

American Computer Science League

2021 Finals • Short Problems • Intermediate/Classroom Divisions

<p>1. Boolean Algebra</p> <p>Which expressions are equivalent to:</p> $\overline{\overline{A + B}} \oplus \overline{\overline{A + B}}$ <p>a. $AB + \overline{A}B$ b. $A \oplus B$ c. $\overline{A \oplus B}$ d. $A\overline{B} + \overline{A}B$</p>	<p>A. a, b B. b, c C. c, d D. b, d E. None of the above</p>
<p>2. Boolean Algebra</p> <p>How many ordered triples make the expression TRUE?</p> $(\overline{AB + C})(\overline{A} \overline{B} + \overline{C})$	<p>A. 2 B. 3 C. 4 D. 5 E. None of the above</p>
<p>3. Bit-String Flicking</p> <p>Evaluate the following expression:</p> $(\text{LSHIFT-3}(\text{RCIRC-2}(\text{NOT}(\text{LCIRC-10 } 011010))))$	<p>A. 101000 B. 100110 C. 110000 D. 011001 E. None of the above</p>
<p>4. Bit-String Flicking</p> <p>How many different values of X (a bitstring of 5 bits) make the following equation TRUE?</p> $(X \text{ AND } (\text{LSHIFT-2 } 01011)) = (\text{RCIRC-3 } 00011)$	<p>A. 2 B. 4 C. 8 D. 16 E. None of the above</p>
<p>5. Recursive Functions</p> <p>Given the following recursive function to find the value of a number, b, raised to a given power, e, for $e \geq 0$, what definition will give the value of a number, b, raised to a given power, e, for $e < 0$ so that $3^{-2} = 1/9$.</p> $f(b, e) = \begin{cases} 1 & \text{if } e = 0 \\ b \cdot f(b, e - 1) & \text{if } e > 0 \\ \text{?????} & \text{if } e < 0 \end{cases}$	<p>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</p>

6. Recursive Functions

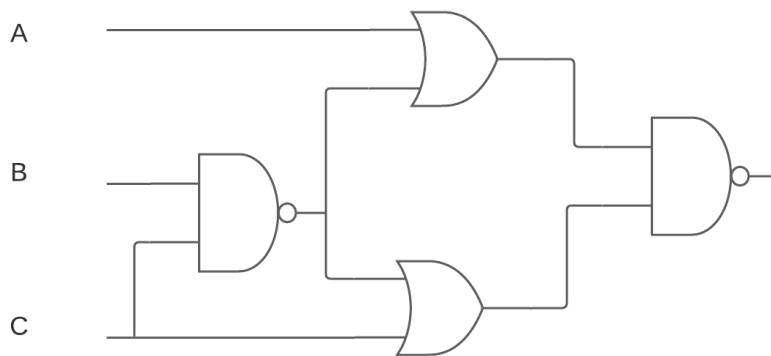
Find $f(1, 20)$ given:

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

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

7. Digital Electronics

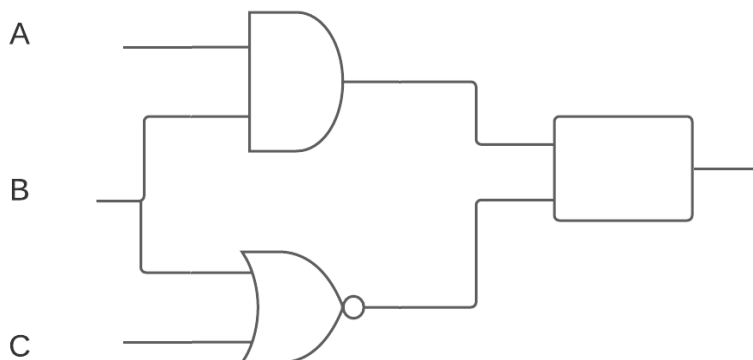
How many ordered triples make the following circuit TRUE?



- 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

<p>9. Prefix-Infix-Postfix</p> <p>Define: $a \# b = a^b + b^a$. Evaluate the following prefix expression (numbers are single digits):</p> $/ - + / \# 2 5 3 1 \# 4 1 + \# 1 3 1$	<p>A. 2 B. 3 C. 19 D. 20 E. None of the above</p>
<p>10. Prefix-Infix-Postfix</p> <p>Convert this infix expression into postfix if $\sqrt{x} = x^{\frac{1}{2}}$:</p> $\frac{A + \sqrt{B^2 - C}}{3D}$	<p>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</p>
<p>11. Computer Number Systems</p> <p>Evaluate and express the answer in octal:</p> $3B4A_{16} \text{ OR } 9D2E_{16}$	<p>A. 127356_8 B. 137556_8 C. 153557_8 D. 173553_8 E. None of the above</p>
<p>12. Computer Number Systems</p> <p>Starting at the number 2021_{10}, find the next lower year number whose binary representation has 4 consecutive 0s.</p>	<p>A. 2012 B. 2020 C. 2017 D. 2016 E. None of the above</p>
<p>13. Data Structures</p> <p>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?</p> <p>ACSL*FINAL**COMPETITION***THIS*YEAR*</p>	<p>A. 2 B. 4 C. 7 D. 9 E. None of the above</p>

14. Data Structures

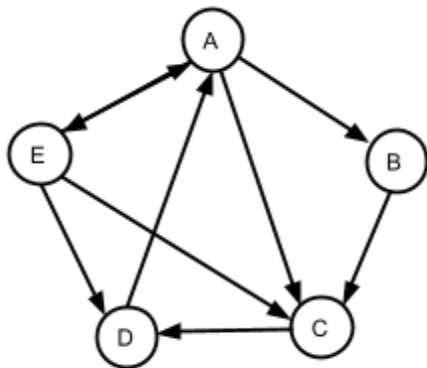
What is the preorder traversal in the binary search tree for:

PTERODACTYL

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

15. Graph Theory

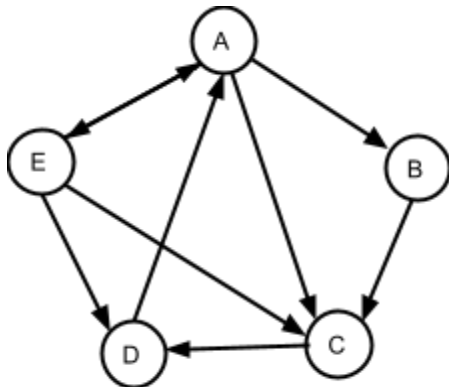
Given the directed graph below, how many unique pairs of vertices do not have a path of length 2 in either direction? (X,X) could be included.



- 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 | e. geometry |
| b. classics | f. chemistry |
| c. physics | g. mathematics |
| d. botany | 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

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<p>1. 布尔代数</p> <p>哪个选项等于以下表达式：</p> $\overline{\overline{A + B} \oplus \overline{A + B}}$ <p>a. $AB + \overline{AB}$ b. $A \oplus B$ c. $\overline{A \oplus B}$ d. $A\overline{B} + \overline{AB}$</p>	<p>A. a, b B. b, c C. c, d D. b, d E. 以上都不正确</p>
<p>2. 布尔代数</p> <p>有多少个有序三元组可使以下表达式成立？</p> $\overline{(AB + C)}(\overline{A}\overline{B} + \overline{C})$	<p>A. 2 B. 3 C. 4 D. 5 E. 以上都不正确</p>
<p>3. 比特位操作</p> <p>计算下列表达式：</p> $(\text{LSHIFT-3}(\text{RCIRC-2}(\text{NOT}(\text{LCIRC-10 } 011010))))$	<p>A. 101000 B. 100110 C. 110000 D. 011001 E. 以上都不正确</p>
<p>4. 比特位操作</p> <p>X (长度为 5 比特的位串) 有多少个不同的值可使下面的等式成立？</p> $(X \text{ AND } (\text{LSHIFT-2 } 01011)) = (\text{RCIRC-3 } 00011)$	<p>A. 2 B. 4 C. 8 D. 16 E. 以上都不正确</p>
<p>5. 递归函数</p> <p>给定以下递归函数，求 b 的 e 次方的值，其中 $e \geq 0$。当 $e < 0$ 时，要使 $3^{-2} = 1/9$，b 的 e 次方如何定义？</p> $f(b, e) = \begin{cases} 1 & \text{设 } e = 0 \\ b \cdot f(b, e - 1) & \text{设 } e > 0 \\ \text{????} & \text{设 } e < 0 \end{cases}$	<p>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. 以上都不正确</p>

6. 递归函数

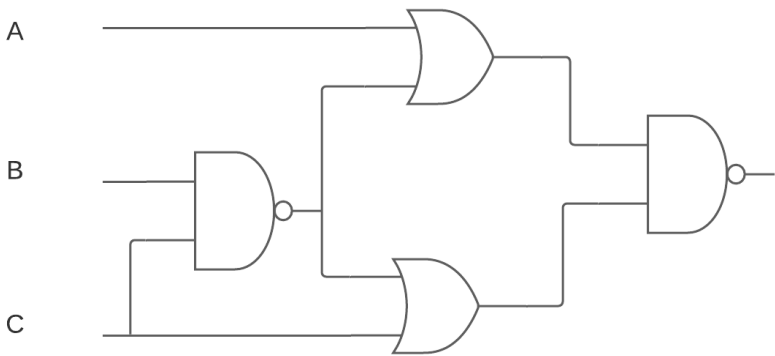
已知下列函数，求 $f(1, 20)$

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

- A. 38
- B. 52
- C. 29
- D. 71
- E. 以上都不正确

7. 数字电路

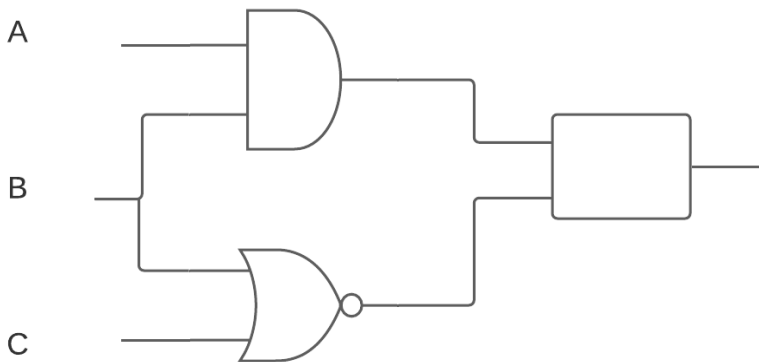
有多少个有序三元组可使下列电路成立？



- A. 1
- B. 3
- C. 5
- D. 7
- E. 以上都不正确

8. 数字电路

用哪个逻辑门替换下方数字电路图中的矩形后，所有输入都可以使以下电路成立？



- A. AND
- B. OR
- C. NAND
- D. NOR
- E. 以上都不正确

<p>9. 前缀-中缀-后缀</p> <p>定义： $a \# b = a^b + b^a$。 计算以下前缀表达式 (所有数字都是个位数)：</p> $/- + / \# 2 5 3 1 \# 4 1 + \# 1 3 1$	<p>A. 2 B. 3 C. 19 D. 20 E. 以上都不正确</p>
<p>10. 前缀-中缀-后缀</p> <p>将下列中缀表达式转换为后缀表达式，设 $\sqrt{x} = x^{\frac{1}{2}}$:</p> $\frac{A + \sqrt{B^2 - C}}{3D}$	<p>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. 以上都不正确</p>
<p>11. 前缀-中缀-后缀</p> <p>计算下列表达式，并将结果表示为八进制：</p> $3B4A_{16} \text{ OR } 9D2E_{16}$	<p>A. 127356_8 B. 137556_8 C. 153557_8 D. 173553_8 E. 以上都不正确</p>
<p>12. 计算机计数系统</p> <p>从比 2021_{10} 小的年份中，找出下一个用二进制表示后有 4 个连续的 0 的年份。</p>	<p>A. 2012 B. 2020 C. 2017 D. 2016 E. 以上都不正确</p>
<p>13. 数据结构</p> <p>在接种 COVID-19 疫苗的队列中，只排有名字以辅音开头的人，当出现 * 时，队列中有 2 人接种疫苗，并将其从队列中移除。假设下面的字符串表示一个人名的开头字母，当它们出现在字符串中时，如果从左到右进入队列，队列中任意一点的最长长度是多少？</p> $ACSL*FINALs**COMPETITION***THIS*YEAR*$	<p>A. 2 B. 4 C. 7 D. 9 E. 以上都不正确</p>

14. 数据结构

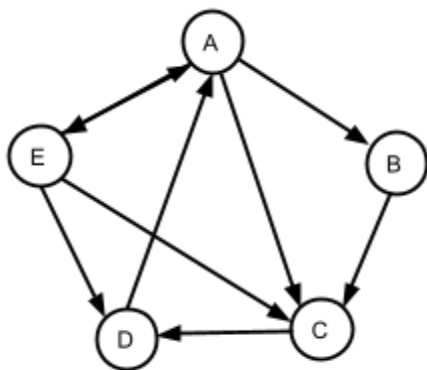
以下二叉搜索树的先序遍历是：

PTERODACTYL

- A. PEDOALCTRYT
- B. PEDACOLTRTY
- C. CADELOPTRTY
- D. CALTDORYETP
- E. 以上都不正确

15. 图论

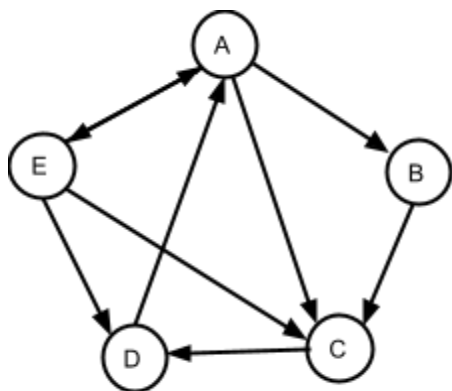
下面的有向图中，有多少对顶点在任意方向都不存在长度为 2 的路径？包括 (X,X)。



- A. 1
- B. 3
- C. 5
- D. 7
- E. 以上都不正确

16. 图论

下面的有向图中，从 A 开始有多少个环？(图同 #15)



- A. 3
- B. 4
- C. 5
- D. 6
- E. 以上都不正确

17. 程序填空

要使下列程序将三个输入值以递增顺序输出，下面的空行处需填入哪个选项？

```
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. 以上都不正确

18. LISP 语言

下面的 LISP 程序运行后，最后一个表达式的值是多少？

```
(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. 以上都不正确

19. FSAs 与正则表达式

给定以下正则表达式：

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

下面哪个字符串无法匹配？

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

- A. b, e
- B. c, d, g
- C. a, b, e
- D. d, f, g, h
- E. 以上都不正确

20. 汇编语言

如果数据是 6，以下程序运行后会输出什么？

```
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. 以上都不正确