COMSATS UNIVERSITY ISLAMABAD

ATTOCK CAMPUS

DEPARTMENT OF COMPUTER SCIENCE

Lab 1 to 12

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SP22-BCS-036

Submitted to:-

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Subject:-

Compiler construction

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Lab 1

```
using System;
using System.Text.RegularExpressions;


public class Program
{
   public static void Main()
   {
      // Hardcoded password for validation
      string password = "Sp22-bcs-036"; // Example password


      // Regular expression pattern for the requirements
      string pattern = @"^(?=(.*\d.*){2})(?=.*[A-Z])(?=(.*[a-z]){4})(?=(.*[-
!@#$%^&*(),.?\""{}|<>]){2}).{1,12}$";


      // Check if the password matches the pattern
      if (Regex.IsMatch(password, pattern))
      {
         Console.WriteLine("Password is valid.");
      }
      else
      {
         Console.WriteLine("Password is invalid.");
      }
   }
}
```

Output

```
Password is valid.

=== Code Execution Successful ===
```

Task 2

```
using System;
using System.Text;
using System.Text.RegularExpressions;

class Program
{
    static void Main(string[] args)
    {
        // Sample inputs
        Console.WriteLine("Enter your first name: ");
        string firstName = Console.ReadLine();

        Console.WriteLine("Enter your last name: ");
        string lastName = Console.ReadLine();

        Console.WriteLine("Enter your registration number: ");
        string regNumber = Console.ReadLine();

        Console.WriteLine("Enter your favorite food: ");
        string food = Console.ReadLine();

        Console.WriteLine("Enter your favorite game: ");
        string game = Console.ReadLine();
```

```
        // Generate the password
        string password = GeneratePassword(firstName, lastName, regNumber, food, game);

        // Display the generated password
        Console.WriteLine("Generated Password: " + password);
    }

    static string GeneratePassword(string firstName, string lastName, string regNumber, string food,
string game)
    {
        // Combine all input values
        string combined = firstName + lastName + regNumber + food + game;

        // Regular expression to remove any unwanted characters (non-alphanumeric)
        string sanitized = Regex.Replace(combined, @"[^a-zA-Z0-9]", "");

        // Make the string more complex by adding special characters and digits
        string complexPassword = sanitized;

        // Add some random numbers and special characters
        Random rand = new Random();
        string specialChars = "!@#$%^&*()_+[]{}|;:,.<>?/~`";
        for (int i = 0; i < 4; i++)
        {
            // Add random number
            complexPassword += rand.Next(0, 10).ToString();

            // Add random special character
```

```
            complexPassword += specialChars[rand.Next(specialChars.Length)];
        }

        // Ensure password length is at least 12 characters
        if (complexPassword.Length < 12)
        {
            complexPassword = complexPassword.PadLeft(12, 'X'); // Add filler 'X' if too short
        }

        // Randomly shuffle the password to increase complexity
        StringBuilder shuffledPassword = new StringBuilder();
        while (complexPassword.Length > 0)
        {
            int index = rand.Next(complexPassword.Length);
            shuffledPassword.Append(complexPassword[index]);
            complexPassword = complexPassword.Remove(index, 1);
        }

        return shuffledPassword.ToString();
    }
}
```

Output

```
Enter your first name:
usman
Enter your last name:
malik
Enter your registration number:
036
Enter your favorite food:
cake
Enter your favorite game:
football
Generated Password: k4a2omnkafsllja6mit!e939luca0?ob!

=== Code Execution Successful ===
```

LAB 2

TASK 1

```
using System;
using System.Text.RegularExpressions;

class Program
{
   static void Main()
   {
      // The regular expression for logical operators and parentheses
      string pattern = @"\s*(&&|\|\||!|\(|\))\s*";

      // Test string with logical operators and parentheses
      string input = "x && y || !z (x || y)";

      // Create a Regex object with the pattern
      Regex regex = new Regex(pattern);

      // Find all matches
      MatchCollection matches = regex.Matches(input);

      // Output the matches
      foreach (Match match in matches)
      {
         Console.WriteLine($"Found: {match.Value}");
      }
   }
}
```

Output

```
Found:  &&
Found:  ||
Found: !
Found:  (
Found:  ||
Found: )

=== Code Execution Successful ===
```

TASK 2

```
using System;
using System.Text.RegularExpressions;

class Program
{
    static void Main()
    {
        // The regular expression for relational operators
        string pattern = @"\s*(==|!=|>=|<=|>|<)\s*";

        // Test string with relational operators
        string input = "a == b && c != d || e >= f && g < h";

        // Create a Regex object with the pattern
        Regex regex = new Regex(pattern);

        // Find all matches
        MatchCollection matches = regex.Matches(input);
```

```
        // Output the matches
        foreach (Match match in matches)
        {
            Console.WriteLine($"Found: {match.Value}");
        }
    }
}
```

Output

```
Found:  ==
Found:  !=
Found:  >=
Found:  <

=== Code Execution Successful ===
```

LAB 3

TASK 1

```
using System;
using System.Text.RegularExpressions;

class Program
{
    static void Main()
    {
        // Regular expression for floating point numbers with length <= 6
        string pattern = @"^[+-]?\d{1,3}(\.\d{1,3})?$|^[+-]?\.\d{1,3}$";

        // Test strings
        string[] testStrings = {
```

```
            "123",       // valid
            "-12.34",    // valid
            "+0.567",    // valid
            ".678",      // valid
            "0.5",       // valid
            "123456",    // invalid
            "1.2345",    // invalid
            "+1234",     // invalid
            ".1234"      // invalid
        };

        // Check each string against the regex
        foreach (var test in testStrings)
        {
            bool isMatch = Regex.IsMatch(test, pattern);
            Console.WriteLine($"{test}: {(isMatch ? "Valid" : "Invalid")}");
        }
    }
}
```

```
Output
123: Valid
-12.34: Valid
+0.567: Valid
.678: Valid
0.5: Valid
123456: Invalid
1.2345: Invalid
+1234: Invalid
.1234: Invalid

=== Code Execution Successful ===
```

LAB 4

TASK 1

```
#include <stdio.h>
#include <ctype.h>
#include <string.h>

#define BUFFER_SIZE 1024
#define KEYWORD_COUNT 3

char buffer1[BUFFER_SIZE], buffer2[BUFFER_SIZE];
char *lexeme_start, *forward;
int active_buffer = 1;

char *keywords[KEYWORD_COUNT] = {"int", "if", "else"};

void switch_buffer() {
    if (active_buffer == 1) {
        forward = buffer2;
```

```
        active_buffer = 2;
    } else {
        forward = buffer1;
        active_buffer = 1;
    }
}

int is_keyword(char *lexeme) {
    for (int i = 0; i < KEYWORD_COUNT; i++) {
        if (strcmp(lexeme, keywords[i]) == 0)
            return 1;
    }
    return 0;
}

void lexical_analyzer() {
    char lexeme[100];
    int lexeme_length = 0;

    while (*forward != '\0') {
        if (isspace(*forward)) {
            forward++;
            continue;
        }

        lexeme_start = forward;

        if (isalpha(*forward)) {
            while (isalnum(*forward)) {
```

```
            lexeme[lexeme_length++] = *forward;
            forward++;
        }
        lexeme[lexeme_length] = '\0';

        if (is_keyword(lexeme))
            printf("Keyword: %s\n", lexeme);
        else
            printf("Identifier: %s\n", lexeme);
    }
    else if (isdigit(*forward)) {
        while (isdigit(*forward)) {
            lexeme[lexeme_length++] = *forward;
            forward++;
        }
        lexeme[lexeme_length] = '\0';
        printf("Number: %s\n", lexeme);
    }
    else {
        printf("Operator: %c\n", *forward);
        forward++;
    }

    lexeme_length = 0;
  }
}

int main() {
  printf("Enter input code: ");
```

```
    fgets(buffer1, BUFFER_SIZE, stdin);  // Take input from user
    forward = buffer1;
    active_buffer = 1;

    lexical_analyzer();
    return 0;
}
```

Output

```
Enter input code: a+b=c
Identifier: a
Operator: +
Identifier: b
Operator: =
Identifier: c


=== Code Execution Successful ===
```

Lab 5

Task 1

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define TABLE_SIZE 10  // Hash table size

// Structure for a symbol table entry
typedef struct Symbol {
    char name[50];      // Identifier name
    char type[20];      // Data type (e.g., int, float)
```

```
    int scope;          // Scope level
    struct Symbol *next; // Pointer for chaining (linked list)
} Symbol;

// Hash table (Array of pointers to Symbol nodes)
Symbol *symbolTable[TABLE_SIZE];

// Hash function (Sum of ASCII values modulo table size)
int hashFunction(char *name) {
    int sum = 0;
    for (int i = 0; name[i] != '\0'; i++) {
        sum += name[i];
    }
    return sum % TABLE_SIZE;
}

// Insert a symbol into the table
void insertSymbol(char *name, char *type, int scope) {
    int index = hashFunction(name);

    // Create a new symbol node
    Symbol *newSymbol = (Symbol *)malloc(sizeof(Symbol));
    strcpy(newSymbol->name, name);
    strcpy(newSymbol->type, type);
    newSymbol->scope = scope;
    newSymbol->next = NULL;

    // Insert at the beginning of the linked list (chaining)
    if (symbolTable[index] == NULL) {
```

```
        symbolTable[index] = newSymbol;
    } else {
        newSymbol->next = symbolTable[index];
        symbolTable[index] = newSymbol;
    }
    printf("Inserted: %s (%s, scope: %d)\n", name, type, scope);
}

// Search for a symbol in the table
Symbol* searchSymbol(char *name) {
    int index = hashFunction(name);
    Symbol *temp = symbolTable[index];

    while (temp != NULL) {
        if (strcmp(temp->name, name) == 0) {
            return temp; // Found
        }
        temp = temp->next;
    }
    return NULL; // Not found
}

// Display the symbol table
void displaySymbolTable() {
    printf("\nSymbol Table:\n");
    printf("--------------------------------\n");
    printf("| Index | Name    | Type   | Scope |\n");
    printf("--------------------------------\n");
```

```
    for (int i = 0; i < TABLE_SIZE; i++) {
        Symbol *temp = symbolTable[i];
        while (temp != NULL) {
            printf("| %5d | %-7s | %-6s | %5d |\n", i, temp->name, temp->type, temp->scope);
            temp = temp->next;
        }
    }
    printf("--------------------------------\n");
}

// Main function for testing
int main() {
    // Initializing the symbol table with NULL
    for (int i = 0; i < TABLE_SIZE; i++) {
        symbolTable[i] = NULL;
    }

    // Insert some symbols
    insertSymbol("x", "int", 1);
    insertSymbol("y", "float", 1);
    insertSymbol("sum", "int", 2);
    insertSymbol("product", "int", 2);
    insertSymbol("y", "char", 3);  // Different scope

    // Search for a symbol
    char searchName[50];
    printf("\nEnter variable name to search: ");
    scanf("%s", searchName);
```

```
    Symbol *result = searchSymbol(searchName);
    if (result) {
        printf("Found: %s (%s, scope: %d)\n", result->name, result->type, result->scope);
    } else {
        printf("Symbol not found.\n");
    }

    // Display the symbol table
    displaySymbolTable();

    return 0;
}
```

Output

```
Inserted: x (int, scope: 1)
Inserted: y (float, scope: 1)
Inserted: sum (int, scope: 2)
Inserted: product (int, scope: 2)
Inserted: y (char, scope: 3)

Enter variable name to search: x+y=c
Symbol not found.

Symbol Table:
--------------------------------
| Index | Name    | Type   | Scope |
--------------------------------
|     0 | x       | int    |     1 |
|     1 | y       | char   |     3 |
|     1 | sum     | int    |     2 |
|     1 | y       | float  |     1 |
|     9 | product | int    |     2 |
--------------------------------
```

Lab 6

Task 1

```
using System;


class RecursiveDescentParser
{
   static string input;
   static int index = 0;


   static void Main()
   {
      Console.WriteLine("Enter an arithmetic expression");
      input = Console.ReadLine();
      input = input.Replace(" ", ""); // remove spaces


      try
      {
         E();
         if (index == input.Length)
         {
            Console.WriteLine("Expression is valid!");
         }
         else
         {
            Console.WriteLine("Invalid Expression!");
         }
      }
      catch
      {
```

```
        Console.WriteLine("Invalid Expression!");
    }
}

// E → T E'
static void E()
{
    T();
    EPrime();
}

// E' → + T E' | ε
static void EPrime()
{
    if (Match('+'))
    {
        T();
        EPrime();
    }
}

// T → F T'
static void T()
{
    F();
    TPrime();
}

// T' → * F T' | ε
```

```
static void TPrime()
{
   if (Match('*'))
   {
      F();
      TPrime();
   }
}

// F → (E) | id
static void F()
{
   if (Match('('))
   {
      E();
      if (!Match(')'))
         throw new Exception("Missing )");
   }
   else if (Char.IsDigit(CurrentChar()))
   {
      while (Char.IsDigit(CurrentChar()))
         index++; // consume the number
   }
   else
   {
      throw new Exception("Invalid character in F()");
   }
}
```

```
    static bool Match(char expected)
    {
        if (index < input.Length && input[index] == expected)
        {
            index++;
            return true;
        }
        return false;
    }

    static char CurrentChar()
    {
        return index < input.Length ? input[index] : '\0';
    }
}
```

```
Output

Enter an arithmetic expression
2+3*4
Expression is valid!

=== Code Execution Successful ===
```

Lab 7

Task 1

```
using System;

class GrammarParser
{
    static string input;
```

```
static int index = 0;

static void Main()
{
    Console.WriteLine("Enter statement (e.g., if(id<num){id=5+3;}else{id=2+1;}):");
    input = Console.ReadLine();
    input = input.Replace(" ", ""); // remove spaces

    try
    {
        S();
        if (index == input.Length)
        {
            Console.WriteLine("Valid Syntax!");
        }
        else
        {
            Console.WriteLine("Invalid Syntax!");
        }
    }
    catch
    {
        Console.WriteLine("Invalid Syntax!");
    }
}

// S → if(C){S}else{S} | id=E;
static void S()
{
```

```
    if (Match("if"))
    {
        Match("(");
        C();
        Match(")");
        Match("{");
        S();
        Match("}");
        Match("else");
        Match("{");
        S();
        Match("}");
    }
    else if (Match("id"))
    {
        Match("=");
        E();
        Match(";");
    }
    else
    {
        throw new Exception("Invalid Statement");
    }
}

// C → id<num
static void C()
{
    Match("id");
```

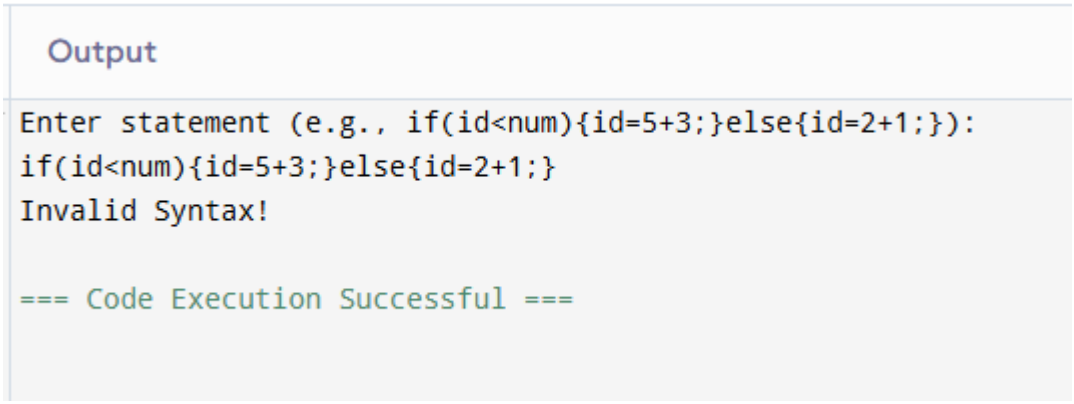
```
    Match("<");
    Match("num");
}

// E → T+T
static void E()
{
    T();
    Match("+");
    T();
}

// T → id | num
static void T()
{
    if (!Match("id") && !Match("num"))
        throw new Exception("Expected id or num");
}

// Helpers
static bool Match(string token)
{
    if (input.Substring(index).StartsWith(token))
    {
        index += token.Length;
        return true;
    }
    return false;
}
```

}



Lab 08

Task 1

```
using System;


class DFA_CVariable
{
   static void Main()
   {
      Console.WriteLine("Enter a variable name to check:");
      string input = Console.ReadLine();


      if (IsValidVariable(input))
         Console.WriteLine("✓ Valid C variable name.");
      else
         Console.WriteLine("✗ Invalid C variable name.");
   }


   static bool IsValidVariable(string input)
   {
      int state = 0;
```

```
        for (int i = 0; i < input.Length; i++)
        {
            char ch = input[i];

            switch (state)
            {
                case 0:
                    if (char.IsLetter(ch) || ch == '_')
                        state = 1;
                    else
                        return false;
                    break;

                case 1:
                    if (char.IsLetterOrDigit(ch) || ch == '_')
                        state = 1;
                    else
                        return false;
                    break; // ✓ add break to fix the error
            }
        }

        return state == 1;
    }
}
```

```
Output
Enter a variable name to check:
my_var1
? Valid C variable name.

=== Code Execution Successful ===
```

Lab 10

Task 1

```
using System;
using System.Collections.Generic;
using System.Linq;

namespace SLRParserDemo
{
    public enum TokenType { id, plus, star, lparen, rparen, dollar }
    public class Production
    {
        public string LHS { get; }
        public string[] RHS { get; }
        public Production(string lhs, params string[] rhs) { LHS = lhs; RHS = rhs; }
        public override string ToString() => $"{LHS} → {string.Join(" ", RHS)}";
    }

    public class SLRParser
    {
        private readonly List<Production> productions = new()
        {
            new Production("E'", "E"),     // 0: augmented
            new Production("E", "E", "+", "T"), // 1
```

```
    new Production("E", "T"),          // 2
    new Production("T", "T", "*", "F"), // 3
    new Production("T", "F"),          // 4
    new Production("F", "(", "E", ")"), // 5
    new Production("F", "id")          // 6
};
private readonly string[,] action = new string[12, 6]
{
    // id   +    *    (    )    $
    { "S5", "",  "",  "S4", "",  ""   },    // 0
    { "","S6", "",  "",  "",  "acc"},       // 1
    { "", "R2","R2", "", "R2","R2"},        // 2
    { "", "R4","R4", "", "R4","R4"},        // 3
    { "S5", "",  "",  "S4", "",  ""   },    // 4
    { "", "R6","R6", "", "R6","R6"},        // 5
    { "S5", "",  "",  "S4", "",  ""   },    // 6
    { "S5", "",  "",  "S4", "",  ""   },    // 7
    { "", "S6","",  "",  "S11","""   },      // 8
    { "", "R1","S7", "", "R1","R1"},        // 9
    { "", "R3","R3", "", "R3","R3"},        //10
    { "", "R5","R5", "", "R5","R5"},        //11
};

private readonly int[,] gotoTable = new int[12, 3]
{
    { 1, 2, 3 }, // 0
    { -1,-1,-1}, // 1
    { -1,-1,-1}, // 2
    { -1,-1,-1}, // 3
```

```
    { 8, 2, 3 }, // 4
    { -1,-1,-1}, // 5
    { -1, 9, 3 },// 6
    { -1,-1,10 },// 7
    { -1,-1,-1}, // 8
    { -1,-1,-1}, // 9
    { -1,-1,-1}, //10
    { -1,-1,-1}  //11
};

private readonly Dictionary<string, int> symbolToCol = new()
{
    {"id",0}, {"+",1}, {"*",2}, {"(",3}, {")",4}, {"$",5}
};
private readonly Dictionary<string, int> gotoToCol = new()
{
    {"E",0}, {"T",1}, {"F",2}
};
public List<string> Tokenize(string input)
{
    var tokens = new List<string>();
    var parts = input.Split(new[] { ' ' }, StringSplitOptions.RemoveEmptyEntries);
    foreach (var part in parts)
    {
        if (part == "id") tokens.Add("id");
        else if (part == "+") tokens.Add("+");
        else if (part == "*") tokens.Add("*");
        else if (part == "(") tokens.Add("(");
        else if (part == ")") tokens.Add(")");
```

```
            else throw new Exception($"Unknown token: {part}");
        }
        tokens.Add("$");
        return tokens;
    }
    public void Parse(string input)
    {
        var tokens = Tokenize(input);
        var stateStack = new Stack<int>();
        var symbolStack = new Stack<string>();

        stateStack.Push(0);
        int ip = 0;

        Console.WriteLine("{0,-20}{1,-30}{2,-30}{3}", "State Stack", "Symbol Stack", "Input", "Action");
        Console.WriteLine(new string('-', 100));

        while (true)
        {
            string currToken = tokens[ip];
            int state = stateStack.Peek();
            string act = action[state, symbolToCol[currToken]];

            Console.WriteLine("{0,-20}{1,-30}{2,-30}{3}",
                string.Join(" ", stateStack.Reverse()),
                string.Join(" ", symbolStack.Reverse()),
                string.Join(" ", tokens.Skip(ip)),
                act == "" ? "error" : act);
```

```
if (act == "")
{
   Console.WriteLine("Parsing error!");
   return;
}
else if (act[0] == 'S')
{
   int nextState = int.Parse(act.Substring(1));
   symbolStack.Push(currToken);
   stateStack.Push(nextState);
   ip++;
}
else if (act[0] == 'R')
{
   int prodNum = int.Parse(act.Substring(1));
   var prod = productions[prodNum];
   for (int i = 0; i < prod.RHS.Length; i++)
   {
      symbolStack.Pop();
      stateStack.Pop();
   }
   symbolStack.Push(prod.LHS);
   int gotoState = gotoTable[stateStack.Peek(), gotoToCol[prod.LHS]];
   stateStack.Push(gotoState);
}
else if (act == "acc")
{
   Console.WriteLine("{0,-20}{1,-30}{2,-30}{3}",
      string.Join(" ", stateStack.Reverse()),
```

```
                string.Join(" ", symbolStack.Reverse()),
                string.Join(" ", tokens.Skip(ip)),
                "accept");
            Console.WriteLine("\nInput accepted!");
            return;
          }
        }
      }
    }

    public class Program
    {
      public static void Main()
      {
        Console.WriteLine("Enter input (tokens separated by spaces, e.g., id + id * id):");
        string input = Console.ReadLine();
        var parser = new SLRParser();
        parser.Parse(input);
      }
    }
}
```

Output Clear

```
Enter input (tokens separated by spaces, e.g., id + id * id):
id + id
State Stack         Symbol Stack                  Input
         Action
-------------------------------------------------------------------------------
    -------------------------
0                                                 id + id $
         S5
0 5                 id                            + id $
         R6
0 3                 F                             + id $
         R4
0 2                 T                             + id $
         R2
0 1                 E                             + id $
         S6
0 1 6               E +                           id $
         S5
0 1 6 5             E + id                        $
         R6
0 1 6 3              E + F                          $
         R4
0 1 6 9              E + T                          $
         R1
0 1                  E                              $
         acc
0 1                  E                              $
         accept

Input accepted!

=== Code Execution Successful ===
```

Lab 11

Task 1

using System;

```
using System.Collections.Generic;
using System.Text.RegularExpressions;

namespace SemanticAnalyzerLab
{
   class Program
   {
      static List<List<string>> Symboltable = new List<List<string>>();
      static List<string> finalArray = new List<string>();
      static List<int> Constants = new List<int>();
      static Regex variable_Reg = new Regex(@"^[A-Za-z_][A-Za-z0-9]*$");
      static bool if_deleted = false;

      static void Main(string[] args)
      {
         InitializeSymbolTable();
         InitializeFinalArray();
         PrintLexerOutput();

         for (int i = 0; i < finalArray.Count; i++)
         {
            Semantic_Analysis(i);
         }

         Console.WriteLine("\nSemantic Analysis Completed.");
         Console.ReadLine();
      }

      static void InitializeSymbolTable()
```

```
{
    Symboltable.Add(new List<string> { "x", "id", "int", "0" });
    Symboltable.Add(new List<string> { "y", "id", "int", "0" });
    Symboltable.Add(new List<string> { "i", "id", "int", "0" });
    Symboltable.Add(new List<string> { "l", "id", "char", "0" });
}

static void InitializeFinalArray()
{
    finalArray.AddRange(new string[] {
        "int", "main", "(", ")", "{",
        "int", "x", ";",
        "x", ";",
        "x", "=", "2", "+", "5", "+", "(", "4", "*", "8", ")", "+", "l", "/", "9.0", ";",
        "if", "(", "x", "+", "y", ")", "{",
        "if", "(", "x", "!=", "4", ")", "{",
        "x", "=", "6", ";",
        "y", "=", "10", ";",
        "i", "=", "11", ";",
        "}", "}",
        "}"
    });
}

static void PrintLexerOutput()
{
    Console.WriteLine("Tokenizing src/main/resources/tests/lexer02.txt...");
    int row = 1, col = 1;
    foreach (string token in finalArray)
```

```
{
    if (token == "int")
        Console.WriteLine($"INT ({row},{col})");
    else if (token == "main")
        Console.WriteLine($"MAIN ({row},{col})");
    else if (token == "(")
        Console.WriteLine($"LPAREN ({row},{col})");
    else if (token == ")")
        Console.WriteLine($"RPAREN ({row},{col})");
    else if (token == "{")
        Console.WriteLine($"LBRACE ({row},{col})");
    else if (token == "}")
        Console.WriteLine($"RBRACE ({row},{col})");
    else if (token == ";")
        Console.WriteLine($"SEMI ({row},{col})");
    else if (token == "=")
        Console.WriteLine($"ASSIGN ({row},{col})");
    else if (token == "+")
        Console.WriteLine($"PLUS ({row},{col})");
    else if (token == "-")
        Console.WriteLine($"MINUS ({row},{col})");
    else if (token == "*")
        Console.WriteLine($"TIMES ({row},{col})");
    else if (token == "/")
        Console.WriteLine($"DIV ({row},{col})");
    else if (token == "!=")
        Console.WriteLine($"NEQ ({row},{col})");
    else if (Regex.IsMatch(token, @"^[0-9]+$"))
        Console.WriteLine($"INT_CONST ({row},{col}): {token}");
```

```
        else if (Regex.IsMatch(token, @"^[0-9]+\.[0-9]+$"))
            Console.WriteLine($"FLOAT_CONST ({row},{col}): {token}");
        else if (Regex.IsMatch(token, @"^[a-zA-Z]$"))
            Console.WriteLine($"CHAR_CONST ({row},{col}): {token}");
        else if (variable_Reg.Match(token).Success)
            Console.WriteLine($"ID ({row},{col}): {token}");
        else
            Console.WriteLine($"UNKNOWN ({row},{col}): {token}");

        col += token.Length + 1;
        if (token == ";") row++;
    }
    Console.WriteLine("EOF ({0},{1})", row, col);
}

static void Semantic_Analysis(int k)
{
    if (k >= finalArray.Count) return;

    if (finalArray[k] == "+" || finalArray[k] == "-")
    {
        if (k > 0 && k < finalArray.Count - 1 &&
            variable_Reg.Match(finalArray[k - 1]).Success &&
            variable_Reg.Match(finalArray[k + 1]).Success)
        {
            string type = finalArray[k - 4];
            string left_side = finalArray[k - 3];
            string before = finalArray[k - 1];
            string after = finalArray[k + 1];
```

```
            int left_side_i = FindSymbol(left_side);
            int before_i = FindSymbol(before);
            int after_i = FindSymbol(after);

            if (type == Symboltable[before_i][2] && type == Symboltable[after_i][2])
            {
               int ans = Convert.ToInt32(Symboltable[before_i][3]) +
Convert.ToInt32(Symboltable[after_i][3]);
               Constants.Add(ans);
            }

            if (Symboltable[left_side_i][2] == Symboltable[before_i][2] &&
               Symboltable[left_side_i][2] == Symboltable[after_i][2])
            {
               int ans = Convert.ToInt32(Symboltable[before_i][3]) +
Convert.ToInt32(Symboltable[after_i][3]);
               if (Constants.Count > 0) Constants.RemoveAt(Constants.Count - 1);
               Constants.Add(ans);
               Symboltable[left_side_i][3] = ans.ToString();
            }
         }
      }

      if (finalArray[k] == ">")
      {
         if (k > 0 && k < finalArray.Count - 1 &&
            variable_Reg.Match(finalArray[k - 1]).Success &&
            variable_Reg.Match(finalArray[k + 1]).Success)
```

```
        {
            string before = finalArray[k - 1];
            string after = finalArray[k + 1];

            int before_i = FindSymbol(before);
            int after_i = FindSymbol(after);

            if (Convert.ToInt32(Symboltable[before_i][3]) > Convert.ToInt32(Symboltable[after_i][3]))
            {
                RemoveElseBlock();
            }
            else
            {
                RemoveIfBlock();
                if_deleted = true;
            }
        }
    }
}

static int FindSymbol(string name)
{
    for (int i = 0; i < Symboltable.Count; i++)
    {
        if (Symboltable[i][0] == name)
            return i;
    }
    return -1;
}
```

```
        static void RemoveElseBlock()
        {
            int start_of_else = finalArray.IndexOf("else");
            int end_of_else = finalArray.Count - 1;
            for (int i = end_of_else; i >= start_of_else; i--)
            {
                if (finalArray[i] == "}") { end_of_else = i; }
            }

            for (int i = start_of_else; i <= end_of_else; i++)
            {
                finalArray.RemoveAt(start_of_else);
            }
        }

        static void RemoveIfBlock()
        {
            int start_of_if = finalArray.IndexOf("if");
            int end_of_if = finalArray.IndexOf("}");

            for (int i = start_of_if; i <= end_of_if; i++)
            {
                finalArray.RemoveAt(start_of_if);
            }
        }
    }
}
```

Output

```
Tokenizing src/main/resources/tests/lexer02.txt...
INT (1,1)
MAIN (1,5)
LPAREN (1,10)
RPAREN (1,12)
LBRACE (1,14)
INT (1,16)
CHAR_CONST (1,20): x
SEMI (1,22)
CHAR_CONST (2,24): x
SEMI (2,26)
CHAR_CONST (3,28): x
ASSIGN (3,30)
INT_CONST (3,32): 2
PLUS (3,34)
INT_CONST (3,36): 5
PLUS (3,38)
LPAREN (3,40)
INT_CONST (3,42): 4
TIMES (3,44)
```

Task 2

```
using System;
using System.Collections.Generic;
using System.Text.RegularExpressions;

namespace InteractiveSemanticAnalyzer
{
    class Program
    {
        static List<List<string>> SymbolTable = new List<List<string>>();
        static List<string> Tokens = new List<string>();
        static Regex variableRegex = new Regex(@"^[A-Za-z_][A-Za-z0-9_]*$");
```

```
static int currentTokenIndex = 0;

static void Main(string[] args)
{
    InitializeSymbolTable();

    Console.WriteLine("Enter your source code line by line (type 'END' to finish):");

    string line;
    while ((line = Console.ReadLine()) != null && line.Trim() != "END")
    {
        var tokenized = Tokenize(line);
        Tokens.AddRange(tokenized);
    }

    Console.WriteLine("\nTokens:");
    foreach (var token in Tokens) Console.Write(token + " ");
    Console.WriteLine("\n\nParsing and Performing Syntax Directed Translation...\n");

    try
    {
        ParseProgram();
        Console.WriteLine("\n✓ Semantic Analysis Completed.");
    }
    catch (Exception ex)
    {
        Console.WriteLine("✗ Error: " + ex.Message);
    }
```

```
    Console.ReadLine();
}

static void InitializeSymbolTable()
{

    // You can pre-add default variables or keep it empty
}

static List<string> Tokenize(string line)
{
    var tokens = new List<string>();
    var pattern = @"\d+(\.\d+)?|[A-Za-z_][A-Za-z0-9_]*|==|!=|<=|>=|[+\-*/=;(){}<>,]";
    foreach (Match match in Regex.Matches(line, pattern))
    {
        tokens.Add(match.Value);
    }
    return tokens;
}

static string Peek(int offset = 0)
{
    if (currentTokenIndex + offset < Tokens.Count)
        return Tokens[currentTokenIndex + offset];
    return null;
}

static bool Match(string expected)
{
```

```
    if (Peek() == expected)
    {
        currentTokenIndex++;
        return true;
    }
    throw new Exception($"Syntax Error: Expected '{expected}', found '{Peek()}'");
}

static void ParseProgram()
{
    Match("int");
    Match("main");
    Match("(");
    Match(")");
    ParseBlock();
}

static void ParseBlock()
{
    Match("{");
    while (Peek() != "}" && Peek() != null)
        ParseStatement();
    Match("}");
}

static void ParseStatement()
{
    if (Peek() == "int")
        ParseDeclaration();
```

```
    else if (Peek() == "if")
        ParseIfStatement();
    else if (variableRegex.IsMatch(Peek()))
        ParseAssignment();
    else
        throw new Exception($"Unexpected token '{Peek()}' in statement.");
}

static void ParseDeclaration()
{
    Match("int");
    string name = Peek();
    Match(name);
    Match(";");
    AddToSymbolTable(name, "int", "0");
}

static void ParseAssignment()
{
    string name = Peek();
    Match(name);
    Match("=");
    int value = ParseExpression();
    Match(";");
    UpdateSymbolTable(name, value.ToString());
    Console.WriteLine($"[Semantic] {name} = {value}");
}

static void ParseIfStatement()
```

```
{
    Match("if");
    Match("(");
    bool condition = ParseCondition();
    Match(")");
    if (condition)
        ParseBlock();
    else
        SkipBlock();
}

static bool ParseCondition()
{
    int left = ParseExpression();
    string op = Peek();
    Match(op);
    int right = ParseExpression();

    return op switch
    {
        "==" => left == right,
        "!=" => left != right,
        ">" => left > right,
        "<" => left < right,
        ">=" => left >= right,
        "<=" => left <= right,
        _ => throw new Exception($"Unknown conditional operator '{op}'"),
    };
}
```

```
static int ParseExpression()
{
   int result = ParseTerm();
   while (Peek() == "+" || Peek() == "-")
   {
      string op = Peek();
      Match(op);
      int right = ParseTerm();
      result = op == "+" ? result + right : result - right;
   }
   return result;
}

static int ParseTerm()
{
   int result = ParseFactor();
   while (Peek() == "*" || Peek() == "/")
   {
      string op = Peek();
      Match(op);
      int right = ParseFactor();
      result = op == "*" ? result * right : result / right;
   }
   return result;
}

static int ParseFactor()
{
```

```
    string token = Peek();
    if (token == "(")
    {
        Match("(");
        int value = ParseExpression();
        Match(")");
        return value;
    }
    else if (int.TryParse(token, out int num))
    {
        Match(token);
        return num;
    }
    else if (variableRegex.IsMatch(token))
    {
        Match(token);
        return GetSymbolValue(token);
    }
    else
    {
        throw new Exception($"Invalid token '{token}' in expression.");
    }
}

static void SkipBlock()
{
    Match("{");
    int braceCount = 1;
    while (braceCount > 0 && currentTokenIndex < Tokens.Count)
```

```
    {
        if (Peek() == "{") braceCount++;
        else if (Peek() == "}") braceCount--;
        currentTokenIndex++;
    }
}

static void AddToSymbolTable(string name, string type, string value)
{
    if (FindSymbol(name) == -1)
    {
        SymbolTable.Add(new List<string> { name, "id", type, value });
        Console.WriteLine($"[Declare] {name} as {type}");
    }
    else
    {
        throw new Exception($"Variable '{name}' already declared.");
    }
}

static void UpdateSymbolTable(string name, string value)
{
    int index = FindSymbol(name);
    if (index != -1)
        SymbolTable[index][3] = value;
    else
        throw new Exception($"Variable '{name}' not declared.");
}
```

```
        static int GetSymbolValue(string name)
        {
            int index = FindSymbol(name);
            if (index != -1)
                return int.Parse(SymbolTable[index][3]);
            throw new Exception($"Variable '{name}' not declared.");
        }

        static int FindSymbol(string name)
        {
            for (int i = 0; i < SymbolTable.Count; i++)
            {
                if (SymbolTable[i][0] == name)
                    return i;
            }
            return -1;
        }
    }
}
```

Output

```
Enter your source code line by line (type 'END' to finish):
int main(){

Tokens:
int main ( ) { int x ; x = 5 ; }

Parsing and Performing Syntax Directed Translation...

[Declare] x as int
[Semantic] x = 5

? Semantic Analysis Completed.

=== Code Execution Successful ===
```

LAB 12

TASK 1

```
using System;
using System.Collections;
using System.Collections.Generic;
using System.Text.RegularExpressions;


namespace LexicalAnalyzerV1
{
   class Token
   {
      public string Type;
      public string Value;
      public int Line;
```

```
        public int Column;

        public Token(string type, string value, int line, int column)
        {
            Type = type;
            Value = value;
            Line = line;
            Column = column;
        }
    }

    class Program
    {
        static List<string> keywordList = new List<string> { "int", "float", "while", "main", "if", "else", "new"
};
        static Regex variable_Reg = new Regex(@"^[A-Za-z_][A-Za-z0-9]*$");
        static Regex constants_Reg = new Regex(@"^[0-9]+([.][0-9]+)?([e]([+|-])?[0-9]+)?$");
        static Regex operators_Reg = new Regex(@"^[-*+/><&|=]$");
        static Regex Special_Reg = new Regex(@"^[.,'\[\]{}();:?]$");

        static List<Token> tokens = new List<Token>();

        static void Main(string[] args)
        {
            Console.WriteLine("Enter code (end with an empty line):");
            string userInput = "";
            string line;

            // Read multi-line input
```

```
    while ((line = Console.ReadLine()) != null && line != "")
    {
        userInput += line + "\n";
    }

    // Lexical Analysis
    TokenizeAndPrint(userInput);

    // Parser
    ParseTokens();
}

static void TokenizeAndPrint(string input)
{
    tokens.Clear();
    int line_num = 1;
    int col_num = 1;
    int i = 0;

    while (i < input.Length)
    {
        char c = input[i];

        if (c == '\n')
        {
            line_num++;
            col_num = 1;
            i++;
            continue;
```

```
}
if (char.IsWhiteSpace(c))
{
   col_num++;
   i++;
   continue;
}

// Identifier or keyword
if (char.IsLetter(c) || c == '_')
{
   int start = i;
   int startCol = col_num;
   while (i < input.Length && (char.IsLetterOrDigit(input[i]) || input[i] == '_'))
   {
      i++; col_num++;
   }
   string word = input.Substring(start, i - start);
   if (keywordList.Contains(word))
   {
      Console.WriteLine($"< keyword, {word} >");
      tokens.Add(new Token("keyword", word, line_num, startCol));
   }
   else
   {
      Console.WriteLine($"< id, {word} >");
      tokens.Add(new Token("id", word, line_num, startCol));
   }
   continue;
```

```
}

// Number
if (char.IsDigit(c))
{
   int start = i;
   int startCol = col_num;
   while (i < input.Length && (char.IsDigit(input[i]) || input[i] == '.'))
   {
      i++; col_num++;
   }
   string num = input.Substring(start, i - start);
   Console.WriteLine($"< digit, {num} >");
   tokens.Add(new Token("digit", num, line_num, startCol));
   continue;
}

// Operator
if (operators_Reg.IsMatch(c.ToString()))
{
   Console.WriteLine($"< op, {c} >");
   tokens.Add(new Token("op", c.ToString(), line_num, col_num));
   i++; col_num++;
   continue;
}

// Punctuation/Special
if (Special_Reg.IsMatch(c.ToString()))
{
```

```
            Console.WriteLine($"< punc, {c} >");
            tokens.Add(new Token("punc", c.ToString(), line_num, col_num));
            i++; col_num++;
            continue;
        }

        // Unknown character
        Console.WriteLine($"ERROR: {c} at line {line_num}");
        tokens.Add(new Token("error", c.ToString(), line_num, col_num));
        i++; col_num++;
    }
}

// --- PARSER ---
static int currentToken = 0;

static Token Peek() => currentToken < tokens.Count ? tokens[currentToken] : null;
static Token Next()
{
    if (currentToken < tokens.Count) return tokens[currentToken++];
    return null;
}

static void Expect(string type, string value = null, string expected = null)
{
    var t = Peek();
    if (t == null || t.Type != type || (value != null && t.Value != value))
    {
        string found = t == null ? "EOF" : t.Value;
```

```
            string errMsg = $"ERROR: {found} at line {(t?.Line ?? tokens[tokens.Count - 1].Line)}, column
{(t?.Column ?? tokens[tokens.Count - 1].Column)}; Expected {expected ?? type.ToUpper()}";
            Console.WriteLine(errMsg);
            throw new Exception(); // stop further parsing after first error
        }
        Next();
    }

    static void ParseTokens()
    {
        currentToken = 0;
        try
        {
            while (currentToken < tokens.Count)
            {
                ParseStatement();
            }
        }
        catch
        {
            // Stop after first syntax error
        }
    }

    static void ParseStatement()
    {
        var t = Peek();
        if (t == null) return;
```

```
        if (t.Type == "keyword" && t.Value == "int")
        {
            Next();
            Expect("id", null, "IDENTIFIER");
            Expect("op", "=", "EQUALS SIGN"); // FIXED: Expect '=' as operator, not punctuation
            ParseExpression();
            Expect("punc", ";", "SEMICOLON");
        }
        else if (t.Type == "id")
        {
            Next();
            if (Peek() != null && Peek().Type == "op" && Peek().Value == "=")
            {
                Next();
                ParseExpression();
                Expect("punc", ";", "SEMICOLON");
            }
            else
            {
                var next = Peek();
                string errMsg = $"ERROR: {next?.Value} at line {next?.Line}, column {next?.Column}; Expected
'='";
                Console.WriteLine(errMsg);
                throw new Exception();
            }
        }
        else
        {
            string errMsg = $"ERROR: {t.Value} at line {t.Line}, column {t.Column}; Unexpected token";
```

```
            Console.WriteLine(errMsg);
            throw new Exception();
        }
    }

    static void ParseExpression()
    {
        var t = Peek();
        if (t != null && (t.Type == "id" || t.Type == "digit"))
        {
            Next();
            if (Peek() != null && Peek().Type == "op")
            {
                Next();
                ParseExpression();
            }
        }
        else
        {
            string errMsg = $"ERROR: {t?.Value ?? "EOF"} at line {t?.Line ?? tokens[tokens.Count - 1].Line},
column {t?.Column ?? tokens[tokens.Count - 1].Column}; Expected EXPRESSION";
            Console.WriteLine(errMsg);
            throw new Exception();
        }
    }
  }
}
```

Output

```
Enter code (end with an empty line):
int a=4;

< keyword, int >
< id, a >
< op, = >
< digit, 4 >
< punc, ; >

=== Code Execution Successful ===
```