

$$\underbrace{(A \cap B^c)}_X \cup \underbrace{C^c}_Y \cap \boxed{\underbrace{(D \cup E)^c}_{\cancel{Z}}}$$

$$(X \cup Y) \cap Z$$

$$= (X \cap Z) \cup (Y \cap Z)$$

Relations

(Binary Relations)

Sets A, B

Relation

$$R \subseteq A \times B$$

$$A = \{1, 2, 3\}$$

$$B = \{0, 1, 2, 3\}$$

$$\{0, 1, 2\}$$

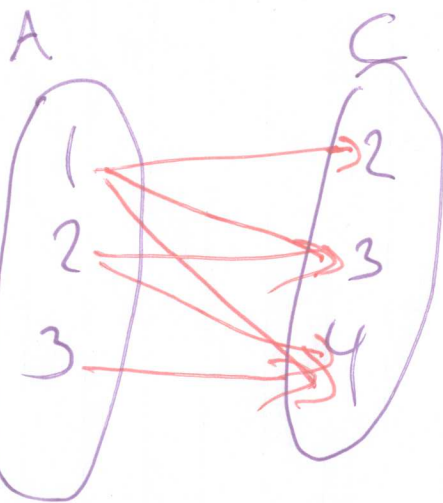
Relation "is strictly smaller"

$$\{(a, b) \in A \times B \mid a \neq b\}$$

$$= \{(1, 2)\}$$

a	c
1	2
1	3
1	4
2	3
2	4
...	...

"Digraph"

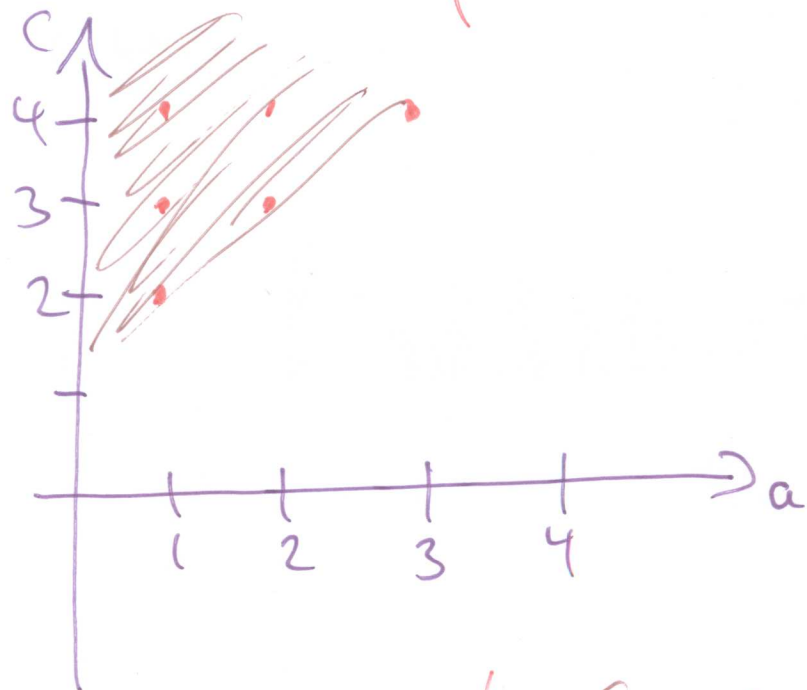


$$C = \{2, 3, 4\}$$

$$\{(a, c) \in A \times C \mid a \neq c\}$$

$$= \{(1, 2), (1, 3), (1, 4), (2, 3), (2, 4), (3, 4)\}$$

A hand-drawn diagram illustrating a network or flow structure. It consists of four nodes labeled 1, 2, 3, and 4. Node 1 is at the top, node 2 is to its right, node 3 is to the right of node 2, and node 4 is at the bottom. Purple arrows indicate a path from node 1 to node 2, then to node 3, and finally to node 4. Red arrows indicate a path from node 1 to node 3, then to node 4. There is also a red arrow from node 1 to node 2 and a purple arrow from node 2 to node 4.



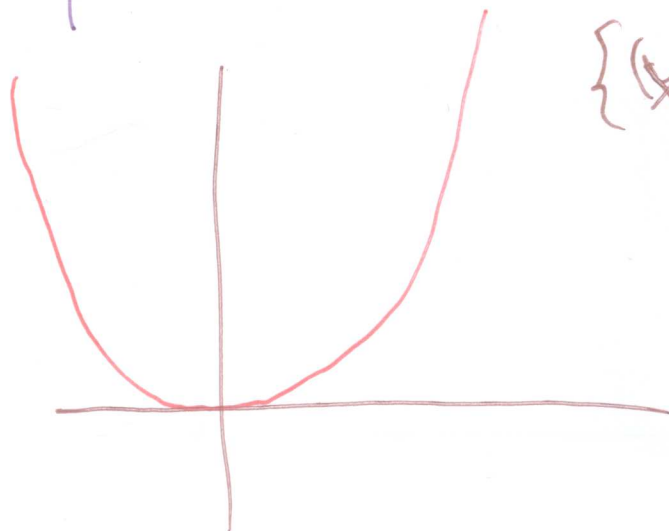
$$(2,3) \in R, \quad (3,2) \notin R$$

2R3

$3R2$

$2 \leq 3$

3 ~~4~~ 2



$$\{(x, y) \in \mathbb{R} \times \mathbb{R} \mid y = x^2\}$$

$|A| \quad R \subseteq A \times B$

A source B Target

R

$\{b \in B \mid (a, b) \in R \text{ for some } a \in A\}$

Domain = $\{a \in A \mid (a, b) \in R \text{ for some } b \in B\}$

A Source

$$A = B = \{1, 2, 3, 4\}$$

$$R = \{(1, 2), (1, 3), (4, 4), (2, 3), (2, 4), (3, 4)\}$$

$$R = \{(a, b) \mid a \neq b, a \in A, b \in B\} \subseteq A \times B$$

Complement: $R^c = \{(a, b) \mid a R b\}$

$$R^c = \{(2, 1), (1, 1), (2, 2)\}$$

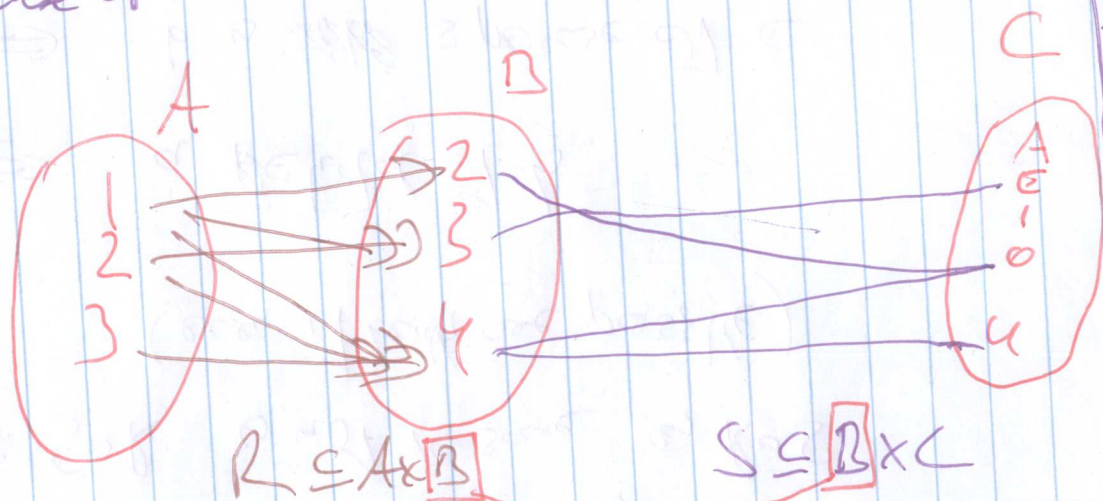
Converse: Converse of R . (sometimes R^{-1})

$$\subseteq B \times A$$

$$= \{(b, a) \in B \times A \mid a R b\}$$

Converse of $R = \{(2, 1), (3, 1), (4, 1), (3, 2), (4, 2), (4, 3)\}$

Composition



$$R \subseteq A \times B$$

$$S \subseteq B \times C$$

$$S \circ R = \{(1, 1), (1, 2), (1, 3), (2, 1), (2, 2), (2, 3), (3, 1), (3, 2), (3, 3)\}$$

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Composition of
 R with S

(cautful: SoR is not the same as RoS
(even if both are possible)

$aRb \Leftrightarrow a$ child of b

$bSc \Leftrightarrow b$ is ~~old~~ spouse of c

$SoR = \{ (a, c) \mid a \text{ child of spouse of } c \}$

$RoS = \{ (a, b) \mid$

(b, a)

$\mid b$ spouse of some c who is child of a