

LATE

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Question 1. Word Bank Matching (1 point each, 16 points total)

For each statement below, input the letter of the term that is best described. Note that you can click each cell to mark it off. Each word can only be used at most once.

| | | | |
|-------------------------|-------------------------------|------------------------------|-------------------------------|
| A. — Call-Graph Profile | B. — Conditional Breakpoint | C. — Observer Design Pattern | D. — Defect |
| E. — Delta Debugging | F. — Fault | G. — Fault Localization | H. — Feature Request |
| I. — Flat Profile | J. — Instrumentation | K. — Priority | L. — Requirements Elicitation |
| M. — Severity | N. — Singleton Design Pattern | O. — Stakeholder | P. — Statistical Profiling |
| Q. — Swiss Cheese Model | R. — Traceability | S. — Triage | T. — Validation |
| U. — Verification | V. — Watchpoint | | |

Q1.1:

Google surveys its users and realizes that the majority dislike the new icons for their apps. Although the icons are not causing actual technical problems in the apps, management decides that reverting the design must happen immediately as their users are reporting to be very unhappy with the changes.

Q1.2:

After Amber and her team develop their application, they enumerate requirements to determine whether each requirement is associated with a test in the final implementation.

Q1.3:

Roberto has a program that has many functions that are dependent on other functions. Roberto uses a descriptive report that details the amount of time spent executing each function as well as each function's children to have a better understanding of the performance of this program.

Q1.4:

Meimei is currently creating a library for people to use to make connections to an API she has created. Meimei needs to make sure that each person has only one connection at a time open or else the data does not get sent back from the API correctly.

Q1.5:

Parth is developing software for a company. He must determine who will be impacted by the software being created, as well as which roles people have within the target company.

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Q1.6:

A new bug report was submitted Friday afternoon. Monday morning, the quality assurance team reviews the report and determines that the report was valid and not a duplicate. The report is then passed onto the development team to address.

Q1.7:

Tom wants to create a social media network called *Tweeter*. He wants to use a design such that every new account is automatically subscribed to his. That is, if he creates a post, all accounts registered receive a notification he has created a post.

Q1.8:

You conduct customer interviews to determine that the requirements gathered accurately and completely reflect the client's needs.

Q1.9:

When Thomas and his Friends are given a project to create a railroad application for Sodor Tank Engine, Inc., they are concerned that they know nothing about the industry for which they are developing software. What can Thomas and Friends do to help understand the details their customer wants?

Q1.10:

The developers of *Brass Effect* are concerned about the performance of the game engine to maintain their beautiful graphics. They randomly interrupt the program and capture the currently-executing function to *approximate* the execution time of each function.

Q1.11:

When Vikram is working on his program, he notices that it keeps crashing, but he does not know where the crash is occurring. To determine where the program crashes, he inserts a print statement before and after each function call to determine the function that leads to the crash. What is he doing to the program?

Q1.12:

While playing *Among sUs*, Bob notices that, during runtime, whenever his character enters a specific room in the level, his score unexpectedly decreases to a negative value.

Q1.13:

Divya needs to use a model that will assist in risk analysis and risk management while also using a model that accounts for weaknesses by splitting up concerns into layers.

Q1.14:

Engineers at a top security firm are tracking a bug related to a variable that should only be changed under very specific secure circumstances. They use *this topic* to halt execution and alert the team if this value ever changes.

Q1.15:

Lynda is not able to receive orders through her *bEtsy* shop because her intern implemented a button whose code sends order information to the wrong account. This is an example of what?

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Q1.16:

... which gives a folder with 100 test inputs. When all of the tests are run in sequence, the program exhibits incorrect behavior.

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Question 2. Design Patterns (18 points total)

Consider a platform for delivering online exams. Suppose we must support a combination of (1) Coding questions, (2) Free response, and (3) Multiple Choice questions. Further, we create an Exam object for each student taking the exam. Our Exam is output as a plaintext string containing the questions.

Consider the class definitions below (While this code runs correctly, it is intentionally imperfect in other ways.):

```

1 class Exam (object):
2     # constructor
3     def __init__ (self):
4         self.coding_questions = []
5         self.free_questions = []
6         self.mc_questions = []
7
8     # coding questions
9 class CodingQuestion (object):
10    def __init__ (self, prompt, code):
11        self.prompt = prompt
12        self.code = code
13
```

Now, suppose you want to leverage polymorphism to reduce code clones.

2a. (2 points) Name a design pattern that you could use to achieve this effect.

Your answer here.

2b. (7 points) In four sentences or fewer, describe how you would change the code above to use that design pattern (summarize—no need to actually write code).

Your answer here.

2c. (4 points) In two sentences or fewer, support or refute the claim that the Exam class should be a Singleton.

Your answer here.

2d. (5 points) In three sentences or fewer, describe an example of an *anti-pattern* present in the code above.

Your answer here.

Question 3. Automated Program Repair (18 points total)

Each snippet below contains a defect (and that at least one test case is failing). Each comment indicates the desired correct behavior of the snippet.

For each snippet, indicate (1) whether or not the defect could likely be repaired by Automated Program Repair as discussed in lecture, and (2) why or why not.

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Part (a):

```

1 // returns the floating point average of a vector of integers
2 double avg(const vector<int> &v) {
3     double s = 0;
4     for (int i = 0; i > v.size(); ++i) {
5         s += v[i];
6     }
7     return (s / v.size());
8 }
9
10
```

(1 point) Yes/No: repairable by APR?

- Yes, readily fixed by APR
 No, not readily fixed by APR

(4 points) Next, Justify your answer in three sentences or fewer.

Justify your answer here.

Part (b):

```

1 // returns the range of values within a vector of integers
2 long int range(const vector<long int> &v) {
3     assert(v.size() >= 2);
4
5     long int _min = INT_MAX, _max = INT_MIN;
6     for (int i = 0; i < v.size(); ++i) {
7         _max = max(_max, v[i-1]);
8         _min = min(_min, v[i]);
9     }
10    return _max - _min;
11 }
12
13
```

(1 point) Yes/No: repairable by APR?

- Yes, readily fixed by APR
 No, not readily fixed by APR

(4 points) Next, Justify your answer in three sentences or fewer.

Justify your answer here.

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Part (c):

```

1 class WaterType { ... };
2 class Squirtle : public WaterType { ... };
3 class Wartortle : public Squirtle { ... };
4 class Blastoise : public Wartortle { ... };

// this code should return
// a Squirtle object if the string pokemon equals "Squirtle",
// a Wartortle object if the string pokemon equals "Wartortle", or
// a Blastoise object if the string pokemon equals "Blastoise".
10
11 WaterType* WaterTypeFactory(const string &pokemon) {
12     if (pokemon == "Squirtle") {
13         return new Squirtle;

```

(1 point) Yes/No: repairable by APR?

- Yes, readily fixed by APR
- No, not readily fixed by APR

(4 points) Next, Justify your answer in three sentences or fewer.

Justify your answer here.

Part d:

(4 points) In five sentences or fewer, support or reject the claim that APR can be readily applied to Java code. In particular, identify relevant issues or assumptions with APR and concretely indicate how those can or cannot be solved at the assembly level.

Justify your answer here.

Question 4. Fault Localization (15 points total)

Below is a buggy snippet from a Python program implementing a graph data structure:

```

1     ...
2 240 def containsEdge(self, fromLabel, toLabel):
3 241     return self.getEdge(toLabel, toLabel) != None
4 242
5 243 def getEdge(self, fromLabel, toLabel):
6 244     fromVertex = self.getVertex(fromLabel)
7 245     toVertex   = self.getVertex(toLabel)
8 246     return fromVertex.getEdgeTo(toVertex)
9 247
10 248 def removeEdge(self, fromLabel, toLabel):
11 249     fromVertex = self.getVertex(fromLabel)
12 250     toVertex   = self.getVertex(toLabel)
13 251     edgeRemovedFlg = fromVertex.removeEdgeTo(toVertex)

```

You are trying to use Tarantula fault localization to determine the buggy line or method. To do so, you measure the lines visited by each of five test cases for the program.

Test case 1 passes. It visits lines [240, 243, 248].

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Test case 2 fails. It visits lines [240, 241, 243, 244, 245, 246, 248].

Test case 3 passes. It visits lines [240, 243, 248].

Test case 4 passes. It visits lines [240, 243, 244, 245, 246, 248].

Test case 5 passes. It visits lines [240, 241, 243, 244, 245, 246, 248, 249, 250, 251, 252, 253, 254].

You are told that the suspiciousness rating for Tarantula is computed as follows:

$$s(s) = (\text{failed}(s) / \text{totalfailed}) / ((\text{failed}(s) / \text{totalfailed}) + \text{passed}(s) / \text{totalpassed}),$$

where totalpassed is the number of passing test cases and $\text{passed}(s)$ is the number of those that executed line s (similarly for totalfailed and $\text{failed}(s)$).

(a) (5 points) Given the information above, use the Tarantula fault localization metric to determine the top 10 most suspicious lines of code, along with their suspiciousness scores.

Give your answer in the form $\{\text{line_no}: \text{sus_score}, \dots, \text{line_no}: \text{sus_score}\}$, in descending order of suspiciousness scores rounded to 3 decimal places. Break ties among suspiciousness scores by ascending line order. For example, $\{143: 1.500, 23: 1.000, 233: 0.500, 407: 0.250, 57: 0.200\}$.

(Hint: You can save time by not computing the suspiciousness scores of lines that correspond to whitespace.)

Suspiciousness scores here.

Example format: $\{143: 1.500, 23: 1.000, 233: 0.500, 407: 0.250, 57: 0.200\}$

(Please make sure your answer is in the form of a valid Python dictionary syntax.)

Use this information to determine which line contains the bug. If no one line is clearly implicated, indicate what method is the buggy one.

Buggy line or method here.

(b) (5 points) Consider now the following buggy `addEdge` method from the same Python program:

```

1 234     def addEdge(self, fromLabel, toLabel, weight):
2 235         fromVertex = self.getVertex(fromLabel)
3 236         toVertex   = self.getVertex(toLabel)
4 237         fromVertex.addEdgeTo(toVertex, weight)
5 238         self._edgeCount -= 1 # bug here: this should be self._edgeCount += 1

```

You can assume the bug in this method is the only bug in the entire program. You re-run all five test cases and use Tarantula to re-compute the suspiciousness scores of the top 10 most suspicious lines.

The scores are as follows:

$\{241: 1.0, 249: 1.0, 250: 1.0, 251: 1.0, 252: 1.0, 253: 1.0, 254: 1.0, 235: 0.600, 236: 0.600, 237: 0.600\}$

(c) (5 points) You see that correct lines are falsely implicated by Tarantula. Furthermore, line 238 (the buggy line) is not implicated by Tarantula (in that it is not part of the top 10 most suspicious lines). What could have caused this to happen? Briefly explain why fault localization metrics such as Tarantula may not always work as expected.

Answer to Question 4b here.

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Question 5. Delta Debugging (15 points)

PowerGlee is a company that produces software for terrible energy meters. They have decided to use Delta Debugging to help with aspects of Requirements Elicitation and Project Planning for quality properties. The company is trying to improve their energy meter software.

There is a finite set $Q = \{q_0, \dots, q_n\}$ of quality properties the software might potentially hold. For example, perhaps q_0 represents the software meeting a particular security standard, q_1 represents the software meeting a particular ease-of-use standard, and so on.

For any subset of properties $Q' \subseteq Q$, the company can construct a prototype to demonstrate to the customer and ask the customer if those properties are enough to be acceptable. We model this with a function $\text{Customer} : Q \rightarrow \text{Boolean}$. For this problem, the function Customer is Monotonic, Unambiguous, and Consistent.

In addition, each property q_i has an associated cost c_i to build into the final developed software. For this problem, the costs are strictly additive, so the total cost of $\{q_3, q_7\}$ is $c_3 + c_7$, and so on. The customer has agreed to pay $price$ for finished software that meets the requirements, so the company is only interested in developing it if the total cost is less than $price$ (i.e., if producing software with those properties would turn a profit).

The company uses Delta Debugging to guide the Requirements Elicitation and Project Planning processes to find a small set of quality properties that is both acceptable to the customer and also profitable:

$$\text{Interesting}(Q) = \text{Customer}(Q) \wedge \sum_{(q_i \in Q)} c_i < price$$

(Prose description: $\text{Interesting}(Q)$ is true if $\text{Customer}(Q)$ is true AND the sum of all costs associated with each quality property is less than $price$.)

In a particular situation, $n = 9$, the customer will accept the software if it contains at least properties q_3 and q_4 , the agreed $price$ is 1000, and the costs c_i are given as follows:

- $c_0 = 396$
- $c_1 = 235$
- $c_2 = 257$
- $c_3 = 200$
- $c_4 = 300$
- $c_5 = 333$
- $c_6 = 392$
- $c_7 = 295$
- $c_8 = 357$

(a) (3 points) What subset of Q will Delta Debugging return in this scenario? Express your answer as a comma-delimited list of integers. For instance, if you think $\{q_4, q_8\}$ is returned, write $4,8$. (If relevant, assume any Delta Debugging details are implemented exactly as presented on Slide 42 of the Delta Debugging lecture slides.)

Your answer

(b) (1 point) Is the subset Interesting? True False

(c) (1 point) Is the subset One-Minimal? True False

(d) (1 point) Is the subset Minimal? True False

Now, in a second situation, the customer will accept the software if it contains at least the properties q_3 and q_8 . Everything else is unchanged from above.

(e) (3 points) What subset of Q will Delta Debugging return in this scenario? Express your answer as a comma-delimited list of integers. For instance, if you think $\{q_4, q_8\}$ is returned, write $4,8$.

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Your answer

(f) (1 point) Is the subset Interesting? True False(g) (1 point) Is the subset One-Minimal? True False(1 point) Is the subset Minimal? True False

(3 points) This use of Delta Debugging is attempting to help with:

- Verification
- Validation
- Both
- Neither

(j) This formulation violates one of the assumptions or preconditions assumed by Delta Debugging. Which one is being violated and why?

Place your answer here. Which assumption is violated and why?

Question 6. Short Answer (18 points total, 6 points each)

Provide an answer to each of the questions below. For each answer, use five sentences or fewer.

(a) (6 points) Support or refute the claim that companies should use "anonymized interviewing" for *technical skills interviews*. In an anonymized interview, the interviewer has no information on physical appearances, accents, races or ethnicities, or the like of candidates. Consider false positives (hiring unqualified candidates), false negatives (failing to hire qualified candidates), and cost (to the company).

Place your answer here.

(b) (6 points) Support or refute the claim that companies should use "anonymized interviewing" for *behavioral interviews*. In an anonymized interview, the interviewer has no information on physical appearances, accents, races or ethnicities, or the like of candidates. Consider false positives (hiring unqualified candidates), false negatives (failing to hire qualified candidates), and cost (to the company).

Place your answer here.

(c) (6 points) Suppose you are eliciting requirements from a company about a new software project that allows users to rate others on the effectiveness of their mask compliance. The customer indicates:

The product should offer a safe experience for the user.

In your answer, indicate:

1. which nonfunctional requirement corresponds to the customer's informal description,
2. what question you might ask the customer that would help create a formal requirement from this informal description, and
3. an example of a test case (no need to write code, just describe what the test case would do) that can be traced to such a formal requirement or indicate why no test case is feasible.

Place your answer here.

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Question 7. Extra Credit (1 point each)

(Feedback) What was your favorite topic covered during the course?

What is one thing you like about this class?

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(Feedback) What was your least favorite topic covered during the course?

What is one thing you dislike about this class?

(Optional Psych) Describe (or make up) a software engineering scenario in which *the suspension bridge effect* may impact software quality.

Suspension bridge effect.

(Optional Reading 1) Identify a single optional reading. Write a sentence about it that convinces us you read it critically.

Optional Reading 1

(Optional Reading 2) Identify another single optional reading. Write a sentence about it that convinces us you read it critically.

asdf

(Optional Lectures) List two things you learned from "World Building", "Quantum Computing and Romance Novels" and/or "Career Development and Failure", in any combination, that were **not** listed on an introductory summary slide.

asdf

Honor Pledge and Exam Submission

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- I have neither given nor received unauthorized aid on this exam.
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