

NATURAL LANGUAGE INTERPRETATION

DIT410/TIN174, Artificial Intelligence

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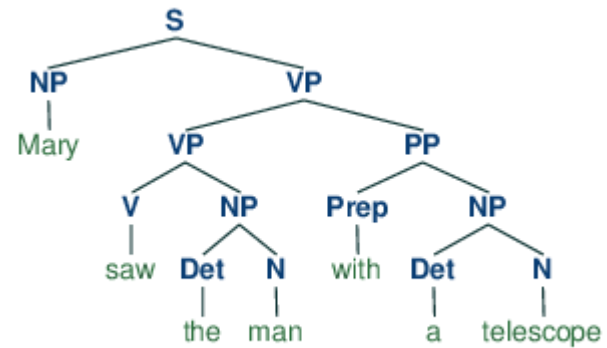
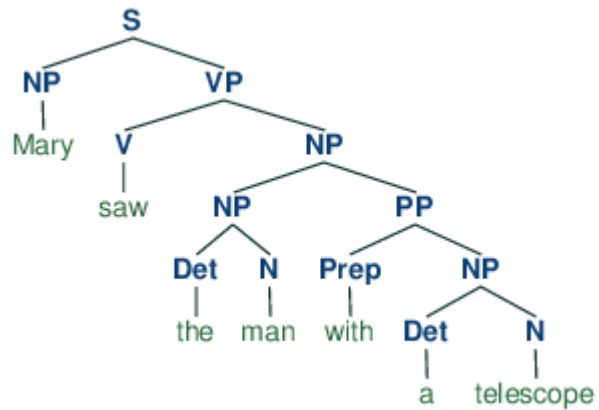
7 April, 2017



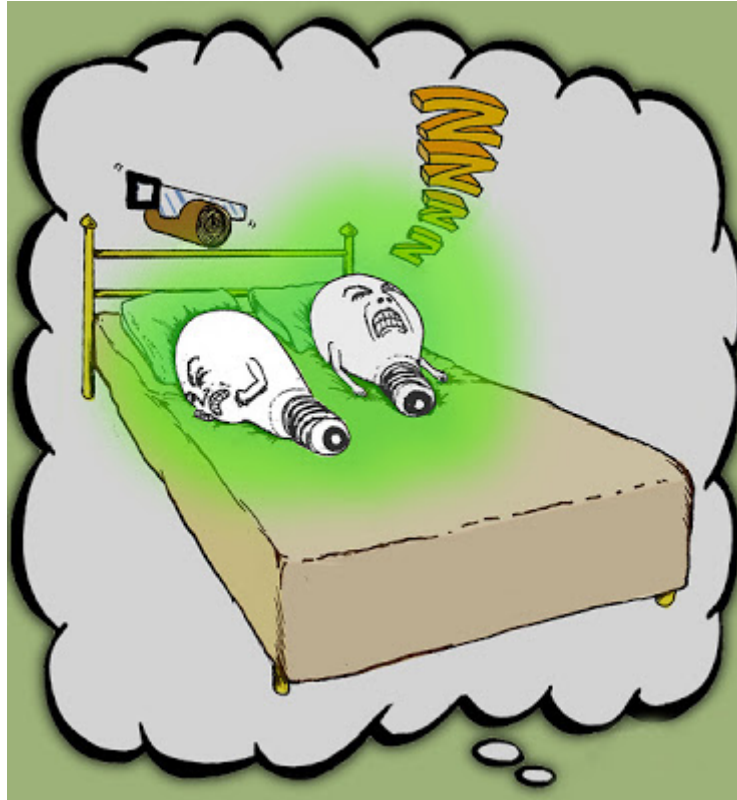
https://img.memesuper.com/7ad355dacca363617cdfcff7defc07ed_-of-morpheus-offering-the-morpheus-pill-meme_520-412.jpeg

LAST TIME...

“Mary saw the man with a telescope”



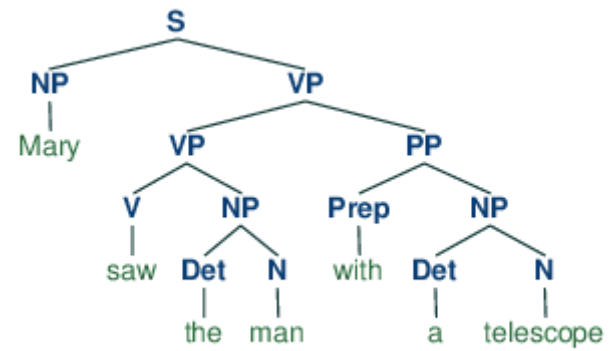
“Colourless green ideas sleep furiously”



<http://wmjasco.blogspot.se/2008/11/colorless-green-ideas-do-not-sleep.html>

Is this sentence valid? Yes or No

WHY SYNTAX?



SEMANTIC REPRESENTATION

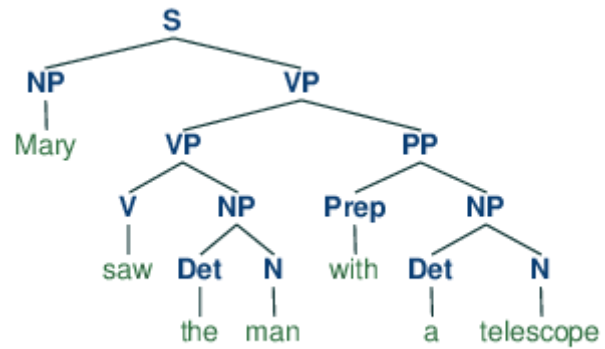
Introducing logical terms

Mary = Mary

the man = Man

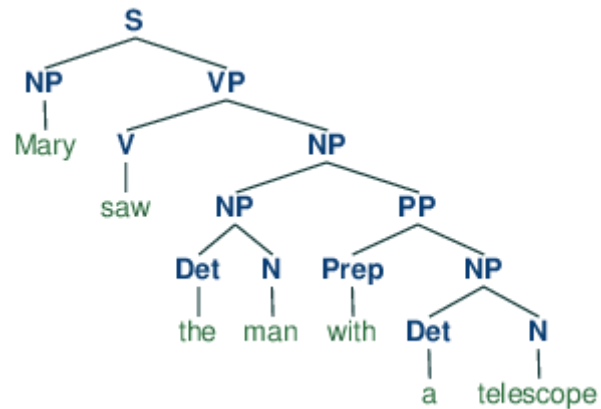
Mary saw the man = Saw(Mary, Man)

SEMANTIC INTERPRETATION (1)



With(Saw(Mary, Man), Telescope)

SEMANTIC INTERPRETATION (2)



Saw(Mary, With(Man, Telescope))

COMPOSITIONAL SEMANTICS

Mary = Mary

the man = Man

Mary saw the man = Saw(Mary, Man)

saw = $\lambda y \lambda x \cdot \text{Saw}(x, y)$

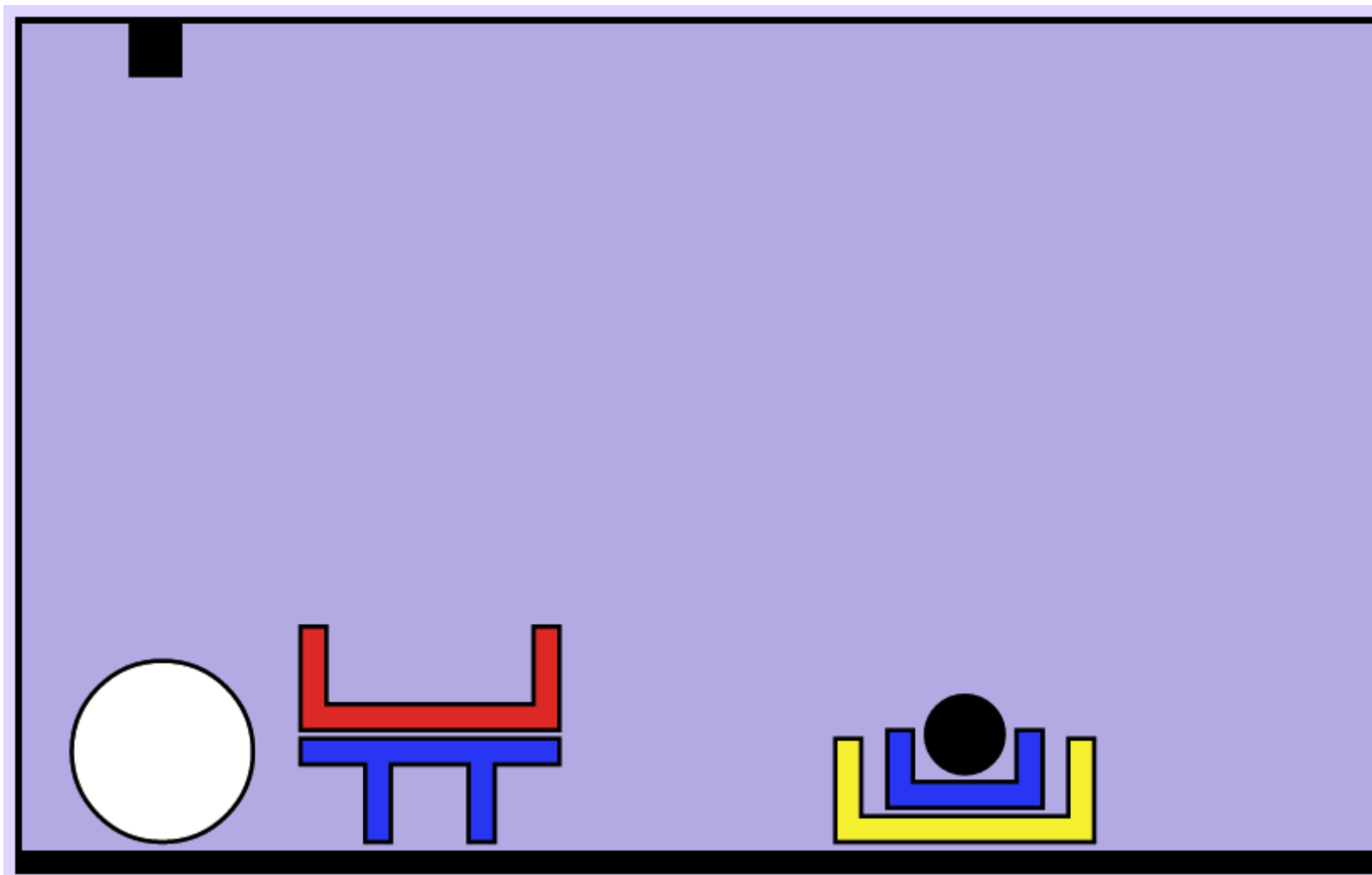
saw the man = $\lambda x \cdot \text{Saw}(x, \text{Man})$

INTERPRETATION

syntactic representation → *semantic* representation

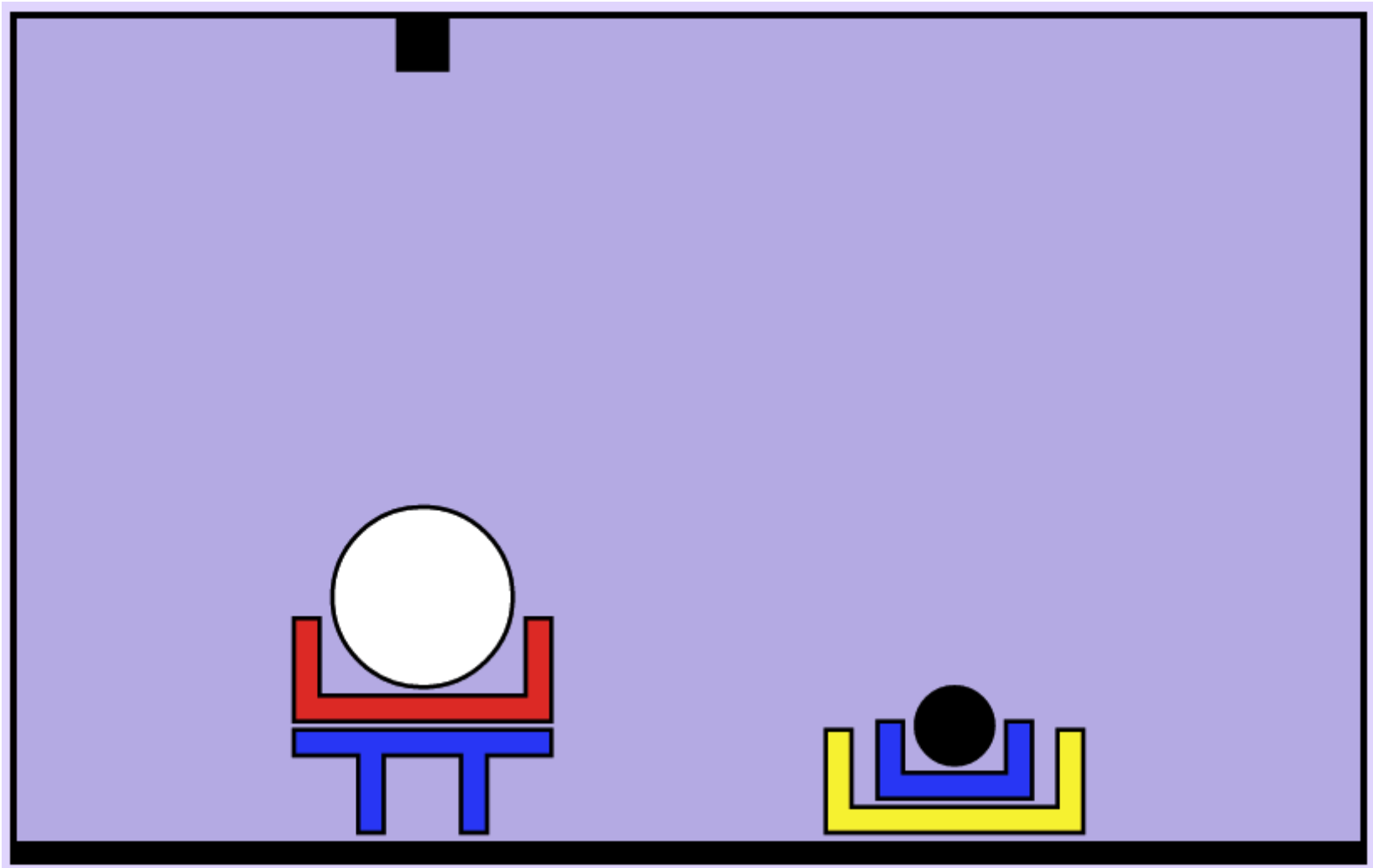
parse tree → logical term

Utterance: *“move the white ball into the red box”*

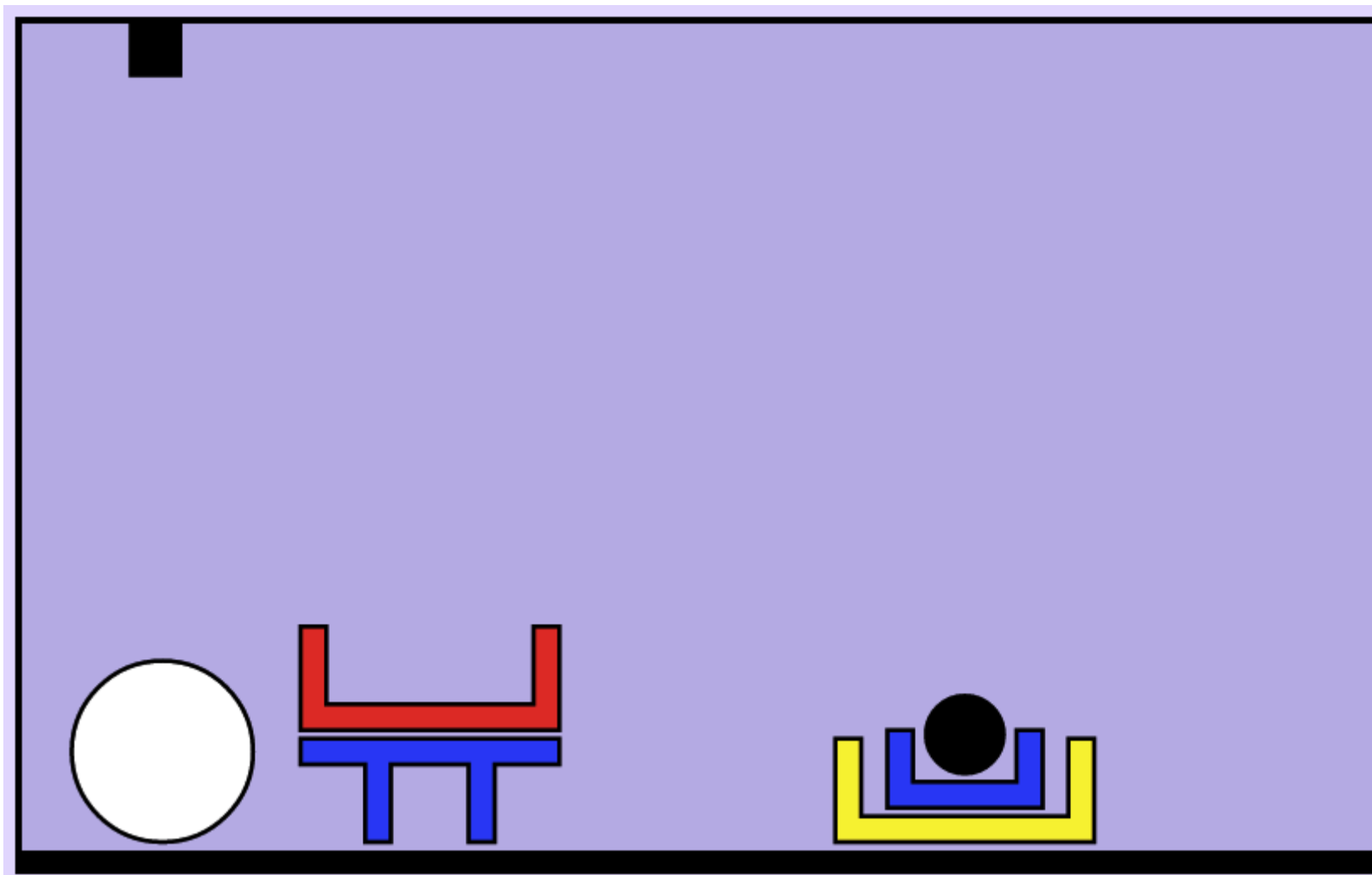


Is this ambiguous? Yes or No

Goal: `inside(white_ball, red_box)`



Utterance: *“move the ball into the red box”*



Is this ambiguous? Yes or No

SHRDLITE PIPELINE

1. *Parsing*: text input → parse trees
2. *Interpretation*: parse tree + world → goals
3. *Ambiguity resolution*: many goals → one goal
4. *Planning*: goal → robot movements

PARSING

text input → parse trees

```
```function parse(input:string) : string | ShrdliteResult[]
```

```
{: .code}

```interface ShrdliteResult {  
    input : string  
    parse : Command  
    interpretation? : DNFFormula  
    plan? : string[]  
}
```

GRAMMAR (SIMPLIFIED)

From file [Grammar.ne](#)

`` ` command -> “put” entity location entity -> quantifier object object -> size:? color:?
form object -> object location location -> relation entity

```
{: .code}
```

```
Notes:
```

- Recursion
- Draw a tree top-down on the board

```
---
```

```
“put the white ball in a box on the floor”
```

```
{:.noborder}
```

```
Is this ambiguous?
```

```
<span style="background:lime;color:white;padding:3px 6px;">Yes</span> or
```

```
<span style="background:magenta;color:white;padding:3px 6px;">No</span>
```

```
---
```

```
“put the white ball in a box on the floor”
```

```
{:.noborder}
```

```
Is the ambiguity
```

```
<span style="background:lime;color:white;padding:3px 6px;">syntactic</span> or
```

```
<span style="background:magenta;color:white;padding:3px 6px;">semantic</span>?
```

```
Notes:
```


LOGICAL INTERPRETATIONS (“GOALS”)

```
```type DNFFormula = Conjunction[] type Conjunction = Literal[]
```

```
{: .code}
```

```
DNF = Disjunctive Normal Form
```

```
Example: $\neg(x \wedge y) \vee (z)$
```

```
```DNFFormula([Conjunction([x, y]), Conjunction(z)])
```

LITERALS

```
```interface Literal { relation : string; args : string[]; polarity : boolean; }
```

```
{: .code}
```

```
Example: `ontop(a,b)`
```

```
```{ relation:"ontop", args:["a","b"], polarity:true }
```

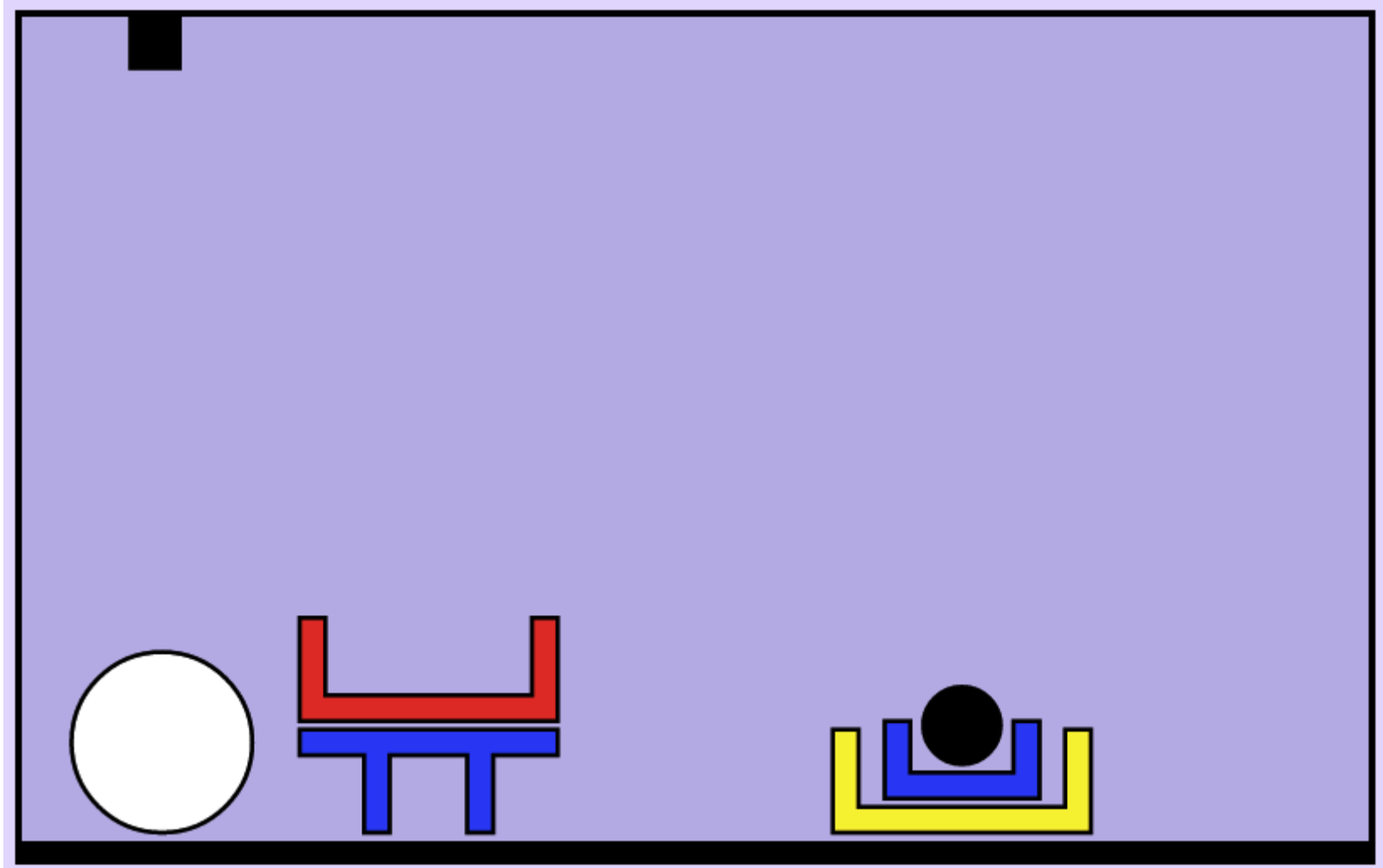
SPATIAL RELATIONS

- x is **on top** of y if it is directly on top
- x is **above** y if it is somewhere above
- ...

AMBIGUITY

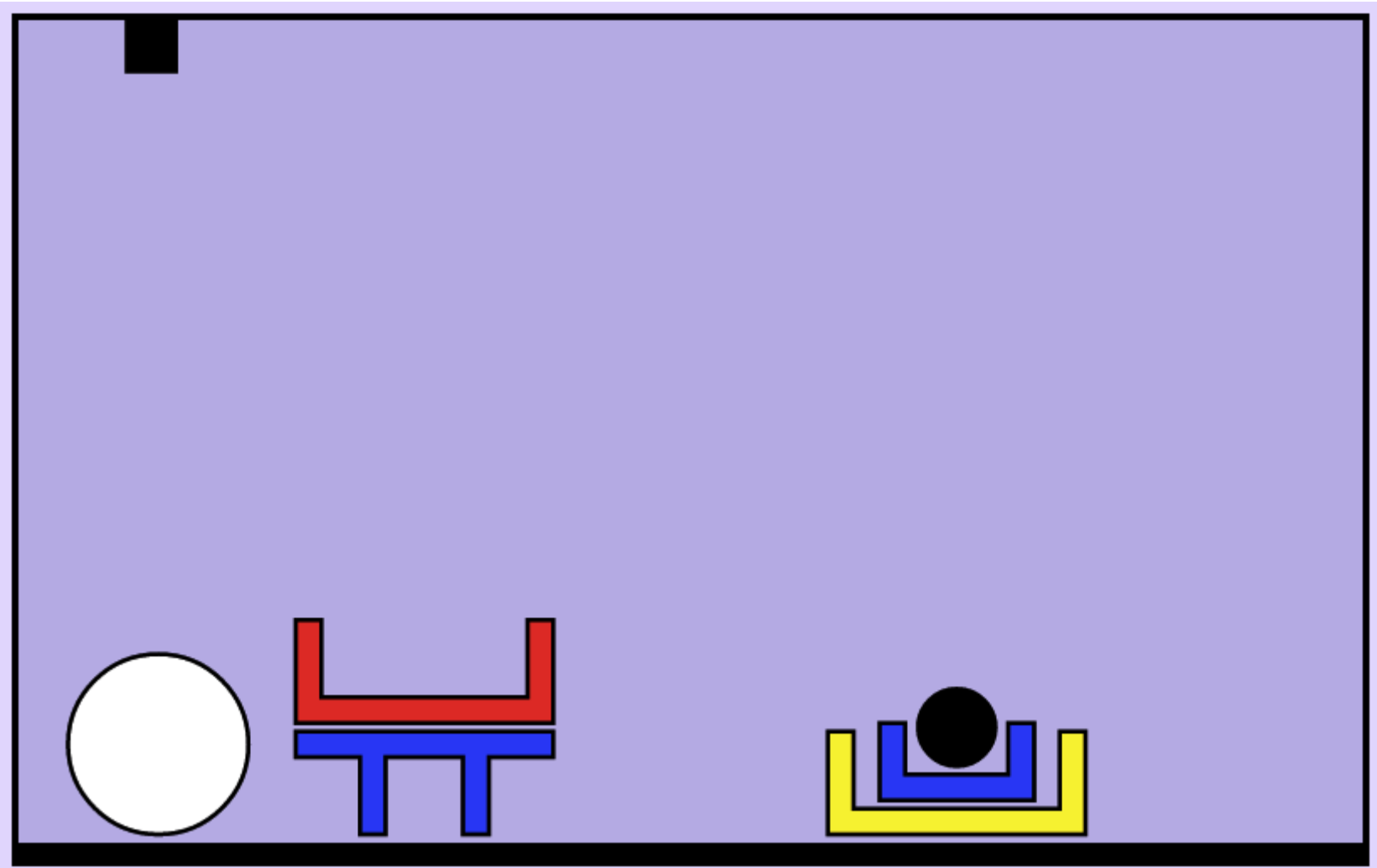
DNF inherently captures ambiguity
But impossible interpretations should be removed

*“put the white ball **that is** in a box on the floor”*



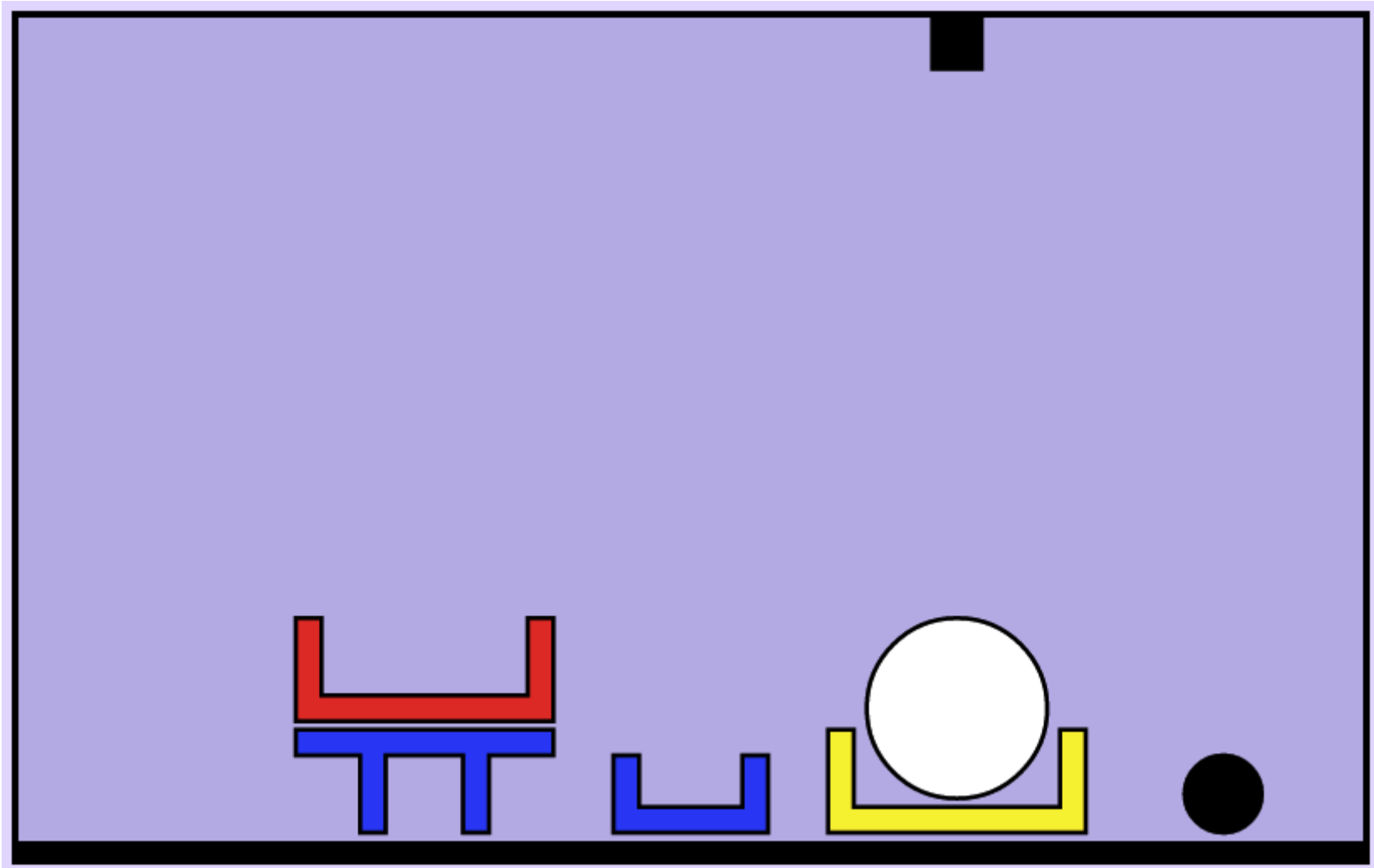
There is no ~~spoon~~ *white ball in a box.*

“put the white ball in a box on the floor”

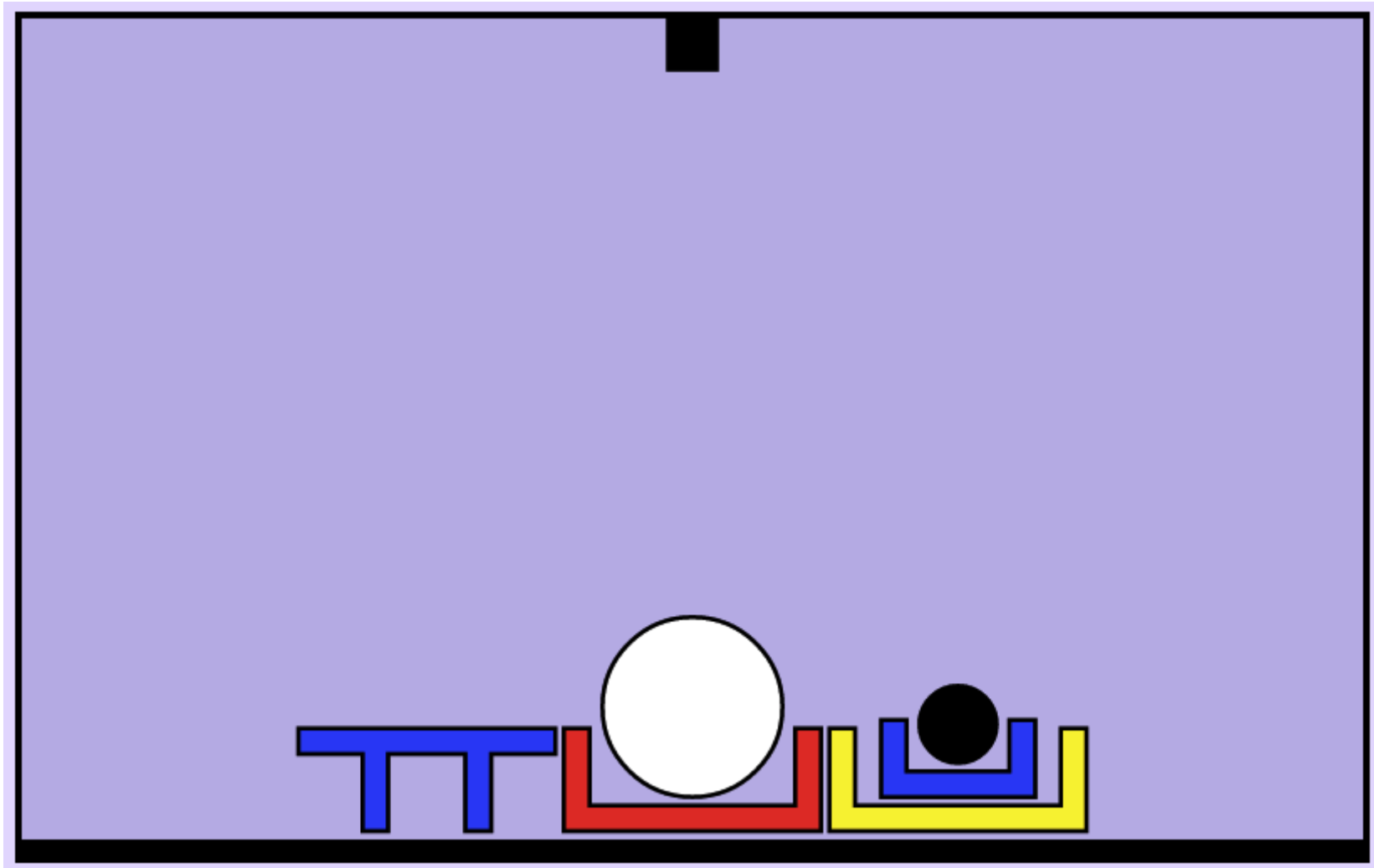


inside(WhiteBall, YellowBox)

Yellow box is already on floor: 3 moves



$\text{inside}(\text{WhiteBall}, \text{RedBox}) \wedge \text{on}(\text{RedBox}, \text{floor})$
Red box can be placed on floor first: 2 moves



FINAL INTERPRETATION

$\text{inside}(\text{WhiteBall}, \text{YellowBox}) \vee (\text{inside}(\text{WhiteBall}, \text{RedBox}) \wedge \text{on}(\text{RedBox}, \text{floor}))$

PHYSICAL LAWS

- Balls must be in boxes or on the floor, otherwise they roll away.
- Small objects cannot support large objects.
- ...

INTERPRETER TEST CASES

Each test case contains a *list of interpretations*
Each interpretation is already a list (a disjunction of conjunctions)

```
world: "small",  
utterance: "take a blue object",  
interpretations: [{"holding(BlueTable)", "holding(BlueBox)"}]  
}
```

```
world: "small",  
utterance: "put a black ball in a box on the floor",  
interpretations: [{"inside(BlackBall, YellowBox)",  
                  ["ontop(BlackBall, floor)"}]  
}
```

CONJUNCTION

```
world: "small",  
utterance: "put all balls on the floor",  
interpretations: [{"ontop(WhiteBall,floor) & ontop(BlackBall,floor)"}]  
}
```

NO VALID INTERPRETATIONS

```
world: "small",  
utterance: "put a ball on a table",  
interpretations: []  
}
```

Breaks the laws of nature!

SOME INTERPRETATIONS ARE MISSING

```
world: "small",  
utterance: "put a ball in a box on the floor",  
interpretations: [{"COME UP WITH YOUR OWN INTERPRETATION"}]  
}
```

TIPS FOR INTERPRETER IN SHRD LITE

- Sub-functions based on grammar types
- Use `instanceof` when traversing parse tree (`Command`)
- Use recursion to handle nesting
“put a box in a box on a table on the floor”

AMBIGUITY RESOLUTION

Handling multiple interpretations

- Fail
- Pick “first”
- Use some rules of thumb
e.g. prefer box already on floor
- Ask the user for clarification (extension)

PLANNING

goal → robot movements

- Movements: *left, right, pick, drop*
- Use graph search
- Given a disjunction of goals, should find the easiest to satisfy

AUDIENCE PARTICIPATION META-QUESTION

Do you prefer **Socratic** or **post-it notes**?

Thank you for returning your post-it notes!