American Computer Science League

2019-2020 **ACSL Finals**

Intermediate and Classroom Shorts

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1. Boolean Algebra

Simplify the following Boolean expression to use AND, OR, and NOT operators with no parentheses. How many OR operators are there?

$$\overline{A + \overline{B}C} + \overline{B + \overline{AC}} + \overline{\overline{C} + AB}$$

A. 0
B. 1
C. 2
D. 3
E. None of the above

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2. Boolean Algebra

Define a new operator, $, as follows: $A \$ B = \overline{A\,\overline{B} + \overline{A}}$

It has the highest precedence among binary operators.

How many ordered triples make the following FALSE?

$$A \$ B + B \$ C + \overline{A} \$ \overline{C}$$

A. 0
B. 1
C. 3
D. 5
E. None of the above

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3. Bit-String Flicking

Evaluate the following bit string expression if

X = 01101 and Y = 10110.

```
(RSHIFT-1 (LCIRC-3 X)) OR
(NOT (LSHIFT-1 ((RCIRC-2 X) & Y)))
```

A. 11111
B. 00101
C. 01101
D. 00000
E. None of the above

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4. Bit-String Flicking

How many different values of x (a bitstring of 5 bits) make the following equation true?

```
(LCIRC-2 01010) OR
(RSHIFT-1 ((LCIRC-2 X) AND 01110))
= 01101
```

A. 0
B. 4
C. 8
D. 10
E. None of the above

5. Recursive Functions

Find $f(f(f(f(30))))$ where $[x]$ is the greatest integer function:

$$f(x) = \begin{cases} 2 \cdot f\left(\left[x/2\right]\right) - 3 & \text{if } x \text{ is odd and } x \text{ is a multiple of } 3 \\ f(x+3) + 1 & \text{if } x \text{ is even and } x \text{ is a multiple of } 3 \\ x - 1 & \text{otherwise} \end{cases}$$

A. 22
B. 21
C. 15
D. 9
E. None of the above

6. Recursive Functions

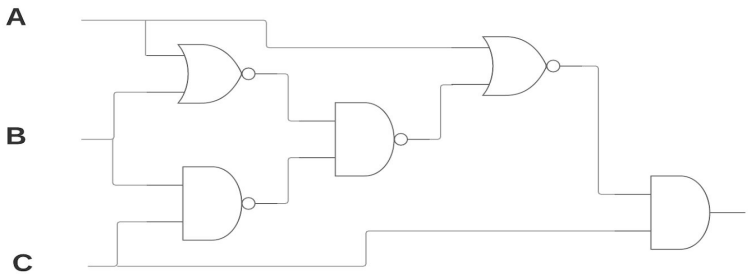
Find $f(14, 20)$ given:

$$f(x,y) = \begin{cases} f(x+1, y-2) + f(y,x) + 1 & \text{if } x < y \\ f\left(f\left(x/2, y\right), x/2\right) - 3 & \text{if } x = y \\ x - y & \text{if } x > y \end{cases}$$

A. 19
B. 18
C. 11
D. 10
E. None of the above

7. Digital Electronics

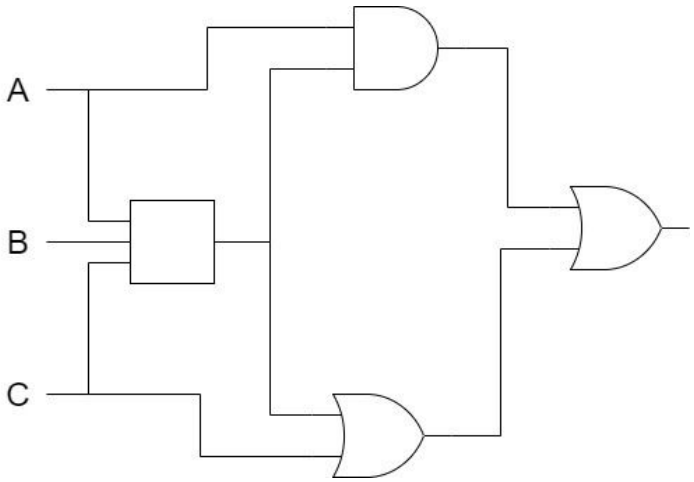
Find all ordered triples that make the following circuit TRUE. Your answer will be a single 3-character string in the format XYZ where each X Y Z is either 0, 1, or * (e.g. 0*1, 110, **0).



A. *01
B. 100
C. 0*0
D. 001
E. None of the above

8. Digital Electronics

Define a new gate , ☐ , with 3 inputs. It is TRUE if there is exactly one TRUE input. How many ordered triples make the following digital circuit TRUE?



A. 0
B. 2
C. 4
D. 6
E. None of the above

9. Prefix-Infix-Postfix

Define: a # b = minimum of {a,b}
a $ b = average of a and b
a& = absolute value of a

Evaluate this postfix expression if all numbers are single digits:

2 4 # 4 2 $ 5 - & + 8 2 $ 7 3 $ * - &

A. 25
B. 29
C. 27
D. 21
E. None of the above

10. Prefix-Infix-Postfix

Evaluate this prefix expression if a = 1, b=3, c=5, and d=2:

*** / + a * b c * a ^ d 3 ^ b - c * 3 a**

A. 9
B. 11
C. 17
D. 18
E. None of the above

11. Computer Number Systems

How many 1's are there in the binary representations of the decimal numbers 50 to 64 inclusive?

A. 56
B. 60
C. 62
D. 70
E. None of the above

12. Computer Number Systems

Evaluate and express the result in hexadecimal:

$$2020_8 - 202_8 - 20_8 + 2_8$$

A. 700
B. 1F0
C. 380
D. 160
E. None of the above

13. Data Structures

What would be the next item popped given the following initially empty queue?

PUSH(R), PUSH(H), PUSH(O), PUSH(D), POP(X), POP(X), PUSH(O), POP(X), PUSH(D), PUSH(E), PUSH(N), POP(X), PUSH(D), PUSH(R), POP(X), POP(X), PUSH(O), PUSH(N), POP(X), POP(X), POP(X)

A. D
B. E
C. N
D. R
E. None of the above

14. Data Structures

How many nodes have only a left child in the binary search tree for:

CORONAVIRUS

A. 4
B. 5
C. 6
D. 8
E. None of the above

15. Graph Theory

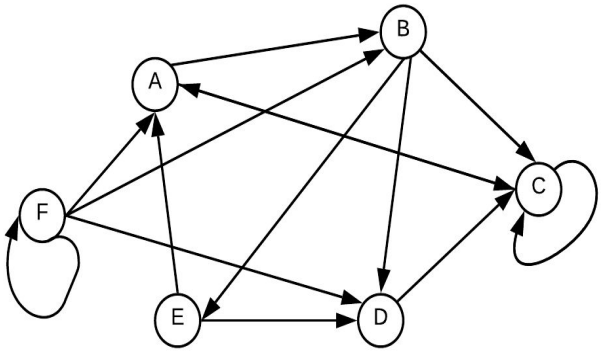
How many cycles are there in the graph represented by the given adjacency matrix?

$$\begin{bmatrix} 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 1 & 0 & 1 & 0 \end{bmatrix}$$

A. 7
B. 6
C. 5
D. 4
E. None of the above

16. Graph Theory

Which two vertices have the most paths of length 2 between them? Write a 2-character string with the starting vertex followed by the ending vertex.



A. FA
B. AC
C. FC
D. BA
E. None of the above

17. What Does This Program Do?

What will be printed when this program is executed?

```
Y = 2020 : S = 0 : N = 0 : F = 0
for A = 1 to Y
    if INT(Y / A) == Y / A then
       S = S + A
       N = N + 1
   end if
   if S > Y and F = 0 then
       output N - 1
     F = 1
   end if
next
```

A. 8
B. 9
C. 10
D. 11
E. None of the above

18. LISP

After the following LISP program is run, what is the value of the last expression?

(SETQ Z '(C(O N)(N(E C)T)(I(C(U)T))))
(SETQ Y (CAR (REVERSE (CDR (CDR Z)))))
(CAR (CDR (CAR (CDR Y))))

A. (C (U) T)
B. (U)
C. ((U) T)
D. U
E. None of the above

19. FSAs and Regular Expressions

Given the regular expression:

[^aeiou]* [aeiou] [fghj-np-t] +. (ing|ful|age|less)?

Which of the following strings are accepted?

a. brush|ing
b. help/ful
c. fractals
d. java
e. python!
f. shapeless
g. igloo
h. apple
i. striving
j. image

A. a, b, d, e, f
B. a, c, d, e, g. h
C. a, b, e, f, h
D. b, d, e, f, h, j
E. None of the above

20. Assembly Language

How many different numbers are printed when the following program is run with input values 13, 24, 37, 45, 51, 60, 74, 0?

```
TOP     READ    N
        LOAD    N
        BE      STOP
        DIV     =10
        STORE   B
        MULT    =10
        STORE   X
        LOAD    N
        SUB     X
        STORE   C
        LOAD    B
        ADD     C
        STORE   M
        DIV     =3
        MULT    =3
        STORE   Y
        LOAD    M
        SUB     Y
        BE      DOWN
        BU      TOP
DOWN    LOAD    N
        PRINT   N
        BU      TOP
STOP    END
```

A. 4
B. 3
C. 2
D. 1
E. None of the above