Final Exam

12 December 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 February 15.

    √ Shred my exam. I never want to see it again.

2. Interpret `0x0DEFACED` (shown in hexadecimal) as an IEEE single-precision floating-point value. Which of the [4 pts] following statements about this value are true?

    ⃝ It is negative.

    √ Its actual exponent is negative.

    ⃝ It is a denormalized value.

    ⃝ It is a NaN.

3. Concerning the reentrant readers-writers lock from the synchronizers assignment, which of the following [4 pts] statements are true:

    ⃝ Each readers-writers lock required two mutexes.

    √ Each readers-writers lock required two condition variables.

    ⃝ A reader always blocks when calling lockRLock function.

    ⃝ A writer never blocks when calling lockWLock function.

4. Encode the following Unicode character (shown in hex) as UTF-8: `0xF303`. The sequence of bytes (shown in [4 pts] hex) would be:

    ⃝ `F3 03`.

    ⃝ `03 F3`.

    √ `EF 8C 83`.

    ⃝ `F0 8F 8C 83`.

    ⃝ none of the above.

5. Which of the following statements about the Intel 64 are true? [4 pts]

    ⃝ All registers are 32 bits.

    √ The **rip** register points to the next instruction to execute.

    ⃝ The runtime stack grows from lower address up towards higher address.

    ⃝ The **ret** instruction pops the top of the runtime stack into the **rax** register.

6. Consider the following C function: [4 pts]

```c
int f(void)
{
    int x = -1;
    return *(signed 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 255.

√ always return -1.

○ none of the above.

7. Consider the following assembly code fragment from the Java Virtual Machine program: [4 pts]

```
top:
    ifle bottom
    iload_2
    iload_1
    iadd
    istore_2
    iinc 1, -1
    goto top
bottom:
```

What is the encoding of the two-byte address (offset) stored in the `ifle` instruction? (The `iload_2`, `iload_1`, `iadd`, and `istore_2` instructions are one-byte instructions. The `ifle` instruction, `iinc`, and `goto` instructions are three-byte instruction.)

○ 0x000C.

√ 0x000D.

○ 0x000E.

○ 0xFFF3.

○ none of the above.

8. Consider how -39 (base 10) would be represented in the memory of a Little Endian machine as a 16-bit 2's [4 pts] complement integer. The two bytes, shown left to right in increasing memory address order, would be:

○ 0xFF 0xD9.

√ 0xD9 0xFF.

○ 0x80 0x27.

○ 0x27 0x80.

○ none of the above.

9. The UTF-16 sequence (shown in hexadecimal) `0xDA22 0xDE22` is represented in UTF-32 (in hexadecimal) [4 pts] as:

○ two Unicode characters, 0x0000DA22 and 0x0000DE22.

○ two Unicode characters, 0x00000220 and 0x00000222.

○ a single Unicode character, 0x00088A22.

√ a single Unicode character, 0x00098A22.

○ 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* holds the lock of the mutex passed as the second argument, then an error code is returned.
- √ The *pthread_cond_signal* never causes its caller to block.
- ◯ If *pthread_cond_wait* is called when there are threads waiting on the condition variable, then an error code is returned.
- √ Multiple threads can be waiting on a condition variable at the same time.

11. Which of the following statements about a POSIX mutex are true? [4 pts]

- ◯ Two threads can hold the lock of a mutex at the same time.
- ◯ A thread will block if the thread tries to unlock 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 cannot own the lock on two different mutexes at the same time.

12. Which of the following are examples of a program exhibiting temporal 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): `0x7F` and `0x7F`. Which [4 pts] of the following are true statements about the result?

- √ 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 virtual-to-physical page translations.
- √ The page table resides in memory.
- ◯ If a virtual page does not have a TLB entry, then it cannot be in physical memory.
- ◯ A write of a word in virtual memory always causes the virtual memory to immediately perform a disk write.

15. Which of the following statements about the Java Virtual Machine are true? [4 pts]

- √ The instructions are of variable length.
- √ It is a stack-based architecture, in which most instruction operands are implicit, meaning they are values on top of the runtime stack.
- ◯ The RAX register is used to return values from functions.
- √ It uses PC-relative addresses for its branch instructions.

16. Which of the following statements about assemblers are true? [4 pts]

- √ They have two passes because the use of a label may come before its definition.
- ◯ They translate machine code into human-readable form.
- ◯ On the second pass, if the assembler sees a reference to a label that is not defined, it is a fatal error and the assembler immediately aborts.
- √ 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.

   ○ It can only be called once per program execution.

18. Which of the following statements about goroutine control blocks (GCBs) are true? [4 pts]

   ○ The GCBs for all blocked goroutines are linked together to form the ready list.

   √ A GCB is used to store the current state of a goroutine when the goroutine yields to another goroutine.

   √ The GCB contains a pointer to the base of the goroutine's stack so that the memory for the stack can be freed after the goroutine finishes executing its work function.

   √ The GCBs for all goroutines waiting to read from a channel are linked together to form a wait queue for the channel.

19. Add the following two IEEE single-precision floating-point values shown in hexadecimal: `0x80A00001` and `0x40A00001`. The result in hexadecimal is: [4 pts]

   ○ `0x40000000`.

   ○ `0xC1400002`.

   ○ `0x40B00001`.

   √ `0x40A00001`.

   ○ none of the above.

20. In an implementation of an exception mechanism for C programs on the Intel 64, the **catchException** function: [4 pts]

   √ pushes the current **rbp**, the saved **rbp** and the saved **rip** onto the "snapshot" stack.

   ○ puts the exception number into the **rax** 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 local variables, parameters and saved registers.

   ○ The sweep phase will combine adjacent marked blocks.

22. A memory cache with only one line per 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 the virtual memory system (with handle **h**) of [4 pts]
    Program 6 with 16 virtual pages, 4 physical pages, 2 TLB entries, and a page size of 4 words. Assume that
    the virtual memory system is initialized as in Program 6.

```
for (i = 0; i < 32; i++)
{
    writeInt(h, i, i);
}
for (i = 0; i < 32; i++)
{
    int tmp = readInt(h, i);
}
```

How many page faults and TLB misses will there be?

- √ 12 page faults and 14 TLB misses.
- ◯ 12 page faults and 12 TLB misses.
- ◯ 14 page faults and 12 TLB misses.
- ◯ 14 page faults and 14 TLB misses.
- ◯ 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 40-bit words.
- ◯ It had 16 registers, numbered r0 to r15.
- √ It had two 20-bit instructions packed into each memory word.

25. Which of the following statements about the Control Data Corporation (CDC) 6600 are true? [4 pts]

- ◯ It had a hardware run-time stack.
- √ It had 1's complement integer values.
- √ 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 union is like a struct except all members are allocated storage starting at the beginning of the union, meaning all members are overlaid in memory.
- √ The **static** keyword is used on global variables and functions to make those symbols not visible outside the file.
- √ The language supports pointers to functions.
- ◯ There is no difference between the **&** operator and the **&&** operator.