EECS 368
Programming Language Paradigms

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Conditional Expressions

As in most programming languages, functions can be defined using conditional expressions.

```
abs :: Int -> Int
abs n = if n >= 0 then n else -n
```

abs takes an integer n and returns n if it is non-negative and -n otherwise.

Conditional expressions can be nested:

```
signum  :: Int -> Int
signum n = if n < 0 then -1 else
                 if n == 0 then 0 else 1
```

In Haskell, conditional expressions must always have an else branch, which avoids any possible ambiguity problems with nested conditionals.

Guarded Equations

As an alternative to conditionals, functions can also be defined using guarded equations.

```
abs n | n >= 0      = n
      | otherwise   = -n
```

As previously, but using guarded equations.

Guarded equations can be used to make definitions involving multiple conditions easier to read:

```
signum n | n < 0      = -1
         | n == 0     = 0
         | otherwise = 1
```

The catch all condition `otherwise` is defined as

```
otherwise = True
```

Pattern Matching

Many functions have a particularly clear definition using pattern matching on their arguments.

```
not       :: Bool -> Bool
not False = True
not True  = False
```

not maps `False` to `True`, and `True` to `False`.

Functions can often be defined in many different ways using pattern matching. For example

```
(&&)             :: Bool -> Bool -> Bool
True  && True  = True
True  && False = False
False && True  = False
False && False = False
```

can be defined more compactly by

```
(&&)             :: Bool -> Bool -> Bool
True && True = True
_    && _    = False
```

List Patterns

Internally, every non-empty list is constructed by repeated use of an operator `(:)` called cons that adds an element to the start of a list.

```
[1,2,3,4]
```

Means `1:(2:(3:(4:[])))`.

List Patterns

Functions on lists can be defined using `x:xs` patterns.

```
head        :: [a] -> a
head (x:_)   = x

tail        :: [a] -> [a]
tail (_:xs) = xs
```

`head` and `tail` map any non-empty list to its first and remaining elements.

- `x:xs` patterns only match non-empty lists:

```
> head []
Error
```

- `x:xs` patterns must be parenthesized, because application has priority over (:). For example, the following definition gives an error:

```
head x:_ = x
```

Lambda Expressions

Functions can be constructed without naming the functions by using lambda expressions.

```
\ x -> x + x
```

This is the nameless function that takes a number x and returns the result x+x.

- The symbol λ is the Greek letter lambda, and is typed at the keyboard as a backslash \.
- In Haskell, the use of the λ symbol for nameless functions comes from the lambda calculus, the theory of functions on which Haskell is based.

Why Are Lambda's Useful?

Lambda expressions can be used to give a formal meaning to functions defined using currying. For example:

```
add x y = x+y
```

means

```
add = \ x -> (\ y -> x+y)
```

Lambda expressions can be used to avoid naming functions that are only referenced once. For example:

```
odds n = map f [0..n-1]
         where
           f x = x*2 + 1
```

can be simplified to

```
odds n = map (\ x -> x*2 + 1) [0..n-1]
```

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Sections

An operator written between its two arguments can be converted into a curried function written before its two arguments by using parentheses. For example:

```
> 1+2
3
> (+) 1 2
3
```

This convention also allows one of the arguments of the operator to be included in the parentheses.
For example:

```
> (1+) 2
3
> (+2) 1
3
```

In general, if $\oplus$ is an operator then functions of the form ($\oplus$), (x$\oplus$) and ($\oplus$y) are called sections.