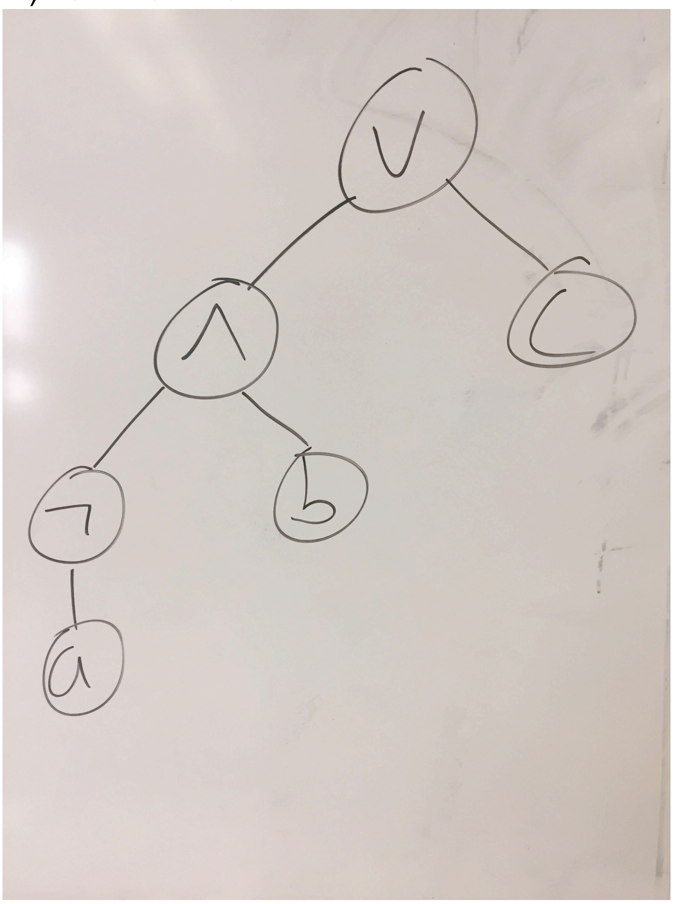
COMP 410
Fall 2022
Midterm Practice Exam #1 (Solutions)

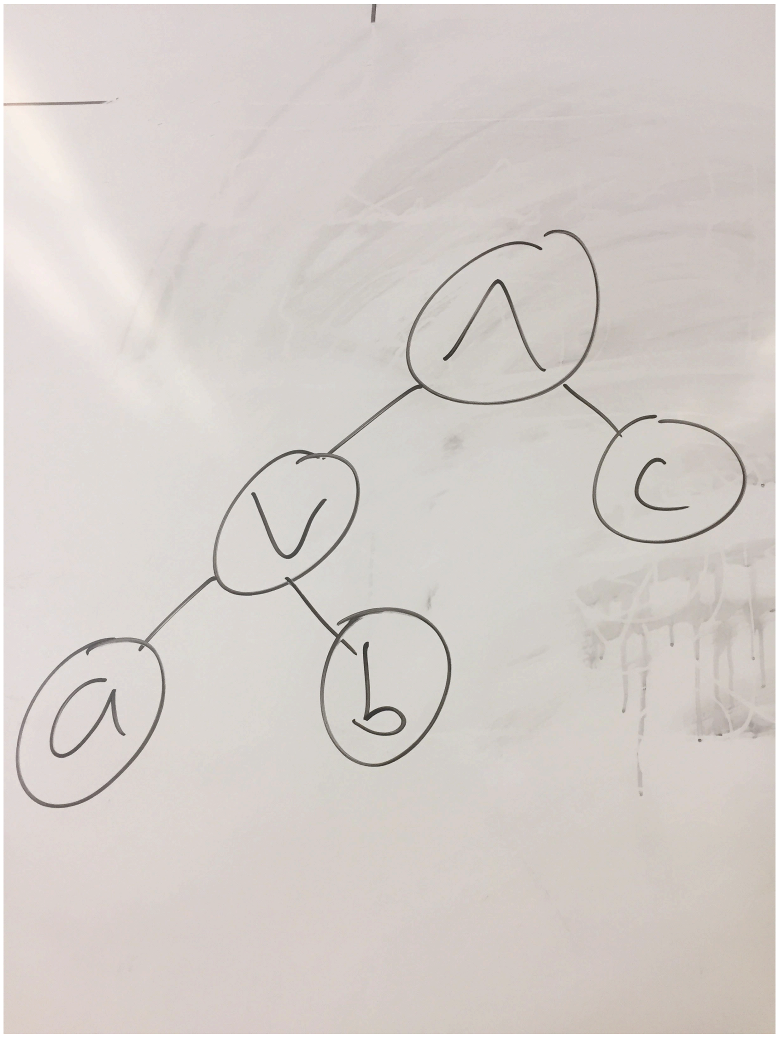
Abstract Syntax Trees

In Boolean expressions, ¬ has the highest precedence, followed by ∧ and ∨. With this in mind, write out the ASTs corresponding to each of the following Boolean expressions:

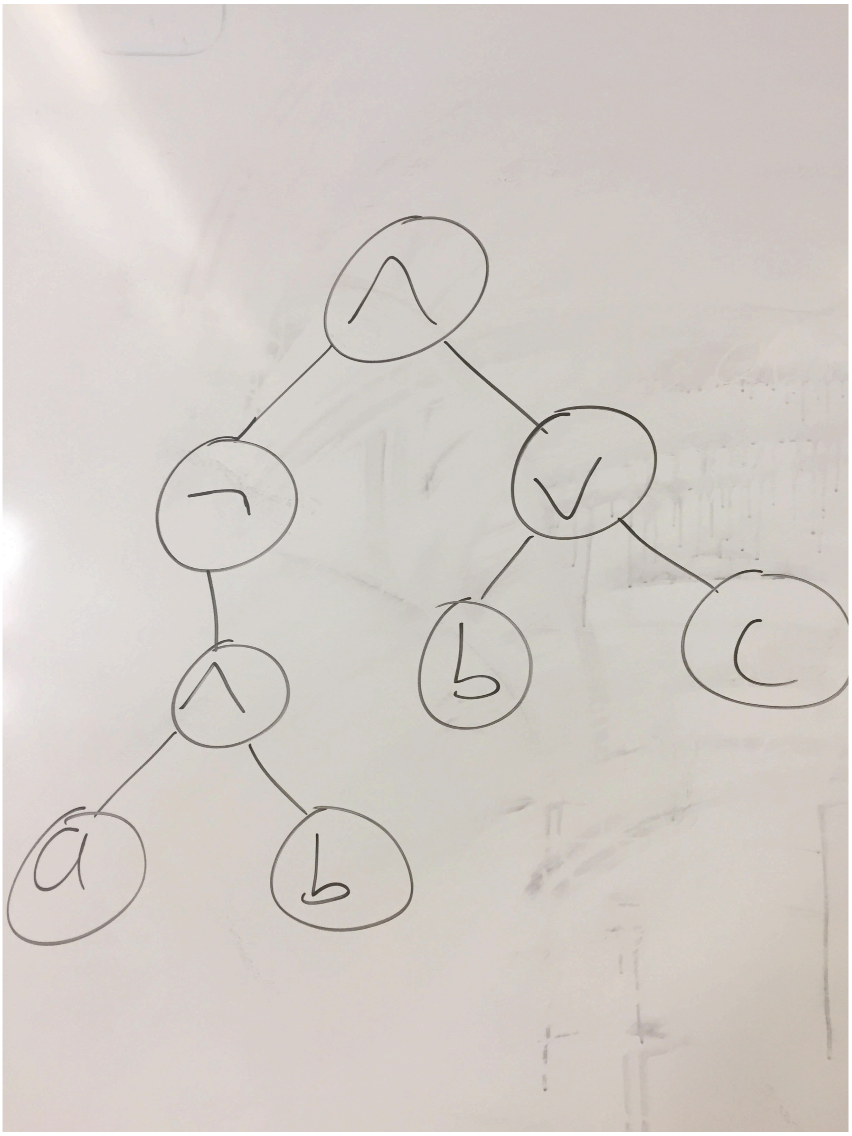
1.) `¬a ∧ b ∨ c`



2.) (a ∨ b) ∧ c

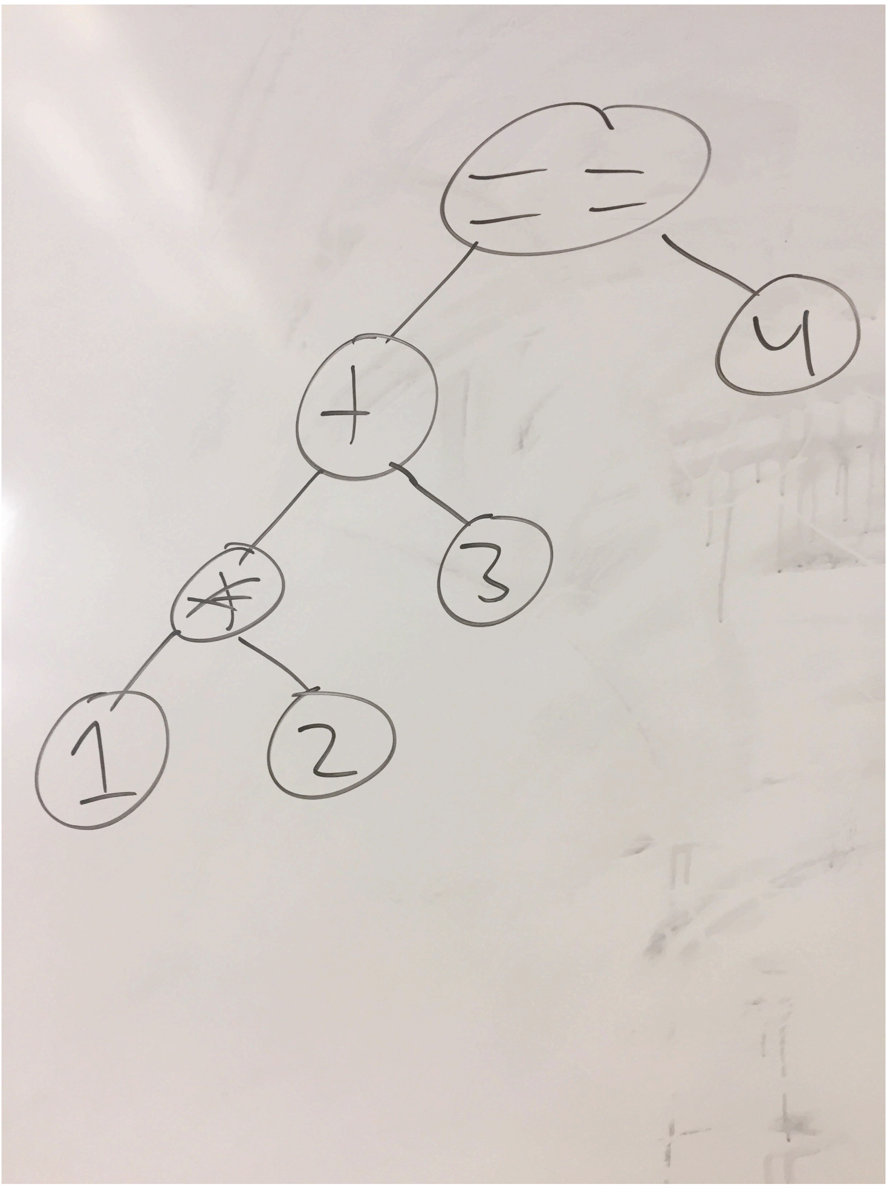


3.) ¬(a ∧ b) ∧ (b ∨ c)

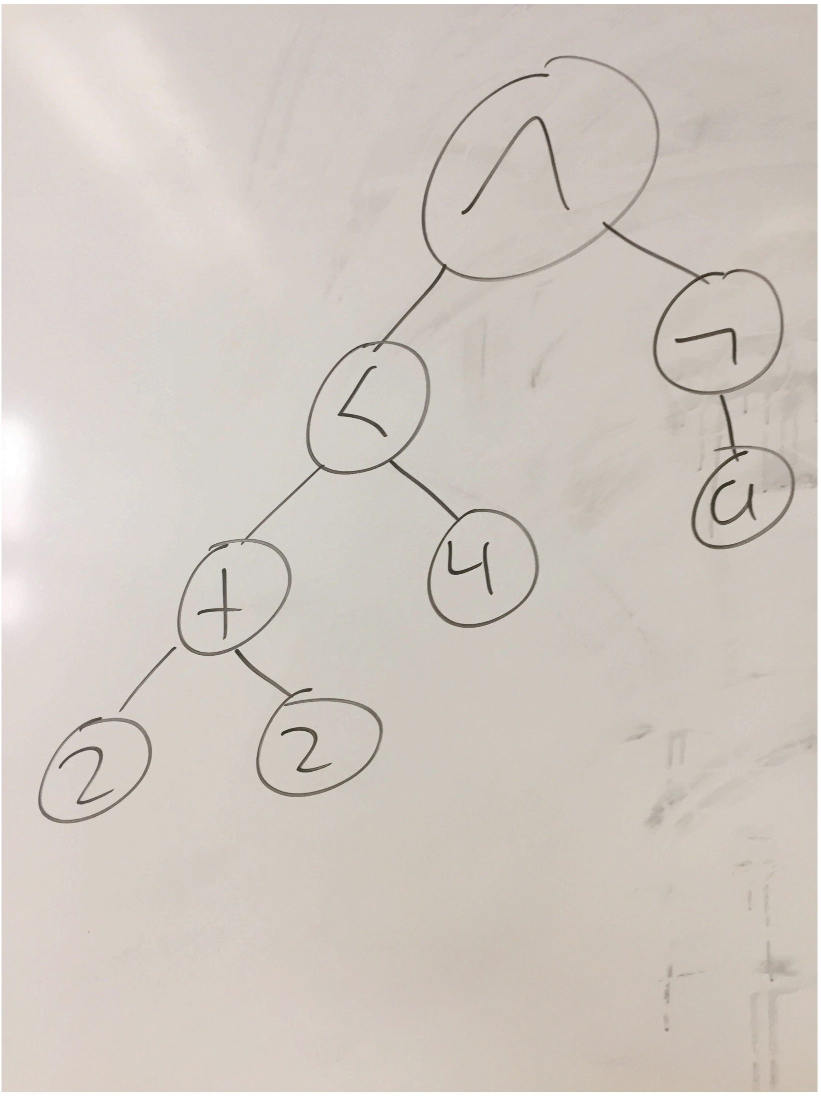


Arithmetic expressions can be used to form Boolean expressions with the help of arithmetic comparisons (e.g., <, <=, >, >=, ==). These comparisons have the lowest possible precedence. With this in mind, write out the ASTs corresponding to each of the following expressions:

4.) `1 * 2 + 3 == 4`



5.) $(2 + 2 < 4) \land \neg a$



6.) Consider the following Python class definitions, which are adapted from assignment 1's boolean evaluator. These classes are used to represent AST nodes.

```
class And:
  def __init__(self, left, right):
    self.left = left
    self.right = right

class Or:
  def __init__(self, left, right):
    self.left = left
    self.right = right
```

Assume that Boolean true is represented as an AST with Python's `True`, and Boolean false is represented as an AST with Python's `False`. With all this in mind, represent the following Boolean expressions in Python using `And`, `Or`, `True`, and `False` as appropriate.

6.a) `true ∧ false`

`And(True, False)`

6.b.) `false ∨ true`

`Or(False, True)`

6.c.) `false ∧ true ∨ true`

`Or(And(False, True), True)`

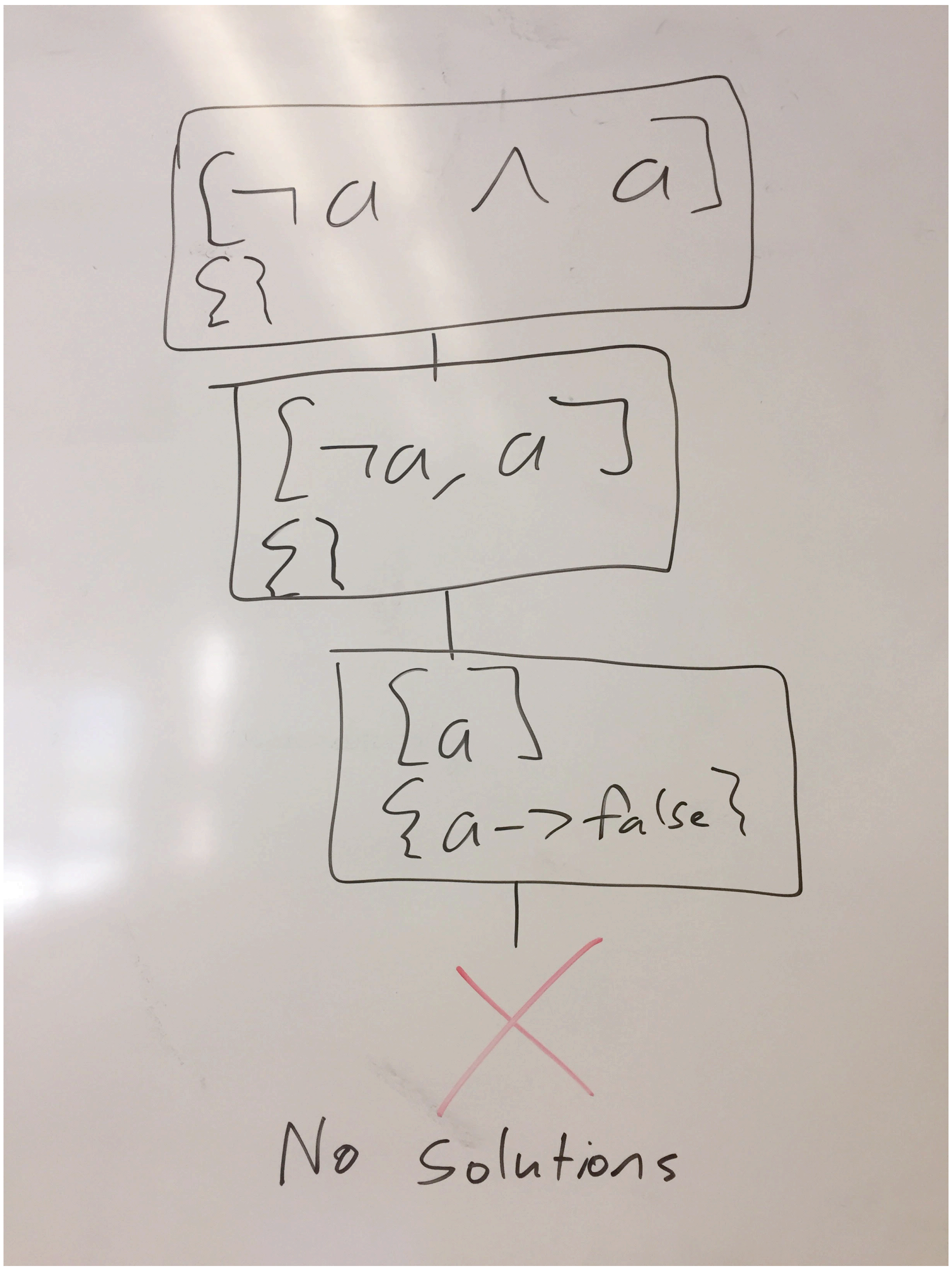
6.d.) `false ∨ true ∧ true`

`Or(False, And(True, True))`

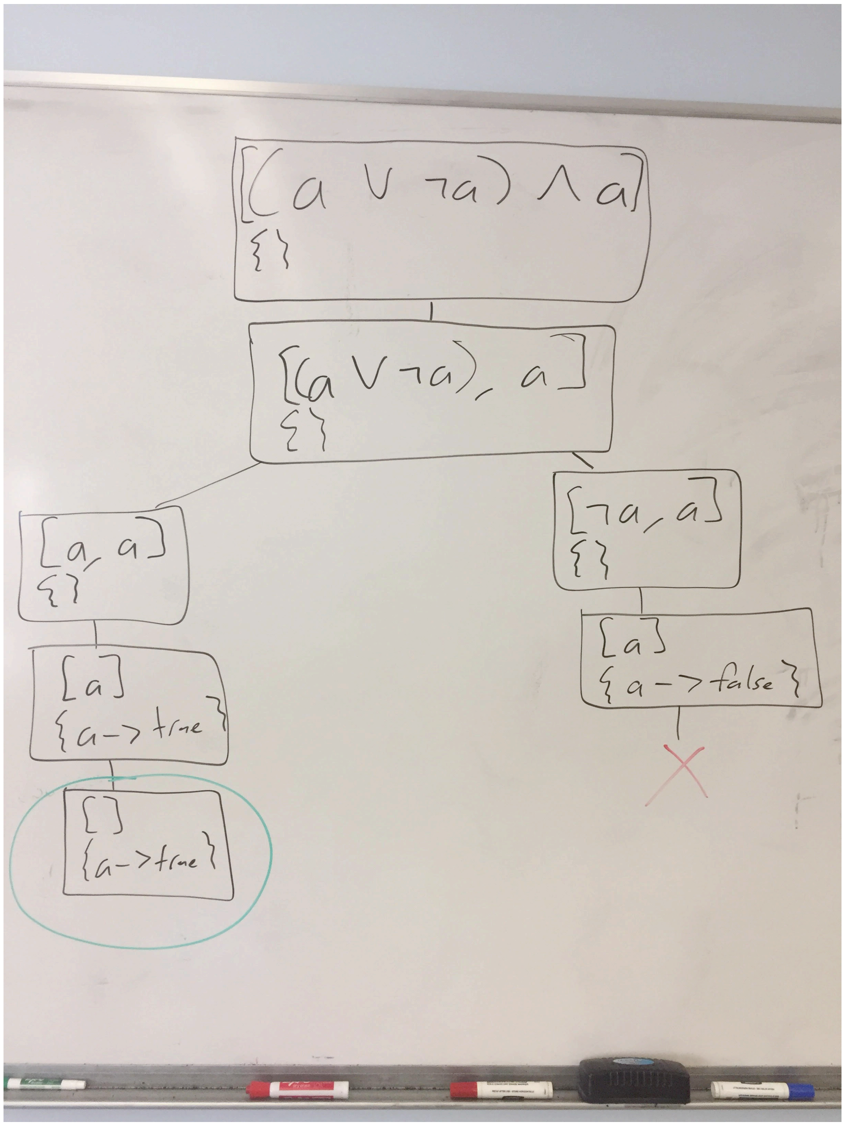
Semantic Tableau

For each of the following Boolean formulas, write out the complete semantic tableau tree. **Circle** the nodes in the tree representing solutions. If a tree has no solutions, say so. **Be sure to write all steps.**

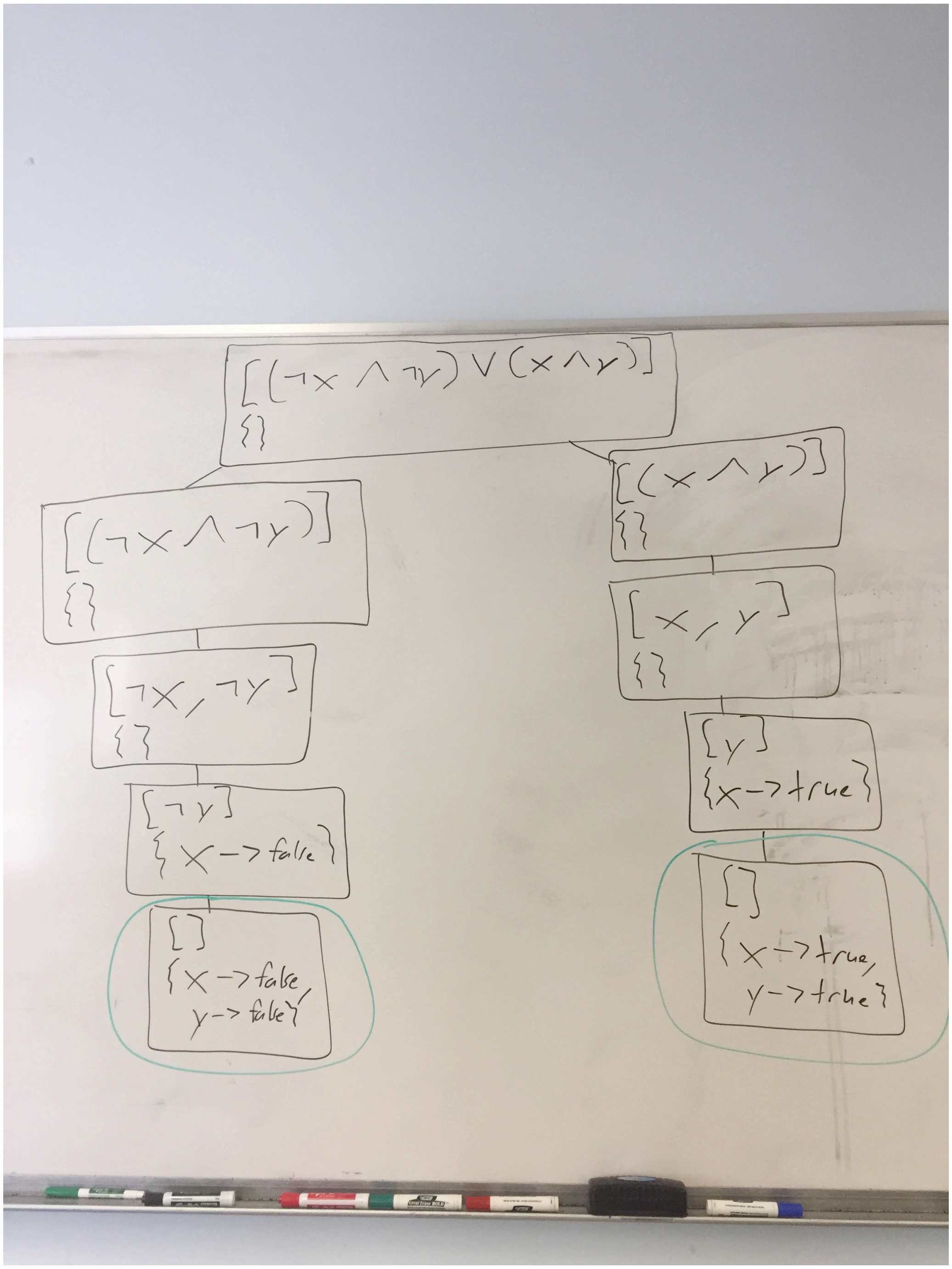
7.) ¬a ∧ a



8.) (a ∨ ¬a) ∧ a



9.) (¬x ∧ ¬y) ∨ (x ∧ y)



Prolog - Modeling the World

10.a)
For this problem, you need to write a clause database encapsulating pricing information for a convenience store. Write Prolog code accurately reflecting the following:

- Soda costs $2
- Chips cost $3
- Hot dogs cost twice as much as soda (do not hardcode $4)
- Soda chips, and hot dogs are food
- Pencils and pens are office supplies
- All office supplies cost $2
- Cold medicine costs $7

```
% all facts and rules with the same name should be placed
% together in the file
cost(soda, 2).
cost(chips, 3).
cost(hot_dog, Cost) :-
    cost(soda, SodaCost),
    Cost is SodaCost * 2.
cost(OS, 2) :-
    office_supplies(OS).
cost(cold_medicine, 7).

food(soda).
food(chips).
food(hot_dog).

office_supplies(pencil).
office_supplies(pen).
```

Using the clause database you previously wrote, write queries to determine the following:

10.b.) Which items cost exactly $2?

```
?- cost(Item, 2).
```

10.c.) Which items cost more than $3?

```
?- cost(Item, Cost), Cost > 3.
```

10.d.) Which foods cost less than $3?

```
?- food(Food), cost(Food, Cost), Cost < 3.
```

10.e.) Which foods are also office supplies?

```
?- food(Item), office_supplies(Item).
```

Unification

Consider each of the following unification attempts. If the unification succeeds, record any values any variables take. If the unification fails, say so.

11.) `foo(1, X) = foo(Y, 2)`

```
X = 2, Y = 1
```

12.) `foo(1, X) = foo(X, 2)`

`false`

13.) `foo(1, _) = foo(X, 2)`

`X = 1`

14.) `foo(1, _) = foo(1, _)`

`true`

15.) `foo(1, 2, bar) = foo(X, _, _, _)`

`false`

16.) `foo(bar(baz), X) = foo(Y, Z), Y = bar(A)`

`X = Z, Y = bar(baz), A = baz`