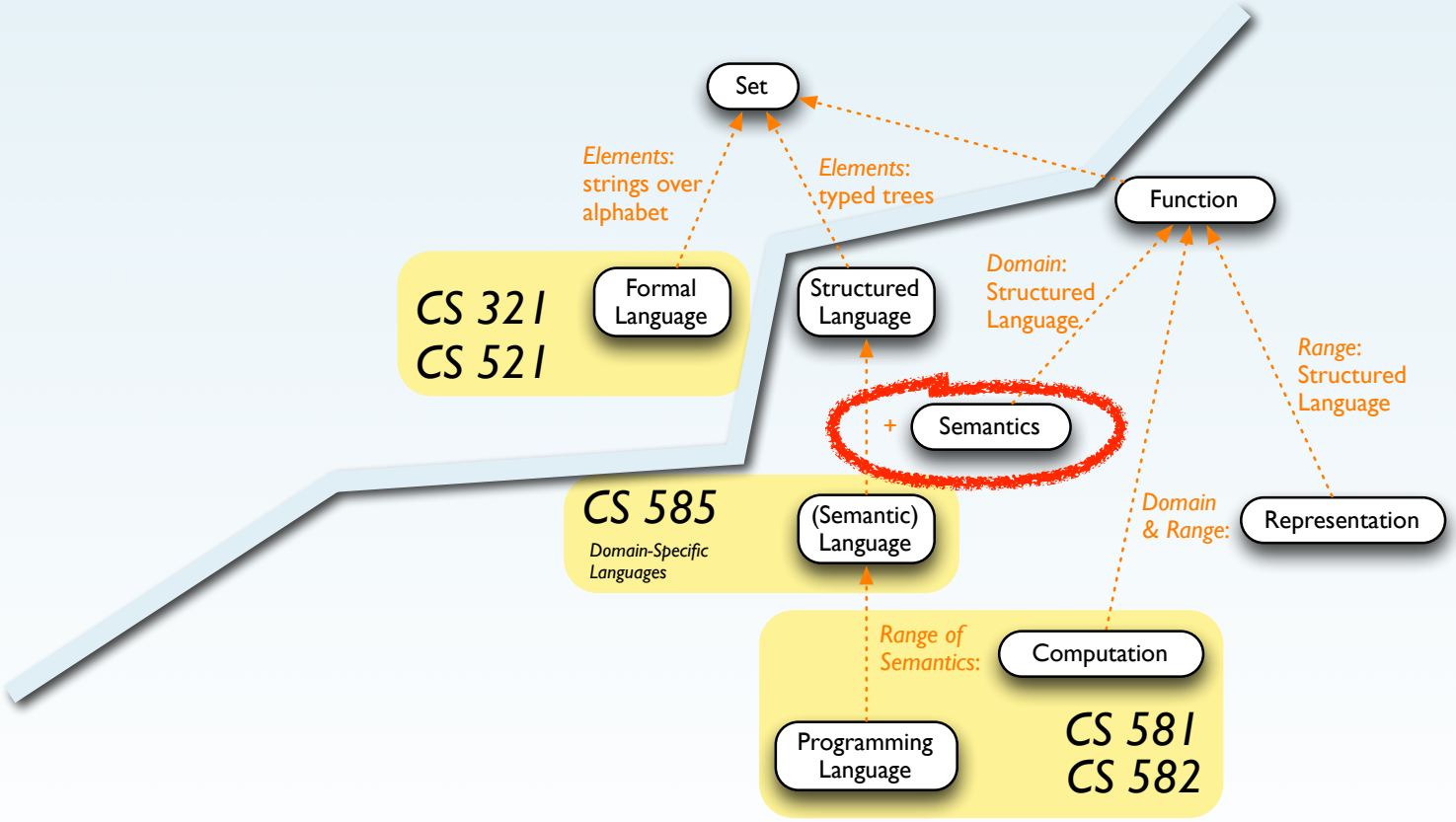
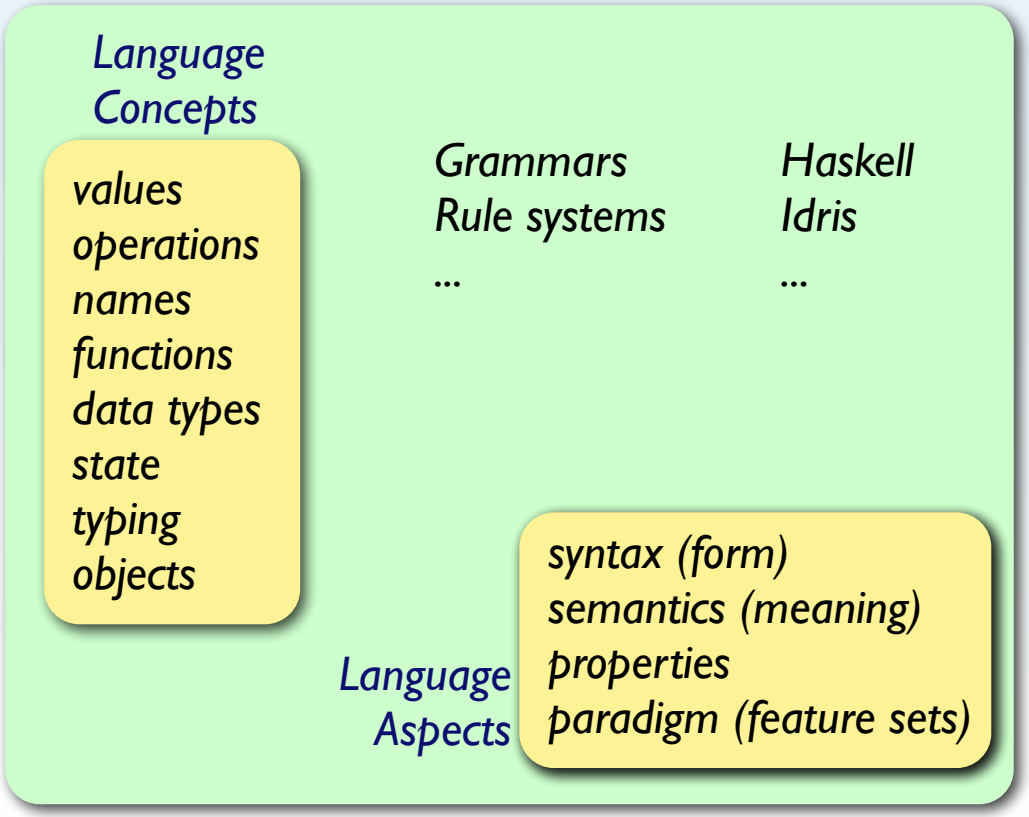
1 Introduction

Before paper and scissors

PL Concept Hierarchy



Languages: The What and How



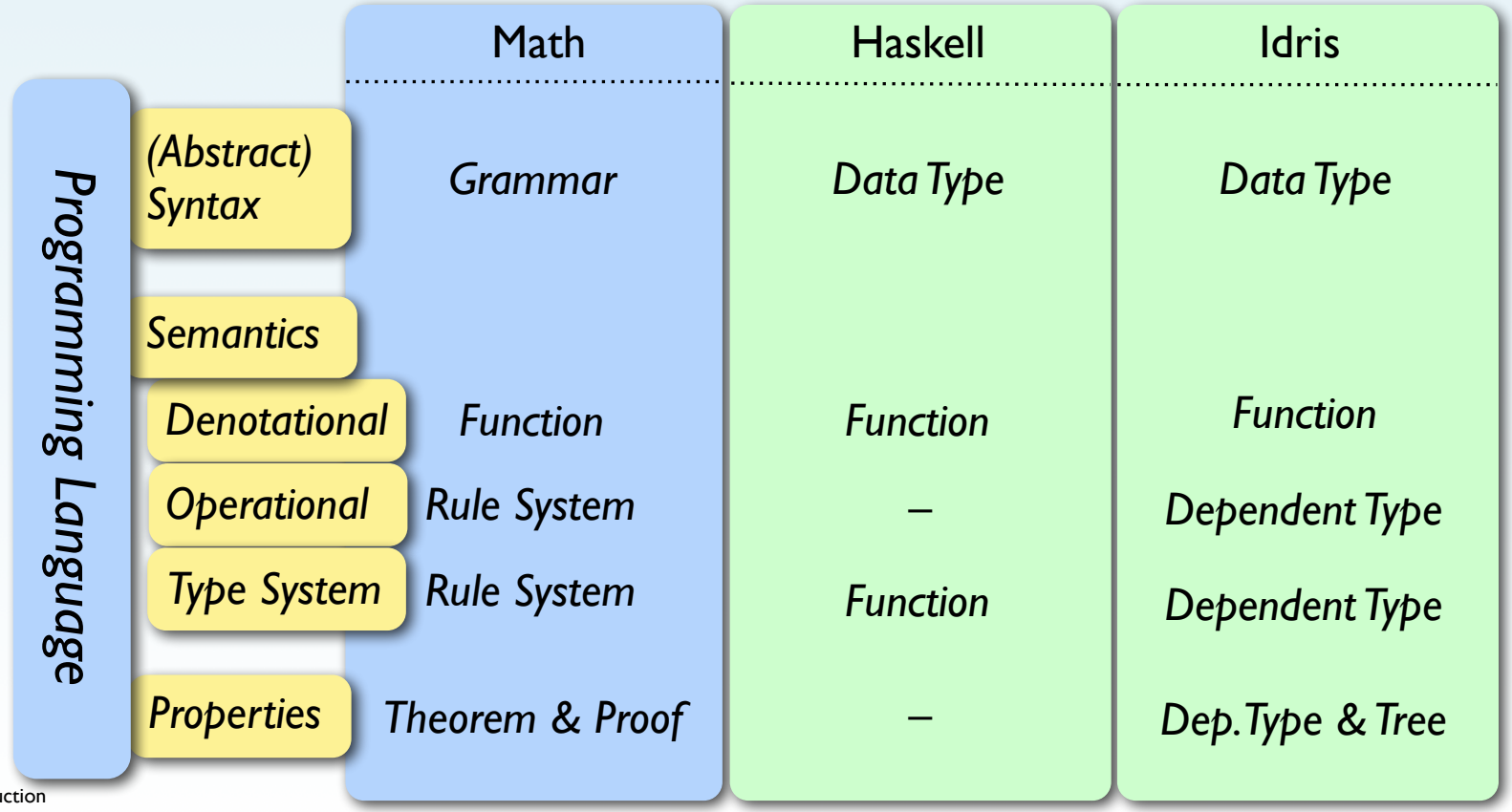
Metalanguages

Language Processing

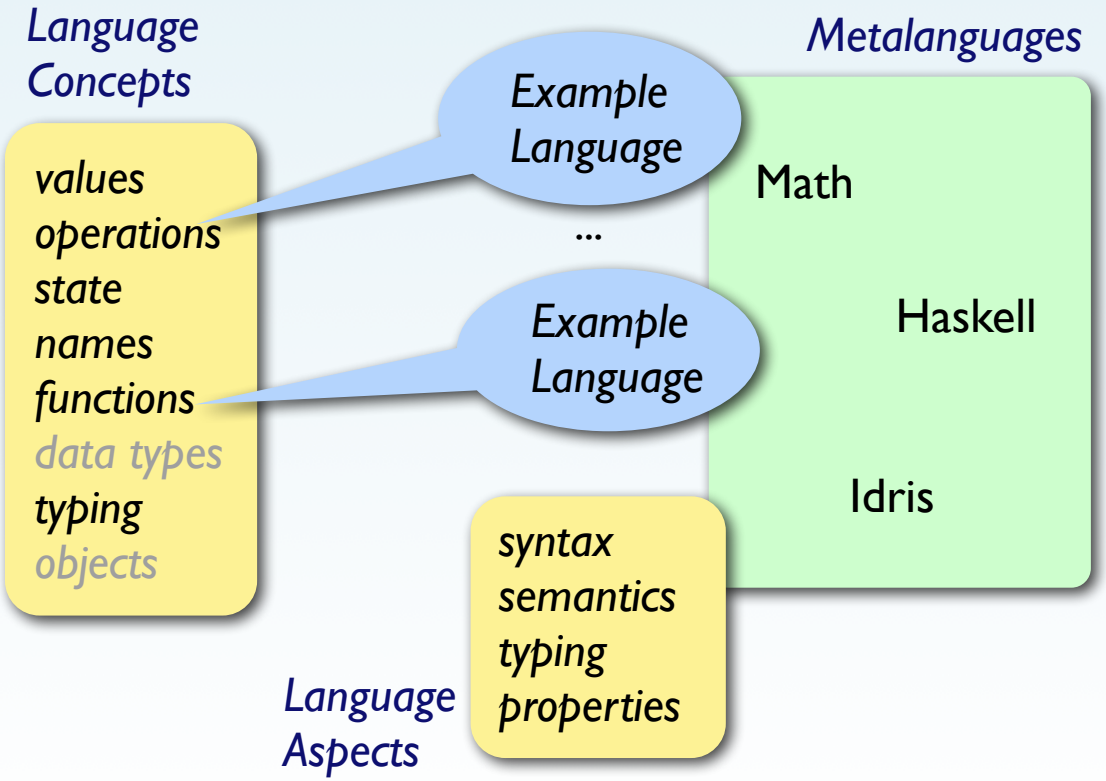
parsing
type checking
compiling
interpreting

("Engineering", CS 480)

Programming Language Descriptions

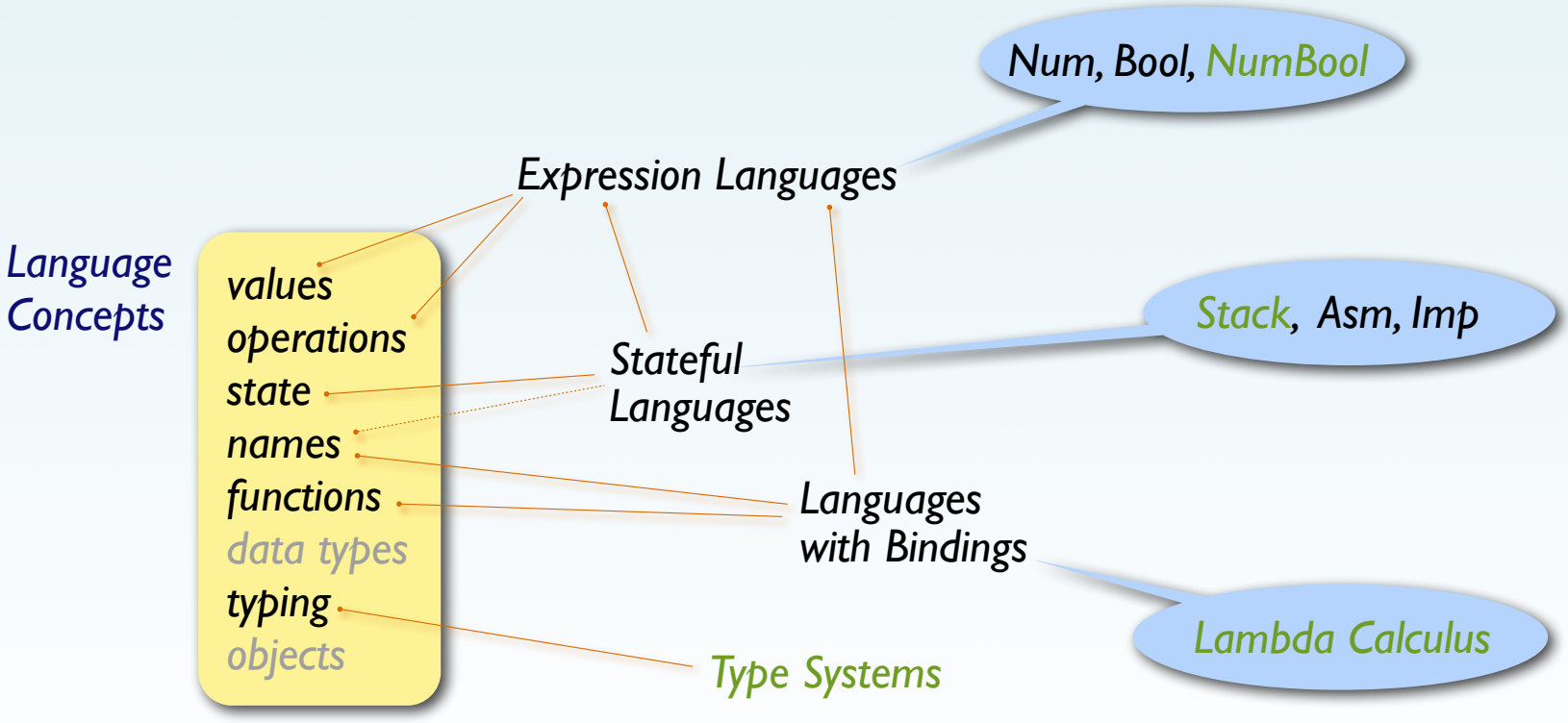


Teaching Approach

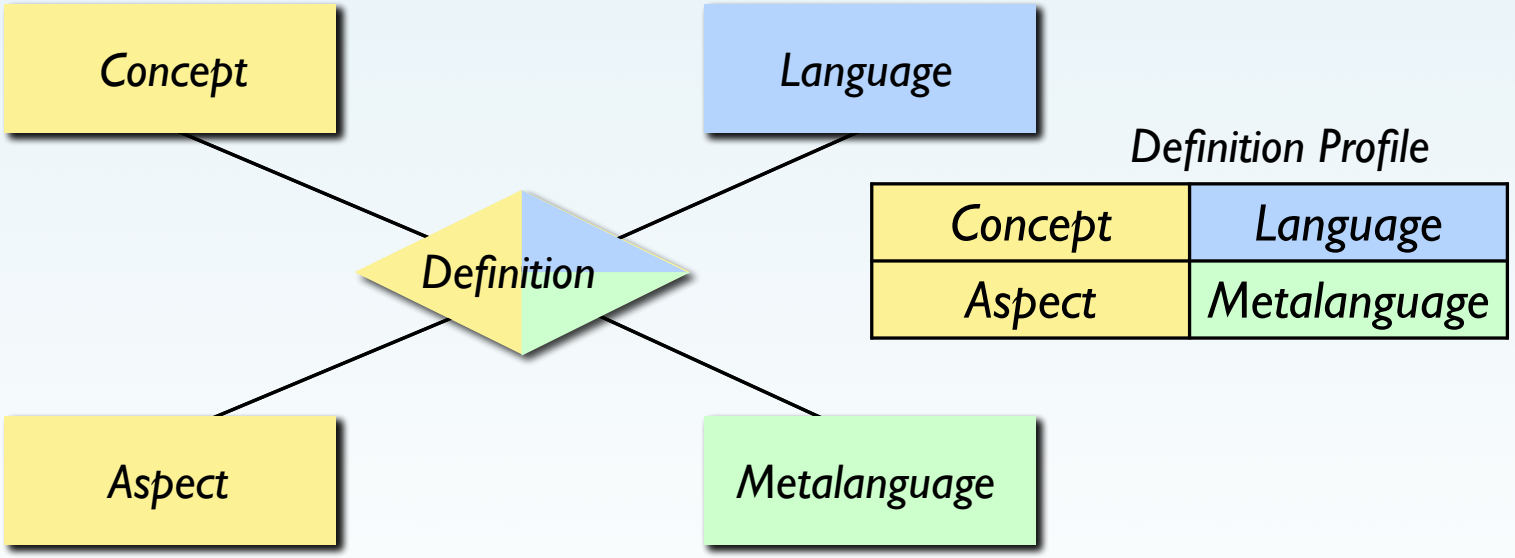


Illustrate a concept by defining its aspects as part of an example language using a metalanguage

Example Languages



Language Definitions



Some Example Definitions

Conditional	NumBool
Syntax	Grammar

$$t \in Term \quad ::= \quad \cdots$$
$$\quad\quad | \quad \texttt{if } t \texttt{ then } t \texttt{ else } t$$

Conditional	NumBool
Syntax	Haskell

```
data Term = ...
          | If Term Term Term
```

Conditional	NumBool
Syntax	Idris

```
data Term : Type where ...
  If : Term → Term → Term → Term
```

Conditional	Java
Syntax	Grammar

$$e \in Expr \quad ::= \quad \cdots$$
$$s \in Stmt \quad ::= \quad \cdots$$
$$\quad\quad | \quad \texttt{if (}e\texttt{) \{}s\texttt{\}} \; [\texttt{else \{}s\texttt{\}}]$$

Conditional	Java
Syntax	Haskell

```
data Expr = ...
data Stmt = ...
  | If Expr Stmt (Maybe Stmt)
```

More Definitions

Denotational Semantics

Conditional	NumBool
Semantics	Haskell

```
data Value = B Bool | I Int

sem :: Term → Value
sem (If c t e) | sem c==B True = sem t
               | otherwise     = sem e
```

Big-Step Operational Semantics

Conditional	NumBool
Semantics	Rules

$$\frac{t_1 \Downarrow \texttt{true} \qquad t_2 \Downarrow t}{\texttt{if } t_1 \texttt{ then } t_2 \texttt{ else } t_3 \Downarrow t}$$

$$\frac{t_1 \Downarrow \texttt{false} \qquad t_3 \Downarrow t}{\texttt{if } t_1 \texttt{ then } t_2 \texttt{ else } t_3 \Downarrow t}$$

Conditional	NumBool
Typing	Rules

$$\frac{t_1 : \texttt{Bool} \qquad t_2 : T \qquad t_3 : T}{\texttt{if } t_1 \texttt{ then } t_2 \texttt{ else } t_3 : T}$$

More Definitions

Conditional	NumBool
Semantics	Idris

```
data (*=>) : Term → Term → Type where
  …
  IfT :
        t1 *=> Tru     →     t2 *=> t  →
        ----------------------------
        (If t1 Then t2 Else t3) *=> t

  IfF :
        t1 *=> Fls     →     t3 *=> t  →
        ----------------------------
        (If t1 Then t2 Else t3) *=> t
```

Conditional	NumBool
Semantics	Rules

$$\frac{t_1 \Downarrow \texttt{true} \qquad t_2 \Downarrow t}{\texttt{if } t_1 \texttt{ then } t_2 \texttt{ else } t_3 \Downarrow t}$$

$$\frac{t_1 \Downarrow \texttt{false} \qquad t_3 \Downarrow t}{\texttt{if } t_1 \texttt{ then } t_2 \texttt{ else } t_3 \Downarrow t}$$

Crucial Representations