2023 Academic Challenge

REGIONAL COMPUTER SCIENCE EXAM

Computer Science Test Production Team

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GENERAL DIRECTIONS

Please read the following instructions carefully. This is a timed test; any instructions from the test supervisor should be followed promptly.

The test supervisor will give instructions for filling in any necessary information on the answer sheet. Most Academic Challenge sites will ask you to indicate your answer to each question by marking an oval that corresponds to the correct answer for that question. One oval should be marked to answer each question. Multiple ovals will automatically be graded as an incorrect answer.

Be sure ovals are marked as ⬤ , not ⦿ , ◑ , ◐ , etc.

If you wish to change an answer, erase your first mark completely before marking your new choice.

You are advised to use your time effectively and to work as rapidly as you can without losing accuracy. Do not waste your time on questions that seem too difficult for you. Go on to the other questions, and then come back to the difficult ones later if time remains.

Time: 40 Minutes   Number of Questions: 30

DO NOT OPEN TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO!

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For each question select the best option. Assume required header files and libraries are included for example programs.

1. Which is *not* a function of a kernel component of an operating system?
   (a) Managing hardware devices
   (b) Processes handling
   (c) Interrupt handling
   (d) Providing an interactive prompt
   (e) Providing an abstraction layer

2. Non-volatile memory has the property of:
   (a) Serving as a hardware cache on a central processing unit
   (b) Is typically implemented with a flip-flop circuit
   (c) Being able to store information without constant power
   (d) Needing to be refreshed regularly
   (e) Not being able to be overwritten once set

3. Internet Protocol version 4 (IPv4) has:
   (a) No limit to the number of unique addresses
   (b) No defined address space
   (c) Approximately 2 million unique addresses
   (d) Approximately 4 billion unique addresses
   (e) Approximately 10^{38} unique addresses

4. The Hypertext Transfer Protocol (HTTP) is:
   (a) Only intended for local area network traffic
   (b) A request-response protocol
   (c) The standard protocol for electronic mail transmission
   (d) The standard protocol for the transfer of computer files
   (e) Defines the transmission control protocol (TCP)

5. Which of the following is *not* a reduced instruction set computer architecture?
   (a) ARM
   (b) x86-64
   (c) Power ISA
   (d) RISC-V
   (e) SPARC

6. Which of the following is a relational database management system?
   (a) ObjectDB
   (b) Apache Giraph
   (c) Extensible Storage ENgine
   (d) Redis
   (e) MySQL

7. Which of the following is true of public-key cryptography?
   (a) Anyone with a public key can decrypt a message
   (b) Is an example of symmetric cryptography
   (c) Is an example of quantum cryptography
   (d) Typically based on one-way functions
   (e) Is too impractical to implement for the web

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8. What is the decimal representation of the hexadecimal number 0x1F75 :
   (a) 8053
   (b) 11575
   (c) 4989
   (d) 17565
   (e) 22513

9. What logic operation is represented by the NAND construction below, where A and B are inputs and C is the output:
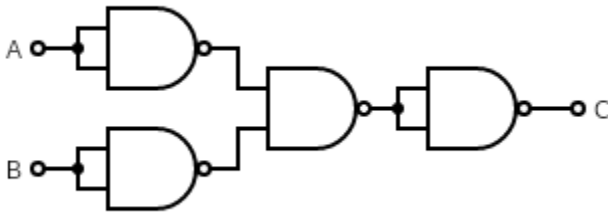
   (a) OR
   (b) NOR
   (c) XNOR
   (d) NOT
   (e) AND

10. Which of the following expressions are identical to $(\overline{A \cdot C} + C \cdot B) \cdot B + \overline{C \cdot D}$:
    (a) 1
    (b) 0
    (c) $B \cdot (\bar{A} + C) + \bar{C} + \bar{D}$
    (d) $B + \bar{C} + \bar{D}$
    (e) $B + C + D$

11. Which of the following produce the logic table below?

A	B	C	Output
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

    (a) $A + B + C$
    (b) $A \cdot B \cdot C$
    (c) $\bar{A} + \overline{B \cdot C}$
    (d) $\bar{B} + \overline{A \cdot C}$
    (e) $B \cdot (A + C)$

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12. What decimal number is represented by the two's complement 8-bit binary number 1000 0011?
    (a) -125
    (b) -124
    (c) 131
    (d) -3
    (e) 3

13. Which of the following logic gates can be used to implement any Boolean function?
    (a) AND
    (b) NOR
    (c) NOT
    (d) OR
    (e) NIMPLY

14. What is the output of the following program:

```
01  #include <iostream>
02
03  int main()
04  {
05      int j = 0;
06      do {
07          j = (j | 1) * 4;
08          std::cout << j << " ";
09      } while (j < 512);
10      std::cout << "\n";
11      return 0;
12  }
```

    (a) Does not terminate
    (b) Buffer overflow
    (c) 4 20 84 340 1364
    (d) 4 20 84 340
    (e) 4 16 32 64 128 256

For questions 15 and 16 consider the following program:

```
01  #include <iostream>
02  #include <bitset>
03  using namespace std;
04
05  void bit_shift(uint8_t& a)
06  {
07      a = a << 2;
08  }
09
10  void bit_shift2(uint8_t a)
11  {
12      a = a << 3;
```

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```
13  }
14
15  int main ()
16  {
17      uint8_t x = 0b01111001;
18      uint8_t y = x + 0b11111001;
19      cout << "Q15: " << std::bitset<8>(y) << endl;
20      bit_shift(x);
21      bit_shift2(x);
22      cout << "Q16: " << std::bitset<8>(x) << endl;
23      return 0;
24  }
```

15. What is the rest of the first line of output after "Q15: " from the program above?
  (a) 00000001
  (b) 00000000
  (c) 10010000
  (d) 01110010
  (e) 01111001

16. What is the rest of the second line of output after "Q16: " from the program above?
  (a) 11111001
  (b) 11100100
  (c) 11100101
  (d) 01110010
  (e) 01101011

For questions 17 and 18 consider the following program:

```
01  #include <iostream>
02  using std::cout, std::endl;
03  namespace N
04  {
05  int x = 6;
06  }
07  int y = 2;
08
09  int main()
10  {
11      int x = -5;
12      using namespace N;
13      cout << "Q17:";
14      for (int y = 0; y < 4; ++y) {
15          x += y;
16          cout << " " << x;
17      }
18      cout << "\nQ18: " << y << endl;
19  }
```

17. What is the rest of the first line of output after "Q17: " from the program above?
  (a) Error: namespace out of scope
  (b) 6 7 9 12 16
  (c) 6 7 9 12
  (d) -5 -4 -2 1 5
  (e) -5 -4 -2 1

18. What is the rest of the first line of output after "Q18: " from the program above?
    (a) Error: multiple declarations
    (b) 1
    (c) 2
    (d) 3
    (e) 4

For questions 19 and 20 consider the following program:

```
1    #include <iostream>
2    #include <string>
3    using namespace std;
4
5    int main ()
6    {
7        float a = 1 / 10;
8        float b = 2.0f / 10.0f;
9        string opinion = a + b == 3 / 10.0f ? "great" : "complicated";
10       cout << "Mixed arithmetic in C++ is " << opinion << "!" << endl;
11       return 0;
12   }
```

19. What is the output of the program?
    (a) Compilation error: incompatible types
    (b) Runtime error: unexpected stream
    (c) Mixed arithmetic in C++ is complicated!
    (d) Mixed arithmetic in C++ is great!
    (e) Mixed arithmetic in C++ is TRUE great and complicated!

20. On line 9 of the source code there is a ternary operator. In *general,* this conditional operator expression has what value category?
    (a) lvalue
    (b) prvalue
    (c) xvalue
    (d) none of the above
    (e) any of a, b, or c

21. What is the output of the following program:

```
1    #include <iostream>
2    using namespace std;
3
4    int flatten(int n)
5    {
6        int x = 3;
7        int y = 0;
8        int z = -4;
9        while (y < n) {
10           ++z;
11           x = x * 3 - 1;
12           y += x;
13       }
```

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```
14        return n + z;
15    }
16
17    int main()
18    {
19        cout << flatten(20) << endl;
20        return 0;
21    }
```

    (a) 20
    (b) 18
    (c) 16
    (d) 31
    (e) flatten(20)

For questions 22-25 consider the following program:

```
1     #include <iostream>
2     using namespace std;
3
4     constexpr int xf = 5;
5     constexpr int yf = 5;
6     int bc[xf + 1][yf + 1];
7
8     int bcf(int x, int y)
9     {
10        int bcxy;
11        if (bc[x][y] != 0) {
12            bcxy = bc[x][y];
13        } else if (x == y || y == 0) {
14            bcxy = 1;
15        } else {
16            bcxy = bcf(x - 1, y - 1) + bcf(x - 1, y);
17            bc[x][y] = bcxy;
18        }
19        return bcxy;
20    }
21
22    int main()
23    {
24        for (int i = 0; i <= xf; ++i) {
25            for (int j = 0; j <= i; ++j) {
26                cout << bcf(i, j) << " ";
27            }
28            cout << "\n";
29        }
30        return 0;
31    }
```

22. What is the final line of output from the program?
    (a) Runtime error: index out of bounds
    (b) 1 4 6 4 1
    (c) 1 5 10 10 5 1
    (d) 1 6 15 20 15 6 1
    (e) 1 1 1 1 1 1

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23. What programing technique(s) are implemented by the bcf function?
    (a) Memoisation
    (b) Byte encoding
    (c) Tree traversal
    (d) Both a and b
    (e) None of the above

24. What is the time complexity of the *program* in xf?
    (a) $O(xf^2)$
    (b) $O(xf \cdot log(xf))$
    (c) $O(xf)$
    (d) $O(log(xf))$
    (e) $O(1)$

25. What is the space complexity of the *program* in xf?
    (a) $O(xf^2)$
    (b) $O(xf \cdot log(xf))$
    (c) $O(xf)$
    (d) $O(log(xf))$
    (e) $O(1)$

26. For randomly ordered data which of the following do *not* have $O(n \cdot log(n))$ average performance:
    (a) Merge sort
    (b) Tree sort
    (c) Quicksort
    (d) Heapsort
    (e) Insertion sort

27. In a breadth first search, what order are the nodes in the following tree traversed if the root is H?
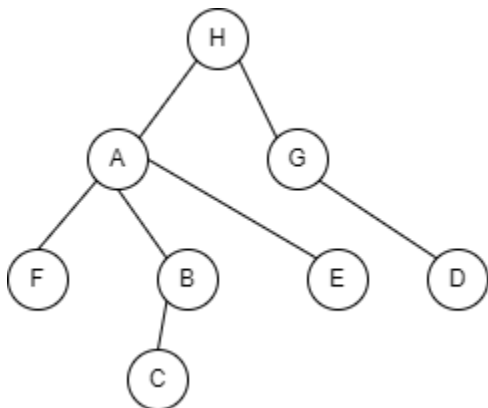
    (a) A B C D E F G H
    (b) H A F B C E G D
    (c) F C B E A D G H
    (d) F A C B E D G H
    (e) H A G F B E D C

28. Which of the following is not a way to store a sparse matrix:
    (a) Compressed sparse row
    (b) Compressed sparse column
    (c) Dictionary of keys
    (d) Circular array
    (e) Coordinate list

29. Linear programming refers to:
    (a) Writing code all on one line
    (b) Navigating a program with only the 'j', 'k'. 'l', and ';' keys.
    (c) Programing using only algorithms that run in linear time
    (d) Mathematical optimization of a set of linear relationships
    (e) Programing for processors with linear shift registers instructions

30. Which of the following is not a type of polymorphism:
    (a) Row polymorphism
    (b) Chimeral polymorphism
    (c) Parametric polymorphism
    (d) Subtyping
    (e) Ad hoc polymorphism

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