

DIRECT PRODUCTS

Why

We generalize the product of two sets to a product of a family of sets. To do so we discuss sets of families.

Discussion for pairs

Let A and B be sets. There is a natural correspondence between the product set $A \times B$ (see Cartesian Products) and the set of families

$$Z = \{z : \{i, j\} \to (A \cup B) \mid z_i \in A \text{ and } z_b \in B\}.$$

The family $z \in Z$ corresponds with the pair (z_i, z_i) . The pair (a, b) corresponds to the family $z \in Z$ defined by z(i) = a and z(j) = b. So, ordered pairs can be put in one-to-one correspondence with families. The generalization of Cartesian products to more than two sets generalizes the notion for families.

Definition

Let X be a set. Let $A: I \to X$ be a family of subsets of X. The direct product or family Cartesian product of A is the set of all families $a: I \to X$ which satisfy $a_i \in A_i$ for every $i \in I$.

A function on a product is called a function of several variables and, in particular, a function on the product $X \times Y$ is called a function of two variables.

Notation

We denote the product of the family $\{A_i\}$ by

$$\prod_{i\in I} A_i$$

We read this notation as "product over i in I of A sub-i."

Projections

The word "projection" is used in two senses with families. Let I be a set, and let $\{A_i\}_{i\in I}$ be a family of sets. Define $A=\prod_{i\in I}A_i$.

First, let $J \subset I$. There is a natural correspondence between the elements of A and those of $\prod_{j \in J} A_j$. To each element $a \in A$, we restrict a to J and this is restriction is an element of $\prod_{j \in J} A_j$. The correspondence is called the *projection* of A onto $\prod_{i \in J} A_i$. The projection in this sense is a set of families.

Second, consider the value of a family $a \in A$ at j. We call a_j the projection of a onto index j or the j-coordinate of a. This word coordinate is meant to follow the language used in defining ordered pairs. The projection in this sense is an element of A_j . The jth projection is a function from $\prod_{i \in I} X_i \to X_j$.

