

American Computer Science League

2022 Finals • Short Problems • Junior Division

1. Boolean Algebra

Simplify the following Boolean expression:

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

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

2. Boolean Algebra

How many ordered triples make the following expression TRUE?

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

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

3. Bit-String Flicking

Evaluate the following expression:

$$((\text{LCIRC-2}(\text{NOT}(\text{RSHIFT-1 } 01100))) \text{ OR } (\text{RCIRC-1}(\text{LSHIFT-2 } 01011)))$$

- A. 00110
- B. 00111
- C. 01011
- D. 01100
- E. None of the above

4. Bit-String Flicking

Evaluate the following expression:

$$(\text{NOT}(01110 \text{ AND NOT } 10110) \text{ OR } (\text{NOT } 00110 \text{ OR } 11011)) \text{ AND NOT } (\text{NOT } 00100 \text{ AND NOT } 01010))$$

- A. 10111
- B. 01010
- C. 11111
- D. 01000
- E. None of the above

5. Recursive Functions

Find $f(18)$:

$$f(x) = \begin{cases} f(x-3) + 4 & \text{if } x \geq 12 \\ f(x-2) - 3 & \text{if } 7 \leq x < 12 \\ 2x & \text{if } x < 7 \end{cases}$$

- A. 4
- B. 7
- C. 12
- D. 16
- E. None of the above

6. Recursive Functions

Define Pisano's function as:

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

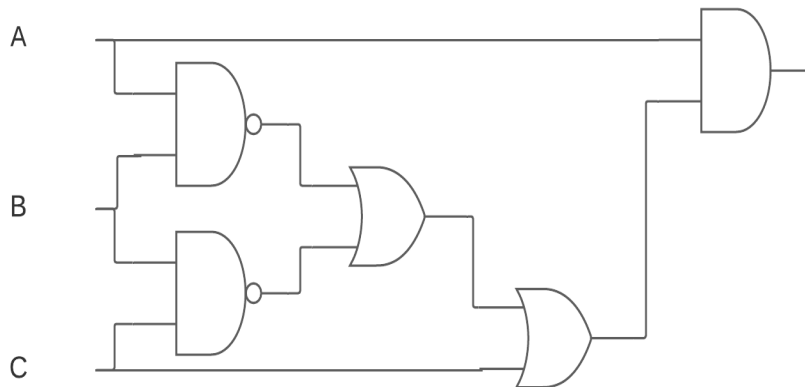
The number of terms that repeat is called the Pisano period. For $\bmod 2$ the sequence becomes 0, 1, 1, 0, 1, 1, ... So the Pisano period for $\bmod 2$ is 3.

What is the Pisano period for $\bmod 3$ (i.e. if $m = 3$)?

- A. 4
- B. 8
- C. 9
- D. 12
- E. None of the above

7. Digital Electronics

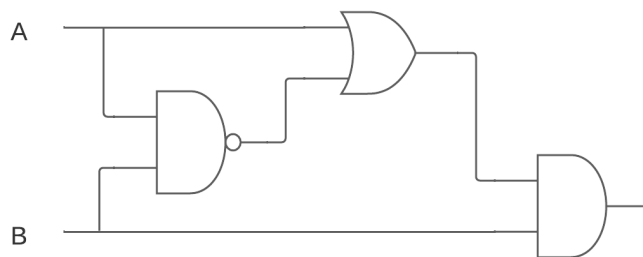
Simplify the Boolean expression represented by the circuit below:



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

8. Digital Electronics

How many ordered pairs make the following circuit TRUE?

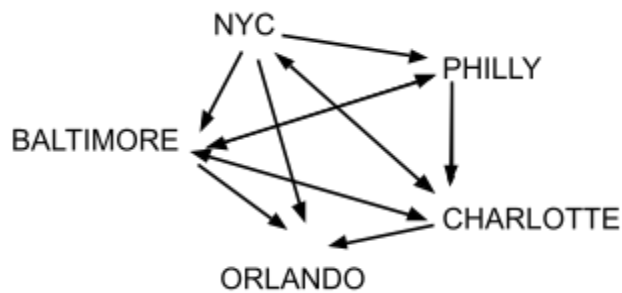


- A. 1
- B. 2
- C. 3
- D. 4
- E. None of the above

<p>9. Prefix-Infix-Postfix</p> <p>Evaluate this prefix expression. (Note: all numbers are single digits.)</p> $* 2 - / * 8 9 * 3 4 4$	<p>A. 4 B. 10 C. 16 D. 20 E. None of the above</p>
<p>10. Prefix-Infix-Postfix</p> <p>Evaluate this postfix expression. (Note: all numbers are single digits.) Define: $a \\$ b = (a + b)^2$</p> $1 2 \$ 2 7 \$ + 5 /$	<p>A. 3 B. 5 C. 18 D. 20 E. None of the above</p>
<p>11. Computer Number System</p> <p>When is the next year (in base10) after 2022_{10} that the year expressed in octal will have 3 octal digits in increasing consecutive order?</p>	<p>A. 2416 B. 2058 C. 4012 D. 4560 E. None of the above</p>
<p>12. Computer Number Systems</p> <p>Evaluate the following and express the result in octal:</p> $2_8 * 35_8 - 124_8 / 2_8$	<p>A. 42 B. 16 C. 52 D. 20 E. None of the above</p>
<p>13. Data Structures</p> <p>Build a binary search tree for: CORONAVIRUS What is the depth of the tree?</p>	<p>A. 4 B. 5 C. 6 D. 7 E. None of the above</p>
<p>14. Data Structures</p> <p>Given an initially empty queue and the following commands on the queue, read left to right first, what item will be popped next?</p> <p>PUSH("M"), PUSH("A"), X=POP(), PUSH("R"), PUSH("A"), X=POP(), X=POP(), PUSH("T"), PUSH("H"), X=POP(), PUSH("O"), X=POP(), PUSH("N")</p>	<p>A. R B. O C. H D. N E. None of the above</p>

15. Graph Theory

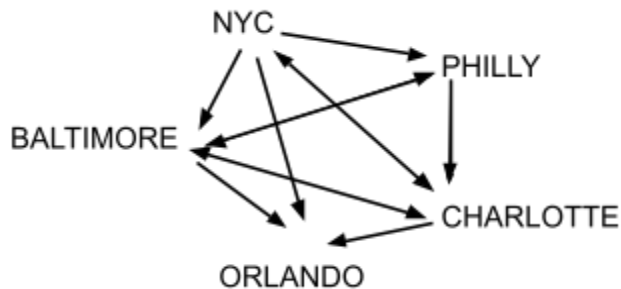
How many flights are there from NYC to Orlando with 1 or 2 stops if no airport is revisited in a trip?



- A. 2
- B. 4
- C. 6
- D. 8
- E. None of the above

16. Graph Theory

How many round trips, without a repeated airport, are there in the directed graph (same as #15)?



- A. 2
- B. 3
- C. 5
- D. 8
- E. None of the above

17. What Does This Program Do?

What is the output for the following program?

```
a = 50: b = 6
c = 66: d = 7
if a > b then
    e = a % b
    f = int(a / b)
end if
if c > d then
    g = c % d
    h = int(c / d)
end if
if f % e == 0 && h % g == 0 then
    output f / e - h / g
else
    output g * h - f * e
end if
```

- A. 1
- B. -1
- C. -11
- D. 11
- E. None of the above

18. What Does This Program Do?

Given the following Fibonacci numbers 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, and 89 as the input values, how many numbers will be output in the following program?

```
for x = 1 to 11
  input n
  a = n % 10
  b = int(n / 10)
  if a + b == x then
    output n
  end if
next x
```

- A. 3
- B. 5
- C. 8
- D. 11
- E. None of the above

19. What Does This Program Do?

Given that array **arr** contains the 9 values below, how many values will be output by the following program?

1	16	4	64	9	25	49	36	81
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```
for x = 1 to 8
  if arr(x) < arr(x-1) then
    t = arr(x)
    arr(x) = arr(x-1)
    arr(x-1) = t
  end if
next x
for x = 0 to 8
  if arr(x) == (x+1) ^ 2 then
    output arr(x)
  end if
next x
```

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

20. What Does This Program Do?

Given that this program is designed to output a message only if a string is the same forwards as backwards, what comparison in ACSL code is needed to fill in the blank to accomplish that on the string **s**?

```
palindrome = 1
for x = 0 to len(s) / 2
  if _____ then
    palindrome = 0
  end if
next x
if palindrome == 1 then
  output "It is a palindrome."
end if
```

- A. $s[x] < s[\text{len}(s) - x]$
- B. $s[x] \neq s[\text{len}(s) / 2]$
- C. $s[x] == s[\text{len}(s) - x - 1]$
- D. $s[x] \neq s[\text{len}(s) - x - 1]$
- E. None of the above

