Testing: Tasty

We will use the **Tasty** implementation of **hunit**, which is based on the Junit testing framework in Java.

Here are some useful links:

https://caiorss.github.io/Functional-Programming/haskell/UnitTest_Hunit.htm

http://hackage.haskell.org/package/HUnit

http://hackage.haskell.org/package/tasty

hunit enables you to create a hierarchical tree structure of tests, based on

- **Assertions** -- True or false assertions about the behavior of your code
- **Test Cases** -- Sequences of related assertions, which fail or succeed as a whole.
- **Test Groups** – Lists of Test Cases or other Test Groups

Testing: Assertions

You test your code by making **assertions** about the values returned by your code. There are two useful ways to do this, the first is

```
assertBool :: String -> Bool -> Assertion
```

This function takes a Boolean expression (something about your code you want to be true) and an error message. Your error message will be printed if the expression is false.

Examples:

```
assertBool "3 is not less than 2!" (3 < 2)

assertBool "4 in [2,3,4]?" (elem 4 [2,3,4])
```

Testing: Assertions

A second, and even more useful is

```
assertEqual :: (Eq a, Show a) => String -> a -> a -> Assertion
```

This is similar to the previous, except that you give it two expressions, typically the correct value you expect, and a call to some function to produce that value; again, if they are not equal, then the error message is printed out.

```
assertEqual "factorial 5 = ?"  120 (factorial 5)
```

An abbreviation for this assertion (without a warning message) is provided using the infix operator (@=?) so the previous assertion could be written as

```
120 @=? (factorial 5)
```

however this does not allow you to give an error message.

Testing: Test Cases

A **test case** is a single assertion or a sequence of assertions in a do expresssion.

A test case succeeds ("OK") if all the assertions are true, and fails ("FAIL") otherwise; thus a sequence of assertions in a do expression act like they are connected with "and" (&&).

Test cases have labels which are printed out when the result is reported.

Example:

```
testCase "Singular Test Case" $ assertBool "What??" True

testCase "Sequence of Tests"
     do assertBool "should be true" True
        assertEqual "(2+1)/= 5 !" (2+1) 5
        assertEqual "4 /= 2 !" 4 2
```

The second testCase will succeed only if all three of the assertions succeed.

Testing: Test Groups

A **test group** is simply a label and a list of test cases.

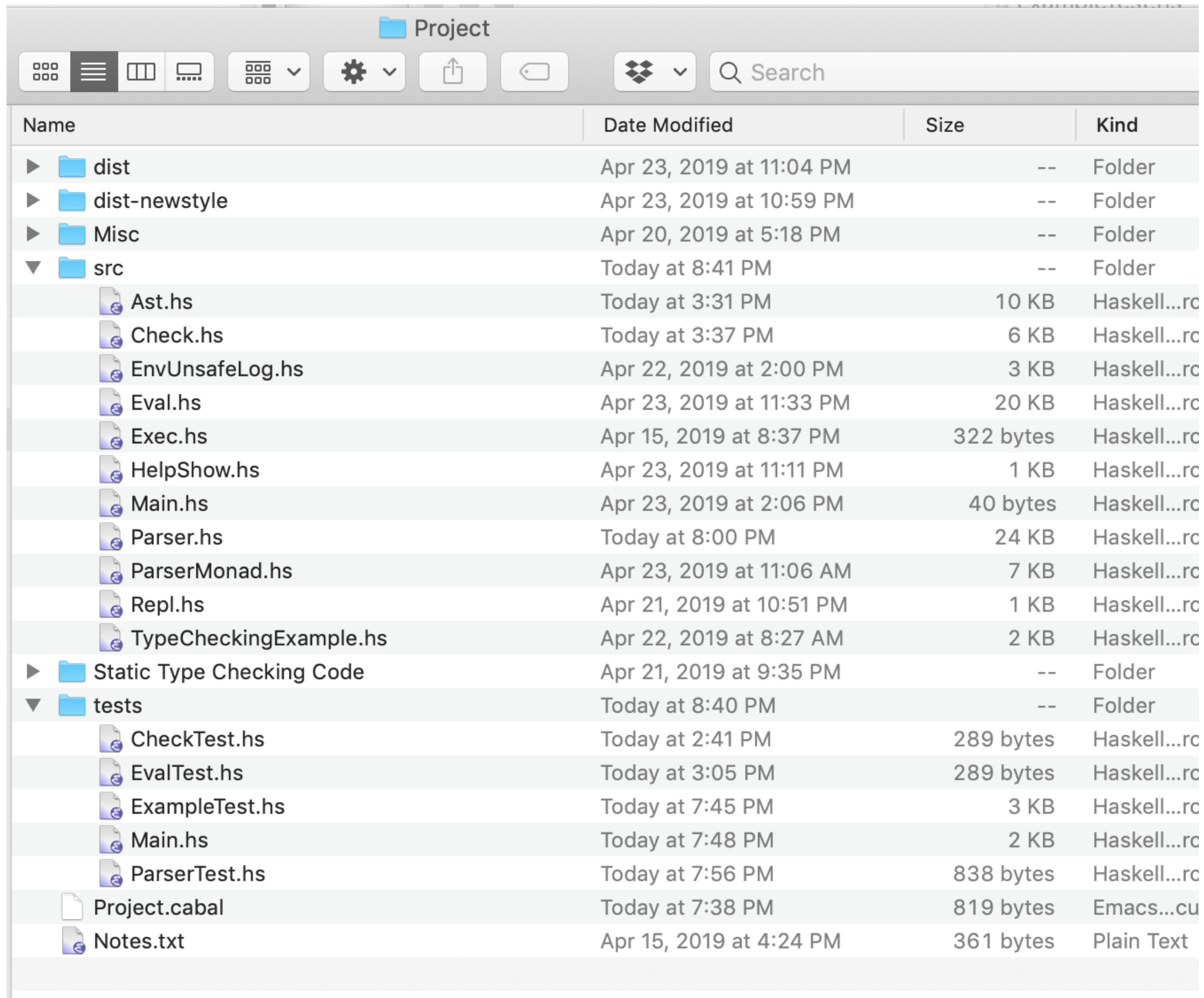
```
tests = testGroup "ExampleTest"
  [ testCase "Fact test" $ assertEqual "fact 5 = ?"  120 (fact 5),
    testCase "Mem test" $ do assertBool "mem 3 []" (not (mem 3 []))
                             assertBool "mem 3 [3]" (mem 3 [3])
                             assertBool "mem 3 [_,3]" (mem 3 [2,3]),
    testCase "Mod test" $ assertEqual "5 % 3 = ?" 2 (5 % 3),
    testCase "Another test" $ 5 @=? 4
  ]
```

Each of the test cases will be tested individually and reported. Make sure to put a comma after each test case, since this is a list!

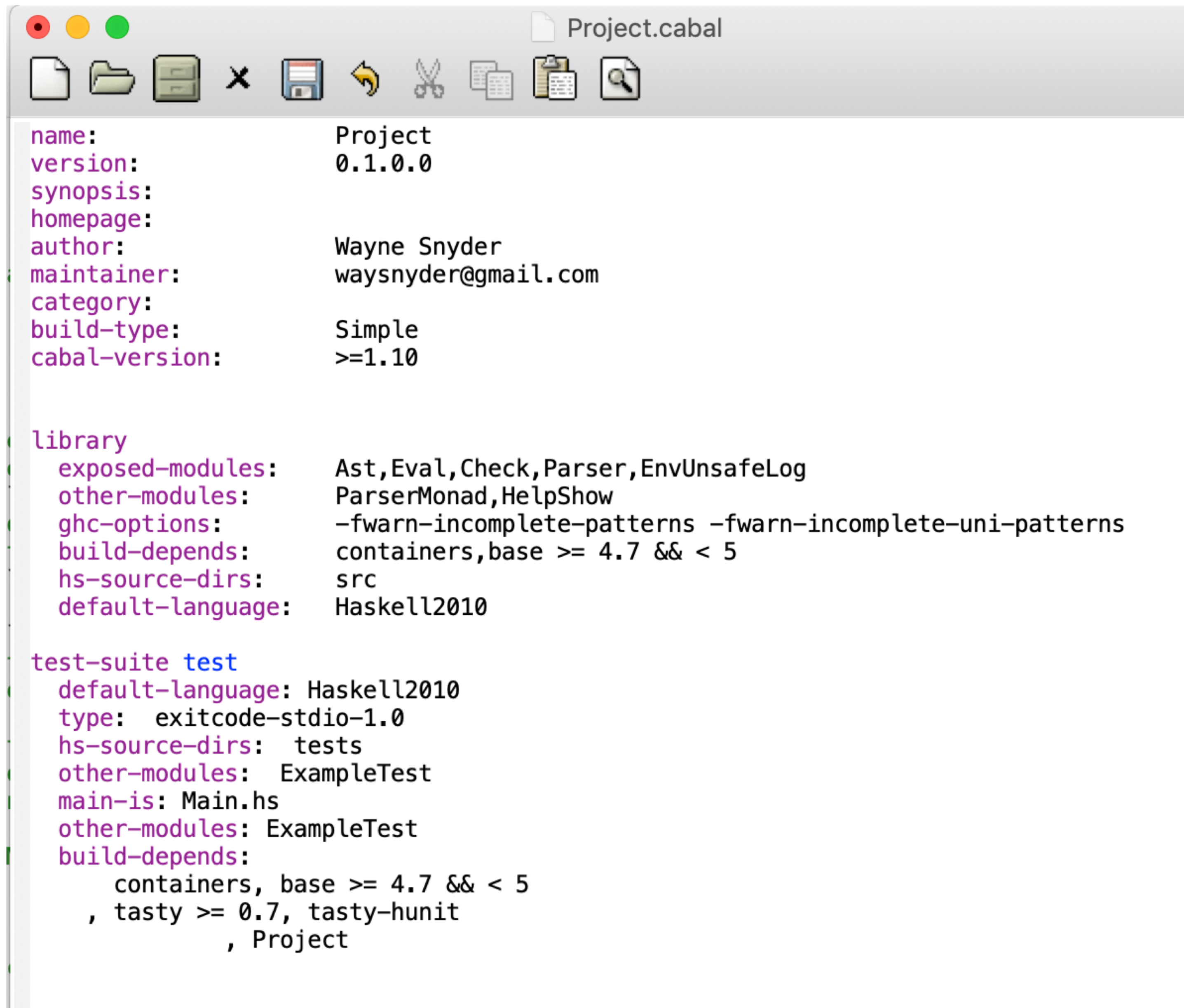
You may have to use parentheses to make sure they get parsed correctly.

You can nest test groups, essentially creating a tree of test cases, which will be displayed indented when the tests are run.

Testing: Example



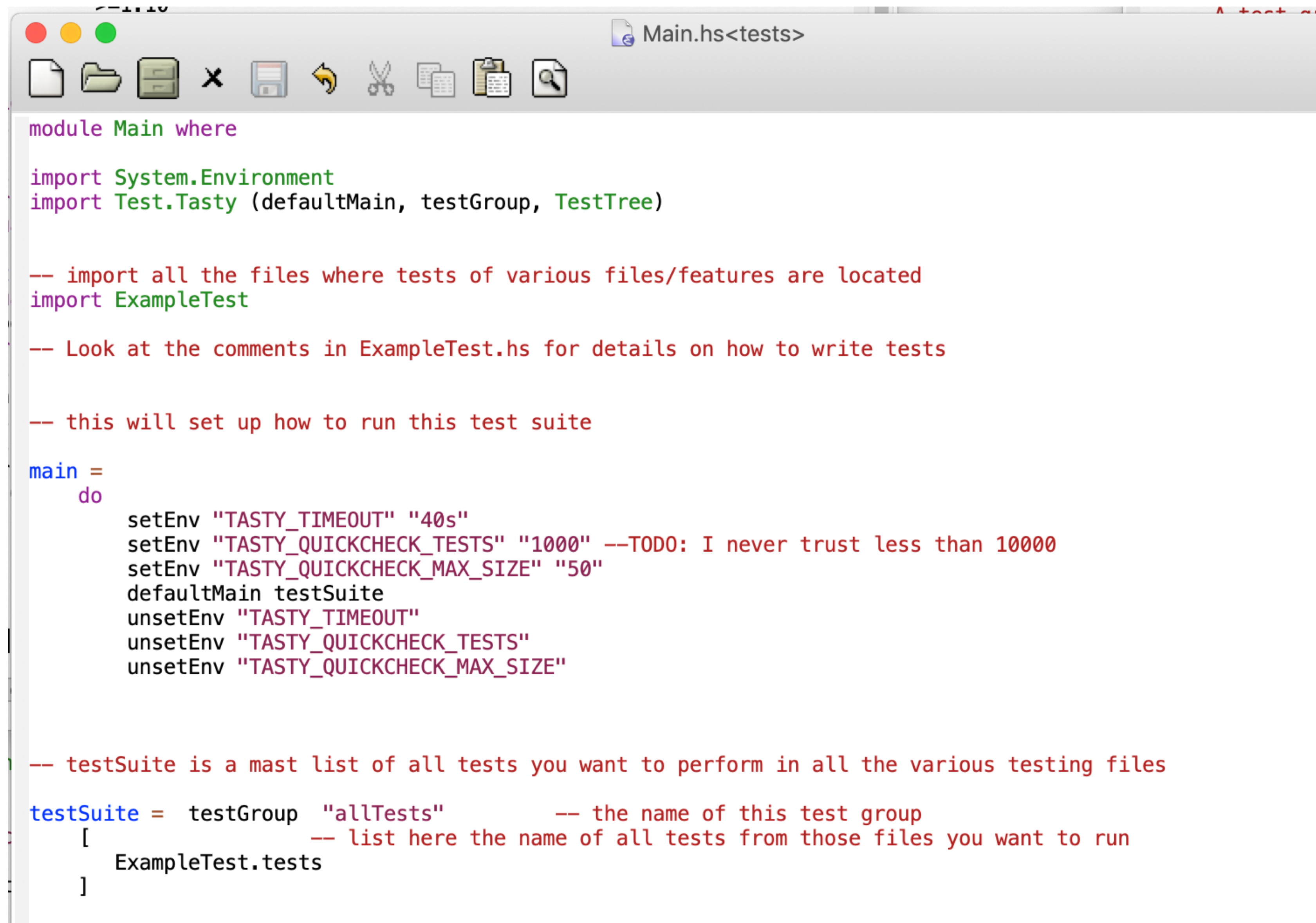
Testing: Example



Project.cabal

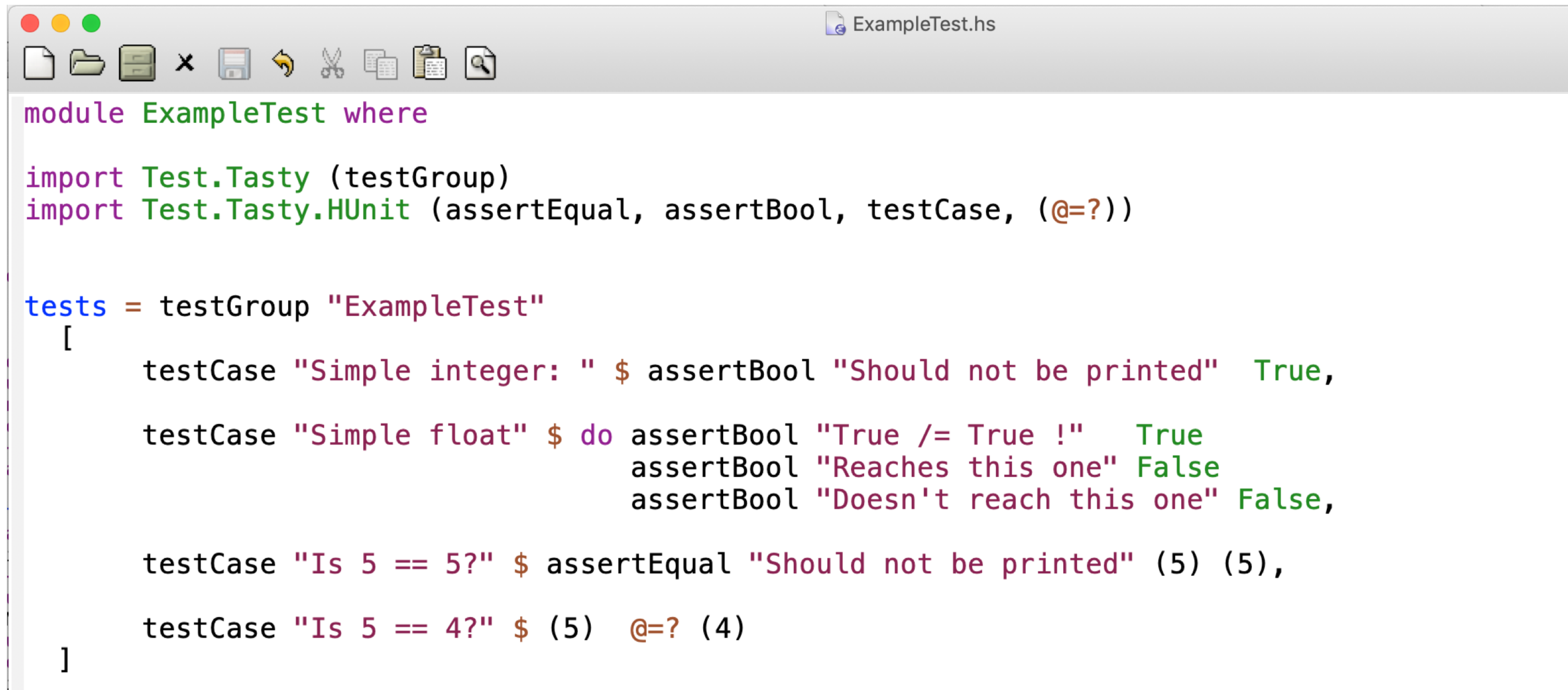
```
name:                  Project
version:               0.1.0.0
synopsis:
homepage:
author:                Wayne Snyder
maintainer:            waysnyder@gmail.com
category:
build-type:            Simple
cabal-version:         >=1.10


library
  exposed-modules:     Ast,Eval,Check,Parser,EnvUnsafeLog
  other-modules:       ParserMonad,HelpShow
  ghc-options:         -fwarn-incomplete-patterns -fwarn-incomplete-uni-patterns
  build-depends:       containers,base >= 4.7 && < 5
  hs-source-dirs:      src
  default-language:    Haskell2010

test-suite test
  default-language: Haskell2010
  type:  exitcode-stdio-1.0
  hs-source-dirs:  tests
  other-modules:  ExampleTest
  main-is: Main.hs
  other-modules: ExampleTest
  build-depends:
      containers, base >= 4.7 && < 5
    , tasty >= 0.7, tasty-hunit
              , Project
```

Testing: Example


Main.hs<tests>

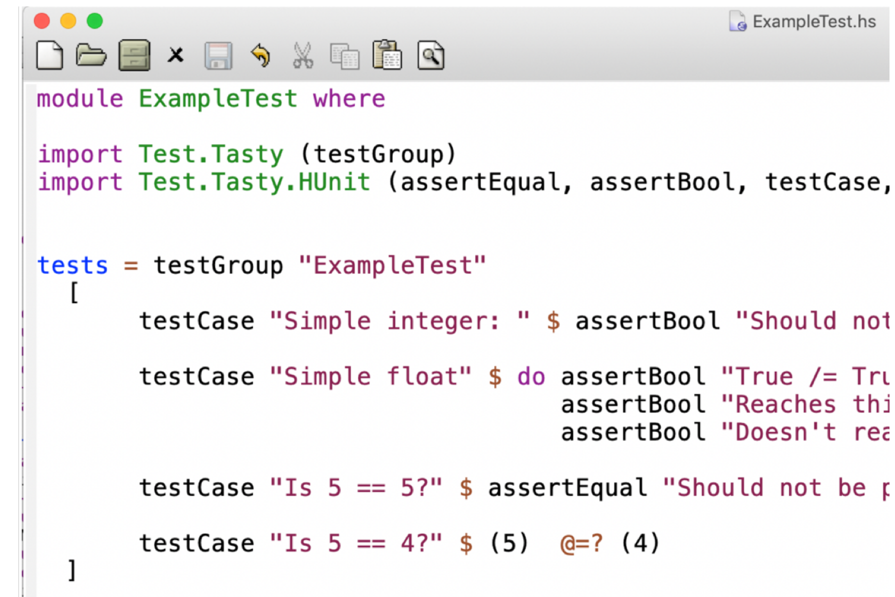
```
module Main where

import System.Environment
import Test.Tasty (defaultMain, testGroup, TestTree)


-- import all the files where tests of various files/features are located
import ExampleTest

-- Look at the comments in ExampleTest.hs for details on how to write tests


-- this will set up how to run this test suite

main =
    do
        setEnv "TASTY_TIMEOUT" "40s"
        setEnv "TASTY_QUICKCHECK_TESTS" "1000" --TODO: I never trust less than 10000
        setEnv "TASTY_QUICKCHECK_MAX_SIZE" "50"
        defaultMain testSuite
        unsetEnv "TASTY_TIMEOUT"
        unsetEnv "TASTY_QUICKCHECK_TESTS"
        unsetEnv "TASTY_QUICKCHECK_MAX_SIZE"



-- testSuite is a mast list of all tests you want to perform in all the various testing files

testSuite =  testGroup  "allTests"         -- the name of this test group
    [                      -- list here the name of all tests from those files you want to run
       ExampleTest.tests
    ]
```

Testing: Example



Testing: Example

```
Project $ cabal new-test
Resolving dependencies...
Build profile: -w ghc-8.6.3 -O1
In order, the following will be built (use -v for more details):
 - Project-0.1.0.0 (lib) (configuration changed)
 - Project-0.1.0.0 (test:test) (configuration changed)
Configuring library for Project-0.1.0.0..
Preprocessing library for Project-0.1.0.0..
Building library for Project-0.1.0.0..
Configuring test suite 'test' for Project-0.1.0.0..
Preprocessing test suite 'test' for Project-0.1.0.0..
Building test suite 'test' for Project-0.1.0.0..
Running 1 test suites...
Test suite test: RUNNING...
allTests
  ExampleTest
    Simple integer: : OK
    Simple float:     FAIL
      tests/ExampleTest.hs:81:
      Reaches this one
    Is 5 == 5?:       OK
    Is 5 == 4?:       FAIL
      tests/ExampleTest.hs:86:
      expected: 5
       but got: 4


2 out of 4 tests failed (0.00s)
Test suite test: FAIL
Test suite logged to: /Users/snyder/Dropbox (BOSTON
UNIVERSITY)/Documents/Teaching/CS320/Web/Homeworks and
Labs/Project/dist-newstyle/build/x86_64-osx/ghc-8.6.3/Project-
0.1.0.0/t/test/test/Project-0.1.0.0-test.log
0 of 1 test suites (0 of 1 test cases) passed.
cabal: Tests failed for test:test from Project-0.1.0.0.
```



Testing: Quickcheck

Quickcheck, which is used by Tasty, is a way of automatically generating tests cases. We will use it to automatically generate Ast expressions to see if our parser and showPretty functions are indeed consistent:

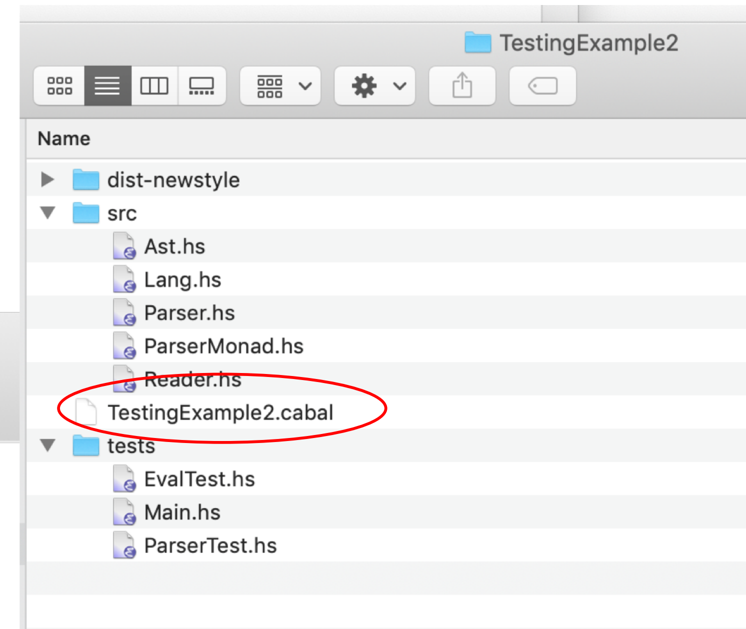
```
For any ast a:   a  ==  parse parser $ showPretty a 0
```

Here is a useful link:

https://begriffs.com/posts/2017-01-14-design-use-quickcheck.html

Quickcheck enables you to create random expressions in your ast by generating all possible expressions under a certain size limit.

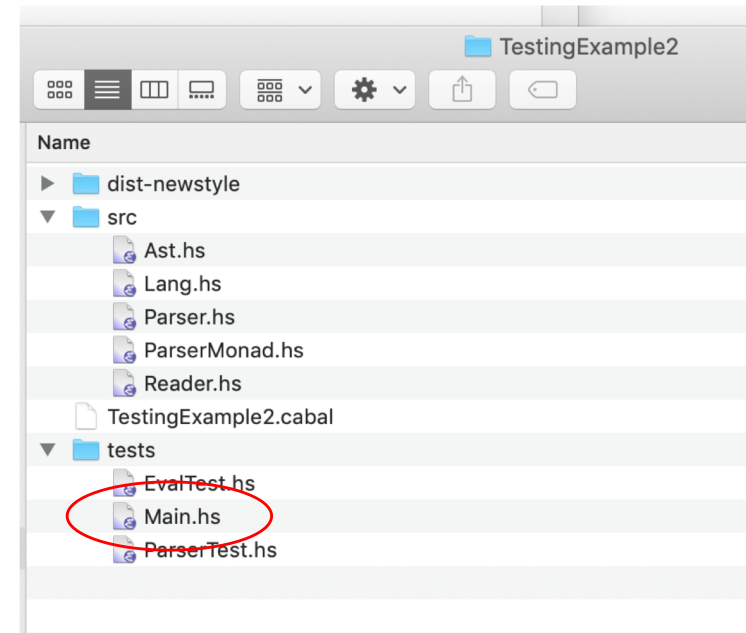
Testing: Quickcheck



TestingExample2.cabal

```
name:                TestingExample2
version:             0.1.0.0
synopsis:
homepage:
author:              Wayne Snyder
maintainer:          waysnyder@gmail.com
category:
build-type:          Simple
cabal-version:       >=1.10


library
  exposed-modules:   Ast,Lang,Parser,ParserMonad,Reader
  ghc-options:       -fwarn-incomplete-patterns -fwarn-incomplete-uni-patterns
  build-depends:     containers,base >= 4.7 && < 5
  hs-source-dirs:    src
  default-language:  Haskell2010

test-suite test
  default-language: Haskell2010
  type:  exitcode-stdio-1.0
  hs-source-dirs:  tests
  main-is: Main.hs
  other-modules: ParserTest,EvalTest
  build-depends:
      containers, base >= 4.7 && < 5
    , tasty >= 0.7, tasty-hunit, tasty-quickcheck
    , TestingExample2
```

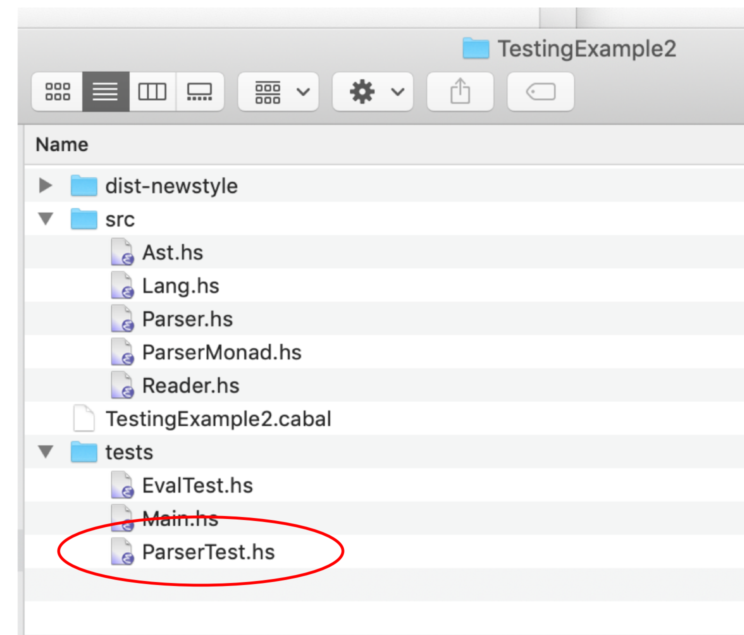
Testing: Quickcheck



Main.hs

```haskell
module Main where

import System.Environment
import Test.Tasty (defaultMain, testGroup, TestTree)


-- import all the files where tests of various files/features are located
import ParserTest
import EvalTest
import Ast
import Lang
import Parser

-- Look at the comments in ExampleTest.hs for details on how to write tests


-- this will set up how to run this test suite

main =
    do
        setEnv "TASTY_TIMEOUT" "40s"
        setEnv "TASTY_QUICKCHECK_TESTS" "1000" --TODO: I never trust less than 10000
        setEnv "TASTY_QUICKCHECK_MAX_SIZE" "50"
        defaultMain testSuite
        unsetEnv "TASTY_TIMEOUT"
        unsetEnv "TASTY_QUICKCHECK_TESTS"
        unsetEnv "TASTY_QUICKCHECK_MAX_SIZE"



-- testSuite is a mast list of all tests you want to perform in all the various testing files

testSuite =  testGroup  "allTests"         -- the name of this test group
    [                  -- list here the name of all tests from those files you want to run
      parserTest,
      evalTest
    ]
```

Testing: Quickcheck

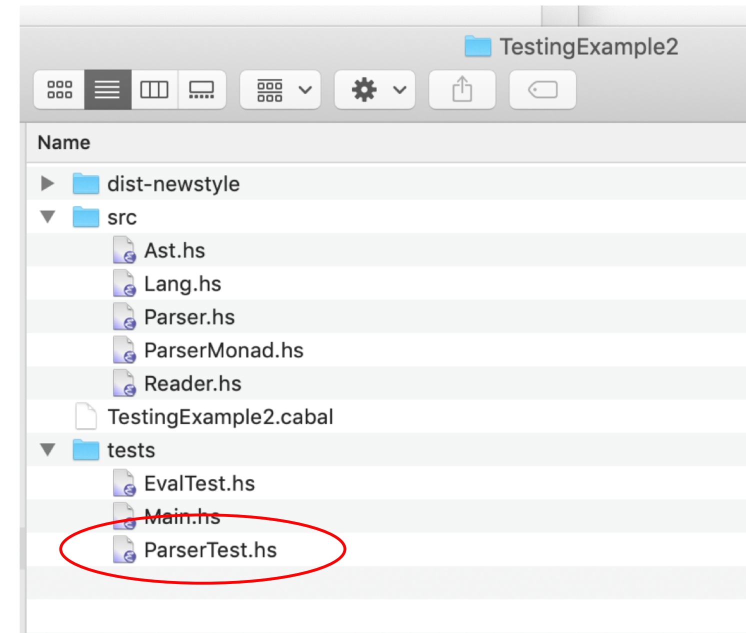


ParserTest.hs

```haskell
module ParserTest where

import Test.Tasty (testGroup)
import Test.Tasty.HUnit (assertEqual, assertBool, testCase)
import Test.Tasty.QuickCheck

-- Import all the modules you need to do the test

import ParserMonad (parse)
import Ast
import Parser (parser)

-- This will generate random instances of types

instance Arbitrary Ast where
    arbitrary = sized arbitrarySizedAst

-- recursively and randomly generate instances up to a given size limit

arbitrarySizedAst ::  Int -> Gen Ast
arbitrarySizedAst m | m < 1 = do i    <- arbitrary -- will choose a random Integer
                                 x    <- elements ["x", "y", "z"]   -- will choose random element from the list
                                 node <- elements [LiteralInt i, Var x]  -- so put all the non-recursive Ast expressions here
                                 return $ node
arbitrarySizedAst m | otherwise = do l <- arbitrarySizedAst (m `div` 2)  -- get ast half as big
                                     r <- arbitrarySizedAst (m `div` 2)  -- ditto
                                     x <- elements ["x", "y", "z"]   -- will choose random element from the list
                                     ifAst <- arbitrarySizedIf m
                                     node <- elements [Plus l r,      -- list here all your binary Ast constructors
                                                       Sub l r,
                                                       Mult l r,
                                                       ifAst,         -- will choose from if expressions
                                                       Let x l r      -- this one takes a string and two asts
                                                      ]
                                     return node
```

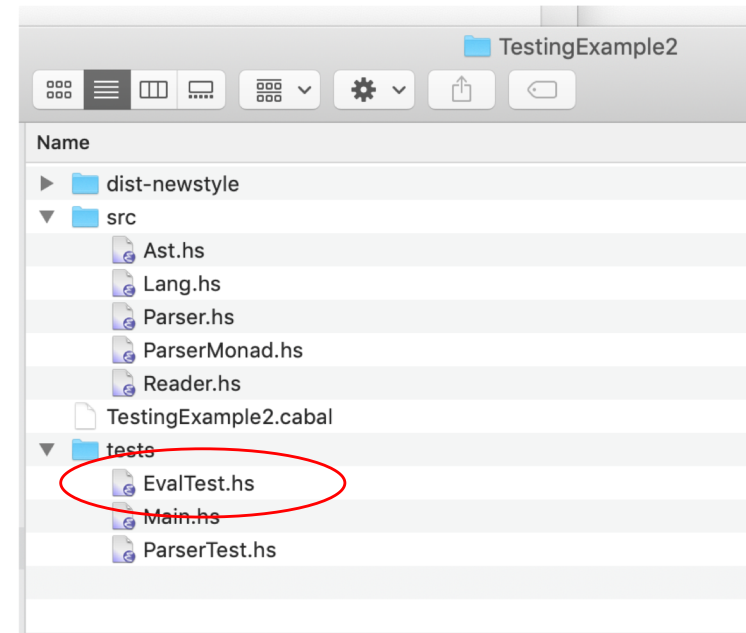
Testing: Quickcheck

ParserTest.hs




```haskell
-- recursively and randomly generate instances up to a given size limit

arbitrarySizedAst ::  Int -> Gen Ast
arbitrarySizedAst m | m < 1 = do i    <- arbitrary -- will choose a random Integer
                                 x    <- elements ["x", "y", "z"]   -- will choose random element from the list
                                 node <- elements [LiteralInt i, Var x]  -- so put all the non-recursive Ast expressions here
                                 return $ node
arbitrarySizedAst m | otherwise = do l <- arbitrarySizedAst (m `div` 2)  -- get ast half as big
                                     r <- arbitrarySizedAst (m `div` 2)  -- ditto
                                     x <- elements ["x", "y", "z"]   -- will choose random element from the list
                                     ifAst <- arbitrarySizedIf m
                                     node <- elements [Plus l r,      -- list here all your binary Ast constructors
                                                       Sub l r,
                                                       Mult l r,
                                                       ifAst,         -- will choose from if expressions
                                                       Let x l r      -- this one takes a string and two asts
                                                      ]
                                     return node

-- break in thirds for mix-fix operators which have three separate sub-asts

arbitrarySizedIf ::  Int -> Gen Ast
arbitrarySizedIf m = do x <- arbitrarySizedAst (m `div` 3)
                        y <- arbitrarySizedAst (m `div` 3)
                        z <- arbitrarySizedAst (m `div` 3)
                        return $ If x y z

parserTest = testGroup
      "parser Test"
      [
      testProperty "parse should return the same AST when fully parenthesized" $
                  ((\ x -> Just (x , "") == (parse parser $ showFullyParen x)) :: Ast -> Bool),

      testProperty "parse should return the same AST when pretty printed" $
                  ((\ x -> Just (x , "") == (parse parser $ showPretty x 0)) :: Ast -> Bool)
      ]
```

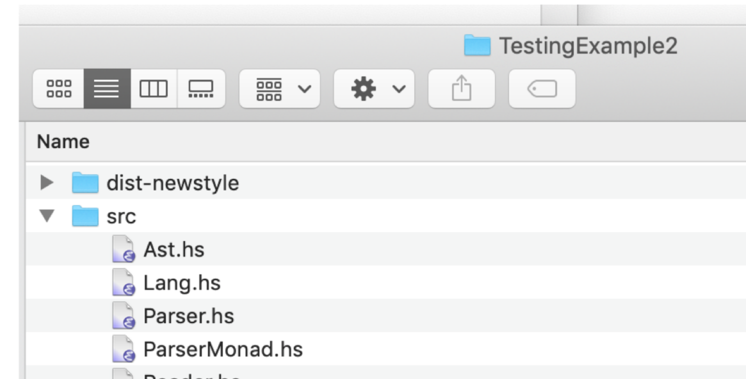
Testing: Quickcheck



EvalTest.hs

```
module EvalTest where

import Test.Tasty (testGroup)
import Test.Tasty.HUnit (assertEqual, assertBool, testCase)
import Test.Tasty.QuickCheck

-- Import all the modules you need to do the test

import Ast
import Parser
import Lang

zero = (LiteralInt 0)
one = (LiteralInt 1)
none = (LiteralInt (-1))
two = (LiteralInt 2)
ntwo = (LiteralInt (-2))
three = (LiteralInt 3)
nthree = (LiteralInt (-3))
four = (LiteralInt 4)
nfour = (LiteralInt (-4))


evalTest = testGroup
      "Eval Test"
      [
         testCase "Basic Arithmetic" $
            do
              assertEqual "2 + 4 =? "    6    (exec (Plus two four))
              assertEqual "2 + -1 =? "   1    (exec (Plus two none))
              assertEqual "2 - 4 =? "    (-2) (exec (Sub two four))
              assertEqual "2 - (-4) =? " 6    (exec (Sub two nfour))
              assertEqual "3 * 2 =? "    6    (exec (Mult three two))
              assertEqual "2 * -2 =? "   (-4) (exec (Mult two ntwo)),
```

Testing: Quickcheck



EvalTest.hs

```
evalTest = testGroup
      "Eval Test"
      [
         testCase "Basic Arithmetic" $
            do
              assertEqual "2 + 4 =? "    6    (exec (Plus two four))
              assertEqual "2 + -1 =? "   1    (exec (Plus two none))
              assertEqual "2 - 4 =? "    (-2) (exec (Sub two four))
              assertEqual "2 - (-4) =? " 6    (exec (Sub two nfour))
              assertEqual "3 * 2 =? "    6    (exec (Mult three two))
              assertEqual "2 * -2 =? "   (-4) (exec (Mult two ntwo)),

         testCase "Compound Arithmetic" $
            do
              assertEqual "2 + 4 * 3 =? "             14   (exec (Plus two (Mult four three)))
              assertEqual "(2 + -4) * 3 =? "          (-6) (exec (Mult (Plus two nfour) three))
              assertEqual "2 * 3 + 3 * 2 - 4 =? "     8    (exec (Sub (Plus (Mult two three) (Mult three two)) four))
              assertEqual "2 * (3 + 3) * (2 - 4) =? " (-24) (exec (Mult (Mult two (Plus three three)) (Sub two four))),

         testCase "If Statements" $
            do
              assertEqual "if 3 then 4 else 2 =? "      4  (exec (If three four two))
              assertEqual "if 0 then 1 else 4"          4  (exec (If zero one four))
              assertEqual "if 3 * 0 then 1 else 2  =? " 2  (exec (If (Mult three zero) one two))
              assertEqual "if 3 * 2 then 1 else 2  =? " 1  (exec (If (Mult three two) one two)),

         testCase "Let Statements" $
            do
              assertEqual "let x = 4 in x * 2 =? "                 8  (exec (Let "x" four (Mult (Var "x") two)))
              assertEqual "let x = 4 * -2 in x - 2 =? "            (-10)  (exec (Let "x" (Mult four ntwo) (Sub (Var "x") two)))
              assertEqual "let x = 2 in let y = x + 1 in y * 2 =? "  6  (exec (Let "x" two (Let "y" (Plus (Var "x") one)  (Mult (Var "y") two))))
```

Testing: Quickcheck

```
TestingExample2 $ cabal new-test
Build profile: -w ghc-8.6.3 -O1
In order, the following will be built (use -v for more details):
 - TestingExample2-0.1.0.0 (test:test) (first run)
Preprocessing test suite 'test' for TestingExample2-0.1.0.0..
Building test suite 'test' for TestingExample2-0.1.0.0..
Running 1 test suites...
Test suite test: RUNNING...
allTests
  parser Test
    parse should return the same AST when fully parenthesized: OK (0.17s)
      +++ OK, passed 1000 tests.
    parse should return the same AST when pretty printed:      OK (0.15s)
      +++ OK, passed 1000 tests.
  Eval Test
    Basic Arithmetic:                                          OK
    Compound Arithmetic:                                       OK
    If Statements:                                             OK
    Let Statements:                                            OK

All 6 tests passed (0.32s)
Test suite test: PASS
Test suite logged to: /Users/snyder/Dropbox (BOSTON
UNIVERSITY)/Documents/Teaching/CS320/Web/Homeworks and
Labs/TestingExample2/dist-newstyle/build/x86_64-osx/ghc-8.6.3/TestingExample2-0.1.0.0/t/
.0.0-test.log
1 of 1 test suites (1 of 1 test cases) passed.
```