

We have received 23 autosaves or submissions from yabella in total.

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We are grading

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Question 1. Word Bank Matching (1 point each, 14 points)

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

A. — Adapter Design Pattern	B. — Bug Bounties	C. — Concurrency Bug	D. — Delta Debugging
E. — Fault Localization	F. — Functional Requirements	G. — Fuzz Testing	H. — Informal Goal
I. — Mocking	J. — Multi-Language Projects	K. — Mutation Testing	L. — Named Constructor Idiom Pattern
M. — Perverse Incentive	N. — Productivity	O. — Profiling	P. — Quality Requirement
Q. — Readability	R. — Requirement Elicitation	S. — Risk	T. — Singleton Design Pattern
U. — Stakeholder	V. — Traceability	W. — Triage	X. — Validation
Y. — Weak Conflict			

Q1.1:

V

Sreya is confused why they have to implement a certain feature. Luckily the design document has **THIS VOCAB TERM**, which allows them to identify which requirement the implementation is decomposed from

Q1.2:

D

Arian works for Netfleecs, a new image sharing service. They have 1000 pictures that they use as test inputs, which leads to 97% code coverage. They believe this amount of videos is excessive and want to find the minimal set of videos that will have the same coverage.

Q1.3:

T

Alex is working on a new music streaming application. Instead of using various global variables to track certain song information, they track these properties using only one instance of a class.

Q1.4:

Y

481andMe is in the ideation phase of a new online movie rental platform. One stakeholder provides the requirement that renters should lose access to a movie after 30 days. Another stakeholder says that renters should lose access to a movie only after the first time that they watch it.

Q1.5:

C

Some users of Ann Arbor Public Library's website are reporting issues where they attempt to place a book on hold that the website says is available. However, when they click 'Confirm!', they are shown a 'Book Not In Stock' error. The website's developers theorize that this is due to different members placing the same book on hold at the same time and hope to use CHESS to help identify this kind of bug.

Q1.6:

G

In order to test the login system of the new social media platform, Pinstagram, Xiangyu writes a test that tries to login with a variety of malformed and unexpected inputs, which are randomly generated, to see if the system is robust enough to handle them.

Q1.7:

U

You are working on a video streaming platform and have an idea to remove advertisements entirely from the platform, hoping to improve customer satisfaction. First, you consult and get feedback from the people/groups who might be affected by this change.

Q1.8:

X

Patrick was contracted by Gogo to fix a slew of security issues in their software. After Patrick met with Gogo's leadership, they reviewed the requirements and noticed that all of them related to usability and latency, not security (their target issue).

Q1.9:

F

Larry is on the advertising infrastructure team for 123movies, who is making a brand new augmented reality headset. 123movies's leadership has this requirement: they want the headset to have a feature where if the user looks at an object for more than 30 seconds, an advertisement about it will pop up.

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Q1.10:

L

Aang is creating an enemy class while developing the new Sonic the Hamster game. The class has many constructors, each differing slightly (number of parameters, parameter types etc...) to improve readability and reduce future confusion, they make these constructors private and make public functions with more descriptive names that call these constructors

Q1.11:

B

Rulu has a very small engineering team that has been working on a banking app. As a result, they may have missed some subtle bugs that could compromise their customers' security. They start a program where users can report novel bugs in their software in exchange for a monetary reward

Q1.12:

K

Jingyi wants to make sure that his test suite is good enough to get all the points on the Autograder. He purposefully makes minor changes to his source code to check if at least one test will fail due to the change.

Q1.13:

A

Emily needs to create a custom Stack interface so they use an already existing LinkedList interface to aid their implementation of the Stack interface.

Q1.14:

J

One of the projects in EECS 485 is to build an Instagram clone using React (JavaScript) for the frontend and Flask (Python) for the backend. Each language is better than the other for its specific task but they communicate with each other using JSON messages. This project is an example of **THIS VOCAB TERM**.

Question 2. Delta Debugging (21 points)

```

2      [5, 6, 7, 8, 9] - Not Interesting
3      [0, 1, 2, 3, 4, 5, 6] - Not Interesting
4      [0, 1, 2, 3, 4, 7, 8, 9] - Not Interesting
5      [0, 1, 2, 3, 4, 5, 6, 7] - Not Interesting
6      [0, 1, 2, 3, 4, 5, 6, 8, 9] - Not Interesting
7      [0, 1, 2, 3, 4, 5, 6, 7, 8] - Not Interesting
8      [0, 1, 2, 3, 4, 5, 6, 7, 9] - Interesting
9      [0, 1, 2, 3, 4, 7, 8, 9, 5] - Not Interesting
10     [0, 1, 2, 3, 4, 7, 8, 9, 6] - Interesting
11     [5, 6, 7, 8, 9, 0, 1] - Interesting
12     [5, 6, 7, 8, 9, 0] - Not Interesting
13     [5, 6, 7, 8, 9, 1] - Not Interesting
14

```

(a) (3 points)

What's The Answer Given The Logs?

Consider running the delta debugging algorithm (from EECS 481) on input `[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]`. The calls to `Interesting()` are shown above along with their results. Based on this, please determine the minimal interesting subset that the algorithm will return.

Please format your answer in the form `[x, y, z, ...]`; for example, `[0, 1, 2]`.

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Your answer here.

ANSWER: [0, 1, 6, 7, 9]

Different students were presented with different logs. Answer was the interection of all the Interesting subsets.

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(b) (6 points)

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Fill In The Blanks

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The following table displays "True" or "False" for the **first three** Interesting() calls. This question involves an Interesting() function that's independent of the one from part A. Given the answers for three of these calls, fill in the expected output for the rest of the calls in this table.

If True, please also indicate which property (Ambiguity, Monotonicity, or Consistency) allows you to conclude that the subset is interesting.

If False, please also indicate which property (Ambiguity, Monotonicity, or Consistency) would be violated if the subset was interesting.

Subset	Output
Interesting({1, 2})	True
Interesting({2})	False
Interesting({6, 7, 8})	True
Interesting({1, 2, 3, 4, 5})	Question 2.b.i
Interesting({2, 4, 5, 6, 7})	Question 2.b.ii
Interesting({2, 4, 5})	Question 2.b.iii

(b.i) (2 points)

- A) True (Ambiguity)
 - B) True (Monotonicity)
 - C) True (Consistency)
 - D) False (Ambiguity)
 - E) False (Monotonicity)
 - F) False (Consistency)
- ANSWER: True (Monotonic)

(b.ii) (2 points)

- A) True (Ambiguity)
 - B) True (Monotonicity)
 - C) True (Consistency)
 - D) False (Ambiguity)
 - E) False (Monotonicity)
 - F) False (Consistency)
- ANSWER: False (Ambiguous)

(b.iii) (2 points)

- A) True (Ambiguity)
 - B) True (Monotonicity)
 - C) True (Consistency)
 - D) False (Ambiguity)
 - E) False (Monotonicity)
 - F) False (Consistency)
- ANSWER: False (Ambiguous)

(c) (3 points)

DD Performance

Please indicate if the following statement is True or False, **and** include a brief justification. Limit your entire answer to at most 2 sentences.

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Delta Debugging is most efficient when a single change is causing the failure

Your answer here.

ANSWER: True - DD runs in $O(\log n)$ time compared to $O(n)$ time if there are multiple candidate changes

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(d) (9 points)

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Will Delta Debugging Be Useful Or Not?

Please indicate whether or not Delta Debugging would be useful in each of the following scenarios. If "Not Useful", please also indicate the reason why.

(d.i) (3 points) You write a large test suite in order to get 100% line coverage when testing your source code. After coding for hours, you notice that your tests are starting to get repetitive and you suspect that your suite might already be sufficient so you want to remove the redundant tests.

- A) Useful
- B) Not Useful (Inconsistent)
- C) Not Useful (Ambiguous)
- D) Not Useful (Not Monotonic)

ANSWER: Useful

(d.ii) (3 points) We have the following line of HTML that fails to pass the HTML parser. We want to find which specific attribute is causing the issue.

```
<input className="textInput" name="color" holder="Enter for favorite color..." type="text" value={this.state.color} onChange={this.handleChange} required />
```

- A) Useful
- B) Not Useful (Inconsistent)
- C) Not Useful (Ambiguous)
- D) Not Useful (Not Monotonic)

ANSWER: Useful

(d.iii) (3 points) You just finished writing a program involving multithreading, but you are still encountering a subtle bug that is causing non-determinism. Confused about why your test suite didn't catch this, you decide to perform mutation testing to evaluate your test suite. You make 50 mutated versions of your source code before realizing that you went overboard and need to cut down on the number of mutated files to a minimal subset.

- A) Useful
- B) Not Useful (Inconsistent)
- C) Not Useful (Ambiguous)
- D) Not Useful (Not Monotonic)

ANSWER: Not Useful (Inconsistent)

Question 3. Short Answer (20 points)

(a) (5 points)

As a new manager of a team that developed an app XYZ (before you joined the team), you found that users of XYZ can see each other's sensitive data. After further analysis, you realized that the requirements elicitation fell short when developing XYZ. As a result, the team never developed functional and quality requirements for this application in terms of its security and privacy.

Give an example of **two** quality requirements that could have been used in this scenario so that the team could understand how to build a more secure application. Additionally, explain how quality requirements could have been used to avoid a situation like this.

Please limit your entire answer to no more than 4 sentences.

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Your answer here.

ANSWER:

- The system must comply with GDPR regulations
- The system must let the user know their data is being handled securely
- Quality requirements will allow the development team to build an application with the characteristics/constraints of the system in mind

(b) (5 points)

Alex, a software engineer at a leading e-commerce company, has been tasked with enhancing the checkout process on their website. Through performance monitoring and user feedback analysis, Alex identifies a bottleneck in the payment processing system that leads to delays and occasional timeouts during high traffic periods. Over the course of a week, Alex works diligently to refactor the payment processing codebase, implementing caching mechanisms and optimizing database queries to improve overall system responsiveness. Once satisfied with the changes, Alex commits the updates with the following message:

Commit: "Optimized payment processing"

Argue whether or not this commit message is a high quality commit message. If it is not a high quality commit message write a new 1-2 sentence 'high-quality' commit message for this change. Use no more than 4 sentences.

Please limit your entire answer to no more than 4 sentences.

Your answer here.

ANSWER: This is not a high quality commit message. Does not provide why the commit was made. Example of a high quality commit is "Optimized payment processing for smoother checkout experience".

(c) (5 points)

Your team is managing a large codebase for a critical software application used in finance. Recently, you've encountered several critical bugs that have been difficult to identify and fix due to the code's complexity and size. To expedite the bug-fixing process and improve overall code reliability, your team is considering implementing an automated program repair tool. However, your team is unsure how automated program repair works.

Based on EECS 481, what are **two** key steps of an automated program repair tool? What is a disadvantage of using an automated program repair tool?

Please limit your entire answer to no more than 5 sentences.

Your answer here.

ANSWER:

Examples of steps include:

- fault localization like delta debugging
- mutation to generate patches
- Static analysis to reduce tested patches
- regression testing to assess patches.

Disadvantages of automated program repair tools can include perverse incentive that optimizes the metric you said (GenProg example in lecture 24), not what you meant, false positives and negatives, etc.

(d) (5 points)

In Professor Ali Movaghar's lecture about "Introduction to Model Checking", he discusses model checking and its applications.

What is model checking? What is the motivation for model checking? Provide one system where model checking would be useful and one system where model checking wouldn't be useful.

Please limit your entire answer to no more than 4 sentences.

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Your answer here.

ANSWER:

- Model checking is an approach for verifying the temporal behavior of a system
- Motivation is to ensure that the behavior of the system is correct to guarantee safe behavior over unbounded time
- Model checking would be useful for safety critical systems (e.g. airplanes, smart vehicles)
- Would not be useful for systems where cost and effort exceeds the gains (e.g. video game)

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Question 4. Fault Localization (15 points)

Consider the following Python function snippet `song_statistics()`. It takes in a song information dictionary as input. The dictionary maps song attributes to lists containing information about that particular attribute. The current implementation calculates the number of songs with a particular length, in addition to generating playlists and other (hidden) functionality.

```
6.         song_types['long-song'] += 1
7.     elif length < 100:
8.         song_types['short-song'] += 1
9.     else:
10.        song_types['medium-song'] += 1
11.
12.    if song_types['long-song'] > 10:
13.        generate_playlist()
14.
15.    while len(song_info['titles']) > 100:
16.        ...
17.        ...
18.        ...
19.        ...
20.        ...
21.    print('song statistics captured!')
```

Consider the following table. Each row corresponds to one test case execution. In particular, each row reports one run of the program, in which it takes some song info (not shown) as input and produces output that is either correct ("Pass") or incorrect ("Fail"). Each row also includes the lines visited while the program executes on that input.

Test Case	Status	Lines Visited
1	Pass	[2, 4, 6, 12, 13, 16, 17, 19]
2	Fail	[2, 4, 12, 13, 15, 16, 17, 18, 19]
3	Pass	[2, 4, 6, 12, 13, 15, 16, 17, 20, 21]
4	Fail	[2, 5, 6, 18, 19, 20]

(a) (5 points)

Using the table information above, compute the Tarantula suspiciousness score for the top 3 most suspicious lines shown in `song_statistics()`, and provide these scores along with the line number in the answer box below. Express the final answer as a list of tuples of line numbers (ints) and scores (floats, rounded to 2 decimal places), sorted by score descending and then by line number ascending; for example, if line 2 has a suspiciousness of 1, line 1 has a suspiciousness of 0.5, and line 5 has a suspiciousness of 0.5, your answer should be [(2, 1.00), (1, 0.50), (5, 0.50)].

Your answer here.

ANSWER: Line 5: 1 Line 18: 1 Line 19: 0.86 [(5, 1.00), (18, 0.75), (19, 0.86)]

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(b) (3 points)

Which line from the above list of lines, do you think, is causing the problem and why? If you think the list does not contain a relevant line, please indicate that and explain why. Limit your entire answer to at most 3 sentences.

Your answer here.

ANSWER: Line 5

(c) (5 points)

As a developer on a software project, you're currently running into an odd bug, and you decide to find the bug using fault localization techniques learned from EECS 481. However, you're unsure whether you should proceed with a fault localization tool or not. Using no more than 4 sentences, compare and contrast (1) tool-based fault localization and (2) manually performing fault location.

Your answer here.

ANSWER: Compare: Both approaches aim to find locations of where the bug might occur

Contrast: Tool based approaches only give you a best guess, human approaches might take more time/nuance to figure out

(d) (2 points)

In addition to fault localization techniques, you look to use profiling to aid in understanding your program's behavior better. Give one example of when you could use profiling to understand your program better and how it could help in identifying and fixing errors. Use at most 2 sentences.

Your answer here.

ANSWER: Call graph profiles can tell you timing information that could lead to understanding the performance of your program (and potential improvements).

Question 5. Design Patterns (15 points)

Suppose you are developing a tax system, and have written the following code.

```
5     else:
6         taxrate = taxrates[country]
7         return subtotal + subtotal * taxrate
8
9
10 def findTimeZone(country, state, zones):
11     timezone = None
12     if country == "US":
13         timezone = zones[state]
14     else:
15         timezone = zones[country]
16     return timezone
17
```

(a.i) (1 points)

During the code review session, your mentor revised your code to the following.

```
1 def USvsNonUSLookup(country, state, lookup):
2     foundValue = None
```


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```
3     if country == "US":
4         foundValue = lookup[state]
5     else:
6         foundValue = lookup[country]
7     return foundValue
8
9
10 def calculateTax(subtotal, country, state, taxrates):
11     taxrate = USvsNonUSLookup(country, state, taxrates)
12     return subtotal + subtotal * taxrate
13
```

What is an issue that your mentor was trying to address?

- A) Copy-pasting code of the same functionality
- B) Typos
- C) Tight coupling
- D) Confusing variable naming

ANSWER: A

(a.ii) (2 points)

Please describe two drawbacks of tight coupling. Limit your entire answer to at most two sentences.

Your answer here.

ANSWER:

Tight coupling: limits modifiability and scalability, makes updates and refactoring difficult, fragile codebase, hard to maintain, challenges in isolating components for testing, etc.

(b.i) (2 points)

Consider the following description for a design pattern X. X provides an interface for creating objects, but allows subclasses to decide which class to instantiate. X is useful when you want to abstract the object creation process and create objects without specifying the exact class.

Please choose the design pattern that best matches the description above.

- A) Factory
- B) Observer
- C) Adapter
- D) Proxy

ANSWER: A

(b.ii) (2 points)

You have an existing unchangeable code base which uses `player` (an instance of `MP3Player`) to play the audio. You now want to additionally support playing the audio of a `MP4File` by utilizing its provided `play_music`, without changing the codebase. You wrap it in a new class `MP4AudioPlayer` inherited from `MP3Player`, and implement the compatible interface `play`.

```
9
10 class MP4File:
11     def play_music(self):
12         print("Playing audio of a MP4 file")
13
14
15 class MP4AudioPlayer(MP3Player):
16     def __init__(self, mp4_file):
17         self.mp4_file = mp4_file
18
19     def play(self):
20         self.mp4_file.play_music()
21
```

Please choose the design pattern that best matches the description above.

- A) Proxy
- B) Iterator
- C) Singleton

D) Adapter

ANSWER: D

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(b.iii) (2 points) The design pattern provides a uniform interface for traversing containers (eg. vectors, list-like objects) regardless of how they are implemented.

Please choose the design pattern that best matches the description above.

- A) Iterator
- B) Singleton
- C) Adapter
- D) Proxy

ANSWER: A

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(b.iv) (2 points)

This design pattern ensures a class only has one instance, and provides a global point of access to it.

Please choose the design pattern that best matches the description above.

- A) Proxy
- B) Observer
- C) Iterator
- D) Singleton

ANSWER: D

(c) (2 points)

Suppose that a particular software development project spends $X=21\%$ of its lifetime effort on implementation, $Y=34\%$ of its lifetime effort on testing, and $Z=45\%$ of its lifetime effort on other non-testing maintenance. You have proposed a new design, and you would like to evaluate its effectiveness. In particular, you have already concluded:

(a) this new design would increase the effort required for implementation by $M=23\%$ (for example, if implementation previously took 10 hours, with an increase effort by 35%, it would now take 13.5 hours);

(b) but this new design would also reduce the effort required for testing by $N=32\%$.

Assume the project originally required 100 hours to complete. Now, with this new design, please calculate the hours required for the same project. **Round your answer to the nearest integer.** For example, 3.4 would be rounded to 3, and 3.6 would be rounded to 4.

Your answer here.

ANSWER: $T = Z + X*(1+M\%) + Y*(1-N\%) = 94$

(d) (2 points)

Support or refute the claim: Given that the time required to read code during activities like code reviews or inspections is proportional to the number of lines, and understanding code is crucial in software maintenance, writing accurate programs with minimal lines of code emerges as the optimal design approach for maintenance. This strategy not only saves time but also enhances the maintainability of software by simplifying comprehension and debugging processes.

Please use concrete lecture and/or reading materials, to back up your answer. Limit your entire answer to at most 4 sentences.

Your answer here.

ANSWER:

Refute: Trying to make the program as small as possible is almost certainly a perverse incentive, as per the Measurement lecture. For example, we know from the Code Inspection lecture that beacons and descriptive variable names really help, but descriptive variables and comments take up space.

Support: From the code review and inspection slides, we know that the recommended reading rate is about 400 LOC per hour and that people get tired after an hour, so it is true that if you have a smaller program, it takes less time to read the whole program. In addition, we saw in the Productivity lecture that the amount of code you can write per day, over the course of the entire project, is a small constant.

Question 6. Requirements Elicitation (8 points)

Suppose you are tasked to develop a mobile banking application for a new bank. This application should be capable of making transactions internationally, and catering to both individuals and business clients.

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(a) (2 points) List 2 possible **verifiable quality** requirements for the application. Each requirement should be described using 1 sentence. Limit your entire answer to at most 2 sentences.

Your answer here.

ANSWER: Answers will vary. The application should have a max response time of 5 seconds for processing transactions. The application should have user account balances appear within 5 seconds of loading the application.

(b) (2 points) List 2 possible **non-functional** requirements for the application. Each requirement should be described using 1 sentence. Limit your entire answer to at most 2 sentences.

Your answer here.

ANSWER: Answers will vary. The application should have security measures to ensure the safety of users' financial data. The application should have fast response times and minimal downtime to provide a seamless user experience.

(c) (4 points) Identify 2 possible stakeholders from the application, and describe a conflict that might arise between the 2 stakeholders. Explain **whether** the conflict you mentioned is a strong or weak conflict and **why**. Limit your answer to no more than 4 sentences.

Your answer here.

ANSWER: Answers will vary. Two stakeholders could be an individual client and a business client. The individual client might want a personalized, simple UI whereas the business client might want advanced features such as invoicing and payroll. This case is a strong conflict because it is not possible for the individual client to have a seamless UI if the business client wants advanced features.

Question 7. Interview (7 points)

Bob is tasked with interviewing an applicant Alice for a software development position and evaluating Alice's technical skills.

The interview question is: given an integer array `nums` and an integer `val`, remove all occurrences of `val` from `nums`. The length of `nums` can be zero or larger. Return the length of the resulting array.

```
1 def removeElement(nums: List[int], val: int) -> int:
2     index = 1 # point to the end of the array after element removal
3     for i in range(1, len(nums)):
4         if nums[i] != val:
5             nums[index] = nums[i]
6             index += 1
7     return index
8
```

(a) (2 points) Upon receiving the problem, Alice asked about the time complexity requirement, and whether the removal should happen in-place. After a short while, Alice presented the above code to you.

Identify **two** points where Alice did well during the interview.

LATE

minutes remaining

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Your answer here.

ANSWER: Asking about requirements; comments; meaningful variable naming; type declaration, etc.

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(b) (5 points) Suppose you are Alice. After you delivered the solution above, Bob prompted you that there was a bug in your code. Bob also asked you to write test cases to better test the code (at least to reveal the bug).

In your answer, please:

- (1) describe the bug in one sentence;
- (2) give one test case that can expose the bug;
- (3) provide an additional test case, different from the one in (2), that you believe is also necessary for better testing the code, and explain the rationale behind it.

Please limit your entire answer to at most five sentences.

Your answer here.

ANSWER:

- 1) index=1 is problematic, because nums can be empty.
- 2) nums=[], val=arbitrary can expose the bug.
- 3) All reasonable answer accepted, eg. nums=[2,4,5,4], val=4, want to test the nums with multiple elements equal to val included; or want to test a general case; or want to test an edge case etc.

Extra Credit

(1) What was your favorite topic or activity during the course? (1 point)

Your answer here.

(2) What is one thing that you think we should do more of next semester? (1 point)

Your answer here.

(3) What is one thing you would most recommend that we change for future semesters? (1 point)

Your answer here.

(4) What're your thoughts on adding some more advanced lectures that dive deeper into a couple topics (such as testing, static analysis, model checking, program synthesis) in more depth? (1 point)

Your answer here.

(5) Identify a single optional reading that was assigned after Exam 1. Write two sentences about it that convince us you read it critically. Please make sure that you identify the title of the reading. (2 points)

Your answer here.

LATE

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The exam is graded out of 100 points.