Tribhuvan University

SHANKER DEV CAMPUS

Putalisadak, Kathmandu

A Lab report on

Operating Systems

Submitted To

BIM Department

In partial fulfillment of the requirement for the award of the Degree of

Bachelor of Information Management (semester 8th)

Submitted By

Name: Nibesh Upadhyaya

Roll No: 11952/20

TU Regd. No: 7-2-39-1685-2020

Date: 2082-02-16

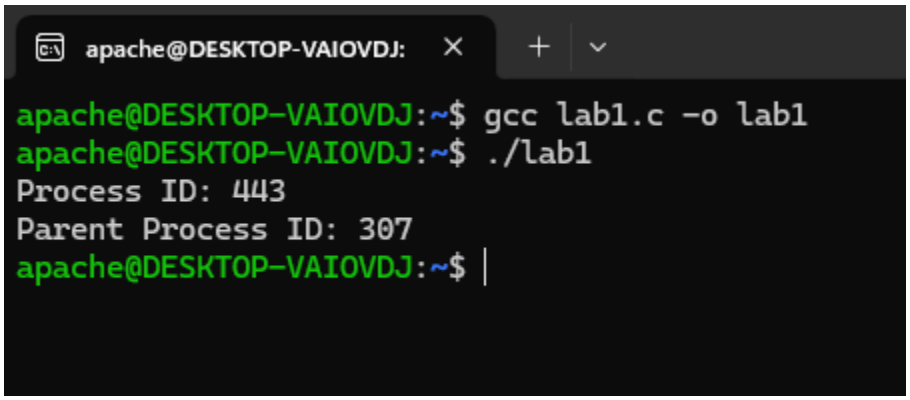
LAB 1: PROCESSES

1.1 Write a program to display process id and parent process id.

Program:

```
#include<stdio.h>
#include<unistd.h>
int main()
{
  printf("Process ID: %d\n", getpid() );
  printf("Parent Process ID: %d\n", getppid() );
  return 0;
}
```

Output:

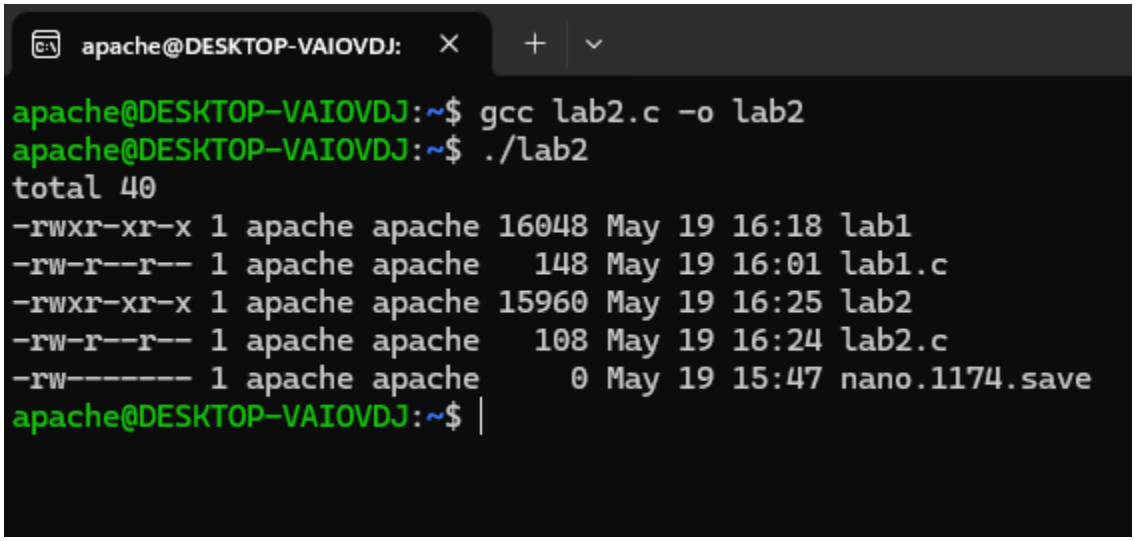


1.2 Write a program to run linux commands using system call.

Program:

```
#include <stdlib.h>

int main() {

    int r_value;

    r_value = system("ls -l");

    return r_value;

}
```

Output:

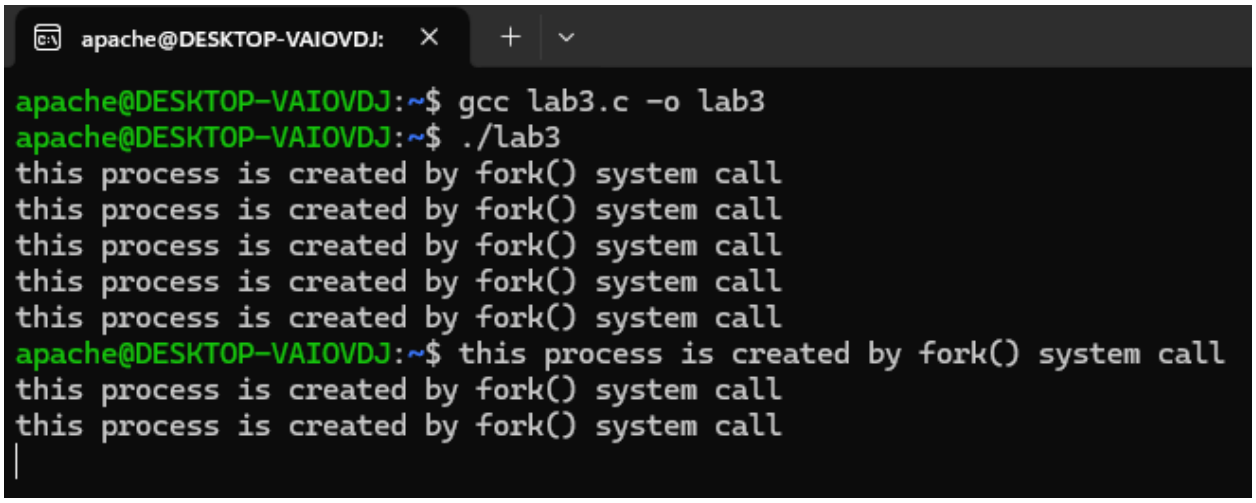


1.3 Write a program to demonstrate fork().

Program:

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>
int main(){
   fork();
   fork();
   fork();
   printf("this process is created by fork() system call\n");
   return 0;
}
```

Output:

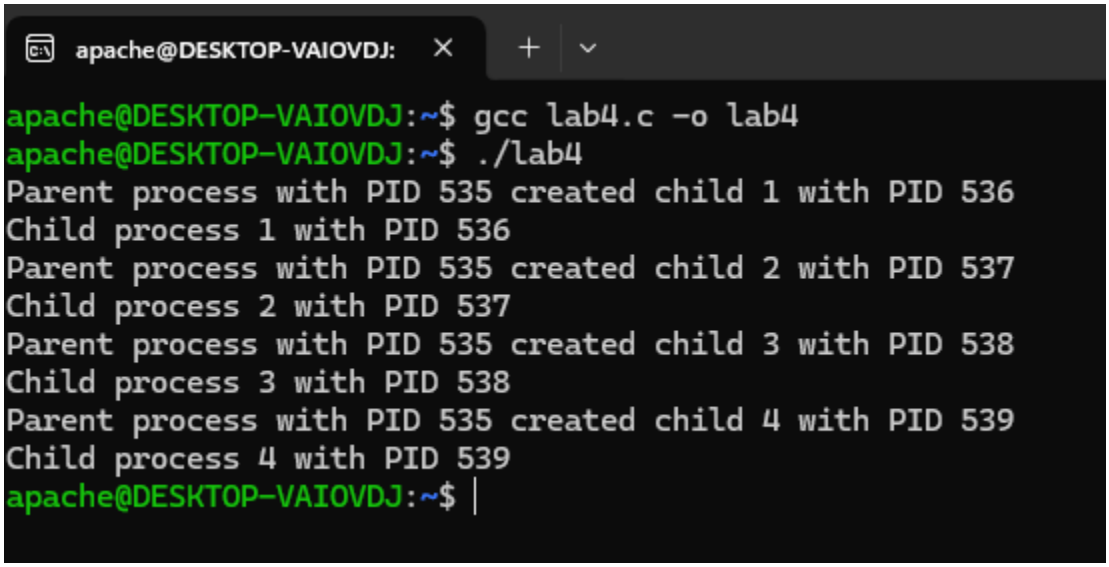


1.4 Write a program that creates four processes using fork() system call.

Program:

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

int main() {
    int i;
    pid_t child_pid;

    for (i = 0; i < 4; i++) {
        child_pid = fork();

        if (child_pid < 0) {
            perror("Fork failed");
            exit(EXIT_FAILURE);
        } else if (child_pid == 0) {
            printf("Child process %d with PID %d\n", i + 1, getpid());
            exit(EXIT_SUCCESS);
        } else {
            printf("Parent process with PID %d created child %d with PID %d\n",
                getpid(), i + 1, child_pid);
        }
    }

    return 0;
}
```

Output:



1.5 List the uses of exec family

The exec family of functions in Unix-like operating systems (including Linux) is used to replace the current process image with a new process image. These functions are commonly used to execute other programs or commands from within a C or C++ program. The primary purpose of the exec functions is to load a new program into the current process's memory space and start its execution. The exec family includes functions like execv, execp, execve, execl, and more, each with slightly different ways of specifying the program to run and the arguments it takes. The choice of which exec function to use depends on your specific requirements and how you want to pass arguments to the new program. Here are some common use cases and reasons for using the exec family of functions:

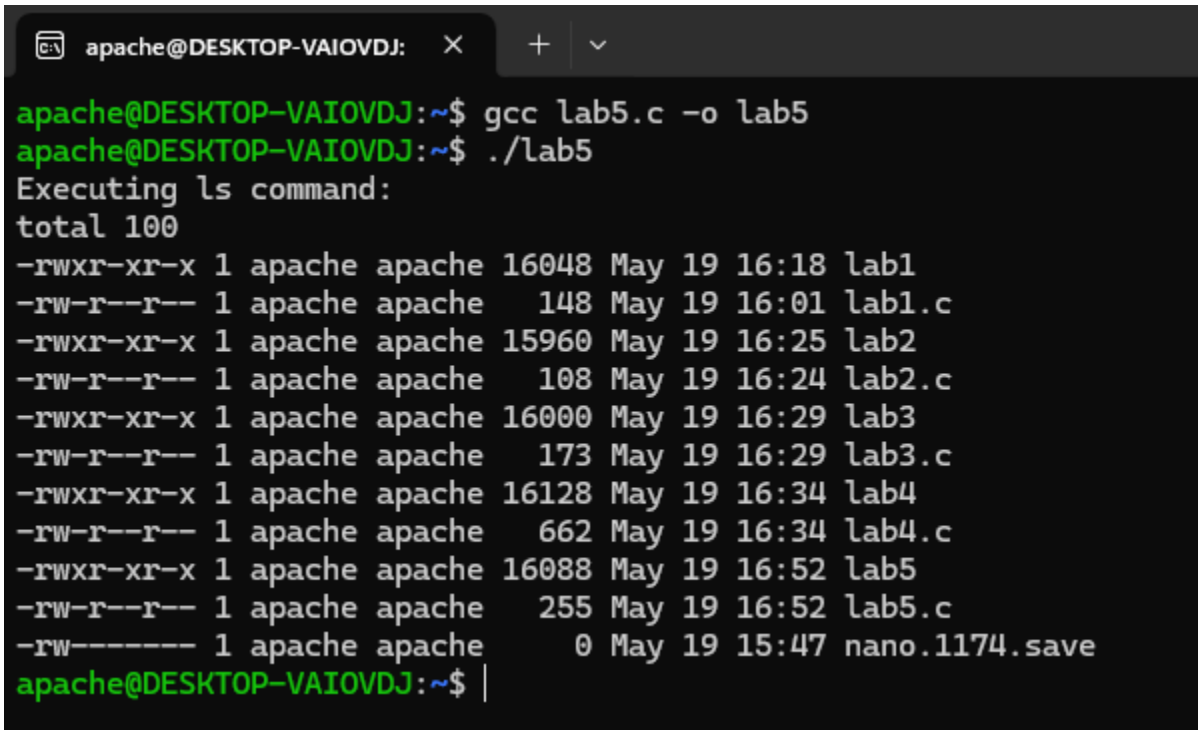
- **Running External Programs**: One of the most common uses is to run external programs or system commands from within a C/C++ program. You can use exec functions to launch programs like compilers, interpreters, system utilities, or any other executable.
- **Process Replacement**: You can use exec to replace the current process with a different program. This is often done in shell scripting when you want to execute a different program based on certain conditions.
- **Custom Shell Implementation**: Building a custom shell involves using exec functions to execute user-entered commands. This is how shells like Bash work under the hood. They use exec to execute commands entered by the user.
- **Setting Up Environment**: You can use exec to set up a specific environment for the child process. This allows you to modify environment variables, working directories, and other process attributes before launching a new program.
- **Running Shell Scripts**: You can use exec to run shell scripts (e.g., Bash, Python, Perl) from within a C/C++ program. This is useful for automation and scripting tasks.
- **Replacing a Running Daemon**: In daemon programming, you may want to replace the running daemon process with a new version without stopping the service. exec allows you to do this seamlessly.
- **Running Compiled Code Dynamically**: In some cases, you might want to compile and run code dynamically within your program. You can use exec to execute code generated at runtime.
- **Creating Child Processes**: The fork system call is often used in conjunction with exec to create child processes. After forking, the child process can use exec to load a different program, while the parent process continues with its own execution.

1.6 Write a program to use execl to run the ls command, which lists files and directories in the current directory.

Program:

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

int main() {
    printf("Executing ls command:\n");
    execl("/bin/ls", "ls", "-l", NULL);
    perror("execl");
    exit(EXIT_FAILURE);
}
```

Output:



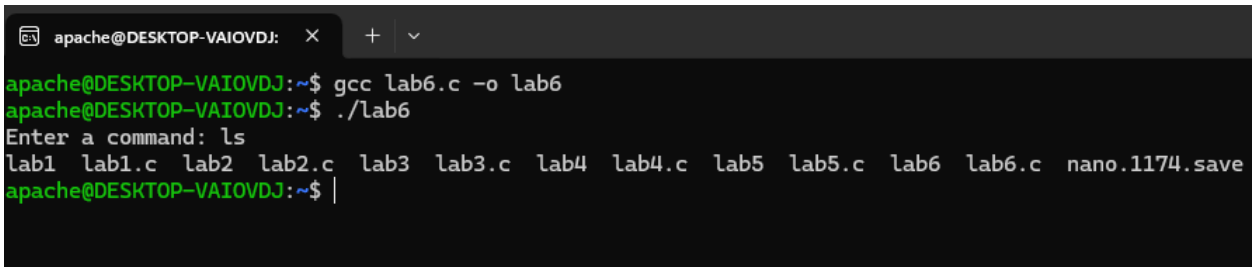
1.7 : Write a program that uses execvp to run a user-specified command.

Program:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#define MAX_ARGS 10
int main() {
    char input[100];
    char *args[MAX_ARGS + 1];
    int i = 0;
    printf("Enter a command: ");
    if (fgets(input, sizeof(input), stdin) == NULL) {
        perror("fgets failed");
        exit(EXIT_FAILURE);
    }
    size_t len = strlen(input);
    if (len > 0 && input[len - 1] == '\n') {
        input[len - 1] = '\0';
    }
    char *token = strtok(input, " ");
    while (token != NULL && i < MAX_ARGS) {
        args[i++] = token;
        token = strtok(NULL, " ");
    }
    args[i] = NULL;
```

```
        execvp(args[0], args);
        perror("execvp");
        exit(EXIT_FAILURE);
}
```

Output:



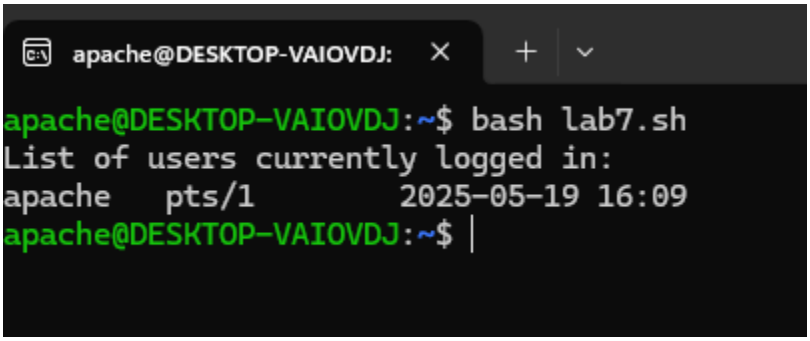
LAB 2: SHELL SCRIPTING

2.1 : Write a shell script program to display list of users currently logged in.

Program:

```
#!/bin/bash
echo "List of users currently logged in:"
who
```

Output:

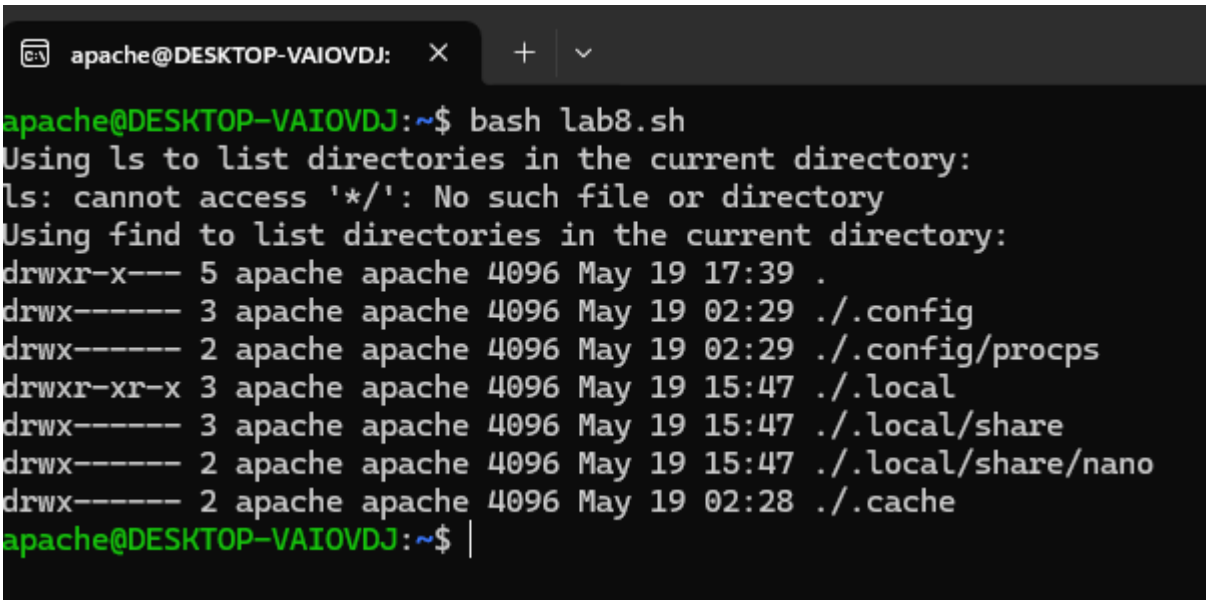


2.2 : Write a shell script program to display the long list of directories.

Program:

```
#!/bin/bash
echo "Using ls to list directories in the current directory:"
ls -ld */
echo "Using find to list directories in the current directory:"
find . -type d -exec ls -ld {} \;
```

Output:

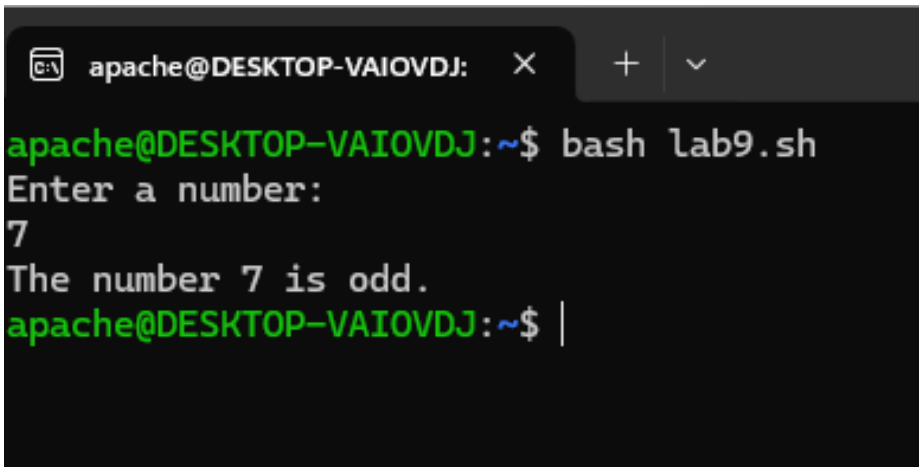


2.3: Write a shell script program to check whether the given number is even or odd.

Program:

```
#!/bin/bash
# Prompt the user to enter a number
echo "Enter a number: "
read number
# Check if the number is even or odd
if [ $((number % 2)) -eq 0 ]; then
  echo "The number $number is even."
else
  echo "The number $number is odd."
fi
```

Output:

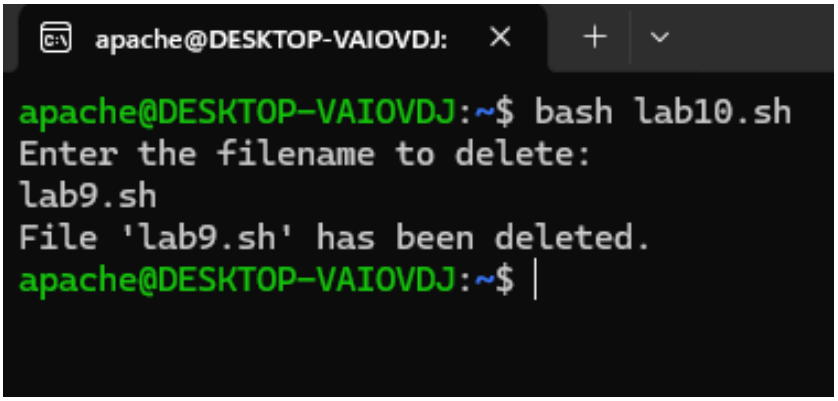


2.4: Write a shell script program to take filename as input and delete the file.

Program:

```
#!/bin/bash
echo "Enter the filename to delete: "
read filename
if [ -f "$filename" ]; then
  rm "$filename"
  echo "File '$filename' has been deleted."
else
  echo "File '$filename' does not exist."
fi
```

Output:

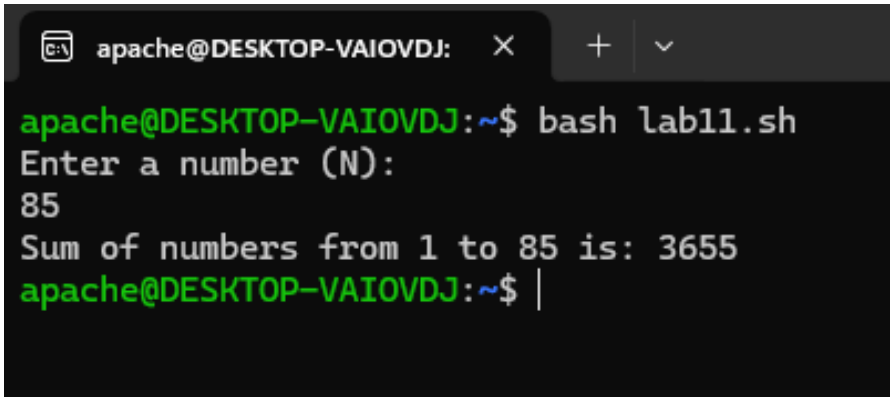


2.5 : Write a shell script to add numbers from 1 to N.

Program:

```
#!/bin/bash
echo "Enter a number (N): "
read N
sum=0
for (( i=1; i<=N; i++ )); do
   sum=$((sum + i))
done
echo "Sum of numbers from 1 to $N is: $sum"
```

Output:

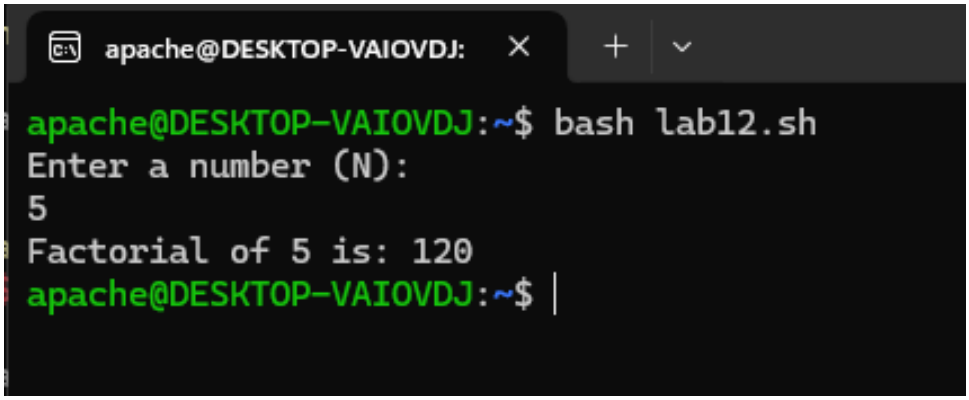


2.6 : Write a shell script to find the factorial of N.

Program:

```
#!/bin/bash
echo "Enter a number (N): "
read N
factorial=1
if [ $N -lt 0 ]; then
   echo "Factorial is not defined for negative numbers."
elif [ $N -eq 0 ]; then
   factorial=1
else
   for ((i = 1; i <= N; i++)); do
      factorial=$((factorial * i))
   done
fi
echo "Factorial of $N is: $factorial"
```

Output:



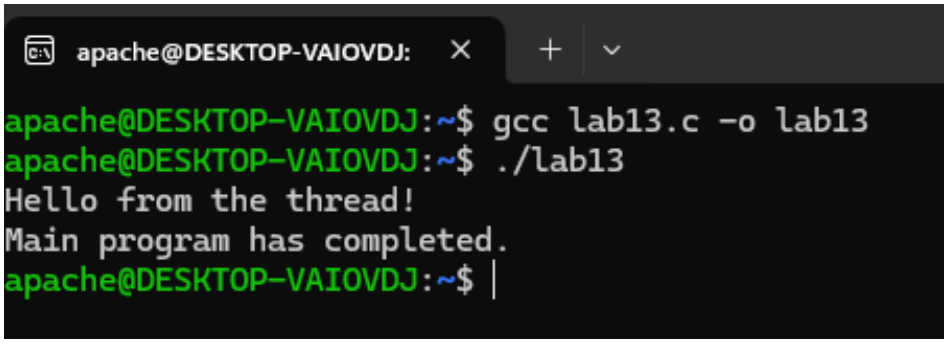
LAB 3: THREADS

3.1 Write a program for thread creation.

Program:

```
#include <stdio.h>
#include <pthread.h>
void *threadFunction(void *arg) {
    printf("Hello from the thread!\n");
    return NULL;
}
int main() {
    pthread_t thread_id;
    int thread_create_result;
    thread_create_result = pthread_create(&thread_id, NULL, threadFunction, NULL);
    if (thread_create_result != 0) {
        printf("Thread creation failed.\n");
        return 1;
    }
    pthread_join(thread_id, NULL);
    printf("Main program has completed.\n");
    return 0;
}
```

Output:



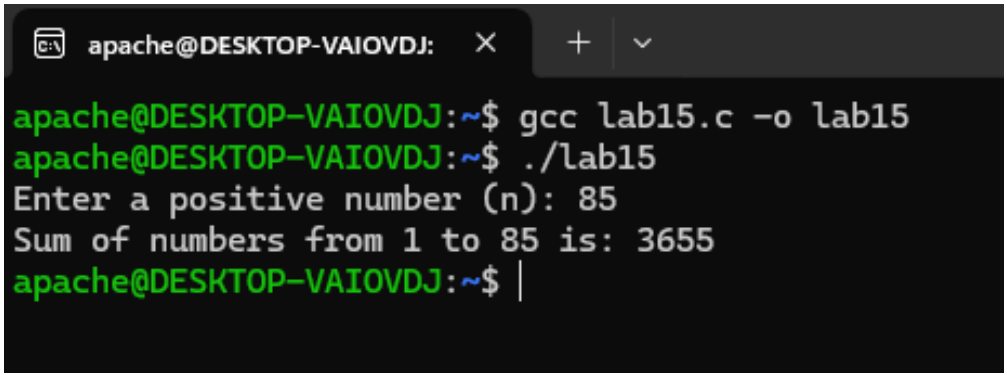
3.2 Write a program using threads that prints sum of numbers up to given positive number n.

Program:

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

#define MAX_THREADS 4

struct ThreadParams {
    int start;
    int end;
};

int sum = 0;
pthread_mutex_t mutex = PTHREAD_MUTEX_INITIALIZER;

void *calculateSum(void *arg) {
    struct ThreadParams *params = (struct ThreadParams *)arg;
    int localSum = 0;
    for (int i = params->start; i <= params->end; i++) {
        localSum += i;
    }

    pthread_mutex_lock(&mutex);
    sum += localSum;
    pthread_mutex_unlock(&mutex);

    pthread_exit(NULL);
}
int main() {
    int n;
    printf("Enter a positive number (n): ");
    scanf("%d", &n);

    if (n <= 0) {
```

```
        printf("Please enter a positive number.\n");
        return 1;
    }
    pthread_t threads[MAX_THREADS];
    struct ThreadParams params[MAX_THREADS];
    int chunkSize = n / MAX_THREADS;
    int remaining = n % MAX_THREADS;
    int start = 1;
    for (int i = 0; i < MAX_THREADS; i++) {
        params[i].start = start;
        params[i].end = start + chunkSize - 1;
        if (i == MAX_THREADS - 1) {
            params[i].end += remaining; // Add remaining numbers to the last thread
        }
        pthread_create(&threads[i], NULL, calculateSum, (void *)&params[i]);
        start = params[i].end + 1;
    }
    for (int i = 0; i < MAX_THREADS; i++) {
        pthread_join(threads[i], NULL);
    }
    printf("Sum of numbers from 1 to %d is: %d\n", n, sum);
    pthread_mutex_destroy(&mutex);
    return 0;
}
```

Output:



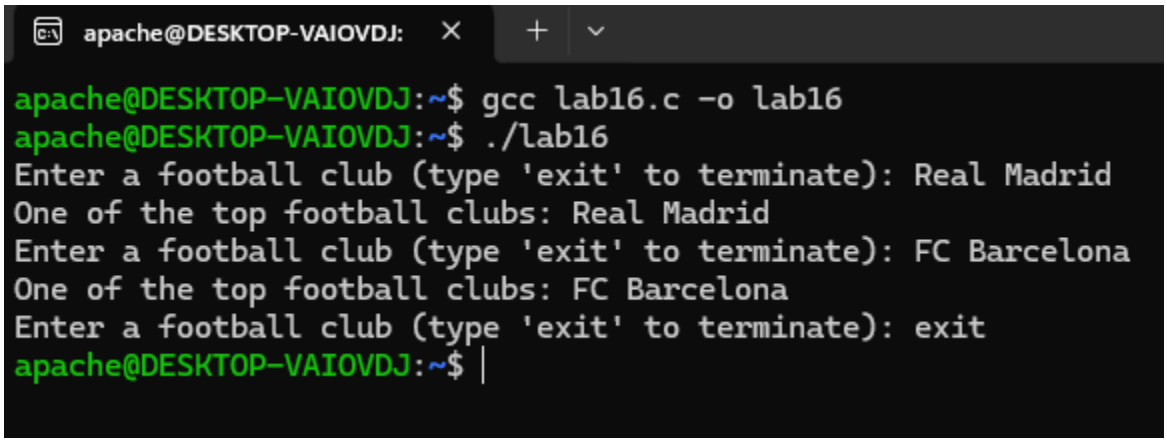
3.3: Write a program that has two threads, one reads a word from keyboard and another checks for valid word (you can use your own word list (at least 10) to check for validity).

Program:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <pthread.h>
#define MAX_CLUBS 10
#define MAX_CLUB_NAME_LENGTH 30
const char *topClubs[MAX_CLUBS] = {
    "FC Barcelona", "Real Madrid", "Manchester United", "Liverpool",
    "Bayern Munich", "AC Milan", "Juventus",
    "Paris Saint-Germain", "Chelsea", "Borussia Dortmund"
};
int isTopClub(const char *club) {
    for (int i = 0; i < MAX_CLUBS; i++) {
        if (strcmp(club, topClubs[i]) == 0) {
            return 1;
        }
    }
    return 0;
}
void *readClub(void *arg) {
    char club[MAX_CLUB_NAME_LENGTH];
    while (1) {
        printf("Enter a football club (type 'exit' to terminate): ");
        fgets(club, MAX_CLUB_NAME_LENGTH, stdin);

        // Remove newline
        int len = strlen(club);
        if (len > 0 && club[len - 1] == '\n') {
            club[len - 1] = '\0';
        }
        if (strcmp(club, "exit") == 0) {
            break;
```

```
            }
            if (isTopClub(club)) {
                printf("One of the top football clubs: %s\n", club);
            } else {
                printf("Not in the list of top football clubs: %s\n", club);
            }
        }
        return NULL;
    }
    int main() {
        pthread_t thread_id;
        pthread_create(&thread_id, NULL, readClub, NULL);
        pthread_join(thread_id, NULL);
        return 0;
}
```

Output:



LAB 4: INTERPROCESS COMMUNICATION

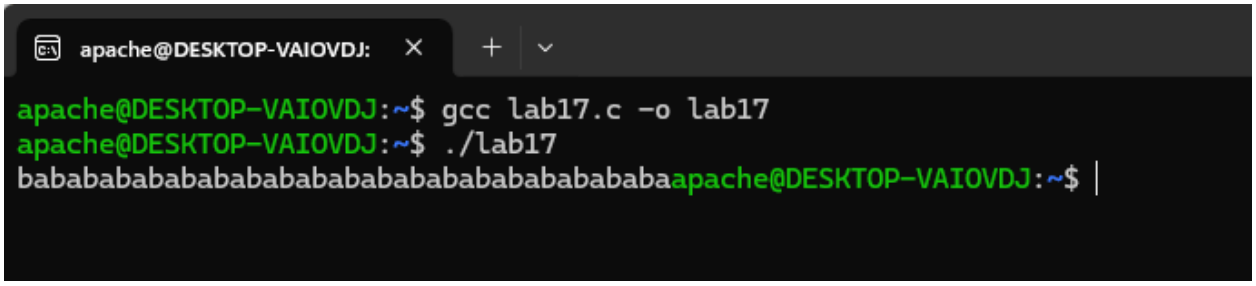
4.1 : Write a program to demonstrate the solution (strict alternation) for critical region problem.

Program:

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

#define NUM_ITERATIONS 20
int turn = 1;  // 1 = thread1's turn, 0 = thread2's turn
pthread_mutex_t mutex = PTHREAD_MUTEX_INITIALIZER;
pthread_cond_t cond = PTHREAD_COND_INITIALIZER;

void *thread1f(void *arg) {
   for (int i = 0; i < NUM_ITERATIONS; i++) {
      pthread_mutex_lock(&mutex);
      while (turn != 1) {
         pthread_cond_wait(&cond, &mutex);
      }
      fputc('b', stderr);
      turn = 0;
      pthread_cond_signal(&cond);
      pthread_mutex_unlock(&mutex);
   }
   return NULL;
}

void *thread2f(void *arg) {
   for (int i = 0; i < NUM_ITERATIONS; i++) {
      pthread_mutex_lock(&mutex);
      while (turn != 0) {
         pthread_cond_wait(&cond, &mutex);
      }
      fputc('a', stderr);
      turn = 1;
      pthread_cond_signal(&cond);
      pthread_mutex_unlock(&mutex);
   }
   return NULL;
}
```

```
int main() {
    pthread_t thid1, thid2;

    pthread_create(&thid1, NULL, thread1f, NULL);
    pthread_create(&thid2, NULL, thread2f, NULL);

    pthread_join(thid1, NULL);
    pthread_join(thid2, NULL);

    pthread_mutex_destroy(&mutex);
    pthread_cond_destroy(&cond);

    return 0;
```

Output:

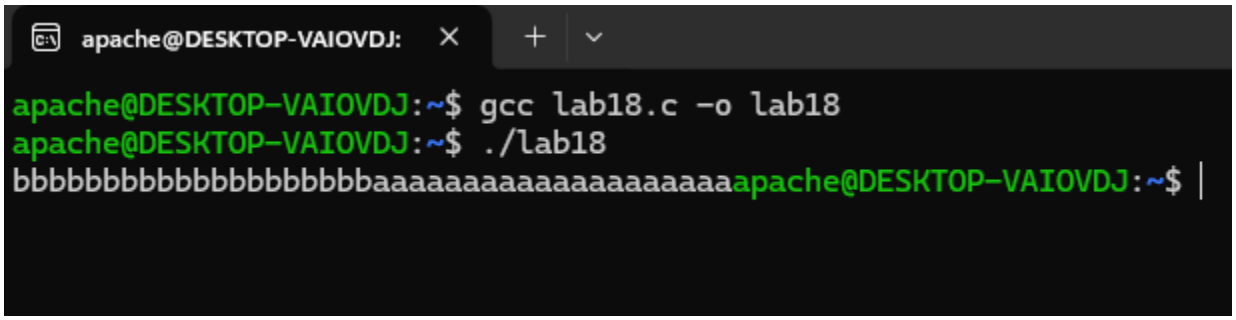


4.2 Modify the above program in 4.1 to demonstrate lock variables solution and comment the deficiencies of this solution.

Program:

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

pthread_mutex_t mutex = PTHREAD_MUTEX_INITIALIZER;

void *thread1f(void *arg);
void *thread2f(void *arg);

int main() {
   pthread_t thid1, thid2;

   pthread_create(&thid1, NULL, thread1f, NULL);
   pthread_create(&thid2, NULL, thread2f, NULL);

   pthread_join(thid1, NULL);
   pthread_join(thid2, NULL);

   pthread_mutex_destroy(&mutex);
   return 0;
}

void *thread1f(void *arg) {
   for (int i = 0; i < 20; i++) {
      pthread_mutex_lock(&mutex);
      fputc('b', stderr);
      pthread_mutex_unlock(&mutex);
   }
   return NULL;
}

void *thread2f(void *arg) {
   for (int i = 0; i < 20; i++) {
      pthread_mutex_lock(&mutex);
      fputc('a', stderr);
      pthread_mutex_unlock(&mutex);
   }
   return NULL;
}
```

Output:



Deficiencies:

- **Efficiency**: Mutex locks provide a more efficient solution compared to busy waiting. In the previous version, the threads were constantly checking the value of turn, which could lead to excessive CPU usage. With mutex locks, a thread is put to sleep when it cannot acquire the lock, and it's awakened when the lock becomes available.
- **Resource Management**: Mutex locks ensure that only one thread can access the critical section (printing 'a' or 'b' in this case) at a time. This prevents race conditions and ensures orderly execution.
- **Synchronization**: Mutex locks provide a way for threads to synchronize their actions and avoid conflicts. In the previous version, there was no synchronization mechanism, which could lead to unpredictable behavior.
- **Reduced CPU Usage**: Mutex locks significantly reduce CPU usage because threads do not need to continuously check for the availability of the resource. Instead, they block and wait for the lock to become available.

4.3: Write the problems in the solution of 4.1.

Problems:

The provided code implements strict alternation for the critical region problem using a shared variable turn to control which thread should execute. However, this code has a few problems:

- **Busy-Waiting**: The code uses busy-waiting (the while loop checking turn) which is inefficient and wastes CPU cycles.
- **Lack of Mutual Exclusion**: While it enforces strict alternation, it doesn't provide mutual exclusion, meaning both threads can access the critical section simultaneously.
- **Deadlock Risk**: There is a risk of deadlock if one of the threads gets blocked or delayed for some reason.
- **No Prioritization**: It doesn't prioritize which thread should execute first; it just enforces strict alternation.

LAB 5: SEMAPHORES

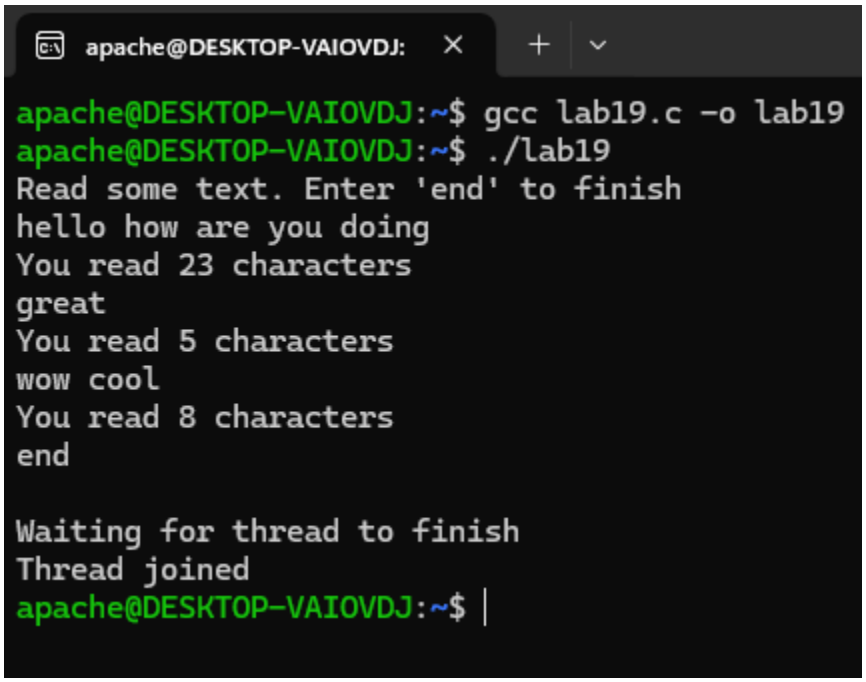
5.1 : Write a program to demonstrate the use of semaphore.

Program:

```
#include <stdlib.h>
#include <unistd.h>
#include <pthread.h>
#include <stdio.h>
#include <string.h>
#include <semaphore.h>
#define WORK_SIZE 1024
char work_area[WORK_SIZE];
sem_t bin_sem;
void *threadf(void *arg);
int main() {
    pthread_t thid;
    sem_init(&bin_sem, 0, 0);
    pthread_create(&thid, NULL, threadf, NULL);
    printf("Read some text. Enter 'end' to finish\n");
    while (1) {
        fgets(work_area, WORK_SIZE, stdin);
        sem_post(&bin_sem);
        if (strncmp("end", work_area, 3) == 0)
            break;
    }
    printf("\nWaiting for thread to finish\n");
    pthread_join(thid, NULL);
    printf("Thread joined\n");
    sem_destroy(&bin_sem);
    exit(EXIT_SUCCESS);
}
void *threadf(void *arg) {
    while (1) {
        sem_wait(&bin_sem);
```

```
        if (strncmp("end", work_area, 3) == 0)
            break;
        printf("You read %ld characters\n", strlen(work_area) - 1); // -1 to exclude newline
    }
    return NULL;
}
```

Output:



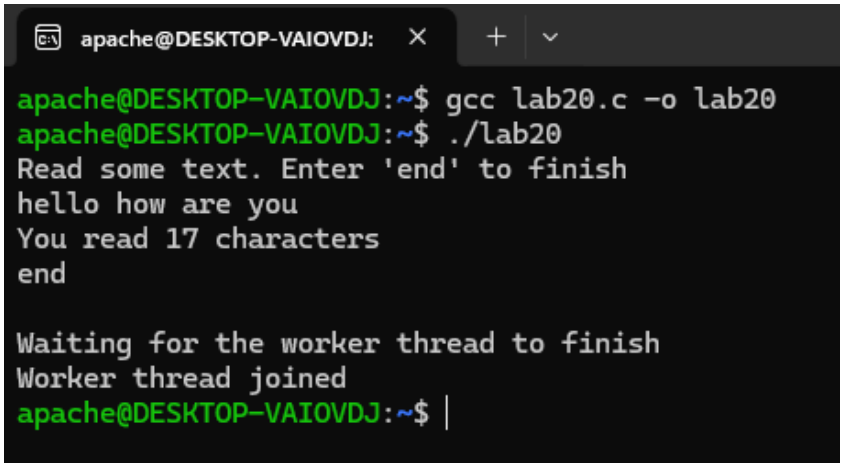
5.2 Write the program 5.1 using mutexes.

Program:

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

#define WORK_SIZE 1024
char work_area[WORK_SIZE];
pthread_mutex_t mutex;
pthread_cond_t cond;
int data_available = 0;
int done = 0;
void *workerThread(void *arg);
int main() {
    pthread_t workerThreadId;
    pthread_mutex_init(&mutex, NULL);
    pthread_cond_init(&cond, NULL);
    pthread_create(&workerThreadId, NULL, workerThread, NULL);
    printf("Read some text. Enter 'end' to finish\n");
    while (1) {
        fgets(work_area, WORK_SIZE, stdin);
        pthread_mutex_lock(&mutex);
        data_available = 1;
        pthread_cond_signal(&cond);
        if (strncmp("end", work_area, 3) == 0) {
            done = 1;  // Signal worker to exit
        }
        pthread_mutex_unlock(&mutex);
        if (done)
            break;
    }

    printf("\nWaiting for the worker thread to finish\n");
```

```
    pthread_join(workerThreadId, NULL);
    printf("Worker thread joined\n");
    pthread_mutex_destroy(&mutex);
    pthread_cond_destroy(&cond);

    exit(EXIT_SUCCESS);
}
void *workerThread(void *arg) {
    while (1) {
        pthread_mutex_lock(&mutex);
        while (!data_available && !done) {
            pthread_cond_wait(&cond, &mutex);
        }
        if (done) {
            pthread_mutex_unlock(&mutex);
            break;
        }
        printf("You read %zu characters\n", strlen(work_area) - 1);
        data_available = 0;
        pthread_mutex_unlock(&mutex);
    }
    pthread_exit(NULL);
}
```

Output:

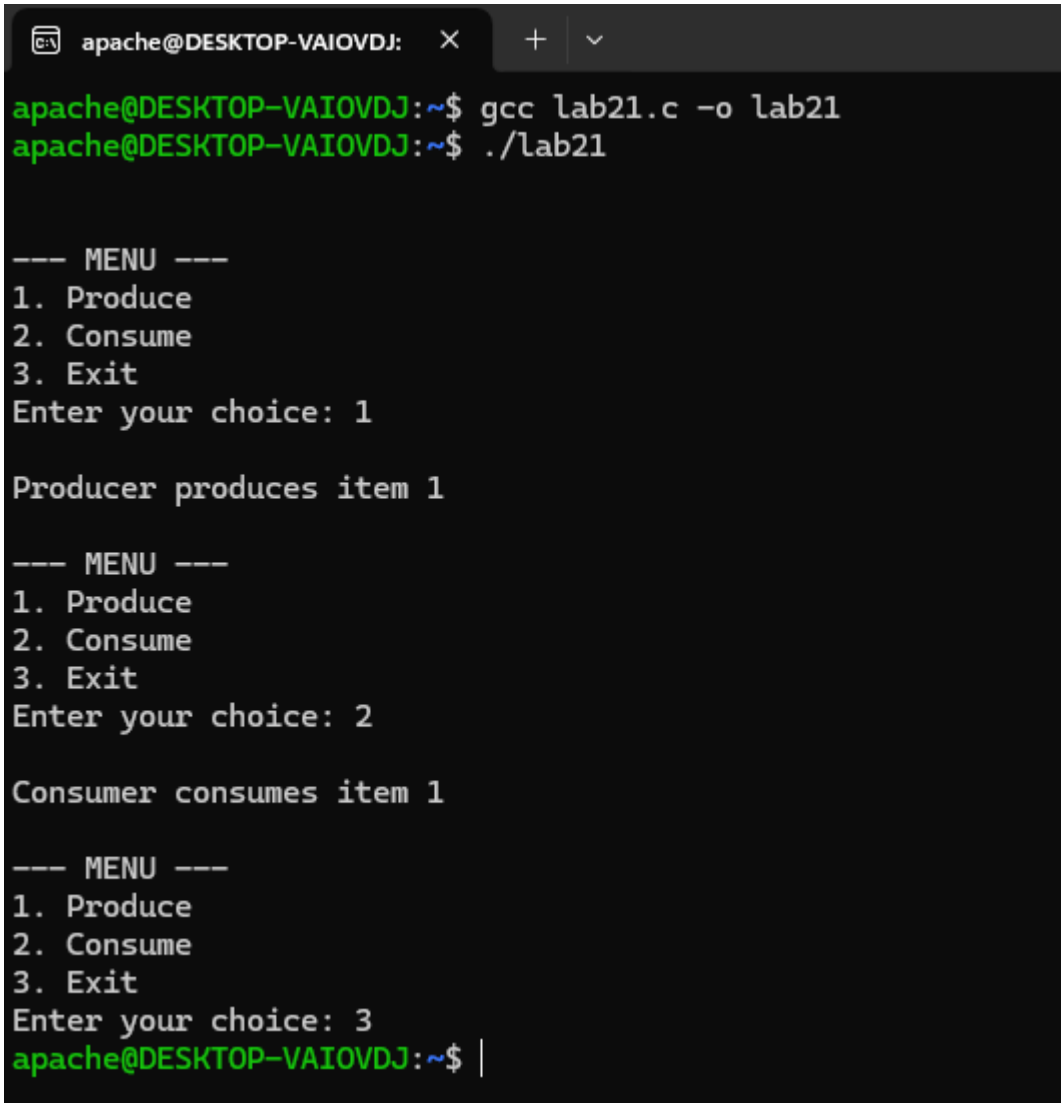


5.3 : Write a program to implement producer-consumer problem.

Program:

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

int mutex = 1;
int full = 0;
int empty = 10;
int x = 0;
void producer() {
   --mutex;
   ++full;
   --empty;
   x++;
   printf("\nProducer produces item %d", x);
   ++mutex;
}
void consumer() {
   --mutex;
   --full;
   ++empty;
   printf("\nConsumer consumes item %d", x);
   x--;
   ++mutex;
}
int main() {
   int choice;
   while (1) {
      printf("\n\n--- MENU ---\n");
      printf("1. Produce\n");
      printf("2. Consume\n");
      printf("3. Exit\n");
      printf("Enter your choice: ");
      scanf("%d", &choice);
```

```
            switch (choice) {
                case 1:
                    if ((mutex == 1) && (empty != 0)) {
                        producer();
                    } else {
                        printf("Buffer is full!");
                    }
                    break;
                case 2:
                    if ((mutex == 1) && (full != 0)) {
                        consumer();
                    } else {
                        printf("Buffer is empty!");
                    }
                    break;
                case 3:
                    exit(0);
                default:
                    printf("Invalid choice!");
            }
        }
        return 0;
}
```


apache@DESKTOP-VAIOVDJ:
apache@DESKTOP-VAIOVDJ:~$ gcc lab21.c -o lab21
apache@DESKTOP-VAIOVDJ:~$ ./lab21
--- MENU ---
1. Produce
2. Consume
3. Exit
Enter your choice: 1
Producer produces item 1
--- MENU ---
1. Produce
2. Consume
3. Exit
Enter your choice: 2
Consumer consumes item 1
--- MENU ---
1. Produce
2. Consume
3. Exit
Enter your choice: 3
apache@DESKTOP-VAIOVDJ:~$

5.4 Write a program to implement the counting semaphores using more than three threads.

Program:

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

#define MAX_COUNT 5
int count = 0;
pthread_mutex_t mutex;
pthread_cond_t condition;
void *incrementer(void *arg) {
    for (int i = 0; i < MAX_COUNT; i++) {
        pthread_mutex_lock(&mutex);
        count++;
        printf("Incrementer: Count = %d\n", count);
        pthread_cond_signal(&condition);
        pthread_mutex_unlock(&mutex);
    }
    pthread_exit(NULL);
}
void *decrementer(void *arg) {
    for (int i = 0; i < MAX_COUNT; i++) {
        pthread_mutex_lock(&mutex);
        while (count == 0) {
            pthread_cond_wait(&condition, &mutex);
        }
        count--;
        printf("Decrementer: Count = %d\n", count);
        pthread_mutex_unlock(&mutex);
    }
    pthread_exit(NULL);
}
int main() {
    pthread_t incrementerThread, decrementerThread1, decrementerThread2;
```

```
    pthread_mutex_init(&mutex, NULL);
    pthread_cond_init(&condition, NULL);
    pthread_create(&incrementerThread, NULL, incrementer, NULL);
    pthread_create(&decrementerThread1, NULL, decrementer, NULL);
    pthread_create(&decrementerThread2, NULL, decrementer, NULL);
    pthread_join(incrementerThread, NULL);
    pthread_join(decrementerThread1, NULL);
    pthread_join(decrementerThread2, NULL);
    pthread_mutex_destroy(&mutex);
    pthread_cond_destroy(&condition);
    return 0;
}
```

Output: