



## Why

We want to define area under a real function. We begin with functions whose area under the curve is self-evident.

## Definition

Consider a measure space. The characteristic function of any measurable set is measurable. A simple function is measurable if and only if each element of its simple partition is measurable.

The *integral* of a measurable non-negative simple function is the sum of the products of the measure of each piece with the value of the function on that piece. For example, the integral of a measurable characteristic function of a subset is the measure of that subset.

The *integral operator* is the real-valued function which associates each measurable non-negative simple function with its integral. The simple integral is non-negative, so the integral operator is a non-negative function.

## Notation

Suppose  $(X, \mathcal{A}, \mu)$  is a measure space and  $f : X \rightarrow \mathbf{R}$  is a measurable simple function; i.e., there are  $A_1, \dots, A_n \in \mathcal{A}$  and  $a_1, \dots, a_n \in \mathbf{R}$  with:

$$f = \sum_{i=1}^n a_i \chi_{A_i}.$$

We denote the integral of  $f$  with respect to measure  $\mu$  by  $\int f d\mu$ , which we defined as

$$\int f d\mu := \sum_{i=1}^n a_i \mu(A_i).$$

