CSE 114A: Fall 2021

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

Zygote Media Group, Inc. ©2006
Image provided courtesy of 3D SCIENCE.COM

#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

$$x = x+1$$

WTF?

$$x = x+1$$

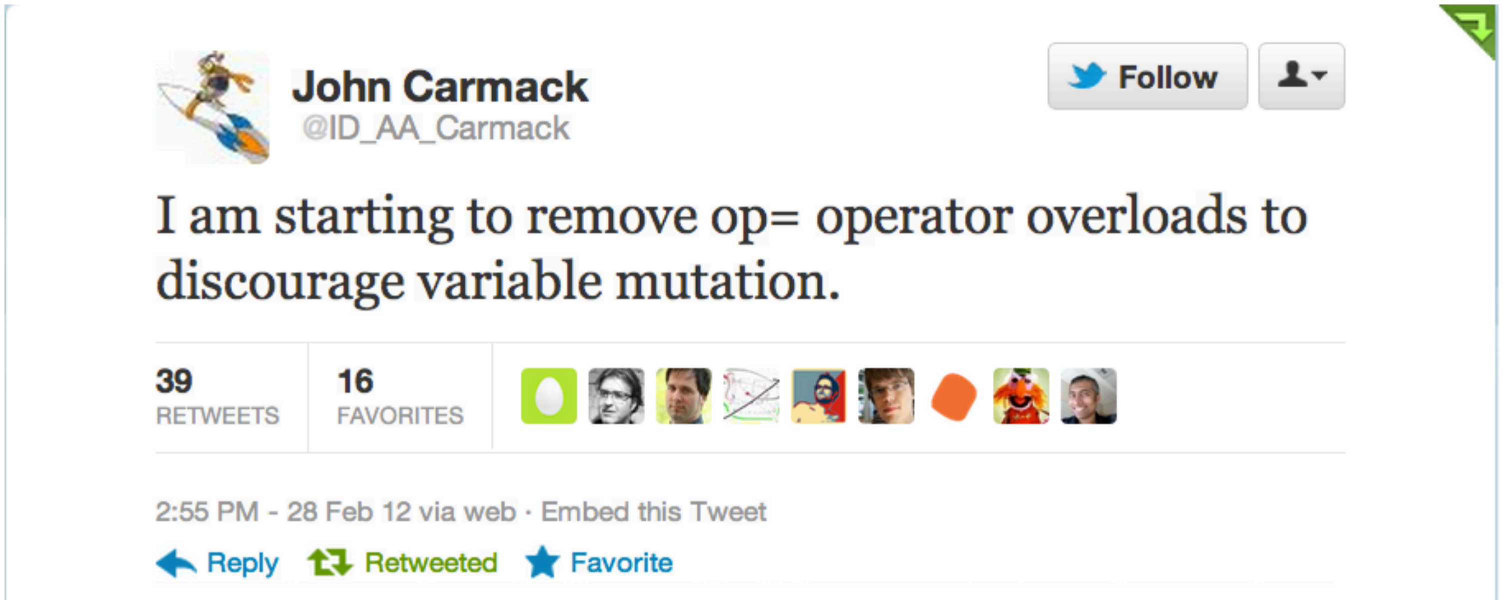
Imperative = Mutation

Imperative = Mutation

Bad!

Don’t take my word for it

John Carmack
Creator of FPS: Doom, Quake,...


John Carmack
@ID_AA_Carmack

I am starting to remove op= operator overloads to discourage variable mutation.

39 RETWEETS 16 FAVORITES

2:55 PM - 28 Feb 12 via web · Embed this Tweet

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 ?

Google

MapReduce

So, Who Uses FP ?

Microsoft®

Linq, F#

So, Who Uses FP ?

facebook

Erlang

So, Who Uses FP ?

Scala

So, Who Uses FP ?

Wall Street

(all of the above)

So, Who Uses FP ?

…CSE 116

Course Mechanics and Logistics

Logistics

Course website:

https://ucsc-cse-114a.github.io/fall21/

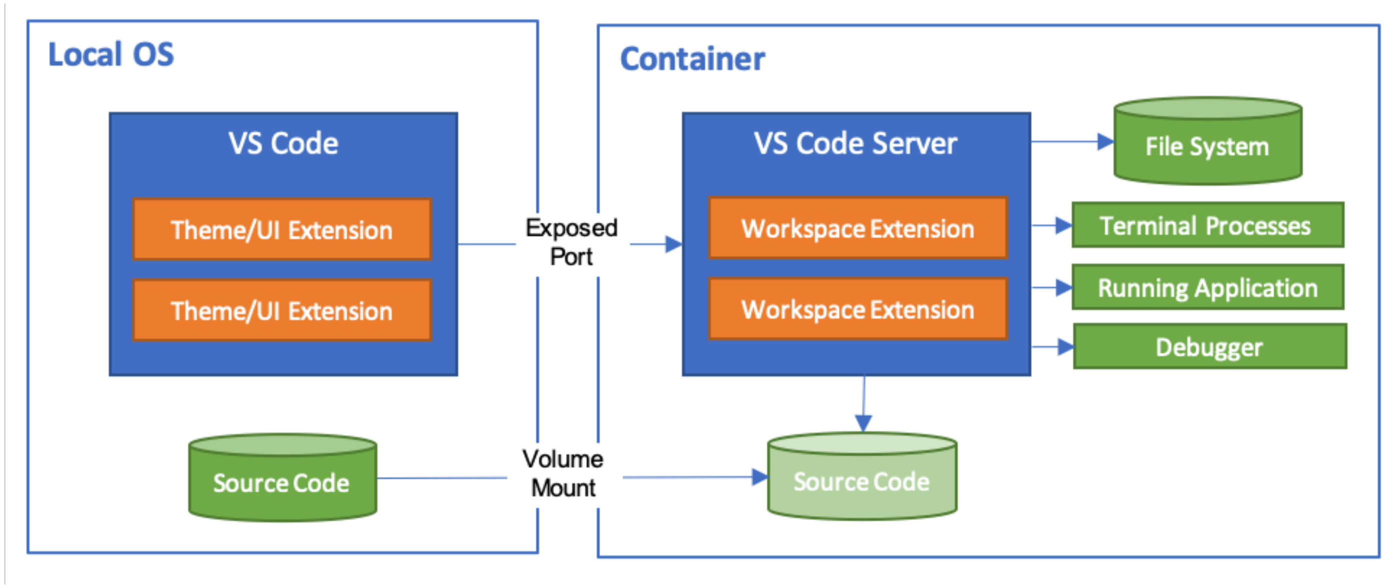
Resources

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

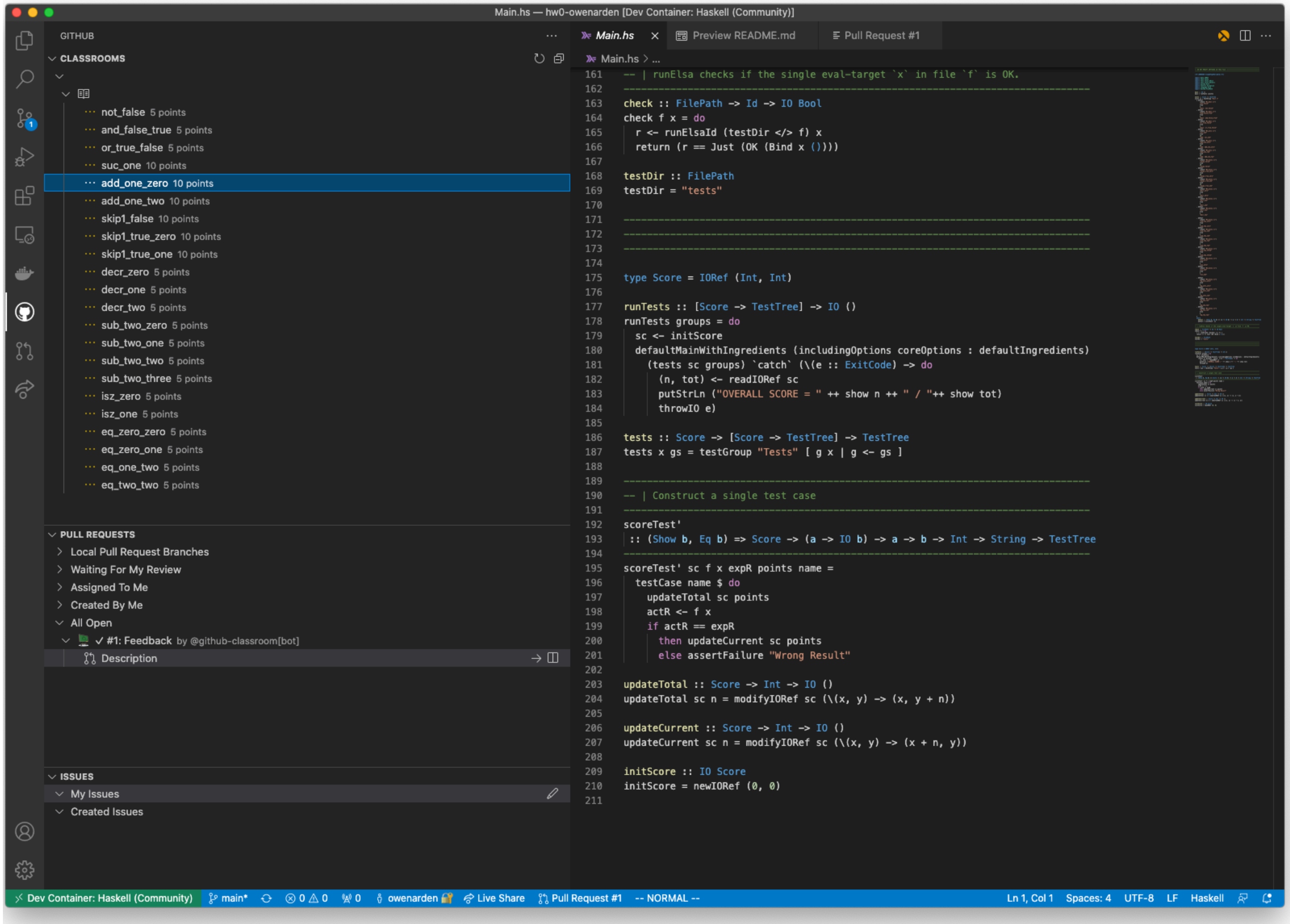


- https://github.com/UCSC-CSE-114A/cs114a-devcontainer

Recommended IDE: VS Code

- New this year, legit IDE setup for Haskell!
  - Devcontainer: A Haskell dev environment is built in a container and VS Code automatically mounts the container volume
  - 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

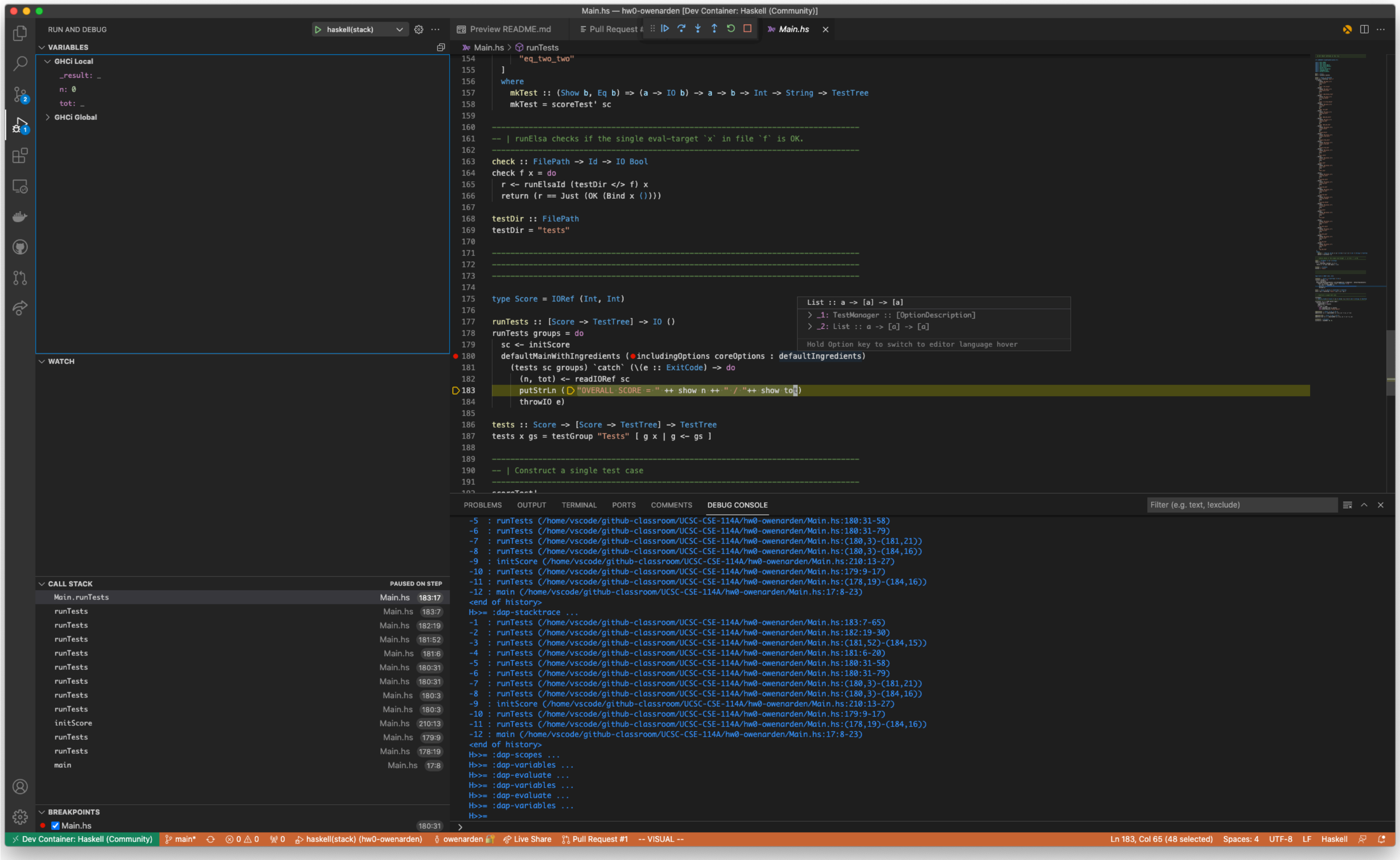
Main.hs | Preview README.md | Pull Request #1

Main.hs > ...

```haskell
-- | 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* | ⊗ 0 ⚠ 0 | 0 | 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

Main.hs > runTests

```haskell
      "eq_two_two"
  ]
  where
    mkTest :: (Show b, Eq b) => (a -> IO b) -> a -> b -> Int -> String -> TestTree
    mkTest = scoreTest' sc

--------------------------------------------------------------------------------
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    (tests sc groups) `catch` (\(e :: ExitCode) -> do
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      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
```

DEBUG CONSOLE

```
-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)
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-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* · 0 0 · 0 · 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

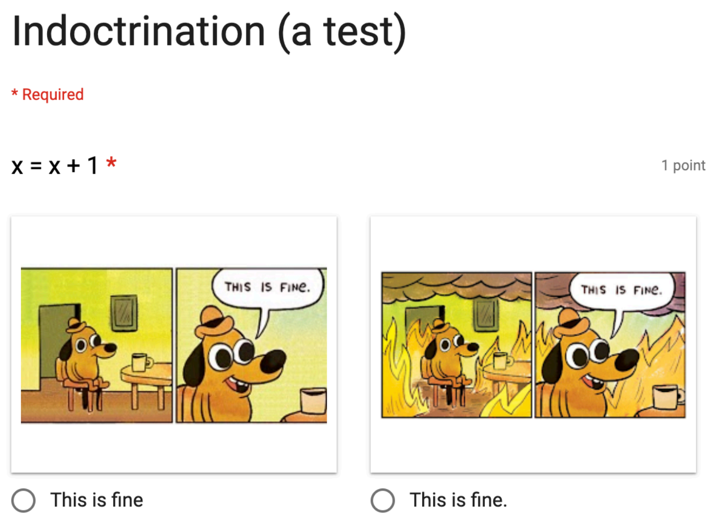
2. Discuss: Analyze Problem with neighbors
   - Practice analyzing, talking about tricky notions
   - Reach consensus
   - Have questions, raise your hand!

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):

Indoctrination (a test)

* Required

x = x + 1 *

1 point

THIS IS FINE.

THIS IS FINE.

○ This is fine

○ This is fine.

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
- Webcasts:
  - User: cse-116-1
  - Pass: lambda
- Pay attention to lecture and section!
- Do assignments yourself (+partner)!

Ask for help!

- Lots of help available, will be adding more soon. (watch website)
- Lab sessions 4 days/wk with tutors to help with assignments
- Discussion sections with TAs to help with lecture concepts

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.

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