Class 14 - From TFL to FOL
A primer on First-Order Logic

Zee R. Perry

Let's do some logic!

The Shortcomings of Truth-Functional Logic

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1. Zee is a human being.
2. All human beings should practice social distancing.

C. Zee should practice social distancing.

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2. All dogs are vegetarians.

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The sentences in these argument contain no sentential connectives! Therefore, we can only translate them into TFL as *atomic sentences*!!

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2. *B*

∴ *C*

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1. A
2. B

∴ C

But the argument "$A, B \therefore C$" is **NOT** valid in TFL!

The sentences in these argument contain no sentential connectives! Therefore, we can only translate them into TFL as *atomic sentences*!!

How can we recover the validity of these arguments?

In order to explain why the argument below is valid, we need to look at what the *form* of these arguments is. That is, we should try to figure out what parts could be replaced with other things without changing the validity of the argument:

1. Zee is a human being.
2. All human beings should practice social distancing.

C. Zee should practice social distancing.

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In order to explain why the argument below is valid, we need to look at what the *form* of these arguments is. That is, we should try to figure out what parts could be replaced with other things without changing the validity of the argument:

1. Sirina McKitten is a dog.
2. All dogs are vegetarians.

C. Sirina McKitten is a vegetarian.

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1. Sirina McKitten is a dog.
2. All dogs are adorable.

C. Sirina McKitten is adorable.

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1. _____ is a dog.
2. All dogs are adorable.

C. Sirina McKitten is adorable.

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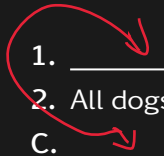

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C. Sirina McKitten is adorable.

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1. _____*a*_____ is __*D*__.
2. All __*D*__ are adorable.

C. _____*a*_____ is adorable.

How can we recover the validity of these arguments?

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1. _____*a*_____ is __*D*__.
2. All __*D*__ are _____*V*_____.

C. _____*a*_____ is adorable.

How can we recover the validity of these arguments?

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1. _____*a*_____ is ___*D*___.
2. All ___*D*___ are _____*V*_____.

C. _____*a*_____ is _____*V*_____.

What did we just do?

We just replaced some words with blanks, and then marked the blanks with a letter (indicating when you need to fill them with ***the same*** word. But what are these blanks really standing for?

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For example, ***THIS*** isn't a valid argument! (It's not even an argument, since it's not made with sentences, just some ungrammatical mish-mash)

1. ___adorable___ is Zee.
2. All _Zee_ are Catt Damon .

C. ___adorable___ is Catt Damon .

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Do the blanks just stand for **ANY word**? No!

The blanks don't stand for just *any* words. Some of them stand for ***THINGS*** (like me or my cats), others stand for ***PREDICATES*** (like verbs, adjectives, or descriptions)

1. ___[Name *a*]___ is _*D*_.
2. All _*D*_ are ____*V*____.

C. _____*a*_____ is ____*V*____.

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1. ___[Name *a*]___ is [Predicate *D*].
2. All __*D*__ are _____*V*_____.

C. ___[Name *a*]___ is _____*V*_____.

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C. ___[Name *a*]___ is [Predicate *V*].

Building Blocks of First-Order Logic (pt 1)

We aren't just trying to understand the form of arguments in English, we're constructing a NEW formal language. So we need to come up with translations:

Names translate as 'a', 'b', 'c', 'd'… 'a_{17}', 'g_3', 'p_7'

So, 'a', or 'x', or 's' (etc.) could stand for 'Catt Damon'.

Other names: 'Ruth Barcan Marcus', 'you', 'this city', 'BTS', 'today', 'the 1800s' etc.

Predicates translate as '$P(\ldots)$', '$Q(\ldots)$', '$R(\ldots,\ldots)$', '$F(\ldots)$', etc.

So, '$F(\ldots)$' or '$D(\ldots)$' (etc.) could stand for '**____ is a dog**'.

Other predicates: '**____ is adorable**', or '**____ stinks**', or '**____ is taller than ____**', or '**____ is taller than Danny Devito**'

Homework Preview

Re-doing an old homework (Homework 2) in FOL!

Your homework for this week will be to re-do Homework 2 in FOL.

I won't officially assign it yet, but I will go through how to approach some of these translations in this class and the next one!

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But first, some examples of what I mean about re-doing these translations!

Quizlet URL: https://tinyurl.com/AttendQuizOct25

Quizlet: Redoing translations from Chap 5

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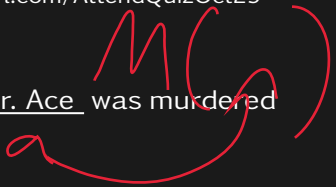
2. Mr. Ace was murdered



4.
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2. '*wasMurdered*(...)' with '*a*' in the blank
4.
6.
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2. '$M(\ldots)$' with 'a' in the blank

4.
6.
8.
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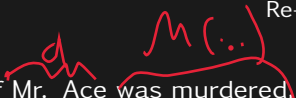

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2. $M(a)$
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D: did the murder = D(...)

2. $M(a) \rightarrow D(c)$

the cook = c

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2. $M(a) \rightarrow D(c)$
   [where '$D(\ldots)$' is the predicate '____ did the murder' and 'c' is the name of the cook]
4.
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2. $M(a) \rightarrow D(c)$
4. $D(b) \vee L(d)$
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   ['$L(\ldots)$' stands for predicate '____ is lying', 'b' and 'd' are names of the butler and the Duchess, respectively]
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2. $M(a) \rightarrow D(c)$
4. $D(b) \vee L(d)$

   ['$L(\ldots)$' stands for predicate '____ is lying', 'b' and 'd' are names of the butler and the Duchess, respectively]
6. $\exists x(W(a,x) \wedge \forall y((W(a,y) \wedge F(x)) \rightarrow D(c)))$
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2. $M(a) \rightarrow D(c)$
4. $D(b) \vee L(d)$
6. $\exists x(W(a,x) \wedge \forall y((W(a,y) \wedge F(x)) \rightarrow D(c)))$
8. $M(a) \leftrightarrow \neg M(e)$
10. $M(a) \rightarrow$
12.

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6. $\exists x(W(a,x) \wedge \forall y((W(a,y) \wedge F(x)) \rightarrow D(c)))$
8. $M(a) \leftrightarrow \neg M(e)$
   [where 'e' is the name of Mr. Edge]
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   [where 'e' is the name of Mr. Edge]
10. $\forall x(W(a,x) \rightarrow F(x))$
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2. $M(a) \to D(c)$
4. $D(b) \vee L(d)$
6. $\exists x(W(a,x) \wedge \forall y((W(a,y) \wedge F(x)) \to D(c)))$
8. $M(a) \leftrightarrow \neg M(e)$
10. ~~$\forall x(M(a) \to F(x))$~~ $M(a) \to F(a)$
    [where '$F(\ldots)$' is the predicate '____ was killed with the frying pan']
12.

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10. If Mr. Ace was murdered, he was done in with the frying pan
12. Of course the Duchess is lying!

2. $M(a) \to D(c)$
4. $D(b) \vee L(d)$
6. $\exists x(W(a,x) \wedge \forall y((W(a,y) \wedge F(x)) \to D(c)))$
8. $M(a) \leftrightarrow \neg M(e)$
10. $\forall x(W(a,x) \to F(x))$
    [where '$F(\ldots)$' is the predicate '____ was killed with the frying pan']
12. $L(d)$

Quizlet: Redoing translations from Chap 5

Re-doing an old homework (Homework 2) in FOL!

2. If Mr. Ace was murdered, then the cook did it
4. Either the butler did it or the Duchess is lying
6. If the murder weapon was a frying pan, then the culprit must have been the cook
8. Mr. Ace was murdered if and only if Mr. Edge wasn't murdered.
10. If Mr. Ace was murdered, he was done in with the frying pan
12. Of course the Duchess is lying!

2. $M(a) \rightarrow D(c)$
4. $D(b) \vee L(d)$
6. $\exists x(W(a,x) \wedge \forall y((W(a,y) \wedge F(x)) \rightarrow D(c)))$
8. $M(a) \leftrightarrow \neg M(e)$
10. $\forall x\,(W(a,x) \rightarrow F(x))$
12. $L(d)$

Quizlet: Redoing translations from Chap 5

Re-doing an old homework (Homework 2) in FOL!

2. If Mr. Ace was murdered, then the cook did it
4. Either the butler did it or the Duchess is lying
6. If the murder weapon was a frying pan, then the culprit must have been the cook
8. Mr. Ace was murdered if and only if Mr. Edge wasn't murdered.
10. If Mr. Ace was murdered, he was done in with the frying pan
12. Of course the Duchess is lying!

2. $M(a) \rightarrow D(c)$
4. $D(b) \vee L(d)$
6. $\exists x(W(a,x) \wedge \forall y((W(a,y) \wedge F(x)) \rightarrow D(c)))$
8. $M(a) \leftrightarrow \neg M(e)$
10. ALTERNATIVELY:
    $M(a) \rightarrow W(a,f)$
    [where '$W(\ldots,\ldots)$' is the 2-place predicate '____ was killed with ____', and 'f' is names the frying pan in question]
12. $L(d)$

From the Homework

Re-doing an old homework (Homework 2) in FOL!

1. Alice and Bob are both spies
2. If either Alice or Bob is a spy, then the code has been broken.
3. If neither Alice nor Bob is a spy, then the code remains unbroken.
4. The German embassy will be in an uproar, unless someone has broken the code.
5. Either the code has been broken or it has not, but the German embassy will be in an uproar regardless.
6. Either Alice or Bob is a spy, but not

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1.
2.

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Make a translation scheme:
(using 'x' as a **Variable** instead of writing out '...' every time)

1.
2.

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Make a translation scheme:
(using '*x*' as a **Variable** instead of writing out '...' every time)

Names: Alice, Bob, the German Embassy, the Code

Predicates: '____ is a spy',
'____ has been broken',
'____ will be in an uproar'

1.

2.

From the Homework

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Make a translation scheme:
(using '*x*' as a **Variable** instead of writing out '...' every time)

Names: Alice, Bob, the German Embassy, the Code
Translations: '*a*', '*b*', '*g*', '*c*', respectively

Predicates: '____ is a spy',
'____ has been broken',
'____ will be in an uproar'

1.

2.

From the Homework

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Make a translation scheme:
(using 'x' as a **Variable** instead of writing out '...' every time)

Names: Alice, Bob, the German Embassy, the Code
Translations: 'a', 'b', 'g', 'c', respectively

Predicates: '____ is a spy', '____ has been broken', '____ will be in an uproar'
Translations: '$S(x)$', '$B(x)$', '$U(x)$'

1.

2.

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Re-doing an old homework (Homework 2) in FOL!

1. Alice and Bob are both spies
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6. Either Alice or Bob is a spy, but not both.

Names: 'a', 'b', 'g', and 'c'

Predicates: '$S(x)$', '$B(x)$', and '$U(x)$'

alice is a spy ∧ bob is a spy

1. $S(a) \wedge S(b)$
2.
3.
4.
5.

From the Homework

Re-doing an old homework (Homework 2) in FOL!

1. Alice and Bob are both spies
2. If either Alice or Bob is a spy, then the code has been broken.
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Names: 'a', 'b', 'g', and 'c'

Predicates: '$S(x)$', '$B(x)$', and '$U(x)$'

1. $S(a) \wedge S(b)$
2. $(S(a) \vee S(b)) \rightarrow B(c)$
3.
4.
5.

From the Homework

Re-doing an old homework (Homework 2) in FOL!

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Names: 'a', 'b', 'g', and 'c'

Predicates: '$S(x)$', '$B(x)$', and '$U(x)$'

1. $S(a) \wedge S(b)$
2. $(S(a) \vee S(b)) \rightarrow B(c)$
3. $\neg(S(a) \vee S(b)) \rightarrow \neg B(c)$
   Or: $(\neg S(a) \wedge \neg S(b)) \rightarrow \neg B(c)$
4. $U(g) \vee$
5.

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Names: 'a', 'b', 'g', and 'c'

Predicates: '$S(x)$', '$B(x)$', and '$U(x)$'

1. $S(a) \wedge S(b)$
2. $(S(a) \vee S(b)) \rightarrow B(c)$
3. $\neg(S(a) \vee S(b)) \rightarrow \neg B(c)$
   Or: $(\neg S(a) \wedge \neg S(b)) \rightarrow \neg B(c)$
4. ~~$Ug \vee \exists x(R(x,c))$~~ $U(g) \vee B(c)$
   (where $R(x,y)$ is '____ has broken ____'.
5. $(B_c \vee \neg B_c) \wedge U_g$

From the Homework

Re-doing an old homework (Homework 2) in FOL!

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6. Either Alice or Bob is a spy, but not both.

Names: 'a', 'b', 'g', and 'c'

Predicates: '$S(x)$', '$B(x)$', and '$U(x)$'

1. $S(a) \wedge S(b)$
2. $(S(a) \vee S(b)) \rightarrow B(c)$
3. $\neg(S(a) \vee S(b)) \rightarrow \neg B(c)$
   Or: $(\neg S(a) \wedge \neg S(b)) \rightarrow \neg B(c)$
4. ~~$\forall g \vee \exists x(R(x,c))$~~ $U(g) \vee B(c)$
   (where $R(x,y)$ is '____ has broken ____'.
5. $(B(c) \vee \neg B(c)) \wedge U(g)$

From the Homework

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6. Either Alice or Bob is a spy, but not both.

Names: 'a', 'b', 'g', and 'c'

Predicates: '$S(x)$', '$B(x)$', and '$U(x)$'

1. $S(a) \wedge S(b)$
2. $(S(a) \vee S(b)) \rightarrow B(c)$
3. $\neg(S(a) \vee S(b)) \rightarrow \neg B(c)$
   Or: $(\neg S(a) \wedge \neg S(b)) \rightarrow \neg B(c)$
4. $Ug \vee \exists x(R(x,c))$
   (where $R(x,y)$ is '____ has broken ____'.
5. $(B(c) \vee \neg B(c)) \wedge U(g)$

Examples: the homework

1. Alice and Bob are both spies
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5. Either the code has been broken or it has not, but the German embassy will be in an uproar regardless.
6. Either Alice or Bob is a spy, but not both.

Names: 'a', 'b', 'g', and 'c'

Predicates: 'Sx', 'Bx', and 'Ux'

1. $Sa \wedge Sb$
2. $(Sa \vee Sb) \rightarrow Bc$
3. $\neg(Sa \vee Sb) \rightarrow \neg Bc$
   OR: $(\neg Sa \wedge \neg Sb) \rightarrow \neg Bc$
4. $Ug \vee \exists x(R(x, c))$
5. $(Bc \vee \neg Bc) \wedge Ug$
6. $(Sa \vee Sb) \wedge \neg(Sa \wedge Sb)$