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Last Time
- Balanced Search Trees
- Red-Black Trees

Today
- RBT example
- Hashing

Next Time
- Hashing (cont’d)
- Examples of hash functions
- Non-Integer Keys
- Advanced Collision Handling
RBT insertion example

Starting with an empty RBT, insert 7, 14, 18, 23, 1, 11, 20, 29, 25, 27 (same values as before)

Complexity of RBT operations

print:

lookup:

insert:

delete:
Hashing

What problem are we solving?

Idea:
Terminology:

- Key
- Hash table
- Table Size (TS)
- Load Factor (LF)
- Hash function
- Collision
- Ideal hashing
Ideal hashing

Student records example:

```c
void insert(K key, D data)

D lookup (K key)
```
void delete(K key)

What if ID numbers are 10-digit numbers:

9012345789 9012345432 9023456789 ...

Collision Handling (basic)
Choosing an appropriate table size

Resizing:

Steps:
Choosing a good hash function

Properties:

Two-step process:
Some Hashing Techniques

% tablesize

Extraction

Folding

Mid-square
Multiplication

Rotation/Weighting/Use-your-imagination/...

What if the keys are not integers?

Java's built-in hash function for Strings: