VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
On

ARTIFICIAL INTELLIGENCE

Submitted by

JAGADEESH A LATTI (1BM21CS079)

in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
(Autonomous Institution under VTU)
BENGALURU-560019
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B. M. S. College of Engineering,
Bull Temple Road, Bangalore 560019
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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled **"ARTIFICIAL INTELLIGENCE"** carried out by **JAGADEESH A LATTI (1BM21CS079)**, who is bonafide student of **B. M. S. College of Engineering**. It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2022-23. The Lab report has been approved as it satisfies the academic requirements in respect of Artificial Intelligence Lab - **(22CS5PCAIN)**work prescribed for the said degree.

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1.Implement Tic –Tac –Toe Game.

```
if(xstate[choice]!=1 and zstate[choice]!=1):
    zstate[choice]=1
    count+=1
else:
    print("Already this space is occupied,
          Try again")
    continue
Cwin=checkwin(xstate,zstate)

if(Cwin!=-1):
    print("Match over")
    printboard(xstate,z_state)
    turn=False
    break
if(count==9):
    print("Match over")
    print("No space left")
    turn=False
    break
turn=1-turn
```

Algorithm:

1) sum(a,b,c):
   - This function takes 3 inputs & returns their sum

2) printboard(xstate,zstate):
   a) It prints tic-tac-toe board based on current states of x & z.
   b) It converts the state of each cell to 'x' if x has marked it, 'O' if z has marked

it or else cell number.

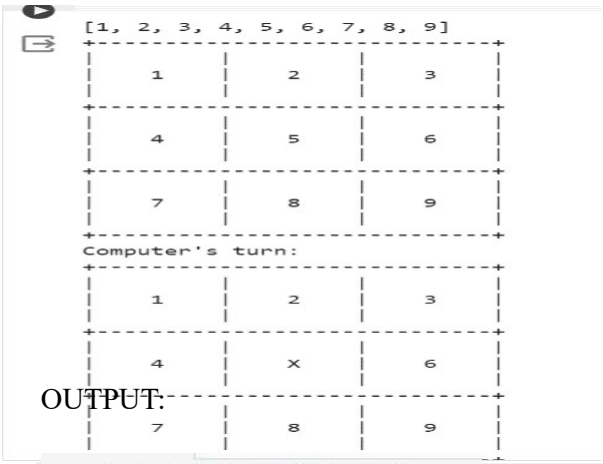
3) checkwin(xstate, zstate) {
   a) It checks who won the game
   b) It checks all possible winning combinations
   1) If x wins, it prints & returns 1
   2) if z wins, it prints & returns 0
   3) if there is no winner, it returns -1

4.
   a. The game runs in a loop until it is explicitly terminated.
   b) The game alternates turns between x & z until there is a winner or a draw.
   c) Printboard function is called to print current state of board.
   d) The checkwin function is called after each move to check if there's winner.
   e) Game ends when there is a winner or all spaces are filled.

Output:

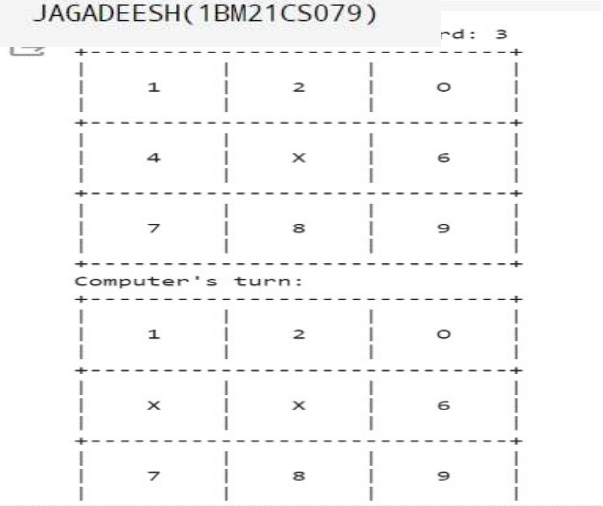
```
0 | 1 | 2
3 | 4 | 5
6 | 7 | 8

x's turn, Enter a number: 0
x | 1 | 2
3 | 4 | 5
6 | 7 | 8
```

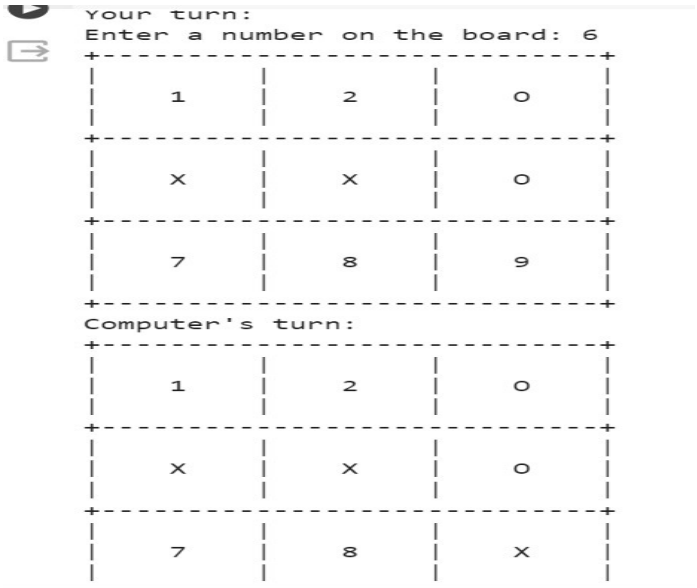
OUTPUT:



OUTPUT:

JAGADEESH(1BM21CS079)





```
Your turn:
Enter a number on the board: 1
+-------------------------------+
|               |               |
|       O       |       2       |       O       |
|               |               |
+-------------------------------+
|               |               |
|       X       |       X       |       O       |
|               |               |
+-------------------------------+
|               |               |
|       7       |       8       |       X       |
|               |               |
+-------------------------------+
Computer's turn:
+-------------------------------+
|               |               |
|       O       |       2       |       O       |
|               |               |
+-------------------------------+
|               |               |
|       X       |       X       |       O       |
|               |               |
+-------------------------------+
|               |               |
|       7       |       X       |       X       |
|               |               |
+-------------------------------+
```

```
Your turn:
Enter a number on the board: 2
+-------------------------------+
|               |               |
|       O       |       O       |       O       |
|               |               |
+-------------------------------+
|               |               |
|       X       |       X       |       O       |
|               |               |
+-------------------------------+
|               |               |
|       7       |       X       |       X       |
|               |               |
+-------------------------------+
Computer's turn:
+-------------------------------+
|               |               |
|       O       |       O       |       O       |
|               |               |
+-------------------------------+
|               |               |
|       X       |       X       |       O       |
|               |               |
+-------------------------------+
|               |               |
|       X       |       X       |       X       |
|               |               |
+-------------------------------+
Winner is X
```

2 .Solve 8 puzzle problems.

3. 8-puzzle:

Initialize the puzzle:

1) Create a Puzzle & class with the initial state, goal state, & possible moves

initial = [1, 2, 3, 4, 5, 6, 0, 7, 8]

goal = [1, 2, 3, 4, 5, 6, 7, 8, 0]

moves = [(0, 1), (1, 0), (0, -1), (-1, 0)]

2) define methods to print the current state, check if the puzzle is solved, get the index of blank tile & apply move.

Print current state:

for i in range(0, 9, 3):

print(state[i : i + 3])

Check if Puzzle is solved:

state == self.goal

Get index of the blank tile (represented by '0')

Apply move function:

Implement a method to apply a move to the current state, swapping the blank tile with adjacent tile.

BFS Algorithm

Initialize visited set to keep track of puzzle state to avoid revisiting.
visited = set()

Create an empty queue. It stores tuples where each tuple consists of puzzle state & corresponding path taken to reach state.
queue = deque()
queue.put((self.initial_state, [7]))

until queue is empty run the loop.
i) Deque a state & its path.
ii) Check if the state is the goal state.
if yes print solution path & break out of loop.

iii) if state is not visited
mark it as visited
iv) Get index of blank tile
v) Apply all move & execute the resulting state & path

Initial state: [1, 2, 3, 4, 5, 6, 0, 7]
Queue: [(new state 1, [move 1]), (new state 2, [move 2])]

OUTPUT

```
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```
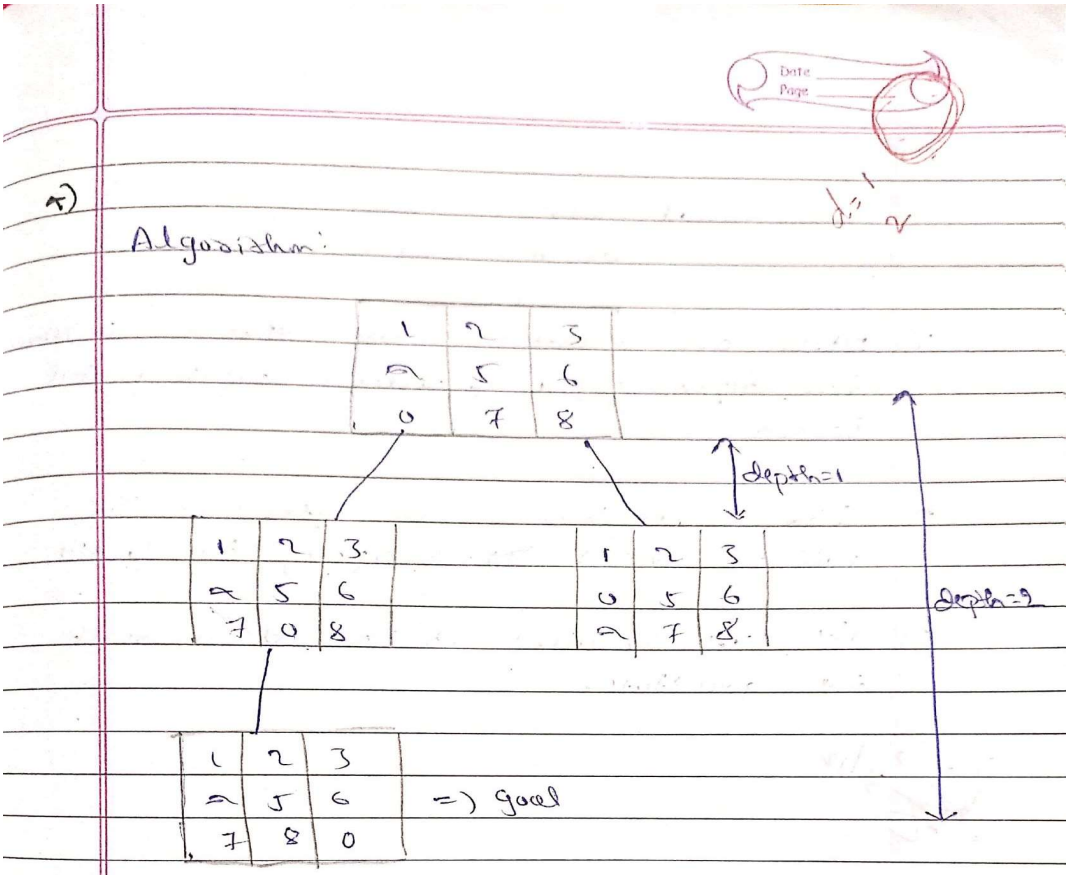

```
1 | 2 | 3
4 | 5 | 6
0 | 7 | 8
-----------
1 | 2 | 3
0 | 5 | 6
4 | 7 | 8
-----------
1 | 2 | 3
4 | 5 | 6
7 | 0 | 8
-----------
0 | 2 | 3
1 | 5 | 6
4 | 7 | 8
-----------
1 | 2 | 3
5 | 0 | 6
4 | 7 | 8
-----------
1 | 2 | 3
4 | 0 | 6
7 | 5 | 8
-----------
1 | 2 | 3
4 | 5 | 6
7 | 8 | 0
-----------
Success
```

3. Implement Iterative deepening search algorithm.



Algorithm:

1) Initialize the initial state = [ ] & goal state for the 8-puzzle.
goal state: [1, 2, 3, 4, 5, 7, 8, 0]

2) set the depth=1 & expand the initial state
The depth_limited_search(depth) is performed
if node.state = goal
return node
else
for neighbour in get_neighbours(node.state)
child = puzzlenode(neighbour, node)
result = depth_limited_search(depth-1)

if result != Failure:
    return result

3) After one iteration where depth > 1, increase the depth by 1 & perform depth limited search.

4) Now get_neighbours will generate the possible moves by swapping the '0' tile

5) The path traversed is printed to reach the goal state.

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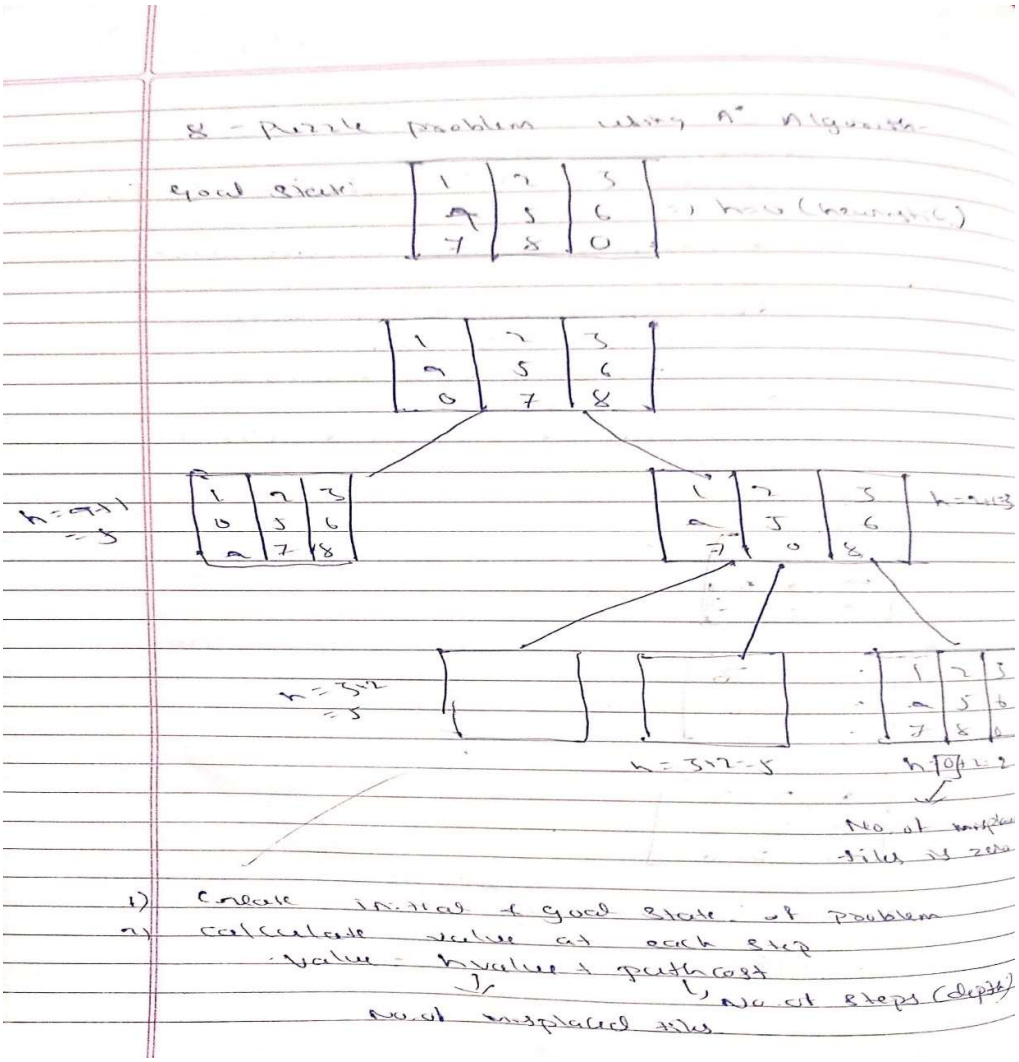
OUTPUT

```
input
Success!! It is possible to solve 8 Puzzle problem
Path: [[1, 2, 3, 0, 4, 6, 7, 5, 8], [1, 2, 3, 4, 0, 6, 7, 5, 8], [1, 2, 3, 4, 5, 6, 7, 0, 8], [1, 2, 3, 4, 5, 6, 7, 8, 0]]


...Program finished with exit code 0
Press ENTER to exit console.
```

4. Implement A* search algorithm.



3) Go to direction where h value is less.

4) All nods stored in open list (keep track of all nods).

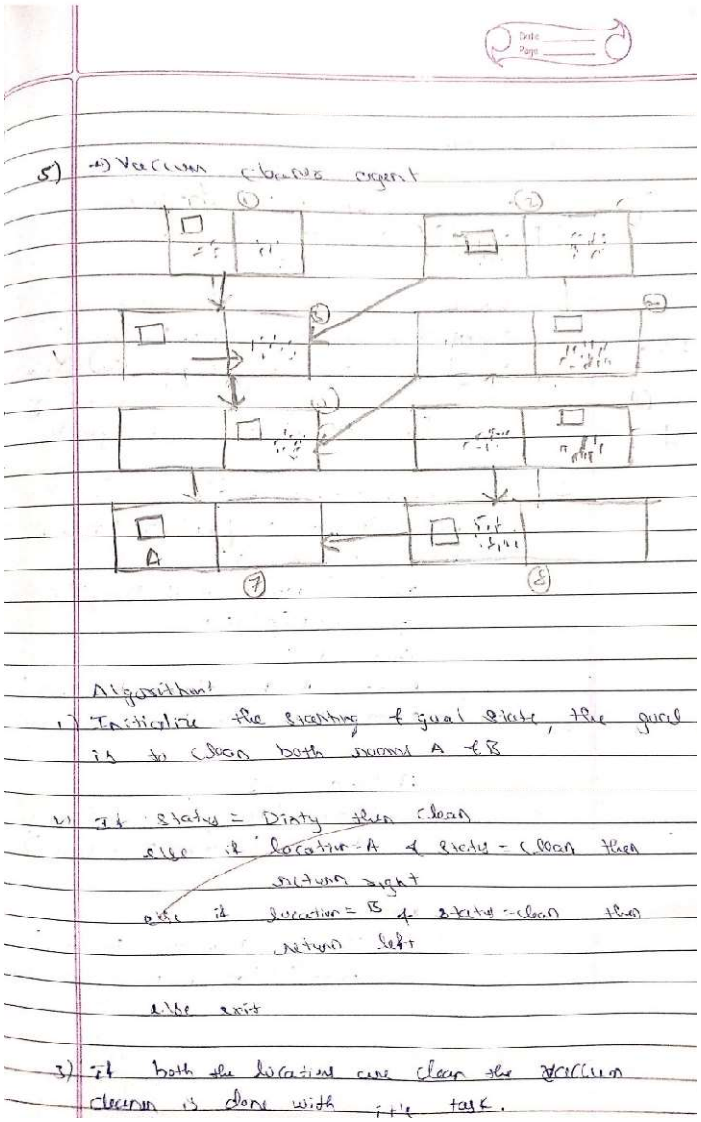
5) Explore nodes stored in closed list.

6) Goal is when h value is 0, implies that we have reached final state.

OUTPUT

```
Success! 8 puzzle problem solved
Path: [[1, 2, 3, 0, 4, 6, 7, 5, 8], [1, 2, 3, 4, 0, 6, 7, 5, 8], [1, 2, 3, 4, 5, 6, 7, 0, 8], [1, 2, 3, 4, 5, 6, 7, 8, 0]]
```

5. Implement vaccum cleaner agent.

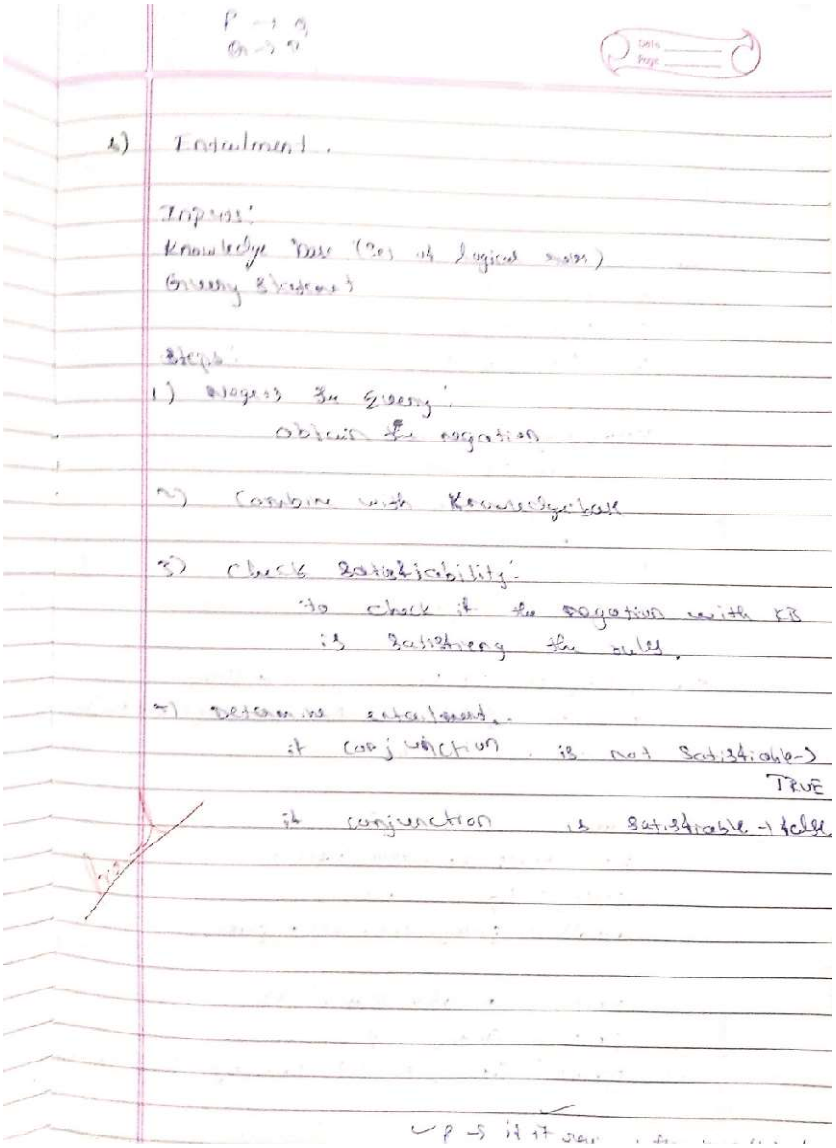


OUTPUT:

```
JAGADEESH(1BM21CS079)
```

```
Enter Location of Vacuumb
Enter status of b1
Enter status of other room1
Initial Location Condition{'A': '0', 'B': '0'}
Vacuum is placed in location B
Location B is Dirty.
COST for CLEANING 1
Location B has been Cleaned.
Location A is Dirty.
Moving LEFT to the Location A.
COST for moving LEFT2
COST for SUCK 3
Location A has been Cleaned.
GOAL STATE:
{'A': '0', 'B': '0'}
Performance Measurement: 3
```

6. Create a knowledge base using prepositional logic and show that the given query entails the knowledge base or not .



OUTPUT:

```
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```
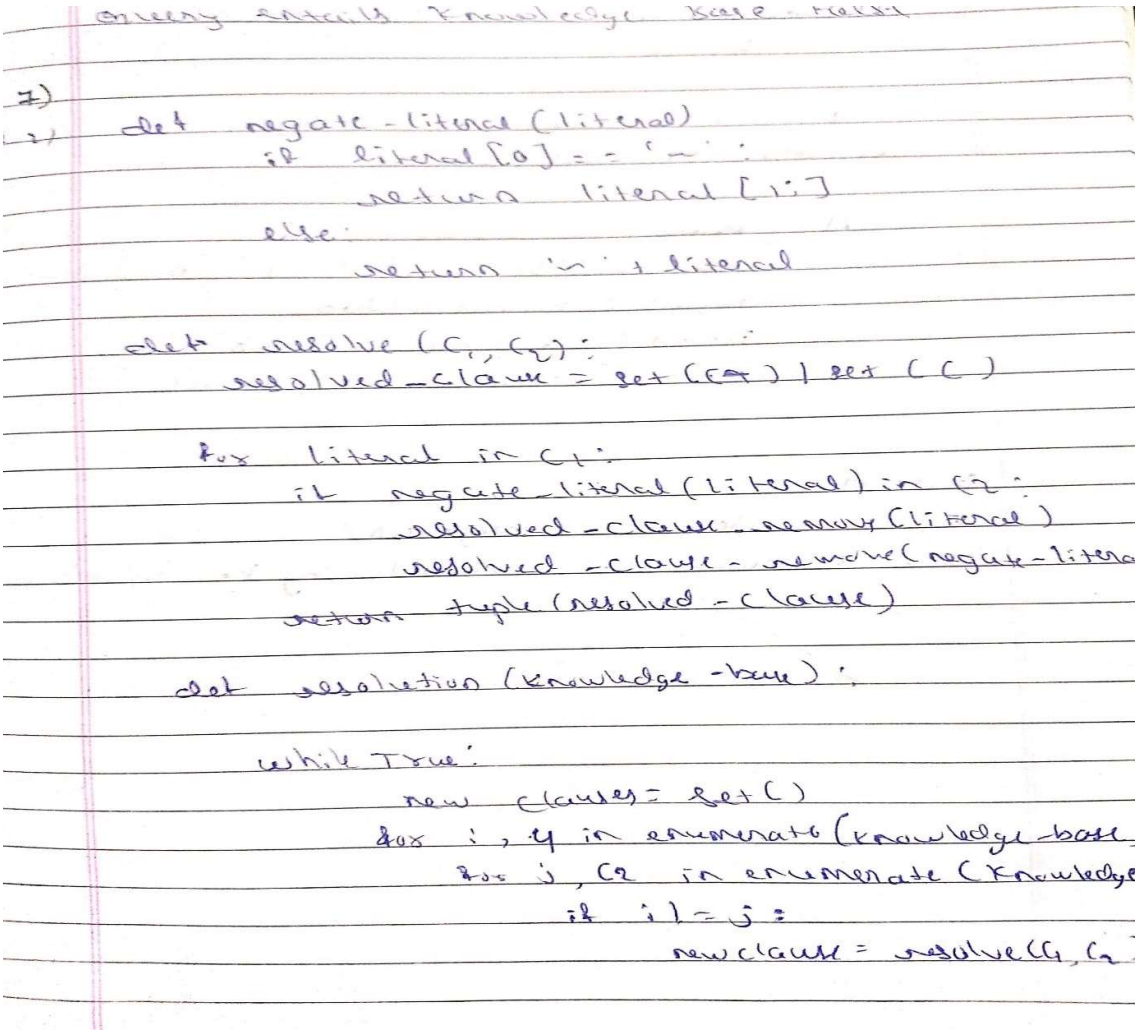

```
Enter the knowledge base: (p^q)v(~pvq)
Enter the query: pvq
[True, True, True] :kb= True :q= True
[True, True, False] :kb= True :q= True
[True, False, True] :kb= False :q= True
[True, False, False] :kb= False :q= True
[False, True, True] :kb= True :q= True
[False, True, False] :kb= True :q= True
[False, False, True] :kb= True :q= False
Doesn't entail!!
```

7. Create a knowledge base using prepositional logic and prove the given query using resolution



```
7)
def negate_literal(literal):
    if literal[0] == '~':
        return literal[1:]
    else:
        return '~' + literal

def resolve(C1, C2):
    resolved_clause = set(C1) | set(C2)

    for literal in C1:
        if negate_literal(literal) in C2:
            resolved_clause.remove(literal)
            resolved_clause.remove(negate_litera
            return tuple(resolved_clause)

def resolution(knowledge_base):

    while True:
        new_clauses = set()
        for i, C1 in enumerate(knowledge_base
            for j, C2 in enumerate(knowledge
                if i != j:
                    new_clause = resolve(C1, C2
```

```
        if len(new_clause)>0 and new_clause not
                                    knowledge_base
            new_clause.add(new_clause)

    if not new_clause
        break

knowledge_base1 = new_clause
return knowledge_base

if __name__ == "__main__":
    kb = Clause('p','q'), ('~p','r'), ('~q','~r')
    result = resolution(kb)
    print("original kb", kb)
    print("resolved KB", result)
```

Output:

Enter statement = Negative

The statement not entailed by knowledge-based

OUTPUT:

```
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Enter the clauses separated by a space: p v ~q ~r v p ~q
Enter the query: ~p
Trying to prove (p)^(v)^(~q)^(~r)^(v)^(p)^(~q)^(~p) by contradiction....
Knowledge Base entails the query, proved by resolution
```
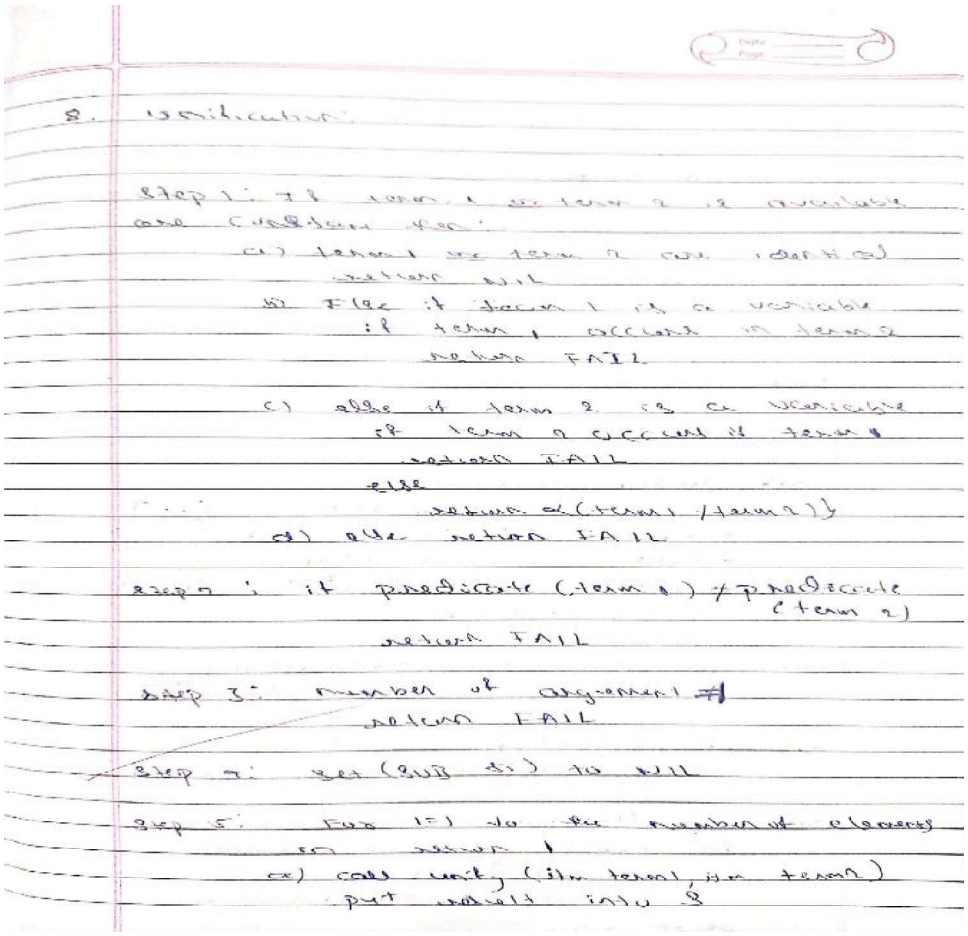
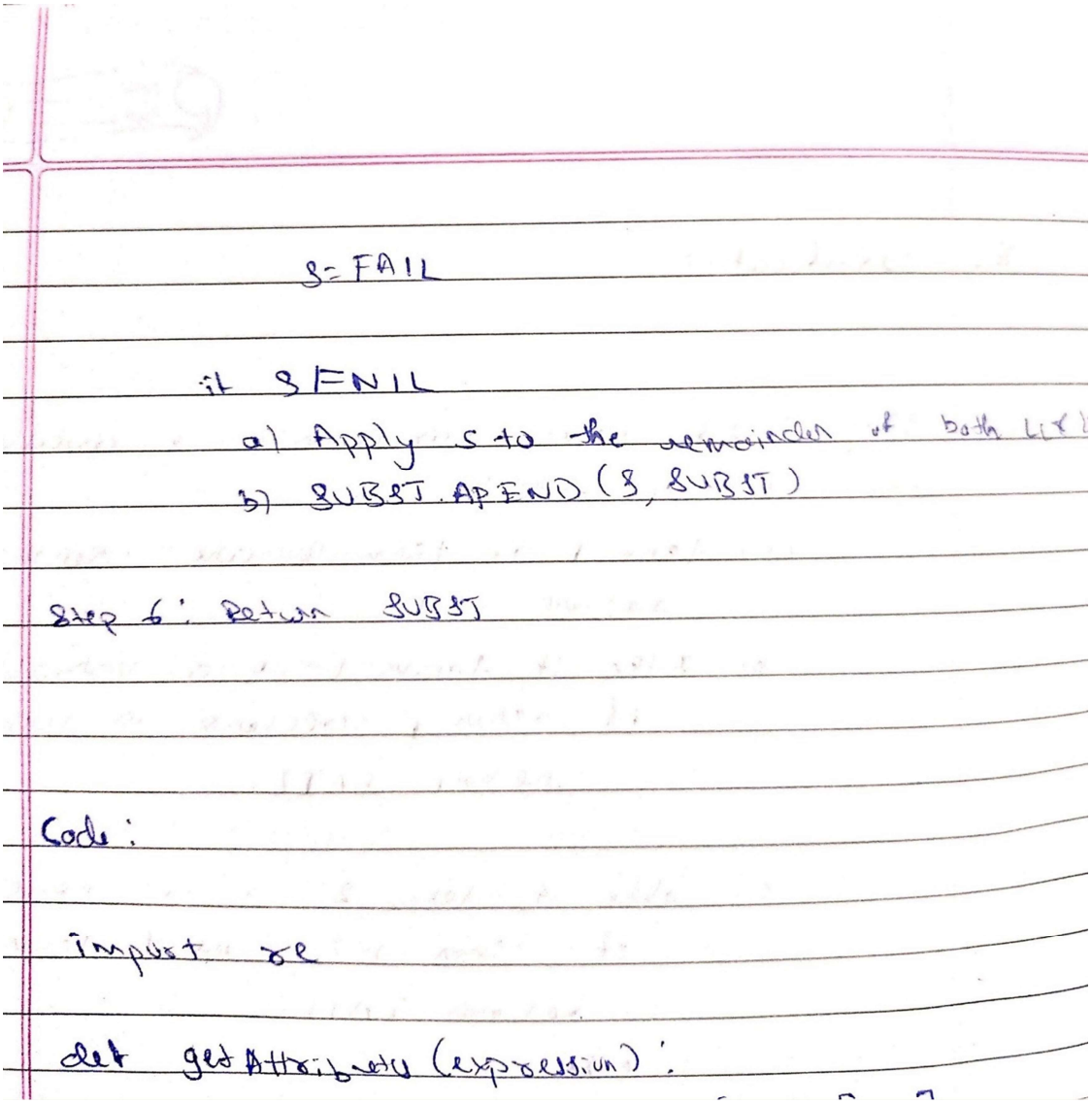

```
Step    |Clause |Derivation
------------------------------
 1.     | Rv~P  | Given.
 2.     | Rv~Q  | Given.
 3.     | ~RvP  | Given.
 4.     | ~RvQ  | Given.
 5.     | ~R    | Negated conclusion.
 6.     |       | Resolved Rv~P and ~RvP to Rv~R, which is in turn null.
A contradiction is found when ~R is assumed as true. Hence, R is true.
```

```
Step    |Clause |Derivation
------------------------------
 1.     | PvQ   | Given.
 2.     | ~PvR  | Given.
 3.     | ~QvR  | Given.
 4.     | ~R    | Negated conclusion.
 5.     | QvR   | Resolved from PvQ and ~PvR.
 6.     | PvR   | Resolved from PvQ and ~QvR.
 7.     | ~P    | Resolved from ~PvR and ~R.
 8.     | ~Q    | Resolved from ~QvR and ~R.
 9.     | Q     | Resolved from ~R and QvR.
 10.    | P     | Resolved from ~R and PvR.
 11.    | R     | Resolved from QvR and ~Q.
 12.    |       | Resolved R and ~R to Rv~R, which is in turn null.
A contradiction is found when ~R is assumed as true. Hence, R is true.
```

8. Implement unification in first order logic :



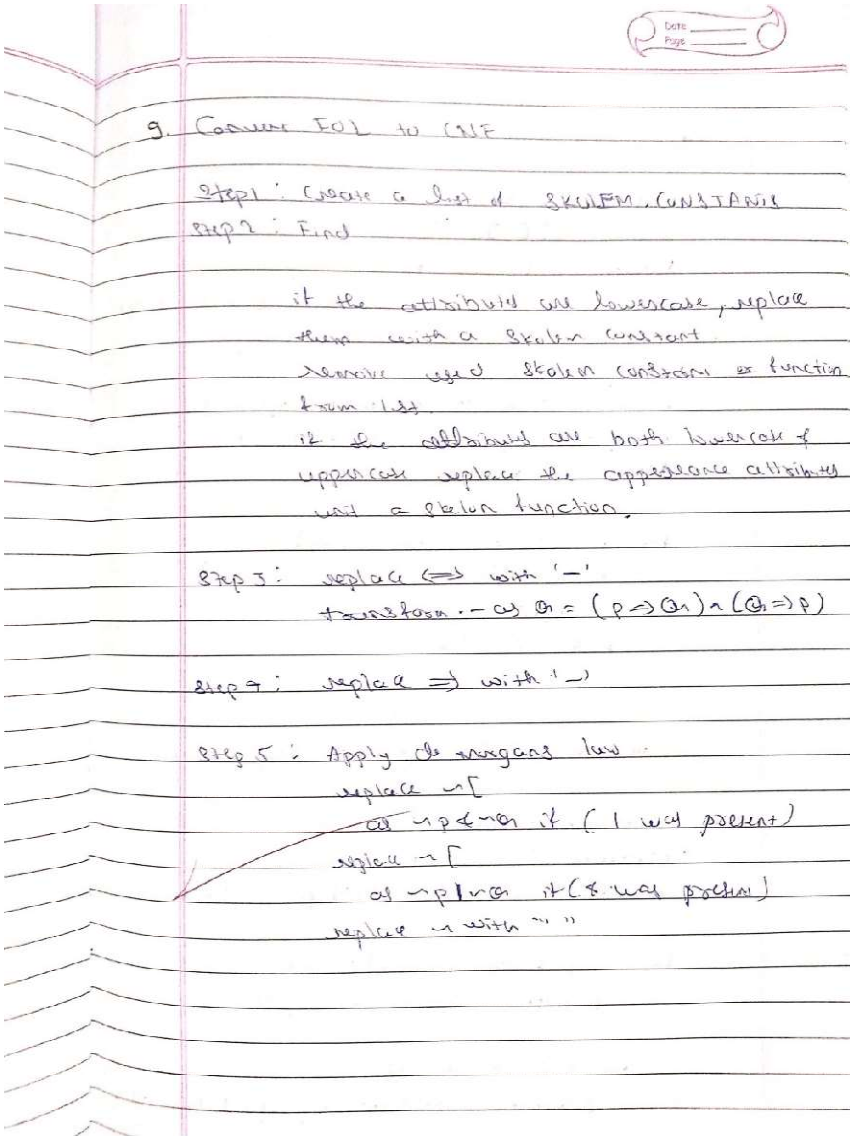


OUTPUT

```
Substitutions:
[('X', 'Richard')]
```

```
Substitutions:
[('A', 'y'), ('mother(y)', 'x')]
```

9.Convert a given first order logic statement into Conjunctive Normal Form (CNF).



9. Convert FOL to CNF

Step1 : Create a list of SKOLEM CONSTANTS

Step2 : Find

if the attributes are lowercase, replace them with a Skolem constant

recursive use of skolem constants or function term list.

if the attributes are both lowercase & uppercase replace the uppercase attribute with a skolem function.

Step3 : replace ⟺ with '→'

translation - $\alpha_1 \Leftrightarrow \alpha_2 = (p \Rightarrow \alpha_1) \wedge (\alpha_2 \Rightarrow p)$

Step4 : replace ⇒ with '→'

Step5 : Apply De morgans law

replace ~[

as ~ operator if (I was present)

replace ~[

as ~ plus it (& was present)

replace ~ with "~"

OUTPUT

```
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```
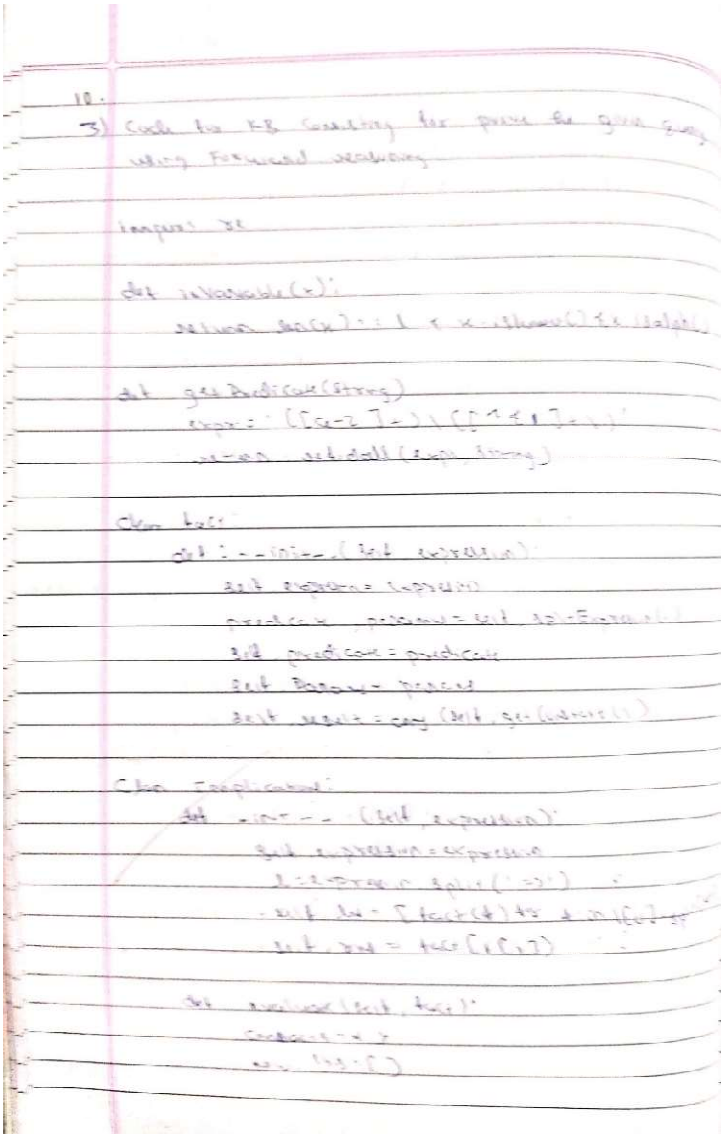
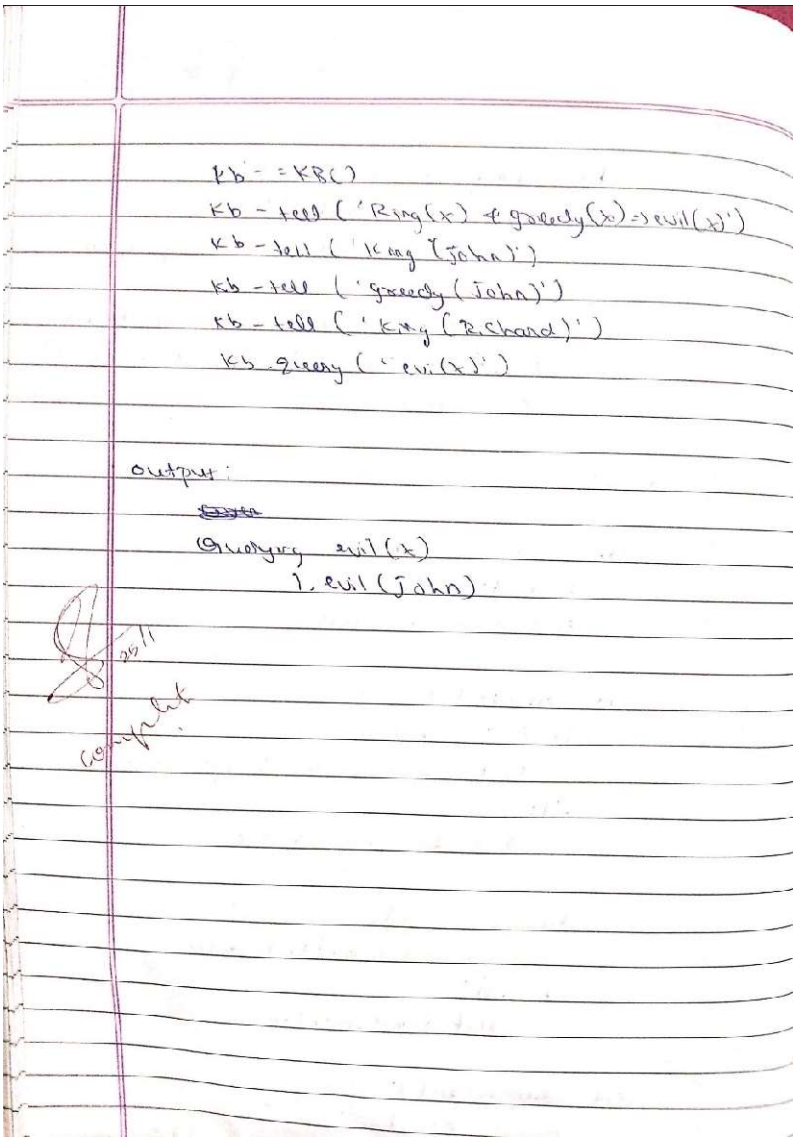

```
Enter FOL statement: x+y_z*s
FOL converted to CNF: [~x+y|z*s]&[~z*s|x+y]
```

10. Create a knowledge base consisting of first order logic statements and prove the given query using forward reasoning



```
for key in customers:
    if customers[key]:
        attributes = attributes.replace

return Fact(expr) if len(new_line) ( all
    ( [f.get_result () for f in new])
    else None

class KB

    def __init__(self):
        self.facts = set()
        self.implications = set()

    def tell(self, e):
        if '=>' in e
            self.implications.add(implication(e))
        else :
            self.facts.add(fact(e))

        for i in self.implications:
            res = i.evaluate(self.facts)
        if res:
            self.facts.add(res)

    def display(self):
        print("All facts: ")
        for i, f in enumerate(set([f.expression
                                  for f in self.facts])):
            print(f'{i+1}. {f}')
```



OUTPUT

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```
Enter number of statements in Knowledge Base: 4
Elephant(x) => Mammal(x)
Lion(Mufasa)
Mammal(x) => Animal(x)
Animal(Simba)
Enter Query:
Mammal(x)
Querying Mammal(x):
All facts:
        1. Lion(Mufasa)
        2. Animal(Simba)
```