1. [25%] A propositional KB contains these sentences:

```
A, B, P \Rightarrow Q, A \land M \Rightarrow P, L \land B \Rightarrow M, A \land B \Rightarrow L
```

- (a) Convert them into CNF.
- (b) Use resolution to prove Q.

```
В
(a) [R1]
                                         [R2]
                        P \Rightarrow Q \rightarrow \neg P \lor Q
        [R3]
                        A \land M \Rightarrow P \rightarrow \neg (A \land M) \lor Q \rightarrow \neg A \lor \neg M \lor Q
        [R4]
                        L \land B \Rightarrow M \rightarrow \neg (L \land B) \lor M \rightarrow \neg L \lor \neg B \lor M
        [R5]
        [R6]
                        A \land B \Rightarrow L \rightarrow \neg (A \land B) \lor L \rightarrow \neg A \lor \neg B \lor L
(b) [R7: R1+R4]
                                         \neg M \lor Q
        [R8: R1+R6]
                                         \neg B \lor L
        [R9: R2+R5]
                                         \neg L \lor M
        [R10: R2+R8]
                                         L
        [R11: R9+R10]
                                         M
        [R12: R7+R11]
                                         0
```

- 2. [30%] Convert the following English sentences to first-order logic sentences. Whenever possible, use the words in the original sentence as the names of predicates, functions, and constant terms.
- (a) Some friends of Bob like baseball.
- $\exists x \text{ Friend(Bob, } x) \land \text{Like(} x, \text{Baseball)}$
- (b) A soccer fan is one who likes soccer.
- $\forall x \text{ Fan}(x, \text{Soccer}) \Rightarrow \text{Like}(x, \text{Soccer})$ [It is ok to use "⇔" here.]

 $[R12 + \neg Q \text{ (negated query)}]$ false \rightarrow contradiction \rightarrow Q is true.

- (c) Bob is the only one in his class who likes soccer. [You can use *Classmate* as a predicate here.]
- $\forall x \ Classmate(Bob, x) \Rightarrow \neg Like(x, Soccer)$
- 3. [25%] Given the FOL sentences in Prob. 2(b) and (c), and the following fact:

Jane is Bob's classmate.

Try to prove

Jane is not a soccer fan.

You can use any sound inference method. Specify the substitutions here.

We have the additional ground term: Classmate(Bob, Jane)

The queried term Q is: \neg Fan(Jane, Soccer)

The following procedure uses the resolution rule.

The CNF forms:

```
[R1]
                                                             Classmate(Bob, Jane)
[R2] Fan(x, Soccer) \Rightarrow Like(x, Soccer) \Rightarrow
                                                             \negFan(v, Soccer) \vee Like(v, Soccer)
                  (The "standardizing apart" step is applied to avoid variable name clash.)
[R3] Classmate(Bob, x) \Rightarrow \neg \text{Like}(x, \text{Soccer}) \rightarrow \neg \text{Classmate}(\text{Bob}, x) \lor \neg \text{Like}(x, \text{Soccer})
Resolution:
                        ¬Like(Jane, Soccer)
                                                       (substitution: {x/Jane})
[R4: R1+R3]
[R5: R2+R4]
                        ¬Fan(Jane, Soccer)
                                                       (substitution: {y/Jane})
                        false \rightarrow contradiction \rightarrow Q is true.
[R5 + \neg Q]
```

4. [20%] Which of the following terms are suitable to be used as Functions in FOL, and which are not? Brother, Mother, Head, Hat.

Give a brief explanation of your criterion.

Mother and Head are suitable as functions, and Brother and Hat are not.

This is because it is expected that only a single object can be someone's mother (or head), but an object can have multiple brothers (or hats).