CSE 114A: Fall 2023

Foundations of Programming Languages

Lecture 1: Course Overview

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A Programming Language

- Two variables
  - `x, y`
- Three operations
  - `x++`
  - `x--`
  - `(x=0)? L1:L2;`

```
L1: x++;
    y--;
    (y=0)?L2:L1
L2: …
```

Fact: This is “equivalent to” to every PL!

Good luck writing quicksort

… or Windows, Google, Spotify!

So why study PL ?

Programming language shapes Programming thought

So why study PL ?

Language affects how:

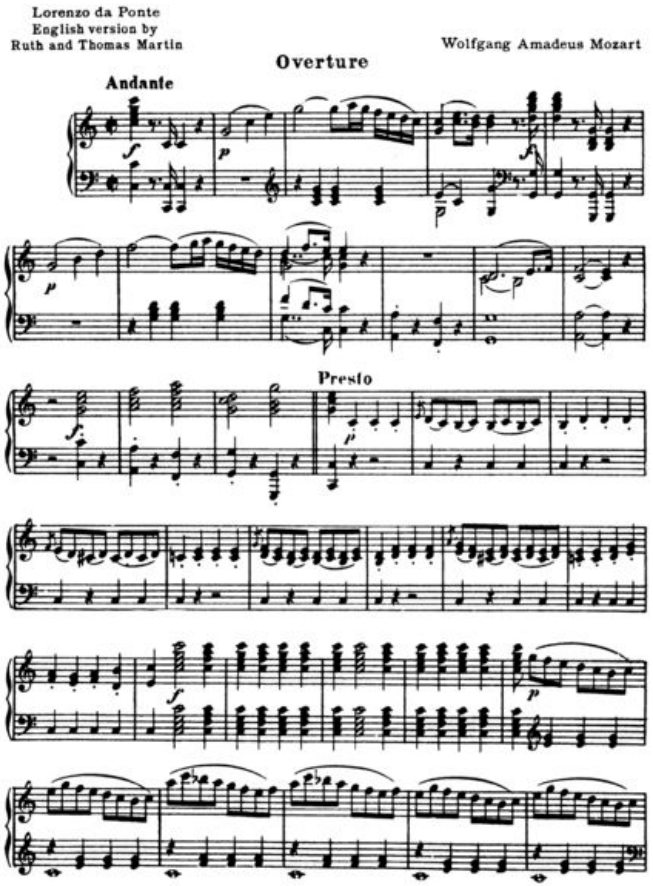
- Ideas are expressed
- Computation is expressed

Course Goals

"Free your mind"

-Morpheus

Learn New Languages/Constructs

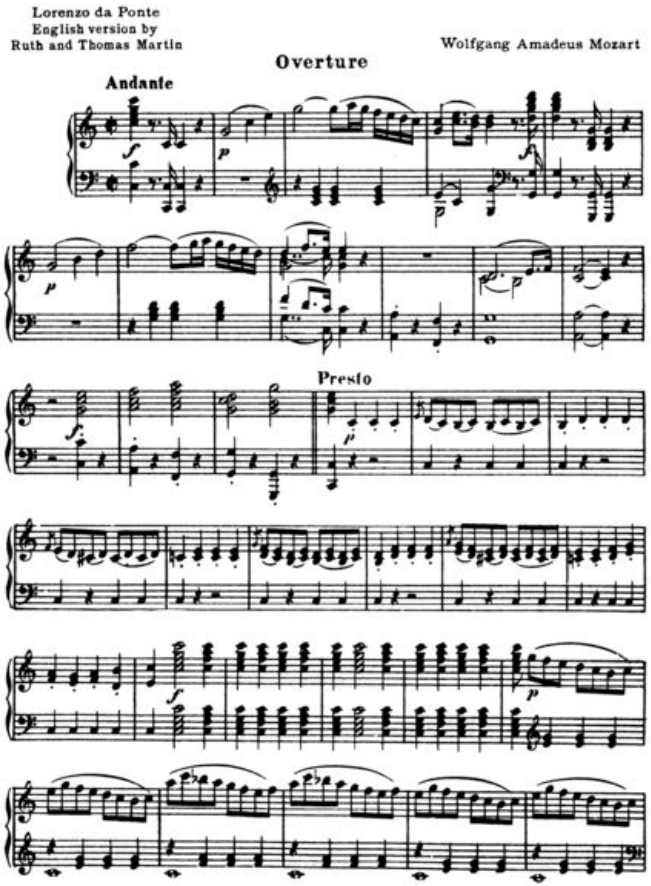


New ways to:

- describe
- organize
- think about

computation

Goal: Enable you to Program



- Readable
- Correct
- Extendable
- Modifiable
- Reusable


#goals
Learn How To Learn
livememe.com

Goal: How to learn new PLs

No Java (C#) 15 (10) years ago

AJAX? Python? Ruby? Erlang? F#?...

Learn the anatomy of a PL

- Fundamental building blocks
- Different guises in different PLs

Re-learn the PLs you already know


#goals
Design new languages
livememe.com

Goal: How to design new PLs

…“who, me ?”

Buried in every extensible system is a PL

- Emacs, Android: Lisp
- Word, Powerpoint: Macros, VBScript
- Unreal: UnrealScript (Game Scripting)
- Facebook: FBML, FBJS
- SQL, Renderman, LaTeX, XML …


#goals
Choose right language
livememe.com

Enables you to choose right PL

"…but isn't that decided by

- libraries,
- standards,
- and my boss ?"

Yes.

My goal: educate tomorrow's tech leaders & bosses, so you'll make informed choices

Speaking of Right and Wrong...

Imperative Programming

$$x = x+1$$

$$x = x+1$$

Imperative = Mutation

Imperative = Mutation

Bad!

Don’t take my word for it

John Carmack

Creator of FPS: Doom, Quake,...

Don’t take my word for it

Tim Sweeney (Epic, Creator of UNREAL)

“In a concurrent world, imperative is the wrong default”

Functional Programming

Functional Programming ?

No Assignment.

No Mutation.

No Loops.

OMG! Who uses FP?!

So, Who Uses FP ?

MapReduce

So, Who Uses FP ?

Microsoft®

Linq, F#

So, Who Uses FP ?

Erlang

So, Who Uses FP ?

twitter

Scala

So, Who Uses FP ?

Wall Street

(all of the above)

So, Who Uses FP ?

…CSE 114A

Course Mechanics and Logistics

Logistics

Course website:

https://ucsc-cse-114a.github.io/fall23/

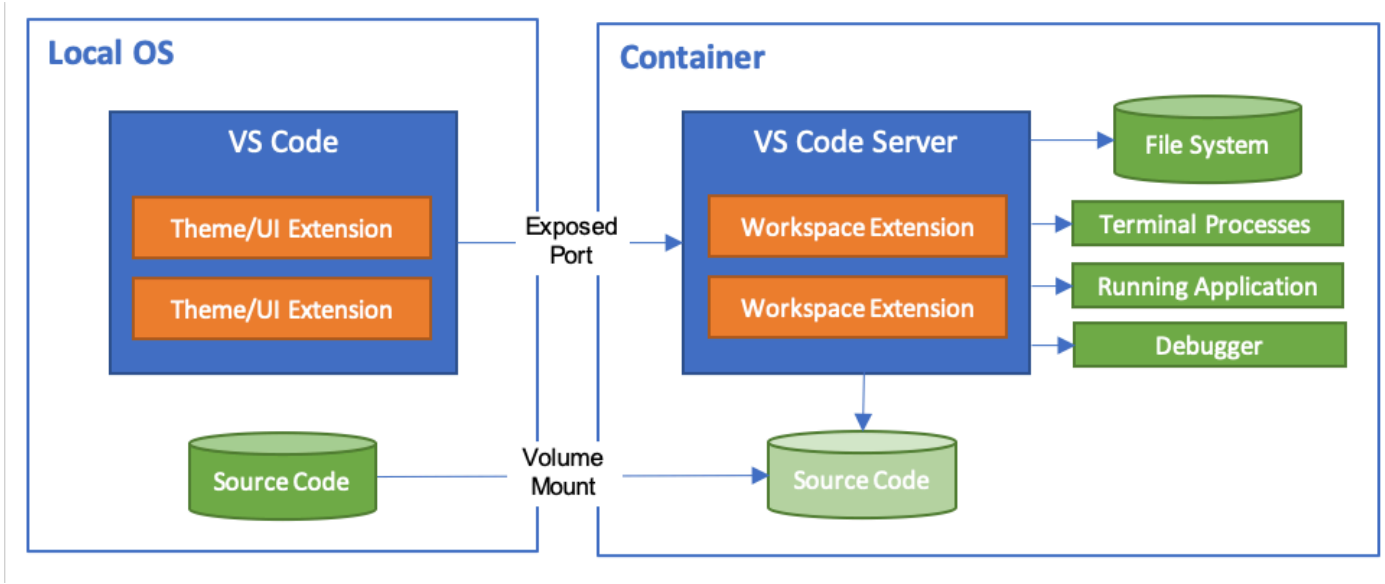
Resources

Course texts (optional):

- An Introduction to Functional Programming Through Lambda Calculus by Greg Michaelson. Free pre-print.
- Thinking Functionally with Haskell by Richard Bird. Available online (free via library).
- Programming in Haskell (2nd ed.) by Graham Hutton.
- Real World Haskell by Bryan O'Sullivan. Available online (free via library).
- Learn You a Haskell for Great Good by Miran Lipovača. Available free online
- Write You a Haskell by Stephen Diehl. (incomplete, but useful) Available free online

Resources

Haskell Dev Container

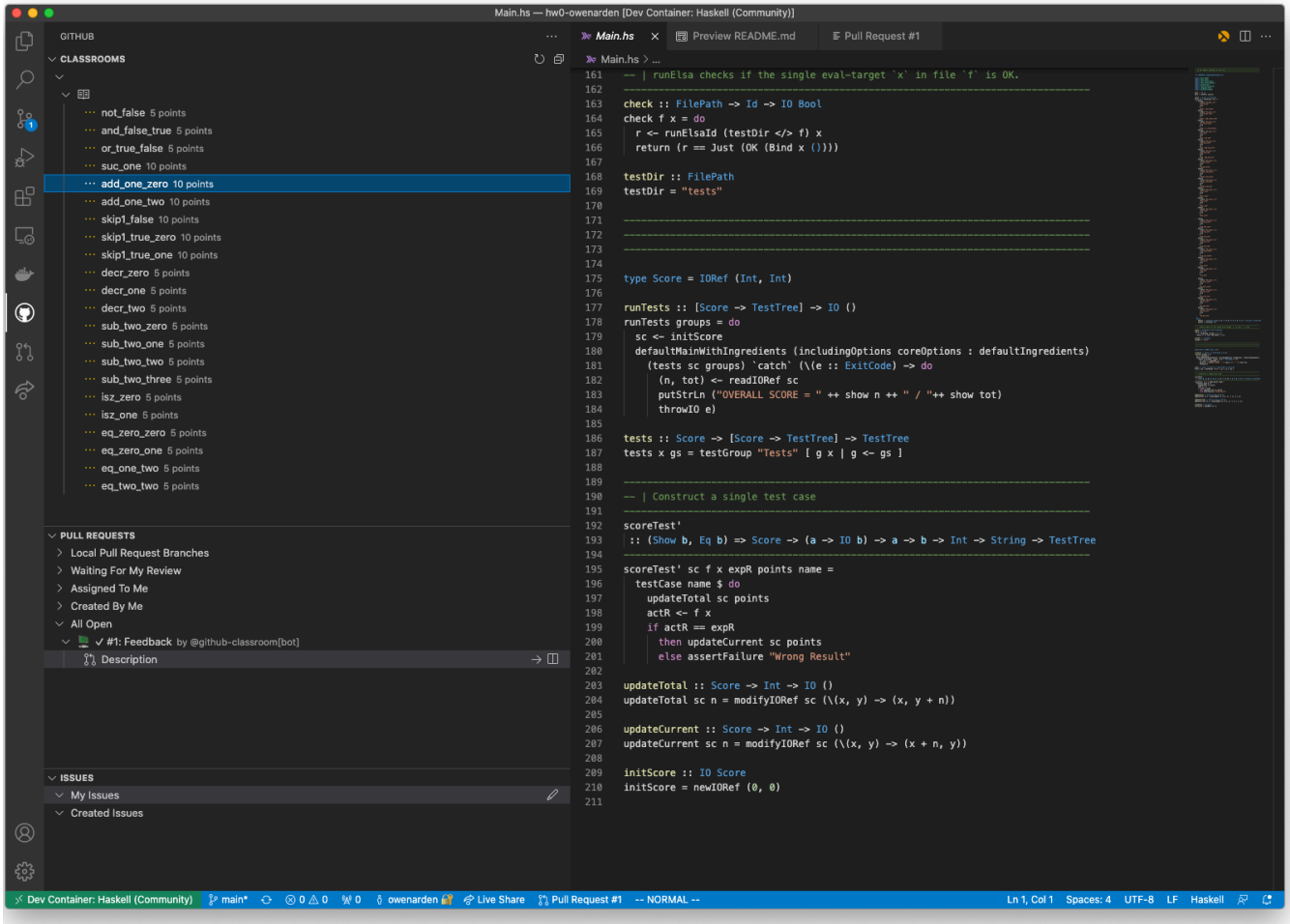


- https://github.com/UCSC-CSE-114A/cs114a-devcontainer

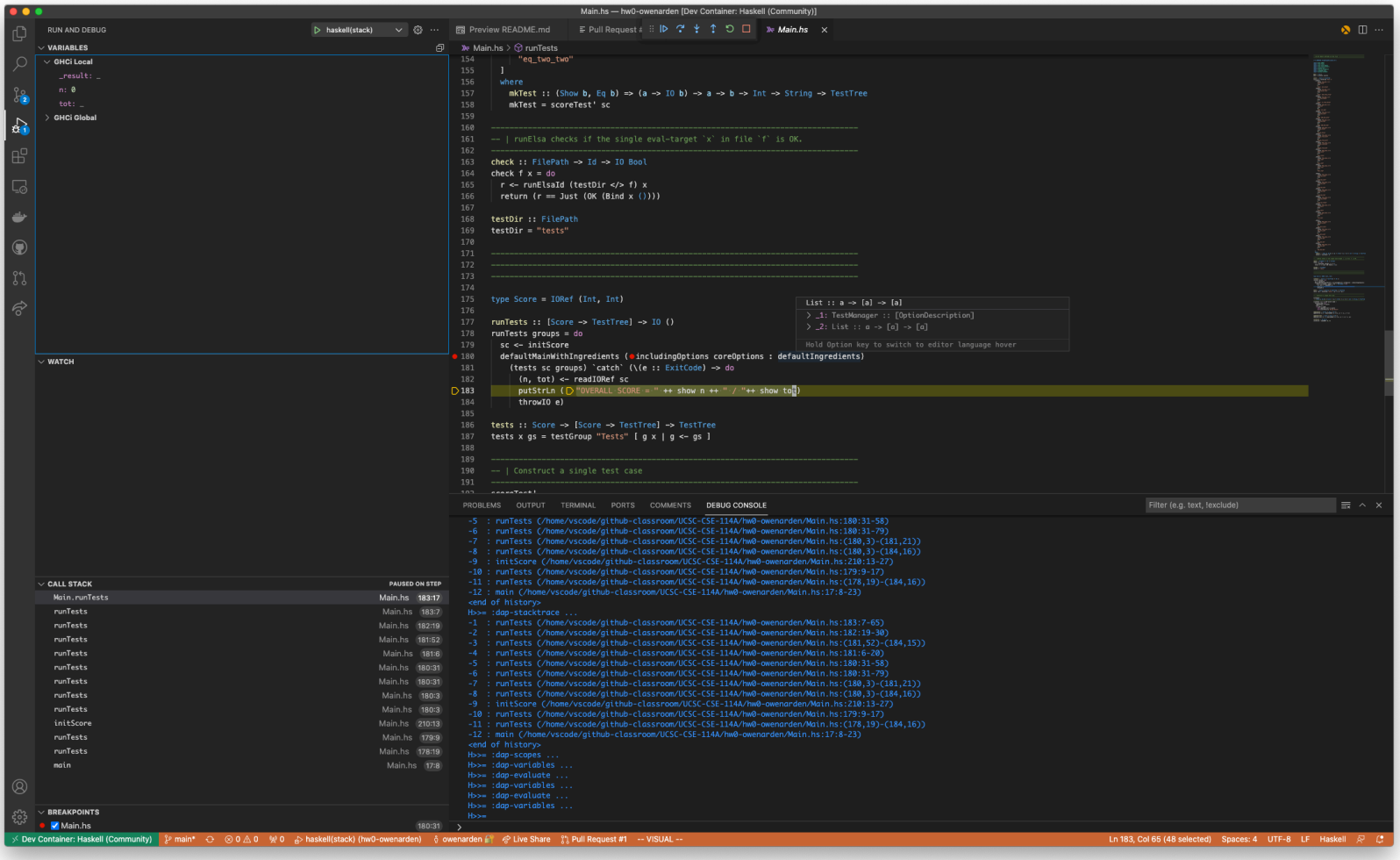
Recommended IDE: VS Code

- Legit IDE setup for Haskell!
  - Devcontainer: A Haskell dev environment is built in a container and VS Code automatically mounts the container volume
  - Codespaces: devcontainers in the cloud!!
  - Also some integrations with Git and GitHub Classroom

VS Code


Main.hs — hw0-owenarden [Dev Container: Haskell (Community)]
GITHUB
CLASSROOMS
not_false 5 points
and_false_true 5 points
or_true_false 5 points
suc_one 10 points
add_one_zero 10 points
add_one_two 10 points
skip1_false 10 points
skip1_true_zero 10 points
skip1_true_one 10 points
decr_zero 5 points
decr_one 5 points
decr_two 5 points
sub_two_zero 5 points
sub_two_one 5 points
sub_two_two 5 points
sub_two_three 5 points
isz_zero 5 points
isz_one 5 points
eq_zero_zero 5 points
eq_zero_one 5 points
eq_one_two 5 points
eq_two_two 5 points
PULL REQUESTS
Local Pull Request Branches
Waiting For My Review
Assigned To Me
Created By Me
All Open
#1: Feedback by @github-classroom[bot]
Description
ISSUES
My Issues
Created Issues
Main.hs
Preview README.md
Pull Request #1
Main.hs > ...
-- | runElsa checks if the single eval-target `x` in file `f` is OK.
check :: FilePath -> Id -> IO Bool
check f x = do
r <- runElsaId (testDir </> f) x
return (r == Just (OK (Bind x ())))
testDir :: FilePath
testDir = "tests"
type Score = IORef (Int, Int)
runTests :: [Score -> TestTree] -> IO ()
runTests groups = do
sc <- initScore
defaultMainWithIngredients (includingOptions coreOptions : defaultIngredients)
(tests sc groups) `catch` (\(e :: ExitCode) -> do
(n, tot) <- readIORef sc
putStrLn ("OVERALL SCORE = " ++ show n ++ " / "++ show tot)
throwIO e)
tests :: Score -> [Score -> TestTree] -> TestTree
tests x gs = testGroup "Tests" [g x | g <- gs]
-- | Construct a single test case
scoreTest'
:: (Show b, Eq b) => Score -> (a -> IO b) -> a -> b -> Int -> String -> TestTree
scoreTest' sc f x expR points name =
testCase name $ do
updateTotal sc points
actR <- f x
if actR == expR
then updateCurrent sc points
else assertFailure "Wrong Result"
updateTotal :: Score -> Int -> IO ()
updateTotal sc n = modifyIORef sc (\(x, y) -> (x, y + n))
updateCurrent :: Score -> Int -> IO ()
updateCurrent sc n = modifyIORef sc (\(x, y) -> (x + n, y))
initScore :: IO Score
initScore = newIORef (0, 0)
Dev Container: Haskell (Community)
main*
owenarden
Live Share
Pull Request #1
-- NORMAL --
Ln 1, Col 1
Spaces: 4
UTF-8
LF
Haskell

VS Code


Main.hs — hw0-owenarden [Dev Container: Haskell (Community)]
RUN AND DEBUG
haskell(stack)
VARIABLES
GHCi Local
_result: _
n: 0
tot: _
GHCi Global
WATCH
CALL STACK
PAUSED ON STEP
Main.runTests Main.hs 183:17
runTests Main.hs 183:7
runTests Main.hs 182:19
runTests Main.hs 181:52
runTests Main.hs 181:6
runTests Main.hs 180:31
runTests Main.hs 180:31
runTests Main.hs 180:3
runTests Main.hs 180:3
initScore Main.hs 210:13
runTests Main.hs 179:9
runTests Main.hs 178:19
main Main.hs 17:8
BREAKPOINTS
Main.hs 180:31
Preview README.md
Pull Request #1
Main.hs
Main.hs > runTests
"eq_two_two"
]
where
mkTest :: (Show b, Eq b) => (a -> IO b) -> a -> b -> Int -> String -> TestTree
mkTest = scoreTest' sc
-- | runElsa checks if the single eval-target `x` in file `f` is OK.
check :: FilePath -> Id -> IO Bool
check f x = do
r <- runElsaId (testDir </> f) x
return (r == Just (OK (Bind x ())))
testDir :: FilePath
testDir = "tests"
type Score = IORef (Int, Int)
runTests :: [Score -> TestTree] -> IO ()
runTests groups = do
sc <- initScore
defaultMainWithIngredients (includingOptions coreOptions : defaultIngredients)
(tests sc groups) `catch` (\(e :: ExitCode) -> do
(n, tot) <- readIORef sc
putStrLn ("OVERALL SCORE = " ++ show n ++ " / " ++ show tot)
throwIO e)
tests :: Score -> [Score -> TestTree] -> TestTree
tests x gs = testGroup "Tests" [g x | g <- gs]
-- | Construct a single test case
List :: a -> [a] -> [a]
_1: TestManager :: [OptionDescription]
_2: List :: a -> [a] -> [a]
Hold Option key to switch to editor language hover
PROBLEMS
OUTPUT
TERMINAL
PORTS
COMMENTS
DEBUG CONSOLE
Filter (e.g. text, !exclude)
-5 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:180:31-58)
-6 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:180:31-79)
-7 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:(180,3)-(181,21))
-8 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:(180,3)-(184,16))
-9 : initScore (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:210:13-27)
-10 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:179:9-17)
-11 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:(178,19)-(184,16))
-12 : main (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:17:8-23)
<end of history>
H>>= :dap-stacktrace ...
-1 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:183:7-65)
-2 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:182:19-30)
-3 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:(181,52)-(184,15))
-4 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:181:6-20)
-5 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:180:31-58)
-6 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:180:31-79)
-7 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:(180,3)-(181,21))
-8 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:(180,3)-(184,16))
-9 : initScore (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:210:13-27)
-10 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:179:9-17)
-11 : runTests (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:(178,19)-(184,16))
-12 : main (/home/vscode/github-classroom/UCSC-CSE-114A/hw0-owenarden/Main.hs:17:8-23)
<end of history>
H>>= :dap-scopes ...
H>>= :dap-variables ...
H>>= :dap-evaluate ...
H>>= :dap-variables ...
H>>= :dap-evaluate ...
H>>= :dap-variables ...
H>>=
Dev Container: Haskell (Community)
main*
haskell(stack) (hw0-owenarden)
owenarden
Live Share
Pull Request #1
-- VISUAL --
Ln 183, Col 65 (48 selected)
Spaces: 4
UTF-8
LF
Haskell

Peer Instruction (ish)

Peer Instruction

- Make class interactive
  - Help YOU and ME understand whats tricky
- Respond to in-class quizzes
  - 5% of your grade
  - Respond to 75% questions
- Bring laptop/phone if you have one

In Class Exercises

1. Solo Vote: Think for yourself, select answer

2. Discuss: Analyze Problem with neighbors
   - Practice analyzing, talking about tricky notions
   - Reach consensus
   - Have questions, raise your hand!

3. Group Vote: Everyone in group votes

4. Class-wide Discussion:
   - What did you find easy/hard?
   - Questions from here show up in exams

In Class Exercises

Let's try it out (if you have a device):

Indoctrination (a test)

* Required

x = x + 1 * 1 point

This is fine

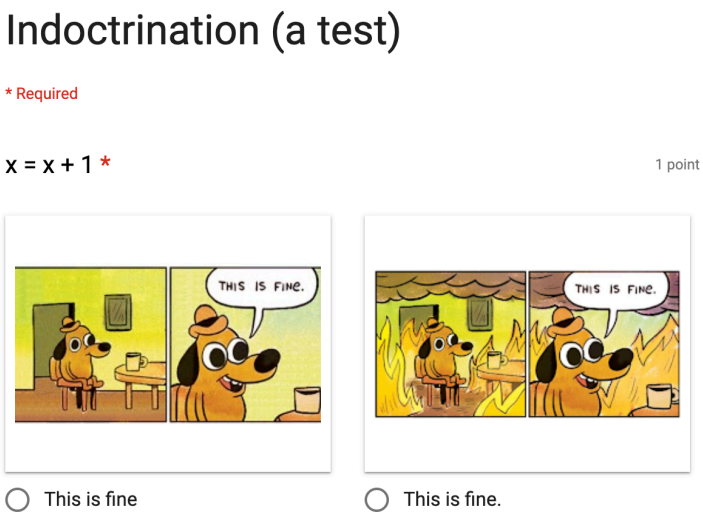
This is fine.

http://tiny.cc/cse116-trial

Make your individual choice

In Class Exercises

Let's try it out (if you have a device):



http://tiny.cc/cse116-trial

Now "confer" with a neighbor and agree on a choice for your group

Requirements and Grading

- In-Class Exercises: 5%
- Midterm: 30%
- Programming Assignments (6): 30%
- Final: 35%

Two hints/rumors:

1. Lots of work
2. Don't worry (too much) about grade

Note: Regrades must be requested *within two weeks of receiving grade*

Resources

- Online lecture notes
- Readings and exercises
- Lecture capture available in Yuja
- Pay attention to lecture and section!
- Do assignments yourself (+partner)!

Ask for help!

- Lots of help available, will be adding more soon. (watch website)
- Goal: course staff available ***every day of the week***
- Discussion sections with TAs to help with lecture concepts and get unstuck on assignments

Programming Assignments

All assignments are managed through GitHub Classroom (link on course page).

- **You must *push* your submitted code.**

Deadline Extension:

- Four “late days”, used as “whole unit”
- 5 mins late = 1 late day
- Plan ahead, **no other extensions**

See course webpage for HW deadlines

Programming Assignments

Unfamiliar languages

\+ Unfamiliar environments

Start Early!

Weekly Programming Assignments

Scoring = Test suite

No Compile, No Score

Weekly Programming Assignments

Forget Java, C, C++ …

… other 20th century PLs

Don't complain

… that Haskell is hard

… that Haskell is @!%@#

Immerse yourself in new language

It is not.

(You can do it)

Immerse yourself in new language

Word from our sponsor …

- Programming Assignments done **ALONE** or in **(official) groups of two** (as permitted)
- We use plagiarism detection software
  - MOSS is fantastic, plagiarize at your own risk
- **Zero Tolerance**
  - offenders punished ruthlessly
- Please see academic integrity statement:
  - https://ue.ucsc.edu/academic-misconduct.html


#goals
Ask me questions
livememe.com