COSC 2436: Stacks

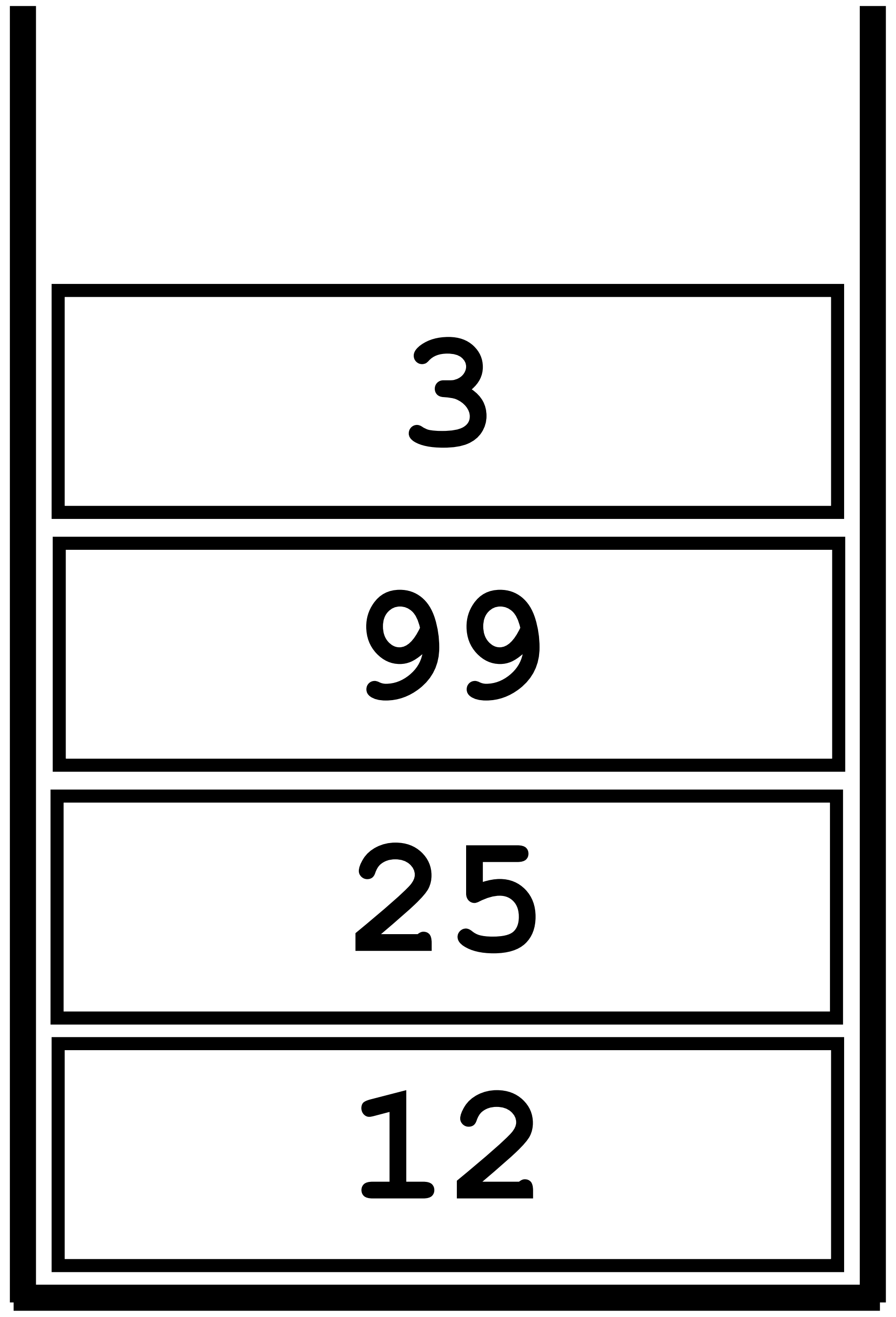
J. Eoin Donovan - 2023

What is a stack?

A stack is a linear data strucutre where elements are inserted and removed in a last-in-first-out (LIFO) order.

How can we implement a stack?

- Linked List
- Array
- C++ stack container



Stack Operations

- push - insert element at top of stack
- pop - remove element from top of stack
- top - return the element at top of stack
- empty - returns true if stack is empty, else returns false

All of these operations have a time complexity of O(1)

What is Infix and Postfix?

- Infix places operators between operands

  2 + 6 × 3

- Postfix places operators after operands

  2 6 3 × +

- Prefix places operators before operands

  6 × 3 2 +

What does this have to do with stacks?

- Infix relies on parentheses for the order of operations
- Postfix & Prefix does not need parentheses
- Infix is intuitive for humans but not for computers
- Postfix & Prefix expressions can be evaluated using stacks

Infix to Postfix

```
strig infixToPostfix(string exp){
  stack<char> s;
  string str;
  for(int i = 0; i < exp.length(); i++){
    if(isdigit(exp[i]))
      str += exp[i];
    else if(exp[i] == ‘(‘)
      s.push(‘(‘);
    else if(exp[i] == ‘)’){
      while(s.top() != ‘(‘)
        str += s.top(); s.pop();
      s.pop();
    }
    else{
      while(!s.empty() && priority(exp[i]) <= priority(s.top()))
        str += s.top(); s.pop();
      s.push(exp[i]);
    }
  }
  while(!s.empty())
    str += s.top(); s.pop();
  return str
}
```

Postfix to Infix

```
string postfixToInfix(string exp){
  stack<string> s;
  string str1, str2, str3;
  for(int i = 0; i < exp.length(); i++){
    if(isdigit(exp[i]))
      s.push(exp.substr(i,1);
    else{
      str1 = s.top(); s.pop();
      str2 = s.top(); s.pop();
      str += ‘(‘ + str2 + exp[i] + str1 + ‘)’;
    }
  }
  return s.top();
}
```

Infix to Prefix

```
string infixToPrefix(string exp){
  reverse(exp.begin(), exp.end());
  for(int i = 0; i < exp.length(); i++){
    if(exp[i] == ‘(‘)
      infix[i] = ‘)’;
    else if(exp[i] == ‘)’)
      infix[i] = ‘(‘;
  }
  string prefix = infixToPostfix(exp);
  reverse(prefix.begin(), prefix.end());
  return prefix;
}
```

Evaluate Prefix

```
int evaluatePrefix(string exp){
  stack<int> s;
  for(int i = exp.length(); i >= 0; i++){
    if(isdigit(exp[i])
      s.push(exp[i]-48);
    else{
      int val1 = s.top(); s.pop();
      int val2 = s.top(); s.pop();
      switch(exp[i]){
        case ‘+’: s.push(val1 + val2); break;
        case ‘-‘: s.push(val1 - val2); break;
        case ‘*’: s.push(val1 * val2); break;
        case ‘/‘: s.push(val1 / val2); break;
      }
    }
  }
  return s.top();
}
```

Evaluate Postfix

```
int evaluatePostfix(string exp){
  stack<int> s;
  for(int i = 0; i < exp.length(); i++){
    if(isdigit(exp[i])
      s.push(exp[i] - 48);
    else{
      int val1 = s.top(); s.pop();
      int val2 = s.top(); s.pop();
      switch(exp[i]){
        case ‘+’: s.push(val2 + val1); break;
        case ‘-‘: s.push(val2 - val1); break;
        case ‘*’: s.push(val2 * val1); break;
        case ‘/‘: s.push(val2 / val1); break;
      }
    }
  }
  return s.top();
}
```

Stack Practice: Valid Parentheses

Given a string exp containing the characters (,), {, }, [, and], determine if the input string is valid. An input string is valid if:

- Open brackets must be closed by same bracket type
- Open brackets must be closed in the correct order
- Every close bracket has a corresponding open bracket of the same type

Input: { [( )] } => Output: True

Input: (} [ )) => Output: False

Stacks Practice: Valid Parentheses

```
bool validParentheses(string exp){
  stack<char> s;
  for(int i = 0; i < exp.length(); i++){
    if(exp[i] == ‘(‘ || exp[i] == ‘[‘ || exp[i] == ‘{‘)
      s.push(exp[i]);
    else if(exp[i] == ‘)’){
      if(s.empty() || s.top() != ‘(‘)
        return false;
      s.pop();
    }
    else if(exp[i] == ‘]’){
      if(s.empty() || s.top() != ‘[‘)
        return false;
      s.pop();
    }
    else if(exp[i] == ‘}’){
      if(s.empty() || s.top != ‘{‘)
        return false;
      s.pop();
    }
  }
  return s.empty();
}
```