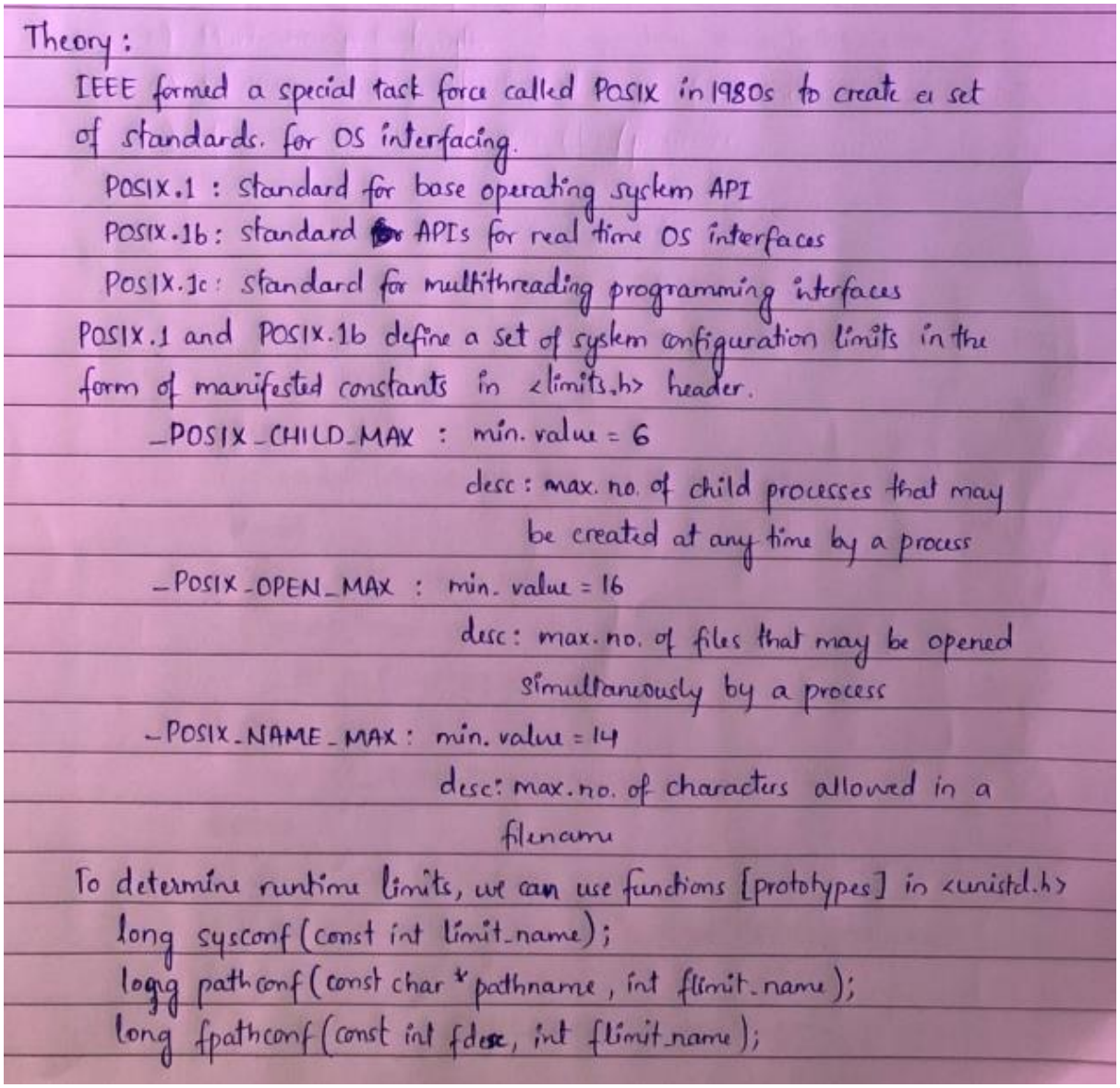
USP LAB

Termwork 1:

Write a C/C++ POSIX compliant program to check the following limits: (i) No. of clock ticks (ii) Max. no. of child processes (iii) Max. path length (iv) Max. no. of characters in a file name (v) Max. no. of open files/ process



Theory :

IEEE formed a special task force called POSIX in 1980s to create a set of standards for OS interfacing.

POSIX.1 : Standard for base operating system API

POSIX.1b : standard for APIs for real time OS interfaces

POSIX.1c : standard for multithreading programming interfaces

POSIX.1 and POSIX.1b define a set of system configuration limits in the form of manifested constants in <limits.h> header.

_POSIX_CHILD_MAX : min. value = 6

desc : max. no. of child processes that may be created at any time by a process

_POSIX_OPEN_MAX : min. value = 16

desc : max. no. of files that may be opened simultaneously by a process

_POSIX_NAME_MAX : min. value = 14

desc : max. no. of characters allowed in a filename

To determine runtime limits, we can use functions [prototypes] in <unistd.h>

long sysconf(const int limit_name);

long pathconf(const char *pathname, int flimit_name);

long fpathconf(const int fdesc, int flimit_name);

Commands to execute:

$ **gedit tw1.cpp**

write your code in this editor given below, save it(Ctrl + s), and exit the editor once done

$ **g++ tw1.cpp -o tw1**

$ **./tw1**

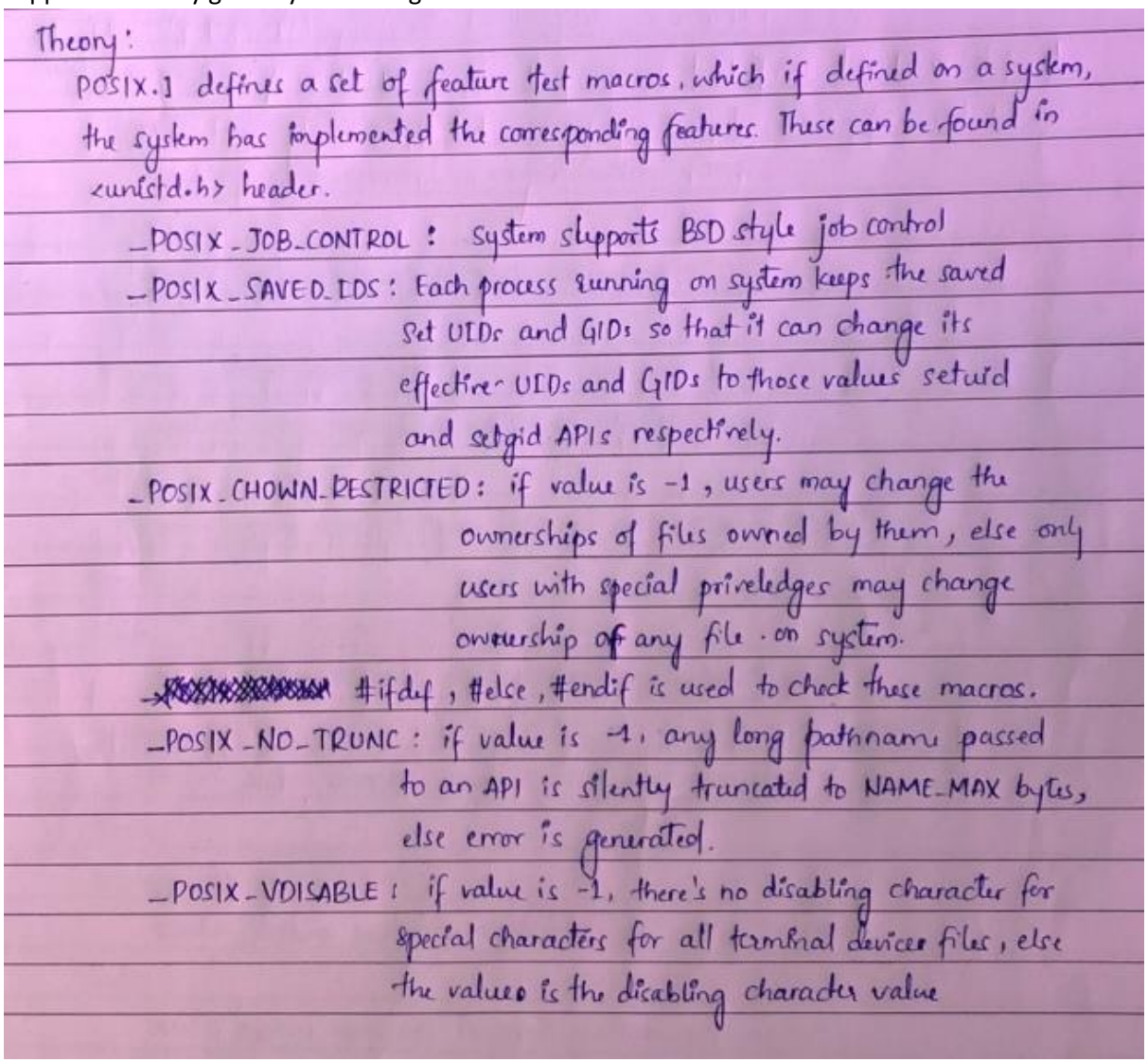
Program:

```
#define _POSIX_C_SOURCE 199309L
#include<iostream>
#include<unistd.h>
#include<limits.h>
using namespace std;
int main(){
	int choice,res=0;
	while(1){
		cout<<"1. Compile Time Values\n2. Run Time Values\n3.Exit\nEnter your choice:";
		cin>>choice;
		switch(choice){
		case 1: cout<<"Compile Time Values.\n";
			#ifdef _POSIX_CLK_TCK
				cout<<"No. of Clock Ticks per second is: "<<_POSIX_CLK_TCK<<endl;
			#else
				cout<<"_POSIX_CLK_TCK not defined\n";
			#endif
			#ifdef _POSIX_CHILD_MAX
				cout<<"Max number of child processes at any time is:
"<<_POSIX_CHILD_MAX<<endl;
			#else
				cout<<"_POSIX_CHILD_MAX not defined\n";
			#endif
			#ifdef _POSIX_PATH_MAX
				cout<<"Max path name is: "<<_POSIX_PATH_MAX<<endl;
			#else
				cout<<"_POSIX_PATH_MAX not defined\n";
			#endif
			#ifdef _POSIX_NAME_MAX
				cout<<"Max no. of characters in file name: "<<_POSIX_NAME_MAX<<endl;
			#else
				cout<<"_POSIX_NAME_MAX not defined\n";
			#endif
			#ifdef _POSIX_OPEN_MAX
				cout<<"Max no. of files simultaneously opened is:
"<<_POSIX_OPEN_MAX<<endl;
```

```
                #else
                        cout<<"_POSIX_OPEN_MAX not defined\n";
                #endif
                break;
        case 2: cout<<"Run Time Values.\n";
                if((res=sysconf(_SC_CLK_TCK))==-1)
                        perror("sysconf");
                else
                        cout<<"No. of Clock Ticks per second is: "<<res<<endl;
                if((res=sysconf(_SC_CHILD_MAX))==-1)
                        perror("sysconf");
                else
                        cout<<"Max number of child processes at any time is: "<<res<<endl;
                if((res=pathconf("/",_PC_PATH_MAX))==-1)
                        perror("pathconf");
                else
                        cout<<"Max path name is: "<<res<<endl;
                if((res=pathconf("/",_PC_NAME_MAX))==-1)
                        perror("pathconf");
                else
                        cout<<"Max no. of characters in file name: "<<res<<endl;
                if((res=sysconf(_SC_OPEN_MAX))==-1)
                        perror("sysconf");
                else
                        cout<<"Max no. of files simultaneously opened is:"<<res<<endl;
                break;
        case 3: exit(0);
        default : cout<<"Invalid Choice.\n";
        }
    }
    return 0;
}
```

Termwork 2:

Write a C/C++ POSIX compliant program that prints the POSIX defined configuration options supported on any given system using feature test macros.



Commands to execute:

$ **gedit tw2.cpp**

write your code in this editor given below, save it (Ctrl + s), and exit the editor once done

$ **g++ tw2.cpp -o tw2**

$ **./tw2**

Program:

```
#define _POSIX_SOURCE
#define _POSIX_C_SOURCE 199309L
#include<unistd.h>
#include<iostream>
using namespace std;
int main(){
	#ifdef _POSIX_JOB_CONTROL
		cout<<"System Supports Job Control feature"<<endl;
	#else
		cout<<"System does not support job control\n";
	#endif
	#ifdef _POSIX_SAVED_IDS
		cout<<"System Supports saved set-UID and saved set-GID"<<endl;
	#else
		cout<<"System does not support saved set-UID\n";
	#endif
	#ifdef _POSIX_CHOWN_RESTRICTED
		cout<<"System Supports change ownership feature"<<endl;
	#else
		cout<<"System does not support change ownership feature\n";
	#endif
	#ifdef _POSIX_NO_TRUNC
		cout<<"System Supports path truncation option."<<endl;
	#else
		cout<<"System does not support path truncation\n";
	#endif
	#ifdef _POSIX_VDISABLE
		cout<<"System Supports disable character for files."<<endl;
	#else
		cout<<"System does not support disable character\n";
	#endif
	return 0;
}
```

Termwork 3:

Consider the last 100 bytes as a region. Write a C/C++ program to check whether the region is locked or not. If the region is locked, print pid of the process which has locked. If the region is not locked, lock the region with an exclusive lock, read the last 50 bytes and unlock the region

Theory:

UNIX systems allows multiple processes to read and write the same file concurrently. It also renders difficulty for any process in determining when data in a file can be overridden by another processes.

Hence UNIX and POSIX systems supports a file and record locking mechanism which is applicable only for regular files

The fcntl API is used for file locking. Prototype of fcntl API is:

```
#include <fcntl.h>
int fcntl(int fdesc, int cmd_flag, ...);
```

fdesc is file descriptor of the file to be locked & cmd_flag can have values as follows:

F_SETLK → Set a file lock, doesn't block if not succeed immediately
F_SETLKW → Set a file lock and block the calling process until released
F_GETLK → Query as to which process locked

third argument to fcntl is address of a struct flock type variable.

```
struct flock {
    short l_type; // what lock to set or to unlock file
    short l_whence; // 0 reference address for next field
    off_t l_short; // offset from l_whence reference address
    off_t l_len; // how many bytes in locked region
    pid_t l_pid; // pid of the process which has locked the file
};
```

Commands to execute:

Create an input.txt file using command:

$ **gedit input.txt**

add some content more than 100 bytes in this editor, save it(Ctrl + s), and exit the editor once done

then execute these commands:

$ **gedit tw3.c**

write your code in this editor given below, save it(Ctrl + s), and exit the editor once done

$ **gcc tw3.c -o tw3**

$ **./tw3 input.txt**

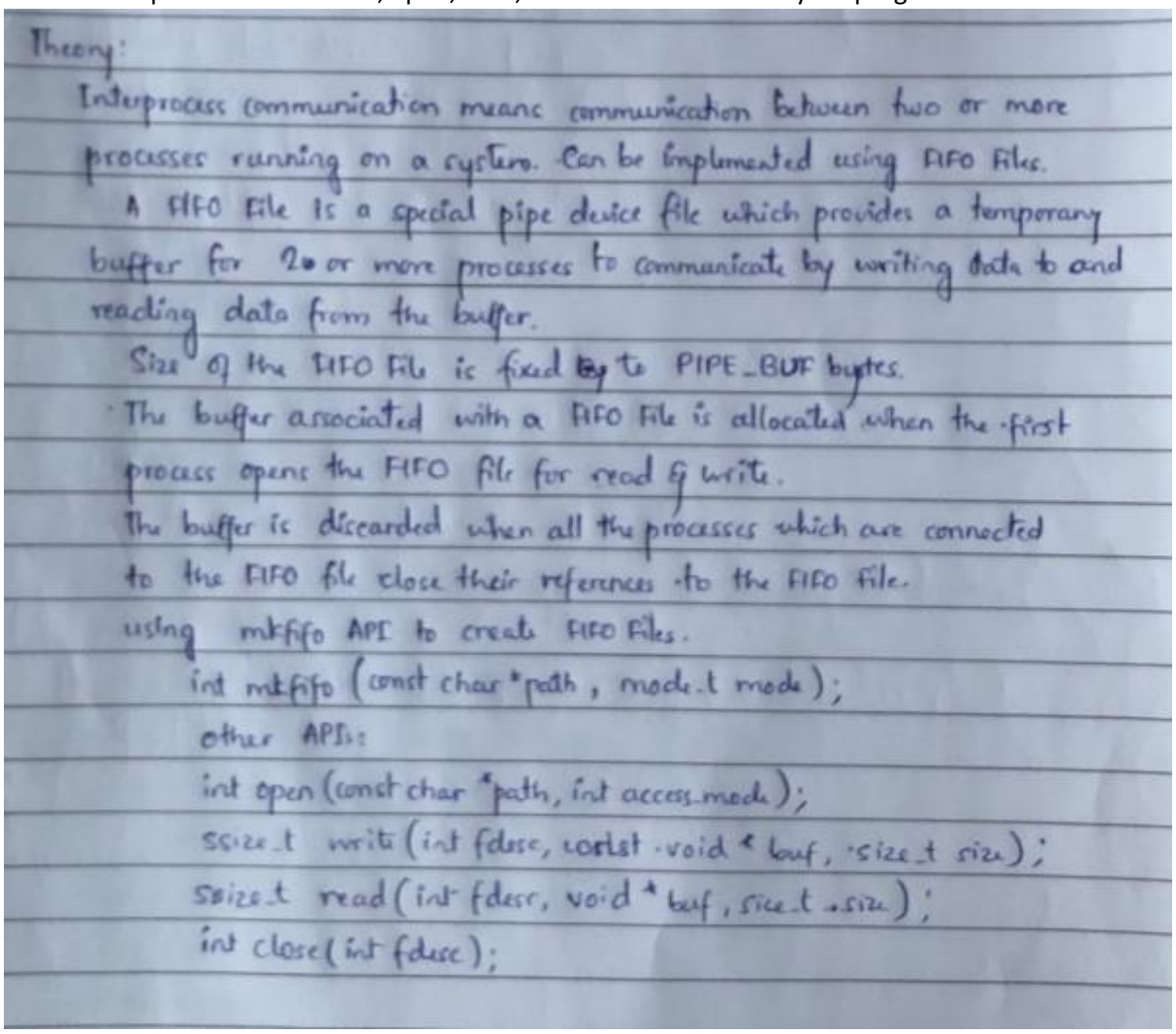
open another terminal while file is locked and try to access this file using **./tw3 input.txt command, same command that's mentioned above. If the terminal says cannot access, file is locked, then your code is working properly.

Program:

```
#include<stdio.h>
#include<stdlib.h>
#include<unistd.h>
#include<fcntl.h>
#include<errno.h>
int main(int argc, char *argv[]){

        int fd;
        char buffer[256];
        struct flock fvar;
        if(argc == 1){

                printf("usage: %s filename\n", argv[0]);
                return -1;

        }

        if((fd=open(argv[1],O_RDWR)) == -1){

                perror("open");
                exit(1);

        }

        fvar.l_type = F_WRLCK;
        fvar.l_whence = SEEK_END;
        fvar.l_start = SEEK_END - 100;
        fvar.l_len = 100;
        printf("trying to get lock ... \n");
        if((fcntl(fd, F_SETLK, &fvar)) == -1){

                fcntl(fd, F_GETLK, &fvar);
                printf("\n File already locked by process with pid = %d\n", fvar.l_pid);
                return -1;

        }
        printf("\nLOCKED..\n");
        if((lseek(fd, SEEK_END - 50, SEEK_END)) == -1){

                perror("lseek");
                exit(1);

        }
        if((read(fd, buffer, 100)) == -1){

                perror("read");
                exit(1);

        }
        printf("\nData Read from he file: ");
        puts(buffer);
        printf("\nPress ENTER to release lock\n");
        getchar();
        fvar.l_type = F_UNLCK;
        fvar.l_whence = SEEK_SET;
        fvar.l_start = 0;
        fvar.l_len = 0;
        if((fcntl(fd, F_UNLCK, &fvar)) == -1){

                perror("fcntl");
                exit(0);

        }
        printf("\nUNLOCKED\n");
        close(fd);
        return 0;

}
```

Termwork 4:

Write a C/C++ program which demonstrates interposes communication between a reader process and a writer process. Use mkfifo, open, read, write and close APIs in your program.



Theory:

Interprocess communication means communication between two or more processes running on a system. Can be implemented using FIFO Files.

A FIFO file is a special pipe device file which provides a temporary buffer for 2 or more processes to communicate by writing data to and reading data from the buffer.

Size of the FIFO file is fixed by to PIPE_BUF bytes.

The buffer associated with a FIFO file is allocated when the first process opens the FIFO file for read & write.

The buffer is discarded when all the processes which are connected to the FIFO file close their references to the FIFO file.

using mkfifo API to create FIFO files.

```
int mkfifo (const char *path, mode_t mode);
```

other APIs:

```
int open (const char *path, int access_mode);
ssize_t write (int fdesc, const void * buf, size_t size);
ssize_t read (int fdesc, void * buf, size_t size);
int close (int fdesc);
```

Commands to execute:

$ **gedit tw4c.c**

*write your code in this editor given below as **client***, save it(Ctrl + s), and exit the editor once done

$ **gedit tw4s.c**

*write your code in this editor given below as **server***, save it(Ctrl + s), and exit the editor once done

$ **gedit test_file.txt**

add some content less than 50 bytes in this editor, save it(Ctrl + s), and exit the editor once done

open two terminals:

in first terminal, execute

$ **gcc tw4c.c -o tw4c**

in second terminal, execute

$ **gcc tw4s.c -o tw4s**

****make sure you run the server program first in second terminal i.e.,

$ **./tw4s**

and then run the client program in first terminal

$ **./tw4c**

request the file created(test_file.txt**) from the first terminal. Content inside file should be printed **in client terminal.**

Program:

Client:

```
#include<stdio.h>
#include<unistd.h>
#include<sys/stat.h>
#include<fcntl.h>
#include<string.h>
#define FIFO1 "fifo1"
#define FIFO2 "fifo2"
#define PERMS 0666
char fname[256];
int main(){

        ssize_t n;
        char buff[512];
        int readfd, writefd;
        printf("Trying to connect to server..\n");
        writefd = open(FIFO1, O_WRONLY,0);
        readfd = open(FIFO2,O_RDONLY,0);
        printf("Connected..\n");
        printf("Enter the filename to request from server: ");
        scanf("%s", fname);
        write(writefd, fname, strlen(fname)+1);
        printf("Waiting for server to reply...\n");
        while((n=read(readfd,buff,512))>0)

                write(1,buff,n);

        close(readfd);
        close(writefd);
        return 0;

}
```

Server:

```
#include<stdio.h>
#include<unistd.h>
#include<sys/stat.h>
#include<fcntl.h>
#include<string.h>
#define FIFO1 "fifo1"
#define FIFO2 "fifo2"
#define PERMS 0666
char fname[256];
int main(){

        int readfd,writefd,fd;
        ssize_t n;
        char buff[512];
        if(mkfifo(FIFO1,PERMS)<0)
           printf("Can't create FIFO files\n");
        if(mkfifo(FIFO2, PERMS)<0)
           printf("Can't create FIFO files\n");
        printf("Waiting for connection request.....\n");
        readfd = open(FIFO1, O_RDONLY,0);
        writefd = open(FIFO2, O_WRONLY,0);
        printf("Connection established...\n");
        read(readfd,fname,255);
        printf("Client has requested file %s\n", fname);
        if((fd= open(fname,O_RDWR))<0){
           strcpy(buff,"File does not exist!\n");
           write(writefd,buff,strlen(buff));
        }
        else{
           while(n=read(fd,buff,512)>0)
              write(writefd,buff,n);

        }
        close(readfd);
        unlink(FIFO1);
        close(writefd);
        unlink(FIFO2);

}
```

Termwork 5:

5a: Write a C/C++ program that outputs the contents of its Environment list

5b: Write a C / C++ program to emulate the unix **ln** command

Theory:

5a: Environment variables have details of environment functionality built into the OS and an environment variable is of the form name = value.

Eg: HOME = /usr/Sagar

These environment variables help programs know what directory to install files in, where to store temporary files, where to find user portal settings, etc.. These variables are null terminated. C-strings. can be accessed as follows:

→ Using environment list passed to main function as argument

→ Using extern char **environ

→ Using getenv() function

5b: ln is a link command used to create new links for existing files. Implemented using link API. If successful, hard link count attribute of the file is increased by 1.

A link can be Hard link or Symbolic link.

Hard links cannot be created across files but symbolic links can be used to do so.

Commands to execute:

For Termwork 5a:

$ **gedit tw5a.c**

write your code in this editor given below, save it(Ctrl + s), and exit the editor once done

$ **gcc tw5a.c -o tw5a**

$ **./tw5a**

For Termwork 5b:

$ **gedit test_file.txt**

add some content less than 50 bytes in this editor, save it(Ctrl + s), and exit the editor once done

$ **gedit tw5b.c**

write your code in this editor given below, save it(Ctrl + s), and exit the editor once done

$ **gcc tw5b.c -o tw5b**

hard link creation:

$ **./tw5b test_file.txt testH**

symbolic link creation:

$ **./tw5b -s test_file.txt testS**

Execute these commands after creating hard and soft links:

$ **ls -li test_file.txt testH testS**

this should result in **test_file.txt and **testH** to have **same inode numbers** and **testS** to point to **test_file.txt**(**testS -> test_file.txt**)

$ **cat test_file.txt testH testS**

this command should display your file content **the exact same as **test_file.txt** by **testH** and **testS**

Program:

5a:

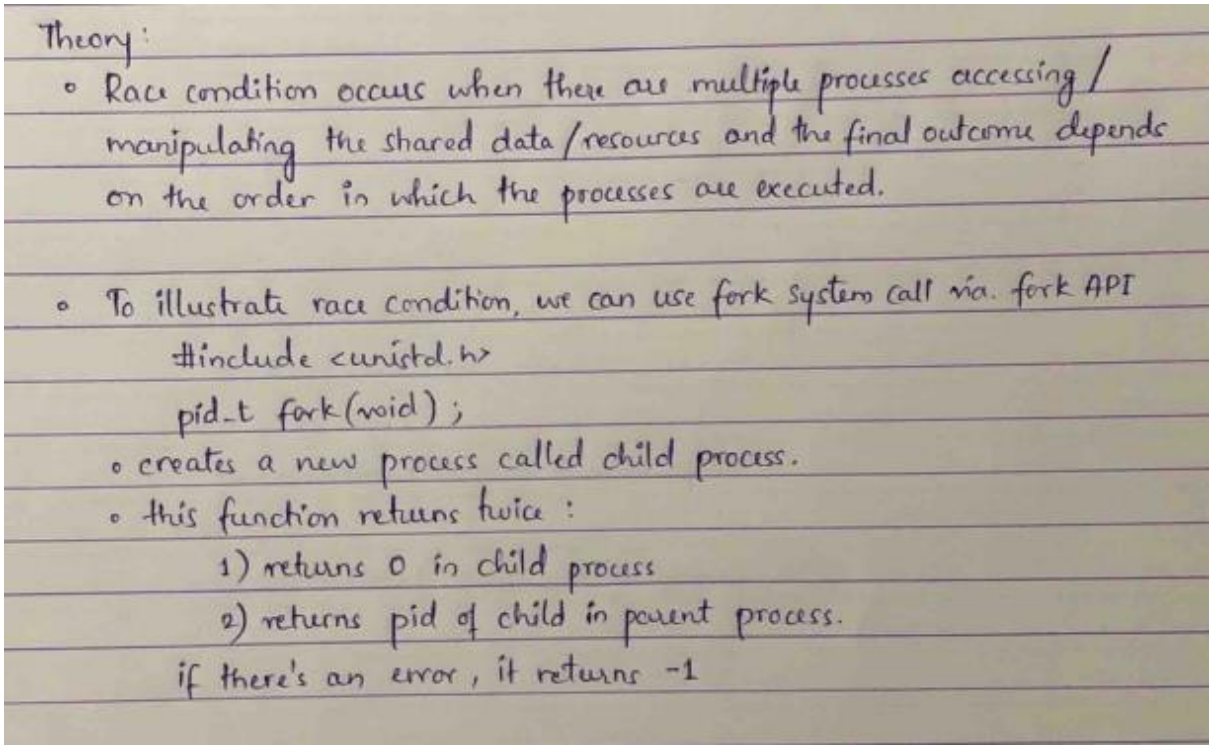
```
#include<stdio.h>
#include<stdlib.h>
#include<unistd.h>
int main(int argc,char *argv[]){

        int i;
        char **ptr;
        extern char **environ;
        for(ptr=environ;*ptr;ptr++)
           printf("%s\n",*ptr);
        exit(0);

}
```

5b:

```
#include<stdio.h>
#include<unistd.h>
#include<string.h>
#include<sys/types.h>
int main(int argc,char *argv[]){

        if(argc==3){

                printf("Hard Link Created\n");
                return link(argv[1],argv[2]);

        }
        else if(argc == 4){

                if(strcmp(argv[1],"-s") == 0){

                        printf("Symbolic link created\n");
                        return symlink(argv[2],argv[3]);

                }

                else
                   printf("Option must be -s for symbolic link\n");

        }
        else
           printf("Invalid number of arguments\n");

        return 0;

}
```

Termwork 6:

Write a C/C++ program to illustrate the race condition.



Commands to execute:

$ **gedit tw6.c**

write your code in this editor given below, save it(Ctrl + s), and exit the editor once done

$ **gcc tw6.c -o tw6**

$ **./tw6**

****output should be jumbled

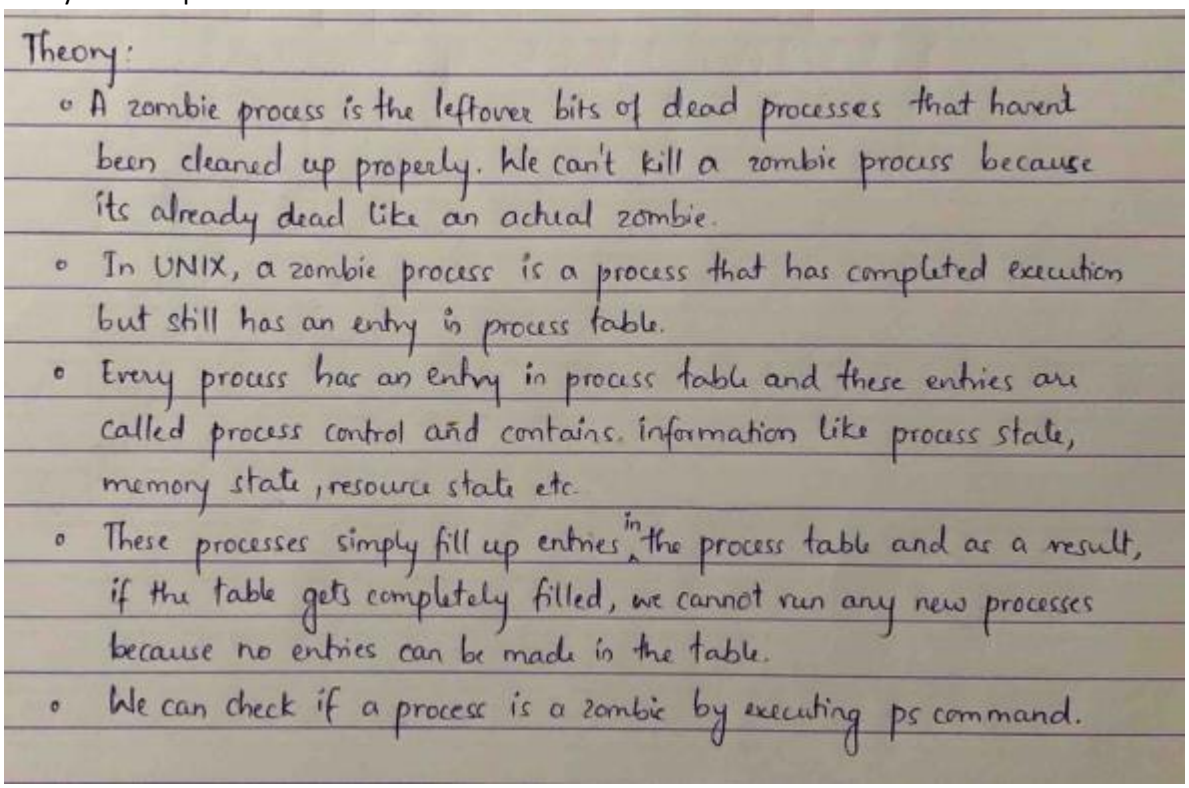
to kill the execution, press **Ctrl + c** together

Program:

```
#define POSIX_SOURCE
#define POSIX_C_SOURCE 199309L
#include<stdlib.h>
#include<stdio.h>
#include<unistd.h>
static void charatatime(char *);
int main(){
        int pid,i;
        for(i=0;i<10;i++){
                if((pid=fork())<0)
                        printf("fork error.\n");
                else if(pid==0)
                        charatatime("output from child\n");
                else
                        charatatime("output from parent\n");
        }
        return 0;
}
static void charatatime(char *str){
        char *ptr;
        int c;
        setbuf(stdout,NULL);
        for(ptr=str;(c=*ptr++)!=0;)
                putc(c,stdout);
}
```

Termwork 7:

Write a C/C++ program that creates a zombie and then calls system to execute the ps command to Verify that the process is zombie.



Commands to execute:

$ **gedit tw7.c**

write your code in this editor given below, save it(Ctrl + s), and exit the editor once done

$ **gcc tw7.c -o tw7**

$ **./tw7**

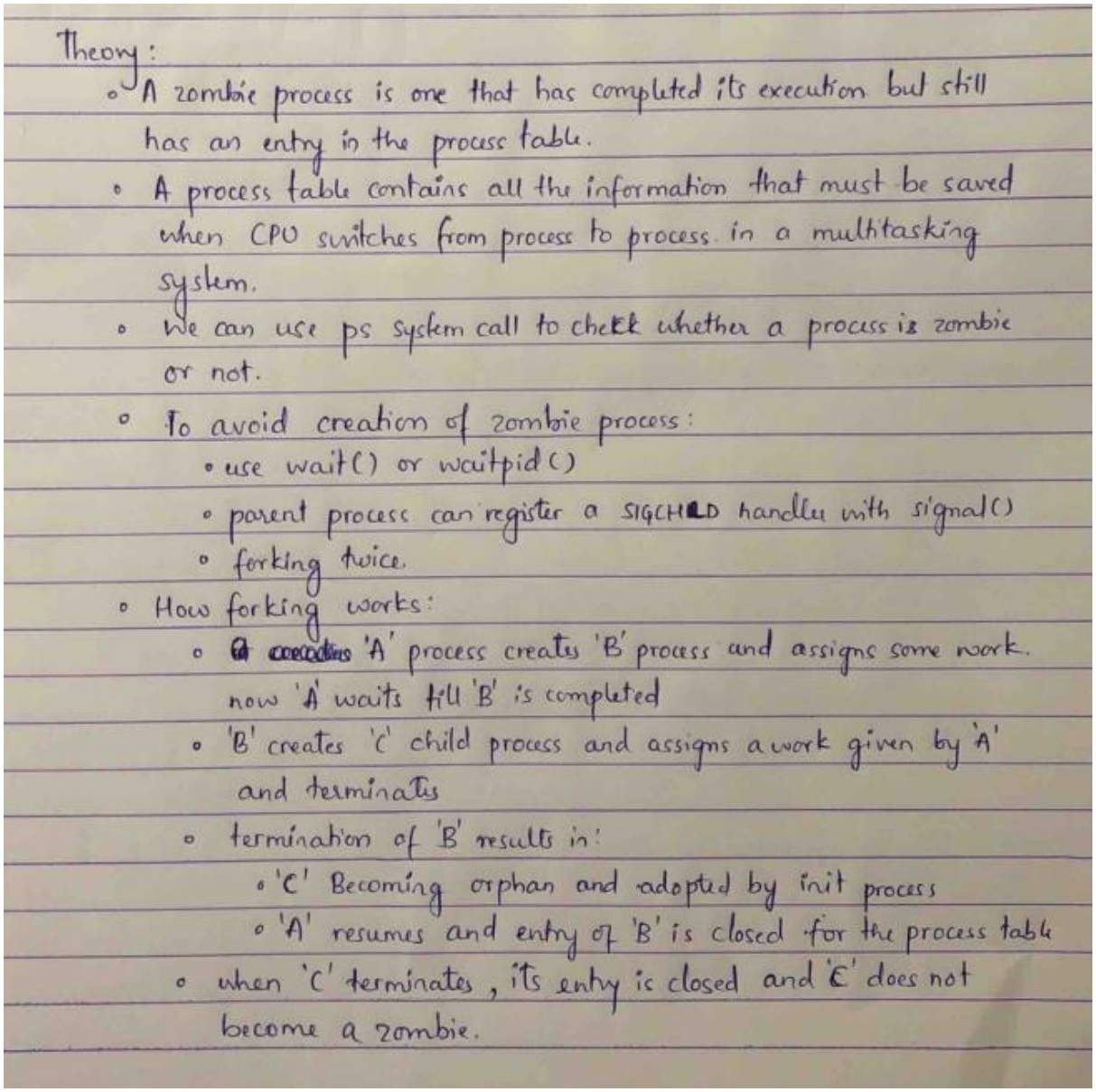
wait until you see a zombie process with **state Z and **tw7 <defunct> as command**

Program:

```
#include<stdio.h>
#include<stdlib.h>
#include<unistd.h>
#include<sys/types.h>
#define PS "ps -eo pid,ppid,state,tty,command"
int main(){
   pid_t child_pid;
   if((child_pid=fork())<0)

      perror("fork error");
   else if (child_pid==0)

      exit(0); //child

   sleep(4); // parent
   system(PS);
   return 0;
}
```

Termwork 8:

Write a C/C++ program to avoid zombie process by forking twice



Commands to execute:

$ **gedit tw8.c**

write your code in this editor given below, save it(Ctrl + s), and exit the editor once done

$ **gcc tw8.c -o tw8**

$ **./tw8**

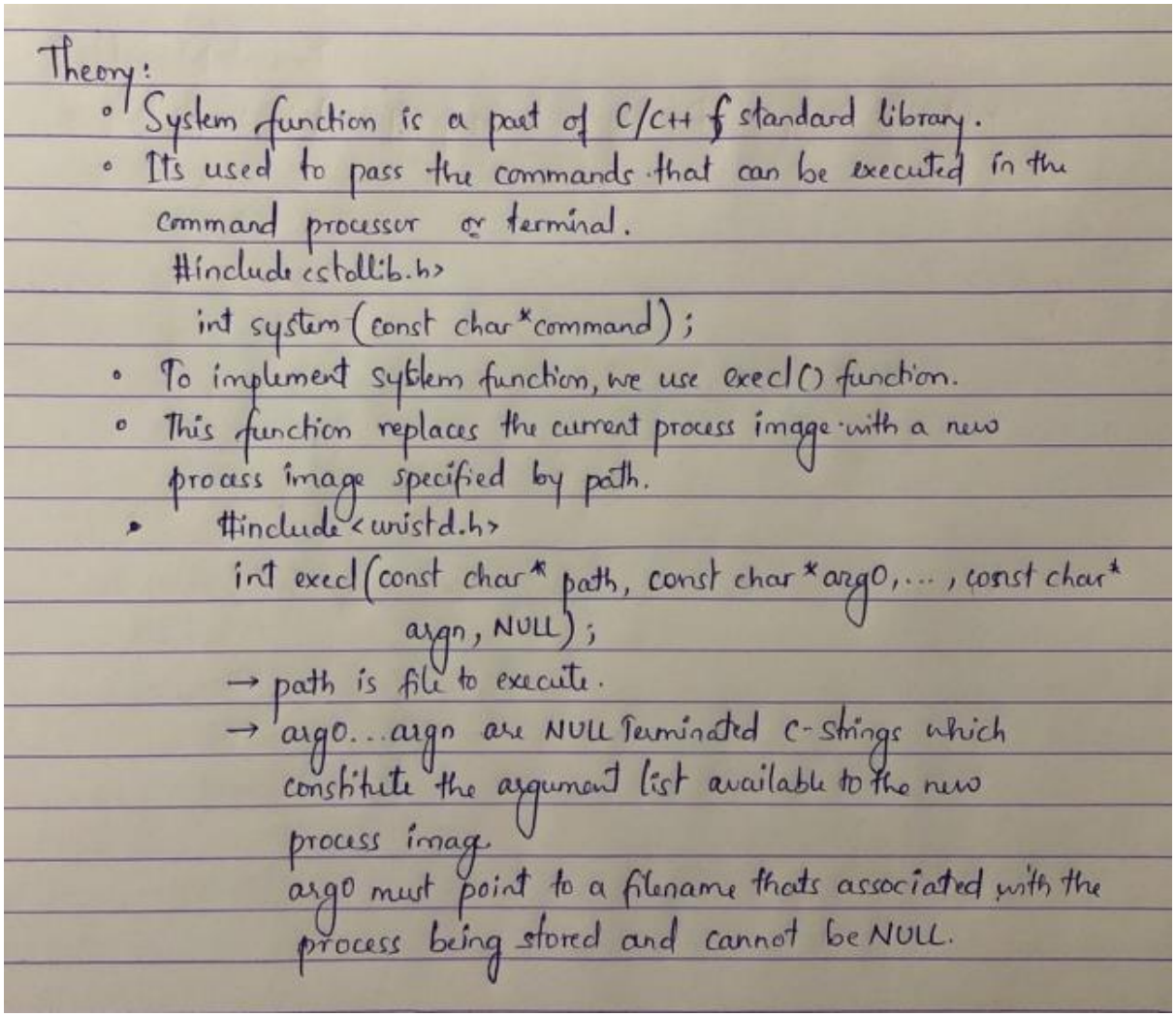
if you see **NO zombie process with **state Z** and **tw8 <defunct> as command** in your output, then your code is working.

Program:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
int main(){

        int pid;
        pid = fork();
        if(pid == 0){

                //first child
                pid = fork();
                if(pid == 0){

                        //second child
                        sleep(1);
                        printf("Second Child: My Parent pid is %d\n",getppid());

                }

        }

        else{

                //parent process
                wait(NULL);
                sleep(2);
                system("ps -o pid,ppid,state,tty,command");

        }

        return 0;

}
```

Termwork 9:

Write a C/C++ program to implement '**system**' function.



Commands to execute:

$ **gedit tw9.c**

write your code in this editor given below, save it(Ctrl + s), and exit the editor once done

$ **gcc tw9.c -o tw9**

$ **./tw9 ls pwd ps whoami who date cal**

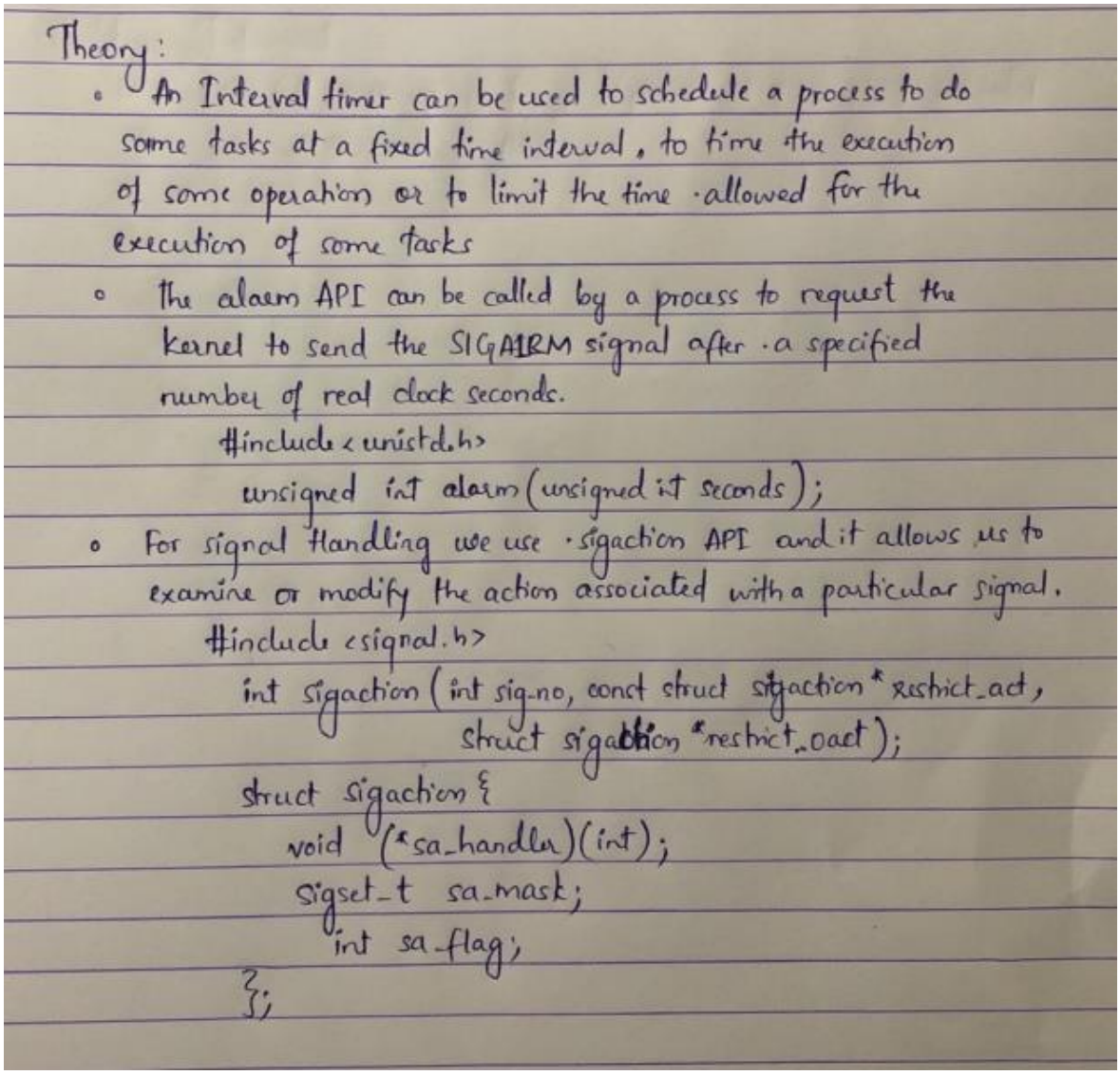
you can put any number of **system commands as arguments to output **./tw9**

Program:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <errno.h>
#include <sys/wait.h>
#include <sys/types.h>
void sys(const char *cmdstr){

        int pid;
        pid = fork();
        if(pid == 0)
           execl("/bin/bash","bash","-c",cmdstr,NULL);
        else
           waitpid(pid,NULL,0);

}
int main(int argc,char *argv[]){

        int i;
        for(i = 1; i < argc; i++){

                sys(argv[i]);
                printf("\n");

        }

        _exit(0);

}
```

Termwork 10:

Write a C/C++ program to set up a real-time clock interval timer using the alarm API.



Commands to execute:

$ **gedit tw10.c**

write your code in this editor given below, save it(Ctrl + s), and exit the editor once done

$ **gcc tw10.c -o tw10**

$ **./tw10**

**after 2 sec, you will see Hello! as output.

Program:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <signal.h>
#define INTERVAL 5
void callme(int sig_no){

        alarm(INTERVAL);
        printf("Hello\n");

}
int main(){

        struct sigaction action;
        action.sa_handler = (void(*)(int))callme;
        sigaction(SIGALRM,&action,0);
        alarm(2); //interrupt
        sleep(5);
        return 0;

}
```