EECE 7205: Introduction of Computer Engineering

Assignment 4

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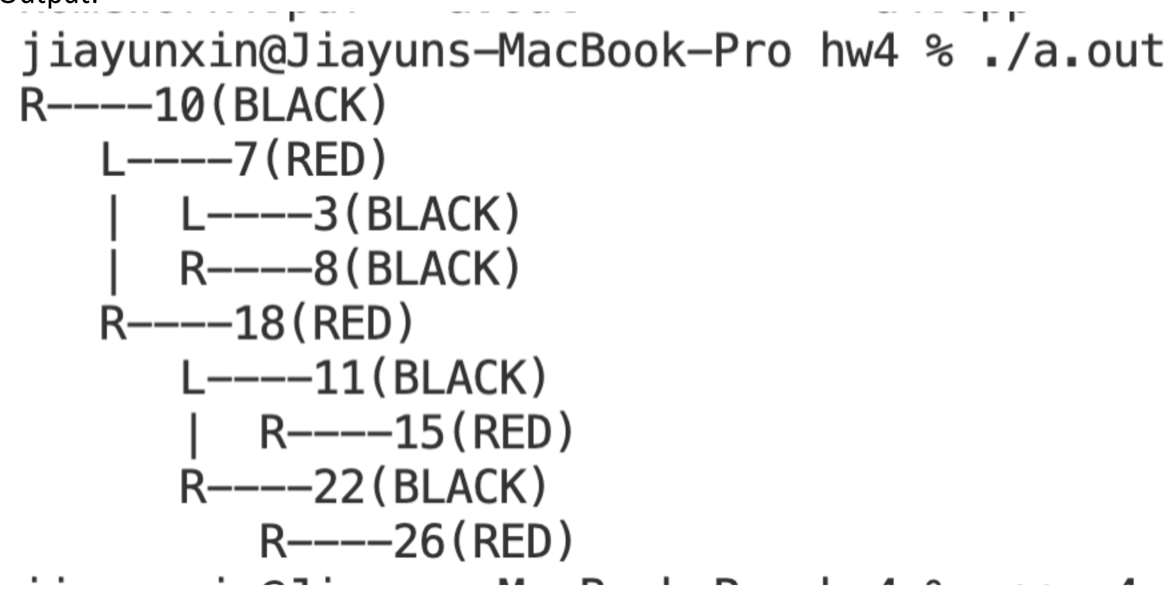
Fall, 2021

Results:

Insert number: 7 3 18 10 22 8 11 26 15

Output:



```
jiayunxin@Jiayuns-MacBook-Pro hw4 % ./a.out
R----10(BLACK)
   L----7(RED)
   |  L----3(BLACK)
   |  R----8(BLACK)
   R----18(RED)
      L----11(BLACK)
      |  R----15(RED)
      R----22(BLACK)
         R----26(RED)
```

Codes:

```
#include <iostream>
using namespace std;

struct Node {
  int data;
  Node *parent;
  Node *left;
  Node *right;
  int color;
};

typedef Node *NodePtr;

class RedBlackTree {
private:
  NodePtr root;
  NodePtr TNULL;

  void initializeNULLNode(NodePtr node, NodePtr parent) {
```

```
  node->data = 0;
  node->parent = parent;
  node->left = nullptr;
  node->right = nullptr;
  node->color = 0;
}

// For balancing the tree after insertion
void insertFix(NodePtr k) {
  NodePtr u;
  while (k->parent->color == 1) {
    if (k->parent == k->parent->parent->right) {
      u = k->parent->parent->left;
      if (u->color == 1) {
        u->color = 0;
        k->parent->color = 0;
        k->parent->parent->color = 1;
        k = k->parent->parent;
      } else {
        if (k == k->parent->left) {
          k = k->parent;
          rightRotate(k);
        }
        k->parent->color = 0;
        k->parent->parent->color = 1;
        leftRotate(k->parent->parent);
      }
    } else {
      u = k->parent->parent->right;

      if (u->color == 1) {
        u->color = 0;
        k->parent->color = 0;
        k->parent->parent->color = 1;
        k = k->parent->parent;
      } else {
        if (k == k->parent->right) {
            k = k->parent;
            leftRotate(k);
          }
          k->parent->color = 0;
          k->parent->parent->color = 1;
          rightRotate(k->parent->parent);
        }
      }
      if (k == root) {
        break;
      }
    }
    root->color = 0;
  }

  void printHelper(NodePtr root, string indent, bool last) {
    if (root != TNULL) {
      cout << indent;
      if (last) {
        cout << "R----";
        indent += "   ";
      } else {
        cout << "L----";
        indent += "|  ";
      }

      string sColor = root->color ? "RED" : "BLACK";
      cout << root->data << "(" << sColor << ")" << endl;
      printHelper(root->left, indent, false);
      printHelper(root->right, indent, true);
    }
  }

public:
  RedBlackTree() {
    TNULL = new Node;
    TNULL->color = 0;
```

```cpp
  TNULL->left = nullptr;
  TNULL->right = nullptr;
  root = TNULL;
}

void leftRotate(NodePtr x) {
  NodePtr y = x->right;
  x->right = y->left;
  if (y->left != TNULL) {
    y->left->parent = x;
  }
  y->parent = x->parent;
  if (x->parent == nullptr) {
    this->root = y;
  } else if (x == x->parent->left) {
    x->parent->left = y;
  } else {
    x->parent->right = y;
  }
  y->left = x;
  x->parent = y;
}

void rightRotate(NodePtr x) {
  NodePtr y = x->left;
  x->left = y->right;
  if (y->right != TNULL) {
    y->right->parent = x;
  }
  y->parent = x->parent;
  if (x->parent == nullptr) {
    this->root = y;
  } else if (x == x->parent->right) {
    x->parent->right = y;
  } else {
    x->parent->left = y;
  }
  y->right = x;
  x->parent = y;
}

// Inserting a node
void insert(int key) {
  NodePtr node = new Node;
  node->parent = nullptr;
  node->data = key;
  node->left = TNULL;
  node->right = TNULL;
  node->color = 1;

  NodePtr y = nullptr;
  NodePtr x = this->root;

  while (x != TNULL) {
    y = x;
    if (node->data < x->data) {
      x = x->left;
    } else {
      x = x->right;
    }
  }

  node->parent = y;
  if (y == nullptr) {
    root = node;
  } else if (node->data < y->data) {
    y->left = node;
  } else {
    y->right = node;
  }

  if (node->parent == nullptr) {
    node->color = 0;
    return;
    }

    if (node->parent->parent == nullptr) {
      return;
    }

    insertFix(node);
  }

  NodePtr getRoot() { return this->root; }

  void printTree() {
    if (root) {
      printHelper(this->root, "", true);
    }
  }
};

int main() {
  RedBlackTree bst;
  bst.insert(7);
  bst.insert(3);
  bst.insert(18);
  bst.insert(10);
  bst.insert(22);
  bst.insert(8);
  bst.insert(11);
  bst.insert(26);
  bst.insert(15);
  bst.printTree();
}
```