

Final Exam

11 May 2018, 120 minutes, 26 questions, 100 points

The exam is closed book and notes.
Please keep all electronic devices turned off and out of reach.
Note that a question may require *multiple* checked boxes for a correct answer. Checking *some* but not *all* of the required boxes will result in a *partial* answer worth only 2 of the 4 points. Checking any box that shouldn't be checked results in an *incorrect* answer, worth zero.

1. Return my exam to my Kingsbury mailbox. [0 pts]
 Hold my exam in your office. I will pick it up prior to September 15.
 Shred my exam. I never want to see it again.
2. Interpret 0xDEADBEEF (shown in hexadecimal) as an IEEE single-precision floating-point value. Which of the following statements about this value are true? [4 pts]
 It is negative.
 Its stored exponent is 0xDB.
 Its actual exponent is 62 (in decimal).
 It is a NaN.
3. Concerning the concurrent buffer assignment, which of the following statements are true: [4 pts]
 Each buffer required two mutexes.
 Each buffer required two condition variables.
 A consumer, pulling a value from the buffer, always blocks.
 A producer, putting a value in the buffer, always blocks.
4. Encode the following Unicode character (shown in hex) as UTF-8: 0x1313. The sequence of bytes (shown in hex) would be: [4 pts]
 13 13.
 E3 13.
 F0 C1 8C 93.
 E1 8C 93.
 none of the above.
5. Which of the following statements about the Intel 64 are true? [4 pts]
 All registers are 64 bits.
 The **rip** register points to the top of the stack.
 The runtime stack grows from higher address down towards lower address.
 The **call** instruction pushes the return address on the top of the runtime stack.

6. Consider the following C function:

[4 pts]

```
unsigned int f(void)
{
    int x = -0;
    return *(unsigned char *) &x;
}
```

On a 2's complement machine with a byte-addressable memory and where an `int` is 32 bits, the function will:

- return 0 if the machine is little-endian and 1 otherwise.
- return 1 if the machine is little-endian and 0 otherwise.
- always return 1.
- always return 0.
- none of the above.

7. Consider the following RISC-V program:

[4 pts]

```
top :
    sbreak
    sbreak
    sbreak
    sbreak
    addi x5, x19, -31
```

What is the encoding of the `addi` instruction?

- `0xFE198293`.
- `0x81F98293`.
- `0xFE199293`.
- `0x81F99293`.
- none of the above.

8. Consider how -31 (base 10) would be represented in the memory of a Little Endian machine as a 16-bit 2's complement integer. The two bytes, shown left to right in increasing memory address order, would be: [4 pts]

- `0xFF 0xE0`.
- `0xE0 0xFF`.
- `0x80 0x1F`.
- `0xE1 0xFF`.
- none of the above.

9. The UTF-16 sequence (shown in hexadecimal) `0xD800 0xDC10` is represented in UTF-32 (in hexadecimal) [4 pts] as:

- two Unicode characters, `0x0000D800` and `0x0000DC10`.
- two Unicode characters, `0x00000000` and `0x00000010`.
- a single Unicode character, `0x00010010`.
- a single Unicode character, `0x00000010`.
- none of the above.

10. Which of the following statements about using a POSIX condition variable are true? [4 pts]
- If the caller of `pthread_cond_wait` does not hold the lock of the mutex passed as the second argument, then an error code is returned.
 - The caller of `pthread_cond_signal` will block if there are threads waiting on the condition variable.
 - If `pthread_cond_wait` is called when there are no threads waiting on the condition variable, then an error code is returned.
 - A maximum of one thread is allowed to wait on a condition variable.
11. Which of the following statements about a POSIX mutex are true? [4 pts]
- Only one thread at a time can hold the lock of a mutex.
 - A thread will block if the thread tries to lock a mutex that is locked by another thread.
 - A critical section is protected by first locking a mutex, then executing the critical section, then unlocking the mutex.
 - A thread can own the lock on two different mutexes at the same time.
12. Which of the following are examples of a program exhibiting spatial locality? [4 pts]
- iterating through all members of an array in order.
 - repeatedly incrementing a loop counter variable inside a loop.
 - a sequence of instructions being executed in order without any branch or call instructions.
 - repeatedly testing the same variable in the condition of a loop.
13. Add together the following two 8-bit 2's complement integers (shown in hexadecimal): `0xFF` and `0xFF`. Which of the following are true statements about the result? [4 pts]
- The result (in hexadecimal) is `0xFE`.
 - The result is negative.
 - The result overflows.
 - The result in decimal is `-2`.
14. Which of the following statements about virtual memory are true? [4 pts]
- The translation lookaside buffer (TLB) is a cache that stores recent physical-to-virtual page translations.
 - The page table resides on disk.
 - A page table entry includes a valid flag that is used to indicate whether a virtual page is currently in physical memory.
 - A read of a word in virtual memory always causes the virtual memory to perform a disk read.
15. Which of the following statements about the Java Virtual Machine are true? [4 pts]
- All instructions are 8 bits.
 - There is no runtime stack.
 - The PC is the only register.
 - It uses PC-relative addresses for its branch instructions.
16. Which of the following statements about assemblers are true? [4 pts]
- They have three passes because the use of a label may come before its definition.
 - They place in the `insymbol` section of the output object file all labels that are defined (and exported) in the input file.
 - They place in the `outsymbol` section of the object file all labels that are referenced (and imported) in the input file but not defined.
 - They use a symbol table to store the address associated with each defined label.

17. Which of the following statements about the Intel 64 **CMPXCHG** instruction are true? [4 pts]
- It is used with the **LOCK** prefix to ensure that its memory actions are atomic.
 - It is a convenient way to swap the values of two memory locations in a single instruction.
 - It is used when implementing mutexes in order to protect the contents of the struct implementing the state of the mutex from concurrent updates by two threads.
 - Its functionality can be utilized in C via the *atomic_flag_test_and_set* library function.
18. Which of the following statements about thread control blocks (TCBs) are true? [4 pts]
- The TCBs for all blocked threads are linked together to form the ready list.
 - A TCB is used to store the current state of a thread when the thread yields to another thread.
 - The TCB contains a pointer to the base of the thread's stack so that the memory for the stack can be freed after the thread finishes executing its work function.
 - The TCBs for all threads waiting on a condition variable are linked together to form the wait queue for the condition variable.
19. Add the following two IEEE single-precision floating-point values shown in hexadecimal: 0x41200001 and 0x40A00002. The result in hexadecimal is: [4 pts]
- 0x40A00003.
 - 0x41200003.
 - 0x41700002.
 - 0x40B00001.
 - none of the above.
20. In an implementation of an exception mechanism for C programs on the Intel 64, the **throwException** function: [4 pts]
- pushes the current **rbp**, the saved **rbp** and the saved **rip** onto the "snapshot" stack.
 - puts the exception number into the **rip** register.
 - prints an "uncaught exception" message if the "snapshot" stack is empty.
 - none of the above.
21. Which of the following statements about a mark-and-sweep garbage collector are true? [4 pts]
- The mark phase is responsible for marking all allocated blocks that are no longer accessible.
 - The sweep phase considers all unmarked blocks to be garbage that can be reclaimed as free (no longer allocated).
 - The mark phase traverses the run-time stack in order to mark blocks pointed to by global variables.
 - The sweep phase will combine adjacent free blocks.
22. A memory cache with only one set is known as a: [4 pts]
- direct-mapped cache.
 - set-associative cache.
 - fully-associative cache.
 - translation lookaside buffer.
 - none of the above.

23. Consider how the following two C loops would be accessed by a memory system with 32 words and a cache [4 pts] with 4 sets, 2 lines per set, and a block size of 4 words.

```
for (i = 0; i < 32; i++)
    a[i] = i;
sum = 0;
for (i = 0; i < 32; i++)
    sum += a[i];
```

Assume the array is an array of words, only the array is in the memory system, and the first word of the array is at address zero. If the cache is initially empty, how many cache hits would there be for writes and how many cache hits would there be for reads?

- 32 read hits and 24 write hits.
- 0 read hits and 0 write hits.
- 24 read hits and 24 write hits.
- 0 read hits and 24 write hits.
- none of the above.
24. Which of the following statements about the IAS computer are true? [4 pts]
- It was a stored-program computer.
- Its memory consisted of 8-bit words.
- It had 16 registers, numbered r0 to r15.
- It had an instruction that would modify the address field of another instruction.
25. Which of the following statements about the Control Data Corporation (CDC) 6600 are true? [4 pts]
- It did not have a hardware run-time stack.
- It implemented the IEEE floating-point standard.
- Its memory consisted of 60-bit words.
- It was a stored-program computer.
26. Which of the following statements about the C programming language are true? [4 pts]
- A declaration of a variable of type **void *** declares a pointer to an opaque type, meaning the underlying type pointed to is hidden.
- The **static** keyword is used on global variables and functions to make those symbols not visible outside the file.
- The language does not support pointers to functions.
- There is no difference between the | operator and the || operator.