

Exercises: Artificial Intelligence

Constraint Processing II & Waltz: The
4 Teachers problem

Constraint Processing II & Waltz: The 4 Teachers problem

PROBLEM

Problem

- Four teachers: A, B ,C & D
 - A, B, C & D assigned rooms
 - 5 rooms available: 1, 2, 3, 4 & 5
 - $A \neq 1$
 - $B \neq 2$
 - $\text{room } D \geq 3$
 - $\text{room } D < \text{room } B$
 - $|C-B| \neq 1$
 - $C \neq 5$

Problem

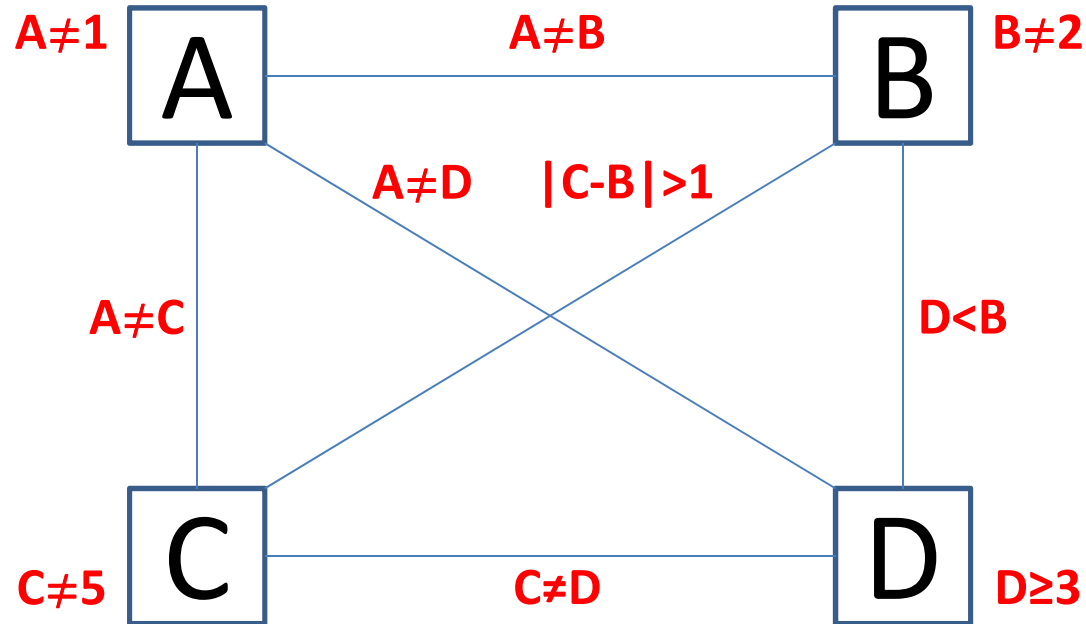
- Which family lives in which house?
- Solve with:
 - Forward checking
 - Dynamic rearrangement forward checking

Constraint Processing II & Waltz: The 4 Teachers problem

CONSTRAINT PROCESSING: PROBLEM REPRESENTATION

Constraint Processing

- Problem representation:

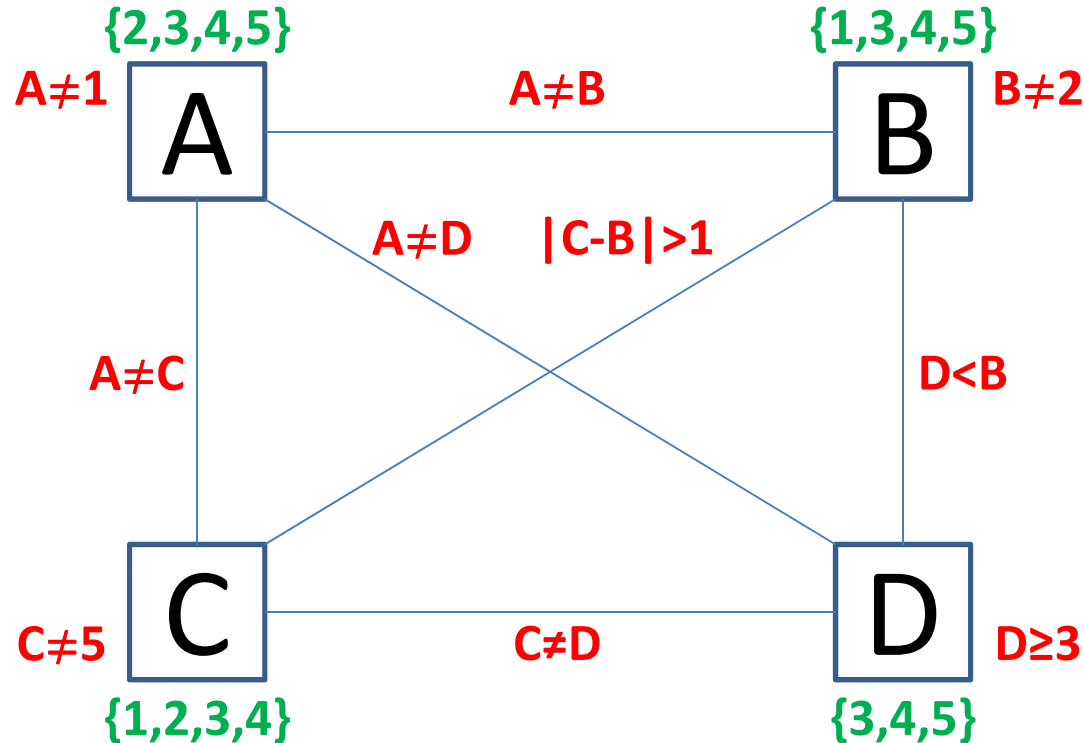


MiniMax & Constraint Processing: The 4 Houses problem

CONSTRAINT PROCESSING: PROBLEM OPTIMIZATION

Problem Optimization

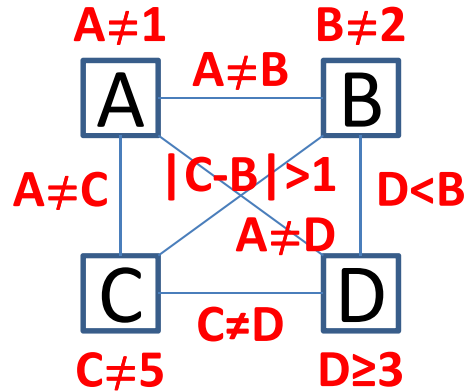
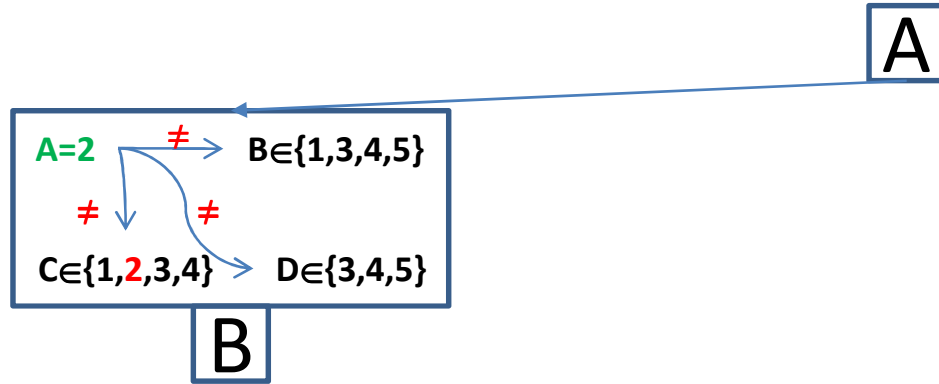
- Problem optimization:



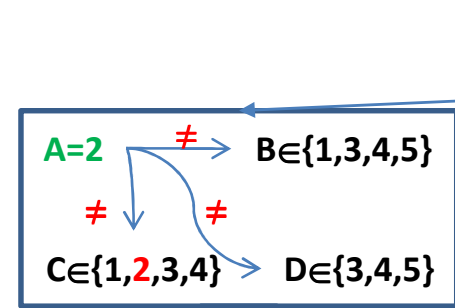
MiniMax & Constraint Processing: The 4 Houses problem

CONSTRAINT PROCESSING: FORWARD CHECKING

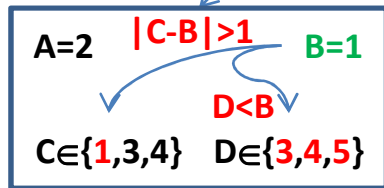
Forward Checking



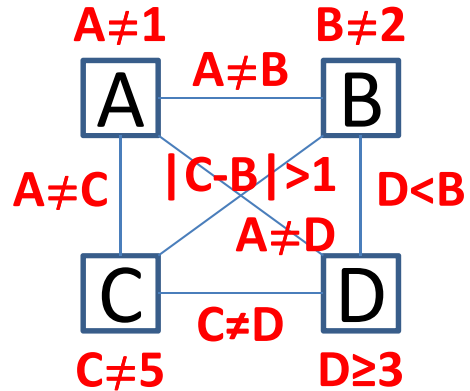
Forward Checking



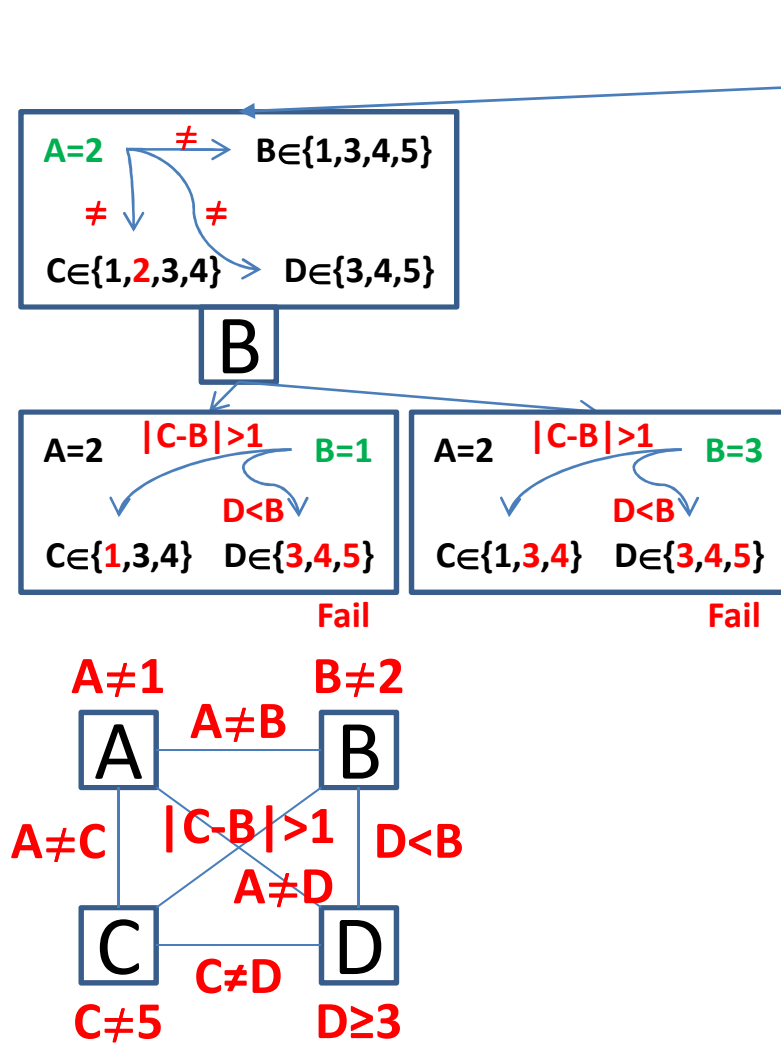
B



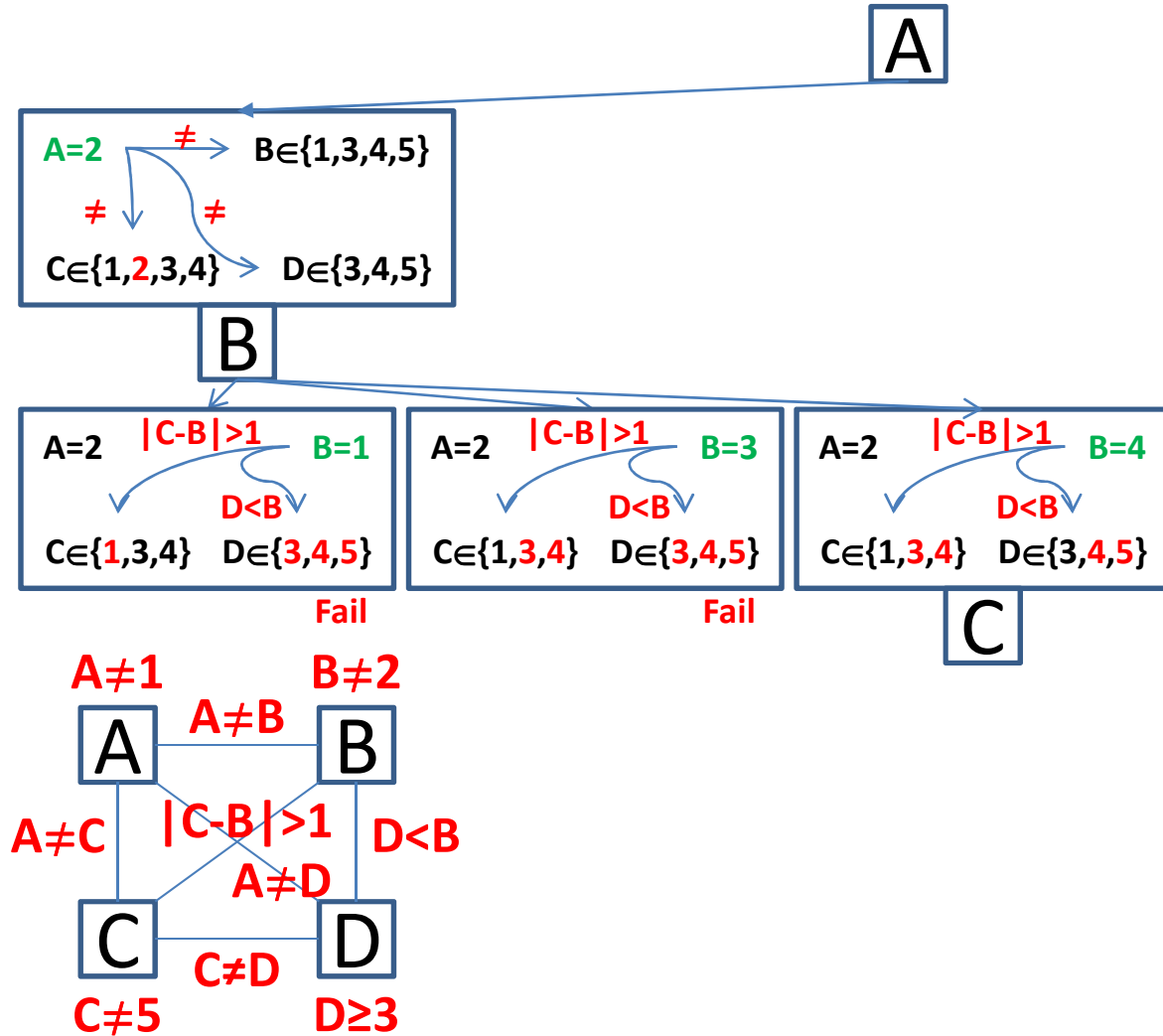
Fail



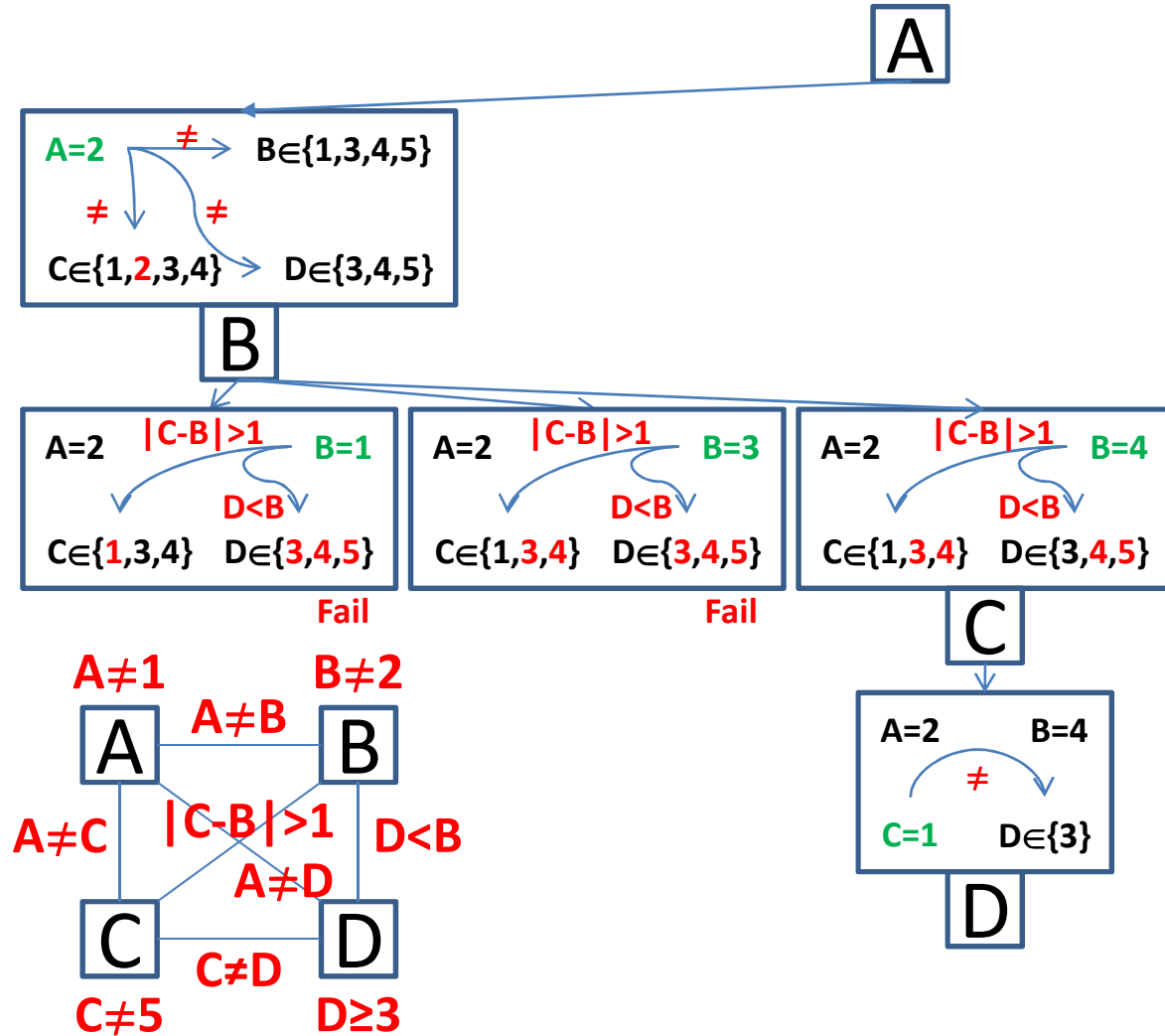
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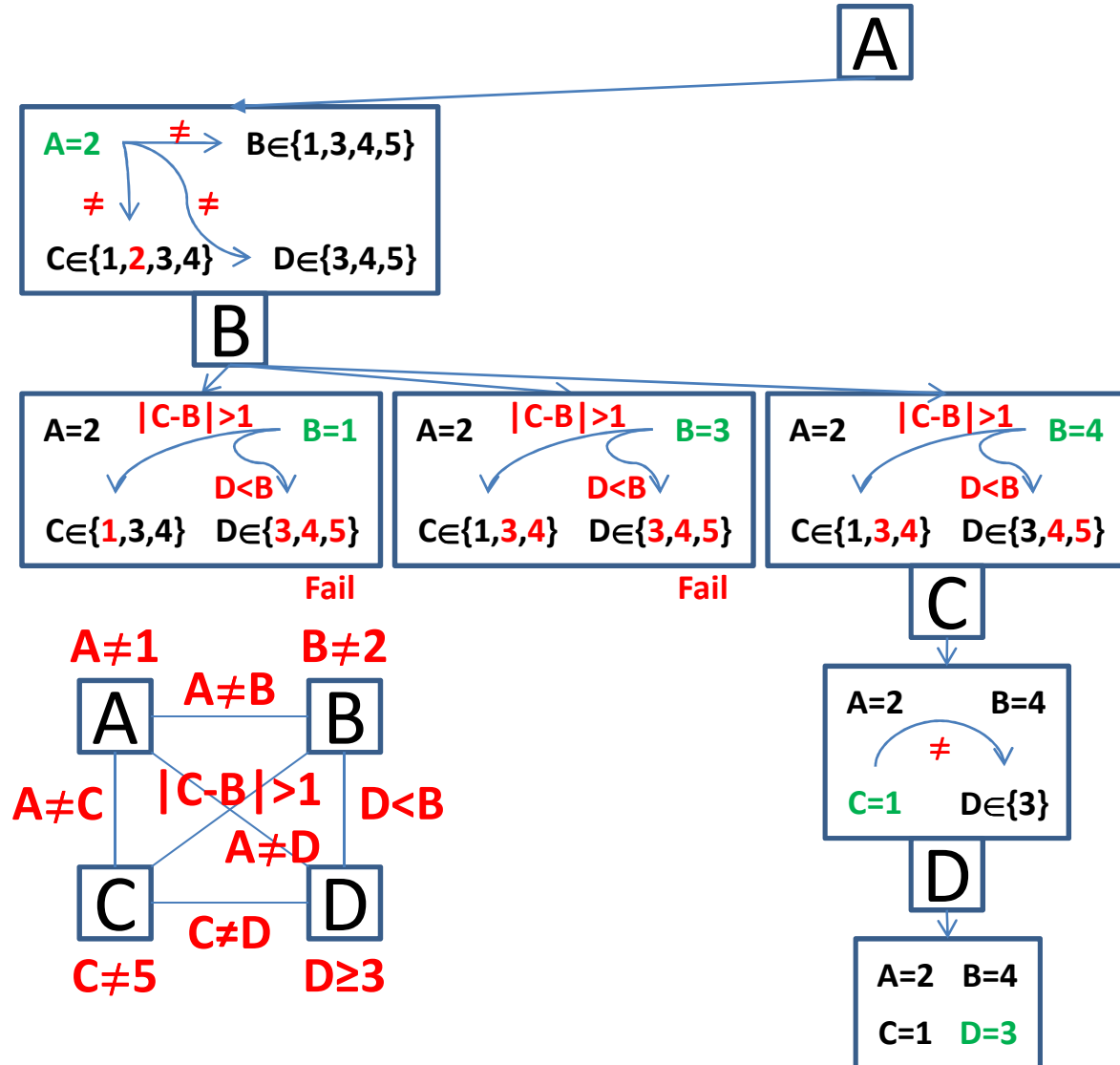
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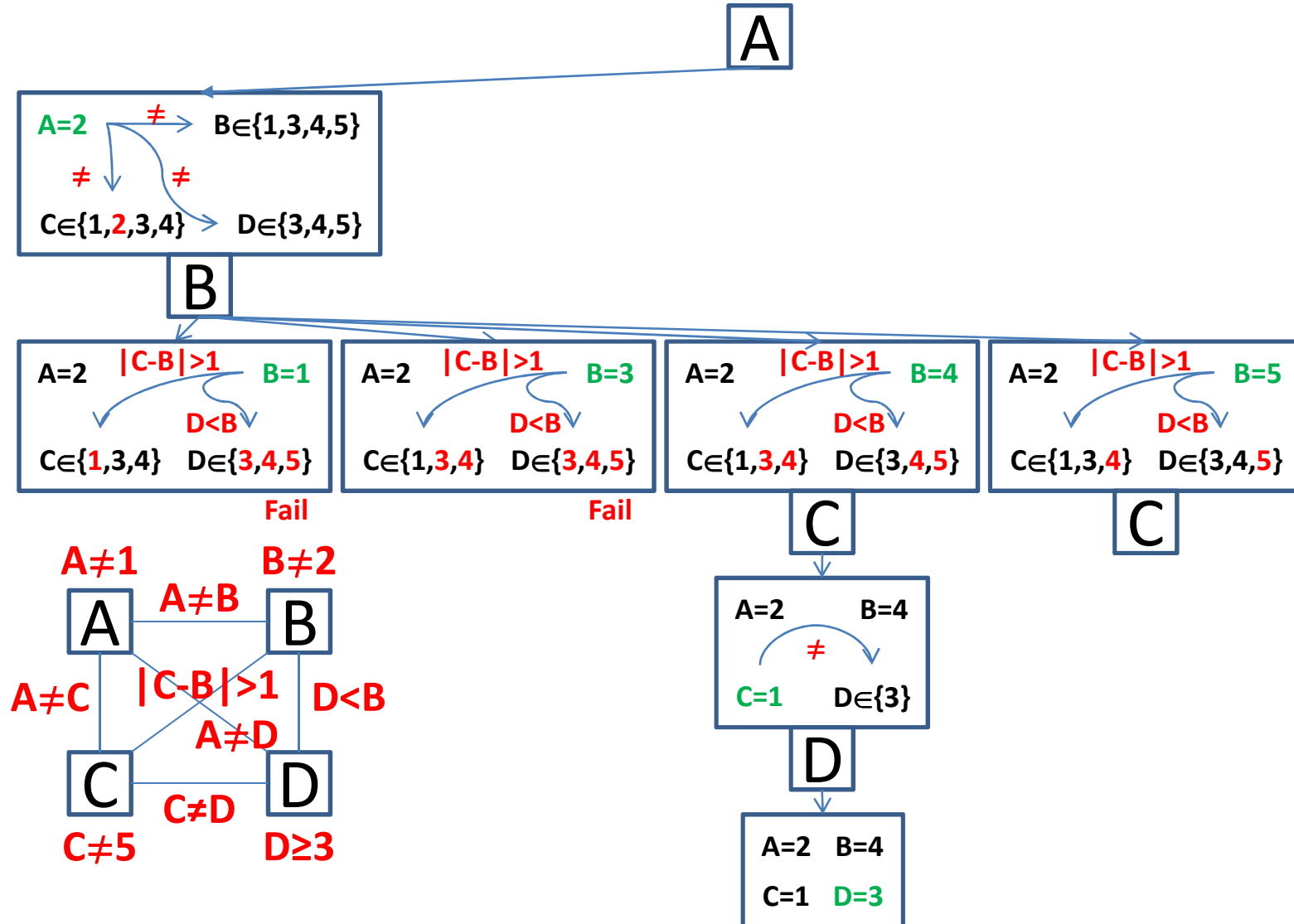
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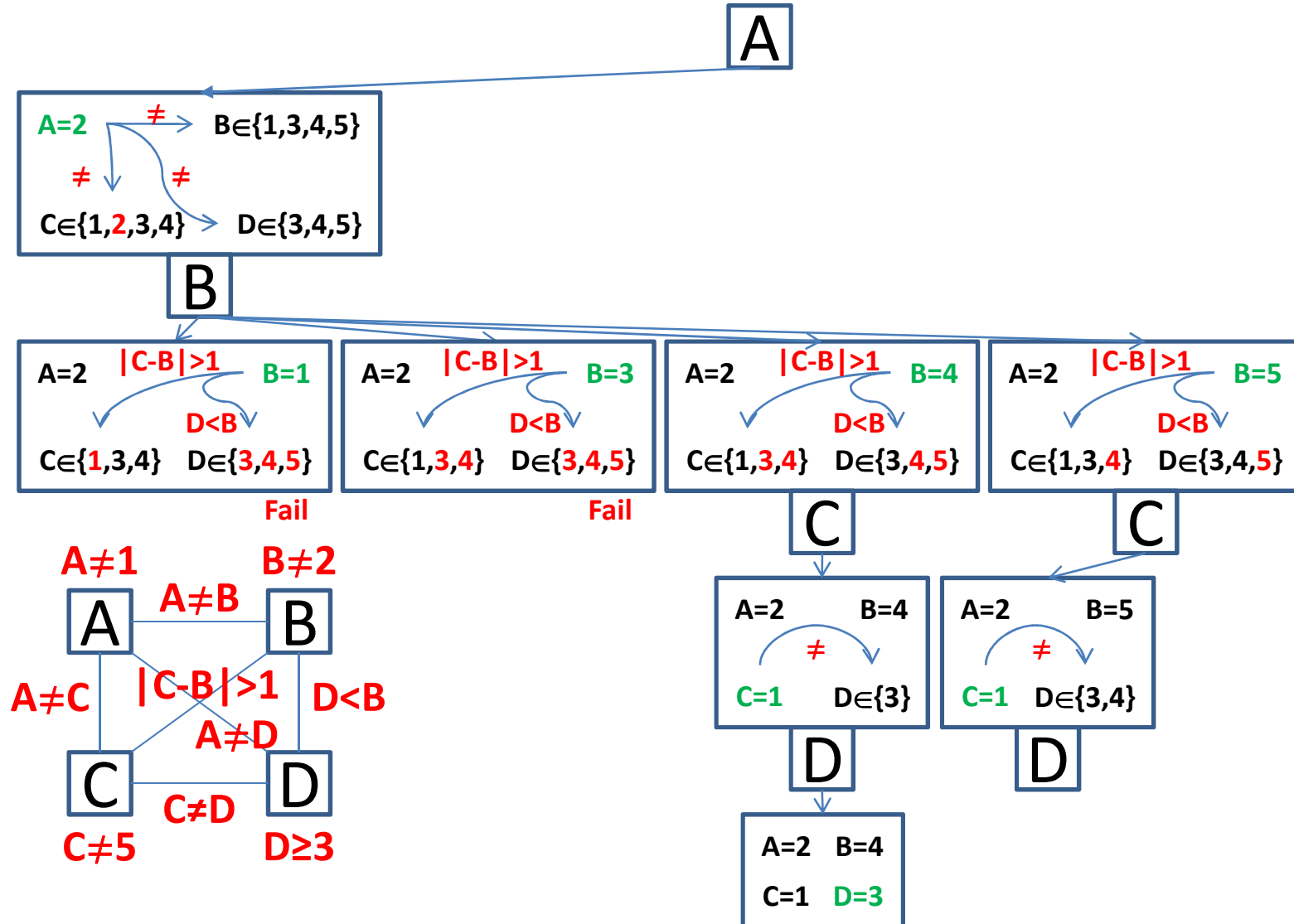
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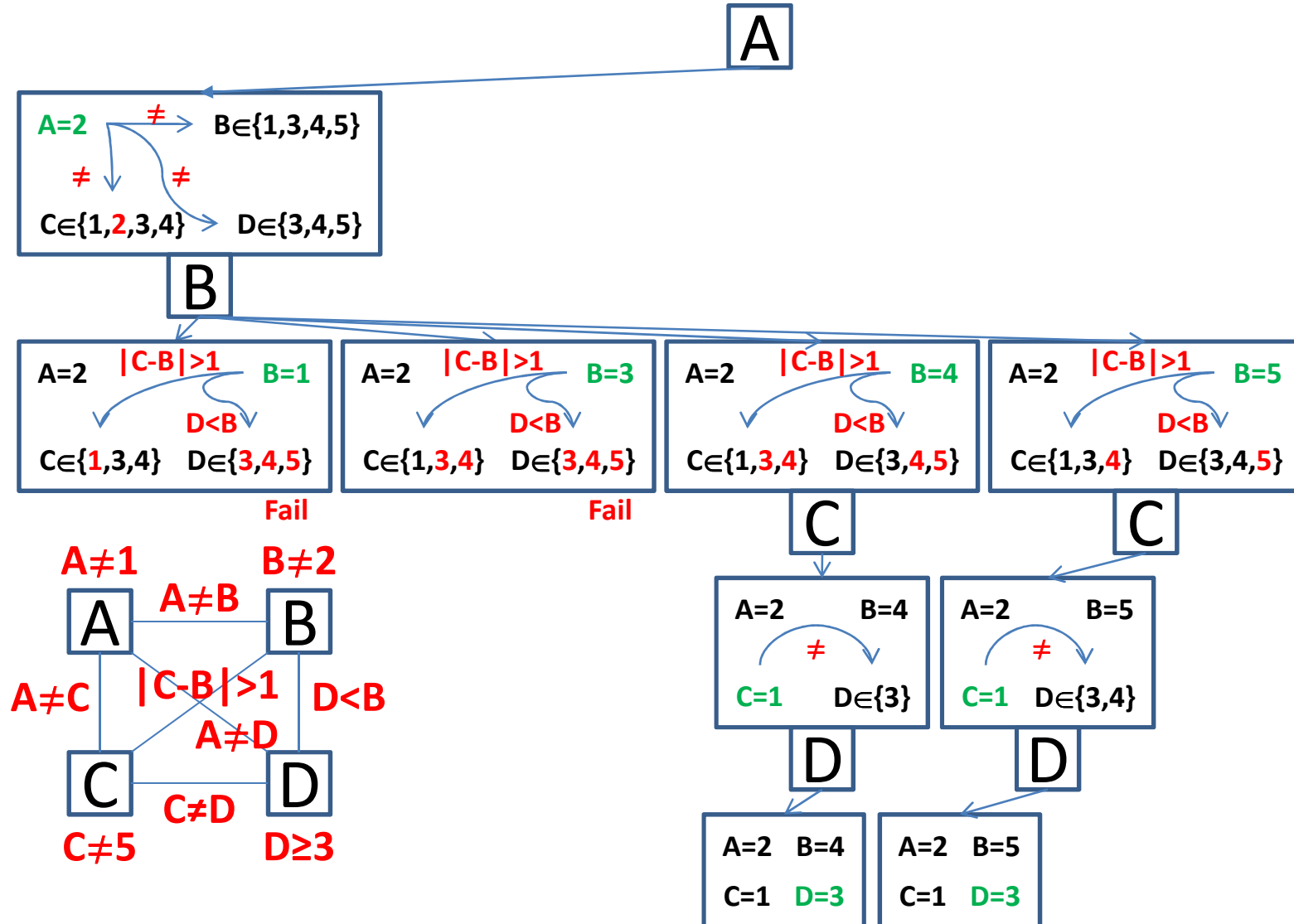
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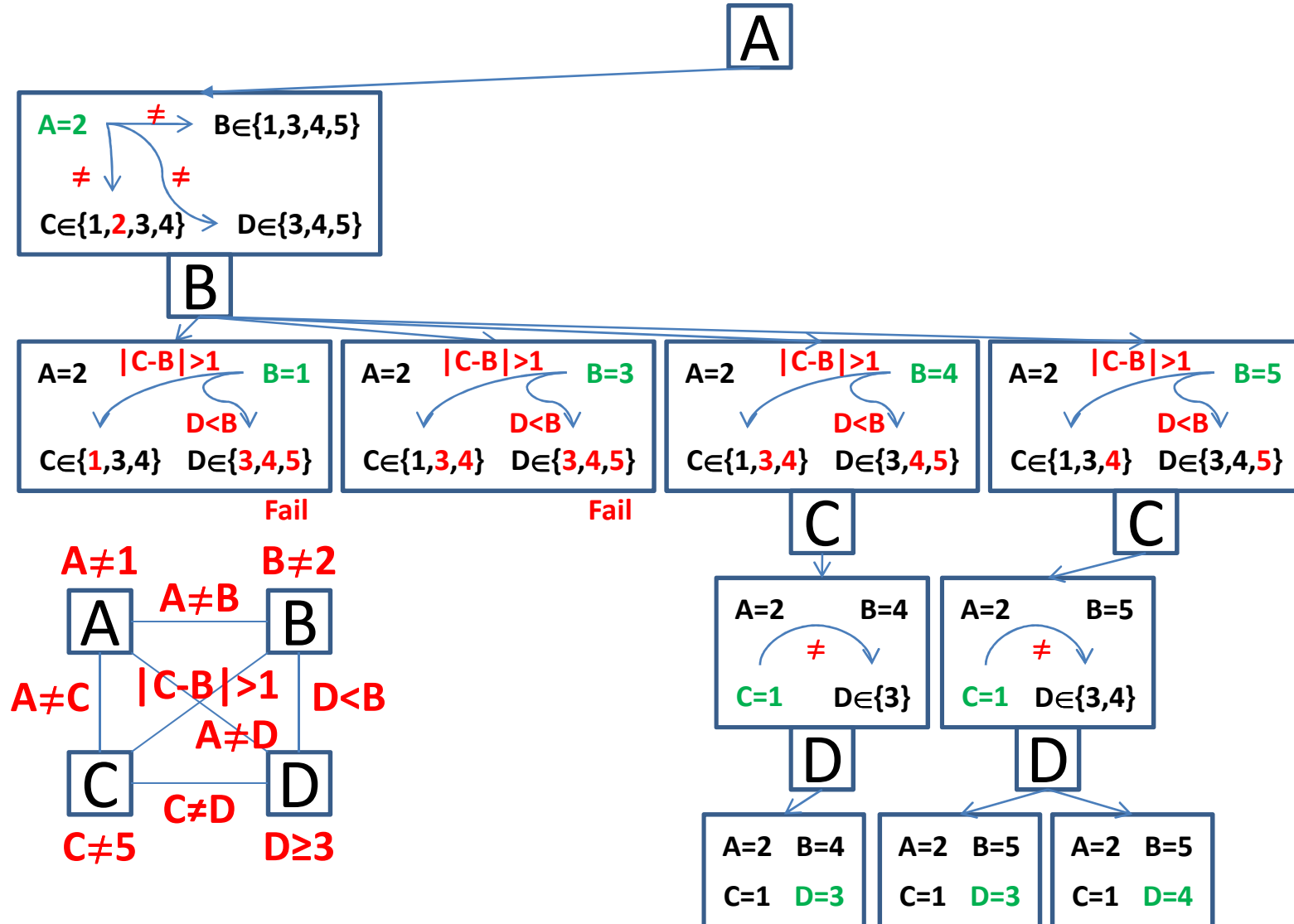
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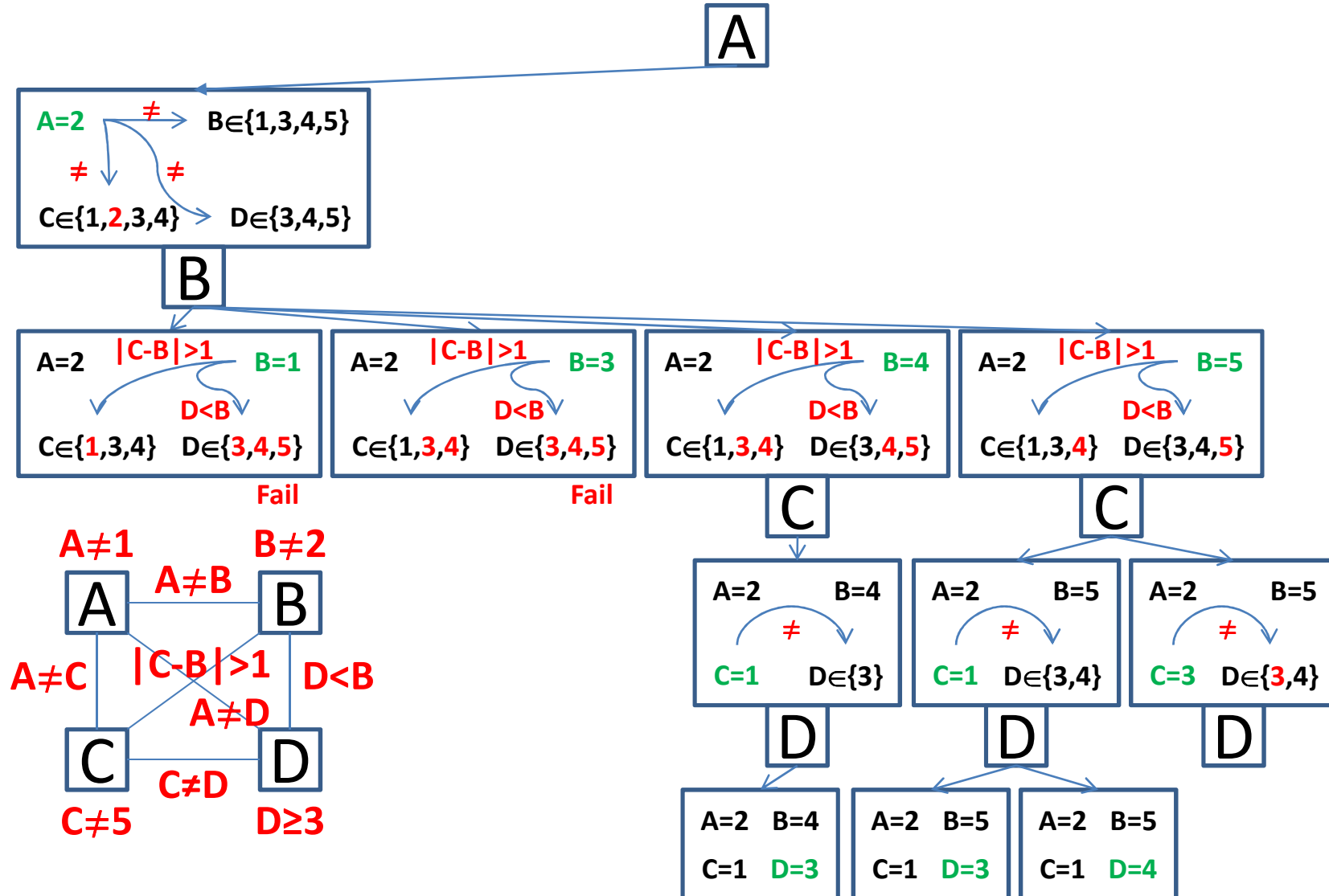
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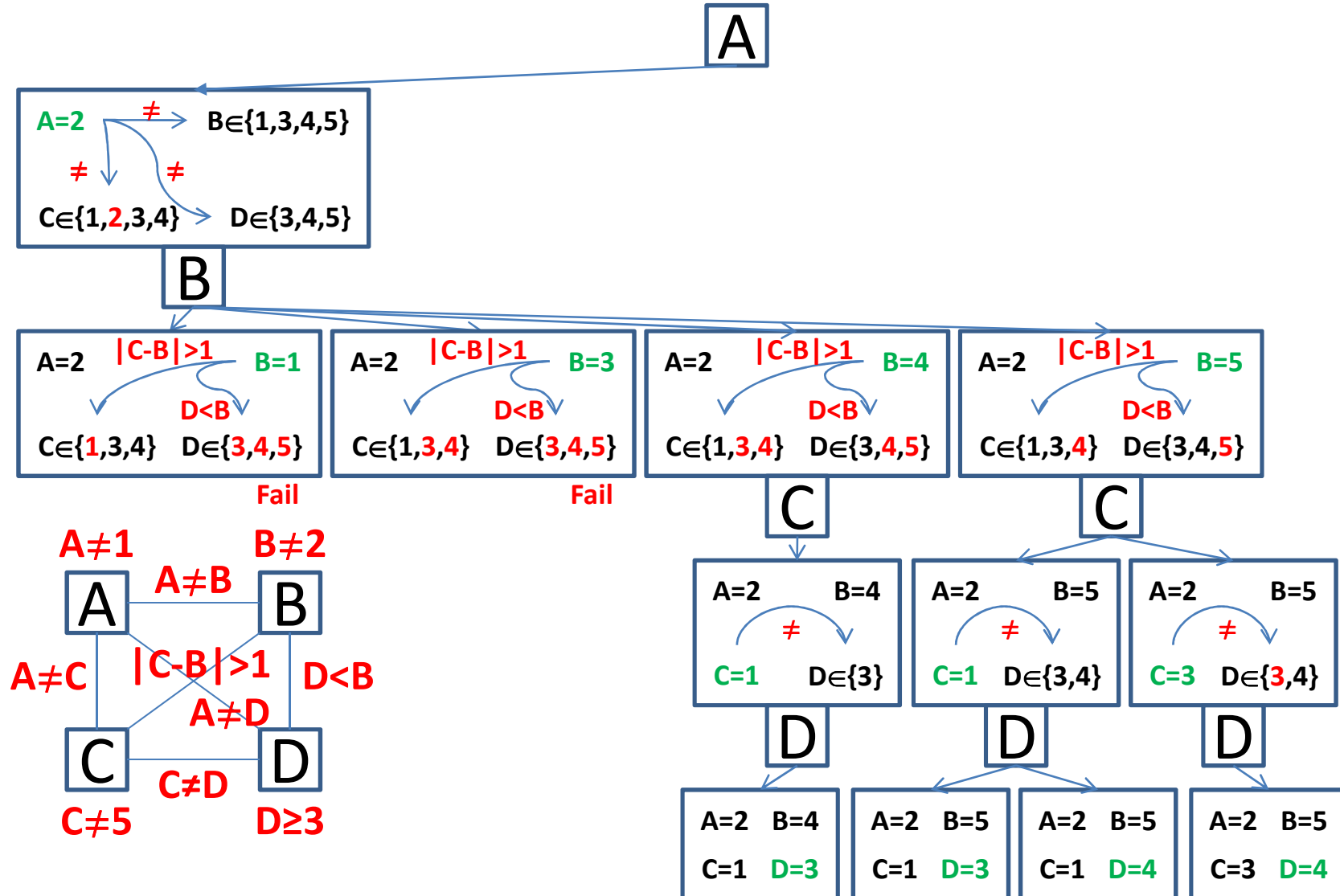
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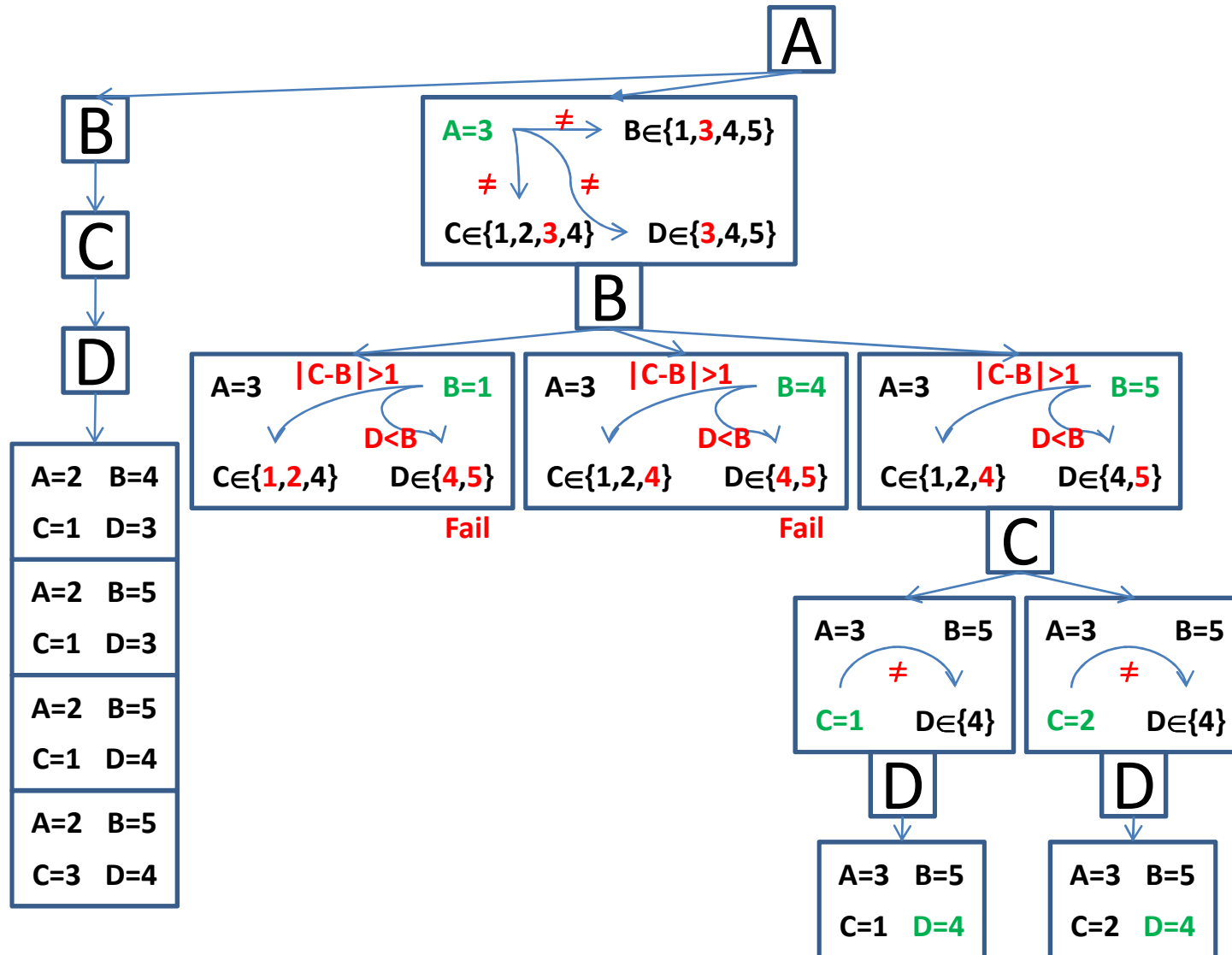
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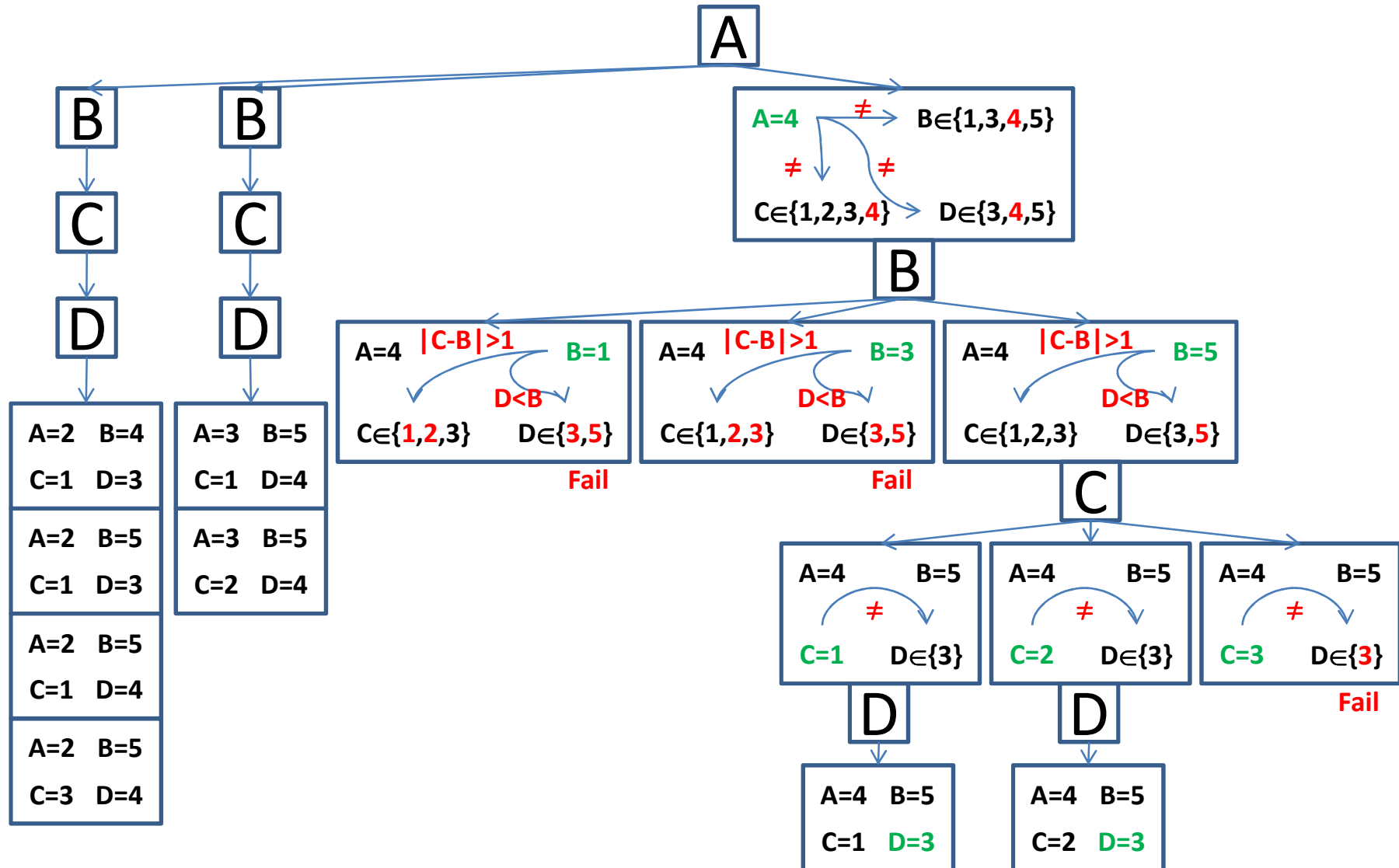
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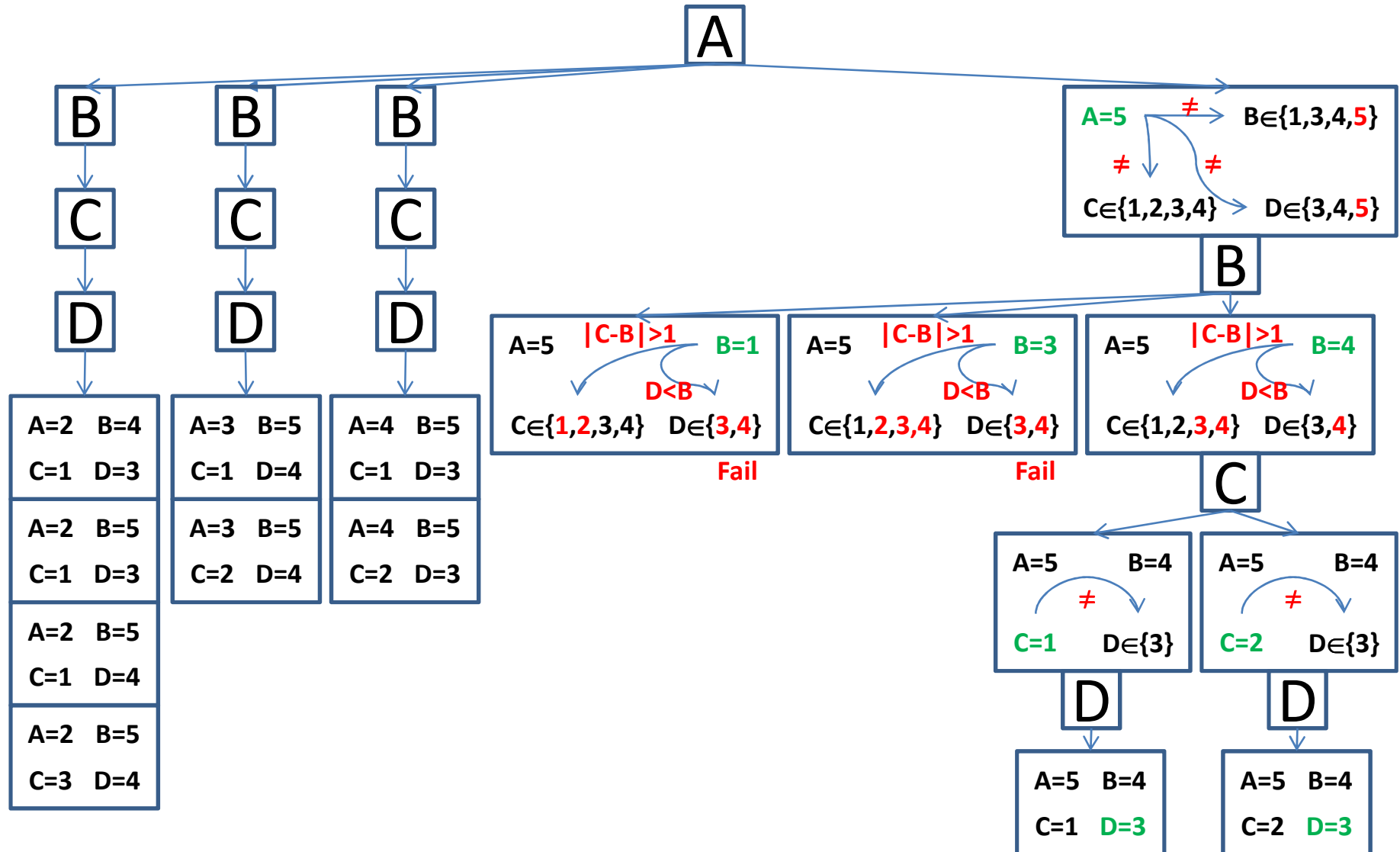
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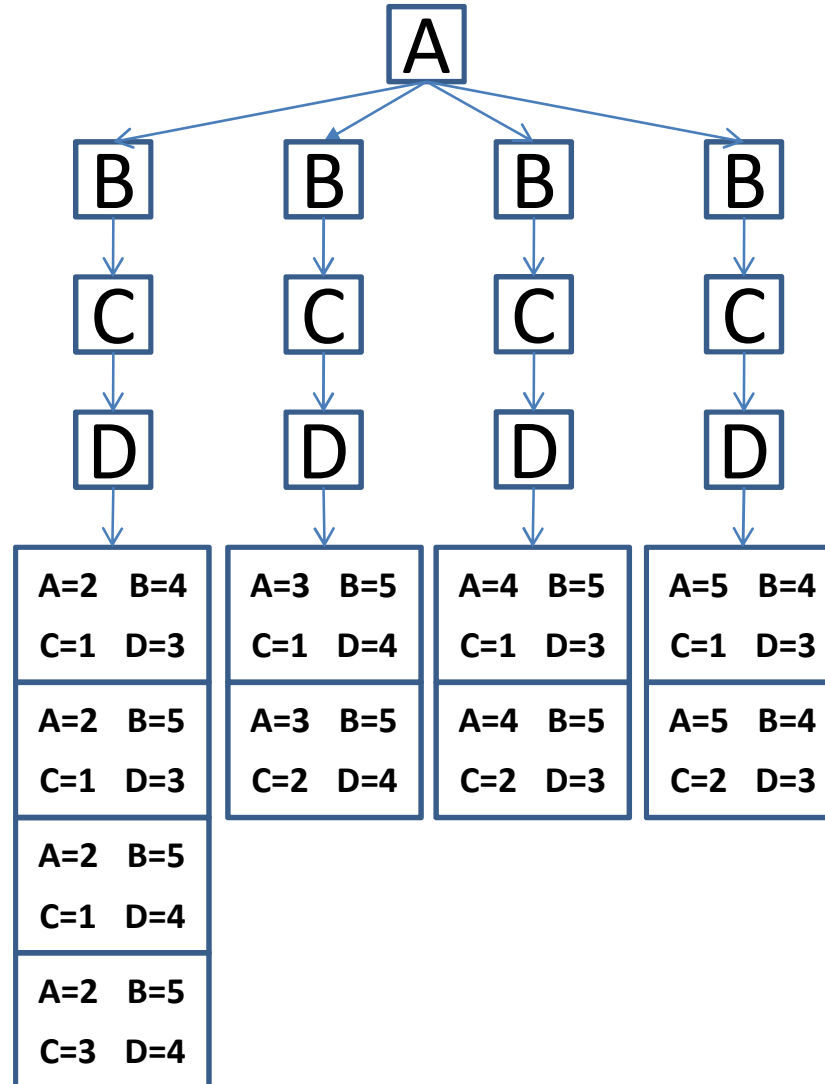
Forward Checking



Forward Checking



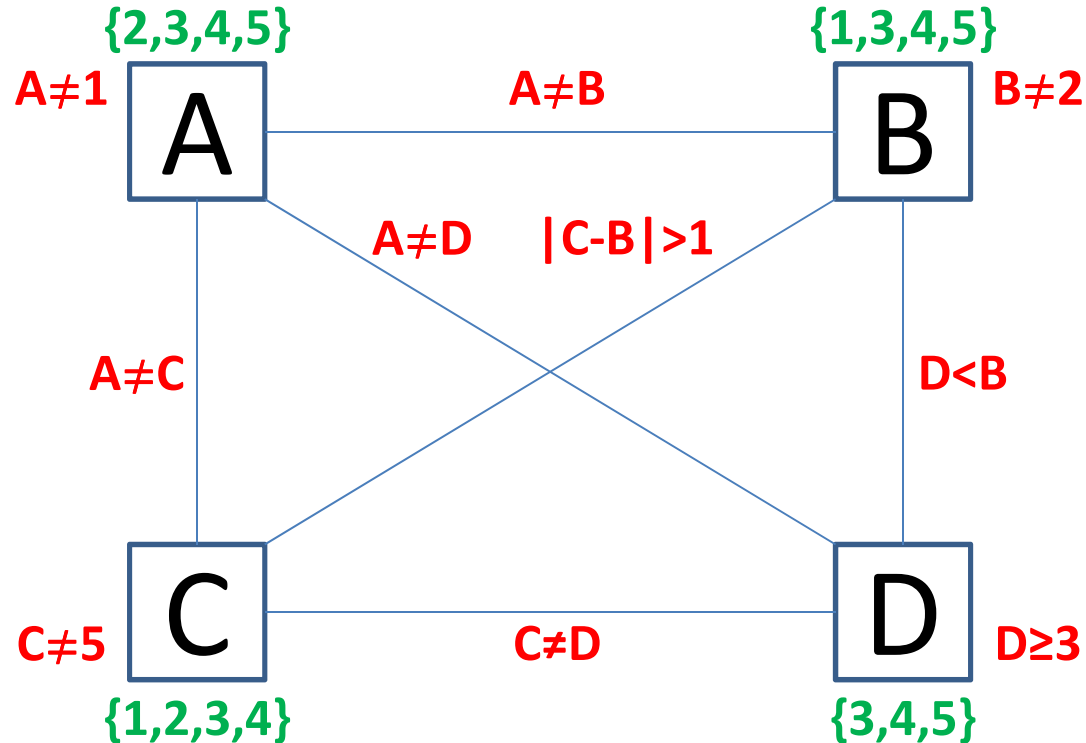
Forward Checking



MiniMax & Constraint Processing: The 4 Houses problem

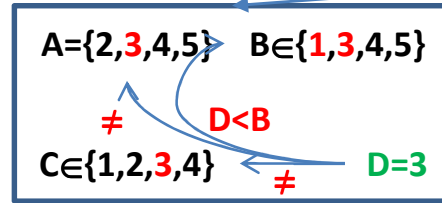
CONSTRAINT PROCESSING: DYNAMIC SEARCH REARRANGEMENT FC

Dynamic Search Rearrangement FC

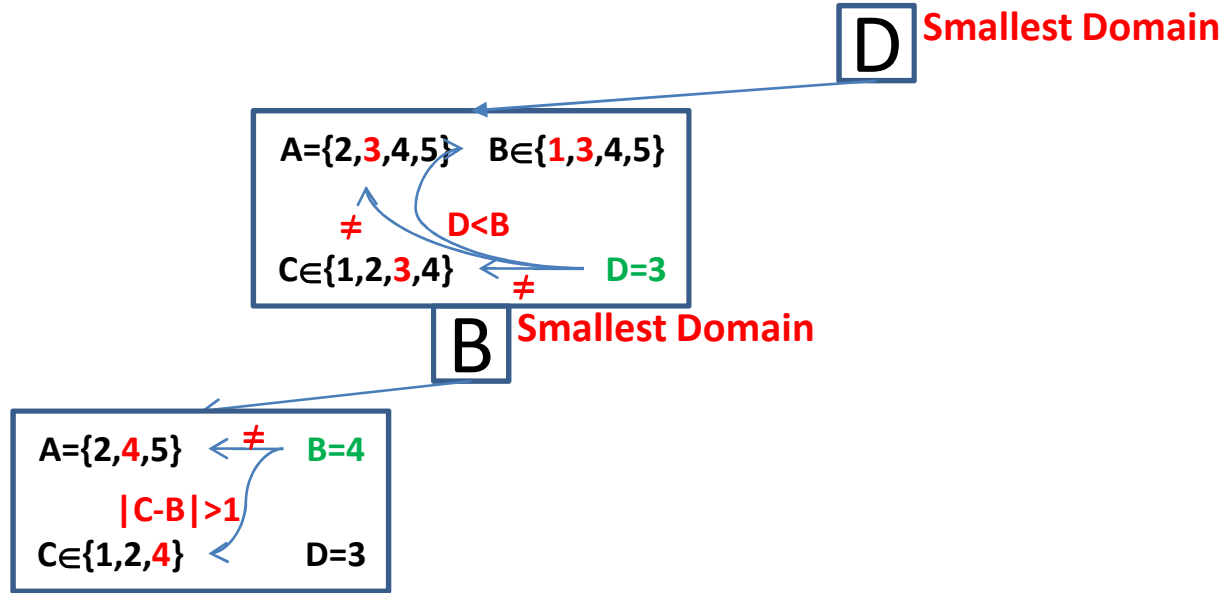


Dynamic Search Rearrangement FC

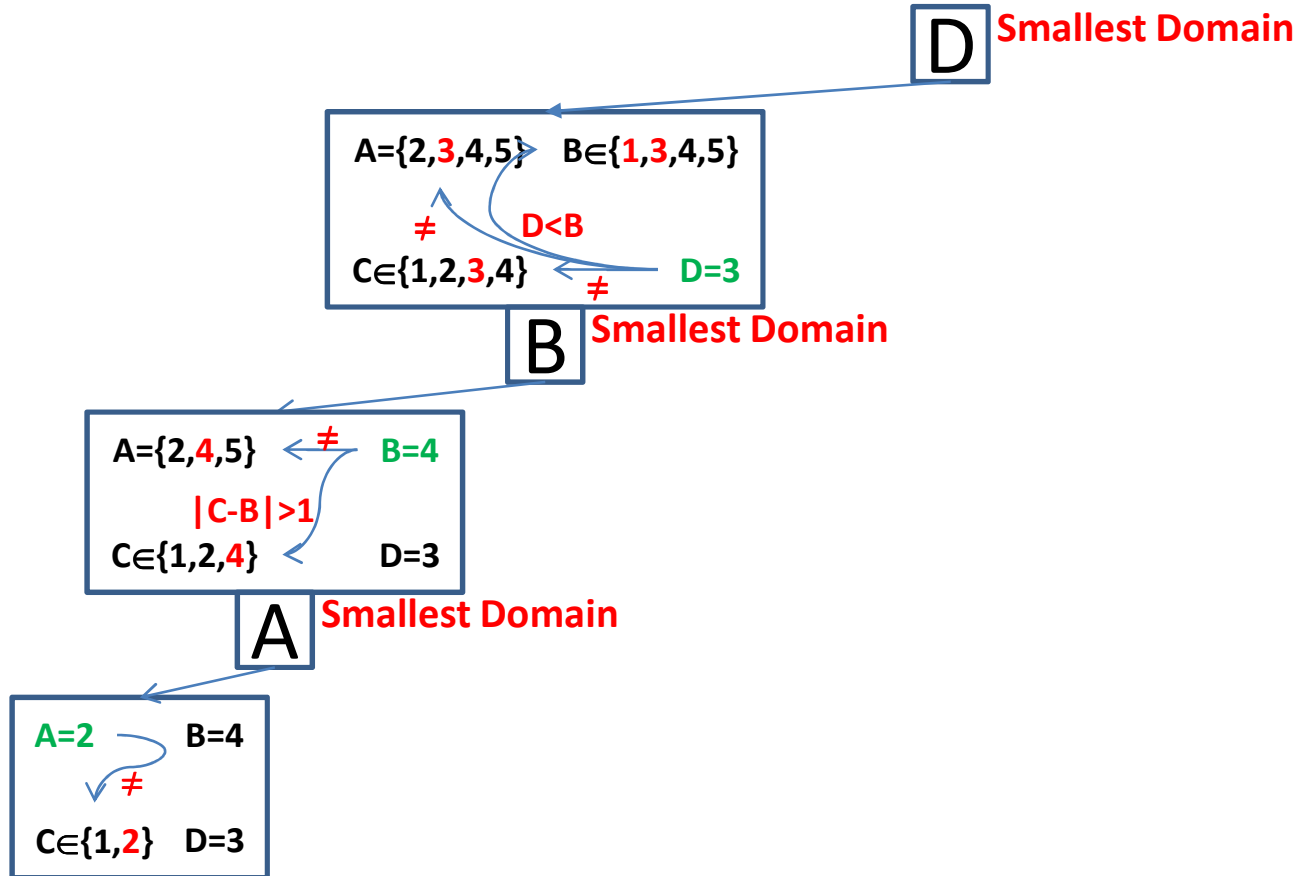
D Smallest Domain



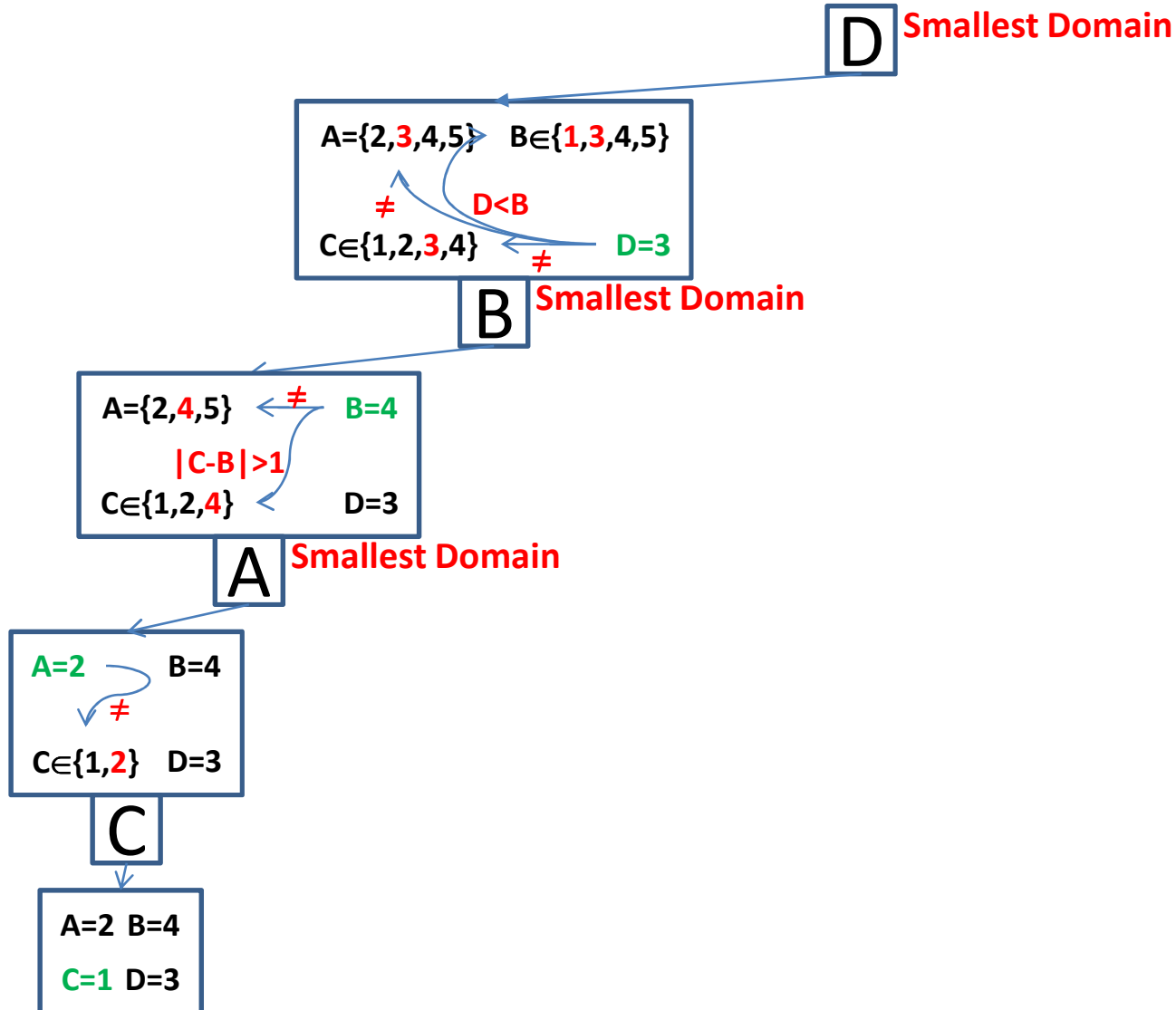
Dynamic Search Rearrangement FC



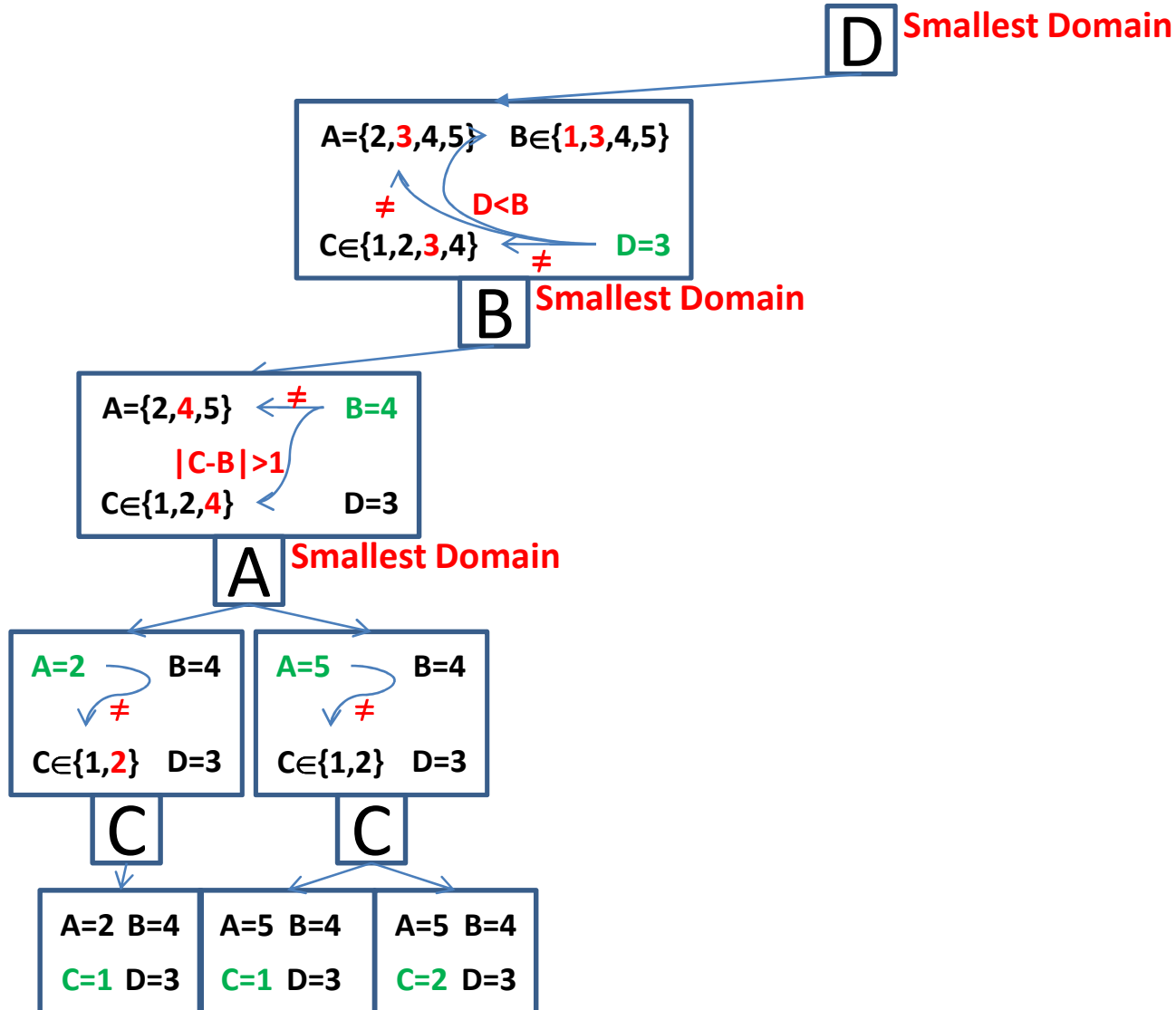
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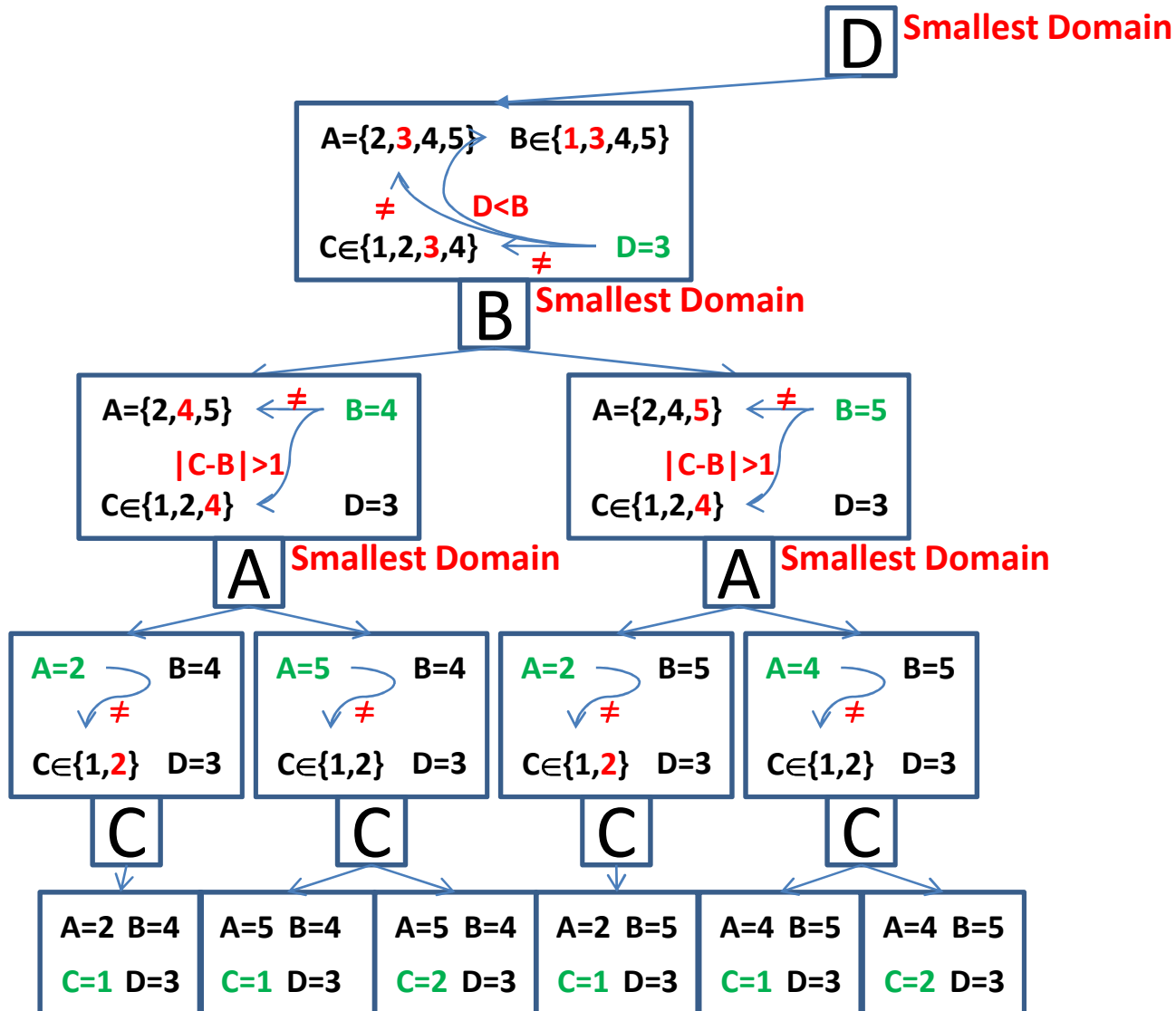
Dynamic Search Rearrangement FC



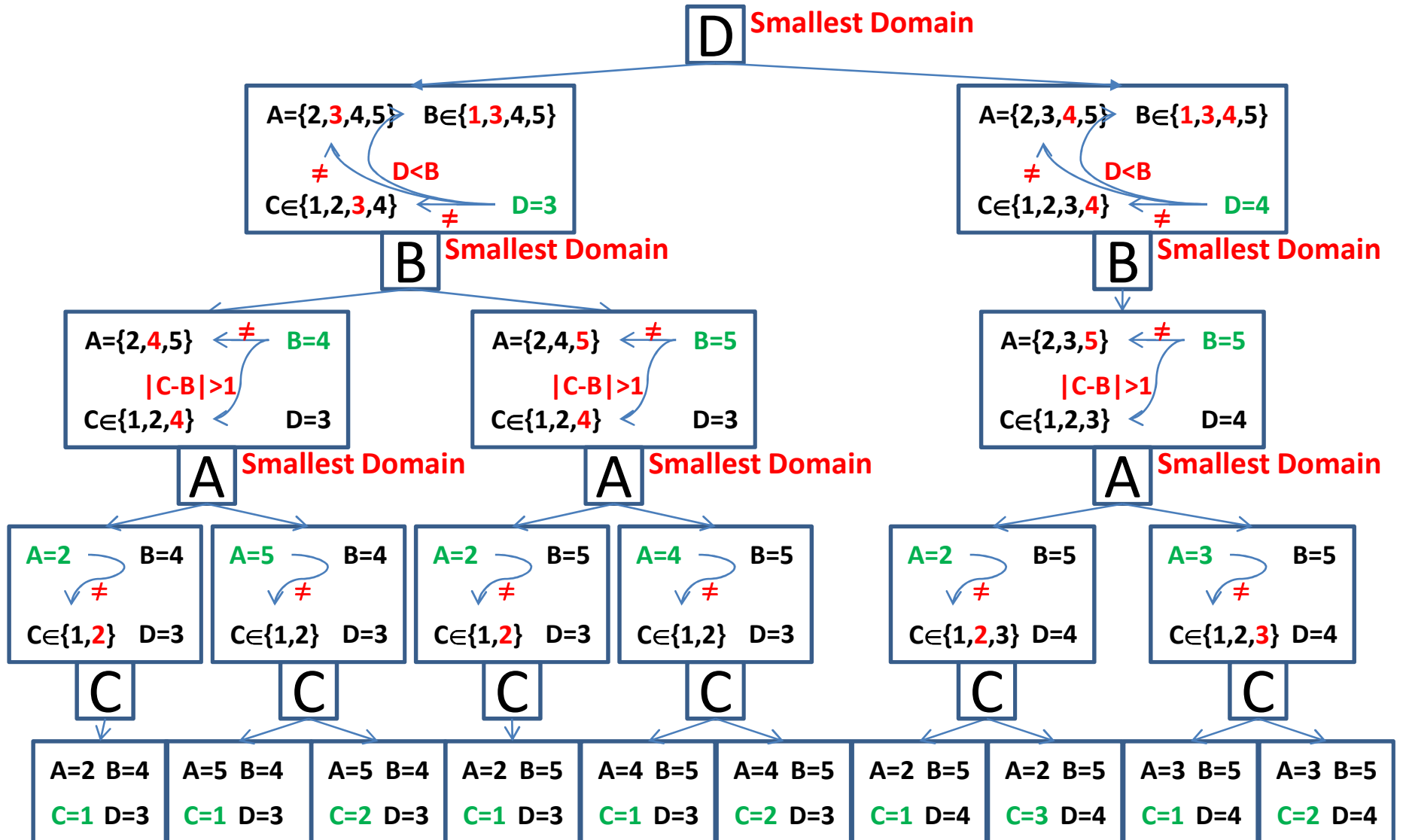
Dynamic Search Rearrangement FC



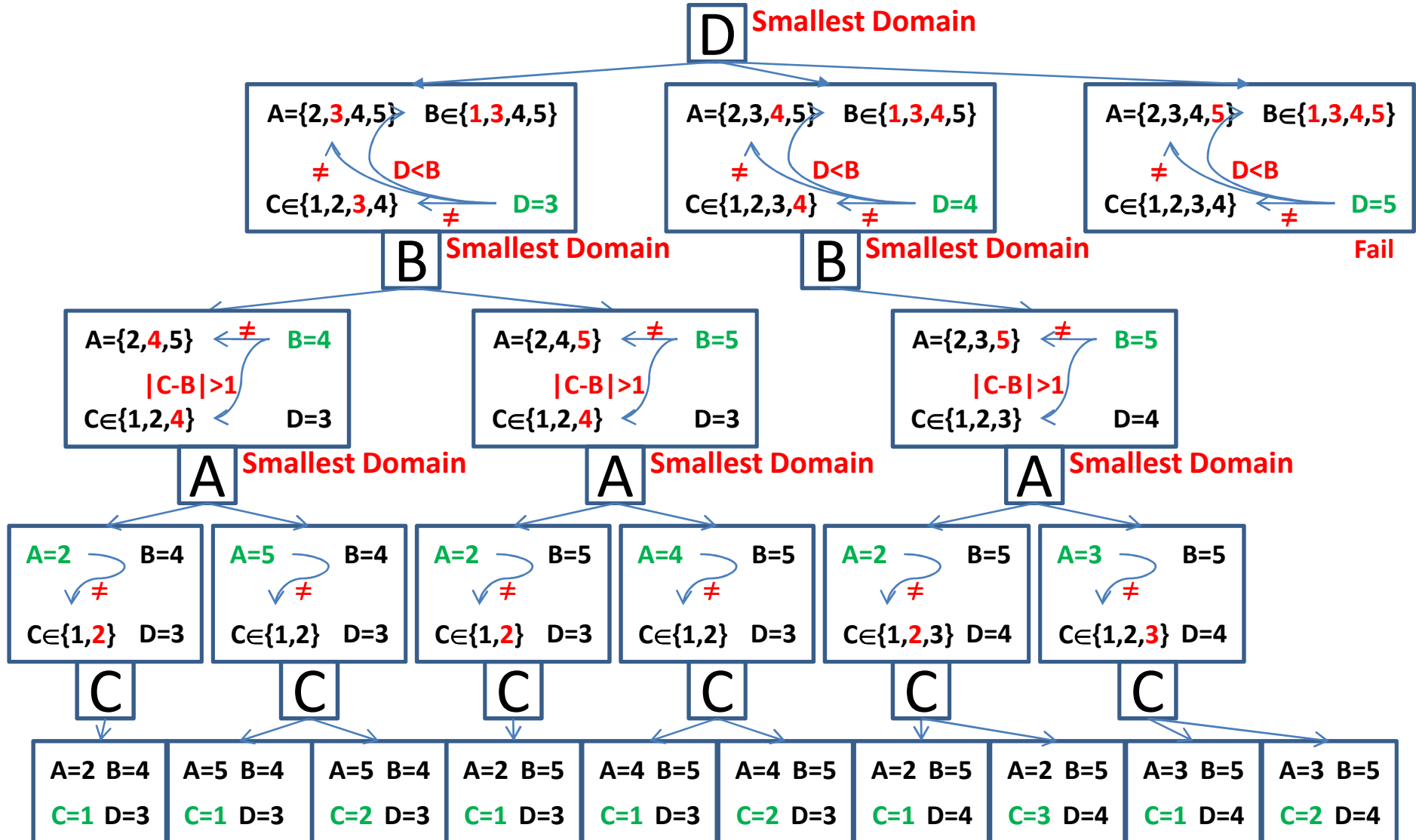
Dynamic Search Rearrangement FC



Dynamic Search Rearrangement FC



Dynamic Search Rearrangement FC



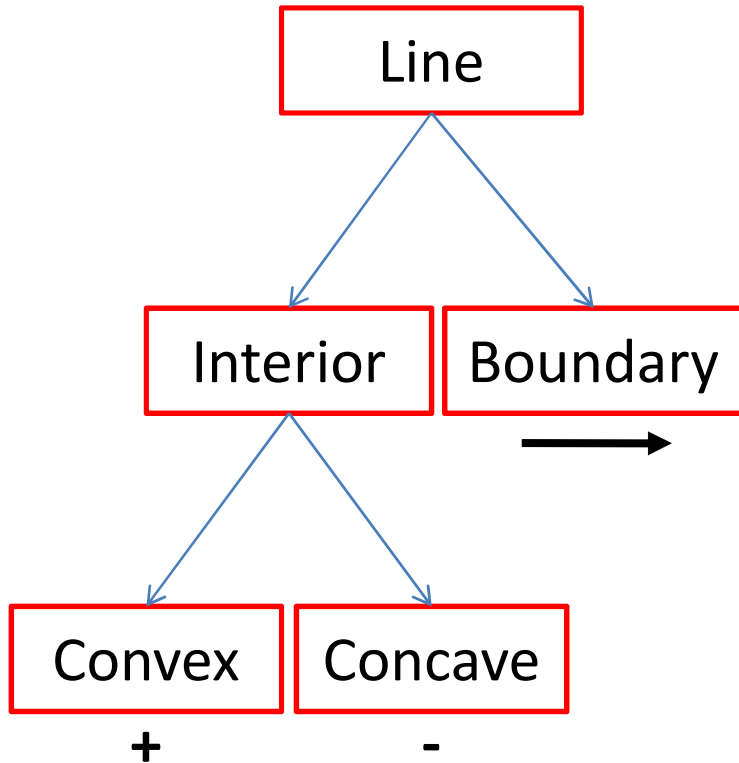
Exercises: Artificial Intelligence

Constraint Processing II & Waltz:
Waltz I

Constraint Processing II & Waltz: Waltz I

INTRODUCTION WALTZ

Introduction Waltz



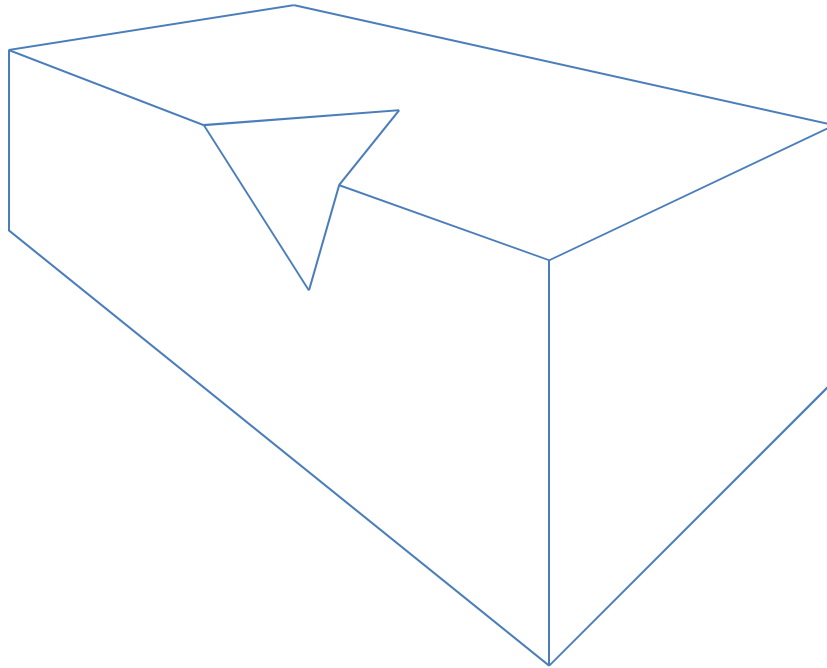
L	Fork	T	Arrow

Constraint Processing II & Waltz: Waltz I

PROBLEM

Problem

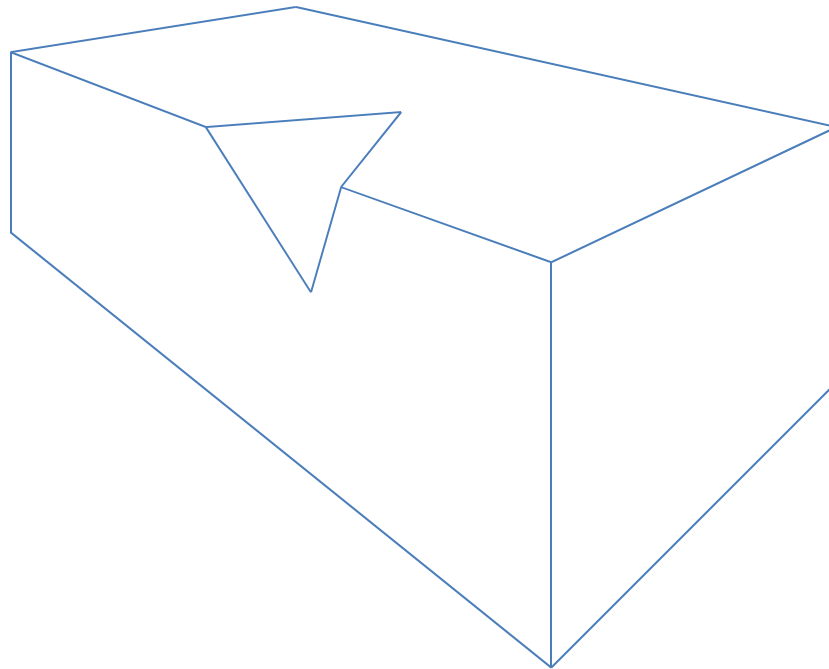
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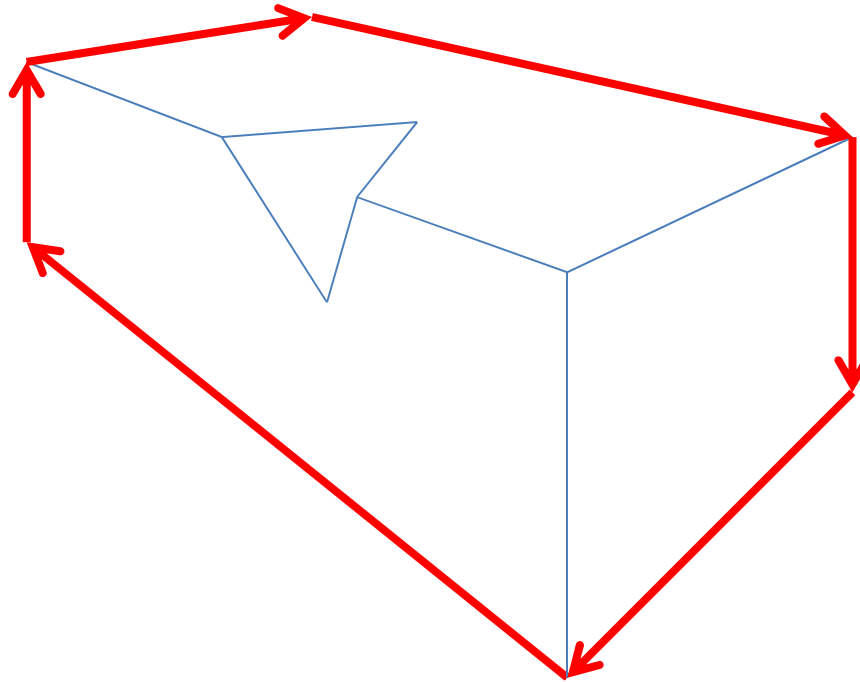
Constraint Processing II & Waltz: Waltz I

SOLUTION

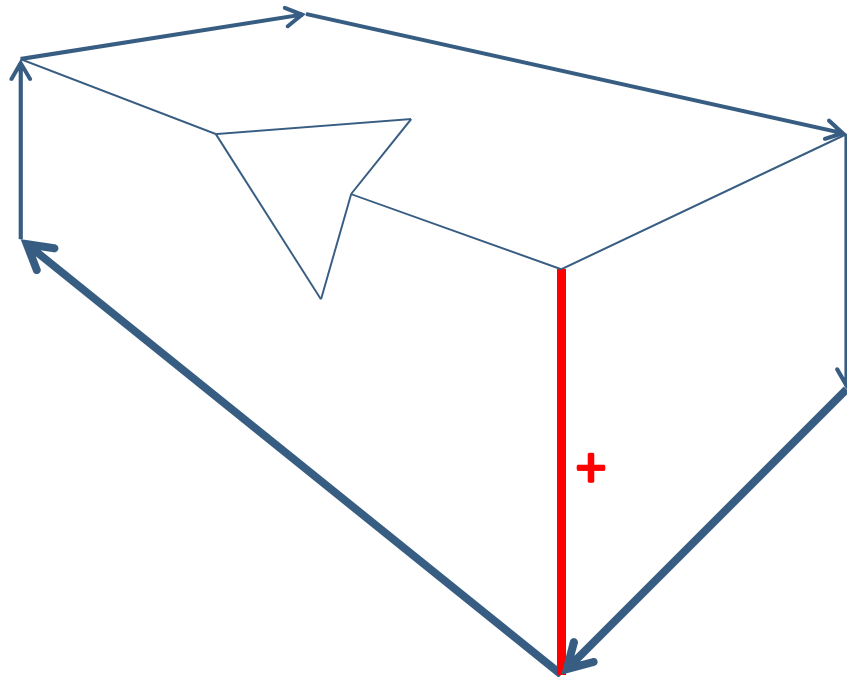
Solution



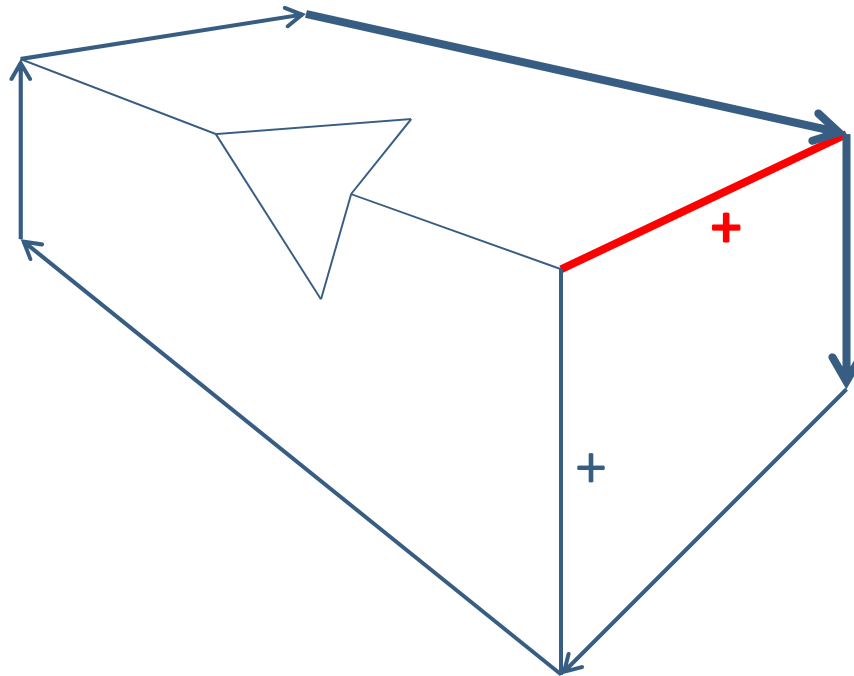
Solution



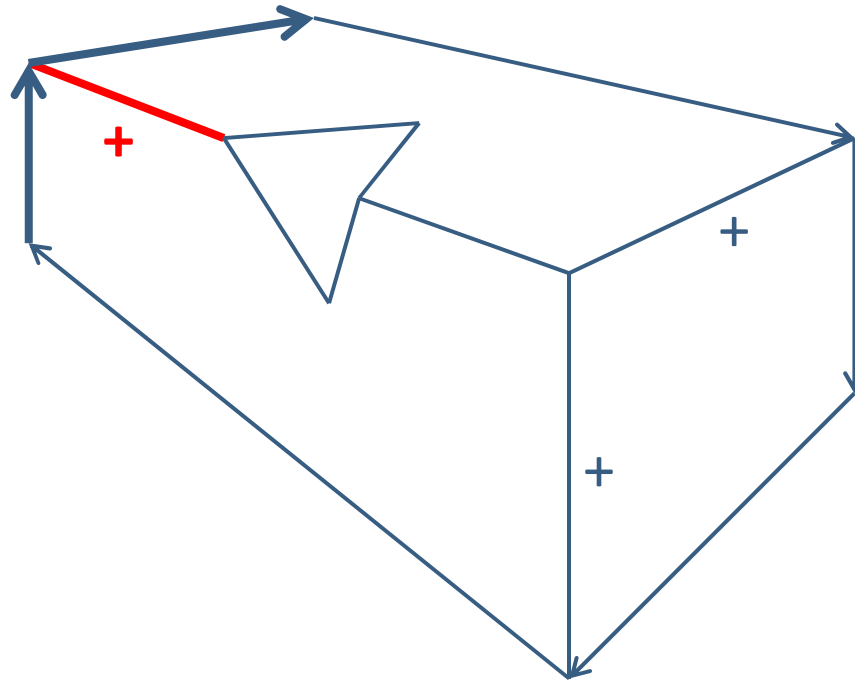
Solution



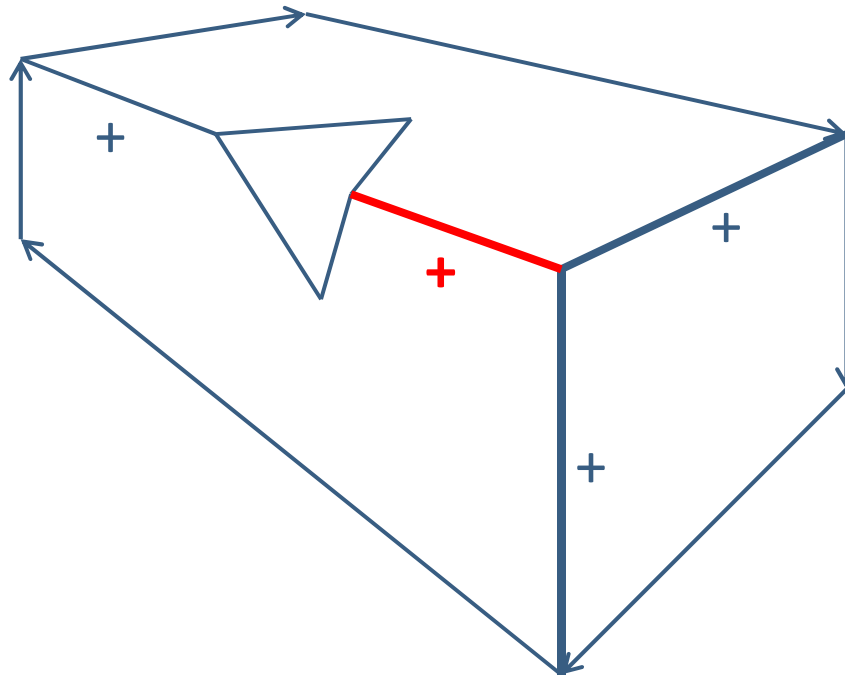
Solution



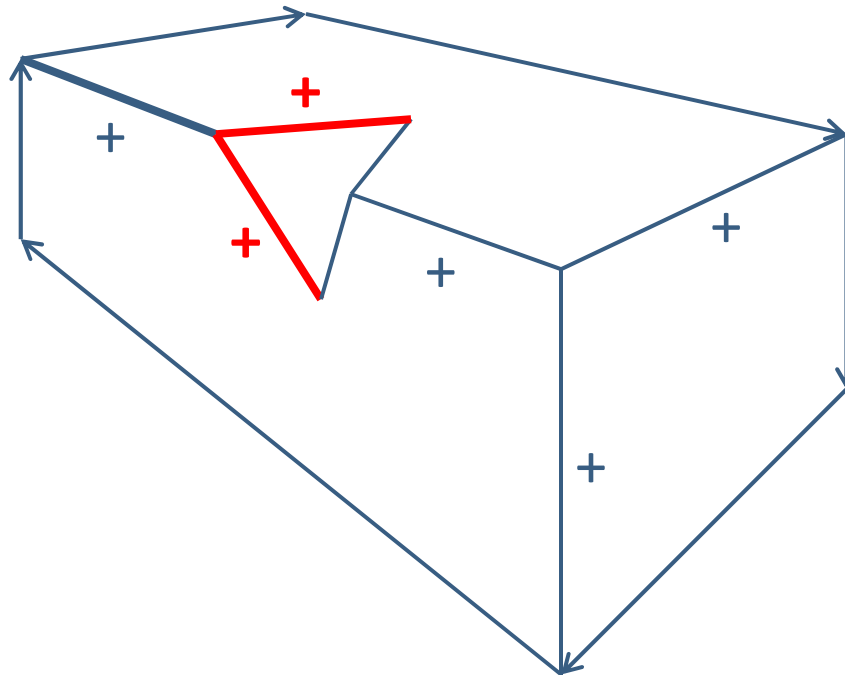
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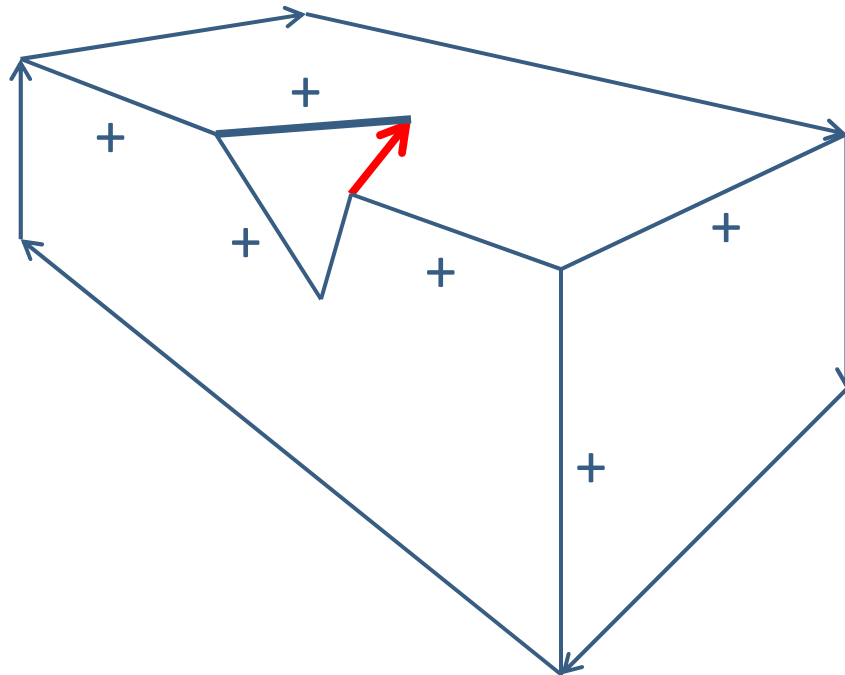
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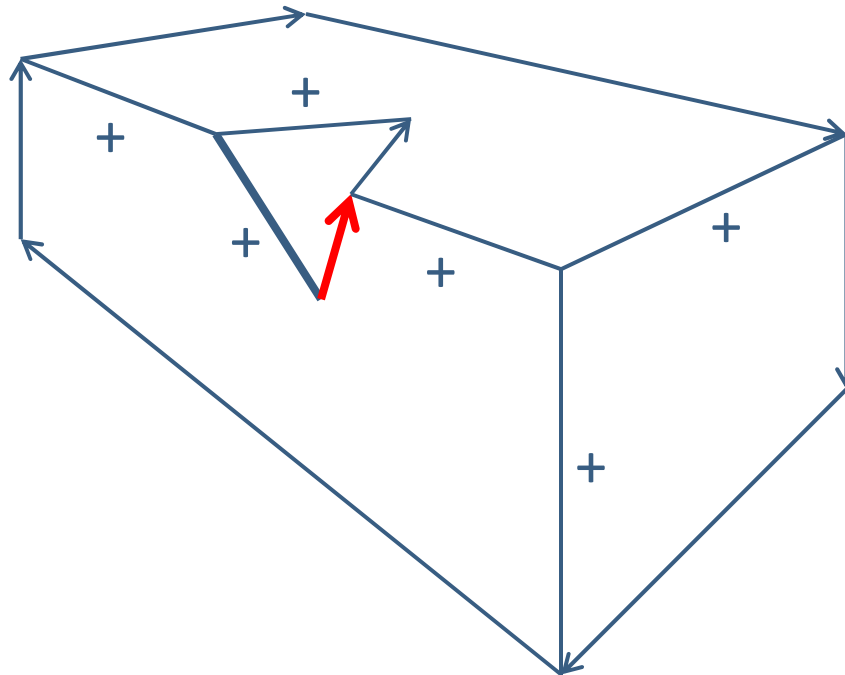
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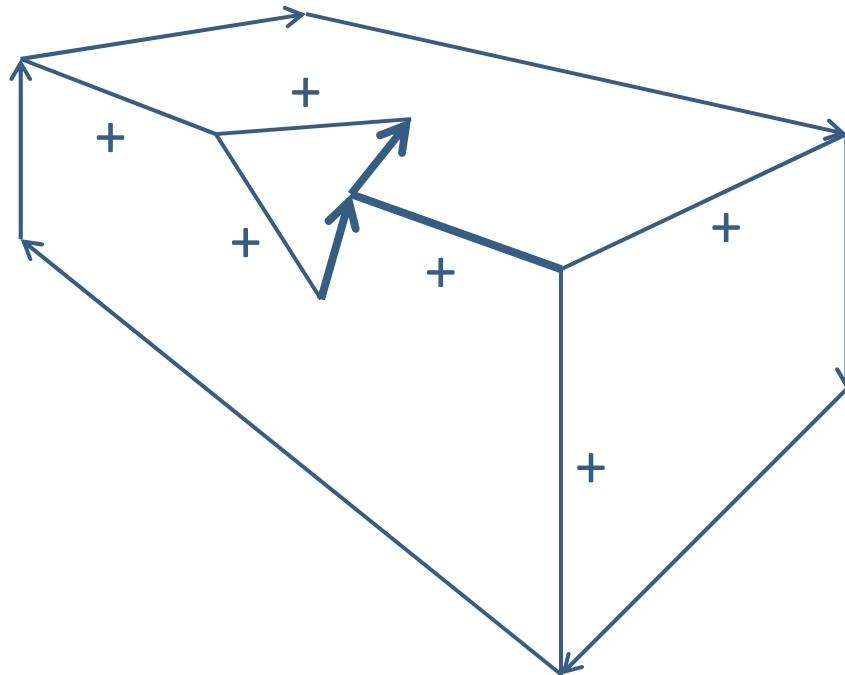
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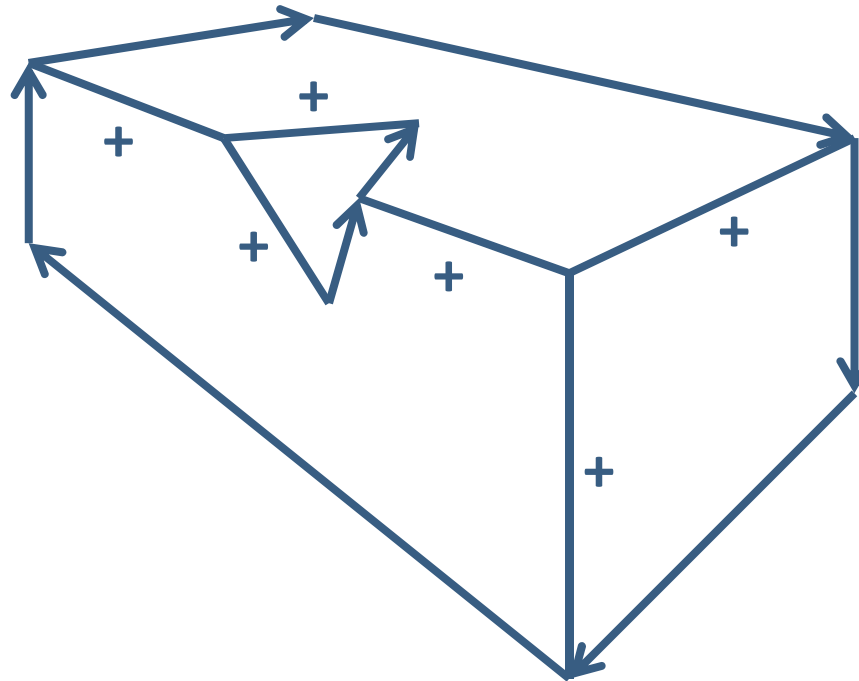
Solution



Solution



Solution

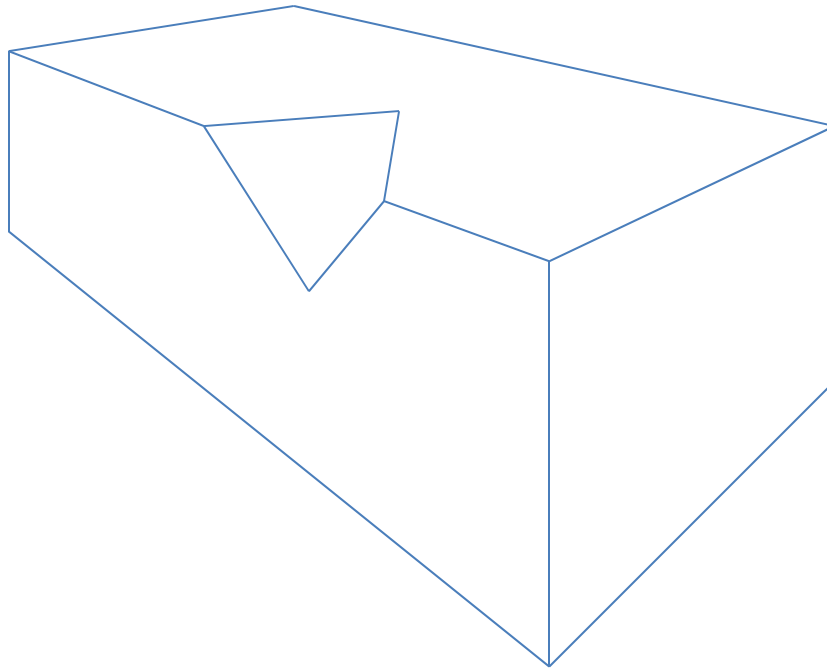


Constraint Processing II & Waltz: Waltz I

PROBLEM

Problem

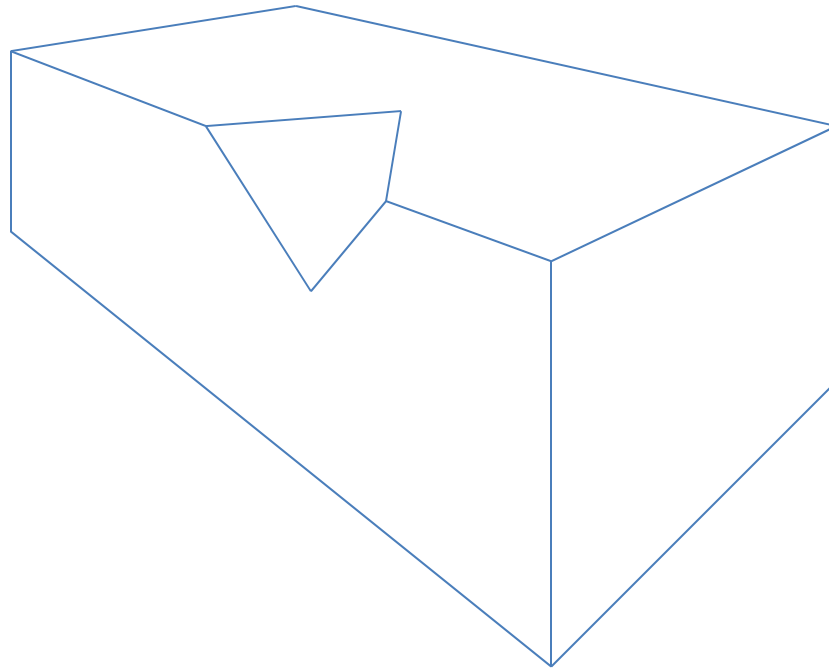
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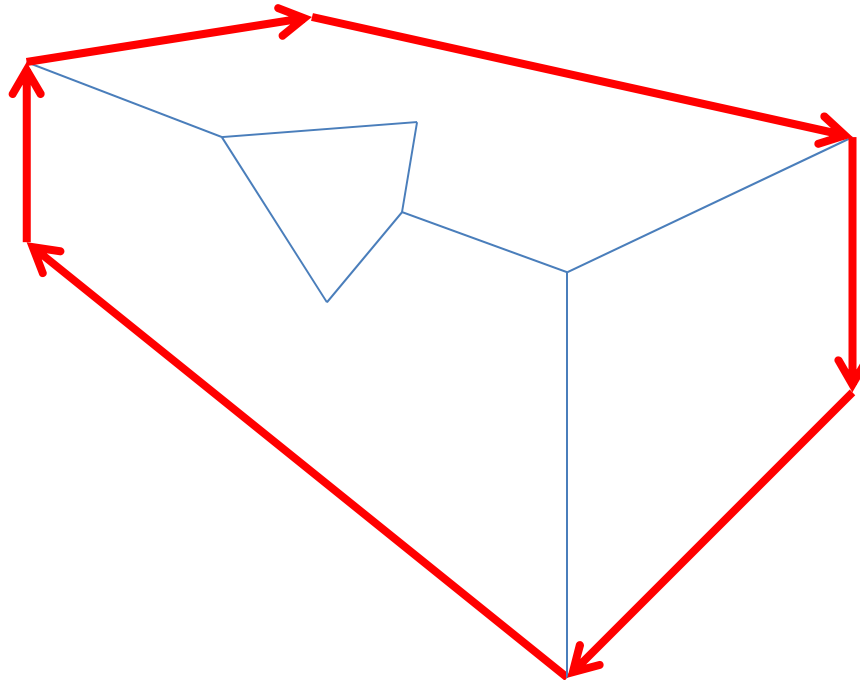
Constraint Processing II & Waltz: Waltz I

SOLUTION

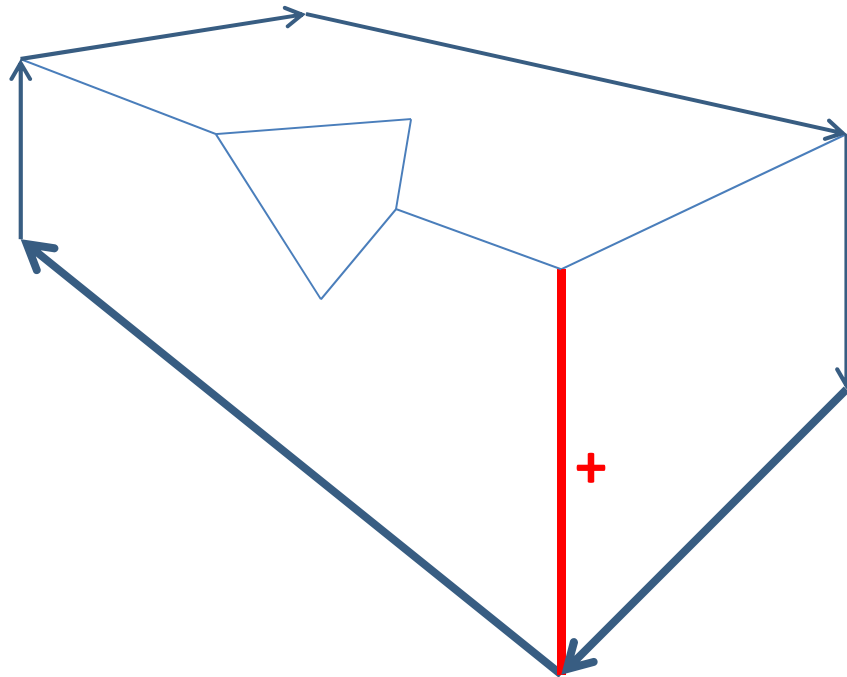
Solution



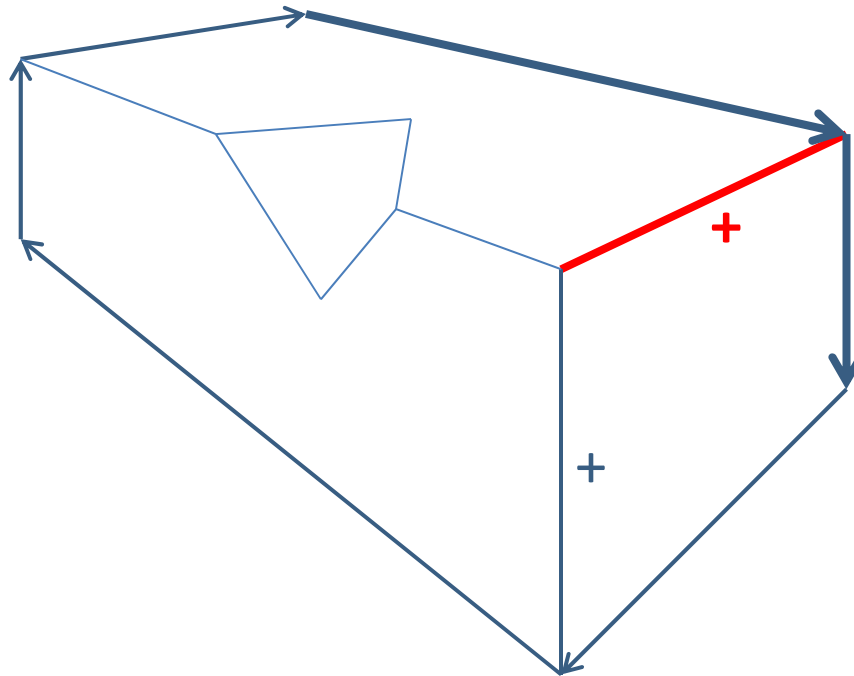
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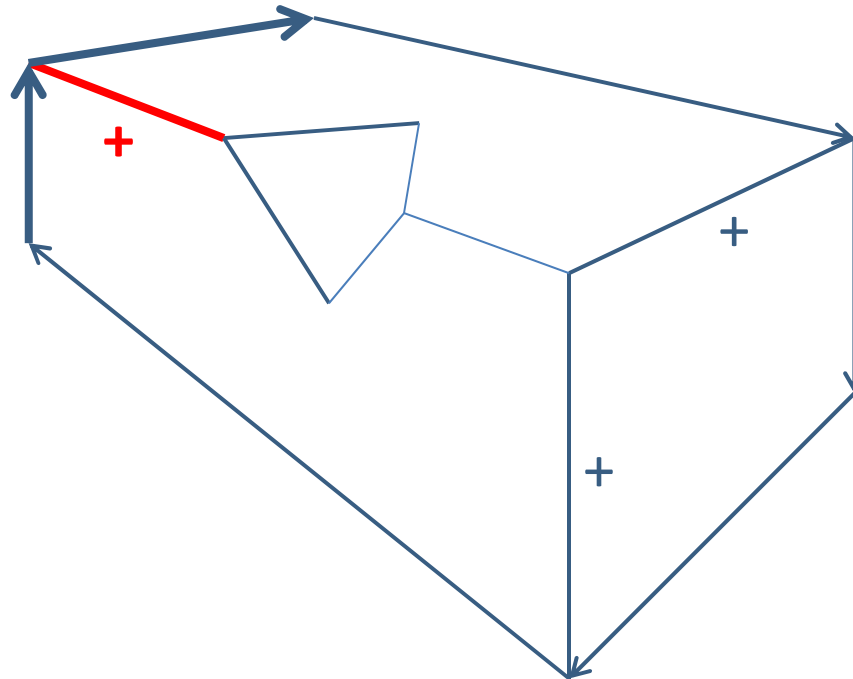
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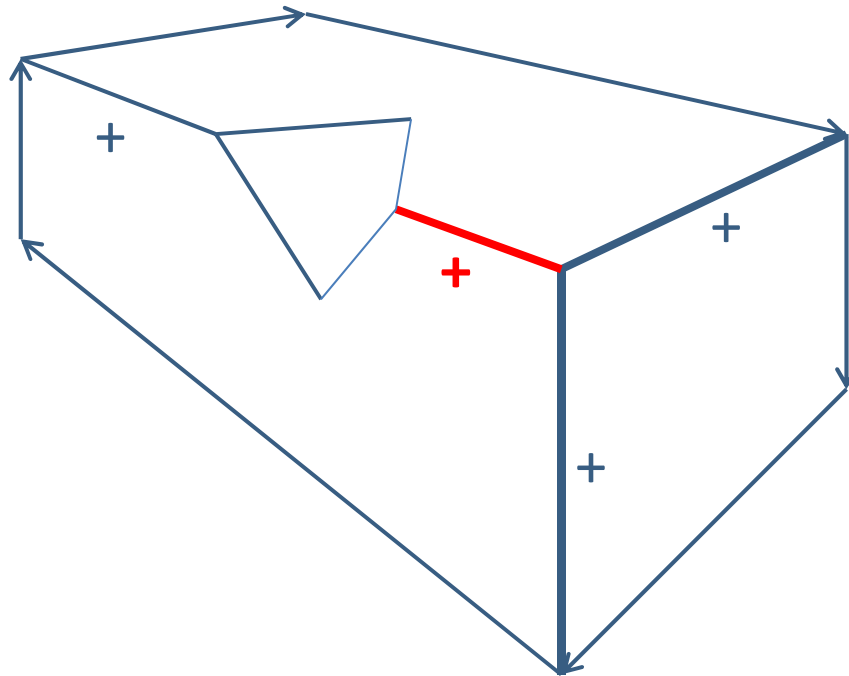
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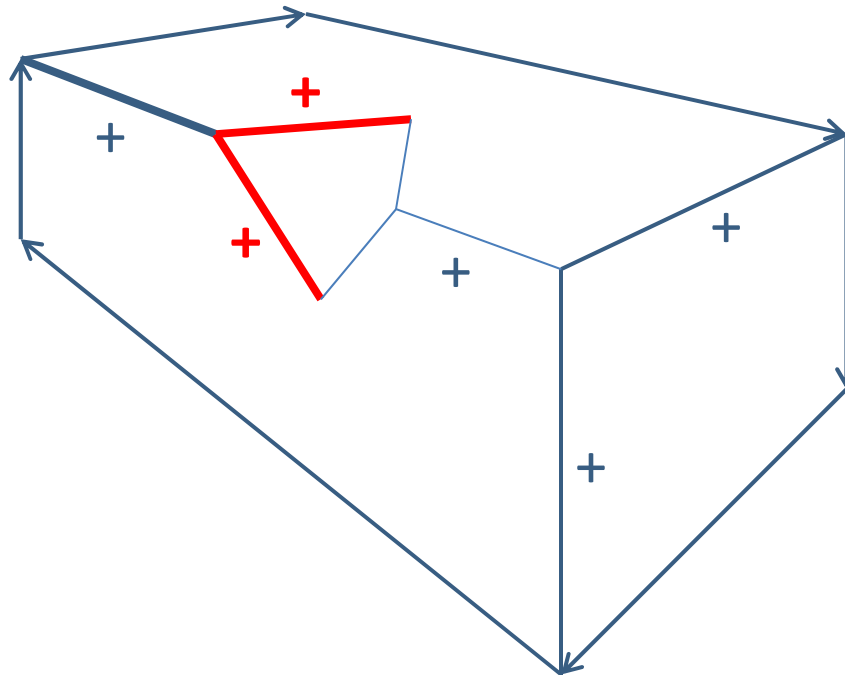
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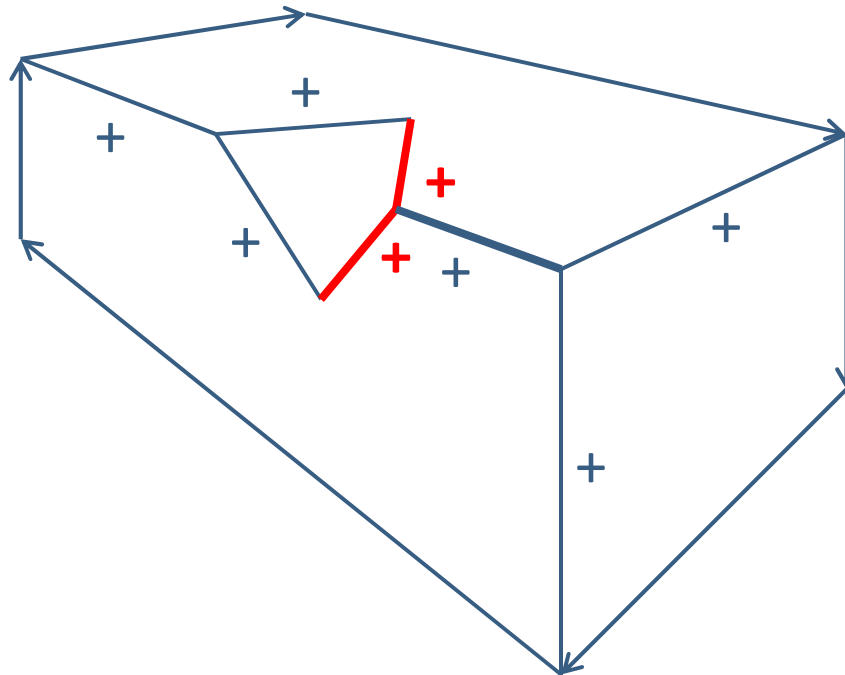
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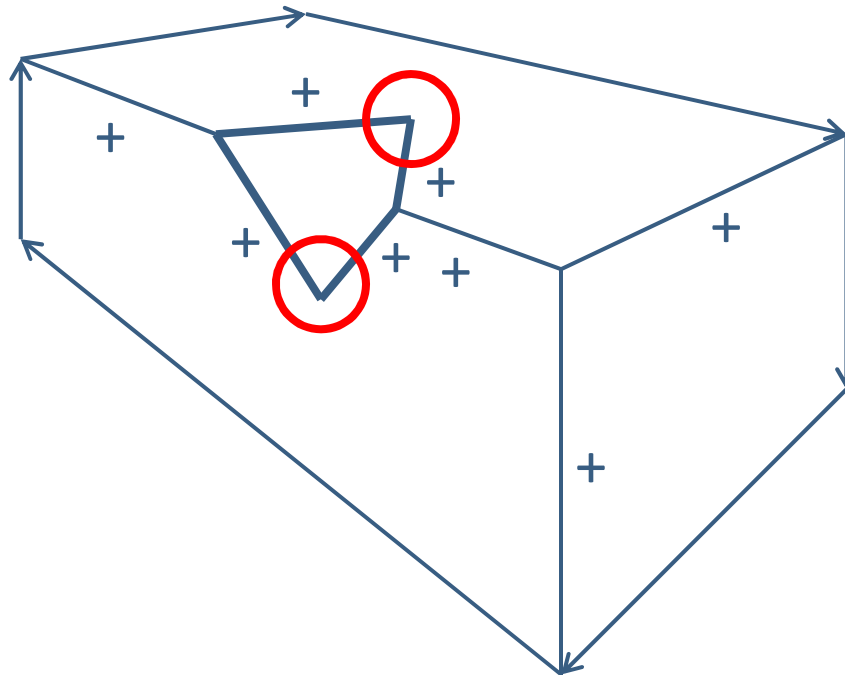
Solution



Solution



Solution

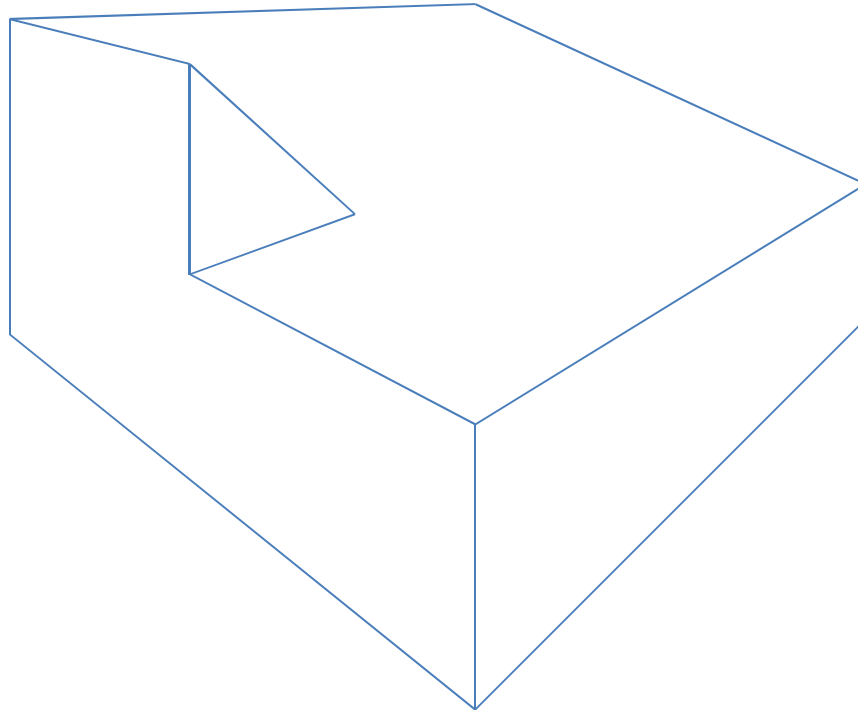


Constraint Processing II & Waltz: Waltz I

PROBLEM

Problem

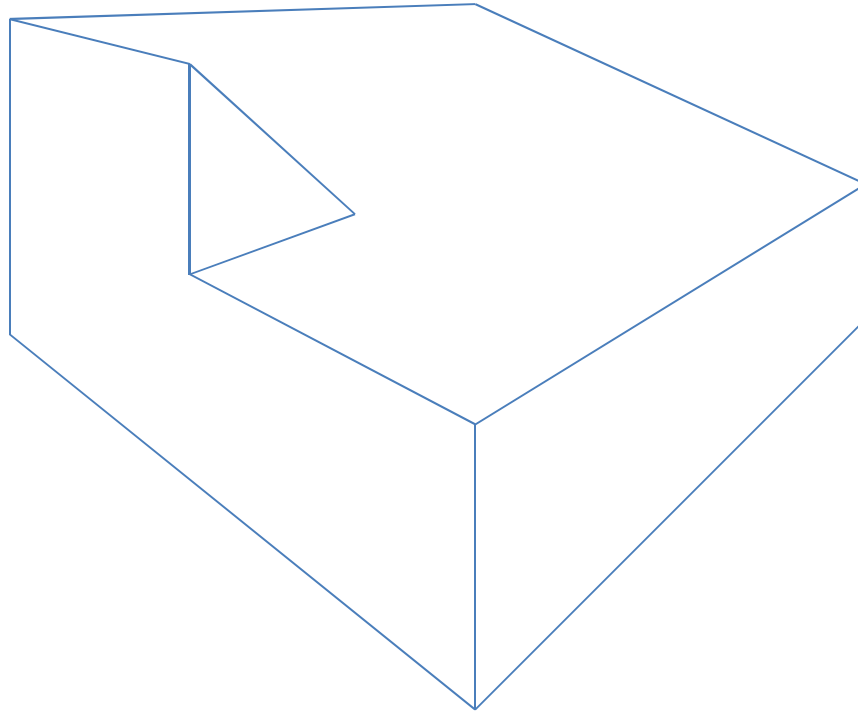
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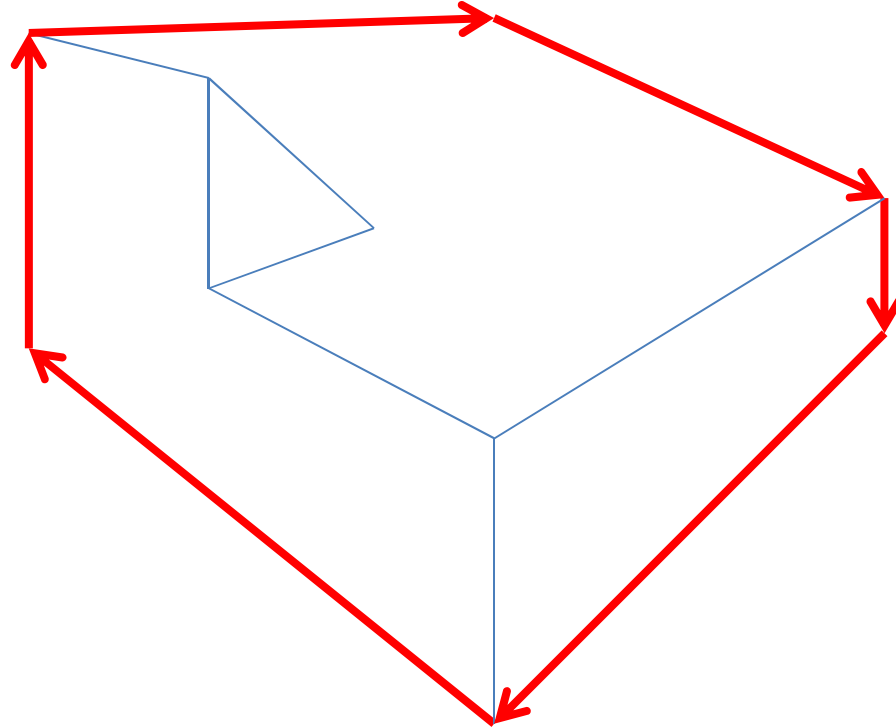
Constraint Processing II & Waltz: Waltz I

SOLUTION

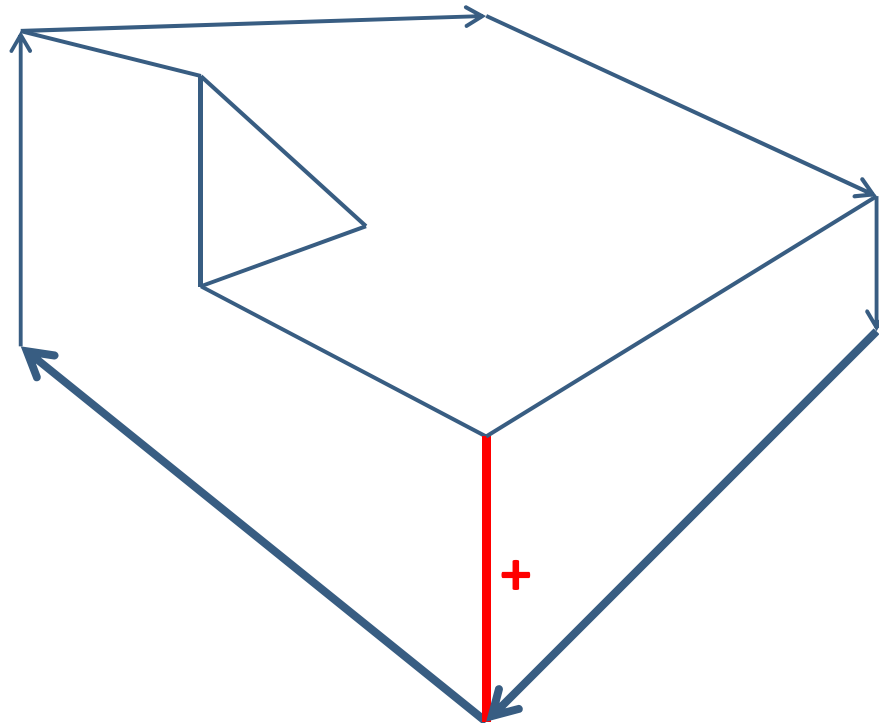
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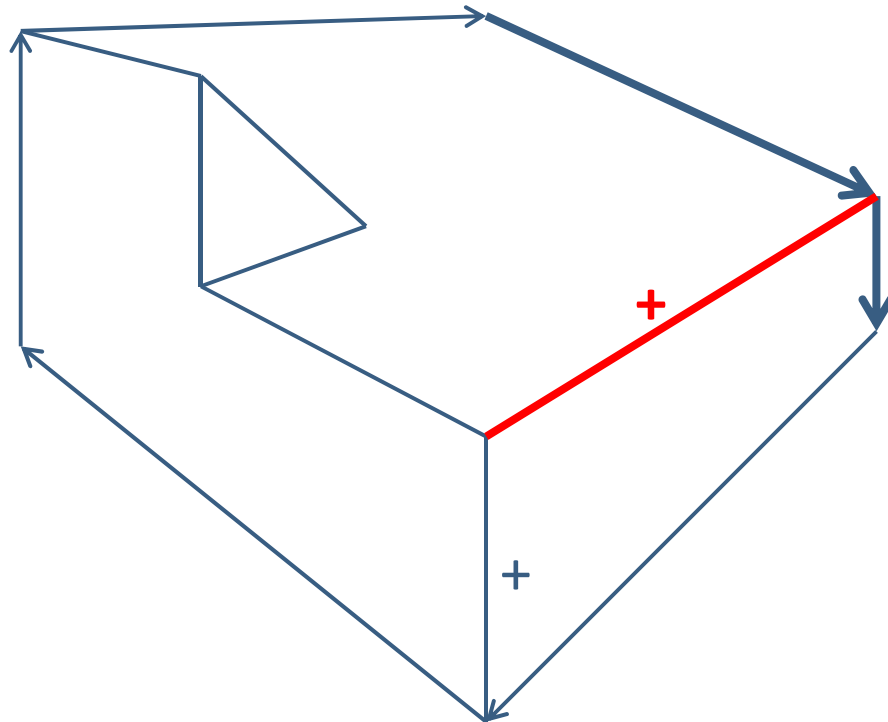
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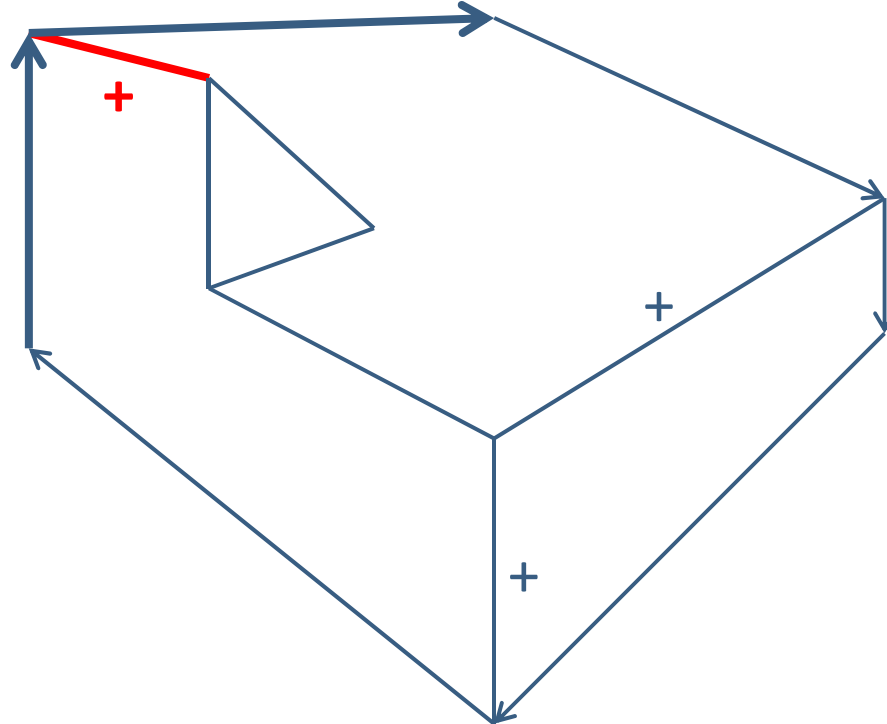
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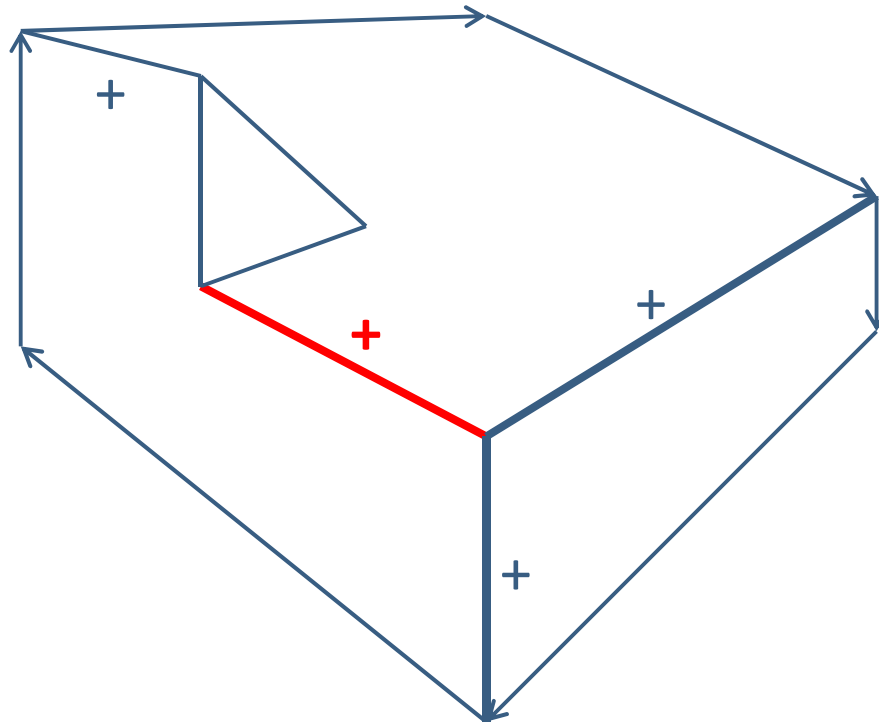
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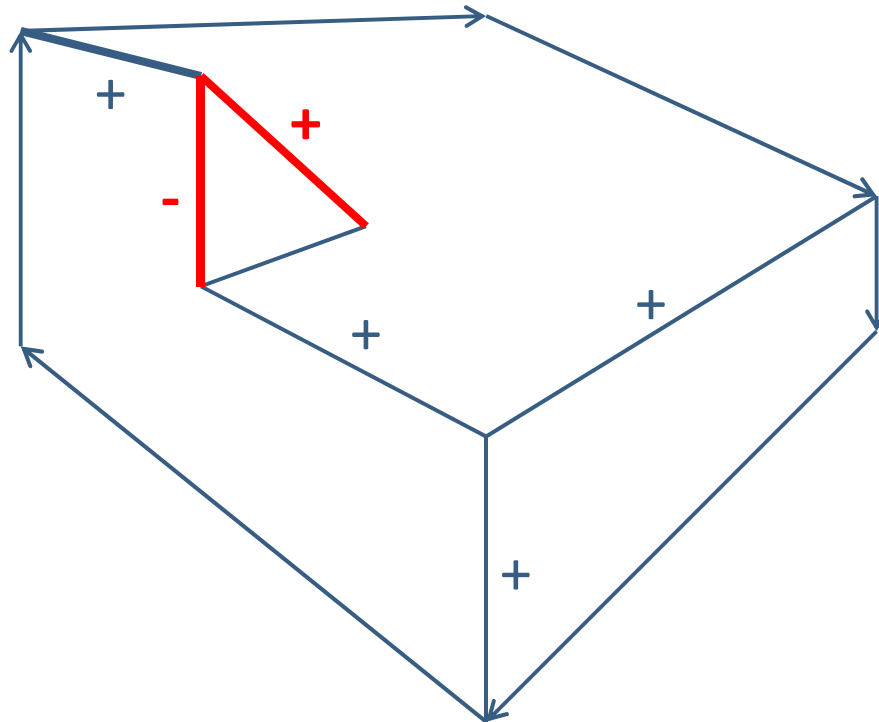
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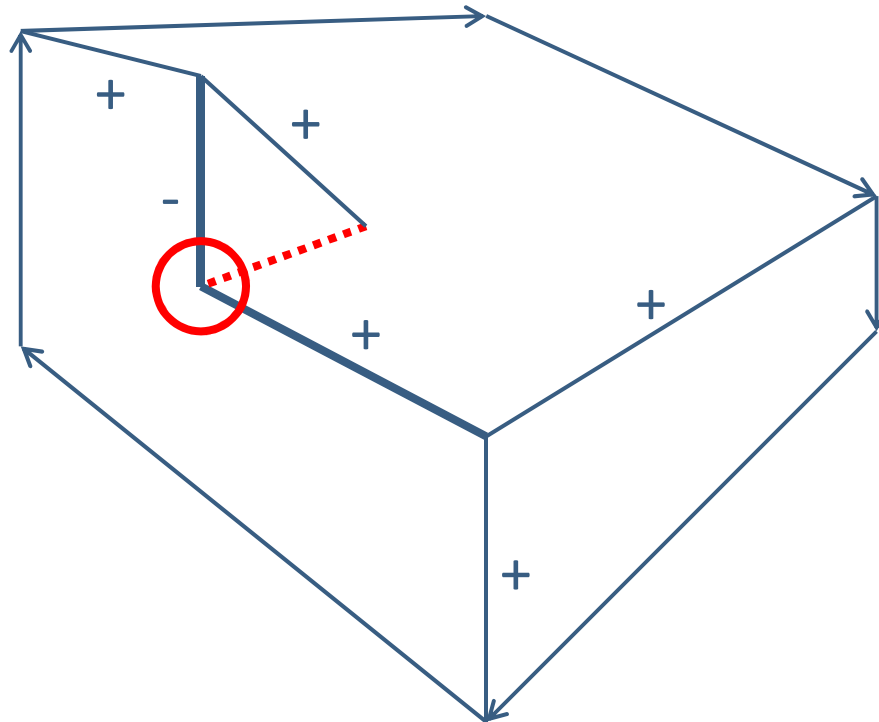
Solution



Solution



Solution

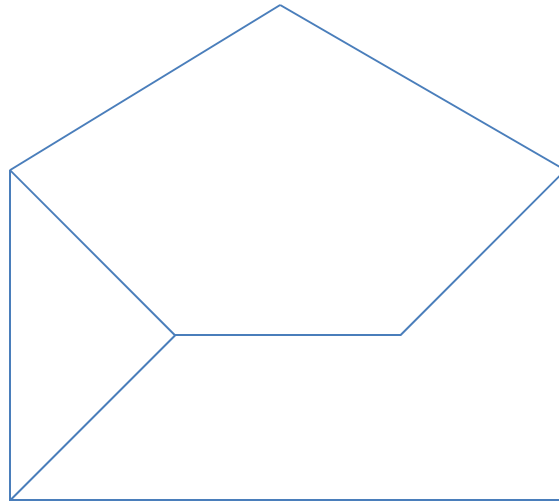


Constraint Processing II & Waltz: Waltz I

PROBLEM

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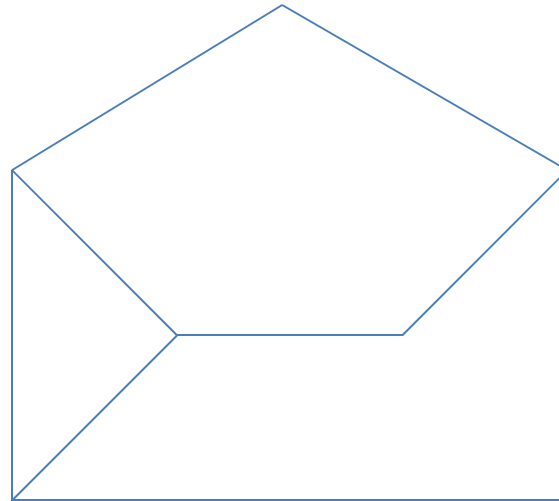
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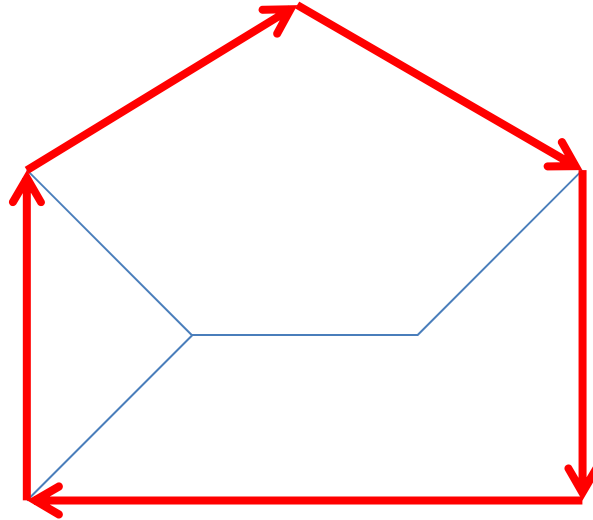
Constraint Processing II & Waltz: Waltz I

SOLUTION

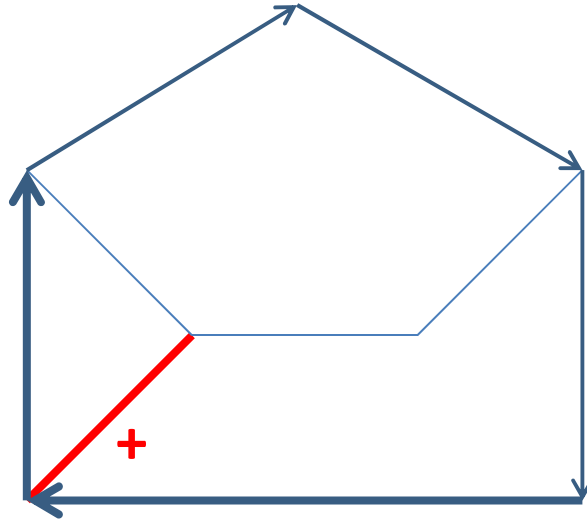
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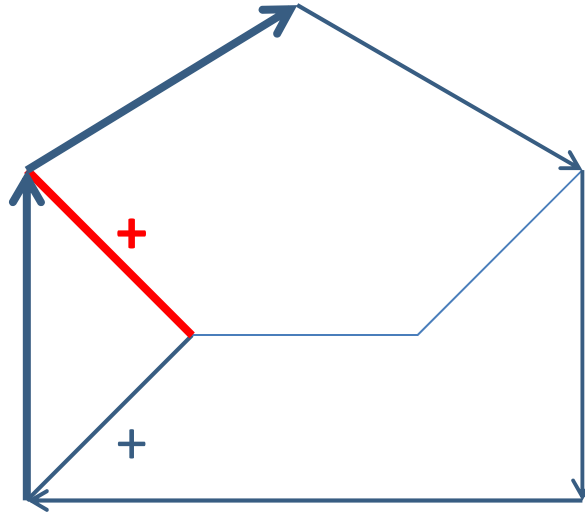
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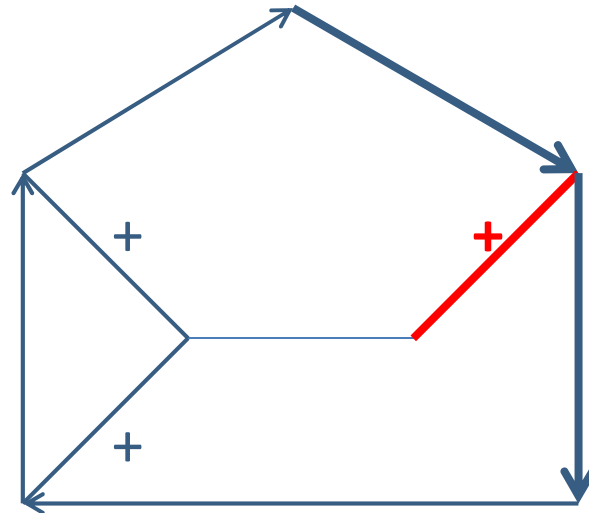
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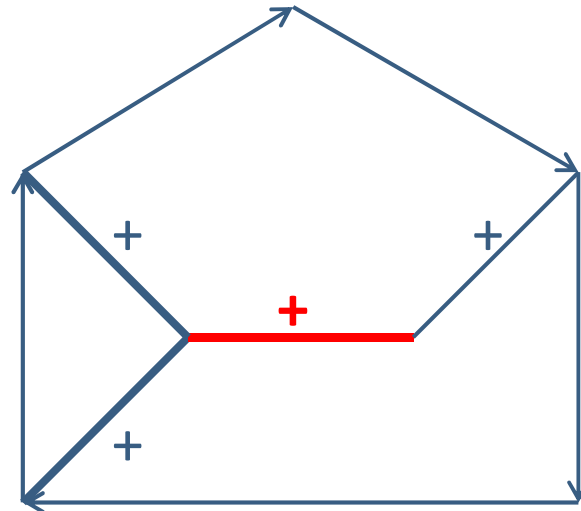
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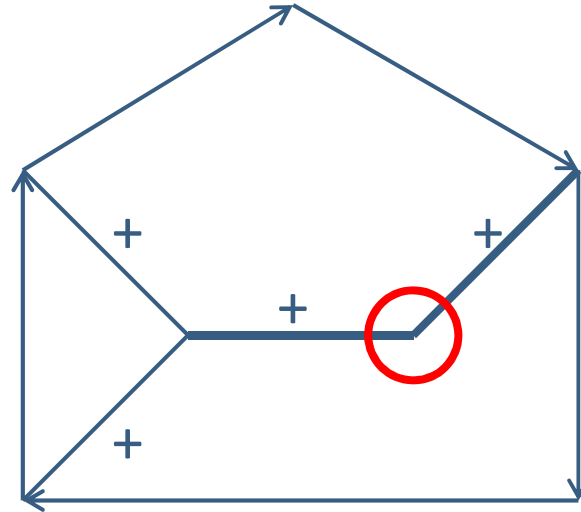
Solution



Solution



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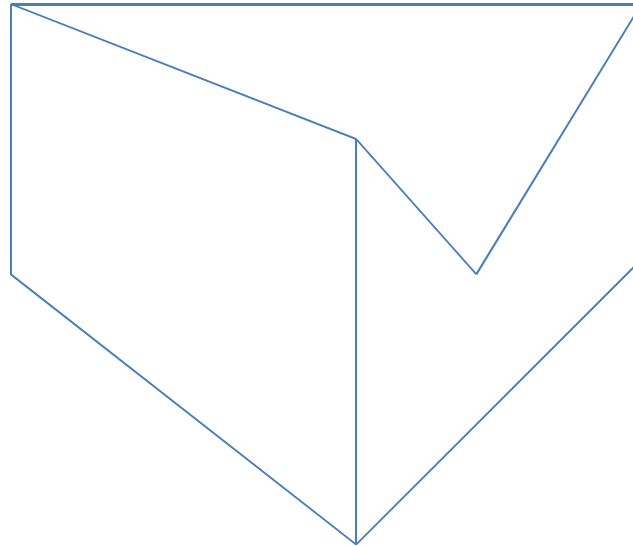


Constraint Processing II & Waltz: Waltz I

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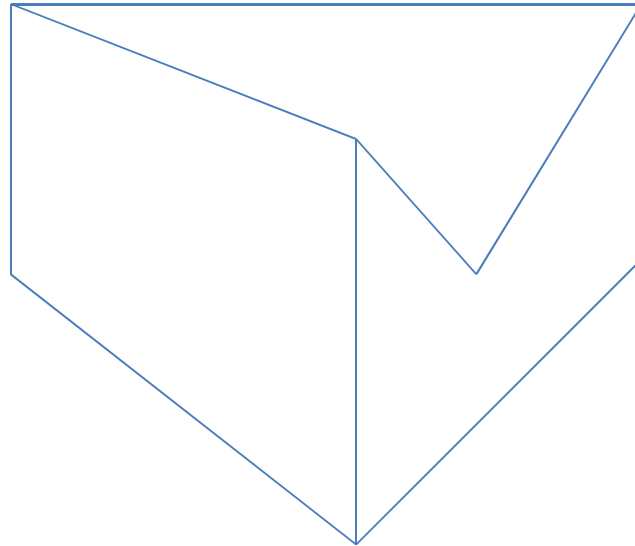
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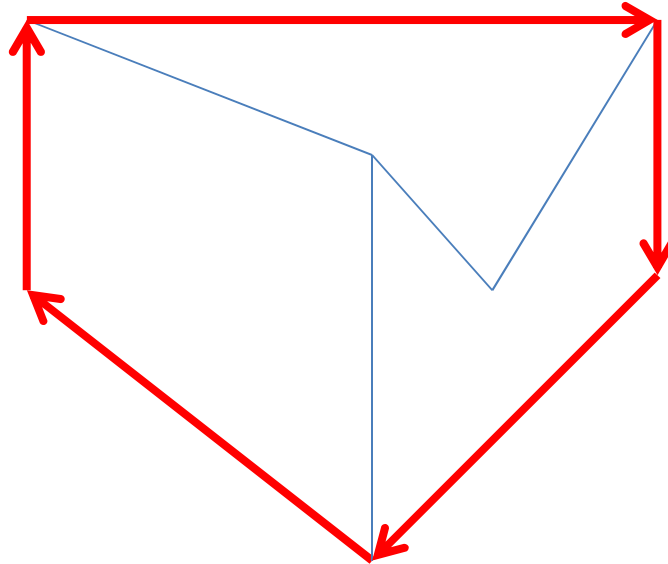
Constraint Processing II & Waltz: Waltz I

SOLUTION

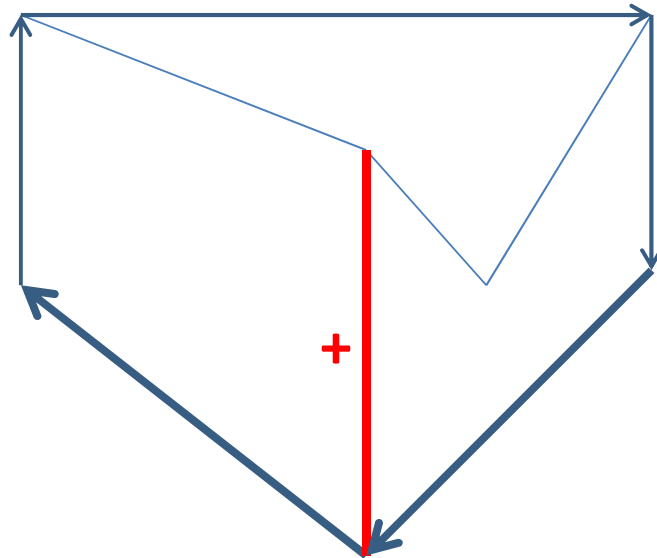
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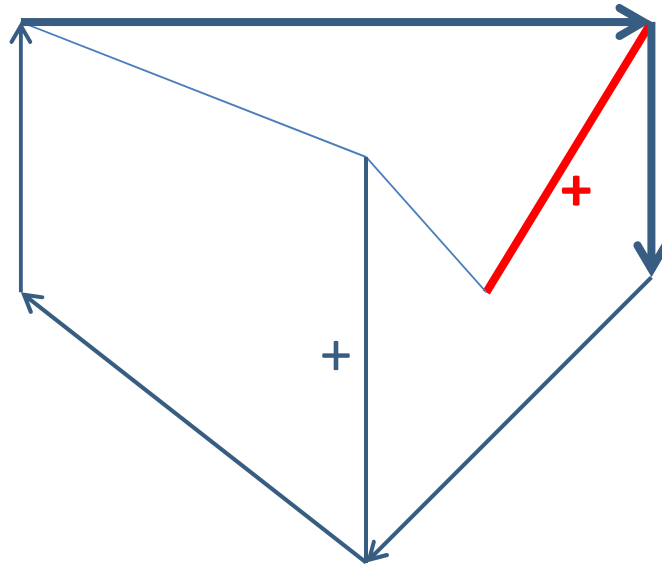
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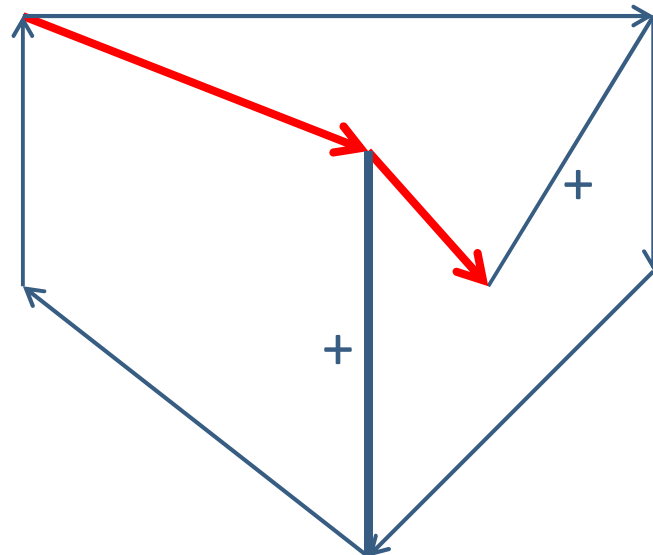
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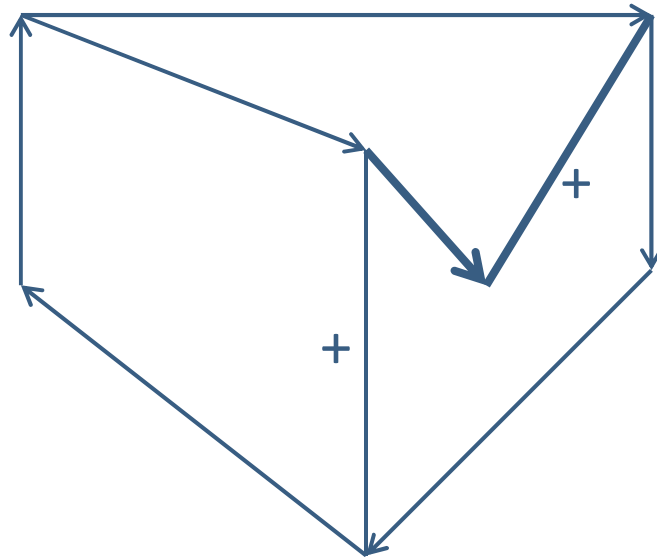
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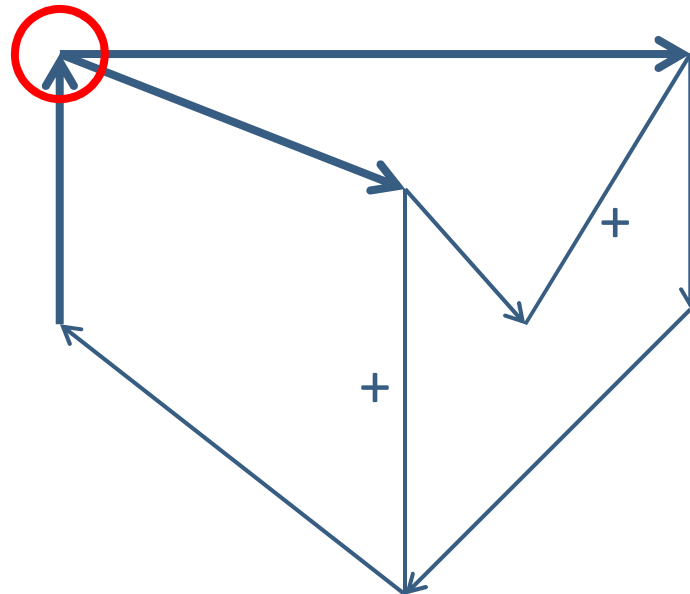
Solution



Solution

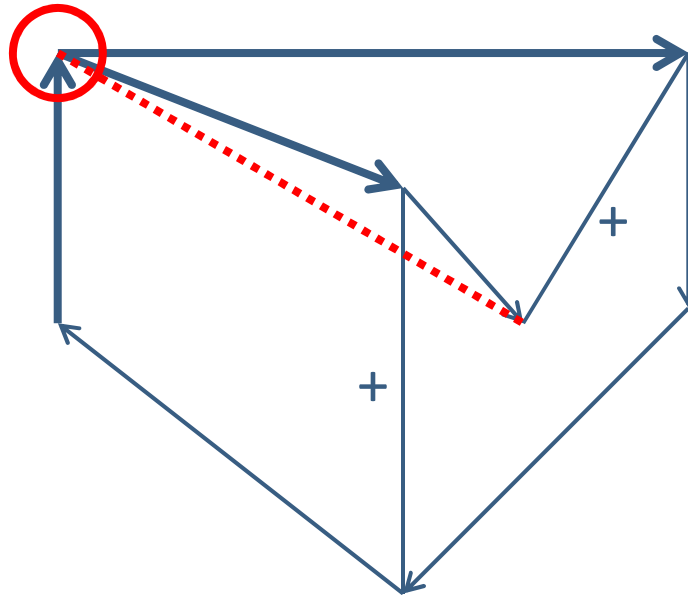


Solution



Solution

Line Drawing NOT allowed: 3-faced vertices!!

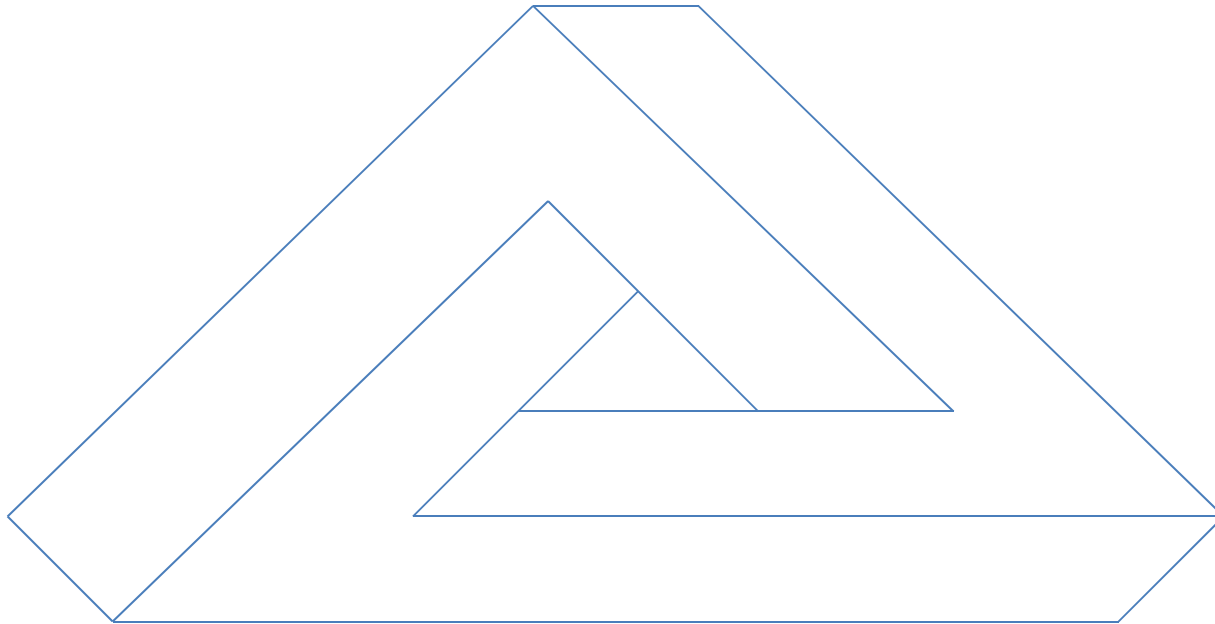


Constraint Processing II & Waltz: Waltz I

PROBLEM

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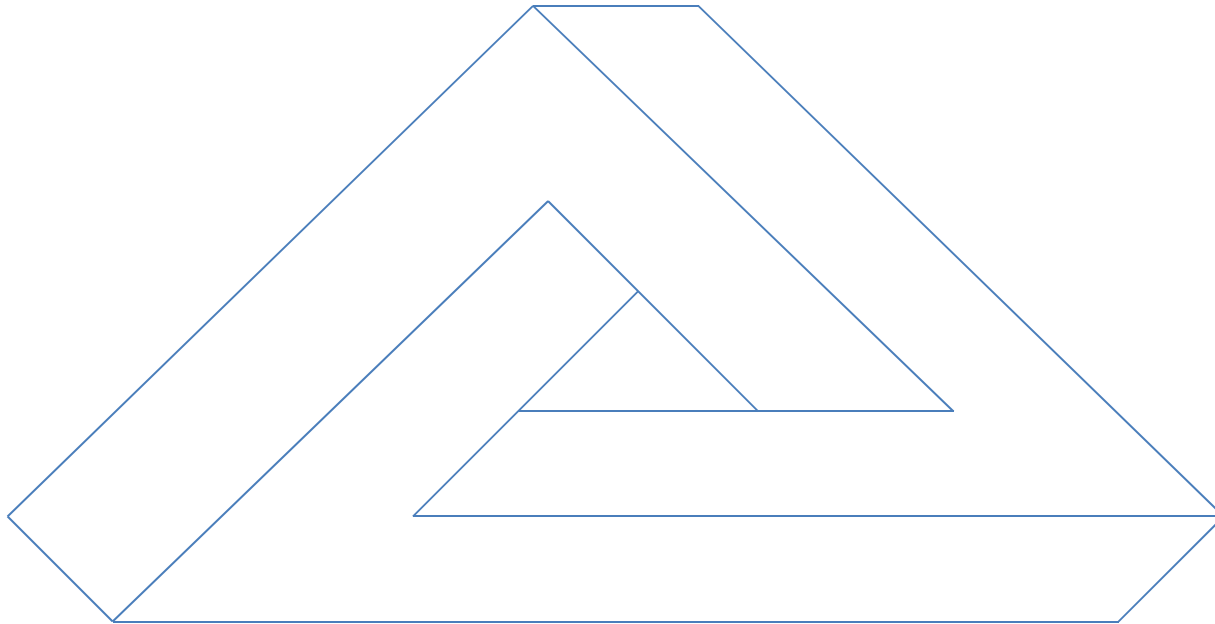
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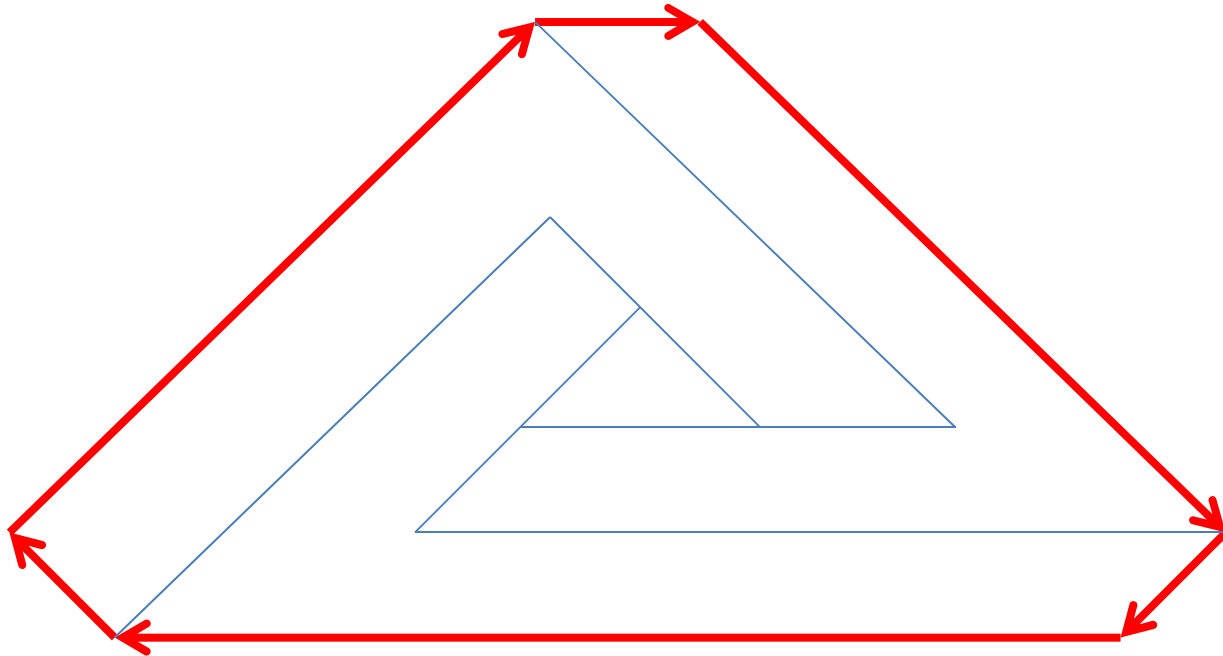
Constraint Processing II & Waltz: Waltz I

SOLUTION

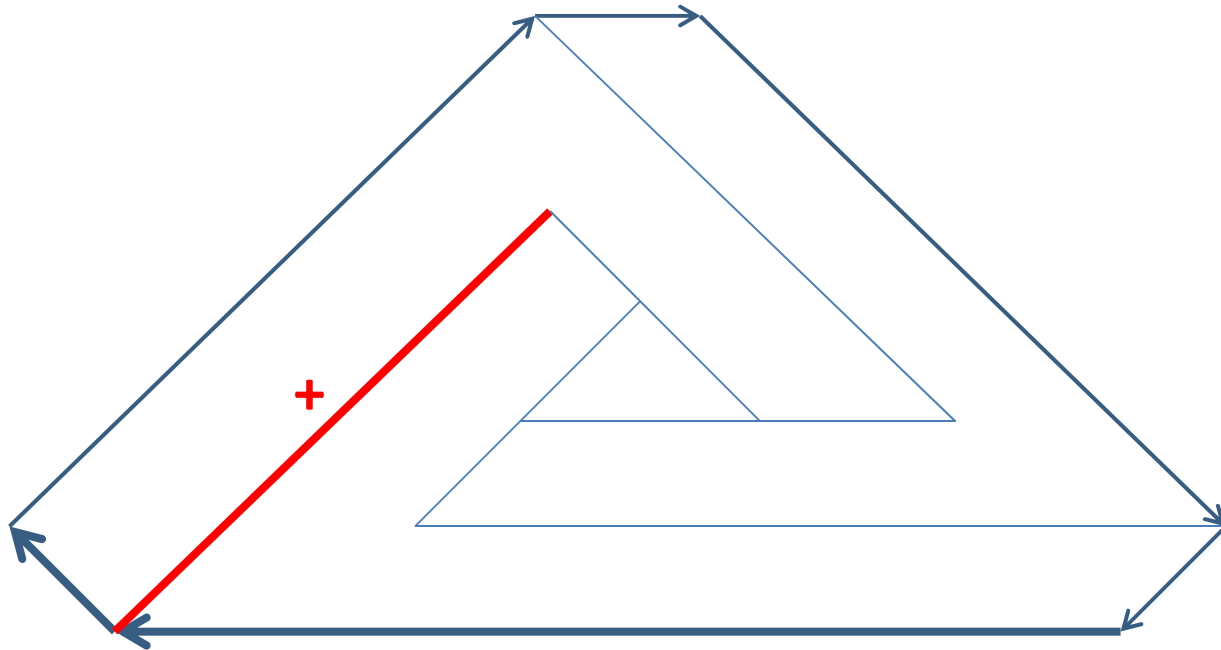
Solution



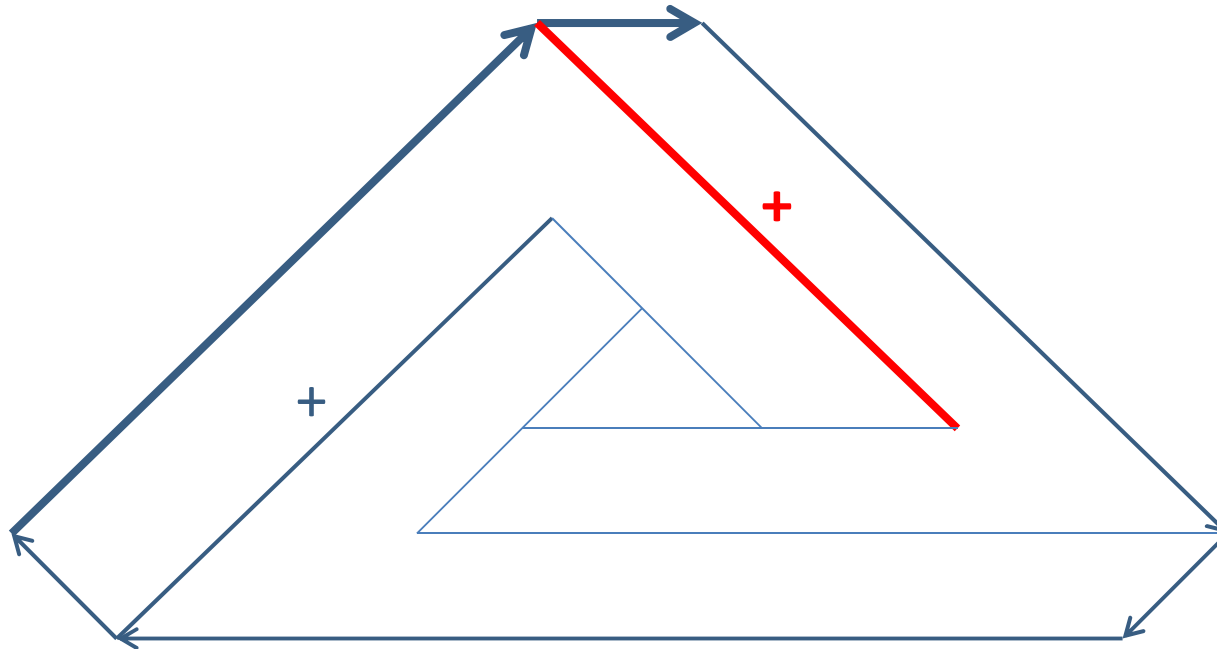
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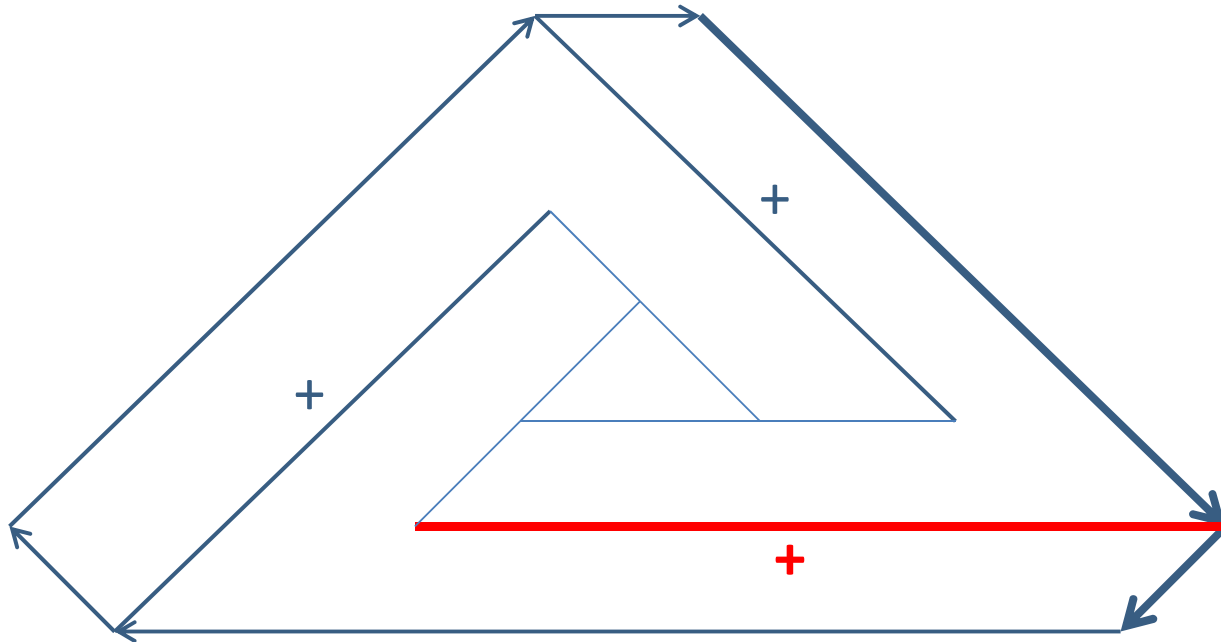
Solution



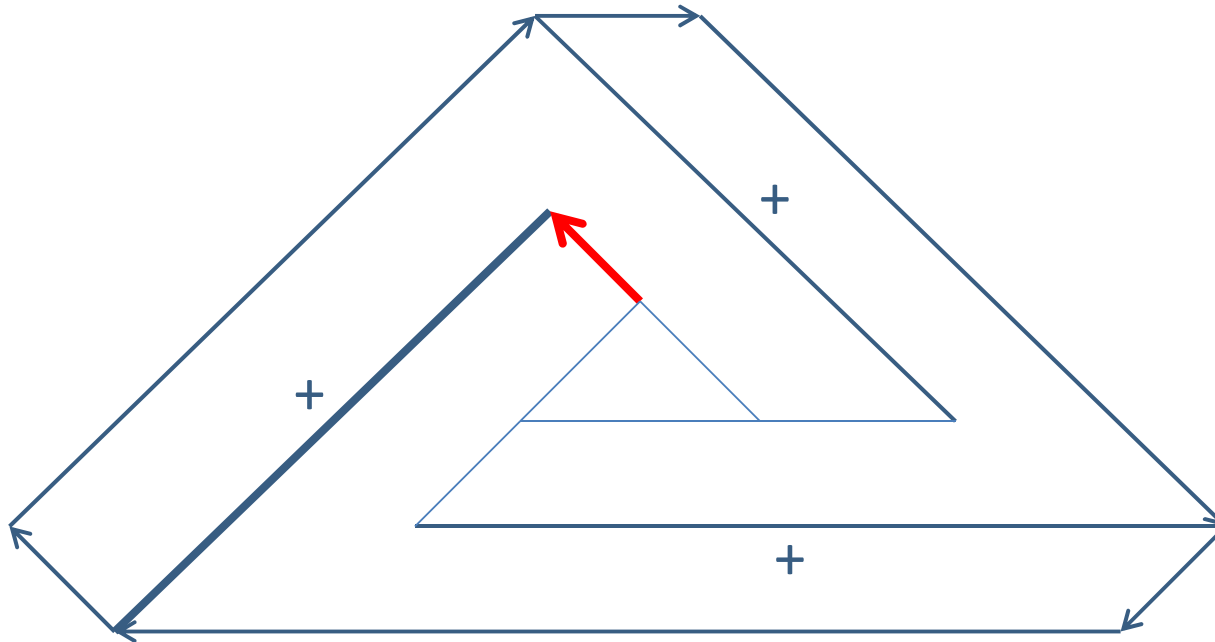
Solution



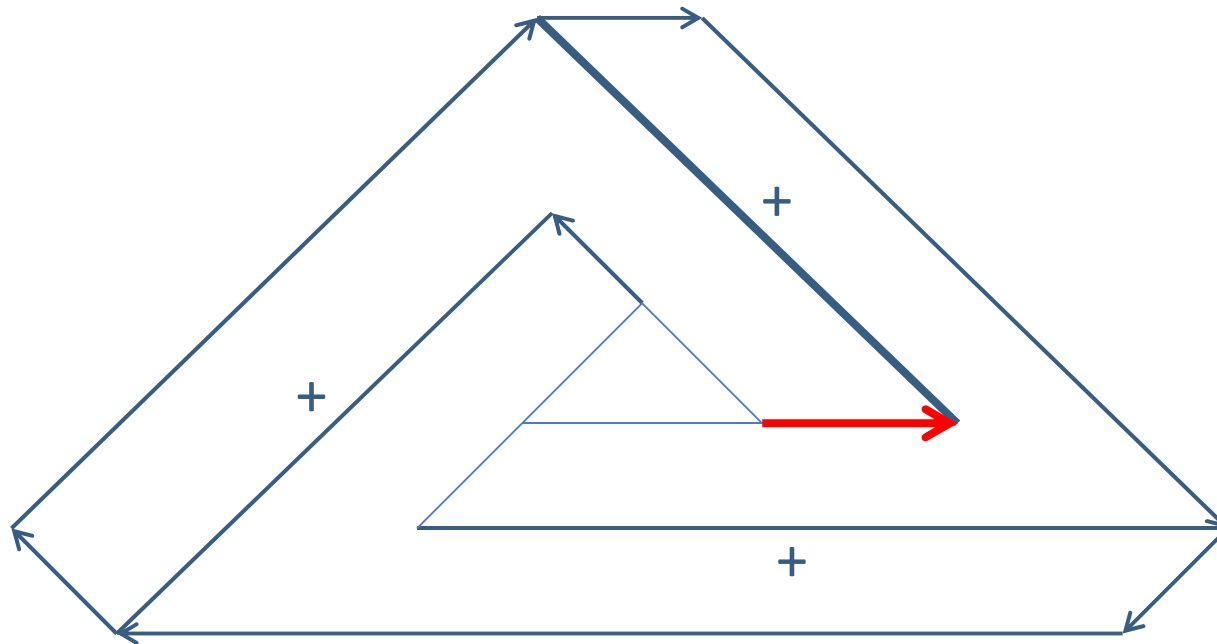
Solution



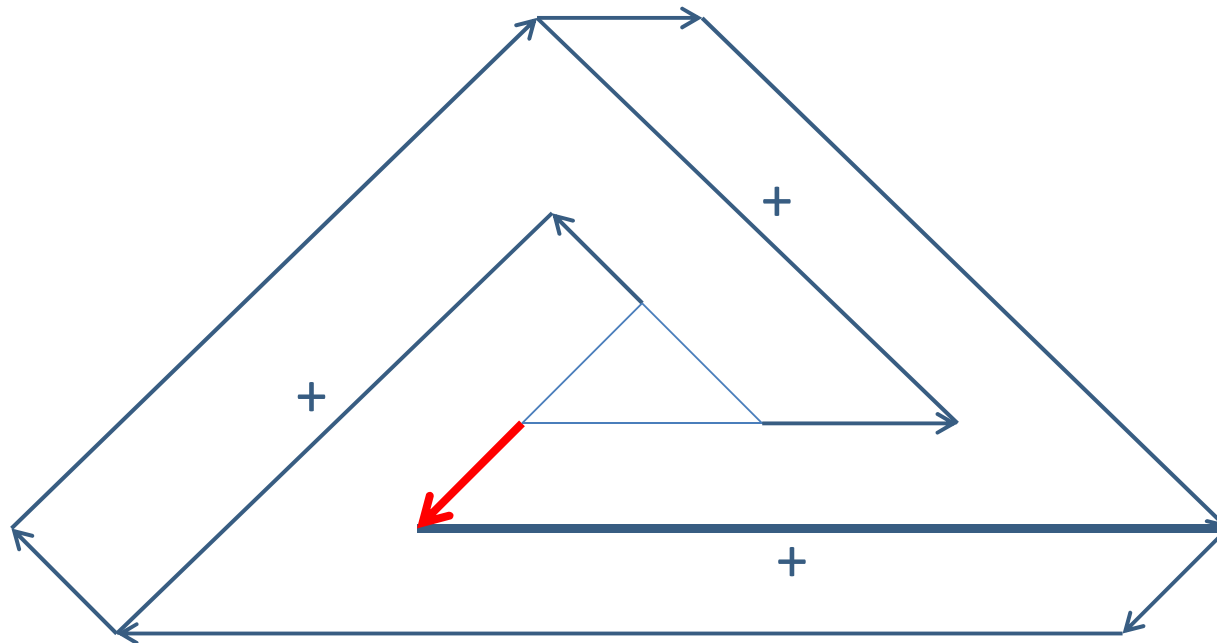
Solution



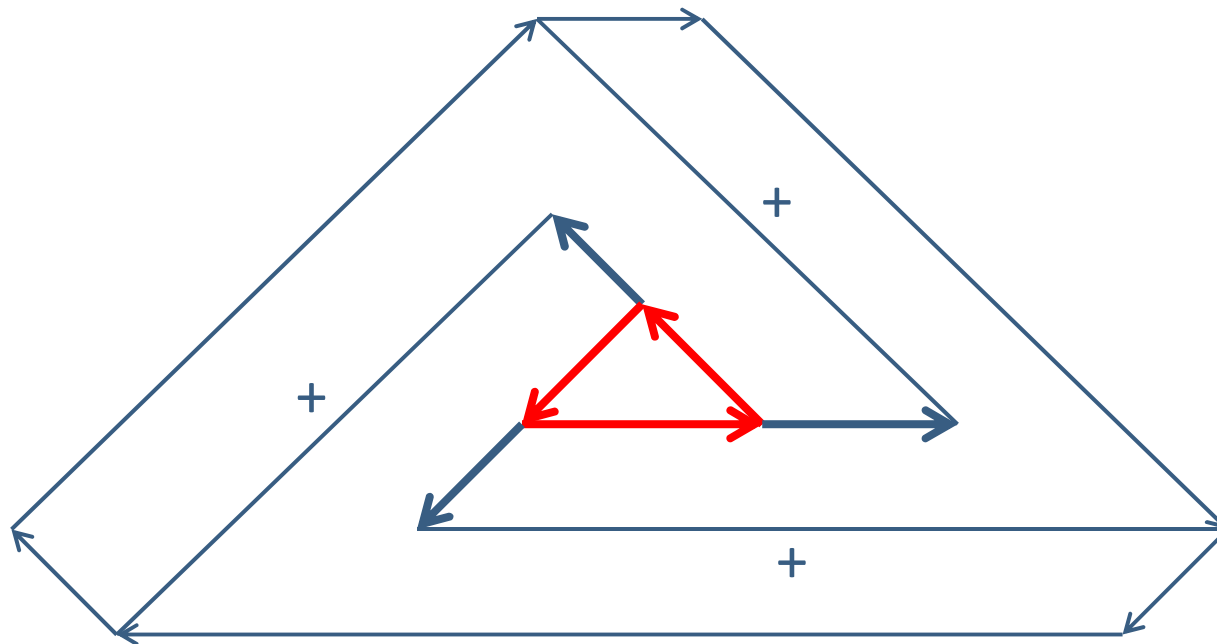
Solution



Solution

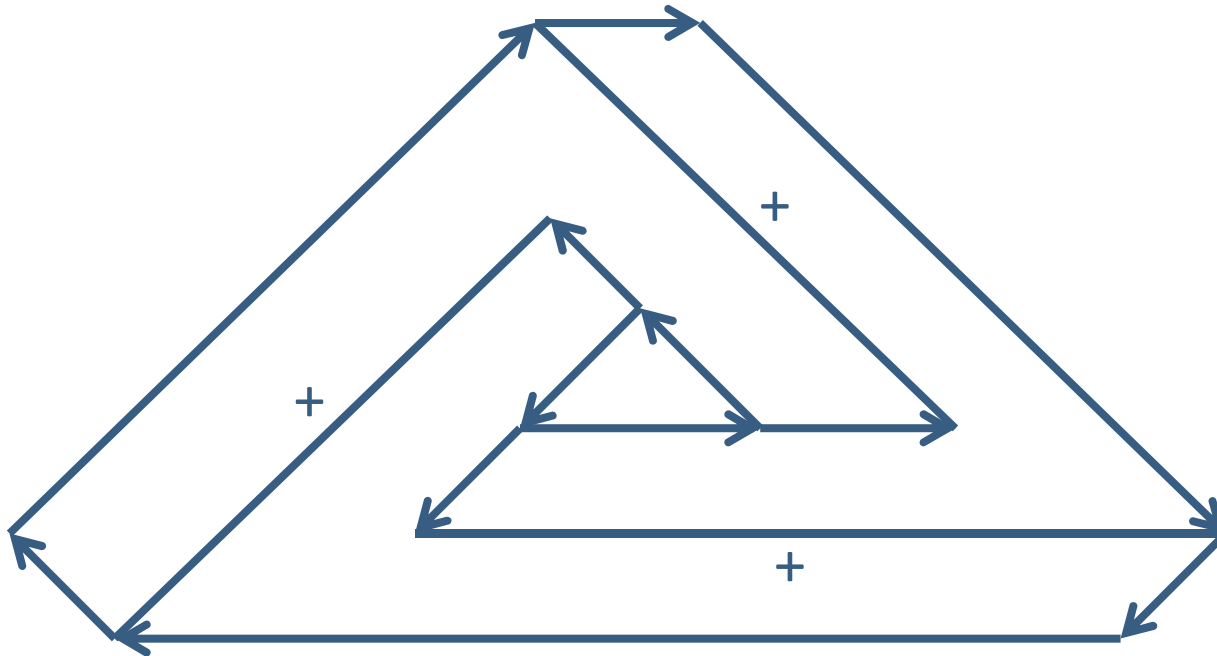


Solution



Solution

Drawing is locally correct, but is globally impossible.
Waltz procedure is local, thus, cannot detect this!



Exercises: Artificial Intelligence

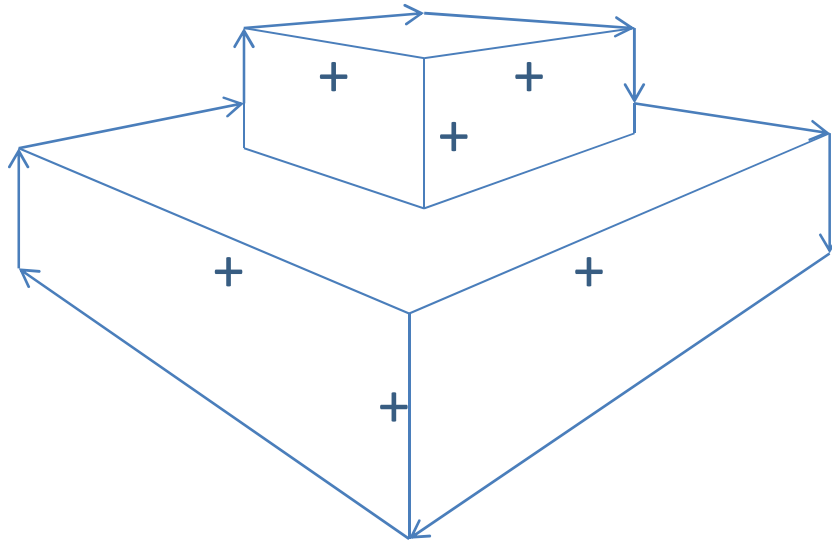
Constraint Processing II & Waltz:
Waltz II

Constraint Processing II & Waltz: Waltz II

PROBLEM

Problem

- Finish the labeling of the following figure.
- Give all solutions:

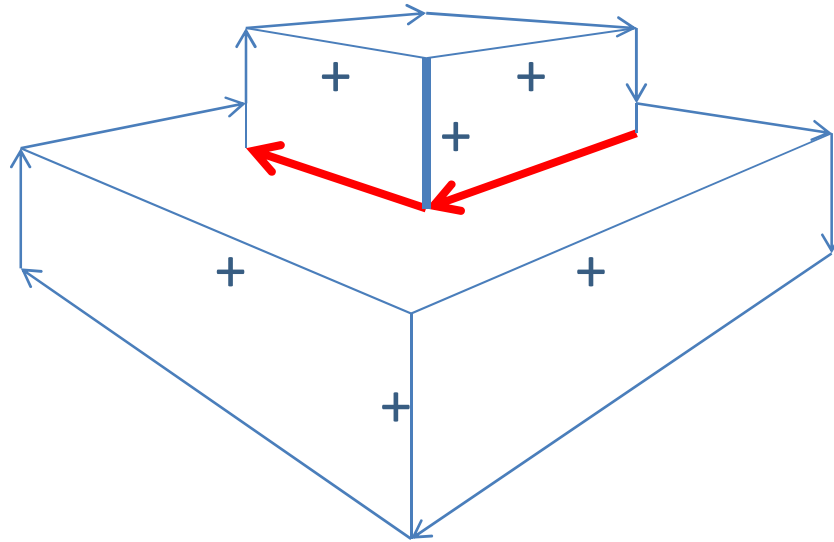


Constraint Processing II & Waltz: Waltz II

SOLUTION

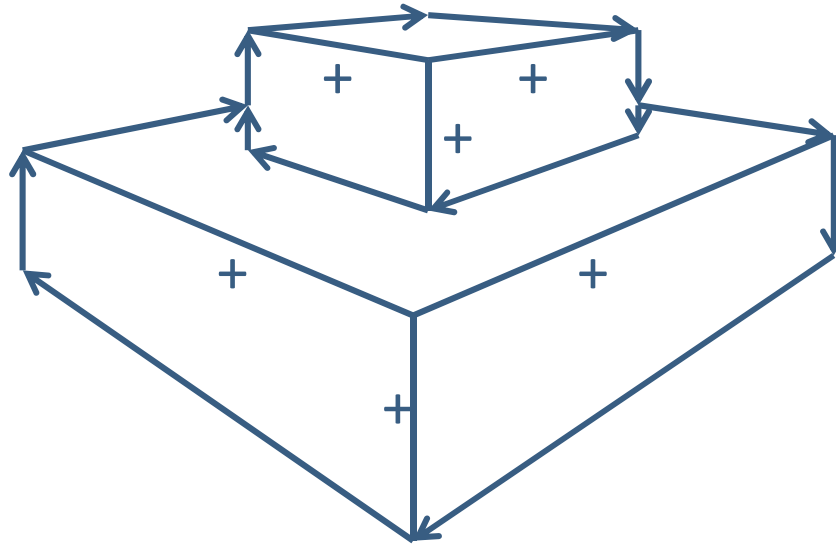
Solution

- Solution 1: Floating cube



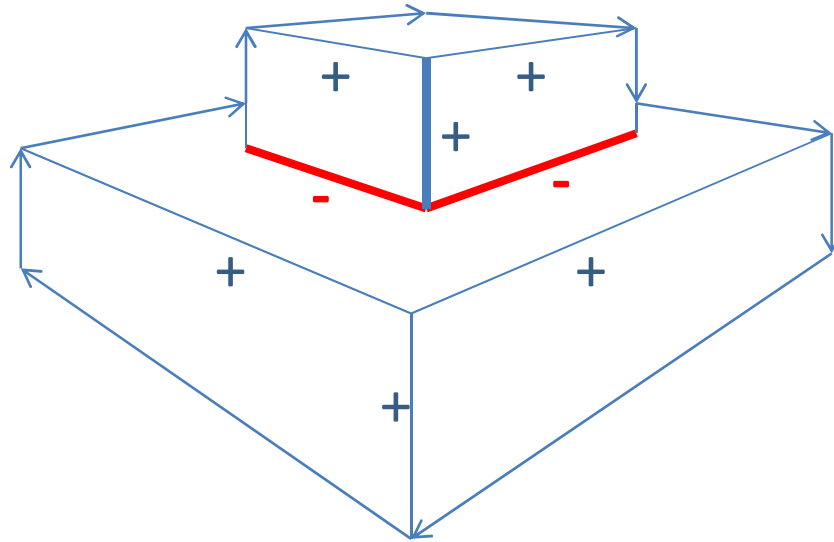
Solution

- Solution 1: Floating cube



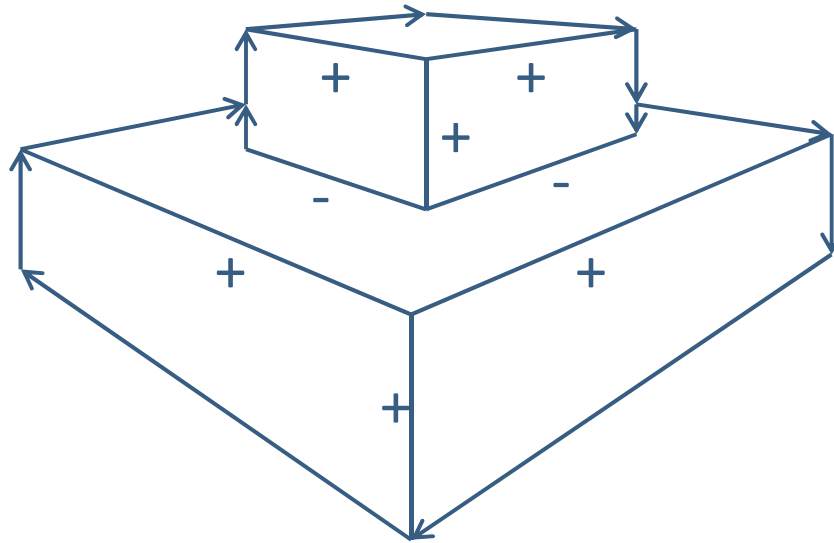
Solution

- Solution 2: Sitting cube



Solution

- Solution 2: Sitting cube



Exercises: Artificial Intelligence

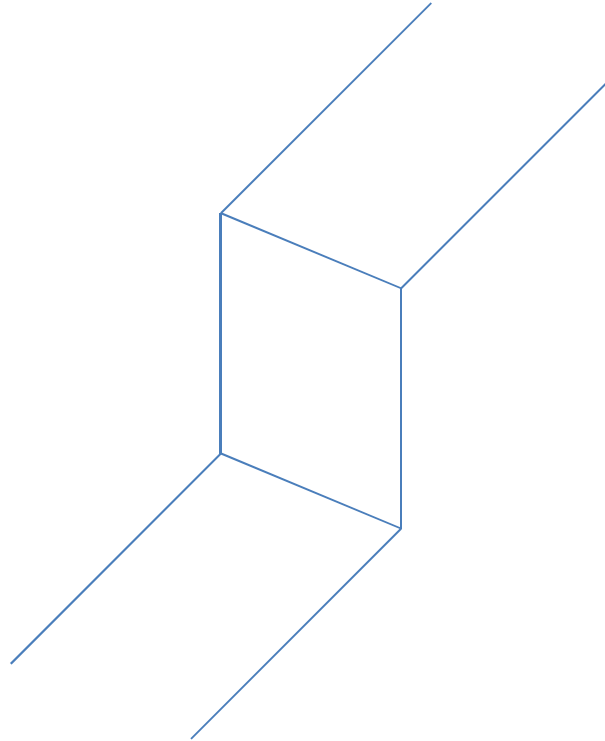
Constraint Processing II & Waltz:
Waltz III

Constraint Processing II & Waltz: Waltz III

PROBLEM

Problem

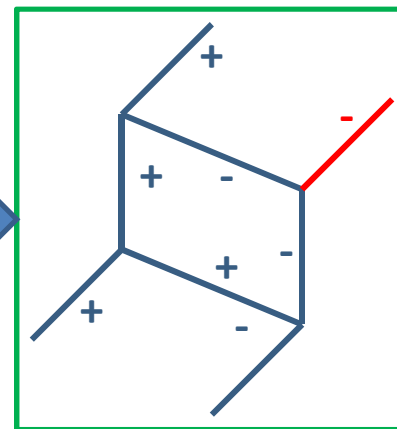
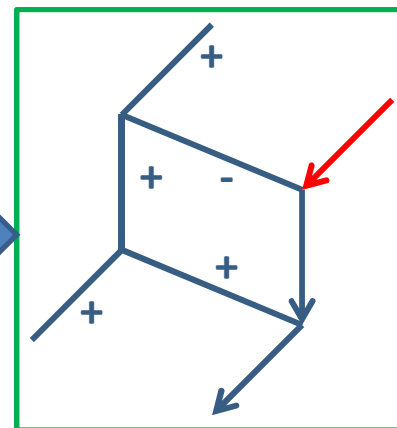
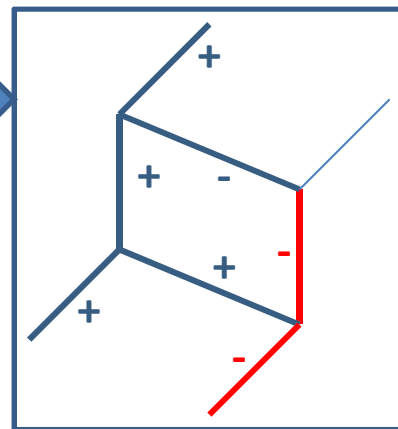
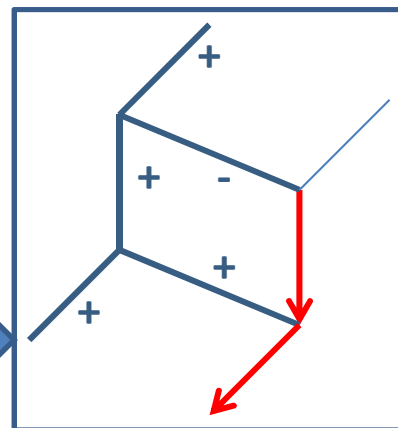
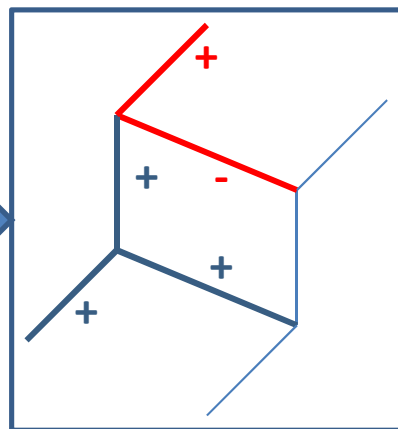
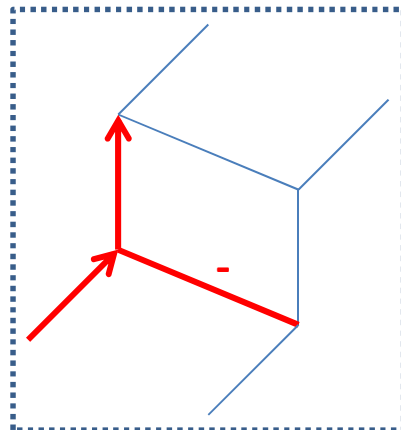
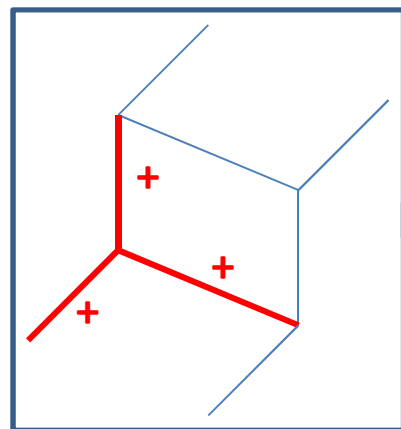
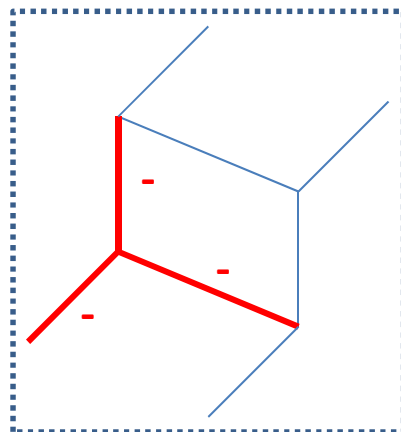
- Labeling the following figure fragment.
- Give all solutions:



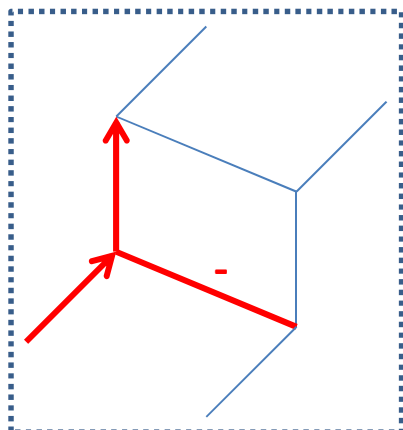
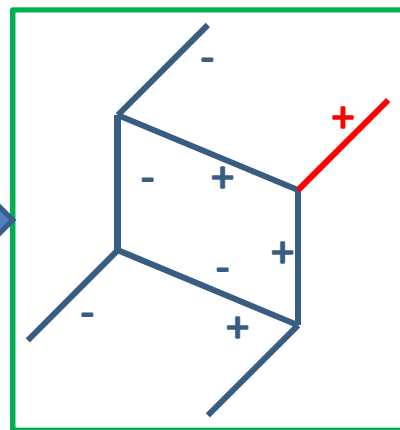
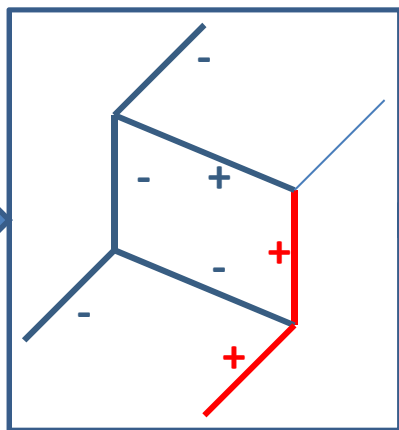
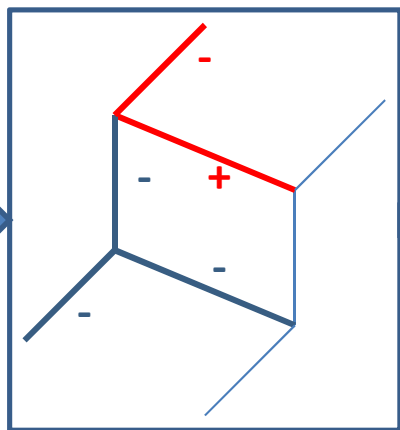
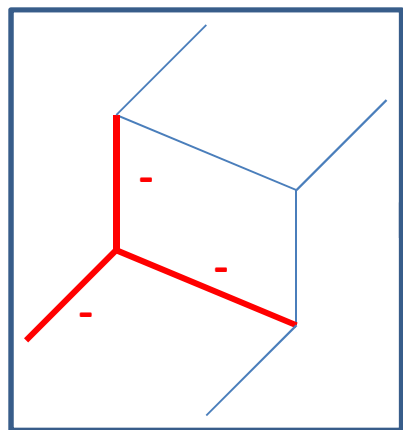
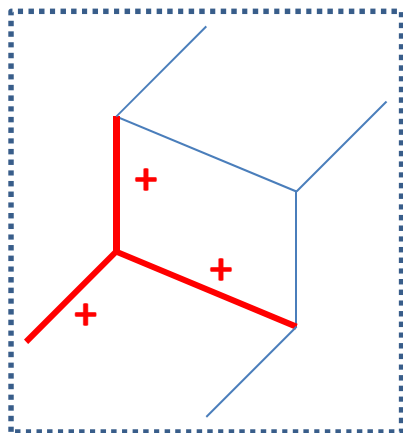
Constraint Processing II & Waltz: Waltz III

SOLUTION

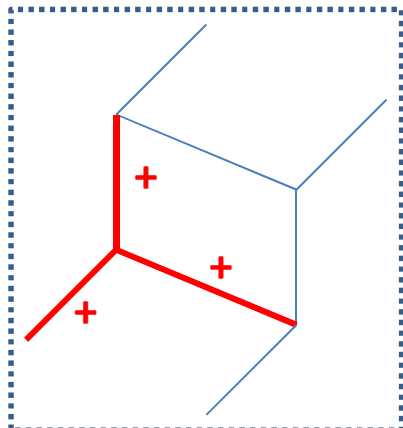
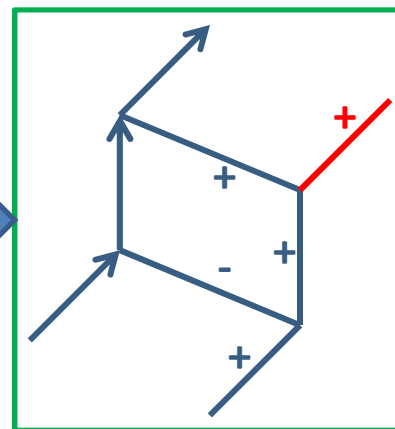
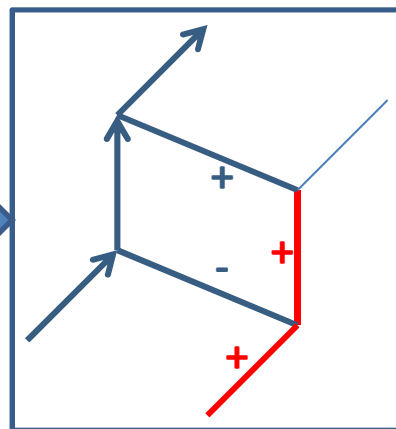
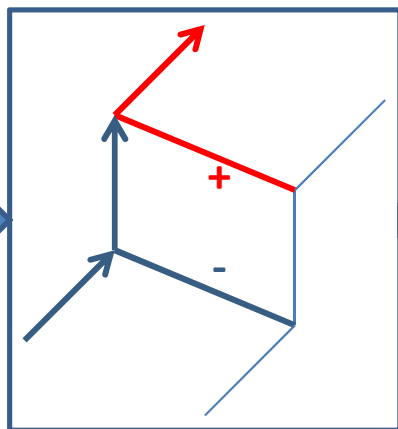
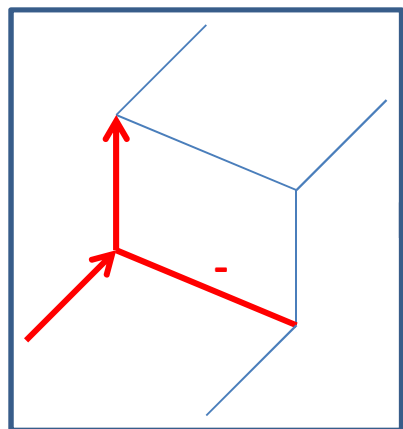
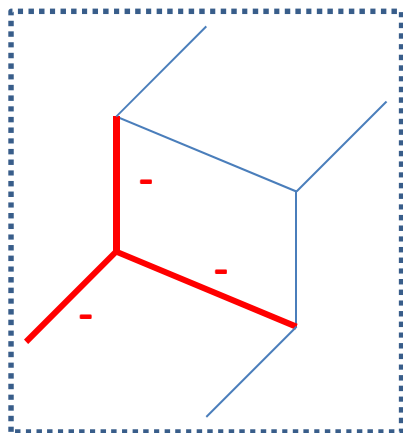
Solution



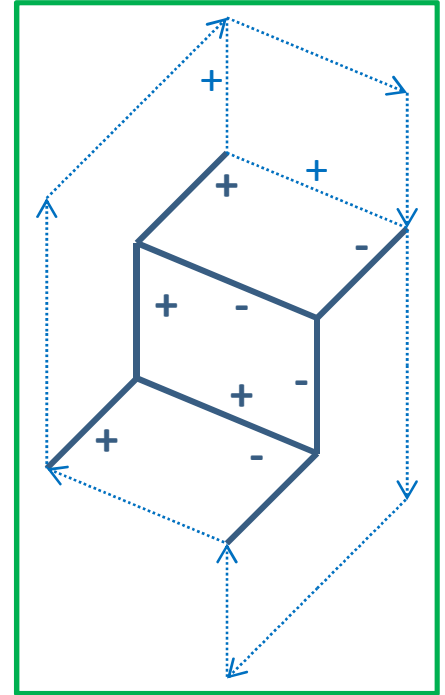
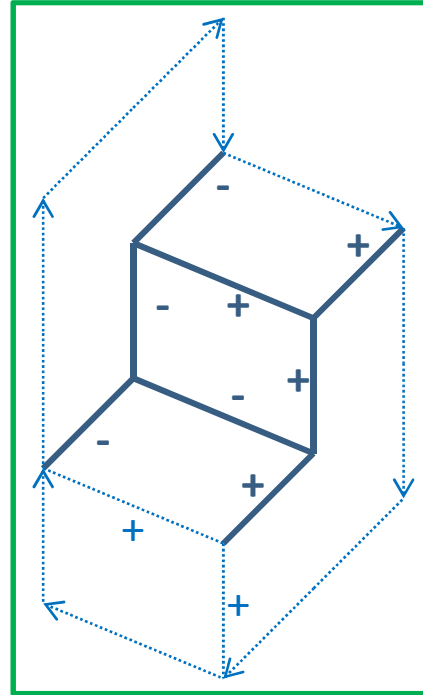
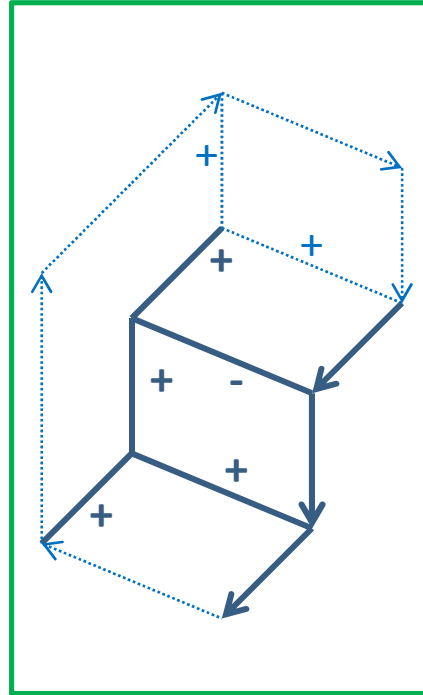
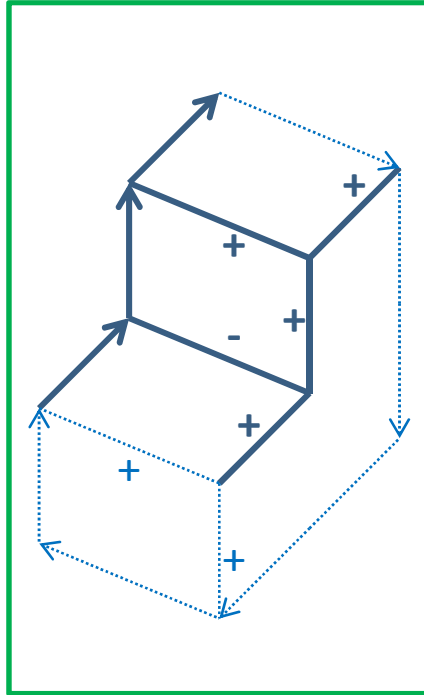
Solution



Solution



Solution



Exercises: Artificial Intelligence

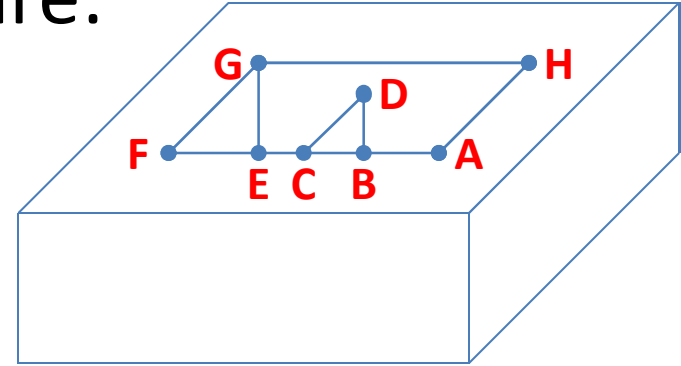
Constraint Processing II & Waltz:
Waltz IV

Constraint Processing II & Waltz: Waltz IV

PROBLEM

Problem

- Consider the following figure:

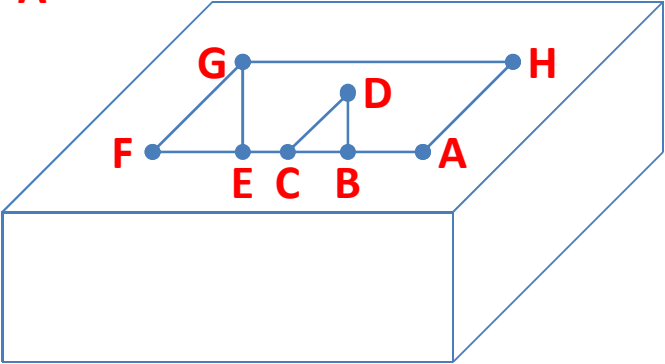
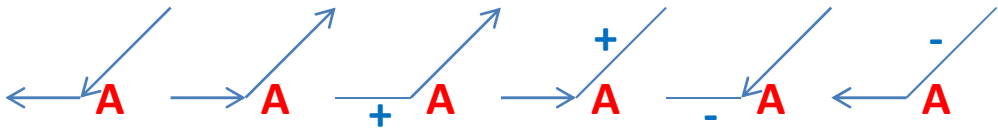


- At most 3 edges
- No shadows/cracks
- Find labelings:
 - Write down junction piles for A,B,...,H
 - Consider nodes in order of A,B,...,H
 - Return to previous nodes for pruning if possible

Constraint Processing II & Waltz: Waltz IV

SOLUTION

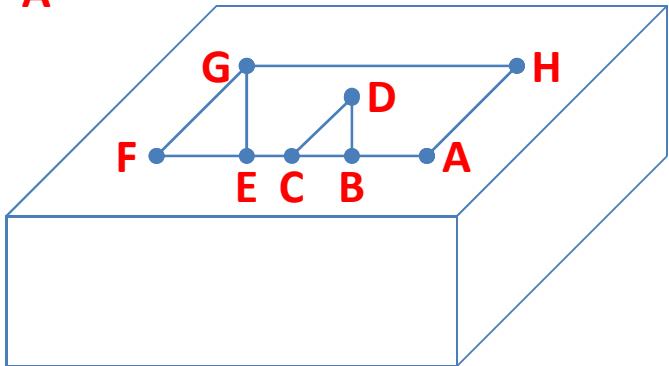
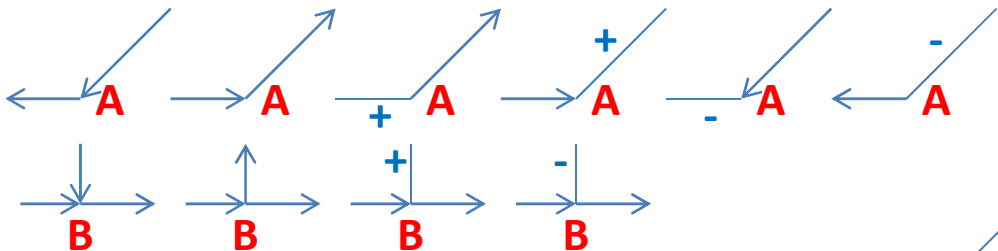
Solution



Solution

A

B

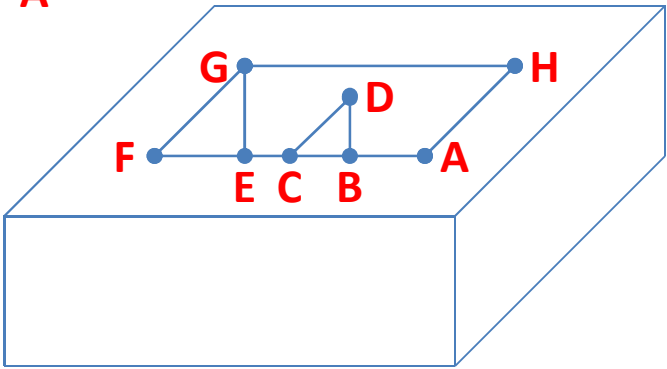
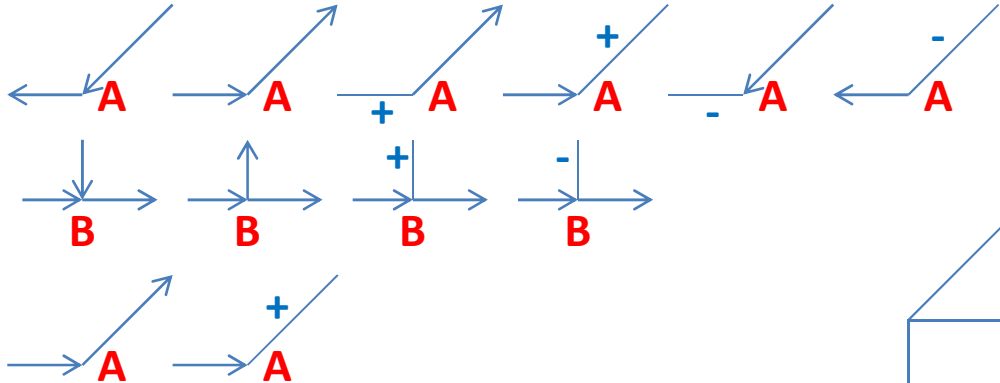


Solution

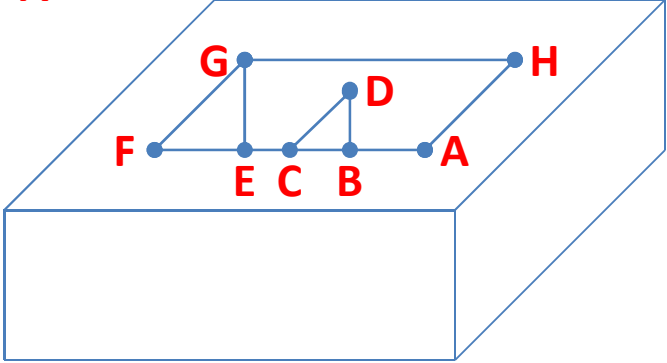
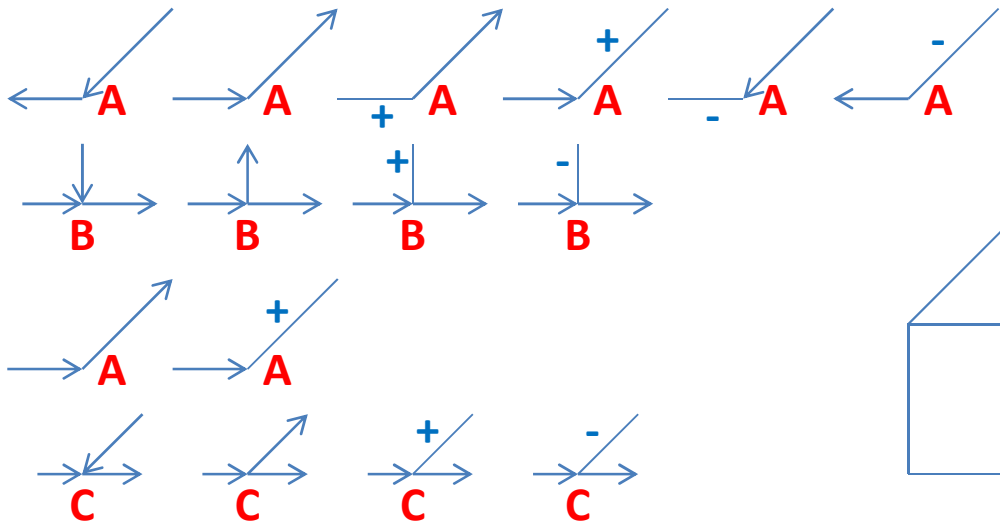
A

B

A



Solution



Solution

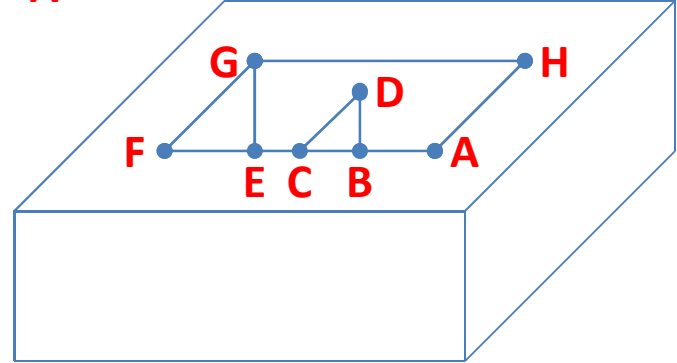
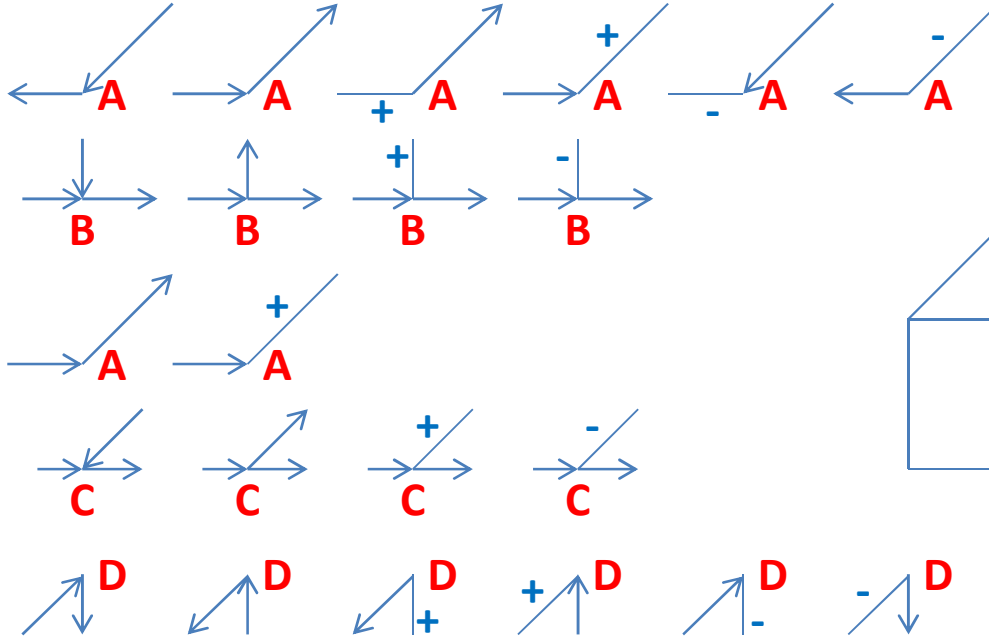
A

B

A

C

D



Solution

A

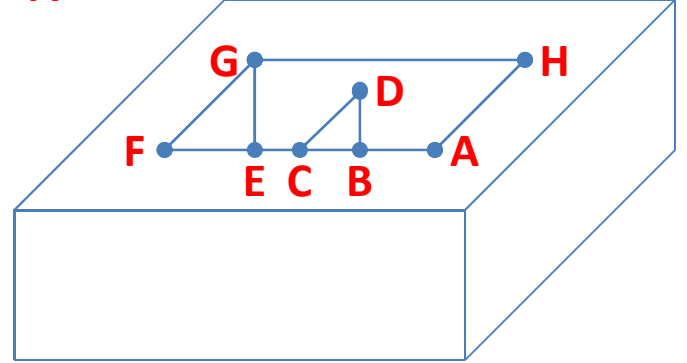
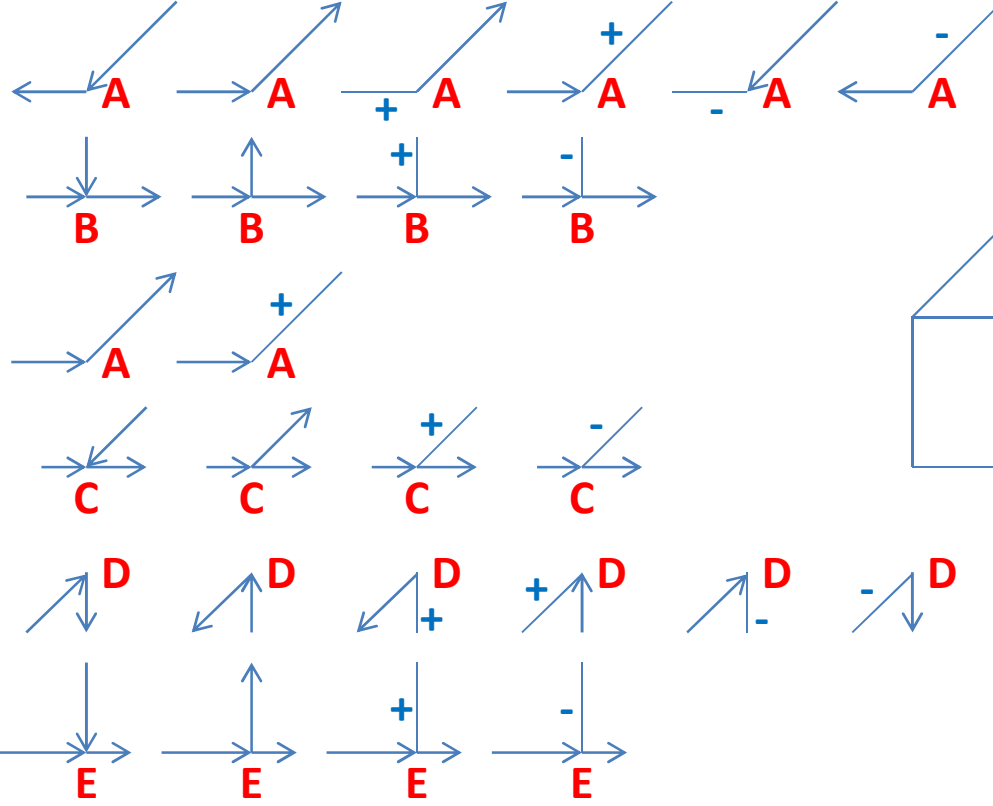
B

A

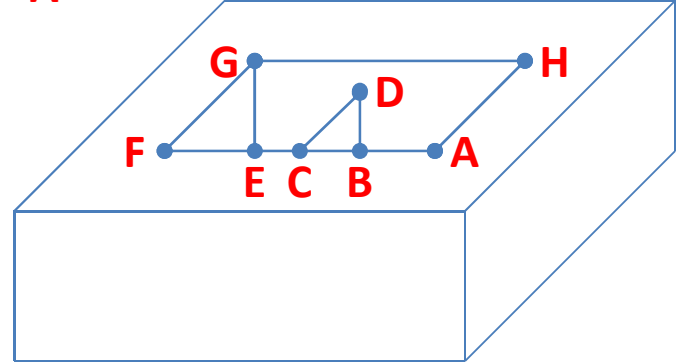
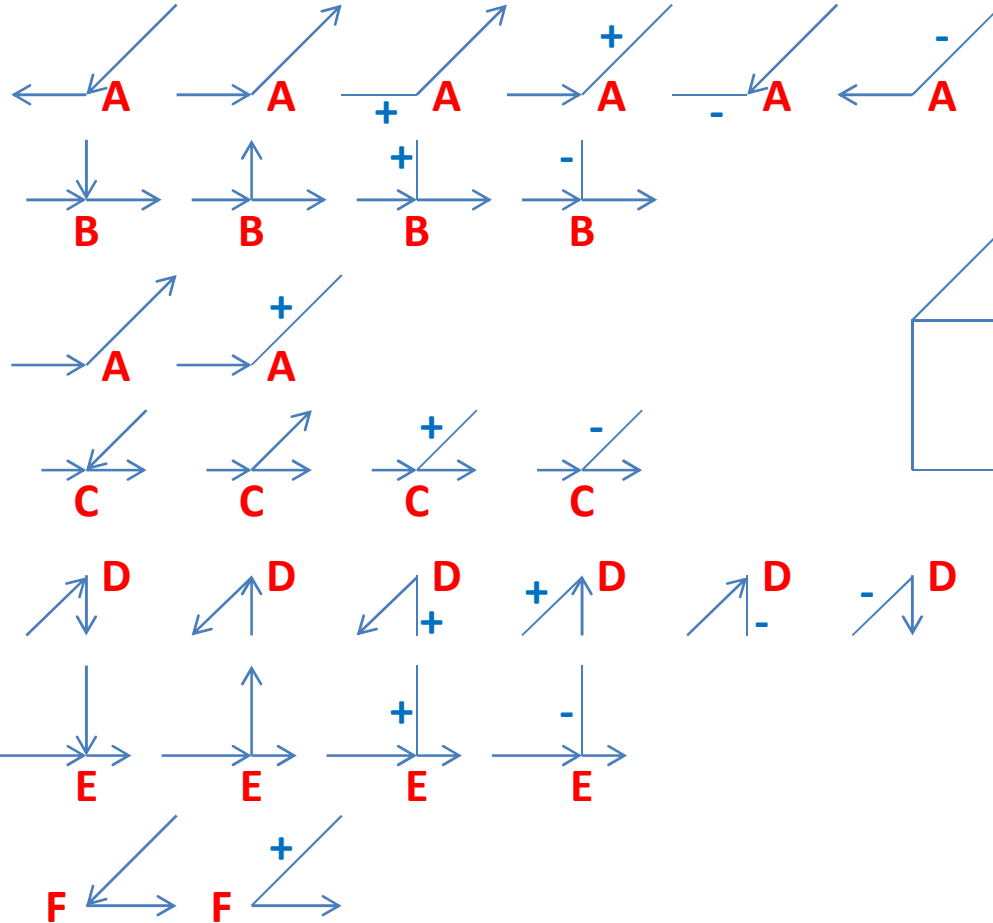
C

D

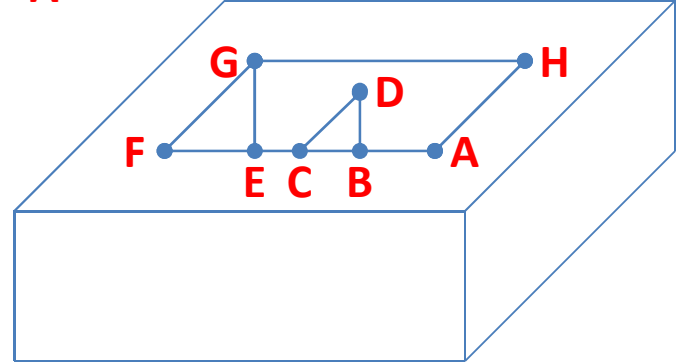
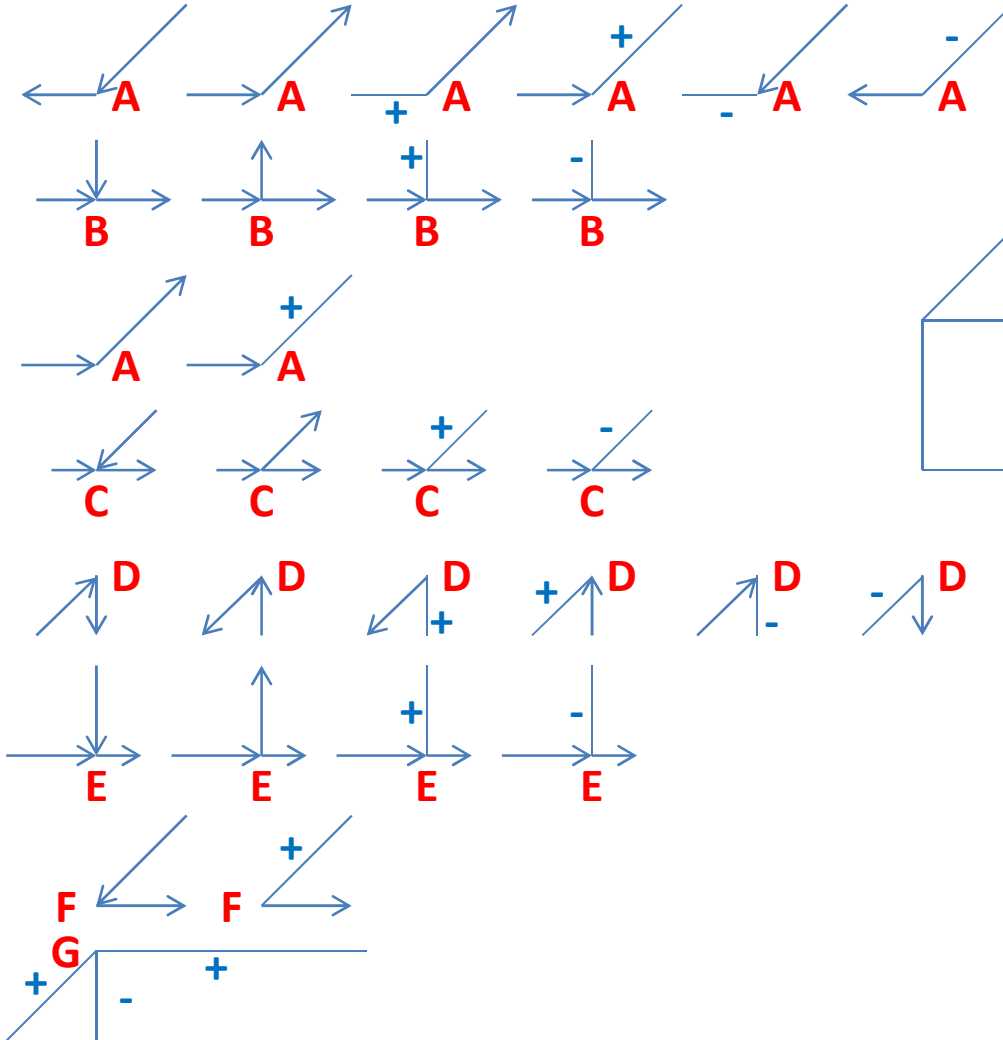
E



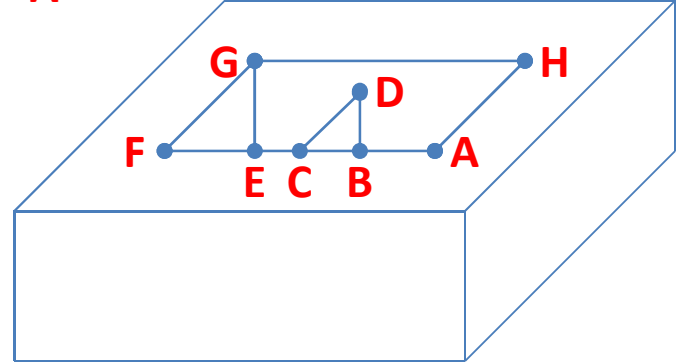
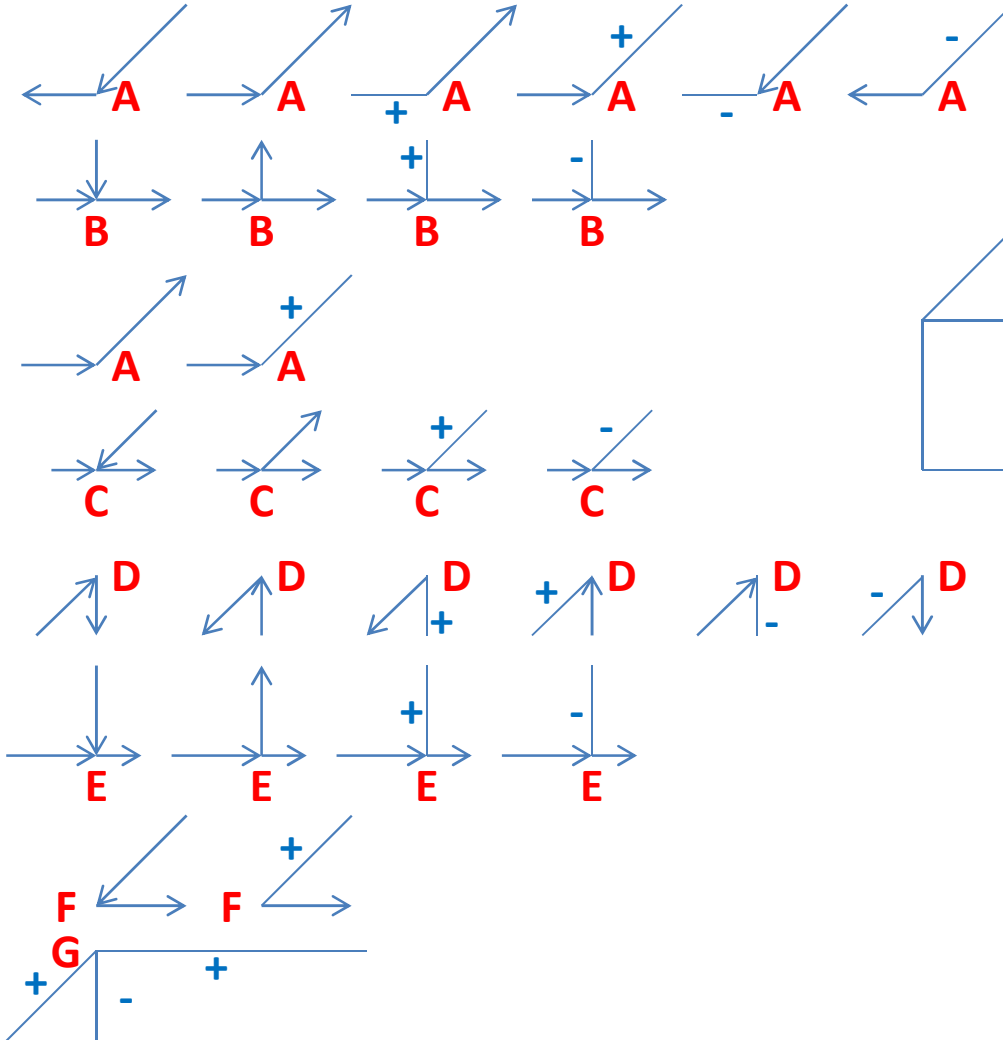
Solution



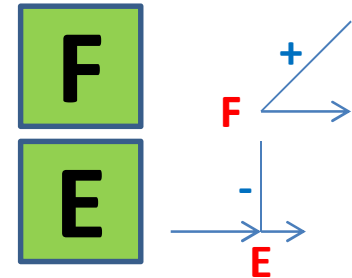
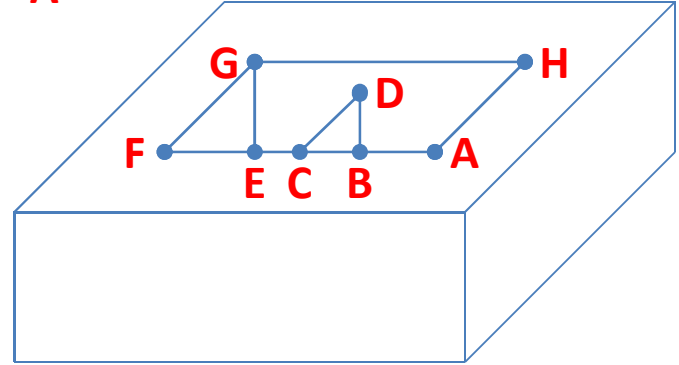
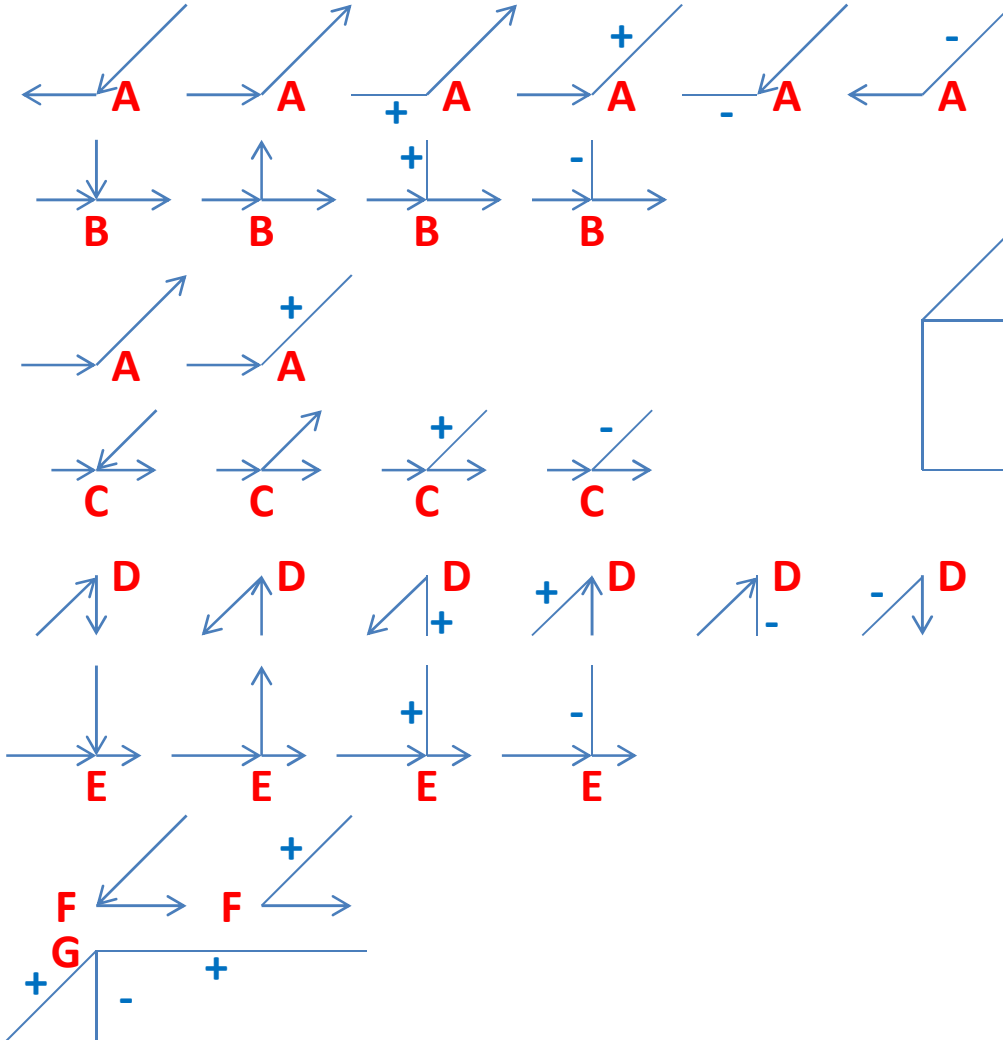
Solution



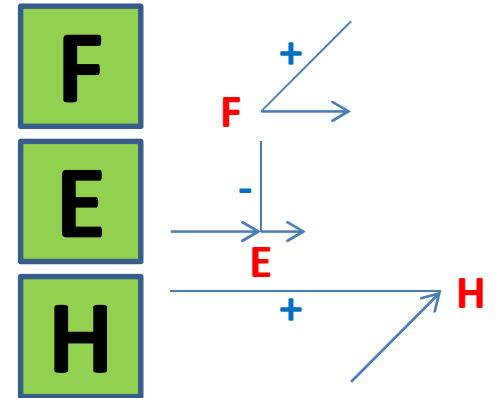
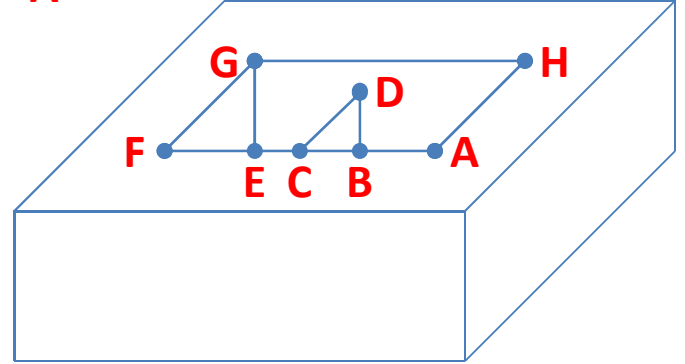
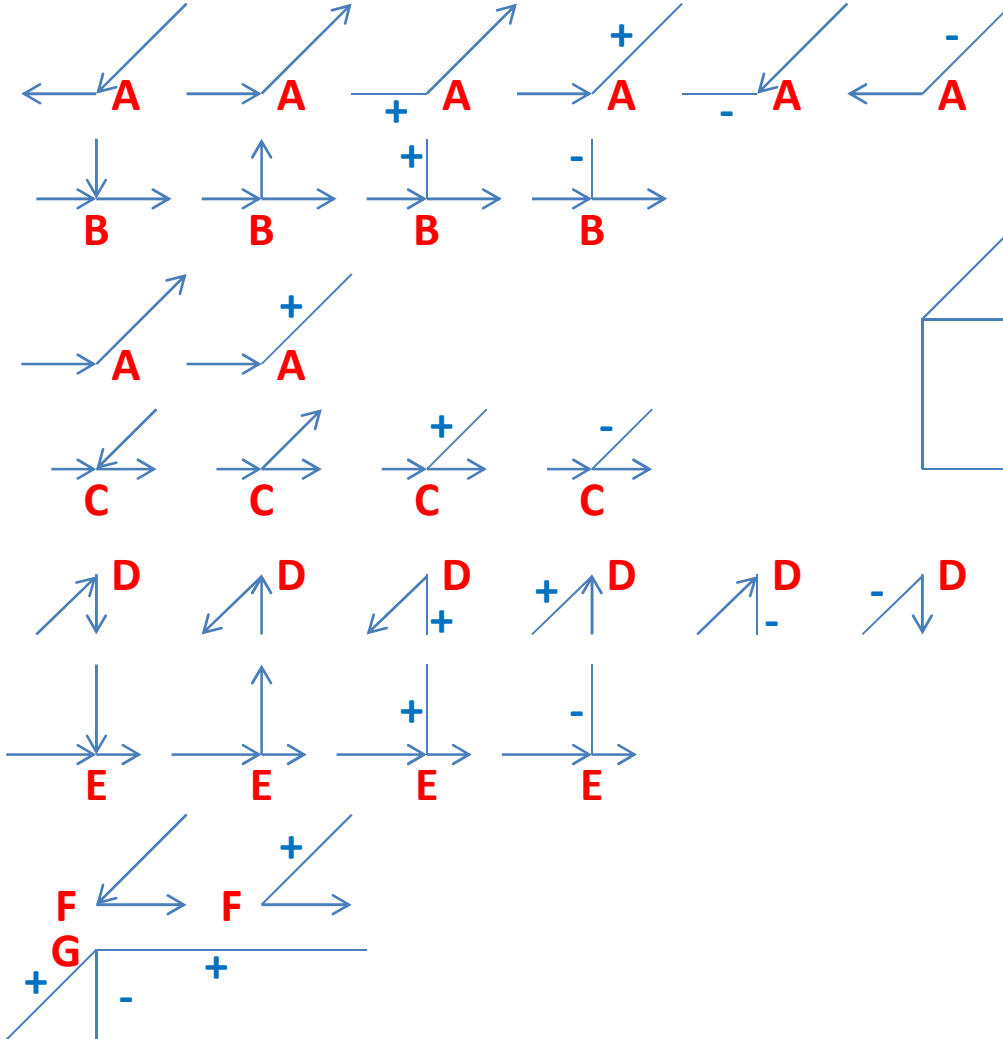
Solution



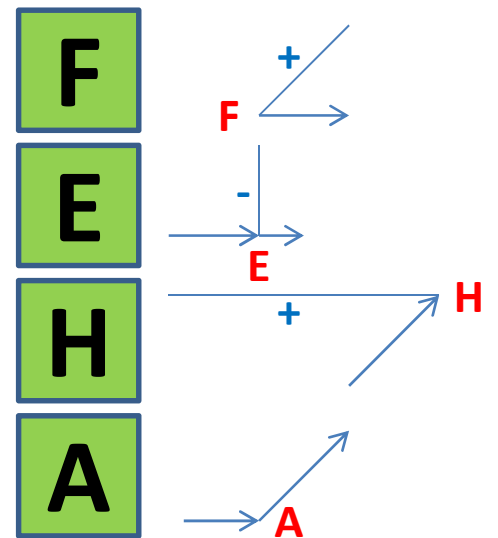
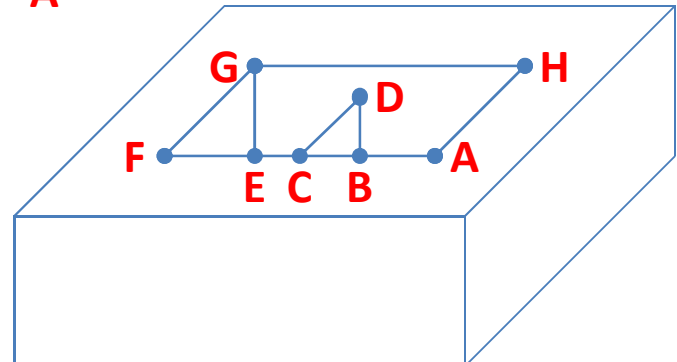
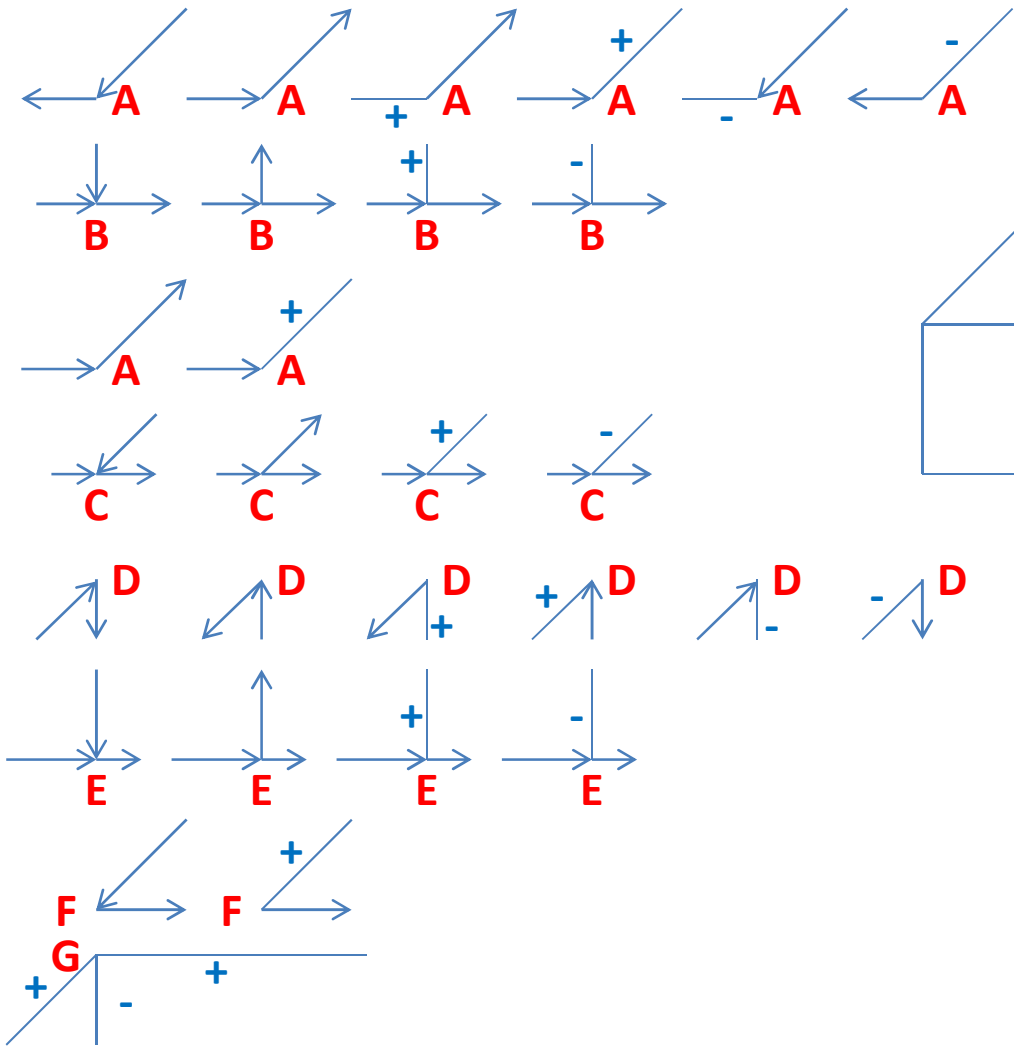
Solution



Solution

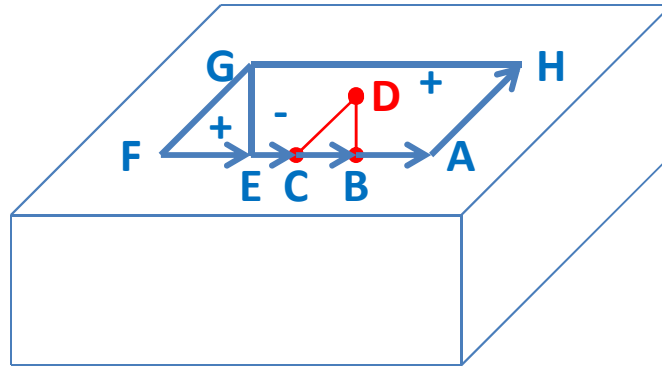


Solution



Solution

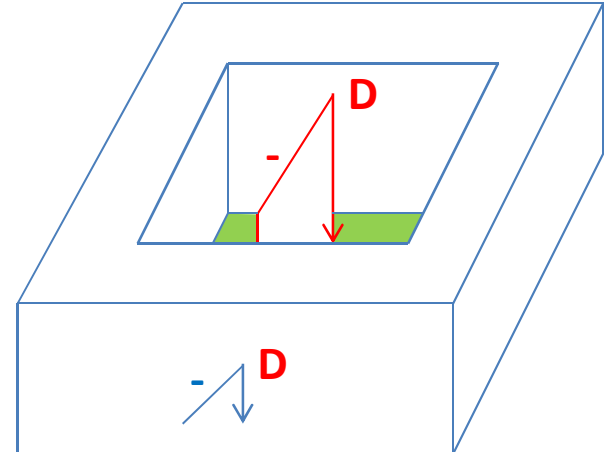
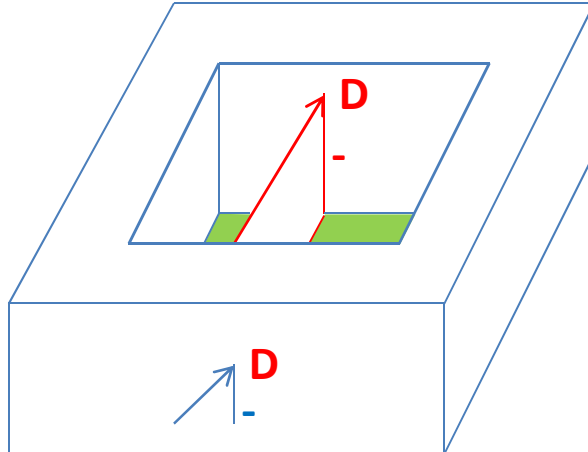
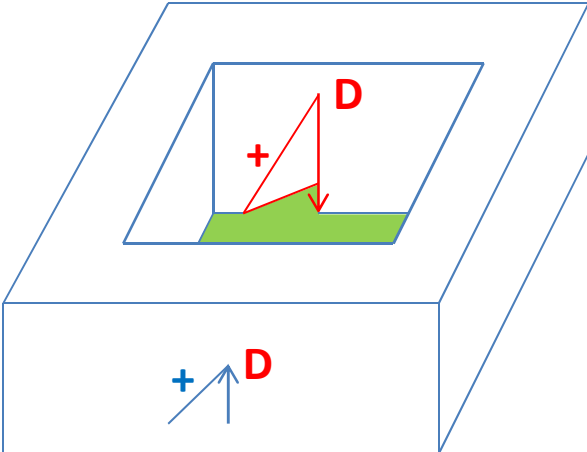
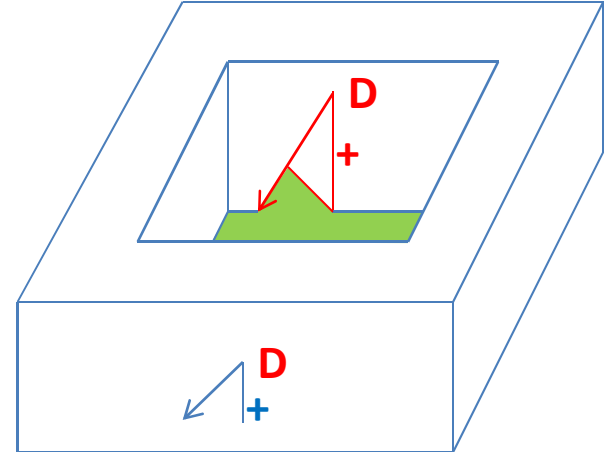
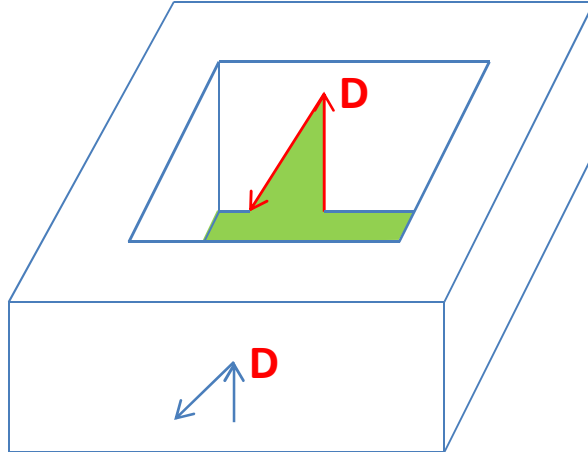
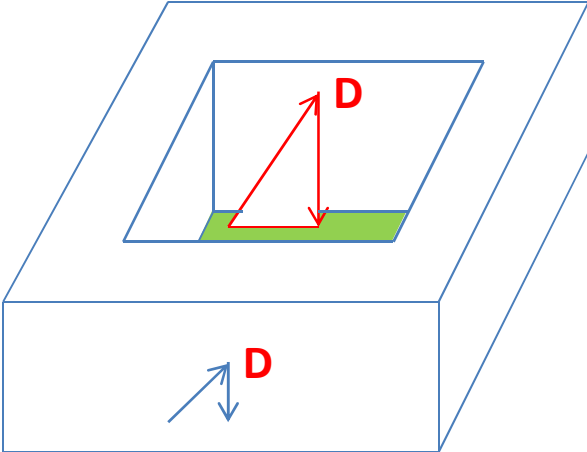
- We can determine **all nodes except for D**:



- **D** can still take **6 interpretations**:



Solution



Exercises: Artificial Intelligence

Constraint Processing II & Waltz:
Waltz V

Constraint Processing II & Waltz: Waltz V

PROBLEM

Problem

- Prove the termination of the Waltz procedure

Constraint Processing II & Waltz: Waltz V

TERMINATION WALTZ

Termination Waltz

- ***Waltz's procedure terminates if***
 - No possibilities for some vertex **OR**
 - No reduction of junction piles
- ***Waltz's procedure does not terminate if***
 - Only non-empty piles **AND**
 - Reduction of piles possible
- **BUT**
 - Piles are finite \implies Number of iterations finite
 \implies **Waltz's procedure terminates**