Hash Tables

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CSC220 Programming II – Spring 2020

Implementations of Map

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- Skip List (SkipMap): add, find, and remove in O(log n) expected time.

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- When you look up a name, it is nice to be able to go forward or back a few names in case you misspelled it.
- If you want Milenkovic in a hash table, you better not look for Milenkovich because it will be far away.

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- We will look at the one for String:

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public int hashCode()
Returns a hash code for this string. The hash code for a
String object is computed as
 s[0]*31^(n-1) + s[1]*31^(n-2) + ... + s[n-1]

 using int arithmetic, where s[i] is the ith character of the
 string, n is the length of the string, and ^ indicates
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WHAT???

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So the letter 'M' is really just a small integer.
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String name = "Milenkovic";
for (int i = 0; i < name.length(); i++) {
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- code = 74346201
- code = -1990234958
- code = -1567741443
- code = -1355344359
- code = 933997936

Hash Code

Let's do the same trick with "Milenkovic" and print out each step:

```
int code = 0;
for (int i = 0; i < name.length(); i++) {
  char c = name.charAt(i);
  code = 31 * code + c;
  System.out.println("code = " + code);
}
```

- code = 77
- code = 2492
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An int can only hold integers in the range from -2147483648 to 2147483647.

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- Using powers of 31 makes these all different.

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```
int hashIndex (String name, int m) {
  int code = name.hashCode();
  int index = code % m;
  if (index < 0)
    index += m;
  return index;
}
```

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- Entries in the same list in the first table will be in different lists in the second table.

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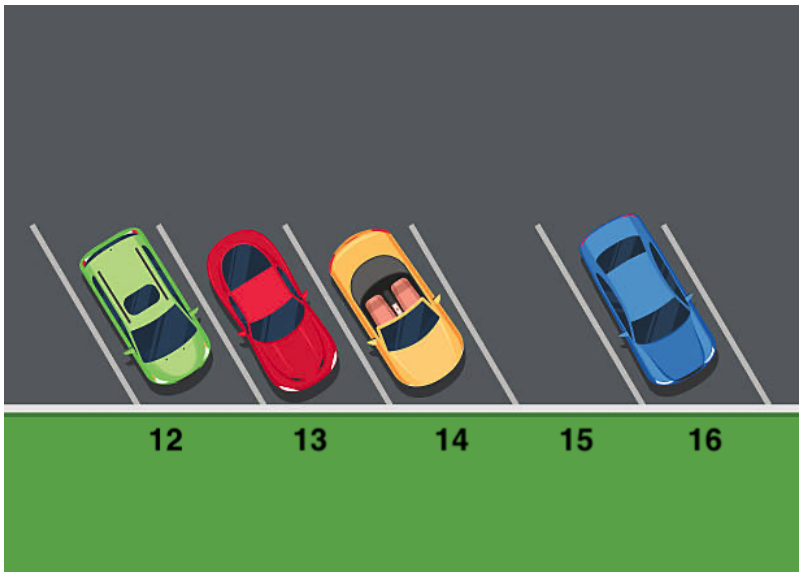
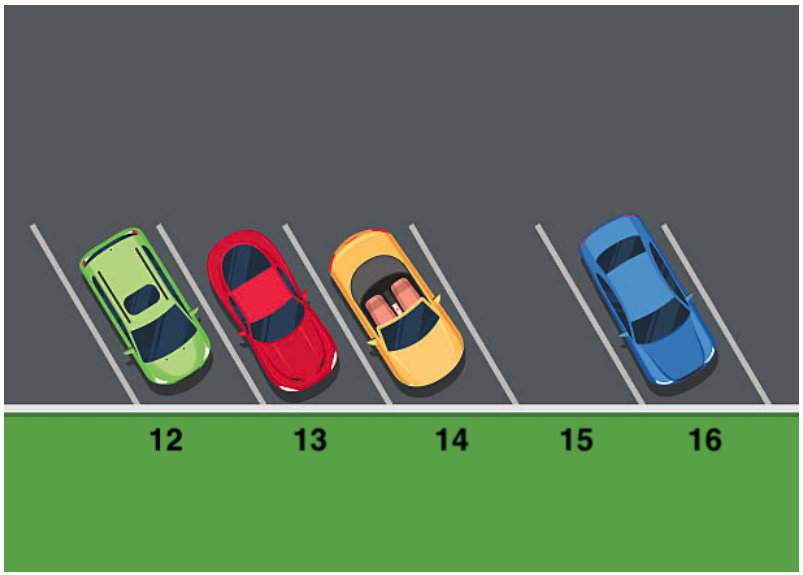
- If you reach the end of the lot, you go back to the beginning.

Add



Add



Here is how to add.

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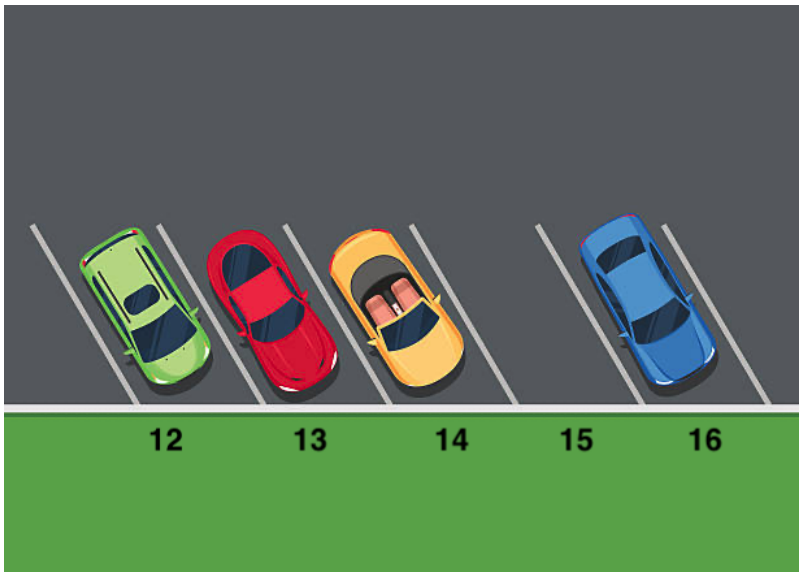

Here is how to add.

- Suppose my assigned number is 12.

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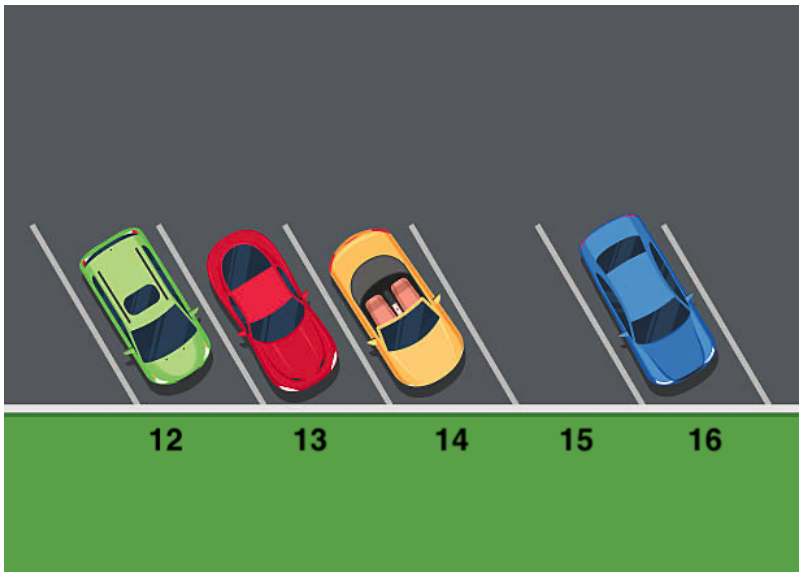

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- Suppose my assigned number is 12.
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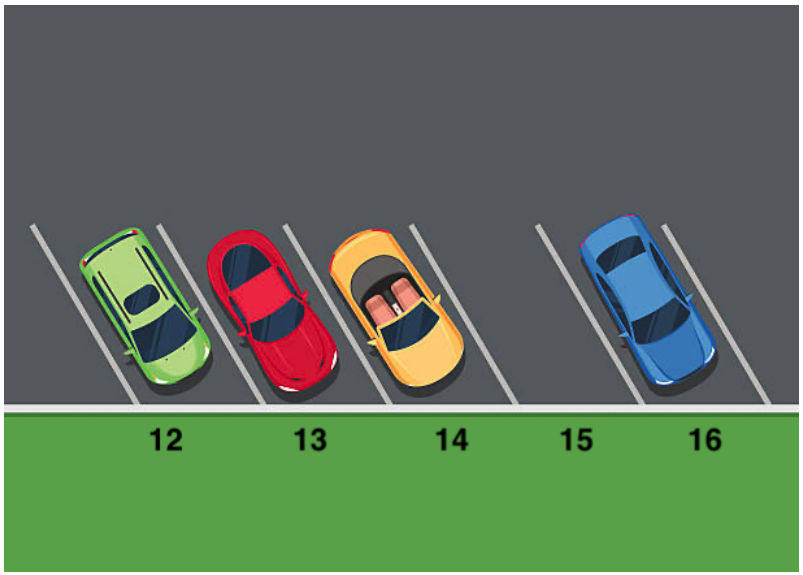

Here is how to add.

- Suppose my assigned number is 12.
- But 12 is full.
- So are 13 and 14.

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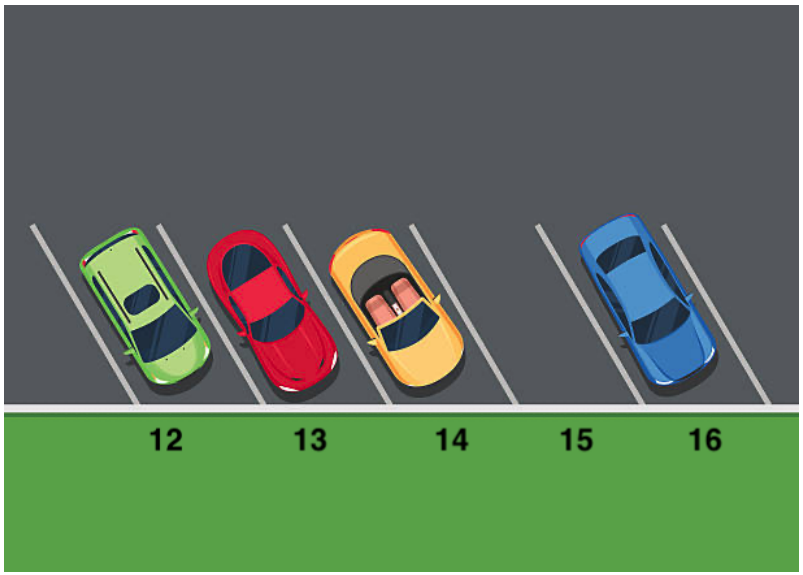

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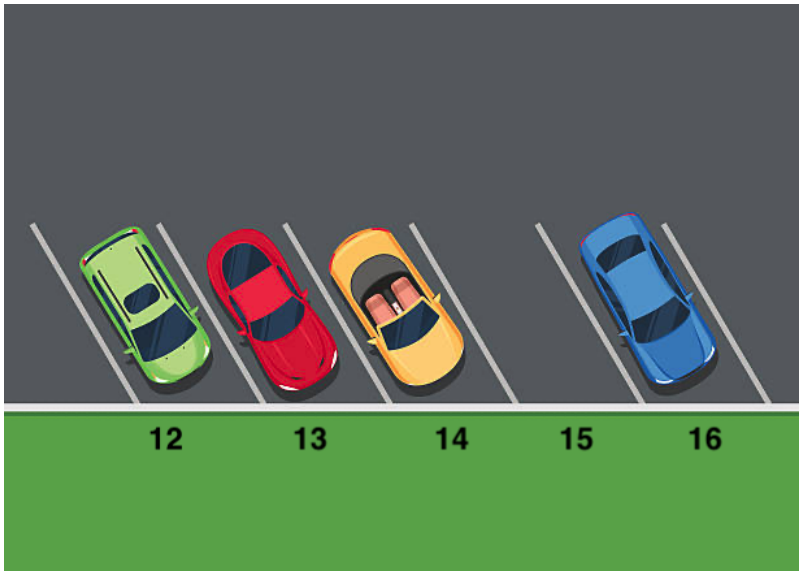
- Suppose my assigned number is 12.
- But 12 is full.
- So are 13 and 14.
- So I park in 15.

Find



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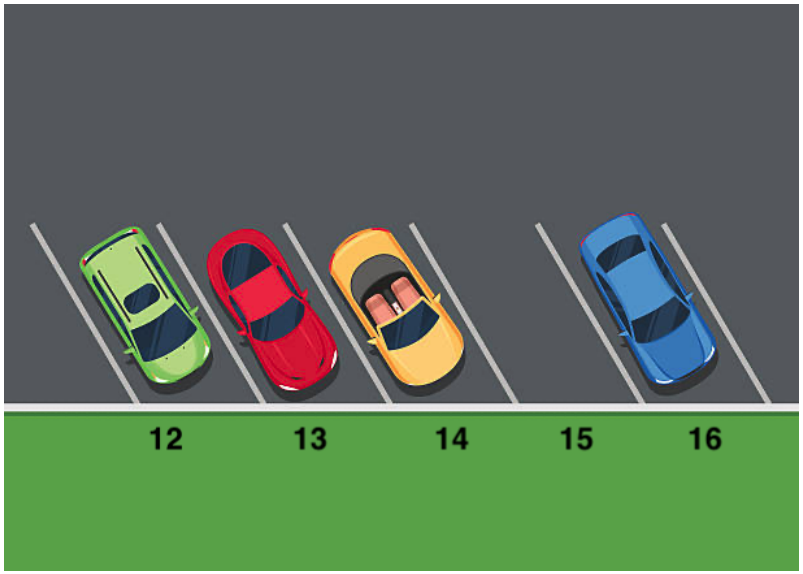

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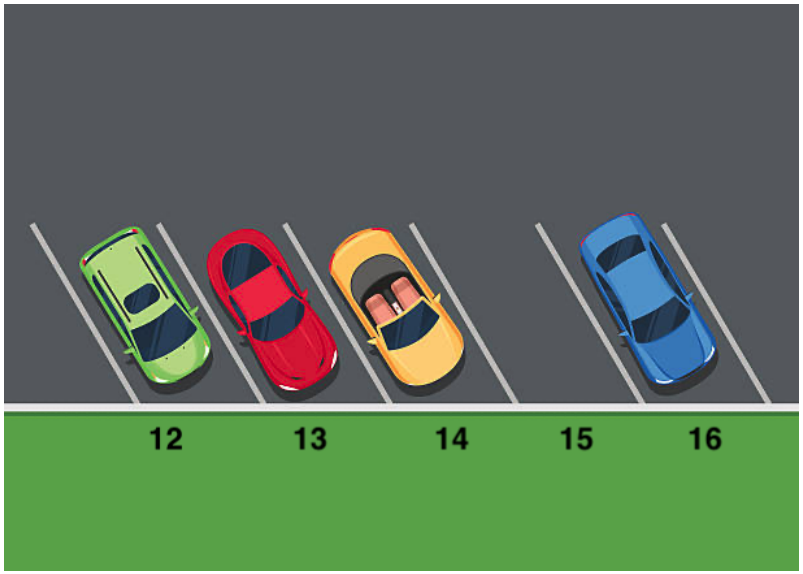
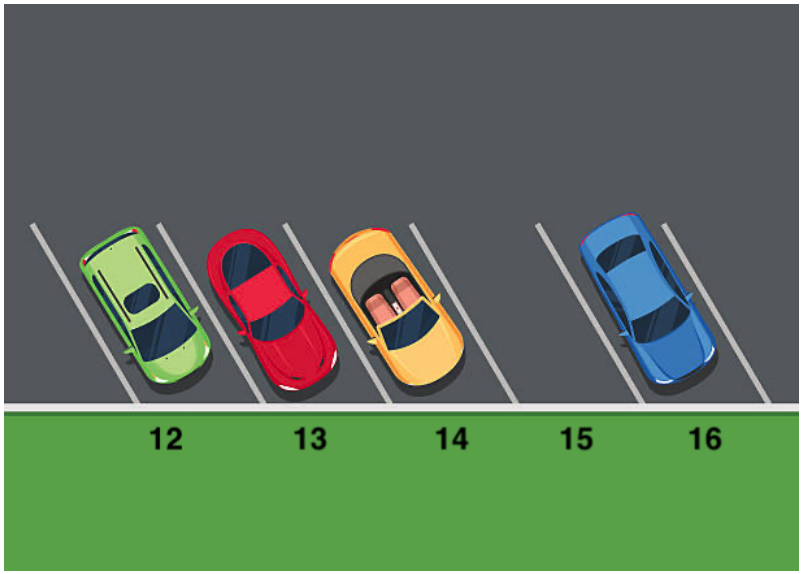


Here is how to find Victor.

- You know my assigned number (hash index of Victor) is 12.

Find



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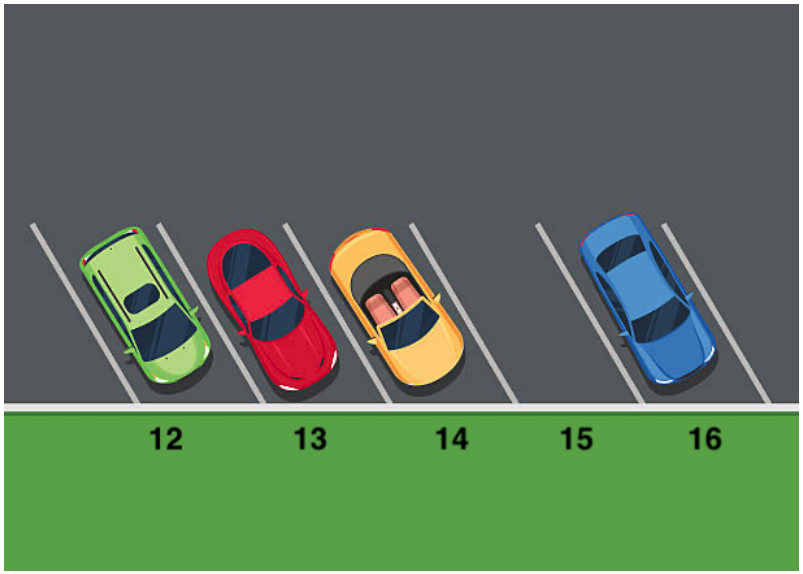

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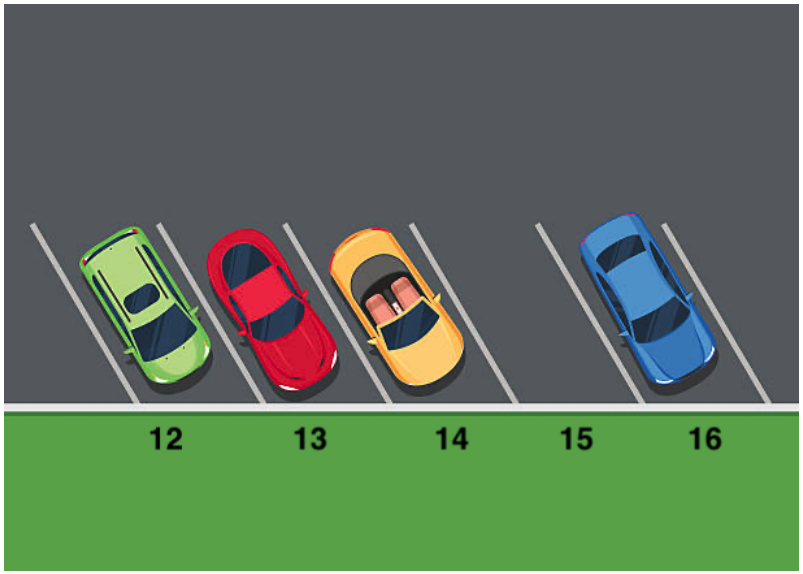

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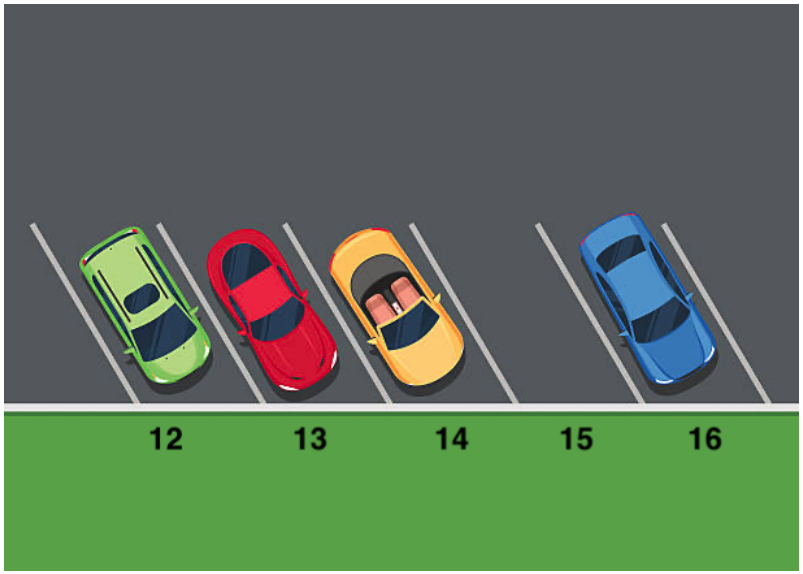

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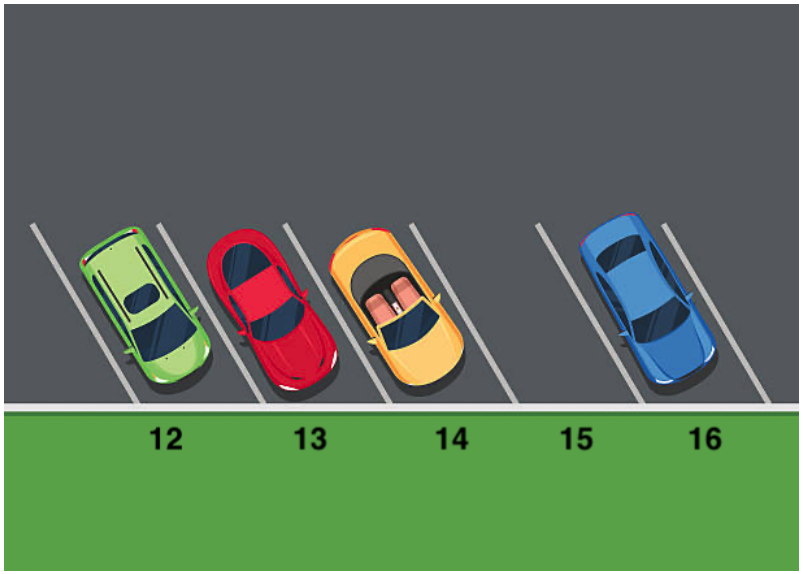

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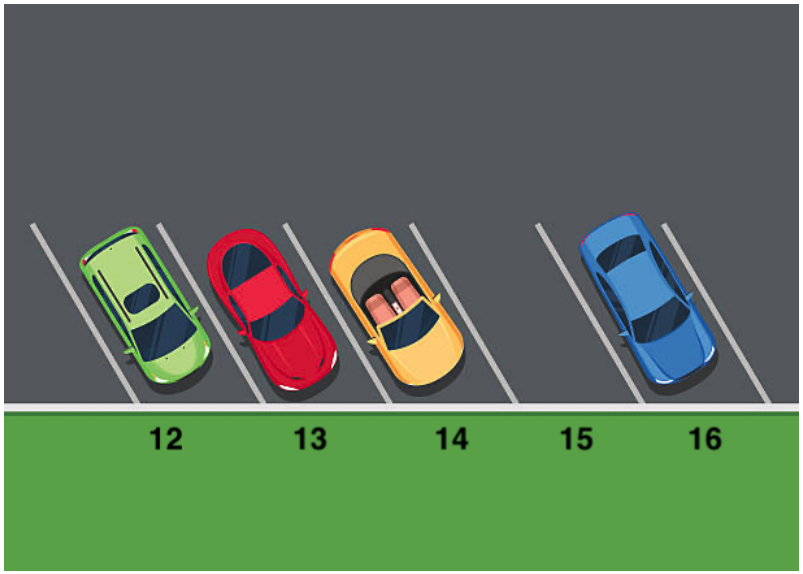

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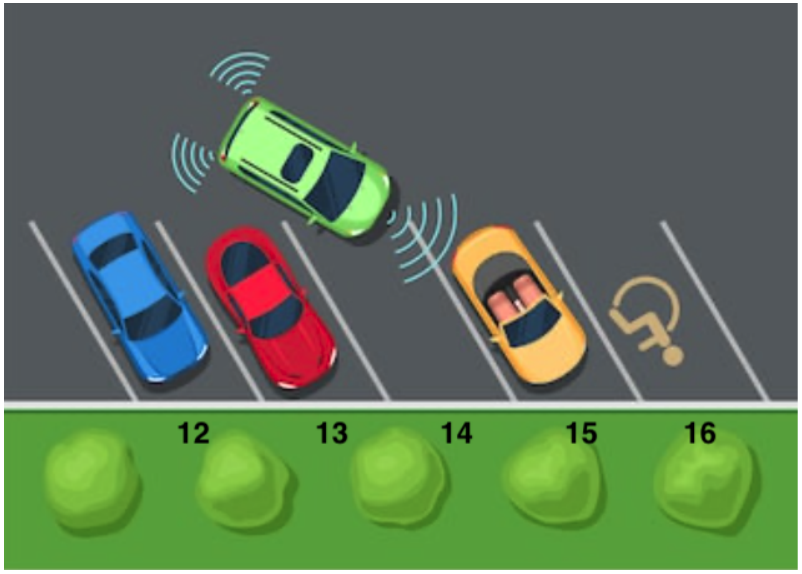

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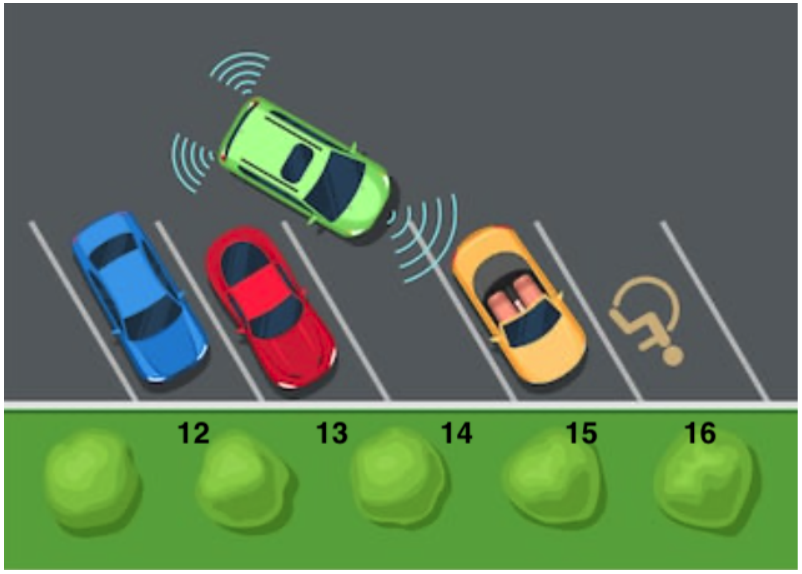

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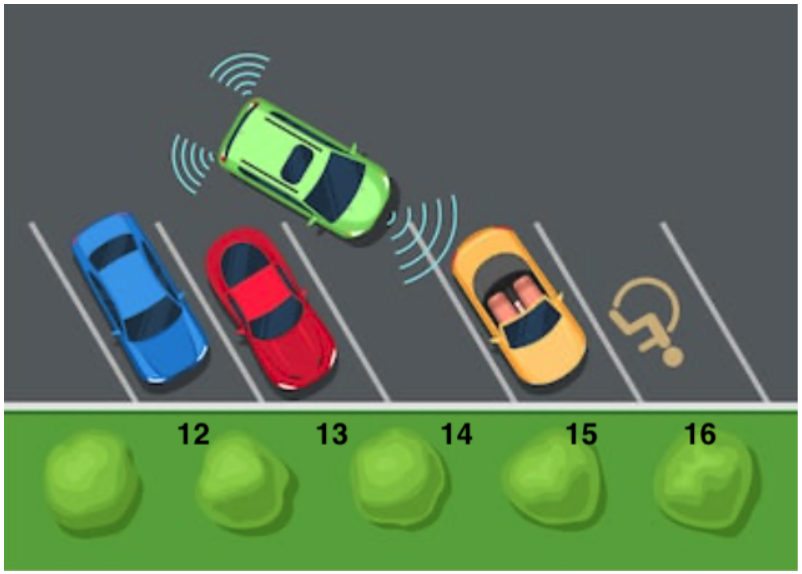

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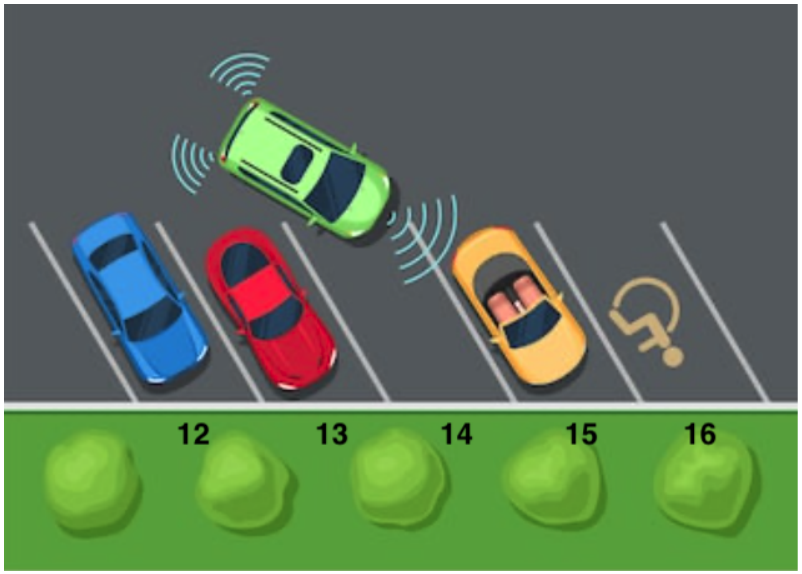

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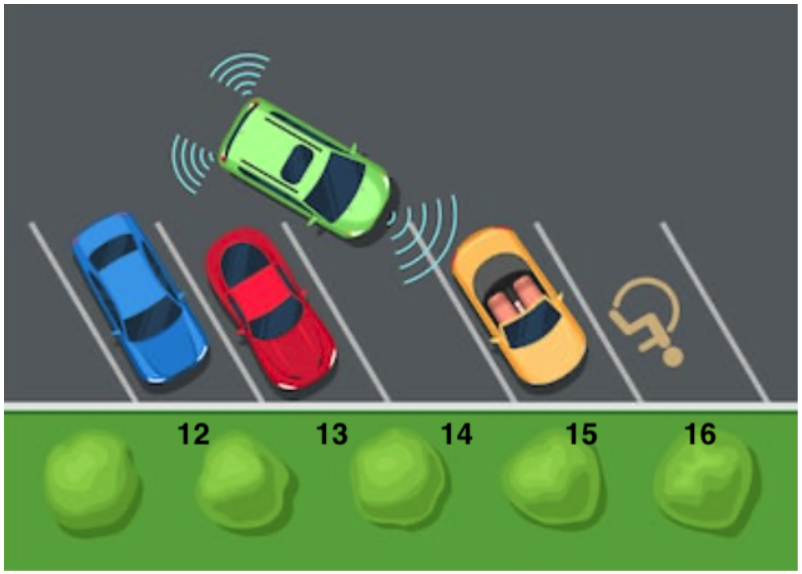

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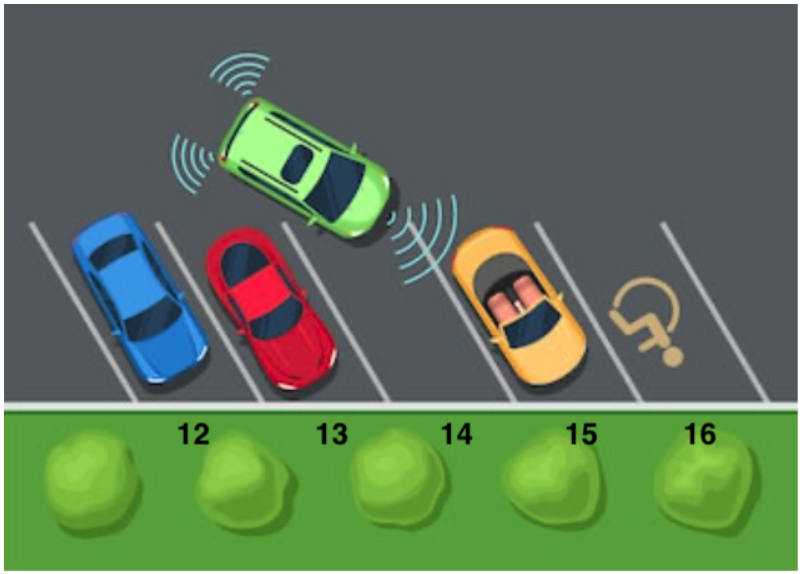

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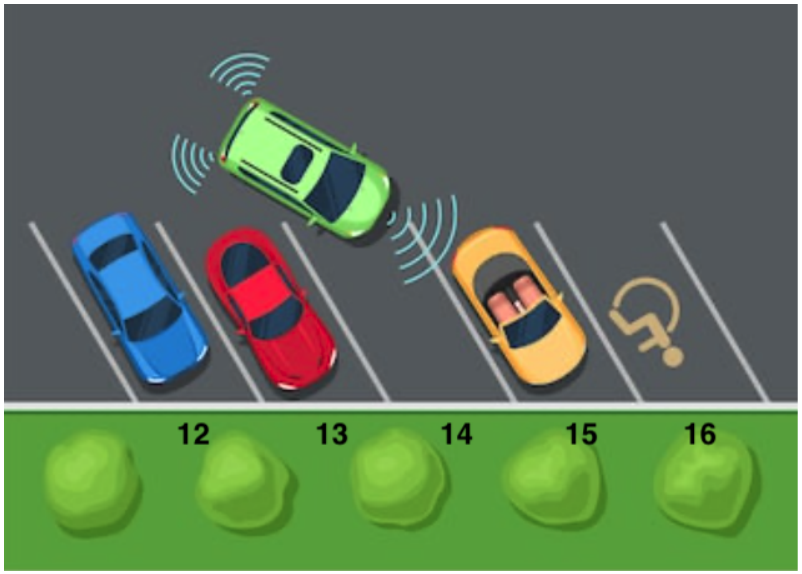

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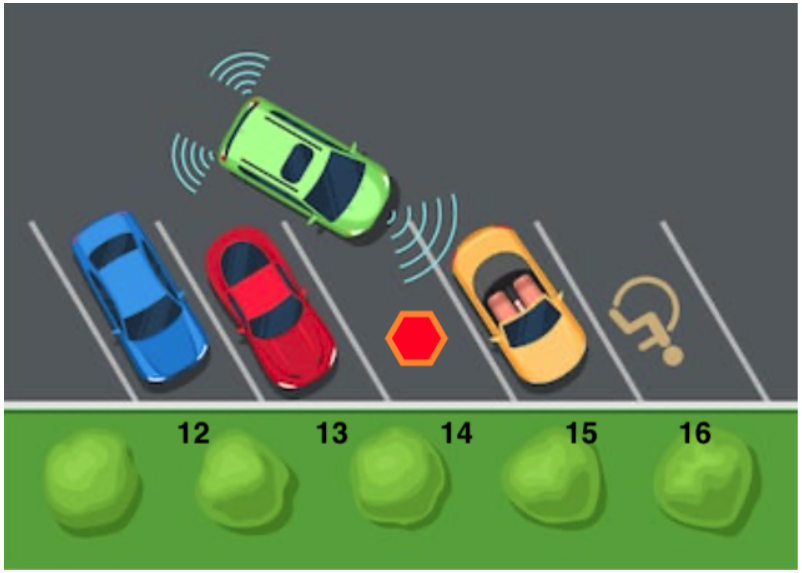

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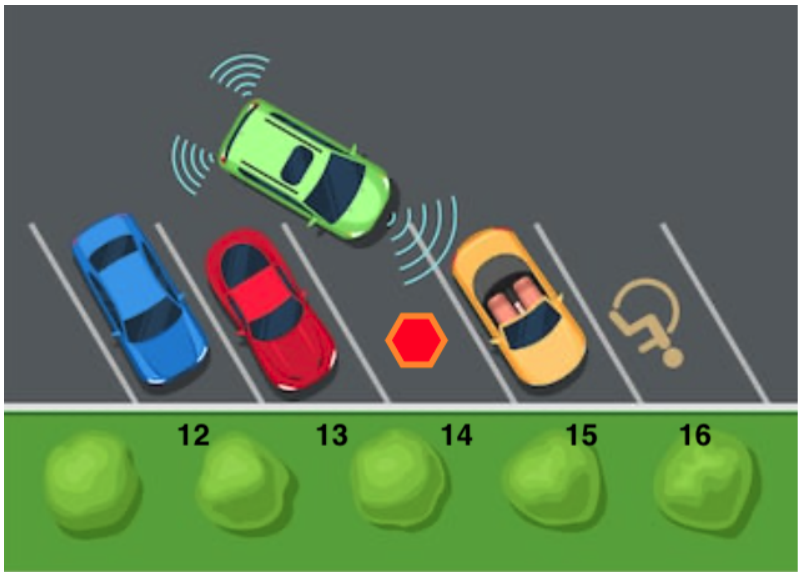

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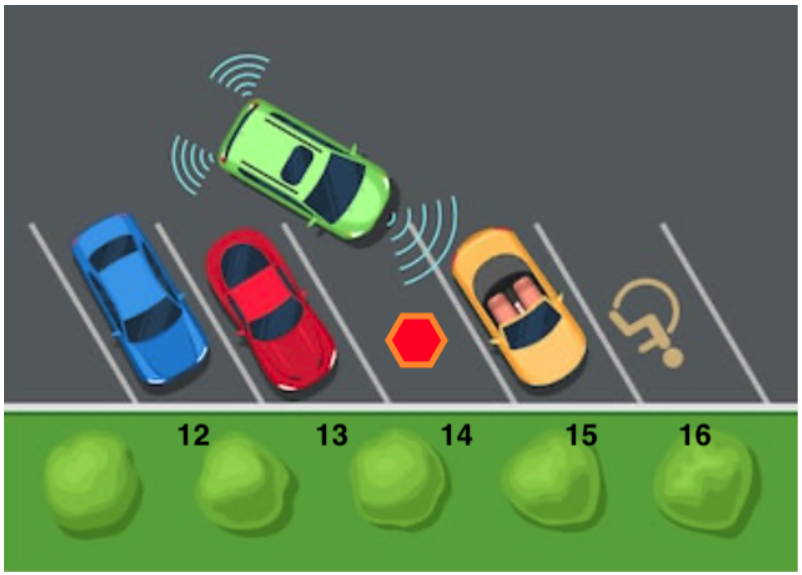

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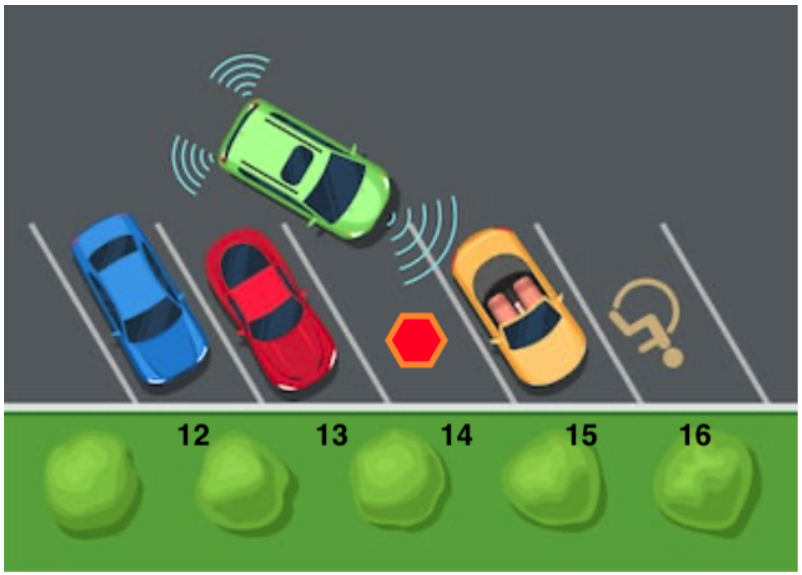

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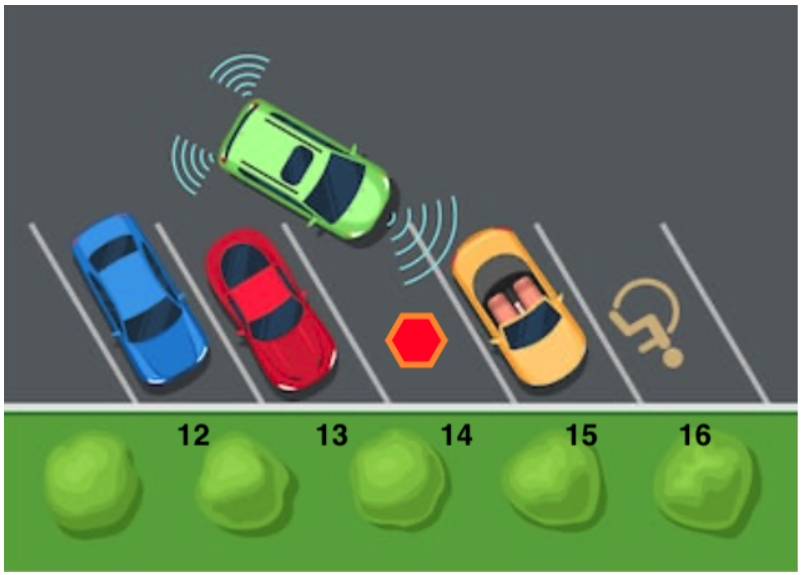

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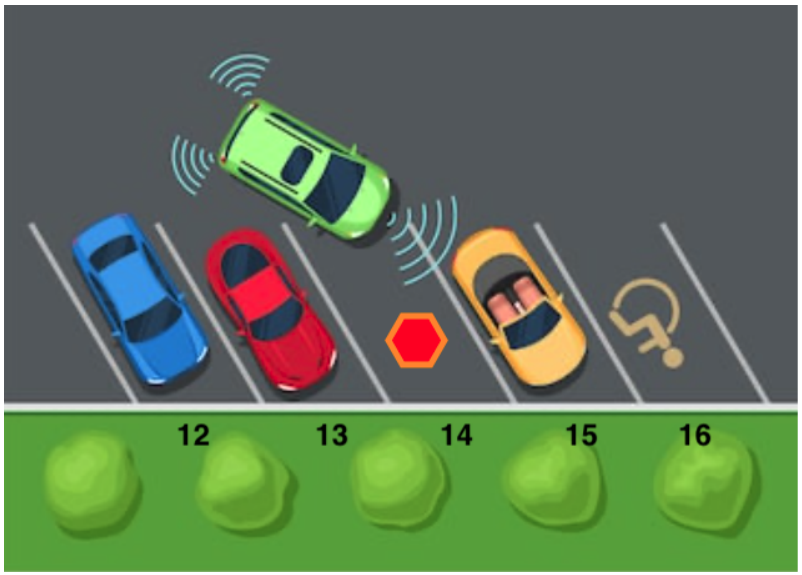

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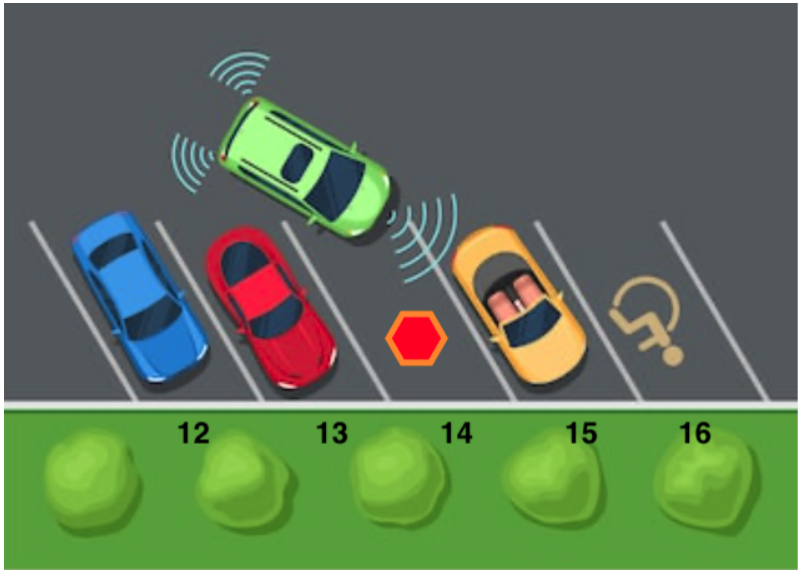

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- usually unique (for up to 65536).
- Don't use ^ or pow when calculating the hash code of a String.

The hash index of an item is an int

- in the range 0 to m-1.
- Mod the hash code by m,
- add m if negative.
- Not unique!

A hash table is an array of length m.

- Item with hash index i is stored at index i,
- unless there is an item there already.

Separate Chaining

- stores a linked list at each index.
- add, find, remove are n/m expected time.
- Need to reallocate and rehash when n > m.

Open Addressing

- More suitable for real-time programming or operating systems.
- Item cycles through the array until it finds an empty spot.
- Removed items need to leave a "traffic cone".

Summary

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- More suitable for real-time programming or operating systems.
- Item cycles through the array until it finds an empty spot.
- Removed items need to leave a "traffic cone".
- Needs to rehash and possibly reallocate when less than m/2 spaces are empty.