Instructions: There are **four** questions which count 100 points in total. Each question may have several sub-questions. Please read the questions carefully before answering.

1. Process Management (34 points)
   A. (4 points) What is the difference between "time sharing" and "multiprogramming"?
   B. (12 points) Consider several operating systems executing over a virtual machine software. Please briefly describe the procedure for a task that runs over an operating system to make a system call to read a data block on a disk.
   C. (8 points) Preemptive CPU scheduling is often considered better than non-preemptive scheduling. Please give me one situation, where preemptive CPU scheduling is no better than non-preemptive CPU scheduling.
   D. (10 points) Consider round-robin scheduling and scheduling criterion being "average waiting time". Will the system performance becomes better with a smaller time quantum? You must explain why.

2. (20 points) Memory management:
   A. (4 points) Please explain the different between internal fragmentation and external fragmentation.
   B. (4 points) Which one of the above two fragmentations occurs in paging systems? Please explain your answer.
   C. (4 points) Which one of the above two fragmentations occurs in pure segmentation? Please explain your answer.
   D. (4 points) If LRU page replacement is used with three page frames and eight pages, how many page faults will occur with the reference string 271230137 if the four frames are initially empty?
   E. (4 points) If Aging page replacement is used with three page frames and eight pages, how many page faults will occur with the reference string 271230137 if the four frames are initially empty?

3. (24 points) A virtual memory system can be structured on fixed-size pages and variable-size segments.
   A. (4 points) Compare the two approaches; describe one scenario the paging approach work better than the segment approach.
   B. (4 points) Following the previous question, describe one scenario the segment-based approach works better than the paging approach.
   C. (4 points) Please explain the different between internal fragmentation and external fragmentation.
   D. (4 points) Which one of the above two fragmentations occurs in paging systems? Please explain your answer.
   E. (8 points) Describe two tradeoffs involved in having a design of smaller pages versus larger pages?

4. (22 points) When using a distributed file system, the server may be either stateless or stateful.
   A. Please give a short description for stateless and stateful distributed file server. (10 points)
   B. Please describe the impact of each of these two mechanisms when the file server crashes and recovers later. (12 points)