Bijections and cardinality

## Bijections and cardinality

Theorem 6.3: Suppose $A$ and $B$ are finite sets, and $f: A \rightarrow B$.

## Bijections and cardinality

Theorem 6.3: Suppose $A$ and $B$ are finite sets, and $f: A \rightarrow B$.
(a) If $f$ is injective, then $|A| \leqslant|B|$.
(b) If $f$ is surjective, then $|A| \geqslant|B|$.
(c) If $f$ is bijective, then $|A|=|B|$.

## Bijections and cardinality

Theorem 6.3: Suppose $A$ and $B$ are finite sets, and $f: A \rightarrow B$.
(a) If $f$ is injective, then $|A| \leqslant|B|$.
(b) If $f$ is surjective, then $|A| \geqslant|B|$.
(c) If $f$ is bijective, then $|A|=|B|$.

Part (c) is often used in counting problems: if we want to find $|A|$ for some set $A$, we find a bijection $A \rightarrow B$ for a set $B$ for which we know $|B|$.

Images of subsets

## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.

## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.
Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\}
$$

## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.

Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

> Example:
> $f:\{1,2,3\} \rightarrow\{$ red, blue, green $\}$, $f(1)=$ red, $f(2)=$ green, $f(3)=$ red.

## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.
Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

## Example:

$f:\{1,2,3\} \rightarrow$ \{red, blue, green $\}$, $f(1)=$ red, $f(2)=$ green, $f(3)=$ red.

- $f(\{1,2\})=\{$ red, green $\}$.


## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.
Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

## Example:

$f:\{1,2,3\} \rightarrow$ \{red, blue, green $\}$,
$f(1)=$ red, $f(2)=$ green, $f(3)=$ red.

- $f(\{1,2\})=\{$ red, green $\}$.
- $f(\{1,3\})=\{$ red $\}$.


## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.
Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

## Example:

$f:\{1,2,3\} \rightarrow$ \{red, blue, green $\}$,
$f(1)=$ red, $f(2)=$ green, $f(3)=$ red.

- $f(\{1,2\})=\{$ red, green $\}$.
- $f(\{1,3\})=\{$ red $\}$.
- $f(\emptyset)=\emptyset$


## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.

Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

## Example:

$f: \mathbb{R} \rightarrow \mathbb{R}, f(x)=x^{2}$.

## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.
Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

## Example:

$f: \mathbb{R} \rightarrow \mathbb{R}, f(x)=x^{2}$.

- $f(\{-1,2\})=\{1,4\}$.


## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.
Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

## Example:

$f: \mathbb{R} \rightarrow \mathbb{R}, f(x)=x^{2}$.

- $f(\{-1,2\})=\{1,4\}$.
- $f([-1,2])=[0,4]$.


## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.

Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

## Example:

$f: \mathbb{R} \rightarrow \mathbb{R}, f(x)=x^{2}$.

- $f(\{-1,2\})=\{1,4\}$.
- $f([-1,2])=[0,4]$.
- $f(\mathbb{Z})=\{0,1,4,9,16, \ldots\}$


## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.

Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

## Example:

$f: \mathbb{R} \rightarrow \mathbb{R}, f(x)=x^{2}$.

- $f(\{-1,2\})=\{1,4\}$.
- $f([-1,2])=[0,4]$.
- $f(\mathbb{Z})=\{0,1,4,9,16, \ldots\}$
- $f(\emptyset)=\emptyset$


## Images of subsets

Suppose $f: A \rightarrow B$, and $C \subseteq A$.

Image of $C$ under $f$ :

$$
f(C)=\{f(a): a \in C\} .
$$

## Example:

$f: \mathbb{R} \rightarrow \mathbb{R}, f(x)=x^{2}$.

- $f(\{-1,2\})=\{1,4\}$.
- $f([-1,2])=[0,4]$.
- $f(\mathbb{Z})=\{0,1,4,9,16, \ldots\}$
- $f(\emptyset)=\emptyset($ true for any function $f)$

Inverse images of subsets

## Inverse images of subsets

Suppose $f: A \rightarrow B$, and $D \subseteq B$.

## Inverse images of subsets

Suppose $f: A \rightarrow B$, and $D \subseteq B$.

Inverse image of $D$ under $f$ :

$$
f^{-1}(D)=\{a \in A: f(a) \in D\} .
$$

## Inverse images of subsets

Suppose $f: A \rightarrow B$, and $D \subseteq B$.

Inverse image of $D$ under $f$ :

$$
f^{-1}(D)=\{a \in A: f(a) \in D\} .
$$

