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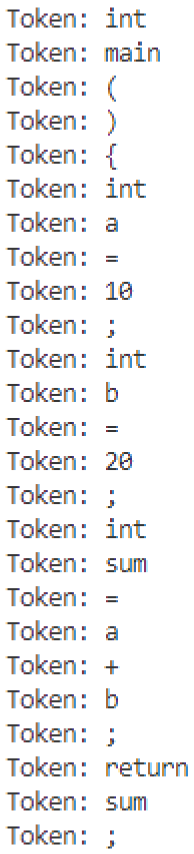
1. WAP to implement Lexical Analyzer to identify tokens.

```
#include <stdio.h>

#include <ctype.h>

#include <string.h>


#define MAX_TOKEN_LEN 100


typedef enum {

   KEYWORD,

   IDENTIFIER,

   NUMBER,

   OPERATOR,

   DELIMITER,

   UNKNOWN

} TokenType;


typedef struct {

   char value[MAX_TOKEN_LEN];

   TokenType type;

} Token;


const char *keywords[] = {

   "int", "float", "return", "if", "else", "while", "for", "do", "void", "char", "double",
"long",

   NULL

};


const char *operators[] = {

   "+", "-", "*", "/", "=", "==", "!=", "<", ">", "<=", ">=", "&&", "||", "!", "&", "|", "^",
"%",

   NULL

};
```

```
const char *delimiters[] = {
    "(", ")", "{", "}", "[", "]", ";", ",", NULL
};

int isKeyword(const char *str);
int isOperator(const char *str);
int isDelimiter(const char *str);
void addToken(Token tokens[], int *tokenCount, const char *value, TokenType type);

int main() {
    char input[] = "int main() { int a = 10; int b = 20; int sum = a+b ; return sum; }";
    Token tokens[100];
    int tokenCount = 0;

    int i = 0;
    while (i < strlen(input)) {
        if (isspace(input[i])) {
            i++;
            continue;
        }

        char buffer[MAX_TOKEN_LEN] = {0};
        int j = 0;

        if (isalpha(input[i])) {
            while (isalnum(input[i])) {
                buffer[j++] = input[i++];
            }
            buffer[j] = '\0';
            if (isKeyword(buffer)) {
                addToken(tokens, &tokenCount, buffer, KEYWORD);
            } else {
                addToken(tokens, &tokenCount, buffer, IDENTIFIER);
            }
        } else if (isdigit(input[i])) {
            while (isdigit(input[i]) || input[i] == '.') {
                buffer[j++] = input[i++];
            }
            buffer[j] = '\0';
            addToken(tokens, &tokenCount, buffer, NUMBER);
        } else if (isOperator((char[]){input[i], '\0'})) {
            buffer[j++] = input[i++];
            buffer[j] = '\0';
            addToken(tokens, &tokenCount, buffer, OPERATOR);
        } else if (isDelimiter((char[]){input[i], '\0'})) {
            buffer[j++] = input[i++];
            buffer[j] = '\0';
            addToken(tokens, &tokenCount, buffer, DELIMITER);
        } else {
            buffer[j++] = input[i++];
            buffer[j] = '\0';
            addToken(tokens, &tokenCount, buffer, UNKNOWN);
        }
    }
    for (i = 0; i < tokenCount; i++) {
        printf("Token: %-10s \n", tokens[i].value);
    }

    return 0;
}

int isKeyword(const char *str) {
    for (int i = 0; keywords[i] != NULL; i++) {
        if (strcmp(str, keywords[i]) == 0) {
            return 1;
        }
    }
    return 0;
}

int isOperator(const char *str) {
    for (int i = 0; operators[i] != NULL; i++) {
        if (strcmp(str, operators[i]) == 0) {
            return 1;
        }
    }
    return 0;
}

int isDelimiter(const char *str) {
    for (int i = 0; delimiters[i] != NULL; i++) {
        if (strcmp(str, delimiters[i]) == 0) {
            return 1;
        }
    }
    return 0;
}

void addToken(Token tokens[], int *tokenCount, const char *value, TokenType type) {
    strcpy(tokens[*tokenCount].value, value);
    (*tokenCount)++;
}
```

Output:

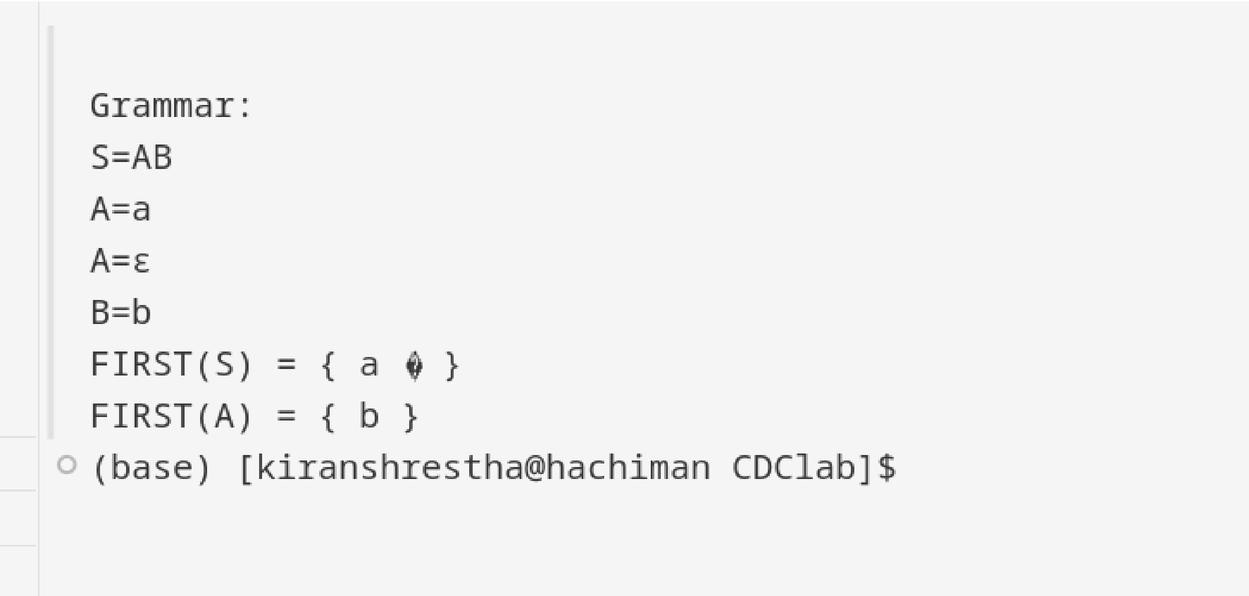


```
Token: int
Token: main
Token: (
Token: )
Token: {
Token: int
Token: a
Token: =
Token: 10
Token: ;
Token: int
Token: b
Token: =
Token: 20
Token: ;
Token: int
Token: sum
Token: =
Token: a
Token: +
Token: b
Token: ;
Token: return
Token: sum
Token: ;
```

2. WAP to implement FIRST of grammar.

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

#define MAX 10

char production[MAX][MAX], first[MAX][MAX];
int n;

void findFirst(int, int);
void addToResultSet(char[], char);

int main() {
    int i, j;
    char result[MAX];

    strcpy(production[0], "S=AB");
    strcpy(production[1], "A=a");
    strcpy(production[2], "A=ε");
    strcpy(production[3], "B=b");
    n = 4;

    printf("Grammar:\n");
    for (i = 0; i < n; i++) {
        printf("%s\n", production[i]);
    }

    for (i = 0; i < n; i++) {
        first[i][0] = '\0';
    }
    for (i = 0; i < n; i++) {
        int nonTerminal = production[i][0] - 'A';
        findFirst(i, nonTerminal);
    }

    for (i = 0; i < n; i++) {
        if (first[i][0] != '\0') {
            printf("FIRST(%c) = { ", production[i][0]);
            for (j = 0; first[i][j] != '\0'; j++) {
                printf("%c ", first[i][j]);
            }
            printf("}\n");
        }
    }

    return 0;
}

void findFirst(int prodIndex, int nonTerminal) {
    int i, j;
    char result[MAX];

    for (i = 0; i < n; i++) {
        if (production[i][0] == (char)('A' + nonTerminal)) {
            if (production[i][2] == 'ε') {
                addToResultSet(first[nonTerminal], 'ε');
            } else {
                for (j = 2; production[i][j] != '\0'; j++) {
                    if (production[i][j] >= 'A' && production[i][j] <= 'Z') {
                        findFirst(i, production[i][j] - 'A');
                        if (!strchr(first[production[i][j] - 'A'], 'ε')) {
                            break;
                        }
                    } else {
                        addToResultSet(first[nonTerminal], production[i][j]);
                        break;
                    }
                }
            }
        }
    }
}

void addToResultSet(char result[], char c) {
    int i;
    for (i = 0; result[i] != '\0'; i++) {
        if (result[i] == c) {
            return;
        }
    }
    result[i] = c;
    result[i + 1] = '\0';
}
```

Output:



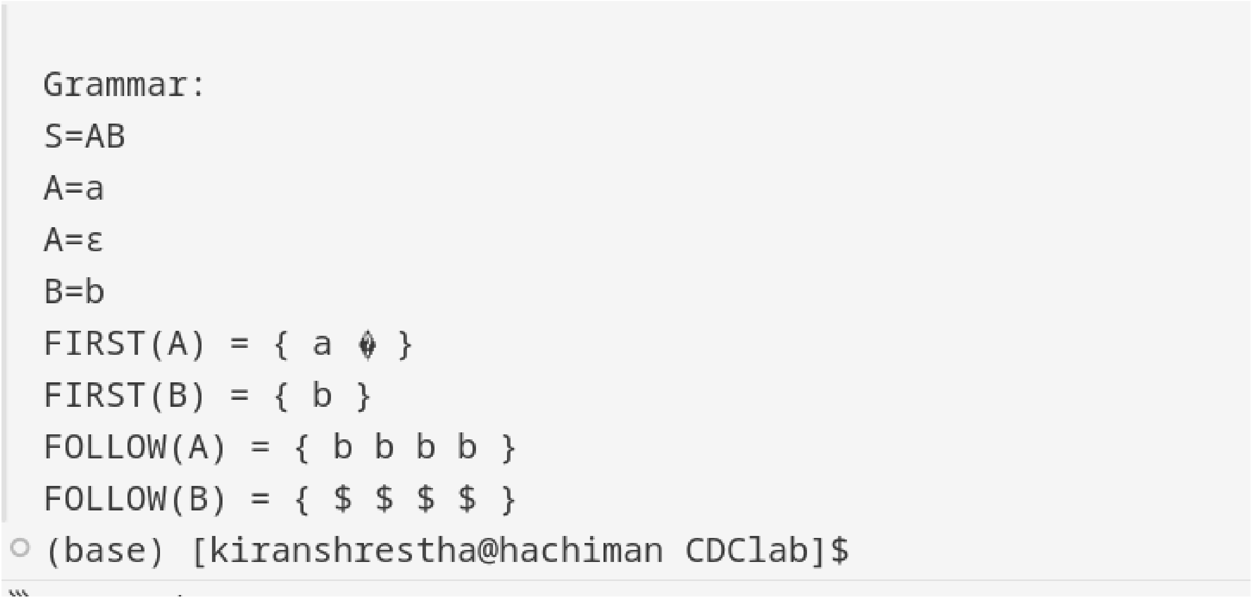
```
Grammar:
S=AB
A=a
A=ε
B=b
FIRST(S) = { a � }
FIRST(A) = { b }
○ (base) [kiranshrestha@hachiman CDClab]$
```

3. WAP to implement FOLLOW of grammar.

```
#include <stdio.h>

#include <string.h>

#include <stdbool.h>


#define MAX 10


char production[MAX][MAX], first[MAX][MAX], follow[MAX][MAX];

int n;

void findFirst(int, int);

void findFollow(int);

void addToResultSet(char[], char);

bool isNonTerminal(char);


int main() {

   int i, j;

   char result[MAX];


   strcpy(production[0], "S=AB");

   strcpy(production[1], "A=a");

   strcpy(production[2], "A=ε");

   strcpy(production[3], "B=b");

   n = 4;


   printf("Grammar:\n");

   for (i = 0; i < n; i++) {

      printf("%s\n", production[i]);

   }


   for (i = 0; i < MAX; i++) {

      first[i][0] = '\0';

      follow[i][0] = '\0';
   }

   for (i = 0; i < n; i++) {
      int nonTerminal = production[i][0] - 'A';
      findFirst(i, nonTerminal);
   }

   addToResultSet(follow['S' - 'A'], '$');

   for (i = 0; i < n; i++) {
      findFollow(i);
   }

   for (i = 0; i < MAX; i++) {
      if (first[i][0] != '\0') {
          printf("FIRST(%c) = { ", 'A' + i);
          for (j = 0; first[i][j] != '\0'; j++) {
              printf("%c ", first[i][j]);
          }
          printf("}\n");
      }
   }

   for (i = 0; i < MAX; i++) {
      if (follow[i][0] != '\0') {
          printf("FOLLOW(%c) = { ", 'A' + i);
          for (j = 0; follow[i][j] != '\0'; j++) {
              printf("%c ", follow[i][j]);
          }
          printf("}\n");
      }
   }
```

```
    return 0;
}

void findFirst(int prodIndex, int nonTerminal) {
    int i, j;
    char result[MAX];

    for (i = 0; i < n; i++) {
        if (production[i][0] == (char)('A' + nonTerminal)) {
            if (production[i][2] == 'ε') {
                addToResultSet(first[nonTerminal], 'ε');
            } else {
                for (j = 2; production[i][j] != '\0'; j++) {
                    if (isNonTerminal(production[i][j])) {
                        findFirst(i, production[i][j] - 'A');
                        if (!strchr(first[production[i][j] - 'A'], 'ε')) {
                            break;
                        }
                    } else {
                        addToResultSet(first[nonTerminal], production[i][j]);
                        break;
                    }
                }
            }
        }
    }
}

void findFollow(int prodIndex) {
    int i, j, k;
    char result[MAX];
    for (i = 0; i < n; i++) {
        for (j = 2; production[i][j] != '\0'; j++) {
            if (isNonTerminal(production[i][j])) {
                int nonTerminal = production[i][j] - 'A';

                for (k = j + 1; production[i][k] != '\0'; k++) {
                    if (isNonTerminal(production[i][k])) {
                        int nextNonTerminal = production[i][k] - 'A';
                        strcat(follow[nonTerminal], first[nextNonTerminal]);
                        if (!strchr(first[nextNonTerminal], 'ε')) {
                            break;
                        }
                    } else {
                        addToResultSet(follow[nonTerminal], production[i][k]);
                        break;
                    }
                }
                if (production[i][k] == '\0' && production[i][0] != production[i][j]) {
                    strcat(follow[nonTerminal], follow[production[i][0] - 'A']);
                }
            }
        }
    }
}

void addToResultSet(char result[], char c) {
    int i;
    for (i = 0; result[i] != '\0'; i++) {
        if (result[i] == c) {
            return;  // Avoid duplicates
        }
    }
    result[i] = c;
    result[i + 1] = '\0';
}

bool isNonTerminal(char c) {
    return c >= 'A' && c <= 'Z';
}
```

Output:

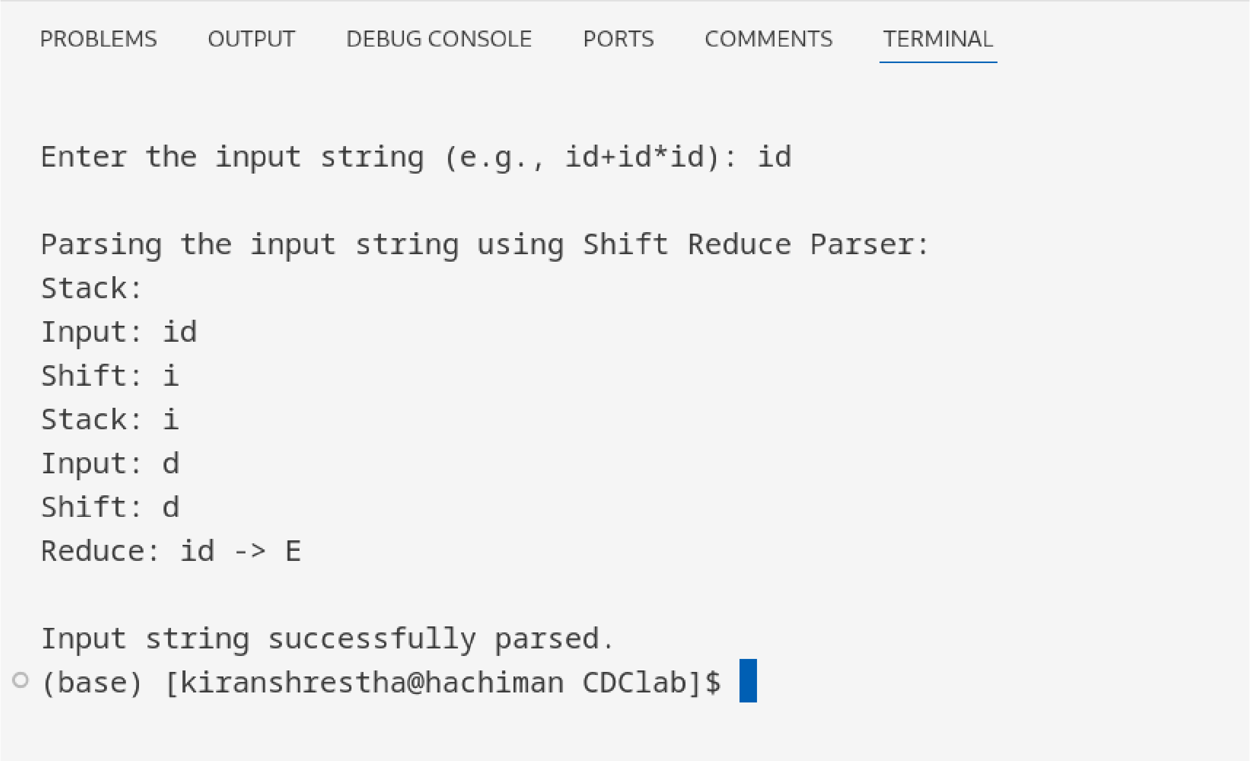


```
Grammar:
S=AB
A=a
A=ε
B=b
FIRST(A) = { a � }
FIRST(B) = { b }
FOLLOW(A) = { b b b b }
FOLLOW(B) = { $ $ $ $ }
○ (base) [kiranshrestha@hachiman CDClab]$
```

4. WAP to implement Shift Reduce Parser.

```
#include <stdio.h>

#include <string.h>

#include <stdlib.h>


#define MAX 100


char stack[MAX];

int top = -1;

char input[MAX];

int inputPointer = 0;


// Grammar rules

const char* rules[] = {

    "E+E",

    "E*E",

    "(E)",

    "id"

};


// Function prototypes

void push(char);

void pop();

void shift();

void reduce();

void displayStack();

void displayInput();


int main() {

    printf("Enter the input string (e.g., id+id*id): ");

    scanf("%s", input);
    printf("\nParsing the input string using Shift Reduce Parser:\n");
    while (1) {
        displayStack();
        displayInput();

        if (input[inputPointer] != '\0') {
            shift();
        }

        reduce();

        if (stack[0] == 'E' && top == 0 && input[inputPointer] == '\0') {
            printf("\nInput string successfully parsed.\n");
            break;
        }
    }

    return 0;
}

void push(char symbol) {
    if (top < MAX - 1) {
        stack[++top] = symbol;
    } else {
        printf("Stack overflow\n");
        exit(1);
    }
}

void pop() {
    if (top >= 0) {
        top--;
    } else {
        printf("Stack underflow\n");
        exit(1);
    }
}

void shift() {
    printf("Shift: %c\n", input[inputPointer]);
    push(input[inputPointer]);
    inputPointer++;
}

void reduce() {
    int i;
    for (i = 0; i < sizeof(rules) / sizeof(rules[0]); i++) {
        int len = strlen(rules[i]);
        if (top >= len - 1) {
            int match = 1;
            for (int j = 0; j < len; j++) {
                if (stack[top - len + 1 + j] != rules[i][j]) {
                    match = 0;
                    break;
                }
            }
            if (match) {
                printf("Reduce: %s -> E\n", rules[i]);
                for (int j = 0; j < len; j++) {
                    pop();
                }
                push('E');
                return;
            }
        }
    }
}

void displayStack() {
    printf("Stack: ");
    for (int i = 0; i <= top; i++) {
        printf("%c", stack[i]);
    }
    printf("\n");
}

void displayInput() {
    printf("Input: %s\n", input + inputPointer);
}
```

Output:



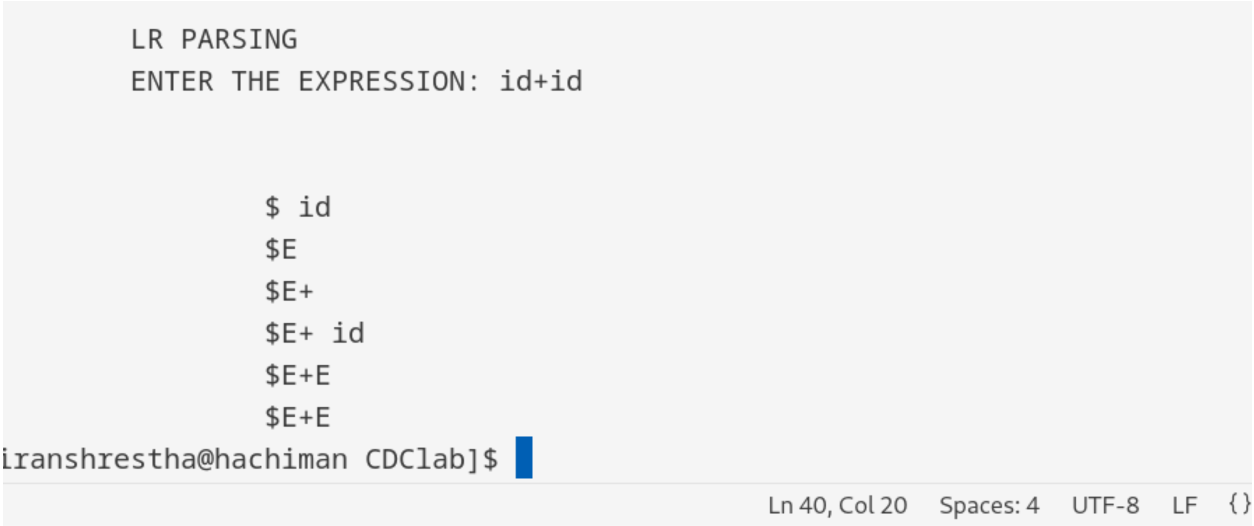
```
Enter the input string (e.g., id+id*id): id

Parsing the input string using Shift Reduce Parser:
Stack: 
Input: id
Shift: i
Stack: i
Input: d
Shift: d
Reduce: id -> E

Input string successfully parsed.
○ (base) [kiranshrestha@hachiman CDClab]$ 
```

5. WAP to implement LR Parser.

```
#include <stdio.h>

#include <stdlib.h>

#include <string.h>

#include <ctype.h>

char stack[30];

int top = -1;

void push(char c) {

    if (top < 29) {

        top++;

        stack[top] = c;

    } else {

        printf("Stack overflow\n");

        exit(EXIT_FAILURE);

    }

}

char pop() {

    if (top != -1) {

        char c = stack[top];

        top--;

        return c;

    }

    return 'x'; // Return 'x' if stack is empty

}

void printstat() {

    printf("\n\t\t\t $");

    for (int i = 0; i <= top; i++) {

        printf("%c", stack[i]);

    }

}

int main() {

    char s1[20];
```

```
int l;
printf("\n\n\t\t LR PARSING");
printf("\n\t\t ENTER THE EXPRESSION: ");
scanf("%s", s1);
l = strlen(s1);
printf("\n\t\t $");
for (int i = 0; i < l; i++) {
    if (s1[i] == 'i' && s1[i + 1] == 'd') {
        s1[i] = ' ';
        s1[i + 1] = 'E';
        printstat();
        printf(" id");
        push('E');
        printstat();
        i++; // Skip next character
    } else if (s1[i] == '+' || s1[i] == '-' || s1[i] == '*' || s1[i] == '/' || s1[i] == 'd') {
        push(s1[i]);
        printstat();
    }
}
printstat();
while (top != -1) {
    char ch1 = pop();
    if (ch1 == 'x') {
        printf("\n\t\t\t $");
        break;
    }
    if (ch1 == '+' || ch1 == '/' || ch1 == '*' || ch1 == '-') {
        char ch3 = pop();
        if (ch3 != 'E') {
            printf("error\n");
            exit(EXIT_FAILURE);
            } else {
                push('E');
                printstat();
            }
        }
    }

    return 0;
}
```

Output:

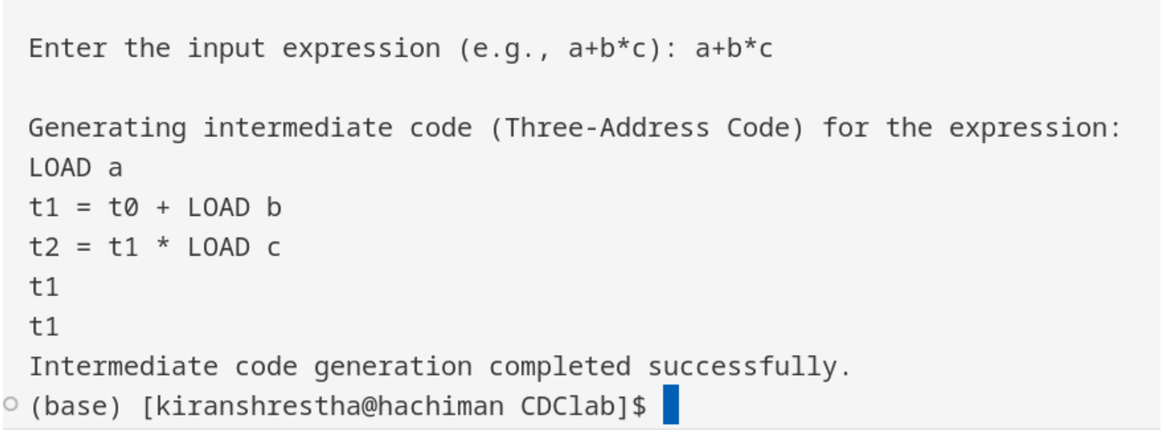


```
        LR PARSING
        ENTER THE EXPRESSION: id+id


                $ id
                $E
                $E+
                $E+ id
                $E+E
                $E+E
iranshrestha@hachiman CDClab]$ █
                                              Ln 40, Col 20   Spaces: 4   UTF-8   LF   {}
```

6. WAP to implement Intermediate code generation.

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

#define MAX 100

char input[MAX];
int inputPointer = 0;
int tempCount = 0;

// Function prototypes
void parse();
void expression();
void term();
void factor();
char* newTemp();

int main() {
    printf("Enter the input expression (e.g., a+b*c): ");
    scanf("%s", input);

    printf("\nGenerating intermediate code (Three-Address Code) for the expression:\n");
    parse();

    return 0;
}

void parse() {
    expression();
    if (input[inputPointer] == '\0') {
        printf("Intermediate code generation completed successfully.\n");
    } else {
        printf("Error: Unexpected input '%c'.\n", input[inputPointer]);
    }
}

void expression() {
    char* temp;
    term();
    while (input[inputPointer] == '+') {
        inputPointer++;
        temp = newTemp();
        printf("%s = t%d + ", temp, tempCount - 1);
        term();
        printf("t%d\n", tempCount - 1);
    }
}

void term() {
    char* temp;
    factor();
    while (input[inputPointer] == '*') {
        inputPointer++;
        temp = newTemp();
        printf("%s = t%d * ", temp, tempCount - 1);
        factor();
        printf("t%d\n", tempCount - 1);
    }
}

void factor() {
    if (input[inputPointer] >= 'a' && input[inputPointer] <= 'z') {
        printf("LOAD %c\n", input[inputPointer]);
        inputPointer++;
    } else if (input[inputPointer] == '(') {
        inputPointer++;
        expression();
        if (input[inputPointer] == ')') {
            inputPointer++;
        } else {
            printf("Error: Unmatched parenthesis\n");
            exit(1);
        }
    } else {
        printf("Error: Unexpected input '%c'\n", input[inputPointer]);
        exit(1);
    }
}

char* newTemp() {
    static char temp[10];
    snprintf(temp, sizeof(temp), "t%d", ++tempCount);
    return temp;
}
```

Output:

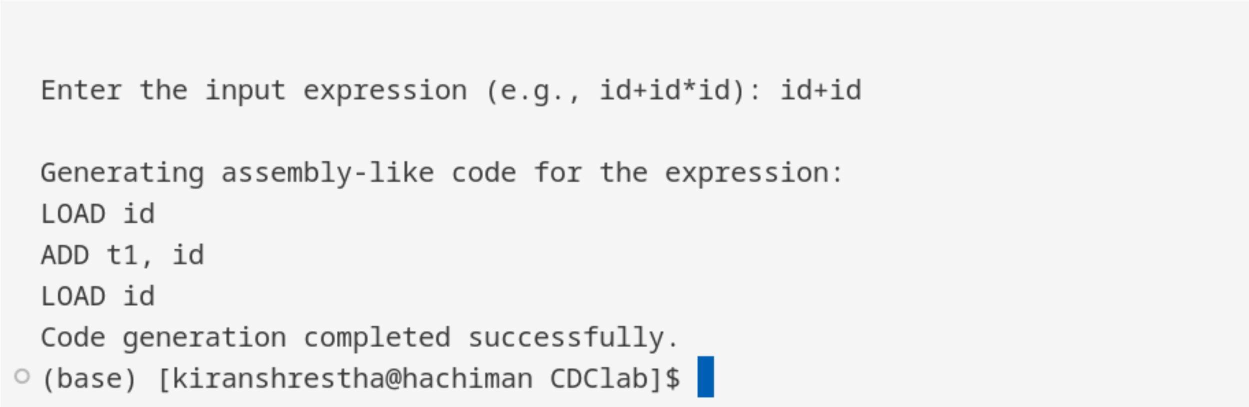


```
Enter the input expression (e.g., a+b*c): a+b*c

Generating intermediate code (Three-Address Code) for the expression:
LOAD a
t1 = t0 + LOAD b
t2 = t1 * LOAD c
t1
t1
Intermediate code generation completed successfully.
○ (base) [kiranshrestha@hachiman CDClab]$
```

7. WAP to implement Final code generation

```
#include <stdio.h>

#include <string.h>

char op[2], arg1[5], arg2[5], result[5];

int main() {

   FILE *fp1, *fp2;

   fp1 = fopen("input.txt", "r");

   if (fp1 == NULL) {

      perror("Error opening input file");

      return 1;

   }

   fp2 = fopen("output.txt", "w");

   if (fp2 == NULL) {

      perror("Error opening output file");

      fclose(fp1);

      return 1;

   }

   while (fscanf(fp1, "%s %s %s %s", op, arg1, arg2, result) == 4) {

      if (strcmp(op, "+") == 0) {

         fprintf(fp2, "\nMOV R0, %s", arg1);

         fprintf(fp2, "\nADD R0, %s", arg2);

         fprintf(fp2, "\nMOV %s, R0", result);

      } else if (strcmp(op, "*") == 0) {

         fprintf(fp2, "\nMOV R0, %s", arg1);

         fprintf(fp2, "\nMUL R0, %s", arg2);

         fprintf(fp2, "\nMOV %s, R0", result);

      } else if (strcmp(op, "-") == 0) {

         fprintf(fp2, "\nMOV R0, %s", arg1);

         fprintf(fp2, "\nSUB R0, %s", arg2);

         fprintf(fp2, "\nMOV %s, R0", result);

      } else if (strcmp(op, "/") == 0) {
            fprintf(fp2, "\nMOV R0, %s", arg1);
            fprintf(fp2, "\nDIV R0, %s", arg2);
            fprintf(fp2, "\nMOV %s, R0", result);
        } else if (strcmp(op, "=") == 0) {
            fprintf(fp2, "\nMOV R0, %s", arg1);
            fprintf(fp2, "\nMOV %s, R0", result);
        } else {
            fprintf(fp2, "\nUnknown operation: %s", op);
        }
    }
    fclose(fp1);
    fclose(fp2);
    return 0;
}
```

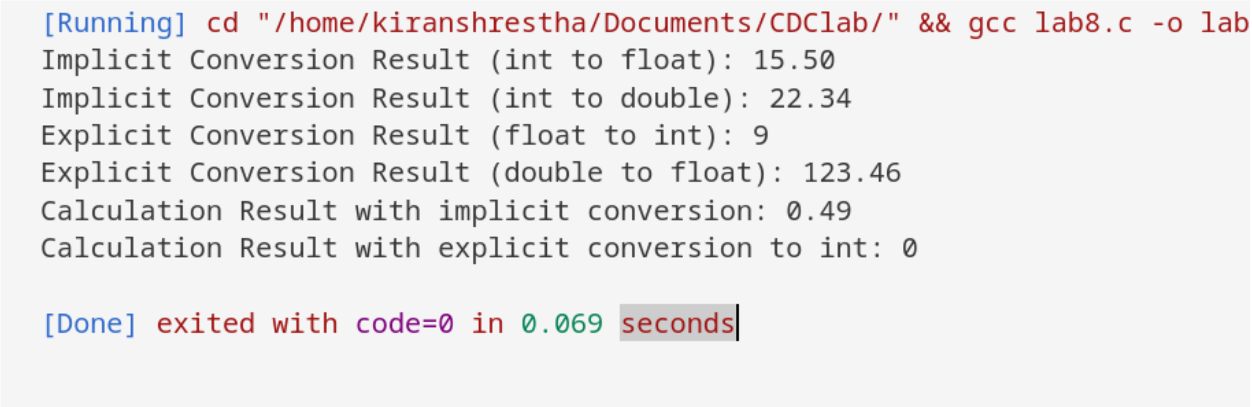
Output:



```
Enter the input expression (e.g., id+id*id): id+id

Generating assembly-like code for the expression:
LOAD id
ADD t1, id
LOAD id
Code generation completed successfully.
○ (base) [kiranshrestha@hachiman CDClab]$
```

8. WAP to implement Type Conversion.

```
#include <stdio.h>

int main() {
    // Implicit Conversion
    int intVar = 10;
    float floatVar = 5.5;
    double doubleVar = 12.34;
    // Implicit conversion: int to float
    float result1 = intVar + floatVar; // intVar is implicitly converted to float
    printf("Implicit Conversion Result (int to float): %.2f\n", result1);
    // Implicit conversion: int to double
    double result2 = intVar + doubleVar; // intVar is implicitly converted to double
    printf("Implicit Conversion Result (int to double): %.2f\n", result2);
    // Explicit Conversion (Type Casting)
    float floatVar2 = 9.99;
    int intVar2;
    // Explicit conversion: float to int
    intVar2 = (int)floatVar2; // floatVar2 is explicitly cast to int
    printf("Explicit Conversion Result (float to int): %d\n", intVar2);
    // Explicit conversion: double to float
    float floatVar3;
    double doubleVar2 = 123.456;
    floatVar3 = (float)doubleVar2; // doubleVar2 is explicitly cast to float
    printf("Explicit Conversion Result (double to float): %.2f\n", floatVar3);
    // Example of conversion in calculations
    int num1 = 10;
    double num2 = 20.5;
    // Result is of type double due to implicit conversion of num1 to double
    double result3 = num1 / num2;
    printf("Calculation Result with implicit conversion: %.2f\n", result3);
    // Result is explicitly cast to int
    int result4 = (int)(num1 / num2);
    printf("Calculation Result with explicit conversion to int: %d\n", result4);
    return 0;
}
```

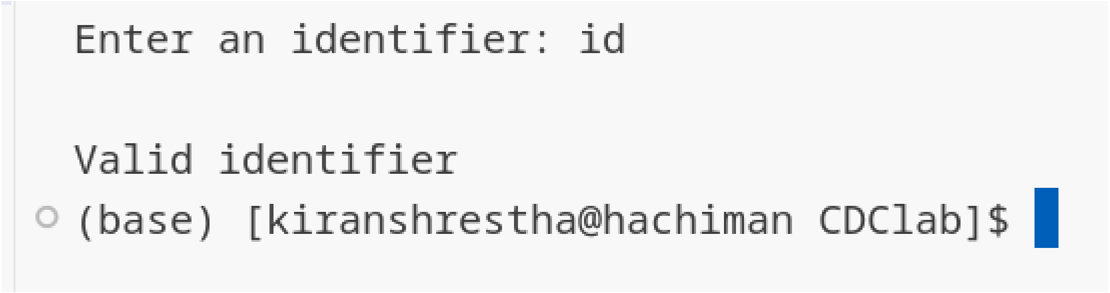


```
[Running] cd "/home/kiranshrestha/Documents/CDClab/" && gcc lab8.c -o lab
Implicit Conversion Result (int to float): 15.50
Implicit Conversion Result (int to double): 22.34
Explicit Conversion Result (float to int): 9
Explicit Conversion Result (double to float): 123.46
Calculation Result with implicit conversion: 0.49
Calculation Result with explicit conversion to int: 0

[Done] exited with code=0 in 0.069 seconds
```

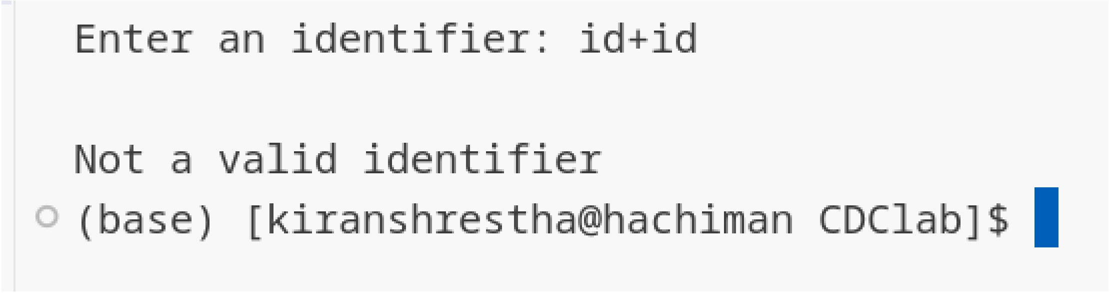
9. WAP to check whether a given identifier is valid or not.

```
#include <stdio.h>
#include <ctype.h>
int main() {
    char a[10];
    int flag = 0, i = 0;
    printf("\nEnter an identifier: ");
    fgets(a, sizeof(a), stdin);
    size_t len = strlen(a);
    if (len > 0 && a[len - 1] == '\n') {
        a[len - 1] = '\0';
    }
    // Check if the first character is valid
    if (isalpha(a[0]) || a[0] == '_') {
        flag = 1;
        while (a[i] != '\0') {
            if (!isdigit(a[i]) && !isalpha(a[i]) && a[i] != '_') {
                flag = 0;  // Invalid character found
                break;
            }
            i++;
        }
    } else {
        printf("\nNot a valid identifier");
        return 0; // Exit the program early if the first character is invalid
    }
    // Output result based on the flag
    if (flag == 1) {
        printf("\nValid identifier");
    } else {
        printf("\nNot a valid identifier");
    }
    return 0;
}
```

Output:



```
Enter an identifier: id

Valid identifier
○ (base) [kiranshrestha@hachiman CDClab]$ 
```



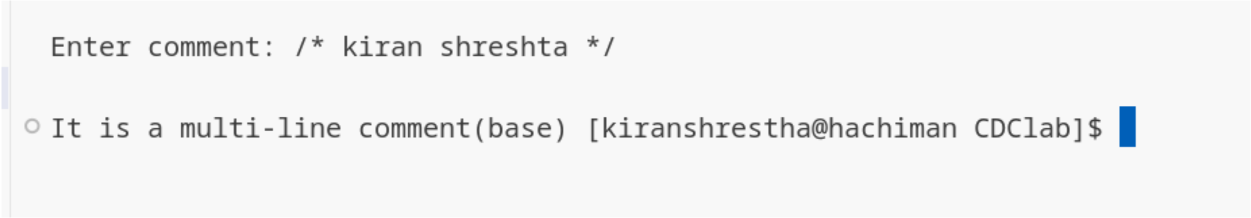
```
Enter an identifier: id+id

Not a valid identifier
○ (base) [kiranshrestha@hachiman CDClab]$ 
```

10. WAP to check whether a given string is within valid comment section or not.

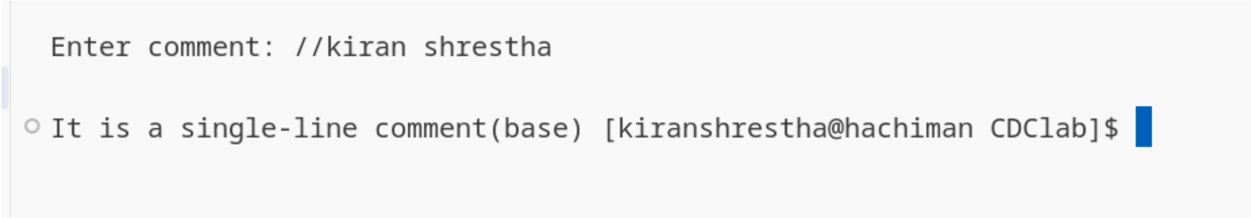
```
#include <stdio.h>
#include <string.h>
int main() {
   char com[30];
   int i;
   int isComment = 0;  // Flag to determine if the input is a comment
   printf("\nEnter comment: ");
   fgets(com, sizeof(com), stdin);
   // Remove newline character if fgets reads it
   size_t len = strlen(com);
   if (len > 0 && com[len - 1] == '\n') {
      com[len - 1] = '\0';
   }
   // Check for single-line comment
   if (com[0] == '/' && com[1] == '/') {
      printf("\nIt is a single-line comment");
      isComment = 1;
   }
   // Check for multi-line comment
   else if (com[0] == '/' && com[1] == '*') {
      for (i = 2; i < len - 1; i++) {
         if (com[i] == '*' && com[i + 1] == '/') {
            printf("\nIt is a multi-line comment");
            isComment = 1;
            break;
         }
      }
      if (isComment == 0) {
         printf("\nIt is not a multi-line comment");
      }
```

```
    } else {
        printf("\nIt is not a comment");
    }
    return 0;
}
```

Output:



```
Enter comment: /* kiran shreshta */
It is a multi-line comment(base) [kiranshrestha@hachiman CDClab]$
```



```
Enter comment: //kiran shrestha
It is a single-line comment(base) [kiranshrestha@hachiman CDClab]$
```