VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
On

ARTIFICIAL INTELLIGENCE

Submitted by

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

B.M.S. COLLEGE OF ENGINEERING
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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 **IMRAN WADRALI (1BM21CS077)**, 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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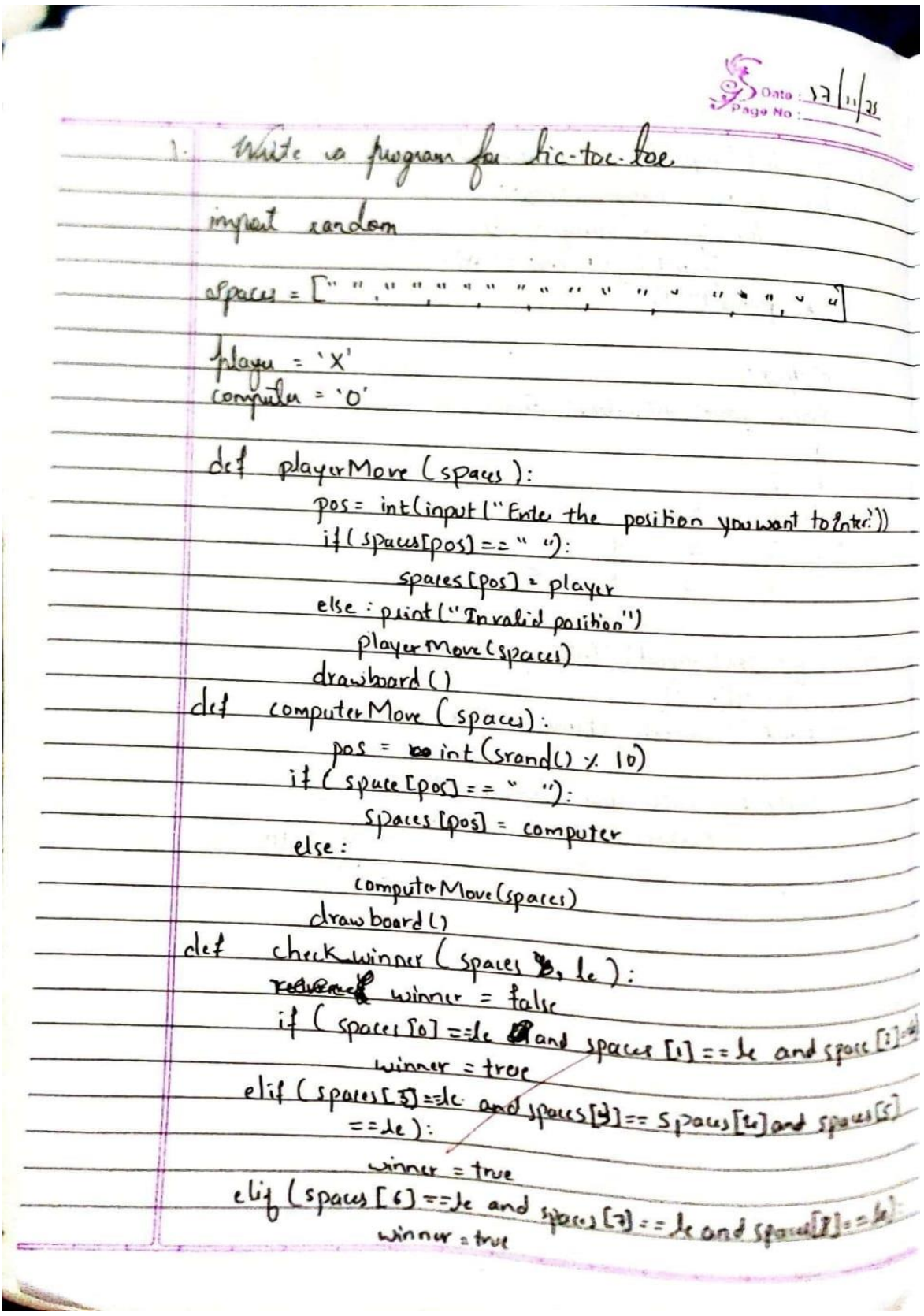
1.Implement Tic –Tac –Toe Game.



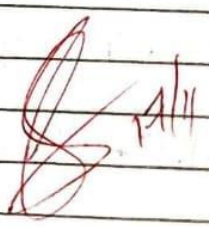
1. Write a program for tic-tac-toe

```
import random

spaces = [" ", " ", " ", " ", " ", " ", " ", " ", " ", " "]

player = 'X'
computer = 'O'

def playerMove (spaces):
    pos = int(input("Enter the position you want to enter:"))
    if (spaces[pos] == " "):
        spaces [pos] = player
    else : print ("Invalid position")
        playerMove (spaces)
    drawboard ()
def computerMove (spaces):
    pos = int (srand() % 10)
    if ( space [pos] == " "):
        spaces [pos] = computer
    else:
        computerMove (spaces)
    drawboard ()
def check_winner ( spaces, le ):
    winner = false
    if ( spaces [0] == le and spaces [1] == le and spaces [2] ==
        winner = true
    elif ( spaces [3] == le and spaces [4] == spaces [5] and spaces [5]
        == le ):
        winner = true
    elif (spaces [6] == le and spaces [7] == le and spaces [8] == le):
        winner = true
```

main()

Algorithm:

Step 1: make a spaces of 9 elements.
Step 2: Take input player move
Step 3: Check winner (if win stop the game)
Step 4: Take computer's random input
Step 5: Check winner. (if won stop the game)



```
elif(spaces[0] == le and spaces[3] == le and spaces[6] == le):
        winner = true
elif(spaces[1] == le and spaces[4] == le and spaces[7] == le):
        winner = true
elif(spaces[2] == le and spaces[5] == le and spaces[8] == le):
        winner = true
elif(spaces[0] == le and spaces[4] == le and spaces[8] == le):
        winner = true
elif(spaces[2] == le and spaces[4] == le and spaces[6] == le):
        winner = true
return winner

def drawboard():
    print(spaces[0] + "|" + spaces[1] + "|" + spaces[2])
    print("-----")
    print(spaces[3] + "|" + spaces[4] + "|" + spaces[5])
    print("-----")
    print(spaces[6] + "|" + spaces[7] + "|" + spaces[8])

def main():
    running = true
    drawboard()
    while(running):
        playermove(spaces)
        if(checkwinner(spaces, player)):
            running = false
            break()
        computerMove(spaces)
        if(checkwinner(spaces, computer)):
            running = false
            break()
```

2 .Solve 8 puzzle problems.

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Lab-3 : 8- puzzle

1) Define the state representation: Represent the initial & final states of the puzzle.
like
initial = [1, 2, 3, 4, 5, 6, 7, 0, 8]
Goal = [1, 2, 3, 4, 5, 6, 7, 8, 0]

2) Initialize the Queue: Begin by making a Queue and store the states. Add the initial state of the puzzle to the queue.

3) Make rules for Moving tiles: The empty tile can move only in 4 directions.
up, down, left, right.
It should take one step at a time
Divide rules like

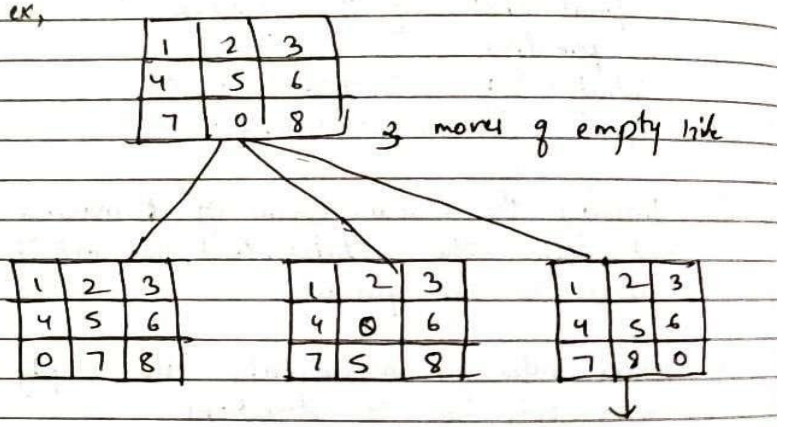
2	3	2
3	4	3
2	3	2

→ Like the corner elements can move only in 2 directions
→ The centre element can move in all 4 directions
→ The corner middle elements can move in 3 directions

4) Next, every time load the current state of board and create the possible moves until current state matches goal state and make a path for the same. Also ensure the states are not already visited to avoid cycles.

5] If BFS reach a solution give the path of solution else print no solution.

For ex,



Program:

```
from collections import deque

def bfs_8puzzle(initial_state, goal_state):
    queue = deque([[initial_state, []]])
    visited = set()
    while queue:
        current_state, path = queue.popleft()
    if (current_state == goal_state): return path
```

Output.

Solution:

[(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)]

3. Implement Iterative deepening search algorithm.

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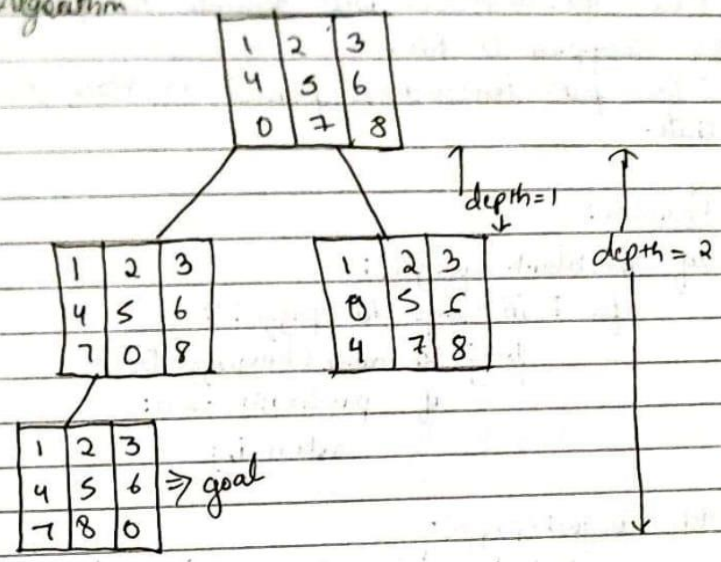
8-puzzle iterative deepening search algorithm

Algorithm



Algorithm:

1] Initialize the initial state = [] and goal state for the 8puzzle

goal_state = [1,2,3,4,5,6,7,8,0] #0 is empty tile

2] Set the depth = 1 and expand the initial state. The depth_limited_search(depth) is performed

```
if node.state = goal
    return node
else
    for neighbour in getneighnode(state)
        child = Puzzlenode(neighbour, node)
        result = depth_limited_search(depth-1)
    if result == True:
        return result;
```

3) After one iteration when depth = 1 increment the depth by 1 and perform limited search again.

4) Here get_neighbour will generate the possible moves by swapping '0' tile.

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

Program:

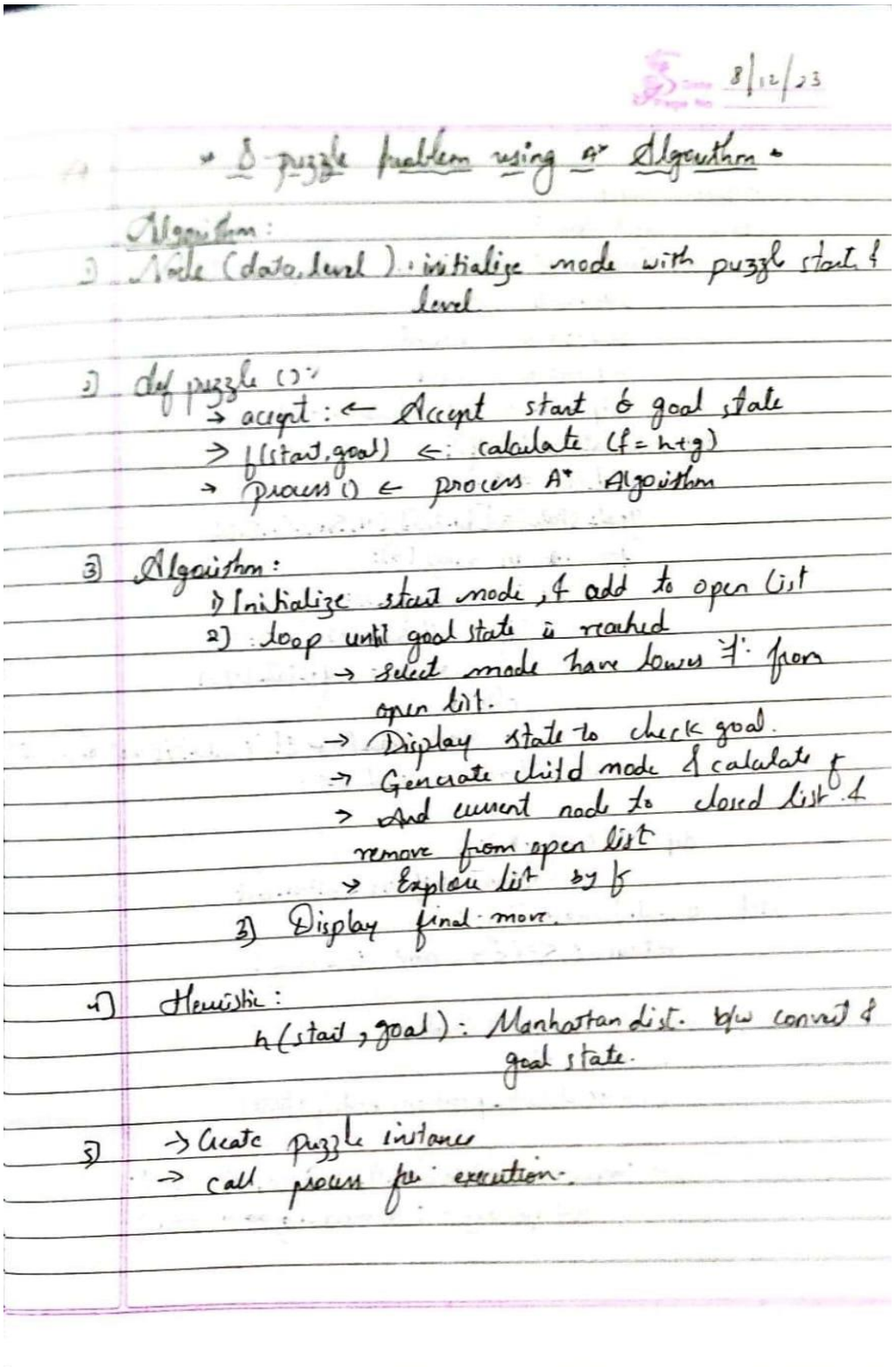
```
def find_blank (puzzle):
    for i in range (len (puzzle)):
        for j in range (len(puzzle[i])):
            if puzzle[i][j] == 0:
                return i, j

def is_goal (puzzle):
    goal_state = [[1,2,3],[4,5,6],[7,8,0]]
    return puzzle == goal_state

def move_tile (puzzle, direction):
    blank_row, blank_col = find_blank (puzzle)
    new_puzzle = [row[:] for row in puzzle]

    if direction == 'up' and blank_row > 0:
        new_puzzle [blank_row][blank_col], new_puzzle
        [blank_row-1][blank_col] = new_puzzle[row...
            [blank_col], new_puzzle [blank_row...
    elif direction == 'down' and blank_row < 2:
        new_puzzle [blank_row][blank_col], new_puzzle
        [blank_row-1][blank_col], new_puzzle
```

4. Implement A* search algorithm.



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* 8 puzzle problem using A* Algorithm *

Algorithm:

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

2) def puzzle ():
   → accept: ← Accept start & goal state
   → f(start, goal) ← calculate (f = h+g)
   → process () ← process A* Algorithm

3) Algorithm:
   1) Initialize start node, & add to open list
   2) loop until goal state is reached
      → Select node have lower f: from open list.
      → Display state to check goal.
      → Generate child node & calculate f
      → And current node to closed list & remove from open list
      → Explore list by f
   3) Display final move.

4) Heuristic:
   h(start, goal): Manhattan dist. b/w current & goal state.

5) → Create puzzle instance
   → call process for execution.

5. Implement vaccum cleaner agent.

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* Vacuum Cleaner Problem *

Algorithm:

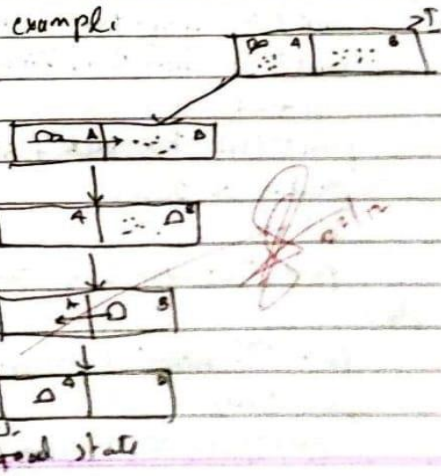
1] Initalize the starting and goal state, the goal state ~~begin~~ being to have both rooms ~~clean~~ clean.

2] If status = Dirty then clean
else if location = A & status = clean ~~return~~ return right
else if location = B & status = clean return left
else exit.

3] Based on above rules, take user input on cleanliness status and show the actions of vacuum cleaner.

4] Once both rooms are clean ~~exit~~ the vacuum cleaner has accomplished the task and reached goal state and then exits.

For example:

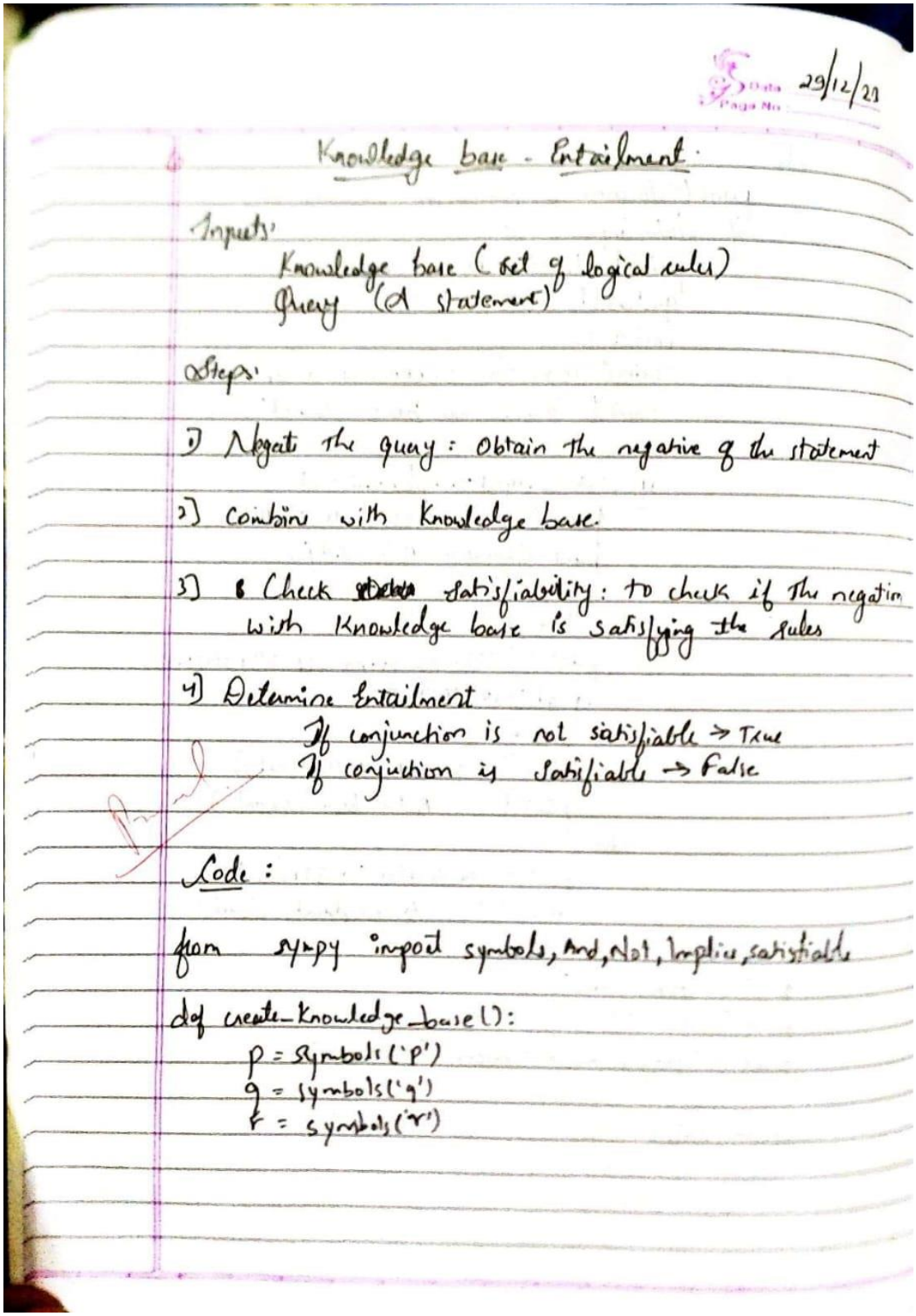


Code:

```
def vacuum_world():
    goal_state = {'A': 0, 'B': 0}
    cost = 0

    location_input = input("Enter location of vacuum")
    status_input = int(input("Enter status of" + location_input))
    status_input_complement = int(input("Enter the status of the other room"))
    print("Initial Location Condition" + str(goal_state))

    if location_input == 'A':
        print("Vacuum is placed in Location A")
        if status_input == 1:
            print("Location A is Dirty.")
            goal_state['A'] = 0
            cost += 1
            print("Cost of CLEANING A" + str(cost))
            print("Loc A has been cleared")

            if status_input_complement == 1:
                print("Moving right to location B")
                print("Location B is Dirty")
                cost += 1
                print("Cost for suck" + str(cost))
                goal_state['B'] = 0
                cost += 1
                print("Location B is cleaned")
            else:
                print("No action" + str(cost))
                print(cost)
                print("Loc B is already clean")
```

```
else:
    print("Vaccum is placed in location B")
    if status_input == 1
        print("Location B is Dirty.")
        good_state['B'] = 0
        cost += 1
        print("COST for CLEANING" + str(cost))
        print("loc B has been cleaned")

        if status_input_complement = = 1
            print("Moving LEFT to locA")
            print("Location A is dirty")

            cost += 1
            print("COST of moving LEFT" + str(cost))
            good_state['A'] = 0
            cost += 1
            print("Cost of suck" + str(cost))
            print("Loc A has been cleaned")
        else:
            print("No action" + str(cost))
            print("Loc A is already clean")

print("GOAL STATE")
print(good_state)
print("performance measurement" + str(cost))

vaccum world()
```

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



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Knowledge base - Entailment

Inputs:
Knowledge base (Set of logical rules)
Query (A statement)

Steps:

1] Negate the query: Obtain the negative of the statement

2] Combine with Knowledge base.

3] Check satisfiability: to check if the negation with Knowledge base is satisfying the rules

4] Determine Entailment
If conjunction is not satisfiable → True
If conjuction is satisfiable → False

Code:

```
from sympy import symbols, And, Not, Implies, satisfiable

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(Knowledge_base, query):
    entailment = Satisfiable(And(Knowledge_base, Not(query)))

    return not entailment

if __name__ == "__main__":
    kb = create_knowledgebase()

    query = symbols('not p')

    result = query_entails(kb, query)

    print("Knowledge Base: ", kb)
    print("Query:", query)
    print("Query entails KnowledgeBase", result)
```

Output

Knowledge Base : ~r & (implies(p,q)) & (implies(q,r))

Query : (not, p)

Query entails knowledge base : False

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

Knowledge Base. Propositional Logic

```
7. Code:
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_literal(literal))
    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_base)
                if i != j:
                    newclause = resolve(C1, C2)
                if len(new_clause) > 0 & new_clause
                        not in knowledge_base:
                    new_clause.add(new_clause)

        if not new_clause
            break.
```

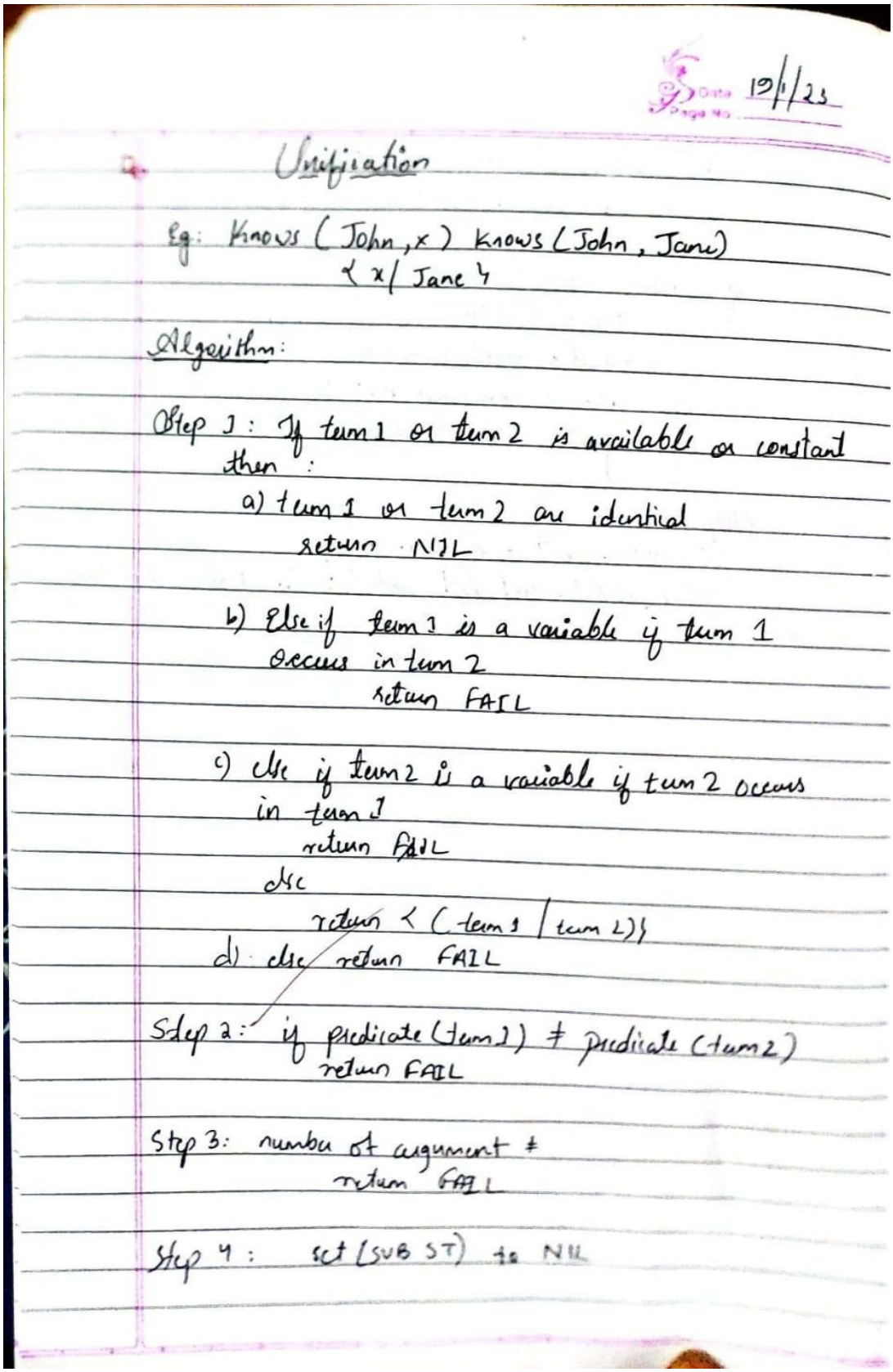
```
        Knowledge_base != new_clause
        Return Knowledge_base

if __name__ == '__main__':
        Kb = [('p', b), ('~p', 'r'), ('~q', '~r')]
        result = resolution(Kb)
        print('original Kb', Kb)
        print('Resolved Kb', result)
```

Output:

Enter Statement = negation

The Statement not entitled in Knowledge base

8. Implement unification in first order logic :



Unification

Eg: Knows (John, x) Knows (John, Jane)
{x/ Jane}

Algorithm:

Step 1: If term 1 or term 2 is variable or constant then:
a) term 1 or term 2 are identical
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 result into S
S = FAIL
return FAIL.

b) if S ≠ NIL
a) Apply S to the remainder of both L_1 & L_2
b) SUBST. APPEND (S, SUBST)

step 6: Return SUBST

Code:

```
import re

def getAttributes(expression):
    expression = expression.split("(")[1:]
    expression = "(".join(expression)
    expression = expression[:-1]
    expression = re.split("(?<!\(),(?!\))", expression)
    return expression

def getInitialPredicate(expression):
    return expression.split("(")[0]

def isVariable(char):
    return char.islower() and len(char)==1
```

```
def apply(exp, substitutions):
    for substitution in substitutions:
        new, old = substitution
        exp = replaceAttributes(exp, old, new)
    return exp

def checkOccurs(var, exp):
    if exp.find(var) == -1
        return false
    return true

def getFirstPart(expression):
    attributes = getAttributes(expression)
    return Attributes[0]

def unify(exp1, exp2):
    if exp1 == exp2
        return []

    if isConstant(exp1):
        return [(exp1, exp2)]

    if isVariable(exp1):
        if checkOccurs(exp1, exp2):
            return false
        else:
            return [(exp2, exp1)]

    if initialSubstitution != []:
        tail1 = apply(tail1, initial)
        tail2 = apply(tail1, initial)
```

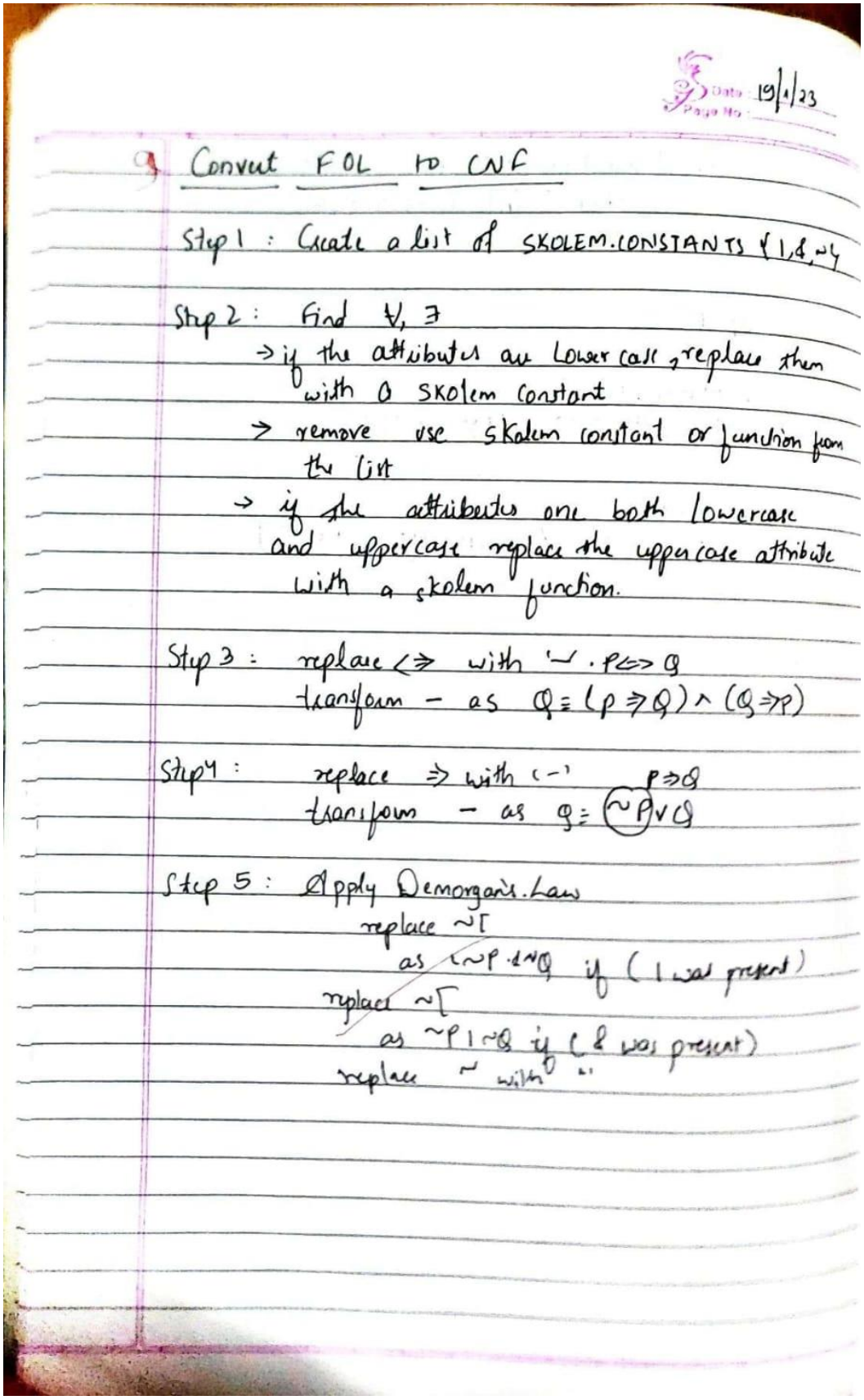
initial Substitution extend (renaming sub)
return initialSubstitution.

Output:

Substitutions:
[('A','Y'), ('Y','x')]

Substitutions:
[('A','Y'), ('Mother(Y)','x')]

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



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Convert FOL to CNF

Step 1 : Create a list of SKOLEM.CONSTANTS {1,2,...}

Step 2 : Find ∀, ∃
→ if the attributes are Lower case, replace them with a skolem constant
→ remove use skolem constant or function from the list
→ if the attributes are both lowercase and uppercase replace the uppercase attribute with a skolem function.

Step 3 : replace <⇒ with '~' . P<=>Q
transform - as Q≡(P⇒Q)∧(Q⇒P)

Step 4 : replace ⇒ with (~) P⇒Q
transform - as Q≡(~P∨Q)

Step 5 : Apply Demorgan's Law
replace ~[
as (~P.~Q if (was present)
replace ~[
as ~P|~Q if (was present)
replace ~ with '.'

Code:

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

def getpredicate(string):
    expr = '[a-zA-Z]+\([A-Za-z,]+\)'
    return re.findall(expr, string)

def deMorgan(sentence):
    string = ''.join(list(sentence).copy())
    string = string.replace('~~', '')
    flag = '~' in string

    for predicate in getPredicate(string):
        string = string.replace(predicate, '~'+predicate)

    S = list(string)

    for i,c in enumerate(string):
        if c == '|':
            S[i] = '&'
        elif c == '&':
            S[i] = '|'

    return ''.join(S)[1:-1] if flag else '~('+''.join(S)+')'
```

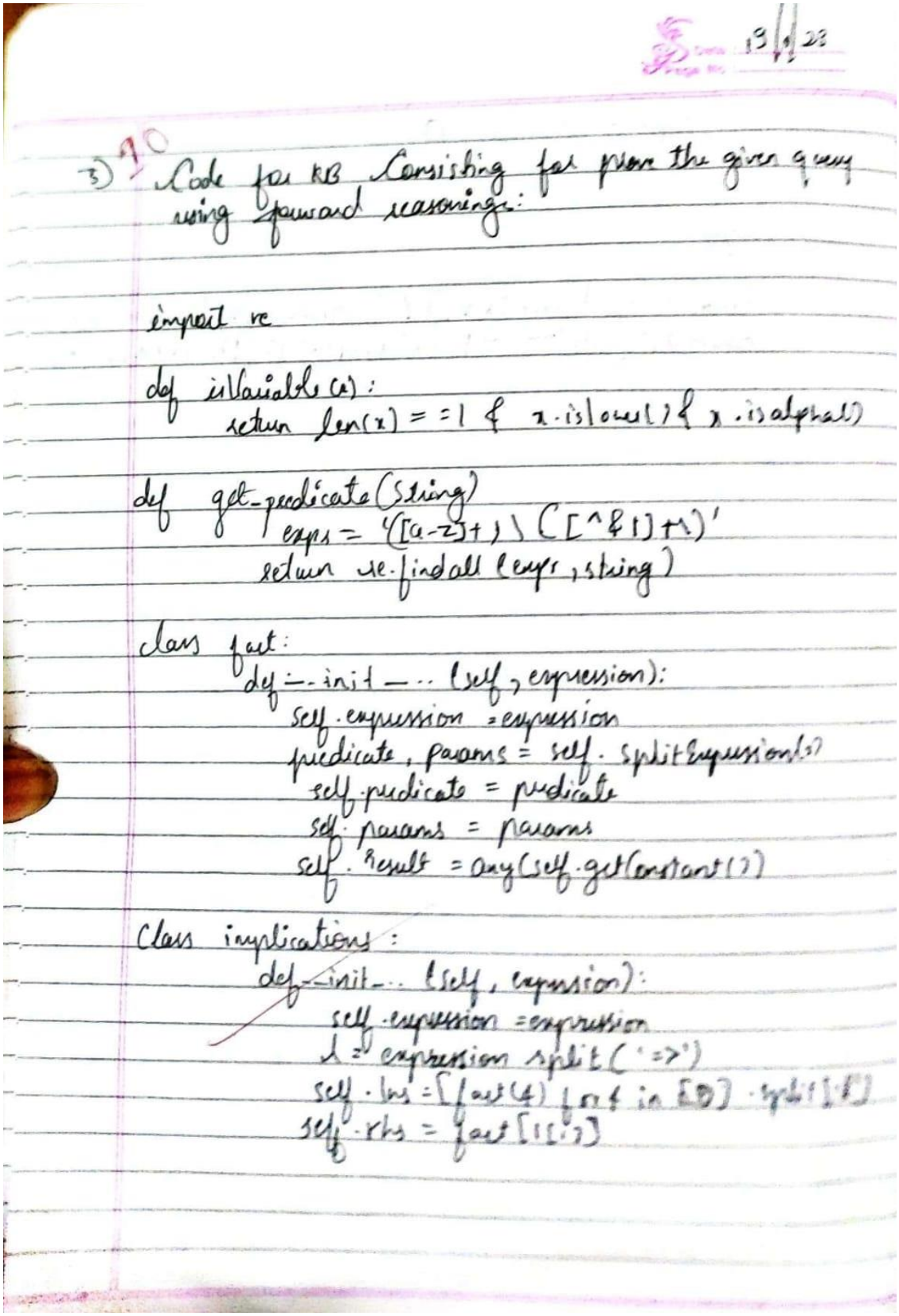
```
def skolemization(sentence):
    statement = ''.join(list(sentence).copy())
    matches = re.findall('[A-Z]', statement)

    for match in matches[::-1]:
        statement = statement.replace(match, '')

    for s in statements:
        statement = statement.replace(s, s[1:-1])


import re

def fol_to_cnf(fol):

    statement = fol.replace("<=>", "-")

    while '-' in statement:
        i = statement.index('-')
        statement = new_statement

    statement = statement.replace('=>', '-')

    while '-' in statement:
        i = statement.index('-')
        br = statement.index('[') + '[' in statement

    while '~A' in statement:
        i = statement.index('~A')
        statement = list(statement)
        statement[i:] = statement[i+2] + "A"
```

expr = (∀ = [A | ∃])

Output:

[¬animals(g) | love(x,y)] ∉ [¬love[x,y] | animals(y)]
[animals[F(z)]] — ¬loves(x, G(x)), [loves(A(x), x]

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



3) Code for KB consisting for prove the given query using forward reasoning:

```
import re

def isVariable(x):
    return len(x) == 1 & x.islower() & x.isalpha()

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

class fact:
    def __init__(self, expression):
        self.expression = expression
        predicate, params = self.splitExpression()
        self.predicate = predicate
        self.params = params
        self.result = any(self.getConstant())

Class implications:
    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, fact):
    constants = {}
    new_lhs = []

    for key in constants:
        if constants[key]:
            attributes = attributes.pop(key)

    return fact(args) if len(new_line) & all
    ([t.getResult() for t in new])
    else none.

class KB:

    def __init__(self):
        self.fact = set()
        self.fact = set()

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

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

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

All facts:

Query: evil(x)

1. evil(John)