American Computer Science League

2021 Finals ● Short Problems ● Intermediate/Classroom Divisions

1. Boolean Algebra

Which expressions are equivalent to:

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

a. $AB + \overline{A}B$ b. $A \oplus B$ c. $\overline{A \oplus B}$ d. $A\overline{B} + \overline{A}B$

A. a, b
B. b, c
C. c, d
D. b, d
E. None of the above

2. Boolean Algebra

How many ordered triples make the expression TRUE?

$$(\overline{AB + C})(\overline{A}\,\overline{B} + \overline{C})$$

A. 2
B. 3
C. 4
D. 5
E. None of the above

3. Bit-String Flicking

Evaluate the following expression:

(LSHIFT-3 (RCIRC-2 (NOT (LCIRC-10 011010))))

A. 101000
B. 100110
C. 110000
D. 011001
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?

(X AND (LSHIFT-2 01011)) = (RCIRC-3 00011)

A. 2
B. 4
C. 8
D. 16
E. None of the above

5. Recursive Functions

Given the following recursive function to find the value of a number, b, raised to a given power, e, for e >= 0, what definition will give the value of a number, b, raised to a given power, e, for e < 0 so that 3^-2 = 1/9.

$$f(b, e) = \begin{cases} 1 & if\ e = 0 \\ b \cdot f(b, e - 1) & if\ e > 0 \\ ????? & if\ e < 0 \end{cases}$$

A. $b/f(b, e - 1)$
B. $f(b, e + 1)/b$
C. $f(b, e - 1)/b$
D. $b/f(b, e + 1)$
E. None of the above

6. Recursive Functions

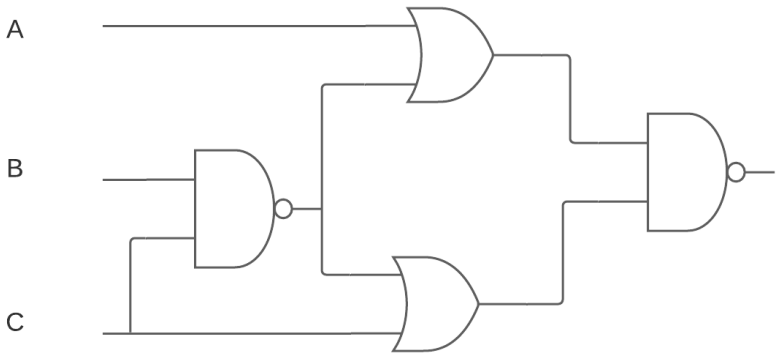
Find $f(1, 20)$ given:

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

A. 38
B. 52
C. 29
D. 71
E. None of the above

7. Digital Electronics

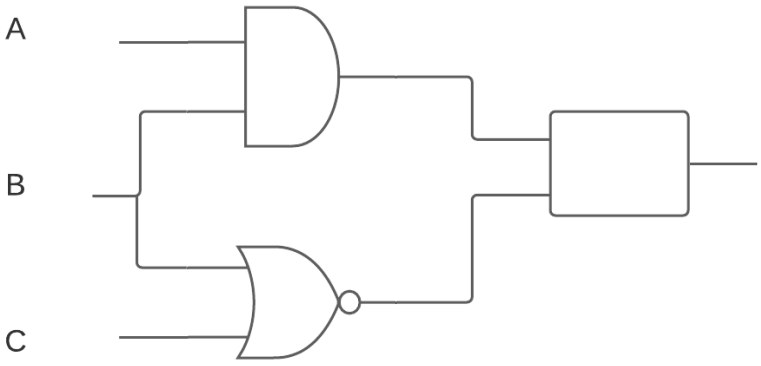
How many ordered triples make the following circuit TRUE?



A. 1
B. 3
C. 5
D. 7
E. None of the above

8. Digital Electronics

What single gate can be placed in the digital diagram to replace the rectangle so that all inputs make the circuit TRUE?



A. AND
B. OR
C. NAND
D. NOR
E. None of the above

9. Prefix-Infix-Postfix

Define: a # b = $a^b + b^a$. Evaluate the following prefix expression (numbers are single digits):

/ - + / # 2 5 3 1 # 4 1 + # 1 3 1

A. 2
B. 3
C. 19
D. 20
E. None of the above

10. Prefix-Infix-Postfix

Convert this infix expression into postfix if $\sqrt{x} = x\text{^}\frac{1}{2}$:

$$\frac{A + \sqrt{B^2 - C}}{3\ D}$$

A. $AB2\uparrow C - 1/2\uparrow + 3D * /$
B. $AB2\uparrow C - 12\uparrow / + 3D * /$
C. $AB2\uparrow C + 12/\uparrow - 3D * /$
D. $AB2\uparrow C - 12/\uparrow + 3D * /$
E. None of the above

11. Computer Number Systems

Evaluate and express the answer in octal:

$3B4A_{16}$ OR $9D2E_{16}$

A. 127356_8
B. 137556_8
C. 153557_8
D. 173553_8
E. None of the above

12. Computer Number Systems

Starting at the number 2021_{10}, find the next lower year number whose binary representation has 4 consecutive 0s.

A. 2012
B. 2020
C. 2017
D. 2016
E. None of the above

13. Data Structures

Given a queue for receiving the COVID-19 vaccine, only people with names starting with a consonant are placed in the queue and when an asterisk appears, 2 people on the queue receive the vaccine and are removed from the queue. Given the following string representing the starting letter of a person's name, what is the longest length of the queue at any point if they enter the queue from left to right as they appear in the string?

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A. 2
B. 4
C. 7
D. 9
E. None of the above

14. Data Structures

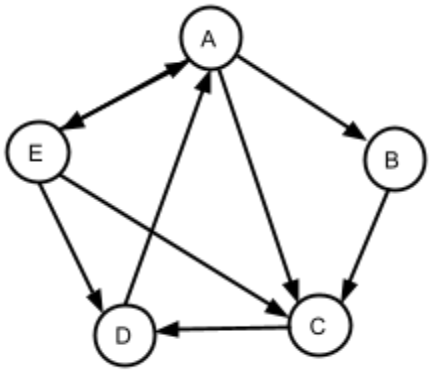
What is the preorder traversal in the binary search tree for:

PTERODACTYL

A. PEDOALCTRYT
B. PEDACOLTRTY
C. CADELOPTRTY
D. CALTDORYETP
E. None of the above

15. Graph Theory

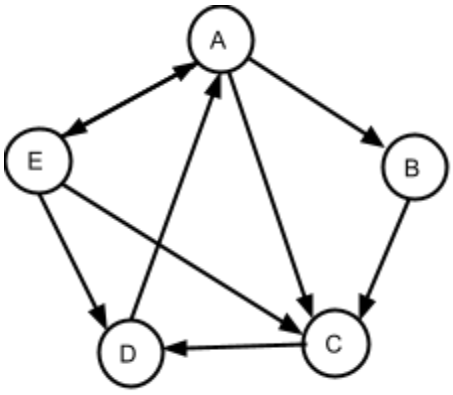
Given the directed graph below, how many unique pairs of vertices do not have a path of length 2 in either direction? (X,X) could be included.



A. 1
B. 3
C. 5
D. 7
E. None of the above

16. Graph Theory

How many cycles from A are there in the directed graph (same graph as in #15)?



A. 3
B. 4
C. 5
D. 6
E. None of the above

17. What Does This Program Do?

In order to have this program print the three inputted numbers in increasing order, what must be in the blank below?

```
input a,b,c
if a > b then
     swap values of a and b
end if
if b > c then
     swap values of b and c
end if
if _________ then
     swap values of the 2 variables being
     compared
end if
output a,b,c
```

A. a > b
B. a > c
C. b > c
D. b < c
E. None of the above

18. LISP

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

(SETQ M '(P (R O) (G (R A) (M M) I) (N G)))
(CDDADDR M)

A. (G (R A))
B. ((M M) I)
C. (N G)
D. (((M M) I) (N G))
E. None of the above

19. FSAs and Regular Expressions

Given the regular expression:

[a-l]*[e-u]*(cs|y)

Which of the following strings are NOT accepted?

a. history
b. classics
c. physics
d. botany
e. geometry
f. chemistry
g. mathematics
h. biology

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

20. Assembly Language

What is printed when the following program is run if the data is 6?

```
S       DC      0
        READ    N
        LOAD    N
        DIV     =2
        STORE   F
TOP     BE      STP
        LOAD    N
        DIV     F
        MULT    F
        SUB     N
        BL      NXT
        LOAD    S
        ADD     F
        STORE   S
NXT     LOAD    F
        SUB     =1
        STORE   F
        BU      TOP
STP     PRINT   S
        END
```

A. 1
B. 3
C. 6
D. 12
E. None of the above