

Red-Black Trees:

Properties that could be violated during insertion:

2. The root is black.
4. If a node is red, then both its children are black.

Case 1: z's uncle y is red

- $p[z].color = \text{black}$
- $y.color = \text{black}$
- $p[p[z]].color = \text{red}$
- $z = p[p[z]]$

Z's parent is a left child and

Case 2a: z's uncle y is black and z is a right child

- $z = p[z]$
- $\text{left-rotate}(z)$

Case 3a: z's uncle y is black and z is a left child

- $p[z].color = \text{black}$
- $p[p[z]].color = \text{red}$
- $\text{right-rotate}(p[p[z]])$

Z's parent is a right child and

Case 2b: z's uncle y is black and z is a left child

- $z = p[z]$
- $\text{right-rotate}(z)$

Case 3b: z's uncle y is black and z is a right child

- $p[z].color = \text{black}$
- $p[p[z]].color = \text{red}$
- $\text{left-rotate}(p[p[z]])$

Before completing the algorithm, make sure the root's color is black.