YEAH A7

- By Trip && Zheng

Logistics

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- In this assignment, you'll be implementing classes for 2 hash tables: a Linear Probing Hash Table, and a Robin Hood Hash Table!
- We **highly** recommend going through Keith's lecture slides for detailed overviews of each.

Overview: Enums

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enum class CarType {
    HONDA,
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};
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- And example usages:
  - `CarType c1 = CarType::HONDA`
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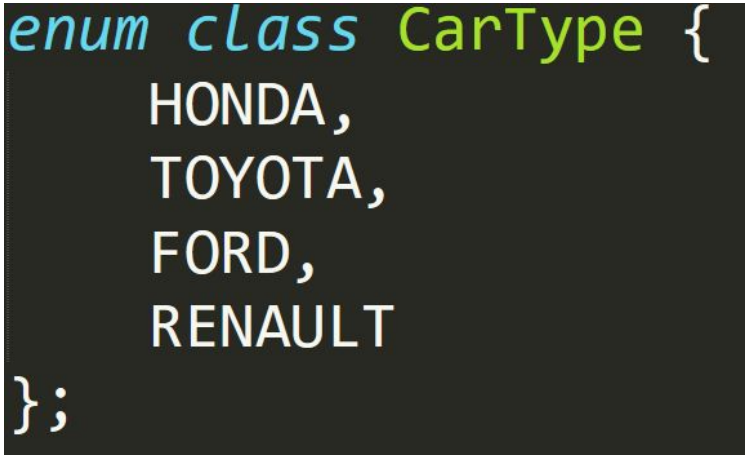
  - `if (c1 == c2) // do something!`



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- Any questions?

```
enum class CarType {
    HONDA,
    TOYOTA,
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};
```

Linear Probing

Linear Probing

- In this first part, your job is to implement the following class:

```
class LinearProbingHashTable {
public:
    LinearProbingHashTable(HashFunction<std::string> hashFn);
    ~LinearProbingHashTable();

    bool contains(const std::string& key) const;

    bool insert(const std::string& key);
    bool remove(const std::string& key);

    bool isEmpty() const;
    int  size() const;

    void printDebugInfo();
```

Linear Probing

- Here's the private section:

```
private:
    enum class SlotType {
        TOMBSTONE, EMPTY, FILLED
    };

    struct Slot {
        std::string value;
        SlotType type;
    };

    Slot* elems;

    /* The rest is up to you to decide; see below */
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Remember these? These **`enums`** signify whether a slot is empty, full, or a tombstone!

This is a **`Slot`**, which is a single entry in the hash table!

Linear Probing

- Here's how to use the HashFunction type:

```
void foo(HashFunction<string> hashFn) {
    HashFunction<string> copy = hashFn // You can resassign HashFunctions!
    string str = "hello";
    int hashCode = copy(str); // Use the HashFunction like a normal function!
    cout << hashCode << endl;
}
```

Linear Probing: Insert

- To insert into the Hash Table, begin by trying to insert at the hashed value of the element. Try the next Slot if the current Slot is FILLED. Insert your element if the slot if EMPTY or TOMBSTONE.

```
LinearProbingHashTable::insert("elem2");
-----------------------------------------
int index = myHashFunction("elem2"); // index = 0
```

{"elem1", SlotType::FILLED }	{"elem2", SlotType::TOMBSTONE }	{"elem3", SlotType::FILLED }	{"", SlotType::EMPTY }	{"", SlotType::EMPTY }
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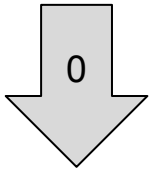
```

This Slot is FILLED.

Keep moving!



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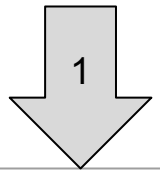

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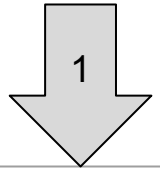
This Slot a TOMBSTONE.

We can fill it! Return true!



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Linear Probing: Insert

- Some edge cases:
  - Be sure to return `false` if the table is full!
  - Also return `false` if the element being inserted **already exists** in the table!

Linear Probing: Contains

- To determine whether an element exists in the Hash Table, linearly scan through the array from the hash position until you either find the element (return true!) or find an empty space (return false!) You should **not** stop at tombstones.

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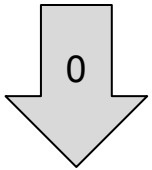
The element at index 0 is filled, but the value is not elem3!

Keep moving!



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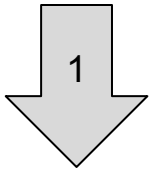

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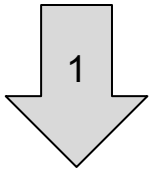
This elem is a tombstone!

Keep moving!



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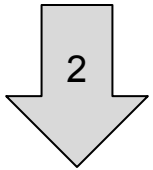

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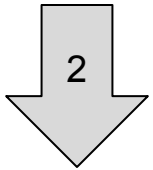
This is our element!
Return true!



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Linear Probing: Contains

- Some edge cases:
  - Be sure to return `false` if the table is empty!
  - That's it :)

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- Remove is just like **`contains`**, except when you locate the element, set its SlotType field to TOMBSTONE.

Linear Probing: Remove

- Remove is just like **`contains`**, except when you locate the element, set its SlotType field to TOMBSTONE.
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Linear Probing: Remove

- Remove is just like **`contains`**, except when you locate the element, set its SlotType field to TOMBSTONE.
- Be sure to return **`false`** if the table is empty, or if you can't find the element!
- Large brain hint: Is there a way you can **consolidate** logic between **`contains()`** and **`remove()`**?

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- Final notes about this problem:
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  - Please don't use **any** auxiliary data structures in this assignment. A Slot * is all you need.

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Any last questions?

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- The public functions are exactly the same:

```
class RobinHoodHashTable {
public:
    RobinHoodHashTable(HashFunction<std::string> hashFn);
    ~RobinHoodHashTable();

    bool contains(const std::string& key) const;

    bool insert(const std::string& key);
    bool remove(const std::string& key);

    bool isEmpty() const;
    int  size() const;

    void printDebugInfo();
```

Robinhood Hashing

- Some changes to the private members:

```
private:
    static const int EMPTY_SLOT = /* something */;

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No tombstones (rip).

We additionally store **distance**. **Distance** measures how many slots to the RIGHT of the original slot (wraps around) the element is.

Robinhood Hashing

- What changed?
- Insert, contain, and remove.

Robinhood Hashing: Insert

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    - Remember to find a home for that element using the same rule :).

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Robinhood Hashing: Contains

- LP: Go through the table and look for it. Stop when you find the element or an open slot.
- Robinhood: Go through the table and look for it. Stop when you find the element or an open slot **OR** an element that is closer to home than you should be.

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  - Repeat this shift until you have found an empty slot or an element situating in its native slot.
  - This is called **backwards-shift deletion**.

Robinhood Hashing: Implementation Thoughts

- Most of the tips from LP applies!

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- Final notes about this problem:
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Robinhood Hashing: Implementation Thoughts

- Most of the tips from LP applies!
- Do not kick elements out when distances are the same.
- Be super careful about your backwards-shift deletion. Use the interactive interface to make sure that you are doing it correctly!
- There are a lot of optimizations you need to make.
- Start early :).

Robinhood Hashing

Questions?