

NAME: _____

SCORE: _____

CLOSED BOOK. YOU CAN HAVE ONE SHEET OF NOTES. ALL QUESTIONS ARE WORTH 20 POINTS.

1. Consider a virtual memory system with a page size of 4 kilobytes and an average process size of 25 pages. What percentage of main memory will be lost to **internal fragmentation**?

Answer: 2 percent (Half a page out of 25 pages.)

2. In the version of the clock policy used by Berkeley UNIX, what happens when the "hand" of the clock encounters:

a) A valid page?

It marks the page invalid (and records some place that the page is actually in main memory).

b) An invalid page?

It expels the page.

3. A virtual memory system has a virtual address space of 4 Gigabytes and a page size of one kilobyte.

a) How many bits are used for the byte offset? 10 bits

b) How many bits are used for the page number? $32 - 10 = 22$ bits

4. Give examples of an **access control list** and a **ticket** in the UNIX/LINUX file systems?

a) **Access control list:** the nine mode bits stored in the i-node.

b) **Ticket:** the file descriptor of an opened file.

5. Consider a UNIX file system with 32 bit addresses and a block size of 16 kilobytes. Given that 12 blocks can be directly accessed from the i-node, how many blocks can be accessed:

a) With **one** level of indirection? $16K/4 = 4,096$ blocks

b) With **two** levels of indirection? $4G/16K - 4,096 - 12 = 256K - 4,108$ blocks

Explain your last answer: The maximum file size is 2^{32} bytes = 4 GB