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SWE30009 - Assignment 1

Task 1

From the program's description, the output can be rewritten as $C = (A - B) * 2$, where A, B, and C are real numbers. For the testing objective of finding **any** incorrect use of arithmetic operators in the program, the test cases must cover two scenarios:

1. Only one operator is incorrect (either the subtraction or multiplication).
2. Both operators are incorrect.

Given that only four operators (+, -, *, /) are allowed, there are 15 possible alternatives, with 6 corresponding to the first scenario and 9 corresponding to the second scenario. They are:

1. $C = (A + B) * 2$
2. $C = (A * B) * 2$
3. $C = (A / B) * 2$
4. $C = (A - B) + 2$
5. $C = (A - B) - 2$
6. $C = (A - B) / 2$
7. $C = (A + B) + 2$
8. $C = (A + B) - 2$
9. $C = (A + B) / 2$
10. $C = (A * B) + 2$
11. $C = (A * B) - 2$
12. $C = (A * B) / 2$
13. $C = (A / B) + 2$
14. $C = (A / B) - 2$
15. $C = (A / B) / 2$

To satisfy the testing objective, the test cases should consist of two real numbers A and B such that the following 15 constraints are satisfied (left column):

C1	$(A - B) * 2 \neq (A + B) * 2$	C1	$B \neq 0$
C2	$(A - B) * 2 \neq (A * B) * 2$	C2	$A - B \neq A * B$
C3	$(A - B) * 2 \neq (A / B) * 2$	C3	$A - B \neq A / B$
C4	$(A - B) * 2 \neq (A - B) + 2$	C4	$A - B \neq 2$
C5	$(A - B) * 2 \neq (A - B) - 2$	C5	$A - B \neq -2$
C6	$(A - B) * 2 \neq (A - B) / 2$	C6	$A \neq B$
C7	$(A - B) * 2 \neq (A + B) + 2$	C7	$A - 3 * B \neq 2$
C8	$(A - B) * 2 \neq (A + B) - 2$	C8	$A - 3 * B \neq -2$
C9	$(A - B) * 2 \neq (A + B) / 2$	C9	$A \neq B * 5 / 3$
C10	$(A - B) * 2 \neq (A * B) + 2$	C10	$(A - B) * 2 \neq (A * B) + 2$
C11	$(A - B) * 2 \neq (A * B) - 2$	C11	$(A - B) * 2 \neq (A * B) - 2$
C12	$(A - B) * 2 \neq (A * B) / 2$	C12	$(A - B) * 2 \neq (A * B) / 2$
C13	$(A - B) * 2 \neq (A / B) + 2$	C13	$(A - B) * 2 \neq (A / B) + 2$
C14	$(A - B) * 2 \neq (A / B) - 2$	C14	$(A - B) * 2 \neq (A / B) - 2$
C15	$(A - B) * 2 \neq (A / B) / 2$	C15	$(A - B) * 2 \neq (A / B) / 2$

Some of the constraints on the left can be shortened into the versions on the right. Designing test cases for the testing objective will thus involve finding A and B such that **all** of the constraints hold.

Task 2

The test case $(A = 3, B = 1)$ will not achieve the required testing objective because it breaks constraint $C4$ $(A - B \neq 2)$. It will not reveal the failure of the program in case #4 where an addition is used instead of a multiplication [$C = (A - B) + 2$]. Indeed, if we substitute A and B with 3 and 1, respectively, in both the correct and incorrect cases, we get:

Correct program: $C = (A - B) * 2 = (3 - 1) * 2 = 4$

Incorrect program, case 4: $C = (A - B) + 2 = (3 - 1) + 2 = 4$

Task 3

As previously mentioned, a test case that satisfies the testing objective must satisfy all 15 constraints. To generate one, first select a real number for B such that $B \neq 0$. The test case now automatically satisfies constraint $C1$. Next, substitute B with the chosen value in the other constraints then solve for A. Suppose that we choose $B = 2$, the other constraints will become:

$C2$	$A - 2 \neq A * 2$	$\Rightarrow A \neq -2$
$C3$	$A - 2 \neq A / 2$	$\Rightarrow A \neq 4$
$C4$	$A - 2 \neq 2$	$\Rightarrow A \neq 4$
$C5$	$A - 2 \neq -2$	$\Rightarrow A \neq 0$
$C6$	$A \neq 2$	$\Rightarrow A \neq 2$
$C7$	$A - 3 * 2 \neq 2$	$\Rightarrow A \neq 8$
$C8$	$A - 3 * 2 \neq -2$	$\Rightarrow A \neq 4$
$C9$	$A \neq 2 * 5 / 3$	$\Rightarrow A \neq \frac{10}{3}$
$C10$	$(A - 2) * 2 \neq (A * 2) + 2$	$\Rightarrow -4 \neq 2$ (This constraint is always satisfied)
$C11$	$(A - 2) * 2 \neq (A * 2) - 2$	$\Rightarrow -4 \neq -2$ (This constraint is always satisfied)
$C12$	$(A - 2) * 2 \neq (A * 2) / 2$	$\Rightarrow A \neq 4$
$C13$	$(A - 2) * 2 \neq (A / 2) + 2$	$\Rightarrow A \neq 4$
$C14$	$(A - 2) * 2 \neq (A / 2) - 2$	$\Rightarrow A \neq \frac{4}{3}$
$C15$	$(A - 2) * 2 \neq (A / 2) / 2$	$\Rightarrow A \neq \frac{16}{7}$

From these constraints, we know the values that A cannot take if $B = 2$. To make a complete test case, pick any real number for A other than those excluded by the constraints. For example, some valid concrete test cases are $(A = 1, B = 2)$, $(A = 3, B = 2)$, $(A = 5, B = 2)$, etc.

To create test cases where B is not 2, repeat the above process with a different value of B.

Task 4

With $B = 1$, constraint $C1$ $(B \neq 0)$ is already satisfied. Therefore, to find concrete test cases that do not achieve the testing objective, we must find values of A that would break one or more constraints from $C2$ to $C15$. To do this, substitute B with 1 in these constraints and solve for A. The values that A cannot be equal to will form these test cases.

C2	$A - 1 \neq A * 1$	$\Rightarrow -1 \neq 0$ (This constraint is always satisfied)
C3	$A - 1 \neq A / 1$	$\Rightarrow -1 \neq 0$ (This constraint is always satisfied)
C4	$A - 1 \neq 2$	$\Rightarrow A \neq 3$
C5	$A - 1 \neq -2$	$\Rightarrow A \neq -1$
C6	$A \neq 1$	$\Rightarrow A \neq 1$
C7	$A - 3 * 1 \neq 2$	$\Rightarrow A \neq 5$
C8	$A - 3 * 1 \neq -2$	$\Rightarrow A \neq 1$
C9	$A \neq 1 * 5 / 3$	$\Rightarrow A \neq \frac{5}{3}$
C10	$(A - 1) * 2 \neq (A * 1) + 2$	$\Rightarrow A \neq 4$
C11	$(A - 1) * 2 \neq (A * 1) - 2$	$\Rightarrow A \neq 0$
C12	$(A - 1) * 2 \neq (A * 1) / 2$	$\Rightarrow A \neq \frac{4}{3}$
C13	$(A - 1) * 2 \neq (A / 1) + 2$	$\Rightarrow A \neq 4$
C14	$(A - 1) * 2 \neq (A / 1) - 2$	$\Rightarrow A \neq 0$
C15	$(A - 1) * 2 \neq (A / 1) / 2$	$\Rightarrow A \neq \frac{4}{3}$

From the above, we can conclude that all values of A that would break one or more constraints are 3, -1, 1, 5, $\frac{5}{3}$, 4, 0, and $\frac{4}{3}$.