VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

ARTIFICIAL INTELLIGENCE

LAB REPORT

Submitted by

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Under the Guidance of

MADHAVI R.P.

Associate Professor, BMSCE

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
(Affiliated To Visvesvaraya Technological University, Belgaum)

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the ARTIFICIAL INTELLIGEENCE Lab for Cycle 2 (CIE 2) carried out by, MAHANTESH GATTINA (1BM19CS219) who are Bonafede students of B. M.S. College of Engineering. It is in partial fulfilment for the award of Bachelor of Engineering in Computer Science and Engineering of the Visvesvaraiah Technological University, Belgaum during the year 2021-2022. The Lab report has been approved as it satisfies the academic requirements in respect of ARTIFICIAL INTELLIGENCE (20CS5PCAIP) work prescribed for the said degree.

Signature of the Guide
Madhavi R.P.
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Signature of the HOD
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Associate Prof.&
Head, Dept. of CSE BMSCE,
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Index

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

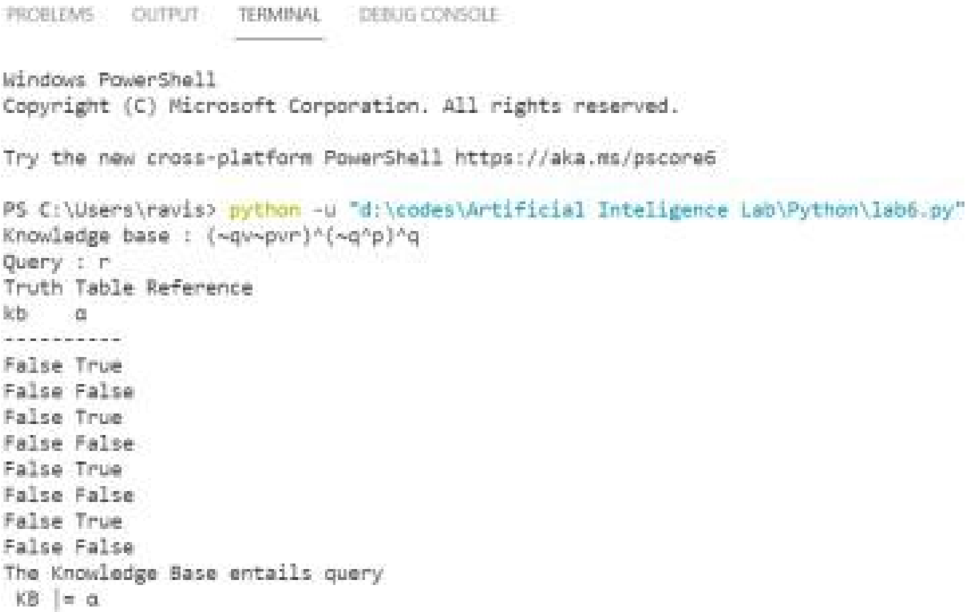
```
combinations=[(True,True,
True),(True,True,False),(True,False,True),(True,False, False),(False,True,
True),(False,True, False),(False, False,True),(False,False, False)]
variable={'p':0,'q':1, 'r':2}
kb=''
q=''
priority={'~':3,'v':1,'^':2}


def
    input_rules()
    : global kb,
    q
    kb = (input("Knowledge
    base : ")) q =
    input("Query : ")


def
    entailment()
    : global kb,
    q
    print(''*10+"Truth Table
    Reference"+''*10) print('kb α')
    print('-'*10)
    for comb in combinations:
        s =
        evaluatePostfix(toPostfix(kb),
        comb) f =
        evaluatePostfix(toPostfix(q),
        comb) print(s, f)
        if s is True and f is
            False: return False
    return True


def isOperand(c):
    return c.isalpha() and c!='v'
```

```
def
   isLeftParanthesis
   (c): return c ==
   '('


def
   isRightParanthesis
   (c): return c == ')'
```

```
def isEmpty(stack):
   return len(stack)
   == 0


def
   peek(stack):
   return
   stack[-1]


def
   hasLessOrEqualPriority(c1,
   c2): try:
      return
   priority[c1]<=priority[c2]
   except KeyError:
      return False


def
   toPostfix(infix)
   : stack = []
   postfix =
   '' for c in
   infix:
      if
         isOperand
         (c): postfix
         += c
      else:
         if
            isLeftParanthesi
            s(c):
            stack.append(c)
         elif
            isRightParanthesis
            (c): operator =
            stack.pop()
            while not
               isLeftParanthesis(operator):
               postfix += operator
            operator = stack.pop()
        else:
          while (not isEmpty(stack)) and
            hasLessOrEqualPriority(c, peek(stack)):
            postfix += stack.pop()
          stack.append(c)
    while (not
    isEmpty(stack)):
      postfix +=

    stack.pop() return

    postfix


  def evaluatePostfix(exp,
    comb): stack = []
    for i in exp:
      if isOperand(i):
        stack.append(comb[varia
        ble[i]])
      elif i == '~':
        val1 = stack.pop()
        stack.append(not
        val1)
      else:
        val1 =
        stack.pop()
        val2 =
        stack.pop()
        stack.append(_eval(i,val2,
    val1)) return stack.pop()


  def _eval(i, val1,
    val2): if i == '^':
      return val2 and
    val1 return val2
    or val1


  input_rules()
  ans =
  entailment() if
  ans:
    print("The Knowledge Base entails
    query") print(" KB |= α ")
  else:
    print("The Knowledge Base does
  not entail query") print("\n")
```

OUTPUT SCREEN

Test Case 1:



```
Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\ravis> python -u "d:\codes\Artificial Inteligence Lab\Python\lab6.py"
Knowledge base : (~qv~pvr)^(~q^p)^q
Query : r
Truth Table Reference
kb    α
----------
False True
False False
False True
False False
False True
False False
False True
False False
The Knowledge Base entails query
 KB |= α
```
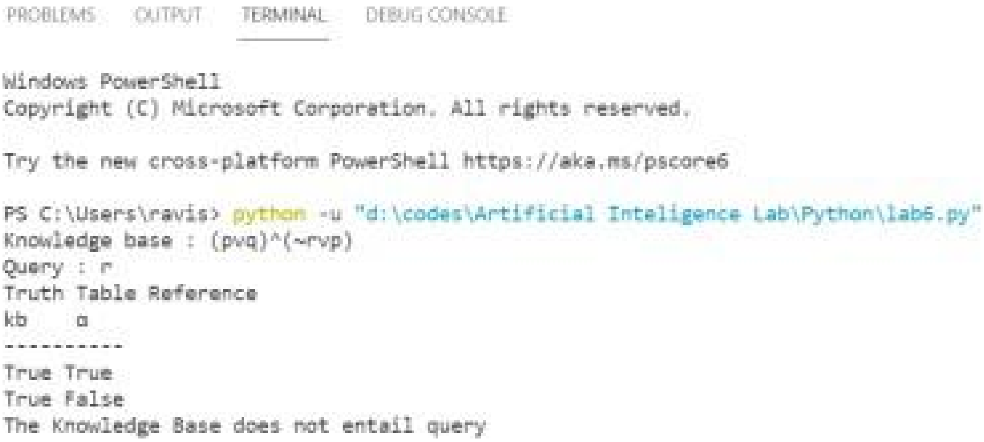

Test Case 2:



```
Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\ravis> python -u "d:\codes\Artificial Inteligence Lab\Python\lab6.py"
Knowledge base : (pvq)^(~rvp)
Query : r
Truth Table Reference
kb    α
----------
True True
True False
The Knowledge Base does not entail query
```

2 Create a knowledgebase using prepositional logic and prove the given query using resolution.

```
# Global variable kb
(knowledge base) kb = []

# Reset kb to an
empty list def Clear():
   global
   kb kb
   = []

# Insert sentence to
the kb def
AddSentence(sentenc
e):
   global kb
   # If the sentence is a clause,
   insert directly. if
   isClause(sentence):
      kb.append(sentence)
   # If not, convert to CNF, and then insert clauses
   one by one. else:
      sentenceCNF =
      convertCNF(sentence) if not
      sentenceCNF:
         print("Illegal
         input") return
      # Insert clauses one by one when there are
      multiple clauses if isAndList(sentenceCNF):
         for s in
            sentenceCNF[1:]:
            kb.append(s)
      else:
         kb.append(sentenceCNF)

# 'Query' the kb whether a sentence is
True or not def Query(sentence):
   global kb
   # Negate the sentence, and convert it to CNF
```

```
accordingly. if isClause(sentence):
   neg =
negation(sentence)
else:
   sentenceCNF =
   convertCNF(sentence) if not
   sentenceCNF:
      print("Illegal input")
```

```
            return
        neg = convertCNF(negation(sentenceCNF))
    # Insert individual clauses that we
    need to ask to ask_list. ask_list = []
    if
        isAndList(ne
        g): for n in
        neg[1:]:
            nCNF = makeCNF(n)
            if type(nCNF).__name_==
                'list': ask_list.insert(0,
                nCNF)
            else:
                ask_list.insert(0, nCNF)
    else:
        ask_list = [neg]
# Create a new list combining the asked
    sentence and kb. # Resolution will happen
    between the items in the list. clauses =
    ask_list + kb[:]

    # Recursivly conduct resoltion between items
    in the clauses list # until it produces an empty
    list or there's no more pregress. while True:
        new_clauses
        = [] for c1 in
        clauses:
            for c2 in
                clauses: if
                c1 is not c2:
                    resolved =
                    resolve(c1, c2) if
                    resolved == False:
                        continue
                    if resolved
                        == []:
                        return True
                    new_clauses.append(resolved)

        if len(new_clauses)
            == 0: return
            False
```

```
new_in_clauses =
True for n in
new_clauses:
    if n not in clauses:
        new_in_clauses =
        False
        clauses.append(n)
if
    new_in_clau
    ses: return
    False
    return False
# Conduct resolution on two CNF
clauses. def resolve(arg_one,
arg_two):
    resolved = False
    s1 =
    make_sentence(arg_one)
    s2 =
    make_sentence(arg_two)

    resolve_s1 =
    None
    resolve_s2 =
    None

    # Two for loops that iterate through the
    two clauses. for i in s1:
        if
            isNotList(
            i): a1 =
            i[1]
            a1_not =
        True else:
            a1 = i
            a1_not = False

        for j in s2:
            if
                isNotList(
                j): a2 =
                j[1]
                a2_not =
            True else:
                a2 = j
                a2_not = False

            # cancel out two literals such as
            'a' $ ['not', 'a'] if a1 == a2:
                if a1_not != a2_not:
                    # Return False if resolution
                    already happend # but
                    contradiction still exists. if
        resolved:
          return
        False else:
          resolved =
          True
          resolve_s1 = i
          resolve_s2 = j
          break
        # Return False if not resolution
happened if not resolved:
        return False
    # Remove the literals that are
    canceled s1.remove(resolve_s1)
    s2.remove(resolve_s2)
    # # Remove duplicates
    result = clear_duplicate(s1 + s2)

      # Format the
           result. if
     len(result) ==
           1: return
           result[0]
    elif len(result) >
        1:
        result.insert(0,
        'or')

    return result

# Prepare sentences for
resolution. def
make_sentence(arg):
    if isLiteral(arg) or
        isNotList(arg): return
        [arg]
    if isOrList(arg):
        return
    clear_duplicate(arg[1:])
    return

# Clear out duplicates in a
sentence. def
clear_duplicate(arg):
    result = []
    for i in range(0,
        len(arg)): if arg[i]
        not in arg[i+1:]:
            result.append(arg[i])
    return result

# Check whether a sentence is a
legal CNF clause. def
```

```
isClause(sentence):
    if
        isLiteral(sente
        nce): return
        True
    if isNotList(sentence):
        if
            isLiteral(sentenc
            e[1]): return True
        else:
         return False
if isOrList(sentence):
        for i in range(1,
            len(sentence)): if
            len(sentence[i]) > 2:
                return False
            elif not
                isClause(sentence[i]):
                return False
        return
    True return
    False

# Check if a sentence is a
legal CNF. def
isCNF(sentence):
    if
        isClause(sente
        nce): return
        True
    elif
        isAndList(sentenc
        e): for s in
        sentence[1:]:
            if not
                isClause(s):
                return False
        return
    True return
    False

# Negate a
sentence. def
negation(sentence)
:
    if
        isLiteral(sentence)
        : return ['not',
        sentence]
    if
        isNotList(sente
        nce): return
        sentence[1]
```

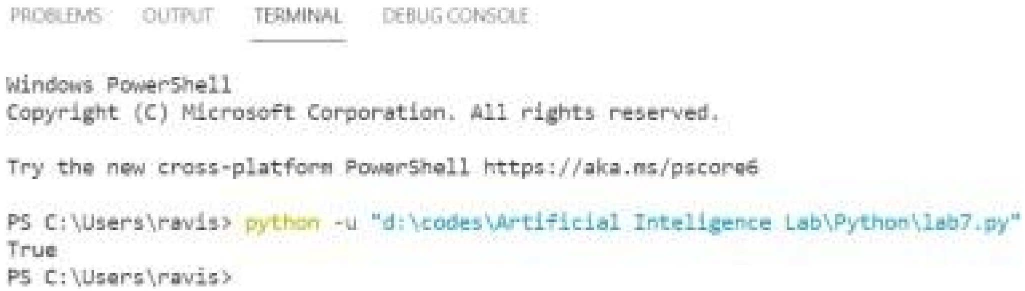
```
# DeMorgan:
if
    isAndList(sente
    nce): result =
    ['or']
    for i in sentence[1:]:
        if
            isNotList(sente
            nce):
            result.append(i[
            1])
        else:
            result.append(['
    not', sentence])
    return result
if
    isOrList(senten
    ce): result =
    ['and']
    for i in sentence[:]:
        if
            isNotList(sente
            nce):
            result.append(i[
            1])
            else:
                result.append(['n
        ot', i]) return result
    return None

# Convert a sentence into
CNF. def
convertCNF(sentence):
    while not
        isCNF(sentence): if
        sentence is None:
            return None
        sentence =
    makeCNF(sentence) return
    sentence


                 def
makeCNF(sentence):
                   if
 isLiteral(sentence):
    return sentence

    if (type(sentence).__name_
        _____________________==
        'list'): operand =
        sentence[0]
        if isNotList(sentence):
            if
                isLiteral(sentenc
                e[1]): return
                sentence
            cnf =
            makeCNF(sentence[1])
            if cnf[0] == 'not':
                return
            makeCNF(cnf[1]) if
            cnf[0] == 'or':
                result = ['and']
                for i in range(1, len(cnf)):
                    result.append(makeCNF(['not',
                    cnf[i]]))
        return result
if cnf[0] == 'and':
     result = ['or']
        for i in range(1, len(cnf)):
            result.append(makeCNF(['not',
            cnf[i]]))
        return result
    return "False:
    not"

# Implication Elimination:
if operand == 'implies' and len(sentence) == 3:
    return makeCNF(['or', ['not', makeCNF(sentence[1])],
   makeCNF(sentence[2])]) # Biconditional
Elimination: if operand == 'biconditional'
and len(sentence) == 3:
   s1 = makeCNF(['implies', sentence[1],
   sentence[2]]) s2 = makeCNF(['implies',
   sentence[2], sentence[1]]) return
   makeCNF(['and', s1, s2])

if
   isAndList(sente
   nce): result =
   ['and']
   for i in range(1,
      len(sentence)): cnf =
      makeCNF(sentence[i])
      # Distributivity:
      if isAndList(cnf):
         for i in range(1, len(cnf)):
            result.append(makeCNF(
            cnf[i]))
         continue
      result.append(makeCNF
      (cnf))
   return result

if
   isOrList(sente
   nce): result1 =
   ['or']
   for i in range(1,
      len(sentence)): cnf =
      makeCNF(sentence[i])
      # Distributivity:
      if isOrList(cnf):
         for i in range(1, len(cnf)):
            result1.append(makeCNF(
            cnf[i])
         ) continue
      result1.append(makeCN
      F(cnf)) # Associativity:
   while True:
      result2 =
['and']
and_clause =
None for r in
result1:
    if isAndList(r):
        and_clause
        = r break

# Finish when there's no
more 'and' lists # inside of
'or' lists
if not and_clause:
```

```
                    return result1

                result1.remove(and_c

                lause)

                for i in range(1,
                    len(and_clause)): temp
                    = ['or', and_clause[i]]
                    for o in result1[1:]:
                        temp.append(makeC
                        NF(o))
                    result2.append(makeCNF(
                temp)) result1 =
                makeCNF(result2)
            return
    None return
    None


# Below are 4 functions that check
the type of a variable def
isLiteral(item):
    if type(item).__name_
        _________________==
        'str': return True
    return False


def isNotList(item):
    if type(item).__name_
        _________________==
        'list': if len(item) == 2:
            if item[0] ==
                'not': return
                True
    return False


def isAndList(item):
    if type(item).__name_
        _________________==
        'list': if len(item) > 2:
            if item[0] ==
               'and': return
               True
    return False


def isOrList(item):
    if type(item).___name_
        __________________==
        'list': if len(item) > 2:
            if item[0] == 'or':
```

```
            return True
    return False

AddSentence(['and', 'p', 'q'])
AddSentence(['or', 'r', 's'])
print(Query(['and',['or','p','r'], ['or',
'q', 's']]))
```

OUTPUT SCREEN

Test Case 1:



```
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PS C:\Users\ravis> python -u "d:\codes\Artificial Inteligence Lab\Python\lab7.py"
True
PS C:\Users\ravis>
```

3 Implement unification in first order logic.

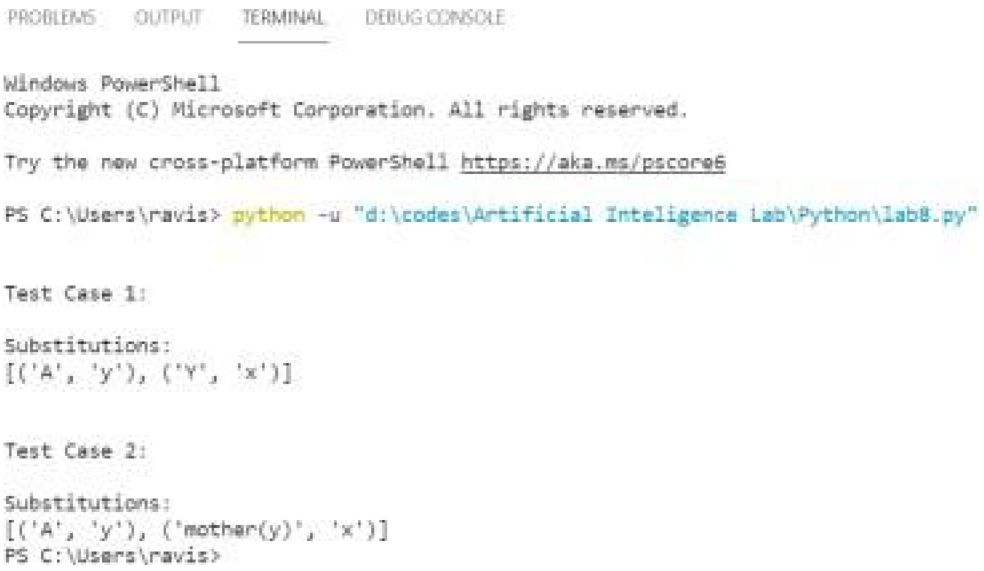
```
import re

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


def
    getInitialPredicate(expres
    sion): return
    expression.split("(")[0]
def isConstant(char):
    return char.isupper() and len(char) == 1
```

```
def isVariable(char):
    return char.islower() 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 checkOccurs(var,
    exp): if exp.find(var)
    == -1:
        return
    False
    return True


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


def getRemainingPart(expression):
    predicate =
    getInitialPredicate(expression)
    attributes =
    getAttributes(expression)
    newExpression = predicate + "(" +
    ",".join(attributes[1:]) + ")" return
    newExpression

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

    if isConstant(exp1) and
        isConstant(exp2): if exp1 !=
        exp2:
```

```
        return False

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

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

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

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

    if getInitialPredicate(exp1) !=
        getInitialPredicate(exp2):
        print("Predicates do not match. Cannot
        be unified") return False

    attributeCount1                          =
    len(getAttributes(exp1))
    attributeCount2                          =
    len(getAttributes(exp2))                 if
    attributeCount1                         !=
    attributeCount2:
        return False

    head1 = getFirstPart(exp1)
    head2 = getFirstPart(exp2)
    initialSubstitution =
    unify(head1, head2) if not
    initialSubstitution:
```

```
    return False
if attributeCount1
    == 1: return
    initialSubstitution

tail1 =
getRemainingPart(exp1)
tail2 =
getRemainingPart(exp2)

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

    remainingSubstitution =
    unify(tail1, tail2) if not
    remainingSubstitution:
        return False

    initialSubstitution.extend(remainingSubstitution
    ) return initialSubstitution

print("\n\nTest Case
1:\n") exp1 =
"knows(A,x)" exp2 =
"knows(y,Y)"
substitutions = unify(exp1,
exp2)
print("Substitutions:")
print(substitutions)

print("\n\nTest Case
2:\n") exp1 =
"knows(A,x)"
exp2 =
"knows(y,mother(y))"
substitutions = unify(exp1,
exp2)
print("Substitutions:")
print(substitutions)
```

OUTPUT SCREEN



```
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PS C:\Users\ravis> python -u "d:\codes\Artificial Inteligence Lab\Python\lab8.py"


Test Case 1:

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


Test Case 2:

Substitutions:
[('A', 'y'), ('mother(y)', 'x')]
PS C:\Users\ravis>
```
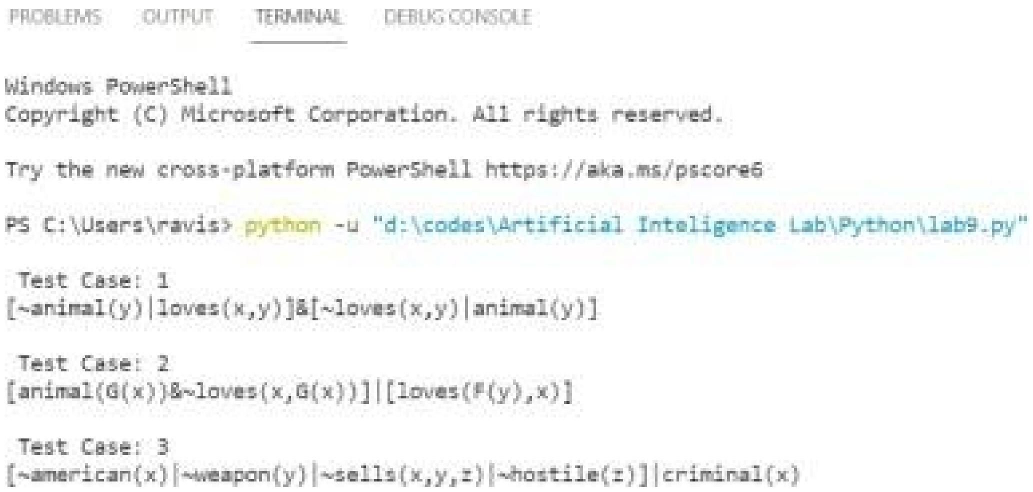

4 Convert given first order logic statement into Conjunctive Normal Form (CNF).

```
def
   getAttributes(stri
   ng): 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('~['，'')
string = string.strip(']')
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
    matches[::-1]:
        statement =
        statement.replace(match, '')
        statements = re.findall('\[\[[^]]+\]]',
        statement) for s in statements:
            statement =
        statement.replace(s, s[1:-1]) for
        predicate in
        getPredicates(statement):
            attributes =
            getAttributes(predicate) if
            ''.join(attributes).islower():
                statement =
            statement.replace(match[1],SKOLEM_CONSTANTS.pop(0)) else:
                aU = [a for a in attributes if not
                a.islower()][0] statement =
                statement.replace(aU,
f'{SKOLEM_CONSTANTS.pop(0)}({match[1]})')
    return statement


import re

def fol_to_cnf(fol):

    statement =
    fol.replace("<=>", "_")
    while '_' in statement:
        i = statement.index('_')
        new_statement = '[' + statement[:i] + '=>' + statement[i+1:] +
']&['+ statement[i+1:] + '=>' + statement[:i] + ']'
        statement = new_statement
    statement =
    statement.replace("=>", "-")
    expr = '\[([^]]+)\]'
    statements = re.findall(expr, statement)
    for i, s in
        enumerate(statements):
        if '[' in s and ']' not in s:
            statements[i]
    += ']' for s in
    statements:
        statement = statement.replace(s,
    fol_to_cnf(s)) while '-' in statement:
        i = statement.index('-')
        br = statement.index('[') if '[' in statement else
        0 new_statement = '~' + statement[br:i] + '|'
        + statement[i+1:] statement = statement[:br]
        + new_statement if br > 0 else
    new_statement while '~∀' in
        statement: i =
        statement.index('~∀')
        statement = list(statement)
        statement[i], statement[i+1], statement[i+2] = '∃',
        statement[i+2], '~' statement = ''.join(statement)
    while '~∃' in statement:
        i =
        statement.index('~
        ∃') s =
        list(statement)
        s[i], s[i+1], s[i+2] = '∀', s[i+2],
        '~' statement = ''.join(s)
    statement                                =
    statement.replace('~[∀','[~∀')
    statement                                =
    statement.replace('~[∃','[~∃')
    expr = '(~[∀|∃].)'
    statements   =   re.findall(expr,
    statement) for s in statements:
        statement    =    statement.replace(s,
    fol_to_cnf(s)) expr = '~\[[^]]+\]'
    statements   =   re.findall(expr,
    statement) for s in statements:
        statement    =    statement.replace(s,
    DeMorgan(s)) return statement


print("\n Test Case: 1")
print(Skolemization(fol_to_cnf("animal(y)<=>lo

ves(x,y)"))) print("\n Test Case: 2")

print(Skolemization(fol_to_cnf("∀x[∀y[animal(y)=>loves(x,y)]]=>[∃z[loves
(z,x)]]")))
```

```
print("\n Test Case: 3")

print(Skolemization(fol_to_cnf("[american(x)&weapon(y)&sells(x,y,z)&hostile(z)]=>crim inal(x)")))

print("\n \n ")
```

OUTPUT SCREEN



```
Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\ravis> python -u "d:\codes\Artificial Inteligence Lab\Python\lab9.py"

 Test Case: 1
[~animal(y)|loves(x,y)]&[~loves(x,y)|animal(y)]

 Test Case: 2
[animal(G(x))&~loves(x,G(x))]|[loves(F(y),x)]

 Test Case: 3
[~american(x)|~weapon(y)|~sells(x,y,z)|~hostile(z)]|criminal(x)
```

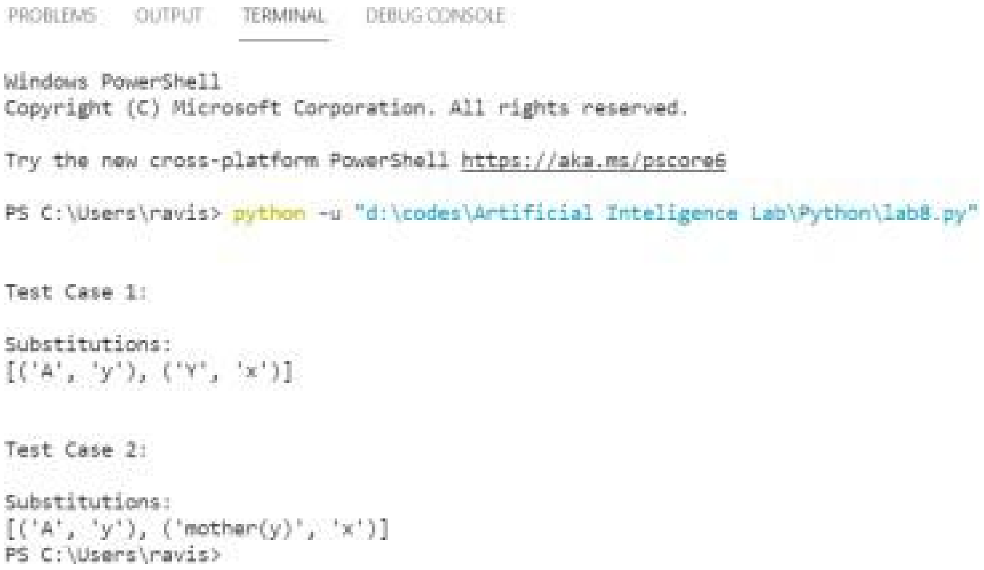

```
Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\ravis> python -u "d:\codes\Artificial Inteligence Lab\Python\lab8.py"


Test Case 1:

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


Test Case 2:

Substitutions:
[('A', 'y'), ('mother(y)', 'x')]
PS C:\Users\ravis>
```

5 Create a knowledgebase consisting of first order logic

statements and prove the given query using forward reasoning.

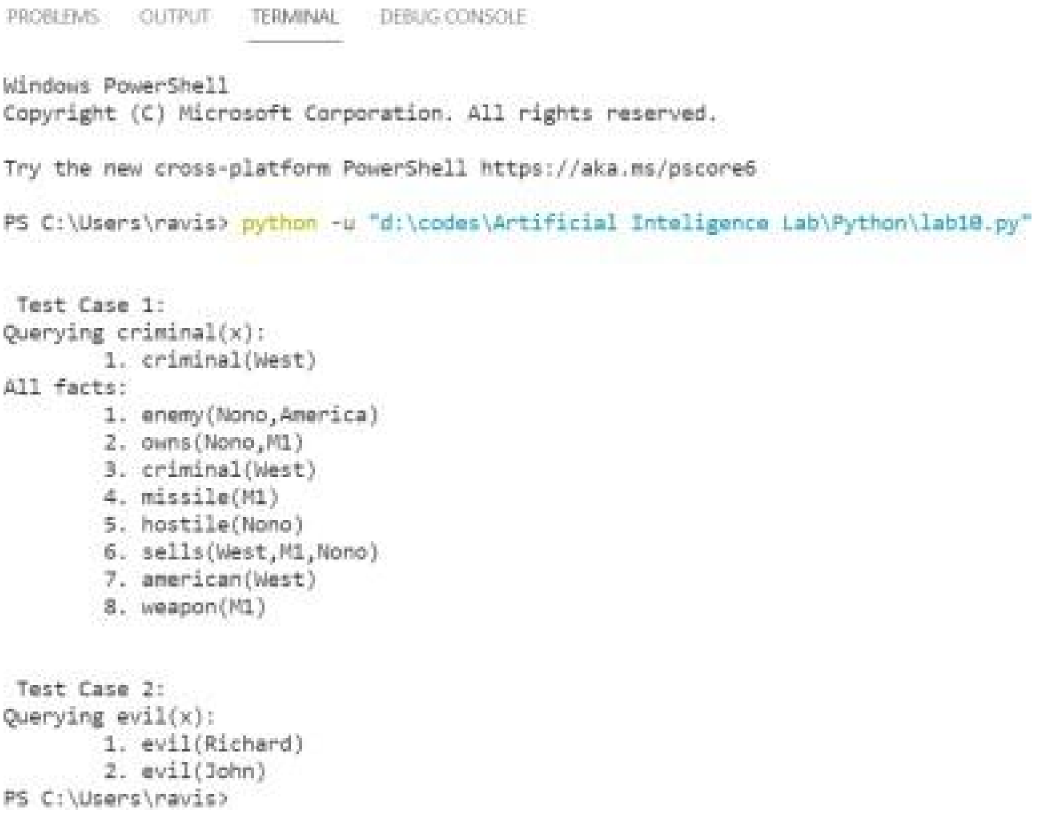
```
import re

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

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

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

class Fact:
   def_init_(self, expression):
      self.expression =
      expression
      predicate, params =
      self.splitExpression(expression)
      self.predicate = predicate
      self.params = params
      self.result = any(self.getConstants())

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

   def
      getResult(sel
      f): return
      self.result
```

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

def getVariables(self):
    return [v if isVariable(v) else None for v in self.params]

def substitute(self,
    constants): c =
    constants.copy()
```

```
        f = f"{self.predicate}({','.join([constants.pop(0) if isVariable(p) else p
for p in self.params])})"
        return Fact(f)

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:
                            constants[v] =
                    fact.getConstants()[i]
                    new_lhs.append(fact)
        predicate, attributes =
getPredicates(self.rhs.expression)[0],
str(getAttributes(self.rhs.expression)[0])
        for key in
            constants: if
            constants[key]
            :
                attributes = attributes.replace(key,
        constants[key]) expr =
        f'{predicate}{attributes}'
        return Fact(expr) if len(new_lhs) and all([f.getResult() for f in new_lhs])
        else None

class KB:
    def__init__(self):
        self.facts = set()
    self.implications =
    set()

def tell(self,
    e): if '=>'
    in e:
        self.implications.add(Implicat
    ion(e)) else:
        self.facts.add(Fac
    t(e)) for i in
    self.implications:
            res =
            i.evaluate(self.facts)
            if res:
                self.facts.add(res)

    def query(self, e):
        facts = set([f.expression for f in
        self.facts]) i = 1
        print(f'Querying
        {e}:') for f in
        facts:
            if Fact(f).predicate ==
                Fact(e).predicate: print(f'\t{i}.
                {f}')
                i += 1

    def display(self):
        print("All facts:
        ")
        for i, f in
            enumerate(set([f.expression for f
            in self.facts])): print(f'\t{i+1}.
            {f}')

print("\n \n Test Case

1:") kb = KB()
kb.tell('missile(x)=>weapon(x)')
kb.tell('missile(M1)')
kb.tell('enemy(x,America)=>hostile(x)')
kb.tell('american(West)')
kb.tell('enemy(Nono,America)')
kb.tell('owns(Nono,M1)')
kb.tell('missile(x)&owns(Nono,x)=>sells(Wes
t,x,Nono)')
kb.tell('american(x)&weapon(y)&sells(x,y,z)&hostile(z)=>criminal(x)')
kb.query('criminal(x)')
kb.display()


print("\n \n Test

Case 2:") 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 SCREEN



```
Windows PowerShell
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PS C:\Users\ravis> python -u "d:\codes\Artificial Inteligence Lab\Python\lab10.py"


 Test Case 1:
Querying criminal(x):
        1. criminal(West)
All facts:
        1. enemy(Nono,America)
        2. owns(Nono,M1)
        3. criminal(West)
        4. missile(M1)
        5. hostile(Nono)
        6. sells(West,M1,Nono)
        7. american(West)
        8. weapon(M1)


 Test Case 2:
Querying evil(x):
        1. evil(Richard)
        2. evil(John)
PS C:\Users\ravis>
```