## Working with SymPy for Proposition Logic

# 2.3 SymPy assignment

# Setup

## Import statements for SymPy package

In [4]:
```
from sympy import *
from tabulate import tabulate
```

## Setup of symbols

In [5]:
```
p, q, r, s, t = symbols('p q r s t') #declare the symboles used
```

## Evaluating truth tables

In [6]:
```
def new_basic_table():
    table = {"p": ["T"] * 16 + ["F"] * 16,
             "q": (["T"] * 8 + ["F"] * 8) * 2,
             "r": (["T"] * 4 + ["F"] * 4) * 4,
             "s": (["T"] * 2 + ["F"] * 2) * 8,
             "t": ["T", "F"] * 16}

    return table
```

In [7]:
```
def tte(inp):
    if inp == "T":
        return true
    elif inp == "F":
        return false
```

In [8]:
```
def add_logical_statement(table, statement):
    row_entries = []
    symbols = list(statement.atoms())




    if len(symbols) == 2:
        sym_1, sym_2 = symbols[0], symbols[1]
        for i in range(32):
            row_entries.append(statement.subs({sym_1: tte(table[str(sym_1)][i]), sy

    elif len(symbols) == 3:
        sym_1, sym_2, sym_3 = symbols[0], symbols[1], symbols[2]
        for i in range(32):
            row_entries.append(statement.subs({sym_1: tte(table[str(sym_1)][i]),
                                               sym_2: tte(table[str(sym_2)][i]),
                                               sym_3: tte(table[str(sym_3)][i])}))

    elif len(symbols) == 4:
        sym_1, sym_2, sym_3, sym_4 = symbols[0], symbols[1], symbols[2], symbols[3]
        for i in range(32):
            row_entries.append(statement.subs({sym_1: tte(table[str(sym_1)][i]),
                                               sym_2: tte(table[str(sym_2)][i]),
                                               sym_3: tte(table[str(sym_3)][i]),
                                               sym_4: tte(table[str(sym_4)][i])}))

    elif (len(symbols)) == 5:
        sym_1, sym_2, sym_3, sym_4, sym_5 = symbols[0], symbols[1], symbols[2], sym
        for i in range(32):
            row_entries.append(statement.subs({sym_1: tte(table[str(sym_1)][i]),
                                               sym_2: tte(table[str(sym_2)][i]),
                                               sym_3: tte(table[str(sym_3)][i]),
                                               sym_4: tte(table[str(sym_4)][i]),
                                               sym_5: tte(table[str(sym_5)][i])}))

    table[statement] = row_entries

    return table
```

# Assignment

Pick a propositional logic formula from the table based: assignment-wk2-logic-table.png

1. Take the first character of your first name, and the last character of your last name. E.g. if your name is Tom Turing, your characters are T and G.
2. Pick two formulas A and B from the table, and define A and B as variables
3. Define AndAB (as A and B), OrAB (as A or B) ImpliesAB (as A implies B) and ImpliesBA
4. Print your variables.

## Assignment step 1

Make truth tables for each formula. Count how often each formula is true and how often it is false (you can count by hand and pout answer in comment. Bonus point for counting using a python function that you define).

In [9]:

```
  #1.
# Rithvik bangarI (R,I)

#2.
# A =  ((p∨q∨s) → (p∧q∧r)) ∧ ¬s
# B = (t∨q) → (¬t∨¬s∨r)
# Countings trues and falses in each column
def count_true_false(table, formula):
    true_count = table[formula].count(True)
    false_count = table[formula].count(False)
    return true_count, false_count

#3.
# Define the logical statements A,B
A = And(Implies(Or(p, q, s), And(p, q, r)), Not(s))
B = Implies(Or(t, q), Or(Not(t), Not(s), r))

# Define the combined logical operations
AndAB = And(A, B)
OrAB = Or(A, B)
ImpliesAB = Implies(A, B)
ImpliesBA = Implies(B, A)
customAandB = And(Or(And(p, q, r), And(Not(p), Not(q), r), And(Not(p), Not(q), Not(



# initialize the basic truth table
table = new_basic_table()

# add formulas to the table
table = add_logical_statement(table, A)
table = add_logical_statement(table, B)
table = add_logical_statement(table, AndAB)
table = add_logical_statement(table, OrAB)
table = add_logical_statement(table, ImpliesAB)
table = add_logical_statement(table, ImpliesBA)
table = add_logical_statement(table, customAandB) # Last column for assignment 3

#4.
# Count true and false values for each formula using count definition
formulas = [A, B, AndAB, OrAB, ImpliesAB, ImpliesBA, customAandB]  #added formula f
for formula in formulas:
    true_count, false_count = count_true_false(table, formula)
    print(f"Formula: {formula}")
    print(f"True: {true_count}, False: {false_count}\n")

# display the truth table
headers = list(table.keys())
rows = list(zip(*table.values()))
print(tabulate(rows, headers=headers, tablefmt="grid"))
```

```
Formula: ~s & (Implies(p | q | s, p & q & r))
True: 6, False: 26

Formula: Implies(q | t, r | ~s | ~t)
True: 28, False: 4

Formula: ~s & (Implies(p | q | s, p & q & r)) & (Implies(q | t, r | ~s | ~t))
True: 6, False: 26

Formula: (Implies(q | t, r | ~s | ~t)) | (~s & (Implies(p | q | s, p & q & r)))
True: 28, False: 4

Formula: Implies(~s & (Implies(p | q | s, p & q & r)), Implies(q | t, r | ~s | ~t))
True: 32, False: 0

Formula: Implies(Implies(q | t, r | ~s | ~t), ~s & (Implies(p | q | s, p & q & r)))
True: 10, False: 22

Formula: ~s & ((p & q & r) | (r & ~p & ~q) | (~p & ~q & ~r))
True: 6, False: 26

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| p   | q   | r   | s   | t   | ~s & (Implies(p | q | s, p & q & r))   | Implies(q |
t, r | ~s | ~t)   | ~s & (Implies(p | q | s, p & q & r)) & (Implies(q | t, r | ~s |
~t))   | (Implies(q | t, r | ~s | ~t)) | (~s & (Implies(p | q | s, p & q & r)))   |
Implies(~s & (Implies(p | q | s, p & q & r)), Implies(q | t, r | ~s | ~t))   | Impli
es(Implies(q | t, r | ~s | ~t), ~s & (Implies(p | q | s, p & q & r)))   | ~s & ((p &
q & r) | (r & ~p & ~q) | (~p & ~q & ~r))   |
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| F   | F   | F   | F   | F   | True                                   | True
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## Assignment step 2

Can you comment on the result? Is it expected that some formules are more often true than others?

In [10]:

```
#The results of the 6 columns are as follows:
# A: True - 6 False - 26
# B: True - 28 False - 4
# AandB: True - 6 False - 26
# AorB: True - 28 False - 4
# AimpliesB: True - 32 False - 0
# BimpliesA: True - 10 False - 22

#It looks like the truth table values of A and AandB are equivalent.
#This means that all true values of A are also in B, and none of them are mutually
#A similar trend can be seen with B and AorB.
#All truth table values of B and AorB are equivalent, meaning B includes all the tr
#This makes A redundant in this disjunction.
#It makes sense that AimpliesB is always true since if A is true, it is also in B,
#On the other hand, BimpliesA is false for all instances where B is true but A is n
#If you add B false values and the AandB false (U and Not(AandB)), then you get 10
#A is therefore a subset of B and more restrictive than B.

#It is also expected that AorB has more truth table values being true than AandB be
#while AandB is only true when both A and B are true, making it more restrictive.
```

## Assignment step 3

Can you find another formula that does not contain A and B as subformulas, looks completely different, that has the same truth table as AndAB? Define your formula and print the truthtable.

In [11]:

```
#1. Extracting all rows where truth value of AandB are true

# P ∧ Q ∧ R ∧ ¬S ∧ T
# P ∧ Q ∧ R ∧ ¬S ∧ ¬T
# ¬P ∧ ¬Q ∧ R ∧ ¬S ∧ T
# ¬P ∧ ¬Q ∧ R ∧ ¬S ∧ ¬T
# ¬P ∧ ¬Q ∧ ¬R ∧ ¬S ∧ T
# ¬P ∧ ¬Q ∧ ¬R ∧ ¬S ∧ ¬T

#2. Simplifying rows

# P ∧ Q ∧ R ∧ ¬S
# ¬P ∧ ¬Q ∧ R ∧ ¬S
# ¬P ∧ ¬Q ∧ ¬R ∧ ¬S

#3. Overall Simplification

#((P ∧ Q ∧ R) ∨ (¬P ∧ ¬Q ∧ R) ∨ (¬P ∧ ¬Q ∧ ¬R)) ∧ ¬S
```

```
#4. Verification
#Checking last column of the truth tables give the correct count of true and false
#It also gives the truth and false values in the same rows.
```

In [ ]:

In [ ]:

In [ ]:

In [ ]: