1. Consider the following FOL sentences. Determine: objects, predicates and their arity, function symbols. Translate the sentences.

   a) Smaller(a,b)
   
   b) Cube(lm(c))
   
   c) Between(b,fm(c),d)

2. How many predicates are there in the FOL of Tarski’s World? Explain what it means for the sentence $\text{Adjoins}(a,b)$ to be true.

3. What is a function symbol?

4. In the following argument identify the premises and conclusion. Determine whether the following argument is valid or not. If it is valid, 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. 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\((f, c)\)

6. State DeMorgan’s Laws. (Full credit for both statements.)

   i)  

   ii)  

7. 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.) Also, name all the predicates in the language of set theory in part e).

   a) \( a \in c \)  

   b) \( b \in c \)  

   c) \( c \in S \)  

   d) \( b \in S \)  

   e)
8. 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 on the bottom of this page.

1. FrontOf(a, b)

2. LeftOf(a, c)

3. SameCol(a, b)

4.

5.

6.

7.

8. FrontOf(c, b)
Use the given TW*-model to determine whether the questions are true or false. Answer True or False in the underlined space provided.

9. Cube(a) ∨ Cube(c)  

10. Between(c, a, b)  

11. Larger(c, b)  

12. FrontOf(a, lm(c))  

13. ¬ (¬ Dodec(e) ∧ Dodec(lm(b)))  

14. Between(c, a, rm(bm(lm(rm(a))))))
15. Use the space below to create a world where all of the following statements are true.

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

b. \( \text{im}(e) \neq e \)

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

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

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

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

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