Stanford ProCo

May 26, 2012

proco.
programming contest. provably cool.

Problem Packet
Advanced Division

Sponsored by:

Stanford Computer Science

Palantir

Microsoft

no starch press
the finest in geek entertainment

Overview: Find the length of the longest run in a string.

Description: A group of Gryffindors are playing a variant of Exploding Snap. Each player gets to play a sequence of cards. They can continue playing until one of their cards explodes, at which point the next person gets a turn. The winner is the person who plays the most cards in a row.

A single string can be used to represent this game: each player is represented by a distinct letter or digit, and the string represents the sequence in which players played their cards. For example, "`aaabba`" means that player "a" played three cards in a row, and then player "b" played two cards and then "a" played one card.

Hermione is looking for a strategy in this game. In particular, she's interested in how many cards in a row it takes to win. Write a program that takes in a game string and outputs the number of cards that it took to win in that game. In the above example, the number of cards to win is three.

Filename: adv21.{java, cpp, c, cc, py}

Input: The first line contains an integer *n* representing the length of the string *s*. The second line contains *s*.

Output: Print a single integer representing the highest number of cards in a row played by any player.

Assumptions: $1 \le n \le 100$
s will only contain lowercase alphanumeric (`a - z`, `0 - 9`) characters.

Sample Input #1:

```
3
aab
```

Sample Output #1:

```
2
```

Sample Input #2:

```
10
abbb123333
```

Sample Output #2:

```
4
```

Overview: Find the smallest integer that can be constructed from a given set of digits.

Description: You are in transfiguration class with Professor McGonagall. Transfiguration is the study of transforming one object into another object, a bullfrog into a broomstick. However, before you can transform bullfrogs to broomsticks, you must first practice on nonliving things, such as strings of digits.

Professor McGonagall has given you your first assignment: given a set of digits `0 - 9`, find the smallest integer that can be formed from those digits. She has promised you that once you have mastered this transfiguration assignment, you can move on to transforming bullfrogs to broomsticks!

Filename: adv22.{java, cpp, c, cc, py}

Input: The first line contains an integer n representing the number of digits in the string. The second line contains a string s of n digits `0 - 9`.

Output: Print the smallest integer that can be formed from the given digits, with no leading zeros.

Assumptions: $1 \leq n \leq 1{,}000$
There will be at least one non-zero digit in s.

Sample Input #1:

```
11
87654332211
```

Sample Output #1:

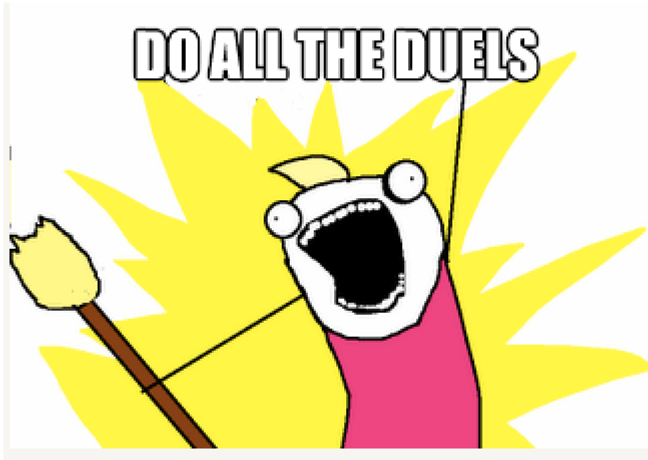
```
11223345678
```

Sample Input #2:

```
3
065
```

Sample Output #2:

```
506
```



Overview: Report the final score of a two-player duel.

Description: You just joined the Hogwarts dueling club! You are so excited for your first practice duel the next day that you decide to read up on duel scoring. At each round of the duel, one wizard is designated as the attacker and the other is the defender. When an attacker wins a round, s/he gets a point and becomes the attacker for the next round. When a defender wins a round, s/he gains no points but becomes the attacker the next round. Practice your new dueling knowledge by calculating the scores of the given duels!

Filename: adv23.{java, c, cpp, cc, py}

Input: The first line contains an integer *n* representing the number of rounds in the duel. The second line contains exactly *n* digits, where each digit is either a `0` or a `1`. A `1` corresponds to your winning the round, and a `0` corresponds to your losing the round.

Output: Print your score, followed by a colon, followed by your opponent's score.

Assumptions: You start the first round as the attacker.
$1 \le n \le 1{,}000{,}000$

Sample Input #1:

```
16
0001111010110011
```

Sample Output #1:

```
5:3
```

Sample Input #2:

```
2
10
```

Sample Output #2:

```
1:0
```

Overview: Convert a number from one base to another.

Description: Hermione is trying to send a number to Harry telling him her whereabouts, but she doesn't want anyone else, especially the Death Eaters, to be able to read it. So she decides to foil any eavesdroppers by transforming the number prior to transmission.

Traditionally, numbers are represented in base 10, but numbers can also be represented in other bases. A number $a_d a_{d-1} ... a_0$ base b, where a_d, a_{d-1}, …, a_0 are the digits, has value $a_d b^d + a_{d-1} b^{d-1} + … + a_0 b^0$. Furthermore, each digit a_i is between 0 and b-1 inclusive. For example, 10 base 7 is the same as 7 base 10 and 123 base 7 is the same as 66 base 10. Hermione decides to transform her number from one base to another. To further confuse eavesdroppers, she uses lowercase alphabetic characters instead of numeric digits. That is, a represents 0, b represents 1, etc. In base h (7), `ca` (20) would be equal to `be` (14) base `k` (10).

Filename: adv24.{java, cpp, c, cc, py}

Input: The first line contains an integer n representing the number of digits in the input string s. The second line contains s, and the third line contains two characters b_s b_e representing the starting and ending bases, respectively.

Output: Print a string of characters representing s in base b_e, with no leading zeroes (a's).

Assumptions: s will represent a valid integer in b_s with no leading zeroes (a's).
s base b_s will have value $< 2^{31}$.
Neither b_s nor b_e will be a or b.

Sample Input #1:

```
4
ccac
kc
```

Sample Output #1:

```
baaabaabbaba
```

Sample Input #2:

```
1
h
kh
```

Sample Output #2:

```
ba
```

Overview: Find the minimal total King distance from a point to all of the other points

Description: Hermione has finally convinced Harry to hold meetings for Dumbledore's Army again, yay! Sadly, the Room of Requirement is not an option, as it has been compromised. Instead, Harry must determine where the best new meeting place is, considering all *n* members of the D.A. are at different locations on a grid. Out of sheer laziness, Harry plans to have the D.A. meet at one of these *n* locations.

The best meeting point is defined as the one that minimizes the sum of King distances between the chosen location and the other *n*-1 points. The King distance between two points is defined as the number of steps it takes to go from one point to the other, at each step travelling to one of the 8 surrounding lattice points (much like a King on a chessboard). For example, it takes one step to go from (0, 0) to the points (0,1), (1,1), (1,0), (1,-1), (0,-1), (-1,-1), (-1,0), and (-1,1).

Math was never Harry's strong point, so he's having trouble figuring out where to meet. Can you help him?

Filename: adv51.{java, cpp, c, cc, py}

Input: The first line contains an integer *n* representing the number of meeting points. The next *n* lines each contains two integers *x y* representing the coordinates of the possible meeting points.

Output: Print the minimum total King distance of the best meeting point.

Assumptions: $1 \le n \le 1{,}000$
Each coordinate will have absolute value ≤ 1,000,000,000

Sample Input #1:
```
2
1 1
1 2
```

Sample Output #1:
```
1
```

Sample Input #2:
```
3
2 1
1 2
0 3
```

Sample Output #2:
```
2
```

Sorting Potions

Overview: Sort a list of strings from shortest to longest.

Description: "*Detention! And twenty points from Slytherin!*" - Professor McGonagall

Gah! You have just been assigned detention with Professor Snape - for *walking disrespectfully*. Tonight your task is to sort the numerous ingredients in his potions cupboard. Unfortunately, Professor Snape is a particular man; instead of sorting the ingredients in alphabetic order, you must sort the string on each ingredient's label from shortest to longest. If two strings are the same length, then they must be sorted in alphabetical order. To prove to Snape that you have properly sorted everything, you must also show him the ingredient labels found at particular indices. Here's to hoping that you'll finish before curfew!

Filename: adv52.{java, cpp, c, cc, py}

Input: The first line contains an integer m representing the number of strings in the list. In the next m lines, the i-th line ($1 \le i \le m$) contains a single string s_i representing the label of ingredient i. The next line contains a single integer n representing the number of indices to print out. In the next n lines, the j-th line ($1 \le j \le n$) contains a single integer n_j indicating an index to print out.

Output: Print exactly n lines, with the j-th line ($1 \le j \le n$) containing the string at index n_j after sorting.

Assumptions:
$1 \le m \le 20{,}000$
$1 \le n \le m$
$0 \le n_j < m$, for all j
All strings s_i will contain only uppercase (A - Z) characters.
All strings s_i will have length between 1 and 10, inclusive.
All strings s_i will be unique.
All indices are 0-based.

Sample Input #1:
```
2
AAA
AA
1
1
```

Sample Output #1:
```
AAA
```

Sample Input #2:
```
3
C
PQ
RT
2
2
0
```

Sample Output #2:
```
RT
C
```

Overview: Find the minimum number of steps to reach a destination.

Description: Although ubiquitous in proper Wizarding society, magical transportation is a complex field of research that many Unspeakables delight in studying. Before his arrest in 1996, Augustus Rookwood had developed a novel mode of transportation called *apparition tokens* that may very well have turned the tide in the Death Eaters' favor, were it not for certain limitations.

Apparition tokens are simply a set of n magically interlinked tokens, each infused with a number and spread throughout the land. Based on the number on the token, a person who knows of the token's existence can instantly travel that many tokens forward or backward, as long as the new token is valid. For example if token 5 had been infused with "2", a Death Eater at that token could travel to token 3 or token 7.

Death Eaters could use these secret tokens to travel about and bypass any pesky anti-apparition wards. But Rookwood faced a practical challenge: apparition tokens are magically taxing, and it is therefore optimal to take as few steps as possible to travel from one token to another. Rookwood never took a programming class so he had no clue how to solve this problem, but fortunately, you have! Assuming you start at tile 1, what is the minimum number of steps you must take to reach tile k?

Filename: adv53.{java, cpp, c, cc, py}

Input: The first line of input contains two integers n k as defined above. In the next n lines, the i-th line ($1 \le i \le n$) contains an integer s_i representing the number infused with token i.

Output: Print the minimum number of steps to move from tile 1 to tile k, or `-1` if no such path exists.

Assumptions: $1 \le k \le n \le 1{,}000$
$0 \le s_i \le 1{,}000$ for all i

Sample Input #1:

```
6 2
2
1
2
1
1
4
```

Sample Output #1:

```
9
```

Sample Input #2:

```
6 2
2
1
2
1
1
5
```

Sample Output #2:

```
-1
```

Overview: Does the index of any number in a sorted array equal its value?

Description: Harry, Ron, and Hermione are attempting to reach the sorcerer's stone before Voldemort can get there! Unfortunately, they have reached a seemingly unsolvable puzzle. In front of them is a line of n numbered boxes, from 0 at the very left to n-1 at the far right. Each box can be opened to reveal a number inside. Behind the boxes are two doors. A note next to the first box explains the puzzle:

Each of these boxes contains a number, and the numbers are in sorted order from left to right. If one of the boxes contains a number that matches the number on the outside, behind the right door is a tiger that will devour you, and behind the left is the sorcerer's stone. If there is no such box, the doors are reversed. However, be warned! You may open at most 42 boxes before all the boxes explode and you are trapped forever!

Help Harry, Ron, and Hermione choose the safe door! You are given the size n of a hidden sorted array. By querying the values in the array at most *42* times, determine whether the value of some element in the array equals its index.

Filename: adv54.{java, cpp, c, cc, py}

Input / Ouput: This is an interactive problem. This means that your program will receive input based on the output your program produces. When your program starts, you will be provided an integer n corresponding to the size of the array A. Your program must then do one of the following:

1. Output an integer i ($0 \le i < n$), after which your program will be provided the integer $A[i]$. This counts as 1 query.
2. Output -1, indicating that there is some i such that $A[i] = i$
3. Output -2, indicating that for all i, $A[i] \neq i$

You MUST output a new line character and flush the output stream after each output:

In C, use `printf("\n"); fflush(stdout);`
In C++, use `cout << endl << flush;`
In Java, use `System.out.println(); System.out.flush();`
In Python, use `sys.stdout.write("\n"); sys.stdout.flush();`

Assumptions: $1 \le n \le 10{,}000$
All values in A are distinct.
All values in A are between -1,000,000,000 and 1,000,000,000, inclusive.
All indices are 0-based.

Sample Sequence #1:

Hidden sequence: 0 1 2 3 4 5 6 7 8 10

```
COMPUTER  10
YOU       0
COMPUTER  0
YOU       -1
```

Sample Sequence #2:

Hidden sequence: 100000 100001

```
COMPUTER  2
YOU       0
COMPUTER  100000
YOU       1
COMPUTER  100001
YOU       -2
```

Overview: Evaluate a postfix ternary logic expression.

Description: Oh, no! It appears that the Gringotts goblins stumbled across a computer science book before Voldemort's anti-Muggle crackdown, because they've added some additional security precautions to Bellatrix Lestrange's vaults. To enter her vault, Harry and company must correctly solve a postfix ternary logic expression. The consequences of failure may be... permanent.

But what is ternary logic, you ask? In ternary logic, there are three literals - true (T), false (F), and unknown (U), and three operators - and (&), or (|), and not (!). The logic rules for T and F are the same as in boolean logic. Hermione has deduced that U is essentially an indeterminate state of either true or false, and has cleverly constructed the following logic rules:

```
Not: !U=U
And: U&F=F&U=F  U&T=T&U=U&U=U
Or : U|T=T|U=T  U|F=F|U=U|U=U
```

In Muggle society, expressions are commonly written in infix notation; that is, operators are placed between their operands (or in the case of unary operators, before their operand). Infix requires the use of parentheses to disambiguate order of operations. However, to further confuse any would-be thieves, the goblins have decided to use postfix representations for their expressions. Postfix eliminates the need for parentheses and gives an unambiguous evaluation order by placing the operator after its operand(s). For instance, infix T&F becomes postfix TF&, infix !U becomes postfix U!, infix (!(!F))|U becomes F!!U|, and infix T&(!(U|F)) becomes postfix TUF|!&.

Time is running short, and the Golden Trio must pass through the vault before the Gringotts dragons discover them. You, my friend, are their only remaining hope. Good luck!

Filename: adv91.{java, cpp, c, cc, py}

Input: The first line contains an integer *n* specifying the length of the expression. The second line contains *n* characters, each either a literal (T, F, or U) or an operator (&, | or !)

Output: Print the evaluation of the postfix expression, one of T, F, or U.

Assumptions: $1 \le n \le 100{,}000$

Sample Input #1:

```
6
TUF|!&
```

Sample Output #1:

```
U
```

Sample Input #2:

```
9
TFTF&|U&|
```

Sample Output #2:

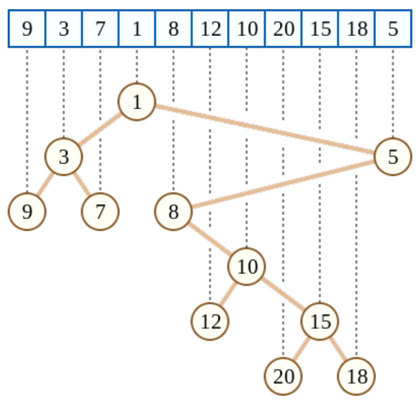
```
T
```

Overview: Given an array, print out the pre-order traversal of the associated Hermione Tree.

Description: Hermione recently faced a conundrum: she wanted to organize her books both by name *and* by importance to her studies! After learning about Computer Science in her Muggle Studies class, she came up with a clever solution: organizing her books as a binary search tree by name. However, to give easy access to her favorite books, she also required that the book at each node of the tree be more important than any of its descendants. Her organization system has become infamous at Hogwarts, and is referred to as the "Hermione Tree."

To implement her tree, Hermione assigns all of her books a distinct "importance" rank, with 1 being the most important. Then, she arranges all of her books in alphabetical order from left to right. She can then represent her book collection as an array, where the index into the array represents the alphabetical rank, and the value stored in the array represents the importance rank.

Your job is to construct a Hermione Tree from a given array. The following is an example of such a tree, constructed from the array `9 3 7 1 8 12 10 20 15 18 5`.



Finally you must print an inventory of her books. Hermione wants to visit each node of the tree in the following recursive manner:

- Write the current node to the end of the list
- Recursively examine the left child of the current node, then the right node.

Thus, the list for the above tree will look like `1 3 9 7 5 8 10 12 15 20 18`.

Filename: adv92.{java, cpp, c, cc, py}

Input: The first line contains a single integer n representing the number of integers in the array. In the next n lines, the i-th line contains a single integer A_i representing the i-th integer in the array.

Output: Print exactly n lines, with the i-th line containing the integer representing the i-th node visited in the pre-order traversal of the Hermione Tree.

Assumptions: $1 \leq n \leq 100$
All numbers A_i will be unique.

Sample Input #1:	3 2 1 3
Sample Output #1:	1 2 3
Sample Input #2:	6 3 4 1 6 2 5
Sample Output #2:	1 3 4 2 6 5

Overview: Transform one string into another.

Description: Neville Longbottom is working on his latest Transfiguration assignment: transforming one object into another object. Unfortunately, he only remembers three spells that can help him out. These spells are quite strange: they change the *name* of the object. Once the name has been transformed to the desired object's name, the object magically transforms as well! The three possible spells Neville can perform:

- Remove a 'z'
- Add an 'a'
- Replace a letter with the next letter in the alphabet. That is, Neville can a replace any 'b' with a 'c', any 'c' with any 'd', etc. He can also replace any 'z' with an 'a'.

Neville is too shy to ask Hermione for homework help, but not too shy to ask a bunch of students coding away on a Saturday morning! If you can, please help Neville figure out the minimum number of spells he needs to complete the transfiguration so he can finish his homework more quickly. He'll really appreciate it!

Filename: adv93.{java, cpp, c, cc, py}

Input: The first line contains the name of the starting object. The second line contains the name of the ending object.

Output: Print the minimum number of spells needed to transform the starting object's name into the ending object's name, using the three spells described above.

Assumptions: Both strings will have length between 1 and 500, inclusive.
Both strings will contain only lowercase (a - z) characters.

Sample Input #1:

```
abcdefghz
bcdefghi
```

Sample Output #1:

```
9
```

Sample Input #2:

```
abcdefghi
bcdefghi
```

Sample Output #2:

```
26
```

Overview: Determine the optimal order of valid matrix multiplications.

Description: Arithmancy is the advanced and incredibly complicated process of predicting the future through numbers. One commonly used strategy to reduce workload in Arithmancy is called “matrix chaining”, or connecting matrices of numbers together for multiplication. Fun fact: aside from increasing the amount by which the future can be predicted, matrix chaining also has practical applications in spell creation and runic studies!

An m-by-n matrix has m rows and n columns, for a total of mn entries. Matrix A can be multiplied with matrix B if and only if the number of columns of A equals the number of rows of B. If matrix A is m-by-n and matrix B is n-by-p, then the matrix product AB is m-by-p. Note that the order of multiplication matters - BA is not a valid matrix product. (In formal terms, matrix multiplication is not commutative.) However, it can be shown that matrix multiplication is associative; that is, the matrix product $ABC = (AB)C = A(BC)$ can be performed in any parenthetical order.

Sadly, as many aspiring Arithmancers have discovered, not all groups of matrices can be multiplied together to create a matrix chain. Given a list of matrix sizes, you need to determine the largest potential matrix that can be result from creating a matrix chain with all of these matrices.

Filename: adv94.{java, cpp, c, cc, py}

Input: The first line contains an integer k indicating the number of matrices to multiply together. The next k lines each contains two integers m n indicating that an m-by-n matrix is in the list.

Output: If no valid matrix multiplication chain exists that uses all matrices, output `-1`. Otherwise, if the final matrix product is r-by-c, output the maximum possible value of the scalar product rc.

Assumptions: $2 \le k \le 1{,}000$
$1 \le m \le 1000$ for all m
$1 \le n \le 1000$ for all n
Multiple matrices may have the same size (that is, m n pairs may not be unique).

Sample Input #1:

```
2
3 4
4 3
```

Sample Output #1:

```
16
```

Sample Input #2:

```
3
1 1
2 3
1 3
```

Sample Output #2:

```
-1
```