Name: _____ **CompID:** _____

For each question, either (a) mark one circle or (b) circle one of T or F for each row or (c) fill in the blank. Unanswered questions will be weighted slightly higher than incorrectly marked questions.

Feel free to write clarifying comments next to any question or option that needs them.

. . . . . .

Question 1 A UDP packet traveling over an Internet cable sends the following data in what order? List the letters below in order, with the first information to traverse the wire on the left.

A IP **A**ddresses
M **M**essage content
P **P**ort numbers

Answer: _____

Information for Q2–Q5 Consider a virtual memory system configured with

- 2-level page tables (i.e., two fewer levels than the Intel model we discussed in class)
- 16-bit page offsets
- the root page table node at address `0x72000000`
- 8-byte PTEs, with 20 flag bits (valid, writeable, etc) in each

Question 2 How many bytes of memory are used store the page table (just the table itself, not the data pages) if there are two pages of memory allocated, one including virtual address `0x12000000` and the other including `0xfebc0a0a`? You may leave operators in your answer, like 5×2^{10}B, if you wish.

Answer: _____

Question 3 How many usable bits are in each virtual address?

Answer: _____

Question 4 What is the maximum amount of physical memory this system could be configured to handle? Answer as a power of two, like 2^{48}

Answer: _____

Question 5 What is the smallest virtual address which will map to the same physical page as the virtual address `0x987654321`? Answer in hex.

Answer: _____

Question 6 Each page table base register (PTBR) contains

- ○ one node of a multi-level page table tree
- ○ (part of) a virtual address
- ○ (part of) a physical address
- ○ two or more of the above are possible; the hardware designer picks one
- ○ two or more of the above are possible; the OS designer picks one

Question 7 If a user-mode process figures out how to read from its page-table pages, it gains the following powers:

- T F it can read other processes' memory
- T F it can jump to kernel code in user mode
- T F it can become an exception handler

Question 8 If a user-mode process figures out how to write to its page-table pages, it gains the following powers:

- T F it can read other processes' memory
- T F it can jump to kernel code in user mode
- T F it can become an exception handler

Question 9 Kernel mode can be entered by

- T F an interrupt
- T F a trap
- T F a signal
- T F a fault

Question 10 Suppose we want to implement a protocol for fast financial trades in order to capitalize on short-term fluctuations in the market. Our system communicates between share owners offering shares for sale and share buyers offering money for shares. For this application, it make more sense to use

- ○ UDP
- ○ TCP

Information for Q11–Q12 The following as about file permissions.

Question 11 File permissions are sometimes written in octal (e.g., `0677`) and sometimes with letters (e.g., `rwxr--r--`). What are the letters associated with the octal number `0654`?

Answer: _____

Question 12 Suppose a file is owned by `mst3k` in group `student` and has permissions `0000`.

T F members of group `student` can read the file

T F any other user can read the file

T F `root` can read the file

T F `mst3k` can read the file

Information for Q13–Q16 The following ask about various related abbreviations

Question 13 DNS

○ routes messages to specific computers

○ provides unreliable communication with a specific program

○ provides reliable communication with a specific program

○ maps a host name to a numerical address

○ assigns a temporary numerical address to a computer

Question 14 IP

○ routes messages to specific computers

○ provides unreliable communication with a specific program

○ provides reliable communication with a specific program

○ maps a host name to a numerical address

○ assigns a temporary numerical address to a computer

Question 15 TCP

○ routes messages to specific computers

○ provides unreliable communication with a specific program

○ provides reliable communication with a specific program

○ maps a host name to a numerical address

○ assigns a temporary numerical address to a computer

Question 16 UDP

○ routes messages to specific computers

○ provides unreliable communication with a specific program

○ provides reliable communication with a specific program

○ maps a host name to a numerical address

○ assigns a temporary numerical address to a computer

Question 17 The following could happen during the handling of an interrupt or a fault. Which one happens for one but not the other? Assume neither the fault nor the interrupt aborts.

- ○ The exception table is consulted
- ○ Processor state is saved
- ○ Processor state is restored
- ○ Kernel mode is entered
- ○ An exception handler is executed
- ○ A user-mode instruction is re-run

Question 18 Which of the following needs to be in the kernel's structure describing a currently-suspended process?

- T F the top-level page table node
- T F the set of open files and sockets
- T F the program register contents
- T F the contents of the PTBR
- T F the contents of the PC
- T F all user-mode physical pages
- T F all allocated intermediate page tables

Question 19 You can write a user-mode program which does which of the following? Assume you do not exploit any bugs or security vulnerabilities

- T F causes kernel-owned code to run as the kernel
- T F causes any code it wishes to run as the kernel
- T F causes any code it wishes to run as `root`
- T F causes `root`-owned code to run as `root`

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Pledge On my honor as a student, I have neither given nor received assistance on this exam.

{Signature}