1. Please fill in the blank. (each blank: 2%)

   a. Each process has a segment of _____, called a critical section, in which the process may be changing _____ variables, updating a table, writing a file.

   b. A semaphore S is an _____ variable that is accessed only through two standard _____ operations: wait and signal.

   c. One protocol that ensures serializability is the _____ locking protocol. In _____ phase, a transaction may obtain lock, but may not _____ any lock.

   d. At system boot time, the hardware starts in monitor mode. The operating system is then loaded, and starts user processes in user mode. Whenever a _____ or _____ occurs, the hardware switches from user mode to monitor mode.

   e. A deadlock situation can arise if the following four conditions hold simultaneously in a system: _____, _____, _____, _____.

   f. If a resource-allocation graph does not have a _____, then the system is not in a _____ state. The resource-allocation graph is not applicable to a resource-allocation system with _____ of each resource type.

   g. One way to ensure that the circular-wait condition never holds is to impose a _____ ordering of all resource types, and to require that each process requests resources in an _____ order of enumeration.

   h. A thread, sometimes called a Lightweight process (LWP), is a basic unit of CPU utilization, and consists of a _____, a _____ set, and a _____.

   i. Files can be allocated space on the disk in three ways: through _____, _____, or _____ allocation. _____ allocation can suffer from external fragmentation. Direct-access files cannot be supported with _____ allocation.

   j. A distributed system is a collection of processors that do not share _____ or a _____.

   k. The FIFO page-replacement algorithm has a _____ The _____ rate may increase as the number of allocated memory frames increase.

   l. Consistency semantics is an import criterion for evaluation of any file system that supports _____ of files. Currently there are three semantics: _____, _____, _____.

   m. A process can be thought of as a _____ in execution.
2. Giving three process P1, P2, P3. Assume that:
   P1 has burst time (interval) a, P2 has burst time b, P3 has burst time c
   and
   \[ a < b < c \]
   There are 6 scheduling sequences (for example P1 P2 P3, P1 P3 P2, ...), please prove the
   sequence P1 P2 P3 has the minimum average waiting time by mathematical method.

3. Assume C language has a semaphore type. The readers/writers programs are shown
   below. Each statement has assigned a statement number. (10%)

   ```c
   1  semaphore mutex = 1; /* control access to rc counter
   2  semaphore db = 1; /* semaphore for accessing database
   3     int rc = 0; /* no. of reader process
   4  void reader(void)
   5  {                           /* noncritical section
   6      while (TRUE) {
   7         wait(&mutex);
   8         rc = rc + 1;
   9         if (rc == 1) wait(&db);
   10        signal(&mutex);
   11        read_database(); /* access the database
   12        wait(&mutex);
   13        rc = rc - 1;
   14        if (rc == 0) signal(&db);
   15        signal(&mutex);
   16        use_data_read(); /* noncritical section
   17     }
   18 }

   19  void writer(void)
   20  {
   21      while (TRUE) {
   22         think_up_data(); /* noncritical section
   23         wait(&db);
   24         write_database(); /* update the database
   25         signal(&db);
   26     }
   27 }
   ```

Please answer the following question with statement number.

a. When a writer process is updating the database, at which statement is the first reader
   process waiting? At which statement all other readers (except first reader) are
   waiting?

b. In problem a, at which signal() statement is the first reader awaken?
   Which process, and at which signal() statement, wake up one of the other readers
   process?
4. In an UNIX system, a C program is shown in the following: (10%)

```c
if (fork())
{
    /* code-section-A */
}
else
{
    /* code-section-B */
}
```

Please select the correct answer.

a. code-section-A is executed by
   ① parent-process  ② forked child process  ③ both processes
b. code-section-B is executed by
   ① parent-process  ② forked child process  ③ both processes
c. if `execve()` system-call used, the system call can be inserted into
   ① code-section-A  ② code-section-B  ③ both code-sections
d. What is `execve()` used for?