Operating Systems Laboratory
Course Code: CSE325
Laboratory Manual

Prepared by
Pushpendra Kumar Pateriya
HoD, System Programming-I

Term: 24251

Name of the Student: ....

Registration Number: ....

Section and Group: ....

Roll No: ....

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Vision of School of Computer Science & Engineering

- To be a globally recognized school through excellence in teaching, learning and research for creating Computer Science professionals, leaders and entrepreneurs of the future contributing to society and industry for sustainable growth.

Mission of School of Computer Science & Engineering

- To build computational skills through hands-on and practice based learning with measurable outcomes.
- To establish a strong connect with industry for in-demand technology driven curriculum.
- To build the infrastructure for meaningful research around societal problems.
- To nurture future leaders through research-infused education and lifelong learning.
- To create smart and ethical professionals and entrepreneurs who are recognized globally.

POs, PSOs, and PEOs of BTech CSE

Program Outcomes (POs)

PO1:: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2:: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3:: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4:: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5:: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6:: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7:: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8:: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9:: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10:: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11:: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12:: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1:: Apply acquired skills in software engineering, networking, security, databases, intelligent systems, cloud computing and operating systems to adapt and deploy innovative software solutions for diverse applications.

PSO2:: Apply diverse IT skills to design, develop, and evaluate innovative solutions for business environments, considering risks, and utilizing interdisciplinary knowledge for efficient realtime projects benefiting society.

Program Educational Objectives (PEOs)

PEO1:: The graduates shall demonstrate professional advancement through expanded leadership capabilities and technical accomplishment providing solutions to local and global societal issues through mindful engagement.

PEO2:: The graduates shall undertake higher education or global certifications or exhibit impactful research accomplishment.

PEO3:: The graduate shall extend global expertise in technology development and deployment by becoming an entrepreneur, consultant and innovator.

PEO4:: Graduates shall embrace ethics and lifelong learning to adapt to a fast-changing world and enhance global employability in diverse work environments.

Contents

Expression of Gratitude

Dear Dr. Rajeev Sobti,
Dean & Head of School,
School of Computer Science & Engineering,
Lovely Professional University

Dear Dr. Prateek Agrawal,
Deputy Dean & Coordinator of School,
School of Computer Science & Engineering
Lovely Professional University

I extend my deepest gratitude to both of you for your invaluable support and guidance throughout the creation of the **CSE325: Operating Systems Laboratory** manual. Your unwavering encouragement, expertise, and mentorship have been pivotal in crafting a comprehensive resource for our students.

Your commitment to academic excellence and dedication to our learning community have been inspirational. Your visionary leadership and continuous support have significantly enriched our educational experiences and have empowered us to produce this manual that will serve as a valuable asset for our students' education.

I am profoundly grateful for the opportunities you have provided us and the trust you have placed in our abilities. Your impactful contributions continue to shape the School of Computer Science & Engineering at Lovely Professional University and nurture an environment of growth and learning.

Once again, thank you for your profound guidance and belief in our endeavors. Your support has been instrumental, and I am honored to have had the privilege of working under your guidance.

With heartfelt appreciation,
Pushpendra Kumar Pateriya
HoD, System Programming Domain, School of Computer Science & Engineering
34-202, Cabin-2, Lovely Professional University
email: `pushpendra.14623@lpu.co.in`
LinkedIn: https://www.linkedin.com/in/pushpendra-pateriya-344b5727/

Lab Rules and Guidelines:

General Guidelines for Students

- **Completion of Lab Manual Exercises:** The completion of lab manual exercises contributes to the Continuous Assessment (CA) marks.
- **Assigned System Usage:** Sit according to your roll number and use the designated system consistently throughout the semester.
- **Reporting System Issues:** It is the student's responsibility to report any issues related to the designated system to the teacher promptly.
- **Use of Electronic Devices:** Use electronic devices in a professional manner, adhering to academic norms.
- **System Settings:** Avoid changing system settings without prior approval from the teacher.
- **Importance of Self-Practice:** Engage in self-practice as it is essential for understanding the concepts covered in this course.
- If you have specific feedback or suggestions for any of the individual experiments, please share them using the following link: `https://forms.gle/592QeMp6fc5qupfQ6`.

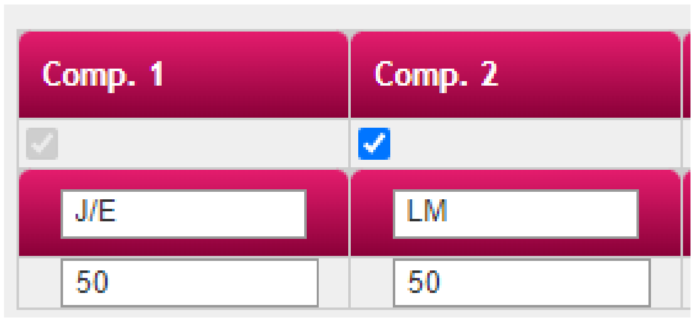
General Guidelines for Teachers

- **Familiarize Students with Lab Equipment:** Introduce students to the lab equipment, including computers, software, and any specific tools they'll use during the experiments.
- **Explain Experiment Objectives:** Clearly explain the objectives and expected outcomes of each experiment to the students before they start working.
- **Provide Detailed Instructions:** Offer step-by-step instructions for conducting the experiments, ensuring clarity and simplicity.
- **Encourage Collaboration:** Foster an environment where students can work together, share knowledge, and assist each other in problem-solving.
- **Address Student Queries:** Be approachable and available to answer students' questions or concerns during the lab sessions.
- **Ensure Safety Measures:** Emphasize safety protocols and guidelines when handling equipment or performing experiments to prevent accidents.
- **Assist with Technical Issues:** Aid students in troubleshooting technical issues they might encounter during the experiments.
- **Evaluate and Provide Feedback:** Evaluate students' work based on predefined parameters and provide constructive feedback to enhance their learning experience.
- **Coordinate with Support Staff:** Collaborate with the IT support team to swiftly resolve technical difficulties beyond your expertise.

- **Encourage Exploration and Understanding:** Promote a deeper understanding of operating systems by encouraging students to explore beyond the prescribed experiments.
- **Maintain a Positive Learning Atmosphere:** Create a positive and supportive learning environment that encourages students to engage actively in their learning process.

Guidelines related to Continuous Practical Assessment

- The teacher will check students' lab manual regularly, sign the manual and ensure the progressive learning of the students.
- The teacher should create practical components by following the path on UMS: UMS Navigation >> Learning Management System (LMS) >> Practical Components.
- Create two components (1. J/E: Job Execution, 2. LM: Lab Manual Completion) of 50-50 marks each.



Comp. 1	Comp. 2
✓	✓
J/E	LM
50	50

  - "J/E grading will be based on the student's performance during the CAP day, marked out of 50."
  - "LM assessment will be out of 50, determined by the teacher's average overall rating from the evaluation of the previous two experiments in the lab manual. The average overall rating will be multiplied by 5."
- There will be total 4 continuous assessment practical (CAP) conducted during the semester (100 marks each).
- Best 3 out of 4 will be considered in grade calculation by the end of the semester.
- During the CAPs, students must upload their solutions in DOC or PDF format both at `https://forms.gle/MmLhykcUVvVf579U9` and on the UMS platform.

Installation of Linux

There are various ways in which Linux can be installed in a system:

1. Windows Subsystem for Linux (WSL)

   Video reference: `https://youtu.be/wjbblOTTMeo?si=DAPNc2NevQeOaRpD`

2. Virtual Machines

   Using VMWare: `https://youtu.be/QONaOf1NtpA?si=BlhtMiQvbK5JAv5u`

   Using Virtual Box: `https://youtu.be/hYaCCpvjsEY?si=HO8PCLVF9HzkQfdi`

3. Dual Boot

   Video reference: `https://youtu.be/MPMnizrPvHE?si=JUnIyOpOXGGfmEJY`

Lab Experiments

1 Experiment 1: Introduction to Linux Commands

1.1 Objective

The objective of this lab experiment is to introduce students to fundamental Linux commands used for navigating the file system, managing files and directories, and performing basic system operations. By the end of this experiment, students should be familiar with commonly used commands such as ls, cd, mkdir, rm, cp, and mv, gaining a foundational understanding of the Linux command-line interface.

1.2 Reference Material[1][3][2]

1.2.1 Important Linux Commands for File and Directory Management

Command	**Description**	**Example**
`ls`	List directory contents	`ls -l`
`cd`	Change the current directory	`cd Documents`
`pwd`	Print the current working directory	`pwd`
`mkdir`	Make directories	`mkdir new_directory`
`rmdir`	Remove directories	`rmdir directory_to_remove`
`cp`	Duplicate and transfer files and directories.	`cp f1.txt f2.txt`
`mv`	Move or rename files and directories	`mv file1.txt new_location`
`rm`	Remove files or directories	`rm file_to_delete.txt`
`touch`	Create an empty file or change file time stamps	`touch new_file.txt`
`cat`	Display or concatenate files	`cat file.txt`
`head`	Display the beginning of a file	`head -n 15 file1.txt`
`tail`	Display the end of a file	`tail -n 10 file.txt`
`grep`	Search text in files	`grep "pattern" file.txt`
`chmod`	Change file permissions	`chmod 644 file.txt`
`chown`	Change file ownership	`chown user:group file.txt`
`ln`	Create links between files	`ln -s /path/to/file linkname`

Table 1: Important Linux Commands for File and Directory Management[2]

1.2.2 Shell Command

A shell command is a directive or instruction provided by a user to a shell (a command-line interpreter) in an operating system.

1.2.3 Types of Shell Commands

- Internal Commands: These commands are built into the shell itself. They are part of the shell's functionalities and do not exist as separate executable files. Examples include cd, echo, exit, alias, export, etc.
- External Commands: These commands are separate executable files located in directories listed in the system's PATH variable. When a user inputs an external command, the shell searches for the command's executable file in these directories and executes it if found.

1.2.4 Linux File System Hierarchy[2]

```
/ (root directory)
├── bin ........................ Essential executable commands
├── boot ....................... Boot loader's static files
├── dev ........................ Files associated with devices
├── etc ........................ System configuration specific to the host
│   ├── passwd ................. User information
│   ├── group .................. Group information
│   └── hosts .................. Hosts file
├── home ....................... Home directories
│   ├── user1
│   ├── user2
│   └── ...
├── lib ........................ Crucial shared libraries and essential kernel modules
├── media ...................... Mount points for removable media
├── opt ........................ Supplementary application software packages
├── proc ....................... Pseudo-filesystem for kernel and process information
├── sys ........................ Kernel and system information
├── tmp ........................ Temporary files
├── usr ........................ Supplementary user data hierarchy
│   ├── bin .................... Non-essential command binaries
│   ├── include ................ Standard include files
│   ├── lib .................... Libraries for programming
│   └── share .................. Architecture-independent data
└── var ........................ Variable data
    ├── log .................... Log files
    └── spool .................. Application spool data
```

1.2.5 Paths

Paths refer to the location or address of a file or directory in the file system.

Types of paths

(i) Absolute Path: An absolute path defines the complete location of a file or directory starting from the root directory (/). It includes the entire directory hierarchy from the root directory to the specific file or directory. For instance, /home/user/documents/file.txt is an absolute path where the file.txt is located in the 'documents' directory inside the 'user' directory within the 'home' directory, starting from the root (/) directory.

(ii) Relative Path: A relative path defines the location of a file or directory with respect to the current working directory. It doesn't start from the root directory but refers to a location relative to the current directory. For example, if the current directory is /home/user/, a file located in the 'documents' directory can be referenced using a relative path like documents/file.txt.

1.2.6 Types of Files in Linux or Unix Environment

`File Types`
- `Regular Files`
  - `Text Files`.........Contain readable text, such as source code, configuration files, and documentation
  - `Binary Files`....Executable programs or compiled code that can be run by the system
  - `Image/Media Files`....Contain multimedia data, such as images, audio, and video files
- `Directory Files`................Directories (or folders) contain other files and directories
- `Device Files`
  - `Character Device Files`...Represent devices that handle data character by character, e.g., terminals, keyboards
  - `Block Device Files` ... Represent devices that handle data in blocks, e.g., hard drives, USB drives
- `Pipe Files`
  - `Named Pipes (FIFOs)`.........Special files that allow for inter-process communication
- `Socket Files`.......................Used for network communication between processes
- `Links`
  - `Hard Links`......Links that point to the same inode as another file, referencing the file content directly
  - `Symbolic Links (Symlinks or Soft Links)`.Files that act as pointers or shortcuts to other files or directories

1.2.7 File Permissions and the `chmod` Command

Linux File Permission Stack

In Linux, file and directory permissions are represented using a permission stack. The format of the permission stack is as follows:

```
- r w x   r - x   r - x
|   | |     | |     | |
|   | |     | |     | +---- Others (permissions for users not covered by owner or group)
|   | |     | +---------- Group (File group permissions for users)
|   | +------------------ Owner (permissions for the file or directory owner)
|   +-------------------- Type of the file (e.g., - for a regular files, d for a directories)
+------------------------ Special permission bits (e.g., s, t, etc.)
```

Each group of permissions (Owner, Group, Others) consists of three characters representing read (r), write (w), and execute (x) permissions. If a permission is allowed, the respective character is displayed, and if it's denied, a hyphen (-) is shown.

For example:

```
-rw-r--r--  1 user group    24 Jan  7 13:20 myfile.txt
```

In this example: - The first character (-) indicates that it's a regular file. - The next three characters (rw-) represent the owner's permissions (read and write, but not execute). - The following three characters (r–) represent the group's permissions (read-only). - The last three characters (r–) represent permissions for others (read-only).

These permissions can be changed using commands like `chmod` in Linux to alter the read, write, and execute permissions for the owner, group, and others.

File Permissions

In Unix or Linux, each file and directory has associated permissions that determine who can read, write, or execute them. These permissions are divided into three categories:

1. **Owner (User)**: The user who owns the file.
2. **Group**: The group that owns the file.
3. **Others**: All other users.

Permissions are represented by a series of ten characters, for example:

```
-rwxr-xr--
```

These characters can be broken down as follows:

- The first character indicates the type of file:
  - `-`: Regular file
  - `d`: Directory
  - `l`: Symbolic link
  - `b`: Block device file
  - `c`: Character device file
  - `p`: Named pipe (FIFO)
  - `s`: Socket file
- The next nine characters are divided into three sets of three characters each:
  - `r` (read), `w` (write), `x` (execute) for the **owner**.
  - `r` (read), `w` (write), `x` (execute) for the **group**.

  – `r` (read), `w` (write), `x` (execute) for **others**.

For example, the permission string `-rwxr-xr--` can be interpreted as:

- `-` : Regular file.
- `rwx` : The owner has read, write, and execute permissions.
- `r-x` : The group has read and execute permissions.
- `r--` : Others have read permission.

`chmod` Command

The `chmod` command is used to change the file permissions. There are two ways to specify the permissions: symbolic mode and numeric (octal) mode.

Symbolic Mode

In symbolic mode, you specify the permissions using characters. The syntax is:

```
chmod [user][operator][permissions] file
```

- **User**: `u` (user/owner), `g` (group), `o` (others), `a` (all).
- **Operator**: `+` (add permission), `-` (remove permission), `=` (set exact permission).
- **Permissions**: `r` (read), `w` (write), `x` (execute).

Examples:

```
chmod u+x file      # Add execute permission for the owner
chmod g-w file      # Remove write permission for the group
chmod o=r file      # Set read-only permission for others
chmod a+rw file     # Add read and write permissions for everyone
```

Numeric (Octal) Mode

In numeric mode, permissions are represented by a three-digit octal number. Each digit is a sum of its component bits: 4 (read), 2 (write), and 1 (execute). The syntax is:

```
chmod [permissions] file
```

Each digit represents different user classes (owner, group, others).
Examples:

- `7` (4+2+1): Read, write, and execute.
- `6` (4+2): Read and write.
- `5` (4+1): Read and execute.
- `4` (4): Read only.

- `0`: No permissions.

Examples:

```
chmod 755 file      # rwxr-xr-x (owner can read, write, execute; group can read, execute; others ca
chmod 644 file      # rw-r--r-- (owner can read, write; group can read; others can read)
chmod 600 file      # rw------- (owner can read, write; no permissions for group and others)
```

Video Reference:

https://youtube.com/playlist?list=PLWjmN065fOfGdAZrlP6316HVHh8jlve

1.3 Lab Exercises

Exercise 1:
- (a) Create a new directory named project in your home directory.
- (b) Inside the project directory, create two subdirectories: src and bin.
- (c) Create a new file named main.cpp inside the src directory and a file named compile.sh inside the bin directory.
- (d) Copy compile.sh to the src directory and rename the copy to build.sh.
- (e) Move main.cpp from the src directory to the bin directory.
- (f) Remove the src directory.
- (g) Use pwd to confirm you are in your home directory and list the contents of the project directory.

Exercise 2:
- (a) In your home directory, create a file named data.txt with some sample content.
- (b) Create another file named backup.txt by copying data.txt.
- (c) Use head and tail commands to display the 11^{th} to 20^{th} lines of data.txt.
- (d) Rename backup.txt to data_backup.txt.
- (e) Change the permissions of data.txt to be read and writable only by the owner.
- (f) Change the ownership of data_backup.txt to a user named student and a group named group1.

Exercise 3:
- (a) In your home directory, create a file named original_file.txt and add some content to it.
- (b) Create a symbolic link named symlink_to_original that points to original_file.txt.
- (c) Create a hard link named hardlink_to_original that also points to original_file.txt.

(d) Use ls -li to display the inode numbers of original_file.txt, symlink_to_original, and hardlink_to_original. Observe and explain the differences in their inode numbers.

(e) Edit original_file.txt and add a new line of content.

(f) Display the contents of symlink_to_original and hardlink_to_original to verify that the changes made to original_file.txt are reflected in both links.

(g) Delete original_file.txt and verify the existence of symlink_to_original and hardlink_to_original. Explain the outcome based on the nature of symbolic and hard links.

Exercise 4: (a) Create a new directory named `grep_practice` in your home directory. Inside this directory, create a text file named `sample.txt` with at least 50 lines of text. Ensure the file contains a mix of sentences, some of which include the word "Linux".

(b) Use the `grep` command to find all lines in `sample.txt` that contain the word "Linux". Display the results on the terminal.

(c) Modify the `grep` command to be case-insensitive and find all lines containing the word "linux" in `sample.txt`.

(d) Use the `grep` command with the `-n` option to display the line numbers of all occurrences of the word "Linux" in `sample.txt`.

(e) Use the `grep` command with the `-v` option to display all lines in `sample.txt` that do not contain the word "Linux".

(f) Use the `grep` command with the `-c` option to count the number of lines in `sample.txt` that contain the word "Linux".

Exercise 5: (a) Create a file named permissions_file.txt in your home directory.

(b) Change the file permissions of permissions_file.txt to be readable, writable, and executable by the owner, but readable only by others. Use chmod to set these permissions.

(c) Verify the permissions using ls -l.

(d) Change the ownership of permissions_file.txt to a user named newuser and a group named newgroup using chown.

(e) Verify the ownership change using ls -l.

1.4 Sample Viva Questions

Question 1: Can you illustrate the process of changing file permissions using chmod with symbolic and octal notation?

Question 2: How do you switch directories using relative and absolute paths in the cd command?

Question 3: Can you provide an example of using grep to search for a specific pattern within a file or multiple files?

Question 4: Distinguish between internal and external commands.

Question 5: Explain file system hierarchy of Linux.

Question 6: List different file systems used in Windows and Linux.

Question 7: What does the ls -l command do?

Question 8: How do you delete a directory with files in it?

1.5 Evaluation Parameters and Rating Scale

1.5.1 Student's Self Rating

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Required Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How Confident you are in Practical Implementation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Timely Completion of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How confident you are in viva questions	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness on the date of evaluation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Student's Signature: ______________________ Date: ______________

1.5.2 Teacher's Rating Student Performance

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Practical Implementation of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Regularity, discipline, & ethics	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Viva Performance	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Teacher's Signature: ______________________ Date: ______________

2 Experiment 2: Basics of Shell Scripting

2.1 Objective

The primary objectives include creating simple yet functional scripts, grasping scripting syntax elements such as variables, loops, and control structures, and executing these scripts effectively. Moreover, this experiment will emphasize the real-world utility of shell scripting in automating routine tasks, performing file manipulations, and simplifying system administration processes.

2.2 Reference Material[1][3][2]

2.2.1 Shell

In computing, a shell refers to a user interface that allows users to interact with an operating system (such as Linux, Unix, or Windows) to execute commands, run programs, and manage files and directories. It acts as an intermediary between the user and the core functionalities of the operating system.

2.2.2 Shell script

A shell program, also known as a shell script, is like a recipe made up of step-by-step instructions written in a special language that the computer understands. Each instruction in this recipe tells the computer what to do. These scripts are saved as files with a .sh ending and are created using programs like vi. To use them, we have to give permission to the computer to run these script files. We do this by using a command called chmod. Then, in a terminal, we use commands like sh or bash to tell the computer to follow the instructions written in the script file. It's like giving the computer a set of tasks to perform, and it does them one after another.

2.2.3 Shell Variables

Shell variables are placeholders used by a shell (like Bash or PowerShell) to store information or data values. These variables act as containers to hold data temporarily, such as strings of text, numbers, file paths, or configuration settings, for example: $VAR\_NAME = value$.

2.2.4 Types of Variables

Some commonly used shell variables include:

(i) Environment Variables: These are variables that contain information about the environment in which the shell operates, such as user settings, system paths, or configuration preferences.

(ii) User-Defined Variables: These are variables created by users to store custom data or information required for specific tasks or scripts.

2.2.5 Important Environment Variables

- `PATH`: Specifies directories where executable programs are located.
- `HOME`: Represents the current user's home directory.

- USER: Displays the username of the current user.
- SHELL: Specifies the default shell for the user.
- PWD: Indicates the present working directory.
- LANG: Determines the language and localization settings.
- TERM: Defines the terminal type or emulator being used.
- EDITOR: Specifies the default text editor.

2.2.6 Shell Redirections

Shell redirections in Linux/Unix allow users to control input and output streams of commands. Here are common redirection symbols:

- **Standard Input Redirection (<)**: Changes the command's input source to a file.

  ```
  command < input_file.txt
  ```

- **Standard Output Redirection (>)**: Redirects command output to a file (overwrites existing content).

  ```
  command > output_file.txt
  ```

- **Appending Output (>>)**: Appends command output to a file.

  ```
  command >> output_file.txt
  ```

- **Piping Output (|)**: Redirects output of one command as input to another.

  ```
  command1 | command2
  ```

- **Standard Error Redirection (2> or 2>>)**: Redirects error messages to a file.

  ```
  command 2> error_file.txt
  ```

2.2.7 Shell Arithmetic using `expr` and `bc` Commands

In shell scripting, arithmetic operations can be performed using different commands:

- `expr` **Command**: Used for integer arithmetic operations within shell scripts. It evaluates and prints the result of expressions.

  Example usage:

  ```
  result=$(expr 5 + 3)   # Adds 5 and 3
  echo "Result: $result" # Output: Result: 8
  ```

  Supported operators in `expr` include addition (+), subtraction (-), multiplication (*), division (/), modulus (

- `bc` **Command**: Stands for 'Basic Calculator' and supports floating-point arithmetic and advanced mathematical functions.

  Example usage:

  ```
  result=$(echo "5.5 + 3.2" | bc) # Adds 5.5 and 3.2
  echo "Result: $result"         # Output: Result: 8.7
  ```

  `bc` handles floating-point arithmetic and provides functions like sine, cosine, square root, etc., for more complex calculations.

These commands offer basic arithmetic functionalities within shell scripts. `expr` is suitable for simple integer arithmetic, while `bc` provides a broader range of mathematical operations and supports floating-point numbers.

2.2.8 Flow Control in Shell Scripting using `if` Statements

Shell scripting offers various forms of `if` statements for conditional flow control:

1. **Basic** `if` **Statement:**

   ```
   if [ condition ]; then
       # Commands to execute if the condition is true
   fi
   ```

2. `if-else` **Statement:**

   ```
   if [ condition ]; then
       # Commands to execute if the condition is true
   else
       # Commands to execute if the condition is false
   fi
   ```

3. `if-elif-else` **Statement:**

```
if [ condition1 ]; then
    # Commands to execute if condition1 is true
elif [ condition2 ]; then
    # Commands to execute if condition2 is true
else
    # Commands to execute if both condition1 and condition2 are false
fi
```

4. **Nested** `if` **Statements:**

```
if [ condition1 ]; then
    if [ condition2 ]; then
        # Commands to execute if both condition1 and condition2 are true
    fi
fi
```

5. `if` **Statement with Logical Operators:**

```
if [ condition1 -a condition2 ]; then
    # Commands to execute if condition1 AND condition2 are true
fi

if [ condition1 -o condition2 ]; then
    # Commands to execute if condition1 OR condition2 is true
fi
```

These variations enable conditional execution of commands based on different conditions within shell scripts, offering flexibility in controlling the flow of the script.

2.2.9 Operators in Shell Scripting

In shell scripting, operators are used to perform various operations on variables, constants, and expressions. Here are the common types of operators:

1. Arithmetic Operators

- `+`, `-`, `*`, `/`, `%`: Perform addition, subtraction, multiplication, division, and modulus respectively.

2. Relational Operators

- `-eq`, `-ne`, `-gt`, `-lt`, `-ge`, `-le`: Compare numbers (equal, not equal, greater than, less than, greater than or equal to, less than or equal to) within `test` or `[ ]` brackets.

3. String Operators

- `=`, `!=`, `<`, `>`: Compare strings (equal, not equal, less than, greater than) within `test` or `[ ]` brackets.

4. Logical Operators

- `&&`, `||`, `!`: Perform logical AND, logical OR, and logical NOT operations respectively.

5. Assignment Operators

- `=`, `+=`: Assign values to variables or concatenate strings.

6. Bitwise Operators

- `&`, `|`, `^`, `<<`, `>>`, `~`: Perform bitwise AND, OR, XOR, left shift, right shift, and bitwise NOT operations respectively.

7. File Test Operators

- `-f`, `-d`, `-r`, `-w`, `-x`: Check file properties (existence, directory, readability, writability, executability) within `test` or `[ ]` brackets.

Understanding and utilizing these operators enable the creation of conditions, calculations, string manipulations, and file property checks within shell scripts, enhancing their functionality and flexibility.

2.2.10 Case Structure in Shell Scripting

In shell scripting, the `case` structure provides a way to perform conditional branching based on the value of a variable or expression. It allows evaluation against multiple patterns and executes commands based on the matching pattern.

The basic syntax of the `case` structure is as follows:

```
case variable in
    pattern1)
        # Commands to execute if variable matches pattern1
        ;;
    pattern2)
        # Commands to execute if variable matches pattern2
        ;;
    pattern3|pattern4)
        # Commands to execute if variable matches pattern3 or pattern4
        ;;
    *)
        # Default commands to execute if no pattern matches
        ;;
esac
```

Example:

```
fruit="apple"

case $fruit in
    apple)
        echo "It's an apple."
        ;;
    banana|orange)
        echo "It's a banana or an orange."
        ;;
    *)
        echo "It's another fruit."
        ;;
esac
```

This example evaluates the variable `$fruit` against different patterns and executes respective blocks based on the matching pattern.

The `case` structure simplifies code readability when multiple conditions need evaluation against a single variable or expression.

2.2.11 Loops in Shell Scripting

In shell scripting, loops are used to execute a block of code repeatedly based on certain conditions. There are various types of loops available:

1. `for` Loop

The `for` loop iterates through a list of items or values. It is suitable when you have a known set of elements to loop through.

Syntax:

```
for variable in list
do
    # Commands to execute for each iteration
done
```

Example:

```
for i in 1 2 3 4 5
do
    echo "Iteration: $i"
done
```

2. `while` Loop

The `while` loop executes a block of code as long as a specified condition remains true.

Syntax:

```
while [ condition ]
do
    # Commands to execute as long as the condition is true
done
```

Example:

```
count=1
while [ $count -le 5 ]
do
    echo "Count: $count"
    ((count++))
done
```

3. `until` Loop

The `until` loop executes a block of code until a specified condition becomes true.

Syntax:

```
until [ condition ]
do
    # Commands to execute until the condition becomes true
done
```

Example:

```
count=1
until [ $count -gt 5 ]
do
    echo "Count: $count"
    ((count++))
done
```

4. Nested Loops

You can nest loops within each other to create more complex control structures.

Example:

```
for i in {1..3}
do
    echo "Outer Loop Iteration: $i"
    for j in A B C
    do
        echo "   Inner Loop Iteration: $j"
    done
done
```

These loops in shell scripting provide various ways to iterate through data, execute code repeatedly based on conditions, and control the flow of a script.

2.3 Steps to Prepare and Execute a Shell Script

1. **Create the Shell Script:**
   - Open a text editor or an Integrated Development Environment (IDE) to write the shell script.
   - Write the desired commands and save the file with a `.sh` extension (e.g., `script.sh`).

2. **Set Execution Permissions (if needed):**
   - If the script doesn't have execution permissions, use the `chmod` command to set the execution permission:

     ```
     chmod +x script.sh
     ```

3. **Run the Shell Script:**
   - Open the terminal.
   - Navigate to the directory where the script is saved using the `cd` command.
   - Execute the script using one of the following methods:
     - Using Bash:

       ```
       bash script.sh
       ```

     - Using Shorthand (if the script has execution permissions):

       ```
       ./script.sh
       ```

     - Using Absolute Path:

       ```
       /path/to/your/script.sh
       ```

4. **Verify Output:**
   - After executing the script, verify the output or actions performed by the script in the terminal or through any generated files or changes made by the script.

5. **Debug and Modify (if needed):**
   - If there are errors or the script doesn't behave as expected, edit the script in the text editor, save the changes, and rerun the script.

6. Exit Code Analysis (Optional):

- After script execution, check the exit code by typing:

  ```
  echo $?
  ```

  An exit code of `0` generally indicates success, while other codes signify different types of errors or warnings.

Video Reference:

https://youtube.com/playlist?list=PLWjmN065fOfGdAZrlP6316HVHh8jlve

2.3.1 Lab Exercises

Exercise 1: Write a shell script that calculates the factorial of a user-provided number using a `for` loop.

Exercise 2: Develop a script that prints the multiplication table for a given number up to 10 using a `for` loop.

Exercise 3: Create a script that reverses a given number using a `while` loop.

Exercise 4: Write a script to display all files in a directory using a `for` loop.

Exercise 5: Write a shell script named `day_of_week.sh` that prompts the user to enter a number between 1 and 7, representing a day of the week. Use a `case` structure to print the corresponding day of the week:

- If the user enters `1`, print ”Sunday”.
- If the user enters `2`, print ”Monday”.
- If the user enters `3`, print ”Tuesday”.
- If the user enters `4`, print ”Wednesday”.
- If the user enters `5`, print ”Thursday”.
- If the user enters `6`, print ”Friday”.
- If the user enters `7`, print ”Saturday”.
- If the user enters a number outside this range, print ”Invalid input. Please enter a number between 1 and 7”.

Exercise 6: Create a menu-driven calculator script that performs basic arithmetic operations based on user selection using a `case` structure.

2.4 Sample Viva Questions

Question 1: Describe how to redirect input and output in a shell script.

Question 2: How do you read user input in a shell script? Explain with an example.

Question 3: Discuss different types of operators used in shell scripting (arithmetic, comparison, logical, etc.).

Question 4: What are variables in shell scripting? How do you declare and use them?

Question 5: What are the different types of shells commonly used in Unix/Linux?

2.5 Evaluation Parameters and Rating Scale

2.5.1 Student's Self Rating

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Required Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How Confident you are in Practical Implementation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Timely Completion of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How confident you are in viva questions	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness on the date of evaluation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Student's Signature: ____________________ Date: ______________

2.5.2 Teacher's Rating Student Performance

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Practical Implementation of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Regularity, discipline, & ethics	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Viva Performance	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Teacher's Signature: ____________________ Date: ______________

2.6 Instructions for the Teacher to Conduct Lab Assessment 1

- Upon finishing the initial two experiments, you are required to carry out CAP1, which is worth 100 marks [comprising two parts: J/E (50) and LM (50)].
- The calculation for LM marks is determined by: (Average of the teacher's overall ratings in Experiment 1 and Experiment 2) multiplied by 5.

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3 Experiment 3: File Manipulation Using System Calls[1][3][2]

3.1 Objective

The goal of this lab is to introduce and apply fundamental system calls like open, read, write, lseek, and close through programming exercises, addressing practical challenges encountered in real-world scenarios.

3.2 Reading Material

3.2.1 System Calls

System calls are functions provided by the operating system kernel that enable user-level processes to request services from the operating system. Examples: Common system calls include open, read, write (for file operations), fork, exec (for process control), malloc, free (for memory management), socket, bind, connect (for networking), and many others.

System Call	Description	Programming Syntax
open	Used to open a file and obtain a file descriptor. Allows specifying flags for read, write, create, and permissions.	`int fd = open("file.txt", O_RDONLY);`
close	Closes a file descriptor, releasing resources associated with the file.	`close(fd);`
read	Reads data from an open file into a buffer in memory.	`read(fd, buffer, nbytes);`
write	Writes data from a buffer in memory to an open file.	`write(fd, buffer, nbytes);`
lseek	Moves the file pointer to a specified position in the file.	`lseek(fd, offset, SEEK_SET);`
unlink	Deletes a file by name.	`unlink("file.txt");`
rename	Renames a file or directory.	`rename("old_name", "new_name");`
stat	Retrieves file status information like permissions, size, and timestamps.	`struct stat fileStat; stat("file.txt", &fileStat);`
chmod	Changes file permissions.	`chmod("file.txt", 0644);`
chown	Changes file ownership.	`chown("file.txt", uid, gid);`
link/symlink	Creates hard or symbolic links to files.	`link("source", "target");`

Table 2: File management related system calls

3.2.2 Sample Programs

1. A C program to Create and Open a File for Reading

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

int main() {
    int fileDescriptor;

    // Create a new file named "file.txt" and open it for reading
    fileDescriptor = open("file.txt", O_CREAT | O_RDONLY, 0644);

    close(fileDescriptor); // Close the file

    return 0;
}
```

2. A C program to Read from Console and Write to Console

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>

#define BUFFER_SIZE 1024

int main() {
    char buffer[BUFFER_SIZE];
    //0 is the file descriptor of standard input.
    ssize_t bytesRead = read(0, buffer, BUFFER_SIZE);
    write(1, buffer, bytesRead); //1 is the file descriptor of standard output.

    return 0;
}
```

3. A C program to Append Data into a File

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>
#include <string.h>

int main() {
    char data[] = "This data will be appended to the file.\n";
    int fileDescriptor;

    fileDescriptor = open("file.txt", O_WRONLY | O_CREAT | O_APPEND, 0644);
    write(fileDescriptor, data, strlen(data));
    close(fileDescriptor);

    return 0;
}
```

4. A C program to Read from and Write to Files

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

#define BUFFER_SIZE 1024

int main() {
    char buffer[BUFFER_SIZE];
    int readFd, writeFd;

    readFd = open("source.txt", O_RDONLY);
    writeFd = open("destination.txt", O_WRONLY | O_CREAT | O_TRUNC, 0644);

    ssize_t bytesRead;
    while ((bytesRead = read(readFd, buffer, BUFFER_SIZE)) > 0) {
        write(writeFd, buffer, bytesRead);
    }

    close(readFd);
    close(writeFd);

    return 0;
}
```

5. A C program that reads characters from the 11th to the 20th position from a file named "input.txt" using the lseek system call.

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

#define BUFFER_SIZE 11

int main() {
    int fileDescriptor;
    char buffer[BUFFER_SIZE];

    fileDescriptor = open("input.txt", O_RDONLY);
    lseek(fileDescriptor, 10, SEEK_SET);
    read(fileDescriptor, buffer, BUFFER_SIZE - 1);
    buffer[BUFFER_SIZE - 1] = '\0';
    printf("Characters from 11th to 20th position: %s\n", buffer);
    close(fileDescriptor);

    return 0;
}
```

6. A C program to delete a file using unlink system call.

```
#include <stdio.h>
#include <unistd.h>  // For unlink()
#include <errno.h>   // For errno
#include <string.h>  // For strerror()

int main() {
    // Name of the file to be deleted
    const char *filename = "sample_file.txt";

    // Attempt to delete the file
    if (unlink(filename) == -1) {
        // If unlink fails, print an error message
        printf("Error deleting the file");
        return 1;
    }

    // Confirm successful deletion
    printf("File '%s' successfully deleted.\n", filename);

    return 0;
}
```

7. C Program to Demonstrate the Use of `rename` System Call

```
#include <stdio.h>
#include <stdlib.h> // For exit()
#include <errno.h>  // For errno
#include <string.h> // For strerror()

int main() {
    // Names of the source and destination files
    const char *old_name = "old_file.txt";
    const char *new_name = "new_file.txt";
    // Attempt to rename the file
    if (rename(old_name, new_name) != 0) {
        // If rename fails, print an error message
        printf("Error renaming the file");
        return -1;
    }

    // Confirm successful renaming
    printf("File renamed from '%s' to '%s'.\n", old_name, new_name);

    return 0;
}
```

8. C Program to Demonstrate the Use of `stat` System Call

```
#include <stdio.h>
#include <sys/stat.h>  // For struct stat and stat()
#include <stdlib.h>    // For exit()
#include <errno.h>     // For errno
#include <string.h>    // For strerror()

int main() {
    // Name of the file to retrieve information about
    const char *filename = "sample_file.txt";

    // Create a struct stat to hold file information
    struct stat fileStat;

    // Retrieve file status information
    if (stat(filename, &fileStat) != 0) {
        // If stat fails, print an error message
        printf("Error retrieving file information");
        return -1;
    }

    // Print file status information
    printf("File: %s\n", filename);
    printf("File Size: %ld bytes\n", fileStat.st_size);
    printf("Number of Links: %ld\n", fileStat.st_nlink);
    return 0;
}
```

Video Reference:

https://youtube.com/playlist?list=PLWjmN065fOfGdAZrlP6316HVHh8jlve

3.3 Lab Exercises

Exercise 1: Write a program in C using system calls that lets users choose to copy either the first half or the second half of a file by entering 1 or 2.

Exercise 2: Create a C program using system calls that keeps reading from the console until the user types '$'. Save the input data to a file called 'input.txt'."

Exercise 3: Write a C program that encrypts a text file using a simple encryption technique and saves the encrypted content to a new file.
Requirements:
Input: Provide a text file named "input.txt" with plain text content.
Encryption Technique: Shift each character in the file content by a fixed number of positions (e.g., shifting each character by 3 positions in the ASCII table).
Output: Save the encrypted content to a new file named "encrypted.txt".

Exercise 4: Write a C program to the following tasks:

(a) Create a new file named `sample.txt` in your current directory.

(b) Using chmod system call to change the permissions of `sample.txt` so that only the owner has read and write permissions, while the group and others have no permissions. Verify the changes using the `ls -l` command.

(c) Change the ownership of `sample.txt` to a different user (replace `username` with the actual username of the different user) using the `chown` command. Verify the changes using the `ls -l` command.

(d) Create a hard link named `sample_link.txt` to `sample.txt` using the `link` system call. Verify the existence and properties of the hard link using the `ls -li` command.

(e) Create a symbolic link named `sample_symlink.txt` to `sample.txt` using the `symlink` system call. Verify the existence and properties of the symbolic link using the `ls -l` command.

3.4 Sample Viva Questions

Question 1: What is the purpose of the open system call?

Question 2: Discuss the parameters of the read system call.

Question 3: What is the significance of the close system call?

Question 4: What parameters does the lseek system call take?

Question 5: How is the lseek system call used to move the file offset?

3.5 Evaluation Parameters and Ratings Scale

3.5.1 Student's Self Rating

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Required Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How Confident you are in Practical Implementation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Timely Completion of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How confident you are in viva questions	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness on the date of evaluation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Student's Signature: ____________________ Date: ______________

3.5.2 Teacher's Rating Student Performance

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Practical Implementation of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Regularity, discipline, & ethics	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Viva Performance	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Teacher's Signature: ____________________ Date: ______________

4 Experiment 4: Directory Manipulation Using System Calls

4.1 Objective

In this lab, we'll explore how shell commands like mkdir (used to create directories), rmdir (used to remove directories) and ls used to list directory contents) actually work behind the scenes. These commands rely on special functions called system calls such as mkdir, opendir, and readdir. By learning about these functions, you'll be able to understand how these commands function and even write your own code using them.

4.2 Reading Material[1][3][2]

4.2.1 Directory Management Related System Calls

System Call	**Description**	**Programming Syntax**
`opendir`	Opens a directory stream corresponding to the given directory name.	`DIR *opendir(const char *dirname);`
`readdir`	Reads the next directory entry from the directory stream.	`struct dirent *readdir(DIR *dir_stream);`
`closedir`	Closes the directory stream.	`int closedir(DIR *dir_stream);`
`chdir`	Changes the current working directory.	`int chdir(const char *path);`
`mkdir`	Creates a new directory with the specified name and permission mode.	`int mkdir(const char *pathname, mode_t mode);`
`rmdir`	Removes a directory.	`int rmdir(const char *pathname);`
`getcwd`	Gets the pathname of the current working directory.	`char *getcwd(char *buf, size_t size);`

Table 3: System calls for directory management

4.2.2 The dirent structure

The dirent structure in C is used to store information about directory entries when working with directory-related system calls. It's commonly associated with functions like readdir and is defined in the <dirent.h> header file in Linux systems.
The structure `dirent` typically contains the following members:

- `ino_t d_ino`: This member represents the inode number of the directory entry.
- `off_t d_off`: It stores the offset of the next `readdir` call within the directory stream.

- `unsigned short int d_reclen`: It denotes the length of this record.
- `unsigned char d_type`: This member identifies the type of the file. For example, `DT_DIR` for directories, `DT_REG` for regular files, and others based on the file type.
- `char d_name[]`: This member holds the name of the directory entry. It is a character array representing the name of the file or directory.

4.3 Sample Programs

1. A C program that prints the contents of a directory using system calls like opendir, readdir, and closedir

```
#include <stdio.h>
#include <dirent.h>

int main() {
    DIR *dir;
    struct dirent *entry;

    dir = opendir(".");

    if (dir) {
        printf("Contents of the directory:\n");
        while ((entry = readdir(dir)) != NULL) {
            printf("%s\n", entry->d_name);
        }
        closedir(dir);
    }

    return 0;
}
```

2. Write a C program to create a new directory named "NewDirectory" within the file system

```
#include <stdio.h>
#include <sys/stat.h>
#include <sys/types.h>

int main() {
    const char *dirname = "NewDirectory";

    // Creating a new directory named "NewDirectory"
    mkdir(dirname, 0777);
    return 0;
}
```

3. C Program to Demonstrate the Use of `getcwd`, `chdir`, and `rmdir` System Calls

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>  // For getcwd(), chdir(), and rmdir()
#include <errno.h>   // For errno
#include <string.h>  // For strerror()
#include <sys/types.h> // For mkdir()
#include <sys/stat.h>  // For mkdir()

#define NEW_DIR "new_directory"

int main() {
    char cwd[1024];  // Buffer to store current working directory
    char *original_dir;

    // Get the current working directory
    if (getcwd(cwd, sizeof(cwd)) == NULL) {
        printf("Error getting current working directory");
        return -1;
    }

    printf("Original Working Directory: %s\n", cwd);

    // Create a new directory
    if (mkdir(NEW_DIR, 0755) != 0) {
        printf("Error creating new directory");
        return -1;
    }

    // Change to the new directory
    if (chdir(NEW_DIR) != 0) {
        printf("Error changing to new directory");
        return -1;
    }

    // Print the new working directory
    if (getcwd(cwd, sizeof(cwd)) == NULL) {
        printf("Error getting new working directory");
        return -1;
    }

    printf("New Working Directory: %s\n", cwd);
    // Change back to the original directory
    if (chdir("..") != 0) {
        printf("Error changing back to original directory");
        return -1;
    }

    // Remove the new directory
    if (rmdir(NEW_DIR) != 0) {
        printf("Error removing new directory");
        return -1;
    }

    printf("Removed directory '%s' and changed back to original directory.\n", NEW_DIR)

    return 0;
}
```

Video Reference:

https://youtube.com/playlist?list=PLWjmN065fOfGdAZrlP6316HVHh8jlve

4.4 Lab Exercises

Exercise 1: Create a C program that prompts the user to enter a directory name and uses the `mkdir` system call to create the directory.

Exercise 2: Write a program that opens the current directory using `opendir` and reads its contents using `readdir`, then displays the list of directory entries.

Exercise 3: Create a C program to delete a directory specified by the user using the `rmdir` system call.

Exercise 4: Write a program that uses the `getcwd` system call to retrieve the current working directory and displays it to the user.

4.5 Sample Viva Questions

Question 1: How is the mkdir system call used in C programming?

Question 2: Discuss the significance of the rmdir system call.

Question 3: How is the opendir system call used in C programming?

Question 4: Explain the chdir system call and its significance.

Question 5: What are the main fields or members of the dirent structure?

4.6 Evaluation Parameters and Rating Scale

4.6.1 Student's Self Rating

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Required Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How Confident you are in Practical Implementation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Timely Completion of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How confident you are in viva questions	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness on the date of evaluation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Student's Signature: ______________________ Date: ______________

4.6.2 Teacher's Rating Student Performance

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Practical Implementation of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Regularity, discipline, & ethics	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Viva Performance	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Teacher's Signature: ______________________ Date: ______________

4.7 Instructions for the Teacher to Conduct Lab Assessment 2

- Upon finishing the experiment 3 and experiment 4, you are required to carry out CAP2, which is worth 100 marks [comprising two parts: J/E (50) and LM (50)].
- The calculation for LM marks is determined by: (Average of the teacher's overall ratings in Experiment 3 and Experiment 4) multiplied by 5.

5 Experiment 5: Process Management using System Calls

5.1 Objective

By the end of this experiment, students will learn about different system commands used to manage processes. They will also gain an understanding of orphan and zombie processes.

5.2 Reading Material[1][3][2]

5.2.1 Process management related system calls

System Call	Description	Programming Syntax
fork()	Creates a new process by duplicating the calling process.	pid$_t fork(void)$;
execv()	Replaces the current process image with a new program specified by the given file path and arguments.	int execv(const char *path, char *const argv[]);
wait()	Causes the parent process to wait until one of its child processes terminates.	pid$_t wait(int * status)$;
exit()	Terminates the calling process and returns an exit status to the operating system.	void exit(int status);
getpid()	Retrieves the process ID (PID) of the calling process.	pid$_t getpid(void)$;
getppid()	Retrieves the parent process ID (PPID) of the calling process.	pid$_t getppid(void)$;
kill()	Sends a signal to a specified process or group of processes.	int kill(pid$_t pid, intsig)$;
nice()	Modifies the priority of a process.	int nice(int incr);
sleep()	Causes the calling process to sleep for a specified number of seconds.	unsigned int sleep(unsigned int seconds);

Table 4: Process management related system calls

5.2.2 Orphan and Zombie Processes

Orphan Process: An orphan process is a child process whose parent process has terminated or finished before the child process completes. When the parent process exits or is terminated unexpectedly without properly waiting for the child to finish, the operating system reassigns the orphaned child process to the init process (PID 1 in Linux). The init process adopts and manages orphan processes until they complete execution.

Zombie Process: A zombie process is a terminated process that has completed its execution but still has an entry in the process table. After a process completes, it sends an exit status to its parent process and becomes a zombie waiting for the parent to retrieve the exit status using the `wait()` system call. If the parent fails to fetch the exit status of the terminated child (due to neglect or termination), the zombie process remains in the process table as an inactive process entry.

5.3 Sample Programs

1. A program to create a child process using fork system call.

```
#include <stdio.h>
#include <unistd.h>

int main() {
    pid_t child_pid;

    // Create a child process
    child_pid = fork();

    if (child_pid == 0) {
        // The child process code section
        printf("Child process: PID = %d\n", getpid());
    } else if (child_pid > 0) {
        // The parent process code section
        printf("Parent process: Child PID = %d\n", child_pid);
    } else {
        // Fork failed
        printf("Fork failed\n");
        return 1;
    }

    return 0;
}
```

2. C program to demonstrates the creation of an orphan process.

```
#include <stdio.h>
#include <sys/types.h>
#include <unistd.h>

int main() {
    pid_t child_pid = fork();

    if (child_pid == 0) {
        // Child process
        printf("Child process: PID = %d\n", getpid());
        sleep(2); // Sleep to ensure the parent process terminates first
        printf("Child process: My parent's PID = %d\n", getppid());
    } else if (child_pid > 0) {
        // Parent process
        printf("Parent process: PID = %d\n", getpid());
        printf("Parent process: Terminating...\n");
```

```c
    } else {
        printf("Fork failed\n");
        return 1;
    }

    return 0;
}
```

3. C program to demonstrate the creation of a Zombie process.

```c
#include <stdio.h>
#include <sys/types.h>
#include <unistd.h>
#include <stdlib.h>

int main() {
    pid_t child_pid = fork();

    if (child_pid == 0) {
        // Child process
        printf("Child process: PID = %d\n", getpid());
        exit(0); // Child process exits immediately
    } else if (child_pid > 0) {
        // Parent process
        printf("Parent process: PID = %d\n", getpid());
        printf("Parent process: Child PID = %d\n", child_pid);
        sleep(10); // Sleep to allow time for the child to become a zombie
        printf("Parent process: Terminating...\n");
    } else {
        printf("Fork failed\n");
        return 1;
    }

    return 0;
}
```

4. C Program to Demonstrate the Use of `execv()` System Call

```c
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <sys/types.h>
#include <sys/wait.h>

int main() {
    pid_t pid;  // Variable to hold the process ID
    char *args[] = {"ls", "-l", NULL};  // Arguments for the command

    // Create a new process
    pid = fork();

    if (pid < 0) {
        // If fork() fails, print an error message
        printf("fork failed");
        return -1;
    }

    if (pid == 0) {
        // This block is executed by the child process

        // Print a message to indicate the child process is running
        printf("Child process (PID: %d) running 'ls -l' command...\n", getpid());

        // Execute the 'ls -l' command
        execv("/bin/ls", args);

        // If execv() fails, print an error message
        printf("execv failed");
        exit(-1);  // Exit the child process with an error status
    } else {
        // This block is executed by the parent process

        // Wait for the child process to finish
        wait(NULL);

        // Print a message to indicate that the child process has finished
        printf("Parent process (PID: %d): Child process has finished.\n", getpid());
    }

    return 0;  // Return success
}
```

5. C Program to Demonstrate the Use of `kill()` System Call

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <signal.h>
#include <sys/types.h>
#include <sys/wait.h>
```

```
int main() {
    pid_t pid;  // Variable to hold the process ID

    // Create a new process
    pid = fork();

    if (pid < 0) {
        // If fork() fails, print an error message
        printf("fork failed");
        return -1;
    }

    if (pid == 0) {
        // This block is executed by the child process

        // Print a message to indicate the child process is running
        printf("Child process (PID: %d) is running...\n", getpid());

        // The child process will wait indefinitely until it receives a signal
        while (1) {
            pause();  // Wait for signals
        }

        // This line will never be reached if the process is terminated by a signal
    } else {
        // This block is executed by the parent process

        // Print a message to indicate that the parent process is sending a signal
        printf("Parent process (%d) sending signal to child (%d)\n",getpid(),pid);

        // Send the SIGTERM signal to the child process
        kill(pid, SIGTERM);

        // Wait for the child process to terminate
        wait(NULL);

        // Print a message to indicate that the child process has been terminated
        printf("Parent process: Child process has been terminated.\n");
    }

    return 0;  // Return success
}
```

Video Reference:

https://youtube.com/playlist?list=PLWjmN065fOfGdAZrlP6316HVHh8jlve

5.4 Lab Exercises

Exercise 1: Write a C program to illustrate that performing 'n' consecutive fork() system calls generates a total of $2^n - 1$ child processes. The program should prompt the user to input the value of 'n'."

Exercise 2: Write a C program utilizing the `fork()` system call to generate the following process hierarchy: P1 $\rightarrow$ P2 $\rightarrow$ P3. The program should display the Process ID (PID) and Parent Process IDs (PPID) for each process created.

Exercise 3: Write a C program to generate a process hierarchy as follows:

$$\begin{tikzcd}
 & P1 \arrow[dl] \arrow[dr] & \\
P2 \arrow[d] & & P3 \arrow[d] \\
P4 \arrow[d] & & P6 \\
P5 & &
\end{tikzcd}$$

The program should create the specified process structure using the appropriate sequence of 'fork()' system calls. Print PID and PPID of each process.

5.5 Sample Viva Questions

Question 1: Explain the fork system call in process management.

Question 2: Discuss the significance of the return values of the fork system call.

Question 3: What is the purpose of the wait system call?

Question 4: Discuss the significance of the getpid and getppid system calls in obtaining process IDs.

Question 5: How many child processes will be created if three consecutive fork statements are used in a main function?

5.6 Evaluation Parameters and Rating Scale

5.6.1 Student's Self Rating

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Required Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How Confident you are in Practical Implementation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Timely Completion of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How confident you are in viva questions	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness on the date of evaluation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Student's Signature: ______________________ Date: ______________

5.6.2 Teacher's Rating Student Performance

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Practical Implementation of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Regularity, discipline, & ethics	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Viva Performance	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Teacher's Signature: ______________________ Date: ______________

6 Experiment 6: Creation of Multithreaded Processes using Pthread Library

6.1 Objective

Introduce the operations on threads, which include initialization, creation, join and exit functions of thread using pthread library.

6.2 Reading Material[1][3][2]

6.2.1 Commonly used library functions related to POSIX threads (pthread)

Function	Description	Programming Syntax
`pthread_create`	Create a new thread	`int pthread_create(pthread_t *thread, const pthread_attr_t *attr, void *(*start_routine) (void *), void *arg);`
`pthread_join`	Wait for termination of a specific thread	`int pthread_join(pthread_t thread, void **retval);`
`pthread_exit`	Terminate calling thread	`void pthread_exit(void *retval);`
`pthread_cancel`	Request cancellation of a thread	`int pthread_cancel(pthread_t thread);`

Table 5: Commonly used library functions related to POSIX threads (pthread)

6.3 Sample Programs

1. A C program using the pthread library to create a thread with NULL attributes.

```
#include <stdio.h>
#include <pthread.h>

void *thread_function(void *arg) {
    printf("Inside the new thread!\n");
    return NULL;
}

int main() {
    pthread_t thread_id;
    pthread_create(&thread_id, NULL, thread_function, NULL);
    pthread_join(thread_id, NULL);
    return 0;
}
```

2. A C program that creates a thread and passes a message from the main function to the thread.

```c
#include <stdio.h>
#include <pthread.h>

void *thread_function(void *message) {
    printf("Message received in thread: %s\n", (char *)message);
    return NULL;
}

int main() {
    pthread_t thread_id;
    pthread_create(&thread_id, NULL, thread_function, "Hello from the main thread!");
    pthread_join(thread_id, NULL);
    return 0;
}
```

3. A C program where a thread returns a value to the main function using pointers.

```c
#include <stdio.h>
#include <pthread.h>

#define NUM_THREADS 1

void *thread_function(void *arg) {
    int *returnValue = malloc(sizeof(int));
    *returnValue = 143; // Set the return value
    pthread_exit(returnValue);
}

int main() {
    pthread_t threads[NUM_THREADS];
    int *thread_return;

    pthread_create(&threads[0], NULL, thread_function, NULL);
    pthread_join(threads[0], (void **)&thread_return);

    printf("Value returned from thread: %d\n", *thread_return);

    free(thread_return); // Free allocated memory for return value
    return 0;
}
```

Video Reference:

https://youtube.com/playlist?list=PLWjmN065fOfGdAZrlP6316HVHh8jlve

6.4 Lab Exercises: [Attempt any 3 within the designated lab hours]

Exercise 1: Develop a program using pthread to concatenate multiple strings passed to the thread function.

Exercise 2: Create a pthread program to find the length of strings passed to the thread function.

Exercise 3: Implement a program that performs statistical operations (calculating average, maximum, and minimum) for a set of numbers. Utilize three threads, where each thread performs its respective operation.

Exercise 4: Write a multithreaded program where a globally passed array of integers is divided into two smaller lists and given as input to two threads. Each thread sorts their half of the list and then passes the sorted lists to a third thread, which merges and sorts them. The final sorted list is printed by the parent thread.

Exercise 5: Create a program using `pthread_create` to generate multiple threads. Each thread should display its unique ID and execution sequence.

Exercise 6: Create a threaded application that demonstrates graceful thread termination using `pthread_exit` for resource cleanup compared to abrupt termination via `pthread_cancel`.

6.5 Sample Viva Questions

Question 1: Discuss the steps involved in creating a thread using the `pthread_create` function.

Question 2: What parameters does the `pthread_create` function take, and what are their purposes?

Question 3: Explain the role and usage of the `pthread_join` function in managing threads.

Question 4: Explain the differences between a thread and a process in terms of memory sharing and execution context.

Question 5: Give two instances where a multi-threaded process offers benefits compared to a single-threaded solution.

6.6 Evaluation Parameters and Rating Scale

6.6.1 Student's Self Rating

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Required Concepts	1 2 3 4 5 6 7 8 9 10
How Confident you are in Practical Implementation	1 2 3 4 5 6 7 8 9 10
Timely Completion of Lab Exercises	1 2 3 4 5 6 7 8 9 10
How confident you are in viva questions	1 2 3 4 5 6 7 8 9 10
Lab-manual Readiness on the date of evaluation	1 2 3 4 5 6 7 8 9 10
Overall Rating	1 2 3 4 5 6 7 8 9 10

Student's Signature: ______________________ Date: ______________

6.6.2 Teacher's Rating Student Performance

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Concepts	1 2 3 4 5 6 7 8 9 10
Practical Implementation of Lab Exercises	1 2 3 4 5 6 7 8 9 10
Regularity, discipline, & ethics	1 2 3 4 5 6 7 8 9 10
Viva Performance	1 2 3 4 5 6 7 8 9 10
Lab-manual Readiness	1 2 3 4 5 6 7 8 9 10
Overall Rating	1 2 3 4 5 6 7 8 9 10

Teacher's Signature: ______________________ Date: ______________

6.7 Instructions for the Teacher to Conduct Lab Assessment 3

- Upon finishing the experiment 5 and experiment 6, you are required to carry out CAP3, which is worth 100 marks [comprising two parts: J/E (50) and LM (50)].
- The calculation for LM marks is determined by: (Average of the teacher's overall ratings in Experiment 5 and Experiment 6) multiplied by 5.

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7 Experiment 7: Process Synchronization using Semaphore/-Mutex

7.1 Objective

The objective of this lab experiment is to acquaint students with the concept of process synchronization in concurrent programming using semaphore or mutex mechanisms.

7.2 Reading Material[1][3][2]

7.2.1 Synchronization

Process or thread synchronization refers to the coordination and orderly execution of concurrent processes or threads in a multi-threaded or multi-process system.

7.2.2 Race Condition

A race condition is a situation in concurrent programming where the outcome of the program depends on the order of execution of threads or processes. It arises when multiple threads or processes access shared resources or critical sections without proper synchronization or coordination, leading to unpredictable or incorrect behavior.

7.2.3 Semaphore

Definition	A semaphore is an abstract data type used for process synchronization in concurrent programming. It controls access to shared resources among multiple processes or threads by maintaining a counter that can be incremented or decremented.
Functionality	Semaphores manage access to shared resources, prevent race conditions, and ensure synchronization. They offer operations like initialization (`sem_init`), waiting (`sem_wait`), signaling (`sem_post`), and destruction (`sem_destroy`).
Types	Common types include Binary Semaphores (with values 0 and 1) and Counting Semaphores (with values greater than 1).

Function	**Description**	**Programming Syntax**
`sem_init`	Initialize a semaphore	`int sem_init(sem_t *sem, int pshared, unsigned int value);`
`sem_destroy`	Destroy a semaphore	`int sem_destroy(sem_t *sem);`
`sem_post`	Increment (signal) a semaphore	`int sem_post(sem_t *sem);`
`sem_wait`	Decrement (wait/block) a semaphore	`int sem_wait(sem_t *sem);`

Table 6: Library Functions Related to Semaphore

7.2.4 Mutex

Definition	A mutex (Mutual Exclusion) is a synchronization primitive used in multi-threaded programming to control access to shared resources. It allows only one thread at a time to access the resource, preventing concurrent access.
Functionality	Mutexes ensure mutual exclusion, preventing race conditions and maintaining data integrity. Operations include initialization (`pthread_mutex_init`), locking (`pthread_mutex_lock`), unlocking (`pthread_mutex_unlock`), and destruction (`pthread_mutex_destroy`).
Types	Mutexes can be recursive (allows the same thread to lock it multiple times) or non-recursive (deadlocks if the same thread tries to lock it multiple times).

Function	**Description**	**Programming Syntax**
`pthread_mutex_init`	Initialize a mutex	`int pthread_mutex_init(pthread_mutex_t *mutex, const pthread_mutexattr_t *attr);`
`pthread_mutex_destroy`	Destroy a mutex	`int pthread_mutex_destroy(pthread_mutex_t *mutex);`
`pthread_mutex_lock`	Lock a mutex	`int pthread_mutex_lock(pthread_mutex_t *mutex);`
`pthread_mutex_unlock`	Unlock a mutex	`int pthread_mutex_unlock(pthread_mutex_t *mutex);`

Table 7: Library Functions Related to Mutex

7.3 Sample Programs

1. C Program Simulating Race Condition.

```
#include <stdio.h>
#include <pthread.h>

#define NUM_THREADS 5
#define MAX_COUNT 1000000

int shared_variable = 0;

void *increment_variable(void *thread_id) {
    for (int i = 0; i < MAX_COUNT; i++) {
        shared_variable++;
    }
    pthread_exit(NULL);
}

int main() {
    pthread_t threads[NUM_THREADS];
    for (int i = 0; i < NUM_THREADS; i++) {
        pthread_create(&threads[i], NULL, increment_variable, (void *)i);
    }

    for (int i = 0; i < NUM_THREADS; i++) {
        pthread_join(threads[i], NULL);
    }

    printf("Value of shared variable after race condition: %d\n", shared_variable);

    return 0;
}
```

2. C Program with Semaphore to Avoid Race Condition.

```
#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>

#define NUM_THREADS 5
#define MAX_COUNT 1000000

int shared_variable = 0;
sem_t semaphore;

void *increment_variable(void *thread_id) {
    for (int i = 0; i < MAX_COUNT; i++) {
        sem_wait(&semaphore);
        shared_variable++;
        sem_post(&semaphore);
    }
    pthread_exit(NULL);
}

int main() {
    pthread_t threads[NUM_THREADS];
    sem_init(&semaphore, 0, 1); // Initializing semaphore with value 1

    for (int i = 0; i < NUM_THREADS; i++) {
        pthread_create(&threads[i], NULL, increment_variable, (void *)i);
    }

    for (int i = 0; i < NUM_THREADS; i++) {
        pthread_join(threads[i], NULL);
    }
    sem_destroy(&semaphore); // Destroying semaphore

    printf("Value of shared variable after synchronization: %d\n", shared_variable);

    return 0;
}
```

3. C Program with Mutex to Prevent Race Condition

```
#include <stdio.h>
#include <pthread.h>

#define NUM_THREADS 5
#define MAX_COUNT 1000000

int shared_variable = 0;
pthread_mutex_t mutex = PTHREAD_MUTEX_INITIALIZER;

void *increment_variable(void *thread_id) {
    for (int i = 0; i < MAX_COUNT; i++) {
        pthread_mutex_lock(&mutex);
        shared_variable++;
        pthread_mutex_unlock(&mutex);
    }
    pthread_exit(NULL);
}

int main() {
    pthread_t threads[NUM_THREADS];
    pthread_mutex_init(&mutex, NULL); // Initializing mutex

    for (int i = 0; i < NUM_THREADS; i++) {
        pthread_create(&threads[i], NULL, increment_variable, (void *)i);
    }

    for (int i = 0; i < NUM_THREADS; i++) {
        pthread_join(threads[i], NULL);
    }

    pthread_mutex_destroy(&mutex); // Destroying mutex

    printf("Value of shared variable after synchronization: %d\n", shared_variable);

    return 0;
}
```

Video Reference:

https://youtube.com/playlist?list=PLWjmN065fOfGdAZrlP6316HVHh8jlve

7.4 Lab Exercises

Exercise 1: Implement the producer-consumer problem using pthreads and mutex operations.
Constraints:

(a) A producer only produces if the buffer is empty, and the consumer only consumes if some content is in the buffer.

(b) A producer writes an item into the buffer, and the consumer deletes the last produced item in the buffer.

(c) A producer writes on the last consumed index of the buffer.

Exercise 2: Implement the reader-writer problem using semaphore and mutex operations to synchronize n readers active in the reader section at the same time and one writer active at a time.
Constraints:

(a) If n readers are active, no writer is allowed to write.

(b) If one writer is writing, no other writer should be allowed to read or write on the shared variable.

7.5 Sample Viva Questions

Question 1: What is a semaphore, and how does it facilitate synchronization among processes or threads?

Question 2: Discuss the functions `sem_init`, `sem_wait`, and `sem_post` in semaphore usage.

Question 3: Compare and contrast mutexes with semaphores in terms of functionality and usage.

Question 4: Explain the functions `pthread_mutex_init`, `pthread_mutex_lock`, and `pthread_mutex_unlock` in mutex usage.

Question 5: Discuss scenarios where mutexes are preferred over other synchronization mechanisms.

7.6 Evaluation Parameters and Rating Scale

7.6.1 Student's Self Rating

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Required Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How Confident you are in Practical Implementation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Timely Completion of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How confident you are in viva questions	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness on the date of evaluation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Student's Signature: ______________________ Date: ______________

7.6.2 Teacher's Rating Student Performance

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Practical Implementation of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Regularity, discipline, & ethics	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Viva Performance	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Teacher's Signature: ______________________ Date: ______________

8 Experiment 8: Inter Process Communication (IPC)

8.1 Objective

The aim of this laboratory is to introduce the Interprocess communication (IPC) mechanism of operating system to allow the processes to communicate with each other.

8.2 Reading Material[1][3][2]

8.2.1 Interprocess communication

Interprocess communication (IPC) involves methods and tools that enable different processes on a computer system to exchange data, coordinate activities, and synchronize operations. It allows programs to communicate with each other, facilitating collaboration and data sharing between processes running concurrently. Examples of IPC methods include pipes, sockets, shared memory, and message queues.

8.2.2 Pipes

In C programming, pipes are a form of interprocess communication (IPC) that allows communication between two processes, with one process writing data into the pipe and the other process reading from it. Pipes are one-way communication channels that can be either anonymous or named.

Function	**Description**	**Programming Syntax**
pipe()	Creates an anonymous pipe, returning two file descriptors - one for reading and one for writing.	`int pipe(int filedes[2]);`
mkfifo()	Creates a named pipe (FIFO) in the file system.	`int mkfifo(const char *pathname, mode_t mode);`
dup()	Duplicates a file descriptor, creating a copy of the specified descriptor.	`int dup(int oldfd);`
close()	Closes a file descriptor.	`int close(int fd);`

Table 8: Functions related to pipes

8.2.3 Unnamed Pipes (Anonymous Pipes)

Functioning: Unnamed pipes are created using the pipe() system call. They provide a one-way communication channel between two related processes, typically a parent and its child process. They allow communication by connecting the standard output (stdout) of one process to the standard input (stdin) of another.

- **Syntax:** `int pipe(int filedes[2]);`
- `filedes[0]` refers to the read end of the pipe.
- `filedes[1]` refers to the write end of the pipe.

Sample Program

```
#include <stdio.h>
#include <unistd.h>

int main() {
    int pipe_fd[2];
    char data[100];

    if (pipe(pipe_fd) < 0) {
        prinft("pipe creation failed");
        return 1;
    }

    pid_t pid = fork();

    if (pid < 0) {
        printf("fork failed\n");
        return 1;
    }

    if (pid > 0) { // Parent process
        // Write to pipe
        close(pipe_fd[0]); // Close the reading end
        char message[] = "Hello, Child Process!";
        write(pipe_fd[1], message, sizeof(message));
        close(pipe_fd[1]); // Close the writing end
    } else { // Child process
        // Read from pipe
        close(pipe_fd[1]); // Close the writing end
        read(pipe_fd[0], data, sizeof(data));
        printf("Received message in child: %s\n", data);
        close(pipe_fd[0]); // Close the reading end
    }

    return 0;
}
```

8.2.4 Named Pipes

Named pipes, also known as FIFOs (First In, First Out), are created using the mkfifo() system call. They are files residing in the file system and allow communication between unrelated processes. Named pipes provide bi-directional communication.

- **Syntax:** `int mkfifo(const char *pathname, mode_t mode);`
- `pathname` is the path and name of the named pipe.

- `mode` specifies the permissions for the named pipe.

Sample Code[3][1]

```
#include <stdio.h>
#include <fcntl.h>
#include <sys/stat.h>
#include <unistd.h>

int main() {
    char *fifo = "/tmp/myfifo"; // Path to the named pipe

    mkfifo(fifo, 0666); // Creating a named pipe

    int fd;
    char data[100];

    fd = open(fifo, O_WRONLY); // Open the pipe for writing
    write(fd, "Hello from writer!", sizeof("Hello from writer!"));
    close(fd);

    fd = open(fifo, O_RDONLY); // Open the pipe for reading
    read(fd, data, sizeof(data));
    printf("Received message: %s\n", data);
    close(fd);

    return 0;
}
```

8.2.5 Shared Memory

Shared memory in C programming is a mechanism that allows multiple processes to share a region of memory. This shared memory segment is created by one process and can be accessed by multiple processes, enabling efficient inter-process communication (IPC).
The primary steps involved in using shared memory are:

1. **Allocation**: A process allocates a shared memory segment using the `shmget()` system call. This call either creates a new shared memory segment or accesses an existing one based on a provided key and size.

2. **Attachment**: After allocation, the process attaches the shared memory segment to its address space using `shmat()`. This attaches the segment to a virtual address in the process's memory, allowing it to read from and write to the shared memory.

3. **Usage**: Processes that share this segment can read from and write to it, treating it like any other memory region. Synchronization mechanisms such as semaphores or mutexes are typically used to control access and prevent race conditions.

4. **Detachment**: When the process finishes using the shared memory, it detaches the segment using `shmdt()`. This detaches the shared memory segment from the process's address space.
5. **Control Operations**: The `shmctl()` function allows for control operations on the shared memory segment, such as removing or modifying it.

Function	Description	Programming Syntax
`shmget()`	Allocates a new shared memory segment or accesses an existing one.	`int shmget(key_t key, size_t size, int shmflg);`
`shmat()`	Attaches the shared memory segment to the address space of the calling process.	`void *shmat(int shmid, const void *shmaddr, int shmflg);`
`shmdt()`	Detaches the shared memory segment from the calling process.	`int shmdt(const void *shmaddr);`
`shmctl()`	Performs control operations on the shared memory segment, such as removing or modifying it.	`int shmctl(int shmid, int cmd, struct shmid_ds *buf);`

Table 9: Functions related to shared memory

8.2.6 Sample program to demonstrate shared memory segment creation and data addition

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <sys/shm.h>
#include <string.h>
#include <errno.h>

#define SHM_SIZE 1024

int main() {
    void *shm;
    char buf[100];
    int shmid;

    // Creating a shared memory segment
    shmid = shmget((key_t)123, SHM_SIZE, 0666 | IPC_CREAT);
    if (shmid == -1) {
        printf("shmget  Error\n");
        exit(EXIT_FAILURE);
    }
    printf("The Key value of shared memory is %d\n", shmid);

    // Attaching the process to the shared memory segment
    shm = shmat(shmid, NULL, 0);
    if (shm == (void *)-1) {
        printf("shmat  Error\n");
        exit(EXIT_FAILURE);
    }
    printf("Process attached to the address of %p\n", shm);

    printf("Write the data to shared memory (max 99 characters): ");
    fgets(buf, sizeof(buf), stdin);
    buf[strcspn(buf, "\n")] = '\0'; // Removing newline character if present

    strncpy((char *)shm, buf, SHM_SIZE); // Ensuring data doesn't exceed SHM_SIZE
    printf("The stored data in shared memory is: %s\n", (char *)shm);

    // Detaching shared memory
    if (shmdt(shm) == -1) {
        printf("shmdt Error\n");
        exit(EXIT_FAILURE);
    }

    return 0;
}
```

8.2.7 Message Queues

Function	Description	Programming Syntax
`msgget()`	Creates a new message queue or gets the identifier of an existing queue.	`int msgget(key_t key, int msgflg);`
`msgsnd()`	Sends a message to a message queue.	`int msgsnd(int msqid, const void *msgp, size_t msgsz, int msgflg);`
`msgrcv()`	Receives a message from a message queue.	`ssize_t msgrcv(int msqid, void *msgp, size_t msgsz, long msgtyp, int msgflg);`
`msgctl()`	Performs control operations on a message queue, such as deleting or modifying it.	`int msgctl(int msqid, int cmd, struct msqid_ds *buf);`

Table 10: Funtions related to message queues

8.2.8 Message Queue Implementation in C

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
```

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/msg.h>
#include <errno.h>

#define MAX_MSG_SIZE 100

struct msg_buffer {
    long msg_type;
    char msg_text[MAX_MSG_SIZE];
};

int main() {
    key_t key;
    int msg_id;
    struct msg_buffer message;

    // Manually generate a key without using ftok
    if ((key = 0x12345678) == -1) {
        printf("key Error\n");
        exit(EXIT_FAILURE);
    }

    if ((msg_id = msgget(key, 0666 | IPC_CREAT)) == -1) {
        printf("msgget Error\n");
        exit(EXIT_FAILURE);
    }

    printf("Message Queue Created with ID: %d\n", msg_id);

    printf("Enter a message to send to the queue: ");
    fgets(message.msg_text, MAX_MSG_SIZE, stdin);
    message.msg_type = 1;

    if (msgsnd(msg_id, &message, sizeof(message), 0) == -1) {
        printf("msgsnd Error\n");
        exit(EXIT_FAILURE);
    }

    printf("Message Sent to the Queue\n");

    if (msgrcv(msg_id, &message, sizeof(message), 1, 0) == -1) {
        printf("msgrcv Error\n");
        exit(EXIT_FAILURE);
    }
    printf("Message Received from the Queue: %s\n", message.msg_text);

    if (msgctl(msg_id, IPC_RMID, NULL) == -1) {
        printf("msgctl Error\n");
        exit(EXIT_FAILURE);
    }

    printf("Message Queue Removed\n");

    return 0;
}
```

Video Reference:

https://youtube.com/playlist?list=PLWjmN065fOfGdAZrlP6316HVHh8jlve

8.3 Lab Exercises

Exercise 1: Develop a program that demonstrates Inter-Process Communication (IPC) using named pipes.
Tasks:

- Create a pair of named pipes: one for sending data and another for receiving data.
- Develop a sender program that writes a message to the sending pipe.
- Create a receiver program that reads from the receiving pipe and displays the received message.

Exercise 2: Demonstrate the usage of Shared Memory for IPC.
Tasks:

- Create a shared memory segment and attach it to multiple processes.
- Develop a producer-consumer model, where one process writes data into the shared memory, and another process reads from it.

Exercise 3: Explore IPC using Message Passing techniques.
Tasks:

- Design two processes where one process sends a signal to another process.
- Develop signal handlers in both processes to manage incoming signals and perform specific actions based on the received signal.

8.4 Sample Viva Questions

Question 1: Discuss the characteristics and limitations of unnamed pipes in inter-process communication.

Question 2: How are unnamed pipes created and used in C programming for IPC between parent and child processes?

Question 3: Can unnamed pipes be used for communication between unrelated processes? Explain.

Question 4: What distinguishes named pipes (FIFOs) from unnamed pipes in inter-process communication?

Question 5: What are the advantages of using shared memory for IPC compared to other methods like pipes or message queues?

Question 6: How is shared memory accessed and utilized by multiple processes concurrently?

Question 7: Explain the process of creating and using message queues for communication between processes.

8.5 Evaluation Parameters and Rating Scale

8.5.1 Student's Self Rating

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Required Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How Confident you are in Practical Implementation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Timely Completion of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
How confident you are in viva questions	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness on the date of evaluation	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Student's Signature: ____________________ Date: ______________

8.5.2 Teacher's Rating Student Performance

Evaluation Parameters	**Rating (Out of 10)**
Understanding of Concepts	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Practical Implementation of Lab Exercises	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Regularity, discipline, & ethics	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Viva Performance	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Lab-manual Readiness	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
Overall Rating	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

Teacher's Signature: ______________________ Date: ______________

8.6 Instructions for the Teacher to Conduct Lab Assessment 4

- Upon finishing the Experiment 7 and Experiment 8, you are required to carry out CAP4, which is worth 100 marks [comprising two parts: J/E (50) and LM (50)].
- The calculation for LM marks is determined by: (Average of the teacher's overall ratings in Experiment 7 and Experiment 8) multiplied by 5.

.

References

[1] Greg Gagne Abraham Silberschatz, Peter B. Galvin. *Operating System Concepts*. Wiley, 10 edition, 2018.

[2] Sumitabha Das. *Unix Concepts And Applications*. Wiley, 4 edition, 2006.

[3] Richard Stones Neil Matthew. *Beginning Linux Programming*. Wiley, 4 edition, 2007.

A Supplementary practice tasks for students.

A.1 Introduction to Linux Commands

Exercise 1:

I. Navigate to your home directory using the cd command. List the contents using ls and display detailed information about a specific file with ls -l.

II. Create a directory named "OSLab." Within it, generate an empty text file called "notes.txt." Afterwards, remove the entire "OSLab" directory along with its contents.

III. Copy the "notes.txt" file to a newly created directory named "Backup." Rename "notes.txt" to "important_notes.txt" and relocate it to the home directory.

IV. Generate three text files: "file1.txt," "file2.txt," and "document.txt." Utilize a wildcard to list only files beginning with "file."

V. Append the text "This is a sample text" to "document.txt." Display the first 5 lines of "document.txt" and count the number of words within the file.

VI. Establish a directory named "Restricted." Set read, write, and execute permissions for the owner exclusively. Attempt to access the directory using another user account.

VII. Employ grep to search for the word "error" in all text files within a specific directory. Display the line number and filename for each match.

VIII. Create a symbolic link named "shortcut" pointing to a file in another directory. Verify that accessing "shortcut" redirects to the original file.

IX. Generate a directory structure with nested subdirectories. Use cp with the -r option to copy the entire structure to a new location. Remove the original directory and its contents.

X. List all the files and directories in the root directory.

XI. Change into the "/etc" directory.

XII. List all the files and directories in the "/etc" directory.

Exercise 2:

I. Create a new directory called "lab_exercises" in your home directory.

II. Inside the "lab_exercises" directory, create a new file called "file1.txt" and write some text in it.

III. Create a copy of "file1.txt" and name it "file2.txt" using the `cp` command.

IV. Verify that "file2.txt" is an exact copy of "file1.txt" by opening both files and comparing their contents.

V. Create a new directory called "backup" inside the "lab_exercises" directory.

VI. Move "file1.txt" and "file2.txt" to the "backup" directory using the `mv` command.

VII. Verify that both files have been moved to the "backup" directory by listing its contents.

VIII. Create a new file called "file3.txt" in the "lab_exercises" directory and write some text in it.

IX. Create a new directory called "archive" inside the "lab_exercises" directory.

X. Move "file3.txt" to the "archive" directory and rename it to "file3_backup.txt" using the `mv` command.

XI. Verify that "file3_backup.txt" has been moved to the "archive" directory and that its contents are the same as "file3.txt".

XII. Create a new directory called "temp" inside the "lab_exercises" directory.

XIII. Create a new file called "file4.txt" in the "temp" directory and write some text in it.

XIV. Move "file4.txt" to the "lab_exercises" directory using the `mv` command.

XV. Verify that "file4.txt" has been moved to the "lab_exercises" directory and that its contents are the same as before.

A.2 Basics of Shell Scripting

Exercise 1: Write a script that accepts two command line arguments and displays their sum.

Exercise 2:

I. Write a script that accepts a directory name as a command line argument and displays the number of files in that directory.

II. Modify the script to display the number of files in the directory and all its subdirectories.

Exercise 3:

I. Write a script that accepts a filename as a command line argument and displays the number of lines, words, and characters in that file.

II. Modify the script to accept multiple file names as command line arguments and display the number of lines, words, and characters in each file.

Exercise 4:

I. Declare a variable called "name" and assign your name to it. Display the value of the variable using the echo command.

II. Declare a variable called "age" and assign your age to it. Display the value of the variable using the echo command.

III. Declare a variable called "color" and assign your favorite color to it. Display the value of the variable using the echo command.

Exercise 5: Declare a variable called "num1" and assign the value 10 to it. Declare a second variable called "num2" and assign the value 5 to it. Add the values of the two variables and display the result using the echo command.

Exercise 6:

I. Declare a variable called "filename" and assign the value "sample.txt" to it. Use the variable to create a new file with that name using the touch command.

II. Declare a variable called "directory" and assign the value "myfolder" to it. Use the variable to create a new directory with that name using the mkdir command.

Exercise 7: Declare a variable called "files" and assign a list of filenames to it. Use a loop to display the contents of each file in the list using the cat command.

Exercise 8:

I. Write a command that displays the contents of a file called "file1.txt" on the screen.

II. Use input redirection to create a new file called "file2.txt" with the contents of "file1.txt".

III. Write a command that appends the contents of "file1.txt" to the end of "file2.txt".

Exercise 9:

I. Write a for loop that prints the numbers from 1 to 10 on the screen.

II. Modify the loop to print only the even numbers from 1 to 10.

Exercise 10:

I. Write a loop that displays the names of all files in the current directory.

II. Modify the loop to display only the names of files with the extension ".txt".

Exercise 11:

I. Write a case/esac statement that displays a message on the screen based on the value of a variable called "day". If the value is "Monday", the message should be "It's the start of the week". If the value is "Friday", the message should be "Thank goodness it's Friday!". For any other value, the message should be "Just another day".

II. Modify the case/esac statement to use a read command to read the value of "day" from the user.

Exercise 12: Write a case/esac statement that calculates the area of a geometric shape based on the user's input. If the input is "square", the statement should ask the user for the length of the side and display the area. If the input is "rectangle", the statement should ask the user for the length and width and display the area. If the input is "circle", the statement should ask the user

Exercise 13:

I. Write an if statement that checks if a variable called "x" is greater than 10. If it is, display the message "x is greater than 10".

II. Modify the if statement to check if "x" is equal to 10 as well. If it is, display the message "x is equal to 10".

A.3 File Manipulation Using System Calls

Exercise 1: Write a program in C that creates a file called "output.txt", writes the text "Hello, World!" to it, and then closes the file.

Exercise 2: Write a program in C that reads the contents of a file called "input.txt" and writes them to a new file called "output.txt". You should use system calls like open(), read(), and write().

Exercise 3: Write a program in C that reads a file called "input.txt" and counts the number of lines in the file. You should use system calls like open(), read(), and write().

Exercise 4:

I. Write a C program that creates a file called "numbers.txt" and writes 100 integers to it, one integer per line.

II. Using the lseek system call, move the file pointer to the beginning of the file.

III. Read the first 10 integers from the file and print them to the console.

Exercise 5: Write a C program that prints the last 10 characters of a file named as "input.txt" on the screen. Use open, read, write and lseek system calls.

Exercise 6: Write a C program that prints half content of a file named as "input.txt" on the screen. Use open, read, write and lseek system calls. If there are 100 characters written in the file, your program should display the first 50 characters on the screen.

A.4 Directory Manipulation Using System Calls

Exercise 1:

I. Write a C program that opens a directory called "my_directory" and reads all the files and directories inside it.

II. For each file and directory, print its name and whether it is a file or a directory.

III. Count the number of files and directories inside the "my_directory" directory.

IV. Close the directory.

A.5 Process Management Using System Calls

Exercise 1: Write a C program that uses the fork system call to create a child process. In the child process, print the process ID (PID) and the parent process ID (PPID). In the parent process, print the PID and the child's PID.

Exercise 2: Write a C program that uses the fork system call to create a child process. In the child process, print a message indicating that it is the child process. In the parent process, print a message indicating that it is the parent process.

Exercise 3: Write a C program that uses the fork system call to create a child process. In the child process, create a file called "child.txt" and write the message "This is the child process" to it. In the parent process, create a file called "parent.txt" and write the message "This is the parent process" to it.

Exercise 4: Write a C program that uses the fork system call to create a child process. In the child process, print the sum of the first 100 positive integers. In the parent process, print the sum of the first 1000 positive integers.

A.6 Creation of Multithreaded Processes Using Pthread Library

Exercise 1: Write a C program that creates two threads using the Pthread library. Each thread should print its thread ID to the console.

Exercise 2: Write a C program that creates two threads using the Pthread library. One thread should generate a random number, print it to the console and another should check for a prime number.

Exercise 3: Write a C program that creates two threads using the Pthread library. One thread should print even numbers from 2 to 100, and the other thread should print odd numbers from 1 to 99.

A.7 Process Synchronization Using Semaphore/Mutex

Exercise 1: Write a C program to create two threads that increment a shared variable using a mutex to synchronize access to the variable.

Exercise 2: Write a C program to create two processes that increment a shared variable using semaphores to synchronize access to the variable.

Exercise 3: Write a C program to create two processes that implement a producer-consumer model using semaphores to synchronize access to the shared buffer.

Exercise 4: You are assigned to create a simulation for a restaurant's dining room, ensuring seamless interactions between customers and chefs. The restaurant has a finite number of tables, and customers follow a series of steps, such as entering, sitting at a table, ordering, eating, and leaving. Meanwhile, chefs are responsible for preparing the dishes. Your task is to use semaphores to synchronize the activities of customers and chefs.

Exercise 5: You need to code a simple file management system where multiple threads need to read and write to a shared file concurrently. The goal is to synchronize the access to the file to prevent data corruption and ensure consistency. Use semaphores or mutexes to achieve synchronization.

Exercise 6: Implement a solution in C for the bounded buffer problem, using semaphores or mutexes to synchronize multiple producer and consumer threads, ensuring proper handling of buffer overflows, underflows, and preventing race conditions.

A.8 Inter Process Communication (IPC)

Exercise 1: Write a C program that creates a file called "file1.txt" and writes some text to it. Then, use the dup system call to create a duplicate file descriptor for the file. Finally, use the duplicate file descriptor to write some more text to the file.

Exercise 2: Write a C program that creates two pipes using the pipe system call. Then, fork a child process. In the parent process, use the dup2 system call to redirect the standard input to one end of the pipe, and the standard output to the other end of the pipe. In the child process, read from the standard input and write to the standard output.

Exercise 3: Write a C program that takes a file name as a command-line argument. Use the open, dup, and dup2 system calls to open the file, create two duplicate file descriptors for it, and redirect the standard input and standard output to those file descriptors. Then, read from the standard input and write to the standard output.

Exercise 4: Write a C program that creates a file called "file1.txt" and writes some text to it. Then, use the dup2 system call to create a duplicate file descriptor for the file, and close the original file descriptor. Finally, use the duplicate file descriptor to read the text from the file and write it to the standard output.

Exercise 5: Write a C program that creates a named pipe (FIFO) using the mkfifo system call. Then, fork a child process. In the parent process, write some data to the pipe using the write system call. In the child process, read the data from the pipe using the read system call.

Exercise 6: Write a C program that creates a named pipe called ”mypipe” using the mkfifo system call. Then, use the open system call to open the pipe for writing. Write some data to the pipe using the write system call. Finally, use the cat command to read the data from the pipe.

Exercise 7: Write a C program that creates a named pipe called ”mypipe” using the mkfifo system call. Then, use the open system call to open the pipe for reading. Read some data from the pipe using the read system call. Finally, use the echo command to write the data to the standard output.

Exercise 8: Write a C program that creates a named pipe called ”mypipe” using the mkfifo system call. Then, fork a child process. In the parent process, use the open system call to open the pipe for writing. In the child process, use the open system call to open the pipe for reading. Then, write some data to the pipe in the parent process and read the data from the pipe in the child process.

Exercise 9: Write a program in C that creates a child process using fork(). The parent process should read a message from the user and send it to the child process using a pipe. The child process should then read the message from the pipe and print it to the console.

Exercise 10: Implement a simple message passing system using shared memory in C. Create a parent process that forks a child process and communicates with it using the shared memory. Use the shmget, shmat, and shmdt functions to create a shared memory segment, attach to it, and detach from it. The parent process should write a message to the shared memory segment, and the child process should read and print the message.