1. Array A is indexed from 0 to 4 and has been initialized with the following data:
   \{3, 2, 1, 4, 0\}
   For how many distinct values of \(i\) is \(i == A[A[i]]\)?
   
   (a) 0
   (b) 1
   (c) 2
   (d) 4
   (e) 5
2. Which of the following terms is another name for a single-layer neural network?

   I. A genetic algorithm
   II. A recurrent network
   III. A perception network

(a) I only
(b) II only
(c) I and II only
(d) III only
(e) I, II, and III
3. This question concerns the non-deterministic finite automaton shown here:

If $D$ is the accepting state of the non-deterministic finite automaton above, which of the following does the automaton accept?

(a) 001
(b) 1101
(c) 01100
(d) 000110
(e) 100100
4. This question concerns the following binary search tree, which stores integers:

```
  10
 /   \
0     30
 /   /   \
-10   7   20
  /   /   /   \
 4   7   20   25
```

In the best case, how many nodes must be visited to determine that an integer value is *not* in the tree?

(a) 1  
(b) 2  
(c) 3  
(d) 7  
(e) 8
5. In this question, \( p(x) \) and \( q(x) \) are predicates, and the symbol “\( \neg \)” means logical negation. Which of the following always has (have) the same truth value as the quantified predicate \( \neg(\exists x(p(x) \lor q(x))) \)?

I. \( \forall x(\neg p(x) \land \neg q(x)) \)
II. \( \neg(\exists y(p(y) \lor q(y)) \)
III. \( \exists x(\neg p(x) \land \neg q(x)) \)

(a) I only
(b) II only
(c) III only
(d) I and II only
(e) I, II and III
6. This question concerns the undirected, weighted graph shown here:

What is the total weight of the minimum cost spanning tree of this graph?

(a) 5  
(b) 6  
(c) 7  
(d) 8  
(e) 9
7. Which of the following is/are true in a strongly typed programming language?

   I. All variables must be declared before first being referenced.
   II. All variables are declared statically.
   III. No legal program contains a type error.

(a) I only  
(b) III only  
(c) I and II only  
(d) I and III only  
(e) II and III only
8. Which of the following statements about directed graphs is (are) true?

I. The total in-degree of all nodes is equal to the total out-degree of all nodes.
II. Every directed graph has a cycle.
III. If (A, E, G, B) is a shortest path from A to B, then (B, G, E, A) must be a shortest path from B to A.

(a) I only
(b) II only
(c) III only
(d) I and II only
(e) II and III only
9. This question concerns the following two database relations.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>B</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What is the result of a natural join of these relations?

(a) 4 5 6 2 4  
(b) 1 2 3 1 3  
(c) 1 2 3 4  
(d) 1 2 3  
(e) the natural join of these relations is empty
10. Which of the following statements about formal language $L$ is (are) true?

I. If $L$ is accepted / recognized by a nondeterministic finite automaton, then it can be accepted / recognized by some deterministic finite automaton.

II. If $L$ is accepted / recognized by a nondeterministic push-down automaton, then it can be accepted / recognized by some deterministic push-down automaton.

III. If $L$ is generated by a context-free grammar, then it can be generated by some regular expression.

(a) I only
(b) II only
(c) I and II only
(d) II and III only
(e) I, II and III
11. A computer uses paging to manage physical memory. Each page contains 1024 words. The page table of a process is shown below. Assume that each page is resident in some page frame in memory.

<table>
<thead>
<tr>
<th>Virtual page number</th>
<th>Physical page number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>

What is the physical address of word 5250 of the process?

(a) 130
(b) 5120
(c) 5250
(d) 6274
(e) 10370
12. Consider the following recursive function.

```plaintext
int f (int n)
    if ( n == 4 )
        return 2
    else
        return 2 * f ( n + 1 )
    end if
end fun
```

What is the value returned by the function call \( f(2) \)?

(a) 2  
(b) 4  
(c) 8  
(d) 16 
(e) 24
13. We can represent a tree as a list using the notation $< x, T_1, T_2, \ldots, T_n >$, where $x$ is the content of the root of the tree and $T_1, T_2, \ldots, T_n$ are the first, second, ... $n^{th}$ subtrees rooted at the node containing $x$. Which of the following trees has a height of 2?

I. $< 0, < 1, < 3 > >, 2 >$
II. $< 0, < 1, < 2, < 3 >, < 4, < 5 >>>>, 6 >$
III. $< 0, < 1 >, < 2, < 3 >, < 4 >>>, < 5, < 6 >>>$

(a) I only
(b) II only
(c) I and II only
(d) I and III only
(e) II and III only
14. What is the Hamming distance between the bit pattern 00110111 and the bit pattern 00010011?

(a) 1  
(b) 2  
(c) 4  
(d) 6  
(e) 8
15. Which of the following C++ expressions does not always correctly compute the mean of the integer variables a, b, c and d?

(a) float((a + b + c + d) / 4.0)
(b) (a + b + c + d) / 4
(c) (float(a + b + c + d)) / 4
(d) (a + b + c + d) / 4.0
(e) (a + float(b) + c + d) / 4
16. Which of the following are examples of version control systems?

I. CVS
II. Git
III. Subversion

(a) II only
(b) I and II only
(c) I and III only
(d) II and III only
(e) I, II and III
17. A computer has a symmetric multi-processor architecture. Each processor uses a load-store memory access model, i.e., there are no memory-to-memory instructions. The hardware ensures cache coherency. The variable $x$ is shared by four threads, and the threads concurrently execute the instruction $x \leftarrow x + 1$. If the initial value of the memory location $x$ is 10, which of the following is not a possible final value of $x$?

(a) 10
(b) 11
(c) 12
(d) 13
(e) 14
18. In a certain piece of software, temporary file names consist of two alphabetic characters followed by two digits. The letters must be different, and the first digit cannot be a zero. How many different file names are possible?

   (a) 5,850
   (b) 6,500
   (c) 58,500
   (d) 62,192
   (e) 67,600
19. If A, B and C are Boolean variables, and \( \land \) and \( \lor \) denote Boolean “and” and “or” respectively, which of the following is (are) true?

I. \( A \land (B \lor C) = (A \land B) \lor (A \land C) \)
II. \( A \lor (B \land C) = (A \lor B) \land (A \lor C) \)
III. \( (B \lor A) \land C = C \land (A \lor B) \)

(a) I only
(b) II only
(c) I and II only
(d) II and III only
(e) I, II, and III
20. In a certain programming language, characters are stored in a single word of memory. Strings are stored as arrays of characters, with the end of the string marked by a special bit value that is different from any legal character.

What is the best case time complexity required to print the concatenation of a string of length \( m \) and a string of length \( n \)?

(a) \( O(1) \)
(b) \( O(m + n) \)
(c) \( O(mn) \)
(d) \( O(\max(m, n)) \)
(e) \( O(\min(m, n)) \)
21. If \( \land \) and \( \lor \) denote Boolean “and” and “or” respectively, which of the following expressions is (are) in conjunctive normal form?

I. \( A \lor (B \land C) \)
II. \( (A \lor B) \land C \)
III. \( A \lor B \lor (A \land C) \)

(a) I only
(b) II only
(c) III only
(d) I and II only
(e) I, II and III
22. The following subprogram exchanges the values stored in its arguments when called:

```plaintext
swap (pass-by-reference int x, pass-by-reference int y)
    int temp ← x
    x ← y
    y ← temp
end swap
```

The parameter passing mode of `x` is changed to pass by value and the following segment of code is executed:

```plaintext
int a = 1
int b = 3
swap (a, b)
```

What are the final values of `a` and `b`?

(a) 1, 3
(b) 3, 1
(c) 3, 3
(d) 1, 1
(e) Undefined, as an error will occur when swap is executed
23. In this question, $\epsilon$ denotes the empty string, and $+$ denotes "alternation" or the "or" operation on regular expressions. Which of the following regular expressions generate(s) no string with two consecutive 1’s?

I. $(1 + \epsilon)(01 + \epsilon)^*$
II. $(01 + 10)^*$
III. $(0 + 1)^*(0 + \epsilon)$

(a) I only
(b) II only
(c) III only
(d) I and II only
(e) II and III only