Problem 203: Detecting Multipaction

Difficulty: Easy

Author: Sowmya Chandrasekaran, Sunnyvale, California, United States

Originally Published: Code Quest 2023

Problem Background

Multipaction is a phenomenon experienced by radio frequency (RF) devices exposed to the vacuum of space. Free electrons floating around can be accelerated by the energy in the RF field. When these electrons hit a metallic surface in the device, they can release additional electrons. These electrons go on to impact more surfaces, creating an exponentially growing electron cascade that can damage or destroy the device. Luckily, it's possible to detect when multipaction events occur in order to protect the integrity of these devices.

Problem Description

Lockheed Martin Space Systems is working on a new communications satellite system that includes an array of RF antennas. Your customer is concerned about the risk of multipaction events, and has asked your team to develop a system to automatically disable an antenna for a short period when it detects a multipaction event.

While most transmitters and antennas are intended to operate on a particular frequency, other frequencies - known as harmonics - can interfere with that signal. To combat this, your satellites will listen on multiple frequencies in order to eliminate this interference. Fortunately, this also gives you the information you need to identify multipaction events.

You've noticed during testing that a multipaction event results in abnormally high readings in both the phase null and third harmonic channels, between 60% and 85% of their maximum power output. Your team lead believes that a subroutine monitoring these two channels could give enough warning about a multipaction event to shut down the antennas before they can overload. Your team needs to develop this subroutine and test it before it's loaded onto the satellites. If, for a given time index, both channels show a power reading between .6 and .85 of their maximum outputs (inclusive), that indicates an event which should be reported.

Sample Input

The first line of your program's input, **received from the standard input channel**, will contain a positive integer representing the number of test cases. Each test case will include two lines of text, containing the readings obtained from the phase null and third harmonic channels, respectively. Each line will consist of a list of decimal values between 0 and 1 exclusive, separated by spaces. Both lines will contain the same number of values.

```
3
.3 .61 .4 .15 .81 .47 .98
.2 .64 .7 .36 .63 .71 .09
.45 .53 .59 .13 .21 .78 .34 .78 .91
.87 .71 .32 .33 .58 .61 .79 .86 .62
.5 .71 .42 .36 .49 .82 .6 .21
.67 .41 .76 .83 .85 .12 .51 .92
```

Sample Output

For each test case, your program must print a single line containing a sentence summarizing the findings of your subroutine, as follows:

- If no multipaction events were detected, print "No multipaction events detected."
- If one multipaction event was detected, print "A multipaction event was detected at time index X.", replacing X with the index number of the detected event.
- If more than one multipaction event was detected, print "N multipaction events were detected at time indices: X.", replacing N with the total number of detected events, and X with a space-delimited list of the index numbers of detected events in increasing order.

Index numbers correspond to the position of the values within the provided arrays of data. The first item in each list has an index number of 0.

```
2 multipaction events were detected at time indices: 1 4.
A multipaction event was detected at time index 5.
No multipaction events detected.
```