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Department of Computer Science and Engineering, IIT Madras
MS/PhD Entrance Test - November 2008

Exam duration is one hour. Each question is worth two marks. There are 25 questions.

Part I - Digital Logic and Computer Organization

1. The first expedition to Mars found only the ruins of a civilization. From the artifacts and pictures, the explorers deduced that the creatures who produced this civilization were four-legged beings with a tentacle that branched out at the end with a number of grasping "fingers". After much study, the explorers were able to translate Martian mathematics. They found the following equation:

$$5x^2 - 50x + 125 = 0$$

with the indicated solutions $x = 5$ and $x = 8$. The value $x = 5$ seemed legitimate enough, but $x = 8$ required some explanation. Then the explorers reflected on the way in which Earth's number system developed, and found evidence that the Martian system had a similar history. How many fingers would you say the Martians had?

- (a) 10
(b) 13
(c) 40
(d) 25
2. Let a function F be *self-dual* if $F = F^D$, where F^D is the dual of function F . How many self-dual logic functions of n variables are there?
- (a) $2n$
(b) 2^n
(c) 2^{2^n-1}
(d) 2^{2^n}
3. Let x and y be Boolean variables. If $xy = 0$, then which of the following statements is correct:
- (a) $x = y'$
(b) $x \oplus y = x + y$
(c) $x \oplus y = x$
(d) $x \oplus y = y$
4. Which of the following expressions represents the minimal expression for $ABC' + AB' + A'$?
- (a) $(ABC)'$
(b) $A' + C'$
(c) $A'B'C'$
(d) $AB + AC + BC$
5. To transmit data bits 1101, the correct even parity seven bit Hamming Code is

- (a) 1100110
 - (b) 1101101
 - (c) 0101101
 - (d) 1100010
6. The instruction *MOV AX, [BX][DI] + 2* represents the following addressing mode:
- (a) register indirect
 - (b) index relative
 - (c) base relative
 - (d) base indexed
7. Part of the operating system is usually stored in ROM so that it can be used to boot up the computer. ROM is used instead of RAM because
- (a) RAM is not big enough to store operating systems
 - (b) ROM is faster than RAM
 - (c) ROM is non-volatile
 - (d) ROM is cheaper than RAM
8. A given memory chip has 16 address pins and 10 data pins. It has the following number of memory locations:
- (a) 2^{10}
 - (b) 2^{16}
 - (c) 2^{26}
 - (d) 2^{32}
9. Suppose that a bus has 32 data lines and requires 4 cycles of $250ns$ each to transfer data. The bandwidth of the bus would be $2MB/s$. If the cycle time of the bus is reduced to $125ns$ and the number of cycles required to transfer stayed the same, what would be the bandwidth of the bus?
- (a) $1MB/s$
 - (b) $0.5MB/s$
 - (c) $4MB/s$
 - (d) Bandwidth does not depend on the cycle time
10. Which of the following statements is wrong:
- (a) Conflict miss rate is less for 4-way set-associative cache as compared to the same sized 2-way set-associative cache.
 - (b) Capacity miss rate increases with reducing cache size.
 - (c) Cold miss rate is high for direct mapped caches as compared to the same sized set-associative caches (keeping the block size constant).
 - (d) Working set can determine cache miss rate.

11. What is the precision with which the numbers having a true exponent of 25 are represented in IEEE standard 754 single precision floating point format?
 - (a) 2^2
 - (b) 2^{-2}
 - (c) 2^{-23}
 - (d) 2^{-25}
12. Consider a 2-way set-associative cache with a word length of 4 bytes, a block size of 8 words, and a capacity of 128KB. What are the lengths of TAG, SET and WORD fields for the 30-bit physical address of a word to be accessed by the cache?
 - (a) 20 bits, 7 bits, 3 bits
 - (b) 18 bits, 9 bits, 3 bits
 - (c) 16 bits, 11 bits, 3 bits
 - (d) 14 bits, 13 bits, 3 bits
13. Which of the following statements is true for a processor with load-store architecture?
 - (a) Only the LOAD and STORE instructions can be executed by the processor
 - (b) All the instructions can refer to a memory operand
 - (c) An arithmetic instruction can refer to only one memory operand
 - (d) Only the LOAD and STORE instructions can refer to a memory operand
14. The target throughput of a 5-stage pipelined processor is
 - (a) 5 instructions per clock cycle
 - (b) 1 instruction per clock cycle
 - (c) 1 instruction per 5 clock cycles
 - (d) None of the above
15. Which of the following statements is false for a microprogrammed control unit?
 - (a) Each machine instruction is a sequence of microinstructions
 - (b) Each microinstruction is a set of control words
 - (c) Each control word is a set of active control signals
 - (d) None of the above
16. The basic cells used to build the main memory unit and cache memory unit respectively are
 - (a) SRAM, SRAM
 - (b) SRAM, DRAM
 - (c) DRAM, SRAM
 - (d) DRAM, DRAM

Part II - Programming and Mathematical Foundations

17. Consider the following structure in C and the function `GetRollNumberName`:

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```
typedef struct {
    char *firstName;
    char *lastName;
    char *rollNumber;
}STUDENT;

void GetRollNumberName (STUDENT s)
{
    scanf ("%s %s %s", s.rollNumber, s.firstName, s.lastName);

} /* End of GetRollNumberName End of GetRollNumberName */
```

The function is supposed to read the values of `firstName`, `lastName`, `rollNumber` and store the same in the structure `s` and return the same to the calling program. Does the function work as expected? If not, correct it.

18. Assume that `array` is an array of `n` integers. What is the output of the following function:

```
void DoSomething(int *array, int n)
{
    int i = 0;
    int j, tmp;

    while (i < n) {
        while (array[i] == 0)
            i++;
        j = i + 1;
        if (array[j] == 0) {
            tmp = array[j];
            array[j] = array[i];
            array[i] = tmp;
            i++;
        } else
```

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```
    j++;  
  }  
}
```

19. Write the recurrence equation for computing the GCD of two numbers.

20. How would you choose the pivot element to ensure that Quicksort has an average running time of $O(n \log n)$?

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21. Evaluate the following recurrence equation:

$$T(1) = O(1)$$

$$T(n) = T(n/2) + O(1)$$

22. Show that $k(k+1)/2 - l(l+1)/2$ is not divisible by $m = 2^n$ for any $k, l \in \{0..m-1\}$ if $k \neq l$.

23. Given that $Pr[X_i > 2lgn] \leq 1/n^2$ for each of a set of random variables $\{X_i, i = 1 \dots n\}$. Show that if $X = \max_{1 \leq i \leq n} X_i$, then $Pr[X > 2lgn] \leq 1/n$.

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24. Show that for Harmonic numbers defined by the equation:

$$H_N = \sum_{1 \leq k \leq N} \frac{1}{k}$$

the following identity is true:

$$\sum_{1 \leq k \leq N} H_k = (N + 1)(H_{N+1} - 1)$$

25. The set of all subsets of Σ^* is an uncountable set. Is this statement true or false? Define a countable set.

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Rough Work-Do not tear this sheet