1. Consider the following FOL sentences. Determine: arguments, predicates, function symbols. Determine the arity of the predicate and say whether it is an infix or prefix. Translate the last sentence in the space provided.

   a) mother($a$) = $b$

   b) Taller(pet(max), scruffy)

   c) Gave(father(max), claire, folly, 2:00)

2. Fill in the following truth table.

3. Prove the following argument. Be sure to say what rule you are using and which steps you are citing for that rule. Only use Ana Con if you cannot use any other rule and in this case cite at most two sentences in support.

   1. SameRow($b$, $c$)
   2. SameRow($a$, $d$)
   3. SameRow($d$, $f$)
   4. FrontOf($a$, $b$)
   5. 
   6. 
   7. 
   8. 
   9. 
   10. FrontOf($f$, $c$)
4. Determine whether the following argument is valid or not. Be sure to identify the premises and conclusion. If it is, determine whether it is sound. Explain your answers.

The people of Bowling Green, OH, believe in freedom of speech. Freedom of speech allows for one to say whatever they feel or think. Consequently, one must be allowed to scream fire in a crowded theater.

5. Determine whether the following argument is valid or not. Be sure to identify the premises and conclusion. If it is valid give a Fitch proof. Otherwise, provide a TW-counterexample in the space provided.

1. FrontOf(a, b)
2. LeftOf(a, c)
3. SameCol(a, b)
4. 
5. 
6. 
7. 
8. 
9. FrontOf(c, b)
6. True or False. The sentence \( \text{Small}(a) \lor \text{Small}(b) \) is a tautological consequence of the statement \( (\text{Tet}(a) \land \text{Small}(a)) \lor \text{Small}(b) \). (Briefly explain your answer.)

7. Give an example of a TW-necessity which is not a logical necessity. Is it possible to give an example of a logical necessity that is not a TW-necessity? Explain.

8. Give an example of a tautology.

9. State DeMorgan’s Laws. (Full credit for both statements.)
   i) 
   ii) 

10. Put the following into Disjunction Normal Form. Assume that \( A, B, \) and \( C \) are literals.
    \[
    (\neg A \lor B) \land C
    \]

11. Working in FOL for set theory we let \( S = \{2, 3, a, b, \{2, a\}\}, a = 3, b = \{2\}, c = \{2, a\}. \) Which of the following are true? (In the underlined space provided check the ones that are true.)
    a) \( a \in c \) 
    b) \( b \in c \) 
    c) \( c \in S \) 
    d) \( c \subseteq S \) 
    e) \( \emptyset \subseteq b \) 
    f) \( b \in S \)
Use the given Tarski’s World to determine whether the questions 12-17 are true or false. In the underlined space provided check if the sentence is a literal.

12. Cube(a) ∨ Cube(c)

13. Between(c, a, b)

14. Larger(c, b)

15. FrontOf(a, lm(c))

16. ¬ (¬ Dodec(e) ∧ Dodec(lm(b))

17. Between(c, a, rm(bm(lm(rm(a))))))
ONLY DO THIS PAGE ONCE YOU HAVE FINISHED THE OTHER PROBLEMS!!!!

Use the space below to create a world where all of the following statements are true.

a. $\text{Dodec}(d) \lor \lnot \text{Large}(e)$

b. $\text{Im}(e) \neq e$

c. $\text{SameCol}(a,d)$

d. $\text{Between}(c, a, e) \land \lnot \text{SameCol}(c,a) \land \lnot \text{SameRow}(e,c)$

e. $\text{SameSize}(a, e)$

f. $\lnot (\text{SameShape}(a, c) \lor \text{SameShape}(a, d) \lor \text{SameShape}(c, d))$

g. $\text{SameRow}(d, b)$