

2019-2020

## American Computer Science League

ACSL Finals

## Senior Shorts

## 1. Boolean Algebra

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

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

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

## 2. Boolean Algebra

Define a new binary operator, \$, as follows:

$$A \$ B = (A \oplus \overline{B})(\overline{A} \oplus B)$$

It has the highest priority among binary operators.

How many ordered triples make the following TRUE?

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

- A. 0
- B. 4
- C. 6
- D. 8
- E. None of the above

## 3. Bit-String Flicking

Evaluate the following expression. Your answer must be written as a 3-digit base 16 number in the form xyz where each digit is 0-9 or A-F.

$$((\text{NOT } (\text{RCIRC}-7 \text{ AB}_{16})) \text{ XOR } (\text{RSHIFT}-3 (\text{CE}_{16} \text{ AND } 915_{16})))$$

- A. 2722
- B. 9CA
- C. 0CB
- D. 4712
- E. None of the above

## 4. Bit-String Flicking

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

$$((\text{RCIRC}-2 (\text{X AND } 11011)) \text{ OR } (\text{RCIRC}-2 \text{ X}) \text{ XOR } 01110) = (\text{NOT } (\text{LSHIFT}-4 01011))$$

- A. 0
- B. 2
- C. 4
- D. 8
- E. None of the above

### 5. Recursive Functions

Find  $f(14, 20)$  given:

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

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

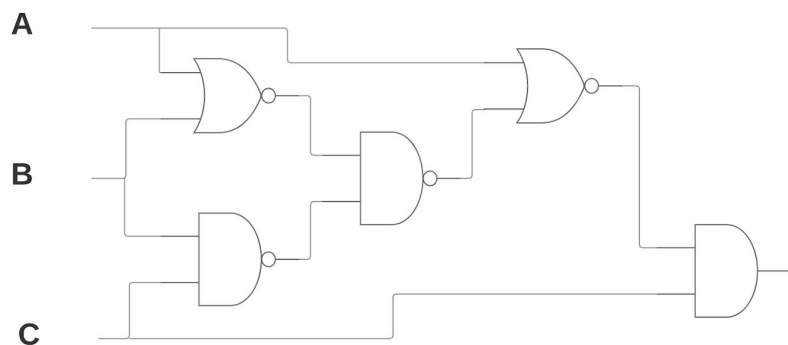
### 6. Recursive Functions

My favorite Oak tree has a trunk that is 128 feet tall. It has 2 branches, each half that length. Each of those branches has 2 branches that are each half the length. If this continues until each branch is 1 foot long, how many total feet of branches is in the entire tree.

- A. 512
- B. 1024
- C. 2048
- D. 4096
- E. None of the above


### 7. Digital Electronics

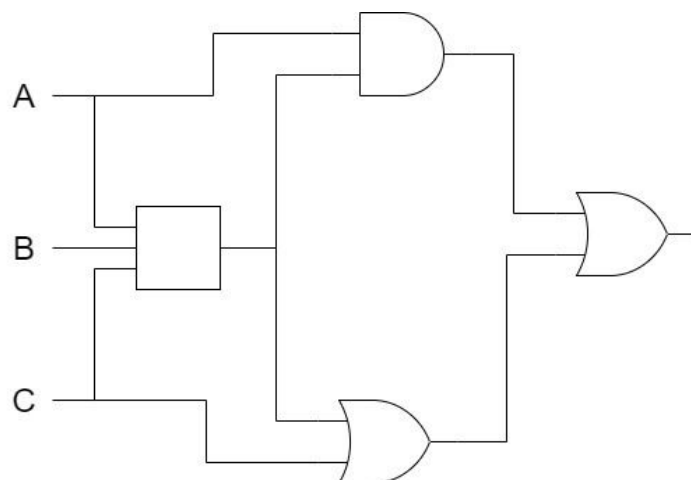
Find all ordered triples that make the following circuit TRUE. Your answer will be a single 3-character string in the format XYZ where each X Y Z is either 0, 1, or \* (e.g. 0\*1, 110, \*\*0).



- 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  $M(x,y,z)$  as a trinary function that returns the smallest value of the three operands,  $A(x,y)$  as a binary function that finds the average of the two operands, and  $R(x)$  as the reciprocal of its operand.

Evaluate the following postfix expression (all numbers are single digits):

3 5 - 0 4 M 4 2 A 6 R \* \* 8 5 3 4 + M 3 A / R

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

### 10. Prefix-Infix-Postfix

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

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

- A. 9
- B. 6
- C. 3
- D. 1
- E. None of the above

**11. Computer Number Systems**

Evaluate and express the result in decimal:

$$2020_{16} - 2020_{10} - 2020_8$$

- A. 5148
- B. 5164
- C. 5224
- D. 11284
- E. None of the above

**12. Computer Number Systems**

How many 1's are in the binary representation of the following expression:

$$(AB_{16} + DA_{16}) * 77_8$$

- A. 10
- B. 11
- C. 12
- D. 13
- E. None of the above

**13. Data Structures**

Perform the following operations on an initially empty queue:

PUSH(C), PUSH(H), PUSH(R), PUSH(Y), POP(X), POP(X),  
PUSH(S), POP(X), PUSH(A), PUSH(N), PUSH(T), POP(X),  
PUSH(H), PUSH(E), POP(X), POP(X), PUSH(M), PUSH(U),  
POP(X), PUSH(M), POP(X), POP(X)

What is the most number of items in the queue at any time?

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

**14. Data Structures**

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

**PROTECTIVEEQUIPMENT**

- A. 2
- B. 4
- C. 6
- D. 9
- E. None of the above

**15. Graph Theory**

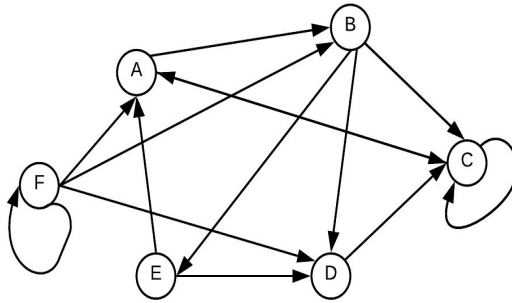
How many cycles are there in the directed graph represented by the following adjacency matrix?

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

- A. 10
- B. 9
- C. 8
- D. 7
- E. None of the above

## 16. Graph Theory

How many pairs of vertices have more than 7 paths of length 4 between them?



- A. 5
- B. 6
- C. 7
- D. 8
- E. None of the above

## 17. What Does This Program Do?

What will be printed when the following program is run?

```
Y = 2020 : S = 0 : N = 0 : F = 0
for A = 1 to Y
  if Y % A == 0 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 CONS expression?

```
(SETQ Z '(C (O N) (N (E C) T) (I (C (U) T))))
(SETQ S (CDR (CDR Z)))
(SETQ Y (CAR (REVERSE S)))
(SETQ X (CAR (CDR (CAR (CDR Y)))))
(SETQ V (CAR (CDR (CAR S))))
(CONS V X)
```

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

## 19. FSAs and Regular Expressions

Given the regular expression:

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

Identify all of the following strings that are accepted.

- |              |              |              |
|--------------|--------------|--------------|
| a. brush ing | f. shapeless | k. grapple   |
| b. help/ful  | g. igloo     | l. rhythmic? |
| c. fractals  | h. apple     | m. allstar   |
| d. java      | i. striving  | n. syzygy    |
| e. python!   | j. image     | o. covid     |

- A. a, b, d, e, f, g
- B. a, c, d, e, l
- C. b, c, d, g, h, n, o
- D. a, b, e, f, h, k
- 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