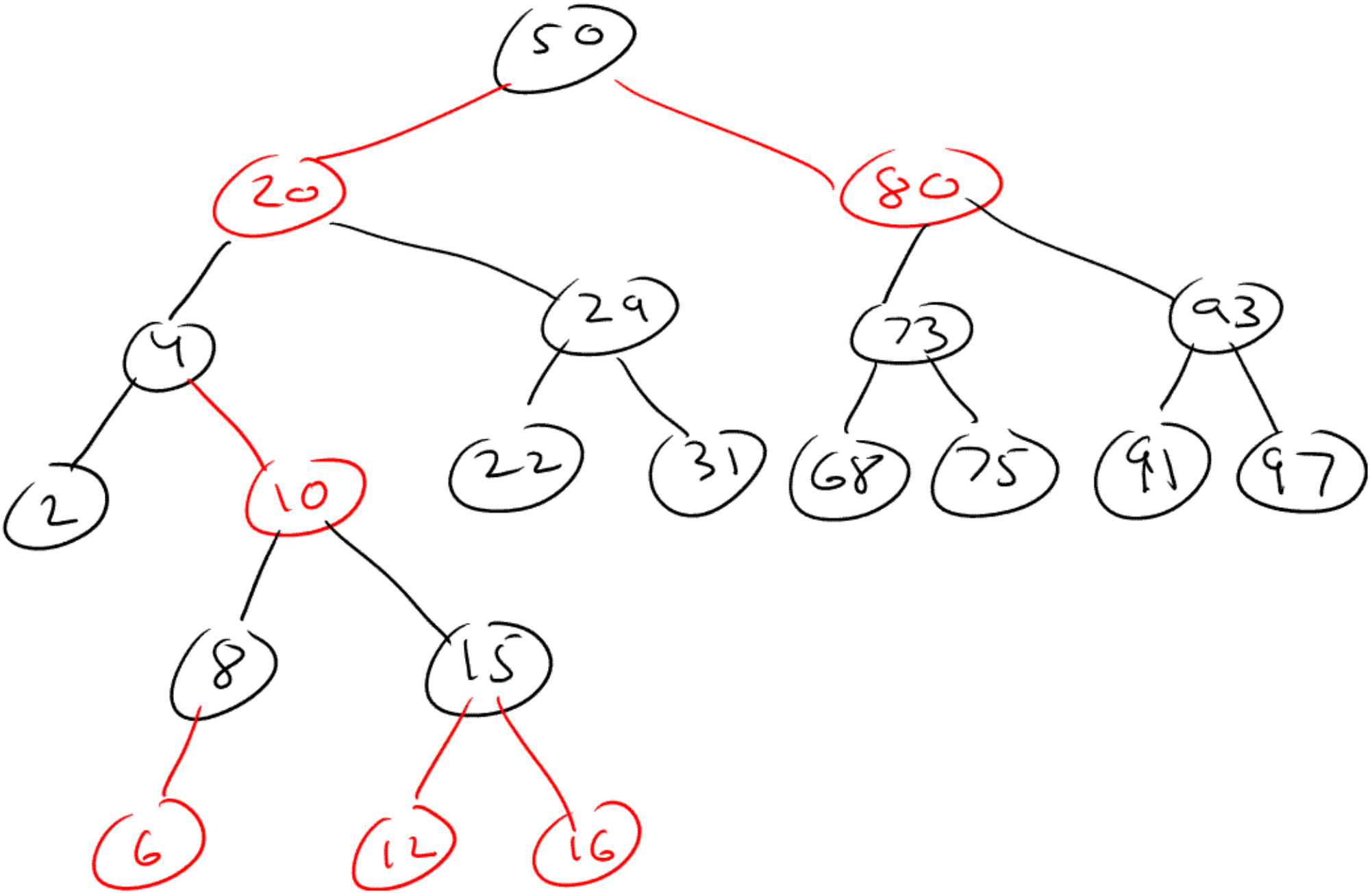
50
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73
93
2
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22
31
68
75
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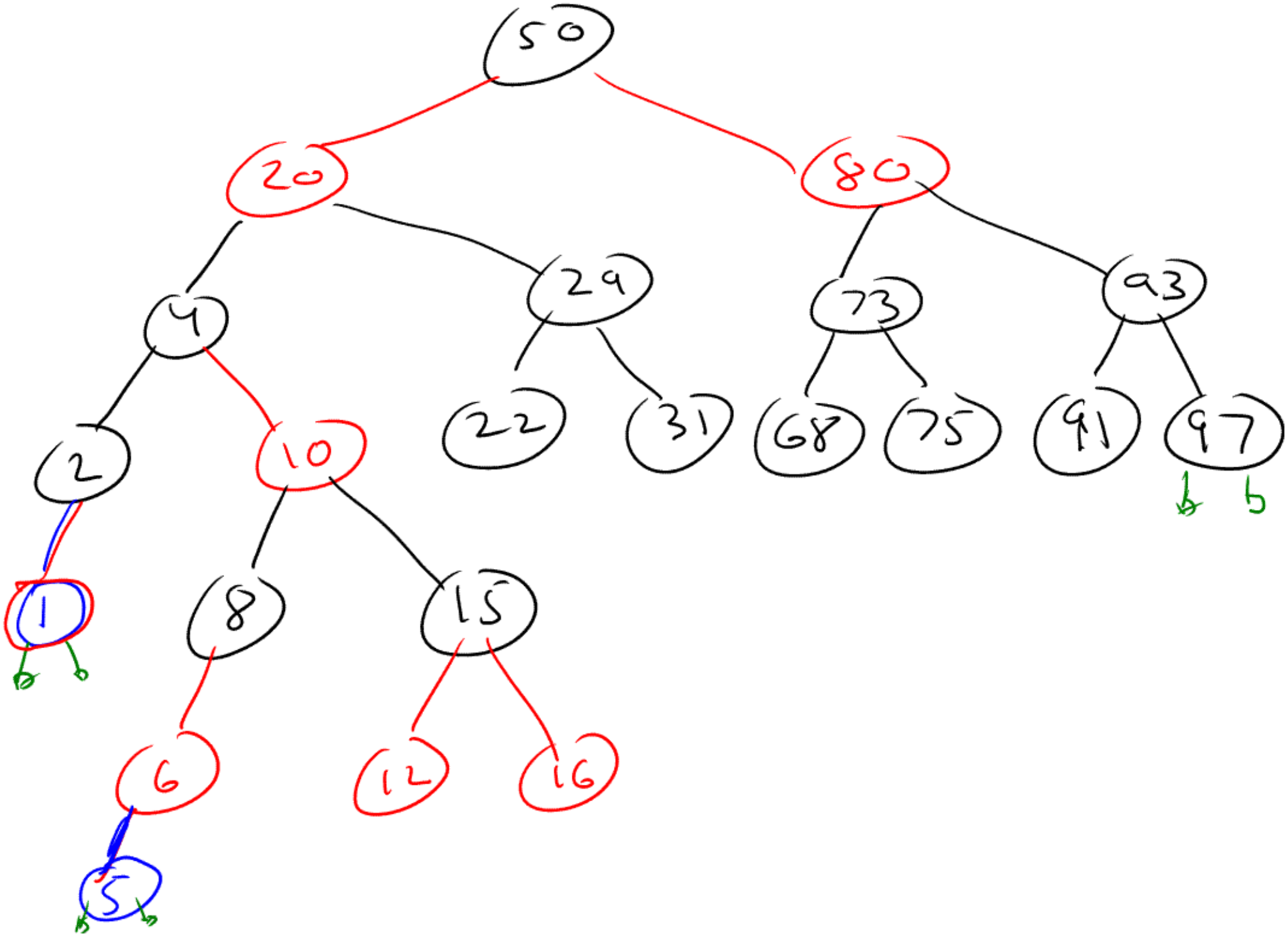
97
8
15
6
12
16

Insert (x)

- BST insert of x
- assign new node a color
  → which color??
    ↳ if we make node black, always a problem because blackheight of two paths are increased but for other paths, no
    ↳ if we make node red, sometimes a problem, when parent is also red


50
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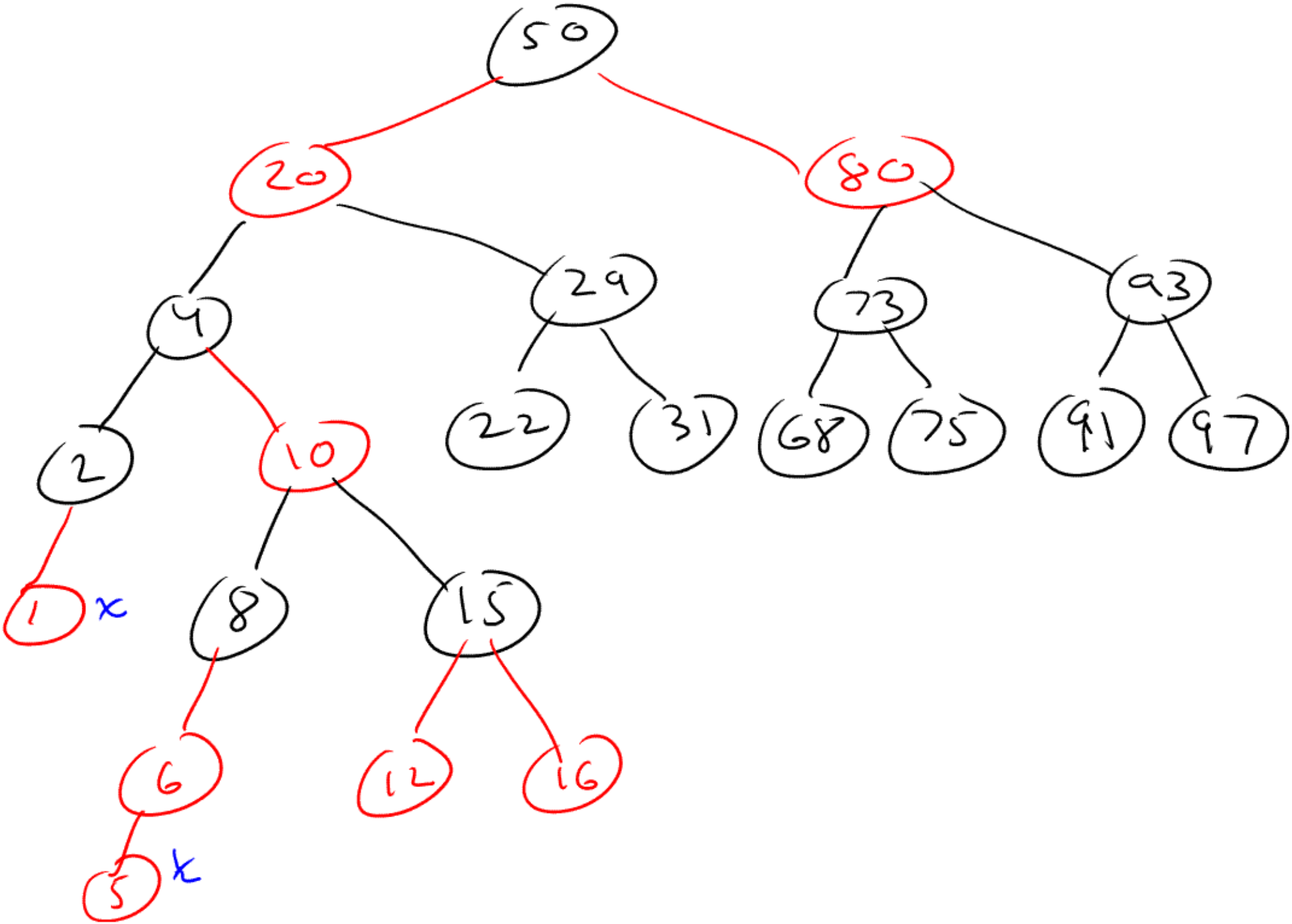
29
73
93
2
10
22
31
68
75
91
97
1
8
15
6
12
16
5

```
Insert (x)
{
    - BST insert of x, make new node red
    - label new node x
    if (x's parent is black)
        STOP;
    else // x's parent is red
    {
        fix problems in tree

    }
}
```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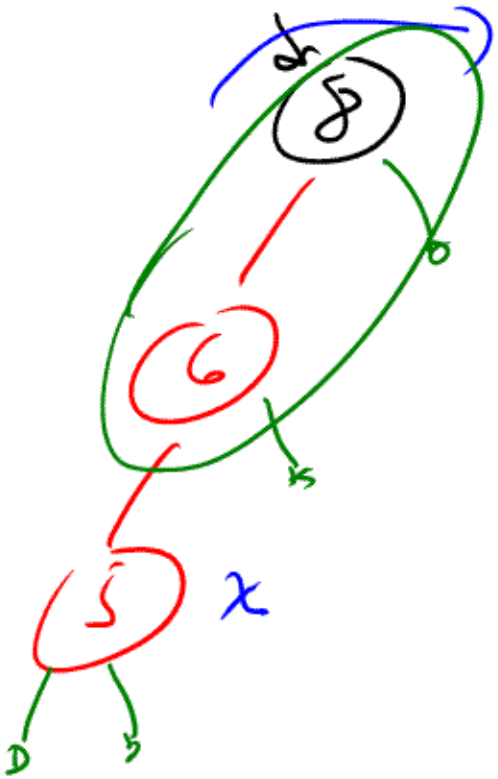
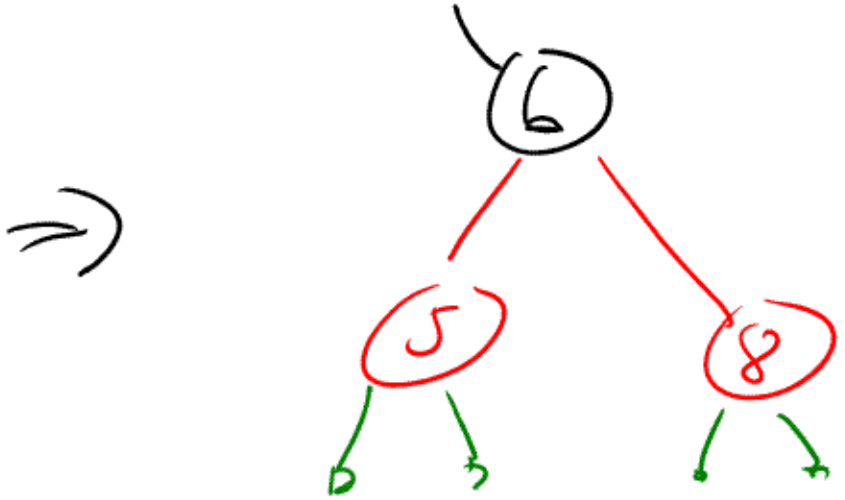
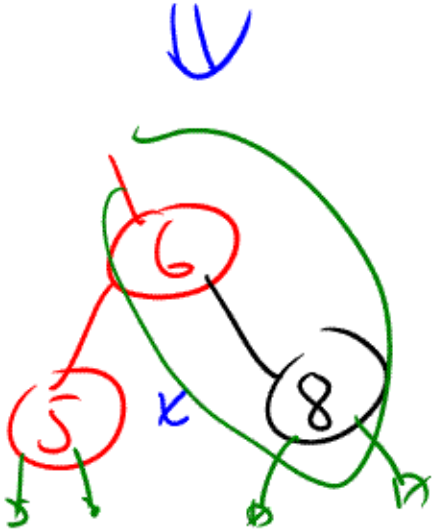
97
1
x
8
15
6
12
16
5
k

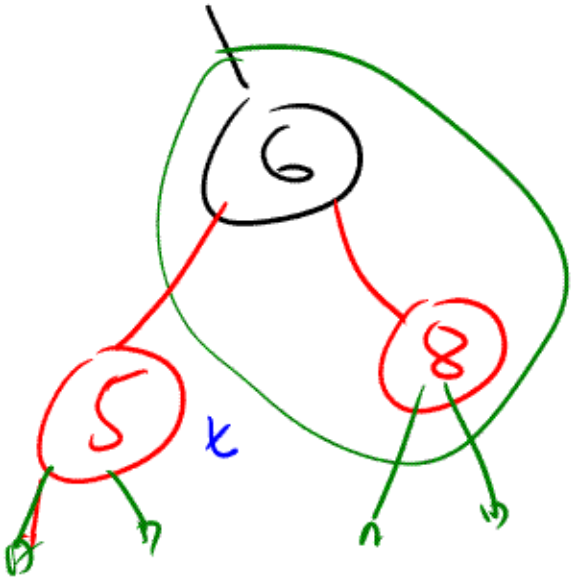


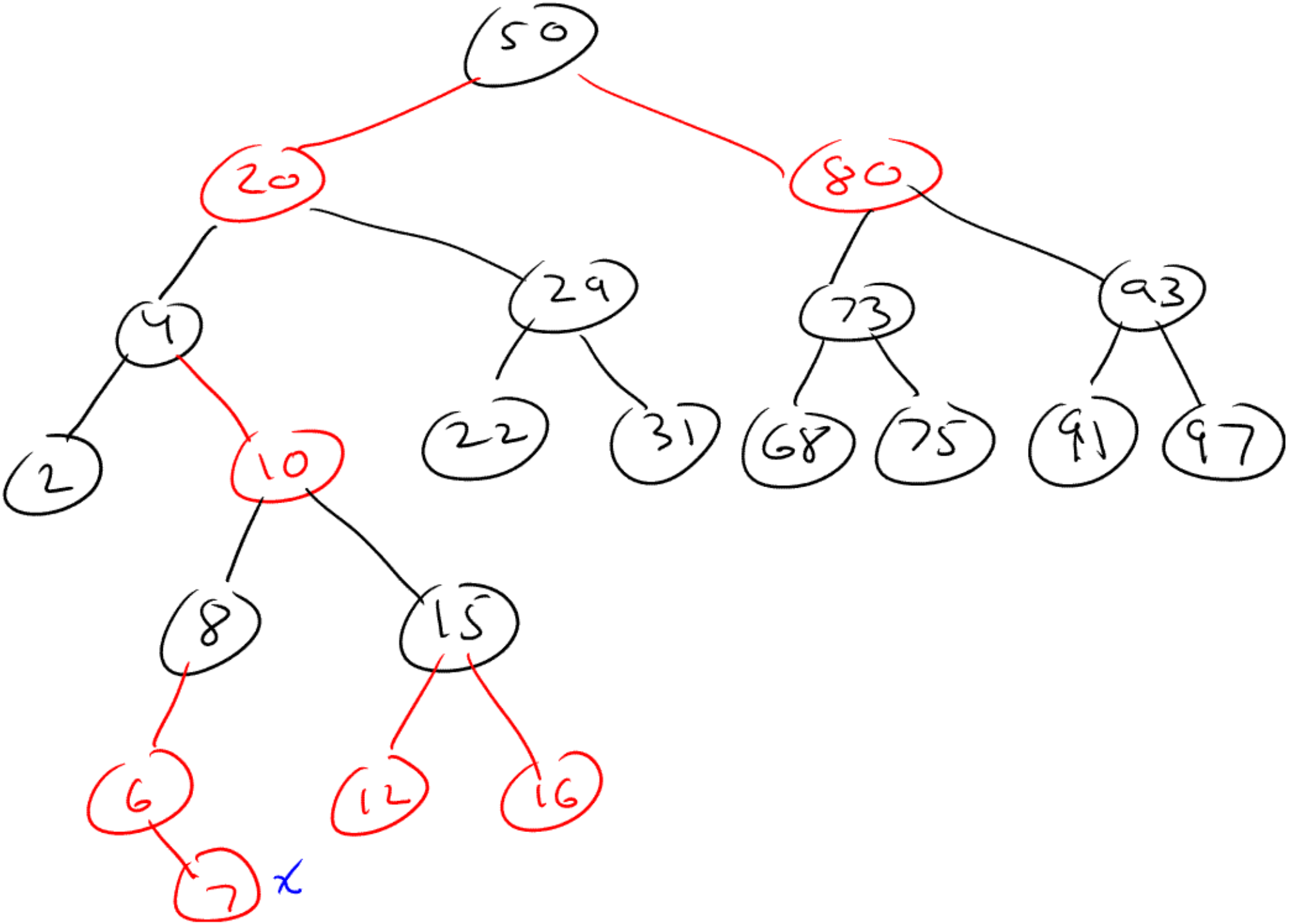


1) SR on x's grandparent

2) swap colors of old subtree root (x's former grandparent) & new subtree root



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91
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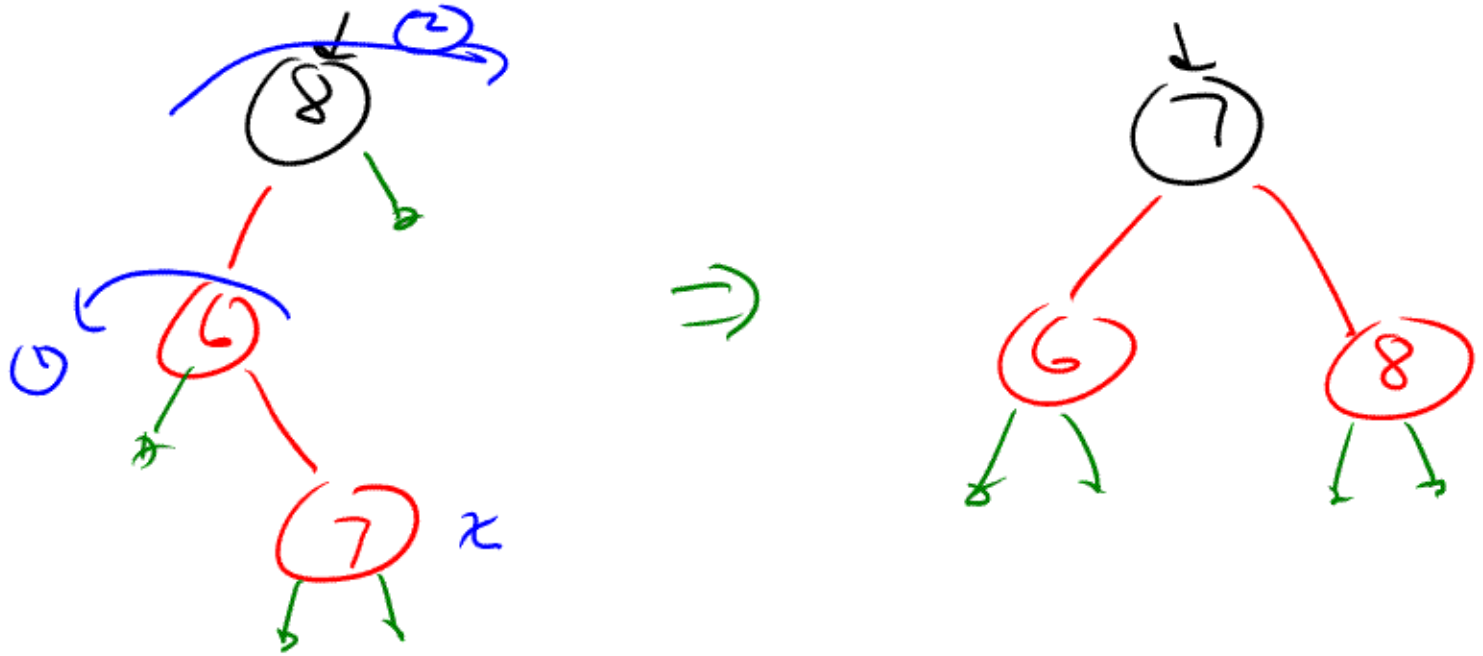
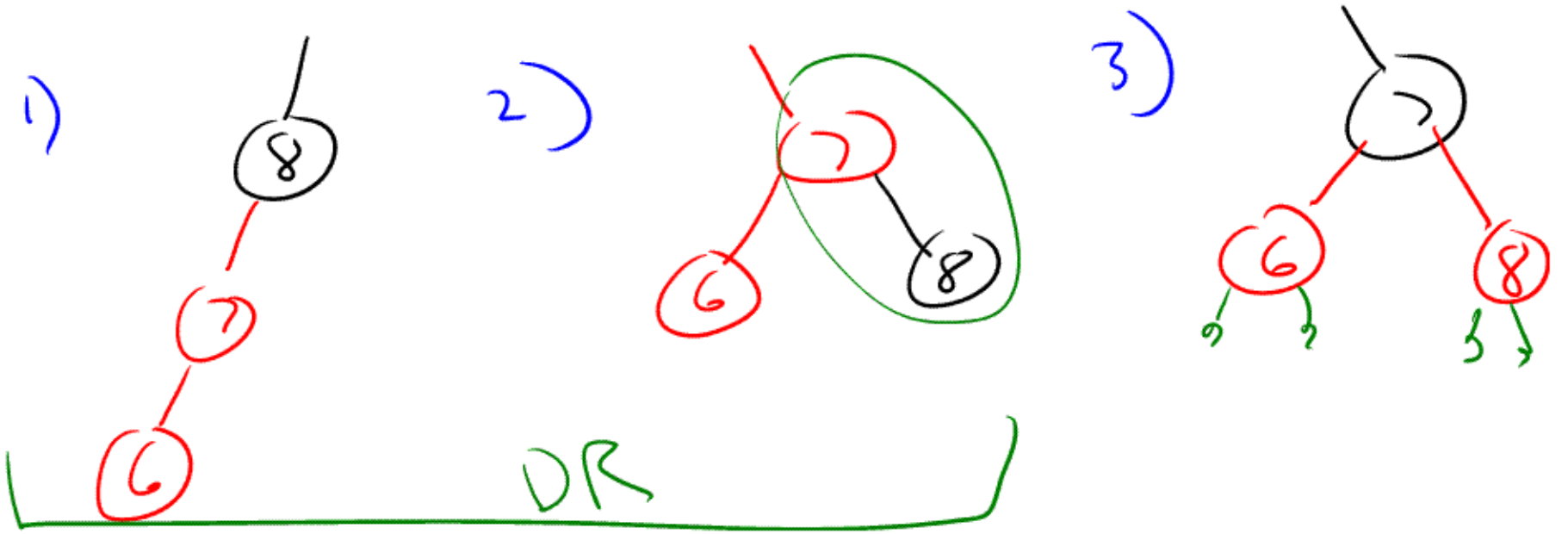
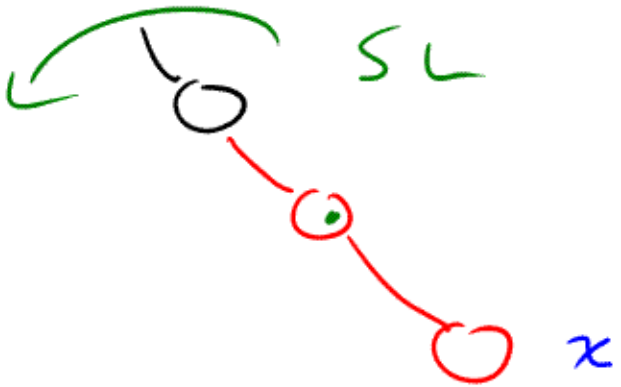
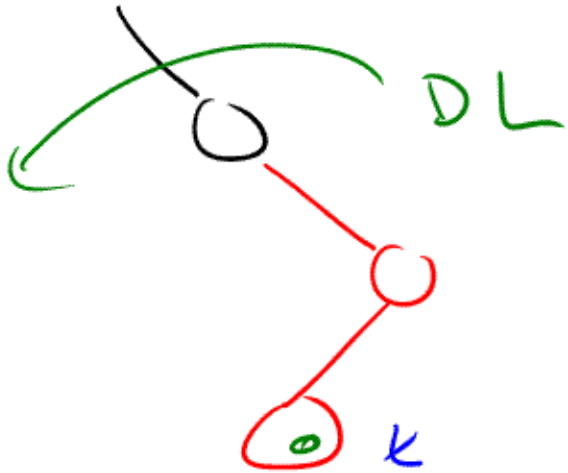
8
15
6
12
16
7
x



DR on 8 (x's grandparent)



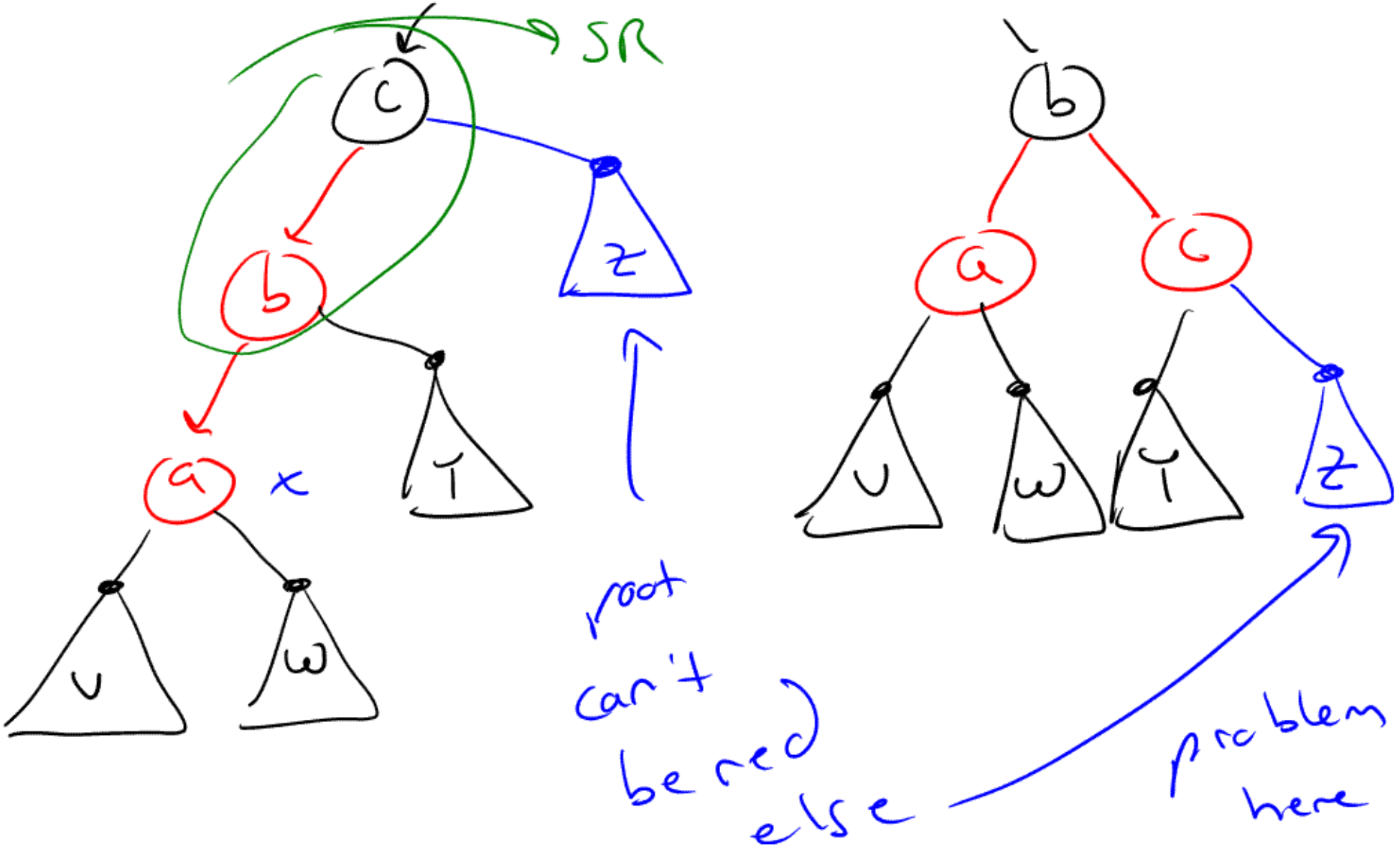




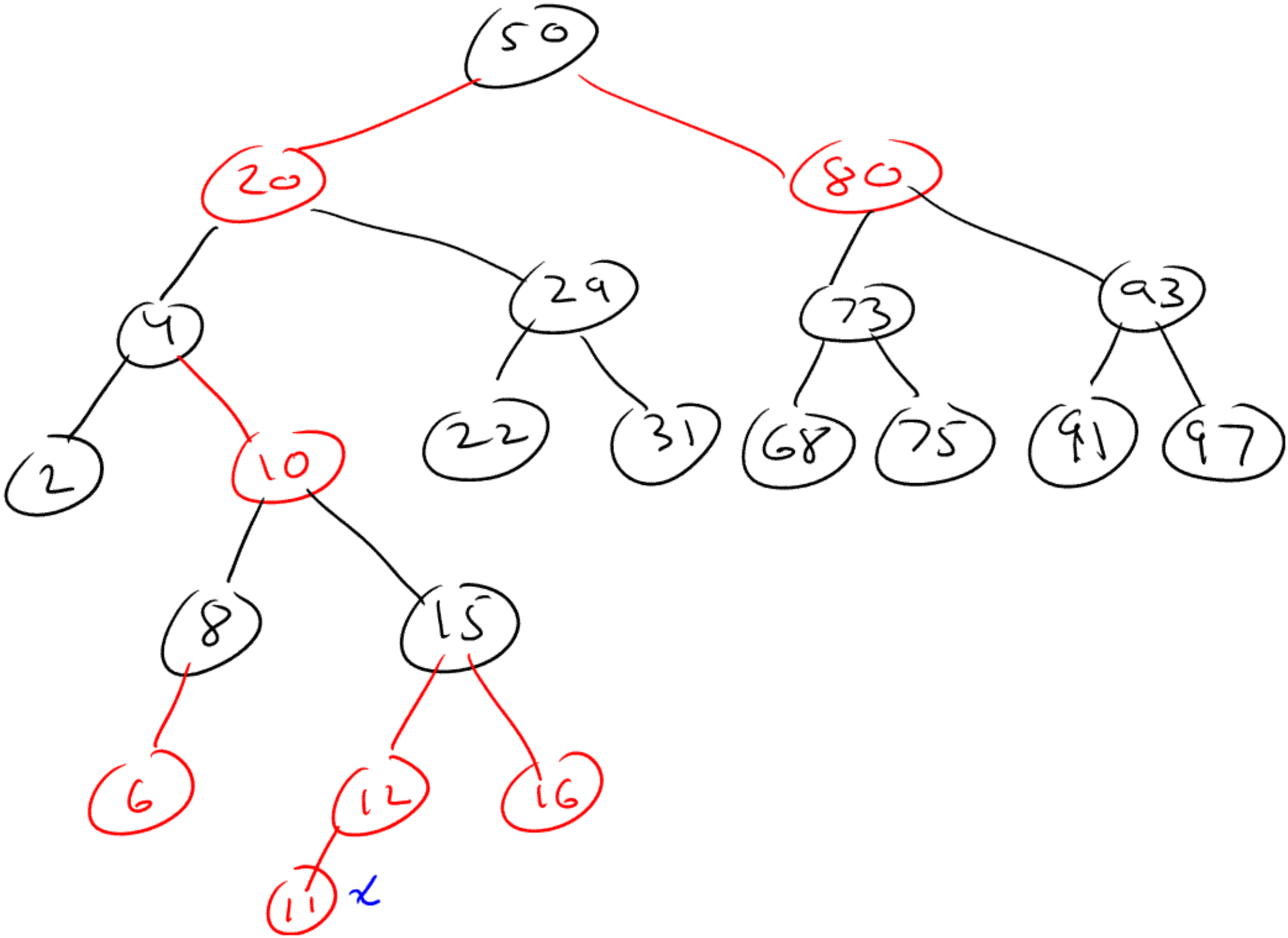
---

1) do a rotation (SR, DR, DL, SL) on x's grandparent

2) x's grandparent 's old root of subtree, swap its color w/ that of new root of subtree


SR
c
b
z
a
x
y
v
w
root
can't
be red
else
b
a
c
v
w
y
z
problem
here

```
Insert (x)
{   - BST insert of x, color new node red
    - label new node "x"
    if ( x's parent is black)
        stop;
    else
    { if (x's parent's sibling is
                                black)
      { rotate, recolor 2 nodes, stop
      }
      else // x's parent's sibling is red
          ?
    )
}
```


50
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73
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2
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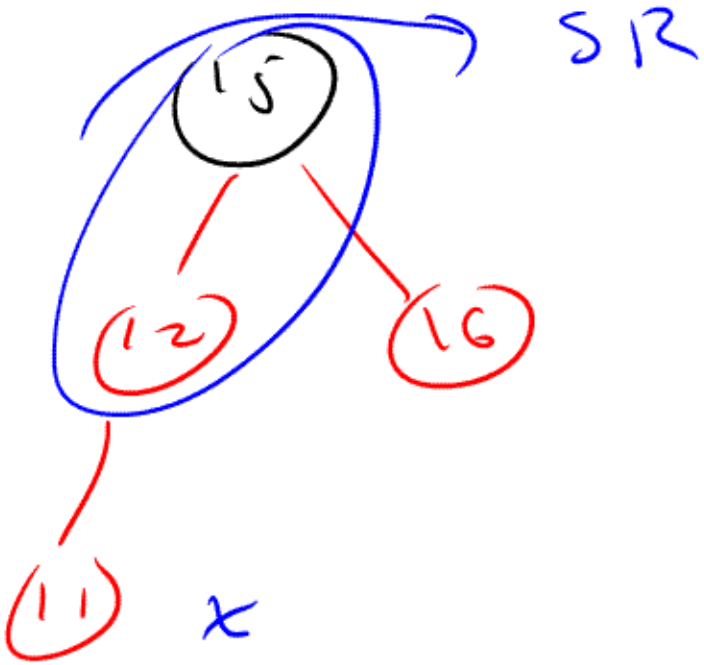
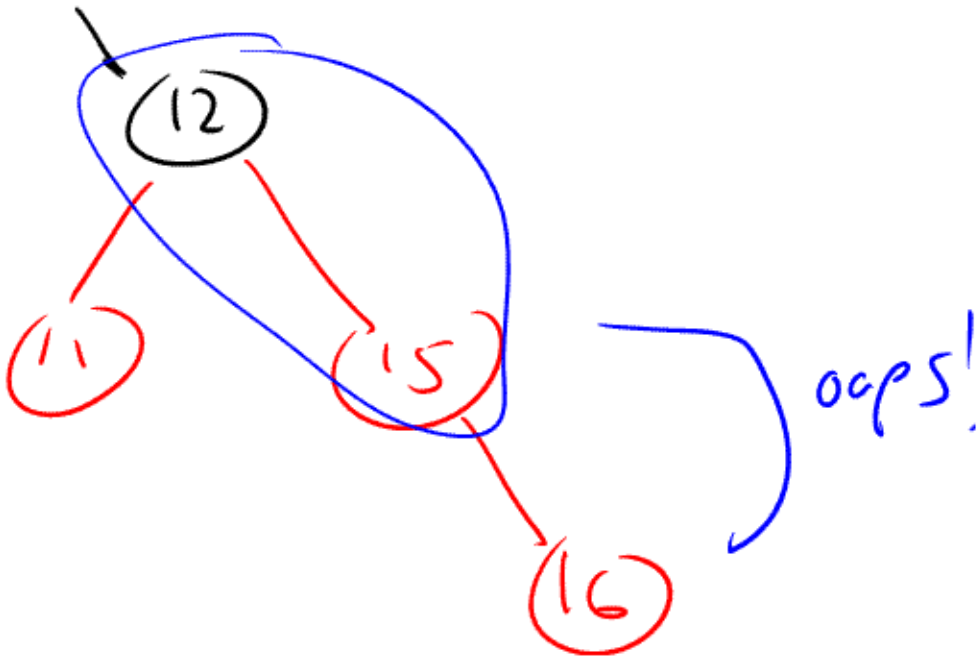
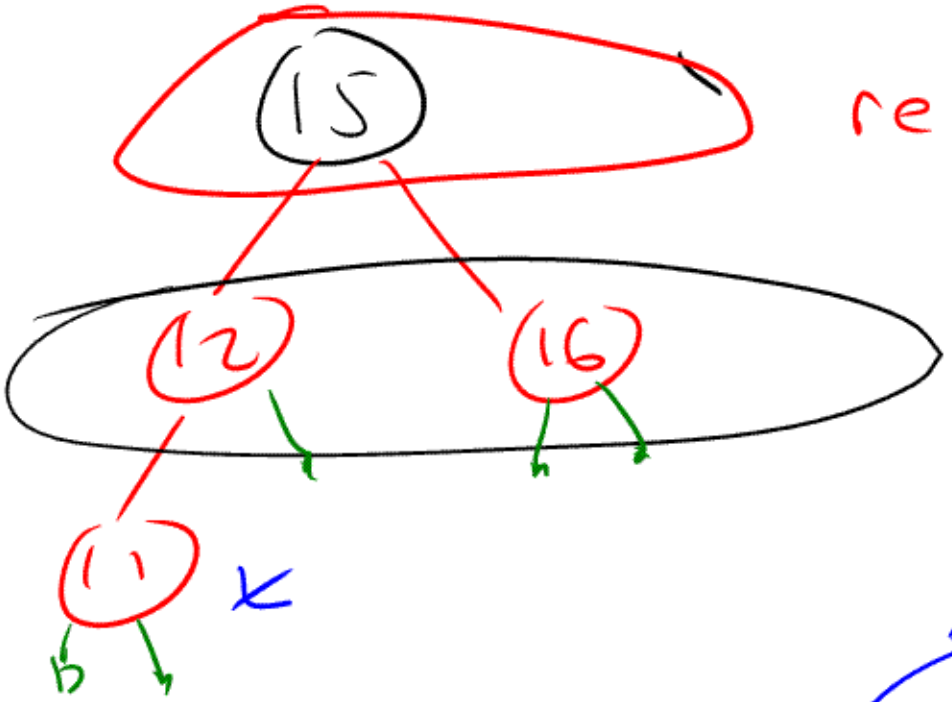
31
68
75
91
97
8
15
6
12
16
11
x

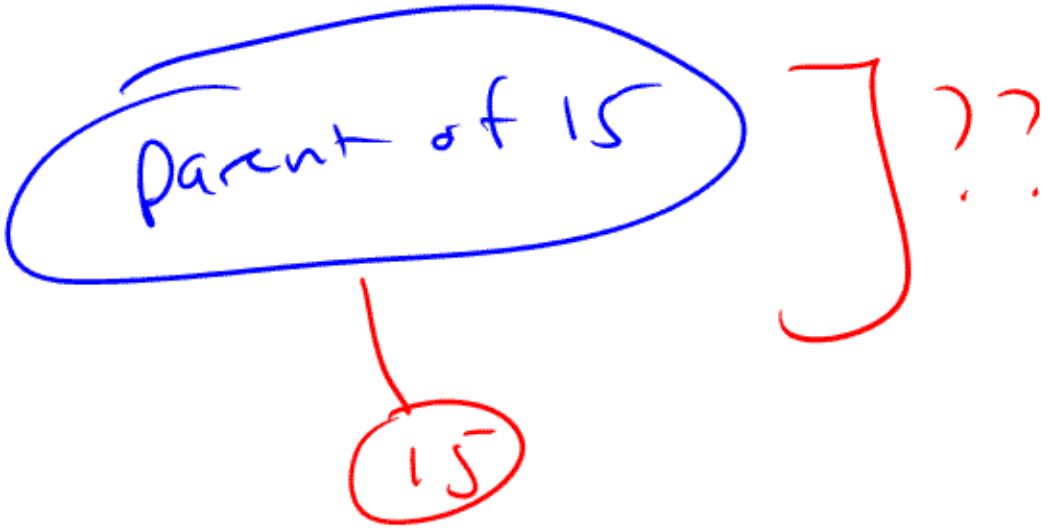

15
12
16
11
SIR
x


12
11
15
16
oops!

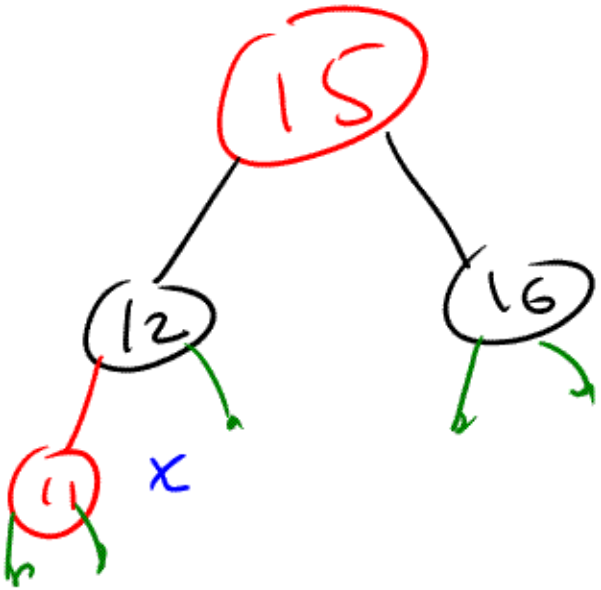


recolor

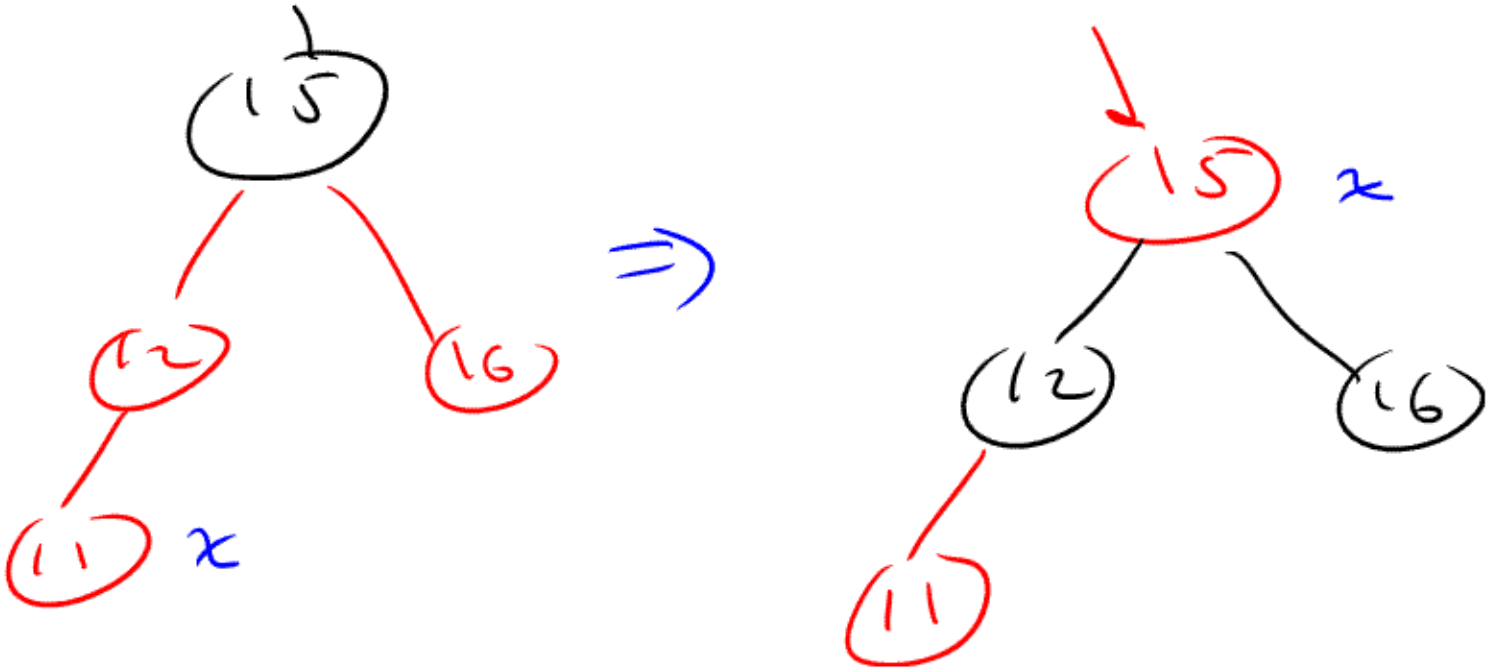
recolor



??



so relabel 15 as x


15
12
16
11
x
15
x
12
16
11

```
Insert (x)
{   - BST insert of x, new node is red
    - label new node as x
    while (x not root AND x's parent is red)
    {   if (x's parent's sib is black
        {   rotate; recolor 3 nodes, stop
        }
        else
        {   recolor 3 nodes, x's grandparent
            relabeled x, continue
        }
    }
    color root black;
}
```