CMPE 287 – Software Quality Assurance and Testing

Homework #3

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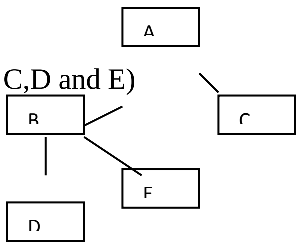
Question #1: Software Integration Testing (25%)

1. (20%) Questions about software integration based on a program structure shown in Figure 1:
   a) Explain the idea of the top-down integration approach. (3%)
   b) List an integration sequence using the top-down approach and its required test stubs (or drivers) using the breath-first order. (5%)
   c) List the required total number of test stubs. (5%)
   d) Explain the idea of the bottom-up integration approach. (2%)
   e) List an integration sequence using the bottom-up approach and its required test drivers. (5%)
   f) List the required total number of test drivers. (5%)

Hints: Please writes your integration sequence as follows:

a) Integrated system (IS) = module A and module B (required test stubs for C,D and E)
b) Integrated system (IS) = IS and module D
……….



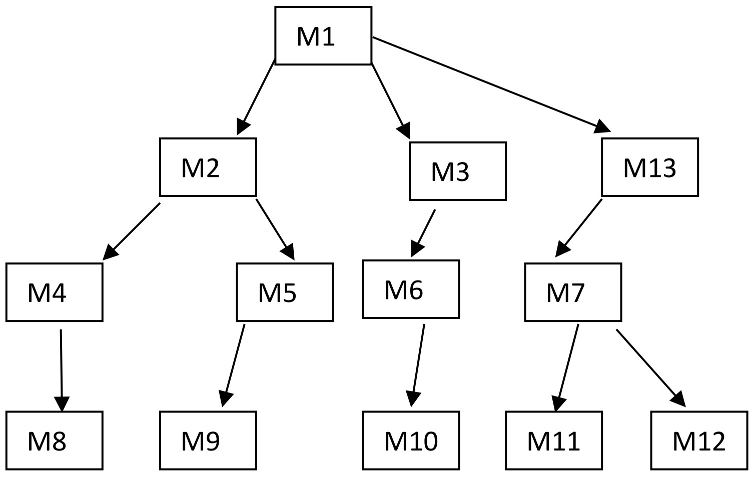


Figure 1.

Answer:

1.a) Top-down Integration Approach:

The top-down integration approach starts with the high-level control modules and works downwards to integrate lower-level components of the system. In this approach, the main control module is developed and tested first. Then the next level modules that are invoked by the main control module are integrated and tested. This continues downwards until all the system components are integrated from top to bottom.

Some key points about top-down integration:

- It begins with the main control module that drives the rest of the system. This allows early testing of critical system functionality.
- High-level modules are developed and tested before detailed lower-level modules. This follows natural abstraction layers in the system architecture.
- Requires stubbing/mocking of components not yet integrated. Stubs emulate lower-level modules that are not yet complete.
- Testing focuses on integration between modules. Allows divide-and-conquer testing of complex systems.
- Promotes early detection of system-level architectural or design flaws. High-level issues can be found before detailed lower-level development.
- Dependency issues are discovered earlier. Missing or conflicting interfaces between modules become evident.
- Can be less flexible for incremental or iterative development. Full high-level design needs to be completed upfront.

1.b) Integration sequence using top-down approach:

Integration Order: Breadth -First (Left Order)

IS: Integrated System Mi’: Software stub for module Mi.

Step #1:	IS = M1 and M2 (need: M3’, M13’, M4’, and M5’)
Step #2:	IS = IS + M3 (need: M13’, M4’, M5’, and M6’)
Step #3:	IS = IS + M13 (need: M4’, M5’, M6’, and M7’)
Step #4:	IS = IS + M4 (need: M5’, M6’, M7’, and M8’)
Step #5:	IS = IS + M5 (need: M6’, M7’, M8’, and M9’)
Step #6:	IS = IS + M6 (need: M7’, M8’, M9’, and M10’)
Step #7:	IS = IS + M7 (need: M8’, M9’, M10’, M11’, and M12’)

Step #8: IS = IS + M8 (need: M9’, M10’, M11’, and M12’)

Step #9: IS = IS + M9 (need: M10’, M11’, and M12’)

Step #10: IS = IS + M10 (need: M11’, and M12’)

Step #11: IS = IS + M11 (need: M12’)

Step #12: IS = IS + M12

1.c) Total number of stubs:

The list of total number of stubs is:

1. M3’
2. M4’
3. M5’
4. M6’
5. M7’
6. M8’
7. M9’
8. M10’
9. M11’
10. M12’
11. M13’

1.d) Bottom-up Integration Approach:

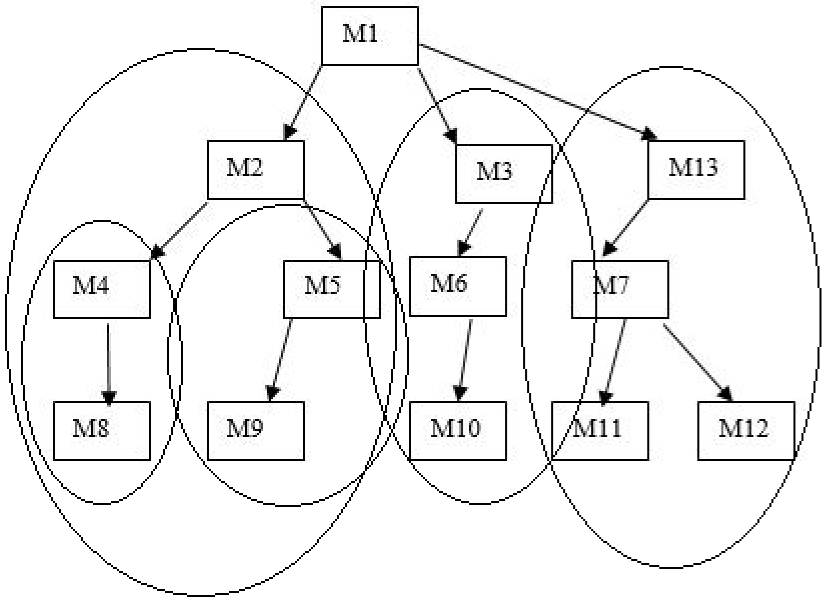
The bottom-up integration approach starts with the low-level components and works upwards to integrate higher-level modules of the system. In this approach, the lowest level components like utilities or drivers are developed and tested first. Then progressively higher-level components that use these lower modules are integrated and tested. This continues upwards until the complete system is integrated from bottom to top.

Some key points about bottom-up integration:

- It begins with detailed low-level modules like device drivers and libraries. These components have limited dependencies.
- Lower-level components are integrated before high-level components that depend on them. Follows dependency hierarchy.
- Allows early development of critical low-level functions like hardware interaction.

- Testing focuses on components progressively, simplifying troubleshooting.
- Allows incremental development and testing of subsystem functionality.
- High-level components may require stubs/mocks representing lower-level modules.
- Architectural issues detected later in development lifecycle after detailed design.
- Less big-picture visibility till high-level modules integrated and tested.

1.e) Integration sequence using bottom-up approach:



Integration Order: Breadth-First (Left Order)

IS: Integrated System Mi”: software driver for Module Mi.

Step #1: IS1 = M8 + M4 (need: M2”)

Step #2: IS2 = M9 + M5 (need: M2”)

Step #3: IS3 = IS1 + M2 (need: M1”)

Step #4: IS3 = IS3 + IS2 (need: M1”)

Step #5: IS4 = M10 + M6 (need: M3”)

Step #6: IS4 = IS4 + M3 (need: M1”)

Step #7: IS5 = M11 + M7 (need: M13”)

Step #8: IS5 = IS5 + M12 (need: M13”)

Step #9: IS5 = IS5 + M13 (need: M1”)

Step #10: IS = IS3 + M1 (need: M3” and M13”)

Step #11: IS = IS + IS4 (need: M13”)

Step #12: IS = IS + IS5

1.f) Total number of test drivers:

The list of total number of test drivers is:

1. M1”
2. M2”
3. M3”
4. M13”

The list of total number of stubs is:

1. M4’
2. M5’
3. M6’
4. M7’
5. M8’
6. M9’
7. M10’
8. M11’
9. M12’

Question #2: Questions about Software Regression Testing (40%)

Figure 2 shows the class relation structure among the classes of a program written in C++. “I” indicates an Inheritance relation between two classes. “AG” represents an aggregation relation between two class objects, “AS” indicates an association relation between two classes. Assume Class 7 and Class 1 are changed. Please follow the class firewall’s concept to identify a class firewall to enclose all affected classes and re-integration links after changing Class 7 and Class 1. (Note: pleased Please present this class firewall by answering the following questions:

a) (10%) What is the class test order based on the class diagram in Figure 2.

b) (10%) What are the class firewalls for the two changed classes, and please present the two firewalls separately using a diagram.

c) (10%) Which classes are not directly affected by each changed class, but must be re-integrated?

d) (10%) Please list the class re-test order for each detected class firewall.

You may need to read the published papers below:

Paper 1: Class Firewall, Test Order, and Regression Testing of Object-Oriented Programs, Journal of Object-Oriented Programming, 1993.

by David C. Kung, Jerry Gao , Pei Hsia , Jeremy Lin , Yasufumi Toyoshima

URL: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.53.6284

Paper 2: A Test Strategy for Object-Oriented Programs

By D. Kung ; J. Gao ; Pei Hsia ; Y. Toyoshima ; C. Chen,

Proceedings., Nineteenth Annual International conference on Computer Software and Applications, 1995. (COMPSAC 95)

URL: http://ieeexplore.ieee.org/abstract/document/524786/

Paper 3: Change Impact Identification in Object-Oriented Software Maintenance

By D. Kung, J. Gao, P. Hsia, F. Wen, Y. Toyoshima, Ray Chen

URL: http://ieeexplore.ieee.org/abstract/document/336774/

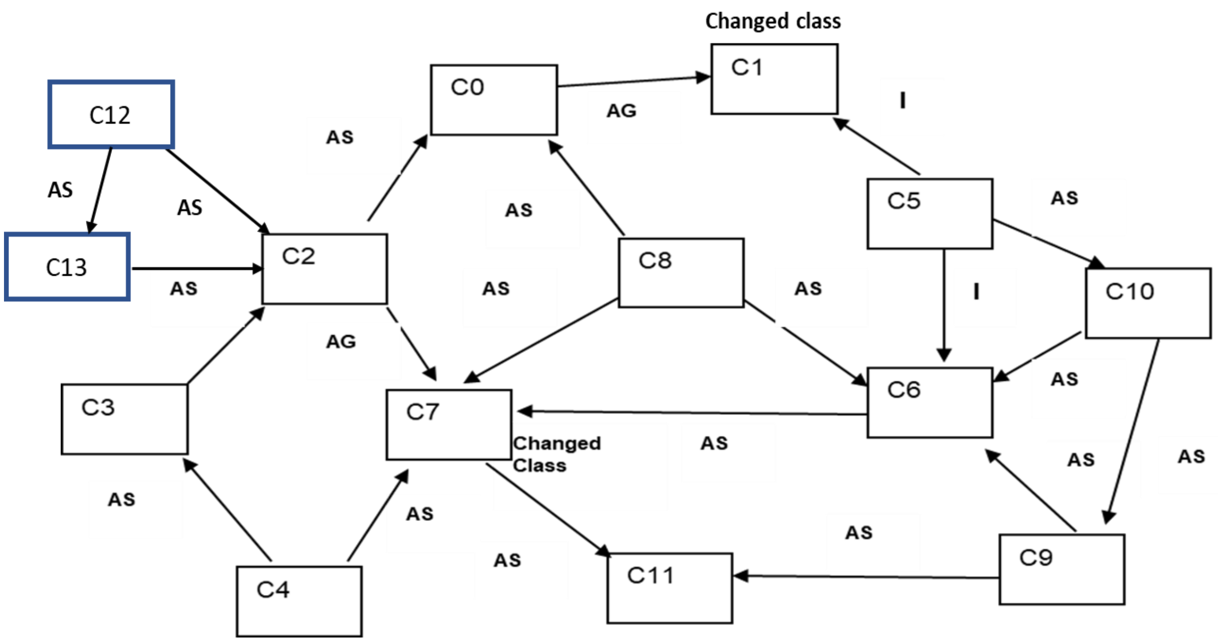
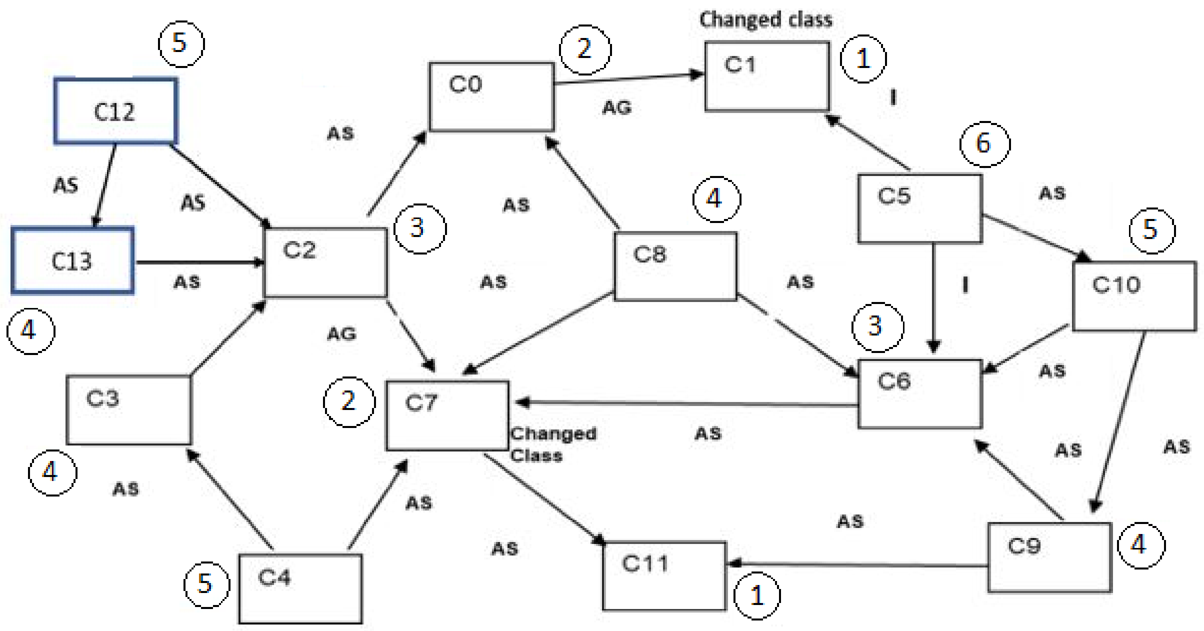


Figure 2.

Answer:

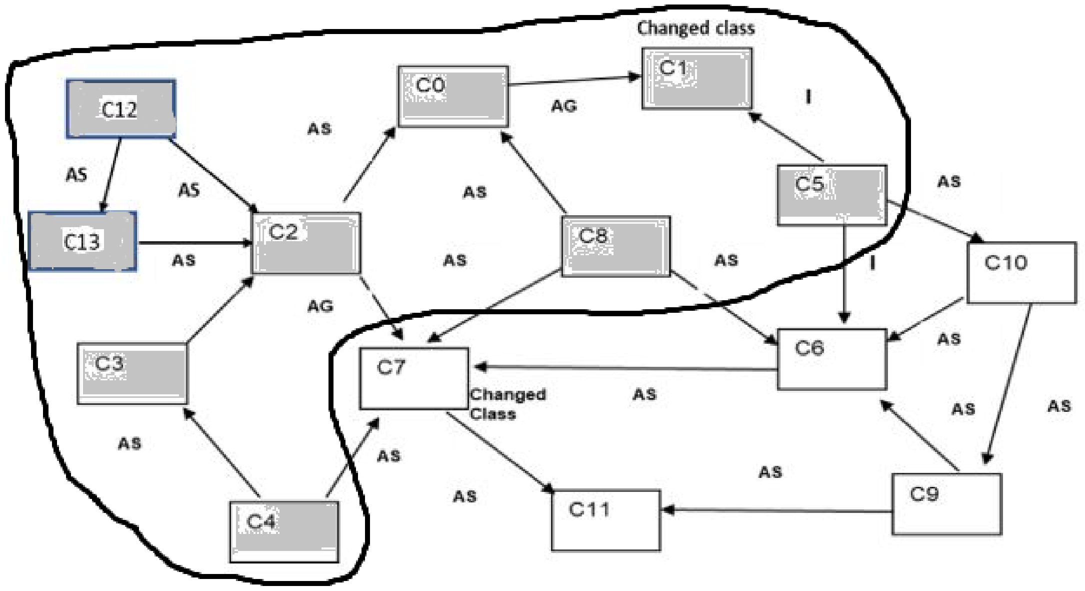
2.a) The class test order is as follows:



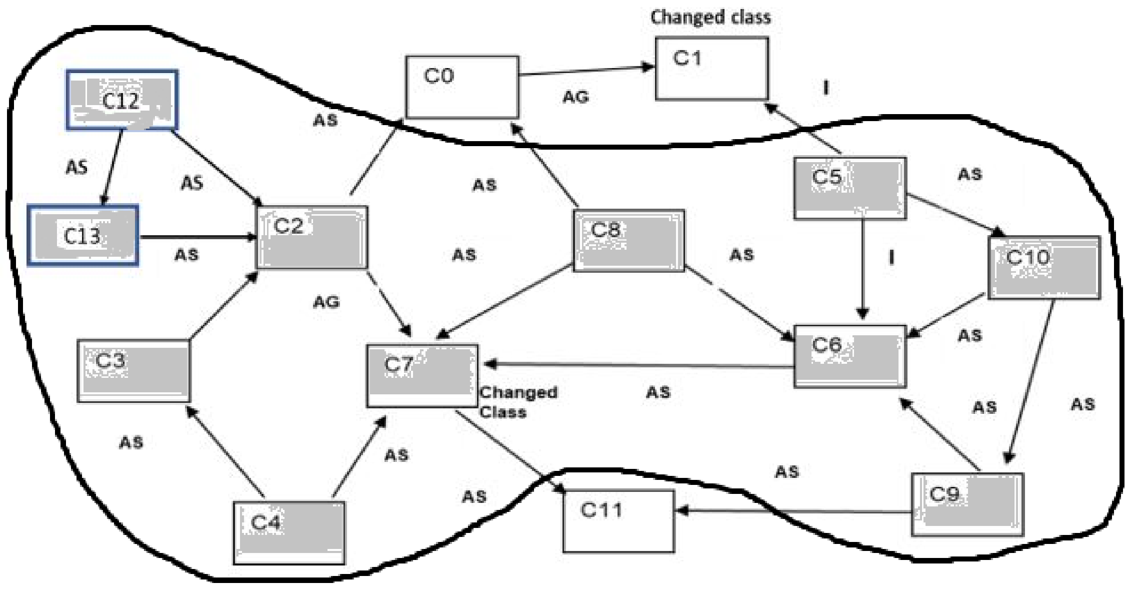
1. C1, C11
2. C0, C7
3. C2, C6
4. C3, C8, C9, C13
5. C4, C10, C12
6. C5

2.b) Class firewalls:

When C1 is changed, the class firewalls are C0, C1, C2, C3, C4, C5, C8, C12, C13.



When C7 is changed, the class firewalls are C2, C3, C4, C5, C6, C7, C8, C9, C10, C12, C13.



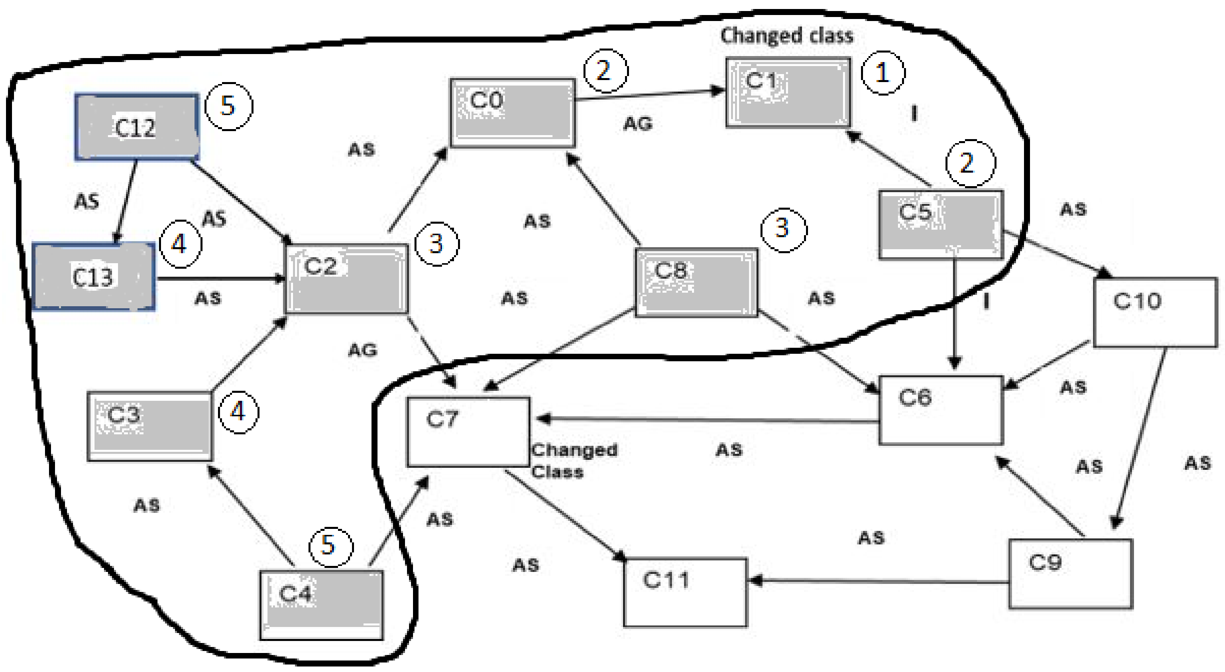
2.c) List of classes not directly affected by each changed class.

By the change of C1, the classes C6, C7, C9, C10, and C11 are not directly affected. Among these, only C6, C7, and C10 classes must be re-integrated as they directly depend on the class firewall.

By the change of C7, the classes C0, C1, and C11 are not directly affected. All three of these classes must be re-integrated as they directly depend on the class firewall.

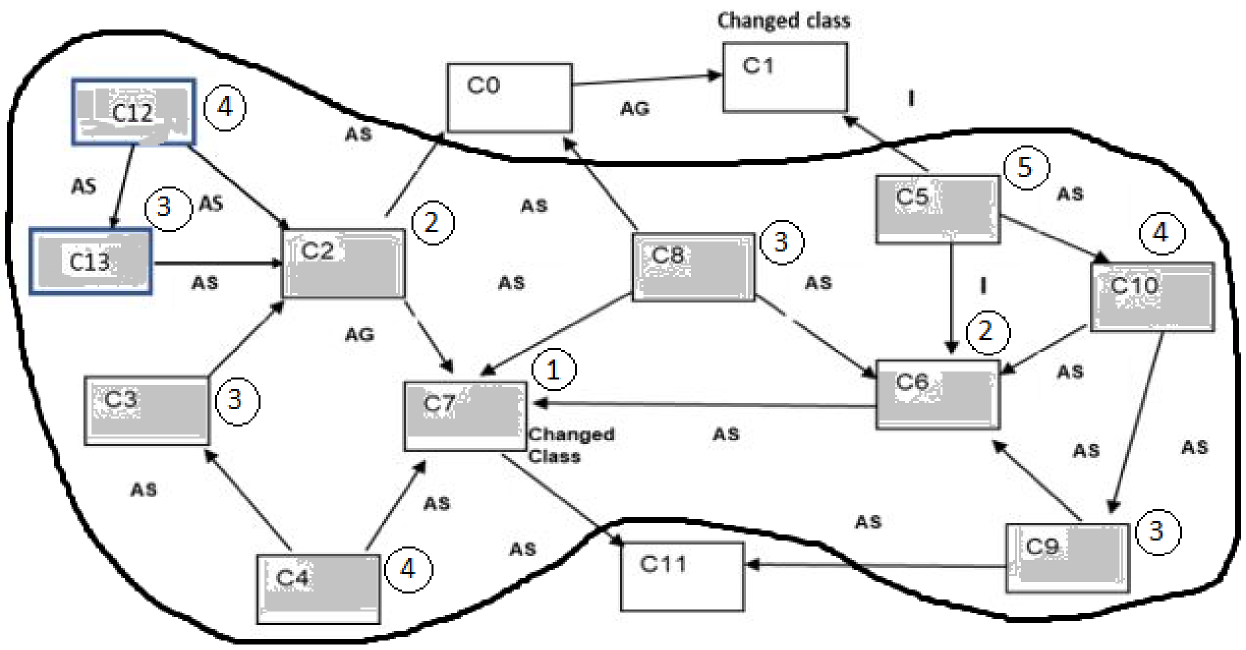
2.d) List of class re-test order for each detected class firewall.

The class re-test order for the change of C1 is as follows:



1. C1
2. C0, C5
3. C2, C8
4. C3, C13
5. C4, C12

The class re-test order for the change of C7 is as follows:



1. C7
2. C2, C6
3. C3, C13, C8, C9
4. C12, C4, C10
5. C5

Question #3: Testing a selected AI Mobile App (35%)

For your selected intelligent function/feature of your mobile app (or online app), please focus on one of your selected AI-powered function and conduct your 3D AI test modeling based on our lecture and given 3D AI test tool.

Please answer the following questions:

a) Your 3D AI test modeling test model: (20%)

 a. Context Model (Context Modeling Tree) (5%)

 b. Input Classification Model (Input Classification Tree) (5%)

 c. Output Classification Model (Output Classification Tree) (5%)

 d. 3D Decision Table (10%)

b) Your test complexity based on your 3D AI decision table (5%)

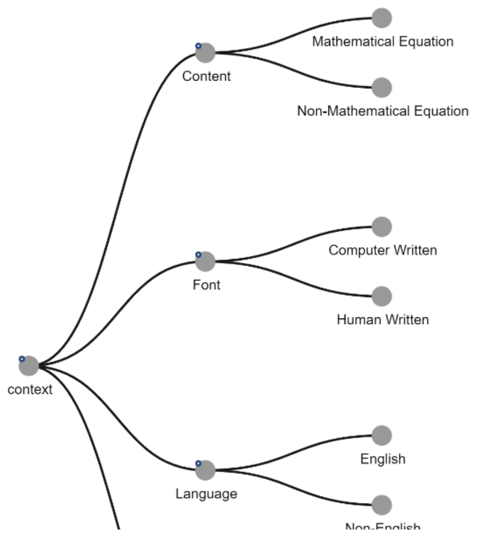
c) Present three your selected bugs you detected. (5%)

Please present your bugs in a well-defined format.

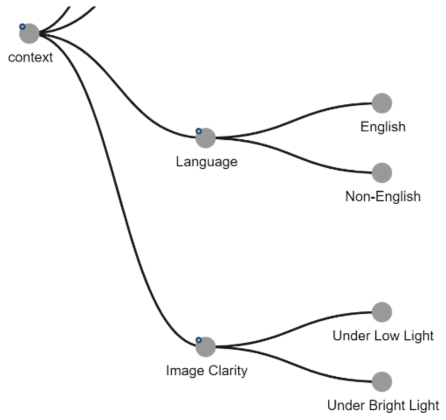
Answer:

3.a) 3D AI test modeling test model:

a. Context Model (Context Modeling Tree):

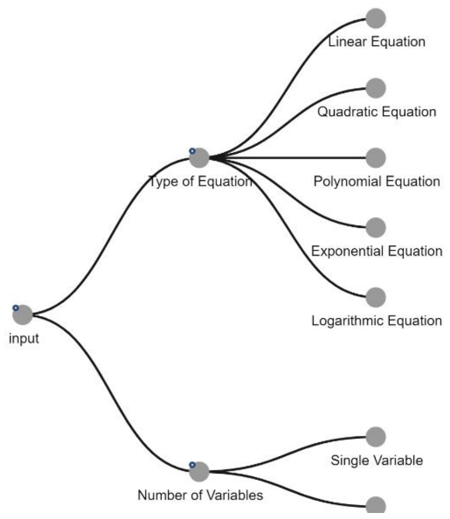


Context Tree Model

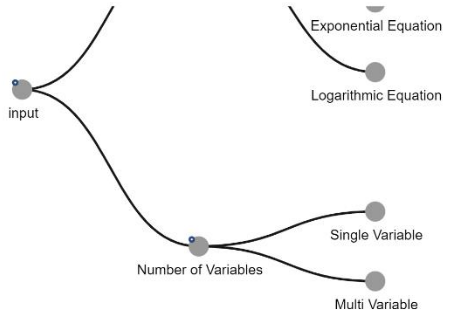


Context Tree Model

b. Input Classification Model (Input Classification Tree):

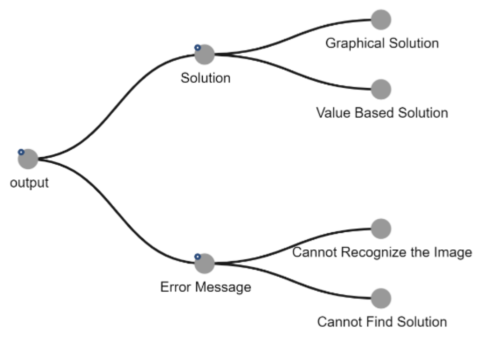


Input Tree Model



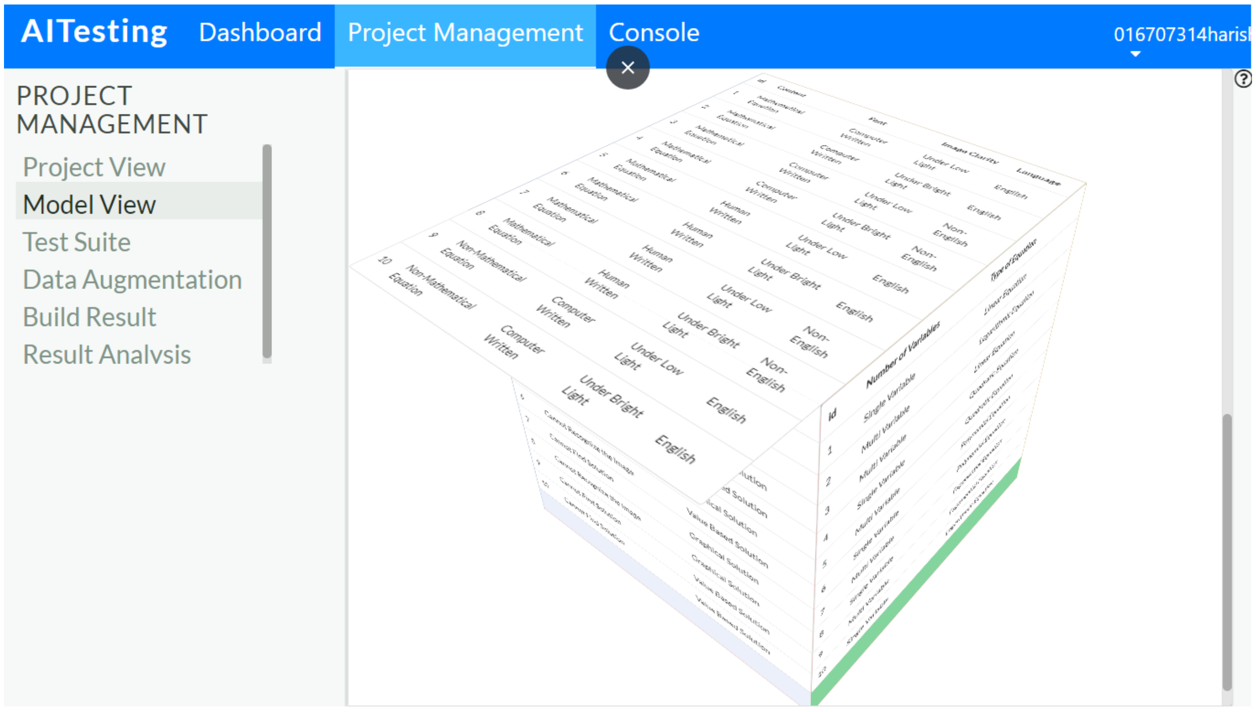
Input Tree Model

c. Output Classification Model (Output Classification Tree):

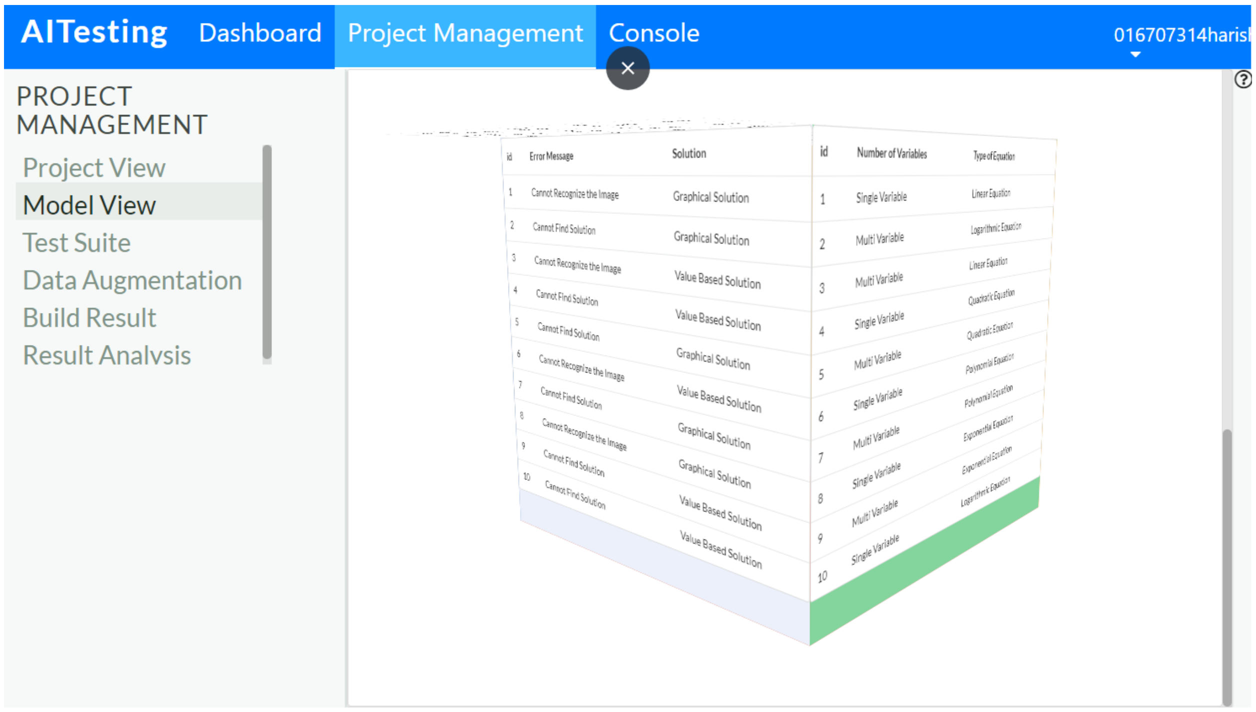


Output Tree Model

d. 3D Decision Table:



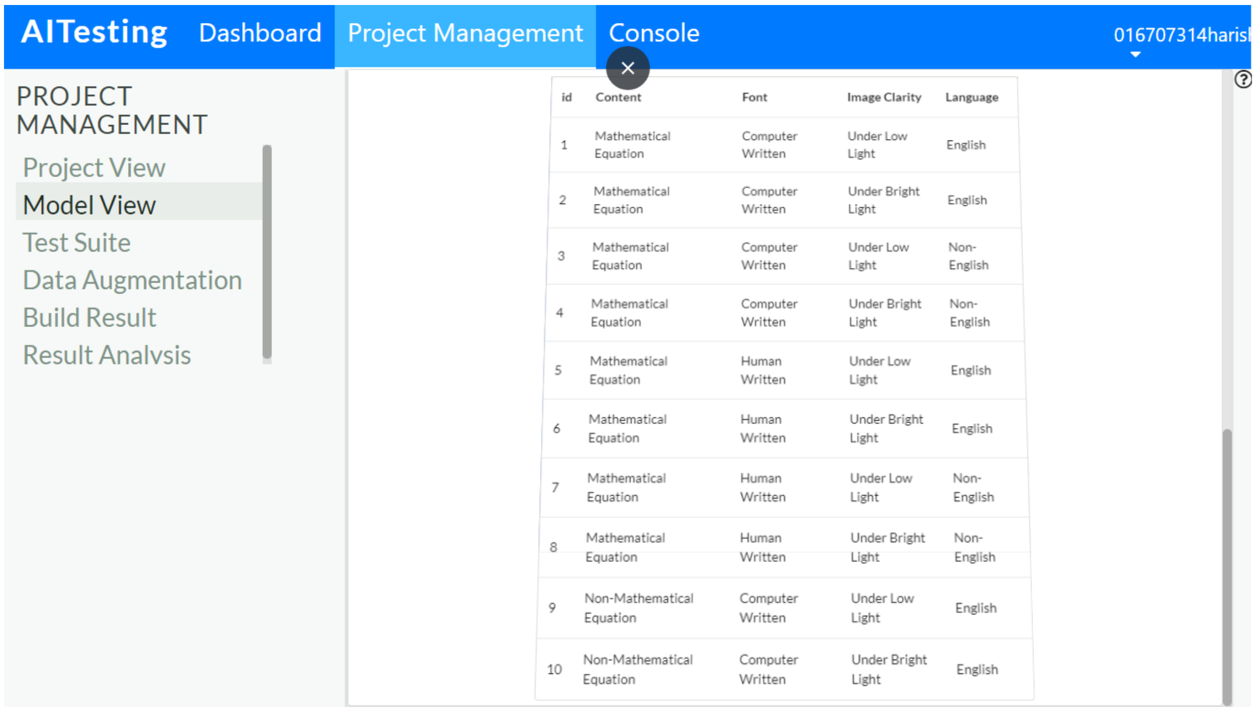
3D Decision Table



id	Error Message	Solution
1	Cannot Recognize the Image	Graphical Solution
2	Cannot Find Solution	Graphical Solution
3	Cannot Recognize the Image	Value Based Solution
4	Cannot Find Solution	Value Based Solution
5	Cannot Find Solution	Graphical Solution
6	Cannot Recognize the Image	Value Based Solution
7	Cannot Find Solution	Graphical Solution
8	Cannot Recognize the Image	Graphical Solution
9	Cannot Find Solution	Value Based Solution
10	Cannot Find Solution	Value Based Solution

id	Number of Variables	Type of Equation
1	Single Variable	Linear Equation
2	Multi Variable	Logarithmic Equation
3	Multi Variable	Linear Equation
4	Single Variable	Quadratic Equation
5	Multi Variable	Quadratic Equation
6	Single Variable	Polynomial Equation
7	Multi Variable	Polynomial Equation
8	Single Variable	Exponential Equation
9	Multi Variable	Exponential Equation
10	Single Variable	Logarithmic Equation

3D Decision Table



id	Content	Font	Image Clarity	Language
1	Mathematical Equation	Computer Written	Under Low Light	English
2	Mathematical Equation	Computer Written	Under Bright Light	English
3	Mathematical Equation	Computer Written	Under Low Light	Non-English
4	Mathematical Equation	Computer Written	Under Bright Light	Non-English
5	Mathematical Equation	Human Written	Under Low Light	English
6	Mathematical Equation	Human Written	Under Bright Light	English
7	Mathematical Equation	Human Written	Under Low Light	Non-English
8	Mathematical Equation	Human Written	Under Bright Light	Non-English
9	Non-Mathematical Equation	Computer Written	Under Low Light	English
10	Non-Mathematical Equation	Computer Written	Under Bright Light	English

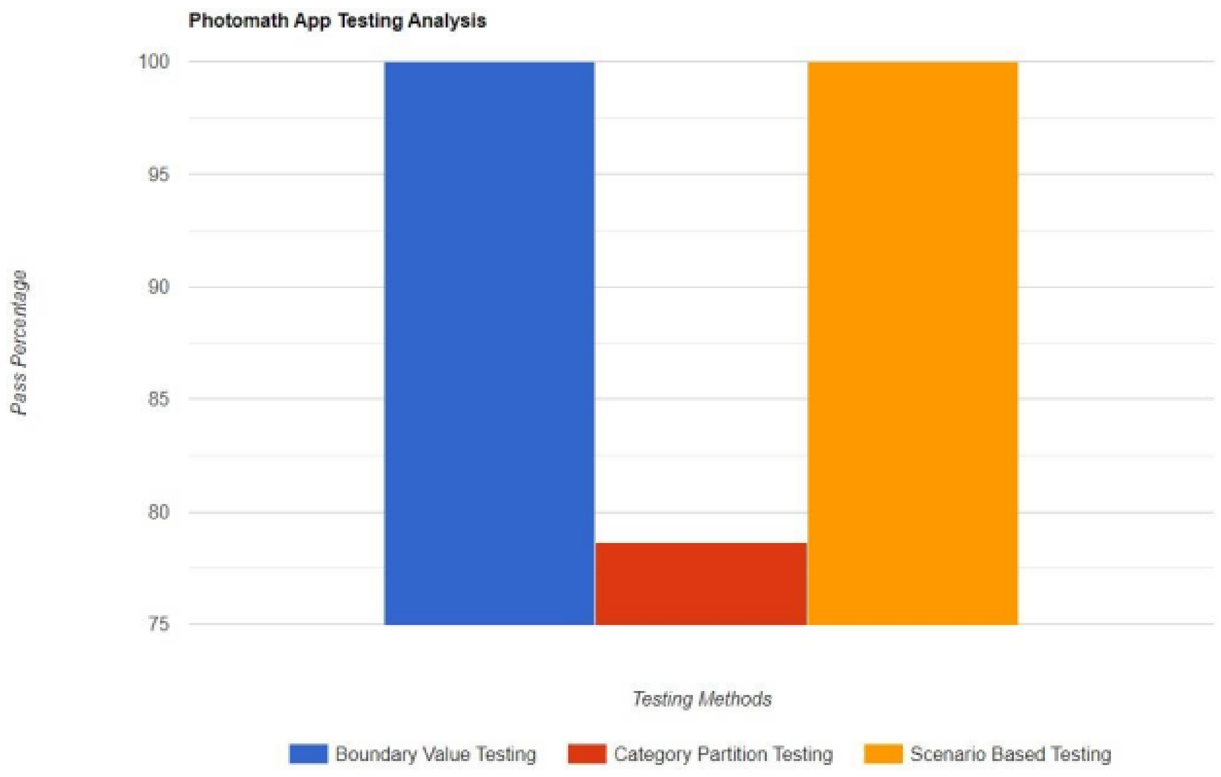
3D Decision Table

3.b) Test complexity based on 3D AI decision table:

We used black box testing techniques like Boundary value testing, category-based testing, scenario-based testing and equivalence partitioning testing for conventional testing. In regard of AI testing we used an AI tool for generating various test cases based on various context features.

We have 160 test cases generated by AI testing tool and for conventional testing we had a total of 72 test cases.

Test Method	Photomath
Boundary Value Testing	100%
Category Partition Testing	78.62%
Scenario Testing	100%



1. Different model-based text complexity
    - Test complexity for context model:
      No. of branches = 4
      No. of nodes = 8
      Test complexity = (1*2)*(1*2)*(1*2)*(1*2) = 16
    - Test complexity for input model:

No. of branches = 2
No. of nodes = 7
Test complexity = (1*5)*(1*2) = 10

- Test complexity for output model:
  No. of branches = 2
  No. of nodes = 4
  Test complexity = (1*2)*(1*2) = 4

2. 3D model-based test complexity = 8*7 = 56

3.c) Three of the selected bugs detected are as follows:
1.

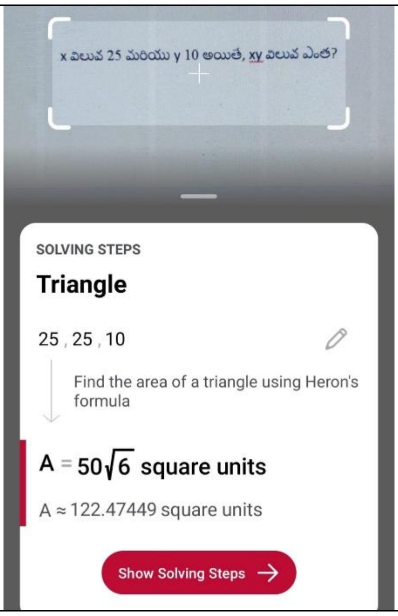
Test Case ID	**1**
Test Topic	Algebra (Polynomial Equations)
Test Description	Word Problem
AI Context Type	Non-Maths Equation
AI Input Type	Single variable
Test Case Input	If John has 25 cars, then what will be the new total number of cars if he sells out one from it?
Performed By	Harish Marepalli
Execution Date	20th November 2023
AI Output Type	Value-based
Expected Result	24
Actual Result	Error (Unable to read the word problem)
Test Case Result	Fail

2.

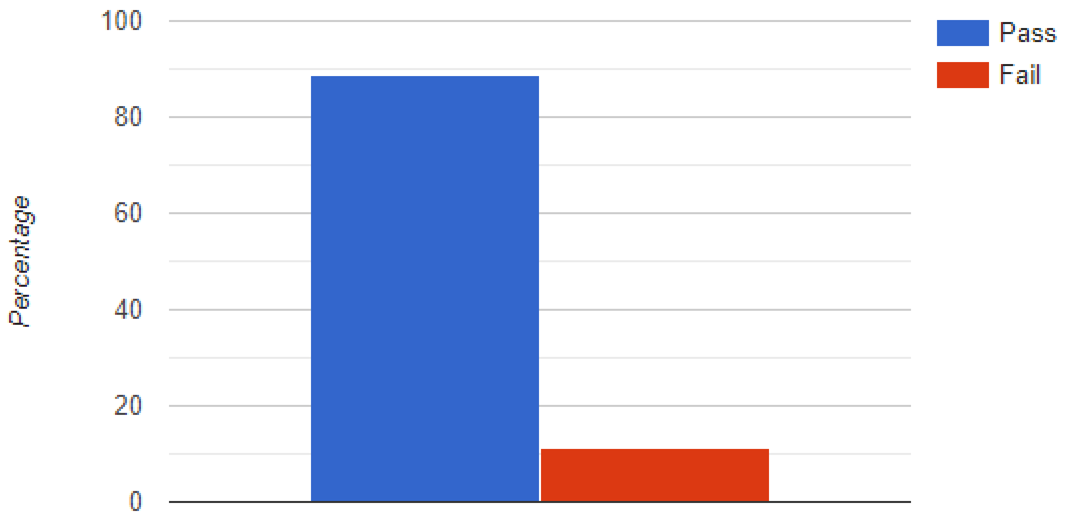
Test Case ID	**2**
Test Topic	Algebra (Polynomial Equations)
Test Description	Word Problem
AI Context Type	English
AI Input Type	Single variable
Test Case Input	If the value of x^2 is 25, what is the value of $x^2 - 1$?
Performed By	Harish Marepalli
Execution Date	20th November 2023
AI Output Type	Value-based
Expected Result	x = 24
Actual Result	Error (Unable to read the word problem)
Test Case Result	Fail

3.

Test Case ID	**3**
Test Topic	Algebra (Polynomial Equations)
Test Description	Word problem
AI Context Type	Non-English
AI Input Type	Multi variable
Test Case Input	x విలువ 25 మరియు y 10 అయితే, xy విలువ ఎంత?
Performed By	Harish Marepalli
Execution Date	20th November 2023

AI Output Type	Value-based
Expected Result	Cannot recognize the problem
Actual Result	 x విలువ 25 మరియు y 10 అయితే, xy విలువ ఎంత? SOLVING STEPS **Triangle** 25 , 25 , 10 Find the area of a triangle using Heron's formula $A = 50\sqrt{6}$ square units $A \approx 122.47449$ square units Show Solving Steps
Test Case Result	Fail

AI Function Bug Analysis:



With the AI tool generated test cases, we can see above that the pass percentage is good but needs a little improvement by getting rid of the bugs.