American Computer Science League

2022 Finals ● Short Problems ● Intermediate/Classroom Divisions

1. Boolean Algebra

Simplify the following Boolean expression:

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

A. $A\ +\ \overline{B}\,C$
B. $\overline{A}\ +\ \overline{B}\,C$
C. $\overline{A}\ +\ B\,C$
D. $\overline{A}\ +\ B\,\overline{C}$
E. None of the above

2. Boolean Algebra

How many ordered pairs make the following Boolean expression TRUE?

$$(A\ \oplus\ B)\ (\overline{A\,B}\ +\ B)$$

A. 0
B. 1
C. 2
D. 3
E. 4

3. Bit-String Flicking

Evaluate the following expression:

(RSHIFT-2 (NOT (RCIRC-6 (LSHIFT-1 (LCIRC-12 10110110)))))

A. 00110110
B. 00101011
C. 11011000
D. 00101001
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?

(RSHIFT-1 00111) OR (LCIRC-2 01110) AND (NOT 10101)
= (LCIRC-1 (RCIRC-2 X))

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

5. Recursive Functions

Find $f(17)$ if given:

$$f(x) = \begin{cases} 2 \cdot f(x-3) + 1 & \text{if } x \geq 12 \\ f\left(\left[\frac{x}{2}\right]\right) - 3 & \text{if } 2 \leq x < 12 \\ x - 4 & \text{if } x < 2 \end{cases}$$

Note: [x] is the greatest integer less than or equal to x

A. -47
B. -45
C. -29
D. -23
E. None of the above

6. Recursive Functions

Define Pisano's function as:

$$P(n) = \begin{cases} 0 & if\ n = 1 \\ 1 & if\ n = 2 \\ (P(n-1) + P(n-2))\ mod\ m & if\ n \geq 3 \end{cases}$$

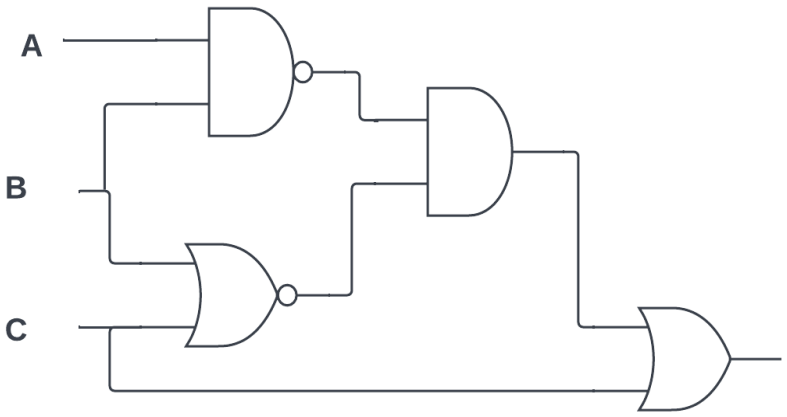
The number of terms that repeat is called the Pisano period. For *mod* 2 the sequence becomes 0, 1, 1, 0, 1, 1, … so the Pisano period for *mod* 2 is 3.

What is the Pisano period for mod 4 (i.e. if m = 4)?

A. 4
B. 6
C. 8
D. 10
E. None of the above

7. Digital Electronics

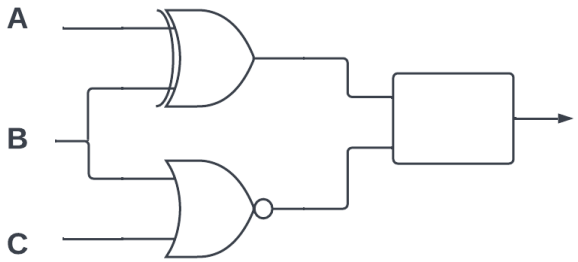
Simplify the Boolean expression represented by the circuit:



A. $\overline{B}\,\overline{C} + C$
B. $\overline{A}\,\overline{C} + C$
C. $\overline{A}\,\overline{B}\,C + \overline{C}$
D. $\overline{A}\,\overline{B}\,\overline{C} + C$
E. None of the above

8. Digital Electronics

What single gate can be placed in the digital diagram to replace the rectangle so that the least number of ordered triples will make the circuit TRUE?



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

9. Prefix-Infix-Postfix

Evaluate the following prefix expression (numbers are single digits):

+ - / + 2 8 5 * 3 + / 9 3 4 ^ 2 4

A. -3
B. 3
C. 9
D. 35
E. None of the above

10. Prefix-Infix-Postfix

Change this postfix expression to prefix:

2 3 * 4 * 6 / 3 2 * 2 ^ 2 4 ^ 2 + / -

A. - * / * 2 3 4 6 / ^ * 3 2 2 + ^ 2 4 2
B. - / * * 2 3 4 6 ^ / * 3 2 2 + ^ 2 4 2
C. - / * * 2 3 4 6 / ^ * 3 2 2 + ^ 2 4 2
D. - / * * 2 3 4 6 / ^ * 3 2 2 + ^ 4 2 2
E. None of the above

11. Computer Number Systems

When is the next year (in base 10) after 2022_{10} that the year expressed in octal will have 3 consecutive octal digits in increasing order?

A. 4012
B. 3746
C. 2416
D. 2058
E. None of the above

12. Computer Number Systems

Evaluate and express the answer in base 16.

$$10110_2 * A_{16} \ / \ 13_8 - 20_{10} + (6_8)^2$$

A. 16
B. 24
C. 36
D. 44
E. None of the above

13. Data Structures

Build a binary search tree for:

DELTAVARIANT

What is the internal path length of the tree?

A. 31
B. 32
C. 33
D. 34
E. None of the above

14. Data Structures

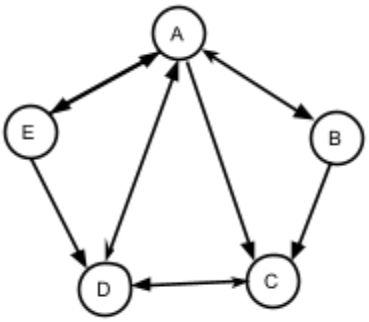
Given an initially empty stack and the following commands on the stack, read left to right first, what item will be popped next?

PUSH("G"),	X=POP(),	PUSH("I"),	PUSH("N"),
PUSH("G"),	X=POP(),	X=POP(),	PUSH("E"),
PUSH("R"),	PUSH("B"),	PUSH("R"),	X=POP(),
X=POP(),	PUSH("E"),	PUSH("A"),	PUSH("D"),
X=POP(),	X=POP(),	X=POP(),	X=POP(),
X=POP()			

A. E
B. D
C. G
D. I
E. None of the above

15. Graph Theory

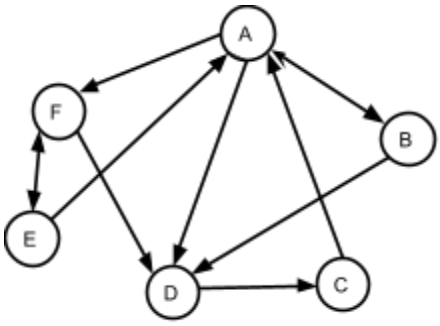
Given the directed graph below, how many paths of length 2 are there from Vertex A?



A. 25
B. 18
C. 7
D. 5
E. None of the above

16. Graph Theory

How many cycles from A are there in this directed graph?



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

17. What Does This Program Do?

Given the array **fib** that is filled with the Fibonacci numbers 1, 2, 3, 5, 8, 13, 21, 55, 89, 144, 233, 377, 610 in locations 0 to 12, how many numbers will be output in the following program?

```
for x = 1 to 10
    stop = 0
    for y = 0 to 12
        if stop==0 && fib(y)% x==0 then
            output x
            stop = 1
        end if
    next y
next x
```

A. 0
B. 5
C. 10
D. 13
E. None of the above

18. LISP

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

(SETQ M '((a b (d)) (b (c a) d) ((a b) (b) d)))
(CADDR M)

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

19. FSAs and Regular Expressions

Welcome to the ACSL Grocery Store! Today items are on sale if they satisfy the following regular expression:

[^abiou] [hro] [a-j]* (e|s)*

How many items are on sale?

bread	cheese	fish	meat
chips	chocolate	cream	pickles
grapes	cookies	coffee	crackers

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

20. Assembly Language

What is printed when this program is run if the data is 8 and 5?

```
T       DC      0
        READ    N3
        READ    N2
LOOP    LOAD    N3
        SUB     N2
        STORE   N1
        LOAD    N3
        MULT    N3
        ADD     T
        STORE   T
        LOAD    N2
        STORE   N3
        LOAD    N1
        STORE   N2
        BG      LOOP
        LOAD    T
        ADD     =1
        STORE   T
        PRINT   T
        END
```

A. 28
B. 40
C. 104
D. 273
E. None of the above