main > .box {
    width: 45%;  /* 2 boxes side by side on tablets */
  }
}

/* Laptop / Desktop */
@media (min-width: 992px) {
  .main > .box {
    width: 30%;  /* 3 boxes side by side on larger screens */
```

```
      }
    }

    /* Large Desktop */
    @media (min-width: 1200px) {
      .container {
        width: 80%;  /* Center content with more space on larger screens */
      }
    }
  </style>
</head>
<body>

  <div class="container">
    <div class="header">
      <h1>Responsive Design Example</h1>
    </div>

    <div class="main">
      <div class="box">
        <h2>Box 1</h2>
        <p>This box will take up 100% of the width on mobile devices, 45% on
tablets, and 30% on desktops.</p>
      </div>
      <div class="box">
        <h2>Box 2</h2>
        <p>This box will adjust similarly depending on screen size.</p>
      </div>
      <div class="box">
        <h2>Box 3</h2>
        <p>On larger screens, you will see 3 boxes in a row. On mobile, the
boxes stack.</p>
      </div>
    </div>

    <div class="footer">
      <p>&copy; 2025 Responsive Design Example</p>
    </div>
  </div>

</body>
</html>
```

Explanation:

1. **Mobile-First Approach:**
    - The base styles are designed for mobile devices (small screens).
    - The `.box` elements have `width: 100%`, meaning they take up the entire width of the container on mobile devices.
2. **Media Queries for Larger Screens:**
    - **`@media (min-width: 600px)`**: Targets devices with a screen width of at least 600px (tablets and larger). The `.box` elements will be displayed side by side with `width: 45%`.
    - **`@media (min-width: 992px)`**: Targets devices with a screen width of at least 992px (laptops and larger). The `.box` elements will be displayed in 3 columns, each with `width: 30%`.
    - **`@media (min-width: 1200px)`**: For screens larger than 1200px (large desktops), the `.container` is given a `width: 80%` to center it with some space around it.

Breakpoints:

- **Mobile (default)**: No media query required, as the base styles are mobile-friendly.
- **Tablet (≥600px)**: `@media (min-width: 600px)`
- **Laptop/Desktop (≥992px)**: `@media (min-width: 992px)`
- **Large Desktop (≥1200px)**: `@media (min-width: 1200px)`

Key Concepts:

- **Mobile-first**: Start with styles for mobile devices and add breakpoints to adjust for larger screens.
- **Flexible Layouts**: Use percentages (%) or `flexbox` to create responsive designs that adjust to different screen sizes.
- **Media Queries**: Use media queries to apply styles based on specific screen widths, making the design responsive.

CSS Animations

What are CSS Animations?

- **CSS Animations** allow you to animate HTML elements without the need for JavaScript.
- They provide a way to change CSS properties smoothly over time, creating dynamic effects like movement, color changes, scaling, rotations, and more.

Syntax:

```
@keyframes animationName {
    from {
        /* Initial state of the animation */
        property: value;
    }
    to {
        /* Final state of the animation */
        property: value;
    }
}

.element {
    animation: animationName duration timing-function delay iteration-count
direction;
}
```

`@keyframes`: Defines the animation and its behavior over time.
`animation`: A shorthand property that includes animation name, duration, timing function, delay, iteration count, and direction.

Key Properties for CSS Animations

- **`@keyframes`**: Defines the sequence of frames in the animation.
  - **`from`**: Starting point of the animation (0%).
  - **`to`**: Ending point of the animation (100%)
- **`animation-name`**: The name of the animation (the name defined in `@keyframes`).
- **`animation-duration`**: Defines how long the animation lasts.
- **`animation-timing-function`**: Specifies the speed curve of the animation (how the transition happens over time).
- **Common values:**
  - `linear`: Constant speed.
  - `ease`: Starts slow, speeds up, then slows down.
  - `ease-in`: Starts slow and speeds up.
  - `ease-out`: Starts fast and slows down.
  - `ease-in-out`: Starts and ends slow, speeds up in the middle.
- **`animation-delay`**: Defines a delay before the animation starts.
- **`animation-iteration-count`**: Specifies how many times the animation should run.
- **`infinite`**: The animation runs indefinitely.
- **`animation-direction`**: Defines whether the animation should play forward, backward, or alternate between forward and backward.
  - `normal`: Default, plays from start to finish.

    - `reverse`: Plays the animation in reverse.
    - `alternate`: Alternates between forward and backward.
- **`animation-fill-mode`**: Defines the style of the element after the animation ends.
    - `forwards`: The animation will retain the styles of the last frame.
    - `backwards`: The animation will retain the styles of the first frame.
    - `both`: Both `forwards` and `backwards`.

Example:

```
<!DOCTYPE html>

<html lang="en">

<head>

  <meta charset="UTF-8">

  <meta name="viewport" content="width=device-width, initial-scale=1.0">

  <title>Simple Animation Example</title>

  <style>

    /* Base styling for the rectangle */

    .rectangle {

      width: 100px;

      height: 100px;

      background-color: #4CAF50;

      position: absolute;

      top: 50%;

      left: 50%;

      transform-origin: center; /* To rotate around the center */

      animation: rotateAndMove 4s linear infinite;

    }
```

```
    /* Keyframes for the animation */

    @keyframes rotateAndMove {

      0% {

        transform: translate(-50%, -50%) rotate(0deg); /* Initial position
and rotation */

      }

      50% {

        transform: translate(150px, -50%) rotate(180deg); /* Move right and
rotate */

      }

      100% {

        transform: translate(300px, -50%) rotate(360deg); /* Move further
right and complete rotation */

      }

    }

  </style>

</head>

<body>

  <div class="rectangle"></div>

</body>

</html>
```

JavaScript

JavaScript is a **high-level, interpreted programming language** that is used to create interactive and dynamic websites. It enables the manipulation of web page elements, control of browser events, communication with servers, and more.
It is an essential part of the **web development stack**, alongside HTML (structure) and CSS (style).

Variables in Javascript

Variables are used to store data values that can be referenced and manipulated in a program. They act as containers for data, allowing developers to store and retrieve values during the execution of the program.

Declaring Variables

JavaScript provides three keywords to declare variables:

- var
- let
- const

Types of Variables

`var` (Older Method)

- Declares a variable that can be re-assigned and re-declared.
- Has **function-scoped** or **global-scoped** behavior.
- Not recommended for modern JavaScript, as it can lead to issues like hoisting and scoping problems.

```
var name = "John"; // Declare a variable using var
name = "Alice"; // Reassigning the variable
```

`let` (Modern Method)

- Declares a variable with block scope (limited to the block, statement, or expression where it's used).
- Can be reassigned but cannot be redeclared within the same scope.
- Preferred for most cases where re-assignment is needed.

```
let age = 25; // Declare a variable using let
age = 30; // Reassigning the variable
```

`const` (Constant)

- Declares a constant, meaning the variable cannot be reassigned after initialization.
- Also block-scoped.
- Typically used for values that are not expected to change, like configuration values.

```
const birthYear = 1995; // Declare a constant using const

// birthYear = 2000; // Error! Cannot reassign a constant
```

Variable Hoisting

- JavaScript **hoists** declarations, but **not initializations**. This means that `var` and `let` declarations are moved to the top of their respective scopes during compilation.

```
console.log(x); //

Undefined var x = 5;

console.log(y); // Error: Cannot access 'y' before initialization

 let y = 10;
```

Variable Scope

- **Global Scope**: A variable declared outside of any function or block is in the global scope. It is accessible anywhere in the code.
- **Function Scope**: Variables declared inside a function using `var` are available only within that function.
- **Block Scope**: Variables declared using `let` and `const` are limited to the block (enclosed in `{}`) in which they are declared.

Best Practices

- Use `let` and `const` instead of `var` for better scoping and avoid potential issues with hoisting and accidental re-declarations.
- Use `const` for variables that should not be reassigned.
- Keep variable names descriptive and follow naming conventions (`camelCase` for variables).

Data Types

JavaScript supports various data types:

1. **Primitive Types**:

- **Number**: `let a = 5;`
- **String**: `let str = "Hello";`
- **Boolean**: `let isTrue = true;`
- **Null**: `let obj = null;`
- **Undefined**: `let data;`
- **Symbol**: `let sym = Symbol('id');`

2. **Object Types**:
   - **Object**: `let person = { name: "John", age: 30 };`
   - **Array**: `let arr = [1, 2, 3];`
   - **Function**: Functions are also objects.

Operators

1. **Arithmetic Operators**:
   - `+`, `-`, `*`, `/`, `%`, `++`, `--`
2. **Assignment Operators**:
   - `=`, `+=`, `-=`, `*=`, `/=`
3. **Comparison Operators**:
   - `==`, `===`, `!=`, `!==`, `>`, `<`, `>=`, `<=`
4. **Logical Operators**:
   - && (AND), || (OR), ! (NOT)

Control Flow

1. **Conditional Statements**:
   - `if`, `else`, `else if`

```
if (x > y) {
    console.log("x is greater than y");
} else if (x < y) {
    console.log("x is smaller than y");
} else {
    console.log("x and y are equal");
}
```

- Switch Statement:

```
switch (day) {
    case 1:
        console.log("Sunday");
        break;
    case 2:
        console.log("Monday");
```

```
            break;
        default:
            console.log("Invalid day");
    }
```

Loops:

- **`for` loop**: Runs a block of code for a specified number of times.
- **`while` loop**: Continues until a condition is false.
- **`do...while` loop**: Executes code at least once, then repeats while the condition is true.

```
for (let i = 0; i < 5; i++) {
    console.log(i);
}
```

Functions

A function in JavaScript is a block of reusable code designed to perform a specific task. Functions help make code modular, reusable, and easier to maintain.

Declaring a Function

A function is declared using the function keyword, followed by a function name, parentheses (), and a block {} that contains the code.

Syntax:

```
function functionName(parameters) {
    // Function body
    return value; // (optional)
}
```

Function Parameters & Arguments

- **Parameters** are placeholders defined in the function declaration.
- **Arguments** are actual values passed to the function when calling it.

```
function greetUser(name) {
    console.log("Hello, " + name + "!");
}
```

```
greetUser("Alice"); // Output: Hello, Alice!
```

Here, `name` is a **parameter**.
`"Alice"` is an **argument**.

Function Return Statement

The return statement is used to send a value back to the caller.

```
function multiply(x, y) {
    return x * y;
}

let result = multiply(3, 4);
console.log(result); // Output: 12
```

- Functions **without return** simply execute code but do not return a value.

Function Expressions (Anonymous Functions)

A function can also be stored inside a variable. These are called **function expressions**.

```
let square = function(num) {

    return num * num;

};

console.log(square(5)); // Output: 25
```

- Function expressions **do not have names** (anonymous functions).
- They must be defined **before** calling them.

Arrow Functions (ES6)

Arrow functions provide a shorter syntax for writing functions.

Syntax:

```
const functionName = (parameters) => expression;
```

Example:

```
const add = (a, b) => a + b;

console.log(add(4, 6)); // Output: 10
```

Single Parameter (No Parentheses Needed)

```
const greet = name => console.log("Hello, " + name);

greet("John"); // Output: Hello, John
```

Multi-line Arrow Function

```
const multiply = (a, b) => {
    let result = a * b;
    return result;
};
console.log(multiply(3, 7)); // Output: 21
```

Function Scope

- **Global Scope**: Variables declared outside a function can be accessed anywhere.
- **Local Scope**: Variables declared inside a function are only accessible within that function.

```
let globalVar = "I am global";

function testScope() {
    let localVar = "I am local";
    console.log(globalVar); // Accessible
    console.log(localVar); // Accessible
}
testScope();

console.log(globalVar); // Accessible

// console.log(localVar); // Error! Not defined outside function
```

Default Parameters (ES6)

If an argument is not passed, the function will use a default value.

```
function greet(name = "Guest") {
    console.log("Hello, " + name);
}

greet(); // Output: Hello, Guest
greet("Alice"); // Output: Hello, Alice
```

Immediately Invoked Function Expression (IIFE)

A function that runs immediately after being defined.

```
(function() {
    console.log("I am an IIFE!");
})(); // Output: I am an IIFE!
```

Why use IIFE?

- To avoid polluting the global scope.
- Useful for initialization code.

Higher-Order Functions

Functions that take another function as an argument or return a function.

```
function operate(a, b, operation) {
    return operation(a, b);
}

let sum = operate(5, 3, (x, y) => x + y);
console.log(sum); // Output: 8
```

Function Hoisting

- **Function declarations** are hoisted to the top of their scope.
- **Function expressions** are **not hoisted**.

```
hoistedFunction(); // Works fine

function hoistedFunction() {
    console.log("This function is hoisted!");
}
—-------------------------------------------------
```

```
nonHoistedFunction(); // Error! Cannot access before
initialization

const nonHoistedFunction = function() {
    console.log("This function is NOT hoisted!");
};
```

Closures

A closure is a function that remembers its surrounding variables even after execution

```
function outer() {
    let count = 0;
    return function inner() {
        count++;
        console.log(count);
    };
}

let counter = outer();
counter(); // Output: 1
counter(); // Output: 2
```

JavaScript Objects

An object in JavaScript is a collection of key-value pairs where values (properties) can be of any data type, including functions. Objects allow us to store and manage related data efficiently.

```
Example:
let person = {
    name: "John",
    age: 30,
    isStudent: false
};
```

Creating an Object

Method 1: Object Literal (Most Common)

```
let car = {
```

```
    brand: "Toyota",
    model: "Camry",
    year: 2022
};
```

Method 2: Using new Object() (Less Common)

```
let person = new Object();
person.name = "Alice";
person.age = 25;
```

Method 3: Using a Constructor Function

```
function Person(name, age) {
    this.name = name;
    this.age = age;
}

let john = new Person("John", 30);
```

Method 4: Using Object.create()

```
let personPrototype = {
    greet: function() {
        console.log("Hello!");
    }
};

let newPerson = Object.create(personPrototype);
newPerson.greet(); // Output: Hello!
```

Accessing Object Properties

Dot Notation (Recommended)

```
console.log(car.brand); // Output: Toyota
```

Bracket Notation (For Dynamic Keys)

```
console.log(car["model"]); // Output: Camry
```

Adding and Modifying Properties

Adding New Properties

```
car.color = "Red";
console.log(car.color); // Output: Red
```

Modifying Existing Properties

```
car.year = 2023;
console.log(car.year); // Output: 2023
```

Deleting Properties

```
delete car.color;
console.log(car.color); // Output: undefined
```

Object Methods (Functions Inside Objects)

An object method is a function stored as a property.

```
let person = {
    name: "Alice",
    age: 25,
    greet: function() {
        console.log("Hello, " + this.name);
    }
};

person.greet(); // Output: Hello, Alice
```

Checking if a Property Exists

- **Using in Operator**

```
console.log("model" in car); // Output: true
console.log("color" in car); // Output: false
```

- **Using hasOwnProperty()**

```
console.log(car.hasOwnProperty("brand")); // Output: true
```

Looping Through an Object

- **Using `for...in` Loop**

```
for (let key in car) {
    console.log(key + ": " + car[key]);
}
```

Object Methods

Object.keys() – Get All Keys

```
console.log(Object.keys(car)); // Output: ["brand", "model", "year"]
```

Object.values() – Get All Values

```
console.log(Object.values(car)); // Output: ["Toyota", "Camry", 2022]
```

Object.entries() – Get Key-Value Pairs

```
console.log(Object.entries(car));
// Output: [["brand", "Toyota"], ["model", "Camry"], ["year", 2022]]
```

Object.assign() – Clone or Merge Objects

```
let newCar = Object.assign({}, car); // Cloning an object
```

Nested Objects

Objects can contain other objects.

```
let student = {
    name: "Mike",
    marks: {
        math: 90,
        science: 85
    }
};

console.log(student.marks.math); // Output: 90
```

JSON (JavaScript Object Notation)

JSON is a lightweight data format that looks like JavaScript objects but is used for data exchange.

Converting an Object to JSON

```
let jsonData = JSON.stringify(student);
console.log(jsonData);
// Output: '{"name":"Mike","marks":{"math":90,"science":85}}'
```

Parsing JSON Back to an Object

```
let parsedData = JSON.parse(jsonData);
console.log(parsedData);
```

this Keyword in Objects

- this refers to the object it belongs to.
- Used in methods to access object properties.

```
let user = {
    name: "John",
    greet: function() {
        console.log("Hello, " + this.name);
    }
};

user.greet(); // Output: Hello, John
```

Object Destructuring

Extract values from objects into variables.

```
let user = { name: "Alice", age: 25 };
let { name, age } = user;

console.log(name); // Output: Alice
console.log(age); // Output: 25
```

Spread Operator (...) with Objects

Merging Objects

```
let obj1 = { a: 1, b: 2 };
let obj2 = { c: 3, d: 4 };

let merged = { ...obj1, ...obj2 };
console.log(merged); // Output: { a: 1, b: 2, c: 3, d: 4 }
```

Classes and Objects (ES6)

```
Objects can also be created using classes.
class Car {
    constructor(brand, model) {
        this.brand = brand;
        this.model = model;
    }

    display() {
```

```
            console.log(this.brand + " " + this.model);
        }
    }

    let myCar = new Car("Honda", "Civic");
    myCar.display(); // Output: Honda Civic
```

Object Freezing & Sealing

`Object.freeze()` – Prevent Modifications

```
    let obj = { name: "John" };
    Object.freeze(obj);
    obj.name = "Alice"; // No effect
    console.log(obj.name); // Output: John
```

`Object.seal()` – Allow Updates but No New Properties

```
    let obj2 = { age: 30 };
    Object.seal(obj2);
    obj2.age = 35; // Allowed
    obj2.city = "New York"; // Not Allowed
    console.log(obj2); // Output: { age: 35 }
```

Asynchronous JavaScript

JavaScript is single-threaded, meaning it executes code line by line. However, it uses an asynchronous model to handle tasks like:

- Fetching data from an API
- Reading files
- Timers (e.g., setTimeout)
- User interactions

This prevents blocking the main thread and keeps the app responsive.

Synchronous vs. Asynchronous Execution

Synchronous Code (Blocking)

Executes line by line, waiting for each operation to complete before moving to the next.

```
console.log("Start");
for (let i = 0; i < 1000000000; i++) {} // Blocking operation
console.log("End");

// Output:
// Start
// End (after delay)
```

Asynchronous Code (Non-Blocking)

Allows other operations to continue while waiting.

```
console.log("Start");
setTimeout(() => console.log("Async Task"), 2000);
console.log("End");

// Output:
// Start
// End
// (After 2 seconds) Async Task
```

Callbacks

A callback is a function passed as an argument to another function, executed later.

Why Use Callbacks?

- JavaScript is **asynchronous** (especially in I/O operations, API calls, and event handling).
- Callbacks ensure that certain code executes only **after** another function completes execution.
- Helps in managing **asynchronous operations** like file reading, database queries, and API calls.

Synchronous vs. Asynchronous Callbacks

Synchronous Callbacks

- These are executed immediately within the function that calls them.
- Example:

```
function greet(name, callback) {
```

```
        console.log("Hello, " + name);

        callback();

    }

    function sayGoodbye() {

        console.log("Goodbye!");

    }

    greet("John", sayGoodbye);
```

Output:

```
    Hello, John

    Goodbye!
```

Asynchronous Callbacks

- These are executed after an asynchronous operation completes (e.g., setTimeout, API calls, file reading).
- Example:

```
function fetchData(callback) {
    setTimeout(() => {
        console.log("Data fetched!");
        callback();
    }, 2000);
}

function processData() {
    console.log("Processing data...");
}

fetchData(processData);
```

Output (after 2 seconds):

```
Data fetched!
Processing data...
```

Callback in Asynchronous JavaScript (API Call Example)

```
function getUserData(id, callback) {
    setTimeout(() => {
```

```
        console.log(`User data for ID: ${id}`);
        callback();
    }, 2000);
}

getUserData(101, function() {
    console.log("Processing user data...");
});
```

Callback Hell (Pyramid of Doom)

- When multiple callbacks are nested, it leads to unreadable and difficult-to-maintain code.
- Example of **callback hell**:

```
setTimeout(() => {
    console.log("Step 1");
    setTimeout(() => {
        console.log("Step 2");
        setTimeout(() => {
            console.log("Step 3");
        }, 1000);
    }, 1000);
}, 1000);
```

Solution: Use **Promises** or **async/await** instead of deep-nested callbacks.

Replacing Callbacks with Promises

Instead of nesting callbacks, use **Promises** to handle asynchronous operations cleanly:

```
function fetchData() {
    return new Promise((resolve) => {
        setTimeout(() => {
            console.log("Data fetched!");
            resolve();
        }, 2000);
    });
}

fetchData().then(() => {
    console.log("Processing data...");
});
```

Promises in JavaScript

A **Promise** in JavaScript is an object that represents the eventual completion (or failure) of an asynchronous operation. It provides a way to handle asynchronous code more efficiently and avoids **callback hell**.

Why Use Promises?

- Helps manage **asynchronous** operations like API calls, file reading, or database access.
- Provides better **readability** compared to nested callbacks.
- Supports **chaining** (`.then()`) and **error handling** (`.catch()`).

States of a Promise

A Promise can be in one of the following states:

1. **Pending** – The initial state, before the operation completes.
2. **Fulfilled** – The operation completed successfully.
3. **Rejected** – The operation failed.

Creating a Promise

```
let myPromise = new Promise((resolve, reject) => {
    let success = true; // Simulating success or failure
    setTimeout(() => {
        if (success) {
            resolve("Data fetched successfully!");
        } else {
            reject("Error fetching data!");
        }
    }, 2000);
});

myPromise
    .then((result) => console.log(result)) // Runs if resolved
    .catch((error) => console.log(error))  // Runs if rejected
    .finally(() => console.log("Operation complete!")); // Always runs
```

Chaining Promises

```
function step1() {
    return new Promise((resolve) => {
        setTimeout(() => {
            console.log("Step 1 completed");
            resolve();
        }, 1000);
```

```
    });
}

function step2() {
    return new Promise((resolve) => {
        setTimeout(() => {
            console.log("Step 2 completed");
            resolve();
        }, 1000);
    });
}

step1().then(step2).then(() => console.log("All steps done!"));
```

Handling Errors with `.catch()`

```
function fetchData() {
    return new Promise((resolve, reject) => {
        setTimeout(() => {
            let success = false;
            if (success) {
                resolve("Data fetched!");
            } else {
                reject("Failed to fetch data!");
            }
        }, 2000);
    });
}

fetchData()
    .then((data) => console.log(data))
    .catch((error) => console.log("Error:", error));
```

Using Promise.all() for Parallel Execution

- Promise.all() runs multiple promises in parallel and waits for all to resolve.
- If **any** promise fails, it rejects the entire operation.

```
let promise1 = new Promise((resolve) => setTimeout(() => resolve("Data
1"), 2000));

let promise2 = new Promise((resolve) => setTimeout(() => resolve("Data
2"), 1000));
```

```
Promise.all([promise1, promise2])
    .then((results) => console.log(results)) // ["Data 1", "Data 2"]
    .catch((error) => console.log(error));
```

Using Promise.race()

- Promise.race() resolves/rejects as soon as **one** of the promises settles.

```
Promise.race([
    new Promise((resolve) => setTimeout(() => resolve("Fast response"), 1000)),
    new Promise((resolve) => setTimeout(() => resolve("Slow response"), 3000))
])
.then((result) => console.log(result)); // Output: "Fast response"
```

Converting Callbacks to Promises

```
function asyncOperation(callback) {
    setTimeout(() => {
        callback("Task completed!");
    }, 2000);
}
// Converting to a Promise-based function
function asyncOperationPromise() {
    return new Promise((resolve) => {
        setTimeout(() => resolve("Task completed!"), 2000);
    });
}
asyncOperationPromise().then(console.log);
```

Async/Await in JavaScript

`async/await` is a modern way to handle asynchronous code in JavaScript, making it easier to read and write than using Promises with `.then() and .catch().`

- **async function**: Always returns a promise.
- **await keyword**: Pauses execution until the promise resolves

Why Use `async/await`?

- Improves **readability** (looks like synchronous code).
- Reduces **callback hell** and **promise chaining**.
- Handles **asynchronous** code efficiently.

Using `async and await`

```
async function fetchData() {

    return "Data received!";

}

fetchData().then(console.log); // Output: "Data received!"
```

Since async always returns a promise, we use .then() to get the result.

Using `await Inside async`

```
async function getData() {

    let result = await new Promise((resolve) => {

        setTimeout(() => resolve("Data fetched!"), 2000);

    });

    console.log(result); // Output after 2 sec: "Data fetched!"

}

getData();
```

The await keyword **pauses** the function until the promise resolves.

This makes the code look synchronous while still being asynchronous.

```
async function fetchData() {
```

```
        try {
            let response = await new Promise((resolve, reject) => {
                setTimeout(() => reject("Error fetching data!"), 2000);
            });
            console.log(response);
        } catch (error) {
            console.log("Caught error:", error);
        }
    }
    fetchData();
```

Using `async/await` with API Calls (Fetch Example)

```
async function getUser() {
    try {
        let response = await
fetch("https://jsonplaceholder.typicode.com/users/1");
        let data = await response.json(); // Convert response to JSON
        console.log(data);
    } catch (error) {
        console.log("API Error:", error);
    }
}
getUser();
```

fetch() returns a promise, so await ensures we get the result before moving ahead.

await response.json() ensures JSON parsing is complete before logging.

REACT JS

Introduction to React.js

- A JavaScript library for building UI components.
- Developed and maintained by Facebook (Meta).
- Follows a component-based architecture.
- Uses a **Virtual DOM** for efficient updates.

Key Features

- **Declarative UI** → React makes it easier to design predictable UI.
- **Component-Based** → UI is built using reusable components.
- **Virtual DOM** → Minimizes direct manipulation of the actual DOM, improving performance.
- **One-Way Data Binding** → Data flows in a single direction, making debugging easier.
- **Hooks & Functional Components** → Enables state and lifecycle features in functional components.
- **React Native** → Used for building mobile applications.

React.js Setup and Installation

- **Using CDN (for basic projects)**

```
<script src="https://unpkg.com/react@18/umd/react.development.js">
</script>
<script
src="https://unpkg.com/react-dom@18/umd/react-dom.development.js">
</script>
```

- **Using Create-React-App (CRA)**

```
npx create-react-app my-app
```

```
cd my-app
npm start
```

- **Using Vite (Faster than CRA)**

```
npm create vite@latest my-app --template react
cd my-app
npm install
npm run dev
```

React Components

A **component** in React is a reusable, self-contained block of UI. Components help break down a user interface into smaller, manageable parts, making development modular and scalable.

Types of React Components

1. **Functional Components (Recommended)**
   - These are simple JavaScript functions that return JSX.
   - Introduced in React 16.8 with Hooks, they can now handle state and side effects.
   - Easier to write, test, and understand.

     Example:

```
import React from 'react';

const Greeting = (props) => {

  return <h1>Hello, {props.name}!</h1>;

};

export default Greeting;
```

2. **Class Components (Older Approach)**
   - ES6 classes that extend `React.Component`.
   - Use this.state for managing state and `this.setState()` for updates.
   - More complex than functional components.

     Example:

```
import React, { Component } from 'react';

class Greeting extends Component {
```

```
    render() {
      return <h1>Hello, {this.props.name}!</h1>;
    }
  }
  export default Greeting;
```

Key Features of Components

- **Props (Properties)**
  - Read-only attributes passed from a parent to a child component.
  - Props are immutable.

  Example:

  ```
  const Welcome = (props) => <h1>Welcome, {props.user}!</h1>;

  <Welcome user="John" />;
  ```

- **State**
  - A component's private, mutable data.
  - Used to handle dynamic behavior.

  Example (Using State in Class Components - Older Approach):

  ```
  class Counter extends React.Component {
    constructor() {
      super();
      this.state = { count: 0 };
    }
    increment = () => {
      this.setState({ count: this.state.count + 1 });
    };
    render() {
  ```

```
    return (
      <div>
        <p>Count: {this.state.count}</p>
        <button onClick={this.increment}>Increment</button>
      </div>
    );
  }
}
```

JSX (JavaScript XML)

JSX Syntax

- JSX allows writing HTML-like syntax in JavaScript.

```
const element = <h1>Hello, React!</h1>;
```

JSX Rules

- Must return a single parent element.
- Use `{}` for embedding JavaScript expressions.
- Use `className` instead of `class` for CSS classes.
- Self-closing tags require `/` (e.g., `<img />`, `<br />`).

Component Communication in React

In React, components often need to communicate with each other to share data or trigger actions. This communication can happen between parent and child components, sibling components, or even unrelated components. Below are the different ways components communicate in React.

1. Parent to Child Communication (via Props)

- The parent component passes data to the child component using **props**.
- Props are **read-only** and cannot be modified by the child component

Example:

```
const Parent = () => {
```

```
  return <Child name="John" />;
};
const Child = (props) => {
  return <h1>Hello, {props.name}!</h1>;
};

export default Parent;
```

Key Points:

- Props are immutable (cannot be changed by the child).
- The child component receives and uses the props.

2. Child to Parent Communication (via Callback Functions)

- The child component sends data to the parent using a function passed down as a prop.
- This is useful when a child component needs to inform the parent about an event (e.g., button click).

```
const Parent = () => {
  const handleChildData = (data) => {
    alert(`Received from child: ${data}`);
  };
  return <Child sendData={handleChildData} />;
};
const Child = ({ sendData }) => {
  return (
    <button onClick={() => sendData("Hello Parent!")}>Click Me</button>
  );
};
```

export default Parent;

Key Points:

- The parent passes a function (`sendData`) as a prop.
- The child calls this function and sends data back to the parent.

3. Communication Between Unrelated Components

When components are not related in a parent-child hierarchy, we use **Context API, Redux, or event-based communication**.

a. Context API (Global State)

- React's built-in **Context API** provides a way to share state without prop drilling.

Step 1: Create Context

```
import React, { createContext, useState } from "react";

export const MessageContext = createContext();

const MessageProvider = ({ children }) => {

  const [message, setMessage] = useState("Hello from Context");

  return (

    <MessageContext.Provider value={{ message, setMessage }}>

      {children}

    </MessageContext.Provider>

  );

};

export default MessageProvider;
```

Step 2: Use Context in Components

```
import React, { useContext } from "react";

import { MessageContext } from "./MessageProvider";
```

```
const ComponentA = () => {

  const { setMessage } = useContext(MessageContext);

  return <button onClick={() => setMessage("New Message")}>Change
Message</button>;

};



const ComponentB = () => {

  const { message } = useContext(MessageContext);

  return <h1>Message: {message}</h1>;

};

export { ComponentA, ComponentB };
```

Key Points:

- `MessageProvider` wraps all components that need access to the shared state.
- `useContext(MessageContext)` allows any component to read/update the context.

Event Handling in React.js

Event handling in React is similar to handling events in plain JavaScript but comes with some differences due to JSX syntax and React's virtual DOM. React provides a way to handle user interactions like clicks, input changes, and form submissions using **event handlers**.

Handling Events in React

In React, event handlers are passed as functions (not strings like in traditional HTML).

```
const ButtonClick = () => {
  const handleClick = () => {
    alert("Button Clicked!");
  };

  return <button onClick={handleClick}>Click Me</button>;
};

export default ButtonClick;
```

Key Points:

- Events in React are camelCased (e.g., onClick instead of onclick).
- The event handler is a function reference (handleClick), not a function call (handleClick()).

Passing Arguments to Event Handlers

Sometimes, you may need to pass additional parameters to event handlers.

```
const ButtonClick = () => {
  const handleClick = (name) => {
    alert(`Hello, ${name}!`);
  };

  return <button onClick={() => handleClick("John")}>Click Me</button>;
};

export default ButtonClick;
```

Synthetic Events in React

React uses **SyntheticEvent**, which is a wrapper around the browser's native event system, ensuring compatibility across different browsers.

```
const InputEvent = () => {
  const handleChange = (event) => {
    console.log("Input Value:", event.target.value);
  };

  return <input type="text" onChange={handleChange} />;
};

export default InputEvent;
```

Handling Events in Class Components

For class components, event handlers are usually defined as class methods.

```
import React, { Component } from "react";

class ButtonClick extends Component {
  handleClick = () => {
    alert("Button Clicked!");
  };
```

```
  render() {
    return <button onClick={this.handleClick}>Click Me</button>;
  }
}

export default ButtonClick;
```

Event Binding in Class Components

In class components, `this` is `undefined` by default in event handlers. There are a few ways to bind `this`.

Method 1: Binding in the Constructor

```
class ButtonClick extends React.Component {
  constructor() {
    super();
    this.handleClick = this.handleClick.bind(this);
  }

  handleClick() {
    alert("Button Clicked!");
  }

  render() {
    return <button onClick={this.handleClick}>Click Me</button>;
  }
}
```

Method 2: Using Arrow Functions in Event Handlers

```
class ButtonClick extends React.Component {
  handleClick = () => {
    alert("Button Clicked!");
  };

  render() {
    return <button onClick={this.handleClick}>Click Me</button>;
  }
}
```

Preventing Default Behavior

In React, you can prevent the default behavior of events using `event.preventDefault()`.

```
const FormSubmit = () => {
  const handleSubmit = (event) => {
    event.preventDefault();
    alert("Form Submitted!");
  };

  return (
    <form onSubmit={handleSubmit}>
      <button type="submit">Submit</button>
    </form>
  );
};

export default FormSubmit;
```

Form Handling in React.js

Forms are a crucial part of any web application. React provides a controlled approach to handling form inputs using **state** and **event handlers**.

Controlled Components

In a controlled component, form data is handled by React **state**, ensuring that React is in control of the input values.

```
import { useState } from "react";

const ControlledForm = () => {
  const [name, setName] = useState("");

  const handleChange = (event) => {
    setName(event.target.value);
  };

  const handleSubmit = (event) => {
    event.preventDefault();
    alert(`Submitted Name: ${name}`);
  };

  return (
    <form onSubmit={handleSubmit}>
      <input type="text" value={name} onChange={handleChange} />
      <button type="submit">Submit</button>
    </form>
```

```
    );
  };

  export default ControlledForm;
```

Key Points:

- The `value` of the input field is controlled by React **state**.
- The `onChange` event updates the state whenever the user types.
- The `handleSubmit` function prevents default form submission and processes the input.

Handling Multiple Input Fields

When dealing with multiple inputs, use a single state object to store all field values.

```
  import { useState } from "react";

  const MultiInputForm = () => {
    const [formData, setFormData] = useState({ name: "", email: ""
});

    const handleChange = (event) => {
      setFormData({ ...formData, [event.target.name]:
event.target.value });
    };

    const handleSubmit = (event) => {
      event.preventDefault();
      alert(`Name: ${formData.name}, Email: ${formData.email}`);
    };

    return (
      <form onSubmit={handleSubmit}>
        <input type="text" name="name" value={formData.name}
onChange={handleChange} placeholder="Enter Name" />
        <input type="email" name="email" value={formData.email}
onChange={handleChange} placeholder="Enter Email" />
        <button type="submit">Submit</button>
      </form>
    );
  };

  export default MultiInputForm;
```

Key Points:

- Use a **single state object** to store multiple input values.
- Use the `[event.target.name]` property to update specific fields dynamically.

Uncontrolled Components

Uncontrolled components use **Refs** instead of state.

```
import { useRef } from "react";

const UncontrolledForm = () => {

  const inputRef = useRef(null);

  const handleSubmit = (event) => {

    event.preventDefault();

    alert(`Entered Value: ${inputRef.current.value}`);

  };

  return (

    <form onSubmit={handleSubmit}>

      <input type="text" ref={inputRef} />

      <button type="submit">Submit</button>

    </form>

  );

};

export default UncontrolledForm;
```

Form Validation in React

```
import { useState } from "react";
```

```
const ValidationForm = () => {
  const [email, setEmail] = useState("");
  const [error, setError] = useState("");

  const handleSubmit = (event) => {
    event.preventDefault();
    if (!email.includes("@")) {
      setError("Invalid email address");
    } else {
      setError("");
      alert("Form submitted successfully");
    }
  };

  return (
    <form onSubmit={handleSubmit}>
      <input type="text" value={email} onChange={(e) =>
setEmail(e.target.value)} placeholder="Enter Email" />
      <button type="submit">Submit</button>
      {error && <p style={{ color: "red" }}>{error}</p>}
    </form>
  );
};

export default ValidationForm;
```

Complete React Form Handling Example

```
import { useState, useRef } from "react";

const FullForm = () => {
  // State for controlled inputs
  const [formData, setFormData] = useState({
    name: "",
    email: "",
    country: "India",
    gender: "",
    termsAccepted: false,
  });

  const [error, setError] = useState("");

  // Ref for an uncontrolled input
  const commentRef = useRef(null);
```

```
        // Handle input changes
        const handleChange = (event) => {
          const { name, value, type, checked } = event.target;
          setFormData({
            ...formData,
            [name]: type === "checkbox" ? checked : value,
          });
        };

        // Handle form submission
        const handleSubmit = (event) => {
          event.preventDefault();

          // Validation
          if (formData.name === "") {
            setError("Name is required");
            return;
          } else if (!formData.email.includes("@")) {
            setError("Invalid email address");
            return;
          } else if (!formData.gender) {
            setError("Please select a gender");
            return;
          } else if (!formData.termsAccepted) {
            setError("You must accept the terms & conditions");
            return;
          }

          setError("");

          // Display form values
          alert(
            `Name: ${formData.name}\nEmail: ${formData.email}\nCountry:
${formData.country}\nGender: ${formData.gender}\nTerms Accepted:
${formData.termsAccepted}\nComment: ${commentRef.current.value}`
          );
        };

        return (
          <form onSubmit={handleSubmit} style={{ maxWidth: "400px", margin:
"auto", padding: "20px", border: "1px solid #ccc", borderRadius: "10px" }}>
            <h2>React Form Handling</h2>
```

```
            {/* Name Input */}
            <label>
              Name: <br />
              <input type="text" name="name" value={formData.name}
onChange={handleChange} placeholder="Enter Name" />
            </label>
            <br /><br />

            {/* Email Input */}
            <label>
              Email: <br />
              <input type="email" name="email" value={formData.email}
onChange={handleChange} placeholder="Enter Email" />
            </label>
            <br /><br />

            {/* Country Dropdown */}
            <label>
              Country: <br />
              <select name="country" value={formData.country}
onChange={handleChange}>
                <option value="India">India</option>
                <option value="USA">USA</option>
                <option value="UK">UK</option>
              </select>
            </label>
            <br /><br />

            {/* Gender Radio Buttons */}
            <label>Gender:</label>
            <br />
            <label>
              <input type="radio" name="gender" value="Male"
checked={formData.gender === "Male"} onChange={handleChange} /> Male
            </label>
            <br />
            <label>
              <input type="radio" name="gender" value="Female"
checked={formData.gender === "Female"} onChange={handleChange} /> Female
            </label>
            <br /><br />
```

```
            {/* Terms & Conditions Checkbox */}
            <label>
              <input type="checkbox" name="termsAccepted"
checked={formData.termsAccepted} onChange={handleChange} />
              I accept the Terms & Conditions
            </label>
            <br /><br />

            {/* Uncontrolled Comment Box */}
            <label>
              Additional Comments: <br />
              <textarea ref={commentRef} placeholder="Enter
comments..."></textarea>
            </label>
            <br /><br />

            {/* Display Validation Error */}
            {error && <p style={{ color: "red" }}>{error}</p>}

            {/* Submit Button */}
            <button type="submit">Submit</button>
          </form>
        );
      };

      export default FullForm;
```

Form Element	Key Handling Method
Text Input	value + onChange
Checkbox	checked + onChange
Radio Buttons	checked + onChange
Select Dropdown	value + onChange
Uncontrolled Form	useRef
Validation	JavaScript conditions inside handleSubmit

Controlled Components

A **controlled component** is a form input element whose value is **controlled by React state**. React fully manages the input's value and updates it using the `onChange` event.

```
import { useState } from "react";

const ControlledComponent = () => {
  const [name, setName] = useState("");

  const handleChange = (event) => {
    setName(event.target.value);
  };

  return (
    <div>
      <input type="text" value={name} onChange={handleChange}
placeholder="Enter Name" />
      <p>Typed Name: {name}</p>
    </div>
  );
};

export default ControlledComponent;
```

Uncontrolled Components

An **uncontrolled component** is a form input element where **React does not control the value**. Instead, the DOM itself maintains the value, and we access it using a **Ref (`useRef`)**.

```
import { useRef } from "react";

const UncontrolledComponent = () => {
  const inputRef = useRef(null);

  const handleSubmit = () => {
    alert(`Entered Value: ${inputRef.current.value}`);
  };

  return (
    <div>
      <input type="text" ref={inputRef} placeholder="Enter Name" />
      <button onClick={handleSubmit}>Submit</button>
    </div>
  );
};

export default UncontrolledComponent;
```

Comparison Table: Controlled vs Uncontrolled Components

Feature	Controlled Component	Uncontrolled Component
Value Storage	Stored in React state (useState)	Stored in the DOM
Handling Input	onChange updates state	useRef accesses value when needed
React Control	Fully controlled by React	React does not manage value
Re-Renders	Rerenders on state change	No rerenders on input change
Validation	Easy (can validate in onChange)	Harder (must use useRef.current.value)
Use Case	Forms that require validation, dynamic updates	Simple forms, third-party libraries

React Lifecycle Methods (Class Components)

React lifecycle methods are special methods that are automatically called at different stages of a **component's lifecycle**.

Three Phases of React Lifecycle

- **Mounting** → Component is created and inserted into the DOM.
- **Updating** → Component is updated due to changes in state or props.
- **Unmounting** → Component is removed from the DOM.

Mounting Phase (When a component is created)
These methods are called **only once** when the component is added to the DOM.

Method	Description
constructor()	Initializes state & binds methods.
static getDerivedStateFromProps(props, state)	Updates state based on props before rendering. Rarely used.

render()	Renders the UI (Required in class components).
componentDidMount()	Runs after the component is added to the DOM (Good for API calls).

Example of Mounting Lifecycle

```
import React, { Component } from "react";

class MountingExample extends Component {
  constructor(props) {
    super(props);
    this.state = { message: "Hello!" };
    console.log("Constructor: State initialized");
  }

  static getDerivedStateFromProps(props, state) {
    console.log("getDerivedStateFromProps: Updating state based on props");
    return null; // Usually, no changes
  }
  componentDidMount() {
    console.log("componentDidMount: Component mounted, good place for API
calls");
  }
  render() {
    console.log("Render: Rendering UI");
    return <h1>{this.state.message}</h1>;
  }
}
export default MountingExample;
```

Execution Order:

1. constructor()
2. getDerivedStateFromProps()
3. render()
4. componentDidMount()

Updating Phase (When component re-renders)\
These methods are called **when state or props change**.

Method	Description
static getDerivedStateFromProps(props, state)	Updates state before rendering.
shouldComponentUpdate(nextProps, nextState)	Controls if the component should re-render (true or false).
render()	Renders the UI (same as in Mounting phase).

getSnapshotBeforeUpdate(prevProps, prevState)	Captures DOM state before update (used with scrolling, animations).
componentDidUpdate(prevProps, prevState, snapshot)	Runs after re-render (Good for API calls based on props/state changes).

Example of Updating Lifecycle

```
import React, { Component } from "react";
class UpdatingExample extends Component {
  constructor(props) {
    super(props);
    this.state = { count: 0 };
  }
  shouldComponentUpdate(nextProps, nextState) {
    console.log("shouldComponentUpdate: Checking if re-render is needed");
    return true; // Allow re-render
  }
  getSnapshotBeforeUpdate(prevProps, prevState) {
    console.log("getSnapshotBeforeUpdate: Capture info before update");
    return null;
  }
  componentDidUpdate(prevProps, prevState, snapshot) {
    console.log("componentDidUpdate: Component updated");
  }
  increaseCount = () => {
    this.setState({ count: this.state.count + 1 });
  };
  render() {
    console.log("Render: Re-rendering UI");
    return (
      <div>
        <h1>Count: {this.state.count}</h1>
        <button onClick={this.increaseCount}>Increase</button>
      </div>
    );
  }
}
export default UpdatingExample;
```

Execution Order (When state changes):

1. getDerivedStateFromProps()
2. shouldComponentUpdate()
3. render()
4. getSnapshotBeforeUpdate()
5. componentDidUpdate()

Unmounting Phase (When a component is removed)

Method	Description
componentWillUnmount()	Called just before the component is removed. Used for cleanup (e.g., clear timers, remove event listeners).

Example of Unmounting Lifecycle

```
import React, { Component } from "react";
class UnmountingExample extends Component {
  componentWillUnmount() {
    console.log("componentWillUnmount: Cleaning up...");
  }

  render() {
    return <h1>Component is Mounted</h1>;
  }
}
export default UnmountingExample;
```

This method is useful for:

- Clearing **setInterval / setTimeout**
- Removing **event listeners**
- Canceling **API calls**

Summary

Phase	Lifecycle Method	Purpose
Mounting	constructor()	Initialize state & bind methods
	getDerivedStateFromProps()	Sync state with props (rarely used)
	render()	Render JSX
	componentDidMount()	Runs after mount (Good for API calls)
Updating	getDerivedStateFromProps()	Sync state with new props
	shouldComponentUpdate()	Optimize re-rendering
	render()	Re-render JSX
	getSnapshotBeforeUpdate()	Capture info before update (e.g., scrolling position)
	componentDidUpdate()	Runs after re-render (Good for API calls)

Unmounting	componentWillUnmount()	Cleanup (Remove event listeners, clear timers)

React Hooks

React Hooks are functions that let you use state and lifecycle features in functional components (without needing class components).

- Introduced in React 16.8
- Simpler & cleaner code (No need for class components)
- Reusable logic via Custom Hooks
- Better performance & readability

Commonly Used Hooks in React

useState() – Manage State in Functional Components

- **Purpose**: Allows components to have state.

```
import React, { useState } from "react";

const Counter = () => {
  const [count, setCount] = useState(0);  // State variable
  return (
    <div>
      <h2>Count: {count}</h2>
      <button onClick={() => setCount(count + 1)}>Increase</button>
    </div>
  );
};
export default Counter;
```

useEffect() – Handle Side Effects (API Calls, Subscriptions, Timers, etc.)

- **Purpose:** Runs after rendering & handles **side effects** (API calls, event listeners, etc.).

```
import React, { useState, useEffect } from "react";

const FetchData = () => {
  const [data, setData] = useState([]);
  useEffect(() => {
    fetch("https://jsonplaceholder.typicode.com/posts")
      .then((response) => response.json())
      .then((json) => setData(json));
    return () => console.log("Cleanup on unmount");  // Cleanup function
  }, []); // Empty dependency array means it runs only once
  return (
    <div>
      <h2>Fetched Data</h2>
      <ul>
        {data.slice(0, 5).map((item) => (
          <li key={item.id}>{item.title}</li>
        ))}
      </ul>
    </div>
  );
};
export default FetchData;
```

useContext() – Manage Global State without Props Drilling

Purpose: Shares state between components **without passing props manually** at every level.

```
import React, { createContext, useContext } from "react";

// Create Context

const UserContext = createContext();


const Child = () => {

  const user = useContext(UserContext);

  return <h2>User: {user}</h2>;

};

const Parent = () => {

  return (

    <UserContext.Provider value="John Doe">

      <Child />

    </UserContext.Provider>

  );

};

export default Parent;
```

React Router - Navigation in React

React Router is a **library** for handling **navigation (routing)** in React applications. It enables the creation of **single-page applications (SPAs)** with **multiple views** without reloading the page.

Single Page Applications (SPA) in React

A Single Page Application (SPA) is a web application that loads a single HTML page and dynamically updates content without refreshing the page. SPAs improve user experience by making web apps faster, smoother, and more responsive.

How Does an SPA Work?

Unlike traditional Multi-Page Applications (MPA), which reload the entire page when navigating, an SPA loads only the necessary content dynamically.

Working of SPA:

1. **Initial Load:** The browser loads a single HTML file along with CSS & JavaScript.
2. **Client-Side Routing:** Navigation happens without full page reloads using JavaScript (React Router).
3. **Dynamic Content Update**: Data is fetched from APIs and updated on the page without reloading.
4. **Faster Experience:** Since only required parts are updated, SPAs feel like native apps.

Installing React Router

```
npm install react-router-dom
```

Setting Up React Router

```
import React from "react";

import { BrowserRouter as Router, Route, Routes } from
"react-router-dom";


const Home = () => <h2>Home Page</h2>;

const About = () => <h2>About Page</h2>;


const App = () => {
  return (
    <Router>
      <Routes>
        <Route path="/" element={<Home />} />
        <Route path="/about" element={<About />} />
      </Routes>
    </Router>
  );
```

```
};

export default App;
```

Key Points:

- `BrowserRouter (or Router)` wraps the app and manages routes.
- `Routes` groups multiple Route components.
- `Route` defines a path and component to render.
- `"path='/'"` → Default (home) route.

Adding Navigation (Links)

Use `<Link>` to navigate between pages without full page reloads.

```
import React from "react";
import { BrowserRouter as Router, Routes, Route, Link } from
"react-router-dom";

const Home = () => <h2>Home Page</h2>;
const About = () => <h2>About Page</h2>;

const App = () => {
  return (
    <Router>
      <nav>
        <Link to="/">Home</Link> | <Link to="/about">About</Link>
      </nav>

      <Routes>
        <Route path="/" element={<Home />} />
        <Route path="/about" element={<About />} />
      </Routes>
    </Router>
  );
};

export default App;
```

Key Points:

- <Link to="/">Home</Link> → Navigates to Home.
- <Link to="/about">About</Link> → Navigates to About.
- No page reloads!

Protected Routes in React (Private Routes)

What are Protected Routes?

Protected Routes (or Private Routes) restrict access to certain pages based on user authentication or roles. If a user is not logged in, they should be redirected to a login page or an error page instead of accessing restricted content.

How Protected Routes Work?

1. Check Authentication – Verify if the user is logged in (using localStorage, context, Redux, etc.).
2. Allow or Restrict Access – If authenticated, render the page; otherwise, redirect to the login page.
3. Use Navigate for Redirection – Redirect unauthorized users to login.

Step-by-Step Implementation

Step 1:

Create an Authentication Context:

We need to manage authentication status globally.

```
import { createContext, useContext, useState } from "react";

// Create Auth Context
const AuthContext = createContext();

// Custom hook to use AuthContext
export const useAuth = () => useContext(AuthContext);

// AuthProvider Component
export const AuthProvider = ({ children }) => {
  const [isAuthenticated, setIsAuthenticated] = useState(false);

  const login = () => setIsAuthenticated(true);
  const logout = () => setIsAuthenticated(false);

  return (
    <AuthContext.Provider value={{ isAuthenticated, login, logout }}>
      {children}
    </AuthContext.Provider>
  );
};
```

Step 2:

Create a Protected Route Component:

We create a component that restricts access based on authentication.

```
import { Navigate } from "react-router-dom";
import { useAuth } from "./AuthContext";

const ProtectedRoute = ({ children }) => {
  const { isAuthenticated } = useAuth();

  return isAuthenticated ? children : <Navigate to="/login" />;
};

export default ProtectedRoute;
```

Step 3:

Define Routes with Protected Pages

Now, let's set up a React Router with authentication-protected pages.

```
import React from "react";
import { BrowserRouter as Router, Routes, Route, Link } from
"react-router-dom";
import { AuthProvider, useAuth } from "./AuthContext";
import ProtectedRoute from "./ProtectedRoute";
const Home = () => <h2>🏠 Home Page</h2>;
const Login = () => {
  const { login } = useAuth();
  return (
    <div>
      <h2>🔑 Login Page</h2>
      <button onClick={login}>Login</button>
    </div>
  );
};
const Dashboard = () => <h2>📊 Dashboard - Protected Page</h2>;
const App = () => {
  return (
    <AuthProvider>
      <Router>
        <nav>
          <Link to="/">Home</Link> | <Link to="/dashboard">Dashboard</Link> |
<Link to="/login">Login</Link>
        </nav>
        <Routes>
          <Route path="/" element={<Home />} />
          <Route path="/login" element={<Login />} />
          <Route path="/dashboard" element={<ProtectedRoute><Dashboard
/></ProtectedRoute>} />
```

```
        </Routes>
      </Router>
    </AuthProvider>
  );
};
export default App;
```

Backend Development

Backend development refers to the server-side of web applications where the main logic, database interactions, and APIs are handled. It is responsible for managing requests from the frontend, processing data, and sending appropriate responses.

Key Responsibilities

- Handling business logic
- Managing databases
- Authentication & Authorization
- API development and integration
- Performance optimization
- Security implementation

Backend Development Architecture

- **Client-Server Model**
    - The frontend (client) sends a request.
    - The backend (server) processes the request and returns a response.
- **MVC Architecture**
    - Model – Handles the database and business logic.
    - View – Represents the frontend/UI.
    - Controller – Manages requests and directs them to the appropriate model.

Backend Technologies

- **Programming Languages**
    - JavaScript (Node.js)
    - Python (Django, Flask)
    - Java (Spring Boot)

    - PHP (Laravel)
    - C# (.NET)
- **Frameworks**
    - Node.js – Express.js, Nest.js
    - Python – Django, Flask, FastAPI
    - Java – Spring Boot, Micronaut
    - PHP – Laravel, CodeIgniter
    - Ruby – Ruby on Rails
- **Databases**
    - SQL (Relational Databases): MySQL, PostgreSQL, MariaDB, MS SQL
    - NoSQL (Non-Relational Databases): MongoDB, Firebase, DynamoDB, Cassandra
- **Web Servers**
    - Apache
    - Nginx
    - IIS
- **APIs and Protocols**
    - RESTful APIs (Representational State Transfer)
    - GraphQL
    - WebSockets for real-time applications
    - gRPC for efficient communication

NODEJS

Introduction to Node.js

- Node.js is a runtime environment that allows JavaScript to run outside the browser.
- Built on the V8 JavaScript engine (same as Chrome).
- Uses an event-driven, non-blocking I/O model, making it efficient for real-time applications.
- Single-threaded but uses asynchronous programming for handling multiple tasks.

Why use Node.js?

- Single programming language (JavaScript) for both client-side and server-side.
- Event-driven and non-blocking I/O model for building scalable applications.
- Large ecosystem with npm (Node Package Manager).

Key Features:

- **Asynchronous and Event-driven:** Handles multiple connections efficiently without waiting for tasks to complete.
- **Fast Execution:** Built on Google Chrome's V8 engine.
- **Single-threaded:** Uses a single thread to handle multiple requests via event loops.
- **Scalability:** Lightweight and efficient.

Installing Node.js

- Steps:
  - Download the installer from the Node.js official website.
  - Install the LTS (Long Term Support) version for production.
  - Verify installation:
    - node -v: Check Node.js version.
    - npm -v: Check npm version.
- Update Node.js and npm:
  - Use nvm (Node Version Manager) to manage multiple Node.js versions.

Core Modules in Node.js

Node.js comes with several built-in modules that provide basic functionality:

- **fs (File System):**
  - Reading and writing files.

```
const fs = require('fs');
fs.readFile('example.txt', 'utf8', (err, data) => {
  if (err) throw err;
  console.log(data);
});
```

- **http:**
  - Creating web servers.
  - Example:

```
const http = require('http');
const server = http.createServer((req, res) => {
  res.write('Hello, World!');
  res.end();
});
server.listen(3000, () => console.log('Server running on port 3000'));
```

- **path:**
  - Handling and transforming file paths.
  - Example:

```
const path = require('path');
```

```
const fullPath = path.join(__dirname, 'folder',
'file.txt');
console.log(fullPath);
```

- **os:**
  - Provides operating system-related utility methods.
- **events**:
  - Working with event emitters.

npm (Node Package Manager)

npm is a package manager for the JavaScript programming language maintained by npm, Inc., a subsidiary of GitHub. npm is the default package manager for the JavaScript runtime environment Node.js and is included as a recommended feature in the Node.js installer.

- Common Commands:
  - **`npm init:`** Initialize a new project.
  - **`npm install <package>:`** Install a package.
  - **`npm uninstall <package>:`** Remove a package.
  - **`npm update:`** Update installed packages.
- Using package.json:
  - Contains metadata about the project.
  - Dependencies, scripts, and version information.

Building a Simple Node.js Application

- Steps to Create:
  1. Initialize a new project: npm init
  2. Create a main file (e.g., app.js).
  3. Use built-in or third-party modules.

Example:

```
const http = require('http');
const server = http.createServer((req, res) => {
  if (req.url === '/') {
    res.write('Welcome to the Home Page');
  } else if (req.url === '/about') {
    res.write('About Us');
  } else {
    res.write('404 Not Found');
  }
  res.end();
});
server.listen(3000, () => console.log('Server is running on port
3000'));
```

ExpressJS

Express.js is a fast, minimal, and flexible web framework for Node.js. It simplifies handling routes, middleware, and server-side logic.

- Built on top of Node.js' http module.
- Commonly used for REST API development.

Key Features:

- Middleware: Enables request and response processing at different layers.
- Routing: Provides an easy-to-use routing mechanism.
- Integration: Works seamlessly with databases like MongoDB, MySQL, and more.
- Templating: Supports various templating engines like EJS, Pug, and Handlebars.
- Static File Serving: Serves static files such as images, CSS, and JavaScript files.

Why Use Express.js?

- Fast, unopinionated, and minimalist framework.
- Large ecosystem and community support.
- Simplifies the development of APIs and web applications.

Installing Express.js

- Prerequisites:
  - Ensure Node.js and npm are installed.
- Installation:
  - npm install express --save

Creating a Basic Express App:

```
const express = require('express');
const app = express();

app.get('/', (req, res) => {
  res.send('Hello, World!');
});

app.listen(3000, () => {
```

```
  console.log('Server running on port 3000');
});
```

Core Concepts in Express.js

- **Middleware**
  - Functions that execute during the lifecycle of a request to the server.
  - Can modify req and res objects.
  - Types:
    - **Application-level Middleware:** Applies to all routes.
    - **Router-level Middleware**: Applies to specific routes.
    - **Error-handling Middleware**: Handles errors in the application.
    - **Built-in Middleware:** Predefined middleware like express.json().

      Example:

```
app.use((req, res, next) => {
  console.log('Middleware executed');
  next();
});
```

- **Routing**
  - Defines how the application responds to client requests for a specific endpoint.
  - HTTP Methods: GET, POST, PUT, DELETE, etc.

    Example:

```
app.get('/', (req, res) => res.send('GET Request'));
app.post('/', (req, res) => res.send('POST Request'));
app.put('/user', (req, res) => res.send('PUT Request'));
app.delete('/user’, (req, res) => res.send('DELETE Request'));
```

- **Static Files**
  - Serves static files such as images, CSS, and JavaScript.

  Example:

```
app.use(express.static('public'));

Folder structure:
/public
      - /images
      - /css
      - /js
```

- **Templating Engines**
  - Render dynamic HTML pages.
  - Popular engines: EJS, Pug, Handlebars.

    Example with EJS:

```
app.set('view engine', 'ejs');
app.get('/', (req, res) => res.render('index', { title: 'Welcome'
}));
```

Building RESTful APIs with Express.js

A **RESTful API** (Representational State Transfer API) is an architectural style for designing networked applications. It relies on a stateless, client-server, cacheable communications protocol -- the HTTP protocol. RESTful APIs use HTTP requests to perform CRUD operations (Create, Read, Update, Delete) on resources, represented by URIs (Uniform Resource Identifiers).

Core Concepts of RESTful APIs

1. **Resources and URIs:**
    - Resources are the fundamental units of information in a RESTful API. They can be anything that a client might need to interact with, such as users, orders, or products.
    - Each resource is identified by a URI.
2. **HTTP Methods:**
    - GET: Retrieve a resource.
    - POST: Create a new resource.
    - PUT: Update an existing resource.
    - DELETE: Remove a resource.
    - PATCH: Apply partial modifications to a resource.
3. **Statelessness**:
    - Each request from a client to a server must contain all the information needed to understand and process the request. The server does not store any state about the client session.
4. **Representation**:
    - Resources are typically represented in JSON or XML format. The representation includes all the necessary details about the resource.

Benefits of RESTful APIs

- **Scalability**: RESTful APIs are stateless, which makes it easier to scale applications horizontally.
- **Flexibility**: Clients can request specific representations of resources using headers and parameters.
- **Performance**: Caching can be utilized to improve performance.
- **Simplicity**: The HTTP protocol, which is the foundation of RESTful APIs, is widely understood and used, making it easier for developers to work with.

Example of a RESTful API

Consider an online bookstore API. Here are some example endpoints and their purposes:

- GET /books: Retrieve a list of books.
- POST /books: Add a new book.
- GET /books/{id}: Retrieve details of a specific book.

- PUT /books/{id}: Update details of a specific book.
- DELETE /books/{id}: Remove a specific book.

Designing a RESTful API

When designing a RESTful API, consider the following best practices:

1. Use nouns to represent resources in URIs (e.g., /users, /orders).
2. Use appropriate HTTP methods for different operations.
3. Implement proper status codes for responses (e.g., 200 OK, 201 Created, 404 Not Found).
4. Support filtering, sorting, and pagination for collections of resources.
5. Secure the API using authentication and authorization mechanisms (e.g., OAuth, JWT).
6. Document the API clearly to make it easy for developers to use.

API in action

Explanation : GET /books/{id}

GET `/books/{id}` is an endpoint used to retrieve information about a specific book. The `{id}` in the URL is a placeholder for the unique identifier of the book you want to fetch. When you make a GET request to this endpoint, the server returns the details of the book with the specified id.

Diagrammatic Representation

Here's a diagram that represents the API endpoint, URL, and the request-response cycle:

Request-Response Cycle

1. **Client Request:**
   a. The client sends an HTTP GET request to the server with the endpoint `/books/{id}`.
   b. Example URL: `https://example.com/books/123` (where 123 is the book's unique identifier).
      i. `GET /books/123 HTTP/1.1`
      ii. `Host: example.com`
2. **Server Processing:**
   a. The server receives the GET request.
   b. It processes the request, usually involving fetching the book details from a database.

```
app.get('/books/:id', (req, res) => {
    const bookId = req.params.id;
```

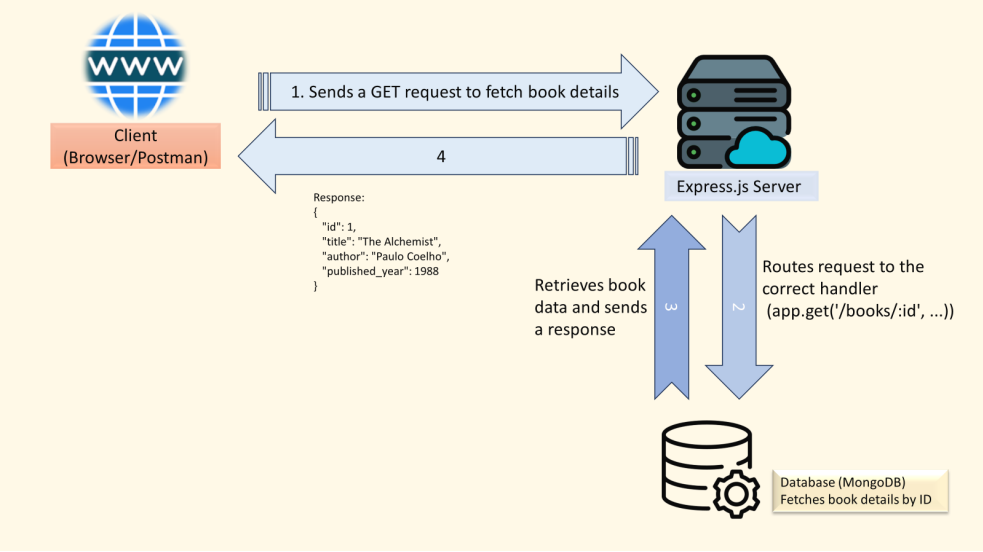
```
    // Code to retrieve book details from database
    // Example:
    const book = {
        id: bookId,
        title: "Sample Book",
        author: "Author Name",
        year: 2023
    };
    res.json(book);
});
```

3. **Server Response:**
    a. The server sends a response back to the client with the book's details in JSON format.

```
HTTP/1.1 200 OK
Content-Type: application/json

{
    "id": "123",
    "title": "Sample Book",
    "author": "Author Name",
    "year": 2023
}
```

Request-Response Cycle with Diagrammatic Representation



Example API

```
const express = require('express');
const app = express();

// Middleware for parsing JSON
app.use(express.json());

let users = [
  { id: 1, name: 'Alice' },
  { id: 2, name: 'Bob' },
];

// GET all users
app.get('/users', (req, res) => {
  res.json(users);
});

// GET user by ID
app.get('/users/:id', (req, res) => {
  const user = users.find(u => u.id === parseInt(req.params.id));
  if (!user) return res.status(404).send('User not found');
  res.json(user);
});

// POST a new user
app.post('/users', (req, res) => {
  const newUser = { id: users.length + 1, name: req.body.name };
  users.push(newUser);
  res.status(201).json(newUser);
});

// PUT update user
app.put('/users/:id', (req, res) => {
  const user = users.find(u => u.id === parseInt(req.params.id));
  if (!user) return res.status(404).send('User not found');
  user.name = req.body.name;
  res.json(user);
});

// DELETE a user
```

```
app.delete('/users/:id', (req, res) => {
  users = users.filter(u => u.id !== parseInt(req.params.id));
  res.send('User deleted');
});

app.listen(3000, () => console.log('Server running on port 3000'));
```

Error Handling in Express.js

- **Error-handling Middleware:**
  - Special middleware function for error handling.
    Example:
    ```
    app.use((err, req, res, next) => {
      console.error(err.stack);
      res.status(500).send('Something went wrong!');
    });
    ```
- Handling 404 Errors:
  - Catch-all route for undefined endpoints.
    Example:
    ```
    app.use((req, res) => {
      res.status(404).send('Route not found');
    });
    ```

Connecting to a Database

MongoDB with Mongoose

- Setup:
  ```
  npm install mongoose
  ```
- **Example**:

```
const mongoose = require('mongoose');
mongoose.connect('mongodb://localhost/mydb', {
  useNewUrlParser: true,
  useUnifiedTopology: true,
});
const userSchema = new mongoose.Schema({
  name: String,
  age: Number,
});
const User = mongoose.model('User', userSchema);
app.post('/users', async (req, res) => {
  const user = new User(req.body);
  await user.save();
  res.status(201).json(user);
});
```

MONGODB

MongoDB is a NoSQL database that stores data in a flexible, JSON-like document format.
It is designed for scalability, high availability, and performance.
Unlike relational databases, MongoDB does not use tables, rows, or schemas.

Key Features:

- **Schema-less Design:** Collections can hold different types of documents.
- **Scalability**: Horizontally scalable through sharding.
- **High Performance**: Optimized for read and write operations.
- **Rich Query Language:** Supports complex queries, aggregations, and full-text search.
- **Replication**: Ensures data availability through replica sets.
- **Indexing**: Supports various types of indexes for efficient query execution.
- Why Use MongoDB?
    - Flexibility in storing structured, semi-structured, or unstructured data.
    - Ideal for modern applications like content management, real-time analytics, and IoT.

MongoDB Architecture

Key Components

1. **Database:**
    - A physical container for collections.
    - Each database has its own set of files on the file system.
2. **Collection:**
    - A group of MongoDB documents, equivalent to a table in relational databases.
    - Collections do not enforce a schema.

3. **Document:**
    - Basic unit of data in MongoDB, represented in JSON-like format.

```
Example:
{
  "_id": "12345",
  "name": "John Doe",
  "age": 30,
  "address": {
    "city": "New York",
    "zip": "10001"
  }
}
```

4. **Replica Set:**
    - A group of MongoDB servers that maintain the same data set for high availability.
    - One primary node and multiple secondary nodes.
5. **Sharding:**
    - Distributes data across multiple servers to handle large datasets.
    - Uses a shard key to partition data.

Installing MongoDB

- **Installation Steps**
    - Download MongoDB from the official website.
    - Install and set up the MongoDB server.
    - Start the MongoDB service:
      mongod
    - Connect to the MongoDB shell:
      mongo
- **Using MongoDB Atlas**
    - MongoDB Atlas is a cloud-based service for hosting MongoDB.
    - Steps to set up:
        - Create an account at MongoDB Atlas.
        - Create a cluster and connect using the provided connection string.

CRUD Operations

- **Create**
    - Insert a single document:
      `db.collection.insertOne({ name: "Alice", age: 25 });`
    - Insert multiple documents:

```
db.collection.insertMany([
  { name: "Bob", age: 30 },
  { name: "Charlie", age: 35 }
```

```
]);
```

- **Read**
  - Find all documents:
    `db.collection.find();`
  - Find with a condition:
    `db.collection.find({ age: { $gt: 25 } });`
  - Project specific fields:
    `db.collection.find({}, { name: 1, _id: 0 });`
- **Update**
  - Update a single document:

```
db.collection.updateOne(
        { name: "Alice" },
        { $set: { age: 26 } });
```

  - Update multiple documents:

```
db.collection.updateMany(
      { age: { $lt: 30 } },
      { $set: { status: "young" } });
```

- **Delete**
  - Delete a single document:
    `db.collection.deleteOne({ name: "Charlie" });`
  - Delete multiple documents:
    `db.collection.deleteMany({ author: "John Doe" })`

Indexing in MongoDB

- **What is Indexing?**
  1. Mechanism to improve query performance.
  2. Creates a data structure to store a small portion of the collection's data for quick lookups.
- **Types of Indexes:**
  1. **Single Field Index:**

     `db.collection.createIndex({ name: 1 });`
  2. **Compound Index:**

     `db.collection.createIndex({ name: 1, age: -1 });`
  3. **Text Index (for full-text search):**

     `db.collection.createIndex({ description: "text" });`
  4. **Geospatial Index (for location-based queries):**

     `db.collection.createIndex({ location: "2dsphere" });`
- **View Indexes**: `db.collection.getIndexes();`

Aggregation Framework

- **What is Aggregation?**
  - A framework for data transformation and computation in MongoDB.
- **Aggregation Pipeline:**
  - Sequence of stages that process data.
  - Common stages:
    1. **$match**: Filters documents.
    2. **$group:** Groups documents and performs aggregations.
    3. **$project:** Shapes the output.

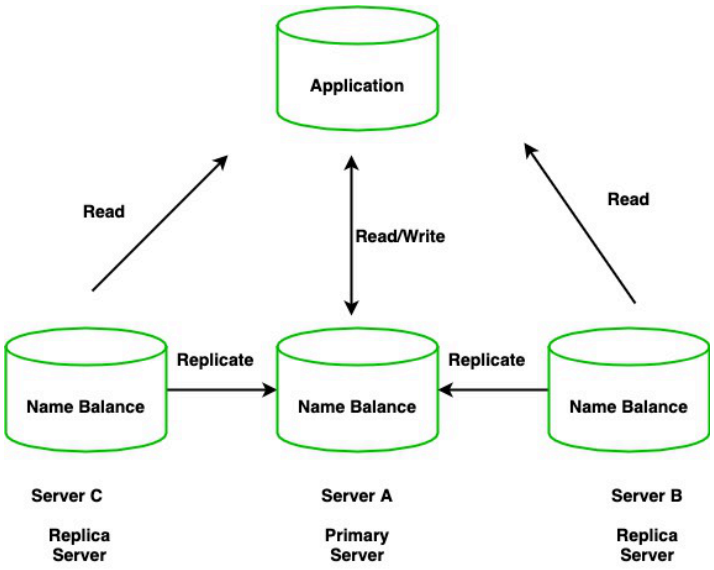
Example:

```
db.collection.aggregate([
  { $match: { status: "active" } },
  { $group: { _id: "$age", total: { $sum: 1 } } },
  { $sort: { total: -1 } }
]);
```

Replication and Sharding

Replication

- Ensures high availability through replica sets.
- Components:
  - Primary Node: Handles all write operations.
  - Secondary Nodes: Replicas of the primary node.



Sharding

- Distributes data across multiple servers.
- Components:
    - **Shard Key:** Determines data distribution.
    - **Config Server**: Stores metadata about the cluster.
    - **Query Router:** Routes queries to the appropriate shard.