# Lab 5: 3 SAT Solver using DPLL Algorithm

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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])
            symbols = list(range(1, num_variables+1))
        else:
            clause = [int(n) for n in line.split()]
            if(len(clause) != 4):
                continue
            if clause[-1] != 0:
                print('Error: Terminal number of one or more clauses is not
0!')
                return (None, 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, None)
            clauses.append(clause)
    f.close()
    if len(clauses) != num_clauses:
        print('Error: Total number of clauses not equal to specification!')
        return (None, None)
    return (clauses, symbols)

def dpll_satisfiable(filename):
    clauses, symbols = get_input(filename)
    if clauses != None:
        return dpll(clauses, symbols, {})

def dpll(clauses, symbols, model):

    # if every clause in clauses is True in model then return True
    if check_all_clauses_true(clauses, model):
        print(f'\nModel = {model}\n')
```

```
        return True

    # if some clause in clauses is False in model then return False
    if check_some_clauses_false(clauses, model):
        return False

    # check for pure symbol
    P, value = find_pure_symbol(clauses, symbols, model)
    if P != None:
        new_symbols = symbols[:]
        new_symbols.remove(P)
        model[P] = value
        return dpll(clauses, new_symbols, model)

    # check for unit clause
    P, value = find_unit_clause(clauses, symbols, model)
    if P != None:
        new_symbols = symbols[:]
        new_symbols.remove(P)
        model[P] = value
        return dpll(clauses, new_symbols, model)

    # branch
    P, rest = symbols[0], symbols[1:]
    left_model, right_model = model.copy(), model.copy()
    left_model[P], right_model[P] = True, False
    return dpll(clauses, rest, left_model) or dpll(clauses, rest,
right_model)


def check_all_clauses_true(clauses, model):
    for clause in clauses:
        if not any(abs(literal) in model.keys() and
evaluate_literal(literal, model) == True for literal in clause):
            return False
    return True

def check_some_clauses_false(clauses, model):
    for clause in clauses:
        if all(abs(literal) in model.keys() and evaluate_literal(literal,
model) == False for literal in clause):
            return True
    return False

def evaluate_literal(literal, model):
    if literal < 0:
        return not model[abs(literal)]
    else:
        return model[literal]

def find_pure_symbol(clauses, symbols, model):
    pure_symbols = symbols[:]
    visited_literals = []
    for clause in clauses:
```

```
        if any(abs(literal) in model.keys() and evaluate_literal(literal,
model) == True for literal in clause):
            continue
        for literal in clause:
            if abs(literal) in pure_symbols:
                if -literal in visited_literals:
                    pure_symbols.remove(abs(literal))
                    visited_literals.remove(-literal)
                elif literal not in visited_literals:
                    visited_literals.append(literal)
    if len(pure_symbols) == 0:
        return (None, None)
    P = pure_symbols[0]
    value = P in visited_literals
    return (P, value)

def find_unit_clause(clauses, symbols, model):
    for clause in clauses:
        if any(abs(literal) in model.keys() and evaluate_literal(literal,
model) == True for literal in clause):
            continue
        vars_in_clause = [literal for literal in clause if abs(literal) in
symbols]
        if len(vars_in_clause) == 1:
            return (abs(vars_in_clause[0]), vars_in_clause[0] in symbols)
    return (None, None)

if len(sys.argv) != 2:
    print('Error: Incorrect number of command line arguments!')
else:
    filename = sys.argv[1]
    if dpll_satisfiable(filename):
        print('Satisfiable!\n')
    else:
        print('Not satisfiable!\n')
```

## Outputs

### Input File 1

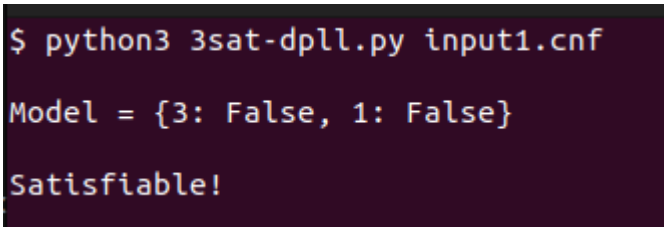
```
c This is a comment
c the follwing line specifies number of variables and number of clauses
respectively
p 4 4
c the following lines are the clauses
1 2 -3 0
-1 -2 4 0
-1 2 -4 0
2 -3 4 0
```

### Output 1

```
$ python3 3sat-dpll.py input1.cnf

Model = {3: False, 1: False}

Satisfiable!
```

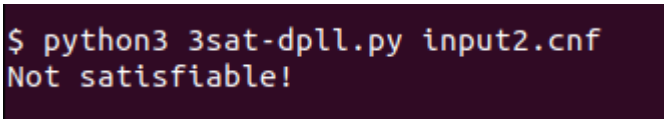



### Input File 2

```
c This is a comment
c the follwing line specifies number of variables and number of clauses
respectively
p 3 8
c the following lines are the clauses
1 2 3 0
1 2 -3 0
1 -2 3 0
1 -2 -3 0
-1 2 3 0
-1 2 -3 0
-1 -2 3 0
-1 -2 -3 0
```

### Output 2

```
$ python3 3sat-dpll.py input2.cnf
Not satisfiable!
```




### Input File 3

```
c FILE: aim-50-2_0-yes1-1.cnf
c
c SOURCE: Kazuo Iwama, Eiji Miyano (miyano@cscu.kyushu-u.ac.jp),
```

```
c          and Yuichi Asahiro
c
c DESCRIPTION: Artifical instances from generator by source.  Generators
c              and more information in sat/contributed/iwama.
c
c NOTE: Satisfiable
c
p cnf 50 100
-9 17 50 0
17 20 -50 0
17 -20 -50 0
-9 -17 39 0
-9 -17 -39 0
9 29 43 0
9 -29 43 0
9 10 -43 0
-10 -27 -43 0
4 -10 -43 0
-4 -6 -10 0
-4 11 -16 0
6 -11 -16 0
-4 6 26 0
11 -26 39 0
6 -11 39 0
-26 32 38 0
32 -38 -39 0
12 -26 -32 0
-12 25 -39 0
-13 -25 -32 0
7 -12 -25 0
-7 28 49 0
-7 -25 49 0
-7 33 -49 0
8 -33 -49 0
1 -8 -49 0
-1 -8 21 0
-1 5 36 0
-5 -8 36 0
-1 -14 -36 0
-21 -36 -50 0
14 24 -36 0
14 -24 -38 0
-23 34 50 0
-23 -24 -34 0
23 -24 -34 0
23 34 -42 0
28 34 42 0
-11 -28 42 0
15 -28 42 0
23 35 45 0
-23 -28 45 0
-15 -35 45 0
-15 -17 -45 0
12 -15 30 0
```

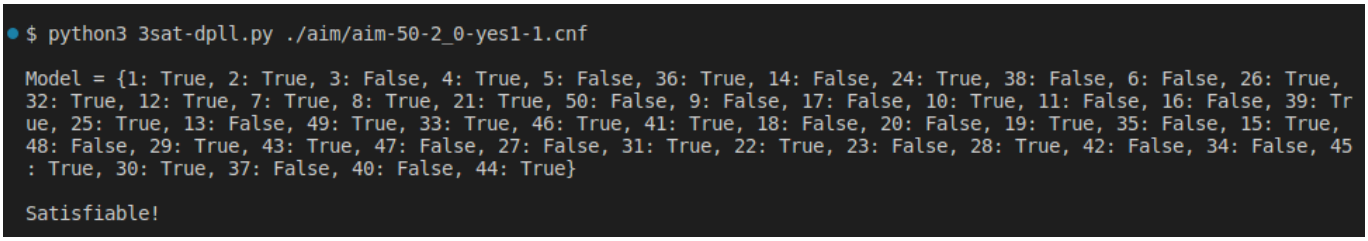
```
-12 30 -45 0
22 -30 -45 0
-22 -30 -37 0
-3 -22 -30 0
3 -22 -47 0
37 40 44 0
-31 40 44 0
4 13 37 0
13 37 -40 0
-13 33 -40 0
-13 -33 44 0
2 3 -44 0
-2 -40 -44 0
27 43 47 0
-2 16 41 0
-16 27 47 0
-27 41 47 0
41 -44 -47 0
-18 38 -41 0
-2 -18 -38 0
40 -41 46 0
-20 33 -46 0
-20 -33 -41 0
18 19 28 0
14 18 19 0
-14 18 19 0
-5 -19 -46 0
-5 -18 -46 0
20 21 -35 0
-19 20 -35 0
3 35 -48 0
-3 -19 -48 0
29 35 48 0
-29 31 38 0
27 31 48 0
-29 31 48 0
4 12 16 0
25 26 -42 0
-6 13 -37 0
11 25 -37 0
8 16 -47 0
1 15 -31 0
1 10 -21 0
-14 22 -42 0
32 -32 36 0
2 10 -21 0
-3 5 8 0
15 21 22 0
5 7 29 0
26 -27 50 0
30 -31 -48 0
7 -34 46 0
-6 24 49 0
2 24 46 0
```

## Output 3

```
$ python3 3sat-dpll.py ./aim/aim-50-2_0-yes1-1.cnf

Model = {1: True, 2: True, 3: False, 4: True, 5: False, 36: True, 14:
False, 24: True, 38: False, 6: False, 26: True, 32: True, 12: True, 7:
True, 8: True, 21: True, 50: False, 9: False, 17: False, 10: True, 11:
False, 16: False, 39: True, 25: True, 13: False, 49: True, 33: True, 46:
True, 41: True, 18: False, 20: False, 19: True, 35: False, 15: True, 48:
False, 29: True, 43: True, 47: False, 27: False, 31: True, 22: True, 23:
False, 28: True, 42: False, 34: False, 45: True, 30: True, 37: False, 40:
False, 44: True}

Satisfiable!
```




## Input File 4

```
c FILE: aim-50-1_6-no-2.cnf
c
c SOURCE: Kazuo Iwama, Eiji Miyano (miyano@cscu.kyushu-u.ac.jp),
c          and Yuichi Asahiro
c
c DESCRIPTION: Artifical instances from generator by source.  Generators
c              and more information in sat/contributed/iwama.
c
c NOTE: Not Satisfiable
c
p cnf 50 80
5 17 37 0
24 28 37 0
24 -28 40 0
4 -28 -40 0
4 -24 29 0
13 -24 -29 0
-13 -24 -29 0
-4 10 -17 0
-4 -10 -17 0
26 33 -37 0
5 -26 34 0
33 -34 48 0
33 -37 -48 0
```

```
5 -33 -37 0
2 -5 10 0
2 -5 -10 0
-2 15 47 0
15 30 -47 0
-2 -15 30 0
20 -30 42 0
-2 20 -30 0
13 -20 29 0
13 16 -20 0
-13 -20 31 0
-13 16 -31 0
-16 23 38 0
-16 19 -38 0
-19 23 -38 0
14 -23 34 0
1 14 -34 0
-1 9 14 0
-1 -9 -23 0
-14 21 -23 0
-14 -16 -21 0
25 -35 41 0
-25 41 50 0
-35 49 -50 0
-25 -49 -50 0
-19 -48 -49 0
3 -39 44 0
1 3 -44 0
9 35 44 0
-9 -31 44 0
22 25 -44 0
-12 -43 46 0
-12 -28 -46 0
6 35 48 0
11 18 -48 0
22 38 -42 0
22 -35 -42 0
-3 11 41 0
27 28 -43 0
-15 -21 31 0
-33 39 50 0
-8 -22 -47 0
-22 -40 -47 0
39 44 -46 0
-25 -26 47 0
38 43 45 0
-6 -14 -45 0
-7 12 36 0
8 -11 45 0
27 -38 -50 0
7 -11 -36 0
-7 -41 42 0
7 21 23 0
-18 32 46 0
```

```
8 19 -36 0
-32 -45 -50 0
7 17 21 0
6 18 43 0
-6 24 -27 0
40 -41 49 0
-11 12 26 0
-3 32 -36 0
-6 36 -44 0
-3 36 42 0
-8 -11 -32 0
-18 -27 -38 0
-18 -27 -39 0
```

## Output 4

```
$ python3 3sat-dpll.py ./aim/aim-50-1_6-no-2.cnf
Not satisfiable!
```