Second Annual Juilfs Contest

May 22, 2010

MISSION: IMPROBABLE

A. Project: NEWS 7 points

Reading between the Lines

The IMF often gives message encoders to agents in the field. The agents communicate with the secretary by placing ads on specific pages of specific newspapers. The ad copy is mostly meaningless, but it will contain something that is preceded by a dash and ends with a dash. This is decoded by the secretary's office. Each agent is given a separate encoder, but the secretary does not want to have a separate device in his office for each agent, so he is asking you to write a universal decoder. Each one has a short program. The program consists of a set of instructions of two single-digit numbers and two letters. For example, the instruction `(a1b2)` tells the decoder that when it is in state 1 and sees an `a` in the message, write a `b` and go into state 2. The decoding process starts at the beginning of the message in state 1 and goes from left to right through the characters of the message, outputting the decoded message.

For example, given the decoder A1G1 A2A1 E1D1 L1A1 N1O2 P1H2 P2E1, the phrase "–An Apple–" becomes "goahead". Spaces are ignored in the input and supplied implicitly in the output. Your mission, should you decide to accept it, is to write a universal decoder so that the secretary can intercept the messages from the field.

Input

The input to your program will begin with a line with a single number $0 < n < 1000$ representing the number of problems to follow. This will be followed by $2n$ lines of text. The first line is the decoder program and the second line is the coded message. The line describing the decoder program with begin with a number $0 < m < 260$, followed by m instructions.

Output

Your output for each pair of input lines should be the decoded message. The input may have added spaces and a mix of upper and lowercase letters. Your output should be all lowercase letters without any spaces.

Sample Data

Sample Input
3 12 B1P3 P1C1 E1U2 U2N1 Y2S1 S1L1 L1A1 A1A2 T1E2 E2N1 Y1H1 E3L1 Sleepy Beauty 11 A1A2 B1H2 H2A1 E1O1 G2H1 A2A3 G1N1 N1P2 T1W1 U2B1 H1B2 Get 12 O1L2 F1S6 G2I3 D2P1 E2N4 G3E3 Y3S3 D4D7 E5P2 E6E2 T7S2 H2U5 Feed the doggy
Sample Output
launchplanes now sendsupplies

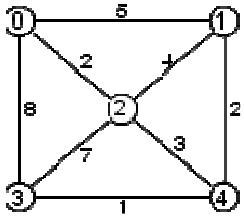
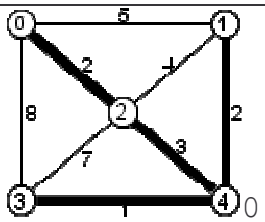
This is not mission-critical, but the secretary would also like to know how to form a decoder from an encoder program. That is, the specification for the encoder is also a list of character-state transitions. The secretary would like to know how to take an encoder specification and create a decoder specification. The current process is just trail and error, but this consumes a lot of agent time. In particular, is this question decidable? Please only devote time to this when you are between missions.

B. Project: N² 10 points

The New and the Now

Good morning, special agent. It's time to bring our operation into the 21st century; these tapes are getting expensive. We've decided our best option is to wire our secret headquarters throughout the globe directly together for secure, instant communication. Your mission, should you choose to accept it, is to determine how much this will all cost us.

Our goal, of course, is to save money; we want to create a single network containing each station for the minimum possible cost. For example, if we have five stations numbered from zero to four with connection costs as shown below to the left, then our network should consist of the highlighted connections shown below to the right, and the total cost will be eight billion dollars. Remember; minimum cost is our highest priority. If two networks are equivalent, either will suffice.

Connection Costs	Cost Matrix	IMF Network	Total Cost
	0 5 2 8 0 5 0 4 0 2 2 4 0 7 3 8 0 7 0 1 0 2 3 1 0		8

Input

Input will consist of a number n with $0 < n < 1000$, which gives the number of individual networks to be created. Each of the n networks will begin with a line containing a single number s with $1 < s < 100$ followed by an $s \times s$ grid (s lines with s space-separated numbers on each line) detailing the connection costs between the stations; a cost of zero indicates no connection.

Output

The output for each case should simply be a single integer indicating how much money, in billions of dollars of course, the project will cost.

Good luck, special agent, and remember: the fate of our bi-quarterly budget report rests in your hands.

Sample Data (on back)

Sample Data (Project: N^2)

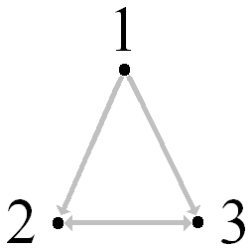
Sample Input	Sample Output
3 5 0 5 2 8 0 5 0 4 0 2 2 4 0 7 3 8 0 7 0 1 0 2 3 1 0 6 0 6 0 0 0 1 6 0 4 5 9 7 0 4 0 7 0 0 0 5 7 0 2 0 0 9 0 2 0 8 1 7 0 0 8 0 7 0 1 8 0 0 0 0 1 0 0 0 2 3 0 8 0 0 9 0 0 0 0 0 9 0 4 0 7 0 2 0 4 0 0 5 0 3 0 0 0 0 7 0 0 0 7 5 7 0	8 18 23

C. Project: W³ 10 points

Who's watching the Watchers?

Because the IMF is a plausibly deniable branch of the secretary's staff, each IMF agent only knows about a few other agents. The secretary knows that certain agents "watch" other agents. Some of the agents are IMF, some are not. But, because of the deniability, we are never sure who is an IMF agent or not. You mission, should you choose to accept it, is to take the list of watchers and make sure that no IMF agent is watching another IMF agent. To do this, you must determine if the list of watchers can be grouped into two sets. Each person in one set may be watching any number of people in the other set, but nobody watches someone in their own set. That is, given the list of who is watching whom, you must determine if we can break them into IMF and non-IMF where each group collectively is spying on only members of the other group.

For example, if we know that agent 1 watches agents 2 and 3, and agents 2 and 3 watch each other, then this is inconsistent, because if agent 1 is IMF, then agent 2 must be non-IMF, but now agent 3 is being watched by both IMF (agent 1) and non-IMF (agent 2).



Input

The input will consist of a line with a single number n with $0 < n < 100$, which gives the number of spy networks that follow. Each of the n spy networks will begin with a single number m with $0 < m < 1000$, which gives the number of spies in that network. This is followed by m lines. Each line will begin with a number s, with $0 < s \leq m$, followed by i numbers s_1 through s_i. This line means that the spy code-named s is watching the spies s_1 through s_i.

Output

Your output for each spy network should either be "consistent" if there is a valid split between IMF and non-IMF or "inconsistent" if no such split exists.

Sample Data (on back)

Sample Data (Project: W^3)

Sample Input	Sample Output
3 5 1 2 4 2 1 3 5 3 2 4 4 1 3 5 5 2 4 5 1 3 2 3 4 3 2 4 5 4 4 2 4 1 3 2 4 3 1 4 2	consistent inconsistent consistent

D. Project: A←S 10 points

Turnabout is Fair Play

Enemy agents are sending messages to one another using a constantly changing encryption method. The encryption equation has the form $E(k) = ak + b$, where a and b are integers and k is the numeric value of the letter of the alphabet you are trying to encrypt. Through careful monitoring, we know that the agents use 29 characters: the 26 letters in the English alphabet and space, comma and period according to the following chart:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	,	.
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28

After intercepting several transmissions, letter frequency analysis has revealed two letters and their corresponding encrypted versions in the messages you will be supplied. It is now your task to decrypt the remaining messages.

> Note: Since 29 is a prime number, $\mathbb{Z}_{29}$ forms a field. That is, considering the integers 0 through 28 and using arithmetic mod 29 guarantees that for every $a \in \mathbb{Z}_{29}$, there exists the multiplicative inverse a^{-1} such that $aa^{-1} = a^{-1}a = 1$ for some $a^{-1} \in \mathbb{Z}_{29}$.
>
> This would not be true, for example, if they were using $\mathbb{Z}_{26}$ to encrypt only the alphabetic characters.

Input

The input will consist of a line with a single number n with $0 < n < 100$, which gives the number of decryption problems that follow. Each of the n decryption problems will consist of exactly two lines of input. The first line of a decryption problem will contain two, comma separated equivalencies. Each equivalency will have the form $e=k$ where k was the letter that appeared in the real message, and e is the letter that appears in the encoded version you are given. The second line of each decryption problem will contain the intercepted encrypted text. The encrypted text will consist of only lowercase letters, space, comma and period.

Output

Your output for each decryption problem should be the original message before it was encrypted. All output should be in lower case text.

Sample Data (on back)

Sample Data (Project: A←S)

Sample Input
3 a=b,t=u buubdlabuaebxo e=u,n=n rhnlyjgntlwunyliuvf e=n,i=z bqqzln.hprwnx.zl.kz,hxnan.ibaw.eooc
Sample Output
attack at dawn man down, send help affine cypher in discrete math book

E. Project: TUNNEL 12 points

Disconnecting the Dots

We have intelligence that the Tunnellers' Underground Nefarious **N**etwork of **E**xtortion & **L**aundering is building tunnels directly (in straight lines) through the Earth, to further their nefarious goals (such as the trafficking of the precious metals they will doubtless encounter in their burrowing).

Additionally, we know the start and end points of several possible tunnels which they might be digging, in the form of pairs of (latitude, longitude) coordinates.

Your mission, should you choose to accept it, is to compute the length of each tunnel. Earth coordinates are specified in terms of longitude and latitude, which are written *d*:*m*:*s* where *d* is the degrees; *m* is the minutes and *s* is the seconds. There are 60 seconds in a minute, and 60 minutes in a degree. Latitude is degrees, minutes, and seconds north from the equator (from -90:0:0 to 90:0:0) and longitude is degrees, minutes and seconds east of the Prime Meridian in Greenwich, UK (from -180:0:0 to 179:59:59) Consider the Earth to be a sphere with circumference 40,000 km.

Recall that spherical coordinates can be translated to rectangular coordinates via the following formulae:

$$x = \rho * \sin(\theta) * \cos(\varphi)$$
$$y = \rho * \sin(\theta) * \sin(\varphi)$$
$$z = \rho * \cos(\theta)$$

where x, y and z are the usual Cartesian coordinates, ρ is the radius of the sphere, and φ is longitude and θ is colatitude. Colatitude is the angle from the North Pole, which can be derived from latitude.

Also, if your trigonometric functions expect radian input, you will have to convert using the identity

$$180° = \pi \text{ radians.}$$

Input

The input will consist of a line with a single number n with $0 < n < 100$, which gives the number of tunnel specifications that follow. Each of the n tunnel specifications will consist of a single line with two ordered pairs of latitude and longitude. There will be no spaces in the input.

Output

Your output should be the number of kilometers between endpoints of the tunnel, rounded to two decimal points.

Sample Data (on back)

Sample Data (Project: TUNNEL)

Sample Input:	Sample Output:
5 (45:0:0,0:0:0)(0:0:0,0:0:0) (44:2:44,-123:4:19)(44:38:6,-124:3:10) (55:45:21,37:37:3)(38:53:42,-77:2:11) (55:45:21,37:37:3)(46:43:57,-117:0:1) (51:30:0,-0:7:34)(48:51:24,2:21:4)	4872.48 101.80 7334.36 7778.90 333.58

F. Project: Beaver 12 points

Keeping the Agents Busy

The secretary has become concerned that although the IMF has numerous agents in the field, Mr. Phelps seems to always choose Cinnamon, Rolin, Barney and Willy to be on his team. True, from week to week he adds some supporting agent, but he seems to only use a small fraction of the expertise at his disposal. The secretary would like you to report back on the scope of this behavior.

Jim Phelps is choosing his team for a mission to disrupt several South American drug cartels. Because he cannot directly assassinate key members, he has an ingenious plan to cause them to take each other out, which requires leaking certain information to at least one of the cartels. Fortunately, his pool of available agents includes exactly one double agent for each cartel. He needs to assemble a team of some given size which includes one or more of these double agents. How many ways can he form a team fulfilling these criteria? Be sure you don't count the same team multiple times.

You may assume that Phelps will always be choosing a team larger than the number of cartels he is attempting to take down.

Input

The input will consist of a line with a single number n with $0 < n < 100$, which gives the number of team specifications that follow. Each of the n team specifications will consist of exactly three, space-separated numbers a, t, and c where $0 < a < 200$ is the number of available IMF agents in the field and $0 < c < t < 20$ for team size t and number of cartels c. Note that c is also the number of double agents since there is exactly one double agent per cartel and a includes regular agents and double agents.

Output

Your output for each team specification should be the number of possible teams that Phelps could assemble from the given parameters.

Sample Data

Sample Input:	Sample Output:
3 13 5 4 10 4 2 20 6 3	1161 140 26384