

Software Testing and Reliability  
SWE30009

ASSIGNMENT 1

**TASK 1:** Explain and show all details on how to design the test cases for the above testing objective.

Combine:  $C = (A + B) * B - 5$ .

To test whether the arithmetic operator is incorrect or not, we will replace the operator with the other arithmetic operator. In this case, we only consider three feasible arithmetic operators, namely, + (addition), - (subtraction), \* and (multiplication), so division will not be considered.

Category	Test cases
Test cases for "+"	$(A - B) * B - 5$ $(A * B) * B - 5$
Test cases for "**"	$(A + B) + B - 5$ $(A + B) - B - 5$
Test cases for "-"	$(A + B) * B + 5$ $(A + B) * B * 5$
Test cases for combination of "+" and "**"	$(A - B) - B - 5$ $(A - B) + B - 5$ $(A * B) - B - 5$ $(A * B) + B - 5$
Test cases for combination of "**" and "-"	$(A + B) + B + 5$ $(A + B) - B + 5$ $[(A + B) + B] * 5$ $[(A + B) - B] * 5$
Test cases for combination of "+" and "-"	$(A - B) * B + 5$ $(A * B) * B + 5$ $(A * B) * B * 5$ $(A - B) * B * 5$
Test cases for combination of "+", "**" and "-"	$(A - B) + B + 5$ ; $(A - B) - B + 5$ $[(A - B) + B] * 5$ ; $[(A - B) - B] * 5$ $(A * B) + B + 5$ ; $(A * B) - B + 5$ $[(A * B) + B] * 5$ ; $[(A * B) - B] * 5$

**TASK 2:** Suppose you use test case ( $A=10$ ,  $B=0$ ) to test the above program. Is this test case able to achieve the required testing objective? Provide your answer with justifications.

**Original program**

- Expression for A:  $A = (A + B) * B$ .
- With  $A = 10$ ,  $B = 0$ :  $A = (10 + 0) * 0 \Rightarrow A = 0$ .

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- Expression for C:  $C = A - 5$ . With  $A = 0$ ,  $C = 0 - 5 = -5$ .

### Modified program (with operator replacement)

- Replace "+" with "-":
  - Modified expression:  $A = (A - B) * B$ .
  - With  $A = 10$ ,  $B = 0$ :  $A = (10 - 0) * 0 \Rightarrow A = 0$ .
  - Result for C:  $C = A - 5 \Rightarrow C = -5$ .
  - Conclusion: Result of C in the modified program is equal to the result of C in the original program.
- Replace "+" with "\*":
  - Modified expression:  $A = (A * B) * B$ .
  - With  $A = 10$ ,  $B = 0$ :  $A = (10 * 0) * 0 \Rightarrow A = 0$ .
  - Result for C:  $C = A - 5 \Rightarrow C = -5$ .
  - Conclusion: Result of C in the modified program is equal to the result of C in the original program.
- Replace "\*" with "+":
  - Modified expression:  $A = (A + B) + B$ .
  - With  $A = 10$ ,  $B = 0$ :  $A = (10 + 0) + 0 \Rightarrow A = 10$ .
  - Result for C:  $C = A - 5 \Rightarrow C = 5$ .
  - Conclusion: Result of C in the modified program is different to the result of C in the original program.
- Replace "-" with "+":
  - Modified expression:  $C = A + 5$ .
  - With  $A = 10$ ,  $B = 0$ :  $A = (10 + 0) * 0 \Rightarrow A = 0$ .
  - Result for C:  $C = A + 5 \Rightarrow C = 5$ .
  - Conclusion: Result of C in the modified program is different with the result of C in the original program.

**Conclusion:** This test case can achieve the required testing objective for certain incorrect operators, but not all of it. Based on the result of C above, this test case cannot achieve the requirement of testing the incorrect operator "+". Overall, this test case is partially effective, it is not enough to detect all the possible incorrect use of operator because of the input  $B = 0$ . With  $B = 0$ , the result of A in the first operation will always be 0 if we use the correct multiplication operator, so that we cannot notice whether the addition operator is incorrect. Therefore, other test cases with different values of B should be used to fully achieve the testing objective.

**TASK 3:** Based on your design in Task 1, what is (or are) the concrete test case (or cases) that can achieve the above testing objective? Explain and justify your concrete test case (or cases).

**Test case:  $A = 3$ ,  $B = 4$ .**

	Expression	Calculation	Output
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Original program	$C = (A + B) * B - 5$	$C = (3 + 4) * 4 - 5$	$C = 23$
Test "+" operator	$C = (A - B) * B - 5$	$C = (3 - 4) * 4 - 5$	$C = -9$
	$C = (A * B) * B - 5$	$C = (3 * 4) * 4 - 5$	$C = 43$
Test "*" operator	$C = (A + B) + B - 5$	$C = (3 + 4) + 4 - 5$	$C = 6$
	$C = (A + B) - B - 5$	$C = (3 + 4) - 4 - 5$	$C = -2$
Test "-" operator	$C = (A + B) * B + 5$	$C = (3 + 4) * 4 + 5$	$C = 33$
	$C = (A + B) * B * 5$	$C = (3 + 4) * 4 * 5$	$C = 140$
Test "+" and "*" operator	$C = (A - B) + B - 5$	$C = (3 - 4) + 4 - 5$	$C = -2$
	$C = (A - B) - B - 5$	$C = (3 - 4) - 4 - 5$	$C = -10$
	$C = (A * B) - B - 5$	$C = (3 * 4) - 4 - 5$	$C = 3$
	$C = (A * B) + B - 5$	$C = (3 * 4) + 4 - 5$	$C = 11$
Test "+" and "-" operator	$C = (A - B) * B * 5$	$C = (3 - 4) * 4 * 5$	$C = -20$
	$C = (A - B) * B + 5$	$C = (3 - 4) * 4 + 5$	$C = 1$
	$C = (A * B) * B + 5$	$C = (3 * 4) * 4 + 5$	$C = 53$
	$C = (A * B) * B * 5$	$C = (3 * 4) * 4 * 5$	$C = 240$
Test "*" and "-" operator	$C = (A + B) + B + 5$	$C = (3 + 4) + 4 + 5$	$C = 16$
	$C = (A + B) - B + 5$	$C = (3 + 4) - 4 + 5$	$C = 8$
	$C = [(A + B) + B] * 5$	$C = [(3 + 4) + 4] * 5$	$C = 55$
	$C = [(A + B) - B] * 5$	$C = [(3 + 4) - 4] * 5$	$C = 15$
Test "+", "-" and "*" operator	$C = (A * B) + B + 5$	$C = (3 * 4) + 4 + 5$	$C = 21$
	$C = [(A * B) + B] * 5$	$C = [(3 * 4) + 4] * 5$	$C = 80$
	$C = (A * B) - B + 5$	$C = (3 * 4) - 4 + 5$	$C = 13$
	$C = [(A * B) - B] * 5$	$C = [(3 * 4) - 4] * 5$	$C = 40$
	$C = (A - B) + B + 5$	$C = (3 - 4) + 4 + 5$	$C = 8$
	$C = [(A - B) + B] * 5$	$C = [(3 - 4) + 4] * 5$	$C = 15$
	$C = (A - B) - B + 5$	$C = (3 - 4) - 4 + 5$	$C = 0$
	$C = [(A - B) - B] * 5$	$C = [(3 - 4) - 4] * 5$	$C = -25$

**Justification:** The value  $A = 3$ ,  $B = 4$  gives different output for different test cases, making it as an effective case for detecting incorrect operator usage. The reason to choose these two values for A and B is because:

- The selected test case should lead to a noticeable difference in the output C if an operator is incorrect.
- The selected test case should also produce a various different output for different test cases which easily help to identify the incorrect operator usage. s
- The selected test case should avoid the value of A or B that makes the expression has the output of 0 (for example,  $B = 0$  makes the multiplication with B equal 0). This test case output might cause confusion to define the incorrect usage of operator.

**TASK 4:** Given  $B=2$ , find all possible values of A so that the concrete test case (A, B) cannot achieve the above testing objective? Explain and justify the correctness of your solution.

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With  $B = 2$ , the expression for  $C$  will be:  $C = (A + 2) * 2 - 5$ .

The original program output:  $C = 2A - 1$

For the test case to fail in detecting an incorrect operator, the output  $C$  should remain the same across different test cases. We will equate the original expression  $C = 2A - 1$  with each output of every test cases.

Test case	Expression	Output	Equation	Value of A
Test "+" operator	$C = (A - B) * B - 5$	$C = 2A - 9$	$2A - 1 = 2A - 9$	No solution
	$C = (A * B) * B - 5$	$C = 4A - 5$	$2A - 1 = 4A - 5$	$A = 2$
Test "*" operator	$C = (A + B) + B - 5$	$C = A - 1$	$2A - 1 = A - 1$	$A = 0$
	$C = (A + B) - B - 5$	$C = A - 5$	$2A - 1 = A - 5$	$A = -4$
Test "-" operator	$C = (A + B) * B + 5$	$C = 2A + 9$	$2A - 1 = 2A + 9$	No solution
	$C = (A + B) * B * 5$	$C = 10A + 20$	$2A - 1 = 10A + 20$	$A = -21/8$ . Not an integer.
Test "+" and "*" operator	$C = (A - B) + B - 5$	$C = A - 5$	$2A - 1 = A - 5$	$A = -4$
	$C = (A - B) - B - 5$	$C = A - 9$	$2A - 1 = A - 9$	$A = -8$
	$C = (A * B) - B - 5$	$C = 2A - 7$	$2A - 1 = 2A - 7$	No solution
	$C = (A * B) + B - 5$	$C = 2A - 3$	$2A - 1 = 2A - 3$	No solution
Test "+" and "-" operator	$C = (A - B) * B * 5$	$C = 10A - 20$	$2A - 1 = 10A - 20$	$A = 19/8$ . Not an integer.
	$C = (A - B) * B + 5$	$C = 2A + 1$	$2A - 1 = 2A + 1$	No solution
	$C = (A * B) * B + 5$	$C = 4A + 5$	$2A - 1 = 4A + 5$	$A = -3$
	$C = (A * B) * B * 5$	$C = 20A$	$2A - 1 = 20A$	$A = -1/18$ . Not an integer.
Test "*" and "-" operator	$C = (A + B) + B + 5$	$C = A + 9$	$2A - 1 = A + 9$	$A = 10$
	$C = (A + B) - B + 5$	$C = A + 5$	$2A - 1 = A + 5$	$A = 6$
	$C = [(A + B) + B] * 5$	$C = 5A + 20$	$2A - 1 = 5A + 20$	$A = -7$
	$C = [(A + B) - B] * 5$	$C = 5A$	$2A - 1 = 5A$	$A = -1/3$ . Not an integer.
Test "+", "-", and "*" operator	$C = (A * B) + B + 5$	$C = 2A + 7$	$2A - 1 = 2A + 7$	No solution
	$C = [(A * B) + B] * 5$	$C = 10A + 10$	$2A - 1 = 10A + 10$	$A = -11/8$ . Not an integer.
	$C = (A * B) - B + 5$	$C = 2A + 3$	$2A - 1 = 2A + 3$	No solution
	$C = [(A * B) - B] * 5$	$C = 10A - 10$	$2A - 1 = 10A - 10$	$A = 9/8$ . Not an integer.
	$C = (A - B) + B + 5$	$C = A + 5$	$2A - 1 = A + 5$	$A = 6$
	$C = [(A - B) + B] * 5$	$C = 5A$	$2A - 1 = 5A$	$A = -1/3$ . Not an integer
	$C = (A - B) - B + 5$	$C = A + 1$	$2A - 1 = A + 1$	$A = 2$
	$C = [(A - B) - B] * 5$	$C = 5A - 20$	$2A - 1 = 5A - 20$	$A = 3/19$ . Not an integer.

**Conclusion:** When  $A \in \{-7, -8, -3, -4, 0, 2, 6, 10\}$ , the concrete test case of  $(A, B)$  cannot achieve the above testing objective. In case the value of  $A$  takes any from this series, the output  $C$  of the modified program will be the same as the output  $C$  of the original program. This means the test cannot detect the incorrect operator, failing the testing objective.