Programming Languages and Techniques (CIS120)

Lecture 1

Welcome

Introduction to Program Design

Introductions

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*Pronounced phonetically as: "zuh dans wick". I won't get upset if you mispronounce my name (really!). I will answer to anything remotely close, or, you can call me just Professor, or Professor Z. Whatever you feel comfortable with.

What is CIS 120?

- CIS 120 is a course in **program design**
- Practical skills:
  - ability to write larger (~1000 lines) programs
  - increased independence ("working without a recipe")
  - test-driven development, principled debugging
- Conceptual foundations:
  - common data structures and algorithms
  - several different programming idioms
  - focus on modularity and compositionality
  - derived from first principles throughout
- It will be fun!

Prerequisites

- We assume you can already write small (10- to 100-line) programs in some imperative or object-oriented language
  - Java experience is *strongly recommended*
  - CIS 110 or AP CS is typical
  - You should be familiar with using a compiler, editing code, and running programs you have created
- CIS 110 is an alternative to this course
  - See: https://advising.cis.upenn.edu/cis110
  - If you have doubts, come talk to an instructor or one of the TAs to figure out the right course for you

CIS 120 Tools

- OCaml
  - Industrial-strength, statically-typed *functional* programming language
  - Lightweight, approachable setting for learning about program design

- Java
  - Industrial-strength, statically-typed *object-oriented* language
  - Many tools/libraries/resources available

- Eclipse
  - Widely used IDE

Codio

- Codio codio.com
  - web-based development environment
  - see Piazza / class mailing list for setup info
  - *remote access for on-line TA help*

- Under the hood:
  - linux virtual machine (Ubuntu)
  - pre-configured per project with everything you need

Why two languages??

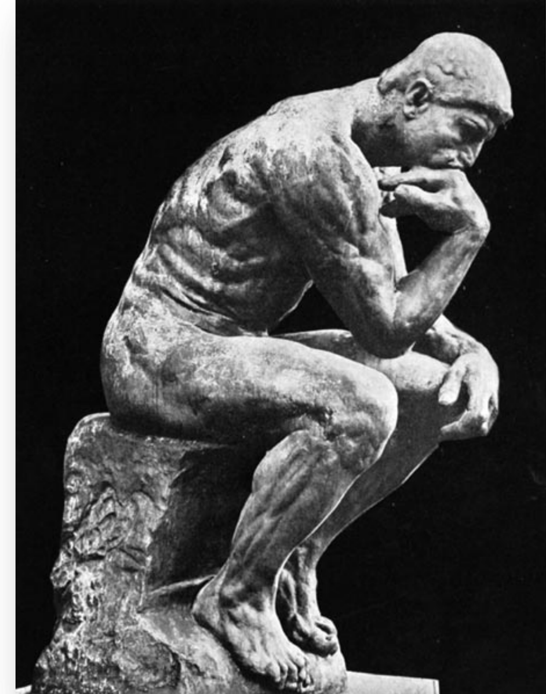
- Clean pedagogical progression
- Level playing field for class with disparate backgrounds
- Practice in learning new tools
- Different perspectives on programming

"[The OCaml part of the class] was very essential to getting fundamental ideas of comp sci across. Without the second language it is easy to fall into routine and syntax lock where you don't really understand the bigger picture."
---Anonymous CIS 120 Student

"[OCaml] made me better understand features of Java that seemed innate to programming, which were merely abstractions and assumptions that Java made. It made me a better Java programmer."
--- Anonymous CIS 120 Student

Philosophy

- Introductory computer science
  - Start with basic skills of "algorithmic thinking" (AP/110)
  - Develop systematic design and analysis skills in the context of larger and more challenging problems (120)
  - Practice with industrial-strength tools and design processes (120, 121, and beyond)
- Role of CIS120 and *program design*
  - Start with foundations of programming using the elegant design and precise semantics of the OCaml language
  - Transition (back) to Java *after* setting up the context needed to understand why Java and OO programming are useful tools
  - Give a taste of the breadth and depth of CS



Administrivia

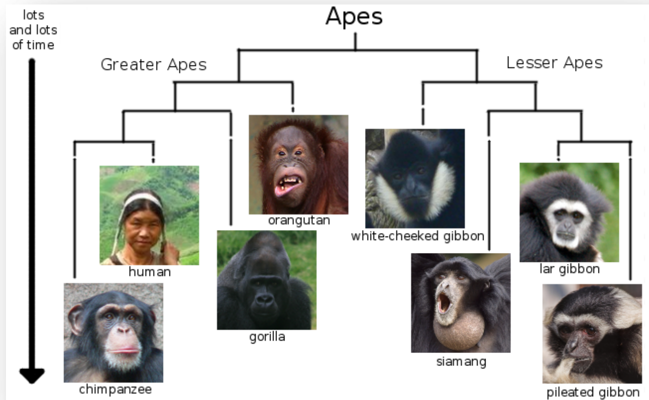
http://www.seas.upenn.edu/~cis120/

Course Grade Breakdown

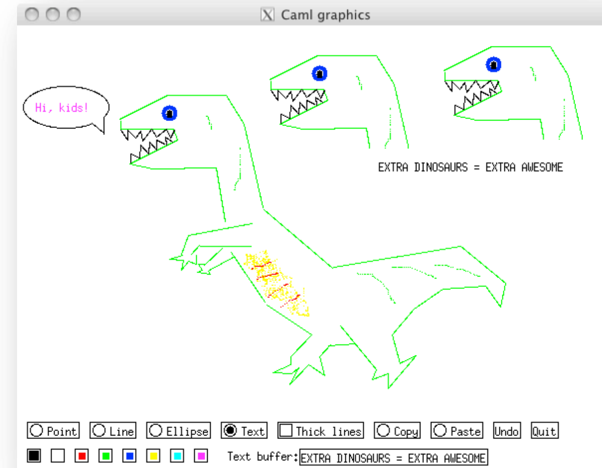
- Lectures (2% of final grade)
  - Presentation of ideas and concepts, interactive demos
  - Lecture notes & screencasts available on course website.
  - Grade based on participation using "Poll Everywhere"
- Recitations / Labs (6% of final grade)
  - Practice and discussion in small group setting
  - Grade based on participation
- Homework (50% of final grade)
  - Practice, experience with tools
  - Exposure to broad ideas of computer science
  - Grade based on automated tests + style
  - First assignment due Sept. 10 – available now
- Exams (42% of final grade)
  - 2 midterms (12% each) and a final (18%)
  - In class exams (pencil and paper)
  - Do you understand the terminology? Can you reason about programs? Can you synthesize solutions?

Warning: This is a *challenging* and *time consuming* (and hopefully rewarding :-)) course!

Some of the homework assignments…



Computing with DNA



Building a GUI Framework

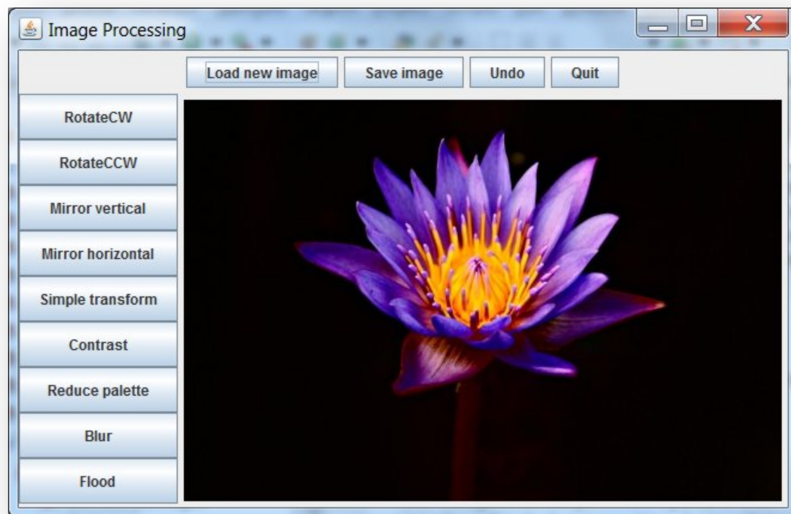
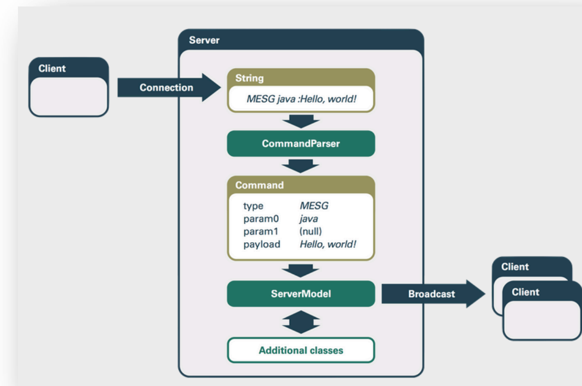
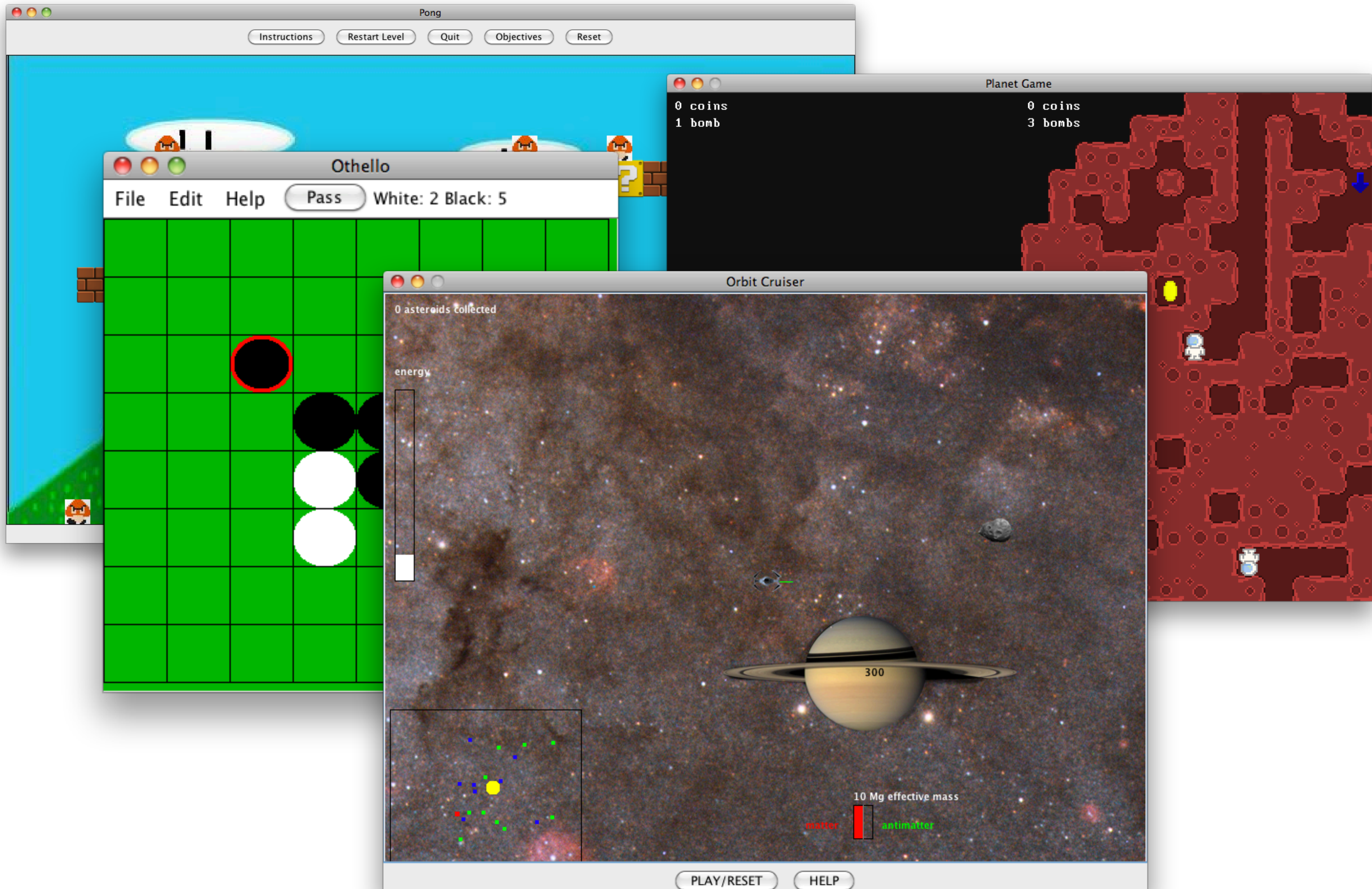


Image Processing



Chat Client/Server

Final project: Design a Game



Lectures / Recitations / Lab Sections

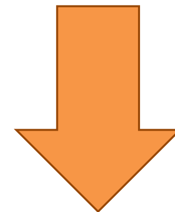
- The lecture material in the sections 001 and 002 will be identical
- Recitations start *next week*
  - Bring your laptops to recitation
  - Try Codio before the first meeting
- Goals of first meeting:
  - Meet your TAs and classmates
  - Practice with OCaml before your first homework is due
- Office hours times on the web site calendar (under “Help” tab)
  - Will be filled out soon

Poll Everywhere

- We will use *Poll Everywhere* for interactive exercises during most lectures
  - Wrong answers do not count against your grade
- You use your phone & website to post your answer.
- You can also *text* the answer directly
- Bring it to lecture every day, beginning Friday
  - Participation grades start Monday in 2 weeks

No Devices

- Laptops *closed*… minds *open*
  - Although this is a computer science class, the use of electronic devices – laptops, cellphones, Kindles, iPads, etc., during lecture (except for participating in quizzes) is *prohibited*.
- Why?
  - Laptop users tend to surf/chat/e-mail/game/text/tweet/etc.
  - They also distract those around them
  - Better to take notes *by hand*
  - You will get plenty of time in front of your computers while working on the course projects :-)



Piazza

- We will use Piazza for most communications in this course
  - from us to you
  - from you to us
  - from you to each other
- If you are registered for the course, you should have been signed up automatically
- If not, please sign up at piazza.com

Academic Integrity

- Submitted homework must be *your individual work*

- Not OK:
  - Copying or otherwise looking at someone else's code
  - Sharing your code in any way
    (copy-paste, github, paper and pencil, …)
  - Using code from a previous semester
- OK (and encouraged!):
  - Discussions of concepts
  - Discussion of debugging strategies
  - Verbally sharing experience

Penn's code of academic integrity:

http://www.upenn.edu/academicintegrity/ai_codeofacademicintegrity.html

Enforcement

- Course staff *will* check for copying
  - We use plagiarism detection tools on your code

Violations will be treated seriously!

- *Questions? See the course FAQ. If in doubt, ask.*

Program Design

Fundamental Design Process

Design is the process of translating informal specifications ("word problems") into running code.

1. *Understand* the problem
   What are the relevant concepts and how do they relate?
2. Formalize the *interface*
   How should the program interact with its environment?
3. Write *test cases*
   How does the program behave on typical inputs?
   On unusual ones? On erroneous ones?
4. *Implement* the required behavior
   Often by decomposing the problem into simpler ones
   and applying the same recipe to each

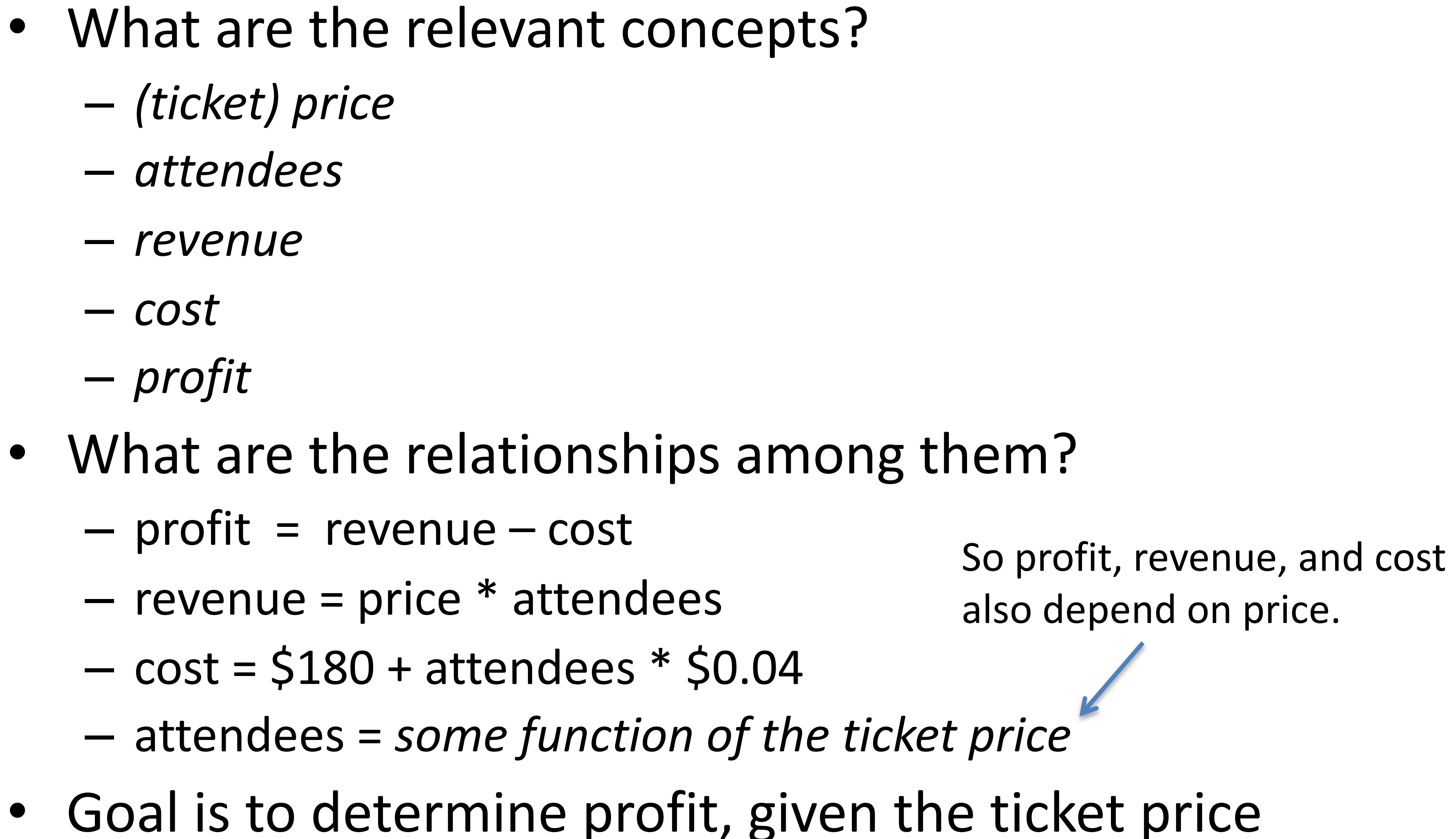
A design problem

Imagine that you own a movie theater. The more you charge, the fewer people can afford tickets. In a recent experiment, you determined a relationship between the price of a ticket and average attendance. At a price of $5.00 per ticket, 120 people attend a performance. Decreasing the price by a dime ($.10) increases attendance by 15.

However, increased attendance also comes at increased cost; each attendee costs four cents ($0.04). Every performance also has a base cost of $180.

At what price do you make the highest profit?

Step 1: Understand the problem



Step 2: Formalize the Interface

*Idea: we'll represent money in cents, using integers**

comment documents the design decision

type annotations declare the input and output types**

```
(* Money is represented in cents. *)
let profit (price : int) : int = …
```

* Floating point is generally a *bad* choice for representing money: bankers use different rounding conventions than the IEEE floating point standard, and floating point arithmetic isn't as exact as you might like. Try calculating 0.1 + 0.1 + 0.1 sometime in your favorite programming language…

**OCaml will let you omit these type annotations, but including them is *mandatory* for CIS120. Using type annotations is good documentation; they also improve the error messages you get from the compiler. When you get a type error message from the compiler, the first thing you should do is check that your type annotations are there and that they are what you expect.

Step 3: Write test cases

- By looking at the design problem, we can calculate specific test cases

```
let profit_500 : int =
   let price     = 500 in
   let attendees = 120 in
   let revenue   = price * attendees in
   let cost      = 18000 + 4 * attendees in
   revenue - cost
```

Writing the Test Cases in OCaml

- Record the test cases as assertions in the program:
  - the *command* run_test executes a test

a *test* is just a function that takes no input and returns true if the test succeeds

```
let test () : bool =
   (profit 500) = profit_500

;; run_test "profit at $5.00" test
```

the string in quotes identifies the test in printed output (if it fails)

note the use of double semicolons before commands

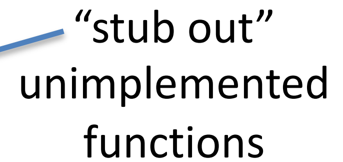
Step 4: Implement the Behavior

`profit`, `revenue`, and **`cost`** are easy to define:

```
let attendees (price : int) = ...

let profit (price : int) =
   (revenue price) - (cost price)
```

Apply the Design Pattern Recursively

`attendees` requires a bit of thought:

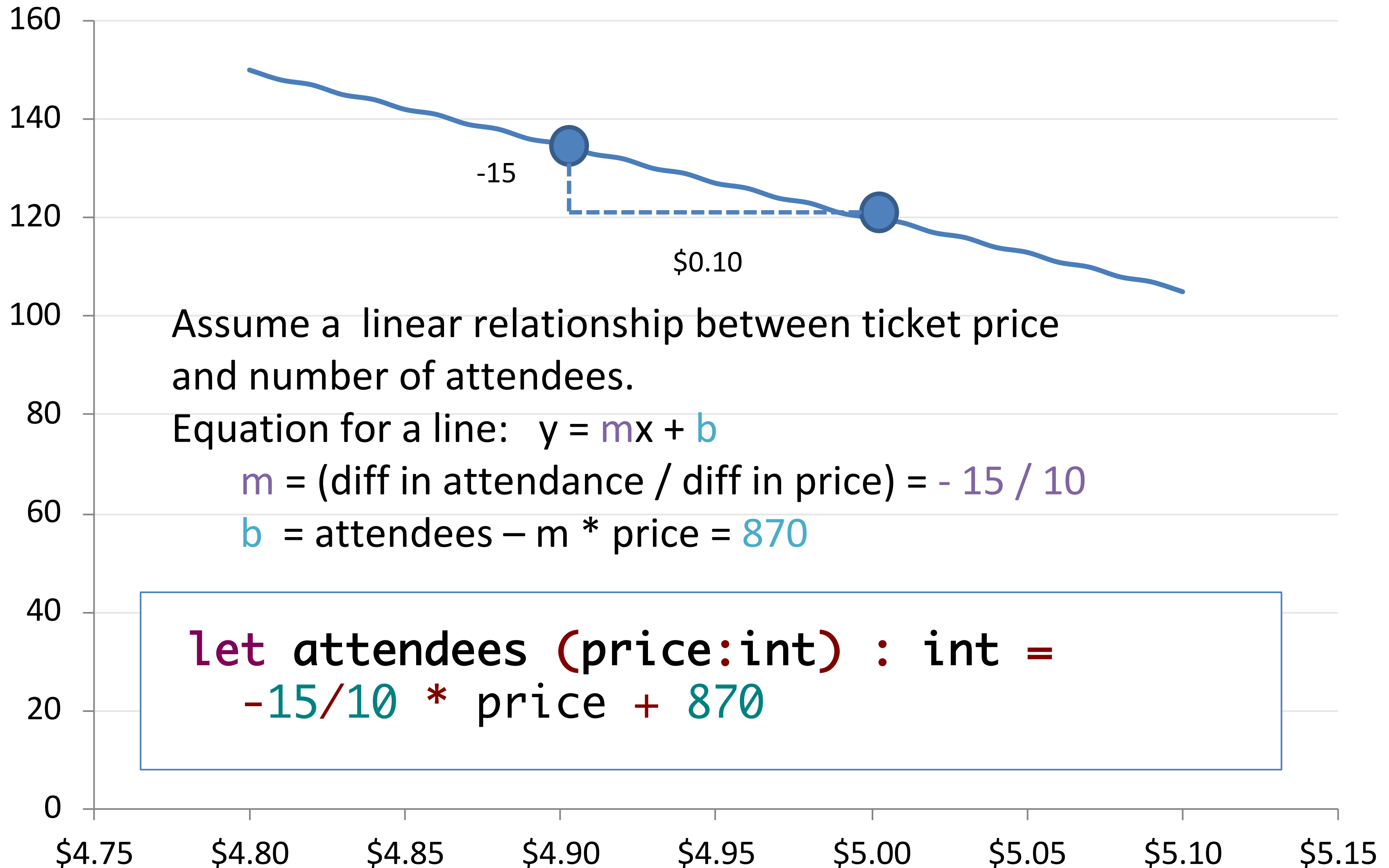



```
let attendees (price : int) : int =
   failwith “unimplemented”

let test () : bool =
   (attendees 500) = 120
;; run_test "attendees at $5.00" test

let test () : bool =
   (attendees 490) = 135
;; run_test "attendees at $4.90" test
```

generate the tests from the problem statement *first*.

*Note that the definition of attendees must go *before* the definition of profit because profit uses the attendees function.

Attendees vs. Ticket Price



Run!

Run the program!

- One of our test cases for attendees failed…
- Debugging reveals that integer division is tricky*
- Here is the fixed version:

```
let attendees (price:int) :int =
    (-15 * price) / 10 + 870
```

*Using integer arithmetic, -15 / 10 evaluates to -1, since -1.5 rounds to -1. Multiplying `-15*price` before dividing by 10 increases the precision because rounding errors don't creep in.

Using Tests

Modern approaches to software engineering advocate *test-driven development*, where tests are written very early in the programming process and used to drive the rest of the process.

We are big believers in this philosophy, and we'll be using it throughout the course.

In the homework template, we may provide one or more tests for each of the problems. They will generally not be complete. You should *start* each problem by making up *more* tests.

How *not* to Solve this Problem

```
let profit price =
   price * (-15 * price / 10 + 870) -
   (18000 + 4 * (-15 * price / 10 + 870))
```

This program is bad because it

- hides the structure and abstractions of the problem
- duplicates code that could be shared
- doesn't document the interface via types and comments

Note that it still *passes all the tests!*

Summary

- *To read:* Chapter 1 of the lecture notes and course syllabus. Both available on the course website
- *To do*: Sign up for Codio and try to log in.
  - TAs will hold office hours this week to help.
  - You can also use Piazza for discussions.
- *To do*: Register for Poll Everywhere.
  - Polls will start on Friday.

Textbook

- Textbook (free download)
  - http://www.seas.upenn.edu/~cis120/current/notes/120notes.pdf
  - written by the course instructors, closely follows the lectures
  - updated throughout the semester