

## Phase 11 a : Function Types

Total functions (every element in domain has a mapping):

$$\begin{array}{c} | \quad f : X \quad Y \\ g : \mathbb{N} \quad \mathbb{N} \end{array}$$

Partial functions (some elements may not have a mapping):

$$\begin{array}{c} | \quad f : X \quad Y \end{array}$$

Injections (one-to-one mappings):

$$\begin{array}{c} | \quad f_{total} : X \quad Y \\ f_{partial} : X \quad Y \end{array}$$

Surjections (onto mappings):

$$\begin{array}{c} | \quad f_{total} : X \quad Y \\ f_{partial} : X \quad Y \end{array}$$

Bijections (one-to-one and onto):

$$\begin{array}{c} | \quad f : X \quad Y \end{array}$$

Complex function types (nested and higher-order):

$$\begin{array}{c} | \quad f : X \quad Y \quad Z \\ g : X \quad (Y \quad Z) \end{array}$$

Mixed operators (relations and function types work together):

$$\begin{array}{c} \begin{array}{c} relation : X \quad Y \\ function : X \quad Y \end{array} \\ \hline function \subseteq relation \end{array}$$