Department of Computer Science and Engineering
Institute of Technical Education & Research, SOA, Deemed to be University

MINOR ASSIGNMENT-06
Processes in UNIX
Practical Programming with C (CSE 3544)

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Course Outcome: CO4 | Program Outcome: PO4 | Learning Level: L5

Problem Statement:

Experiment with programs, processes, memory allocation and manipulation for processes in UNIX.

Assignment Objectives:

Students will be able to differentiate programs and processes, also able to learn how to create processes and able to explore the implication of process inheritance.

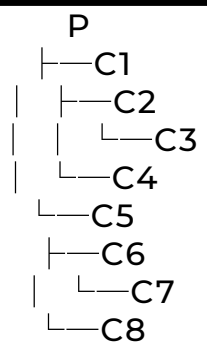
Programming/ Output Based Questions:

1. Construct the process tree diagram and also find the number of processes along with output of the following code snippet.

```
int main(void) {
    fork();        fork();
    fork();
    printf("ITER\n");
    printf("ITER\n");
    return 0;

}
/* Any formula can be
    devised for number
     of processes
     created here?
If so, state.*/
```

Process tree, # of processes and output



processes created: $2^n = 8$

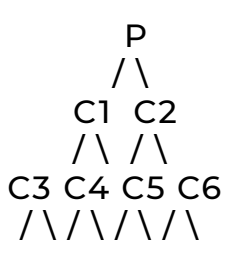
ITER
ITER
ITER
ITER

... (16 times total)

2. Construct the process tree diagram and also find the number of processes along with output of the following code snippet.

```
int main(void){
   printf("hello\n");
   fork();
   printf("hello\n");
   fork();
   printf("hello\n");
   fork();
   printf("hello\n");
   return 0;
}
/* Any formula for
    nuber of outputs?
If so, state.*/
```

Process tree, # of processes and output



Number of Processes → 8

OUTPUT-
1 + 2 + 4 + 8 = 15 hello lines.

3. Run the following code on your machine and write the output. Suggest a way to avoid the mismatch of machine output w.r.t. dry run output.

```
#include<stdio.h>
#include<unistd.h>
main(void)
{
    printf("A");
    fork();
    printf("P\n");
    return 0;
}
```

Output, Reason and Suggestion		
AP AP	Because A is buffered (no newline), its copy gets printed by both parent and child after fork().	To avoid duplication → use fflush(stdout); before fork() or include a newline

4. Draw the process tree and write the output of the following code snippet.

```
int  main()
{
    fork() && fork();
    printf("Able to\n");
    return 0;
}
```

Process tree and output	
P ├──C1 (does not run 2nd fork) └──C2	Able to Able to Able to

5. Draw the process tree and write the output of the following code snippet.

```
int  main()
{
    fork();
    fork() && fork();
    fork();
    printf("Got!!!\n");
    return 0;
}
```

Process tree and output	
P / \ A1 A2 / | \ / | \ B1 B2 B3 B4 B5 B6 (each then forks again)	Got!!! ... (12 times)

6. Draw the process tree and write the output of the following code snippet.

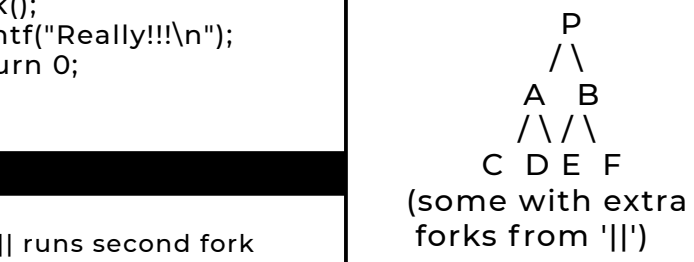
```
int  main()
{
    fork();
    fork() + fork();
    fork();
    printf("doing!\n");
    return 0;
}
```

Process tree and output	
P | ├──C1 | ├──C1a | └──C1b | └──C2 ├──C2a └──C2b	doing! printed 16 times

7. Draw the process tree and write the output of the following code snippet.

```
int  main(){
    fork();
    fork() || fork();
    fork();
    printf("Really!!!\n");
    return 0;
}
```

Process tree



Output

Really!!!
→ 12 lines

Remark

|| runs second fork only when the first returns 0, i.e., in the child of the first fork, leading to an extra branch.

8. Draw the process tree and write the output of the following code snippet.

```
int  main(){
 fork();
 fork()&& fork()||fork();
 fork();
 printf("guess\n");
 return  0;
}
```

Process tree

Output

Output
guess printed 20 times

Remark

Precedence: && runs before ||. Each logical fork pattern creates multiple branches depending on return values.

9. Draw the process tree and write the output of the following code snippet.

```
int  main(){
 fork()&&fork();
 fork()||fork();
 printf("Hi\n");
 return  0;
}
```

Process tree

Step 1: fork() && fork() → 3 processes
Step 2: each executes fork() || fork() → 3×3

Output

Output
Hi printed 9 times

Remark

Both logical patterns multiply by 3 independently

10. Construct the process tree diagram and also find the number of processes along with output of the following code snippet.

```
int  main(){
 int  pid,pid2;
 pid=fork();
 if(pid){
    pid2=fork();
    printf("I\n");
 }
 else{
       printf("C\n");
       pid2=fork();
 }
 return  0;
}
```

Process tree, # of processes and output		
P / \ (if) (else) | | A B | └—C └—D	Number of Processes 4 total (P, A, B, C)	I I C

11. Construct the process tree diagram and also find the number of processes along with output of the following code snippet.

```
int
main(void){
 pid_t  childpid;
 int  i,   n=3;
       for(i=1;i<n;i++){
      childpid=fork();
       if(childpid==-1)
       break;
 }
 printf("i:%d\n",i);
 return  0;
}
```

Process tree, # of processes and output		
P / \ C1 C2 | | C3 C4	Number of Processes For loop executes 2 times (i=1,2) → total 2 forks → 4 processes.	i:3 i:3 i:3 i:3

12. Draw the process tree because of the following code snippet and state number of times x=0 as well as **x=0**will be displayed.

```
pid_t
add(pid_t a, pid_t b){
a+b; return
}
int      main(void){
 pid_t      x=10;
      printf("%d\n",x);
   x=add(fork(),fork());
      printf("%d\n",x);
 return      0;}
```

Process tree	#of x=0	#of **x**= 0
P / \ C1 C2 / \ C3 C4	# of processes: 4 # of times x=0: 1	

13. Determine the total number of displayed for the given code snippet.

```
int  main(void){
       x[]={10,20,fork(),fork()+fork()};
       len=sizeof(x)/sizeof(int);
            i=0;i<len;i++)
    fprintf(stderr," %d ",x[i]);
 printf("\n");
 return  0;
}
```

# of display	# of Processes
Each process prints 4 numbers (array elements). Hence 8 processes × 4 values = printed multiple times	

14. Determine the number of process(s) will be created when the below program becomes process and also write the output.

```
void show(){
    if(fork()==0)
    printf("1\n");
   if(fork()==0)
    printf("2\n");
 if(fork()==0)
    printf("3\n");
}
int main(void){
 show();
 return 0;
}
```

# of processes	Output
Each fork doubles, three sequential forks → $2^3 = 8$ processes. Output "1" printed by first fork's child → 1 time "2" printed by 2nd fork's children → 2 times "3" printed by 3rd fork's children → 4 times Total 7 print lines	

15. Draw the process tree of the following code snippet. Also give a count of processes and the output of the following code. Can the code segment generate fan of processes.

```
int main(void){
 if(fork()==0)
   printf("1\n");
else if(fork()==0)
   printf("2\n");
else if(fork()==0)
   printf("3\n");
else if(fork()==0)
   printf("4\n");
else
   printf("5\n");
return 0;
}
```

Process tree, # of processes and output		
P ├── C1 ├── C2 ├── C3 ├── C4 └── P	Each else if(fork()==0) adds one new process → 5 total.	1 2 3 4 5

16. Find the output of the code segment showing the corresponding process tree.

```
int main(){
 pid_t p1,p2;
 p2=0;
 p1=fork();
 if (p1 == 0)
    p2 = fork();
 if (p2 > 0)
    fork();
 printf("done\n");
return 0;
}
```

Process tree	Output
P / \ A B / \ C D | E	done done done done done done done done done

17. Find the number of direct children to the main process, the total number of processes and the output.

```
int main(){pid_t c1=1,c2=1;
 c1=fork();
 if(c1!=0)
    c2=fork();
 if(c2==0){
    fork();printf("1\n");
  }
return 0;}
```

# of direct children to main process	Totalprocesses	Output
Direct children of main: 2 (A, B) Total processes: 5		1 1 1

18. Find the output of the code segment.

```
int  main(){
   struct stud s1={1,20};
   pid_t  pid=fork();
   if(pid==0){
       struct stud s1={2,30};
       printf("%d %d\n",s1.r,s1.m);
       return 0;
   }
   else{
      sleep(10);
      printf("%d %d\n",s1.r,s1.m);
      return 0;
   }
}
```

```
struct  stud{
   int  r;
   int  m
};      ;
```

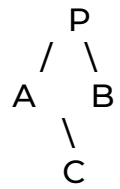
Output

```
2 30
1 20
```

19. Find the output of the code segment showing the corresponding process tree.

```
int  main(){
    if(fork()){
     if(!fork()){
        fork();
        printf("S ");
     }
     else{
        printf("T ");
     }
 }
 else{
        printf("D ");
 }
 printf("A ");
 return  0;
}
```

Process tree



Output

```
S A T A D A
```

20. Calculate the number of processes the following code snippet will generate.

```
int  main(){int i;
   for(i=0;i<12;i++){
       if(i%3==0){
             fork();
       }
 }
 return  0;
}
```

Process tree

Each iteration where i = 0,3,6,9 doubles all active processes

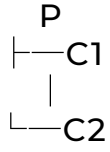
Output

(No explicit print — 16 processes created)

21. State the possible values of x for the given code snippet;

```
int  x;
int  a[2]={10,20};
x=5+a[fork() || fork()];
printf("%d ",x);
```

Process tree



Output

```
15 25 25
```

22. Suppose four user-defined exit handlers X, Y, P, and Q are installed in the order X then Y then P then Q using atexit() function in a C program. Exit hadler X is designed to display 1, Y is designed to display 2, P is designed to display 3, and Q to display 4. State the order of their display, when the program is going to terminate after calling return 0/exit(0).

(A)4,3,21 (C)1,2,4,3

(B)1,2,3,4 (D)none

Choice: A

23. You know that the **ps** utility in UNIX reports a snapshot of the current processes. Determine the state code of the given program, that became a process.

```
int main(void){
 fprintf(stderr,"PID=%ld\n",(long)getpid());
 while(1); 0;
 return
}
```

(A)R (C)T

(B)S (D)Z

Choice: A

24. Find the process state code of the given program, that became a process using the Unix utility ps.As youknow ps displaysinformationaboutaselectionoftheactiveprocesses.

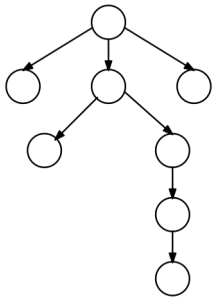
```
int main(void){
 fprintf(stderr,"PID=%ld\n",(long)getpid());
 while(1)
      sleep(1);
 return 0;
}
```

(A)R (C)T

(B)S (D)Z

Choice: B

25. Develop a C code to create the following process tree. Display the process ID, parent ID and return value of fork() for each process.



OBSERVARIONS:

- Use ps utility to verify the is-a-parent relationship?
- Are ypu gettig any orphan process case?
- Are you getting any ZOMBIE case?

Figure 1: Process tree

Code here

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

int main(){
pid_t pid=fork();
if(pid==0){
printf("Child PID=%d, PPID=%d\n",getpid(),getppid());
} else {
printf("Parent PID=%d, PPID=%d\n",getpid(),getppid());
}
return 0;
}
```

26. Create two different user-defined functions to generate the following process hierarchy shown in Figure-(a) and Figure-(b). Finally all the processes display their process ID and parent ID.

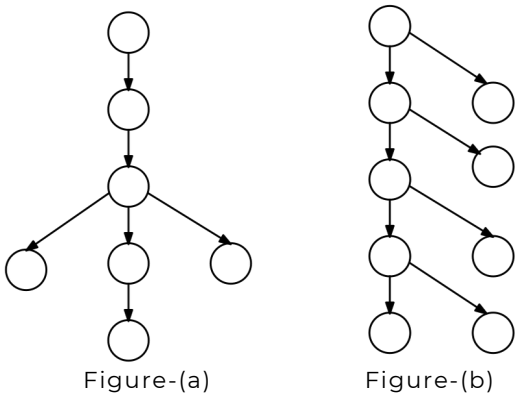


Figure 2: Process tree

Code here

```
void figA(){
if(fork()==0) fork();
else fork();
}
void figB(){
fork();
if(fork()==0) fork();
}
```

27. What output will be at Line X and Line Y?

```
#define SIZE 5
int  nums[SIZE] = { 0,1,2,3,4 }       ;
int  main(){
 int  i;
 pid  t  pid; fork(); == 0){ (i = 0; i
 pid  =  < SIZE; i++)
 if(pid  *-i;
 for                                   {
        nums[i]  *= nums[i]
        printf("CHILD:%d ",nums[i]);      /* LINE  X */
    }
 }
 else  if   (pid > 0) {
    wait(NULL);
    for   (i = 0; i < SIZE; i++)
        printf("PARENT: %d ",nums[i]);     /* LINE  Y */
    }
  return  0;
}
```

Output

```
CHILD:0 CHILD:0
CHILD:-8 CHILD:-27
CHILD:-64
PARENT:0 PARENT:1
PARENT:2 PARENT:3
PARENT:4
```

28. The Fibonacci sequence is the series of numbers 0, 1, 1, 2, 3, 5, 8,

Write a C program using the fork() system call that generates the Fibonacci sequence in the child process. The number of the sequence will be provided in the command line. For example, if 5 is provided, the first five numbers in the Fibonacci sequence will be output by the child.

Code here

```
if(fork()==0){
    a=0;b=1;
for(i=2;i<n;i++){ c=a+b; printf("%d ",c); a=b; b=c; }
}else wait(NULL);
```

29. Write a **MulThree.c** program to multiply three numbers and display the output. Now write another C program **PracticeExecl.c**, which will fork a child process and the child process will execute the file **MulThree.c** and generate the output. The parent process will wait till the termination of the child and the parent process will print the process ID and exit status of the child.

Code here

MulThree.c

```
printf("Multiplication: %d\n",2*3*4);
```

PracticeExecl.c

```
if(fork()==0)
execl("./MulThree","MulThree",NULL);
else{
wait(NULL);
printf("Parent: Child complete\n");
}
```

30. You know the usages of the command **grep**. Implement the working of **grep -n pattern filename** in a child process forked from the parent process using **execl** system call. The par- ent process will wait till the termination of the child and the parent process will print the process ID and exit status of the child.

Code here

```
if(fork()==0)
execl("/bin/grep","grep","-n","pattern","file.txt",NULL);
else{
wait(NULL);
printf("Parent: grep done\n");
}
```

31. Implement the above question using execv, execlp, execvp, execle, execve system calls.

Code here for execv

a) Using execv

```
char *args[] = {"/bin/grep", "-n", "pattern", "file.txt", NULL};
execv("/bin/grep", args);
perror("execv failed");
```

(b) Using execlp

```
execlp("grep", "grep", "-n", "pattern", "file.txt", NULL);
perror("execlp failed");
```

(c) Using execvp

```
char *args[] = {"grep", "-n", "pattern", "file.txt", NULL};
execvp("grep", args);
perror("execvp failed");
```

(d) Using execve

```
char *args[] = {"grep", "-n", "pattern", "file.txt", NULL};
char *envp[] = {NULL};              // inherit current environment
execve("/bin/grep", args, envp);
perror("execve failed");
```

(e) Using execle

```
char *envp[] = {NULL};
execle("/bin/grep", "grep", "-n", "pattern", "file.txt", NULL, envp);
perror("execle failed");
```