Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

Lehrstuhl für
INFORMATIK I
Algorithmen & Komplexität

Institut für Informatik

Seminar:
Themen der Algorithmik

Sommersemester 2024

Einführungsveranstaltung am 16. April 2024

Lehrstuhl für Informatik I

Boris Klemz, Diana Sieper, Johannes Zink

Ziele und Inhalte

In diesem Seminar geht es teils um **aktuelle Forschungsthemen**, teils **klassische Resultate** aus dem Gebiet **Algorithmik**.

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JedeR TeilnehmerIn arbeitet sich in ein abgegrenztes Thema ein. Dieses ist didaktisch aufzubereiten und den anderen KursteilnehmerInnen in einem **Vortrag** zu vermitteln, sowie in einer **schriftliche Ausarbeitung** darzustellen.

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- Ausblick auf den eigentlichen Vortrag geben
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- Wichtigste Resultate nennen & einordnen

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Ziele:

- Zeitnah einarbeiten
- Themenauswahl prüfen
- Vortragen üben
- Feedback bekommen ohne Bewertun

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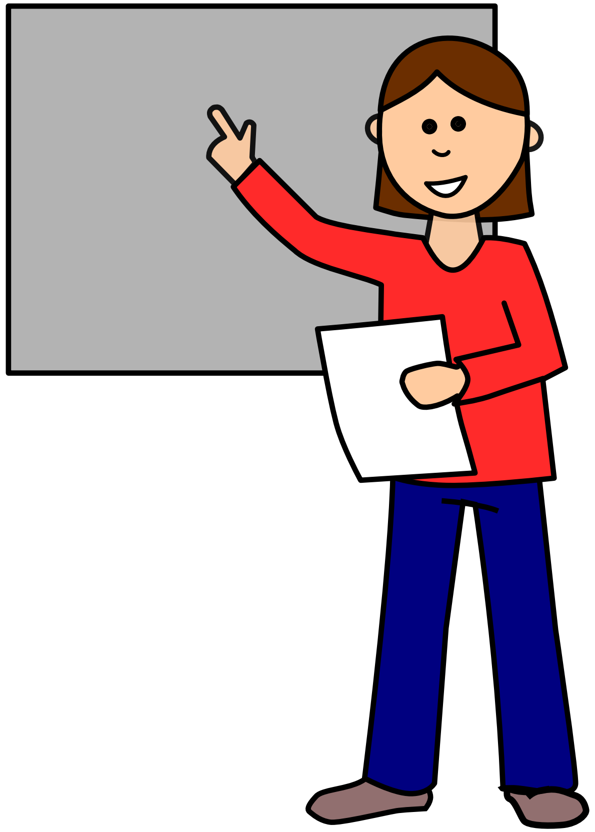
- ab Di, 14.05.2024: **Vorträge** (i.d.R. einer pro Woche)



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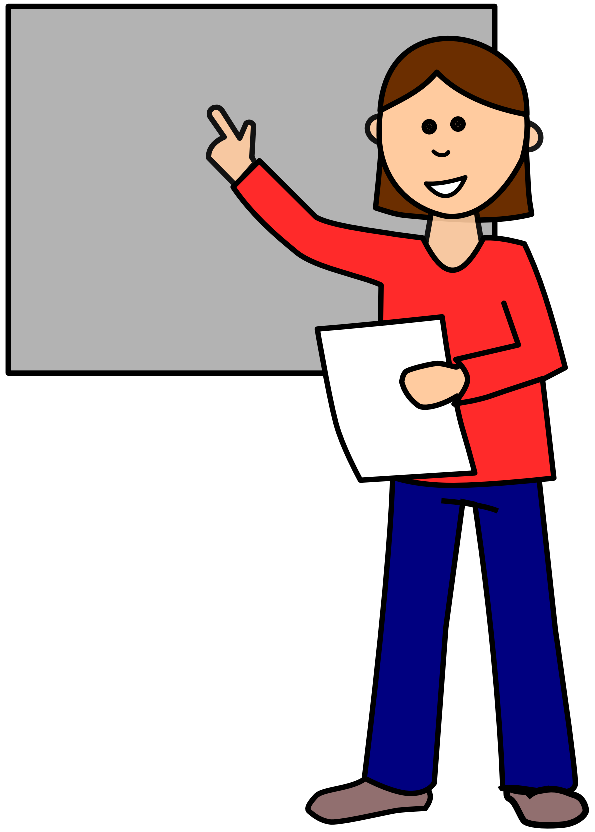
- Mo, 19.08.2024: **Ausarbeitungen** abgeben



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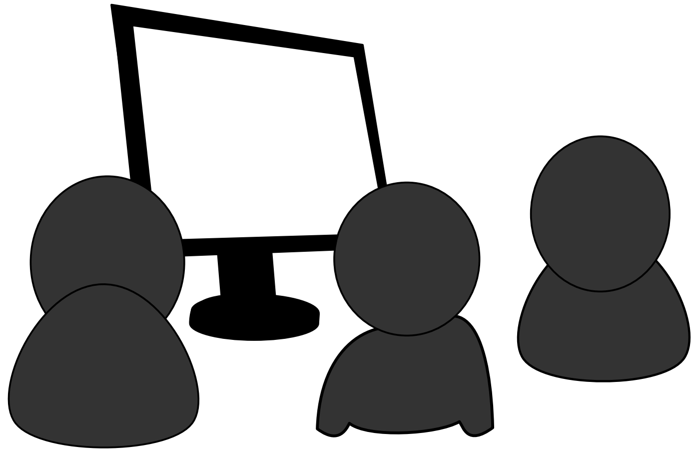
  (zu zweit etwa 60 Minuten)



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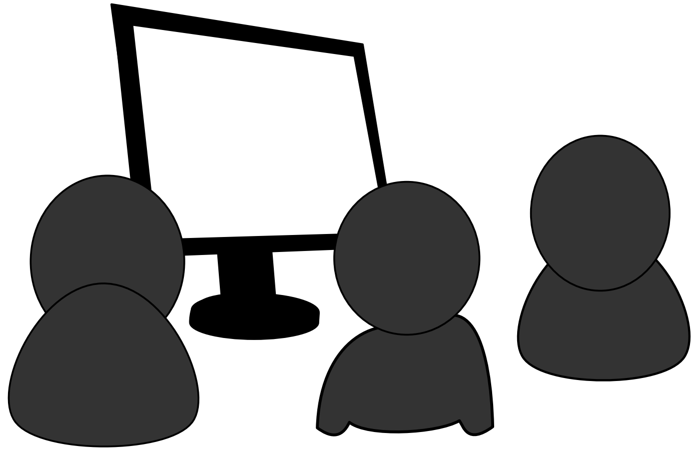

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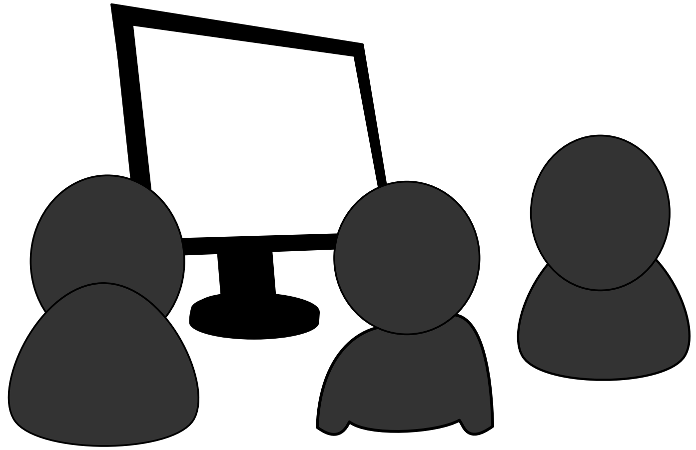

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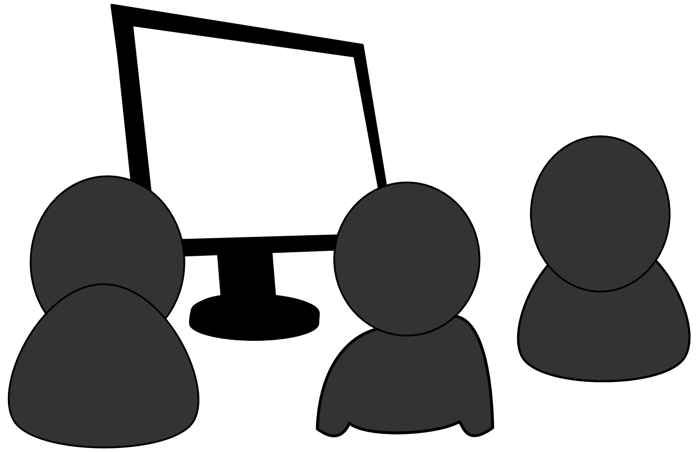

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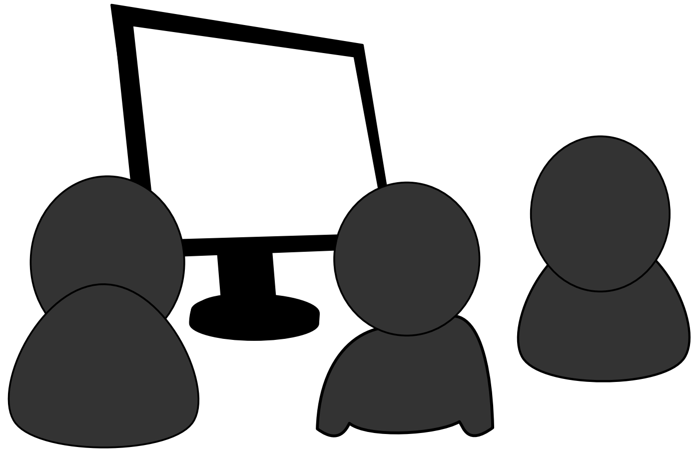

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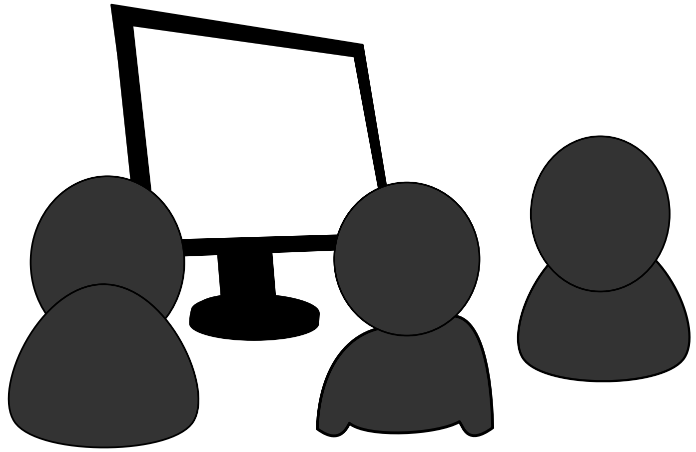

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  (Übungsaufgaben, interaktive Beispiele, Besprechung offener Probleme, etc.) (geht nicht in die Zeit ein)

  Ideen aus der Diskussion in die Ausarbeitung mitaufnehmen!

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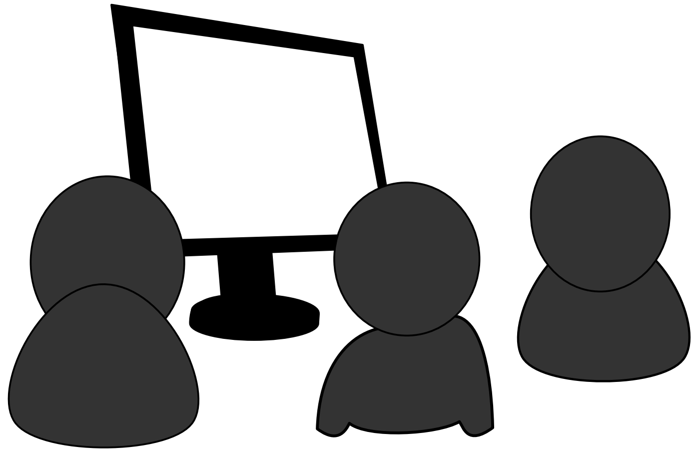

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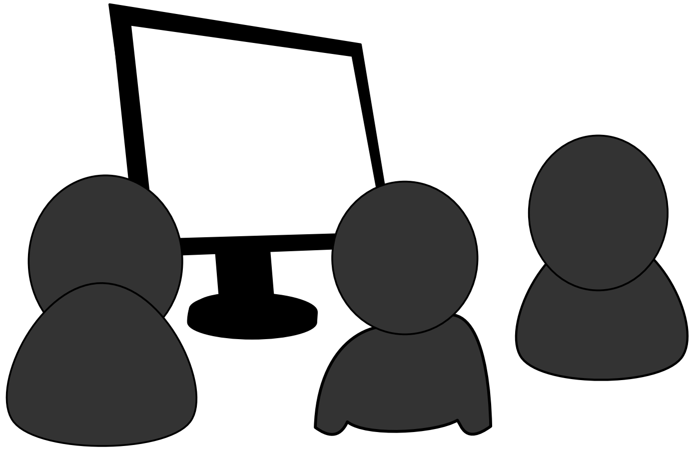

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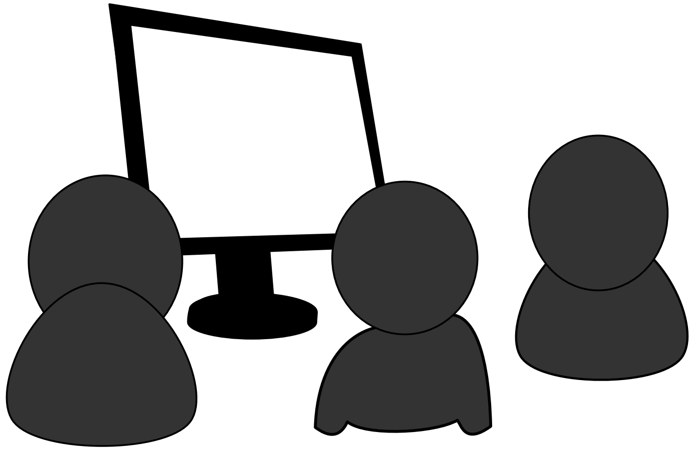

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Diese Termine sind **strikt** (außer für den 1. Vortrag)!

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- alleine 7–9, zu zweit 11–13 Seiten;

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- LaTeX-Vorlage
- **Vorabversion** der Ausarbeitung bis spätestens 2 Wochen nach dem eigenen Vortrag abgeben, um Feedback zu erhalten (freiwillig)

Bestehen & Bewertung

Voraussetzungen für das Bestehen des Seminars

- Halten einer Präsentation zum gewählten Thema
- Anfertigen einer Ausarbeitung
- Anwesenheit bei den anderen Vorträgen
- Einmaliges Fehlen ist erlaubt
- Teilnahme an den Diskussionen

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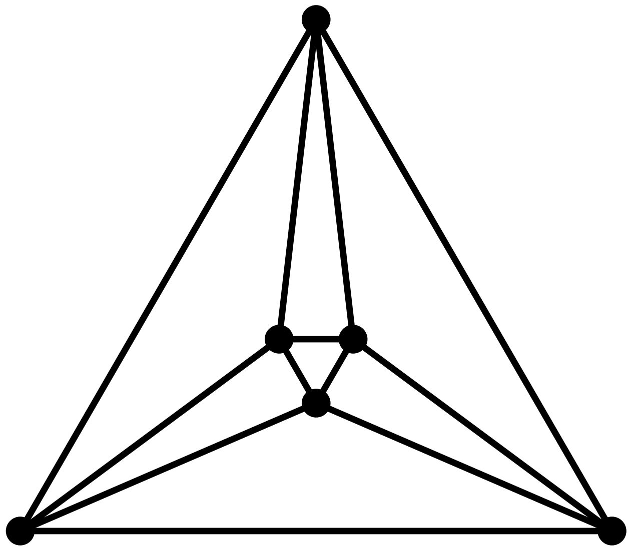
Bewertung

- Vortrag (Inhalte, Gestaltung der Folien, Verständlichkeit, Interaktivität)
- Ausarbeitung (Inhalte, roter Faden, sprachliche Darstellung, Rechtschreibung, eigener Beitrag)
- 50 : 50

Themenübersicht

1. Global and local edge-length ratios of planar straight line graph drawings
2. Recognition Complexity of Subgraphs of 2- and 3-Connected Planar Cubic Graphs
3. Min-k-planar Drawings of Graphs
4. On RAC Drawings of Graphs with Two Bends per Edge
5. Edge-disjoint Plane Spanning Paths in a Point Set
6. Parameterized Complexity of Simultaneous Planarity
7. Removing Popular Faces in Curve Arrangements
8. Computing the Enclosing Depth
9. Robust Bichromatic Classification with Lines
10. Clustering with Few Disks to Minimize the Sum of Radii
11. Maximum Leaf Spanning Tree Approximations
12. NP-hard Puzzle Games: Tetris, Nondango
13. On the Complexity of Lombardi Graph Drawing
14. Efficient Exact Algorithms on Planar Graphs: Exploiting Sphere Cut Decompositions
15. Solving 2-SAT in Linear Time

1. Global and local edge-length ratios



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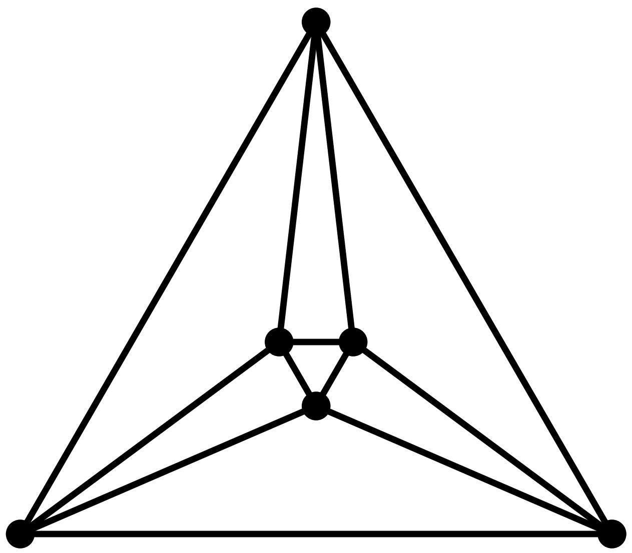

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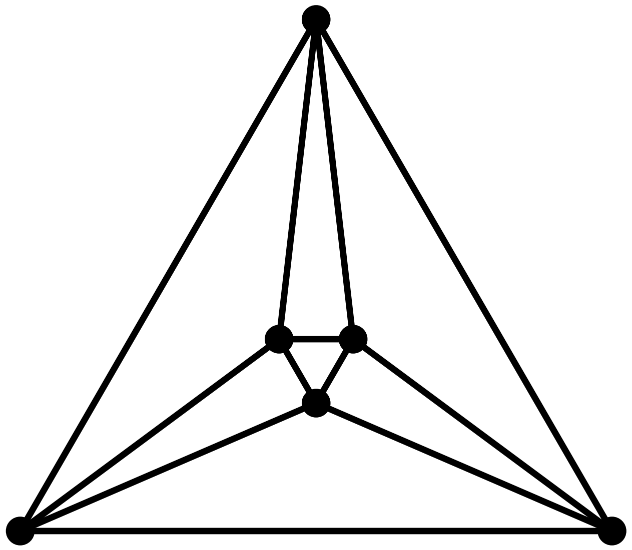

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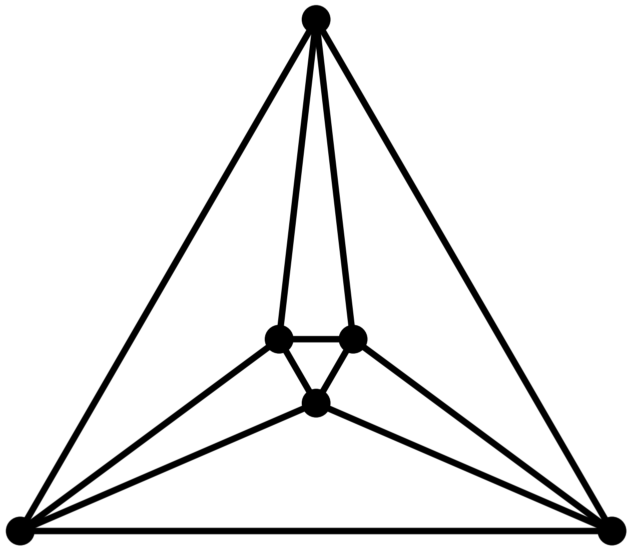

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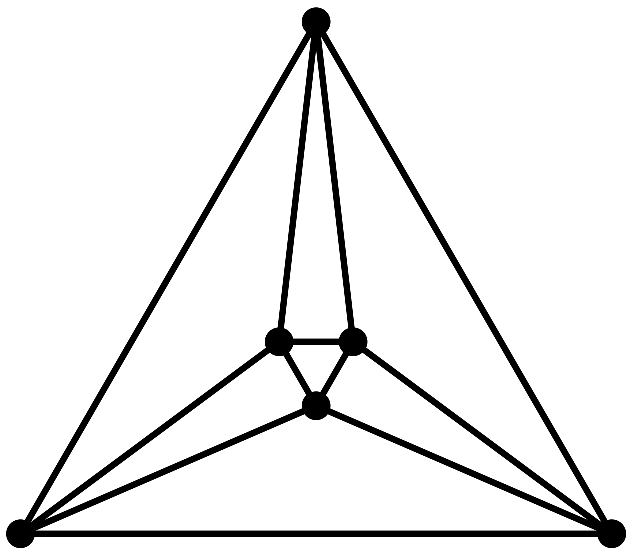

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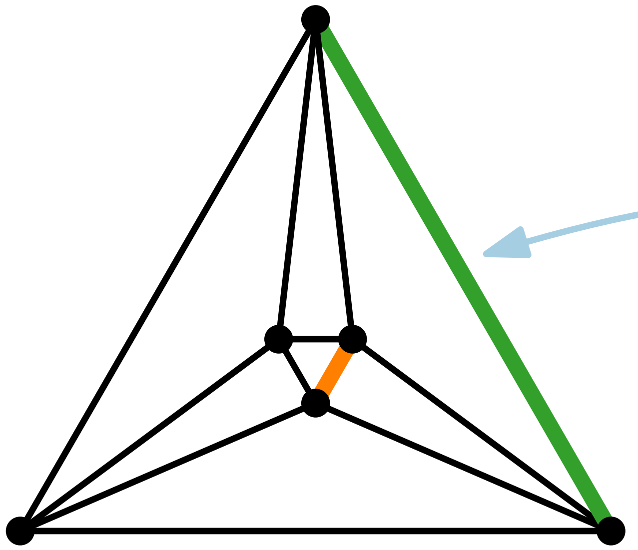

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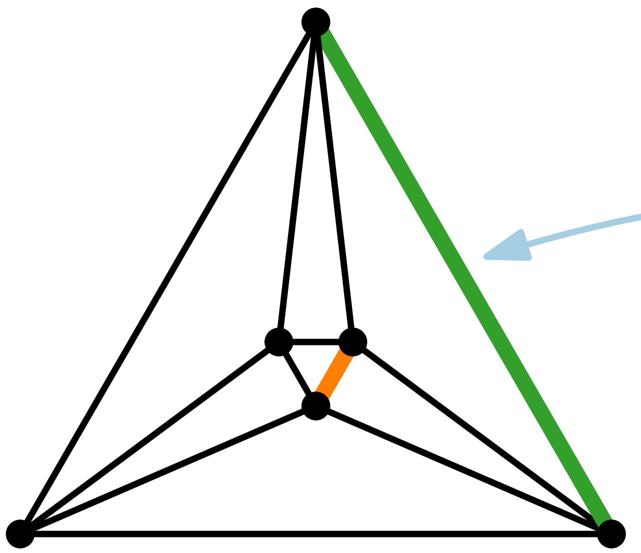

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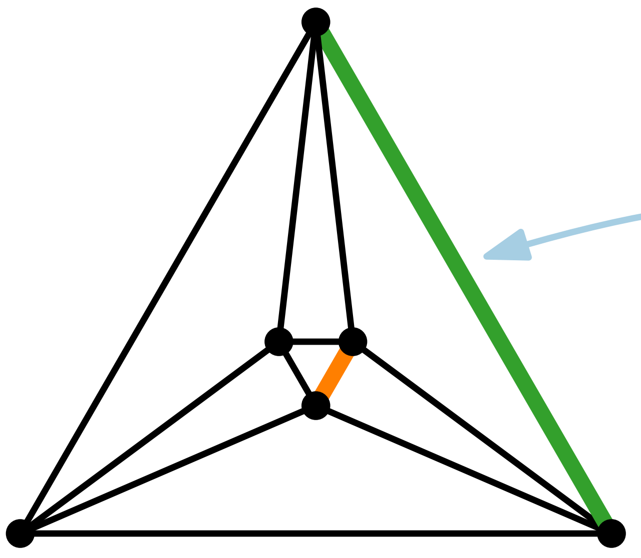

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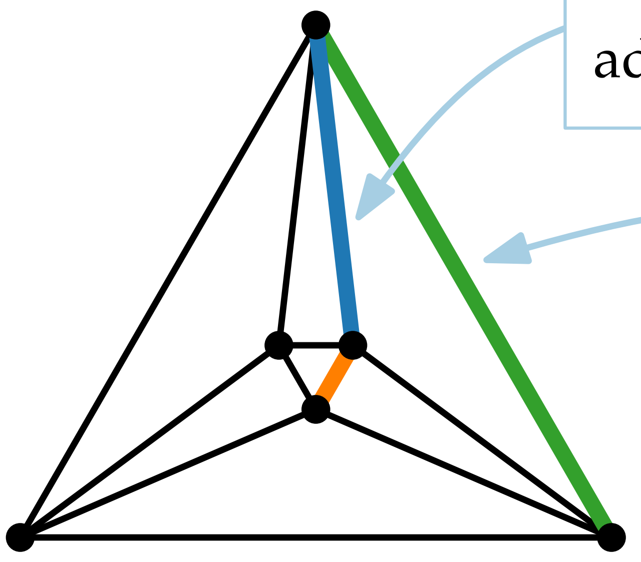

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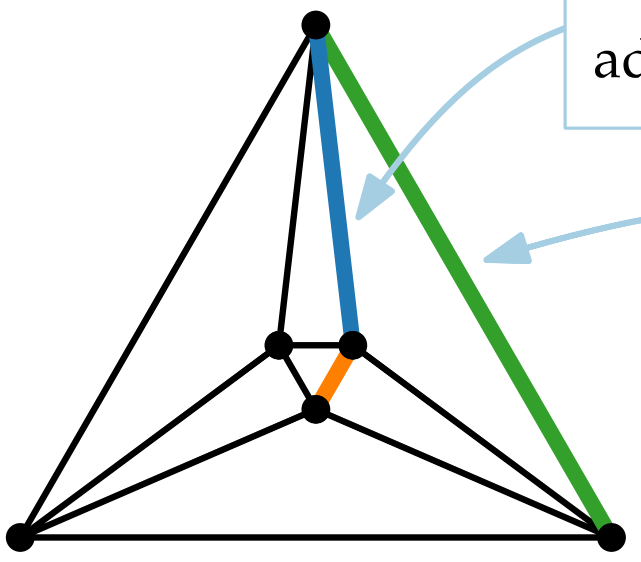

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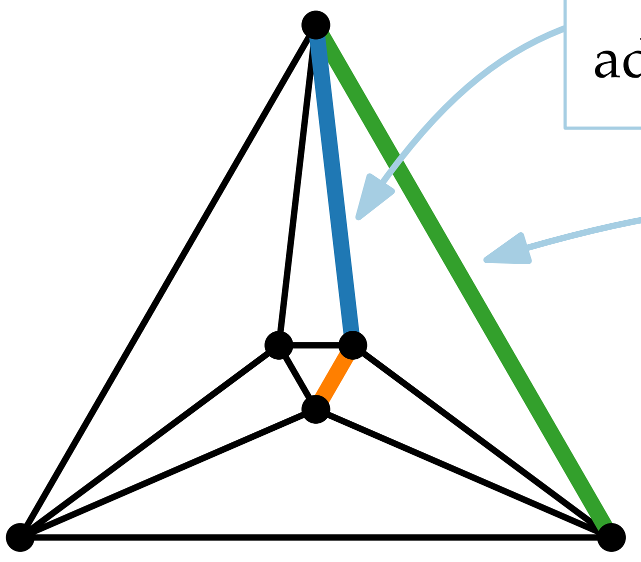

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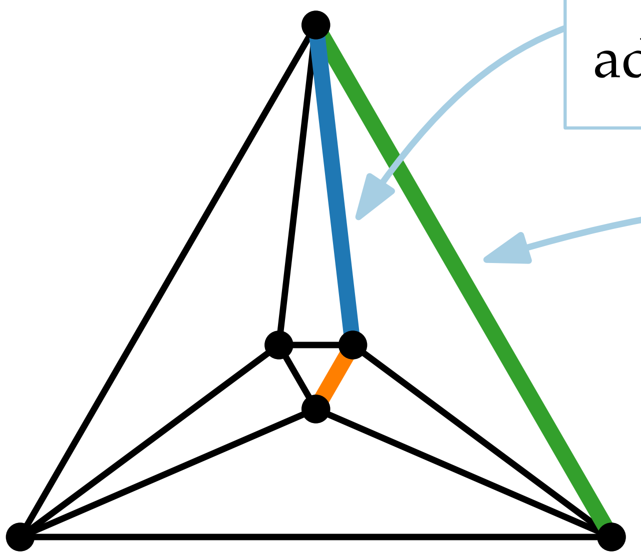

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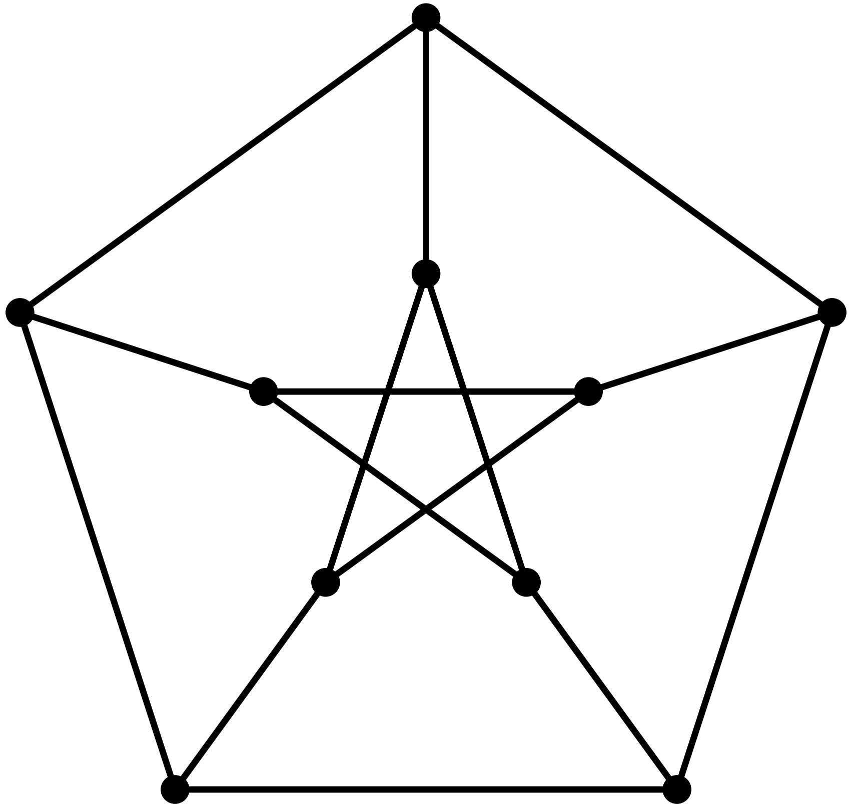

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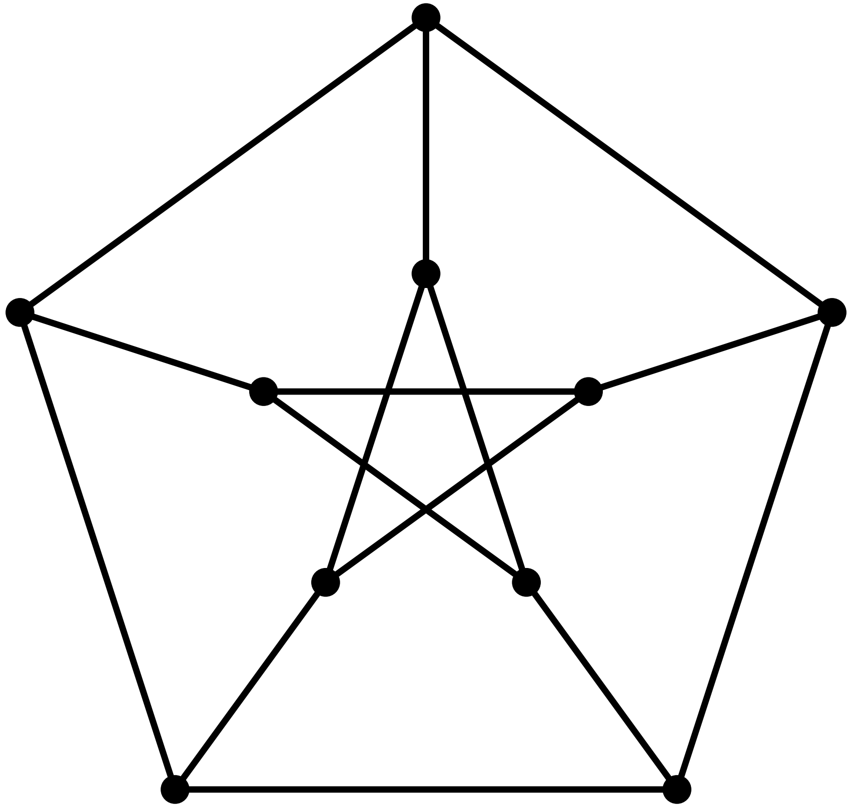

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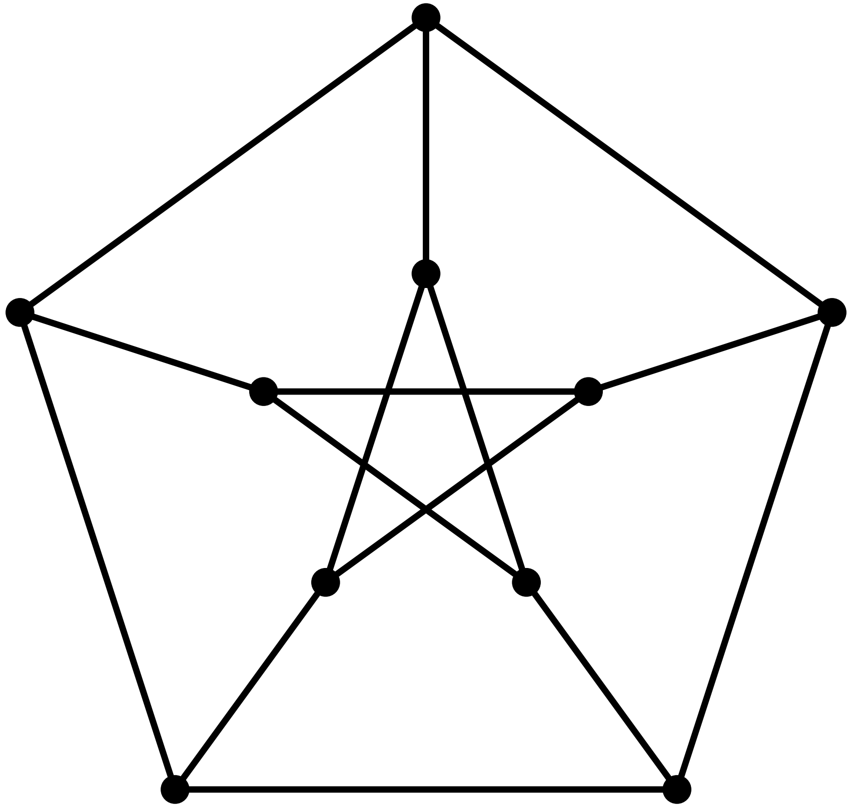

✓

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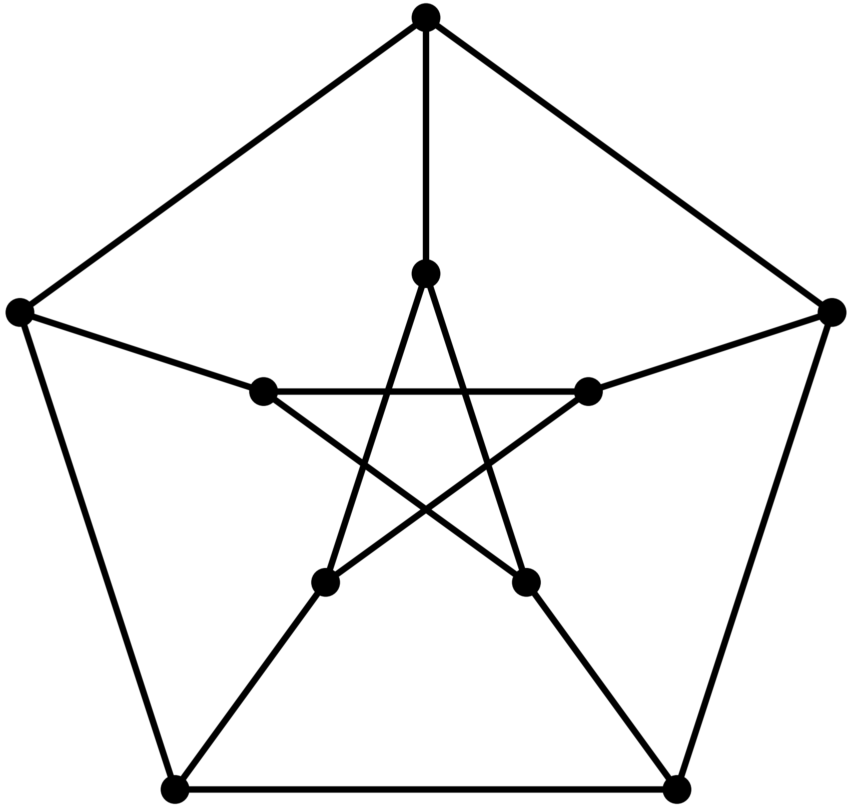

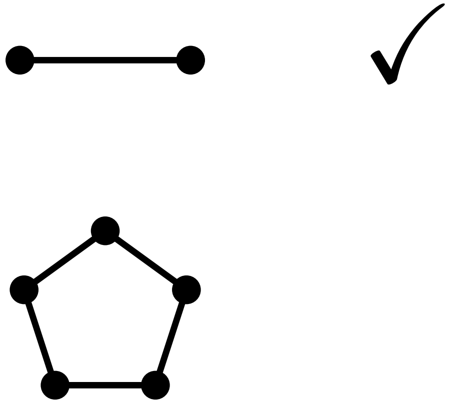

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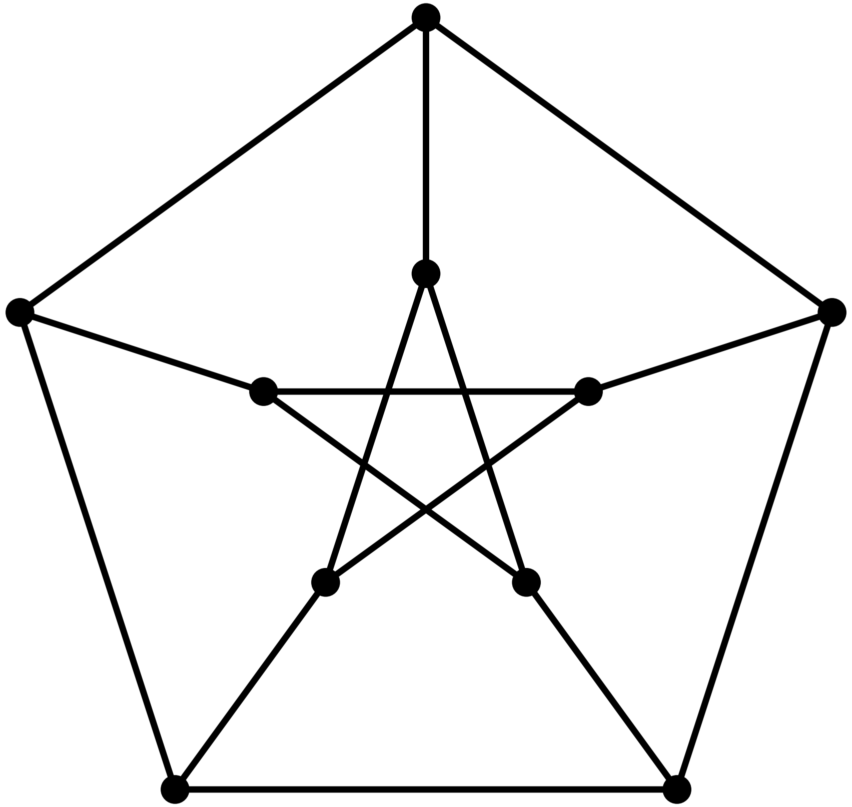

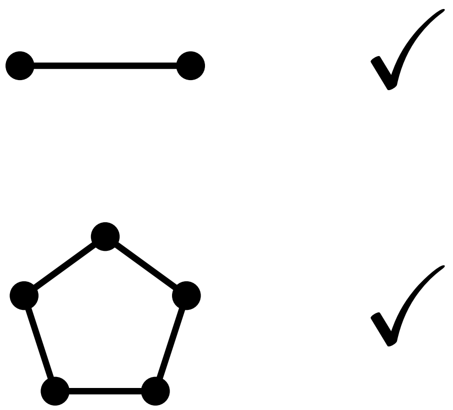

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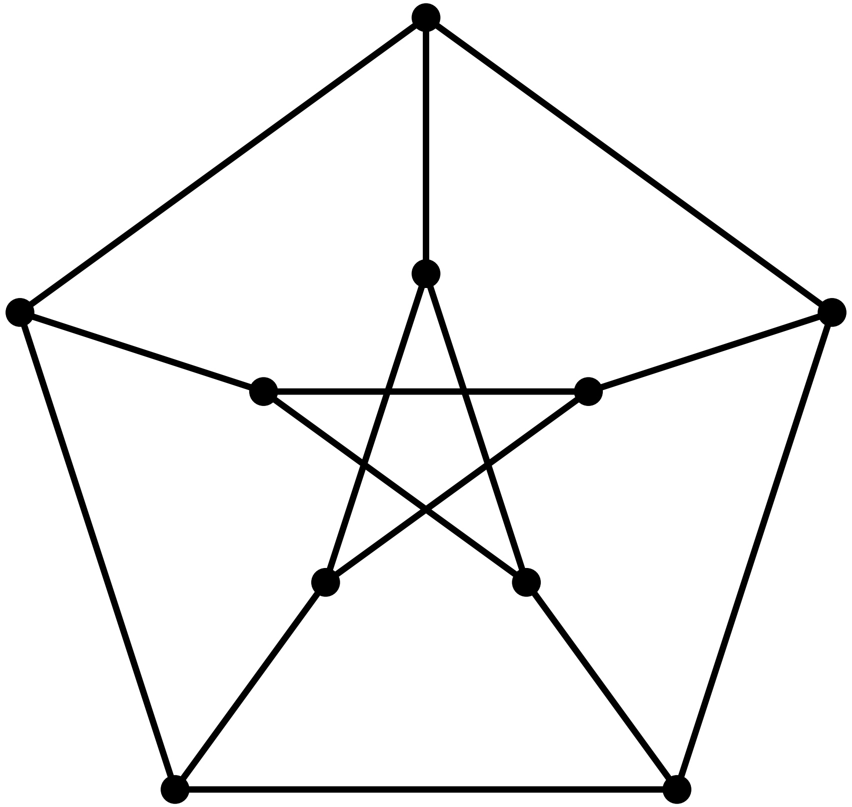
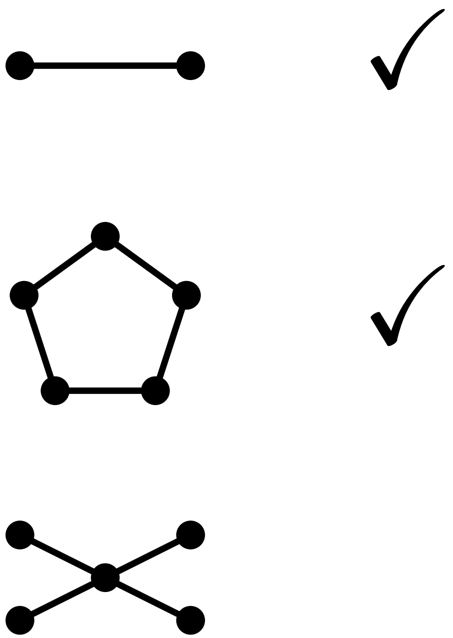
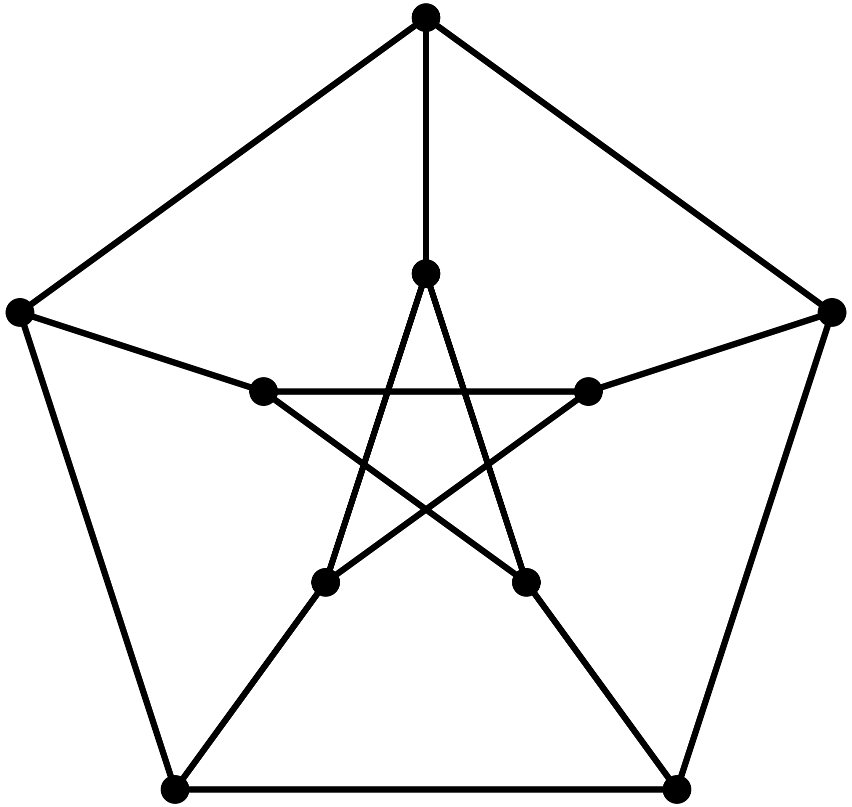
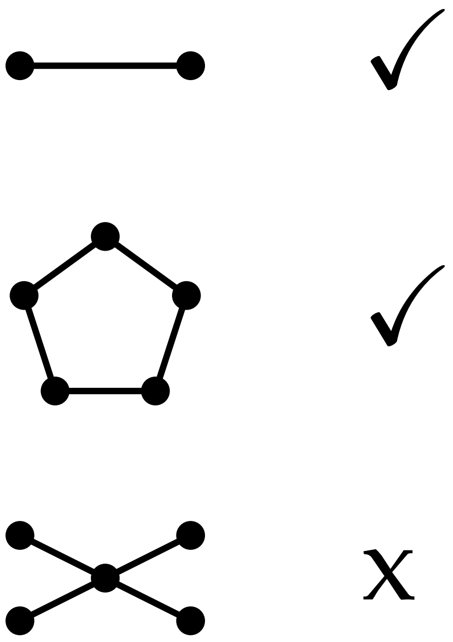


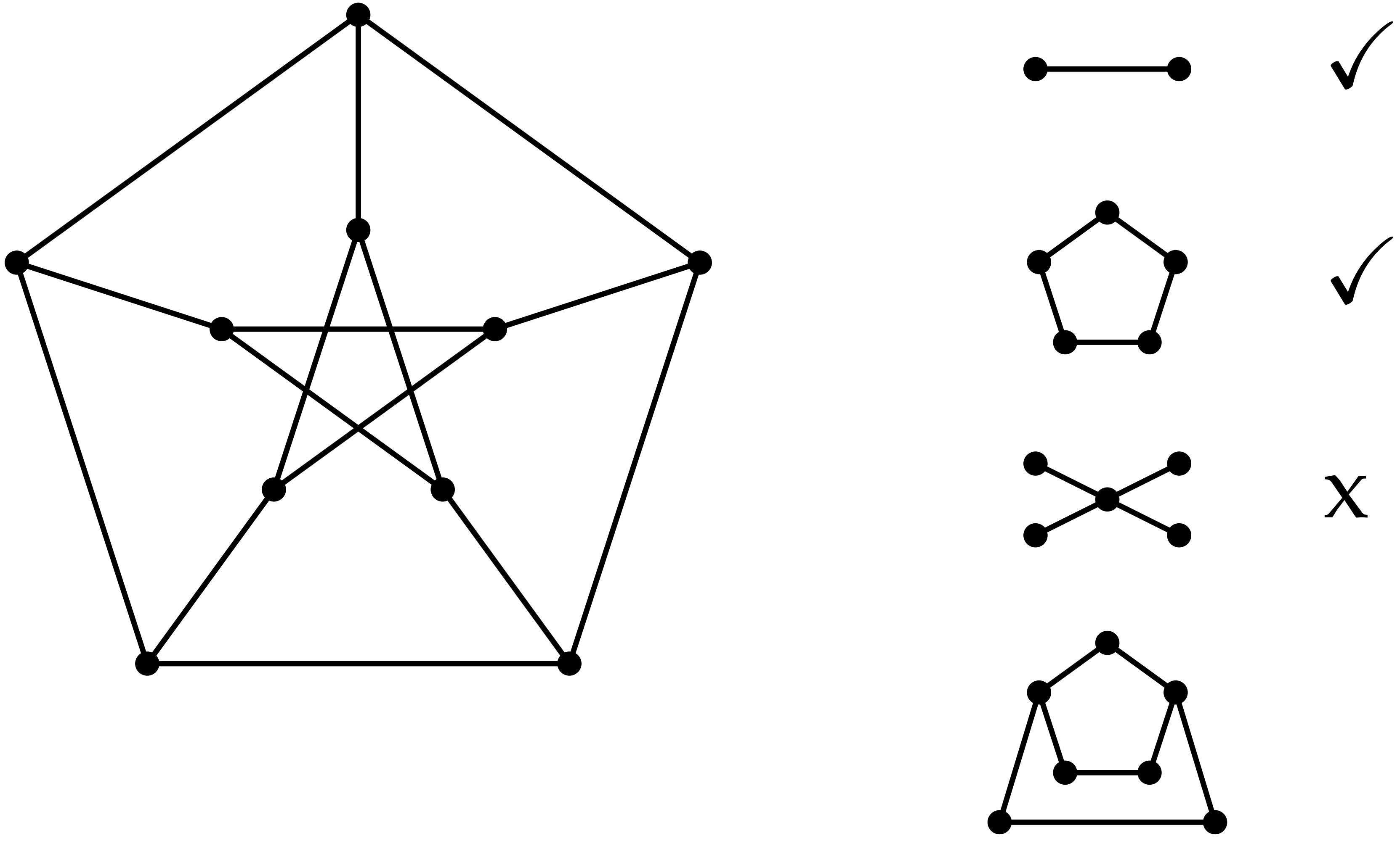


2. Subgraphs of 2- and 3-Connected Planar Cubic Graphs

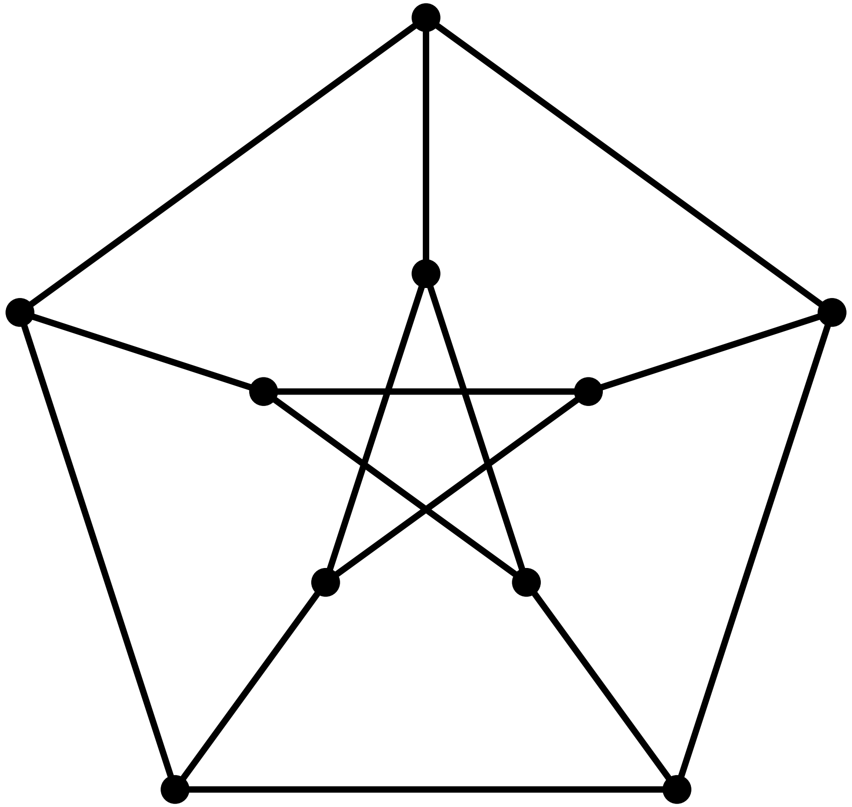


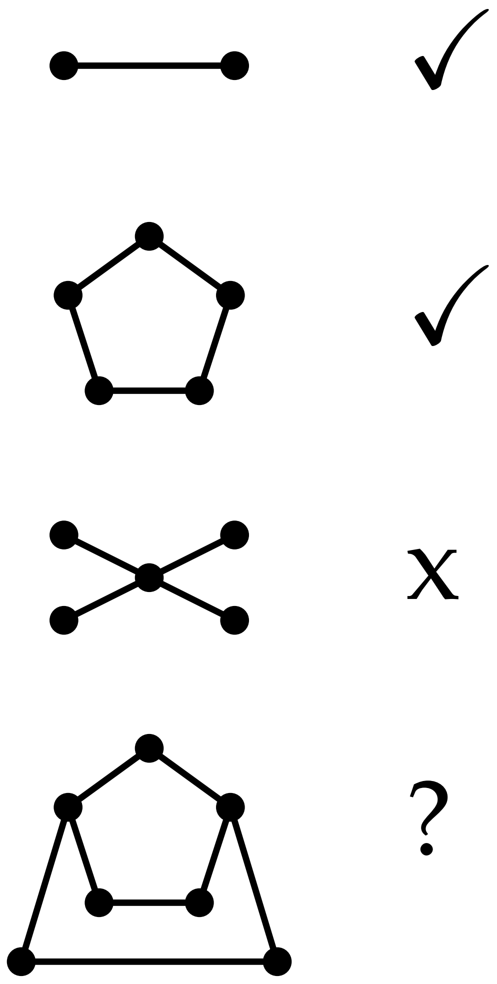


2. Subgraphs of 2- and 3-Connected Planar Cubic Graphs

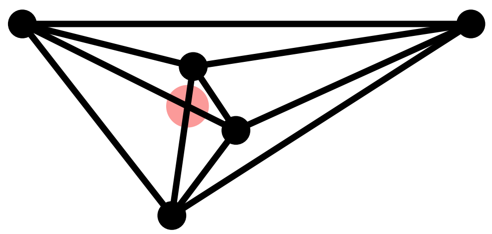


2. Subgraphs of 2- and 3-Connected Planar Cubic Graphs



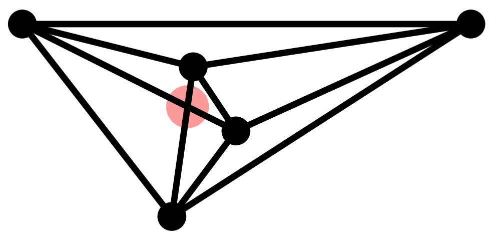


3. Min-k-planar Drawings of Graphs

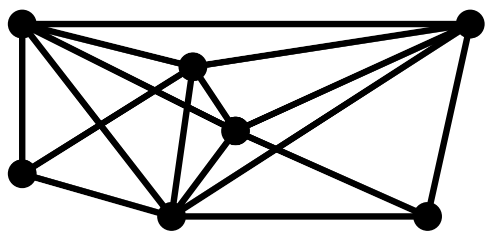


1-planar

3. Min-k-planar Drawings of Graphs

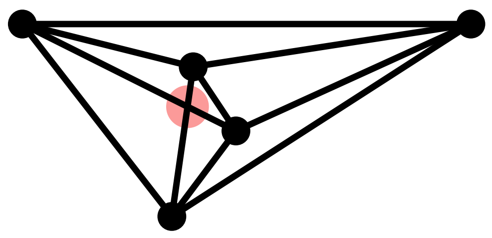


1-planar

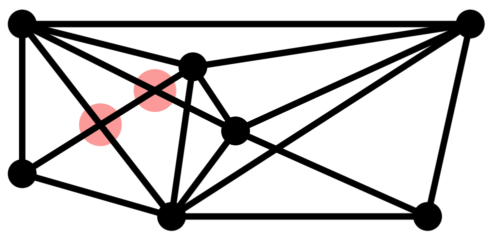


2-planar

3. Min-k-planar Drawings of Graphs

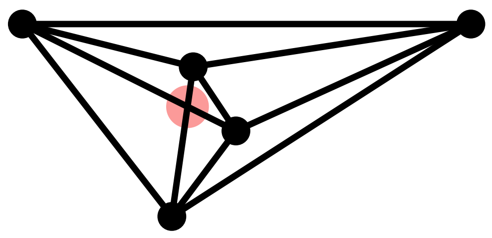


1-planar

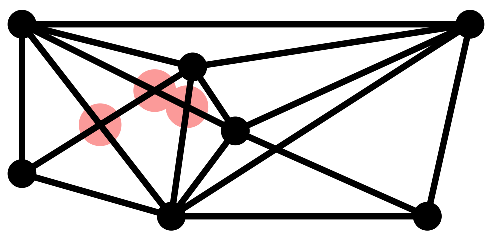


2-planar

3. Min-k-planar Drawings of Graphs

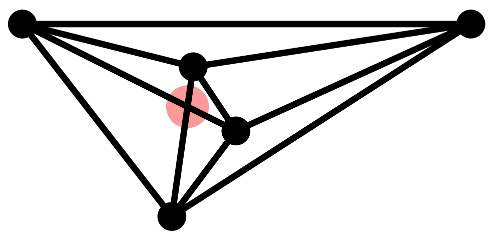


1-planar



2-planar

3. Min-k-planar Drawings of Graphs



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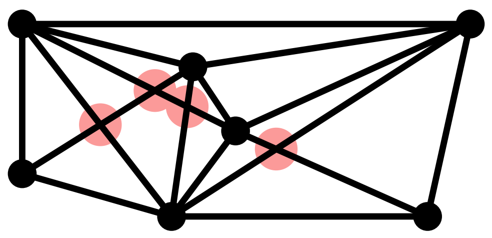
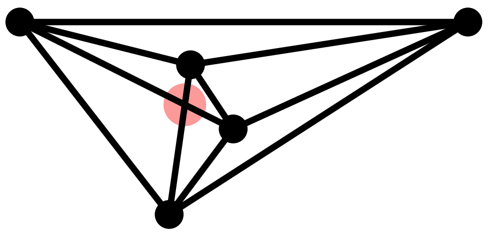
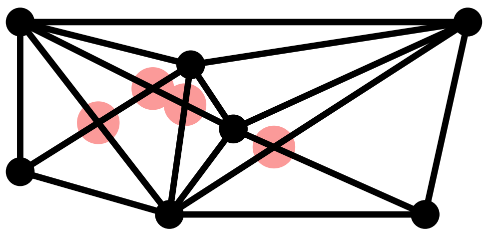


2-planar

3. Min-k-planar Drawings of Graphs



1-planar

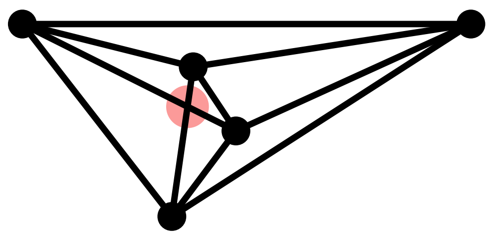


2-planar

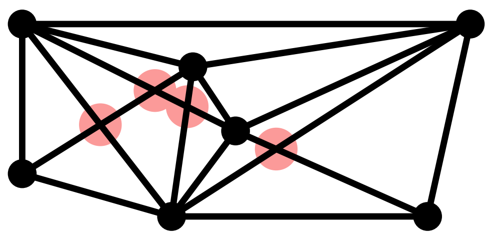
…

k-planar

3. Min-k-planar Drawings of Graphs



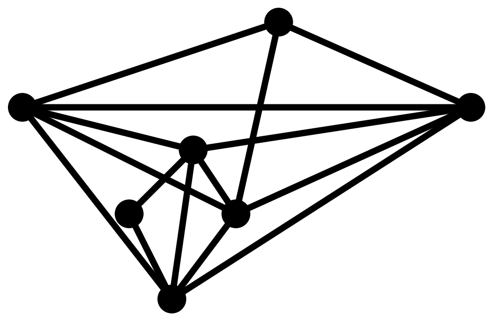
1-planar



2-planar

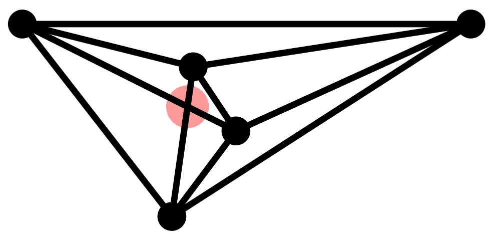
…

k-planar

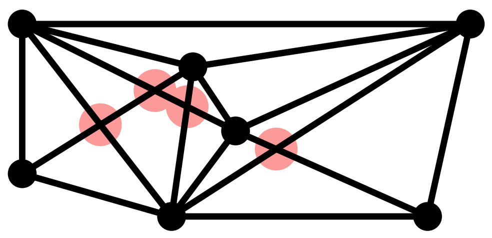


min-1-planar

3. Min-k-planar Drawings of Graphs



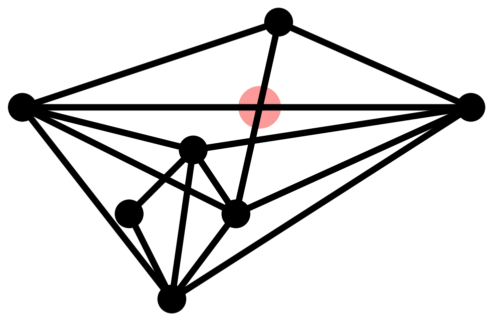
1-planar



2-planar

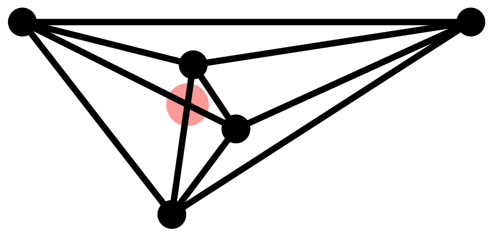
…

k-planar

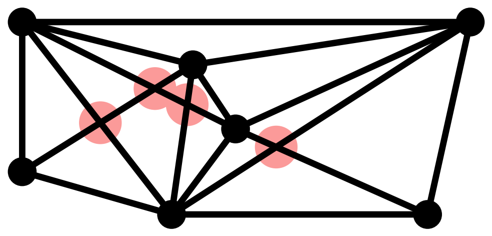


min-1-planar

3. Min-k-planar Drawings of Graphs



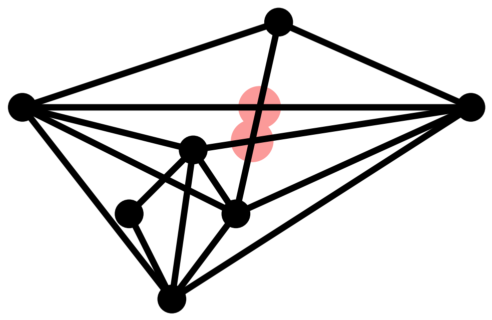
1-planar



2-planar

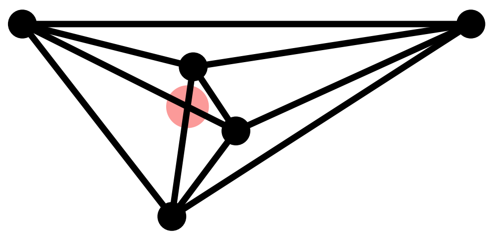
…

k-planar

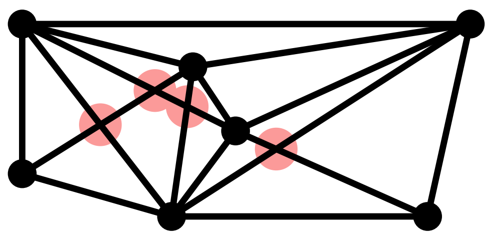


min-1-planar

3. Min-k-planar Drawings of Graphs



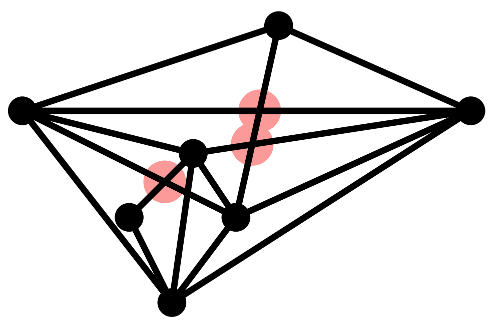
1-planar



2-planar

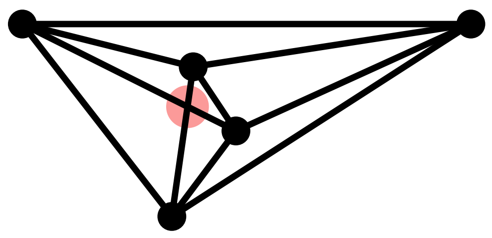
...

k-planar

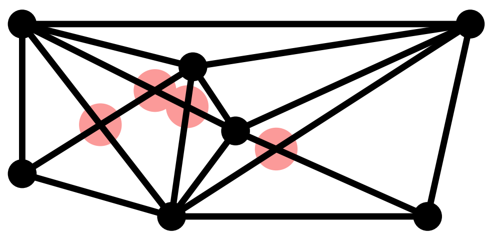


min-1-planar

3. Min-k-planar Drawings of Graphs



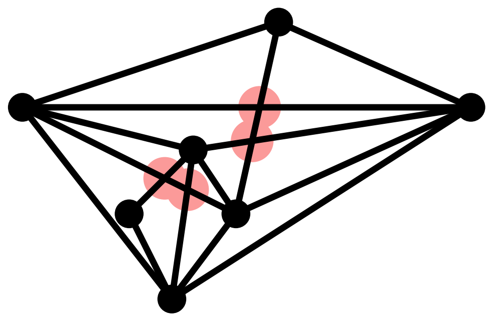
1-planar



2-planar

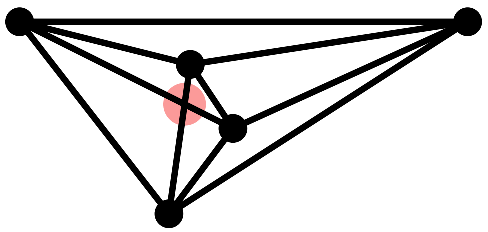
…

k-planar

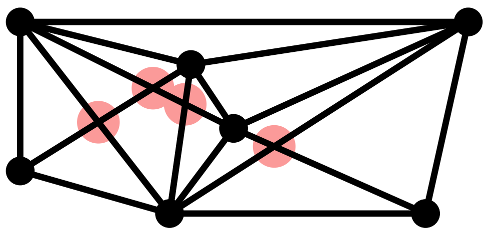


min-1-planar

3. Min-k-planar Drawings of Graphs



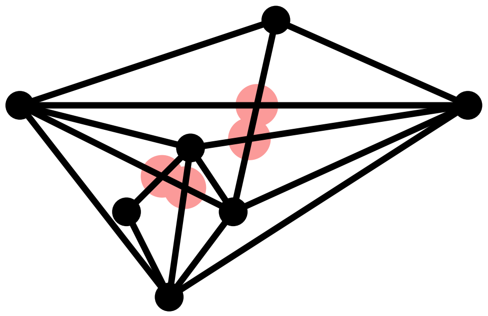
1-planar



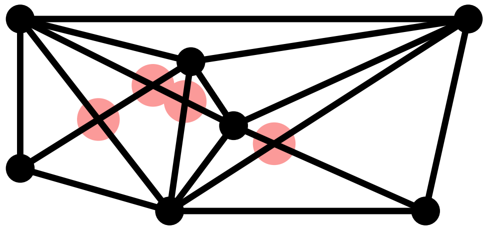
2-planar

…

k-planar

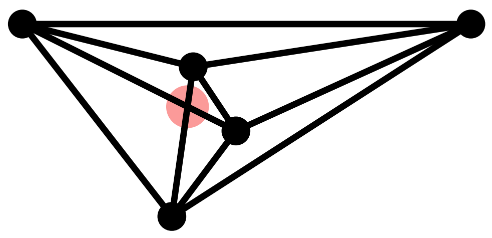


min-1-planar

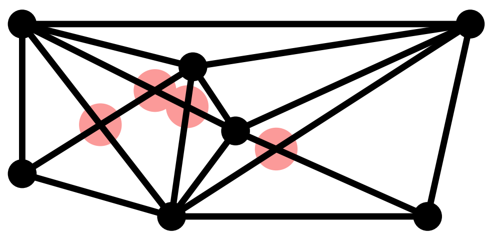


min-2-planar

3. Min-k-planar Drawings of Graphs



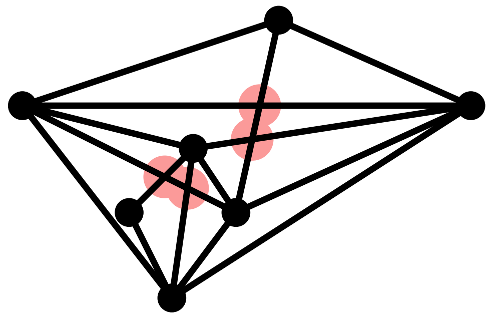
1-planar



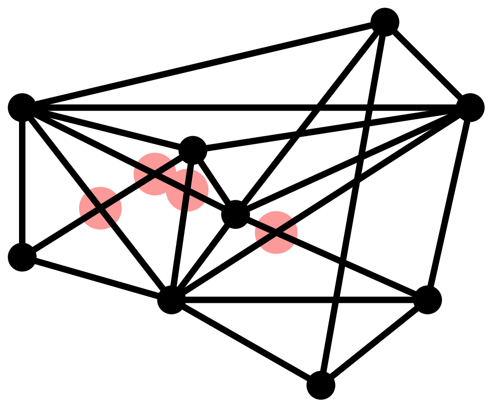
2-planar

…

k-planar

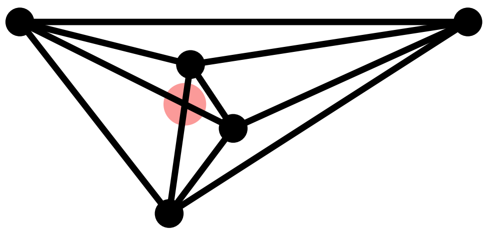


min-1-planar

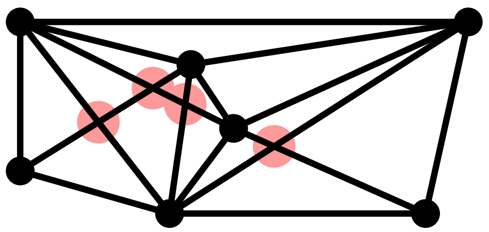


min-2-planar

3. Min-k-planar Drawings of Graphs



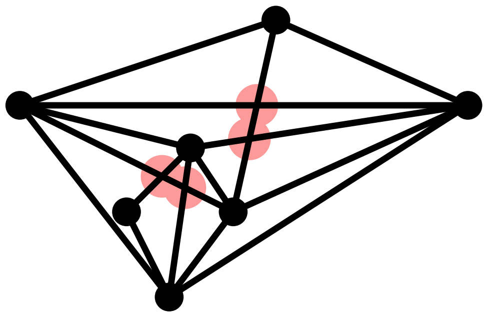
1-planar



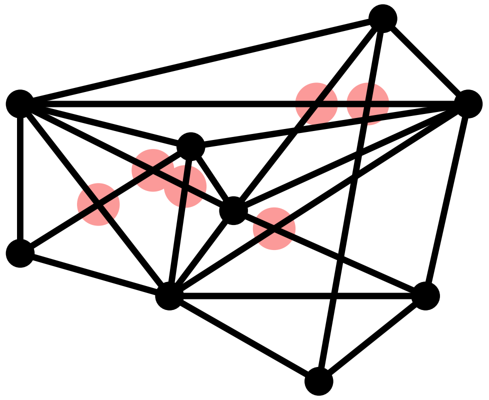
2-planar

…

k-planar

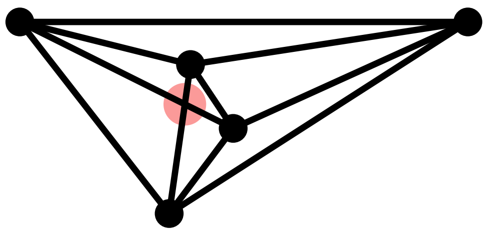


min-1-planar

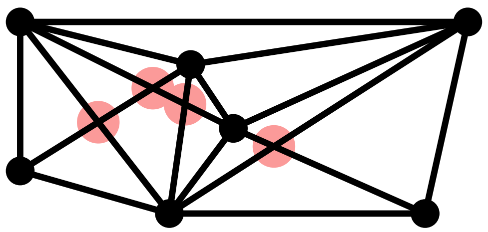


min-2-planar

3. Min-k-planar Drawings of Graphs



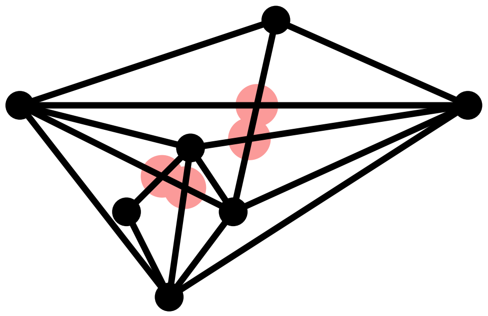
1-planar



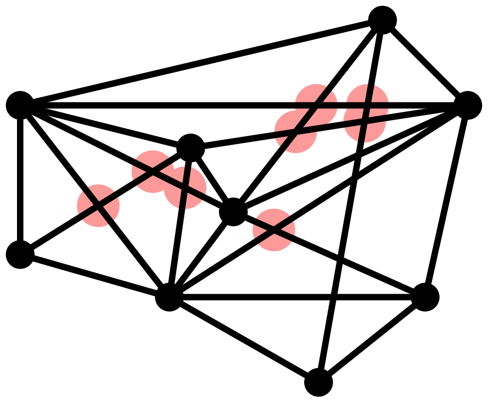
2-planar

…

k-planar

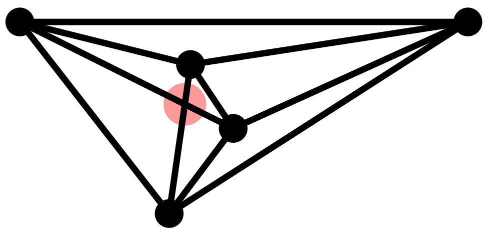


min-1-planar

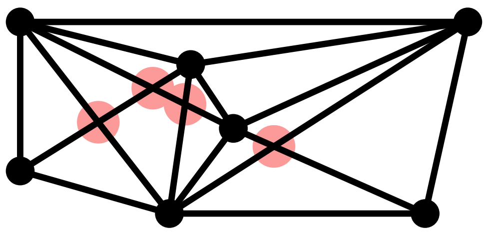


min-2-planar

3. Min-k-planar Drawings of Graphs



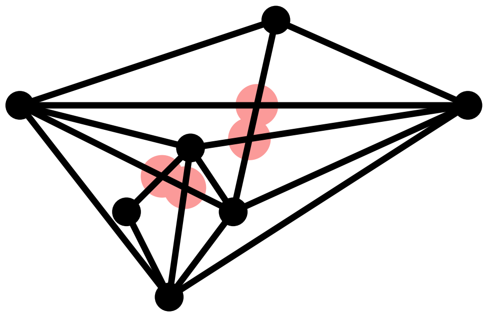
1-planar



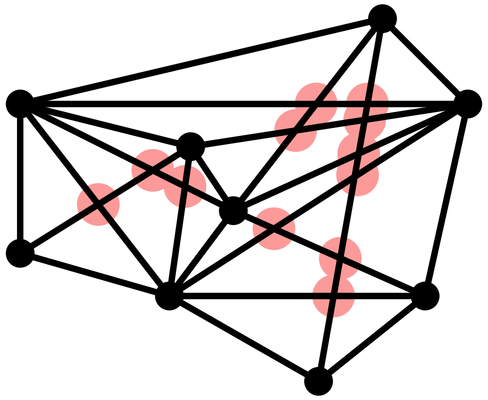
2-planar

…

k-planar

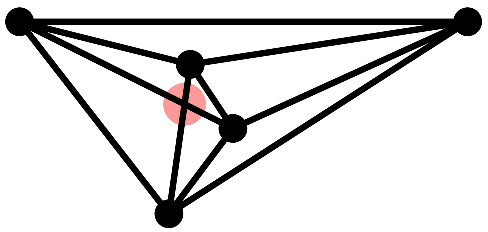


min-1-planar

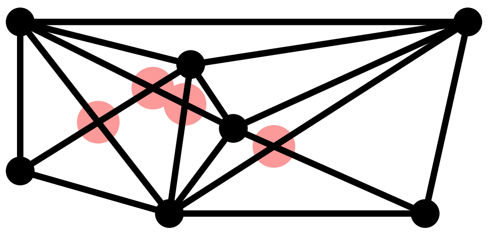


min-2-planar

3. Min-k-planar Drawings of Graphs



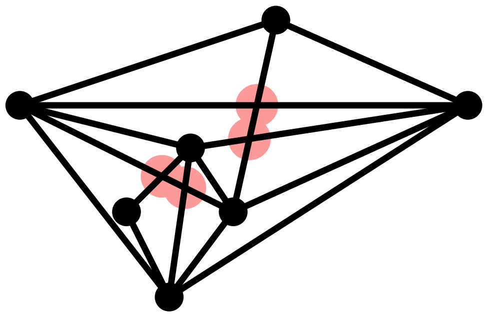
1-planar



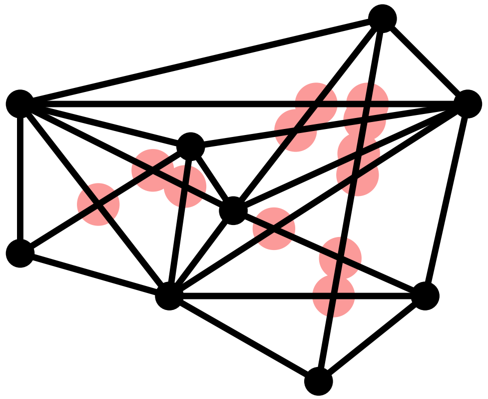
2-planar

…

k-planar



min-1-planar

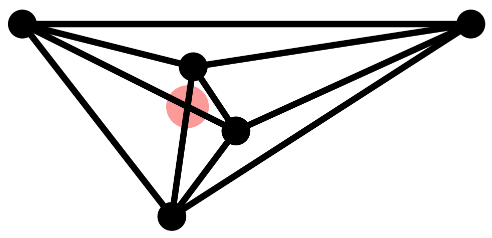


min-2-planar

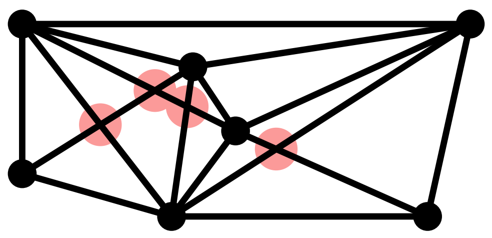
…

min-*k*-planar

3. Min-k-planar Drawings of Graphs



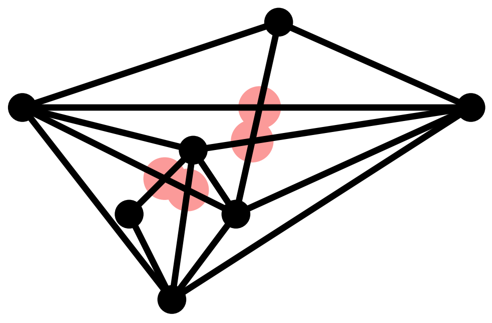
1-planar



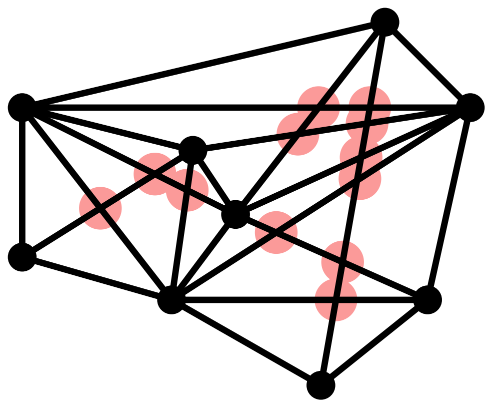
2-planar

…

k-planar



min-1-planar



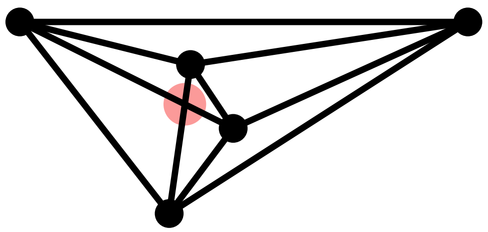
min-2-planar

…

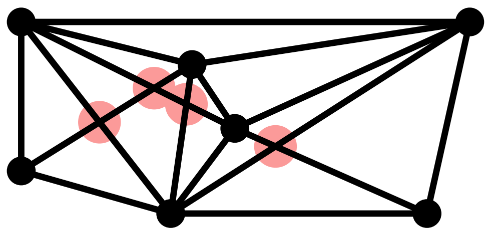
min-k-planar

Welche Beziehung besteht zwischen k-planaren und min-k-planaren Graphen?

3. Min-k-planar Drawings of Graphs



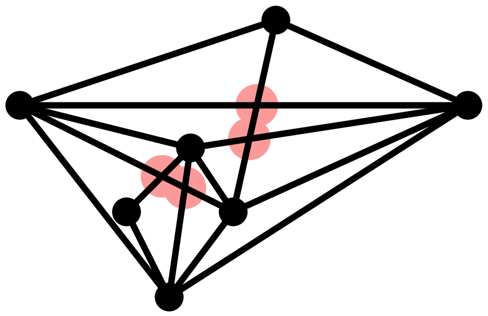
1-planar



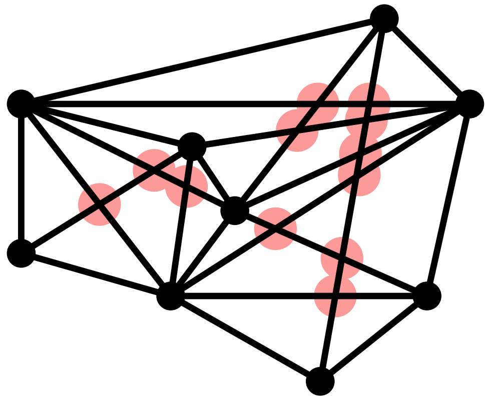
2-planar

…

k-planar



min-1-planar



min-2-planar

…

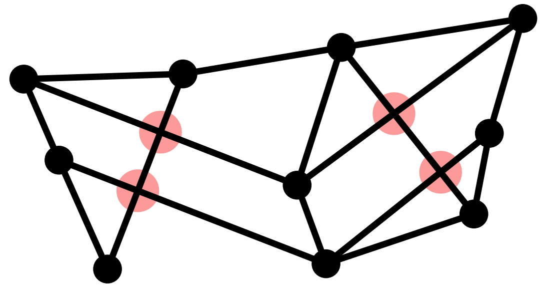
min-k-planar

Welche Beziehung besteht zwischen k-planaren und min-k-planaren Graphen?

Was ist die maximale Kantendichte eines min-k-planaren Graphen?

4. RAC Drawings of Graphs with Two Bends per Edge

RAC- (right-angle-crossing) Zeichnung:
Kreuzungen sind erlaubt, müssen aber jeweils an vier rechte Winkel grenzen.



4. RAC Drawings of Graphs with Two Bends per Edge

RAC- (right-angle-crossing) Zeichnung:
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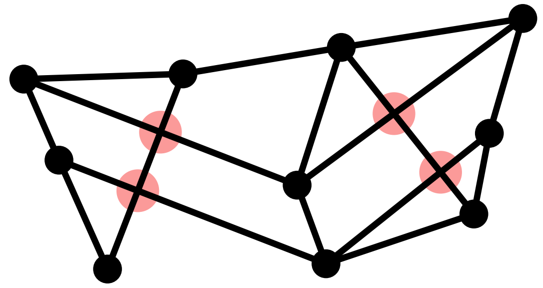
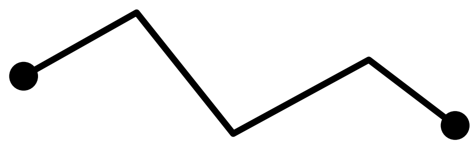


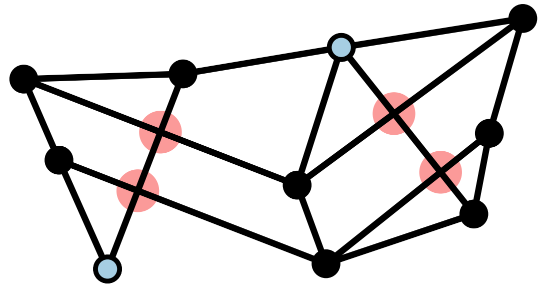
***k*-Knick-Zeichnung:**
Jede Kante darf $\leq k$ **Knicke** aufweisen.



4. RAC Drawings of Graphs with Two Bends per Edge

RAC- (right-angle-crossing) Zeichnung:

Kreuzungen sind erlaubt, müssen aber jeweils an vier rechte Winkel grenzen.



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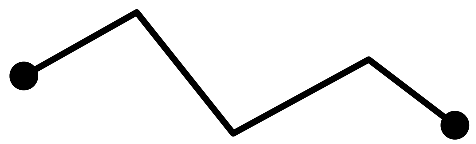

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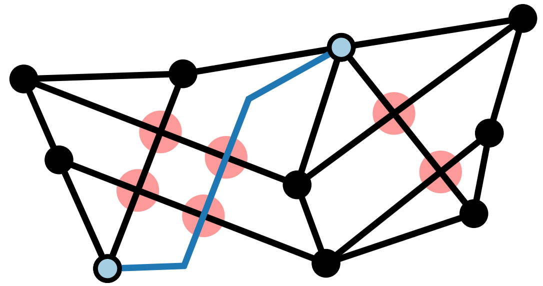

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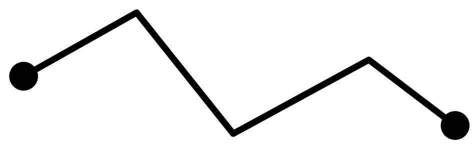

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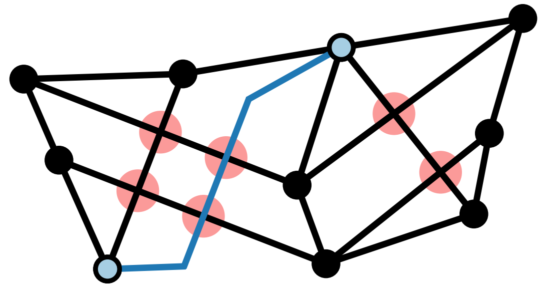

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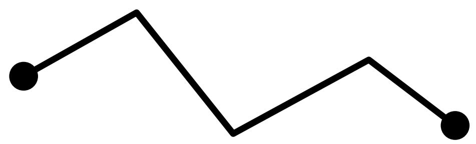

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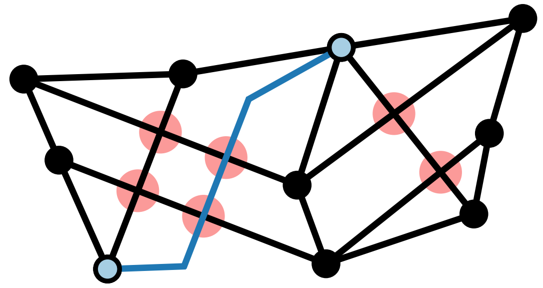

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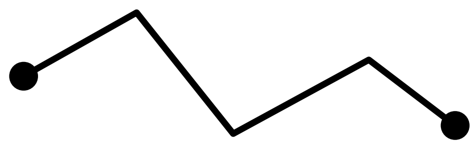

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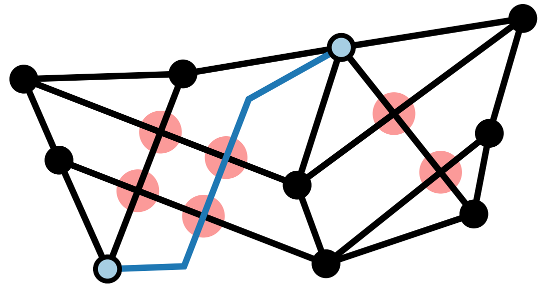

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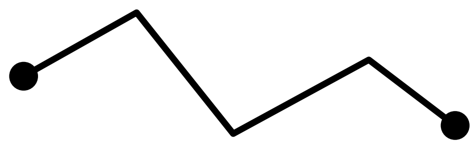

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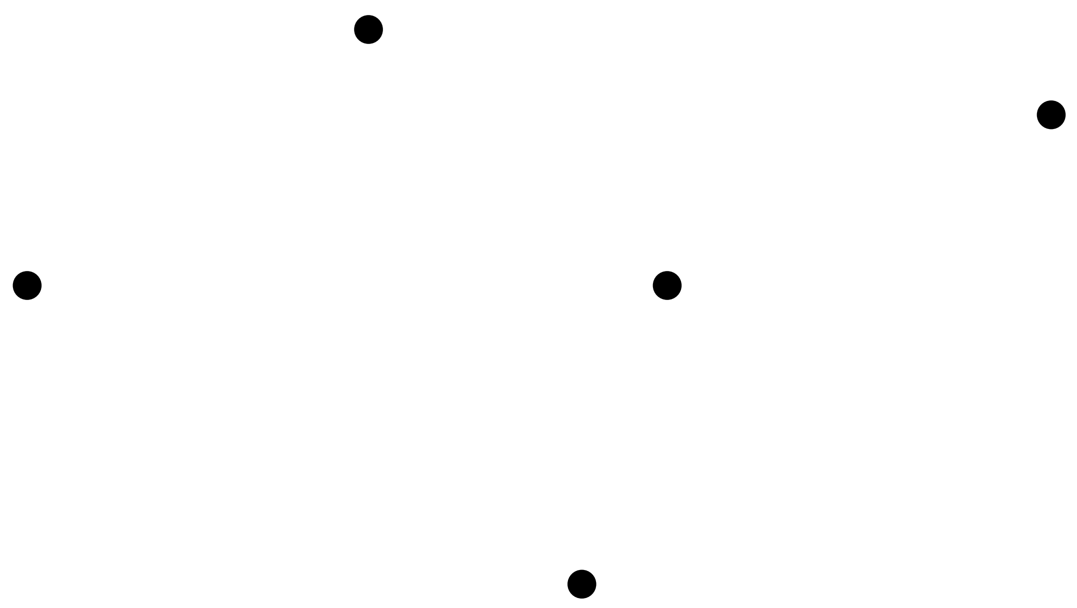
Hier:

Untersuchung von 2-Knick-Zeichnungen.

5. Edge-disjoint Plane Spanning Paths in a Point Set

How many edge-disjoint plane spanning paths can we pack in a given complete geometric (straight-line) graph?



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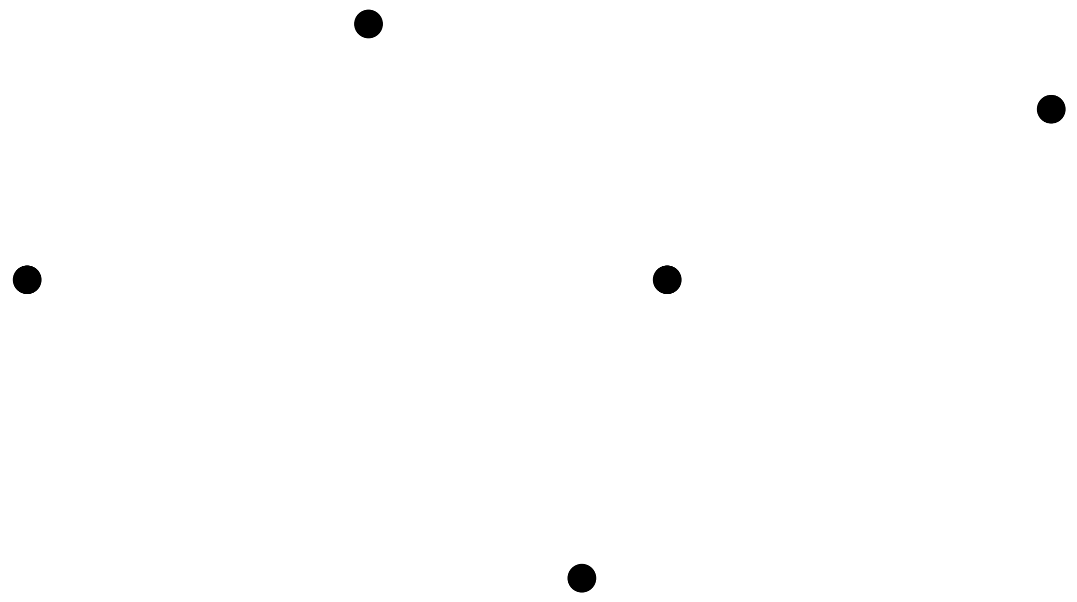

no three points on a line
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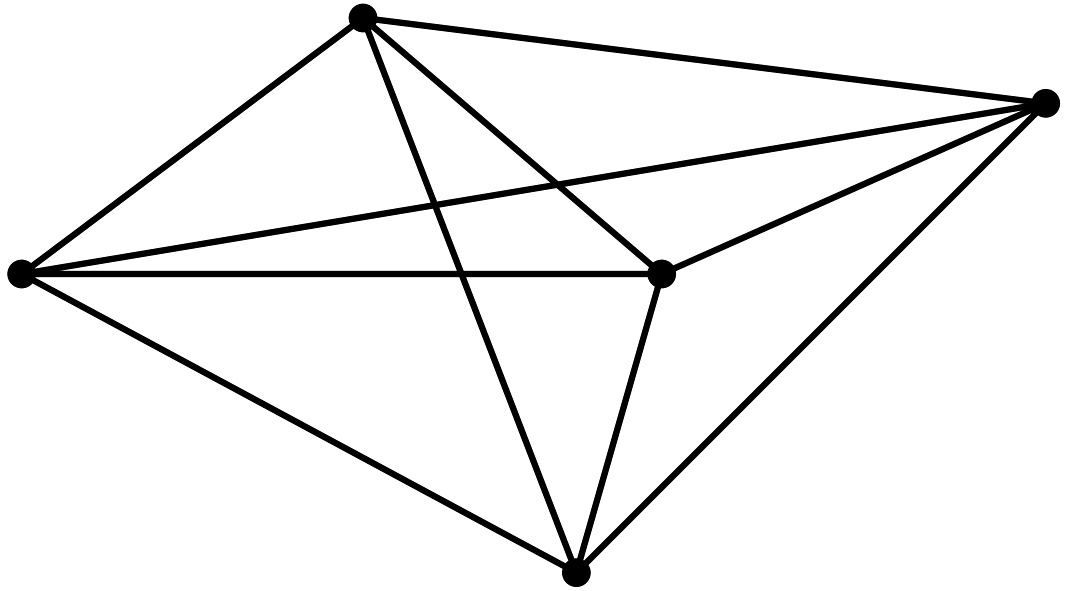

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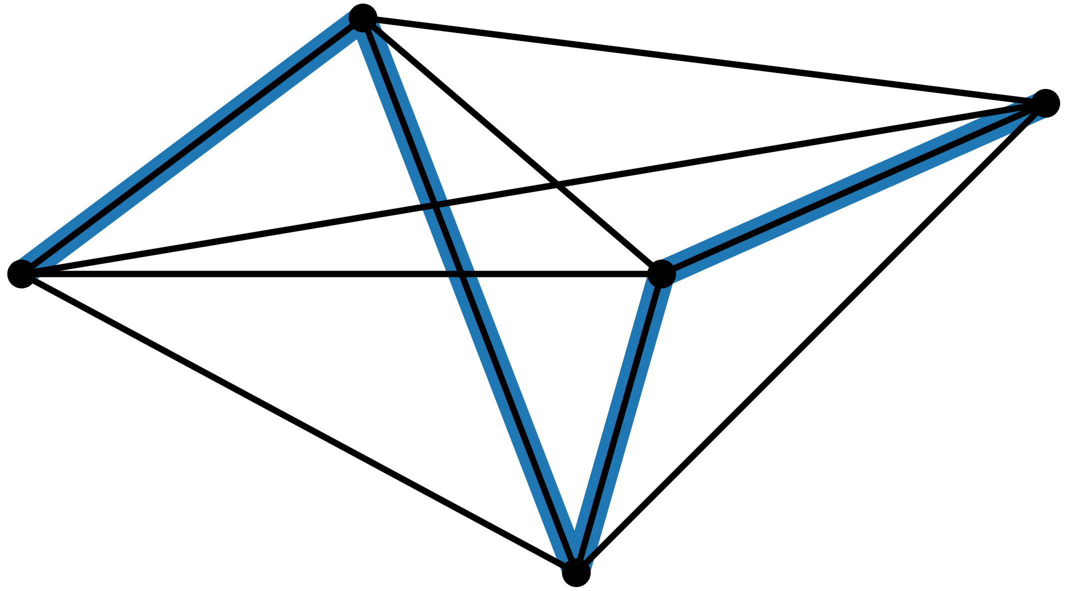

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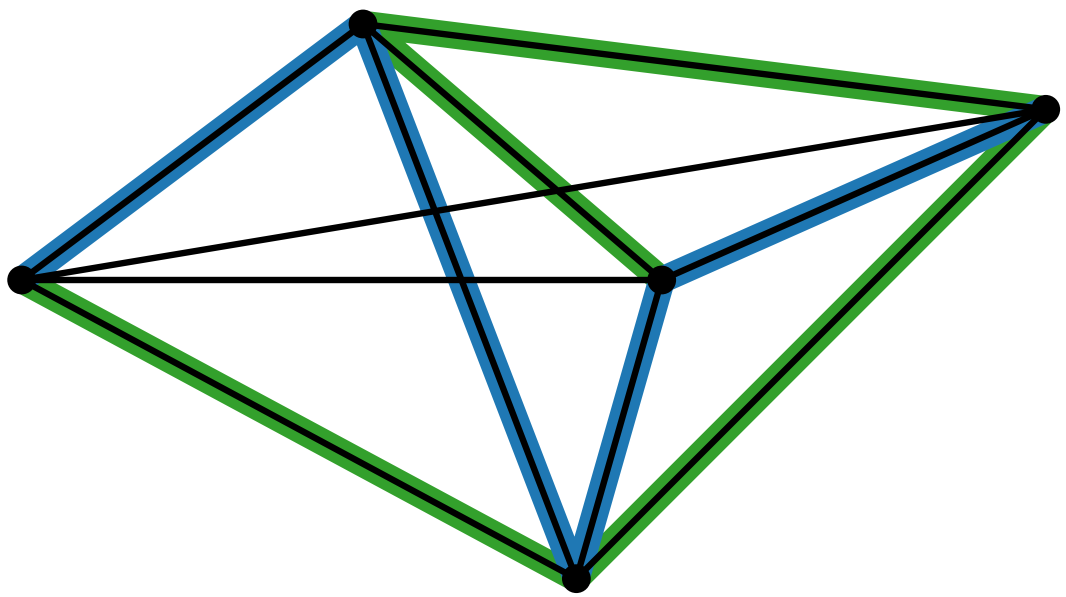

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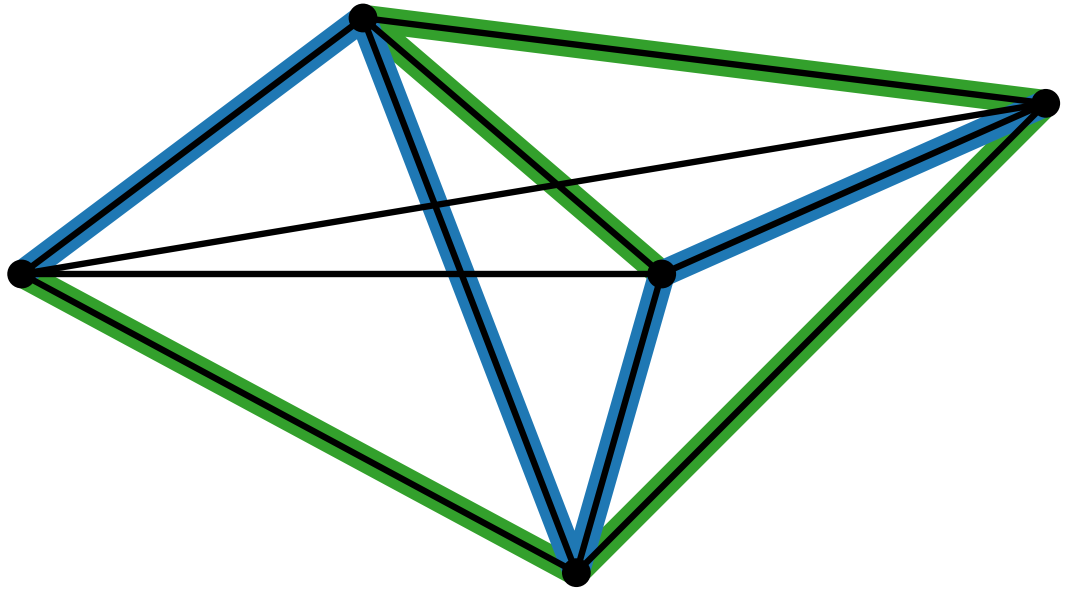

If points are in convex position, there are $\lfloor n/2 \rfloor$ paths.

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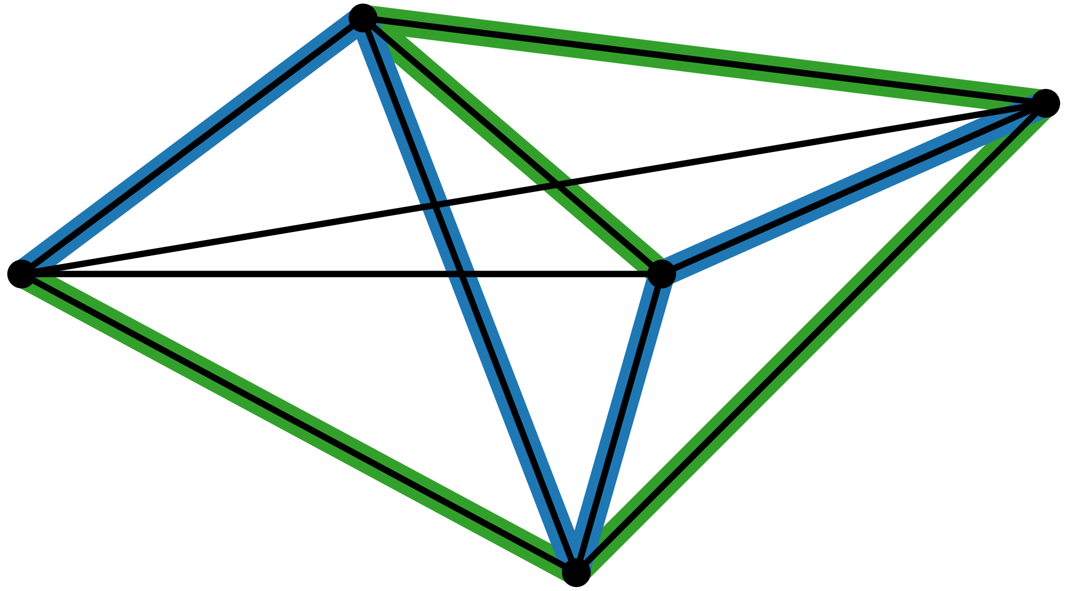

For $n \geq 4$, **at least 2 paths**.

"Packing plane spanning trees and paths in complete geometric graphs." [Aichholzer et al., IPL'17]

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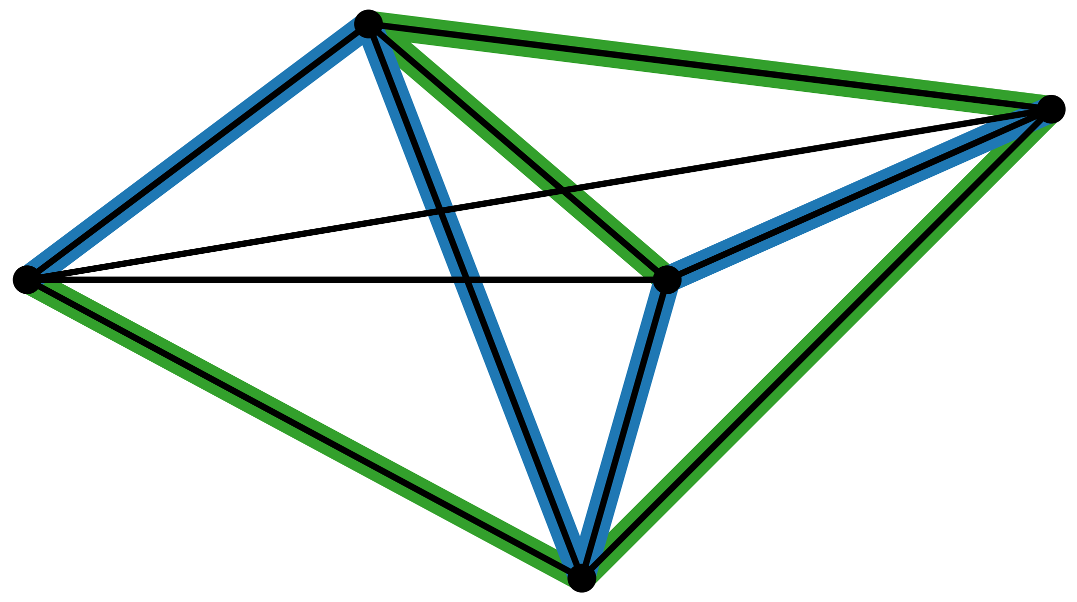

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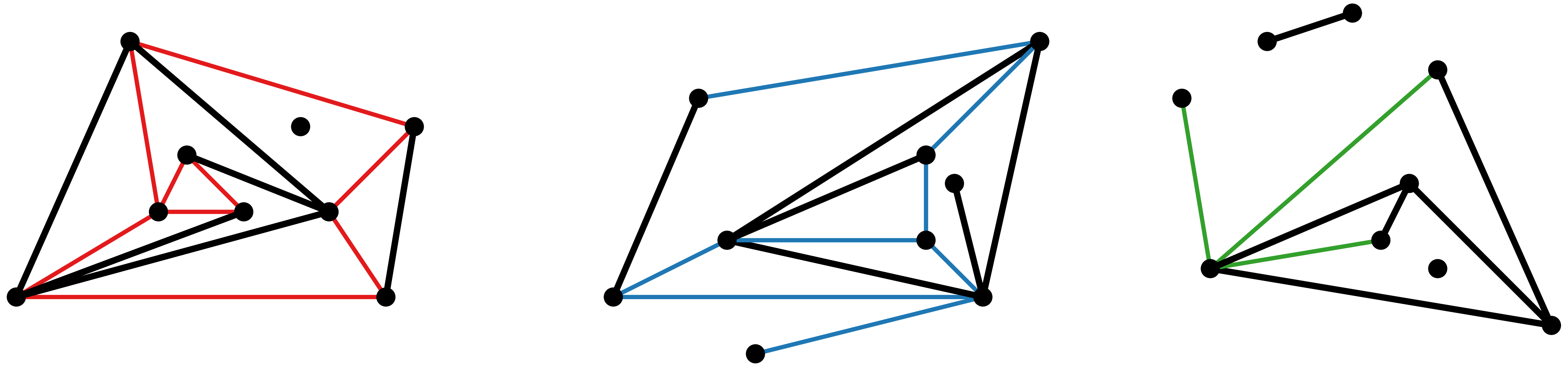
For $n \geq 10$, **at least 3 paths.**

"Three Edge-disjoint Plane Spanning Paths in a Point Set." [Kindermann et al., GD'23]

6. Parameterized Complexity of Simultaneous Planarity



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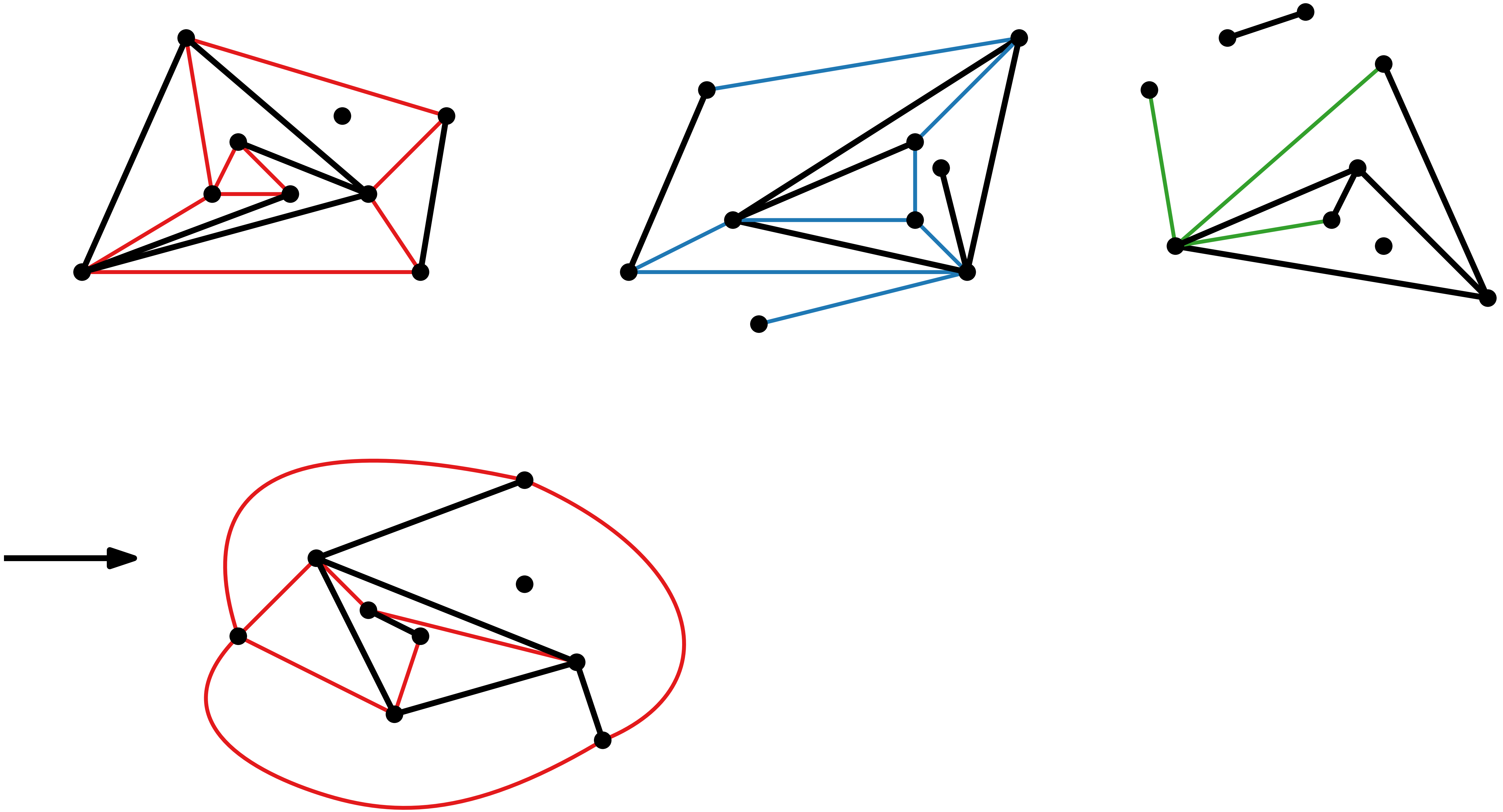

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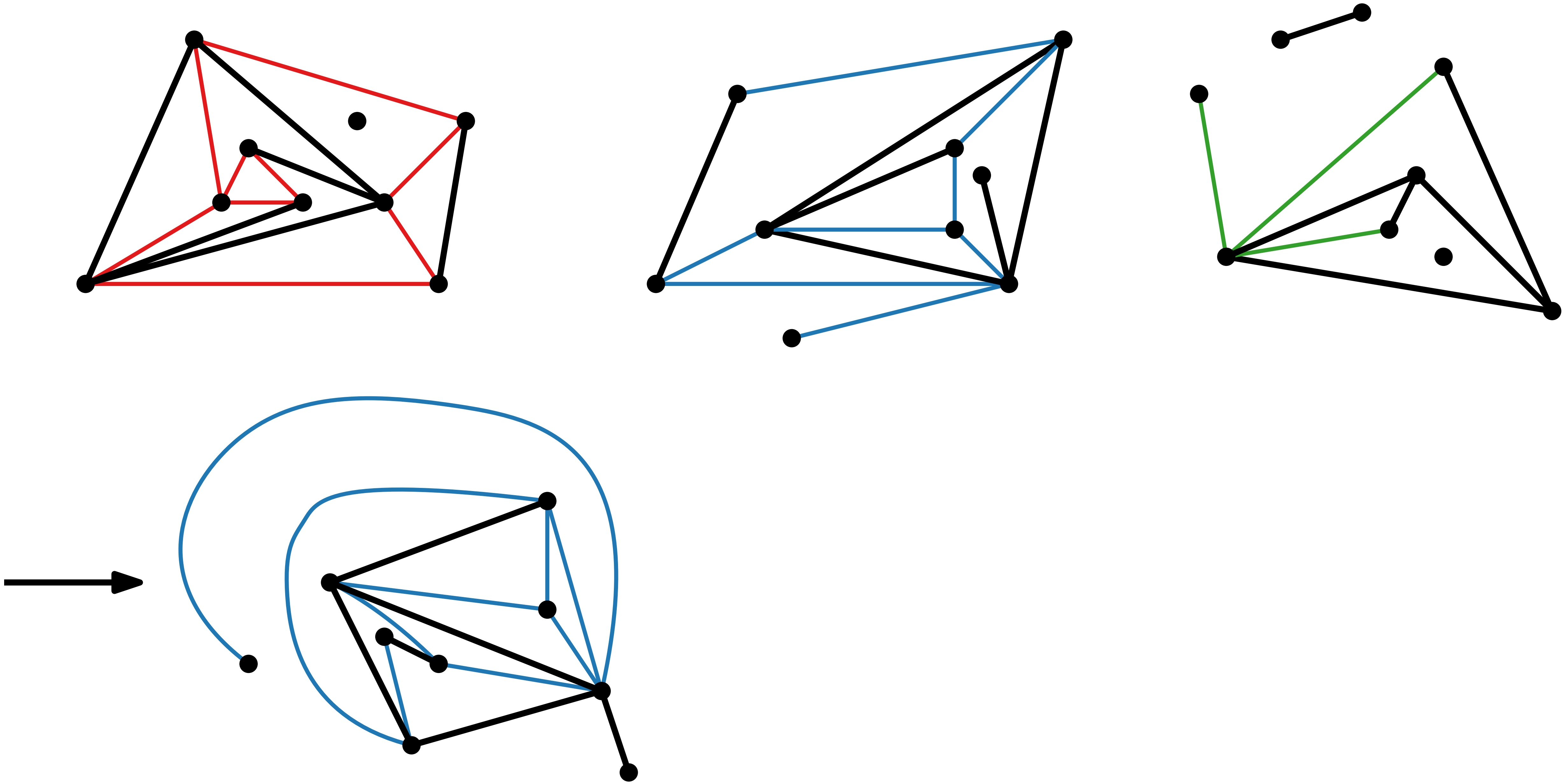

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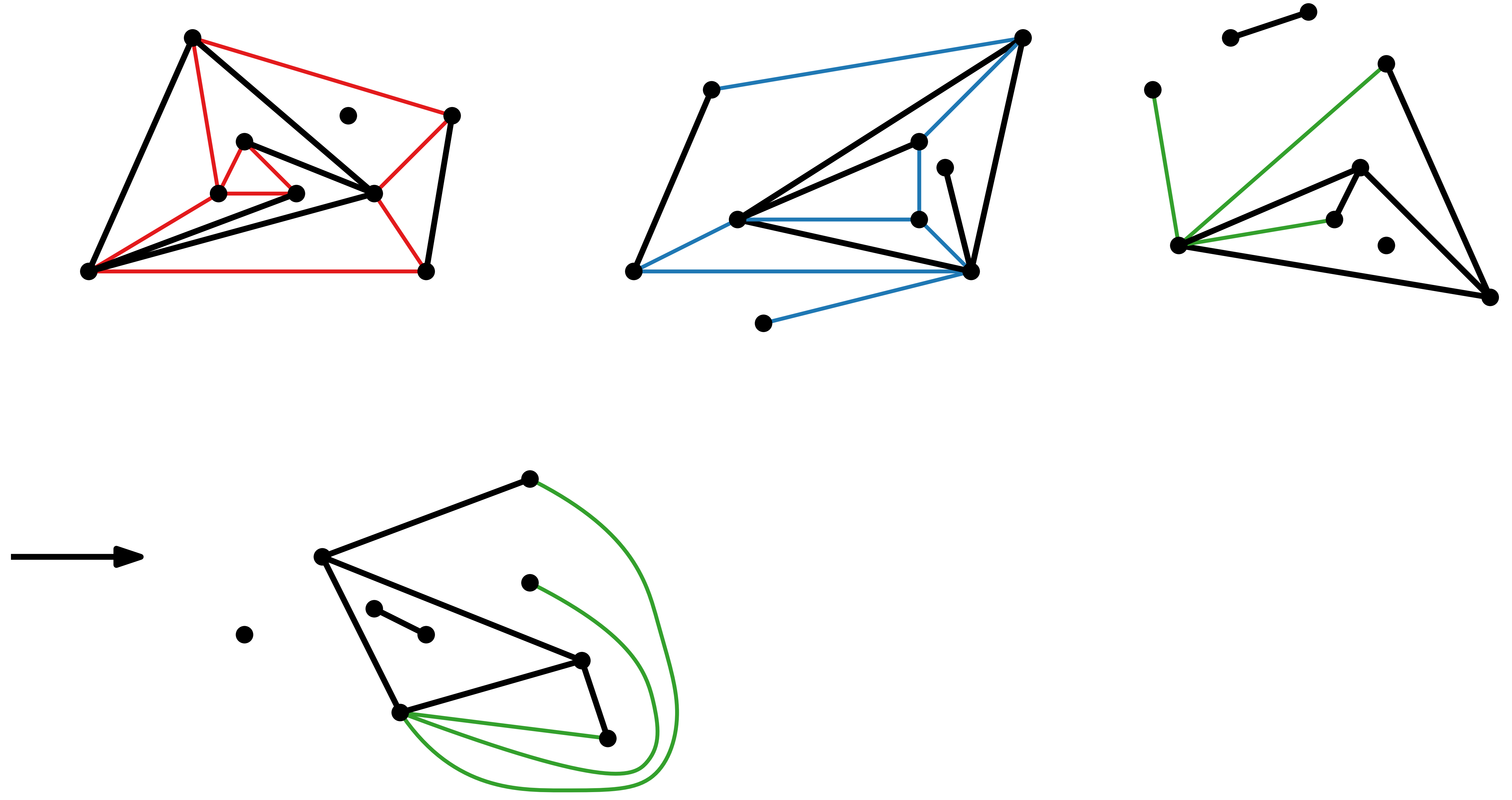

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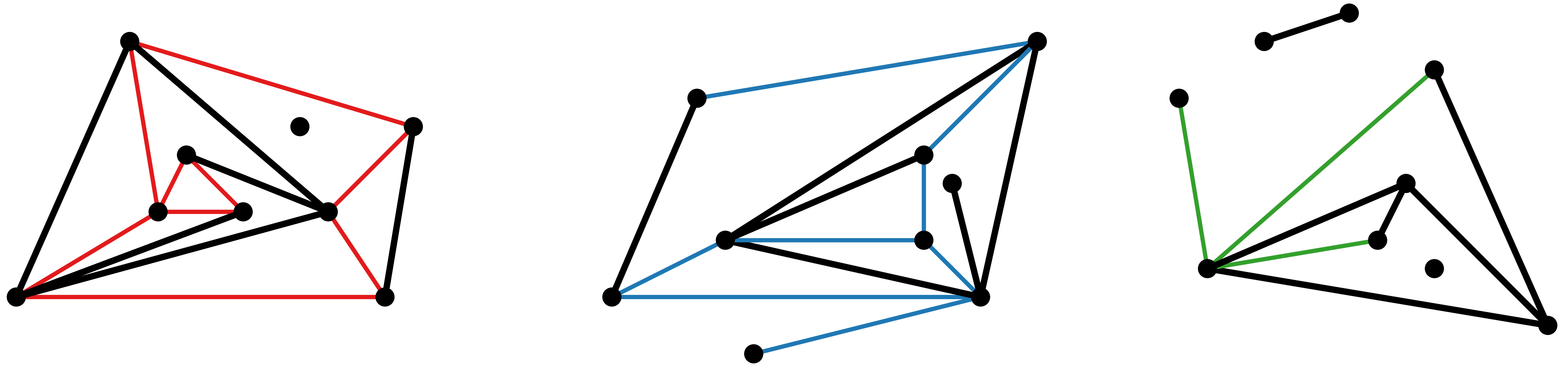

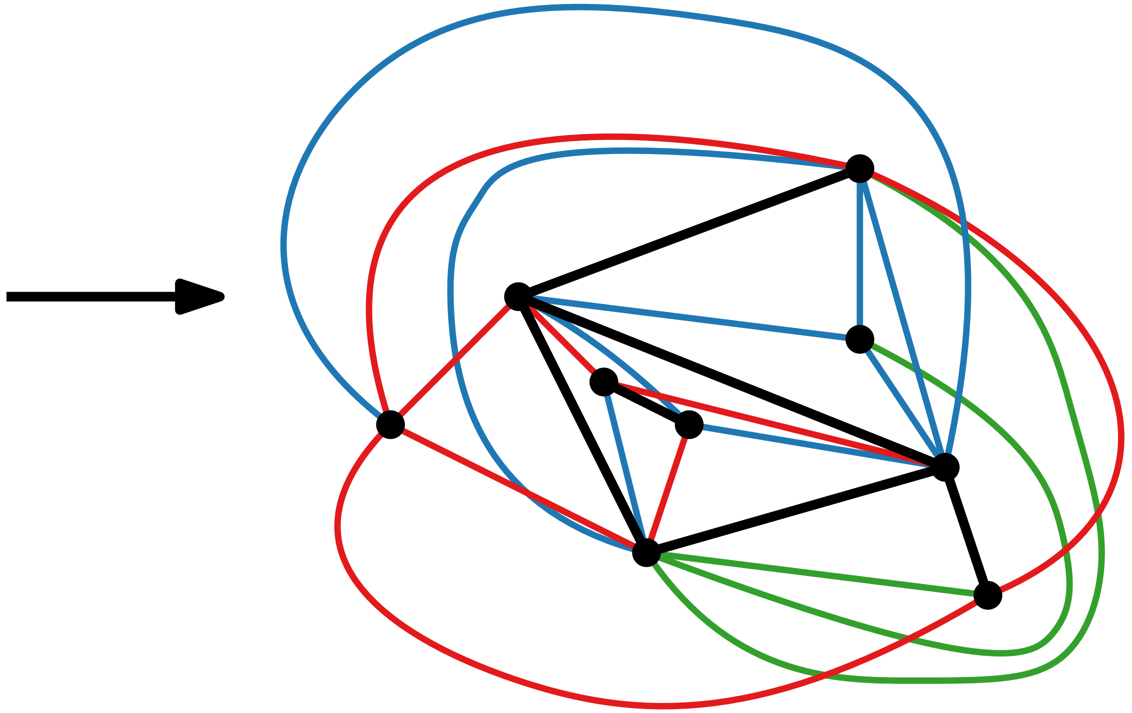

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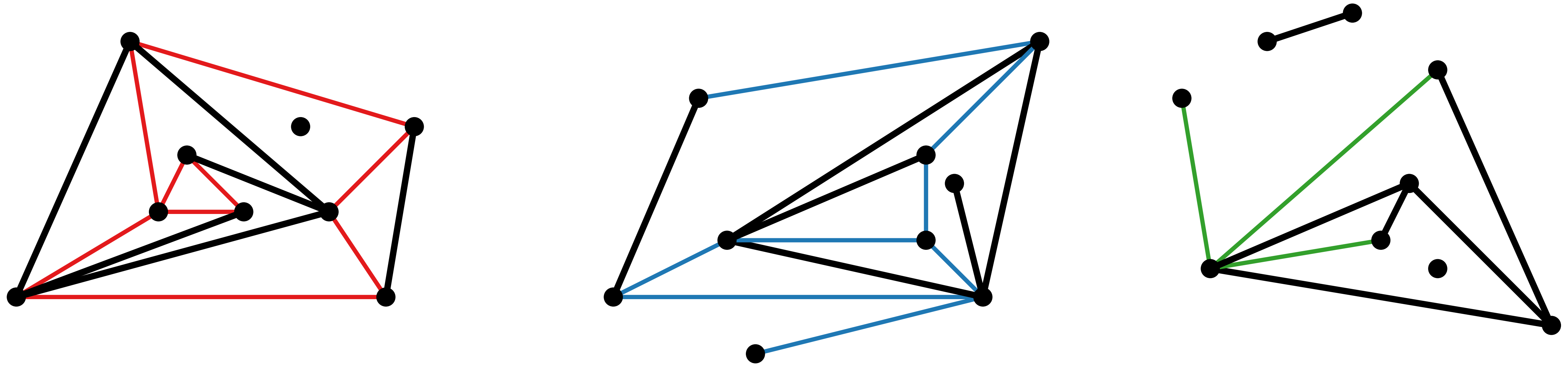

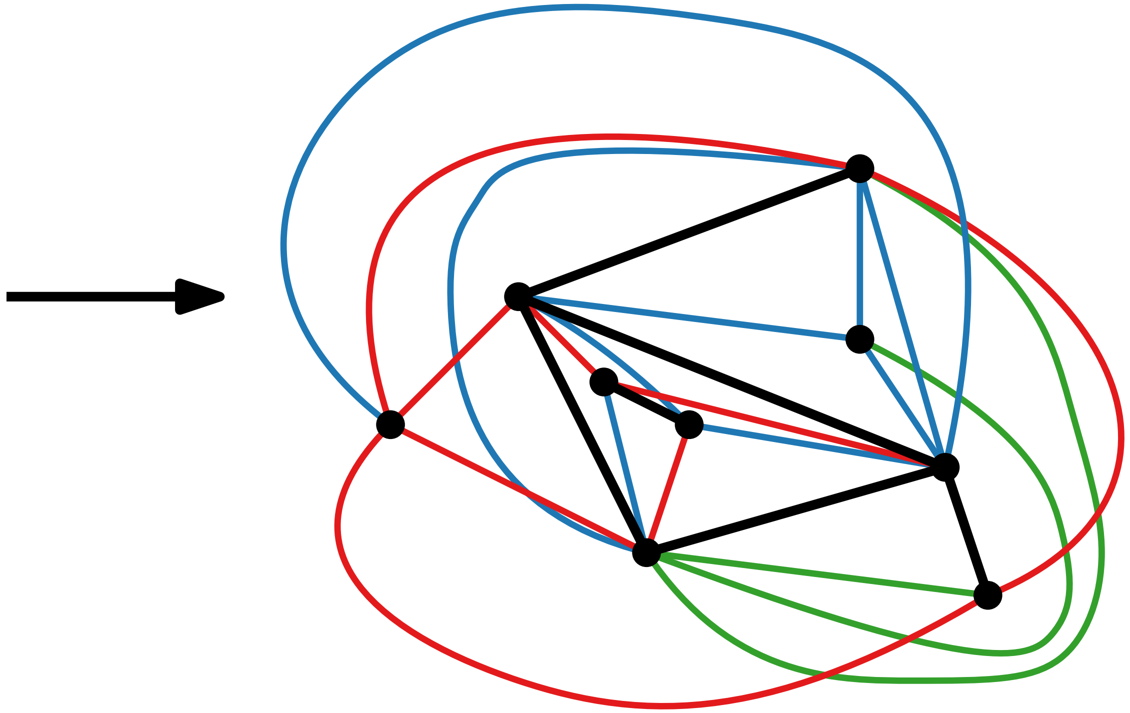

Simultaneous Embedding with Fixed Edges:

Eingabe: k planare Graphen, die sich paarweise überschneiden.
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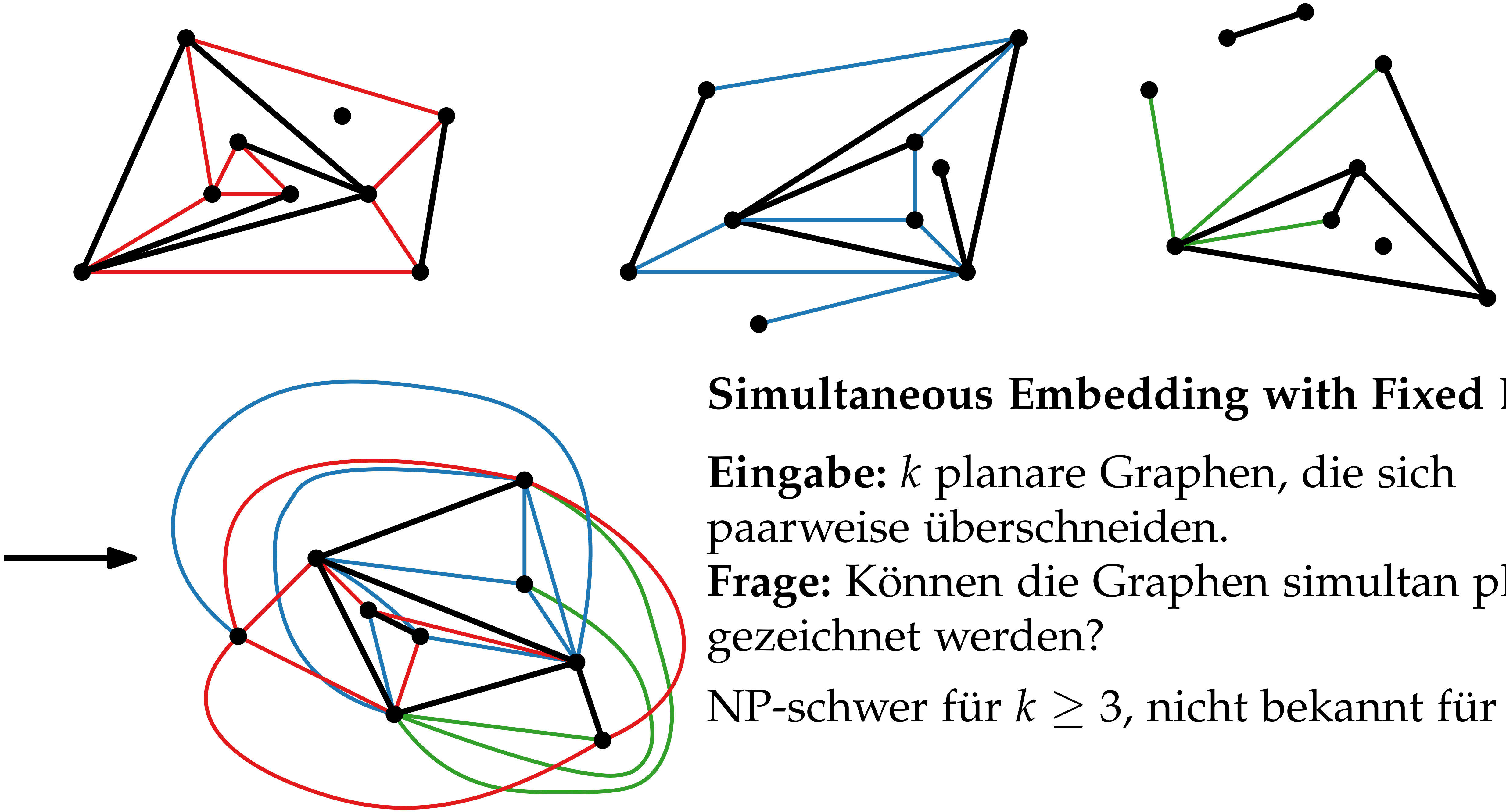

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NP-schwer für $k \geq 3$, nicht bekannt für $k = 2$.

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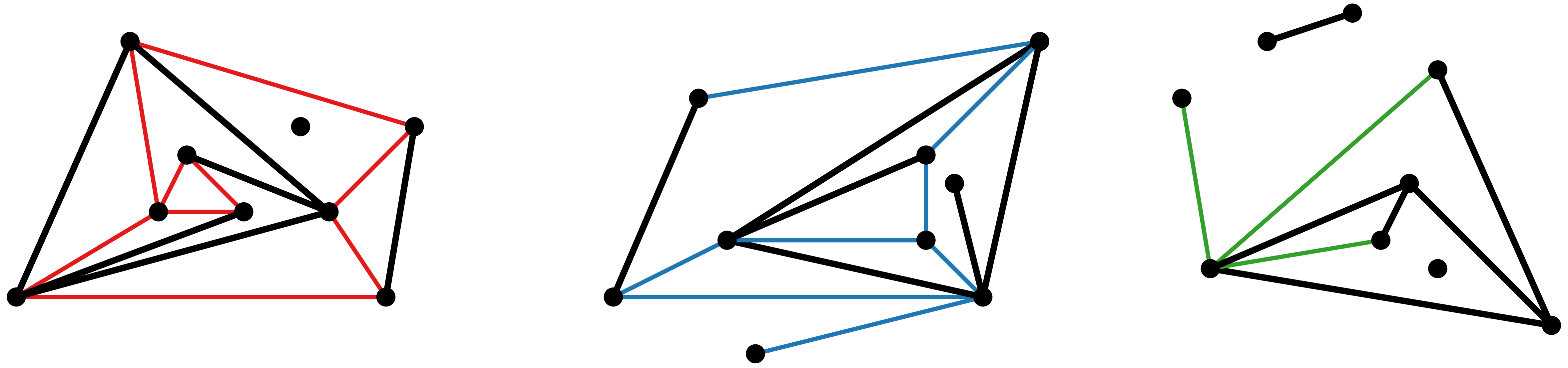

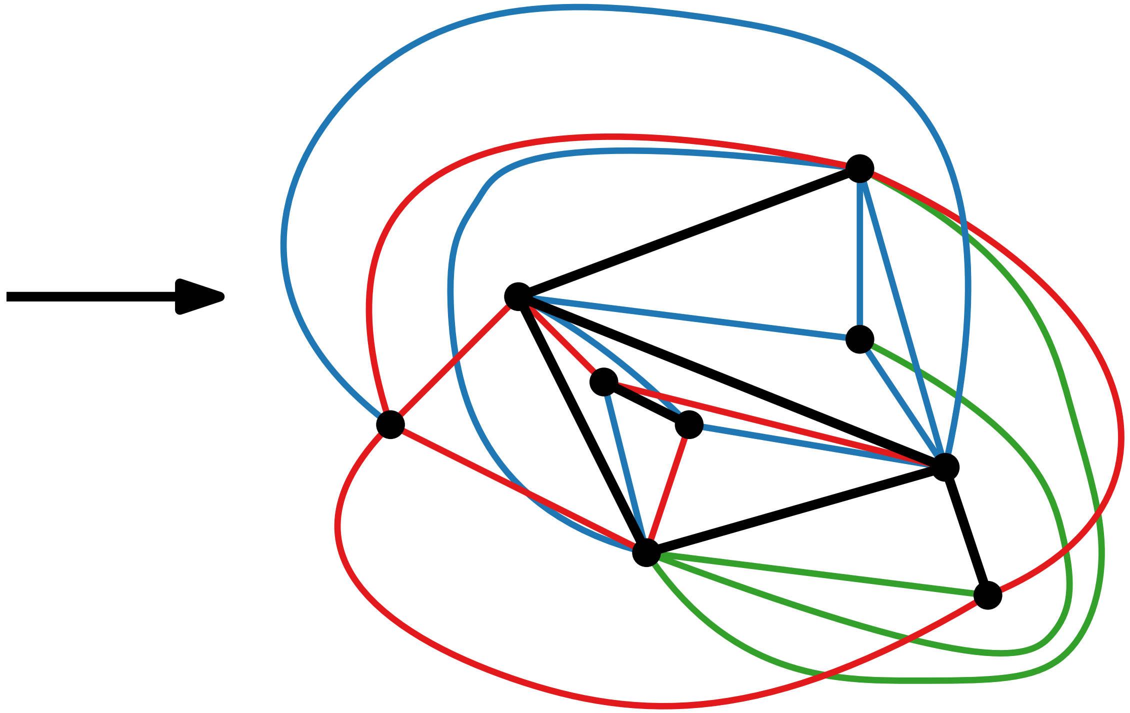

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In diesem Seminar: **Was ist die parametrisierte Komplexität von SEFE?**

7. Removing Popular Faces in Curve Arrangements

		1	3	1	3
1	1				
1	1				
	3				
	1				

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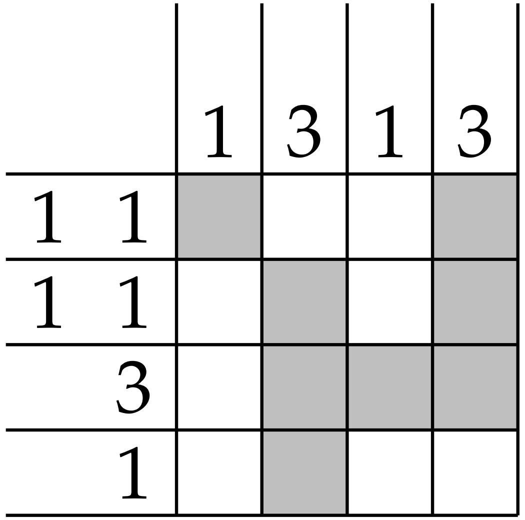

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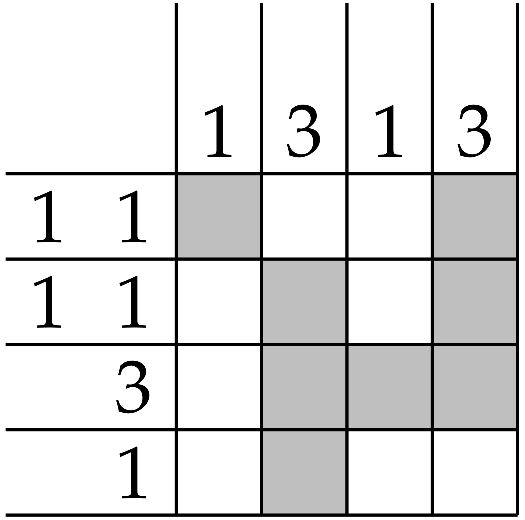

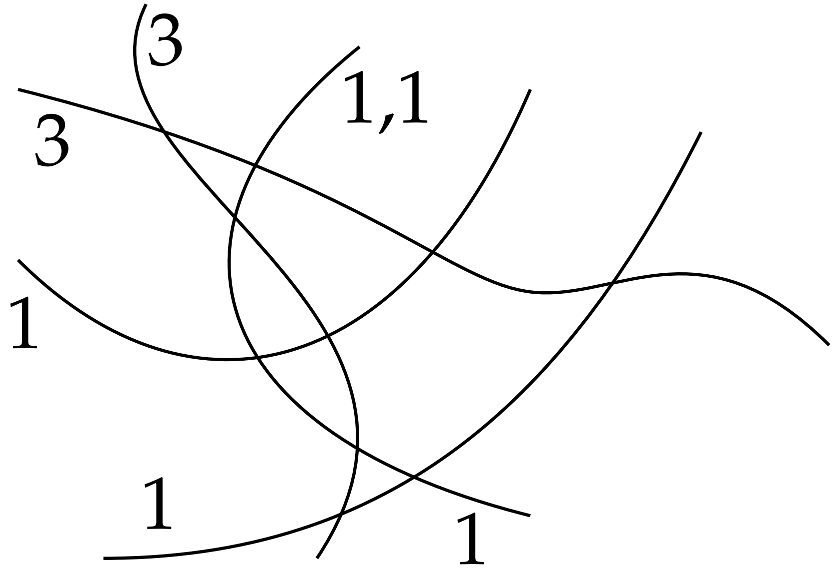

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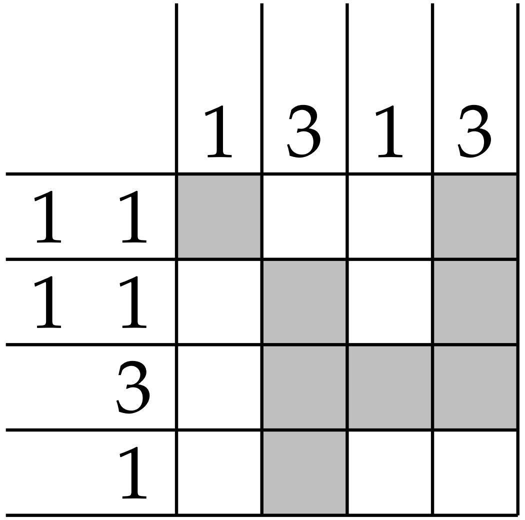

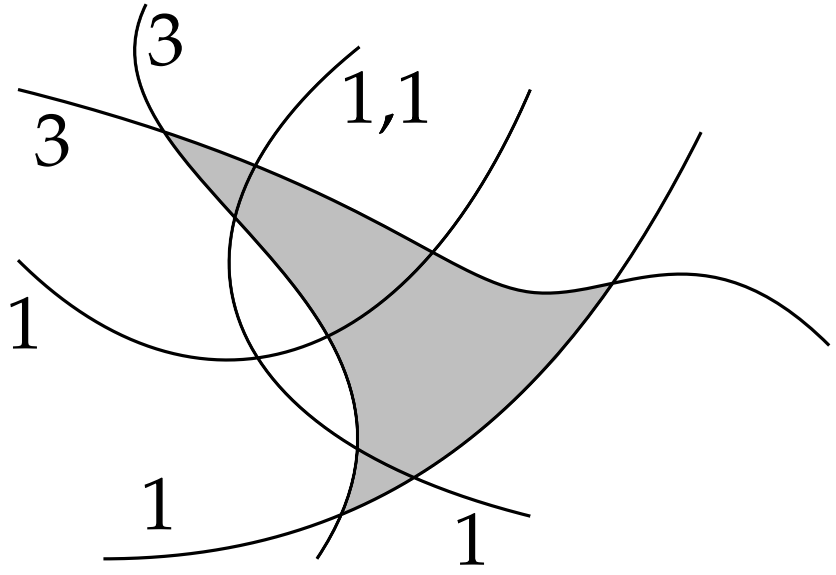

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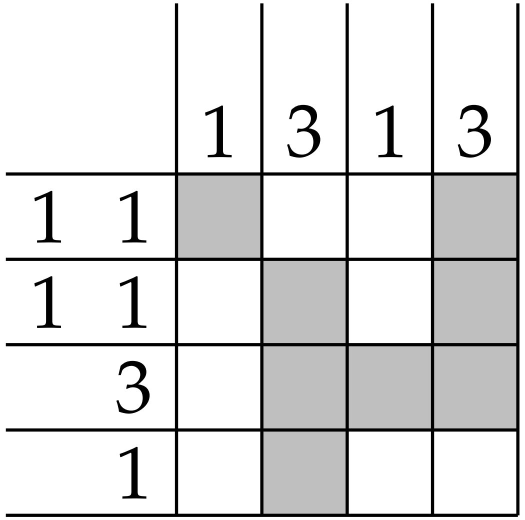

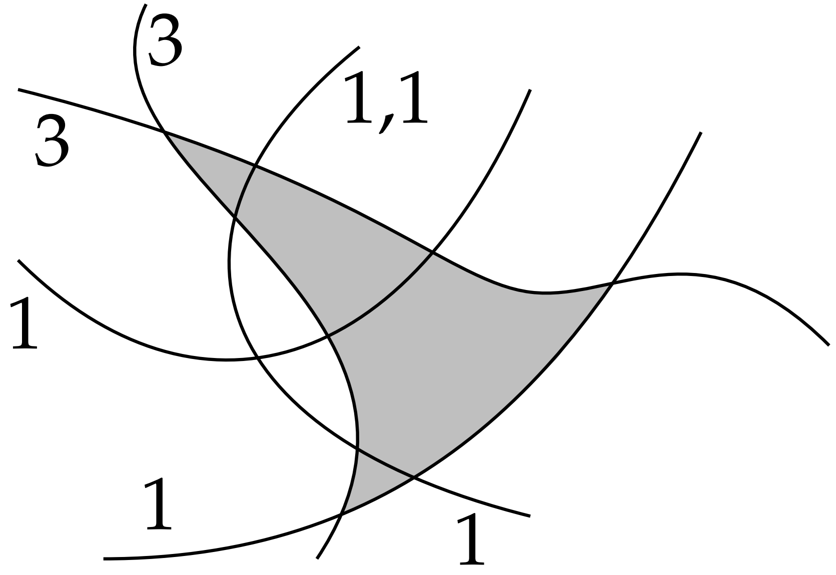

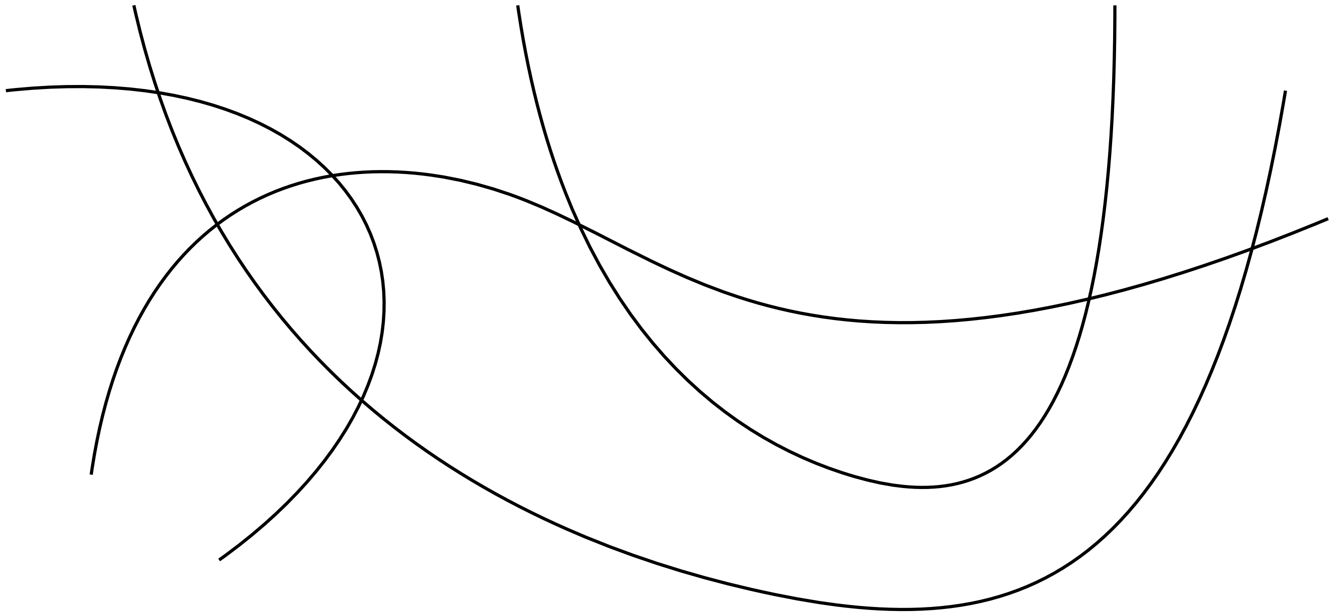

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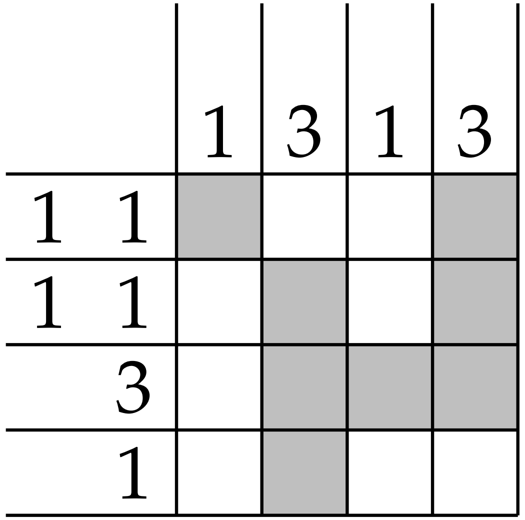
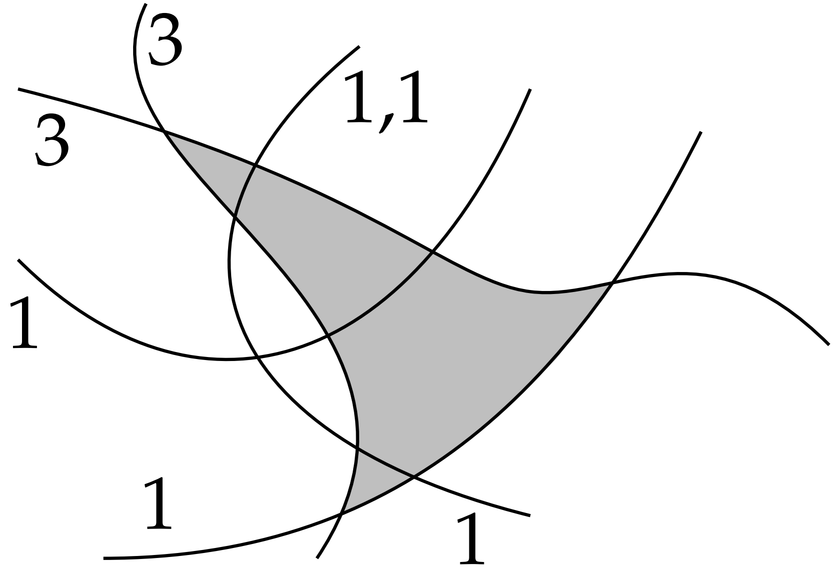
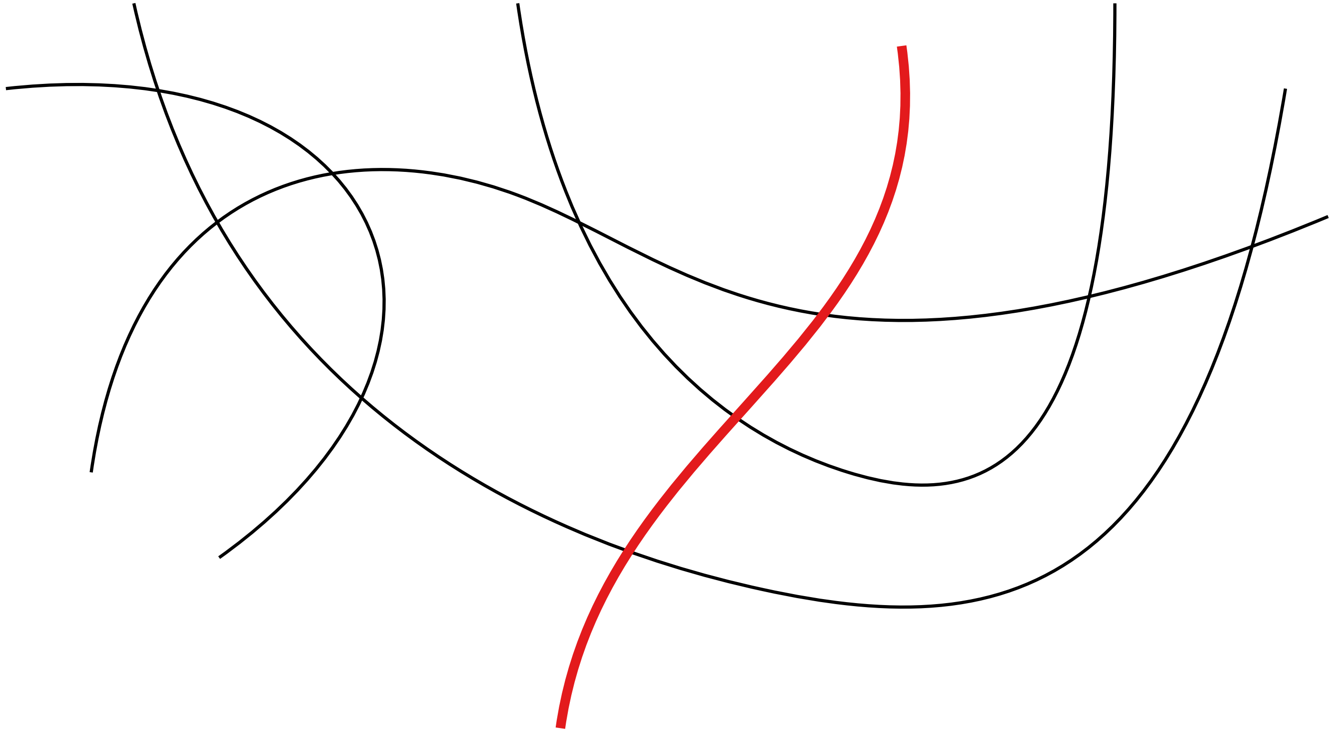
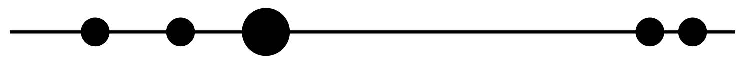






8. Computing the Enclosing Depth

Median on a line: 

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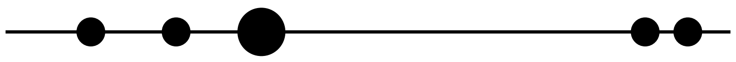
Median on a line: 

Depth of the points: 1 1

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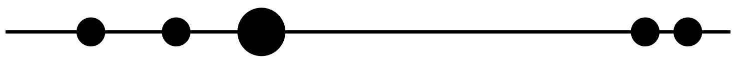
Median on a line: 

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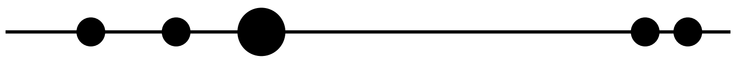
Median on a line: 

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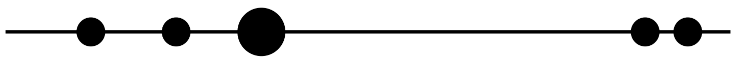
Median on a line: 

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How to generalize these concepts to higher dimensions?

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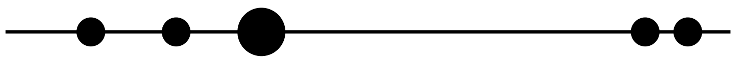

Depth of the points: 1 2 3 21

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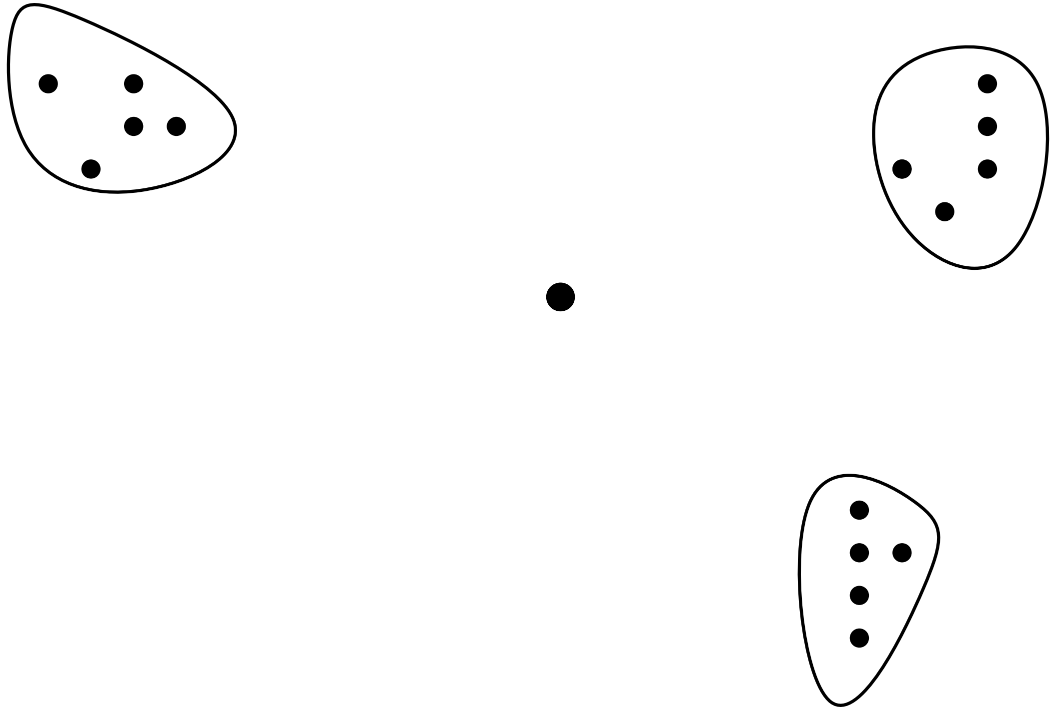
Enclosing Depth: Point p has depth k, if there are subsets of size k such that they always contain p in their convex hull.



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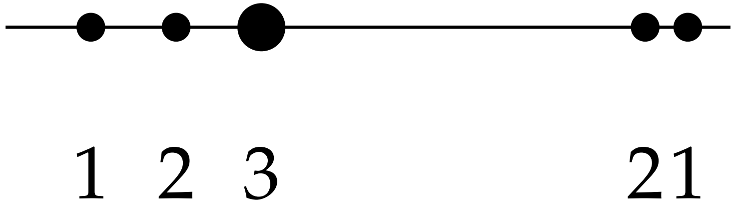

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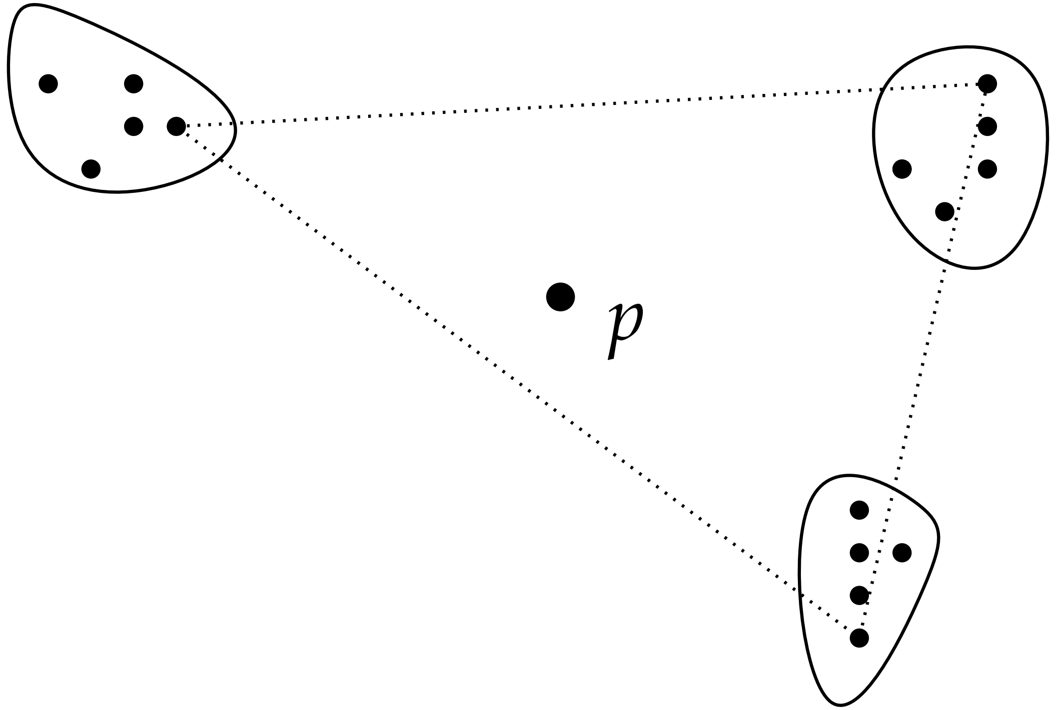

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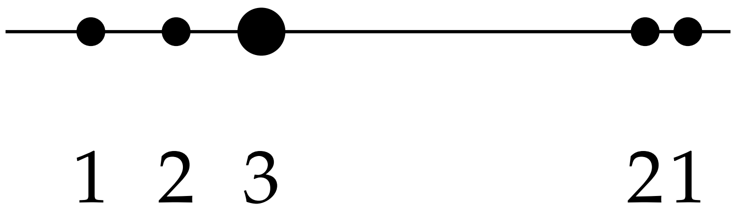

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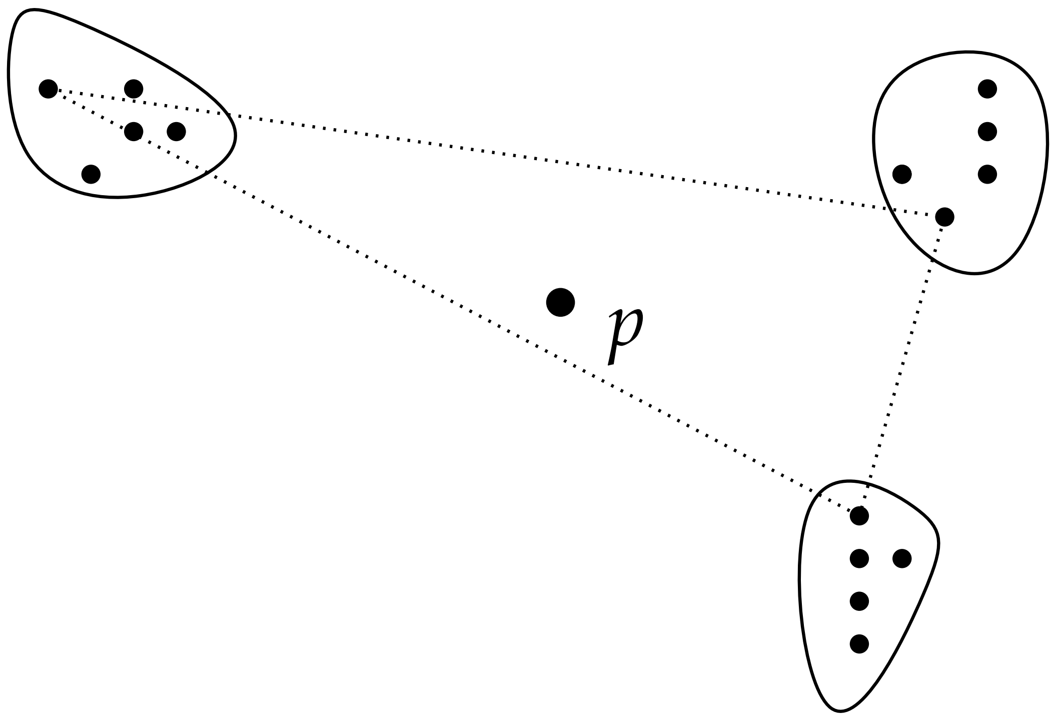

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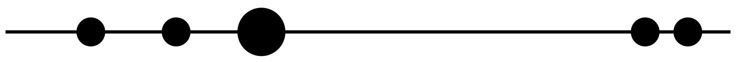

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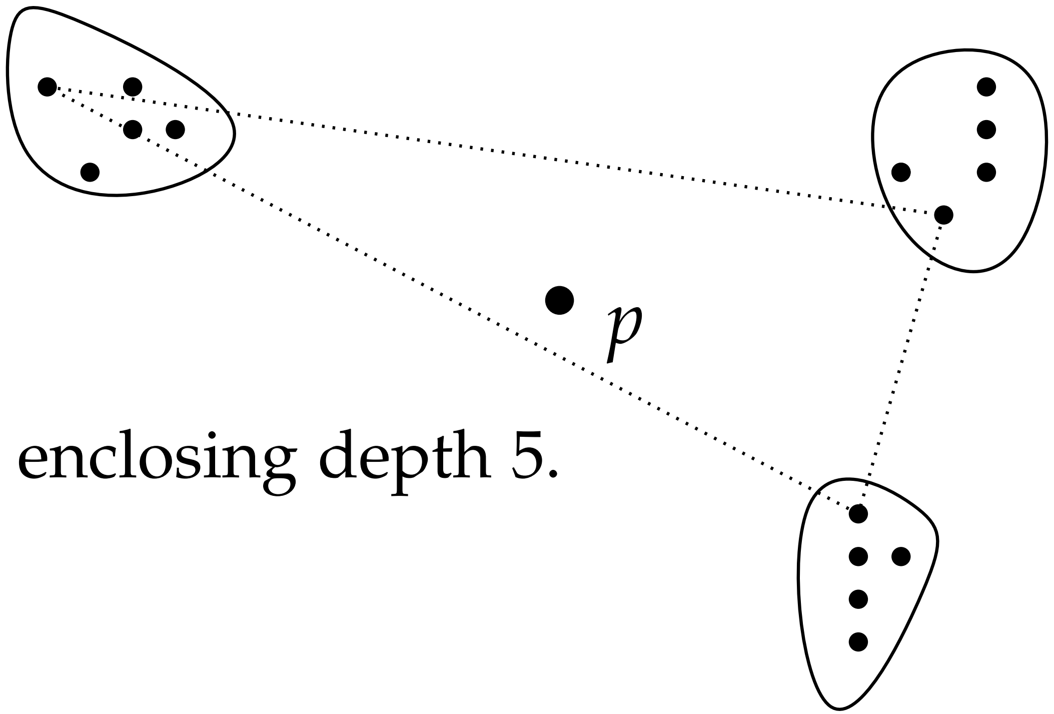

$\Rightarrow$ p has enclosing depth 5.

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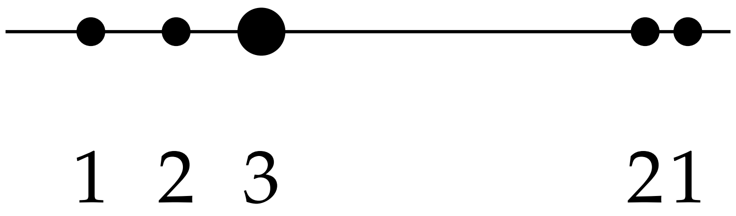

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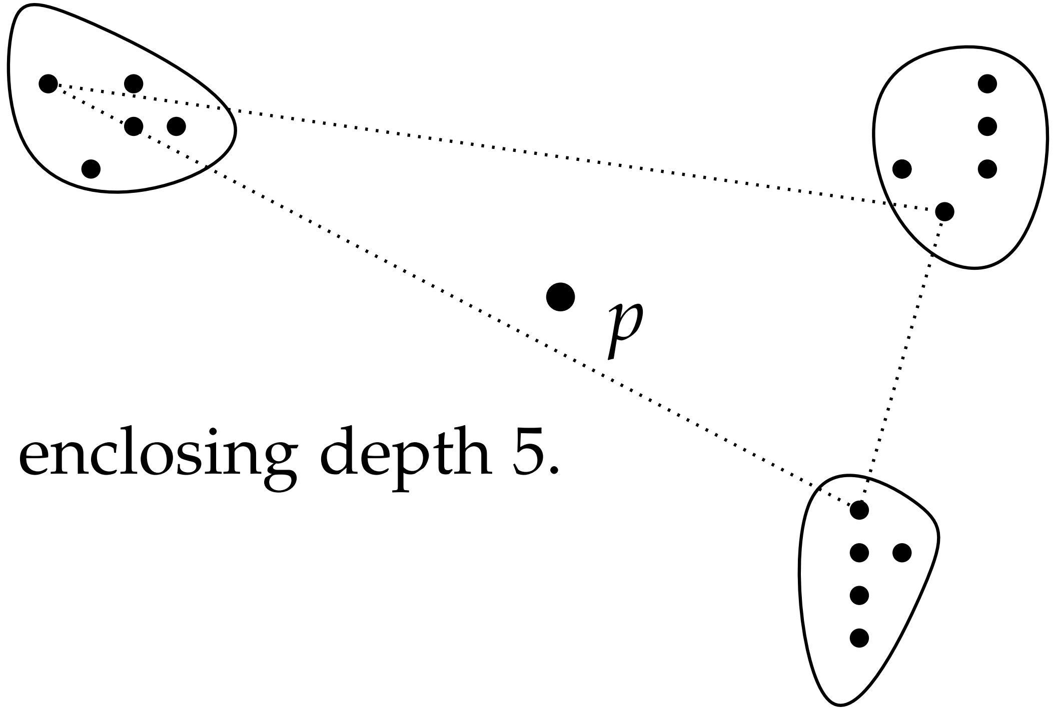
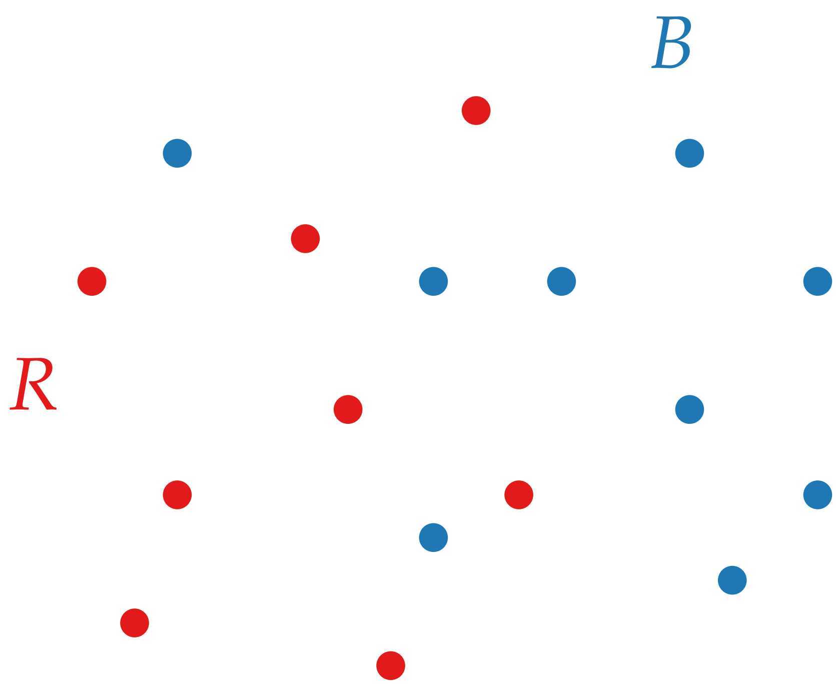


⇒ p has enclosing depth 5.

How can this depth be computed?

9. Robust Bichromatic Classification with Lines



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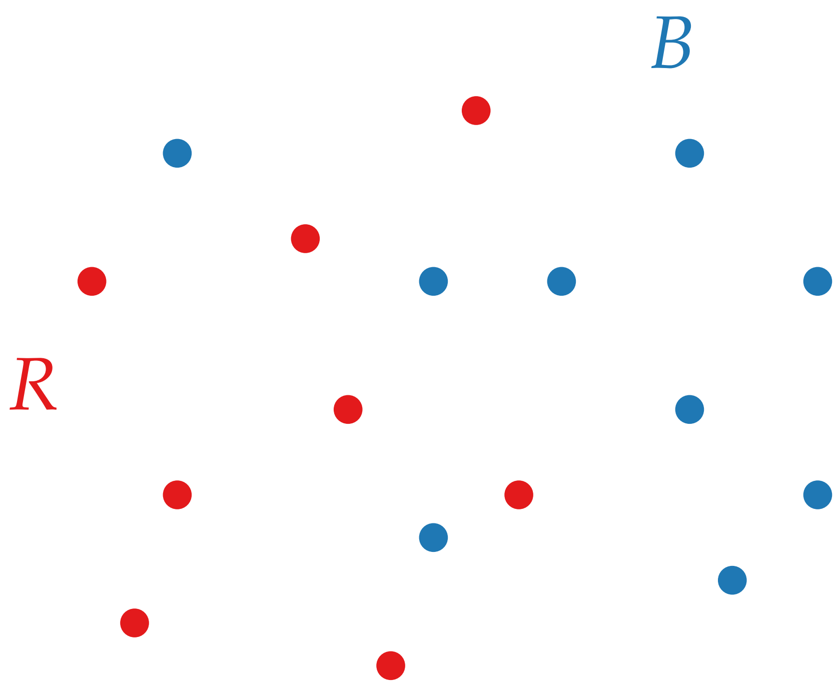

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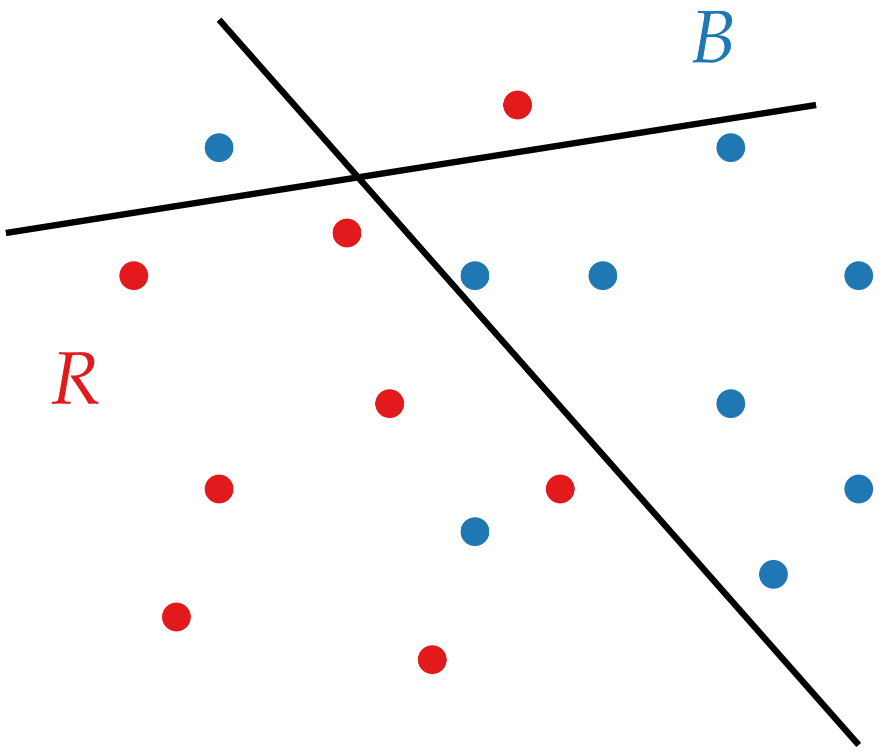

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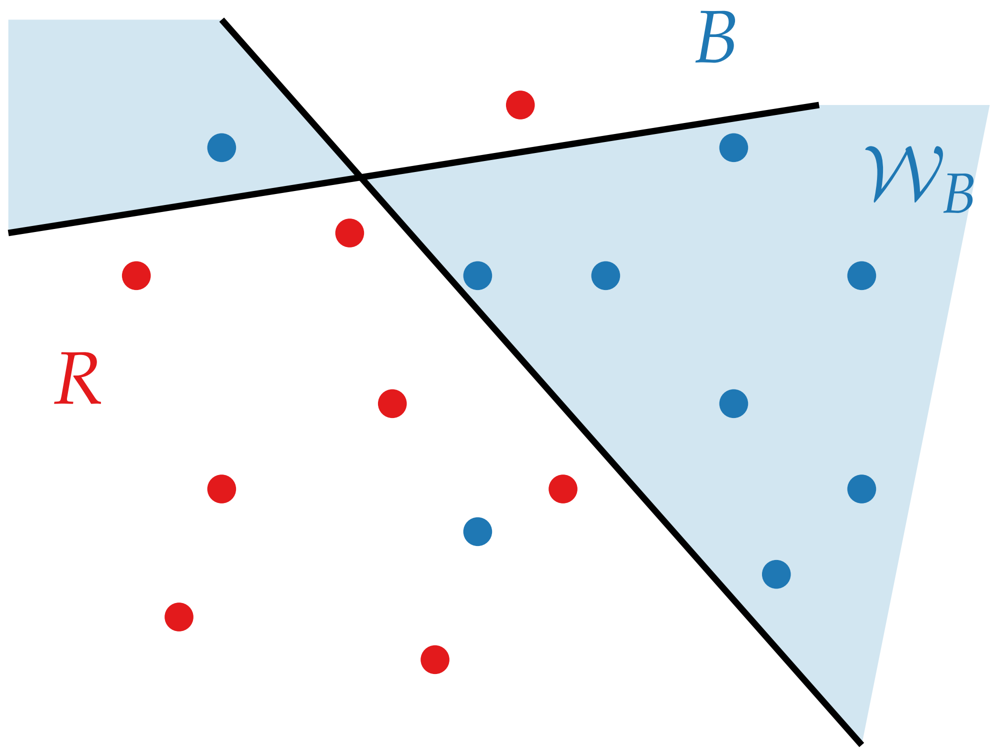

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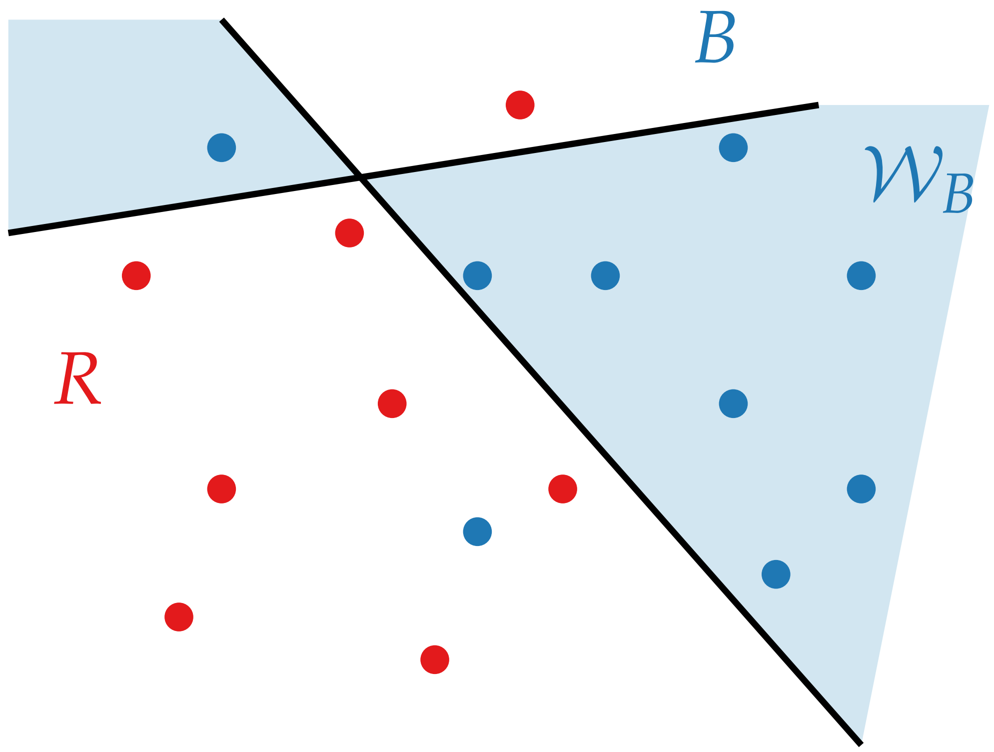

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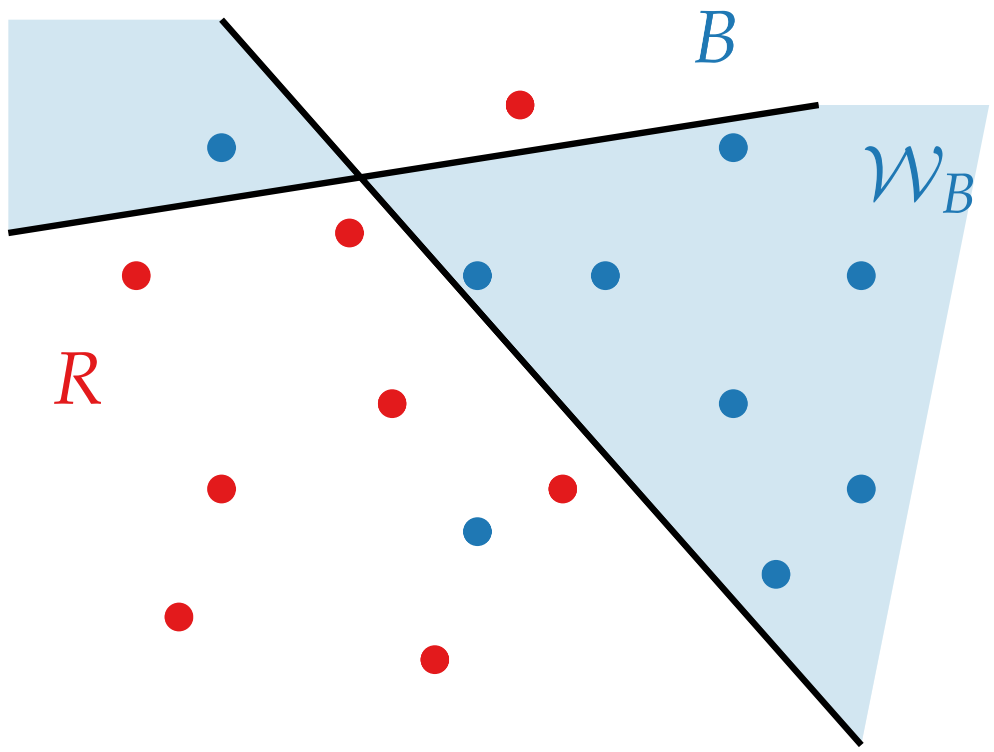

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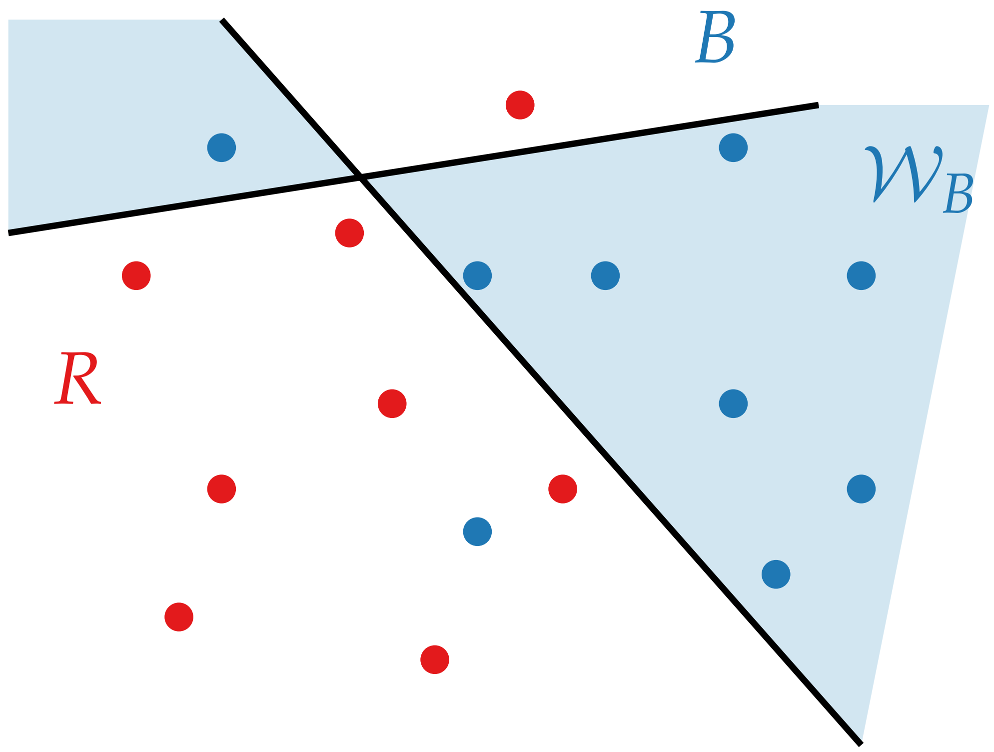

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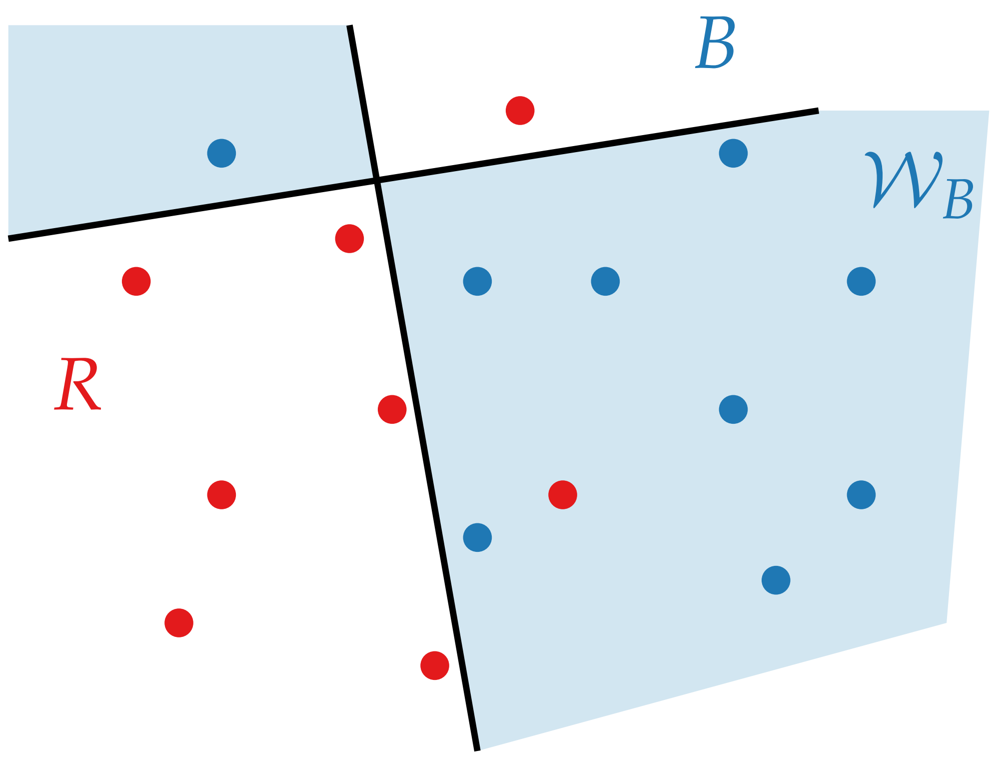

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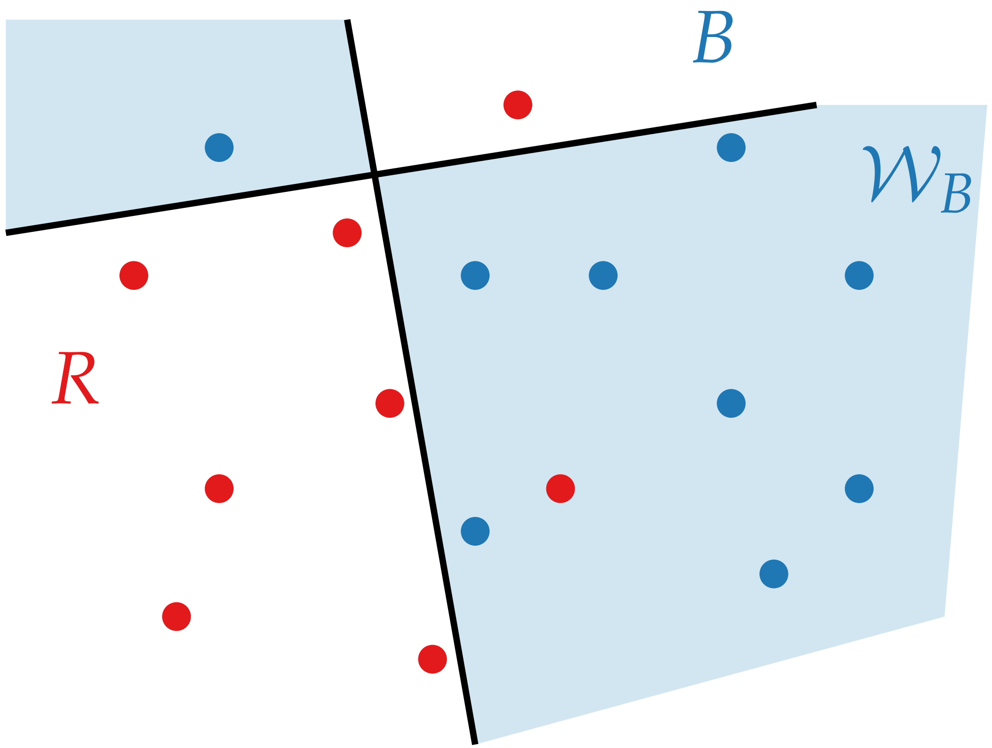

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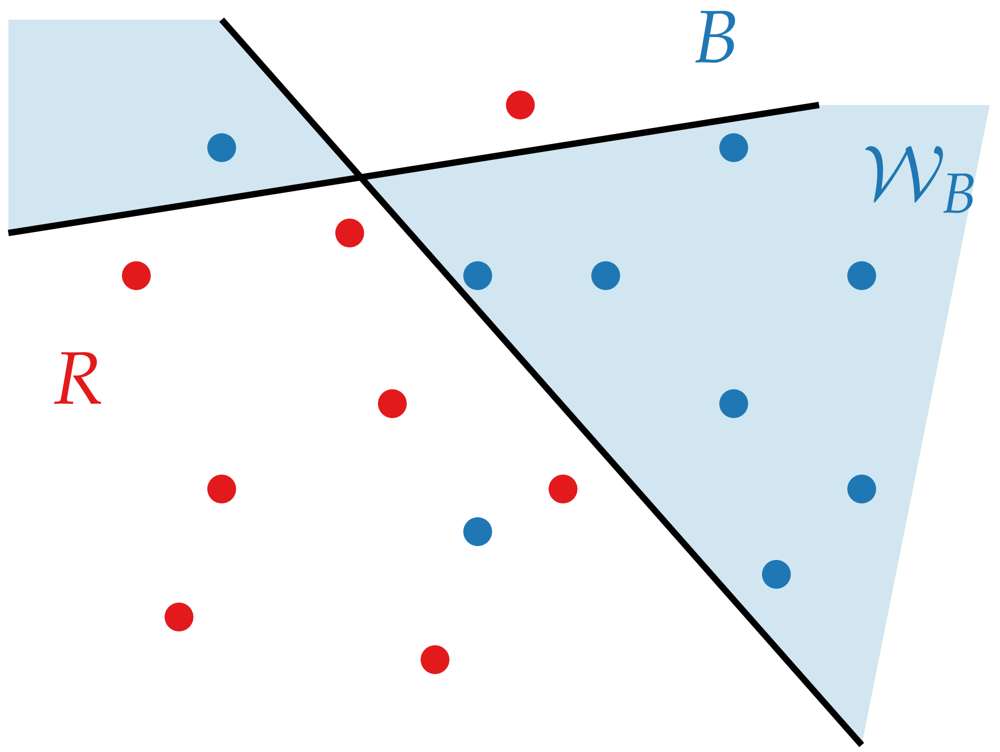

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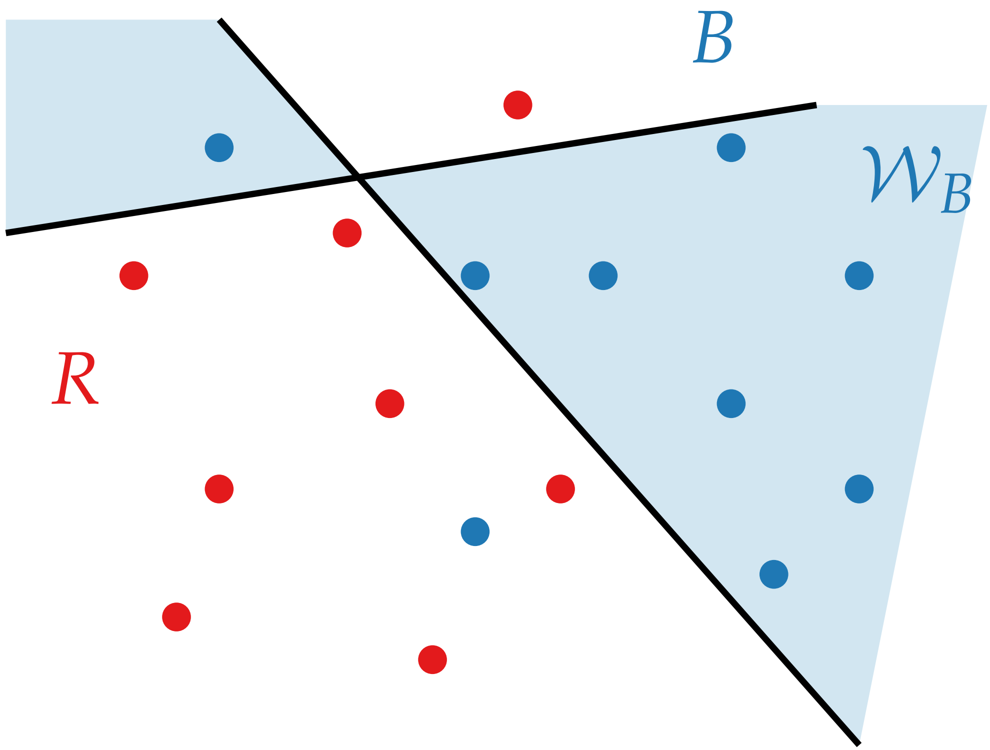

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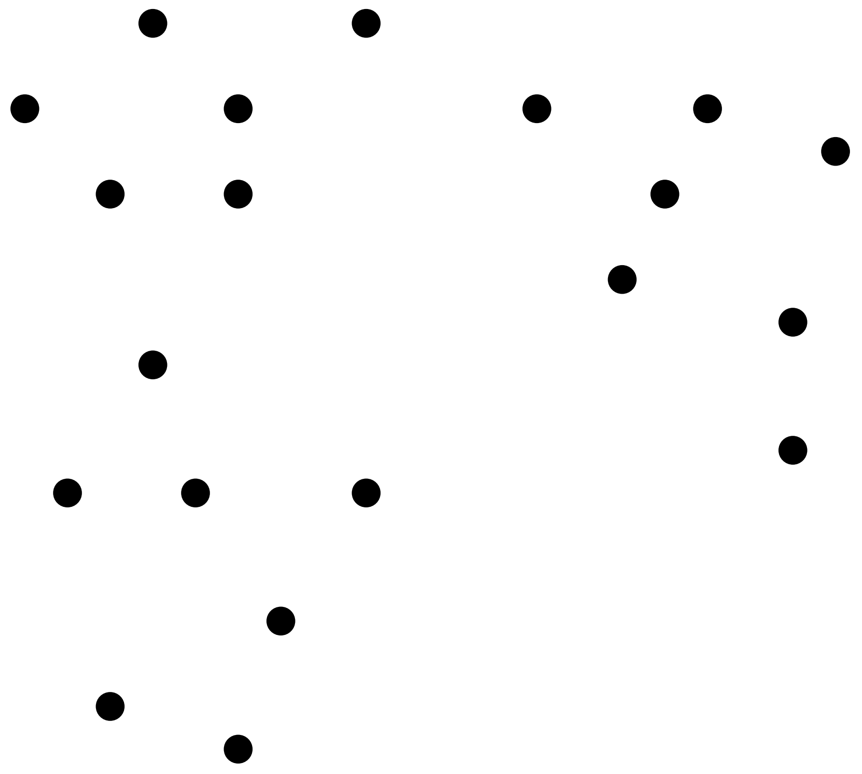
Results: efficient algorithms for different cases

10. Clustering with Disks to Minimize the Sum of Radii



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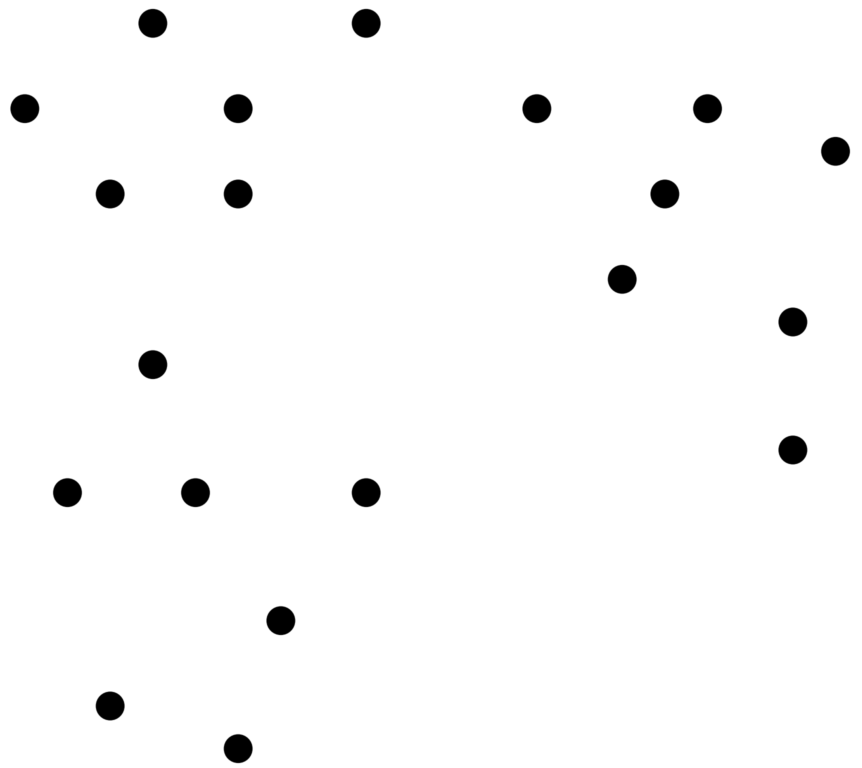

k-MinSumRadius

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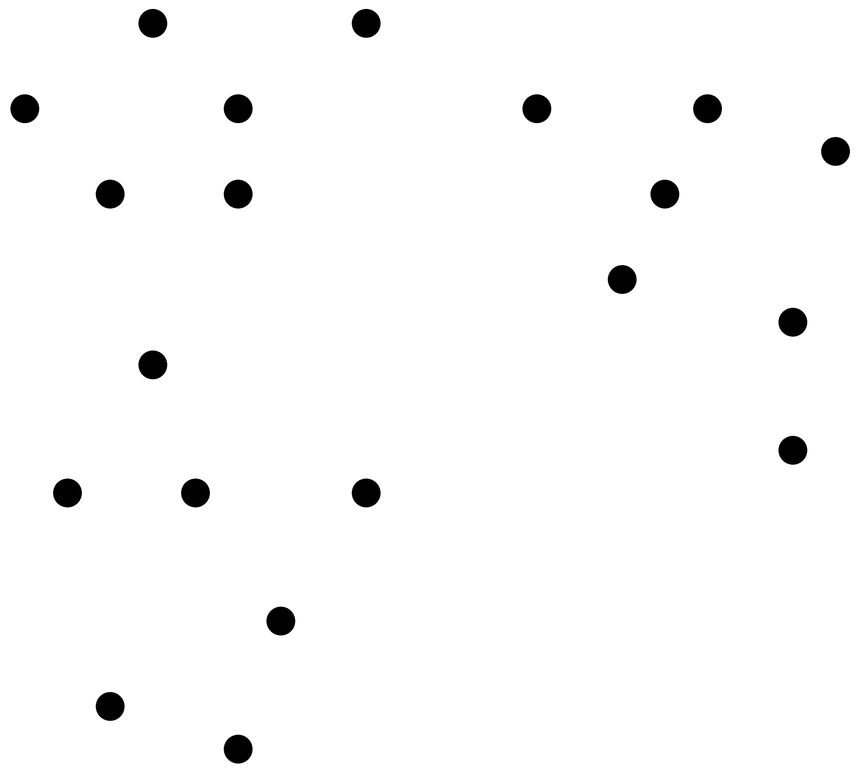

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Task: cover a given point set using k disks such that the sum of the radii of the disks is minimized.

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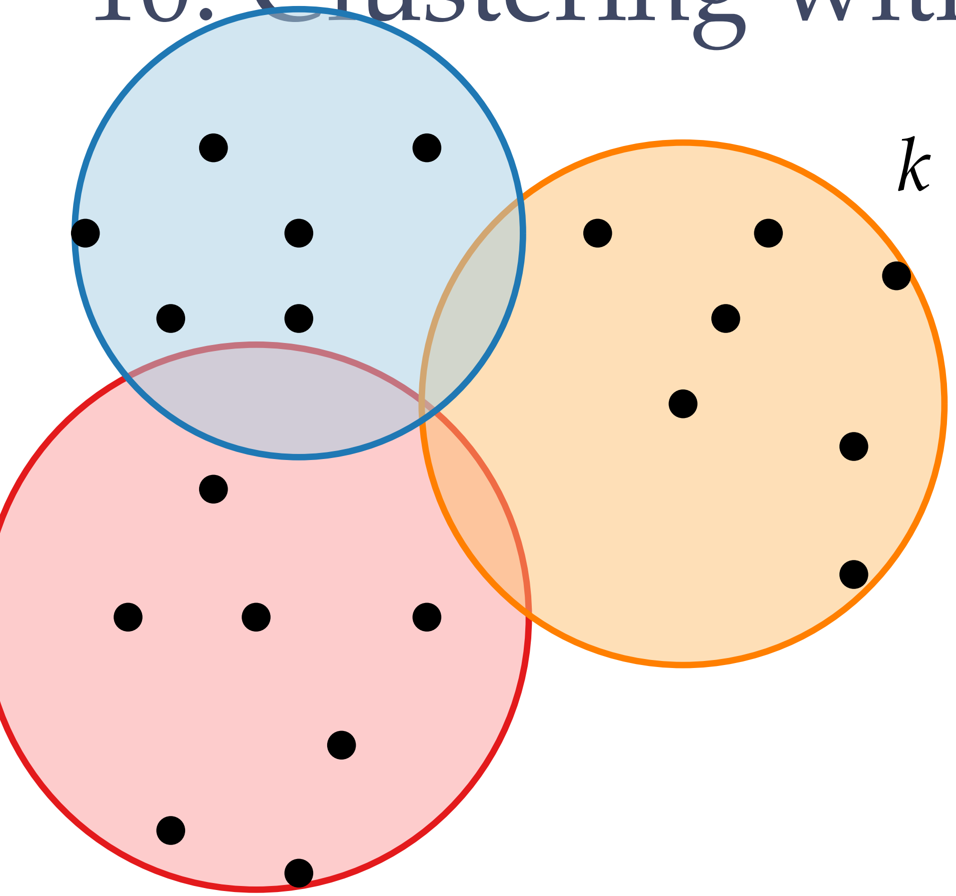

$k = 3$

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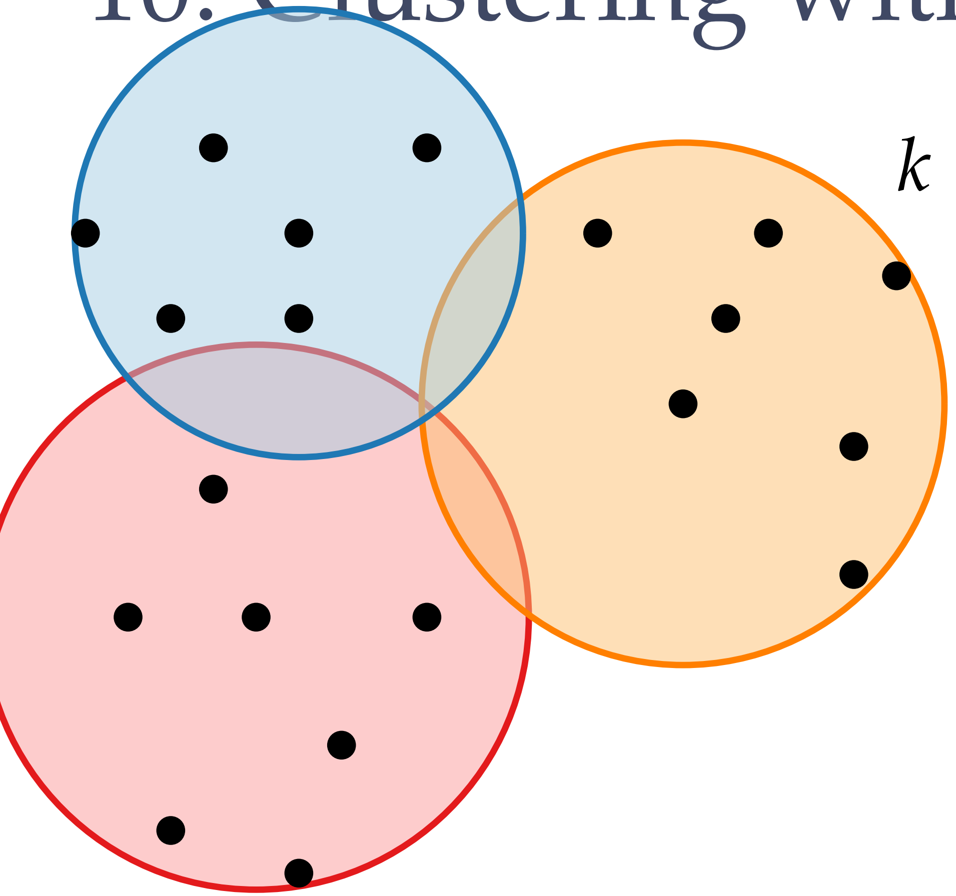

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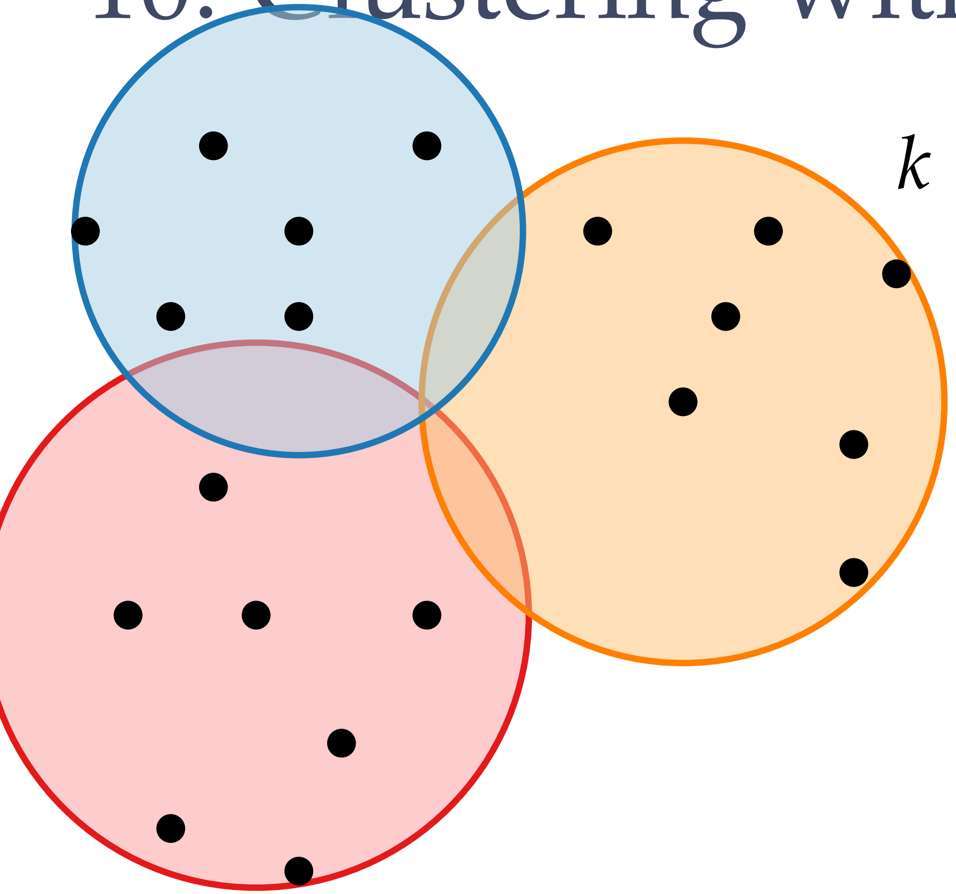

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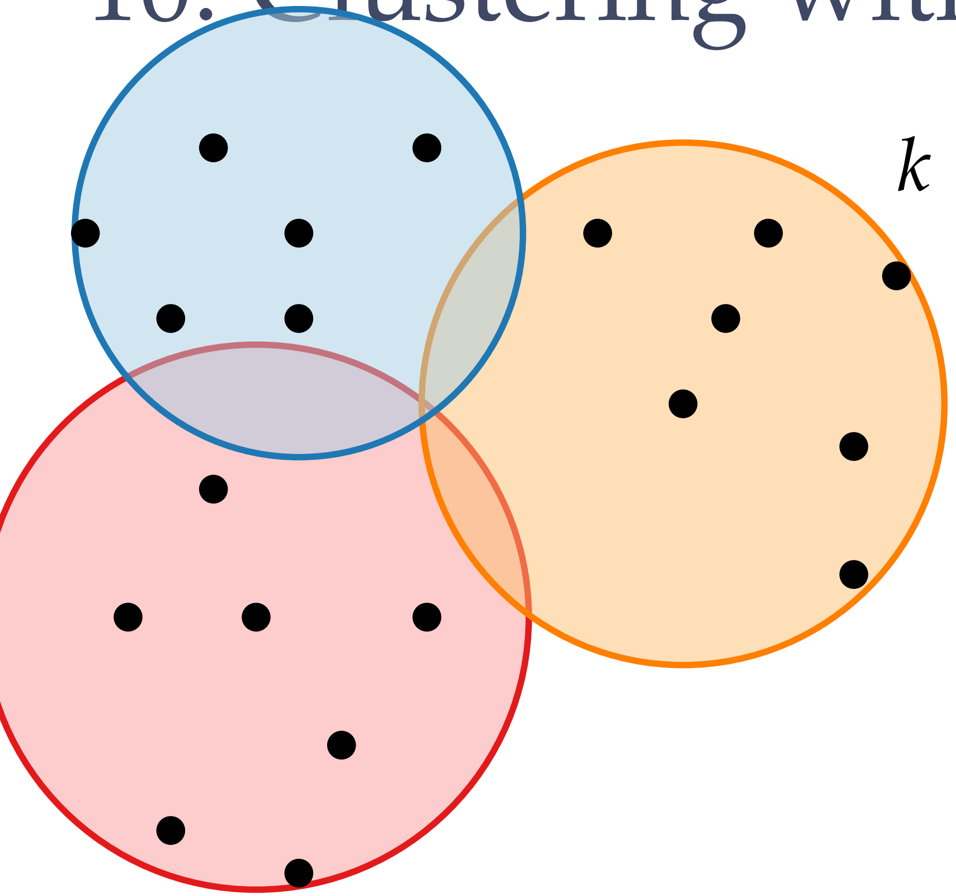

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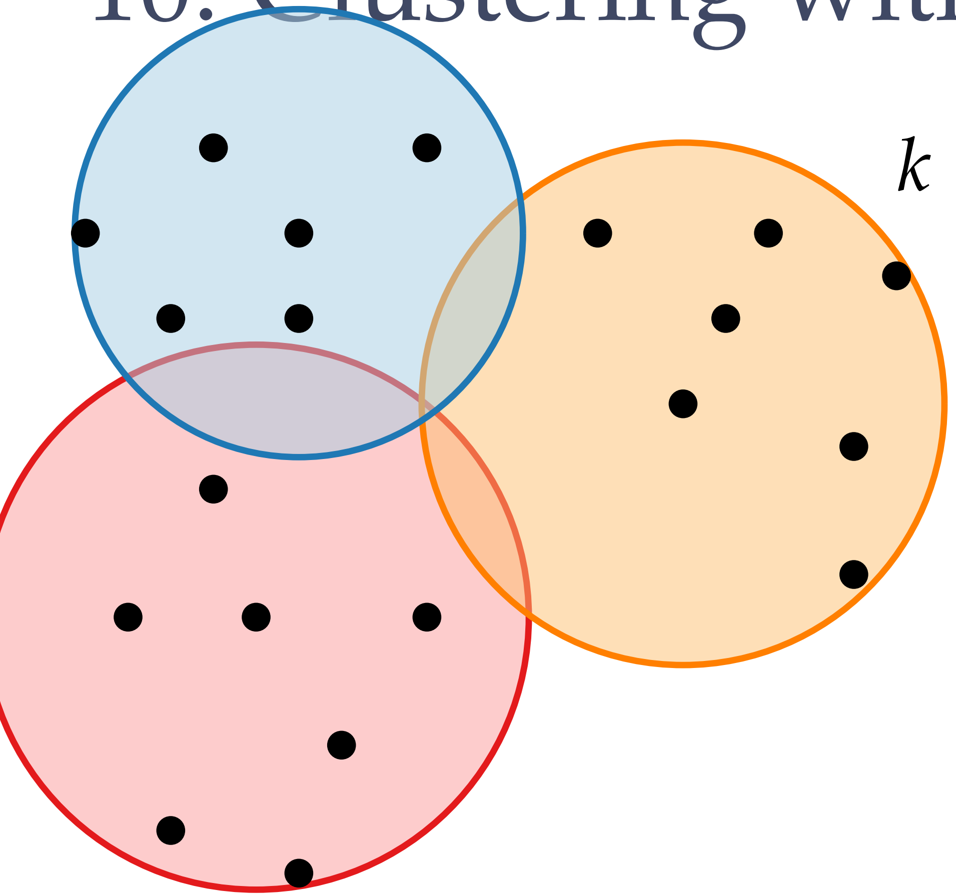

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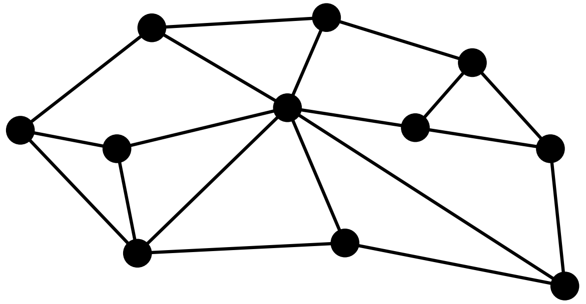
New: algorithms with better running time for $k = 2$ and $k = 3$.

11. Maximum Leaf Spanning Tree Approximations

Ein gegebener Graph kann viele verschiedene Spannbäume haben:



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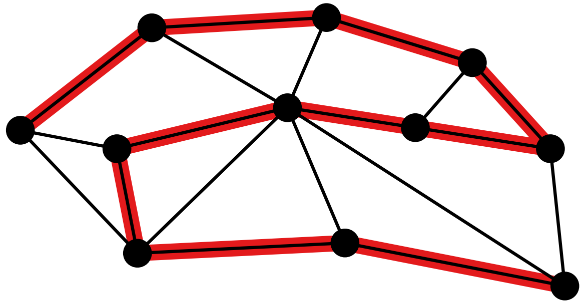

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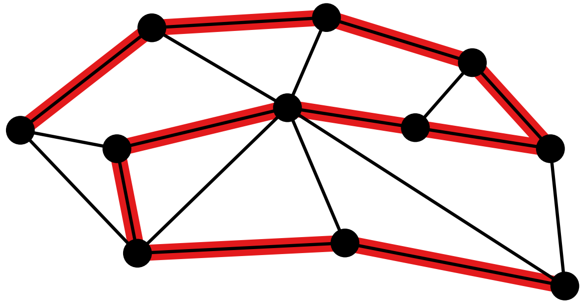

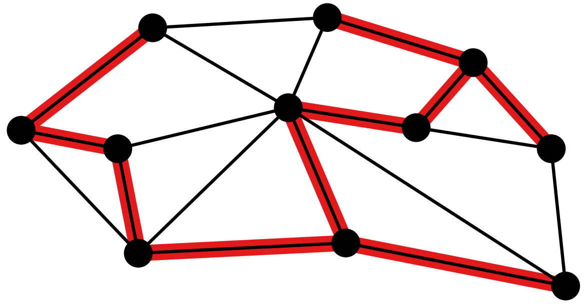

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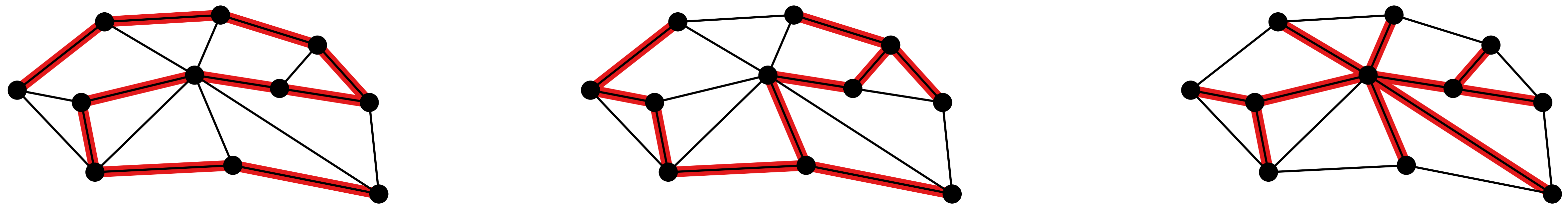

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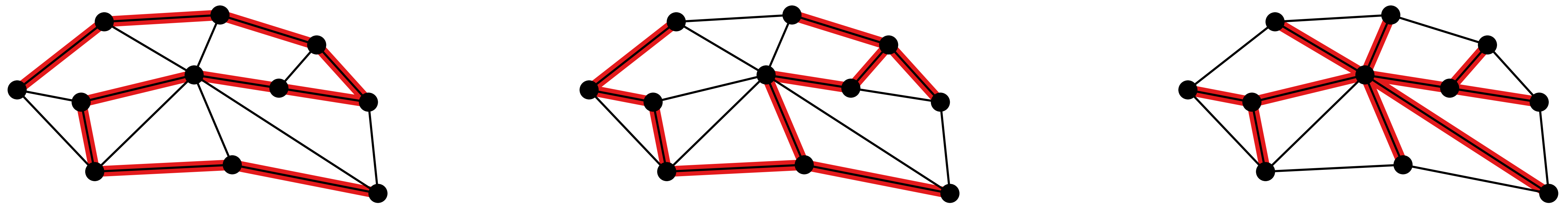

Gesucht: Ein Spannbaum mit vielen Blättern!

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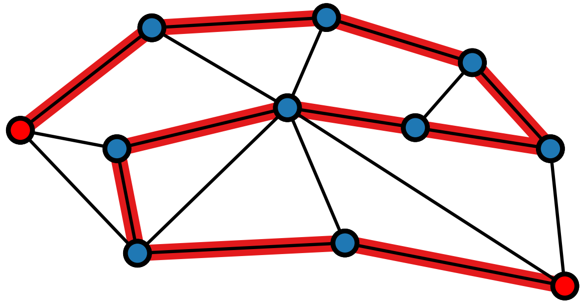
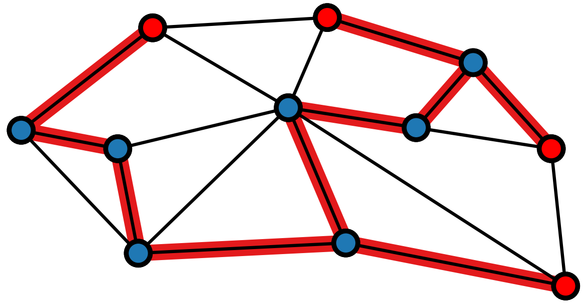


2 Blätter



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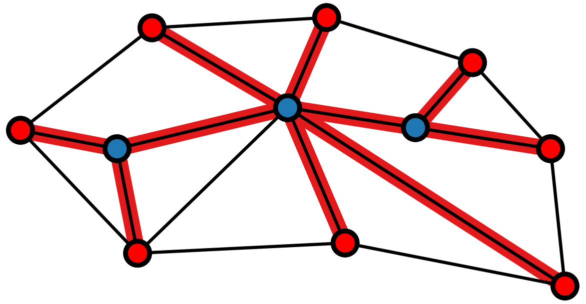

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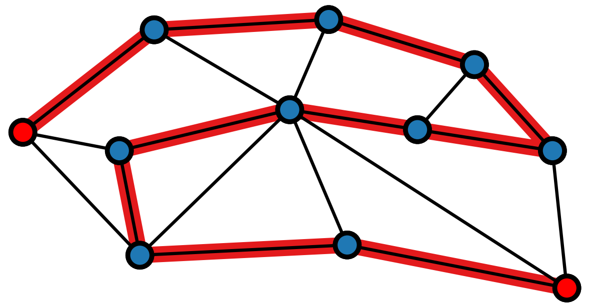

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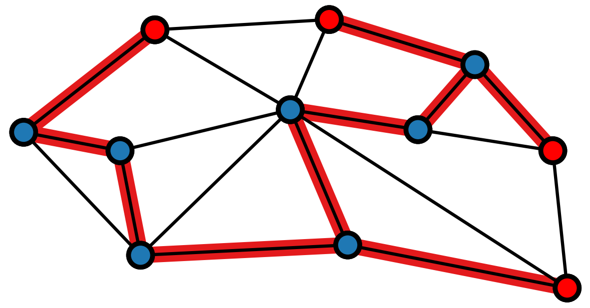

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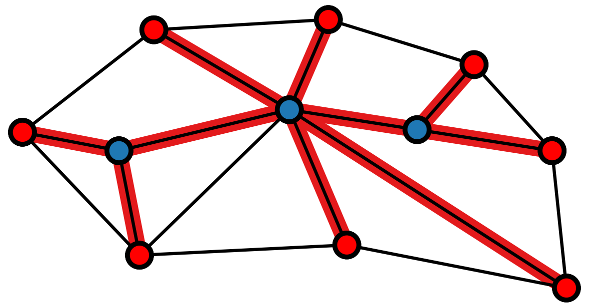

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Das entsprechende Maximierungsproblem ist NP-schwer :-(

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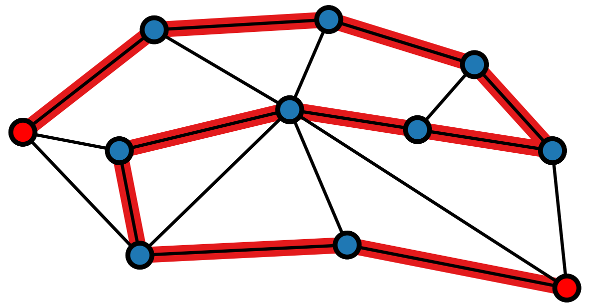

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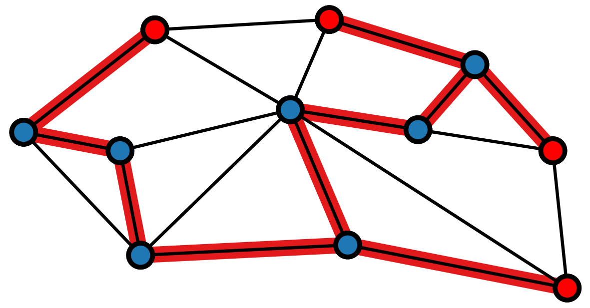

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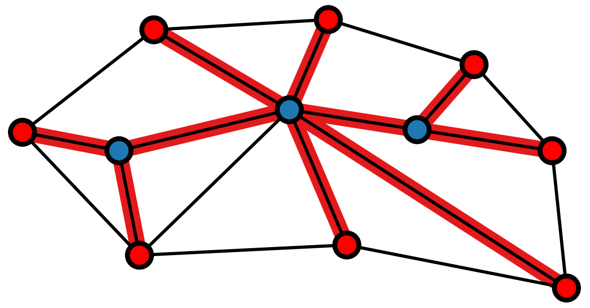

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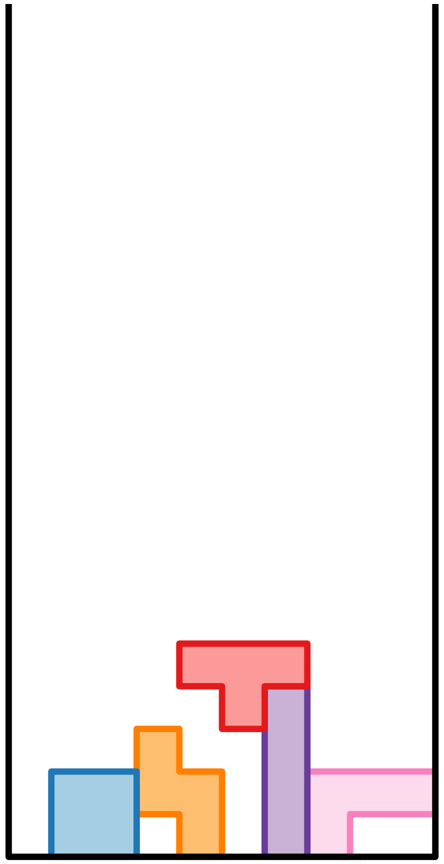
Hier: Wie sieht es mit Approximationsalgorithmen für dieses Problem aus?

12. NP-hard Puzzle Games: Tetris, Nondango



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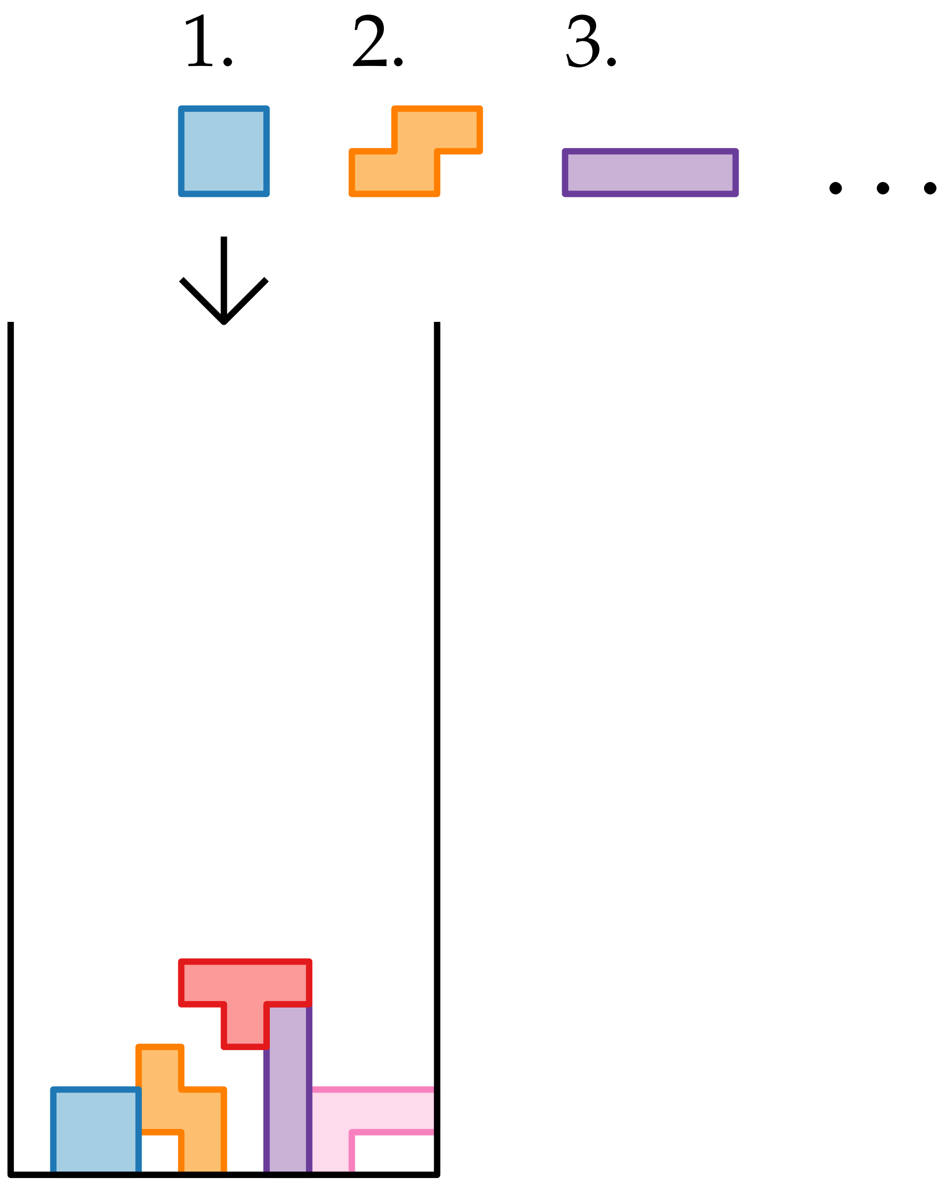

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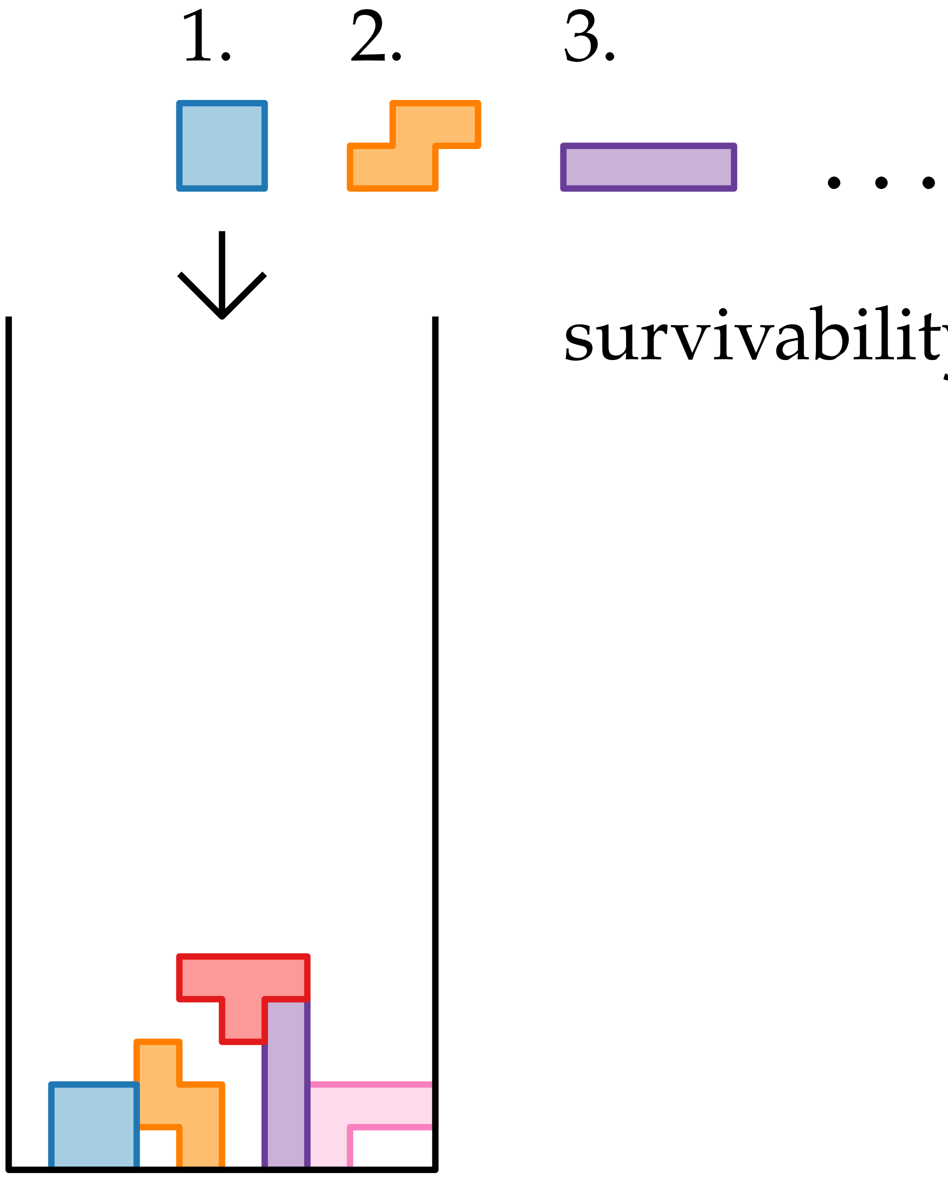

survivability?

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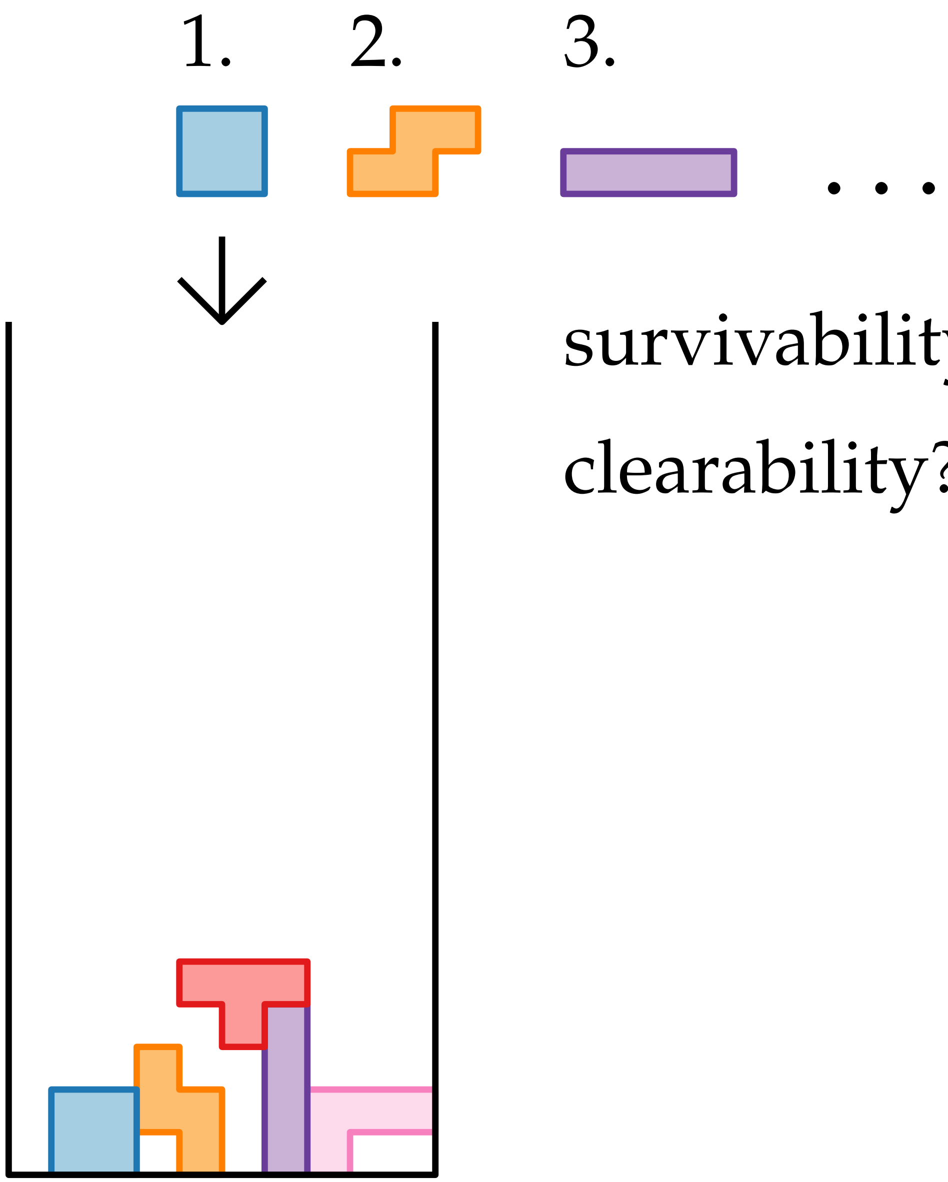

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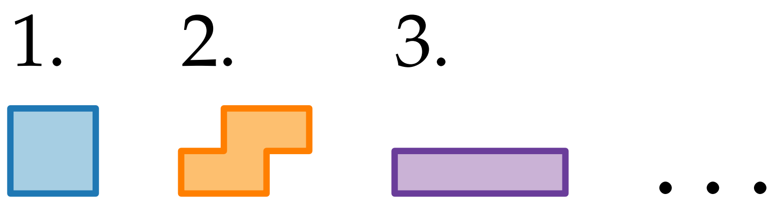

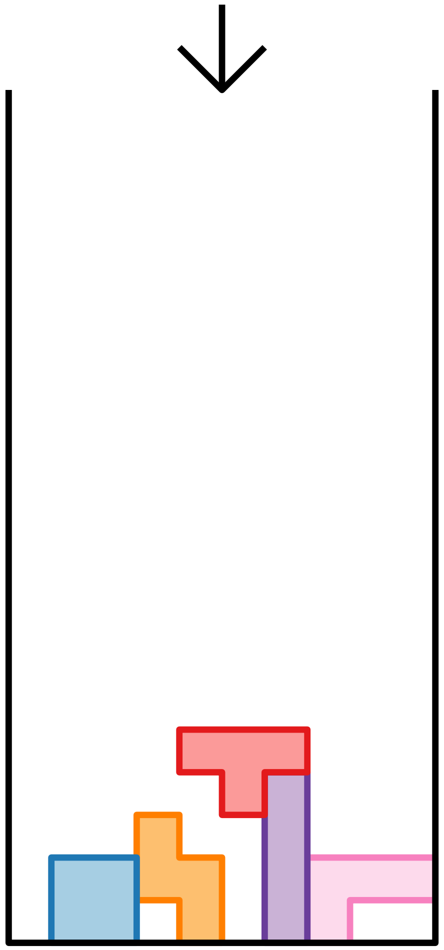

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#columns

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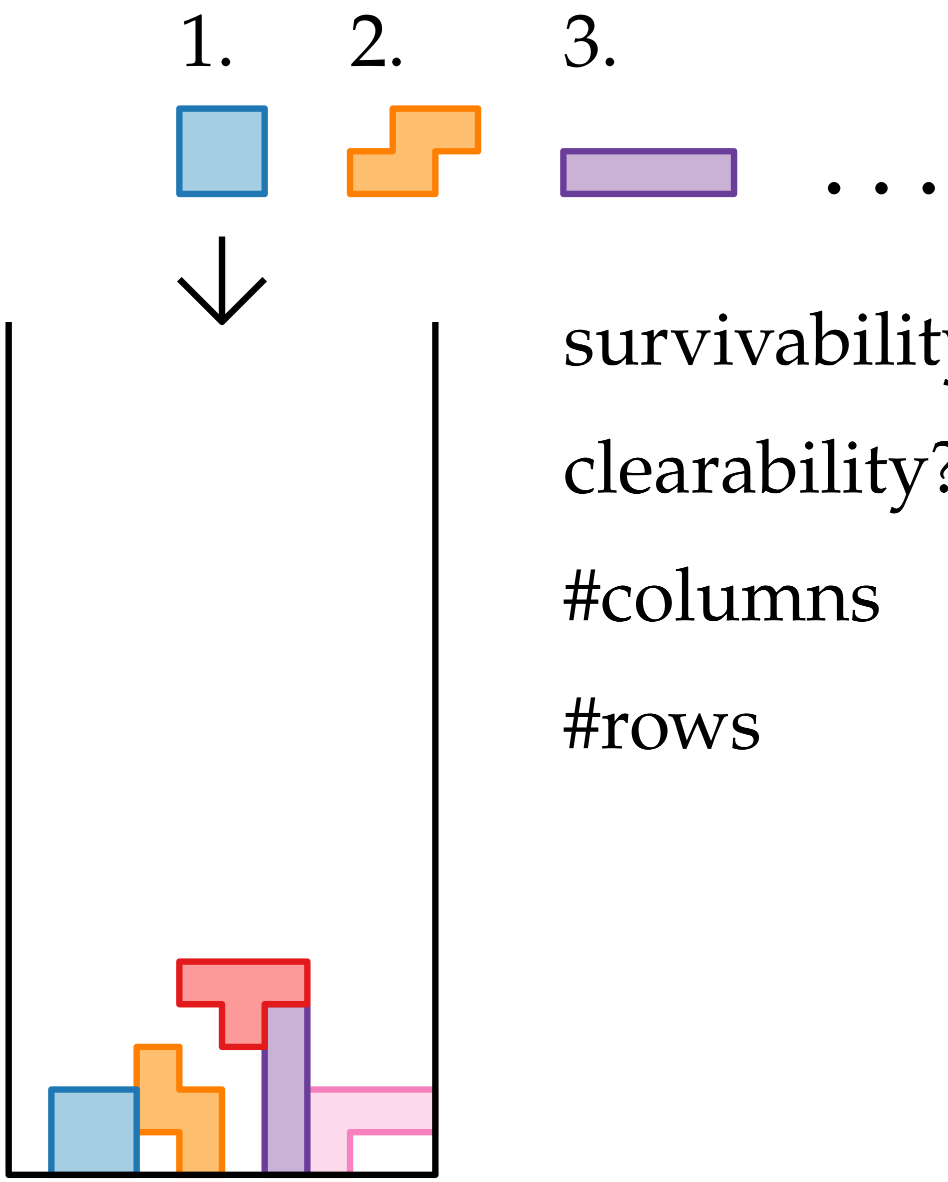

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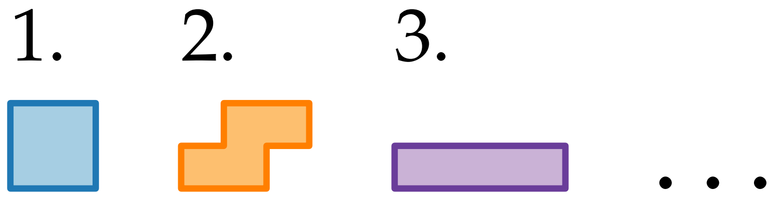

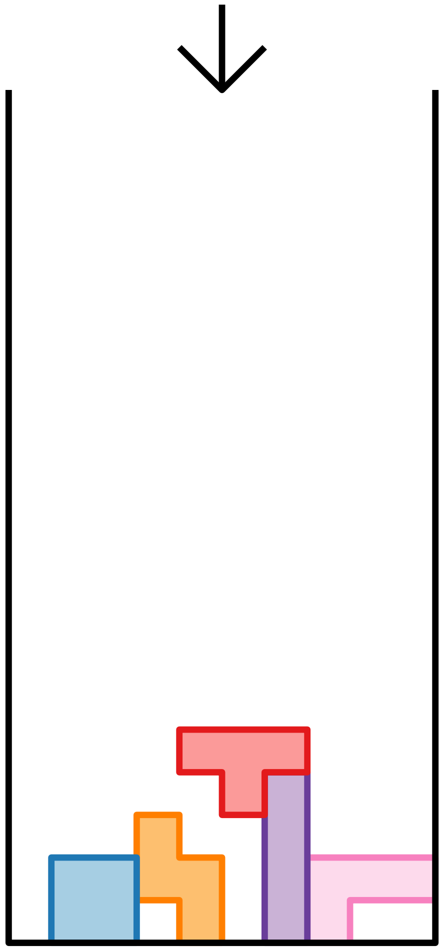

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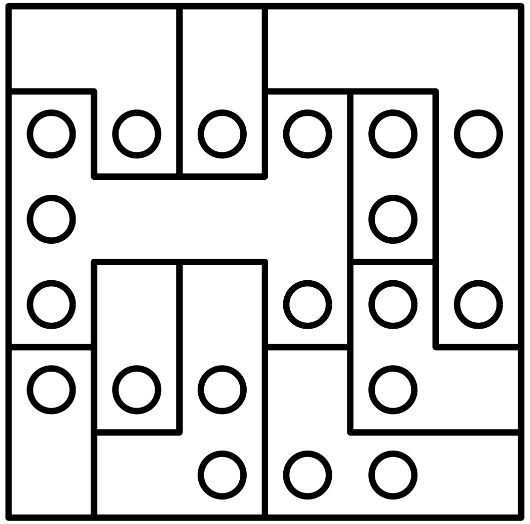

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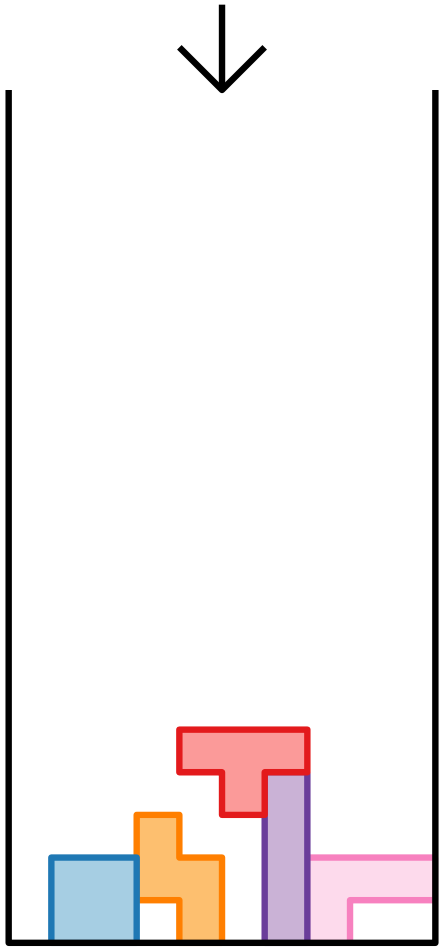

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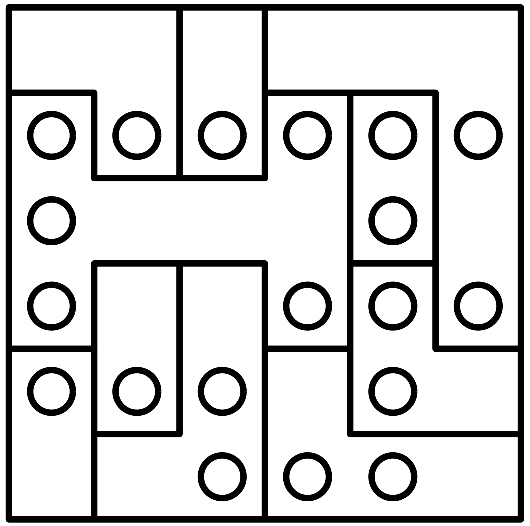

fill one circle per region

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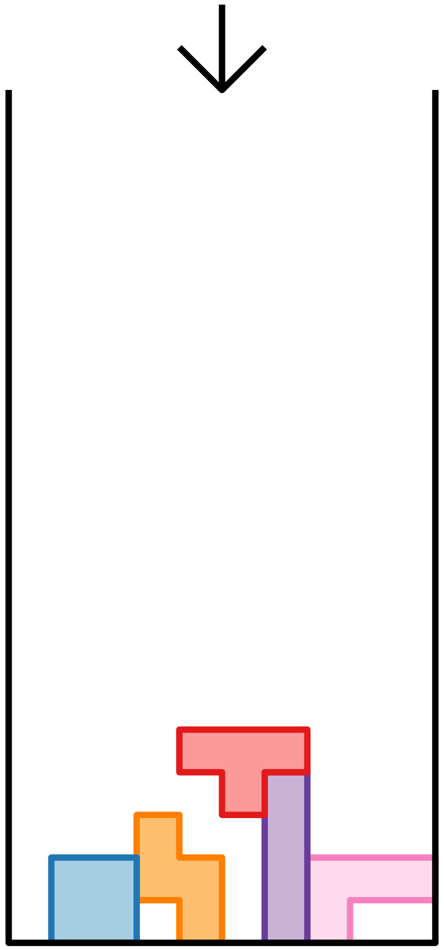

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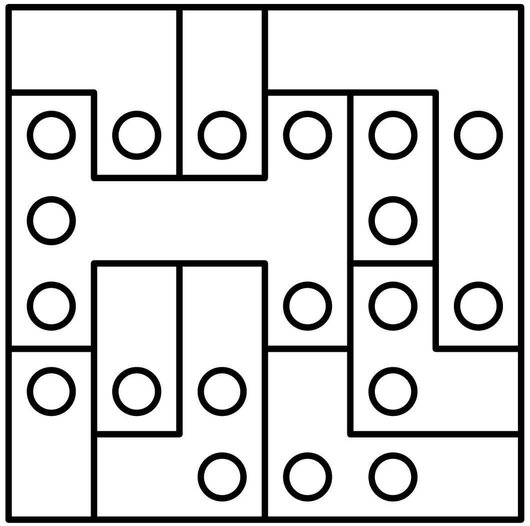

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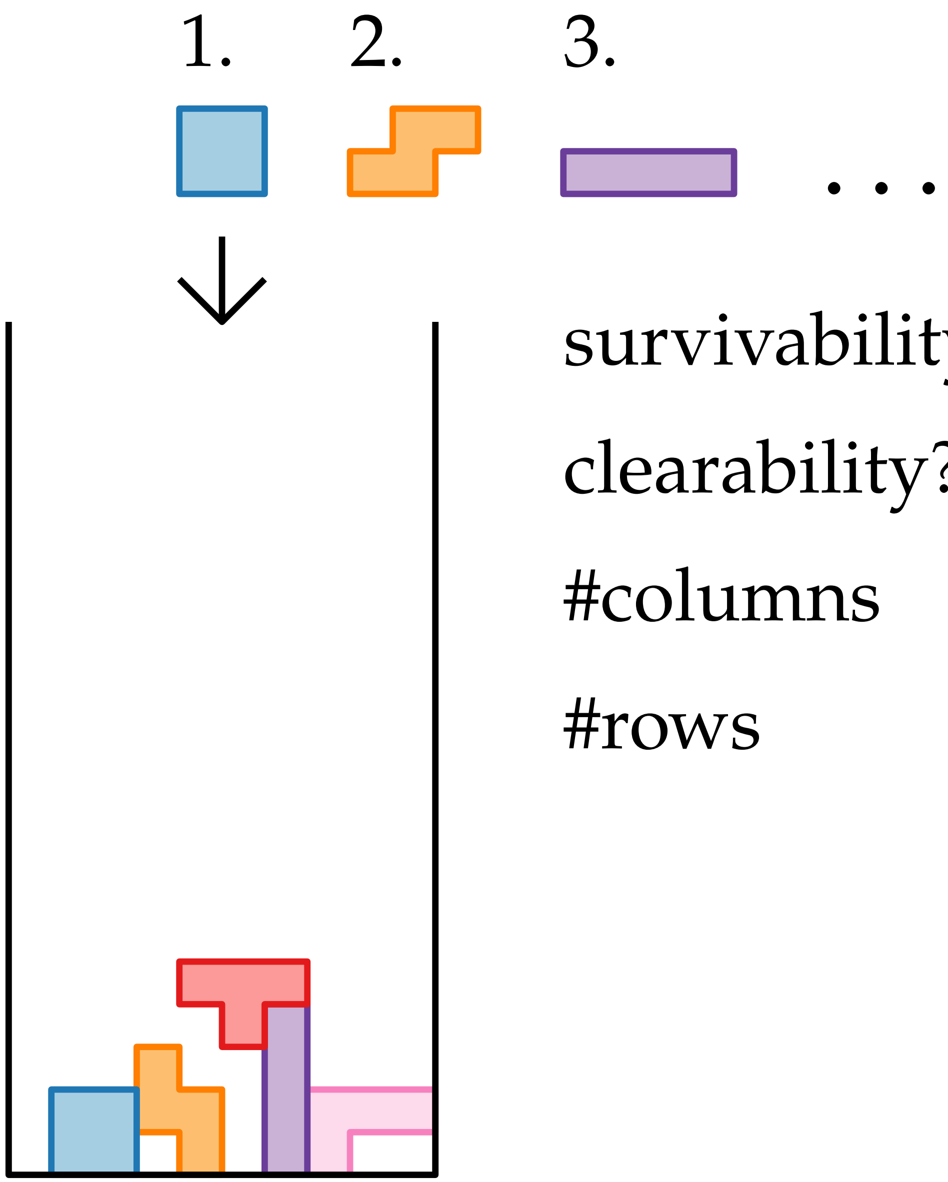

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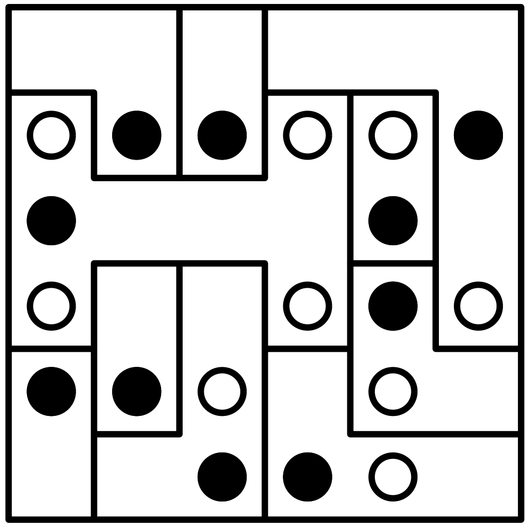

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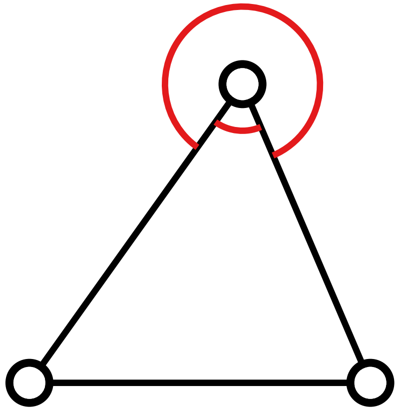
13. On the Complexity of Lombardi Graph Drawing

Lombardi-Zeichnung

- **Knoten:** Punkte in $\mathbb{R}^2$
- **Kanten:** Kreis- oder Liniensegmente
- **Bedingung:** Perfekte Winkelverteilung



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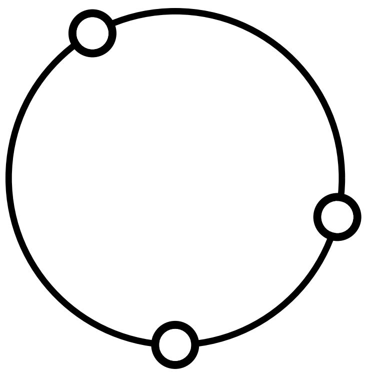

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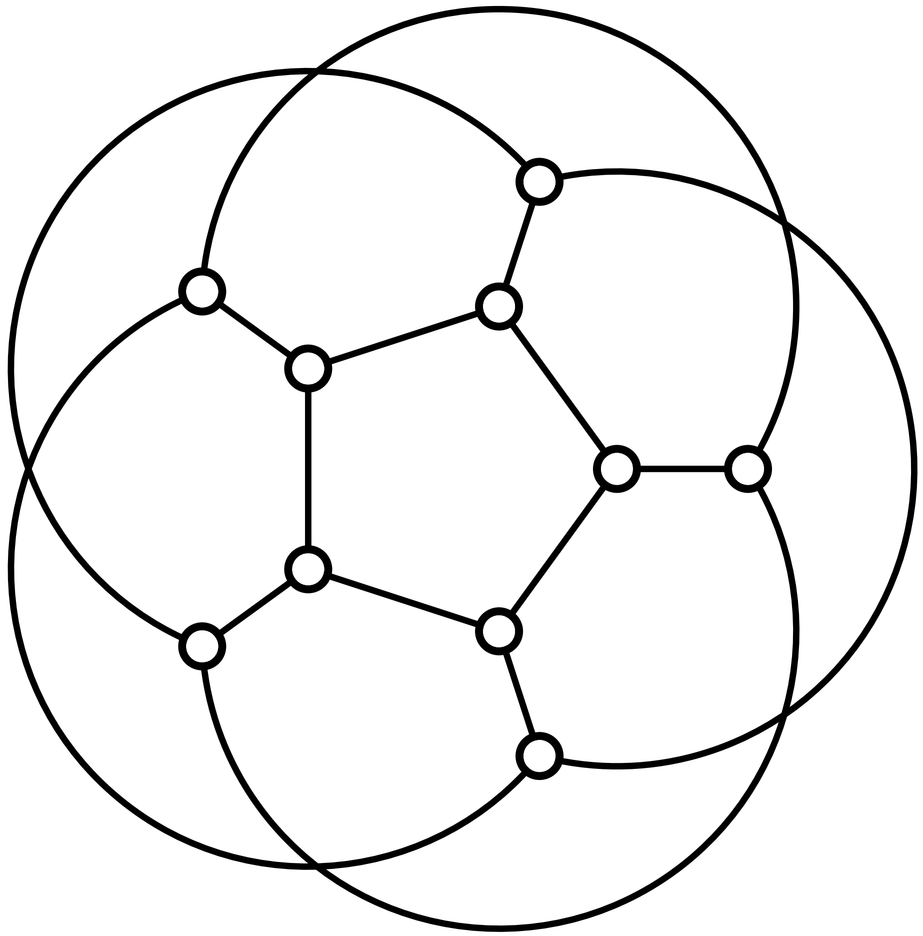

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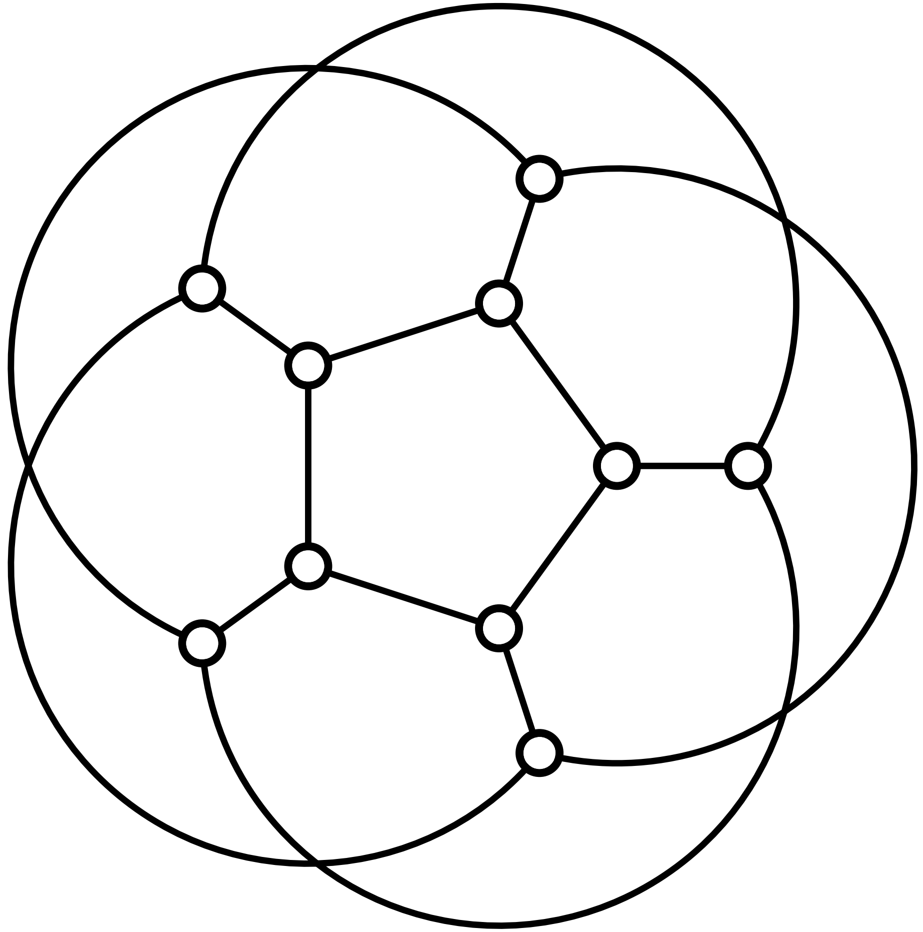

Gegeben: Graph G, Rotationssystem R.

Frage: Existiert eine Lombardi-Zeichnung von G, die R berücksichtigt?

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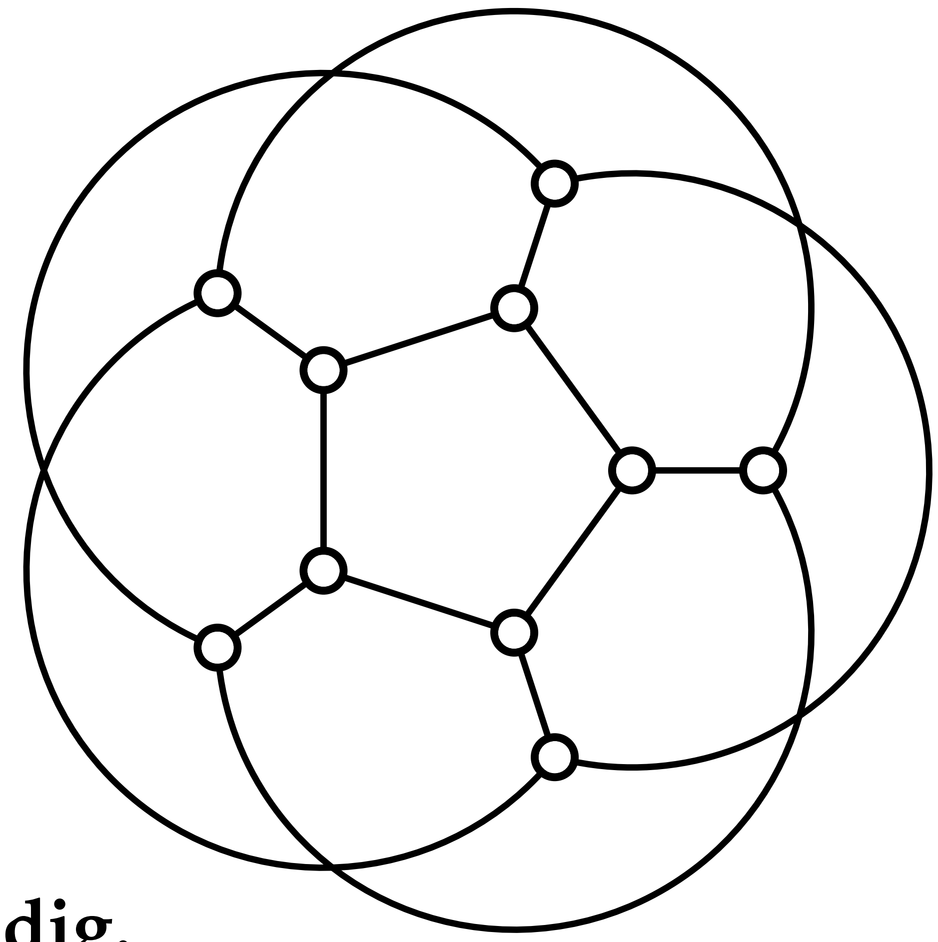


Gegeben: Graph G, Rotationssystem R.

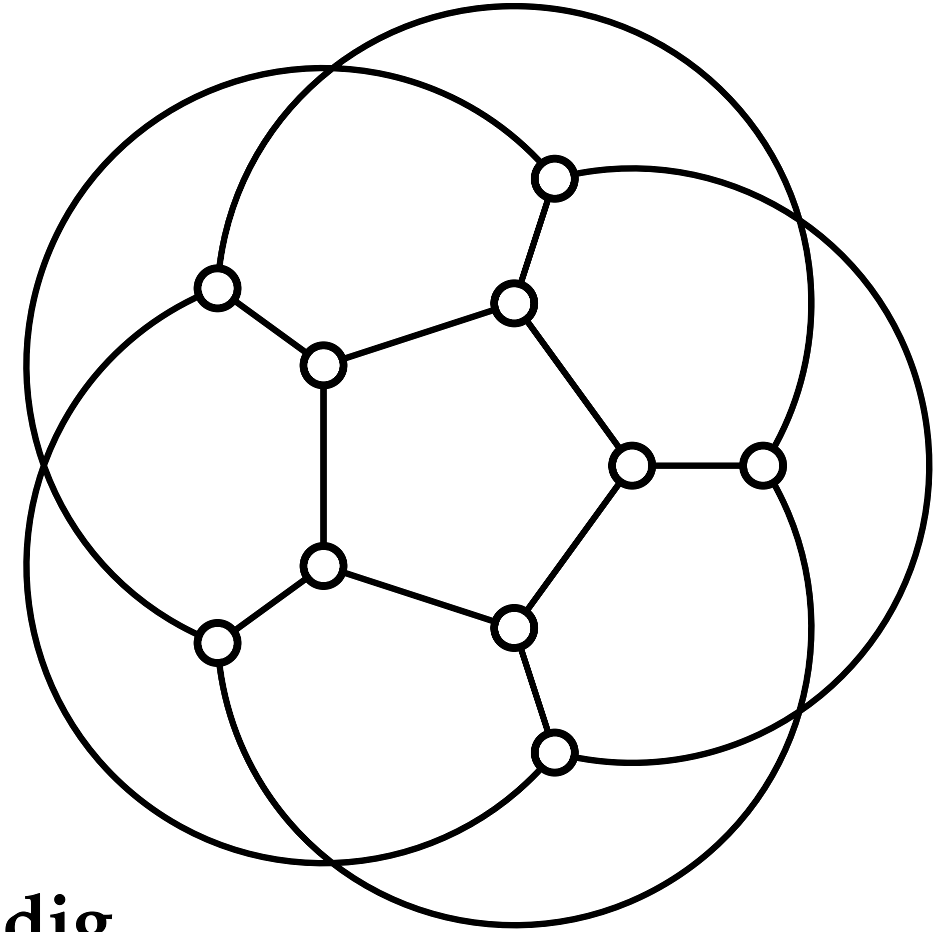
Frage: Existiert eine Lombardi-Zeichnung von G, die R berücksichtigt?

In diesem Seminar: **Das Problem ist $\exists\mathbb{R}$-vollständig.**

13. On the Complexity of Lombardi Graph Drawing

Lombardi-Zeichnung

- **Knoten:** Punkte in $\mathbb{R}^2$
- **Kanten:** Kreis- oder Liniensegmente
- **Bedingung:** Perfekte Winkelverteilung



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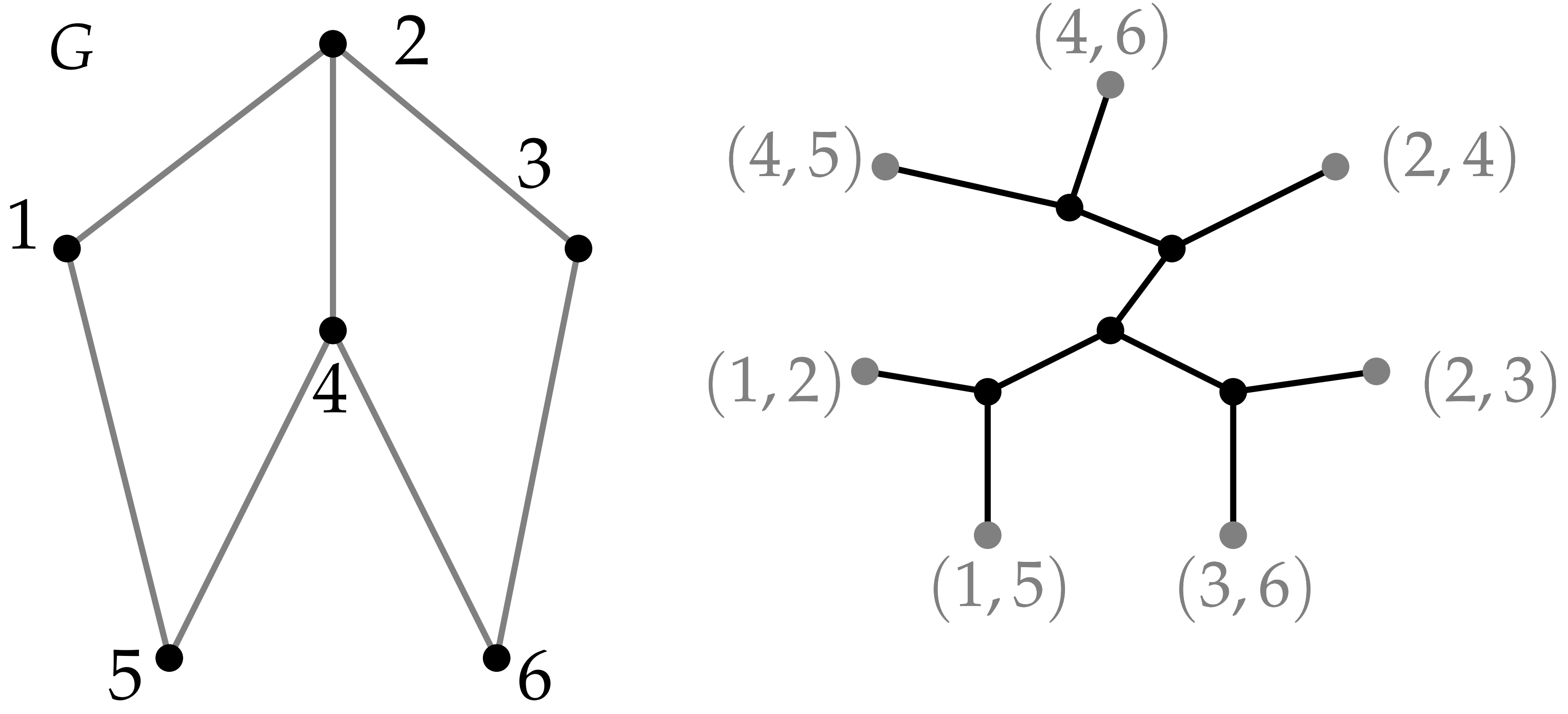
In diesem Seminar: **Das Problem ist $\exists\mathbb{R}$-vollständig.**

Komplexitätsklasse mit
$NP \subseteq \exists\mathbb{R} \subseteq PSPACE$

14. Sphere Cut Decompositions

Let G be a connected planar graph embedded in the sphere. A **Sphere-Cut Decomposition** of G is set of simple closed curves that impose a tree-like structure on the edges.



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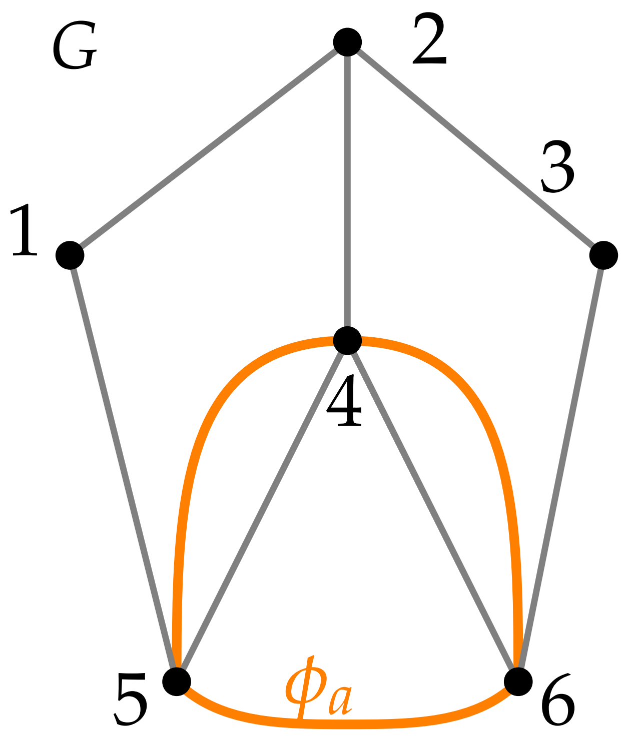

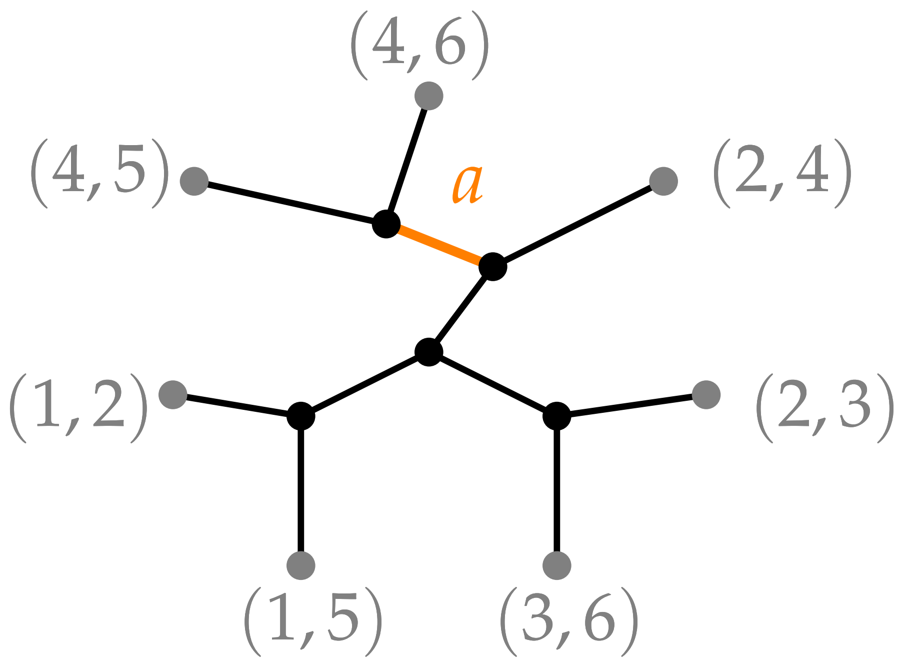

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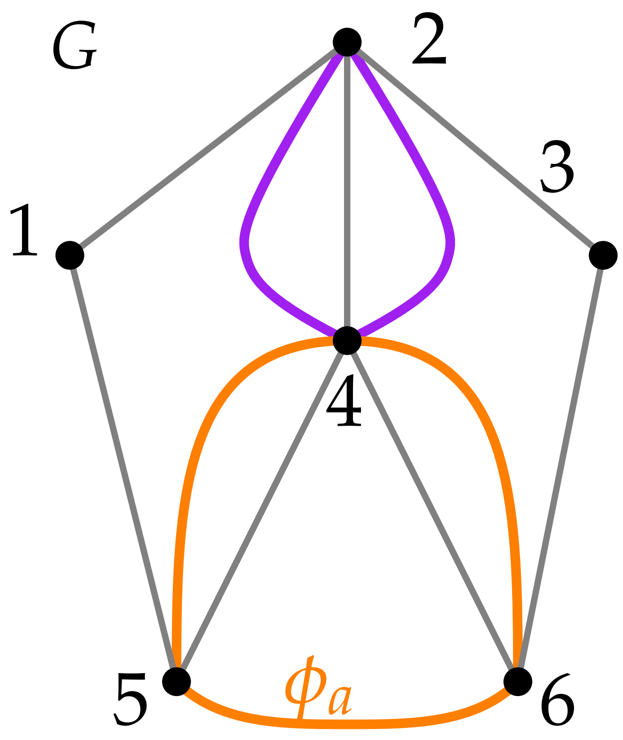

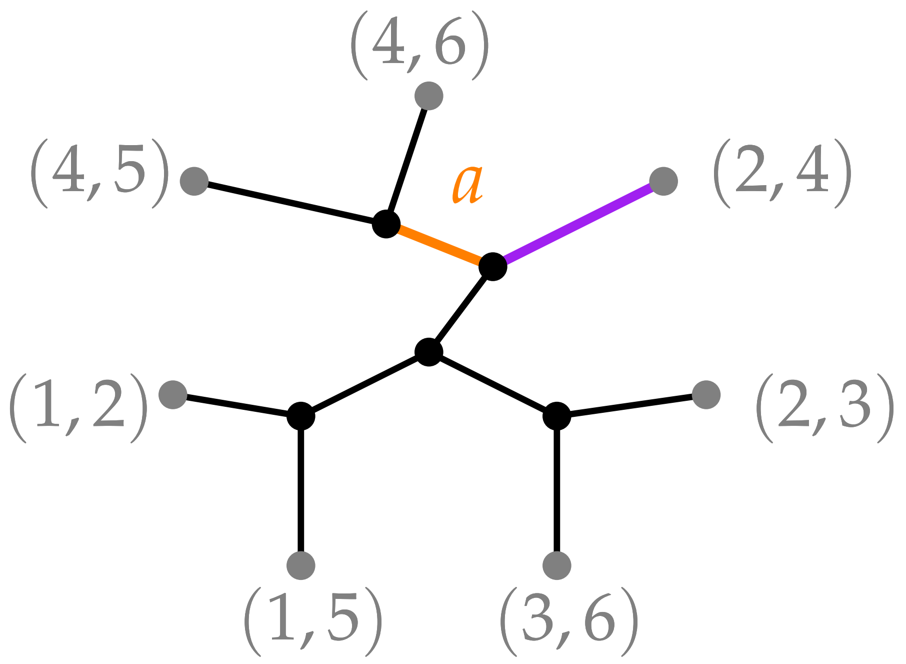

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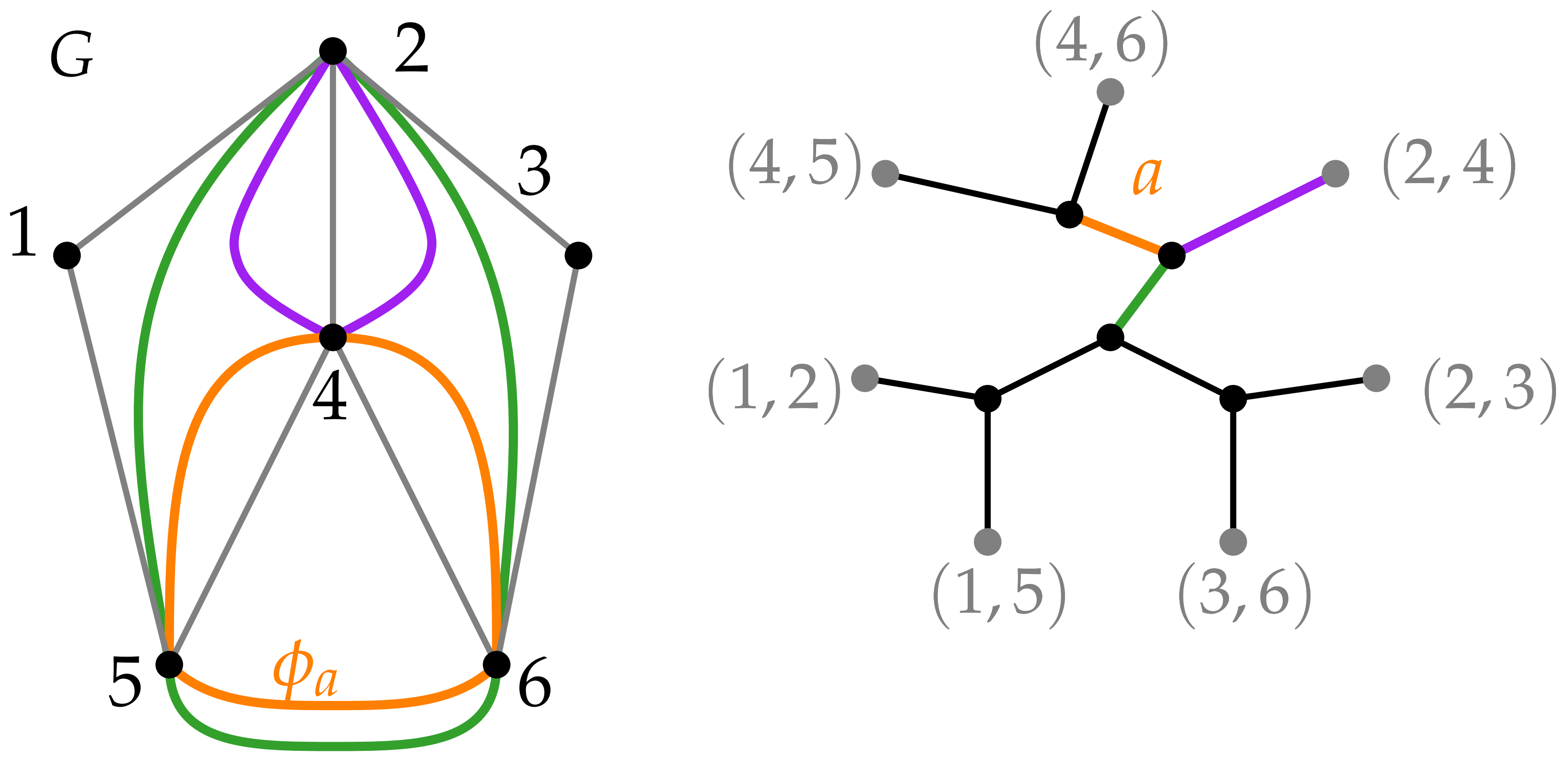

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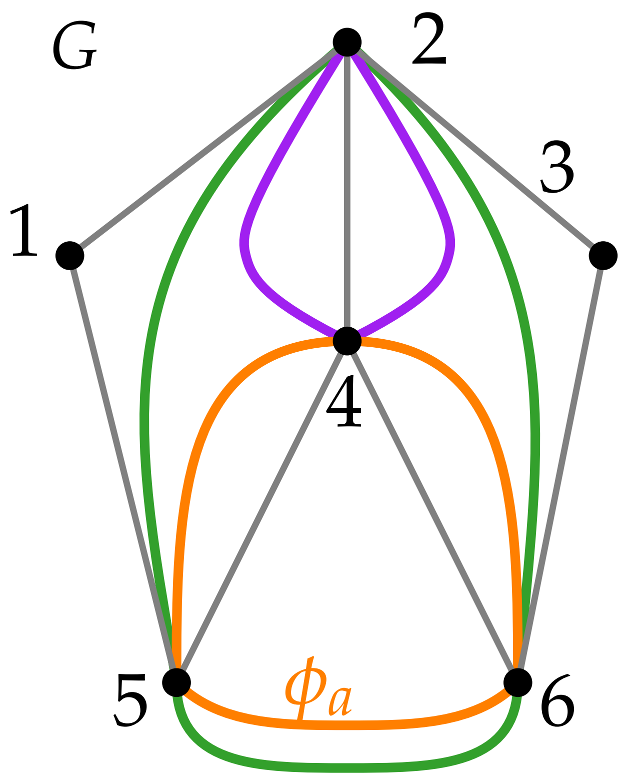

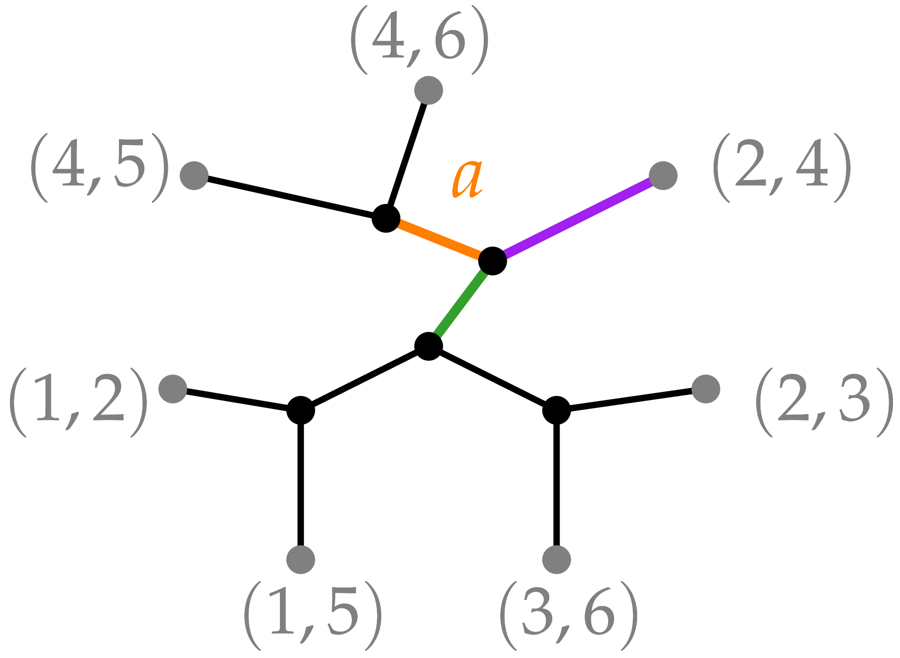

Can be exploited to find good exact algorithms for planar graphs!

15. Solving 2-SAT in Linear Time

Satisfiability (SAT)

Gegeben: Boolesche Formel in konjunktiver Normalform.

Frage: Gibt es eine erfüllende Belegung?

$$(A \vee \neg B \vee \neg C) \wedge (B \vee C \vee \neg D) \wedge (B \vee \neg D \vee E) \wedge (\neg B \vee D \vee \neg E)$$

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k-SATISFIABILITY (k-SAT): Wie SAT, aber jede Klausel darf $\leq k$ Literale enthalten.

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eine 3-SAT Formel

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← eine 3-SAT Formel

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$(A \lor B)$

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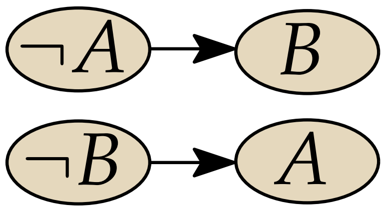

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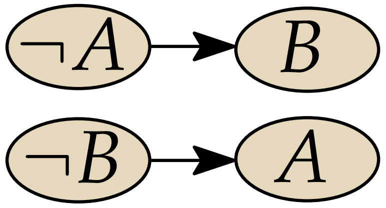
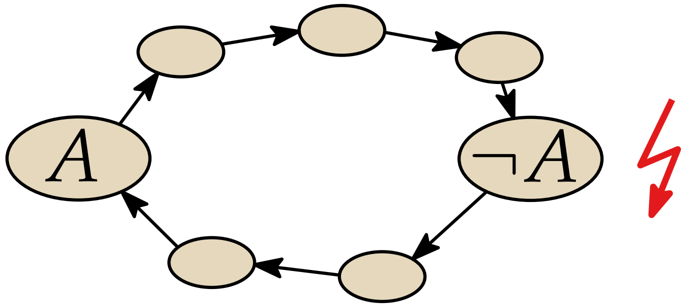


Gerichtete Kreise geben Aufschluß über Lösbarkeit!



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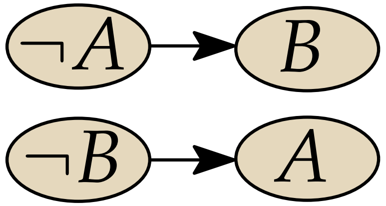

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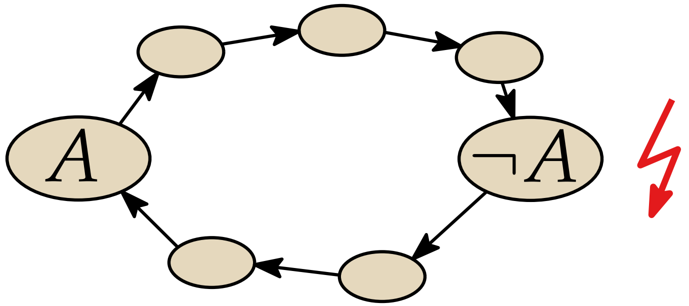

Hauptschwierigkeit: Berechnung der starken Zusammenhangskomponenten.

Themenverteilung

1. Global and local edge-length ratios of planar straight line graph drawings
2. Recognition Complexity of Subgraphs of 2- and 3-Connected Planar Cubic Graphs
3. Min-k-planar Drawings of Graphs
4. On RAC Drawings of Graphs with Two Bends per Edge
5. Edge-disjoint Plane Spanning Paths in a Point Set
6. Parameterized Complexity of Simultaneous Planarity
7. Removing Popular Faces in Curve Arrangements
8. Computing the Enclosing Depth
9. Robust Bichromatic Classification with Lines
10. Clustering with Few Disks to Minimize the Sum of Radii
11. Maximum Leaf Spanning Tree Approximations
12. NP-hard Puzzle Games: Tetris, Nondango
13. On the Complexity of Lombardi Graph Drawing
14. Efficient Exact Algorithms on Planar Graphs: Exploiting Sphere Cut Decompositions
15. Solving 2-SAT in Linear Time

Nächste Schritte

- In WueCampus anmelden

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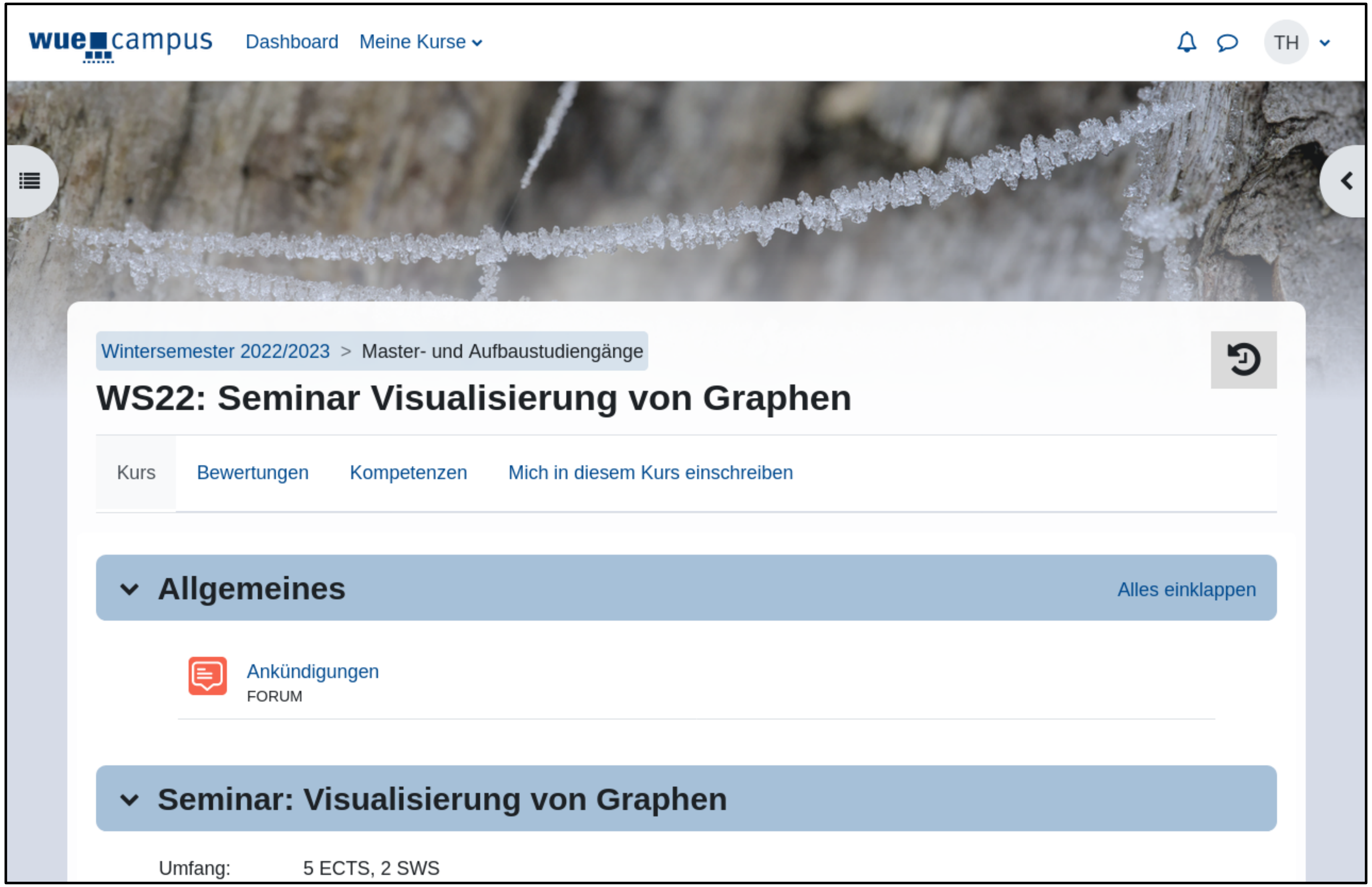

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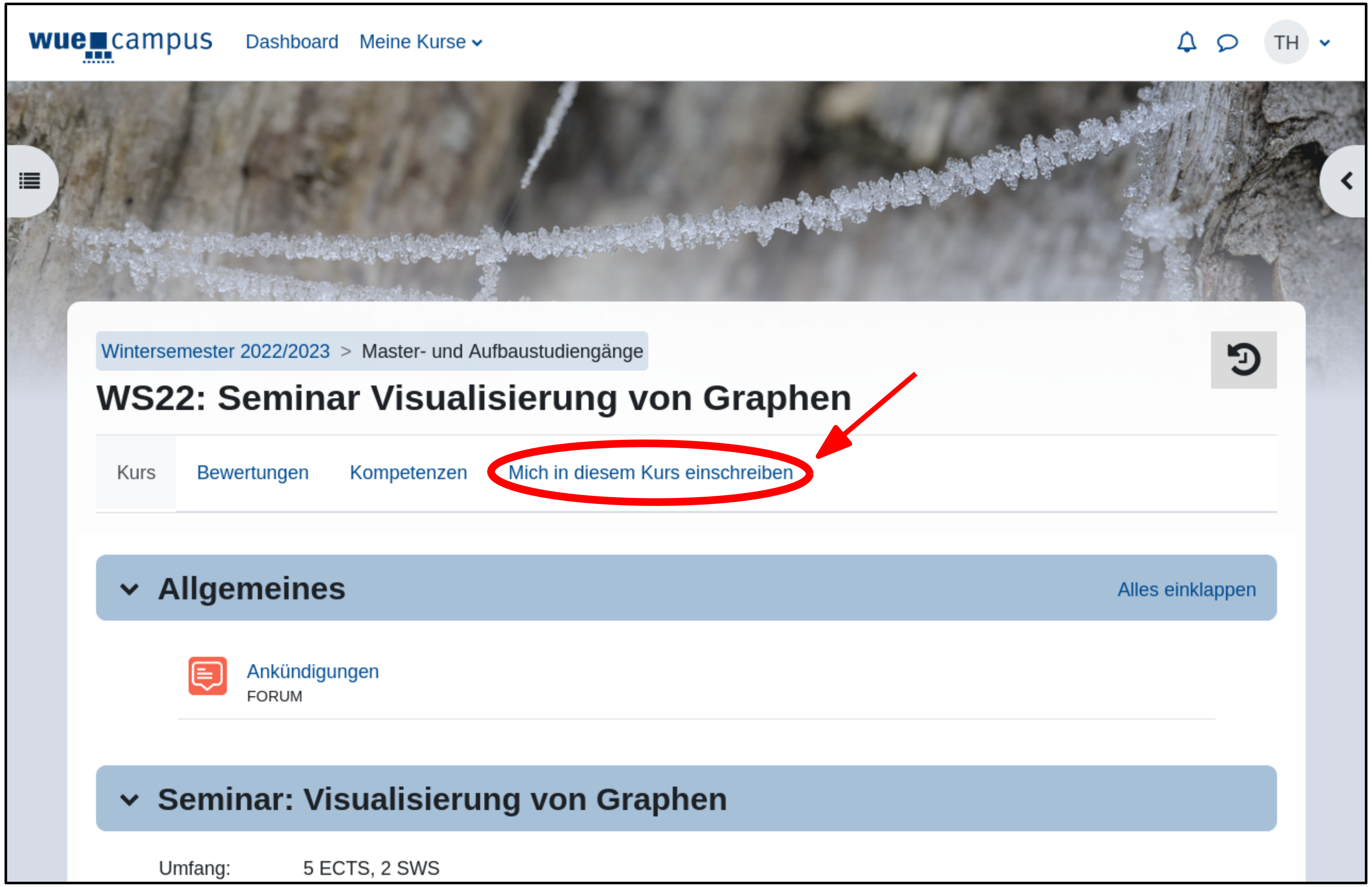

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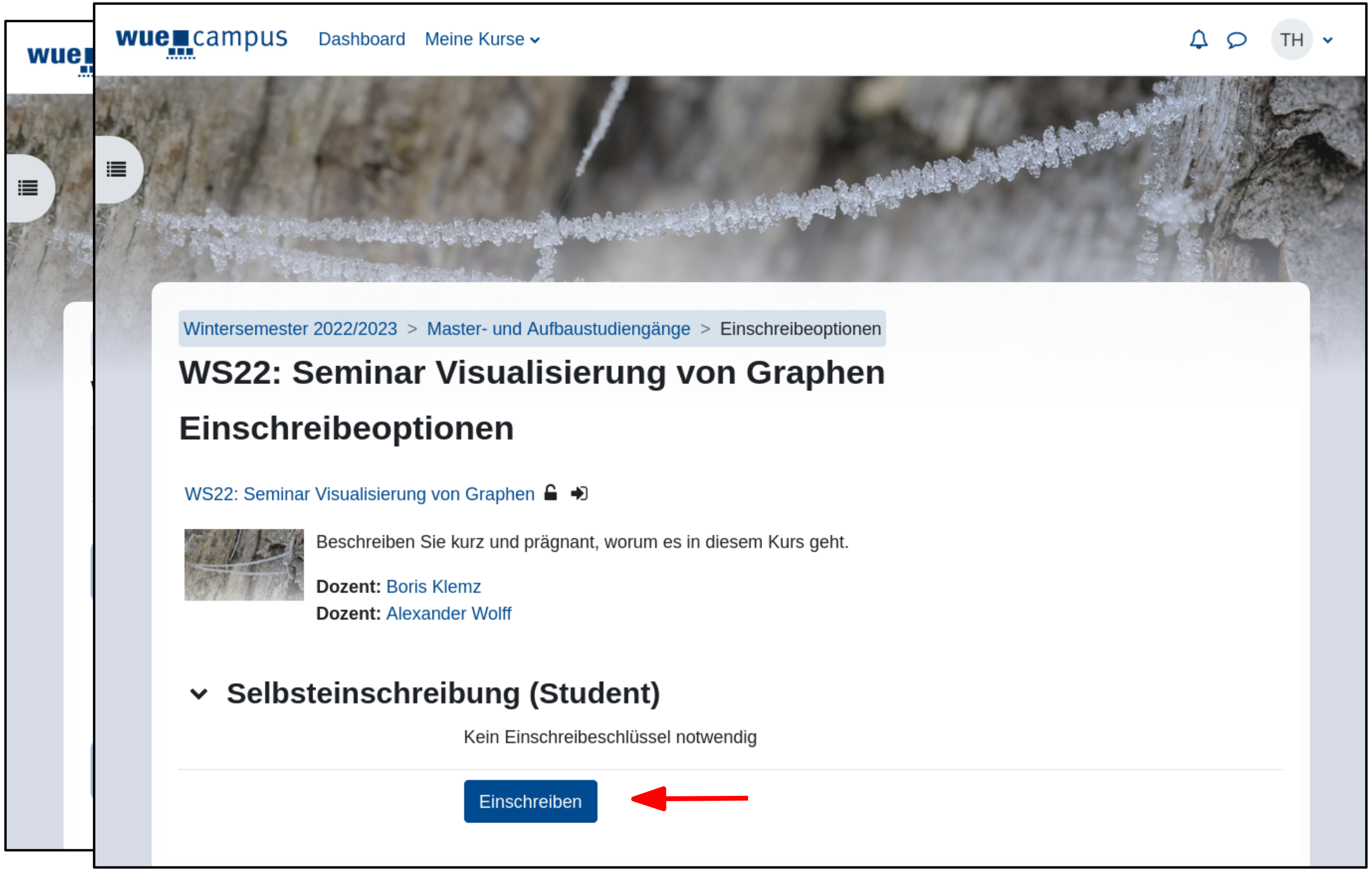

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Zum Abschluss:

Demonstration des Programms IPE
zum Erstellen von Abbildungen und Folien

http://ipe.otfried.org/

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