### 1 Symbolize

Definitions:

C(x) x is a cat

D(x) x is a dog

S(x,y) x has been seen by y

B(x,y)x has bitten y

T(x,y) x is taller than y

#### **a**)

No dog bites any cat that sees it

There does not exist a dog which bites a cat who sees the dog

There does not exist a dog who has both been seen by and bitten a given cat

There does not exist a dog such that there exists a cat where the following hold:

- 1) the cat has seen the dog
- 2) the cat has been bitten by the dog

$$\neg \exists x [D(x) \land \exists y (C(y) \land S(x,y) \land B(x,y))]$$

Another possible interpretation is:

If x is a Dog and y is a Cat and dog has been seen by cat, then dog has not bitten cat

$$\forall x [D(x) \to \forall y (C(y) \land S(x,y) \to \neg B(x,y))]$$

#### b)

The tallest dog bites at least one cat

There exists a dog which no dog is taller than and there exists a cat that the tallest dog has bitten

$$\exists x [D(x) \land \neg \exists y (D(y) \land T(y,x)) \land \exists z (C(z) \land B(x,z))]$$

**c**)

There are at least two cats that bit each other

There exists a cat x and a cat y such that x is not y, x has bitten y, and y has bitten x

$$\exists x [C(x) \land \exists y (C(y) \land x \neq y \land B(x,y) \land B(y,x))]$$

# 2 Prove

$$\begin{array}{c|cccc}
1 & \neg \exists y (\exists x F(x) \to F(y)) & \text{ASS for IP} \\
2 & \forall y \neg (\exists x F(x) \to F(y)) & \text{QN 1} \\
3 & \neg (\exists x F(x) \to F(c)) & \text{UI 2} \\
4 & \exists x F(x) \land \neg F(c) & \text{CN 3} \\
5 & \exists x F(x) & \text{Simp 4} \\
6 & \neg F(c) & \text{Simp 4} \\
7 & F(c) & \text{ASS for EI} \\
8 & \neg F(c) & \text{Rep 6} \\
9 & F(c) \land \neg F(c) & \text{Conj 7,8} \\
10 & \bot & \text{Contradiction 9} \\
11 & \bot & \text{UI 5,7-10} \\
12 & \exists y (\exists x F(x) \to F(y)) & \text{IP 1-11}
\end{array}$$

# 3 Symbolize and Prove

**a**)

```
Identity is transitive \forall xyz[(x=y \land y=z) \rightarrow x=z]
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```
\neg \forall x \forall y \forall z [(x = y \land y = z) \to x = z]
                                                                ASS for IP
        \exists x \neg \forall y \forall z [(x = y \land y = z) \rightarrow x = z]
                                                                QN 1
 2
          \neg \forall y \forall z [(c = y \land y = z) \to c = z]
                                                                ASS for EI
 3
          \exists y \neg \forall z [(c = y \land y = z) \to c = z]
                                                                QN 3
 4
            \neg \forall z [(c = b \land b = z) \to c = z]
                                                                ASS for EI
 5
             \exists z \neg [(c = b \land b = z) \to c = z]
                                                                QN5
 6
               \neg[(c=b \land b=f) \to c=f]
                                                                ASS for EI
 7
                (c = b \land b = f) \land c \neq f
                                                                CN7
 8
                c \neq f
                                                                Simp 8
9
                (c = b \land b = f)
10
                                                                Simp 8
                c = b
                                                                Simp 10
11
                b = f
                                                                Simp 10
12
               c = f
                                                                LL 11,12
13
                c = f \land c \neq f
                                                                Conj 12,9
14
                                                                Contradiction 14
15
                                                                EI 7-15
16
                                                                EI 5-16
17
         \perp
                                                                \rm EI~3\text{-}17
18
      \forall x \forall y \forall z [(x = y \land y = z) \rightarrow x = z]
                                                                IP 1-18
```

## b)

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If 1+1=2 and 3-1=2 then 1+1=3-1 let x represent 1+1 let y represent 2 let z represent 3 - 1 Show (x=y \land y=z) \rightarrow x=z
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If we had access to functions like Plus(x,y) which return x+y, we could prove this more clearly. We only have access to T/F predicates, so I think this proof is the best I can do