

Academic Challenge 2021

Sectionals

Computer Science

Select the single best answer to each question. All code examples are in C++ and are monospace font. Assume required headers are included for partial programs.

1. Which logical database model is organized as a directed graph where records are associated with nodes, and nodes can have multiple children and parents?

- A. Network Database
- B. Object-Oriented Database
- C. Relational Database
- D. Hierarchical Database
- E. Multivalued Databases

2. Which expression is equivalent to $\overline{D} \cdot A + \overline{A \cdot (B \cdot C + C \cdot B)}$:

- A. $B \cdot \overline{D} + B \cdot \overline{C}$
- B. $D + \overline{A} + (\overline{B} + \overline{C}) \cdot (\overline{C} + \overline{B})$
- C. $\overline{D} \cdot A + \overline{A} \cdot \overline{(B \cdot C)}$
- D. $\overline{A} + \overline{B} + \overline{C} + \overline{D}$
- E. $A \cdot B \cdot C \cdot D$

3. What is the console output from running the following program:

```
01 #include <iostream>
02 using namespace std;
03
04 int myFunction(int n) {
05     if (n == 0) {
06         return 1;
07     } else {
08         return (myFunction(n-1) + myFunction(n-2));
09     }
10 }
11
12 int main() {
13     int testVals[6] = {0, 1, 2, 3, 5, 7};
14     for (int i = 0; i < 6; ++i){
15         std::cout << myFunction(testVals[i] + 1) << " ";
16     }
17 }
```

- A. 1 1 2 3 8 21
- B. 1 1 3 5 9 13

- C. -1 1 3 5 9 13
- D. None of the above - runtime error
- E. None of the above - compilation error

4. What is the output of the following program:

```
01 #include <iostream>
02 using namespace std;
03
04 class gem {
05     private:
06         static double hardness;
07         double carat;
08
09     public:
10         gem(double mohs, double weight) {
11             hardness = mohs;
12             carat = weight;
13         }
14
15         void print() {
16             cout << "hardness: " << hardness;
17             Cout << ", carat: " << carat << endl;
18         }
19 };
20
21 double gem::hardness = 0;
22 double carat = 0;
23
24 int main() {
25     gem diamond(10., 2.0);
26     gem ruby(9., 0.8);
27
28     diamond.print();
29     ruby.print();
30 }
```

- A. hardness: 10, carat: 2
hardness: 9, carat: 0.8
- B. hardness: 9, carat: 2
hardness: 9, carat: 0.8
- C. hardness: 0, carat: 0
hardness: 0, carat: 0
- D. hardness: 0, carat: 2
hardness: 0, carat: 0.8
- E. Run time error, the gem constructor cannot modify a static member

5. The code in question 4 is an example of which of the following concepts:

- A. Class variables
- B. Inheritance

- C. Polymorphism
- D. Generic programming
- E. Open recursion

6. What is the output of the following code:

```
01 #include <iostream>
02 using namespace std;
03
04 int main() {
05     int x = 128;
06     do {
07         x = x >> 2;
08         cout << x << " ";
09     } while (x > 0);
```

- A. 32 8 2
- B. 64 32 16 8 4 2 1
- C. 32 8 2 0
- D. 1
- E. Run time error, integer out of bounds

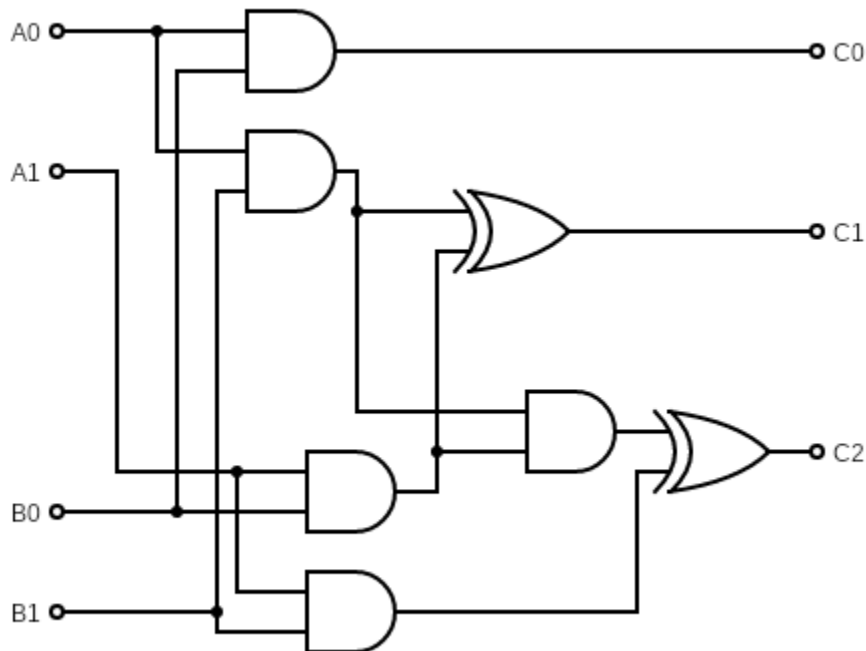
7. What is the output of the following program?

```
01 #include <iostream>
02 using namespace std;
03
04 int quotient(double x, double y){
05     return x/y;
06 }
07
08 double quotient(int x, int y){
09     return x/y;
10 }
11
12 int main() {
13     double x = -7.0, y = -3.8;
14     int a = -7.0, b = -3.8;
15     cout << quotient(x,y) << " " << quotient(a,b) << endl;
16 }
```

- A. 1 1
- B. 2 2
- C. 1 2
- D. 1 1.75
- E. 2 1.75

8. Given input {A1, A0, B1, B0} = {1, 1, 1, 0}, what does the digital logic circuit shown output for

{C2, C1, C0}:



- A. {1, 1, 0}
- B. {1, 0, 1}
- C. {0, 0, 1}
- D. {1, 0, 1}
- E. {1, 0, 0}

9. ALOHAnet was a computer networking system using a hub machine (called Menehune) wirelessly broadcasting to and receiving from various remote units. Which of the following best describes this network topology:

- A. Bus network
- B. Tree network
- C. Star network
- D. Mesh network
- E. Peer-to-peer network

10. Which of the following is not characteristic of a reduced instruction set computer (RISC) architecture:

- A. Limited instruction set
- B. Limited addressing modes
- C. Optimized register usage
- D. A small number of general purpose registers.
- E. Optimized instruction pipeline

11. What is the output of running the following program:

```

01 #include <iostream>
02 using namespace std;
03
04 int fun(int x, int &y){
05     return x + y++;
06 }
07
08 int main ()
09 {
10     int a = 1, b = fun(a,a), c = fun(b,b);
11
12     cout << a << " " << b << " " << c << endl;
13
14     return 0;
15 }

```

- A. Compile error
- B. 1 2 4
- C. 2 3 4
- D. 2 4 7
- E. 1 3 7

12. Given the declarations

```

01 struct album {
02     string title;
03     string artist;
04 };
05
06 struct fan {
07     string name;
08     album favorite_album;
09 } alice, bob;
10
11 fan *pfans = &bob;

```

Which of the following are not valid expressions:

- A. alice.favorite_album.title;
- B. bob.name;
- C. pfans.name;
- D. bob.favorite_album.artist;
- E. pfans->favorite_album.artist;

13. Given the following declaration:

```
int *x = new x[5];
```

What is the correct way to free the memory associated with this declaration?

- A. `for (int i = 0; i < 5; i++) delete x[i];`
- B. `delete x*;`
- C. `delete x;`
- D. `delete [] x;`
- E. `delete x [];`

14. What is the output of the following program:

```
01 #include <iostream>
02 using namespace std;
03
04 double x = 3.14;
05
06 namespace e
07 {
08     double x = 2.72;
09 }
10
11 int main() {
12     double x = 1.62;
13     cout << x + e::x + ::x << endl;
14 }
```

- A. 7.48
- B. 4.86
- C. 7.06
- D. 1.62 2.72 3.14
- E. Error, `::x` references an unknown namespace

15. What is the output of the following program:

```
01 #include <iostream>
02
03 int main() {
04     int i, x;
05     i = 3;
06     x = 1;
07     for (int i; i < 6; i++) {
08         x *= 2;
09     }
10
11     std::cout << x << std::endl;
12 }
```

- A. 1
- B. 8
- C. 16
- D. 32
- E. 64

16. What is the output of the following program:

```
01 #include <iostream>
02
03 int main() {
04     int A[8] = {1, 2, 3, 4, 5, 6, 7, 8};
05     int i = 0, j = 0;
06     while(i < 8){
07         std::cout << *(A+j%8) << " ";
08         j += 3;
09         i += 1;
10     }
11 }
```

- A. 1 4 7
- B. 1 2 3 4 5 6 7 8
- C. 1 4 7 2 5 8 3 6
- D. 1 2 3
- E. 8 8 8 8 8 8 8 8

17. Given the negative binary (base -2) expression $01111_{-2} - 10110_{-2}$ what is the evaluation in decimal:

- A. 13
- B. -7
- C. -23
- D. 5
- E. 6

18. What is the output of the following program:

```
1 #include <iostream>
2
3 int main() {
4     for (int i = 0; i < 10; ++i){
5         if (!(i < 3 || i > 6)) continue;
6         if (i == 5) break;
7         std::cout << i << " ";
8     }
9 }
```

- A. 3 4
- B. 0 1 2
- C. 0 1 2 7 8 9
- D. 3 4 5
- E. 0 1 2 3 4 5 6 7 8 9

Consider the following code for questions 19 – 21:

```
01 #include <iostream>
02 using namespace std;
03
04 int main() {
05     int N = 6;
06     for (int n = 0; n < N; n++) {
07         int val = 1;
08         for (int k = 0; k <= n; k++) {
09             cout << " " << val;
10             val = val * (n - k) / (k + 1);
11         }
12         cout << endl;
13     }
14     return 0;
15 }
```

19. What is the last line printed to the standard output?

- A. 1 4 6 4 1
- B. 1 5 10 10 5 1
- C. 1 2 3 2 1
- D. 0 4 9 9 4 0
- E. 1 5 2 1 0 0

20. Which of the following describes the value at the k th entry of the n th row:

- A. $n!$
- B. $k!/n!$
- C. $n!/k!$
- D. $n!/(k! \cdot (n - k!))$
- E. $(n - k)!/(k + 1)!$

21. What is the runtime of the code?

- A. $O(N)$
- B. $O(N^{1.5})$
- C. $O(N^2)$
- D. $O(\log_2(N))$
- E. $O(\sqrt{N})$

For questions 22 and 23 consider the following program

```
01 #include <iostream>
02 using namespace std;
03
04 int main() {
05     const unsigned int mask1 = 0b01010101; // periodic mask up to 8 bits
06     const unsigned int mask2 = 0b00110011;
07     const unsigned int mask4 = 0b00001111;
08
09     unsigned int x = 0x6A;
10     cout << x << endl;
```



```

11
12     x = (x & mask1 ) + ((x >> 1) & mask1 );
13     x = (x & mask2 ) + ((x >> 2) & mask2 );
14     x = (x & mask4 ) + ((x >> 4) & mask4 );
15
16     cout << x << endl;
17 }

```

22. What is the first line printed by the program:

- A. 70
- B. 16
- C. 512
- D. 32
- E. 106

23. What is the last line printed by the program:

- A. 0
- B. 8
- C. 3
- D. 4
- E. NaN

For questions 24 - 26 consider the following program:

```

01 #include <iostream>
02 using namespace std;
03
04 class Arthropod {
05     protected:
06         string color;
07         int legs;
08     public:
09         Arthropod() : color{"blue"}, legs(0) {}
10         Arthropod(string s, int x) : color(s),legs(x){}
11         void set_color(string c){ color = c; }
12         void print() {
13             cout << "Arthropod. Color: " << color;
14             cout << ", Legs: " << legs << endl;
15         }
16 };
17
18 class Lobster: public Arthropod {
19     public:
20         Lobster(string s, int x) : Arthropod(s, x) {}
21         void print () {
22             cout << "This is a " << color;
23             cout <<" lobster with " << legs << " legs." << endl;
24         }
25 };

```

```

26
27 int main () {
28     Lobster lobster("brown",8);
29     Arthropod *apod = &lobster;
30     apod->set_color("red");
31     lobster.print();
32     return 0;
33 }

```

24. What is the output of the program?

- A. This is a brown lobster with 8 legs.
Arthropod. Color: brown, Legs: 8
- B. This is a red lobster with 8 legs.
- C. This is a brown lobster with 8 legs.
- D. Arthropod. Color: red, Legs: 8
- E. Arthropod. Color: brown, Legs: 8

25. Line 29 is an example of:

- A. Copy constructor
- B. Constant casting
- C. Polymorphism
- D. Multiple Inheritance
- E. Static casting

26. If we add a new class defined:

```

1 class Crab: private Arthropod{
2     public:
3         Crab(string s, int x) : Arthropod(s, x) {}
4         void print(){
5             cout << "I'm a crab!" << endl;
6         }
7     } MrKrabs;

```

which of the following are valid statements:

- A. MrKrabs.print()
- B. Arthropod *a2 = &MrCrabs;
- C. MrKrabs.set_color("green");
- D. None of the above
- E. A, B, and C are all valid

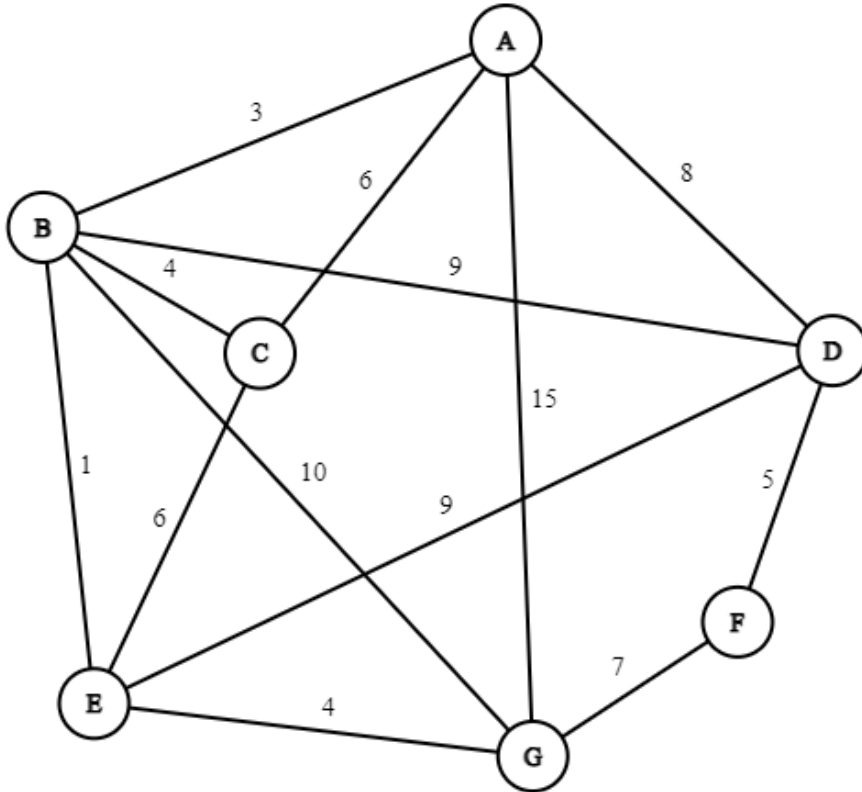
27. Which of the following represents the order from fastest to slowest of access times for typical storage devices?

- A. Processor register, processor cache, random access memory, magnetic drives, magnetic tape
- B. Processor cache, Processor registers, random access memory, magnetic drives, magnetic tape
- C. Processor cache, Processor registers, random access memory, magnetic tape, magnetic drives
- D. Processor register, random access memory, processor cache, magnetic drives,

magnetic tape

- E. Processor cache, Processor register, random access memory, magnetic drives, magnetic tape

For questions 28 - 30 consider the following graph where edges represent distances:



28. Starting at node A which of the following are valid breadth first search traversals of the graph.
- A. ABCDEFG
 - B. ABCGDEF
 - C. ABEGFDC
 - D. ACEGFDB
 - E. A cyclically connected graph cannot be traversed by a breadth first search algorithm
29. What is the length of the shortest route from node C to F?
- A. 3
 - B. 4
 - C. 16
 - D. 17
 - E. 18
30. Which of the following algorithms could be implemented to solve Question 28?
- A. Dijkstra's Algorithm
 - B. Minimum spanning tree
 - C. Feasible Flow
 - D. Traveling salesman

E. Spanning fill