Week 10 Assignment

Problem

10. Lab Assignment: Implement a Predictive Parser using C for the Expression Grammar

E → TE’

E’→ +TE’ | ε

T → FT’

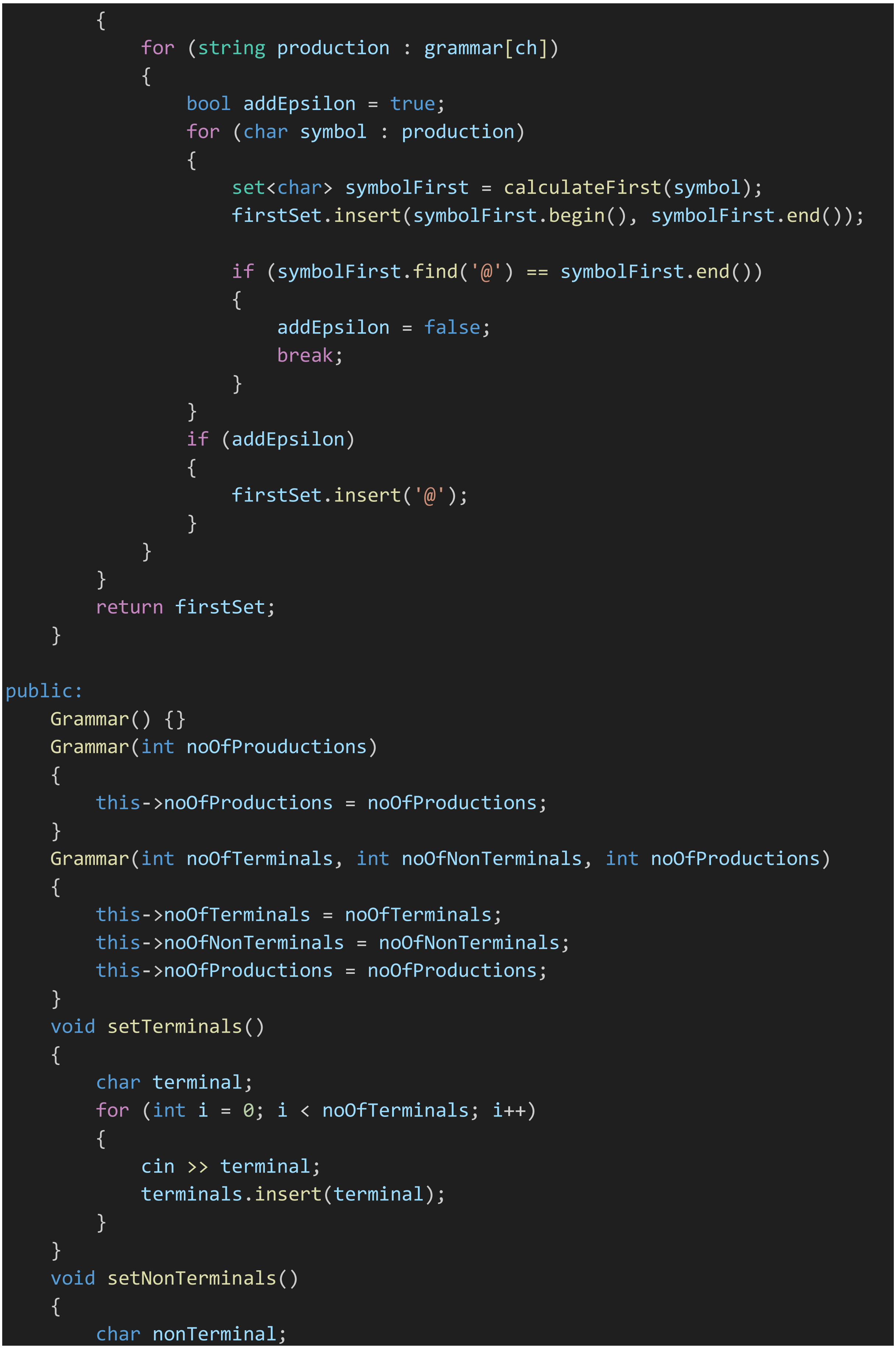
T’→ *FT’ | ε

F → (E) | d

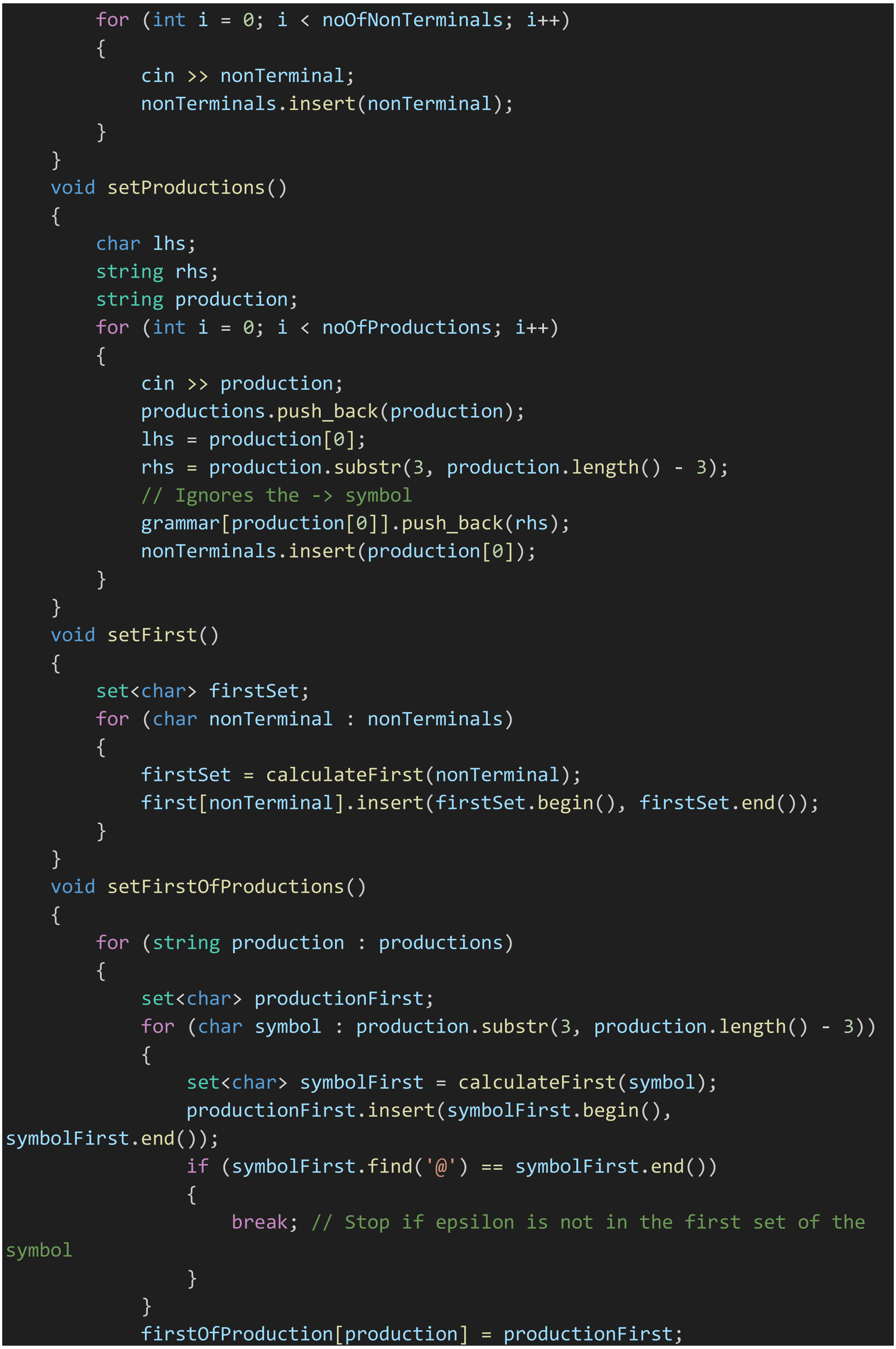
Parse the string d*d+d

Program

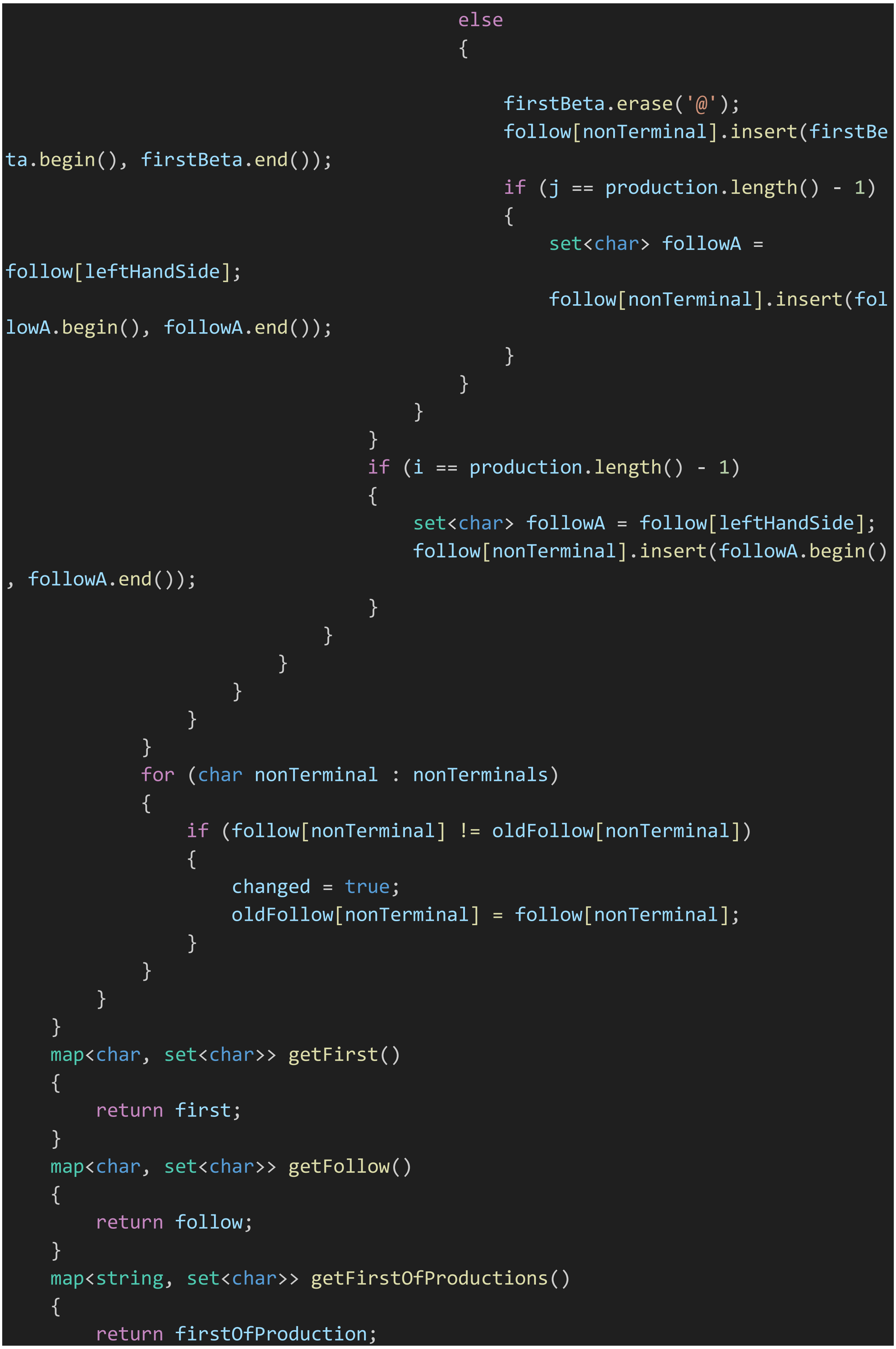
```
#include <iostream>
#include <string>
#include <map>
#include <vector>
#include <set>
#include <stack>
#include <algorithm>
using namespace std;

class Grammar
{
private:
    int noOfProductions;
    int noOfTerminals;
    int noOfNonTerminals;
    map<char, vector<string>> grammar;
    set<char> nonTerminals;
    set<char> terminals;
    map<char, set<char>> first;
    map<string, set<char>> firstOfProduction;
    map<char, set<char>> follow;
    map<char, set<char>> oldFollow;
    vector<string> productions;
    set<char> calculateFirst(char ch)
    {
        set<char> firstSet;
        if (terminals.find(ch) != terminals.end())
        {
            firstSet.insert(ch);
        }
        else
```



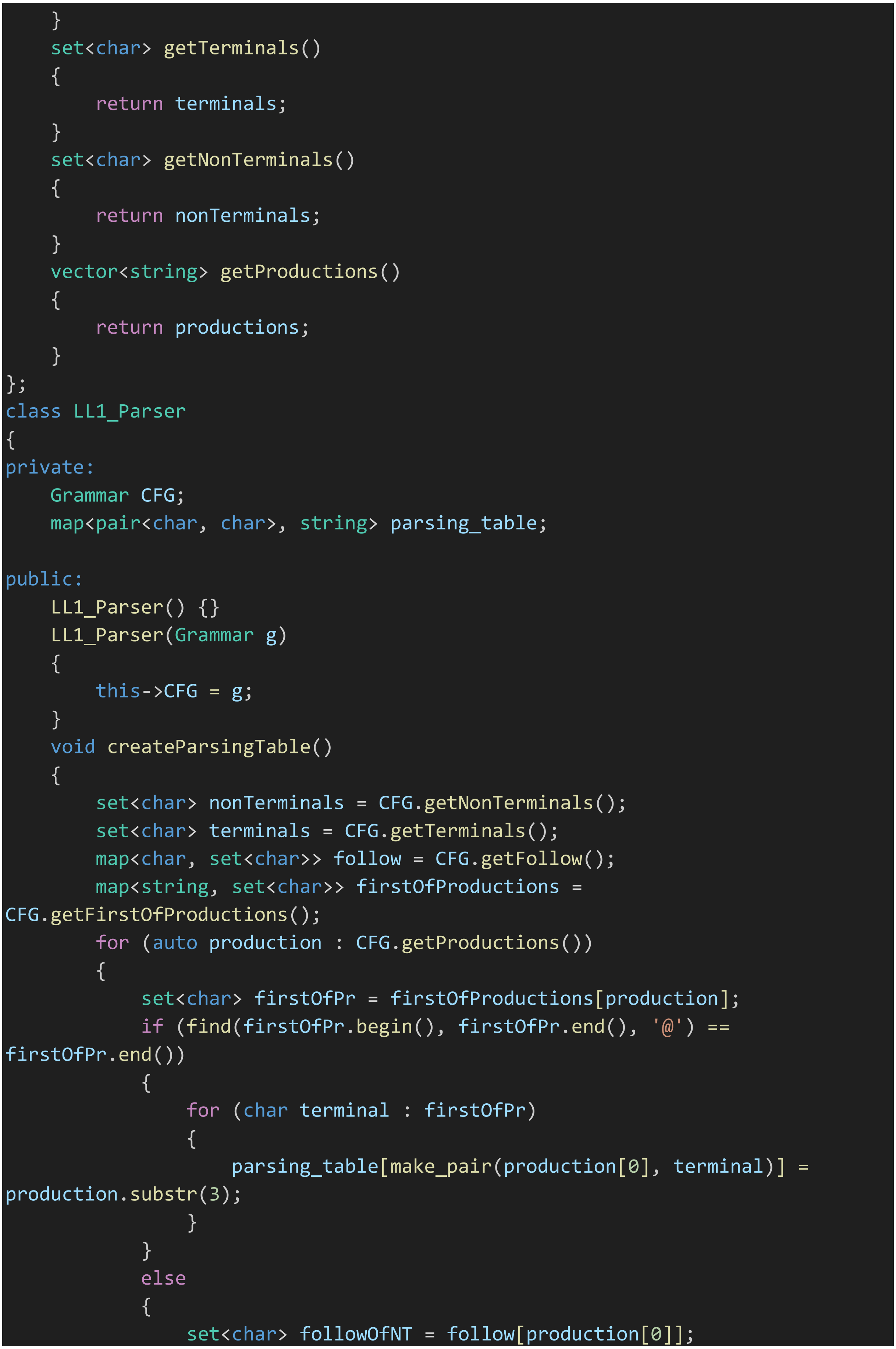
```
        {
            for (string production : grammar[ch])
            {
                bool addEpsilon = true;
                for (char symbol : production)
                {
                    set<char> symbolFirst = calculateFirst(symbol);
                    firstSet.insert(symbolFirst.begin(), symbolFirst.end());

                    if (symbolFirst.find('@') == symbolFirst.end())
                    {
                        addEpsilon = false;
                        break;
                    }
                }
                if (addEpsilon)
                {
                    firstSet.insert('@');
                }
            }
        }
        return firstSet;
    }

public:
    Grammar() {}
    Grammar(int noOfProuductions)
    {
        this->noOfProductions = noOfProductions;
    }
    Grammar(int noOfTerminals, int noOfNonTerminals, int noOfProductions)
    {
        this->noOfTerminals = noOfTerminals;
        this->noOfNonTerminals = noOfNonTerminals;
        this->noOfProductions = noOfProductions;
    }
    void setTerminals()
    {
        char terminal;
        for (int i = 0; i < noOfTerminals; i++)
        {
            cin >> terminal;
            terminals.insert(terminal);
        }
    }
    void setNonTerminals()
    {
        char nonTerminal;
```



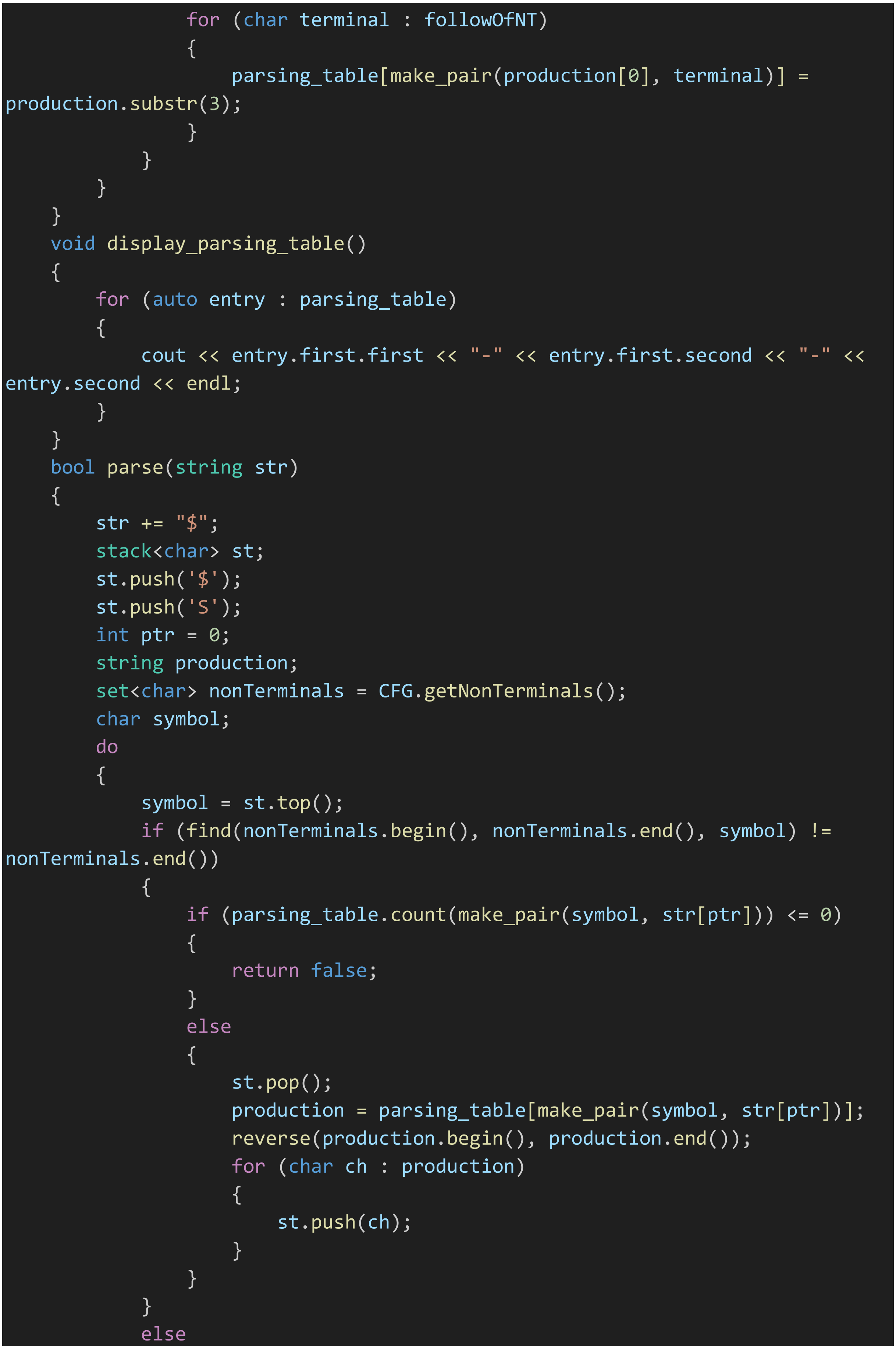
```
        for (int i = 0; i < noOfNonTerminals; i++)
        {
            cin >> nonTerminal;
            nonTerminals.insert(nonTerminal);
        }
    }
    void setProductions()
    {
        char lhs;
        string rhs;
        string production;
        for (int i = 0; i < noOfProductions; i++)
        {
            cin >> production;
            productions.push_back(production);
            lhs = production[0];
            rhs = production.substr(3, production.length() - 3);
            // Ignores the -> symbol
            grammar[production[0]].push_back(rhs);
            nonTerminals.insert(production[0]);
        }
    }
    void setFirst()
    {
        set<char> firstSet;
        for (char nonTerminal : nonTerminals)
        {
            firstSet = calculateFirst(nonTerminal);
            first[nonTerminal].insert(firstSet.begin(), firstSet.end());
        }
    }
    void setFirstOfProductions()
    {
        for (string production : productions)
        {
            set<char> productionFirst;
            for (char symbol : production.substr(3, production.length() - 3))
            {
                set<char> symbolFirst = calculateFirst(symbol);
                productionFirst.insert(symbolFirst.begin(),
symbolFirst.end());
                if (symbolFirst.find('@') == symbolFirst.end())
                {
                    break; // Stop if epsilon is not in the first set of the
symbol
                }
            }
            firstOfProduction[production] = productionFirst;
        }
    }
    void setFollow()
    {
        for (char nonTerminal : nonTerminals)
        {
            follow[nonTerminal] = {};
        }
        follow['S'].insert('$');
        bool changed = true;
        while (changed)
        {
            changed = false;

            for (char nonTerminal : nonTerminals)
            {
                for (auto it = grammar.begin(); it != grammar.end(); it++)
                {
                    char leftHandSide = it->first;
                    vector<string> productions = it->second;

                    for (string production : productions)
                    {
                        for (int i = 0; i < production.length(); i++)
                        {
                            if (production[i] == nonTerminal)
                            {
                                for (int j = i + 1; j < production.length();
j++)
                                {
                                    char symbol = production[j];
                                    if (terminals.find(symbol) !=
terminals.end())
                                    {
                                        follow[nonTerminal].insert(symbol);
                                        break;
                                    }
                                    else
                                    {
                                        set<char> firstBeta =
calculateFirst(symbol);

                                        if (firstBeta.find('@') ==
firstBeta.end())
                                        {
                                            follow[nonTerminal].insert(firstBe
ta.begin(), firstBeta.end());
                                            break;
                                        }
```



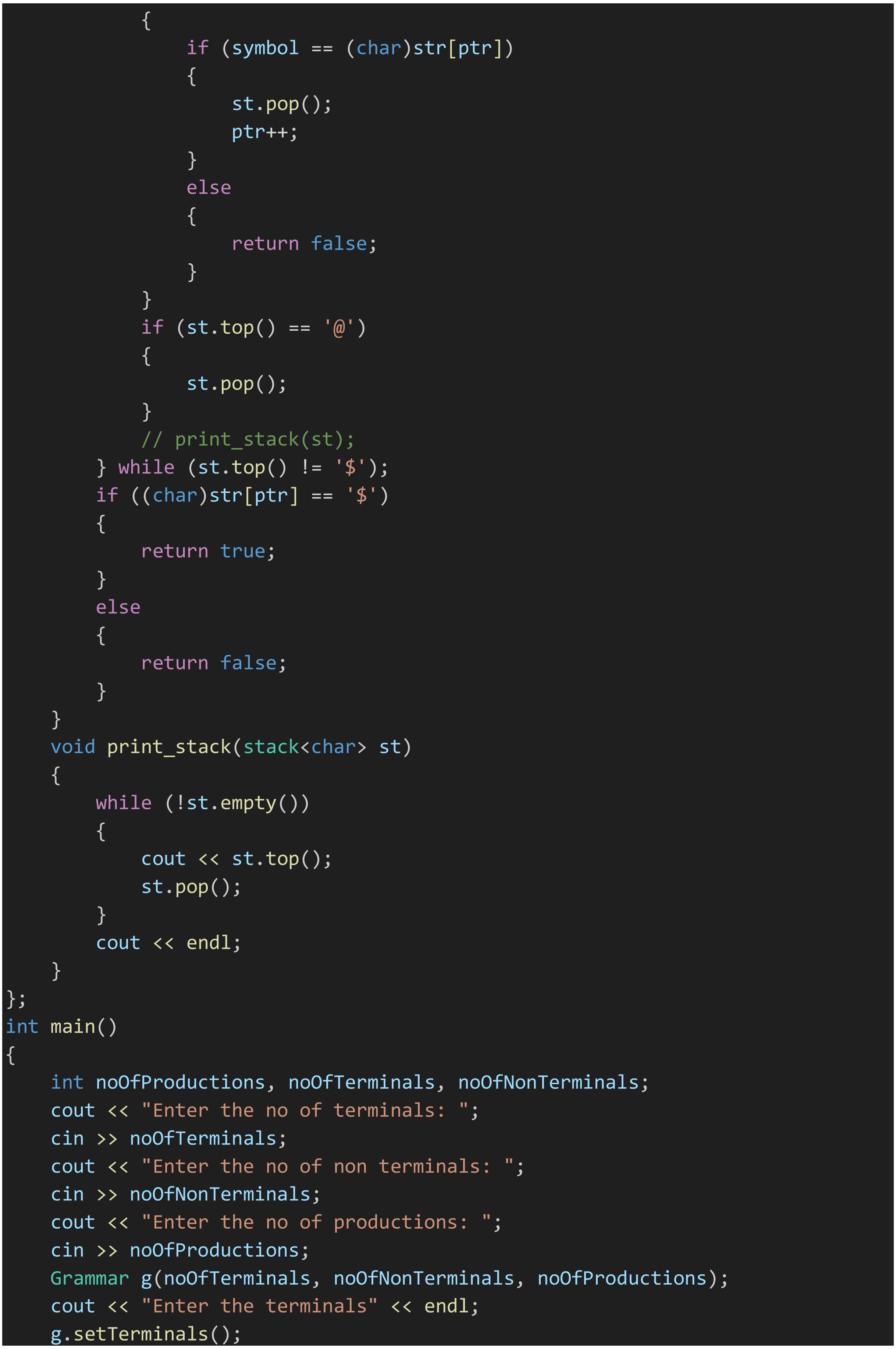
```
                                        else
                                        {

                                            firstBeta.erase('@');
                                            follow[nonTerminal].insert(firstBe
ta.begin(), firstBeta.end());
                                            if (j == production.length() - 1)
                                            {
                                                set<char> followA =
follow[leftHandSide];
                                                follow[nonTerminal].insert(fol
lowA.begin(), followA.end());
                                            }
                                        }
                                    }
                                }
                                if (i == production.length() - 1)
                                {
                                    set<char> followA = follow[leftHandSide];
                                    follow[nonTerminal].insert(followA.begin()
, followA.end());
                                }
                            }
                        }
                    }
                }
            }
            for (char nonTerminal : nonTerminals)
            {
                if (follow[nonTerminal] != oldFollow[nonTerminal])
                {
                    changed = true;
                    oldFollow[nonTerminal] = follow[nonTerminal];
                }
            }
        }
    }
    map<char, set<char>> getFirst()
    {
        return first;
    }
    map<char, set<char>> getFollow()
    {
        return follow;
    }
    map<string, set<char>> getFirstOfProductions()
    {
        return firstOfProduction;
```



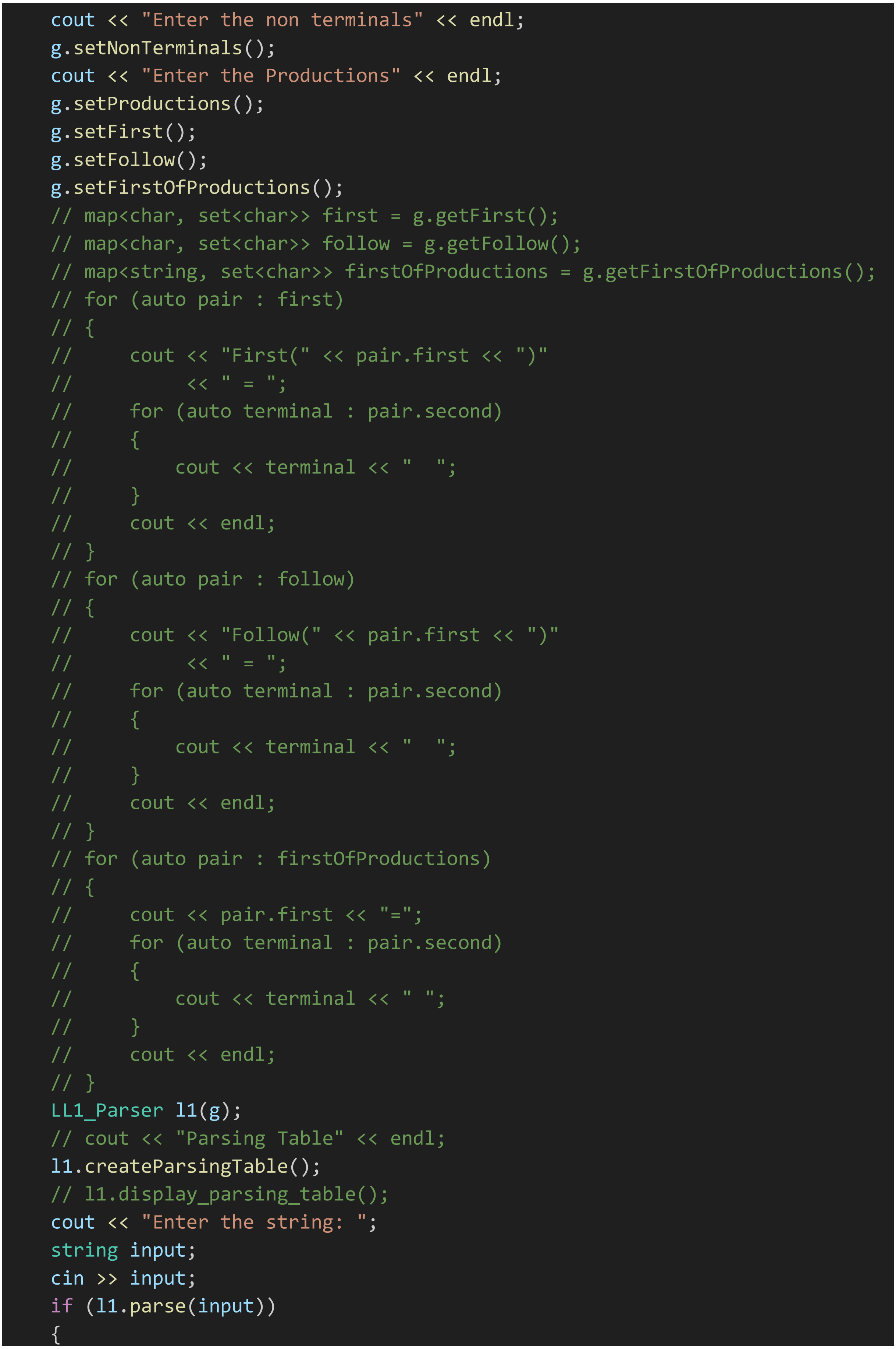
```
    }
    set<char> getTerminals()
    {
        return terminals;
    }
    set<char> getNonTerminals()
    {
        return nonTerminals;
    }
    vector<string> getProductions()
    {
        return productions;
    }
};
class LL1_Parser
{
private:
    Grammar CFG;
    map<pair<char, char>, string> parsing_table;

public:
    LL1_Parser() {}
    LL1_Parser(Grammar g)
    {
        this->CFG = g;
    }
    void createParsingTable()
    {
        set<char> nonTerminals = CFG.getNonTerminals();
        set<char> terminals = CFG.getTerminals();
        map<char, set<char>> follow = CFG.getFollow();
        map<string, set<char>> firstOfProductions =
CFG.getFirstOfProductions();
        for (auto production : CFG.getProductions())
        {
            set<char> firstOfPr = firstOfProductions[production];
            if (find(firstOfPr.begin(), firstOfPr.end(), '@') ==
firstOfPr.end())
            {
                for (char terminal : firstOfPr)
                {
                    parsing_table[make_pair(production[0], terminal)] =
production.substr(3);
                }
            }
            else
            {
                set<char> followOfNT = follow[production[0]];
```



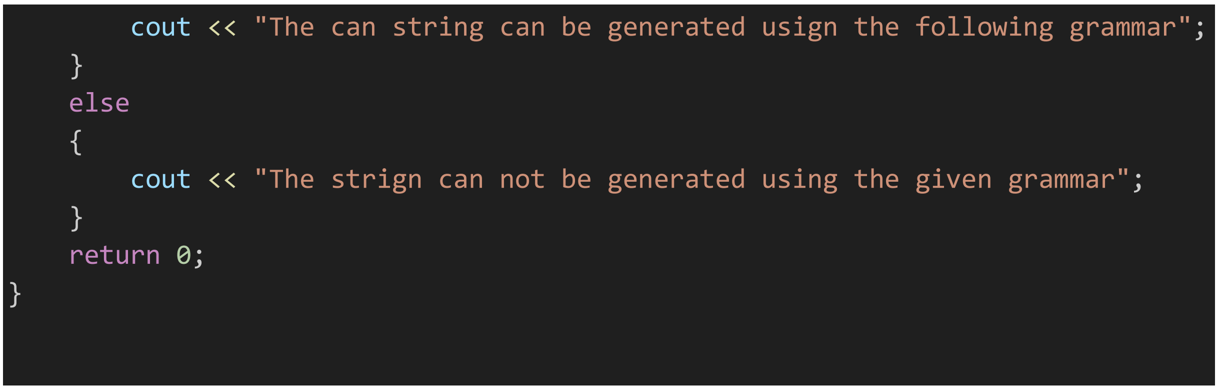
```
                for (char terminal : followOfNT)
                {
                    parsing_table[make_pair(production[0], terminal)] =
production.substr(3);
                }
            }
        }
    }
    void display_parsing_table()
    {
        for (auto entry : parsing_table)
        {
            cout << entry.first.first << "-" << entry.first.second << "-" <<
entry.second << endl;
        }
    }
    bool parse(string str)
    {
        str += "$";
        stack<char> st;
        st.push('$');
        st.push('S');
        int ptr = 0;
        string production;
        set<char> nonTerminals = CFG.getNonTerminals();
        char symbol;
        do
        {
            symbol = st.top();
            if (find(nonTerminals.begin(), nonTerminals.end(), symbol) !=
nonTerminals.end())
            {
                if (parsing_table.count(make_pair(symbol, str[ptr])) <= 0)
                {
                    return false;
                }
                else
                {
                    st.pop();
                    production = parsing_table[make_pair(symbol, str[ptr])];
                    reverse(production.begin(), production.end());
                    for (char ch : production)
                    {
                        st.push(ch);
                    }
                }
            }
            else
```



```
            {
                if (symbol == (char)str[ptr])
                {
                    st.pop();
                    ptr++;
                }
                else
                {
                    return false;
                }
            }
            if (st.top() == '@')
            {
                st.pop();
            }
            // print_stack(st);
        } while (st.top() != '$');
        if ((char)str[ptr] == '$')
        {
            return true;
        }
        else
        {
            return false;
        }
    }
    void print_stack(stack<char> st)
    {
        while (!st.empty())
        {
            cout << st.top();
            st.pop();
        }
        cout << endl;
    }
};
int main()
{
    int noOfProductions, noOfTerminals, noOfNonTerminals;
    cout << "Enter the no of terminals: ";
    cin >> noOfTerminals;
    cout << "Enter the no of non terminals: ";
    cin >> noOfNonTerminals;
    cout << "Enter the no of productions: ";
    cin >> noOfProductions;
    Grammar g(noOfTerminals, noOfNonTerminals, noOfProductions);
    cout << "Enter the terminals" << endl;
    g.setTerminals();
```

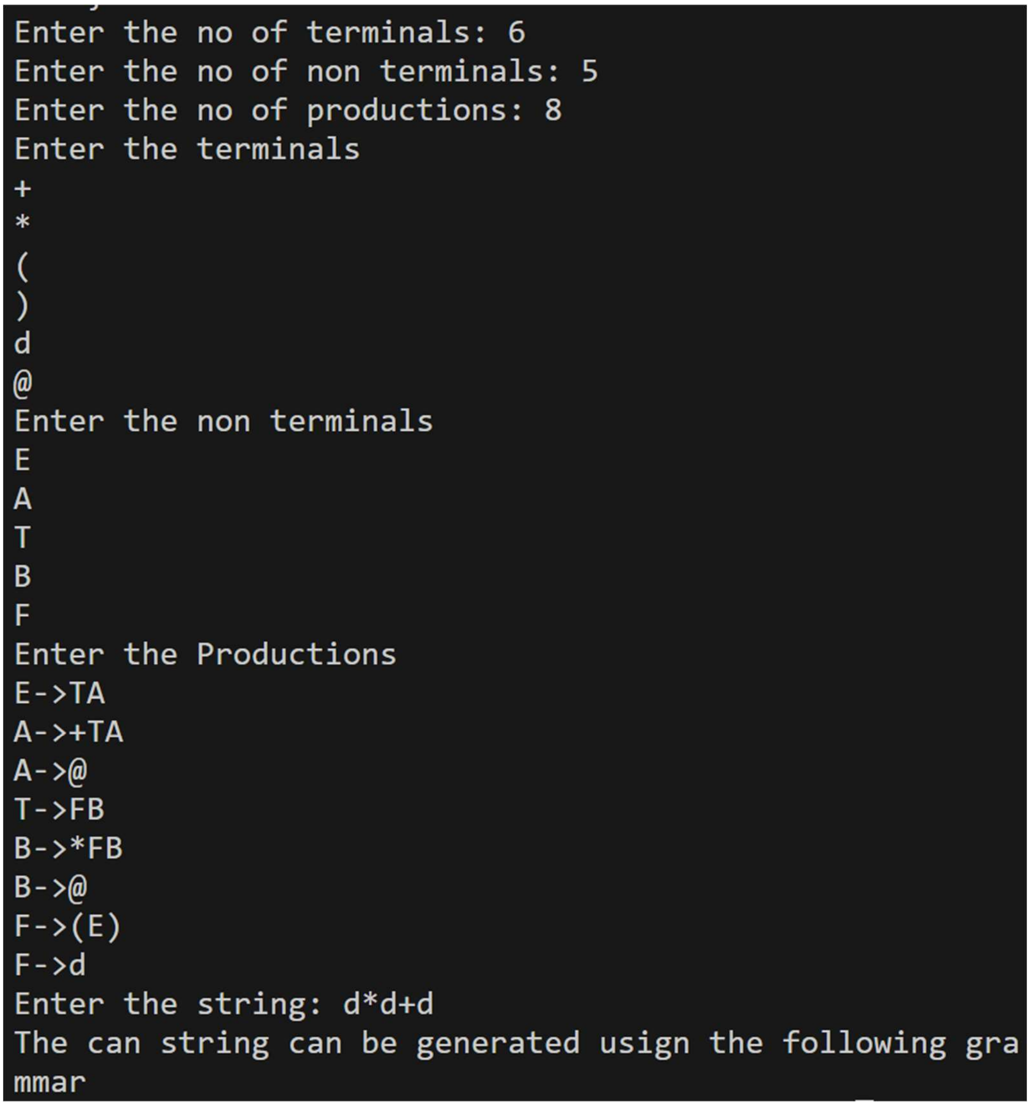


```
    cout << "Enter the non terminals" << endl;
    g.setNonTerminals();
    cout << "Enter the Productions" << endl;
    g.setProductions();
    g.setFirst();
    g.setFollow();
    g.setFirstOfProductions();
    // map<char, set<char>> first = g.getFirst();
    // map<char, set<char>> follow = g.getFollow();
    // map<string, set<char>> firstOfProductions = g.getFirstOfProductions();
    // for (auto pair : first)
    // {
    //     cout << "First(" << pair.first << ")"
    //          << " = ";
    //     for (auto terminal : pair.second)
    //     {
    //         cout << terminal << "  ";
    //     }
    //     cout << endl;
    // }
    // for (auto pair : follow)
    // {
    //     cout << "Follow(" << pair.first << ")"
    //          << " = ";
    //     for (auto terminal : pair.second)
    //     {
    //         cout << terminal << "  ";
    //     }
    //     cout << endl;
    // }
    // for (auto pair : firstOfProductions)
    // {
    //     cout << pair.first << "=";
    //     for (auto terminal : pair.second)
    //     {
    //         cout << terminal << " ";
    //     }
    //     cout << endl;
    // }
    LL1_Parser l1(g);
    // cout << "Parsing Table" << endl;
    l1.createParsingTable();
    // l1.display_parsing_table();
    cout << "Enter the string: ";
    string input;
    cin >> input;
    if (l1.parse(input))
    {
```

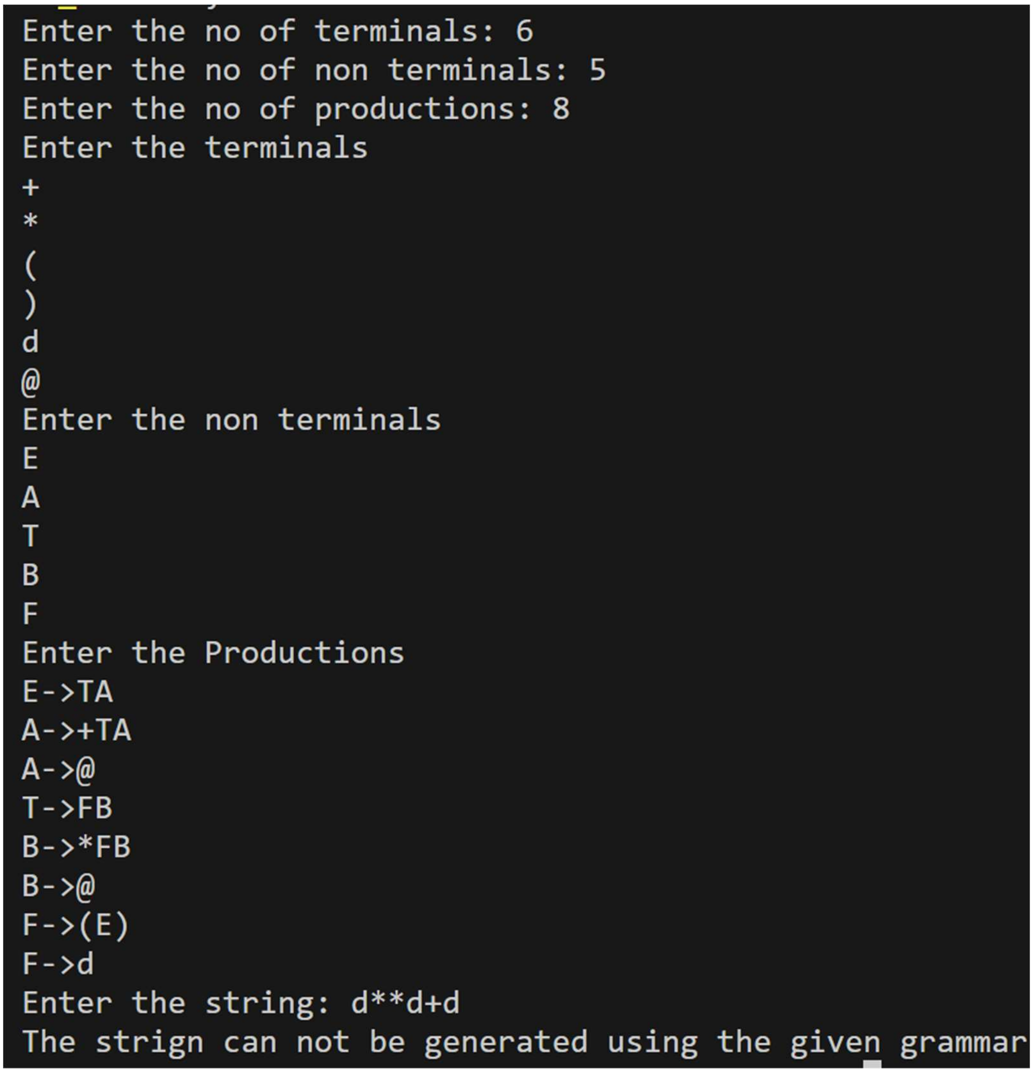


```
        cout << "The can string can be generated usign the following grammar";
    }
    else
    {
        cout << "The strign can not be generated using the given grammar";
    }
    return 0;
}
```

Input & Output:



```
Enter the no of terminals: 6
Enter the no of non terminals: 5
Enter the no of productions: 8
Enter the terminals
+
*
(
)
d
@
Enter the non terminals
E
A
T
B
F
Enter the Productions
E->TA
A->+TA
A->@
T->FB
B->*FB
B->@
F->(E)
F->d
Enter the string: d*d+d
The can string can be generated usign the following gra
mmar
```



```
Enter the no of terminals: 6
Enter the no of non terminals: 5
Enter the no of productions: 8
Enter the terminals
+
*
(
)
d
@
Enter the non terminals
E
A
T
B
F
Enter the Productions
E->TA
A->+TA
A->@
T->FB
B->*FB
B->@
F->(E)
F->d
Enter the string: d**d+d
The strign can not be generated using the given grammar
```