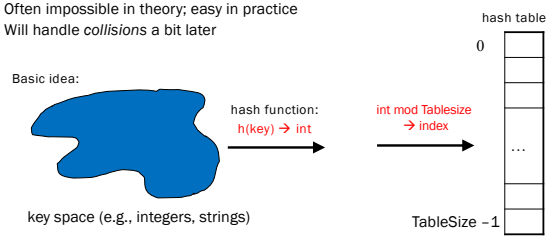
Hash Functions

An *ideal* hash function:

- Is fast to compute
- Is different for any two objects where `.equals() == false`
  - Often impossible in theory; easy in practice
  - Will handle *collisions* a bit later



Hashing integers (try it out)

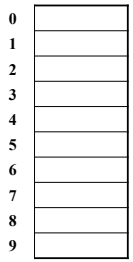
key space = integers

Simple hash function:

- Client: **`h(x) = x`**
- Library: **`g(x) = h(x) % TableSize`**
- Fairly fast and natural

Example:

- TableSize = 10
- Insert **7, 18, 41, 34, 10**
- (As usual, ignoring corresponding data)



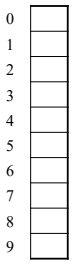
What if the key is not an int?

- If keys aren't **`int`**s, the **client** must convert to an **`int`**
  - Trade-off: speed and distinct keys hashing to distinct **`int`**
- Common and important example: Strings
  - Key space K = $s_0 s_1 s_2 \ldots s_{m-1}$
    - where s_i are chars: $s_i \in [0,256]$
  - Some choices: Which avoid collisions best?

1. h(K) = s_0
2. h(K) = $\left(\sum_{i=0}^{m-1} s_i \right)$
3. h(K) = $\left(\sum_{i=0}^{m-1} s_i \cdot 37^i \right)$

Then on the **library side** we typically mod by Tablesize to find index into the table

Separate Chaining



Chaining: All keys that map to the same table location are kept in a list (a.k.a. a "chain" or "bucket")

As easy as it sounds

Example: insert 10, 22, 107, 12, 42 with mod hashing and **`TableSize`** = 10

More rigorous separate chaining analysis

Definition: The load factor, λ, of a hash table is

$$\lambda = \frac{\text{N}}{\text{TableSize}}$$ ← number of elements

Under chaining, the average number of elements per bucket is ___

So if some inserts are followed by *random* finds, then on average:

- **Each unsuccessful `find` compares against ____ items**
- **Each successful `find` compares against _____ items**

- **How big should TableSize be??**