

# How does the calculator percent key work?

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The Windows calculator percent sign works the same way as those cheap pocket calculators (which are often called four-function calculators even though they have around six function nowadays). What you first have to understand is that the percent key on those pocket calculators was not designed for mathematicians and engineers. It was designed for your everyday person doing some simple calculations. Therefore, the behavior of the key to you, an engineer, seems bizarrely counter-intuitive and even buggy. But to an everyday person, it makes perfect sense. Or at least that's the theory.

Let's look at it from the point of view of that everyday person. Suppose you want to compute how much a \$72 sweater will cost after including 5% tax.<sup>1</sup> Pull out your handy pocket calculator<sup>2</sup> (or fire up Calc if you don't have a pocket calculator) and type

$$| 72 + 5\% =$$

The result is 75.6, or \$75.60, which is the correct answer, because 5% of 72 is 3.6. Add that to 72 and you get 75.6.

Similarly, suppose that sweater was on sale at 20% off. What is the sale price?

$$| 72 - 20\% =$$

The result is 57.6 or \$57.60. This is the correct answer, because 20% of 72 is 14.4. Subtract that from 72 and you get 57.6.

You can chain these percentage operations, too. For example, how much will you have to pay for that 20%-off sweater after adding 5% tax?

$$| 72 - 20\% + 5\% =$$

The result is 60.48. A mathematician or engineer would have calculated the same result via the equivalent computation:

$$| 72 \times 0.80 \times 1.05 =$$

Okay, now that we see how the calculator product designer intended the percent key to be used, let's look at what the calculator engineer it has to do in order to match the specification. When the user enters  $A + B \% =$ , the result should be  $A \times (1 + B/100)$  or  $A + (A \times B/100)$  after you distribute the multiplication over the addition. Similarly, when the user enters  $A - B \% =$ , the result should be  $A \times (1 - B/100)$  or  $A - (A \times B/100)$ .

Aha, the calculator engineer says, we can achieve this result by defining the percent key as follows:

When the user enters a value, an operator, a second value, and then the percent key, the first two values are multiplied and the product divided by 100, and that result replaces the second value in the ongoing computation.

Let's walk through that algorithm with our first example.

You type	Remarks
72	First value is 72
+	Operation is addition
5	Second value is 5
%	$72 \times 5 \div 100 = 3.6$
	3.6 becomes the new second value
=	$72 + 3.6 = 75.6$ , the final result

If you watch the display as you go through this exercise, you will even see the number 3.6 appear in the display once you press the % key. The percentage is calculated and replaces the original value in the ongoing computation.

This algorithm also works for the chained percentages.

You type	Remarks
72	First value is 72
-	Operation is subtraction
20	Second value is 20
%	$72 \times 20 \div 100 = 14.4$
	14.4 becomes the new second value

+	$72 - 14.4 = 57.6$ , intermediate result
	57.6 is the new first value
	Operation is addition
5	Second value is 5
%	$57.6 \times 5 \div 100 = 2.88$
	2.88 becomes the new second value
=	$57.6 + 2.88 = 60.48$ , the final result

This even works for multiplication and division, but there is much less call for multiplying or dividing a number by a percentage of itself.

$$| 500 \times 5 \% =$$

The result of this is 12,500 because you are multiplying 500 by 5% of 500 (which is 25). The result of  $500 \times 25$  is 12,500. You aren't computing five percent *of* 500. You're multiplying 500 by 5% of 500. (It appears that the authors of [this Knowledge Base article](#) didn't consult with the calculator engineer before writing up their analysis. The percent key is behaving as designed. The problem is that the percent key is not designed for engineers.)

What if you want to compute 5% of 500? Just pick a dummy operation and view the result when you press the percent key.

$$| 500 + 5 \%$$

When you hit the percent key, the answer appears: 25. You could've used the minus key, multiplication key, or division key instead of the addition key. It doesn't matter since all you care about is the percentage, not the combined operation. Once you hit the % key, you get your answer, and then you can hit Clear to start a new calculation.

## Footnotes

<sup>1</sup>In the United States, quoted prices typically do not include applicable taxes.

<sup>2</sup>In my limited experiments, it appears that no two manufacturers of pocket calculators handle the percent key in exactly the same way. Casio appears to handle it in a manner closest to the engineering way. TI is closer to the layman algorithm. And when you get into cases like  $1 \div 2 \%$ , calculators start wandering all over the map. Should the answer be 50, since  $1/2$  is equal to 50%? Or should it be 0.005 since that is the numeric value of 0.5%? Should that answer appear immediately or should it wait for you to hit the equals sign? I don't know what the intuitive result should be either.

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