Lab 7: Implementation of Resolution

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Code

```
import sys

def get_input(filename):
    # Input follows the DIMACS format:
https://www.cs.utexas.edu/users/moore/acl2/manuals/current/manual/index-
seo.php/SATLINK____DIMACS
    f = open(filename, 'r')
    clauses = []
    for line in f:
        if line[0] in ['c','0','%']:
            continue
        elif line[0] == 'p':
            words = line.split()
            num_clauses = int(words[-1])
            num_variables = int(words[-2])
        else:
            clause = [int(n) for n in line.split()]
            if clause[-1] != 0:
                print('Error: Terminal number of one or more clauses is not
0!')
                return None
            clause = clause[:-1]
            if any(abs(n) > num_variables or abs(n) < 1 for n in clause):
                print('Error: Total number of variables exceeds limit!')
                return None
            clauses.append(set(clause))
    f.close()
    if len(clauses) != num_clauses:
        print('Error: Total number of clauses not equal to specification!')
        return None
    return clauses

def pl_resolution(clauses, query):

    if clauses == None:
        return None

    clauses.append({-query})
    new_clauses = []

    while True:

        # iterate through every pair of clauses
        for i in range(len(clauses)):
            for j in range(i+1, len(clauses)):

                resolvent = pl_resolve(clauses, i, j)

                # if no resolution obtained, skip current pair of clauses
                if resolvent == None:
                    continue

                # if resolution is empty (i.e.: False) return True
                if set() == resolvent:
                    return True

                # add resolvent to new_clauses
                if resolvent not in new_clauses:
                    new_clauses.append(resolvent)

        # if new_clauses is a subset of clauses, return False
        if all(clause in clauses for clause in new_clauses):
            return False

        # clauses = clauses U new_clauses
        clauses += [clause for clause in new_clauses if clause not in
clauses]

def pl_resolve(clauses, i, j):
    # factoring
    resolvent = clauses[i].union(clauses[j])

    # unit resolution
    complementary_vars = [literal for literal in resolvent if literal > 0
and -literal in resolvent]

    # if no complementary variables, return disjunction of both clauses
    if len(complementary_vars) == 0:
        return resolvent

    # if exactly one complementary variable, remove the corresponding
literals and return
    elif len(complementary_vars) == 1:
        var = complementary_vars[0]
        resolvent.remove(var)
        resolvent.remove(-var)
        return resolvent

    # if more than one complementary variable, return None

def human_readable_kb(clauses):
    print()
    for clause in clauses:
        for idx, literal in enumerate(clause):
            if literal > 0:
                print(f'x{literal}', end=' ')
            else:
                print(f'~x{-literal}', end=' ')
            if idx != len(clause)-1:
                print(f'v', end=' ')
            else:
                print()

if len(sys.argv) != 3:
    print('Usage: ./resolution.py [INPUT_FILE] [QUERY]\n\nInput file must
be a cnf file in DIMACS format\nThe query must be in the form of a single
non-zero integer')
else:
    filename = sys.argv[1]
    query = int(sys.argv[2])
    clauses = get_input(filename)

    print('\nKnowledge Base')
    print('--------------')
    human_readable_kb(clauses)
    print('\nYour Query: ', end='')
    if query > 0:
        print(f'x{query}')
    else:
        print(f'~x{-query}')
    result = pl_resolution(clauses, query)
    print('\nFinal Knowledge Base')
    print('--------------------')
    human_readable_kb(clauses)
    print('\nQuery Result: ', result, end='\n\n')
```

Outputs

Input File

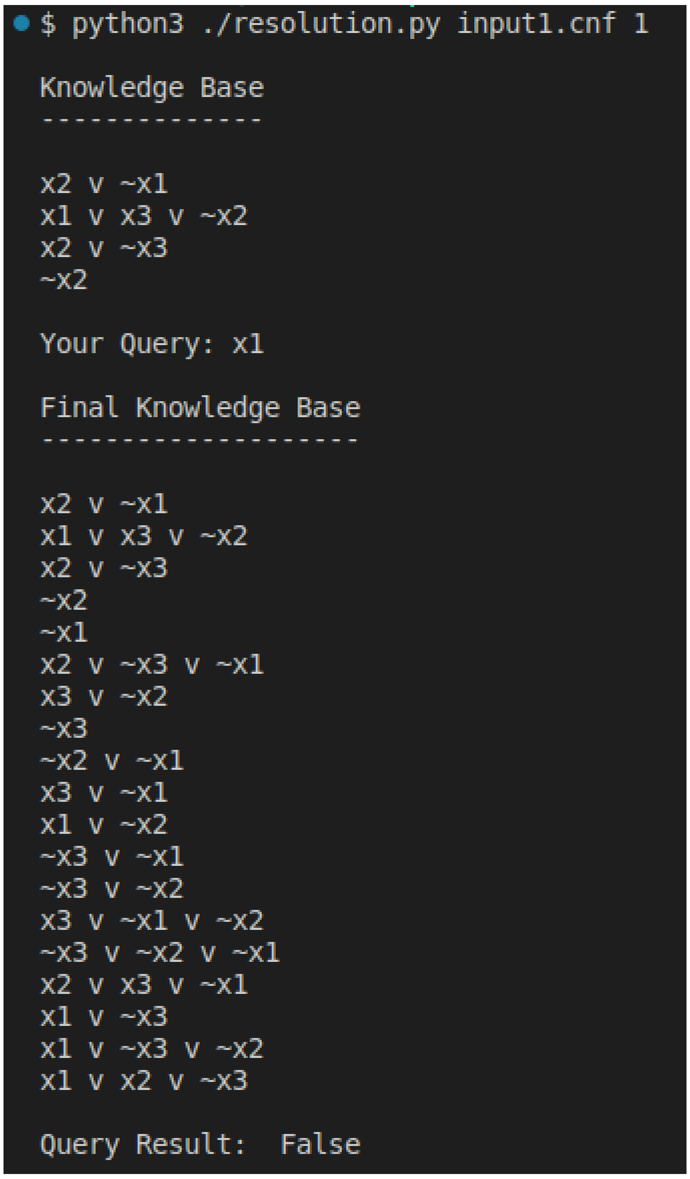
```
c This is a comment
c This file is in DIMACS cnf format
c Each variable is indicated by a natural number
c Negative literals are prefixed with a minus symbol
c Positive literals are not prefixed with any symbol
c The 2 numbers below indicate number of variables and number of clauses
respectively
p 3 4
c the clauses are listed below
c each clause is terminated with a 0
-1 2 0
-2 3 1 0
-3 2 0
-2 0
```

Output 0

```
$ python3 ./resolution.py
Usage: ./resolution.py [INPUT_FILE] [QUERY]

Input file must be a cnf file in DIMACS format
The query must be in the form of a single non-zero integer
```

Output 1

```
$ python3 ./resolution.py input1.cnf 1

Knowledge Base
--------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2

Your Query: x1

Final Knowledge Base
--------------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2
~x1
x2 v ~x3 v ~x1
x3 v ~x2
~x3
~x2 v ~x1
x3 v ~x1
x1 v ~x2
~x3 v ~x1
~x3 v ~x2
x3 v ~x1 v ~x2
~x3 v ~x2 v ~x1
x2 v x3 v ~x1
x1 v ~x3
x1 v ~x3 v ~x2
x1 v x2 v ~x3

Query Result:  False
```

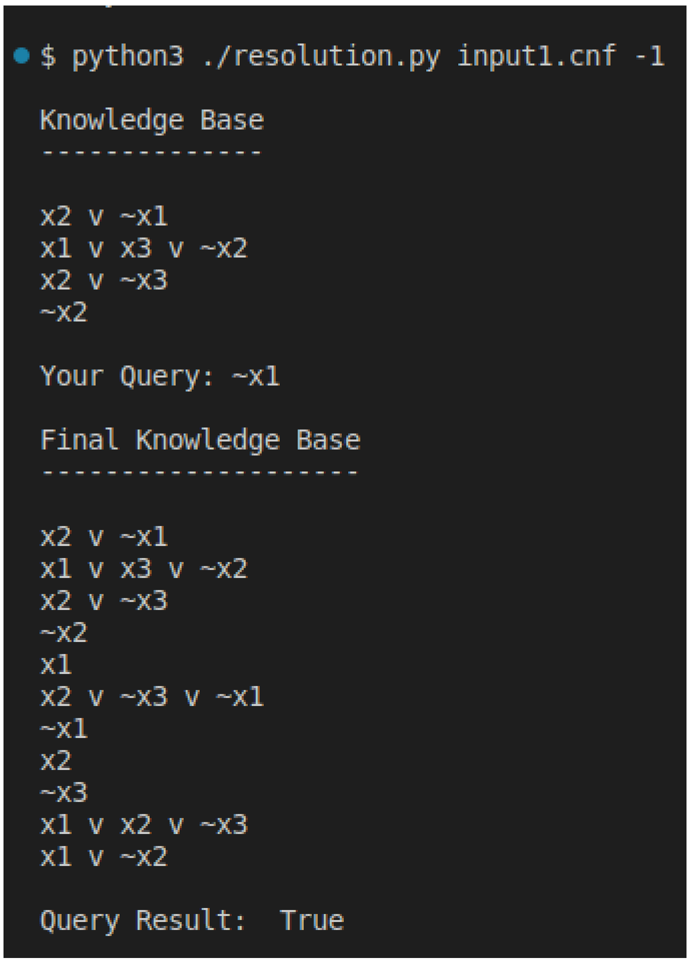


```
$ python3 ./resolution.py input1.cnf 1

Knowledge Base
--------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2

Your Query: x1

Final Knowledge Base
--------------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2
~x1
x2 v ~x3 v ~x1
x3 v ~x2
~x3
~x2 v ~x1
x3 v ~x1
x1 v ~x2
~x3 v ~x1
~x3 v ~x2
x3 v ~x1 v ~x2
~x3 v ~x2 v ~x1
x2 v x3 v ~x1
x1 v ~x3
x1 v ~x3 v ~x2
x1 v x2 v ~x3

Query Result:  False
```

Output 2

```
$ python3 ./resolution.py input1.cnf -1

Knowledge Base
--------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2

Your Query: ~x1

Final Knowledge Base
--------------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
```

```
~x2
x1
x2 v ~x3 v ~x1
~x1
x2
~x3
x1 v x2 v ~x3
x1 v ~x2

Query Result:  True
```

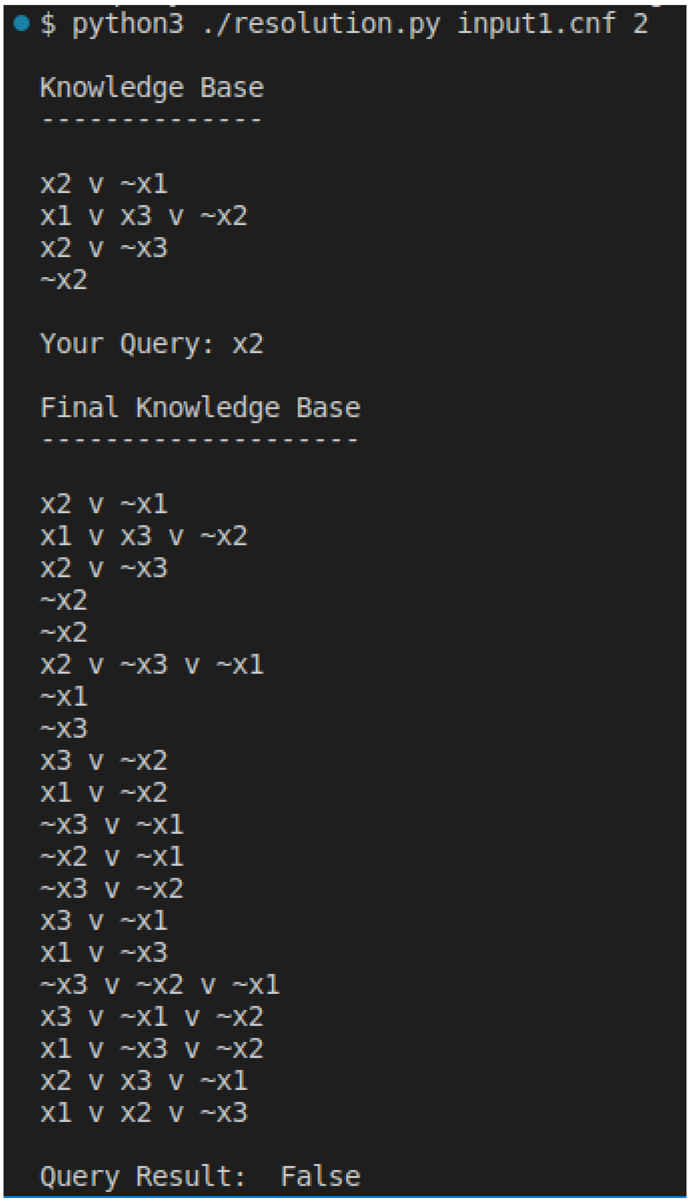


```
$ python3 ./resolution.py input1.cnf -1

Knowledge Base
--------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2

Your Query: ~x1

Final Knowledge Base
--------------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2
x1
x2 v ~x3 v ~x1
~x1
x2
~x3
x1 v x2 v ~x3
x1 v ~x2

Query Result:  True
```

Output 3

```
$ python3 ./resolution.py input1.cnf 2

Knowledge Base
--------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2

Your Query: x2
```

```
Final Knowledge Base
--------------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2
~x2
x2 v ~x3 v ~x1
~x1
~x3
x3 v ~x2
x1 v ~x2
~x3 v ~x1
~x2 v ~x1
~x3 v ~x2
x3 v ~x1
x1 v ~x3
~x3 v ~x2 v ~x1
x3 v ~x1 v ~x2
x1 v ~x3 v ~x2
x2 v x3 v ~x1
x1 v x2 v ~x3

Query Result:  False
```

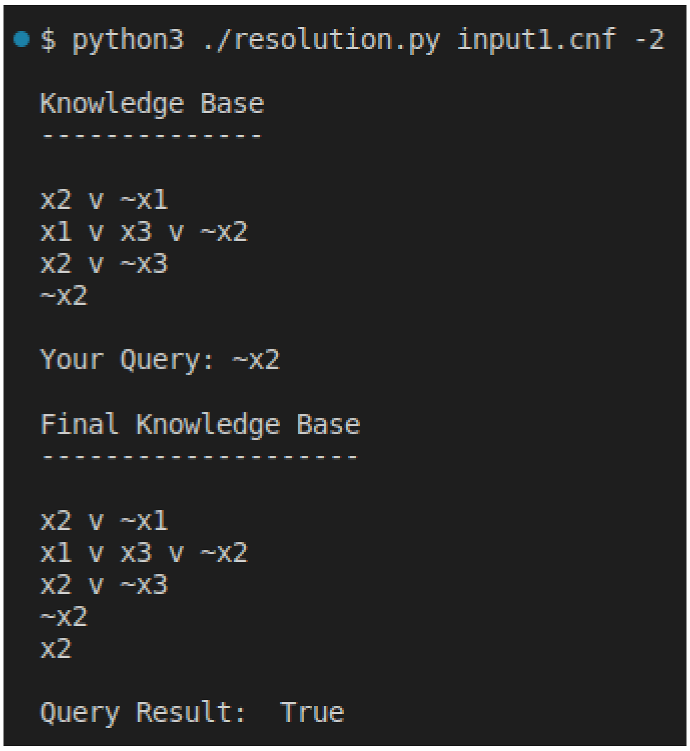


```
$ python3 ./resolution.py input1.cnf 2

Knowledge Base
--------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2

Your Query: x2

Final Knowledge Base
--------------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2
~x2
x2 v ~x3 v ~x1
~x1
~x3
x3 v ~x2
x1 v ~x2
~x3 v ~x1
~x2 v ~x1
~x3 v ~x2
x3 v ~x1
x1 v ~x3
~x3 v ~x2 v ~x1
x3 v ~x1 v ~x2
x1 v ~x3 v ~x2
x2 v x3 v ~x1
x1 v x2 v ~x3

Query Result:  False
```

Output 4

```
$ python3 ./resolution.py input1.cnf -2

Knowledge Base
--------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2

Your Query: ~x2

Final Knowledge Base
--------------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
```

```
~x2
x2

Query Result:  True
```



```
$ python3 ./resolution.py input1.cnf -2

Knowledge Base
--------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2

Your Query: ~x2

Final Knowledge Base
--------------------

x2 v ~x1
x1 v x3 v ~x2
x2 v ~x3
~x2
x2

Query Result:  True
```