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Lecture 1 Introduction

Thursday, January 7, 2021 11:12 AM

Equivalence relations

A binary relation R on a set X is a subset of $X \times X$ i.e. it is a set of pairs

[NOTATION: $(a,b) \in R$ as aRb]

R must satisfy:

(i) Reflexivity $\forall x \in X \; xRx$

(ii) Symmetry $\forall x,y \in X \; xRy \Rightarrow yRx$

(iii) Transitivity $\forall x,y,z \in X \; xRy \,\&\, yRz \Rightarrow xRz$

Eg $n \equiv m \pmod 7$

means remainder after dividing n by 7 and m by 7 is the same.

Partial order $\leqslant$

"Think less than or equal to"

A binary relation R is a partial order on X if:

(i) $\forall x \in X \quad xRx$

ANTISYMMETRY

(ii) $\forall x, y \in X \quad xRy \;\&\; yRx \Rightarrow x = y$

(iii) $\forall x, y, z \quad xRy \;\&\; yRz \Rightarrow xRz$

e.g. numerical inequality

e.g. 2 set inclusion

$\{a, b, c\}$

$\{a, b\} \subseteq \{a, b, c\}$ $\quad \subseteq$ is a partial order

$\{b, c\} \subseteq \{a, b, c\}$

$\{a\} \subseteq \{a, b\}$

$\{a, b\} \not\subseteq \{a, c\}$

$\{a, c\} \not\subseteq \{a, b\}$

It is not necessarily true that $\forall x, y$
xRy OR yRx.

If every pair of elements can be compared then we have a total order also called a linear order.

If we have a partial order $\leq$
we say $a < b$ if $a \leq b$ AND $a \neq b$.

a is strictly less than b

BASIC FACTS :

Suppose X is a set and R is an equivalence relation $\forall x \in X$ we define

$[x] = \{ y \in X \mid x R y \}$

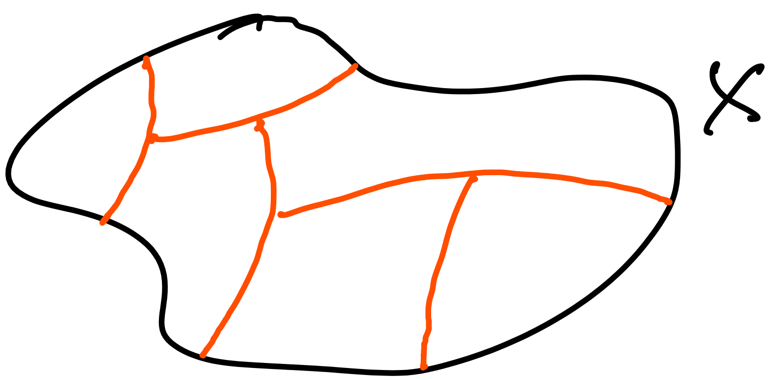
↳ the <u>equivalence class</u> of x.

1. If xRy then $[x] = [y]$ (why?)

2. If $x, y \in X$ then either $[x] = [y]$

OR $[x] \cap [y] = \phi$ ← empty set (why?)

The equivalence classes divide X into <u>disjoint</u> "clumps".

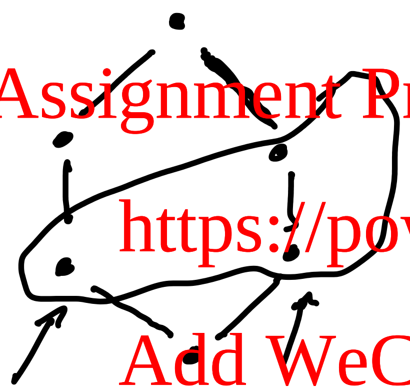


THIS IS CALLED A PARTITION

WELL-FOUNDED ORDERS

A partial order $\leq$ on S is well founded if every non-empty subset $U \subseteq S$ has a <u>minimal</u> element.

<u>Remark</u> We say $u \in U$ is minimal if there is nothing else in U <u>strictly</u> <u>less</u> than u.



2 minimal elements

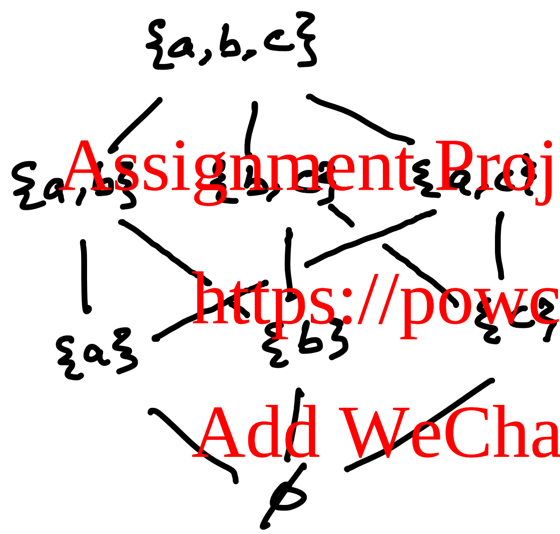
WHO CARES?

The non-negative integers <u>are</u> a well-founded order with the usual numerical order

<u>All</u> the integers do <u>not</u> form a well founded set.

<u>Thm</u> The principle of induction can be used if and <u>only if</u> the order is well founded.

AFTER CLASS QUESTIONS:



$\{\{a,b,c\}, \{a,b\}, \{a\}\} \xrightarrow{\text{MINIMAL?}} \{a\}$

$\{\underbrace{\{a,b\}}_{x}, \{a,c\}, \{b\}\} \longrightarrow$ BOTH ARE MINIMAL.

$\{a,b,c\}$ MINIMAL $\rightarrow$ MEANINGLESS.

$\{\{a,b,c\}\} \longrightarrow \{a,b,c\}$

$\{\{a,b,c\}, \{a,b\}, \{a\}, \phi\} \rightarrow \phi$ ✓