--- Author: Richard Eisenberg
--- File: Data.hs

Demonstrates the use of datatypes in Haskell

module Data where

-- A day is one of seven possibilities:

data DayOfWeek
  = Sunday
  | Monday
  | Tuesday
  | Wednesday
  | Thursday
  | Friday
  | Saturday
  deriving (Eq, Show)

  -- This last line allows us to compare weekdays for equality (Eq)
  -- and for GHCi to print them (Show)

  -- The constants Sunday, Monday, etc., are called *constructors* of DayOfWeek

  -- Is this a weekday?

isWeekday :: DayOfWeek -> Bool
isWeekday Sunday   = False
isWeekday Saturday = False
isWeekday _        = True

  -- What’s the next day after this one?

nextDay :: DayOfWeek -> DayOfWeek
nextDay Sunday    = Monday
nextDay Monday    = Tuesday
nextDay Tuesday   = Wednesday
nextDay Wednesday = Thursday
nextDay Thursday  = Friday
nextDay Friday    = Saturday
nextDay Saturday  = Sunday

  -- Datatypes can also hold data. Suppose we have homework during the week,
  -- but not over weekends.

  -- This makes a type synonym, saying that Homework is just a String.

  type Homework = String

data HWDayOfWeek
  = SundayHW
  | MondayHW Homework
  | TuesdayHW Homework
  | WednesdayHW Homework
  | ThursdayHW Homework
  | FridayHW
  | SaturdayHW
  deriving (Eq, Show)

  -- extract the day’s homework, if any

getHomework :: HWDayOfWeek -> Maybe Homework
getHomework (MondayHW hw)    = Just hw
getHomework (TuesdayHW hw)   = Just hw
getHomework (WednesdayHW hw) = Just hw
getHomework (ThursdayHW hw)  = Just hw
getHomework _                = Nothing

-------------------------------------------------------------

-- This type is just like the built-in list, but with different
-- names.

data List a
  = Nil
  | Cons a (List a)
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73: deriving (Eq, Show)
74:
75: -- List is a *parameterized type*, meaning that it takes a type parameter
76: -- named "a". Like other type variables, this parameter can be anything.
77: -- In the Cons constructor, we see that a Cons holds both an "a" and a
78: -- list.
79:
80: -- get the length of a list
81: myLength :: List a -> Int
82: myLength Nil           = 0
83: myLength (Cons _ xs)   = 1 + myLength xs
84:
85: -- convert to a normal list
86: toNormalList :: List a -> [a]
87: toNormalList Nil       = []
88: toNormalList (Cons x xs) = x : toNormalList xs
89:
90: -- find an element
91: find :: Eq a => a -> List a -> Maybe Int
92: find _ Nil = Nothing
93: find x (Cons y ys)
94:  | x == y              = Just 0
95:  | Just n <- find x ys = Just (n+1)
96:  | otherwise           = Nothing
97:
98: {- The following types are defined in the Haskell Prelude, which is
99: automatically imported into every module.
100:
101: data Bool
102:   = False
103:   | True
104:
105: data Maybe a
106:   = Nothing
107:   | Just a
108:
109: data [a]
110:   = []
111:   | a : [a]
112:   -}
113: ----------------------------------------------------------
114: -- Here is a definition of a binary search tree:
115:
116: data BST a
117:   = Leaf
118:   | Node (BST a)   -- left child
119:        a         -- data
120:        (BST a)  -- right child
121: deriving Show
122:   -- We don’t derive Eq, because two trees are the same
123:   -- as long as the hold the same data, even if they are
124:   -- structurally distinct
125:
126: -- insert into a tree
127: insert :: Ord a => a -> BST a -> BST a
128: insert x Leaf = Node Leaf x Leaf
129: insert x (Node left dat right)
130:   | x <= dat  = Node (insert x left) dat right
131:   | otherwise = Node left dat (insert x right)
132:
133: -- check if an element is in a tree
134: elemBST :: Ord a => a -> BST a -> Bool
135: elemBST _  Leaf = False
136: elemBST x (Node left dat right)
137:   | x == dat  = True
138:   | x < dat   = elemBST x left
139:   | otherwise = elemBST x right
140:
141: -- make a tree from the elements in a list
142: insertAll :: Ord a => [a] -> BST a
143: insertAll []     = Leaf
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145: insertAll (x:xs) = insert x (insertAll xs)
146:
147:  -- some QuickCheck properties that should hold of all trees
148:
149:  -- inserting an element means it’s in the tree
150:  prop_insertAll :: Int -> [Int] -> Bool
151:  prop_insertAll = \x xs -> elemBST x (insert x (insertAll xs))
152:
153:  -- If x isn’t in xs, then it’s not in the tree.
154:  prop_notInTree :: Int -> [Int] -> Bool
155:  prop_notInTree = \xs -> (x 'elem' xs) || (not (x 'elemBST' insertAll xs))