1. (15%) Please draw the process parent-child relationship graph resulting from the execution of the following pseudo code. **Please explain your answer**. Note that the following code is included in an executable file called ***programP***, and assume that **no error occurs** during the execution of the fork() calls.

```
main() {
    r = fork();
    if ( r < 0 )            exec("programA");
    else if ( r > 0) {
        exec("programA"); exec("programB");
        fork(); exec("programC");
    }
    else {
        if ( fork() == 0 )    { exec("programB"); fork(); }
        else    { fork(); exec("programC"); }
    }
    while (1);
}
```

2. (10%) Please describe system calls, UNIX signals, and their difference(s).

3. (15%)
   (a) (10%) What is the difference between local variables, global variables, and thread-specific data?
   (b) (5%) Which type(s) of variables/data are shared among functions in a thread?

4. (10%) Please describe the difference between parallelism and concurrency? Can they co-exist in a system? Why or why not?

5. (10%) Assume that a thread is in the deferred cancellation mode. Which of the following is/are not suitable to be done when the thread is in the middle of updating a shared data in the memory. **Please explain your answers.** (a) access global variables (b) access local variables (c) access heap data (d) open a file by open() (e) write data to the console by printf()

6. (10%) Please describe why a medium term scheduler should consider whether processes are CPU-bound or IO-bound when it swaps in/out the processes.

7. (10%) About virtualization and hypervisors

   (a) (5%) What's the main difference between Type I and Type II hypervisors?

   (b) (5%) Why virtualization is typically faster than emulation?

8. (10%) Typical operating system structures are *simple structure, layered structure, microkernel and modules*. Which structure(s) does Linux belong to? Please explain your answer briefly.

9. (10%) Please briefly describe how an interrupt vector table (IVT) can be used when an interrupt occurs.