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| **2017-2018** | **American Computer Science League** Senior Shorts Solutions | **All-Star Contest** |

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| 1. Boolean Algebra     =  =  =  =  =  =  =  If  = 0, then all terms are 0.  If , then  and .  If , then  and . (1, 0, \*, \*)  If , then  and . (1, 1, 1, 0)  If , then .  So , , . (0,0,1,0)  Therefore 6 ordered triples make it FALSE. | B. 6 |
| 1. Bit-String Flicking   Let x = abcdef  LHS = (x OR 110110 AND x) = (abcdef OR (110110 AND abcdef))  = (abcdef OR ab0de0) = abcdef  RHS = (LSHIFT-1 x) = (LSHIFT-1 abcdef) = bcdef0  LHS = RHS → abcdef = bdcef0  Therefore a = b, b = c, c = d, d = e, e = f, f = 0. → 000000 | A. 1 |
| 1. Recursive Functions   = − 1 = 10 − 1 = 9  =  = 7 + 3 = 10  =  = 8 − 1 = 7  =  = 9 − 1 = 8  =  = 10 − 1 = 9  =  = 7 + 3 = 10  =  = 4 + 3 = 7  = 4  Now substitute backwards. | C. 9 |
| 1. Digital Electronics   Let D represent the diamond, R represent the rectangle  and O represent the oval. The digital circuit is represented  by the following Boolean expression:  (~A R (A D B D C) R ((A D B D C) O C O ~D))  D ((A D B D C) O C O ~D) D D  Let # = A D B D C and & = (A D B D C) O C O ~D   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | A | B | C | D | ~A | ~D | # | & | ~AR#R& | ~A#&D&DD | | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |   Therefore there are 3 that make it TRUE: (0, 0, 0, 0), (0, 0, 1, 1), (1, 1, 0, 0). | B. 3 |
| 1. Prefix-Infix-Postfix   + − / \* 3 # # 0 2 2 \* 2 3 / # 4 − 8 6 \* 3 2 ↑ 2 4  = + − / \* 3 # (# 0 2) 2 (\* 2 3) / # 4 (− 8 6) (\* 3 2) (↑ 2 4)  = + − / \* 3 (# 4 2) 6 / (# 4 2) 6 16  = + − / (\* 3 12) 6 (/ 12 6) 16  = + − (/ 36 6) 2 16  = + (− 6 2) 16  = (+ 4 16)  = 20 | B. 20 |
| 1. Computer Number System     There are 23 numbers that have ascending digits in both bases from 100  to 400. They are (in base 10):  123, 124, 125, 126, 127, 137, 138, 139, 156, 157, 158, 159, 189,  239,  345, 346, 347, 348, 349, 359, 367, 378, 379. | C. 23 |
| 1. What Does This Program Do   The first nested loop defines the array.  The initial array is:   |  |  |  |  |  | | --- | --- | --- | --- | --- | | 1 | 2 | 3 | 4 | 5 | | 4 | 5 | 6 | 7 | 8 | | 9 | 10 | 11 | 12 | 13 | | 16 | 17 | 18 | 19 | 20 | | 25 | 26 | 27 | 28 | 29 |   The second nested loop checks for numbers divisible by 3, 4 and 5. The  resulting array is:   |  |  |  |  |  | | --- | --- | --- | --- | --- | | 1 | 2 | 1 | 1 | 1 | | 1 | 1 | 2 | 7 | 2 | | 3 | 2 | 11 | 4 | 13 | | 4 | 17 | 6 | 19 | 1 | | 5 | 26 | 9 | 7 | 29 |   The final nested loop sums all the even entries. The sum is 44.  This is not one of the choices, so the answer is E. None of the above. | E. None of the above |
| 1. Data Structures     The smallest internal path length would occur for a balanced tree with  no gaps. For 32 nodes, levels 0 through 4 would be filled with 31  nodes and 1 on level 5. The internal path length would be:  2 \* 1 + 4 \* 2 + 8 \* 3 + 16 \* 4 + 1 \* 5 = 103 | B. 103 |
| 1. Graph Theory   Two stops → adjacency matrix3   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | 3 | 7 | 2 | 3 | **9** | 9 | 3 | | 2 | 1 | 1 | 0 | 3 | 1 | 0 | | 1 | 2 | 1 | 1 | 3 | 2 | 1 | | 6 | 4 | 4 | 1 | 9 | 4 | 2 | | 0 | 3 | 0 | 1 | 2 | 4 | 1 | | 4 | 2 | 3 | 0 | 5 | 2 | 1 | | 3 | 5 | 2 | 1 | 5 | 6 | 2 |   9 flights  One stop → adjacency matrix2   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | 3 | 2 | 2 | 0 | **3** | 2 | 1 | | 0 | 1 | 0 | 0 | 1 | 2 | 0 | | 1 | 1 | 0 | 0 | 1 | 1 | 0 | | 1 | 3 | 0 | 1 | 2 | 4 | 1 | | 1 | 0 | 1 | 0 | 2 | 0 | 0 | | 0 | 2 | 0 | 1 | 1 | 2 | 1 | | 1 | 1 | 1 | 1 | 3 | 1 | 1 |   3 flights  Direct flight → adjacency matrix   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | 0 | 1 | 0 | 1 | **1** | 1 | 1 | | 0 | 0 | 1 | 0 | 1 | 0 | 0 | | 0 | 0 | 0 | 0 | 1 | 1 | 0 | | 1 | 0 | 1 | 0 | 1 | 0 | 1 | | 0 | 1 | 0 | 0 | 0 | 1 | 0 | | 1 | 0 | 0 | 0 | 1 | 0 | 0 | | 1 | 1 | 0 | 0 | 0 | 1 | 0 |   1 flight    Total number of possible flights from Atlant  However there are 5 paths (APAO, AJAO, ASAO, AOAO, AOPO) with 2 stops that repeat airports. So the number of possible flights is 1 + 3 + 4 = 8. | A. 8 |
| 1. LISP     U = ((a (b c)) (d e f) (g) (h (i j k)) (l m) n)  V = (p (q r) (s (t u v)) (w (x y) z))  X = (CDR (CAR (CDR (CDR V))))  = (CDR (CAR (CDR (CDR ‘(p (q r) (s (t u v)) (w (x y) z))))))  = (CDR (CAR (CDR ‘((q r) (s (t u v)) (w (x y) z)))))  = (CDR (CAR ‘((s (t u v)) (w (x y) z))))  = (CDR ‘(s (t u v)))  = ((t u v))  Y = (CAR (CDR (CAR (CDR (CDR (CDR U))))))  = (CAR (CDR (CAR (CDR (CDR (CDR ‘((a (b c)) (d e f)  (g) (h (i j k)) (l m) n)))))))  = (CAR (CDR (CAR (CDR (CDR ‘((d e f) (g) (h (i j k)) (l m) n))))))  = (CAR (CDR (CAR (CDR ‘((g) (h (i j k)) (l m) n)))))  = (CAR (CDR (CAR ‘((h (i j k)) (l m) n))))  = (CAR (CDR ‘(h (i j k))))  = (CAR ‘((i j k)))  = (i j k)  (REVERSE (CONS Y X)) = (REVERSE (CONS ‘(i j k) ((t u v))))  = (REVERSE ‘((i j k) (t u v)))  = ((t u v) (i j k)) | A. ((t u v) (i j k)) |
| 1. FSAs and Regular Expressions   ((0  1)\* (11  00) 1\*100\*)\*  Note: regular expression must end in 0 and contain 10 or be null  a, b, d, and g do not end in 0. c, e, and f are valid. | E. None of the above |
| 1. Assembly Language   An alternate code for this program is:  10 num = 24  20 cnt = 0  30 if num - 1 = 0 then 300  35 cnt = cnt + 1  40 if int(num/2) \* 2 - num = 0 then 200  50 num = num \* 3 + 1  60 goto 30  200 num = int(num/2)  210 goto 30  300 print cnt  400 end  The final count (cnt) is 10. | B. 10 |