

# Pattern Matching

Principles of Functional Programming

## Reminder: Decomposition

The task we are trying to solve is find a general and convenient way to access heterogeneous data in a class hierarchy.

*Attempts seen previously:*

- ▶ *Classification and access methods*: quadratic explosion
- ▶ *Type tests and casts*: unsafe, low-level
- ▶ *Object-oriented decomposition*: causes coupling between data and operations, need to touch all classes to add a new method.

## Solution 2: Functional Decomposition with Pattern Matching

Observation: the sole purpose of test and accessor functions is to *reverse* the construction process:

- ▶ Which subclass was used?
- ▶ What were the arguments of the constructor?

This situation is so common that many functional languages, Scala included, automate it.

## Case Classes

A *case class* definition is similar to a normal class definition, except that it is preceded by the modifier `case`. For example:

```
trait Expr
case class Number(n: Int) extends Expr
case class Sum(e1: Expr, e2: Expr) extends Expr
```

Like before, this defines a trait `Expr`, and two concrete subclasses `Number` and `Sum`.

However, these classes are now empty. So how can we access the members?

# Pattern Matching

*Pattern matching* is a generalization of switch from C/Java to class hierarchies.

It's expressed in Scala using the keyword `match`.

## Example

```
def eval(e: Expr): Int = e match
  case Number(n) => n
  case Sum(e1, e2) => eval(e1) + eval(e2)
```

# Match Syntax

## Rules:

- ▶ match is preceded by a selector expression and is followed by a sequence of *cases*, `pat => expr`.
- ▶ Each case associates an *expression* `expr` with a *pattern* `pat`.
- ▶ A `MatchError` exception is thrown if no pattern matches the value of the selector.

# Forms of Patterns

Patterns are constructed from:

- ▶ *constructors*, e.g. Number, Sum,
- ▶ *variables*, e.g. n, e1, e2,
- ▶ *wildcard patterns* `_`,
- ▶ *constants*, e.g. 1, true.
- ▶ *type tests*, e.g. `n: Number`

Variables always begin with a lowercase letter.

The same variable name can only appear once in a pattern. So, `Sum(x, x)` is not a legal pattern.

Names of constants begin with a capital letter, with the exception of the reserved words `null`, `true`, `false`.

## Evaluating Match Expressions

An expression of the form

$$e \text{ match } \{ \text{case } p_1 \Rightarrow e_1 \dots \text{case } p_n \Rightarrow e_n \}$$

matches the value of the selector  $e$  with the patterns  $p_1, \dots, p_n$  in the order in which they are written.

The whole match expression is rewritten to the right-hand side of the first case where the pattern matches the selector  $e$ .

References to pattern variables are replaced by the corresponding parts in the selector.



## What Do Patterns Match?

- ▶ A constructor pattern  $C(p_1, \dots, p_n)$  matches all the values of type  $C$  (or a subtype) that have been constructed with arguments matching the patterns  $p_1, \dots, p_n$ .
- ▶ A variable pattern  $x$  matches any value, and *binds* the name of the variable to this value.
- ▶ A constant pattern  $c$  matches values that are equal to  $c$  (in the sense of  $==$ )

# Example

## Example

eval(Sum(Number(1), Number(2)))

→

Sum(Number(1), Number(2)) match

case Number(n) => n

case Sum(e1, e2) => eval(e1) + eval(e2)

→

eval(Number(1)) + eval(Number(2))

## Example (2)

→

```
Number(1) match  
  case Number(n) => n  
  case Sum(e1, e2) => eval(e1) + eval(e2)  
+ eval(Number(2))
```

→

```
1 + eval(Number(2))
```

⇒

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## Pattern Matching and Methods

Of course, it's also possible to define the evaluation function as a method of the base trait.

### Example

```
trait Expr:
  def eval: Int = this match
    case Number(n) => n
    case Sum(e1, e2) => e1.eval + e2.eval
```

## Exercise

Write a function `show` that uses pattern matching to return the representation of a given expressions as a string.

```
def show(e: Expr): String = ???
```

## Exercise (Optional, Harder)

Add case classes `Var` for variables  $x$  and `Prod` for products  $x * y$  as discussed previously.

Change your `show` function so that it also deals with products.

Pay attention you get operator precedence right but to use as few parentheses as possible.

### Example

```
Sum(Prod(2, Var("x")), Var("y"))
```

should print as " $2 * x + y$ ". But

```
Prod(Sum(2, Var("x")), Var("y"))
```

should print as " $(2 + x) * y$ ".