EECS 481 — Software Engineering  
Winter 2019 — Exam #1

• Write your UM uniqname and UMID and your name on the exam.

• There are ten (10) pages in this exam (including this one) and seven (7) questions, each with multiple parts. Some questions span multiple pages. If you get stuck on a question, move on and come back to it later.

• You have 1 hour and 20 minutes to work on the exam.

• The exam is closed book, but you may refer to your two page-sides of notes.

• Even vaguely looking at a cellphone or similar device (e.g., tablet computer) during this exam is cheating.

• Please write your answers in the space provided on the exam. Clearly mark your solutions. You may use the backs of the exam pages as scratch paper. Do not use any additional scratch paper.

• Solutions will be graded on correctness and clarity. Each problem has a relatively simple and straightforward solution. We may deduct points if your solution is far more complicated than necessary.
  
  – Good Writing Example: Testing is an expensive activity associated with software maintenance.
  – Bad Writing Example: Im in ur class, @cing ur t3stz!!

• If you leave a non-extra-credit portion of the exam blank, you will receive one-third of the points for that small portion (rounded down) for not wasting time.

UM uniqname:  ________________________________

UM ID:  ________________________________

Name (print):  ________________________________
UM uniqname: (yes, again!) _______________________

UM ID: (yes, again!) _______________________

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How do you think you did? _______________________________
Unrealistic Software is developing a hot new online multiplayer game, *ApexUnknown’s Defense League of OverGrounds Legendary Pals 76*.

--- Managers decide to plan the organization of various software development activities into distinct phases.

--- Managers decide to focus on the construction of an increasingly-complex series of working prototypes.

--- Managers decide to use the Maintainability Index to assess the code because it is built in to Visual Studio.

--- The Maintainability Index misleads the managers by pointing out code that is large, rather than code that is truly difficult to maintain.

--- Developers are instructed to lower the Maintainability Index at any cost, resulting in methods that are very short but almost impossible to comprehend or maintain.

--- Developers are worried about the quality of the software prototype. Internally, they use a tool to randomly generate and run inputs.

--- Developers decide, for simplicity, that at the very least their software should not crash or throw exceptions on those random inputs.

--- A new defect report comes in. QA finds it to be a valid report and not a duplicate. Developers are instructed to address it.

--- Management decides that the new defect report must be addressed immediately: the business cost of not fixing it is deemed to be too high.

--- Management asks developers to predict how long it will take to localize and fix the defect.

--- Developers modify the code to print out which lines are visited during execution.

--- The bug report mentions the corruption of a particular memory address, so the developer uses a debugger to halt execution whenever the value at that address changes.

--- However, the code works fine when the developers run it. They cannot reproduce the defect, so they move on to other tasks.
2 Test Inputs and Coverage (18 points)

(4 pts.) Give a smallest test suite for lamarr() below that maximizes statement coverage for statements S_1 through S_8. (A test for lamarr() is a value for x and a value for y. A test suite is a set of tests.)

```c
1 void lamarr(bool x, bool y) {
2   S_1;
3   if (x == y) S_2;
4   else S_3;
5   if (x || y) S_4;
6   else S_5;
7   if (x && y) S_6;
8   else S_7;
9   S_8;
10 }
```

(2 pts.) What is the maximum path coverage possible for lamarr() in practice? (Express your answer as a fraction.)

(4 pts.) Give a smallest test suite for lamarr() that maximizes path coverage.

(4 pts.) Suppose we define full boolean coverage to require that every boolean variable or expression evaluate to true (e.g., on one input) and also to false (e.g., on another input). Give a smallest test suite for hedy() below that maximizes boolean coverage.

```c
1 void hedy(int a, int b) {
2   bool p, q;
3   p = a < b;
4   q = a > b;
5   if (p || q) S_1;
6   else S_2;
7 }
```

(4 pts.) Give a smallest test suite for hedy() that maximizes branch coverage but not boolean coverage.
3 Short Answer (18 points)

(a) (4 pts.) Support or refute the claim that spectrum-based fault localization (such as the Tarantula tool), which is based on differences in coverage between passing and failing runs, would be a useful technique for localizing memory corruption bugs.

(b) (3 pts.) For each of mocking, unit testing and integration testing, describe a defect or development scenario for which that technique is likely to work well.

(c) (3 pts.) Explain the relationship between reopened bug reports and regression testing. What process would you suggest to minimize reopened bug reports?
(d) (4 pts.) Support or refute the claim that modern passaround code review should be performed after the new code is subjected to unit and regression testing if goals of code review are taken to be “code improvement” and “reduce costs”.

(e) (4 pts.) Choose a modern passaround code review requirement from a large company (such as Facebook’s “all changes have at least two reviewers” or Google’s “you must have a readability badge in the programming language”) and support or refute the claim that that requirement aids the goals of “defect finding” and “knowledge transfer”.
4 Mutation Testing (16 points)

Consider the following implementation of ascending bubble sort and some associated test inputs, oracles and suites:

1. `def BubbleSort(arr):
2. n = len(arr) # reminder: len([5,6]) = 2
3. for i in range(n): # reminder: range(3) = [0,1,2]
4. for j in range(i):
5. if (arr[j] >= arr[j+1]):
6. arr[j], arr[j+1] = arr[j+1], arr[j] # cool python swap
7. 
8. testInput1 = [11, 22] # oracle1 = [11, 22]
9. testInput2 = [88, 66, 77] # oracle2 = [66, 77, 88]
10. testInput3 = [55, 33, 0, 99] # oracle3 = [0, 33, 55, 99]
11. 
12. testSuiteA = [ testInput1 ]
13. testSuiteB = [ testInput2, testInput3 ]

(6 pts.) Suppose the only mutation operator available to you is single variable renaming: on line A change the Bth instance of variable C to variable D. For example, one mutation might be “on line 6 change the 3rd instance of j to i”. You may only mutate the method body (lines 2–6), not the tests. Give an example of a single mutation such that both testSuiteA and testSuiteB kill that mutant (i.e., that mutant fails at least one test in testSuiteA and also fails at least one test in testSuiteB) without any Python runtime errors (i.e., no mutants that reference undefined variables and no index out of bounds accesses, etc.).

(6 pts.) You are still limited to single variable renaming mutations. Give an example of a single mutation such that one of testSuiteA or testSuiteB kills the mutant but not both (with no Python runtime errors) — and say which one kills the mutant.

(4 pts.) You may now consider any and all mutation operators. Give two advantages of higher-order mutation (i.e., multiple mutations per mutant) and two disadvantages of higher-order mutation. Use at most four sentences total.
5 Dataflow Analysis (20 points)

Consider a constant propagation dataflow analysis for string values. We associate with each variable an analysis fact: either * ("the variable holds a value, but our analysis cannot be certain which value"), # ("this point has not yet been reached by our analysis") or a particular constant string ("at this point in the program, we are certain this variable holds exactly hello"). We also include simple string concatenation. For example, if \( x = 'ada ' \) before the statement \( y = x+'lovelace' \), we conclude that \( y = 'ada lovelace' \) after it.

(10 pts.) Complete this forward string constant propagation dataflow analysis below by filling in each blank for both string variables \( s \) and \( t \).

\[ \begin{align*}
\text{START} & \quad s = \text{read()} & s = \text{read()} \\
& \quad t = "a" & t = "a" \\
& \quad s = ___, t = ___ & s = ___, t = ___ \\
& \quad s = s+"b" & s = s+"b" \\
& \quad s = ___, t = ___ & s = ___, t = ___ \\
& \quad s = t+"c" & s = t+"c" \\
& \quad \text{use}(t) & \text{use}(t) \\
& \quad s = ___, t = ___ & s = ___, t = ___ \\
& \quad t = \text{sanitize}(s) & t = \text{sanitize}(s) \\
& \quad \text{use}(t) & \text{use}(t) \\
& \quad s = ___, t = ___ & s = ___, t = ___ \\
& \quad \text{use}(t) & \text{use}(t) \\
& \quad s = ___ & s = ___ \\
& \quad \text{END} & \text{END}
\end{align*} \]

(10 pts.) We also want to known if uncontrolled string values may be used un-sanitized (i.e., in an unsafe manner). It is a bug if \textit{even part} of the string passed to the \texttt{use()} function comes from an un-sanitized, unsafe read. We associate with each variable either PU for "possibly used unsafely later" or NU for "not used unsafely later". For the same program, complete this backward dataflow analysis by filling in each blank for both string variables.

\[ \begin{align*}
\text{START} & \quad s = \text{read()} & s = \text{read()} \\
& \quad t = "a" & t = "a" \\
& \quad s = ___, t = ___ & s = ___, t = ___ \\
& \quad s = s+"b" & s = s+"b" \\
& \quad s = ___, t = ___ & s = ___, t = ___ \\
& \quad s = t+"c" & s = t+"c" \\
& \quad \text{use}(t) & \text{use}(t) \\
& \quad s = ___, t = ___ & s = ___, t = ___ \\
& \quad t = \text{sanitize}(s) & t = \text{sanitize}(s) \\
& \quad \text{use}(t) & \text{use}(t) \\
& \quad s = ___, t = ___ & s = ___, t = ___ \\
& \quad \text{use}(t) & \text{use}(t) \\
& \quad s = ___ & s = ___ \\
& \quad \text{END} & \text{END}
\end{align*} \]
6 Quality Assurance Analyses (15 points)

(5 pts.) CHESS and Eraser are dynamic analysis approaches that find bugs in concurrent or multi-threaded programs. How are they affected by test quality? List one other advantage of each approach and one other disadvantage of each approach.

(5 pts.) List two scientific or algorithmic challenges (e.g., a theoretical or “whiteboard” concern) associated with deploying a static bug-finding tool like FindBugs at a large company like Google. List three “software engineering” (e.g., process, people, management, etc.) challenges associated with deploying such a tool at such a company.

(5 pts.) Support or refute the claim that an effective approach to finding security defects (e.g., leaked passwords, buffer overruns, etc.) would be to identify frequently-executed regions of code via sampling-based profiling and apply formal code inspection to them.
7 Extra Credit (1 pt each; we are tough on reading questions)

(Feedback) What is one thing you would change about this class for next year? What is one thing you like about this class?

(Free/Participation) Make up one “believable” (but possibly outlandish) claim about the class, professor or course staff. If we get enough interesting responses, we’ll post them.

(Your Choice Reading 1) Identify one of the optional readings. Write a sentence about it that convinces us that you read it critically. (Our subjective judgment applies here — sorry!).

(Your Choice Reading 2) Identify a different optional reading. Write a sentence about it that convinces us that you read it critically. (Our subjective judgment applies here — sorry!).

(My Choice Reading 1) In “Automated Whitebox Fuzz Testing”, for what sort of “well-formed input” did they need to use the whitebox information to generate inputs?

(My Choice Reading 2) In “A Decade of Software Model Checking with SLAM”, give one key technique used by that static analysis to find API violations in software such as device drivers.