

## 1.10: Binary Operation

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A **binary operation** on a set  $S$  is a mapping  $f$  from the Cartesian product  $S \times S$  to  $S$ . A mapping from  $K \times S$  to  $S$ , where  $K$  need not be  $S$ , is called an **external binary operation**.

Many binary operations are commutative (i.e.  $f(a,b) = f(b,a)$  holds for all  $a, b$  in  $S$ ) or associative (i.e.  $f(f(a,b), c) = f(a, f(b,c))$  holds for all  $a,b,c$  in  $S$ ). Many also have identity elements and inverse elements. Typical examples of binary operations are the addition (+) and multiplication (\*) of numbers and matrices as well as composition of functions or symmetry operations.

Examples of binary operations that are not commutative are subtraction (-), division (/), exponentiation(^), super-exponentiation(@), and composition.

Binary operations are often written using infix notation such as  $a * b$ ,  $a + b$ , or  $a \cdot b$  rather than by functional notation of the form  $f(a,b)$ . Sometimes they are even written just by concatenation:  $ab$ .

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