Quiz

- What are three perspectives/roles from which you may consider software quality?
- What is one concern for each of these perspectives?
Why Do We Test?

- Recall: What role did testing play in the process we saw last time?
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  - Measurement – Testing provides a metric of software quality
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  Each test T can check a requirement
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E.g. for requirements / criteria R1, R2, R3, R4
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\[ T_1 \rightarrow R_1, R_2 \]
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T₁ → R₁, R₂ ✓
T₂ → R₃ ✓
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\[
\begin{align*}
T₁ & \rightarrow R₁, R₂ & \checkmark \\
T₂ & \rightarrow R₃ & \checkmark \\
T₃ & \rightarrow R₄ & \times 
\end{align*}
\]
But What is Testing?

_Reasoning_ about behavior is hard/subtle.
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*Reasoning* about behavior is hard/subtle.

*Running* a program is easy (easier)....
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*Testing* (informally):
Running the program to see if it behaves as expected
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**Testing** (informally):
Running the program to see if it behaves as expected

Simple idea, but...
- More than half of development cost
- Still cheaper than not testing
- Testing well is hard
Ideas?

Run a program on all inputs:

```python
for test in allPossibleInputs:
    run_program(test)
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A primitive example of fuzz testing.
Need A Bit More Care

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We can use this framework to refine how we test
Targeting Quality Objectives

- **Functional**
  - Does the program provide expected output for a given input?
  
  e.g. ...
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We'll start this semester by looking at functional goals.
Subtle Terminology

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The later a defect is found, the more it costs to fix. *Why?*
void toUppercase(char *str) {
    for (int i = 0, e = strlen(str) - 1; i < e; ++i) {
        if (isletter(str[i]) && islower(str[i])) {
            str[i] = str[i] - 32;
        }
    }
    printf("%s\n", str);
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What exactly do we mean by test case?
Test Cases

Test cases need

- Input to provide the program
- Expected output or behavior to check for correctness
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But where does the expected behavior come from?
- An *oracle*
Test Oracles

- In general, a means of deciding whether a test *passes* or *fails* (was the behavior expected or not)
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  - Is result strictly specified? (content, order, timing, ...)
  - Is the program deterministic?
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  - How are unit tests evaluated? (Test Drivers!)
- Sometimes tricky
  - Is result strictly specified? (content, order, timing, ...)
  - Is the program deterministic?
- Sometimes requires a person
  - Expensive and undesirable
  - “Does this software meet my needs?”
Coverage / Adequacy

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- Lack of failures provides enough confidence that the software is acceptable
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Key Idea:

- Find a smaller test suite that is representative of our goals
Approaches

- Test until you run out of time
- Test until you run out of money
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- Identify redundant inputs based on *the specification*
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No approach covers everything you want! Need to combine them for a balanced approach toward the desired goals.
Next Up...

Revisit the basics of unit testing.