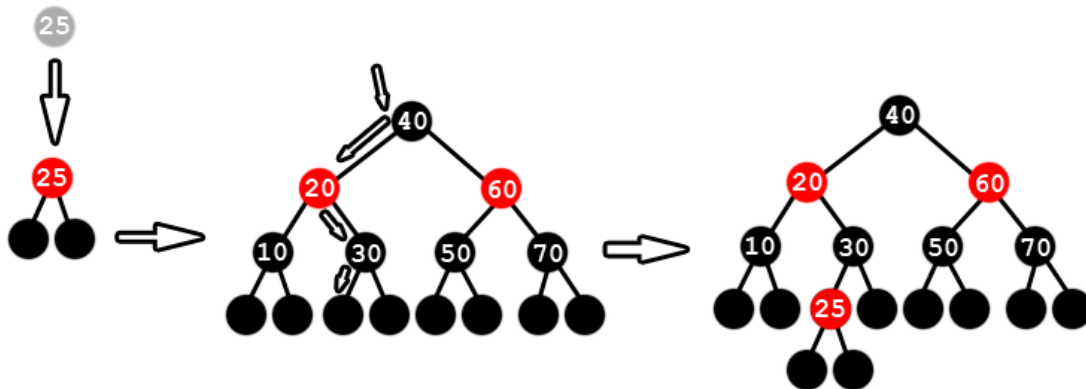


## Red-Black Trees – Insertion, Deletion

### Insertion:

#### Insertion:

- Find the correct leaf to insert new node instead of it
- Color node in red, and attach 2 black leaves to it
- Make sure RB-tree properties hold

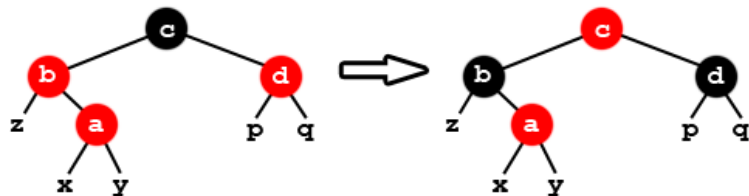


#### Correction:

When a violation is created for inserting **a** (cases 4-6 are symmetric):

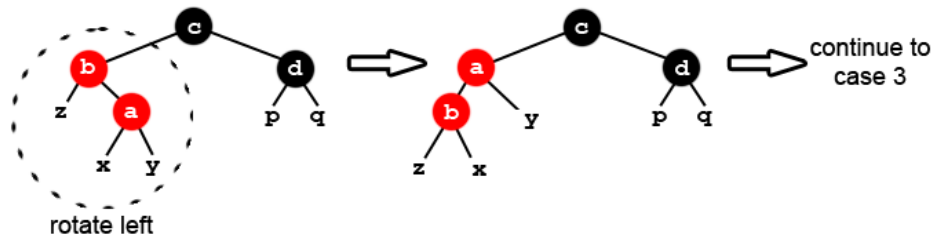
##### Case 1: a's uncle (d) is red:

- Color a's father (b) and uncle (d) black
- Color a's father (c) red



##### Case 2: a's uncle is black, a is a right child:

- Rotate left around a's father (b)
- Continue to case 3



##### Case 3: a's uncle is black, a is a left child:

- Rotate right around a's grandfather (c)
- Switch colors between a's father (b) and a's (new) sibling (c)

