



# 2007 ACM Asia Programming Contest

Singapore

14 December 2007

## Contest Problems

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## Before You Start

Welcome to the the 2007 ACM Asia Programming Contest. Before you start the contest, please be aware of the following notes:

1. There are seven (7) problems in the packet, using letters A–G.

**A:** MODEX

**B:** JONES

**C:** ACORN

**D:** TUSK

**E:** SKYLINE

**F:** USHER

**G:** RACING

These Contest Problems contain eighteen (18) pages; check that your set is complete.

2. Any of your solutions can use any of the languages C, C++ or Java. Use only the compilers `gcc`, `g++`, and `javac`.
3. All solutions must read from standard input and write to standard output. In C this is `scanf/printf`, in C++ this is `cin/cout`, and in Java this is `System.in/out`. The judges will ignore all output sent to standard error. From your workstation you may test your program with an input file by redirecting input from a file:

```
program < file.in
```

or in Java:

```
java Program < file.in
```

4. Solutions for problems submitted for judging are called runs. Each run will be judged. The judges will respond to your submission with one of the following responses. In the event that more than one response is applicable, the judges may respond with any of the applicable responses.

Response	Explanation
Correct	Your submission has been judged correct.
Wrong Answer	Your submission generated output that is not correct or is incomplete.
Output Format Error	Your submission's output is not in the correct format or is misspelled.
Excessive Output	Your submission generated output in addition to or instead of what is required.
Compilation Error	Your submission failed to compile.
Run-Time Error	Your submission experienced a run-time error.
Time-Limit Exceeded	Your submission did not solve the judges' test data within the allocated time.
Memory Limit Exceeded	Your submission did not solve the judges' test data within the allocated memory limits.
No Output Produced	Your submission does not generate any output to standard output.

5. A team's score is based on the number of problems they solve and penalty points, which reflect the amount of time and number of incorrect submissions made before the problem is solved. For each problem solved correctly, penalty points are charged equal to the time at which the problem was solved plus 20 minutes for each incorrect submission. No penalty points are added for problems that are never solved. Teams are ranked first by the number of problems solved and then by the fewest penalty points.
6. This problem set contains sample input and output for each problem. However, you may be assured that the judges will test your submission against several other more complex datasets, which will not be revealed until after the contest. Several questions require an efficient rather than naive solution. If the response is "Time-Limit Exceeded", chances are that you need to implement a more efficient algorithm.
7. In the event that you feel a problem statement is ambiguous or incorrect, you may request a clarification. Read the problem carefully before requesting a clarification. If the judges believe that the problem statement is sufficiently clear, you will receive the response, "The problem statement is sufficient; no clarification is necessary." If you receive this response, you should read the problem description more carefully. If you still feel there is an ambiguity, you will have to be more specific or descriptive of the ambiguity you have found. If the problem statement is ambiguous in specifying the correct output for a particular input, please include that input data in the clarification request. If a clarification is issued during the contest, it will be broadcast to all teams.
8. Runs for each particular problem will be judged in the order they are received. However, it is possible that runs for different problems may be judged out of order. For example, you may submit a run for B followed by a run for C, but receive the response for C first. Do not request clarifications on when a response will be returned. If you have not

received a response for a run within 30 minutes of submitting it, you may have a runner ask the site judge to determine the cause of the delay. If, due to unforeseen circumstances, judging for one or more problems begins to lag more than 30 minutes behind submissions, a clarification announcement will be issued to all teams. This announcement will include a change to the 30 minute time period that teams are expected to wait before consulting the site judge.

9. All lines of program input and output should end with a newline character (`\n`, `endl`, or `println()`).
10. All input sets used by the judges will follow the input format specification found in the problem description. You do not need to test for input that violates the input format specified in the problem.
11. Best wishes for your team. Remember the Olympic ideal: Treasure the experience of participation!

## Problem A: MODEX

Many well-known cryptographic operations require modular exponentiation. That is, given integers  $x$ ,  $y$  and  $n$ , compute  $x^y \bmod n$ . In this question, you are tasked to program an efficient way to execute this calculation.

### Input

The input consists of a line containing the number  $c$  of datasets, followed by  $c$  datasets, followed by a line containing the number 0.

Each dataset consists of a single line containing three positive integers,  $x$ ,  $y$ , and  $n$ , separated by blanks. You can assume that  $1 < x, n < 2^{15} = 32768$ , and  $0 < y < 2^{31} = 2147483648$ .

### Output

The output consists of one line for each dataset. The  $i^{\text{th}}$  line contains a single positive integer  $z$  such that

$$z = x^y \bmod n$$

for the numbers  $x, y, z$  given in the  $i^{\text{th}}$  input dataset.

### Example

Sample Input	Sample Output
2	3
2 3 5	11
2 2147483647 13	
0	

## Problem B: JONES



The time now is 12 noon and Indiana Jones is standing on the western bank of a river. He wants to reach the eastern bank as fast as possible. Across the river is a series of stones, arranged in a straight line, and each stone is 1 meter away from its immediate neighbours or the two river banks.

Let us divide the time into intervals of one minute each, such that Interval 0 starts at 12:00:00, Interval 1 starts at 12:01:00, and so on. At the start of each

interval, Indiana Jones can hop once from a stone/river bank to any stone/bank that is not more than 1.5 meters away, or stay put. He can hop so fast that we assume the time taken per hop is negligible.

The tricky part is this: The stones may sink and resurface! Within a time interval, a stone may sink at the middle of the interval, remains submerged and may resurface at the middle of another interval. If Indiana Jones is standing on a sinking stone, he will drown. Of course, Indiana Jones cannot hop to a stone that is submerged. At 12 noon, all stones are above the water and Indiana Jones is ready to hop. He has already derived the pattern of sinking/resurfacing for each stone during the next few intervals. Our task is to find the fastest way to cross the river.

Figure 1 shows an example of sinking and resurfacing stones over time. The example contains three stones, each of which is first sinking, then resurfacing and then sinking. The fastest way for Indiana Jones to cross the river is shown as a black line.

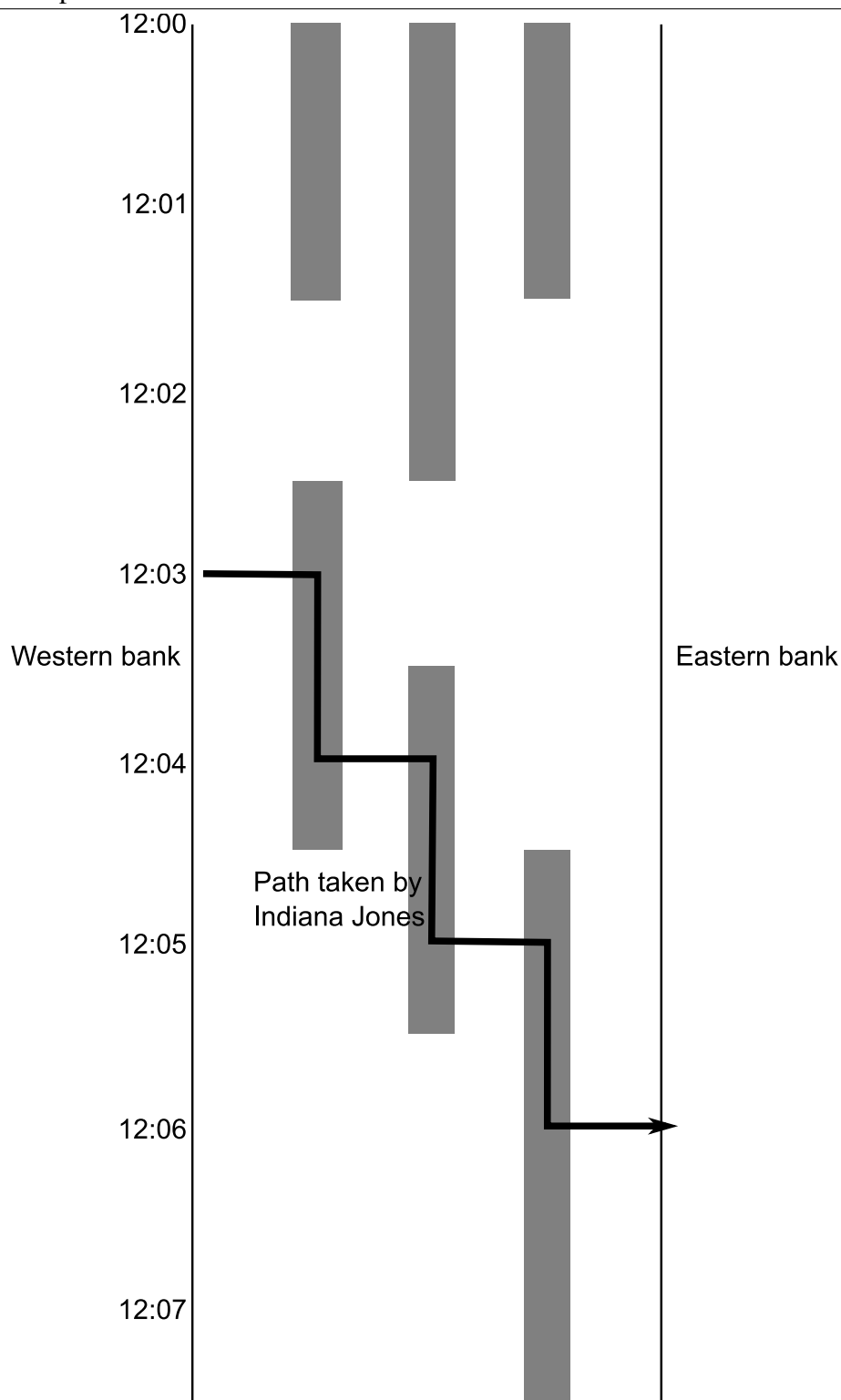
### Input

The input consists of a line containing the number  $c$  of datasets, followed by  $c$  datasets, followed by a line containing the number 0.

The first line of each dataset contains two positive integers, separated by a blank. The first value  $s$  is the number of stones. The second value  $t$  is the number of intervals whose movement pattern Indiana Jones can predict. You can assume  $1 \leq s \leq 500$  and  $1 \leq t \leq 500$ . The following  $t$  lines of each dataset describe the behavior of the stones in each interval. The  $i^{\text{th}}$  line describes the behavior of the stones in Interval  $i$ , where  $0 \leq i < t$ . Within each line, there are  $s$  characters, separated by blanks. The  $j^{\text{th}}$  character indicates the movement of the  $j^{\text{th}}$  stone in the middle of the  $i^{\text{th}}$  interval as follow:

- “s”: The stone is sinking.
- “r”: The stone is resurfacing.
- “u”: The stone is not moving.

**Figure 1** Example of a Pattern and Indiana Jones's Path



## Output

The output consists of one integer, which indicates the earliest interval at the beginning of which Indiana Jones can reach the eastern bank. If there is no way Indiana Jones can cross the river within  $t$  minutes, the output should be  $-1$ . Note that Indiana Jones actually has  $t + 1$  chances to hop.

## Example

Sample Input	Sample Output
<pre> 1 3 7 u u u s u s r s u u r u s u r u s u u u u 0 </pre>	<pre> 6 </pre>

In this dataset, the fastest way to cross over is as follows:

1. Stay put at the beginning of Interval 0.
2. Stay put at the beginning of Interval 1.
3. Stay put at the beginning of Interval 2.
4. Jump from the western bank to the first stone at the beginning of Interval 3.
5. Jump from the first stone to the second stone at the beginning of Interval 4.
6. Jump from the second stone to the third stone at the beginning of Interval 5.
7. Jump from the third stone to the eastern bank at the beginning of Interval 6.

Thus, Indiana Jones can reach the eastern bank the earliest at the beginning of Interval 6.



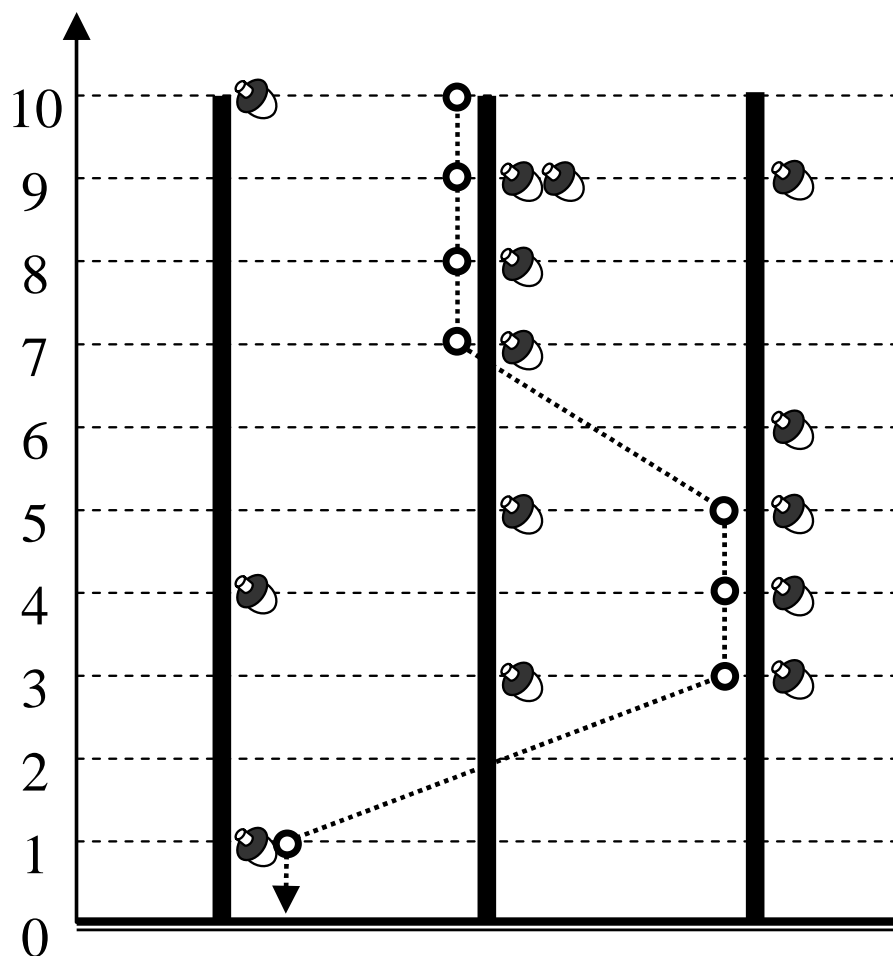
## Problem C: ACORN

In the first morning of every summer, when the first ray of sunlight breaks into the oak forest, Jayjay, the flying squirrel, quickly climbs to the top of an oak tree in the forest. From there, he starts his descent to the ground, and tries to gather as many acorns from the trees on his way down. Being a flying squirrel, Jayjay can choose, at any moment, to climb down the tree trunk or to fly from one tree to any other tree on his descending journey. However, he loses  $f$  feet of height every time he flies from one tree to another.

Suppose the forest has  $t$  oak trees, and all the trees have the same height of  $h$  feet. Given the height of every acorn on each tree, write a program to compute the maximal possible number of acorns Jayjay can collect by choosing a tree to climb and descend as described.

Figure 2 shows an example of  $t = 3$  oak trees with three, six, and five acorns, respectively. The white circles and grey line indicate a path for Jayjay to collect the maximal possible number of eight acorns, assuming that the height he loses for each flight is  $f = 2$ .

**Figure 2** Example of oak trees with acorns



## Input

The input consists of a line containing the number  $c$  of datasets, followed by  $c$  datasets, followed by a line containing the number 0.

The first line of each dataset contains three integers,  $t, h, f$ , separated by a blank. The first integer  $t$  is the number of oak trees in the forest. The second integer  $h$  is the height (in feet) of all the oak trees. The third integer,  $f$ , is the height (in feet) that Jayjay loses every time he flies from one tree to another. You may assume that  $1 \leq t, h \leq 2000$ , and  $1 \leq f \leq 500$ .

The first line of each dataset is followed by  $t$  lines. The  $i^{\text{th}}$  line specifies the height of every acorn on the  $i^{\text{th}}$  tree. The line begins with a non-negative integer  $a$  that specifies how many acorns the  $i^{\text{th}}$  tree has. Each of the following  $a$  integers  $n$  indicates that an acorn is at height  $n$  on the  $i^{\text{th}}$  tree. The positive integers in each line are sorted in ascending order, and repetitions are allowed. Thus, there can be more than one acorn at the same height on the same tree. You can assume that  $0 \leq a \leq 2000$ , for each  $i$ .

## Output

The output consists of one line for each dataset. The  $c^{\text{th}}$  line contains one single integer, which is the maximal possible number of acorns Jayjay can collect in one single descent for dataset  $c$ .

## Example

Sample Input	Sample Output
1 3 10 2 3 1 4 10 6 3 5 7 8 9 9 5 3 4 5 6 9 0	8

This dataset and Jayjay's path to collect the maximal number of 8 acorns are shown in Figure 2.

## Problem D: TUSK



Cross-section of an elephant tusk

A conservation group found a way to scan the cross-section of elephant tusks like the one shown on the left. The scanned image of a tusk is a collection of bright spots, which can be treated as a set of points on the plane, where no three points form a straight line. The group made a database of many tusks and hope that the database can help in tracking illegal ivory trade.

To facilitate retrieval from the database, it is desirable to have a feature representation that remains unchanged even if a scanned image is translated or rotated. They decided to use the number of  $k$ -sets to represent a set of points, which is defined below.

Consider a set  $P$  of  $n$  points in the plane, where no three points form a straight line. Any line in the plane that does not contain a point in  $P$  will split the set into two sets  $X, Y$ , where  $X$  contains points on one side of the line and  $Y$  contains points on the other side. If the number of points in  $X$  is  $k$ , then we call the collection  $\{X, Y\}$  a  $k$ -set in  $P$ . Note that  $\{X, Y\} = \{Y, X\}$ , and thus a  $k$ -set is also an  $(n - k)$ -set. Given a set  $P$  and  $k$ , your task is to compute the number of different  $k$ -sets in  $P$ .

### Input

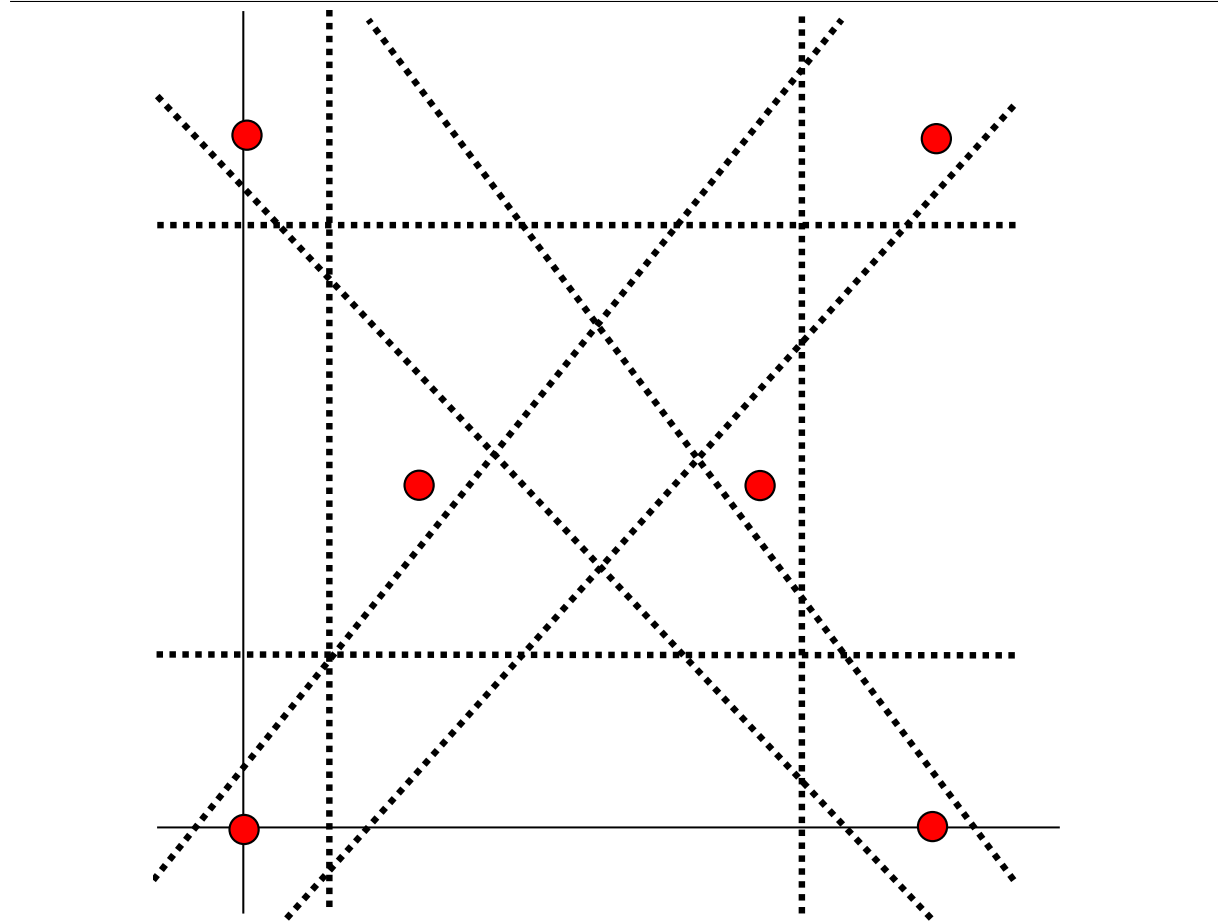
The input consists of a line containing the number  $c$  of datasets, followed by  $c$  datasets, followed by a line containing the number 0.

The first line of each dataset contains two integers, separated by a blank. The first integer gives the number  $n$  of points in  $P$ , and the second integer gives  $k$ , where  $(0 < k < n \leq 300)$ . The following  $n$  lines of each dataset each contains two non-negative integers, indicating the  $x$  and  $y$ -coordinates of the corresponding point. The  $x$  and  $y$ -coordinates range from 0 to 10000.

### Output

The output consists of one line for each dataset. The  $c^{\text{th}}$  line contains the number of  $k$ -sets for dataset  $c$ .

**Figure 3** Illustration of sample input and sample output



### Example

Sample Input	Sample Output
1 6 2 0 0 4 0 4 4 0 4 1 2 3 2 0	8

This dataset and the lines that form its 2-sets are shown in Figure 3.

## Problem E: SKYLINE



Skyline of Singapore at Night

The skyline of Singapore as viewed from the Marina Promenade (shown on the left) is one of the iconic scenes of Singapore. Country X would also like to create an iconic skyline, and it has put up a call for proposals. Each submitted proposal is a description of a proposed skyline and one of the metrics that country X will use to evaluate a proposed skyline is the amount of overlap in the proposed skyline.

As the assistant to the chair of the skyline evaluation committee, you have been tasked with determining the amount of overlap in each proposal. Each proposal is a sequence of buildings,  $\langle b_1, b_2, \dots, b_n \rangle$ , where a building is specified by its left and right endpoint and its height. The buildings are specified in back to front order, in other words a building which appears later in the sequence appears in front of a building which appears earlier in the sequence.

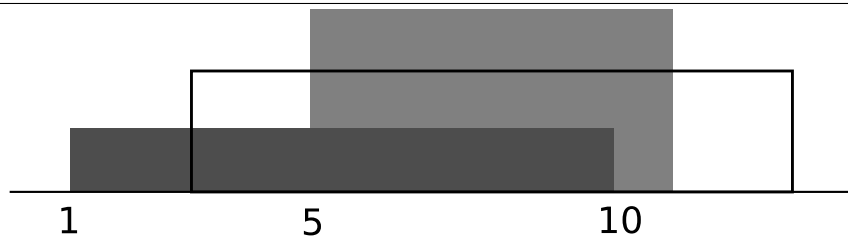
The skyline formed by the first  $k$  buildings is the union of the rectangles of the first  $k$  buildings (see Figure 4). The overlap of a building,  $b_i$ , is defined as the total horizontal length of the parts of  $b_i$ , whose height is greater than or equal to the skyline behind it. This is equivalent to the total horizontal length of parts of the skyline behind  $b_i$  which has a height that is less than or equal to  $h_i$ , where  $h_i$  is the height of building  $b_i$ . You may assume that initially the skyline has height zero everywhere.

### Input

The input consists of a line containing the number  $c$  of datasets, followed by  $c$  datasets, followed by a line containing the number 0.

The first line of each dataset consists of a single positive integer,  $n$  ( $0 < n < 100000$ ), which is the number of buildings in the proposal. The following  $n$  lines of each dataset each contains a description of a single building. The  $i^{\text{th}}$  line is a description of building  $b_i$ . Each building  $b_i$  is described by three positive integers, separated by spaces, namely,  $l_i$ ,  $r_i$  and  $h_i$ , where  $l_i$  and  $r_j$  ( $0 < l_i < r_i \leq 100000$ ) represents the left and right end point of the building and  $h_i$  ( $0 < h \leq 10^9$ ) represents the height of the building.

**Figure 4** Computing Skyline Overlap



## Output

The output consists of one line for each dataset. The  $c^{\text{th}}$  line contains one single integer, representing the amount of overlap in the proposal for dataset  $c$ . You may assume that the amount of overlap for each dataset is at most 2000000.

## Example

Sample Input	Sample Output
<pre> 1 3 5 11 3 1 10 1 3 13 2 0 </pre>	<pre> 14 </pre>

In this test case, the overlap of building  $b_1$ ,  $b_2$  and  $b_3$  are 6, 4 and 4 respectively. Figure 4 shows how to compute the overlap of building  $b_3$ . The grey area represents the skyline formed by  $b_1$  and  $b_2$  and the black rectangle represents  $b_3$ . As shown in the figure, the length of the skyline covered by  $b_3$  is from position 3 to position 5 and from position 11 to position 13, therefore the overlap of  $b_3$  is 4.

## Problem F: USHER

In a large church in New Zealand, after the church service, the priest gives an empty collection box that can hold  $c$  dollar coins to the “light-fingered usher”. The usher then passes the collection box to a nearby parishioner. When receiving the box a parishioner adds a few dollar coins, then passes it to another nearby parishioner. When the light-fingered usher receives the box, he quietly removes one dollar coin from the box, slips it into his pocket, and passes the box to a nearby parishioner.

The behavior of the usher is given by a set of parishioners to whom he may pass the box. The behavior of a parishioner is given by a set of rules, each consisting of a donation of at least two dollar coins, and another parishioner to whom the box is passed after he places the coins in the box. As soon as the box is full, containing  $c$  coins, it is immediately passed to the priest, even when a parishioner cannot finish entering all the coins specified by the chosen rule.

Your problem is to compute the maximal possible gain for the usher, which is achieved when the parishioners always choose a rule that leads to the biggest number of coins in the usher’s pocket.

### Input

The input consists of a line containing the number  $c$  of datasets, followed by  $c$  datasets, followed by a line containing the number 0.

The first line of each dataset contains two numbers  $b$  and  $p$ , separated by a blank. The number  $b$  specifies the capacity of the box, and  $p$  the number of parishioners. You can assume that  $1 \leq b \leq 1000000$  and  $1 \leq p \leq 500$ . The next line specifies the behavior of the usher, represented by integers separated by a blank. The first integer specifies the number  $q$  of parishioners, to which the usher may pass the box. The next  $q$  integers each represent a parishioner to whom he may pass the box. The parishioners are numbered from 1 to  $p$ . Each line  $i$  ( $1 \leq i \leq p$ ) of the next  $p$  lines of each dataset describes the behavior of parishioner  $i$ , and consists of integers separated by a blank. The first integer of the line specifies the number of rules for the parishioner. Each rule is represented by a pair of integers, the first of which specifies the number of coins to give, which must be equal or greater than 2. The second number indicates the parishioner to receive the box next, where the number 0 identifies the usher. When there are two or more rules, the parishioner may choose to apply any of them. You can assume that the number of rules per parishioner is at least 1 and less than or equal to 1000; there may be multiple rules with the same parishioner to receive the box.

### Output

The output consists of one line for each dataset. The  $c^{\text{th}}$  line contains the maximal number of coins that the usher can obtain for dataset  $c$ .

## Example

Sample Input	Sample Output
<pre> 1 10 2 2 1 2 2 6 0 4 2 1 5 0 0 </pre>	<pre> 2 </pre>

This dataset specifies that the box can hold up to 10 coins, and that there are two parishioners. The usher may pass the box to either one of the two parishioners, as indicated by the second line. Parishioner 1 has two rules, and can choose either one, when the box is passed to him. The first rule says to put down 6 dollar coins and pass the box to the usher (indicated by 0), and the second rule is put down 4 dollar coins and pass the box to parishioner 2. The last line specifies one single rule for parishioner 2, who must put down 5 dollar coins, and then pass the box to the usher.

The usher can obtain the maximal amount of 2 dollars by passing the box to parishioner 2, who passes it back to the usher. At that point, there are 5 dollars on the box. After removing one dollar, the box goes with 4 dollars to parishioner 2, and back to the usher, now with 8 dollars. The usher removes another dollar, and the box goes to parishioners 2 with 7 dollars. Parishioner 2 starts to apply his rule, and manages to put three more coins into the box, after which the box is full and goes to the priest. The usher ends up with two dollar coins in his pocket.



## Problem G: RACING



Saint Andrew's Road, part of the Formula One circuit  
(Kenny Pek, Piccom)

Singapore will host a Formula One race in 2008. The race will be held on a 5.067km long street circuit, consisting of 14 left hand turns and 10 right hand turns. In the run up to the F1 race, the number of illegal night street racing activities have been on the rise. Such races consists of several rounds around a designated street circuit.

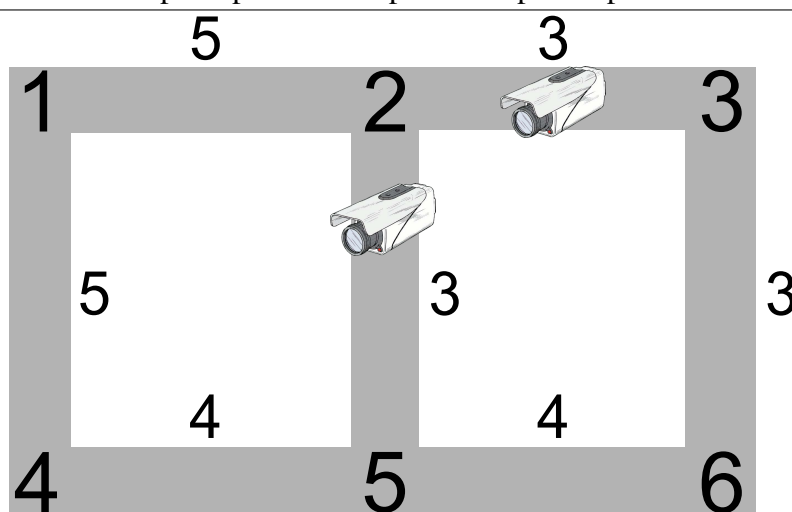
The authorities would like to deploy a new vehicle monitoring system in order to catch these illegal racers. The system consists of a number of cameras mounted along

various roads. For the system to be effective, there should be at least one camera along each of the possible circuits.

The Singapore road system can be represented as a series of junctions and connecting bidirectional roads (see Figure 5). A possible racing circuit consists of a start junction followed by a path consisting of three or more roads that eventually leads back to the start junction. Each road in a racing circuit can be traversed only in one direction, and only once.

Your task is to write a program that computes the optimal placement of the vehicle-monitoring cameras. You will be provided with a description of a connected road network to be monitored in terms of the roads and junctions. The junctions are identified by the bigger numbers in Figure 5. A camera can be deployed on the roads (and not the junctions).

**Figure 5** Illustration of sample input and one possible optimal placement of cameras



The cost of deploying a camera depends on the road on which it is placed. The smaller numbers by the roads in Figure 5 indicate the cost of deploying a camera on that road. Your job is to select a set of roads that minimizes the total cost of deployment while ensuring that there is at least one camera along every possible racing circuit ( i.e. loop in the road network).

## Input

The input consists of a line containing the number  $c$  of datasets, followed by  $c$  datasets, followed by a line containing the number 0.

The first line of each dataset contains two positive integers,  $n$  and  $m$ , separated by a blank, which represent the number of junctions and number of roads, respectively. You may assume that  $0 < n < 10000$  and  $0 < m < 100000$ . For simplicity, we label each of the  $n$  junctions from 1 to  $n$ . The following  $m$  lines of each dataset each describes one road. Each line consists of three positive integers which are the labels of two different junctions and the cost of deploying a camera on this road. The cost of deploying a camera is between 1 and 1000.

## Output

The output consists of one line for each dataset. The  $c^{\text{th}}$  line contains one single number, representing the minimal cost of setting up the vehicle monitoring system such that there is at least one camera along every possible circuit.

## Example

Sample Input	Sample Output
1 6 7 1 2 5 2 3 3 1 4 5 4 5 4 5 6 4 6 3 3 5 2 3 0	6

This data set depicts the situation shown in Figure 5. The two cameras show where cameras might be placed in order to monitor each circuit at minimal cost. Since each of the cameras have a cost of 3, the total minimal cost is 6.