

## set.1 Comparing Sets

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sec

**Proposition set.1.** *The formula  $\forall x (X(x) \rightarrow Y(x))$  defines the subset relation, i.e.,  $\mathfrak{M}, s \models \forall x (X(x) \rightarrow Y(x))$  iff  $s(X) \subseteq s(Y)$ .*

**Proposition set.2.** *The formula  $\forall x (X(x) \leftrightarrow Y(x))$  defines the identity relation on sets, i.e.,  $\mathfrak{M}, s \models \forall x (X(x) \leftrightarrow Y(x))$  iff  $s(X) = s(Y)$ .*

**Proposition set.3.** *The formula  $\exists x X(x)$  defines the property of being non-empty, i.e.,  $\mathfrak{M}, s \models \exists x X(x)$  iff  $s(X) \neq \emptyset$ .*

A set  $X$  is no larger than a set  $Y$ ,  $X \preceq Y$ , iff there is an injective function  $f: X \rightarrow Y$ . Since we can express that a function is injective, and also that its values for arguments in  $X$  are in  $Y$ , we can also define the relation of being no larger than on subsets of the domain.

**Proposition set.4.** *The formula*

$$\exists u (\forall x (X(x) \rightarrow Y(u(x))) \wedge \forall x \forall y (u(x) = u(y) \rightarrow x = y))$$

*defines the relation of being no larger than.*

Two sets are the same size, or “equinumerous,”  $X \approx Y$ , iff there is a bijective function  $f: X \rightarrow Y$ .

**Proposition set.5.** *The formula*

$$\begin{aligned} \exists u (\forall x (X(x) \rightarrow Y(u(x))) \wedge \\ \forall x \forall y (u(x) = u(y) \rightarrow x = y) \wedge \\ \forall y (Y(y) \rightarrow \exists x (X(x) \wedge y = u(x)))) \end{aligned}$$

*defines the relation of being equinumerous with.*

We will abbreviate these formulas, respectively, as  $X \subseteq Y$ ,  $X = Y$ ,  $X \neq \emptyset$ ,  $X \preceq Y$ , and  $X \approx Y$ . (This may be slightly confusing, since we use the same notation when we speak informally about sets  $X$  and  $Y$ —but here the notation is an abbreviation for formulas in second-order logic involving one-place relation variables  $X$  and  $Y$ .)

**Proposition set.6.** *The sentence  $\forall X \forall Y ((X \preceq Y \wedge Y \preceq X) \rightarrow X \approx Y)$  is valid.*

*Proof.* The sentence is satisfied in a structure  $\mathfrak{M}$  if, for any subsets  $X \subseteq |\mathfrak{M}|$  and  $Y \subseteq |\mathfrak{M}|$ , if  $X \preceq Y$  and  $Y \preceq X$  then  $X \approx Y$ . But this holds for any sets  $X$  and  $Y$ —it is the Schröder-Bernstein Theorem.  $\square$

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**Bibliography**