

CS333 Final Exam
Winter 2019
Instructor: Morrissey

Name: _____

Registered Section: M/W Tu/Th

This exam has 23 questions. The total number of points is 105.

Instructions In the event that multiple answers appear correct, select the **most** correct answer. For multiple choice questions, *circle only the **letter** of the correct answer.*

- (5 points) Draw and properly label the xv6 state transition diagram.
- (2 points) What is the primary purpose of the Memory Management Unit (MMU)?
 - Garbage collection of unused memory.
 - Service calls to `mmap` and `free`
 - Translate virtual addresses to physical addresses.
 - Translate physical addresses to virtual addresses.
 - To manage physical memory
- (2 points) In a single level page table, the virtual address consists of a Virtual Page Number (VPN) and an offset. What are the parts of a virtual address, in the correct order, when using a multi-level page table? Assume 2-levels.
 - Index Entry, Page Number, Offset
 - Page Directory Index, Page Table Index, Offset
 - Page Table Index, Page Directory Index, Offset
 - Table of Contents, Chapter, Offset
 - Page Directory Entry, Page Table Entry, Offset
 - VPN, PFN, offset

4. (4 points) For each of the following, choose an advantage and a disadvantage:

	Advantage	Disadvantage
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Segmentation	_____	_____
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Paging	_____	_____
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- A. No internal fragmentation.
 - B. Allows efficient use of memory and eliminates external fragmentation.
 - C. Only supports coarse grained memory allocation.
 - D. Complex to implement.
 - E. Simple to implement.
 - F. Can waste memory unless compaction is used
5. (10 points) List the rules for the MLFQ algorithm that were used in Project 4.

6. (2 points) Assuming a multi-level page table, which of the following is the correct interpretation of the present and valid bits in the page table entry:
- A. Valid indicates that the page frame number is correct.
Present means that the page is in an allocated part of the address space.
If valid is not set, a segmentation fault results.
 - B. Valid indicates the memory is working correctly.
Present indicates that there is enough memory in the system.
If both bits are 0, reboot.
 - C. Valid indicates that VPN is in an allocated portion of the process address space.
Present indicates that the referenced page is in memory.
If the valid bit is 0, seg fault.
 - D. Valid indicates that VPN is in an allocated portion of the process address space.
Present indicates that there is enough memory present.
If both bits are 0, the page is in memory.
 - E. Valid indicates that the page table is valid.
Present indicates that the page table is present in memory.
If the valid bit is 0, seg fault.
 - F. Valid indicates that the page is part of the process address space.
Present indicates that the page is in virtual memory.
If both are set, it means that the page is in the MMU.
 - G. Valid indicates that the page is not part of the process address space.
Present indicates that the page is in virtual memory.
If both are set, it means that the page is in the MMU.
7. (2 points) What is the purpose of the valid bit in the TLB?
8. (2 points) What modification to the TLB allows for the possibility of a warm cache on a context switch?

9. (2 points) What is the principle advantage of a multi-level page table over a single level page table?
10. (2 points) What is the principle disadvantage of a multi-level page table over a single level page table?
11. (5 points) Explain how a log-structured file-system is able to overcome the performance limitations of a journaling file-system.

12. (5 points) Explain how crash recovery is handled in a journaling file-system.
13. (5 points) Explain how crash recovery is handled in the log structured file-system.
14. (5 points) In the log structured file-system, is the checkpoint region marked as the most recent before or after the corresponding checkpoint region is written to disk? Explain why the order matters for file-system consistency.
15. (5 points) How does the log structured file system avoid unnecessarily running out of disk space? Explain how this mechanism works.

16. (2 points) What is the principle performance benefit of using a buffer cache?
- A. Once a file is in memory, all subsequent reads are satisfied by the buffer cache.
 - B. The buffer cache can be out-of-sync with the copy on disk.
 - C. Memory is cheaper than disk.
 - D. The complexity of caching is greater than the benefit of using memory.
 - E. The buffer cache simplifies the programming model.
17. (2 points) What is the principle disadvantage of using a buffer cache.
- A. Once a file is in memory, all subsequent reads are satisfied by the buffer cache.
 - B. The buffer cache can be out-of-sync with the copy on disk.
 - C. Memory is cheaper than disk.
 - D. The complexity of caching is greater than the benefit of using memory.
 - E. The buffer cache complicates the programming model.
18. (5 points) The buffer cache can have a negative effect on file-system consistency. Why is the buffer cache used despite this limitation?
19. (10 points) Explain the clock page replacement algorithm.

20. (10 points) Name and define the conditions necessary and sufficient for deadlock.

For the remaining questions, assume a 32KB virtual address space and a 128KB physical memory. Virtual addresses are 15 bits and segmentation is being used. The segment information is:

Segment	Segment Number	Base	Size	Grows Negative
Code	00	16K	3.5K	0
Heap	01	8K	5.0K	0
Stack	11	48K	4.0K	1

21. (6 points) A call to `malloc()` returns a virtual address of 0x31C7. What is the physical address, in decimal, of this virtual address?
22. (6 points) Virtual address 0xB28 refers to what physical address in decimal?
23. (6 points) What virtual address, in decimal, is three-quarters ($\frac{3}{4}$) into the stack?