ACSL All-Star Practice

By BB, GG, JP and DP for WCI PEG, GL (KTHXBAI)

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Question 1. What is printed by the following program?

```
10 read D$
20 read S$
25 for J = len(S$) to 1 step -1
30    for K = 1 to len(D$)
40       if mid$(D$, K, 1) = mid$(S$, J, 1) then 100
50    next K
51 next J
53 goto 111
100 S$ = left$(S$, J-1) + right$(S$, len(S$)-J)
105 goto 51
111 print S$
122 data DROP
123 data ROOFTOPS
```

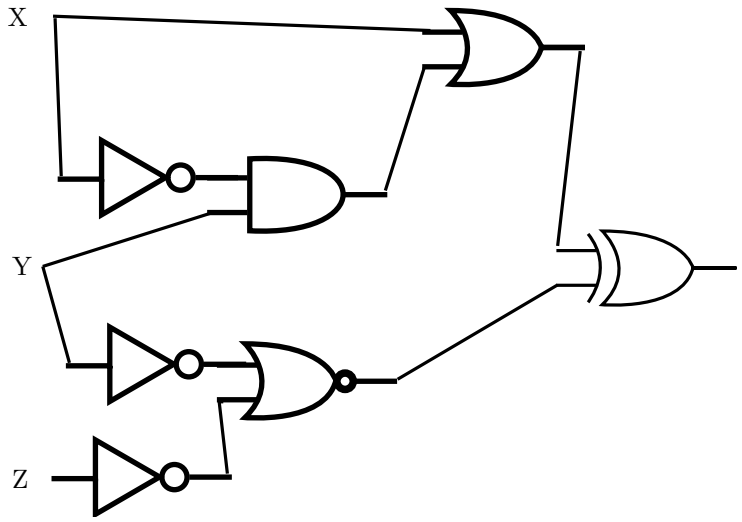
Question 2. What are the values of the following two expressions?

```
(ATOM '(EVAL (ATOM '(ATOM ATOM))))
(EVAL '(ATOM (ATOM '(ATOM ATOM))))
(REVERSE '(ATOM (ATOM '(ATOM ATOM))))
```

Question 3. Let the hyphen character pop, and every other character push that character, on to a data structure.

- Using a stack, what is the sequence of characters popped for `MY-STACK-IS-OK`
- Using a queue, what is the sequence of characters popped for `QUEUE-ARE-ESS-TEA`

Question 4. Simplify the following circuit to use at most 3 gates. Bonus: use only 2 gates.



Question 5. Which ordered quintuplets (A,B,D,E,C) satisfy the following system of Boolean equations?
(D + E) xor (C + A) = 1
A xor B = 1
AB xor D = 0
CB + A = 1

Question 6. Evaluate the following two expressions, where A = 10, B = 11, etc and the / is division-with-truncation (dropping the remainder):

* / * / * * 50 40 52 100 + 100 4 4 3
B E D M A S - + / - *

Question 7. Calculate Forth(6), given the following definitions:

$$\text{Forth}(a) := \begin{cases} 2 * \text{Forth}(\text{Back}(2)) & a \geq 6; \\ \text{Forth}(a-1) + 3 * \text{Back}(a) + 2 * \text{Back}(a-2) - 4 * \text{Back}(a-3) & 2 \leq a \leq 5; \\ 1 & a \leq 1. \end{cases}$$

$$\text{Back}(a) := \begin{cases} 3 + 2 * \text{Back}(a-1) & a \geq 2; \\ 1 & a \leq 1. \end{cases}.$$

Question 8. What value does `leaders` get in the last statement?

```
(DEF SECOND(params) (CAR (CDR params)))
(SETQ barack '(president of usa))
(SET 'harper '(prime minister canada))
(SETQ leaders (CONS (CAR (REVERSE barack)) (CONS (SECOND (CDR harper)) NIL)))
```

Question 9. Simplify the following expression:

$$((FO + \overline{O}) + FX)(O + F + XO)(\overline{(\overline{O} + \overline{X})})$$

Question 10. Match the four regular expressions below to their four English descriptions.

1. $((b \cup bb)aa^*)^*(\lambda \cup b \cup bb)$
2. $(a \cup bbb^*)^*$
3. $(ab \cup b)^*(\lambda \cup a)$
4. $(ba \cup ab \cup a)^*$

K : contains no "aa" substring

L : contains no "bbb" substring

M : each b is next to at least one a

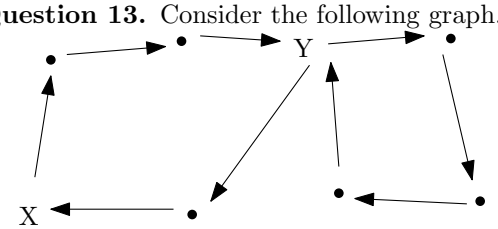
N : each b is next to at least one other b

Question 11. The input to this program is 13. What is printed?

```
X      DC     1                          DIV    Y
Y      DC     0                          STORE  Z
Z      DC     0                          PRINT  Z
B      DC     10                         MUL    Y
       INPUT  Y                          MUL    =-1
HARUN: LOAD   X                          ADD    X
       MUL    B                          MUL    B
       STORE  X                          STORE  X
       SUB    B                          SUB    B
       BG     ROSS                       BE     BOSCO
       BU     HARUN                      BU     ROSS
ROSS:  LOAD   X                   BOSCO: END
```

Question 12. Find all numbers n between 0 and 15, such that their 4-bit binary representation x satisfies LCIRC-n x = NOT x.

Question 13. Consider the following graph.



What is the largest integer n, so that there is no path from X to Y of length n?

Question 14. What is the sum of these numbers, expressed in base 16?

```
011000110
100101010
100100010
011001111
```

Question 15. Translate the following prefix expression into postfix, without simplifying:

`9 B 5 + ↑ 0 + 3 4 7 X - - - E * 5 6 / N ↑ + +`

Question 16. Construct a Binary Search Tree from the letters FOXESRULE, and draw your result. Then, delete the node S, insert the letter N, and draw the final tree.

Question 17. Draw an FSA which is equivalent to the regular expression

$$a((bc^*b \cup bcc^*b)^*aa)^*$$

and uses at most 3 states.

Question 18. Find all 5-bit strings X satisfying

LSHIFT-3 x XOR x = RCIRC-1 NOT x AND 11101.

Question 19. For this question, we introduce a new LISP command, the IF statement. Here is the syntax:

```
(IF (Boolean Condition) TrueStatement ElseStatement)
```

The `(Boolean Condition)` is executed. If the value is true then the `TrueStatement` is executed; otherwise, the `ElseStatement` is executed. Here are some examples:

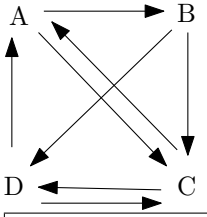
`(IF (EQ 3 3) (SETQ adam (MULT 3 5)) (SETQ adam '(football)))`: changes `adam` to 15.

`(IF (NEG (MULT 4 2)) (SETQ peter (REVERSE adam)) (SETQ peter 'adam))`: changes `peter` to `adam`.

What is the value of the last statement? Assume SECOND is defined as in Question 8, and DIVINT gives only the integer part of the division (dropping the remainder), e.g. `(DIVINT 10 3)` is 3.

```
(DEF MULT2(params)
    (IF (EQ 1 (SECOND params))
        (CAR params)
        (EXP (MULT2 (CONS (DIVINT (CAR params) 2) (CDR params))) 2)))
(MULT2 '(13 3))
```

Question 20. In the following graph, how many paths of length 8 are there from A to D?

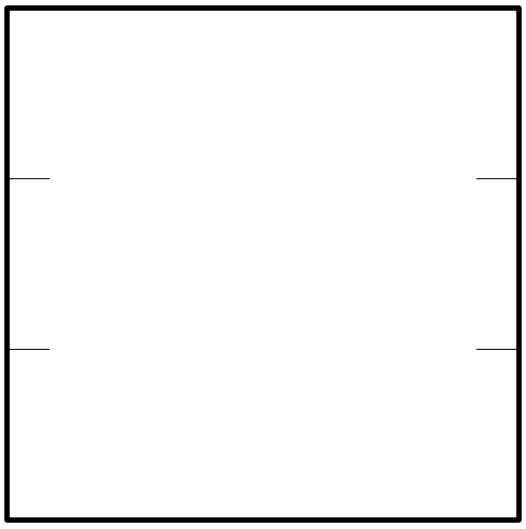


Question 21. What will be printed when the program below is executed?

```
10  data 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18
20  for Y=1 to 3
30     for X=1 to 3
40        read A(X,Y):read B(X,Y)
50     next X
60  next Y
70  for Y=1 to 3
80     for X=1 to 3
90           for Z=1 to 3
100          S=S+A(Z,Y)*B(X,Z)
110       next Z
120    next X
130 next Y
140 print S
```

Question 22. Construct a heap from the letters NITCHES, and draw your result. Then, delete the root node, and draw the resulting heap.

Question 23. You are in a two-dimensional jail cell (pictured) with two input wires (at the left) and two output wires (at the right). Draw the simplest circuit which makes the bottom output equal the top input and the top output equal the bottom input, but where two wires never cross. (It is allowed for one wire to split into two.)



Question 24. What is the value of the last statement? We use IF from question 19.

```
(DEF EXTRACT(params)
    (IF (EQ NIL params)
        NIL
        (CONS (CAR (CAR params)) (EXTRACT (CDR params)))))
(DEF REDUCEBYONE(params)
     (IF (EQ NIL params)
        NIL
        (CONS (CDR (CAR params)) (REDUCEBYONE (CDR params)))))
(DEF ZIP(params)
    (IF (EQ NIL params)
        NIL
        (CONS (EXTRACT params) (ZIP (REDUCEBYONE params)) )))
(ZIP '((a b c d) (e f g h) (i j k l)))
```

Question 25. Jacob created two mutually recursive functions, Fox and Wolf, defined below. Unfortunately, he made a mistake with the definitions, so that infinite recursion can sometimes occur when trying to evaluate these functions. However, his friend, Brian, noticed that it is still possible to unambiguously assign a value to Fox(4,2) in such a way that the definitions of both functions are satisfied, although determining this value may require solving some equations. Can you help Jacob find this value?

$$\text{Fox}(z,x) = \begin{cases} \text{Wolf}(x) - 2\text{Wolf}(z), & x > z; \\ \text{Wolf}(x-z) - \text{Wolf}(z-x), & x < z; \\ x + z, & x = z. \end{cases}$$

$$\text{Wolf}(y) = \begin{cases} \text{Fox}(y-1, y), & y > 0; \\ y + 1, & y \leq 0. \end{cases}$$

Question 26. Find a base (better yet, all bases) in which 1M is a divisor of 311.

Question 27. Suppose the input to this program is 7. What is the output?

```
K       DC      0               SUB     K               MULT    I
S       DC      0               ADD     =1              STORE   U
T       DC      0               SUB     I               LOAD    I
U       DC      0               BG      CONAN           ADD     =1
I       DC      0               LOAD    I               STORE   I
        INPUT   N               MULT    T               BU      HANSON
GURU:   LOAD    K               STORE   T       JACOB:  LOAD    T
        SUB     N               LOAD    I               DIV     U
        BG      ROGER           SUB     =1              ADD     S
        LOAD    N               STORE   I               STORE   S
        STORE   I               BU      DULUXAN         LOAD    K
        LOAD    =1      CONAN:  LOAD    =1              ADD     =1
        STORE   T               STORE   I               STORE   K
DULUXAN:LOAD    N               STORE   U               BU      GURU
                        HANSON: SUB     K       ROGER:  PRINT   S
                                BG      JACOB           END
                                LOAD    U
```