



Daily Coding Problem #224

Problem

This problem was asked by Amazon.

Given a sorted array, find the smallest positive integer that is not the sum of a subset of the array.

For example, for the input `[1, 2, 3, 10]`, you should return 7.

Do this in $O(N)$ time.

Solution

A naive solution would be to start with 1 and keep incrementing until we find a solution. However, since the problem of determining whether a subset of an array sums to a given number is NP-complete, this approach cannot succeed in linear time.

Looking at the example given above may provide some insight.

Before looking at our list, we know the smallest "impossible sum" is 1- the lowest positive integer. When we come across 1 as the first element in our array, though, this must change. What should the new impossible sum be? In this case, it's easy to see that it must be 2.

Let's continue traversing the array. The next element we come across is 2. Since the impossible sum at the moment is 2, we know we can make any (non-negative) sum less than that. So by adding our new element to each, we can make two new sums: $0 + 2$ and $1 + 2$. This motivates us to increase our impossible sum to 4.

Now we move on to the third element, 3. Again, since our current impossible sum is 4, we are already able to make sums from 0 through 3. Adding 3 to each of these generates three new sums: $0 + 3$, $1 + 3$, $2 + 3$, and $3 + 3$, and allows us to bump the impossible sum to 7.

Finally, since the next element is 10, it will be of no help in creating a subset that sums to 7, and so we have our answer.

The pattern above is as follows: as we traverse the array, whenever we see a value less than or equal to our current impossible sum, we increment the impossible sum by that value. Once we find a value greater than the impossible sum, we return that sum.

```
def smallest_impossible_sum(nums):  
    impossible_sum = 1  
    for n in nums:  
        if n <= impossible_sum:  
            impossible_sum += n  
        else:  
            break  
    return impossible_sum
```

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