PRACTICAL FILE

COURSE : ARTIFICIAL INTELLIGENCE

SUBJECT CODE : MC 307

B.TECH SEMESTER-V

DEPARTMENT OF APPLIED MATHEMATICS

DELHI TECHNOLOGICAL UNIVERSITY

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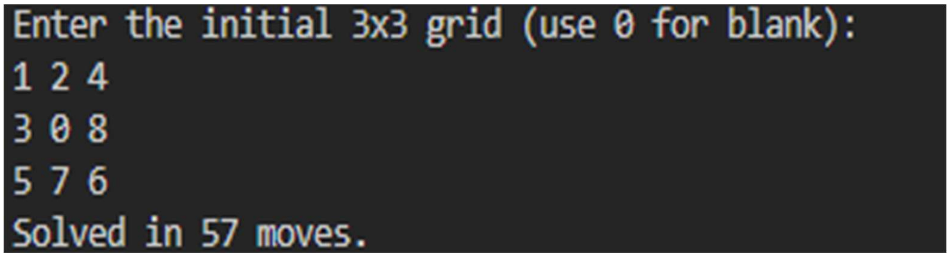
Experiment 1

Aim: Write a program to solve the 8-Puzzle problem using Generate and Test Strategy.

Code:

```
#include<bits/stdc++.h>
using namespace std;

int solve8Puzzle(vector<vector<int>> &grid){
    vector<vector<int>> dir={{1,3},{0,2,4},{1,5},{0,4,6},{1,3,5,7},{2,4,8},{3,7},{4,6,8},{5,7}};
    string start="", goal="123804765";
    int zeroPos;

    for(int i=0;i<3;i++){
        for(int j=0;j<3;j++){
            start+=to_string(grid[i][j]);
            if(grid[i][j]==0) zeroPos=3*i+j;
        }
    }

    queue<pair<string,int>> q;
    unordered_set<string> visited;
    q.emplace(start,zeroPos);
    visited.insert(start);
    int moves=0, sz;

    while(!q.empty()){
        sz=q.size();
        while(sz--){
            auto ele=q.front(); q.pop();
            string state=ele.first;
            int pos=ele.second;
            if(state==goal) return moves;
            for(int next:dir[pos]){
                swap(state[pos],state[next]);
                if(!visited.count(state)){
                    visited.insert(state);
                    q.emplace(state,next);
                }
                swap(state[pos],state[next]);
            }
        }
        moves++;
    }
    return -1;
}

int main(){
    vector<vector<int>> grid(3,vector<int>(3));
    cout<<"Enter the initial 3x3 grid (use 0 for blank):\n";
    for(int i=0;i<3;i++)
        for(int j=0;j<3;j++) cin>>grid[i][j];

    int result=solve8Puzzle(grid);
    if(result!=-1) cout<<"Solved in "<<result<<" moves.\n";
    else cout<<"Unsolvable puzzle.\n";
    return 0;
}
```

Output:



```
Enter the initial 3x3 grid (use 0 for blank):
1 2 4
3 0 8
5 7 6
Solved in 57 moves.
```

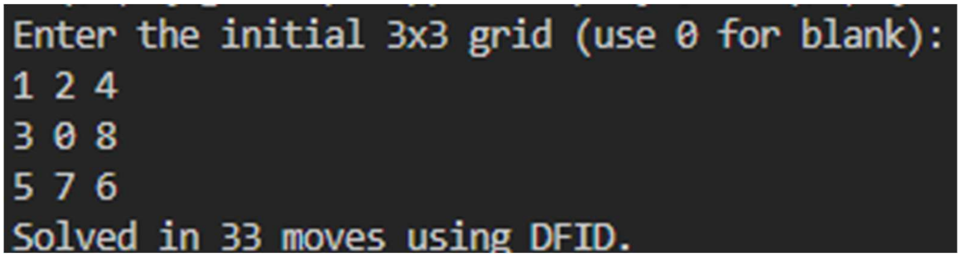
Experiment 2

Aim: Write a program to solve the 8-Puzzle problem using DFID Technique.

Code:

```
#include<bits/stdc++.h>
using namespace std;

vector<vector<int>> dir={{1,3},{0,2,4},{1,5},{0,4,6},{1,3,5,7},{2,4,8},{3,7},{4,6,8},{5,7}};
string goal="123804765";

bool DLS(string state, int pos, int depth, unordered_set<string> &visited){
   if(state==goal) return true;
   if(depth==0) return false;

   visited.insert(state);
   for(int next:dir[pos]){
      swap(state[pos],state[next]);
      if(!visited.count(state)){
         if(DLS(state, next, depth-1, visited)) return true;
      }
      swap(state[pos],state[next]);
   }
   visited.erase(state);
   return false;
}

int DFID(vector<vector<int>> &grid){
   string start="";
   int zeroPos;
   for(int i=0;i<3;i++)
      for(int j=0;j<3;j++){
         start += to_string(grid[i][j]);
         if(grid[i][j]==0) zeroPos = 3*i + j;
      }

   for(int depth=0; depth<=50; depth++){
      unordered_set<string> visited;
      if(DLS(start, zeroPos, depth, visited)) return depth;
   }
   return -1;
}

int main(){
   vector<vector<int>> grid(3,vector<int>(3));
   cout<<"Enter the initial 3x3 grid (use 0 for blank):\n";
   for(int i=0;i<3;i++)
      for(int j=0;j<3;j++) cin>>grid[i][j];

   int result = DFID(grid);
   if(result != -1) cout<<"Solved in "<<result<<" moves using DFID.\n";
   else cout<<"Unsolvable puzzle (or exceeds depth limit).\n";

   return 0;
}
```

Output



```
Enter the initial 3x3 grid (use 0 for blank):
1 2 4
3 0 8
5 7 6
Solved in 33 moves using DFID.
```

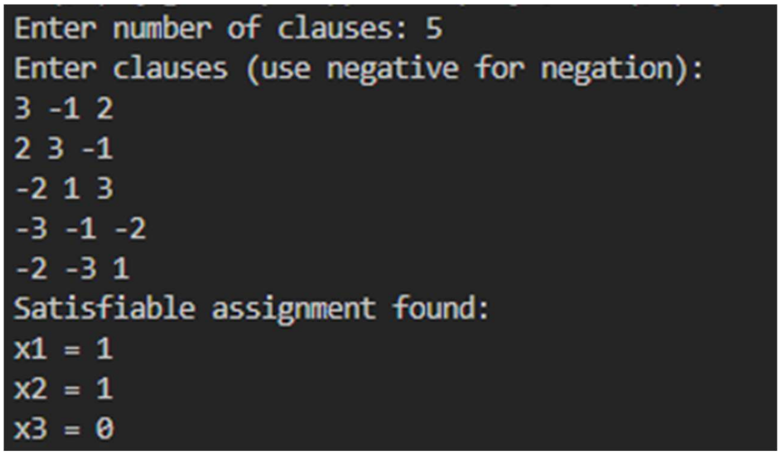
Experiment 3

Aim: Write a program to solve the 3-SAT Problem using Variable Neighbourhood Descent Algorithm.

Code:

```
#include<bits/stdc++.h>
using namespace std;

using Clause = vector<int>;
using Formula = vector<Clause>;

int evaluate(Formula &formula, vector<bool> &assignment) {
    int satisfied = 0;
    for(const auto &clause : formula){
        for(int lit : clause){
            int var = abs(lit) - 1;
            bool val = (lit > 0) ? assignment[var] : !assignment[var];
            if(val){ satisfied++; break; }
        }
    }
    return satisfied;
}

bool VND(const Formula &formula, int nVars, vector<bool> &assignment){
    int totalClauses = formula.size();
    int bestScore = evaluate(formula, assignment);

    while(true){
        bool improved = false;
        for(int i=0;i<nVars;i++){
            assignment[i] = !assignment[i];
            int newScore = evaluate(formula, assignment);
            if(newScore > bestScore){
                bestScore = newScore;
                improved = true;
                break;
            } else assignment[i] = !assignment[i];
        }
        if(!improved) break;
    }

    return bestScore == totalClauses;
}

int main(){
    int nVars=3, nClauses;
    cout << "Enter number of clauses: ";
    cin >> nClauses;

    Formula formula(nClauses);
    cout << "Enter clauses (use negative for negation):\n";
    for(int i=0;i<nClauses;i++){
        Clause clause(3);
        for(int j=0;j<3;j++) cin >> clause[j];
        formula[i] = clause;
    }

    for(int attempt=0;attempt<1000;attempt++){
        vector<bool> assignment(nVars);
        for(int i=0;i<nVars;i++) assignment[i] = rand()%2;

        if(VND(formula, nVars, assignment)){
            cout << "Satisfiable assignment found:\n";
            for(int i=0;i<nVars;i++) cout << "x" << (i+1) << " = " << assignment[i] << "\n";
            return 0;
        }
    }

    cout << "No satisfying assignment found (may be unsatisfiable).\n";
    return 0;
}
```

Output:



```
Enter number of clauses: 5
Enter clauses (use negative for negation):
3 -1 2
2 3 -1
-2 1 3
-3 -1 -2
-2 -3 1
Satisfiable assignment found:
x1 = 1
x2 = 1
x3 = 0
```

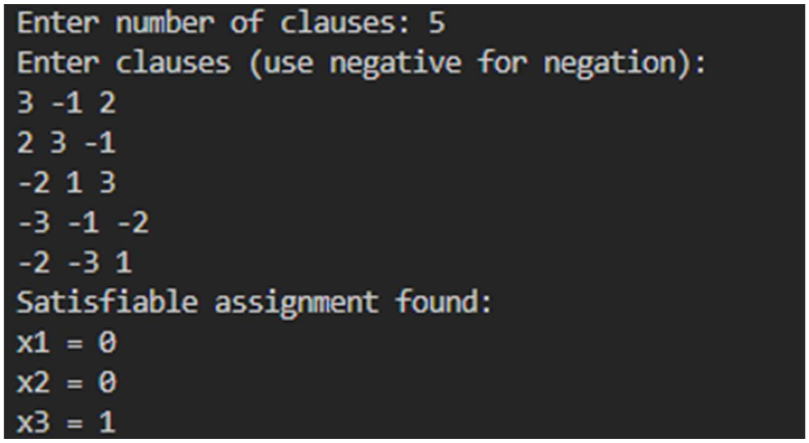
Experiment 4

Aim: Write a program to solve the 3- SAT Problem using Stochastic Hill Climbing Algorithm.

Code:

```
#include<bits/stdc++.h>
using namespace std;

using Clause = vector<int>;
using Formula = vector<Clause>;

int evaluate(Formula &formula, vector<bool> &assignment) {
    int satisfied = 0;
    for(const auto &clause : formula){
        for(int lit : clause){
            int var = abs(lit) - 1;
            bool val = (lit > 0) ? assignment[var] : !assignment[var];
            if(val){ satisfied++; break; }
        }
    }
    return satisfied;
}

bool stochasticHillClimbing(Formula &formula, int nVars, vector<bool> &assignment, int maxIter = 10000){
    int totalClauses = formula.size();
    int bestScore = evaluate(formula, assignment);

    for(int iter=0;iter<maxIter;iter++){
        int var = rand() % nVars;
        assignment[var] = !assignment[var];

        int newScore = evaluate(formula, assignment);
        if(newScore >= bestScore){
            bestScore = newScore;
            if(bestScore == totalClauses) return true;
        } else {
            assignment[var] = !assignment[var];
        }
    }

    return false;
}

int main(){
    srand(time(0));

    int nVars, nClauses;
    cout << "Enter number of variables and clauses: ";
    cin >> nVars >> nClauses;

    Formula formula(nClauses);
    cout << "Enter clauses (use negative for negation):\n";
    for(int i=0;i<nClauses;i++){
        Clause clause(3);
        for(int j=0;j<3;j++) cin >> clause[j];
        formula[i] = clause;
    }

    for(int attempt=0;attempt<100;attempt++){
        vector<bool> assignment(nVars);
        for(int i=0;i<nVars;i++) assignment[i] = rand() % 2;

        if(stochasticHillClimbing(formula, nVars, assignment)){
            cout << "Satisfiable assignment found:\n";
            for(int i=0;i<nVars;i++)
                cout << "x" << (i+1) << " = " << assignment[i] << "\n";
            return 0;
        }
    }

    cout << "No satisfying assignment found (may be unsatisfiable).\n";
    return 0;
}
```

Output:



```
Enter number of clauses: 5
Enter clauses (use negative for negation):
3 -1 2
2 3 -1
-2 1 3
-3 -1 -2
-2 -3 1
Satisfiable assignment found:
x1 = 0
x2 = 0
x3 = 1
```

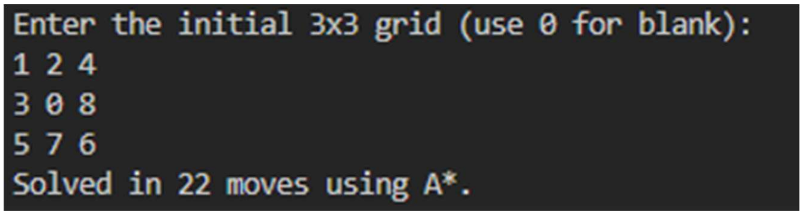
Experiment 5

Aim: Write a program to solve the 8-Puzzle problem using A* algorithm.

Code:

```
#include<bits/stdc++.h>
using namespace std;

int heuristic(string &state, string &goal){
    int cnt=0;
    for(int i=0;i<9;i++) cnt+=(state[i]!=goal[i]);
    return cnt;
}

int solve8PuzzleAStar(vector<vector<int>> &grid){
    vector<vector<int>> dir={{1,3},{0,2,4},{1,5},{0,4,6},{1,3,5,7},{2,4,8},{3,7},{4,6,8},{5,7}};
    string start="", goal="123804765";
    int zeroPos;

    for(int i=0;i<3;i++)
        for(int j=0;j<3;j++){
            start+=to_string(grid[i][j]);
            if(grid[i][j]==0) zeroPos=3*i+j;
        }

    using State=tuple<int,int,string,int>; // f, g, state, pos
    priority_queue<State,vector<State>,greater<State>> pq;
    unordered_set<string> visited;

    int h=heuristic(start,goal);
    pq.emplace(h,0,start,zeroPos);
    visited.insert(start);

    while(!pq.empty()){
        State S=pq.top(); pq.pop();
        int f=get<0>(S), g=get<1>(S), pos=get<3>(S);
        string state=get<2>(S);
        if(state==goal) return g;
        for(int next:dir[pos]){
            swap(state[pos],state[next]);
            if(!visited.count(state)){
                int h=heuristic(state,goal);
                pq.emplace(g+1+h,g+1,state,next);
                visited.insert(state);
            }
            swap(state[pos],state[next]);
        }
    }
    return -1;
}

int main(){
    vector<vector<int>> grid(3,vector<int>(3));
    cout<<"Enter the initial 3x3 grid (use 0 for blank):\n";
    for(int i=0;i<3;i++)
        for(int j=0;j<3;j++) cin>>grid[i][j];

    int result=solve8PuzzleAStar(grid);
    if(result!=-1) cout<<"Solved in "<<result<<" moves using A*.\n";
    else cout<<"Unsolvable puzzle.\n";

    return 0;
}
```

Output:



```
Enter the initial 3x3 grid (use 0 for blank):
1 2 4
3 0 8
5 7 6
Solved in 22 moves using A*.
```

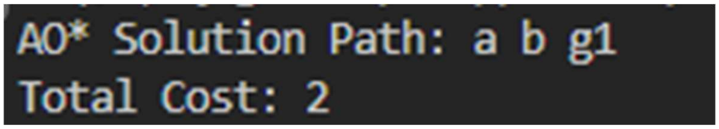
Experiment 6

Aim: Write a program to solve AND OR Graph using AO* Search Algorithm.

Code:

```
#include <bits/stdc++.h>
using namespace std;

struct Node {
    string name;
    vector<vector<string>> children;
    vector<int> costs;
    bool solved = false;
    int finalCost = INT_MAX;
    vector<string> solution;
};

unordered_map<string, Node> graph;

// Function to recursively apply AO* Search
pair<vector<string>, int> aoStar(string nodeName) {
    Node &node = graph[nodeName];

    if (node.solved) return {node.solution, node.finalCost};

    // Goal node (no children)
    if (node.children.empty()) {
        node.solved = true;
        node.finalCost = 0;
        node.solution = {nodeName};
        return {node.solution, 0};
    }

    int minCost = INT_MAX;
    vector<string> bestSol;

    for (int i = 0; i < node.children.size(); ++i) {
        int cost = node.costs[i];
        vector<string> tempSol = {nodeName};
        int subCost = 0;
        bool allSolved = true;

        for (const string &child : node.children[i]) {
            auto ele = aoStar(child);
            vector<string> sol=ele.first;
            int c=ele.second;
            if (graph[child].solved) {
                tempSol.insert(tempSol.end(), sol.begin(), sol.end());
                subCost += c;
            } else {
                allSolved = false;
                break;
            }
        }

        if (allSolved && cost + subCost < minCost) {
            minCost = cost + subCost;
            bestSol = tempSol;
        }
    }
    node.solved = true;
    node.finalCost = minCost;
    node.solution = bestSol;
    return {bestSol, minCost};
}

int main() {
    graph["g1"] = {"g1", {}, {}, true, 0, {"g1"}};
    graph["g2"] = {"g2", {}, {}, true, 0, {"g2"}};
    graph["g3"] = {"g3", {}, {}, true, 0, {"g3"}};

    graph["b"] = {"b", {{"g1"}}, {1}};
    graph["c"] = {"c", {{"g2", "g3"}}, {2}};

    graph["a"] = {"a", {{"b"}, {"c"}}, {1, 2}};

    auto ele = aoStar("a");
    vector<string> solution=ele.first;
    int cost=ele.second;

    cout << "AO* Solution Path: ";
    for (auto &node : solution) cout << node << " ";
    cout << "\nTotal Cost: " << cost << endl;

    return 0;
}
```

Output:



```
AO* Solution Path: a b g1
Total Cost: 2
```

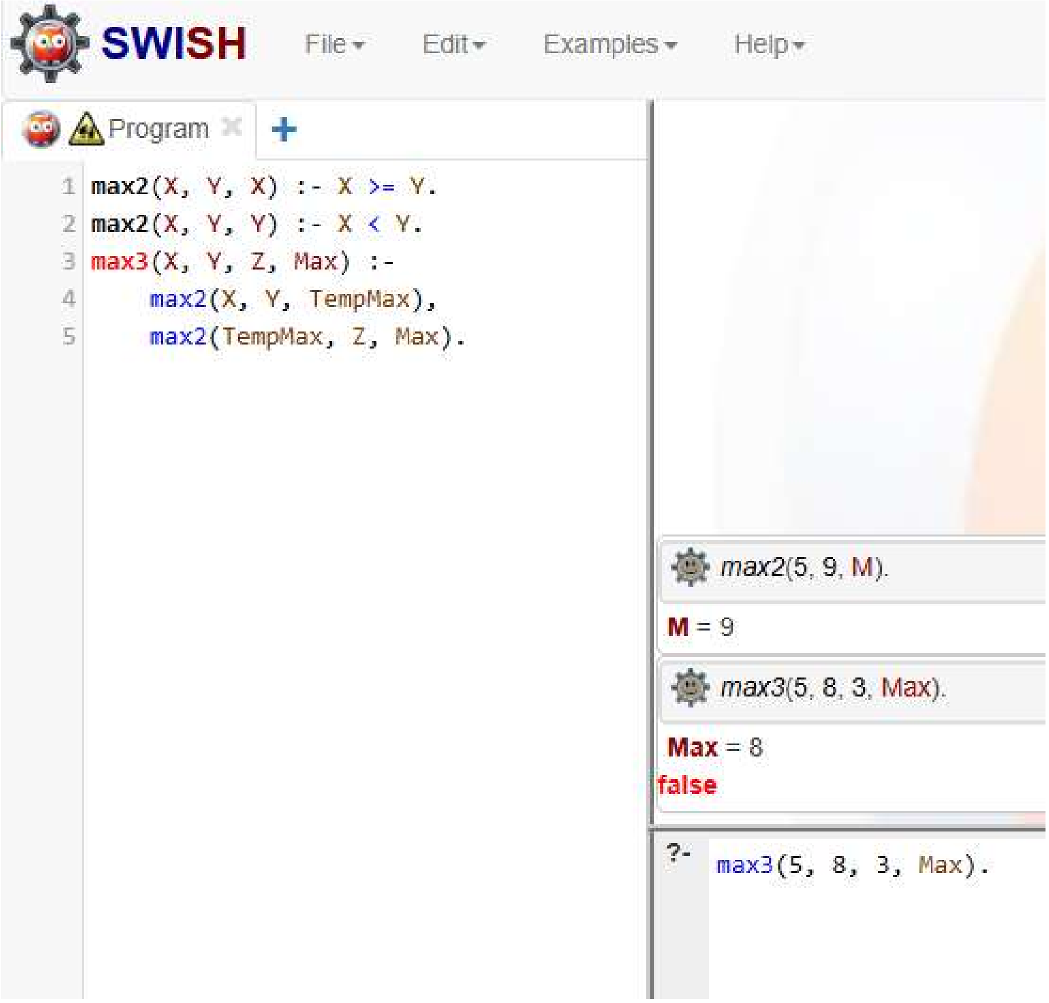
Experiment 7

Aim: **WAP to find maximum of two/three numbers.**

Code:

```
max2(X, Y, X) :- X >= Y.
max2(X, Y, Y) :- X < Y.
max3(X, Y, Z, Max) :-
   max2(X, Y, TempMax),
   max2(TempMax, Z, Max).
```

Output:



```
max2(X, Y, X) :- X >= Y.
max2(X, Y, Y) :- X < Y.
max3(X, Y, Z, Max) :-
    max2(X, Y, TempMax),
    max2(TempMax, Z, Max).
```

```
max2(5, 9, M).
M = 9
max3(5, 8, 3, Max).
Max = 8
false
?- max3(5, 8, 3, Max).
```

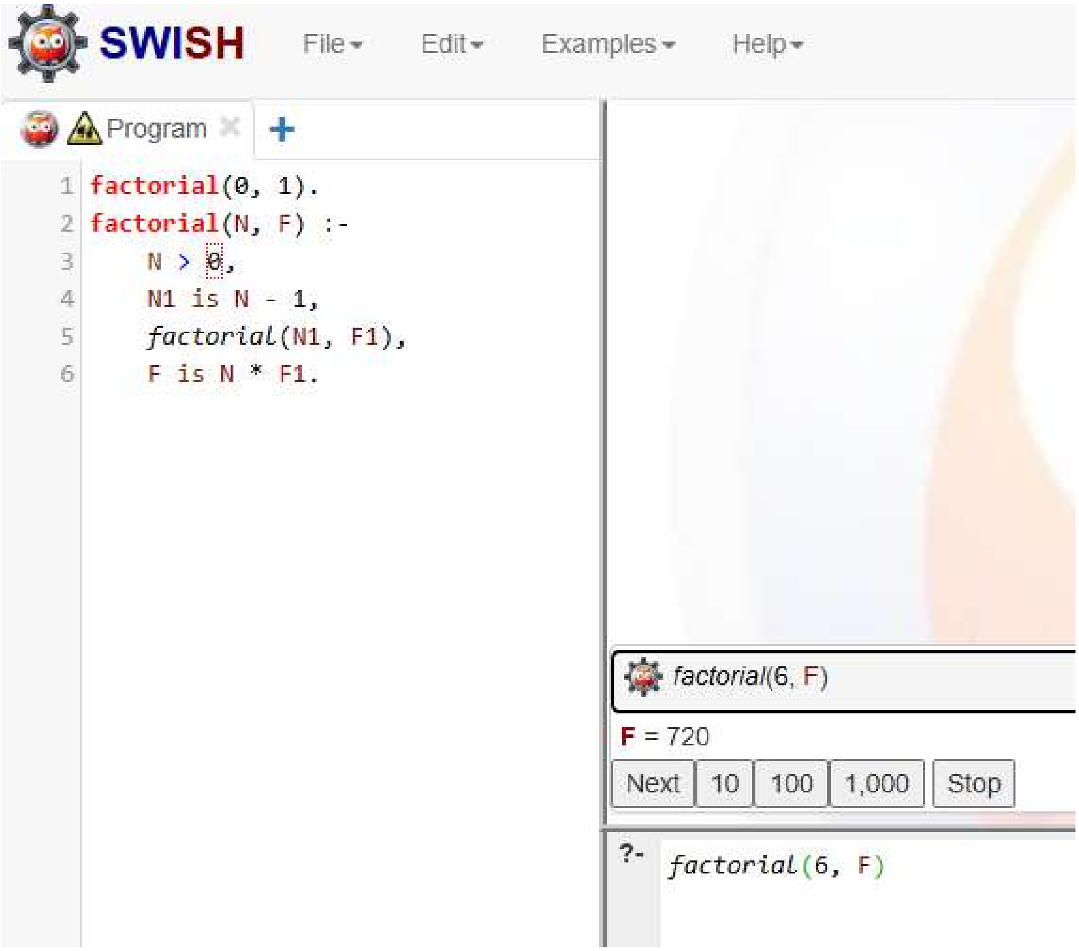
Experiment 8

Aim: **WAP to find factorial of a number.**

Code:

```
factorial(0, 1).
factorial(N, F) :-
   N > 0,
   N1 is N - 1,
   factorial(N1, F1),
   F is N * F1.
```

Output:



```
factorial(0, 1).
factorial(N, F) :-
    N > 0,
    N1 is N - 1,
    factorial(N1, F1),
    F is N * F1.
```

```
factorial(6, F)
F = 720
```

```
?- factorial(6, F)
```

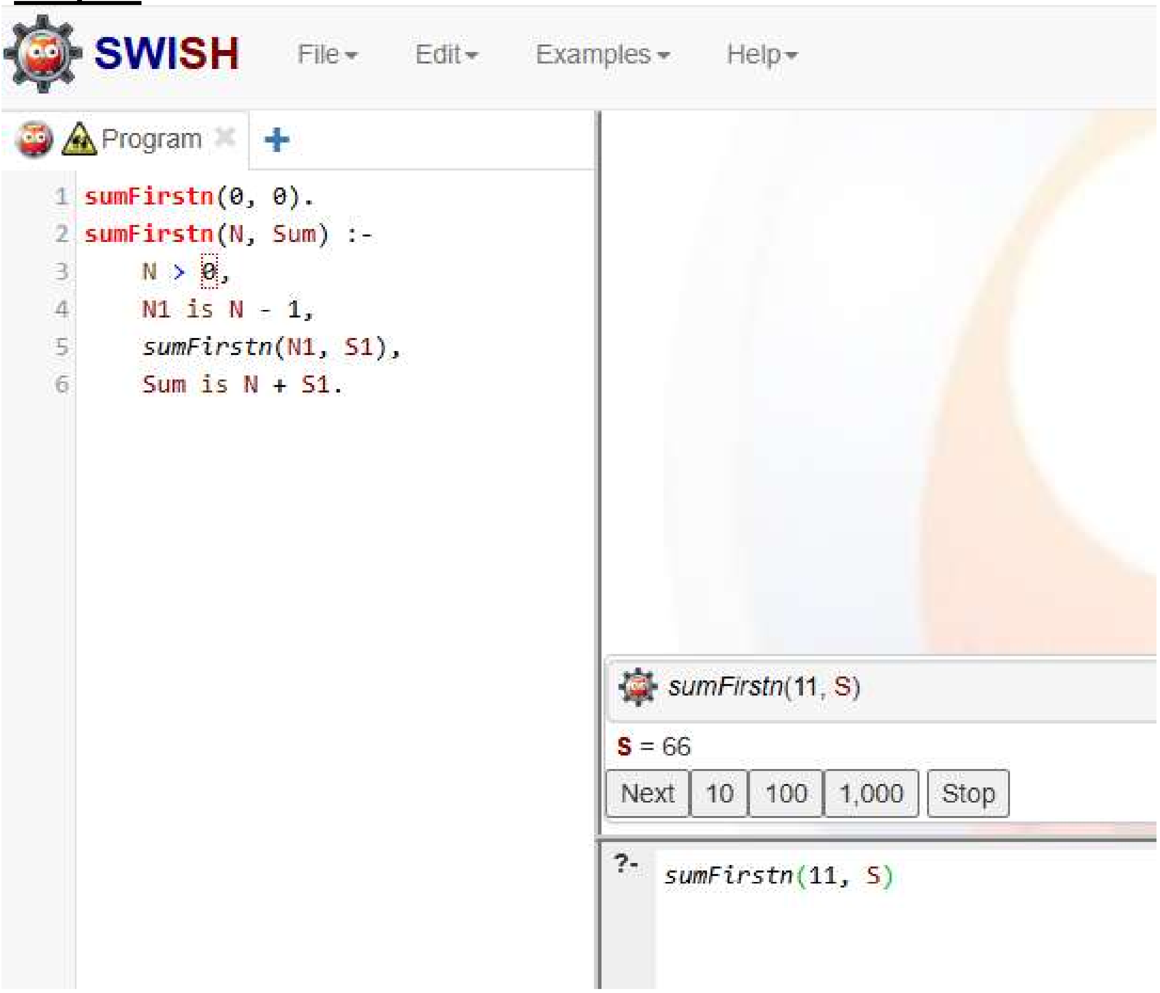
Experiment 9

Aim: WAP to find sum of first N numbers.

Code:

```
sumFirstn(0, 0).
sumFirstn(N, Sum) :-
   N > 0,
   N1 is N - 1,
   sumFirstn(N1, S1),
   Sum is N + S1.
```

Output:



```
sumFirstn(0, 0).
sumFirstn(N, Sum) :-
    N > 0,
    N1 is N - 1,
    sumFirstn(N1, S1),
    Sum is N + S1.
```

```
sumFirstn(11, S)
S = 66
```

```
?- sumFirstn(11, S)
```

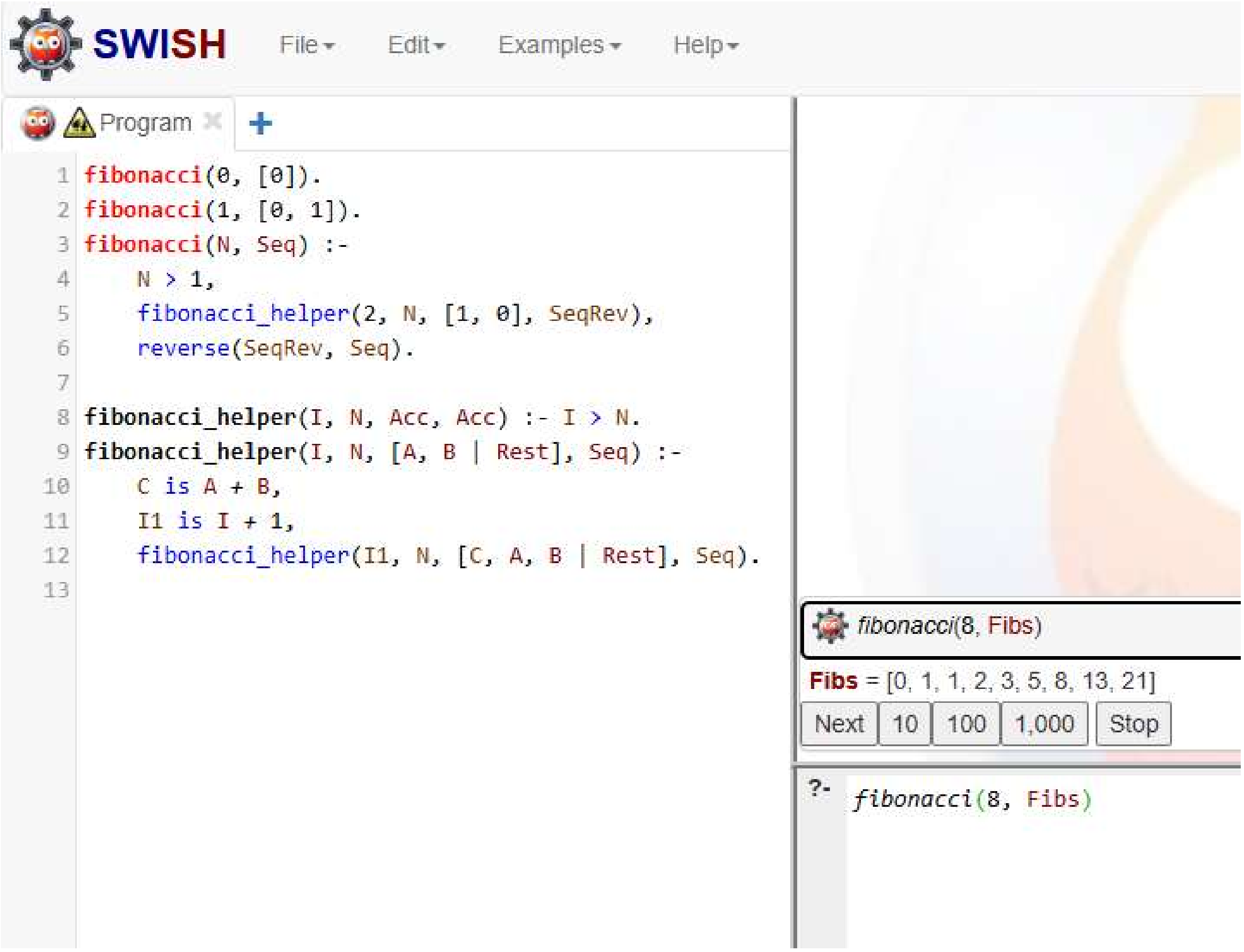
Experiment 10

Aim: **Write a program to find Fibonacci sequence upto Nth term.**

Code:

```
fibonacci(0, [0]).
fibonacci(1, [0, 1]).
fibonacci(N, Seq) :-
    N > 1,
    fibonacci_helper(2, N, [1, 0], SeqRev),
    reverse(SeqRev, Seq).

fibonacci_helper(I, N, Acc, Acc) :- I > N.
fibonacci_helper(I, N, [A, B | Rest], Seq) :-
    C is A + B,
    I1 is I + 1,
    fibonacci_helper(I1, N, [C, A, B | Rest], Seq).
```

Output:



```
fibonacci(0, [0]).
fibonacci(1, [0, 1]).
fibonacci(N, Seq) :-
    N > 1,
    fibonacci_helper(2, N, [1, 0], SeqRev),
    reverse(SeqRev, Seq).

fibonacci_helper(I, N, Acc, Acc) :- I > N.
fibonacci_helper(I, N, [A, B | Rest], Seq) :-
    C is A + B,
    I1 is I + 1,
    fibonacci_helper(I1, N, [C, A, B | Rest], Seq).
```

```
fibonacci(8, Fibs)
Fibs = [0, 1, 1, 2, 3, 5, 8, 13, 21]
```

```
?- fibonacci(8, Fibs)
```