Find a duplicate, Space Edition™ BEAST MODE

In Find a duplicate, Space Edition™ (find-duplicate-optimize-for-space), we were given a list of integers where:

1. the integers are in the range $1..n$
2. the list has a length of $n + 1$

These properties mean the list *must have at least 1 duplicate*. Our challenge was to find a duplicate number, while optimizing for *space*. We used a divide and conquer approach, iteratively cutting the list in half to find a duplicate integer in $O(n \lg n)$ time and $O(1)$ space (sort of a modified binary search).

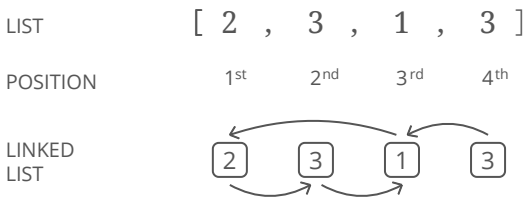
But we can actually do *better*. **We can find a duplicate integer in $O(n)$ time while keeping our space cost at $O(1)$.**

This is a tricky one to derive (unless you have a strong background in graph theory), so we'll get you started:

Imagine each item in the list as a node in a linked list. In any linked list, each node has a **value** and a **"next"** pointer. In *this* case:

- The **value** is the *integer* from the list.
- The **"next"** pointer points to the **value-eth** node in the list (numbered starting from 1). For example, if our value was 3, the "next" node would be the *third* node.

Here's a full example:



> **Notice we're using "positions" and not "indices."** For this problem, we'll use the word "position" to mean something *like* "index," but different: indices start at 0, while positions start at 1. More rigorously: `position` = `index` + 1.

Using this, **find a duplicate integer in $O(n)$ time while keeping our space cost at $O(1)$.**

> **Drawing pictures will help a lot with this one.** Grab some paper and pencil (or a whiteboard, if you have one).
