Main Memory:

**Easy: (solve within 3 mins for each)**
1. Why are page sizes always powers of 2? (2)
2. Explain the difference between internal and external fragmentation. (2+2 = 4)
3. What is the purpose of paging the page table? (2)

**Medium: (solve within 5 mins)**
4. Consider a logical address space of 64 pages of 1024 words each, mapped onto a physical memory of 32 frames.
   a. How many bits are there in the logical address? (2+2 = 4)
   b. How many bits are there in the physical address?

**Hard: (solve within 10 mins)**
5. Assume that a system has a 32-bit virtual address with a 4-KB page size. Write a C program that is passed a virtual address (in decimal) on the command line and have it output the page number and offset for the given address. As an example, your program would run as follows: (10)
   ```
   ./a.out 19986
   Your program would output:
   The address 19986 contains:
   page number = 4
   offset = 3602
   ```
   Writing this program will require using the appropriate data type to store 32 bits. You’re encouraged to use unsigned data types.

Virtual Memory:

**Medium: (solve within 5 mins. However, this is a knowledge-based question - you can answer it sooner.)**
1. Discuss the hardware support required to support demand paging. (4)

**Hard: (solve within 15 mins)**
2. Consider a demand-paging system with the following time-measured utilizations: (2x7 = 14)
   - CPU utilization 20%
   - Paging disk 97.7%
   - Other I/O devices 5%
   For each of the following, indicate whether it will (or is likely to) improve CPU utilization. Explain your answers.
   a. Install a faster CPU.
   b. Install a bigger paging disk.
   c. Increase the degree of multiprogramming.
   d. Decrease the degree of multiprogramming.
   e. Install more main memory.
   f. Install a faster hard disk.
   g. Increase the page size.