Database Systems (CPH) – Fall 2025
Teacher: Tiantian Liu
Exercise Sheet: Lecture 8: Physical Design

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1. Review the following terms.

Volatile storage, Non-volatile storage
Block (Page)

Fixed-length record
Variable-length record

Heap file organization
Sequential file organization
Multitable clustering file organization

B+-tree
Leaf node, Internal node, Root node
Search key, pointer
Insert, Delete

Primary index (clustering index)
Secondary index (nonclustering index)
Dense index
Sparse index

Hashing

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2. Consider the following B+tree.

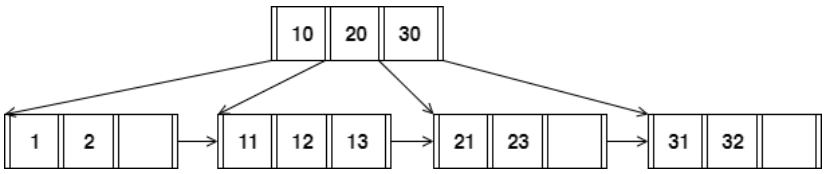


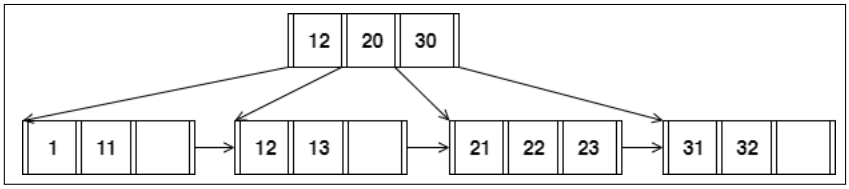
Figure: B+ Tree of degree $n = 4$.

When answering the following questions, be sure to follow the procedures described in class and in your textbook. You can make the following assumptions:

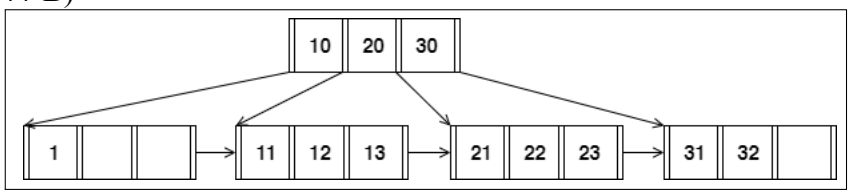
- A left pointer in a non-leaf node guides towards keys less than its corresponding key, while a right pointer guides towards keys greater than or equal to its corresponding key.
- A leaf node underflows when the number of keys goes below $\lceil \frac{n-1}{2} \rceil$.
- An internal node underflows when the number of pointers goes below $\lceil \frac{n}{2} \rceil$.

2.1 Insert 22^* into the B+tree, then delete 2^*. Select the resulting tree.

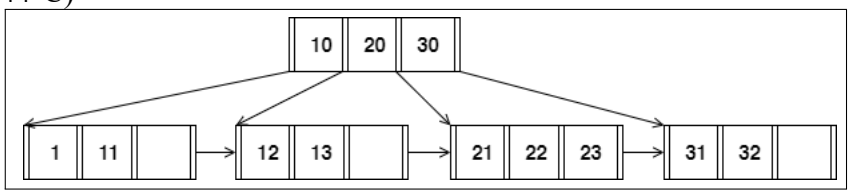
☐ A)



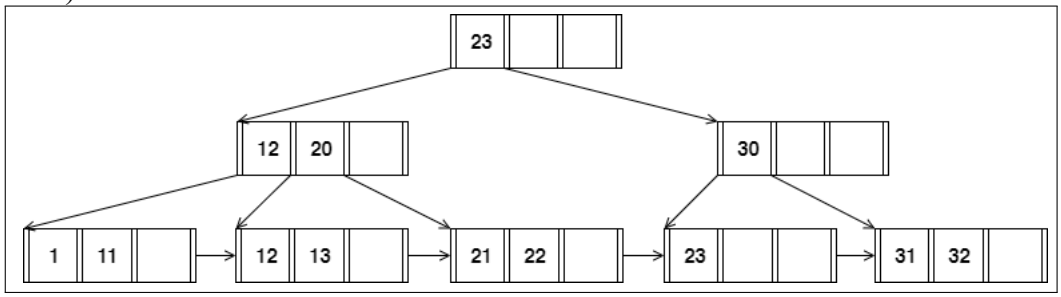
☐ B)



☐ C)

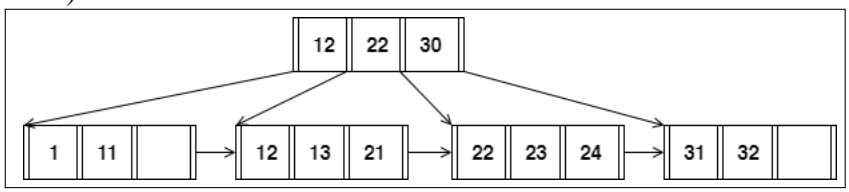


☐ D)

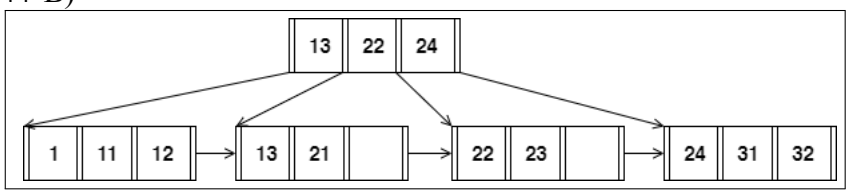


2.2 Then Insert 24* (based on the result in 2.1). Select the resulting tree.

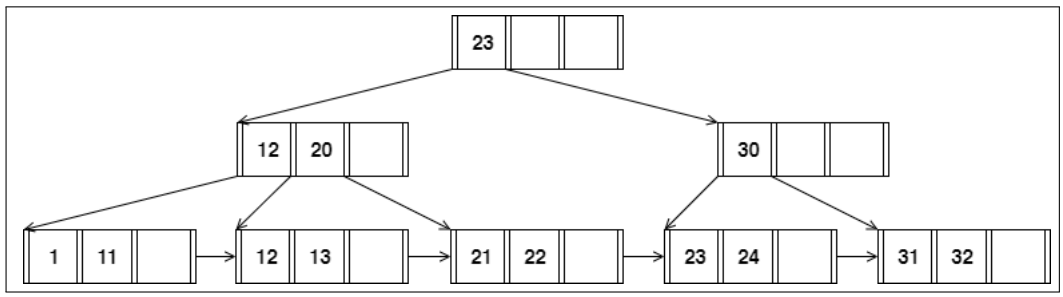
☐ A)



☐ B)



☐ C)



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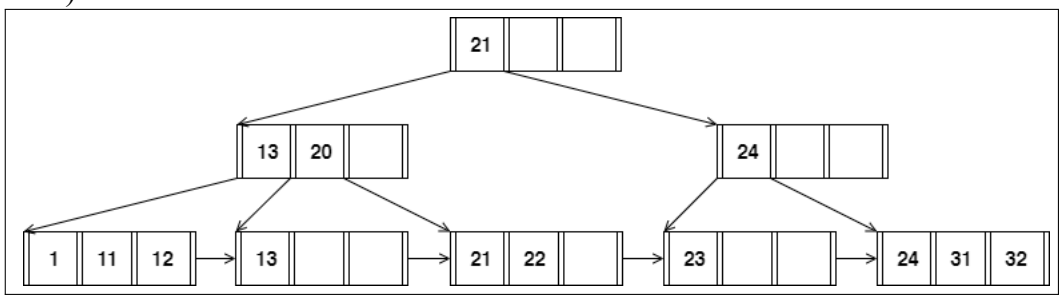
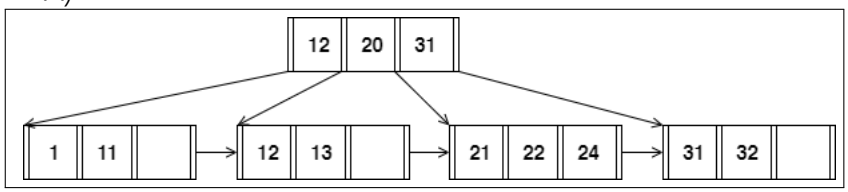
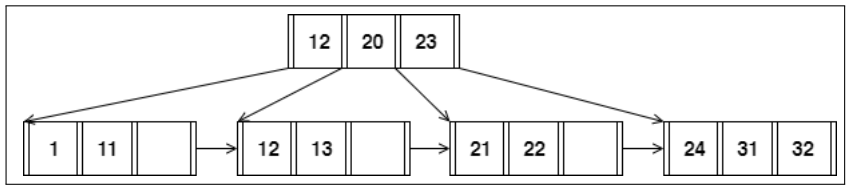


2.3 Finally, delete 23^* (based on the result in 2.2). Select the resulting tree.

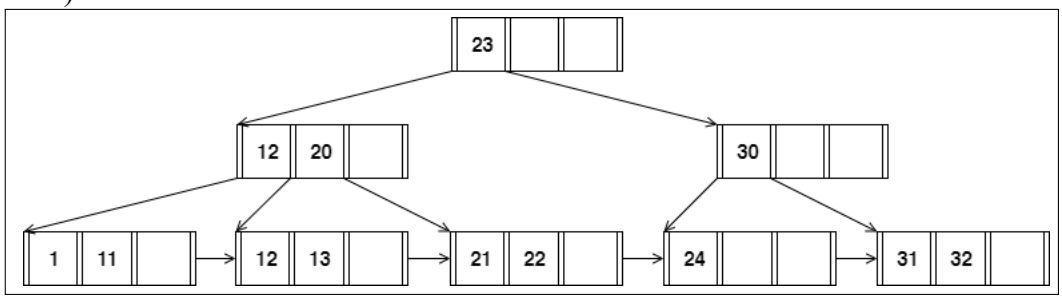
☐ A)



☐ B)



☐ C)



☐ D)