2.4 Binary Heap Demo

click to begin demo
Binary heap operations

**Insert.** Add node at end, then swim it up.
**Remove the maximum.** Exchange root with node at end, then sink it down.

heap ordered
Binary heap operations

**Insert.** Add node at end, then swim it up.

**Remove the maximum.** Exchange root with node at end, then sink it down.

**insert S**
**Binary heap operations**

**Insert.** Add node at end, then swim it up.

**Remove the maximum.** Exchange root with node at end, then sink it down.

`insert S`

---

Diagram:
- **Root** `T`
- **Parents** `P`, `R`
- **Children** `N`, `H`, `O`, `A`, `E`, `I`, `G`, `S`
- Node `S` with value `11` violates heap order (swim up)

---

**Array Representation:**
```
T P R N H O A E I G S
```

**Value:** 11
**Binary heap operations**

**Insert.** Add node at end, then swim it up.

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**insert S**

[Binary heap diagram showing the process of inserting and maintaining the heap order.]
**Binary heap operations**

**Insert.** Add node at end, then swim it up.

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---

**insert S**

![Binary heap diagram](image)

- The heap structure is shown with nodes labeled from T to H.
- The insertion of 'S' violates the heap order, which can be resolved by swimming up.
- The heap order is maintained after the insertion.
Binary heap operations

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**heap ordered**
Binary heap operations

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```
T S R N P O A E I G H
1 1
```
Binary heap operations

**Insert.** Add node at end, then swim it up.

**Remove the maximum.** Exchange root with node at end, then sink it down.

```
     T
   /   \
  S     R
 /     / \
N     P   O
 |     |   |
E     I   G
```

```
1 1 11
```

```
  exchange with root
```

remove the maximum
Binary heap operations

**Insert.** Add node at end, then swim it up.

**Remove the maximum.** Exchange root with node at end, then sink it down.

**remove the maximum**

![Binary heap diagram](image)

---

<table>
<thead>
<tr>
<th>H</th>
<th>S</th>
<th>R</th>
<th>N</th>
<th>P</th>
<th>O</th>
<th>A</th>
<th>E</th>
<th>I</th>
<th>G</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11</td>
</tr>
</tbody>
</table>
Binary heap operations

Insert. Add node at end, then swim it up.
Remove the maximum. Exchange root with node at end, then sink it down.

remove the maximum

violates heap order (sink down)
Binary heap operations

**Insert.** Add node at end, then swim it up.

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**remove the maximum**

![Binary heap diagram]

- Violates heap order (sink down)
Binary heap operations

Insert. Add node at end, then swim it up.

Remove the maximum. Exchange root with node at end, then sink it down.

remove the maximum

\[ \begin{array}{cccccccccccc}
    S & P & R & N & H & O & A & E & I & G & T \\
    1 & 2 & 5 \\
\end{array} \]
Binary heap operations

**Insert.** Add node at end, then swim it up.

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heap ordered

![Binary heap diagram](image)
Binary heap operations

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---

**remove the maximum**

![Binary heap diagram]

---

<table>
<thead>
<tr>
<th>S</th>
<th>P</th>
<th>R</th>
<th>N</th>
<th>H</th>
<th>O</th>
<th>A</th>
<th>E</th>
<th>I</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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Binary heap operations

**Insert.** Add node at end, then swim it up.

**Remove the maximum.** Exchange root with node at end, then sink it down.

**remove the maximum**

```plaintext
S
P
N
E
G
H
I

1

O

R

A
```

exchange with root
Binary heap operations

**Insert.** Add node at end, then swim it up.

**Remove the maximum.** Exchange root with node at end, then sink it down.

```
  G
 /   \
P     R
 /   /  \
N   H   O
 /   /    /
E   I   S
```

remove the maximum

exchange with root

```
G P R N H O A E I S
1 1 10
```
Binary heap operations

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**Binary heap operations**

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**remove the maximum**

```
  R
 /   \
P     G
 |   / /
N    H  O
 |  /  |
E   I  A
```

violates heap order (sink down)
Binary heap operations

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**remove the maximum**

![Binary heap diagram]

- Violates heap order (sink down)

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<th>P</th>
<th>O</th>
<th>N</th>
<th>H</th>
<th>G</th>
<th>A</th>
<th>E</th>
<th>I</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td></td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>
Binary heap operations

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heap ordered
Insert. Add node at end, then swim it up.
Remove the maximum. Exchange root with node at end, then sink it down.

**insert S**

```
R
 /   \
O   P
 /   \
G   H
 /   \
N   E
 /   \
S   I
```

10
Binary heap operations

**Insert.** Add node at end, then swim it up.

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*insert S*

[Diagram of a binary heap with a node labeled 'S' inserted and showing that it violates the heap order, with an arrow indicating that it should be 'swum up'.]
Binary heap operations

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*insert S*

```

```

![Binary heap diagram]

```

```
Binary heap operations

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Binary heap operations

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```
insert S

violates heap order
(swim up)
```
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heap ordered