Q 1 Write a program for Tic-Tac-Toe game:

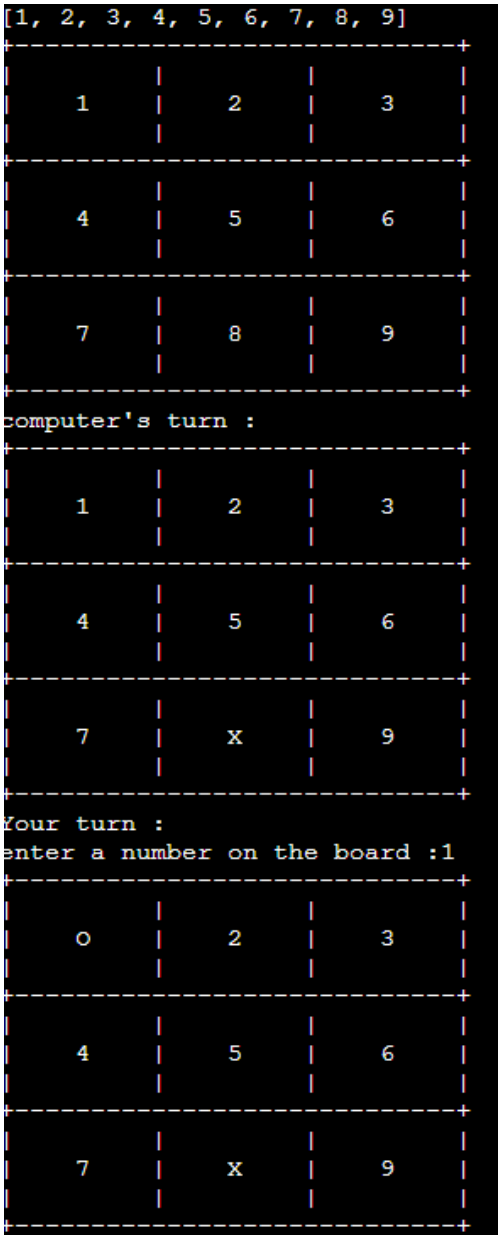
```
import random
tic=[1,2,3,4,5,6,7,8,9]

def printBoard(tic)
    print(tic[0]+'|'+tic[1]+'|'+tic[2])
    print("-----")
    print(tic[3]+'|'+tic[4]+'|'+tic[5])
    print("-----")
    print(tic[6]+'|'+tic[7]+'|'+tic[8])


def isWinner(tic,pos)
    if tic[0]==tic[4] and tic[4]==tic[8] or
        tic[2]==tic[4] and tic[4]==tic[6]
    return True
    else if tic[pos-0] = tic[pos-3] and tic[pos-3]==
        return True                    tic[pos-6]
    else if tic[pos//3+1]=tic[pos//3+2] and tic[pos//3+2]
                                        ==tic[pos//3+3]

    return True

return False
def update_user(tic):
    num = int(input("Enter a number on the board"))
    while(!num not in tic):
        num = int(input("Enter a number on the board
    tic[num-1]=='0'

def update_cop(tic):
    for i in tic:
        if i!='X' and i!='O':
            tic[i-1]='X'
            if(isWinner(tic,i-1)==True):
```

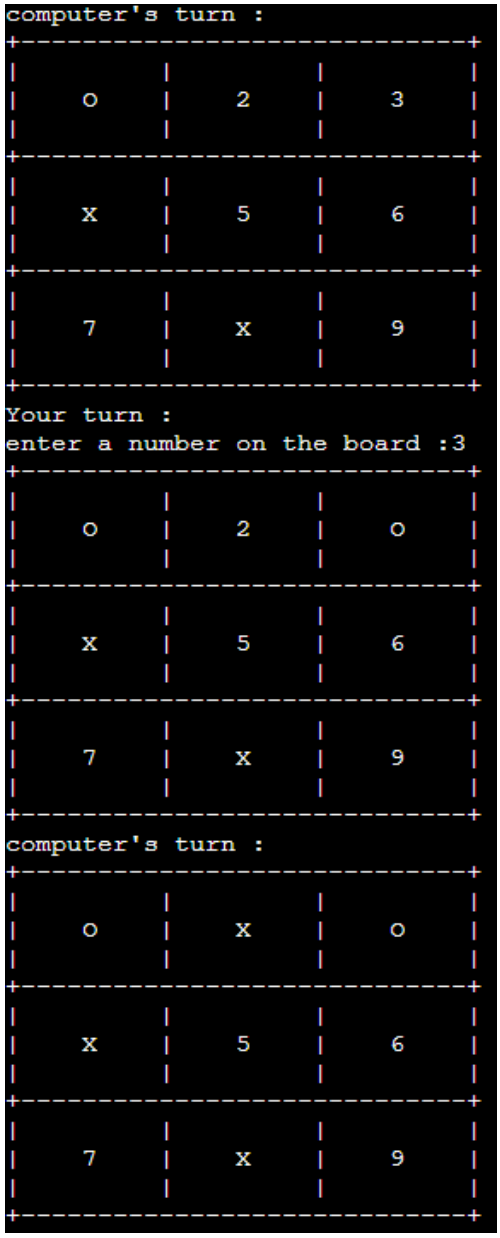
else
tic[i-1] = i

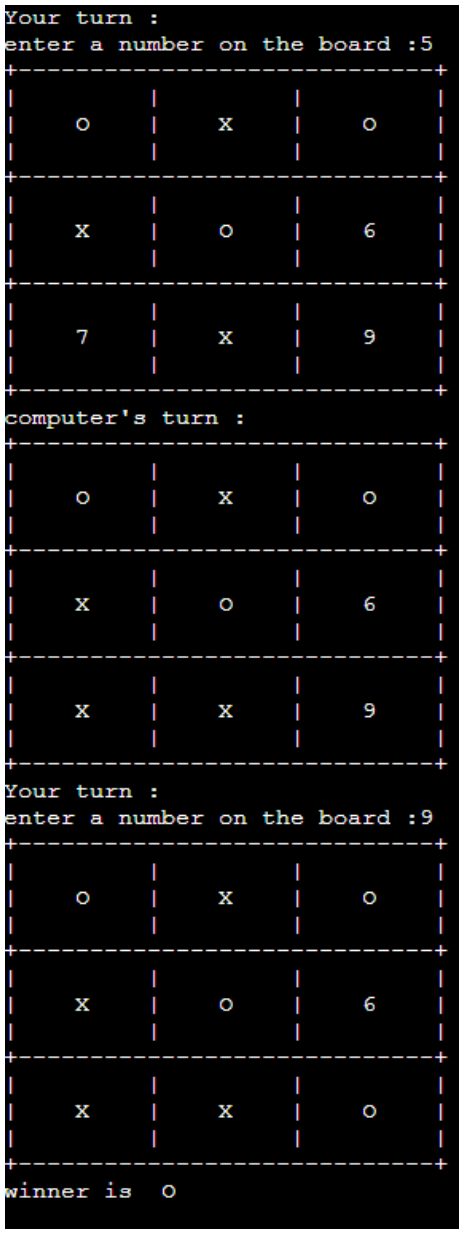
algorithm :-

(i) make a board ad initialize the value
(ii) Make a winner function check for the winner possibilities
(iii) Make a user function which will take no as input.
(iv) make a computer function :
  (i) Maximize computer wins
  (ii) Maximize user wins
  (iii) generate random position.
(v) Now check for any combination after 5 steps as there can be a 3 combination
(vi) ~~put~~ main function
  print the board
  ad shift b/w the user & computer.

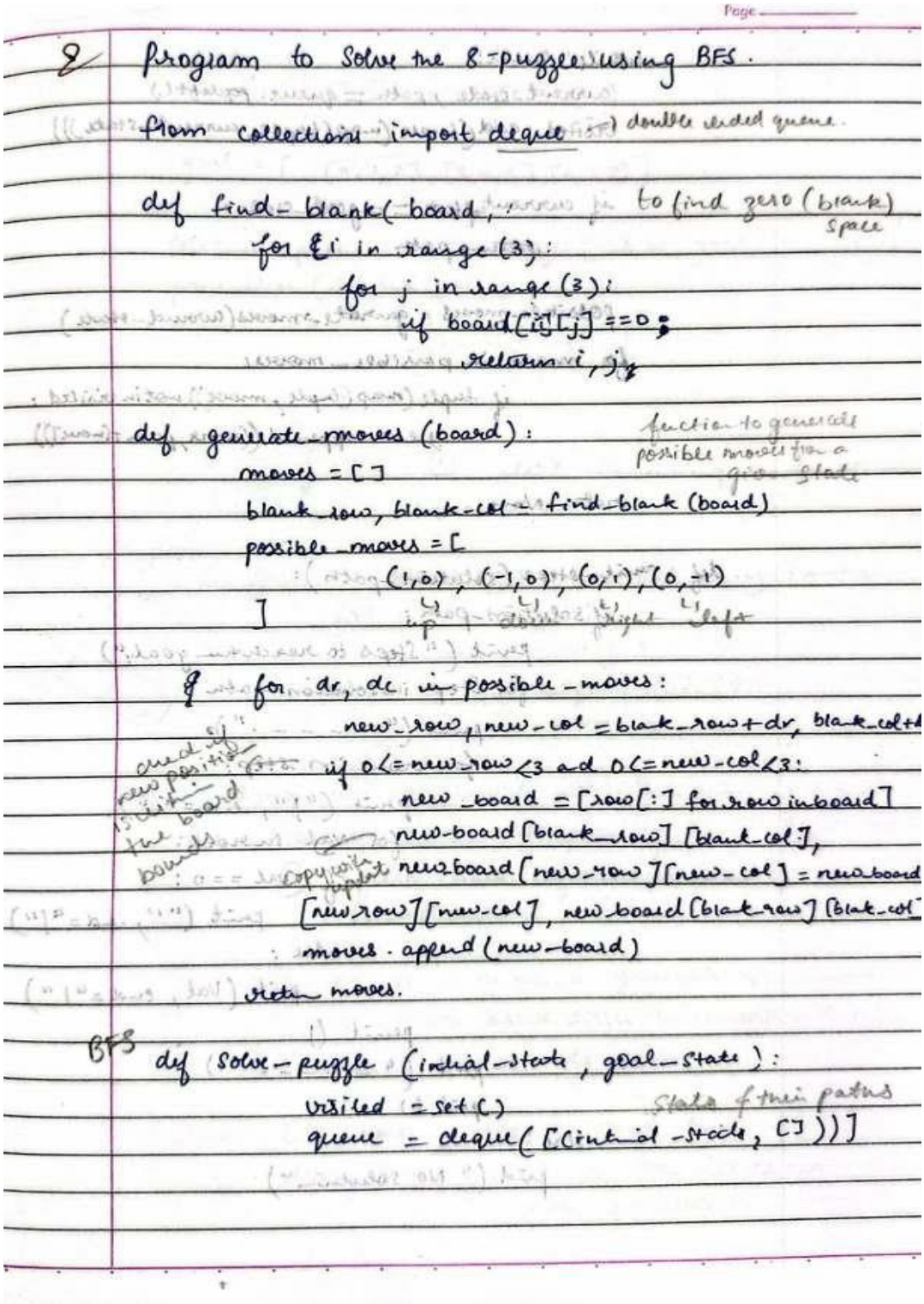
output:-


[1, 2, 3, 4, 5, 6, 7, 8, 9]
1 2 3
4 5 6
7 8 9
computer's turn :
1 2 3
4 5 6
7 X 9
Your turn :
enter a number on the board :1
O 2 3
4 5 6
7 X 9


computer's turn :
O 2 3
X 5 6
7 X 9
Your turn :
enter a number on the board :3
O 2 O
X 5 6
7 X 9
computer's turn :
O X O
X 5 6
7 X 9


Your turn :
enter a number on the board :5
O X O
X O 6
7 X 9
computer's turn :
O X O
X O 6
X X 9
Your turn :
enter a number on the board :9
O X O
X O 6
X X O
winner is O

8 puzzle bfs
Code:



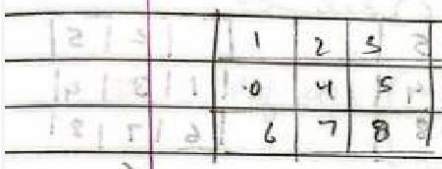
```
Page
8  Program to Solve the 8-puzzle using BFS.
from collections import deque  # double ended queue.

def find_blank(board,):  # to find zero (blank) space
    for i in range(3):
        for j in range(3):
            if board[i][j] ==0;
            return i,j;

def generate_moves(board):  # fuction to generate posible moves for a given state
    moves = []
    blank_row, blank_col = find_blank(board)
    possible_moves = [
        (1,0), (-1,0), (0,1), (0,-1)
    ]                  # up  down  right  left
    for dr, dc in possible_moves:
        new_row, new_col = blank_row+dr, blank_col+d
        # check if new position is within the board
        if 0<=new_row<3 and 0<=new_col<3:
            new_board = [row[:] for row in board]
            new_board[blank_row][blank_col],
            # copy with slice
            new_board[new_row][new_col] = new_board
            [new_row][new_col], new_board[blank_row][blank_col]
            moves.append(new_board)
    return moves.

BFS
def solve_puzzle(initial_state, goal_state):
    visited = set()
    queue = deque([(initial_state, [])])  # State & their paths
```

```
while queue:
    current_state, path = queue.popleft()
    visited.add(tuple(map(tuple, current_state)))

    if current_state == goal_state:
        return path

    possible_moves = generate_moves(current_state)
    for move in possible_moves:
        if tuple(map(tuple, move)) not in visited:
            queue.append((move, path + [move]))

return None

def print_steps(solution_path):
    if solution_path:
        print("Steps to reach the goal:")
        for step in solution_path:
            print("+---+---+---+")
            for row in step:
                print("|", end=" ")
                for val in row:
                    if val == 0:
                        print(" ", end="|")
                    else:
                        print(val, end="|")
                print()
            print("+---+---+---+")
    else:
        print("No solution")
```

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

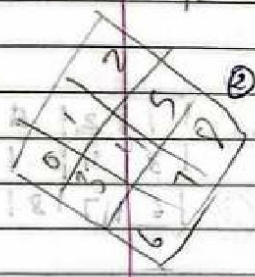
goal = [[0, 1, 2], [3, 4, 5], [6, 7, 8]]

Solution_path = solve_puzzle(initial, goal)
print steps (Solution_path)



1	2	3
0	4	5
6	7	8

① will use using a doubleend queue



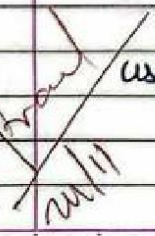
② find the blankspace here (0) using function

```
for i in range 3:
    for j in range3
        if board[i][j]==0 :
            return i, j
```

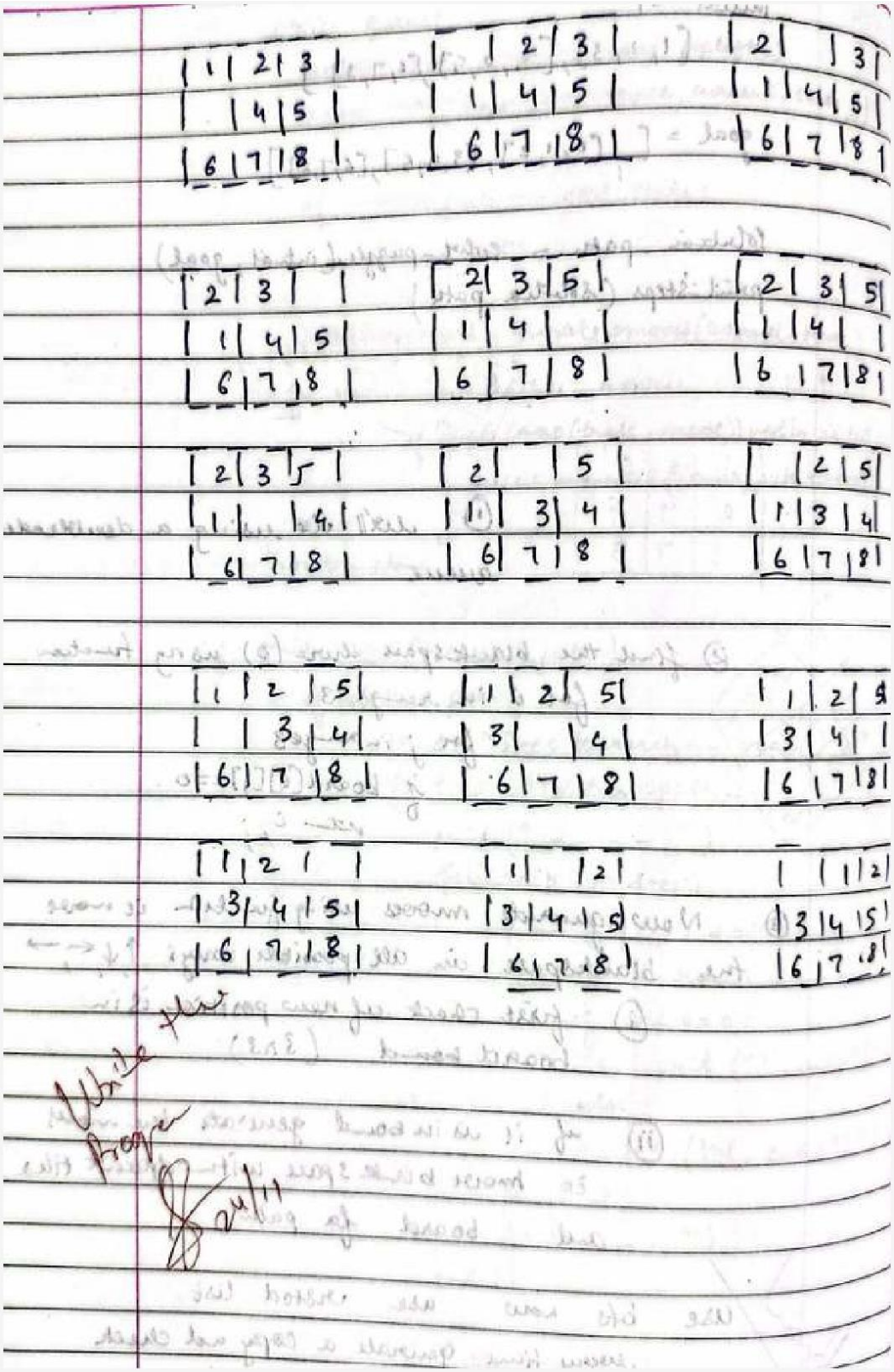
③ Now generate moves using function ie move the blankspace in all possible ways ↑ ↓ ← →

(i) first check if new position is in board bound (3×3)

(ii) if it is in bound generate the move ie move blank space with adjacent tiles and board fa path.



use bfs now use visited list every time generate a copy and check with goalState.


Write proper
24/11

output:-

main.py

```
    d=[]
    if b not in [0,1,2]:
        d.append('u')
    if b not in [6,7,8]:
        d.append('d')
    if b not in [0,3,6]:
        d.append('l')
    if b not in [2,5,8]:
        d.append('r')

```

```
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


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

8 puzzle iterative deepening search:-
Code:-

Lab - 5

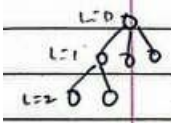
8/12/2023

3 8 puzzle problem using iterative deepening search algorithm.

(1) Node(data, level) : initialize node with puzzle state & level.

(2) def puzzle:
→ output() ← Start & goal state
→ dls() = (node, goal, depth) ← perform dls

(3) def dls (node, goal, depth)
if (current state == goal):
return solution



else:
generate child node, recursively call with increase level

(4) def IDS (start, goal)
→ start with depth : 0
→ repeat until goal is found:
→ perform DLS with current depth
→ if sol^n found ← exit
increment depth.

(5) → generate puzzle instance
→ call IDS (start, goal)

```
def id_dfs (puzzle, goal, get_moves):
    import itertools
    def dfs (route, depth):
        if depth == 0:
            return
        if route[-1] == goal:
            return route
        for move in get_moves (route[-1]):
            if move not in route:
                next_route = dfs (route[move], dep
                if next_route:
                    return next_route
    for depth in itertools.count():
        route = dfs ([puzzle], depth)
        if route:
            return route

def possible_moves (state):
    b = state.index (0)
    d = []
    if b not in [0,1,2]:
        d.append ('u')
    if b not in [6,7,8]:
        d.append ('d')
    if b not in [0,3,6]:
        d.append ('l')
    pos_moves = []
    for i in d:
        pos_moves.append (generate (state, i, b))
    return pos_moves

initial = [1,2,3,0,4,6,7,5,8]
goal = [1,2,3,4,5,6,7,8,0]
route = id_dfs (initial, goal, possible_moves)
if route:
    print ("Success")
    print ("Path:", path)
else:
    print ("Failed to find Solution")
```

Output:-

Success !!

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]]

output:-

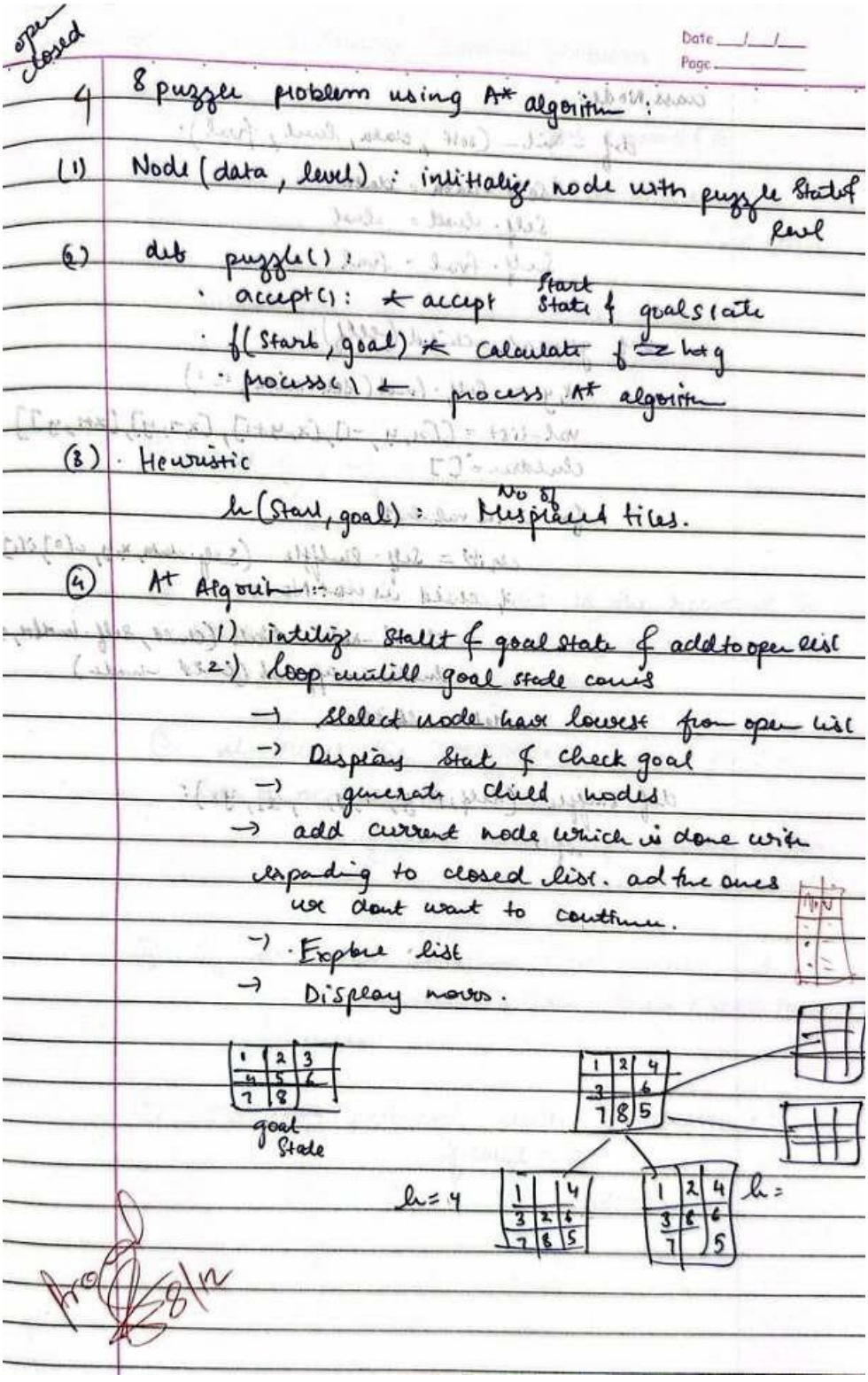
main.py

```
        d.append('l')
    if b not in [2, 5, 8]:
        d.append('r')

    pos_moves = []
    for i in d:
        pos_moves.append(generate(state, i, b))
    return pos_moves


def generate(state, m, b):
    temp = state.copy()

    if m == 'd':
        temp[b + 3], temp[b] = temp[b], temp[b + 3]
    if m == 'u':
        temp[b - 3], temp[b] = temp[b], temp[b - 3]
    if m == 'l':
        temp[b - 1], temp[b] = temp[b], temp[b - 1]
    if m == 'r':
        temp[b + 1], temp[b] = temp[b], temp[b + 1]

    return temp


# calling ID-DFS
initial = [1, 2, 3, 0, 4, 6, 7, 5, 8]
goal = [1, 2, 3, 4, 5, 6, 7, 8, 0]

route = id_dfs(initial, goal, possible_moves)

if route:
    print("Success!! It is possible to solve 8 Puzzle problem")
    print("Path:", route)
else:
```

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.
```

8 puzzle A*
Code:-



```
class Node:
    def __init__(self, data, level, fval):
        self.data = data
        self.level = level
        self.fval = fval

    def generate_child(self):
        x, y = self.find(self.data, '_')
        val_list = [[x, y-1], [x, y+1], [x-1, y], [x+1, y]]
        children = []
        for i in val_list:
            child = self.shuffle(self.data, x, y, i[0], i[1])
            if child is not None:
                child_node = Node(child, self.level+1,
                children.append(child_node)
        return children

    def shuffle(self, puz, x1, y1, x2, y2):
        if x
```

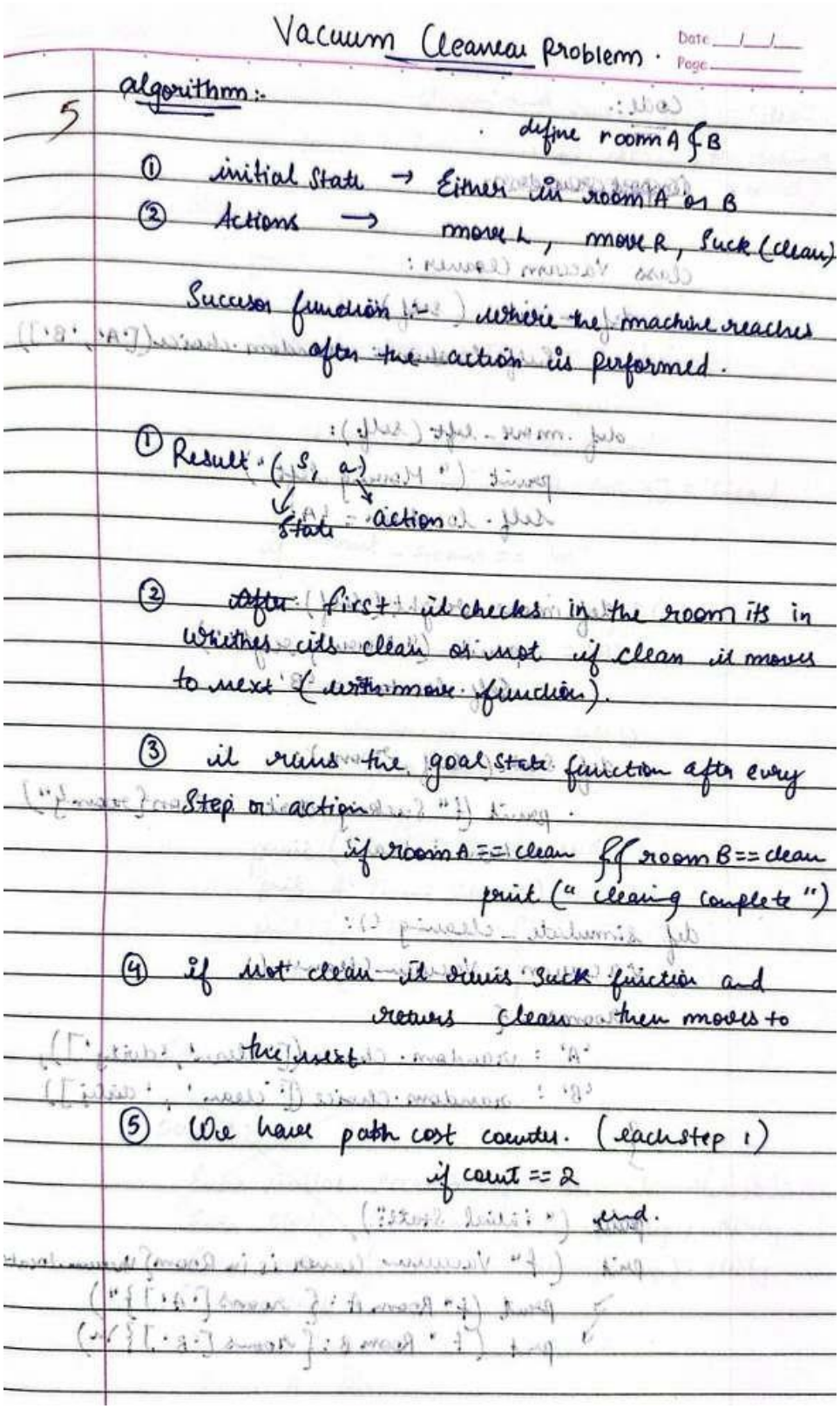
output:-

main.py

```
88          print("Enter the goal state matrix \n")
89          goal = self.accept()
90
91          start = Node(start,0,0)
92          start.fval = self.f(start,goal)
93          """ Put the start node in the open list"""
```

```
Enter the start state matrix

1 2 3
4 5 6
_ 7 8
Enter the goal state matrix

1 2 3
4 5 6
7 8 _




  |
  |
 \'/

1 2 3
4 5 6
_ 7 8

  |
  |
 \'/

1 2 3
4 5 6
7 _ 8

  |
  |
 \'/

1 2 3
4 5 6
7 8 _


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

Vacuum cleaner:-
Code:-



Vacuum Cleaner Problem.

Date __/__/__
Page

5

algorithm:-

- define room A & B

① initial state → Either in room A or B

② Actions → move L, move R, Suck (clean)

Succesor function (:-) where the machine reaches after the action is performed.

① Result (S, a)
↓ ↓
State = action

② First it checks in the room its in whether its clean or not if clean it moves to next (with move function).

③ it runs the goal state function after every Step or action.

if room A == clean && room B == clean
print ("cleaning complete")

④ if not clean it runs suck function and returns clean then moves to the next.

⑤ We have path cost counter. (each step 1)
if count == 2
end.

Code:-

```
import random

class VacuumCleaner:
    def __init__(self):
        self.location = random.choice(['A', 'B'])

    def move_left(self):
        print("Moving left")
        self.location = 'A'

    def move_right(self):
        print("Moving right")
        self.location = 'B'

    def suck(self, room):
        print(f"Sucking dirt in Room {room}")
        return 'clean'

def simulate_cleaning():
    vacuum = VacuumCleaner()
    rooms = {
        'A': random.choice(['clean', 'dirty']),
        'B': random.choice(['clean', 'dirty'])
    }

    print("Initial State:")
    print(f"Vacuum cleaner is in Room {vacuum.location}")
    print(f"Room A: {rooms['A']}")
    print(f"Room B: {rooms['B']}\n")
```

```
if rooms['A']=='clean' and rooms['B']=='clean':
        print("Both rooms are clean, No cleaning needed")
else
    print("Starting the cleaning process...")
    current_room = vacuum.location
    cleaned_room = vacuum.suck(current_room)

    if cleaned_room == 'clean':
        rooms[current_room] = 'clean'

    if current_room == 'A'
        vacuum.move_right()
        current_room = 'B'
    else:
        Vacuum.move_left()
        current_room = 'A'

    print("\nCleaning completed.")
    print(f"Final State")
    print(f"Room A: {rooms['A']}")
    print(f"Room B: {rooms['B']}")

Simulate_cleaning()
```

Output :-

```
Enter initial location of vacuum cleaner(A/B): A
Enter state for Room A (clean/dirty): dirty
Enter State for Room B (clean/dirty): dirty
Initial State:-
Vacuum cleaner is in Room A
Room A: dirty
Room B: dirty
```

Starting the cleaning process
Sucking dirt in Room A
moving right
Sucking dirt in Room B
cleaning completed.
Final State:
Vacuum cleaner is in Room B
Room A : clean
Room B : clean

Output:-

main.py

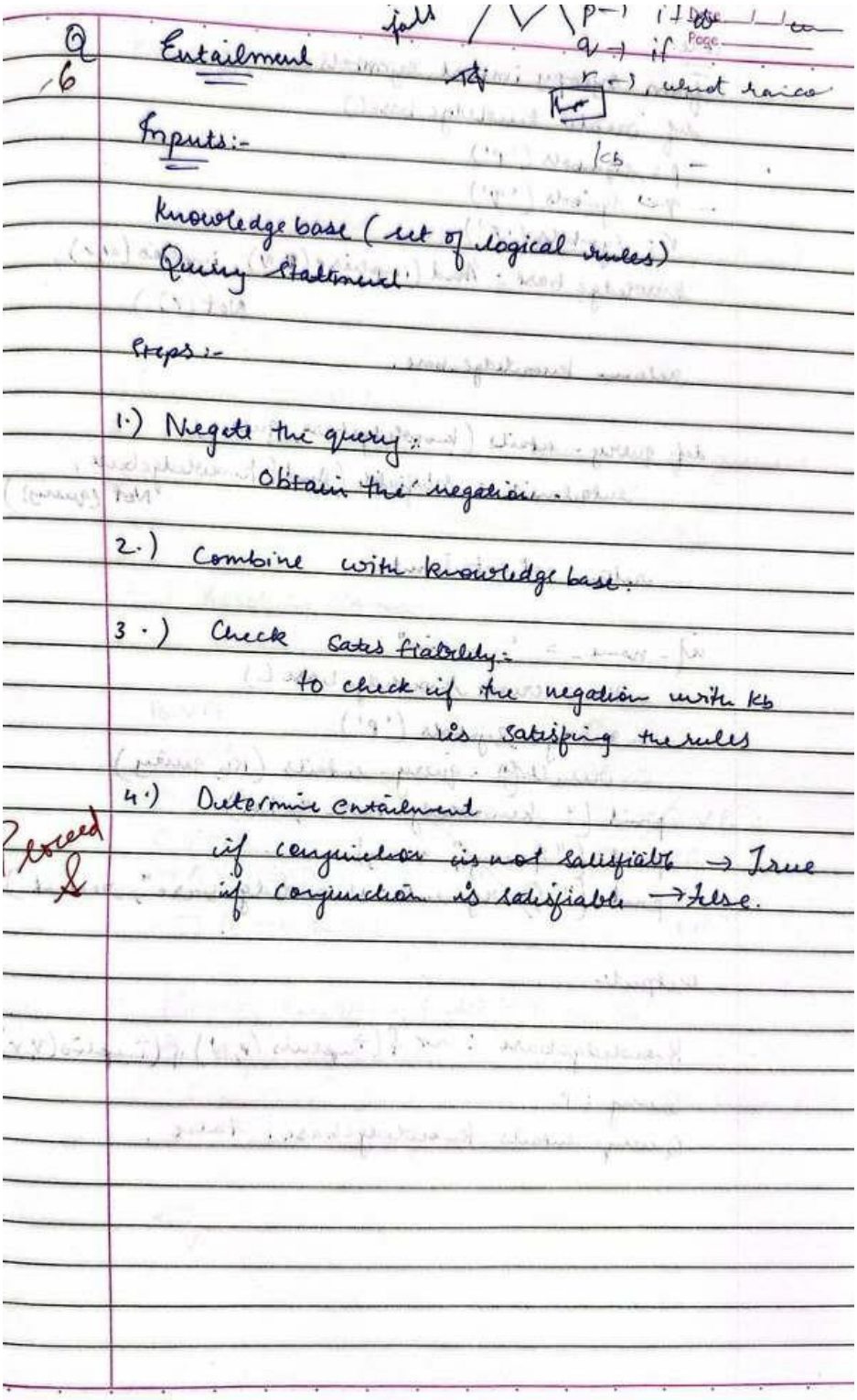
```
        nonlocal cost
        if goal_state[room] == 1:
            print(f"Cleaning Room {room}...")
            goal_state[room] = 0
            cost += 1  # Cost for cleaning
            print(f"Room {room} has been cleaned. Current cost: {cost}")
        else:
            print(f"Room {room} is already clean.")

    # Cleaning logic
    rooms = ['A', 'B', 'C', 'D']
    current_index = rooms.index(location_input)

    # Clean all rooms starting from the initial location
    for i in range(current_index, len(rooms)):
        clean_room(rooms[i])

    # Clean remaining rooms (if the initial location was not 'A')
    for i in range(0, current_index):
        clean_room(rooms[i])

```

input

```
Enter Initial Location of Vacuum (A/B/C/D): B
Enter status of each room (1 - dirty, 0 - clean):
Status of Room A: 1
Status of Room B: 0
Status of Room C: 1
Status of Room D: 1
Initial Location Condition: {'A': 1, 'B': 0, 'C': 1, 'D': 1}
Room B is already clean.
Cleaning Room C...
Room C has been cleaned. Current cost: 1
Cleaning Room D...
Room D has been cleaned. Current cost: 2
Cleaning Room A...
Room A has been cleaned. Current cost: 3
Final State of Rooms: {'A': 0, 'B': 0, 'C': 0, 'D': 0}
Performance Measurement (Total Cost): 7


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

Knowledge-based entailment:-

Code:-



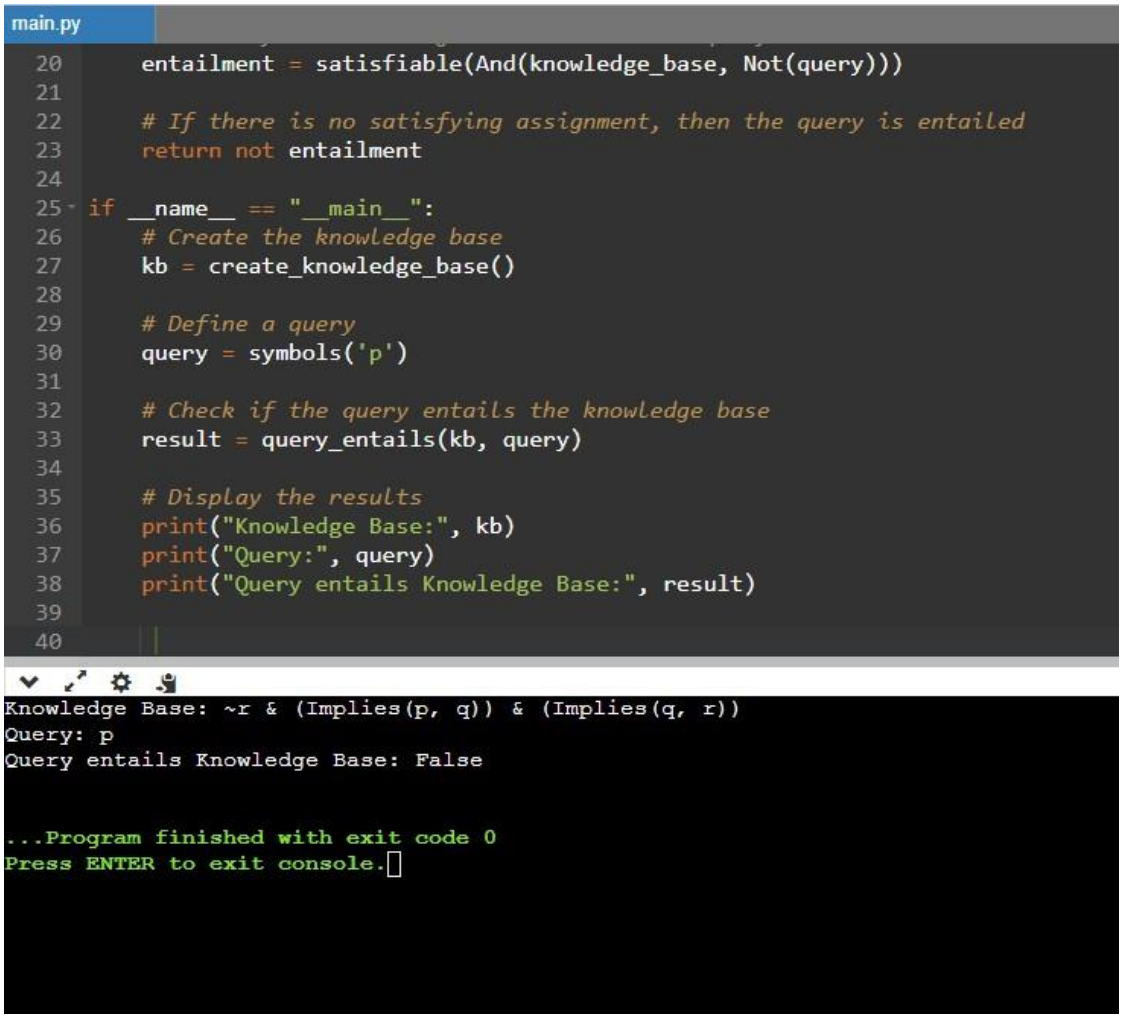
code:-

```
from sympy import symbols
def create knowledge base()
    p = symbols('p')
    q = symbols('q')
    r = symbols('r')
    knowledge base = And (implies(p,q), implies(q,r),
                          Not(r))
    return knowledge base.

def query - entails (knowledgebase, query)
    entailment = satisfiable (And (knowledgebase,
                                   Not (query)
    return not entailment.

if - name_ = '__main__"
    kb = create knowledge base()
    query = symbols('p')
    result = query - entails (kb, query)
    print ("knowledge Base", kb)
    print ("Query", query)
    print ("Query entails knowledge base", result)
```

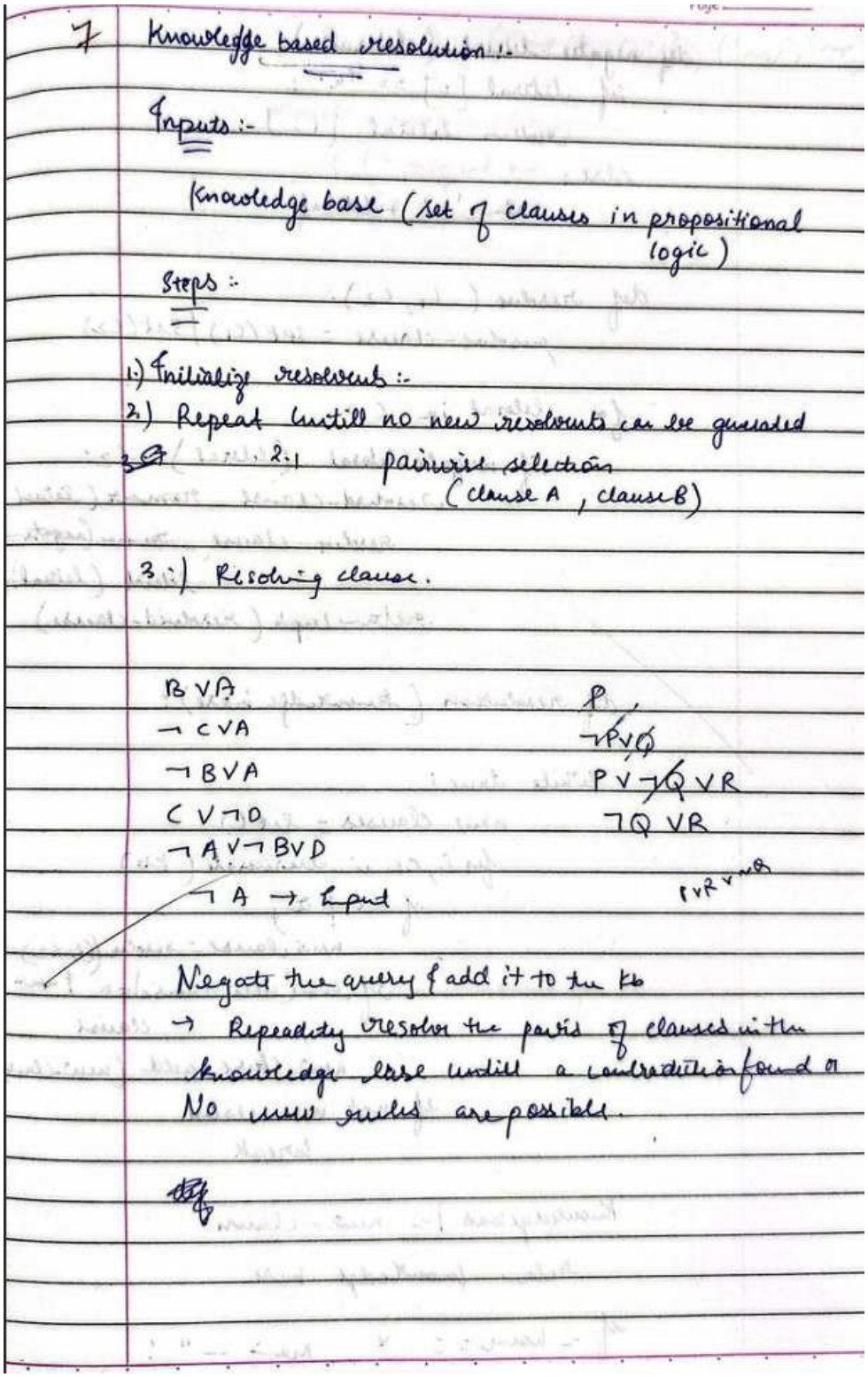
Output:-

```
Knowledgebase : ~r & (Implies (p,q) & (Implies(q,r
Query : p
Query entails Knowledgebase : False.
```

output:-


main.py
entailment = satisfiable(And(knowledge_base, Not(query)))
# If there is no satisfying assignment, then the query is entailed
return not entailment
if __name__ == "__main__":
# Create the knowledge base
kb = create_knowledge_base()
# Define a query
query = symbols('p')
# Check if the query entails the knowledge base
result = query_entails(kb, query)
# Display the results
print("Knowledge Base:", kb)
print("Query:", query)
print("Query entails Knowledge Base:", result)
Knowledge Base: ~r & (Implies(p, q)) & (Implies(q, r))
Query: p
Query entails Knowledge Base: False
...Program finished with exit code 0
Press ENTER to exit console.

Knowledge-based resolution
Code:-



7 Knowledge based resolution :-

Inputs :-

Knowledge base (set of clauses in propositional logic)

Steps :-

1.) Initialize resolvents :-
2.) Repeat until no new resolvents can be generated
2.1 pairwise selection (clause A, clause B)
3.) Resolving clause.

B ∨ A
¬ C ∨ A
¬ B ∨ A
C ∨ ¬ D
¬ A ∨ ¬ B ∨ D
¬ A → Input

P,
¬P ∨ Q
P ∨ ¬Q ∨ R
¬Q ∨ R
P ∨ R ∨ ¬Q

Negate the query & add it to the KB
→ Repeatedly resolve the pairs of clauses in the knowledge base until a contradiction found or No more pairs are possible.

```
def negate-literal (literal
    if literal [0] == 'n':
        return literal [1:]
    else:
        return 'n' + literal

def resolve (c1, c2):
    resolve-clause = set(c1) | set(c2)
    for literal in c1:
        if negate-literal (literal) in c2:
            resolved-clause - remove (lit
            resolve clause - remove (negat
                literal (litera
            return tuple (resolved-clause)

def resolution (knowledge base):
    while true:
        new clauses = set()
        for i, c1 in enumerate (kb)
            of i != j
                new clause = resolve (c1,c2)
                if len (new clause) = 0 f
                    clause
                new-clause.add (new
            if not new-clause
                break
        knowledgebase |= new-clause
        return knowledge-base
if - name == : " - main - " :
```

Page

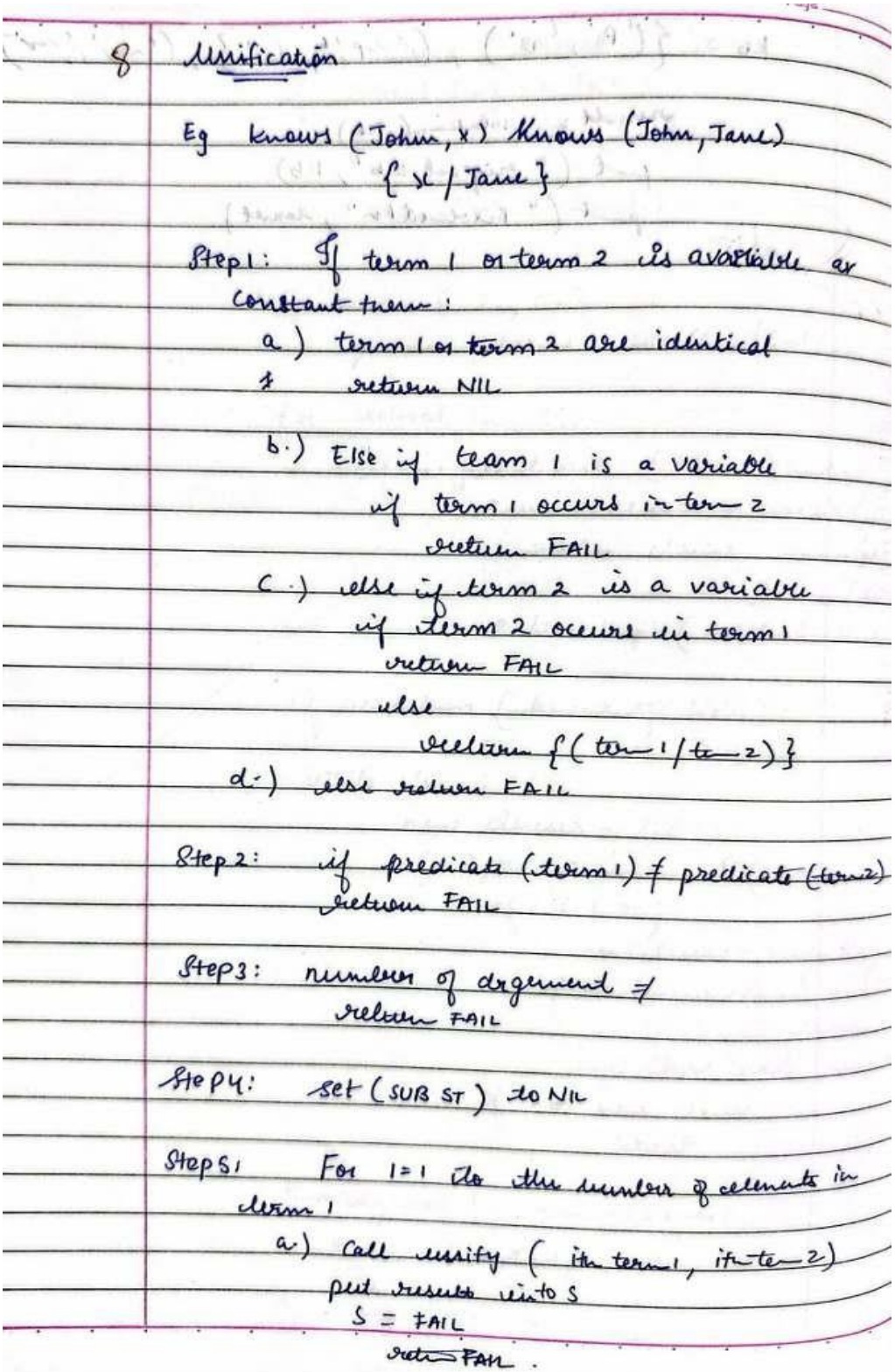
```
kb = {('P', 'Q'), ('~P', 'R'}, ('~Q', '~R')}

result = resolution(kb)
print("Original kb", kb)
print("Resolved kb", result)
```

Output:-

```
rules = 'PvQ ~PvR ~QvR' #P=vQ, P=>Q : ~PvQ, Q=>R, ~QvR
goal = 'R'
main(rules, goal)
```

```
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.
```

Unification
Code:-



8 Unification

Eg knows (John, x) knows (John, Jane)
{x / Jane}

Step 1: If term 1 or term 2 is a variable or constant then:
a) term 1 or term 2 are identical
then return NIL

b.) Else if term 1 is a variable
if term 1 occurs in term 2
return FAIL

c.) else if term 2 is a variable
if term 2 occurs in term 1
return FAIL
else
return {(term 1 / term 2)}

d.) else return FAIL

Step 2: if predicate (term 1) ≠ predicate (term 2)
return FAIL

Step 3: number of argument ≠
return FAIL

Step 4: set (SUB ST) to NIL

Step 5: For i = 1 to the number of elements in term 1
a) Call unify (ith term 1, ith term 2)
put results into S
S = FAIL
return FAIL.

Steps: c.) if S ≠ NIL

a.) Apply S to the remainder of both lists L_1 & L_2

b.) SUBST . APPEND (S, SUBST)

Step 8: Return SUBST

① predicate same

② No of arguments

③ John X Jane

turn put in subset

Pseudo

```
import re
def getInitialPredicate (expression):
    return expression.split ("(")[0]
def: isConstant (char):
    return char.isupper() and len(char)==1
def replaceAttributes (exp, old, new):
    attributes = getAttributes (exp)
    for index, val in enumerate (attributes):
        if val == old:
            attributes[index] = new
    predicate = getInitialPredicate (exp)
    return predicate + "(" + ",".join(attributes) + ")"
def apply (exp, substitutions):
    for substitution in substitutions:
        new, old = substitution
        exp = replaceAttributes (exp, old, new)
    return exp.
def getFirstPart (expression):
    predicate = getInitialPredicate (expression)
    attributes = getAttributes (expression)
    return new Expression.
```

```
def unify (exp1, exp2)
    if exp1 == exp2
        return false.
    if isConstant (exp1):
        return [(exp2, exp1)]
    if isVariable (exp1):
        if checkOccurs (exp1, exp2):
            return False
    attribute count1 = len (getAttributes (exp1))
    AttributeCount2 = len (getAttributes (exp2))
    if attributeCount1 != attribute count2:
        return false.
    head1 = get firstPart (exp1)
    head2 = get firstPart (exp2)
    initial Substitution = unify (heads, heads2)
    if not initial. Substitution:
        return False.
    return initial Substitution
    tail1 = getRemainPart (exp1)
    tail2 = getRemainingPart (exp2)
    . initial Substitution . extend (remainingSubstitution)
    return initial Substitution.
```

output:-

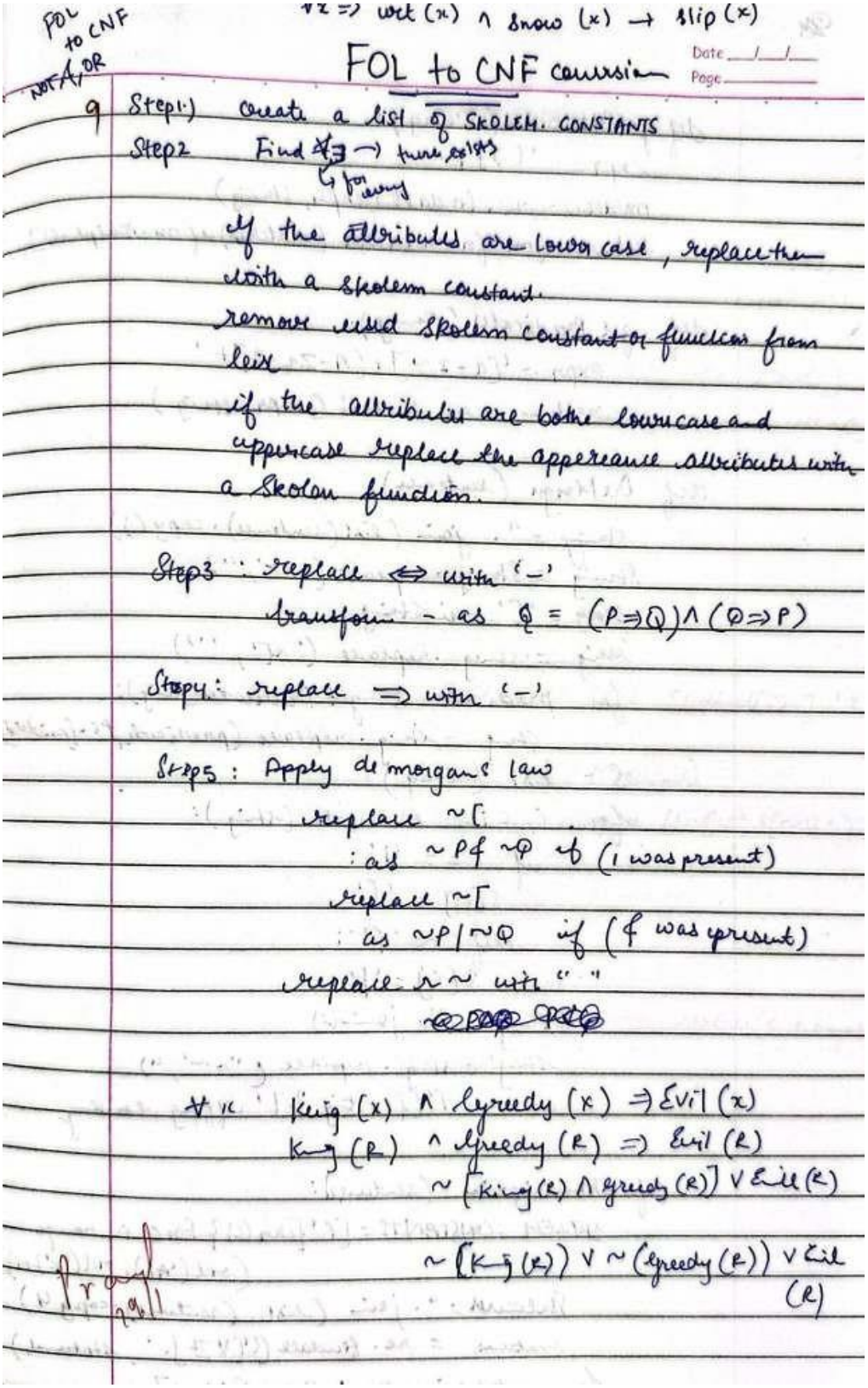
```
exp1 = "knows(X)"
exp2 = "knows(Richard)"
substitutions = unify(exp1, exp2)
print("Substitutions:")
print(substitutions)
```

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

```
[7] exp1 = "knows(A,x)"
    exp2 = "knows(y,mother(y))"
    substitutions = unify(exp1, exp2)
    print("Substitutions:")
    print(substitutions)
```

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

Fol to cnf
Code:-



FOL to CNF

∀x => wet(x) ∧ snow(x) → slip(x)

FOL to CNF conversion

Date __/__/__
Page

Step1:) create a list of SKOLEM CONSTANTS

Step2 Find ∀,∃ → turn existing

↳ for every

if the attributes are lower case, replace them with a skolem constant.

remove used skolem constant or functions from list

if the attributes are both lowercase and uppercase replace the appearance attributes with a skolem function.

Step3 : replace ⇔ with '→'

transform - as $\phi = (P \Rightarrow Q) \wedge (Q \Rightarrow P)$

Step4: replace ⇒ with '→'

Step5 : Apply de morgan's law

replace ~[

: as ~P∨~Q if (∧ was present)

replace ~[

: as ~P∧~Q if (∨ was present)

replace ~~ with " "

∀x king(x) ∧ greedy(x) ⇒ Evil(x)

king(R) ∧ greedy(R) ⇒ Evil(R)

~[king(R) ∧ greedy(R)] ∨ Evil(R)

~[king(R)) ∨ ~(greedy(R)) ∨ Evil(R)

```
def getAttributes(string):
    expr = '([^)]+)'
    matches = re.findall(expr, string)
    return [m for m in str(matches) if m.isalpha()]

def getPredicates(string):
    expr = '[a-z~]+([A-Za-z]+)'
    return re.findall(expr, string)

def DeMorgan(sentence):
    string = ''.join(list(sentence).copy())
    string = string.replace('~~', '')
    flag = '[' in string
    string = string.replace('~[', '')
    for predicate in getPredicates(string):
        string = string.replace(predicate, f'~{predicate}')
    s = list(string)
    for i, c in enumerate(string):
        if c == '|':
            s[i] = '&'
        elif c == '&':
            s[i] = '|'
    string = ''.join(s)
    string = string.replace('~~', '')
    return f'[{string}]' if flag else string

def Skolemization(sentence):
    SKOLEM_CONSTANTS = [f'{chr(c)}' for c in range
                        (ord('A'), ord('Z')+1)]
    Statement = ''.join(list(sentence).copy())
    matches = re.findall('[∀∃].', Statement)
    for match in reversed(matches[::-1]):
```

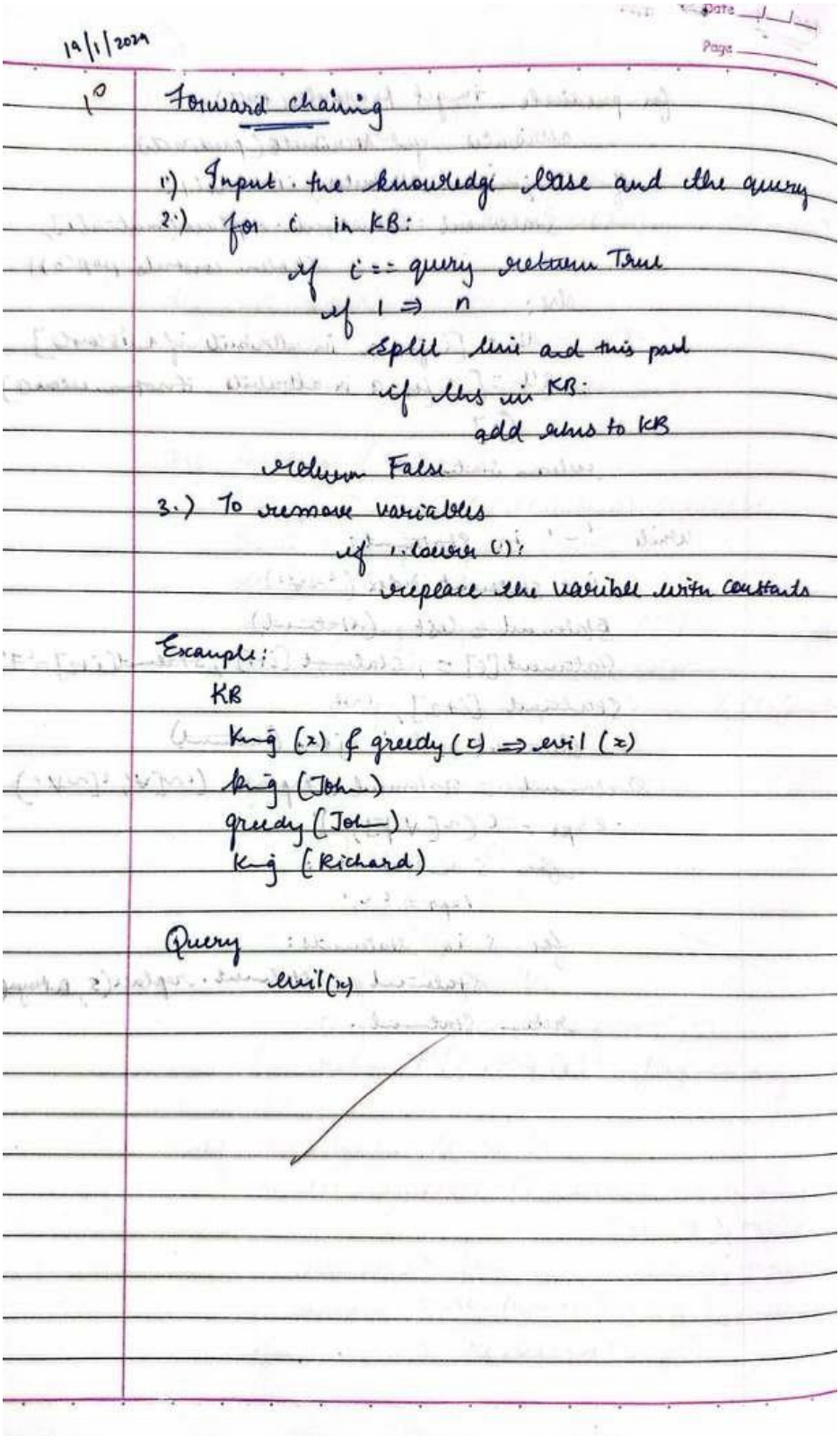
```
for predicate in get predicates(state):
    attributes = get Attributes(predicate)
    if ",".join(attributes) : is lower():
        Statement = Statement.replace(match[1],
                                      Skolem_constants.pop(0))
    else:
        al = [a for a in attributes if a.islower()]
        all = [a for a in attributes if not a.islower()
               [0]
        return Statement

while '-' in Statement:
    i = statement.index('~∀')
    Statement = list(statement)
    Statement[i] = , statement[i+1], Statement[i+2]='∃
    Statement[i+2], '~'
    Statement = ''.join(Statement)
Statement = Statement.replace('~[∀', '[~∀')
exps = '([~[∀|∃])'
    for S in Statements:
        exps = '~'
    for S in statements:
        Statement = Statement.replace(S, Anyon
return Statement.
```

output:-

```
print(Skolemization(fol_to_cnf("animal(y)<=>loves(x,y)")))
print(Skolemization(fol_to_cnf("∀x[∀y[animal(y)=>loves(x,y)]]=>[∃z[loves(z,x)]]")))
print(fol_to_cnf("[american(x)&weapon(y)&sells(x,y,z)&hostile(z)]=>criminal(x)"))
```

```
[~animal(y)|loves(x,y)]&[~loves(x,y)|animal(y)]
[animal(G(x))&~loves(x,G(x))]|[loves(F(x),x)]
[~american(x)|~weapon(y)|~sells(x,y,z)|~hostile(z)]|criminal(x)
```

Forward chaining
Code:-



19/1/2024

1⁰ Forward chaining

1.) Input the knowledge base and the query
2.) for i in KB:
    if i == query return True
    if l ⇒ r
        split lhs and rhs part
        if lhs in KB:
            add rhs to KB
    return False
3.) To remove variables
    if i.lower():
        replace the variable with constants

Example:

KB

King(x) & greedy(x) ⇒ evil(x)
King(John)
greedy(John)
King(Richard)

Query

evil(x)

Code :-

```
import re
def is_variable(x):
    return len(x)==1 and x.islower() and x.isalpha()

def getAttributes(string):
    expr = '\([^)]+\)'
    matches = re.findall(expr, string)
    return matches

def get_predicates(string):
    expr = '([a-z~]+)\([^&|]+\)'
    return re.findall(expr, string)

class Fact:
    def __init__(self, expression):
        self.expression = expression
        self.params = params
        self.result = any(self.getconstants())

    def splitExpression(self, expression):
        predicate = get_predicates(expression)[0]
        params = getAttributes(expression[0]
                               .strip('()').split(','))
        return [predicate, params]

    def getresult(self):
        return self.result

    def getconstants(self):
        return [None if is_variable(c) else c for
                c in self.params]
```

```
def get_variable(self):
    return [v if isVariable(v) else None for v in
            self.parms]

class Implication:
    def __init__(self, expression):
        self.expression = expression
        l = expression.split('=>')
        self.lhs = [fact(f) for f in l[0].split('&')]
        self.rhs = fact(l[1])

    def evaluate(self, facts):
        constants = {}
        new_lhs = []
        for fact in facts:
            for val in self.lhs:
                if val.predicate == fact.predicate:
                    for i,v in enumerate(val.getVariables()):
                        if v:

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

    def tell(self, e):
        if '=>' in e:
            self.implications.add(Implication(e))

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

```
def query (self, q):
    facts = set ([f.expression for in self.facts]
def display (self):
    print ("All facts")
        for i, in enumerate (set ([f.expression
                for in self.facts
            print (fact {i+1} {f})
kb = KB()
KB - tell ("King(x) & greedy(x) => evil(x))
kb = tell ('King(John)')
kb - tell ('greedy(John)')
kb = tell ('King(Richard)')
kb - query ('evil(x)')
```

Output:

Querying evil(x):

evil (John)

29/11/24

Complete!

Output:-

```
kb_ = KB()
kb_.tell('king(x)&greedy(x)=>evil(x)')
kb_.tell('king(John)')
kb_.tell('greedy(John)')
kb_.tell('king(Richard)')
kb_.query('evil(x)')
```

```
Querying evil(x):
        1. evil(John)
```