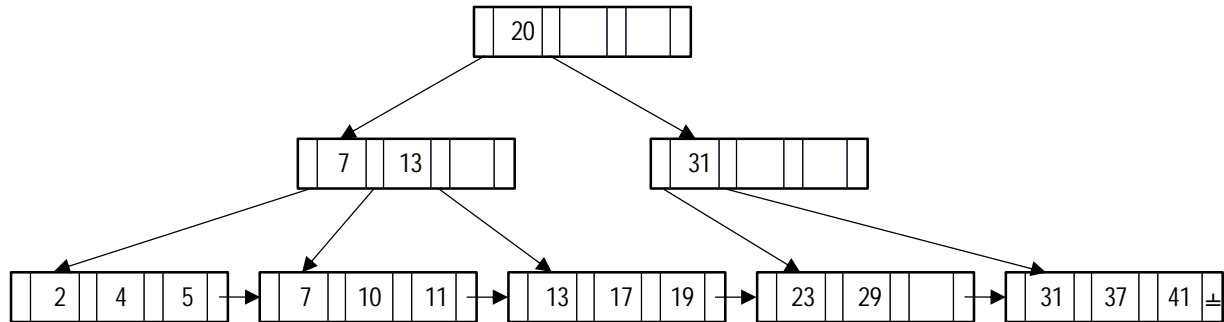# COMP 3311: Database Management Systems

Lecture 12 Exercises
Indexing: B⁺-tree

Exercise 1: For the B⁺-tree below with order 2 and fan out 4, show the tree that would result after *successively* applying the following operations in order.
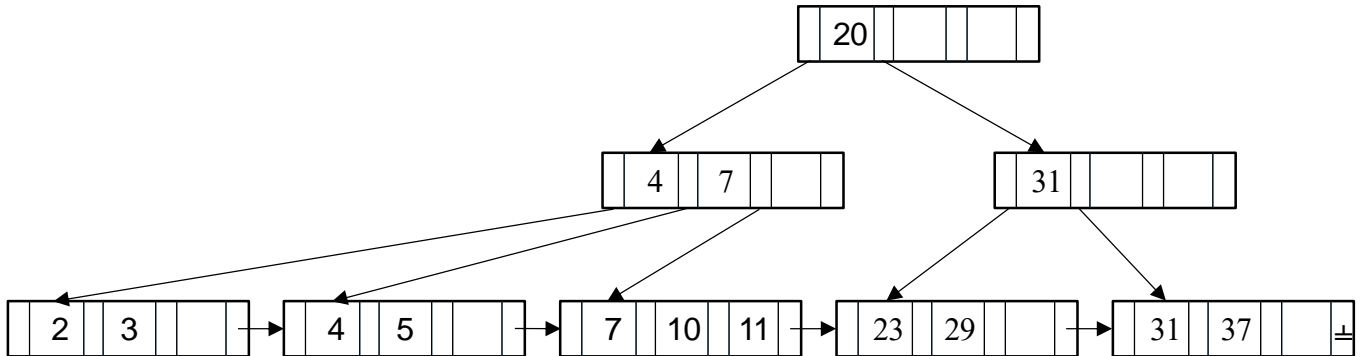
        i. insert 3   ii. insert 8

```
                              ┌──┬──┬──┬──┬──┬──┬──┐
                              │  │20│  │  │  │  │  │
                              └──┴──┴──┴──┴──┴──┴──┘
                   ┌─────────────┘                └─────────────┐
        ┌──┬──┬──┬──┬──┬──┬──┐              ┌──┬──┬──┬──┬──┬──┬──┐
        │  │7 │  │13│  │  │  │              │  │31│  │  │  │  │  │
        └──┴──┴──┴──┴──┴──┴──┘              └──┴──┴──┴──┴──┴──┴──┘
```

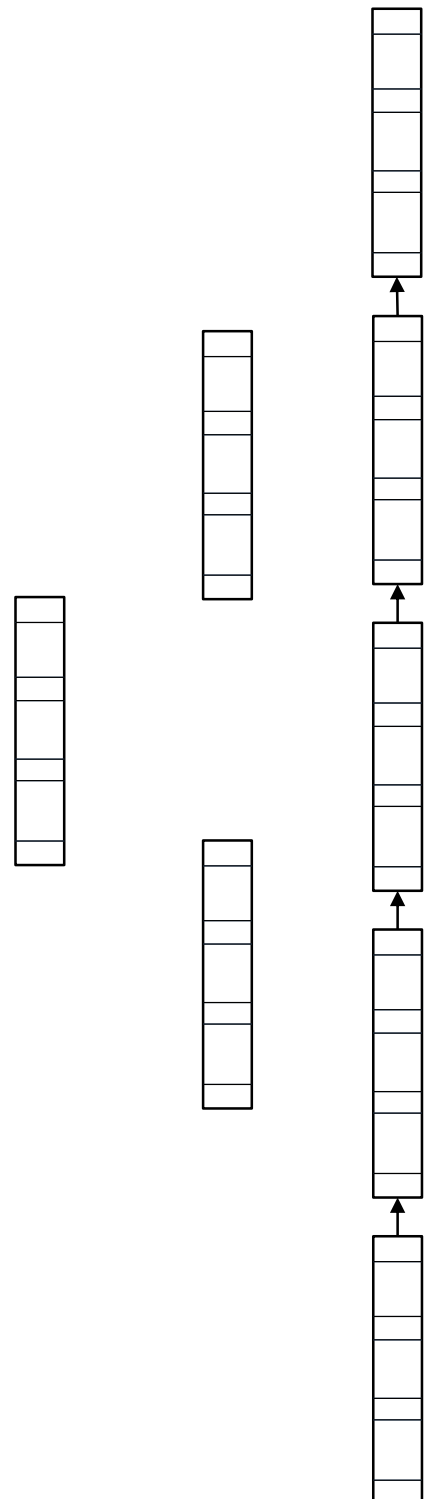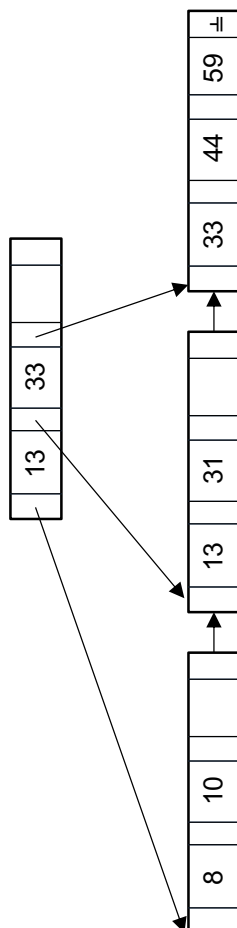| | 2 | | 4 | | 5 | | → | | 7 | | 10 | | 11 | | → | | 13 | | 17 | | 19 | | → | | 23 | | 29 | | | | → | | 31 | | 37 | | 41 | ⊥ |

COMP 3311: Database Management Systems

Lecture 12 Exercises
Indexing: B⁺-tree

Exercise 2: For the B⁺-tree below with order 2 and fan out 4, show the tree that would result after *successively* applying the following operations in order.

i. delete 5   ii. delete 3   iii. delete 7   iv. delete 11

```
                          ┌──┬──┬──┬──┐
                          │20│  │  │  │
                          └──┴──┴──┴──┘
                   ┌─────────┘        └─────────┐
            ┌──┬──┬──┬──┐              ┌──┬──┬──┬──┐
            │4 │7 │  │  │              │31│  │  │  │
            └──┴──┴──┴──┘              └──┴──┴──┴──┘
```

```
┌──┬──┬──┬──┐   ┌──┬──┬──┬──┐   ┌──┬──┬──┬──┐   ┌──┬──┬──┬──┐   ┌──┬──┬──┬──┐
│2 │3 │  │  │→ │4 │5 │  │  │→ │7 │10│11│  │→ │23│29│  │  │→ │31│37│  │ ⊥│
└──┴──┴──┴──┘   └──┴──┴──┴──┘   └──┴──┴──┴──┘   └──┴──┴──┴──┘   └──┴──┴──┴──┘
```

COMP 3311: Database Management Systems

Lecture 12 Exercises
Indexing: B⁺-tree

Exercise 3: For the B⁺-tree below with order 2 and fan out 4, show the tree that would result after *successively* applying the following operations in order. Add nodes to or cross out nodes in the empty B⁺-tree below as necessary.

i. insert 45   ii. insert 35   iii. insert 40   iv. delete 59

Perform the following operations in the order given

i. insert 45   ii. insert 35   iii. insert 40   iv. delete 59

Initial B⁺-tree

COMP 3311: Database Management Systems

Lecture 12 Exercises
Indexing: B$^+$-tree

Exercise 4: Using the template below, construct a B$^+$-tree for the following set of search-key values using <u>bulk loading</u>, which creates leaf nodes from left to right. Assume each node can hold 4 pointers (i.e., 3 values) and that each leaf node is loaded with the <u>minimum number</u> of values.

2   3   5   7   11   17   19   23   29   31