

PLEASE HAND IN

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UNIVERSITY OF TORONTO  
Faculty of Arts and Science  
APRIL EXAMINATIONS 2004

CSC 209H1 S  
St. George Campus  
Duration — 3 hours

Examination aids: none

Student Number:

Last Name:

First Name: SOLUTIONS

Instructor:

*Do **not** turn this page until you have received the signal to start.*  
(In the meantime, please fill out the identification section above,  
and read the instructions below.)

This examination consists of 10 questions on 16 pages (including this one). *When you receive the signal to start, please make sure that your copy of the examination is complete and fill in your student number on every page.* If you need more space for one of your solutions, use the last pages of the exam or the back of this page and *indicate clearly the part of your work that should be marked.*

# 1: \_\_\_\_\_/15

# 2: \_\_\_\_\_/ 8

# 3: \_\_\_\_\_/ 7

# 4: \_\_\_\_\_/ 9

# 5: \_\_\_\_\_/ 7

# 6: \_\_\_\_\_/ 7

# 7: \_\_\_\_\_/ 6

# 8: \_\_\_\_\_/ 9

# 9: \_\_\_\_\_/10

# 10: \_\_\_\_\_/14

TOTAL: \_\_\_\_\_/92

*Good Luck!*

**Question 1.** [15 MARKS]**Part (a)** [8 MARKS]

Circle the correct answer below.

- TRUE     FALSE    The statement, `unsigned int y = x >> 16` gives `y` the value of the upper 16 bits of `x` (assuming `x` is an unsigned int).
- TRUE     FALSE    I can only execute a program that is in my current working directory or in one of the directories found the `PATH` variable.
- TRUE     FALSE    Sockets are not a good candidate for sending messages between processes on the same machine because the overhead is too high.
- TRUE     FALSE    It is important to free memory that you allocate using `malloc` before you exit a program because otherwise that memory will no longer be available for other programs to use.
- TRUE     FALSE    The function `strncpy(dest, src, n)` will work correctly even if the null-termination character is not found in the first `n` bytes of `src` or `dest`.
- TRUE     FALSE    The following is legal C code:
- ```
int *p = malloc(10*sizeof(int));
p[3] = 10;
*p = 5;
```
- TRUE     FALSE    Blocking a signal means that the signal is thrown away and can never be received.
- TRUE     FALSE    We do not need to allocate memory for the pointer `ptr` when it is used in the following statement: `ptr = fgets(ptr, 10, stdin);`

**Part (b)** [7 MARKS]

The directory `adir` is a subdirectory of the current working directory. In `adir` are four files. Two files (`prog1` and `prog2`) are C object files, and two (`getone` and `getall`) are shell programs. Assume that the four programs are correct.

```
d-wx-wx-wx   adir/
---x--x--x   adir/prog1
-r-xr-xr-x   adir/prog2
---x--x--x   adir/getone
-r-xr-xr-x   adir/getall
```

For each of the following commands, circle TRUE if the command will run correctly and FALSE otherwise. Consider each command independently.

|                               |                                |                          |
|-------------------------------|--------------------------------|--------------------------|
| TRUE                          | <input type="checkbox"/> FALSE | <code>ls adir</code>     |
| <input type="checkbox"/> TRUE | FALSE                          | <code>cd adir</code>     |
| <input type="checkbox"/> TRUE | FALSE                          | <code>adir/prog1</code>  |
| <input type="checkbox"/> TRUE | FALSE                          | <code>adir/prog2</code>  |
| TRUE                          | <input type="checkbox"/> FALSE | <code>adir/getone</code> |
| <input type="checkbox"/> TRUE | FALSE                          | <code>adir/getall</code> |
| TRUE                          | <input type="checkbox"/> FALSE | <code>rm adir/xx</code>  |

NOTE: We had to accept either answer for the last one

**Question 2.** [8 MARKS]**Part (a)** [2 MARKS]

We cannot reliably use the `select` function to check when data is ready to read from a file pointer returned by `popen` even though it is possible to add the appropriate file descriptor to the set that `select` is waiting on. Briefly explain why not.

*Because popen returns a file pointer, the output from popen is buffered. This means that a call to fgets or fscanf on the file pointer will not need data to be loaded from the os into the buffer.*

**Part (b)** [1 MARK]

Write a C statement that reads an integer from file descriptor `fd`. Include any necessary variable declarations.

```
int x;
read(fd, &x, sizeof(int));
```

**Part (c)** [2 MARKS]

Briefly explain how to terminate or kill a process that is running in the background.

*{\em Find out its pid using ps or top and use the kill command to kill it. Use killall on the process name. Get it into the foreground and type ^C.}*

**Part (d)** [3 MARKS]

In assignment 3, a child process wrote data to the parent process through a pipe. A number of students wrote code that called `wait` in the parent before the parent read from the pipe. Explain why this seemed to work.

*The child didn't write much data to the pipe, so it was able to complete its task without blocking in a write call waiting for data from the pipe to be consumed.*

If the parent waits before it reads from the child, explain what error might occur, and why the error occurs.

*If the child writes more data than the capacity of the pipe, the child will block. The parent will block waiting for the child to terminate so neither process will make any progress (deadlock)*

**Question 3.** [7 MARKS]

When a process terminates it sends the SIGCHLD signal to its parent. Normally, the parent ignores the signal until it calls wait. Your task is to write a C program that prints a message as soon as a child process terminates and the SIGCHLD signal is received.

If the child process terminates normally, the parent will print the message, "Child x terminated with y" where "x" is the process id of the child and y is its exit status. If the child terminated abnormally, then the parent will print the message, "Child x terminated" where "x" is the child's process id.

To make this program complete, the child and the parent need something to do. The child will call the function playTime() and the parent will call makeDough(). Do **not** write these two functions.

```
void catch(int signo) {
    int status;
    int pid;
    if((pid = wait(&status)) != -1) {
        if(WIFEXITED(status)) {
            printf("Child %d exited with %d\n", pid, WEXITSTATUS(status));
        } else {
            printf("Child %d exited\n", pid);
        }
    } else {
        printf("Error\n");
    }
}

int main()
{
    struct sigaction sa;
    sa.sa_handler = catch;
    sigemptyset(&sa.sa_mask);
    sa.sa_flags = 0;

    if((sigaction(SIGCHLD, &sa, NULL)) < 0) {
        perror("sigaction");
    }

    if (fork()) {
        playTime("parent");
    } else {
        makeDough("Child");
    }

    return 0;
}
```

**Question 4.** [9 MARKS]**Part (a)** [2 MARKS]

The buffer returned by `fgets` contains the newline character. Write a C code fragment to remove the newline character from `line`.

```
char line[MAXBUF];
fgets(line, MAXBUF, stdin);

line[strlen(line)-1] = '\0';
```

**Part (b)** [7 MARKS]

Write a C program that implements a limited form of “grep”. The first command line argument is the word to search for and the remaining command line arguments are the files to search. The program prints to standard output each line in the files that contains the word. If a file cannot be searched, the program prints “permission denied”.

For example if the program was run with the arguments “foo file1 file2” then all of the lines in file1 and file2 that contain the word “foo” would be printed.

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

#define MAXSIZE 128

int main(int argc, char **argv) {
    FILE *fp;
    char line[MAXSIZE];
    char *word = argv[1];
    int i;
    for(i = 2; i < argc; i++) {
        if((fp = fopen(argv[i], "r")) == NULL) {
            printf("%s: Permission denied\n", argv[i]);
        } else {
            while(fgets(line, MAXSIZE, fp) != NULL) {
                if(strstr(line, word) != NULL) {
                    printf(line);
                }
            }
        }
        fclose(fp);
    }
}
```

**Question 5.** [7 MARKS]

Write a program that creates 5 child processes, numbered 0 through 5. Each child process computes the sum of the integers  $5 \times i$  through  $5 \times i + 4$ , where  $i$  is its index number. It then returns this value as the process exit status. The parent waits for all of its children and outputs the total of the exit statuses, which will be the sum of the integers from 0 to 24 inclusive.

```
int main()
{
    int sum, i, status;
    extern void doit(int i);

    for (i = 0; i < 5; i++)
        if (fork() == 0)
            doit(i);
    for (sum = i = 0; i < 5; i++) {
        if(wait(&status) > 0) {
            if(WIFEXITED(status)) {
                printf("Got %d\n", WEXITSTATUS(status));
                sum += WEXITSTATUS(status);
            }
        }
    }
    printf("%d\n", sum);
    return(0);
}

void doit(int i)
{
    int j, sum = 0;
    i *= 5;
    for (j = 0; j < 5; j++)
        sum += i + j;
    _exit(sum);
}
```

**Question 6.** [7 MARKS]

Consider the following C program.

```

1 int main() {
2     printf("Start\n");

3     if(fork() == 0) {
4         printf("Child1 start\n");
5         if((j = fork()) == 0) {
6             printf("Child2");
7             return 0 ;
8         } else {
9             printf("Child1 end\n");
10            return 0;
11        }
12    } else if (i > 0) {
13        printf("Parent\n");
14    }

15    printf("End\n");
16    return 0;
17 }
```

**Part (a)** [3 MARKS]

Circle the correct answer

- |      |       |                                                                    |
|------|-------|--------------------------------------------------------------------|
| TRUE | FALSE | It is possible for "Child1 end" to be printed before "Child2"      |
| TRUE | FALSE | It is possible for "Child1 end" to be printed before "Child1start" |
| TRUE | FALSE | It is possible for "Parent" to be printed before "Child1 start"    |
| TRUE | FALSE | It is possible for "End" to be printed before "Child1 start"       |
| TRUE | FALSE | It is possible for "Child2" to be printed before "Child1 start"    |
| TRUE | FALSE | It is possible for "End" to be printed more than once              |



**Part (b)** [2 MARKS]

Is it possible to insert a call to `wait(0)` that would guarantee that “Parent” would be printed after “Child1 end”? \_\_\_\_\_

If so, the call to `wait(0)` should be placed immediately following line number \_\_\_\_\_.

**Part (c)** [2 MARKS]

The program can be modified to guarantee that “Parent” will be printed after “Child 2”, by adding one or more calls to `wait(0)`. After which line or lines should a call to `wait(0)` be added? (Full marks will be awarded only if the minimum number of `wait(0)` calls are added.)

**Question 7.** [6 MARKS]

Write a Bourne shell program that takes a path as an argument. It prints the number of path elements and “relative” if it is a relative path or “absolute” if it is an absolute path.

The man page descriptions of `dirname` and `basename` may help you:

```
SYNOPSIS      dirname NAME
DESCRIPTION   Print NAME with its trailing /component removed; if NAME
              contains no /'s, output '.' (meaning the current directory).
```

```
SYNOPSIS      basename NAME
DESCRIPTION   Print NAME with any leading directory components removed.
```

```
path=$1

sub='dirname $path'
count=1

while [ 'dirname $path' != 'basename $path' ]
do
    path='dirname $path'
    count='expr $count + 1'
done

if [ $path == "." ]
then
    echo $count relative
else
    echo $count absolute
fi
```

**Question 8.** [9 MARKS]**Part (a)** [5 MARKS]

The file “classlist” contains a list of student ids. Write a Bourne shell program that creates a subdirectory for each student in /u/csc209/marks/a3 and copies the file whose name is given as a command line argument to each student’s directory. Do not use cd.

```
#!/bin/sh

file = $1

marksdir=/u/csc209/marks/a3

students='cat classlist'

for s in $students
do
    mkdir $marksdir/$s
    cp $file $marksdir/$s
done
```

**Part (b)** [2 MARKS]

To run the program in part (a), is it necessary for the file passed in as an argument to be in the same directory as the program?

*No*

If yes, explain how to run the program if the file given as an argument is in a different directory. If no, explain why not.

*We just need to pass in the relative or absolute path to the file, and the program will work fine.*

**Part (c)** [2 MARKS]

To run the program in part (a) is it necessary for the file class list to be in the current working directory?

*Yes*

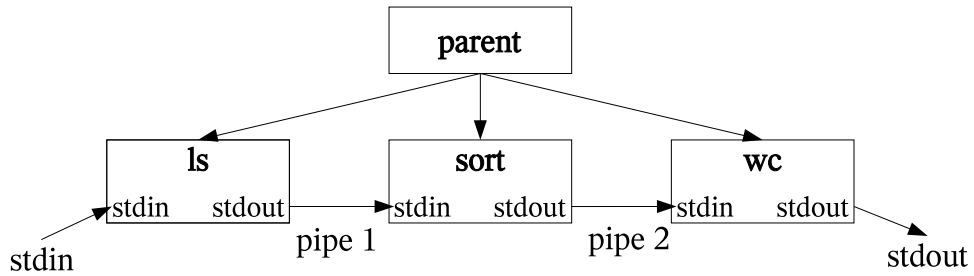
If yes, explain how to run the program if “classlist” in a different directory. If no, explain why not.

*We need to give the path to classlist, or to pass it in as an argument and change the code to use the path.*

**Question 9.** [10 MARKS]

Pipes are frequently used in Unix to connect the standard output from one process to the standard input of the next. Write a C program that takes 2 or more program names as command line arguments, constructs pipes, and executes the programs so that the output of one process becomes the input of the next. Full marks will only be awarded if the pipes are closed correctly.

For example, if the program is run with the arguments “ls sort wc”, the parent creates three processes to execute the programs and sets up two pipes.



This page is provided for rough work and any answers that didn't fit.

**Question 10.** [14 MARKS]**Part (a)** [6 MARKS]

One problem that may occur with sockets is that a read on a socket may block indefinitely. This is undesirable if there are other connections that the process could be handling. Name and describe three techniques that may be used to solve this problem.

Technique 1: \_\_\_\_\_

Technique 2: \_\_\_\_\_

Technique 3: \_\_\_\_\_

**Part (b)** [8 MARKS]

A port scanner is a program that tries to find out which ports have servers actively listening on them. A simple way to do this is to iterate over a set of ports, trying to establish a connection on each port.

Complete the C program on the next page to implement a port scanner that is looking for a web server listening on ports in the range 8000 to 10000. It attempts to determine whether a server listening on a port is a web server by sending a “GET” request, and checking if a response begins with “HTTP”. (Note that the “GET” request message is already set up for you.) You do not need to handle the problem described in part (a).

The program will print the following messages in the appropriate circumstances. In each case “x” is the port number.

- Port x answered with HTTP
- Port x is not a web server
- Port x is not listening

```
#define BLOCK_SIZE 128

int main(int argc, char* argv[])
{
    int i, soc;
    char buf[BLOCK_SIZE];
    struct hostent *hp;
    struct sockaddr_in peer;

    strcpy(buf, "GET /index.html HTTP/1.0\r\n");
    peer.sin_family = AF_INET;

    hp = gethostbyname(argv[1]);
    if ( hp == NULL ) {
        fprintf(stderr, "%s: %s unknown host\n", argv[0], argv[1]);
        exit(1);
    }

    peer.sin_addr = *((struct in_addr *)hp->h_addr);
    soc = socket(AF_INET, SOCK_STREAM, 0);

    for(i = 2999; i < 30010; i++) {
        int n;
        peer.sin_port = htons(i);
        if(connect(soc, (struct sockaddr *)&peer, sizeof(peer)) != -1){
            /* Try sending a GET request */
            write(soc, buf, strlen(buf));
            if((n = read(soc, buf2, sizeof(buf))) > 0) {
                if(strncmp(buf2, "HTTP", 4) == 0) {
                    printf("Port %d answered with HTTP\n", i);
                } else {
                    printf("Port %d not an http server\n", i);
                }
            } else {
                printf("No answer from port %d\n", i);
            }
            close(soc);
        } else {
            printf("No one listening at port %d\n", i);
        }
    }
    return 0;
}
```

Total Marks = 92