Red-Black Tree Rotations
Red-Black Diagrams

The diagrams which follow show the rotations and recoloring for each “case” for Bottom-Up Insertion, Top-Down Insertion and Bottom-Up Deletion.

Bear in mind that each case has a left-right symmetrical twin which is not shown here.
Bottom-Up Insertion

Case 0 - X is the root

Case 1 - U is Red

Case 2 - Uncle is black, X and P are opposite children

Case 3 - Uncle is Black, X and P are both left (right) children

Color it Black

Recolor P, G, U
Move X up to G
Move to another case

Zig-Zag Rotation
Recolor X and G

Rotate P around G
Recolor P and G
Bottom-Up Deletion
Top Down Insertion

**Case 1** – P is Black

![Tree diagram showing Case 1 with P black.]

1. Recolor X, Y and Z
2. Move P to the root

**Case 2** – P is red and P and X are both left (right) children

![Tree diagram showing Case 2 with P red and X as left child.]

1. Recolor X, Y, Z, P, G
2. Rotate P around G

**Case 3** – P is red and P and X are opposite children

![Tree diagram showing Case 3 with P red and X as opposite children.]

1. Recolor X, Y, Z
2. Rotate X around P
3. Recolor X, G
4. Rotate X around G