**Artificial Intelligence Lab**

**LAB 7 – Unification and Resolution**

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**O2 Section**

**Date – 15/3/22**

**Problem Statement :**

Implementation of unification

**Algorithm :**

1. Initialize the substitution set to be empty.
2. Recursively unify atomic sentences:

* Check for Identical expression match.
* If one expression is a variable vi, and the other is a term ti which does not contain variable vi, then:
* Substitute ti / vi in the existing substitutions
* Add ti /vi to the substitution setlist.
* If both the expressions are functions, then function name must be similar, and the number of arguments must be the same in both the expression.

For each pair of the following atomic sentences find the most general unifier (If exist).

**Code:**

def get\_index\_comma(string):

index\_list = list()

par\_count = 0

for i in range(len(string)):

if string[i] == ',' and par\_count == 0:

index\_list.append(i)

elif string[i] == '(':

par\_count += 1

elif string[i] == ')':

par\_count -= 1

return index\_list

def is\_variable(expr):

for i in expr:

if i == '(' or i == ')':

return False

return True

def process\_expression(expr):

expr = expr.replace(' ', '')

index = None

for i in range(len(expr)):

if expr[i] == '(':

index = i

break

predicate\_symbol = expr[:index]

expr = expr.replace(predicate\_symbol, '')

expr = expr[1:len(expr) - 1]

arg\_list = list()

indices = get\_index\_comma(expr)

if len(indices) == 0:

arg\_list.append(expr)

else:

arg\_list.append(expr[:indices[0]])

for i, j in zip(indices, indices[1:]):

arg\_list.append(expr[i + 1:j])

arg\_list.append(expr[indices[len(indices) - 1] + 1:])

return predicate\_symbol, arg\_list

def get\_arg\_list(expr):

\_, arg\_list = process\_expression(expr)

flag = True

while flag:

flag = False

for i in arg\_list:

if not is\_variable(i):

flag = True

\_, tmp = process\_expression(i)

for j in tmp:

if j not in arg\_list:

arg\_list.append(j)

arg\_list.remove(i)

return arg\_list

def check\_occurs(var, expr):

arg\_list = get\_arg\_list(expr)

if var in arg\_list:

return True

return False

def unify(expr1, expr2):

if is\_variable(expr1) and is\_variable(expr2):

if expr1 == expr2:

return 'Null'

else:

return False

elif is\_variable(expr1) and not is\_variable(expr2):

if check\_occurs(expr1, expr2):

return False

else:

tmp = str(expr2) + '/' + str(expr1)

return tmp

elif not is\_variable(expr1) and is\_variable(expr2):

if check\_occurs(expr2, expr1):

return False

else:

tmp = str(expr1) + '/' + str(expr2)

return tmp

else:

predicate\_symbol\_1, arg\_list\_1 = process\_expression(expr1)

predicate\_symbol\_2, arg\_list\_2 = process\_expression(expr2)

# Step 2

if predicate\_symbol\_1 != predicate\_symbol\_2:

return False

# Step 3

elif len(arg\_list\_1) != len(arg\_list\_2):

return False

else:

# Step 4: Create substitution list

sub\_list = list()

# Step 5:

for i in range(len(arg\_list\_1)):

tmp = unify(arg\_list\_1[i], arg\_list\_2[i])

if not tmp:

return False

elif tmp == 'Null':

pass

else:

if type(tmp) == list:

for j in tmp:

sub\_list.append(j)

else:

sub\_list.append(tmp)

# Step 6

return sub\_list

if \_\_name\_\_ == '\_\_main\_\_':

f1 = 'Q(a, g(x, a), f(y))'

f2 = 'Q(a, g(f(b), a), x)'

# f1 = input('f1 : ')

# f2 = input('f2 : ')

result = unify(f1, f2)

if not result:

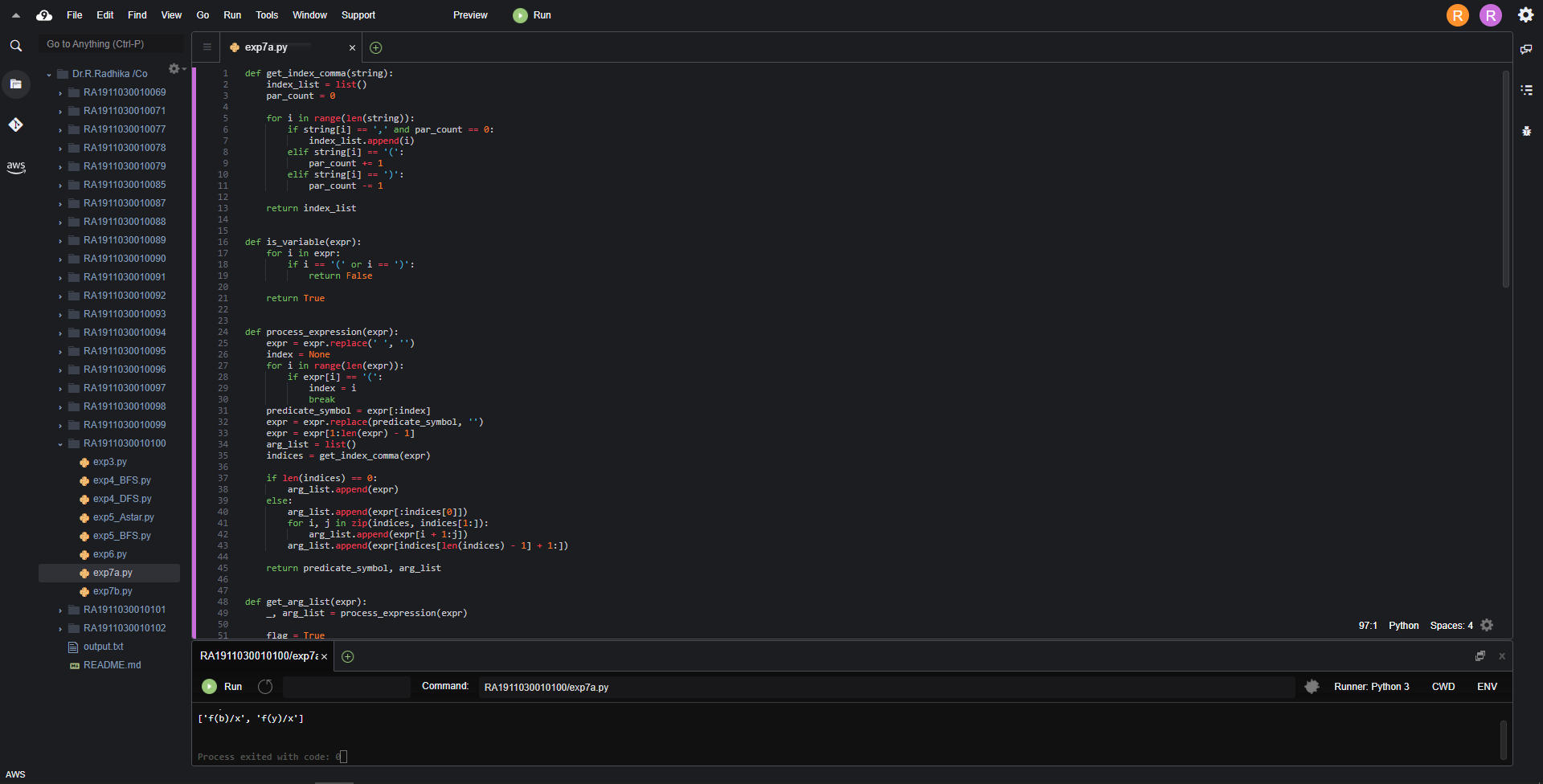
print('The process of Unification failed!')

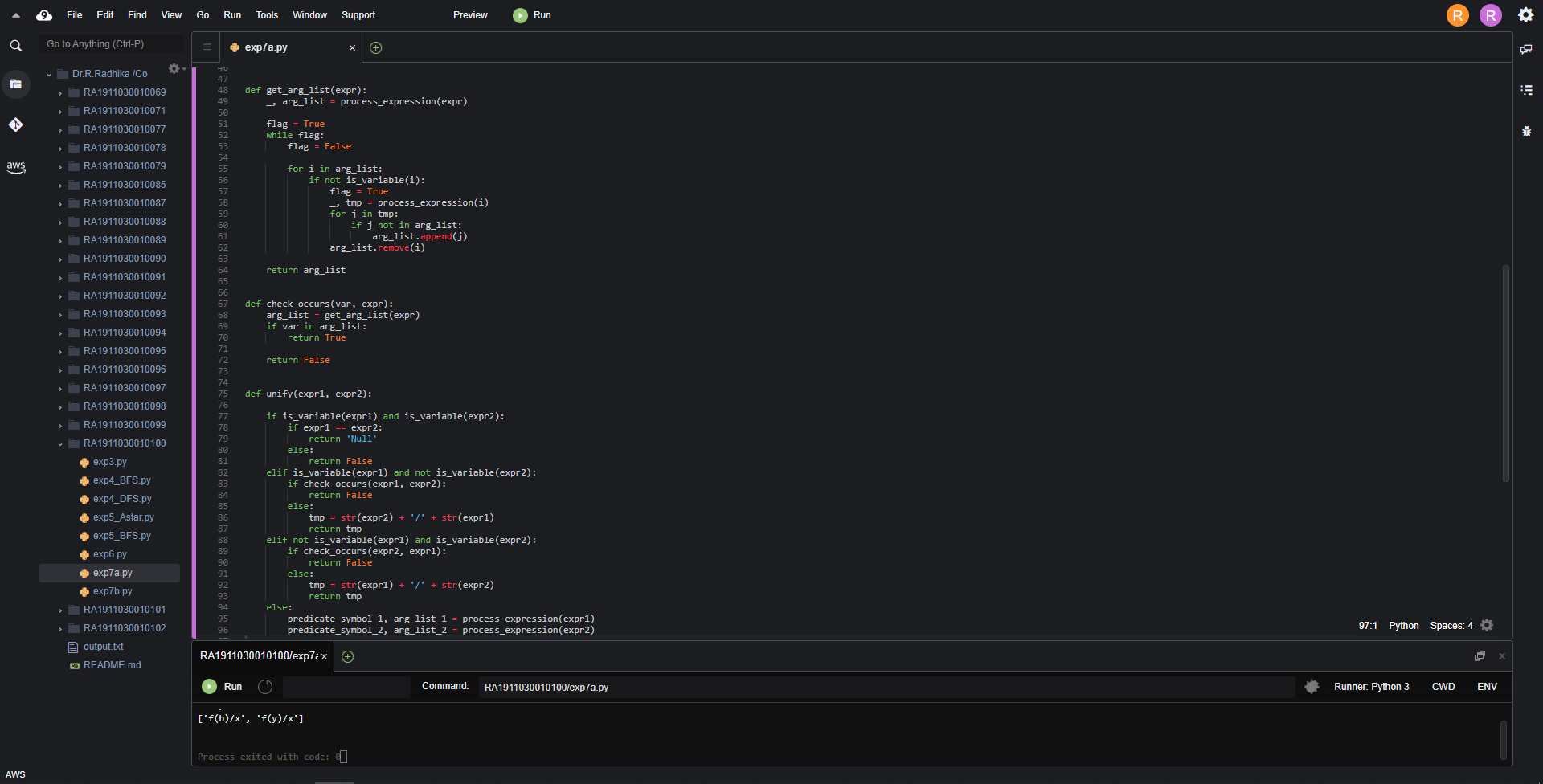
else:

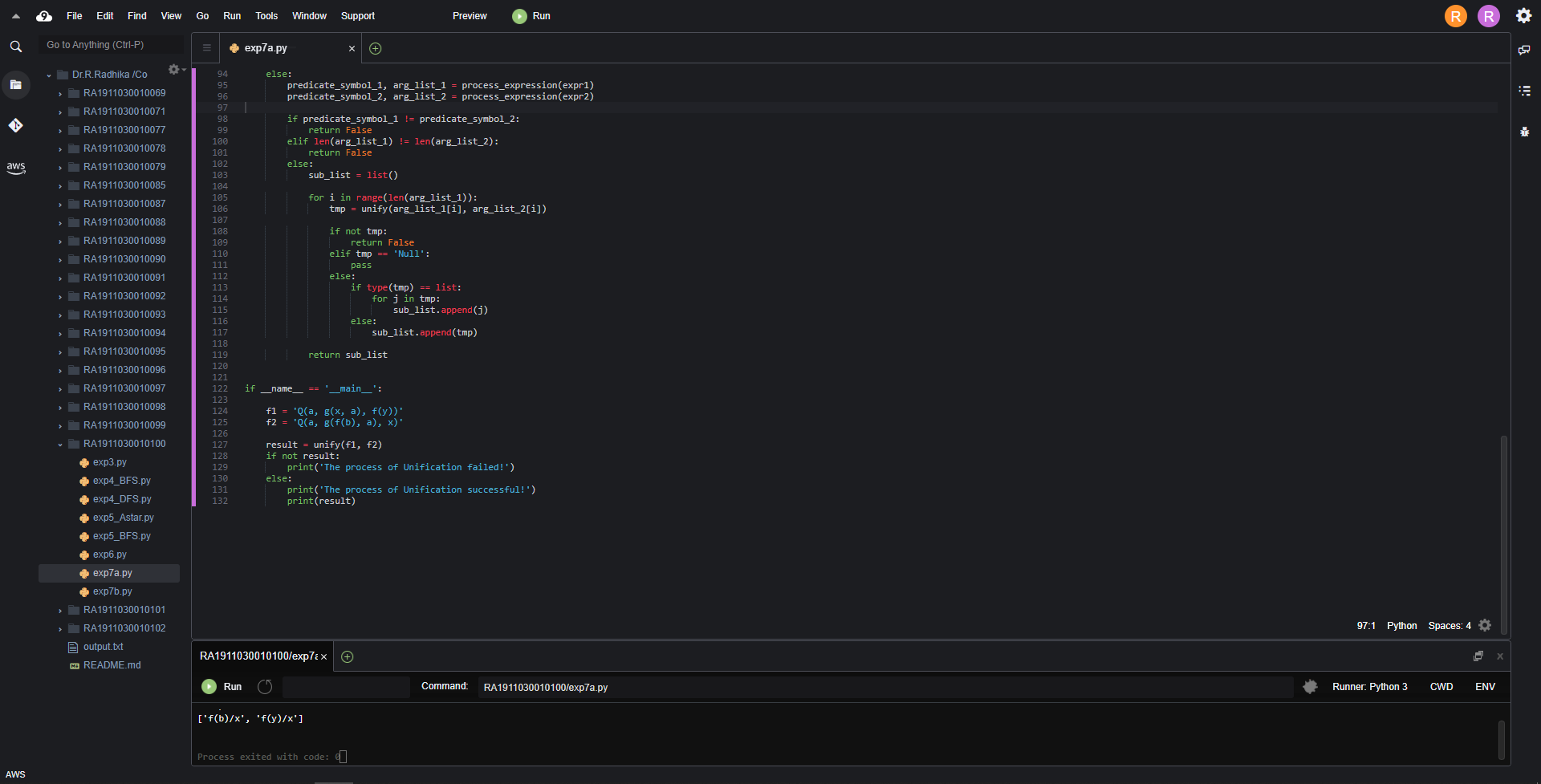
print('The process of Unification successful!')

print(result)

**Output:**







**Result:**

Hence we performed unification.

**Artificial Intelligence Lab**

**LAB 7 – Unification and Resolution**

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**Problem Statement :**

Implementation of resolution

**Algorithm :**

Resolution is used, if there are various statements are given, and we need to prove a conclusion of those statements. Unification is a key concept in proofs by resolutions. Resolution is a single inference rule which can efficiently operate on the **conjunctive normal form or clausal form.**

1. Conversion of facts into first-order logic.
2. Convert FOL statements into CNF
3. Negate the statement which needs to prove (proof by contradiction)
4. Draw resolution graph (unification).

**Code :**

import copy

import time

class Parameter:

variable\_count = 1

def \_\_init\_\_(self, name=None):

if name:

self.type = "Constant"

self.name = name

else:

self.type = "Variable"

self.name = "v" + str(Parameter.variable\_count)

Parameter.variable\_count += 1

def isConstant(self):

return self.type == "Constant"

def unify(self, type\_, name):

self.type = type\_

self.name = name

def \_\_eq\_\_(self, other):

return self.name == other.name

def \_\_str\_\_(self):

return self.name

class Predicate:

def \_\_init\_\_(self, name, params):

self.name = name

self.params = params

def \_\_eq\_\_(self, other):

return self.name == other.name and all(a == b for a, b in zip(self.params, other.params))

def \_\_str\_\_(self):

return self.name + "(" + ",".join(str(x) for x in self.params) + ")"

def getNegatedPredicate(self):

return Predicate(negatePredicate(self.name), self.params)

class Sentence:

sentence\_count = 0

def \_\_init\_\_(self, string):

self.sentence\_index = Sentence.sentence\_count

Sentence.sentence\_count += 1

self.predicates = []

self.variable\_map = {}

local = {}

for predicate in string.split("|"):

name = predicate[:predicate.find("(")]

params = []

for param in predicate[predicate.find("(") + 1: predicate.find(")")].split(","):

if param[0].islower():

if param not in local: # Variable

local[param] = Parameter()

self.variable\_map[local[param].name] = local[param]

new\_param = local[param]

else:

new\_param = Parameter(param)

self.variable\_map[param] = new\_param

params.append(new\_param)

self.predicates.append(Predicate(name, params))

def getPredicates(self):

return [predicate.name for predicate in self.predicates]

def findPredicates(self, name):

return [predicate for predicate in self.predicates if predicate.name == name]

def removePredicate(self, predicate):

self.predicates.remove(predicate)

for key, val in self.variable\_map.items():

if not val:

self.variable\_map.pop(key)

def containsVariable(self):

return any(not param.isConstant() for param in self.variable\_map.values())

def \_\_eq\_\_(self, other):

if len(self.predicates) == 1 and self.predicates[0] == other:

return True

return False

def \_\_str\_\_(self):

return "".join([str(predicate) for predicate in self.predicates])

class KB:

def \_\_init\_\_(self, inputSentences):

self.inputSentences = [x.replace(" ", "") for x in inputSentences]

self.sentences = []

self.sentence\_map = {}

def prepareKB(self):

self.convertSentencesToCNF()

for sentence\_string in self.inputSentences:

sentence = Sentence(sentence\_string)

for predicate in sentence.getPredicates():

self.sentence\_map[predicate] = self.sentence\_map.get(

predicate, []) + [sentence]

def convertSentencesToCNF(self):

for sentenceIdx in range(len(self.inputSentences)):

# Do negation of the Premise and add them as literal

if "=>" in self.inputSentences[sentenceIdx]:

self.inputSentences[sentenceIdx] = negateAntecedent(

self.inputSentences[sentenceIdx])

def askQueries(self, queryList):

results = []

for query in queryList:

negatedQuery = Sentence(negatePredicate(query.replace(" ", "")))

negatedPredicate = negatedQuery.predicates[0]

prev\_sentence\_map = copy.deepcopy(self.sentence\_map)

self.sentence\_map[negatedPredicate.name] = self.sentence\_map.get(

negatedPredicate.name, []) + [negatedQuery]

self.timeLimit = time.time() + 40

try:

result = self.resolve([negatedPredicate], [

False]\*(len(self.inputSentences) + 1))

except:

result = False

self.sentence\_map = prev\_sentence\_map

if result:

results.append("TRUE")

else:

results.append("FALSE")

return results

def resolve(self, queryStack, visited, depth=0):

if time.time() > self.timeLimit:

raise Exception

if queryStack:

query = queryStack.pop(-1)

negatedQuery = query.getNegatedPredicate()

queryPredicateName = negatedQuery.name

if queryPredicateName not in self.sentence\_map:

return False

else:

queryPredicate = negatedQuery

for kb\_sentence in self.sentence\_map[queryPredicateName]:

if not visited[kb\_sentence.sentence\_index]:

for kbPredicate in kb\_sentence.findPredicates(queryPredicateName):

canUnify, substitution = performUnification(

copy.deepcopy(queryPredicate), copy.deepcopy(kbPredicate))

if canUnify:

newSentence = copy.deepcopy(kb\_sentence)

newSentence.removePredicate(kbPredicate)

newQueryStack = copy.deepcopy(queryStack)

if substitution:

for old, new in substitution.items():

if old in newSentence.variable\_map:

parameter = newSentence.variable\_map[old]

newSentence.variable\_map.pop(old)

parameter.unify(

"Variable" if new[0].islower() else "Constant", new)

newSentence.variable\_map[new] = parameter

for predicate in newQueryStack:

for index, param in enumerate(predicate.params):

if param.name in substitution:

new = substitution[param.name]

predicate.params[index].unify(

"Variable" if new[0].islower() else "Constant", new)

for predicate in newSentence.predicates:

newQueryStack.append(predicate)

new\_visited = copy.deepcopy(visited)

if kb\_sentence.containsVariable() and len(kb\_sentence.predicates) > 1:

new\_visited[kb\_sentence.sentence\_index] = True

if self.resolve(newQueryStack, new\_visited, depth + 1):

return True

return False

return True

def performUnification(queryPredicate, kbPredicate):

substitution = {}

if queryPredicate == kbPredicate:

return True, {}

else:

for query, kb in zip(queryPredicate.params, kbPredicate.params):

if query == kb:

continue

if kb.isConstant():

if not query.isConstant():

if query.name not in substitution:

substitution[query.name] = kb.name

elif substitution[query.name] != kb.name:

return False, {}

query.unify("Constant", kb.name)

else:

return False, {}

else:

if not query.isConstant():

if kb.name not in substitution:

substitution[kb.name] = query.name

elif substitution[kb.name] != query.name:

return False, {}

kb.unify("Variable", query.name)

else:

if kb.name not in substitution:

substitution[kb.name] = query.name

elif substitution[kb.name] != query.name:

return False, {}

return True, substitution

def negatePredicate(predicate):

return predicate[1:] if predicate[0] == "~" else "~" + predicate

def negateAntecedent(sentence):

antecedent = sentence[:sentence.find("=>")]

premise = []

for predicate in antecedent.split("&"):

premise.append(negatePredicate(predicate))

premise.append(sentence[sentence.find("=>") + 2:])

return "|".join(premise)

def getInput(filename):

with open(filename, "r") as file:

noOfQueries = int(file.readline().strip())

inputQueries = [file.readline().strip() for \_ in range(noOfQueries)]

noOfSentences = int(file.readline().strip())

inputSentences = [file.readline().strip()

for \_ in range(noOfSentences)]

return inputQueries, inputSentences

def printOutput(filename, results):

print(results)

with open(filename, "w") as file:

for line in results:

file.write(line)

file.write("\n")

file.close()

if \_\_name\_\_ == '\_\_main\_\_':

inputQueries\_, inputSentences\_ = getInput(‘/home/ubuntu/environment/RA1911030010100/input.txt')

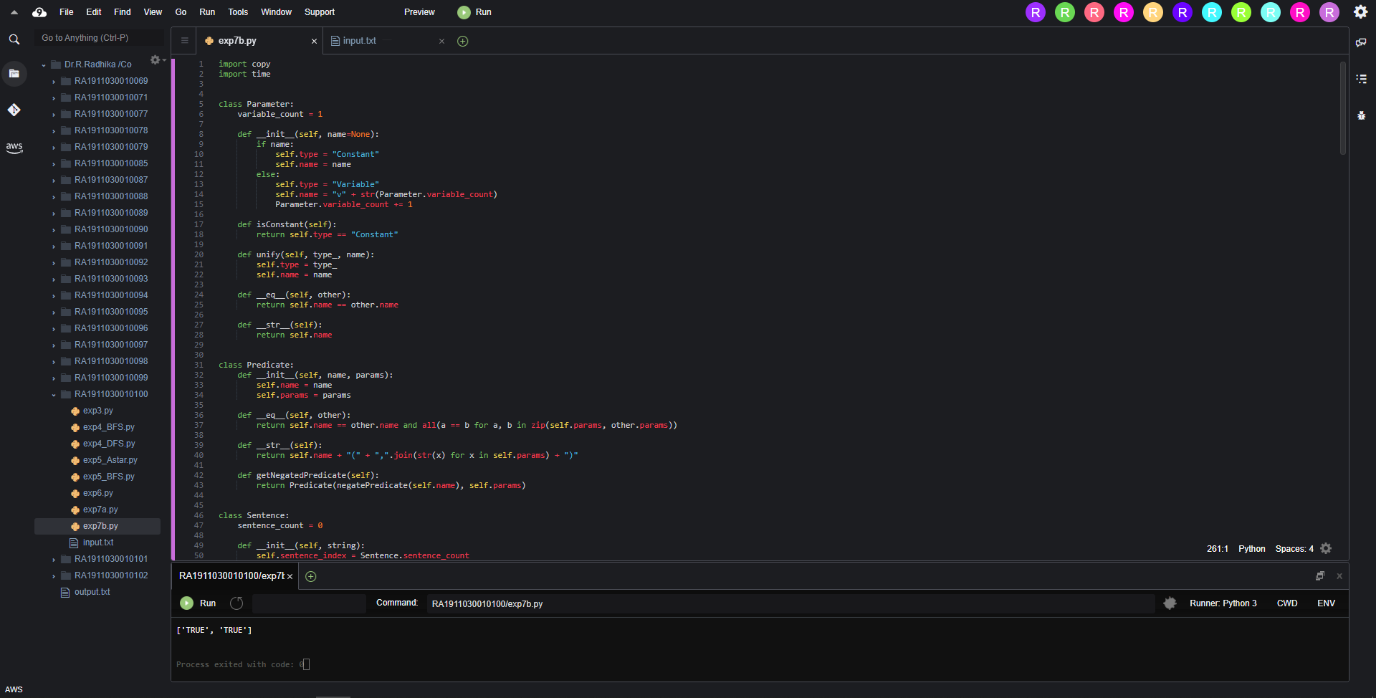
knowledgeBase = KB(inputSentences\_)

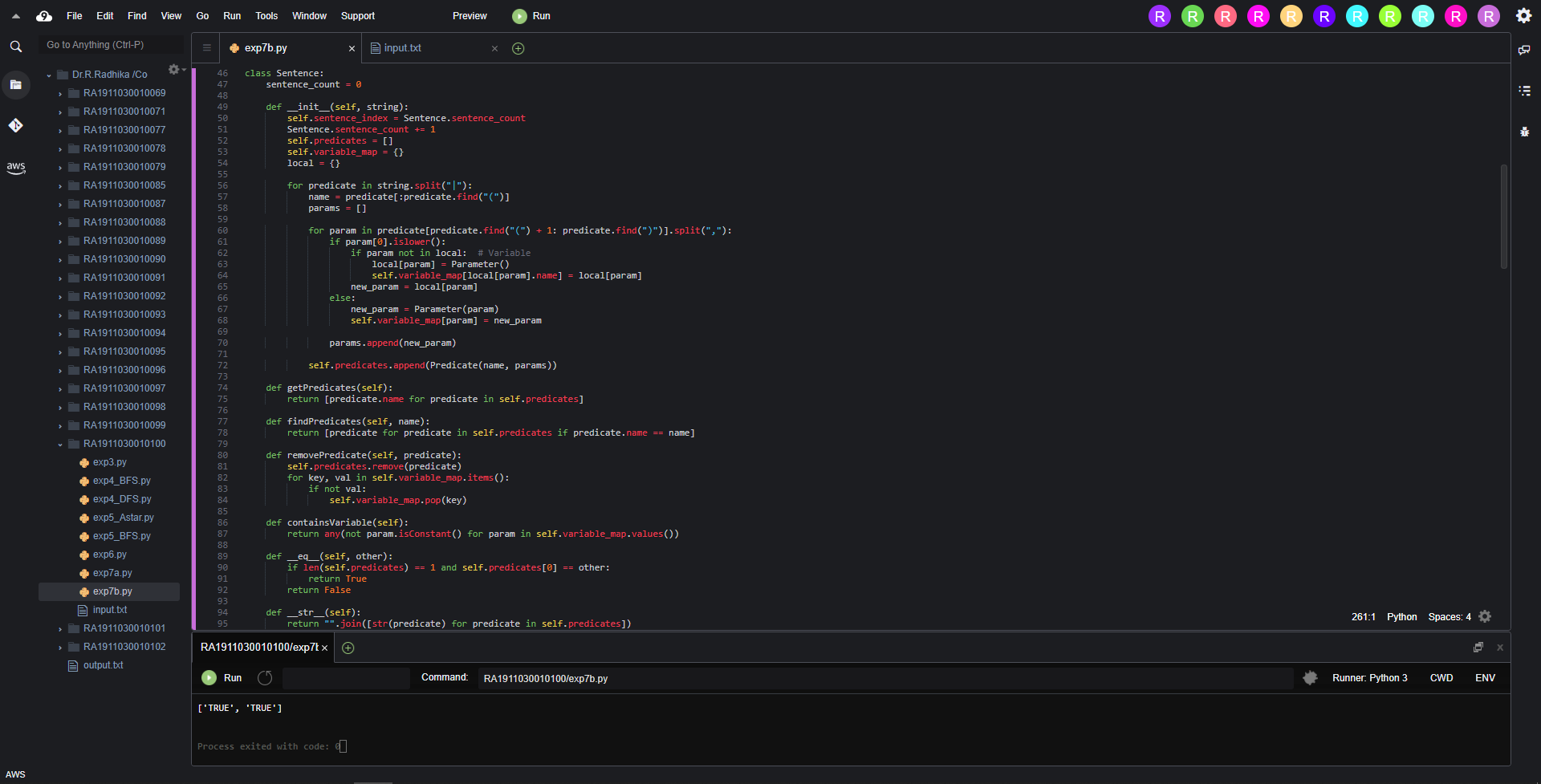
knowledgeBase.prepareKB()

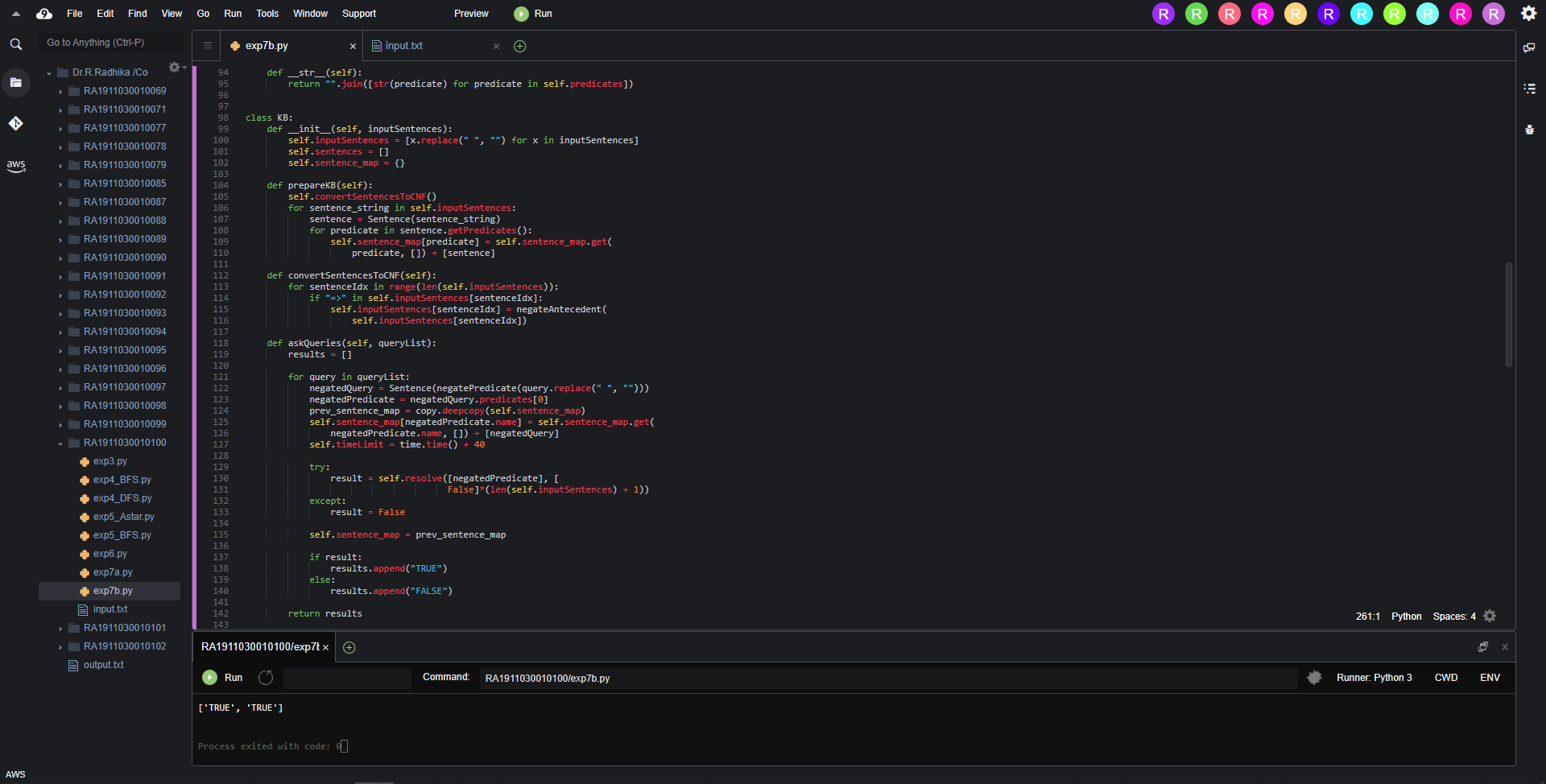
results\_ = knowledgeBase.askQueries(inputQueries\_)

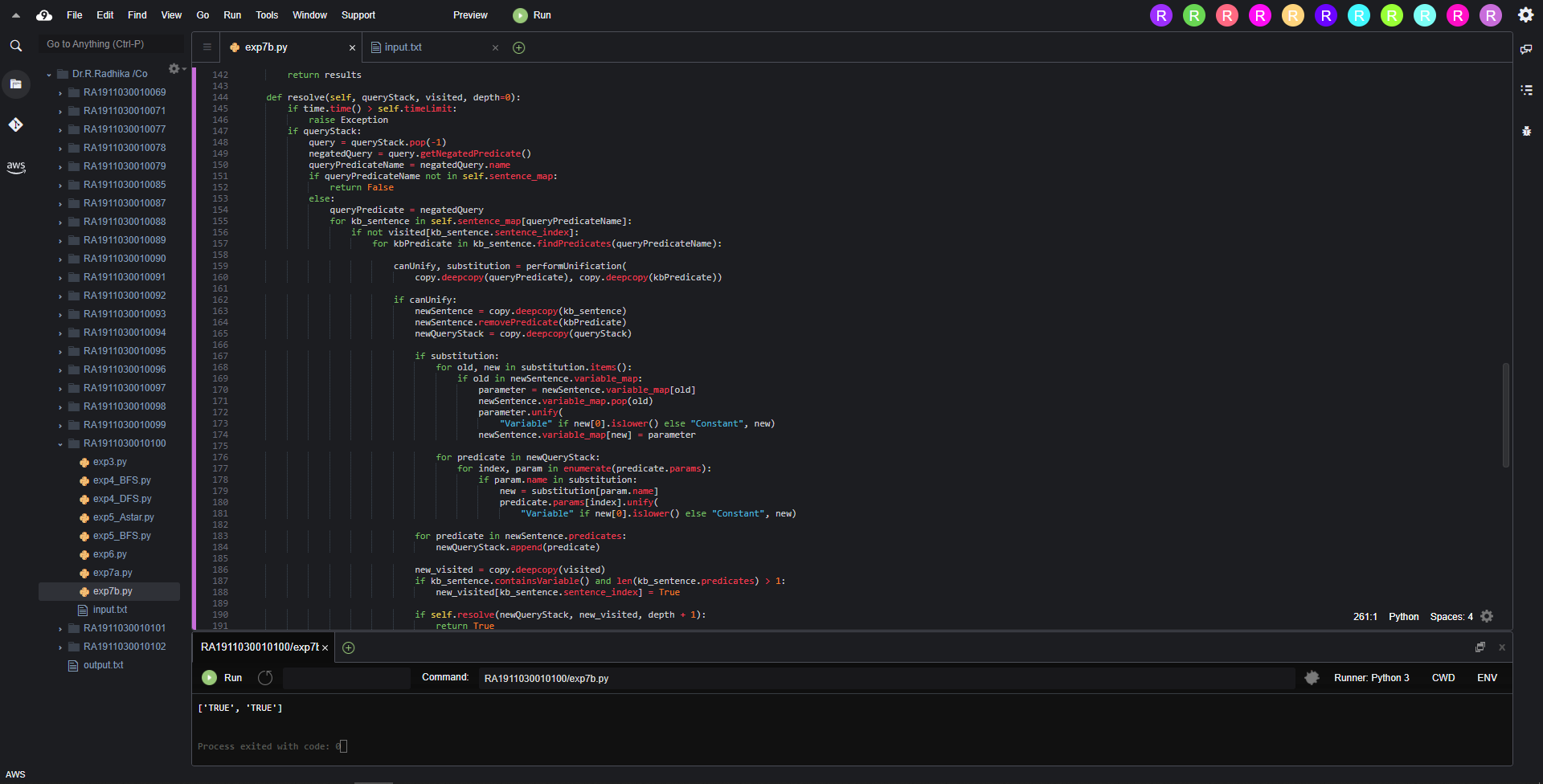
printOutput("output.txt", results\_)

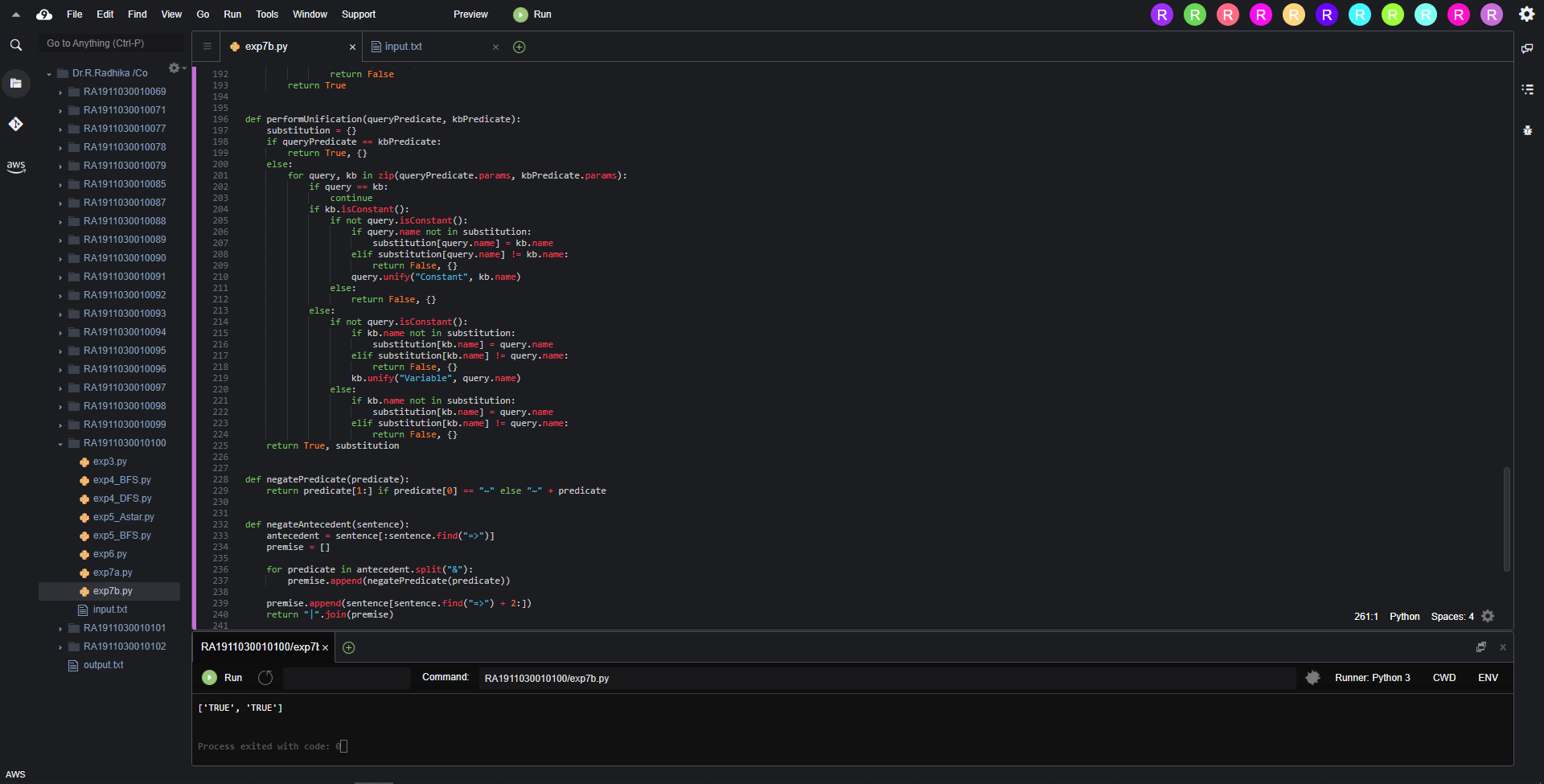
**Output :**

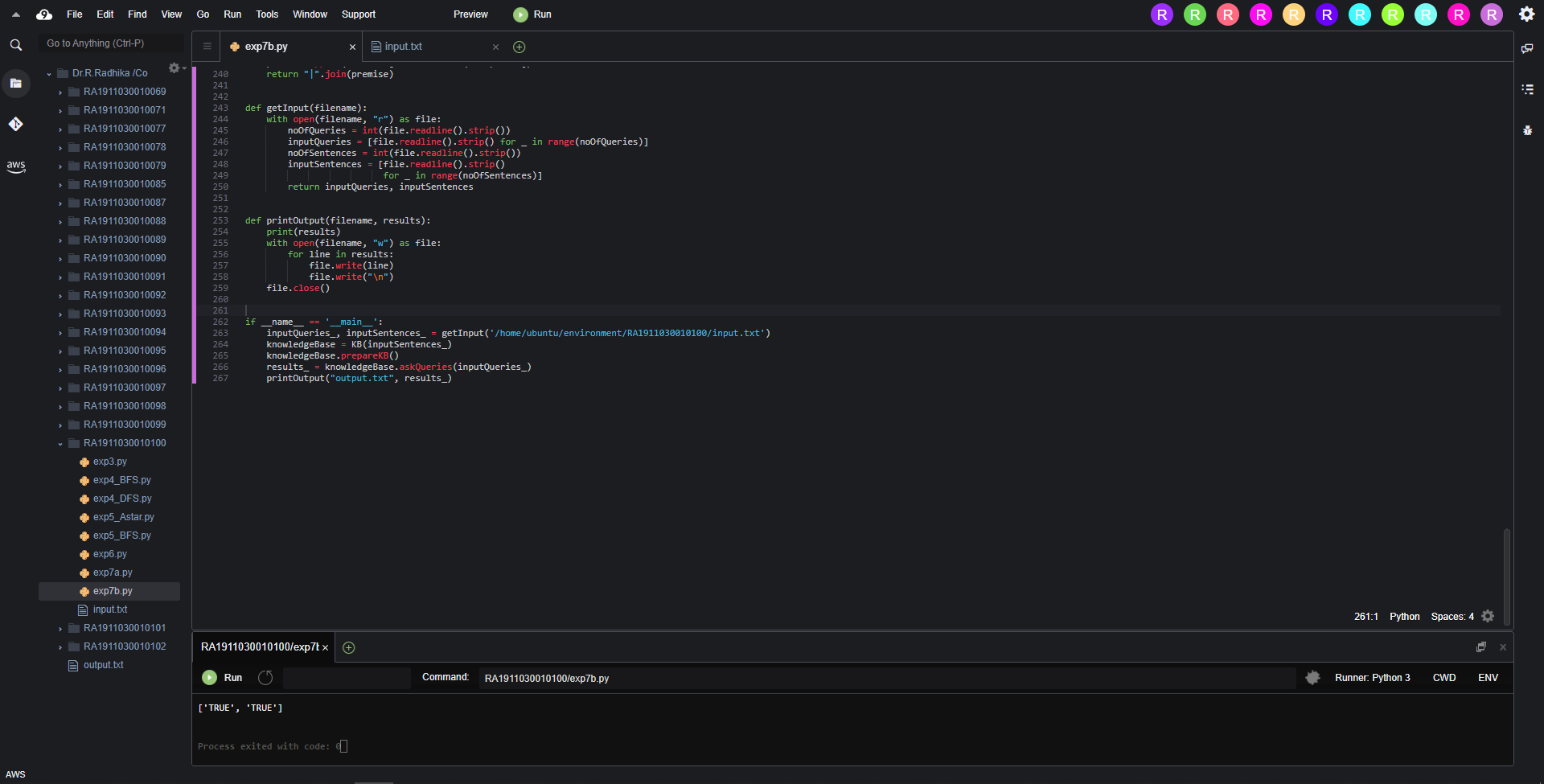


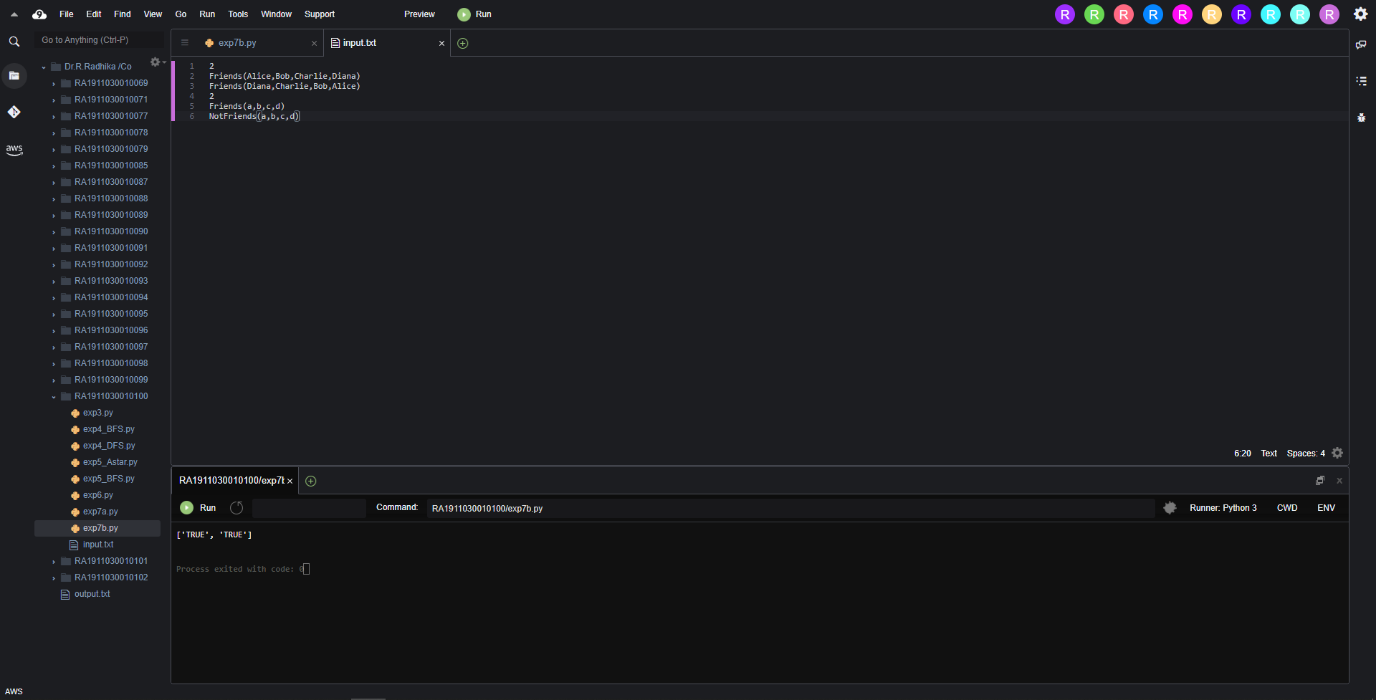












**Result :**

Hence we performed Resolution.