

# PhD Thesis Title

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## Thesis Subtitle

Doctoral thesis for obtaining the academic degree of  
Doctor of Engineering Sciences (Dr.-Ing.)

submitted by

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at the



**BERGISCHE  
UNIVERSITÄT  
WUPPERTAL**

School of Electrical, Information and Media Engineering  
Data & Knowledge Engineering Group

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Chairperson	Prof. Dr. Chair Person
Supervisor	Prof. Dr. First Supervisor
Supervisor	Second Supervisor, PhD
Adviser	Dr. Ad Viser

Wuppertal, 2021



## Front Matter

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### Contents

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FRONT MATTER .....	iii
List of Figures.....	v
List of Tables.....	vii
Abstract.....	ix
Zusammenfassung .....	xi
Acknowledgements.....	xiii
 CHAPTER 1	
<b>Introduction</b> .....	<b>1</b>
1.1 Elements of This Template.....	1
1.2 Example Section .....	4
1.3 Example Outline .....	5
1.3.1 Example Overview of Publications .....	5
 CHAPTER 2	
<b>Related Work</b> .....	<b>7</b>
2.1 Background and Overview .....	7
2.2 Formats and Conversions.....	7
2.3 Presentation and Content.....	7
2.3.1 Subsection .....	7
2.3.2 Subsection 2 .....	8
2.3.3 Subsection 3 .....	8
2.4 Closing Section .....	8
 BACK MATTER .....	<b>9</b>
Appendix .....	9
A My First Appendix .....	9
B Another Appendix .....	9
C Appendix With Subsections .....	9
C.1 A Nested Subsection.....	9
C.2 Another Subsection.....	10
C.3 And Another .....	10
D My Last Appendix .....	10
Glossary .....	11
Bibliography of Publications, Submissions & Talks.....	13
Bibliography .....	15



List of Figures

1.1 Short caption for the List of Figures. . . . . 3



Front Matter

List of Tables

1.1 Example table with math and verbatim texts. . . . . 1

1.2 Short caption for LOTS. . . . . 2

1.3 Example of short caption for the List of Tables. . . . . 5





# FRONT MATTER

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## Abstract

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Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

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Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

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## FRONT MATTER

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### Zusammenfassung

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### Acknowledgements

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Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

*I went to the woods because I wanted to live deliberately. I wanted to live deep and suck out all the marrow of life. To put to rout all that was not life; and not, when I had come to die, discover that I had not lived.*

Neil Perry - *Dead Poet Society*

# CHAPTER 1

## Introduction

### Contents

1.1	Elements of This Template.....	1
1.2	Example Section .....	4
1.3	Example Outline .....	5
1.3.1	Example Overview of Publications .....	5

The following content outlines a typical section structure. It is intended to show you how the structure may look like including tables, pictures, and several examples of info boxes. Note also the glossary entries, such as BM25 [3], or math glossary links, such as  $\text{mBM25}(t, d)$ . Those are linked to the glossary in the PDF. All colors are defined in the `preamble.tex` file. Feel free to change them. There are two color modes, the non-printing and the printing mode. The printing mode is intended to reduce the number of colored pages (e.g., the vertical line on each page next to the page number will be gray rather than blue in print mode) but keep the highlights (e.g., info boxes) colored.

### 1.1 Elements of This Template

Here is an example of cool tables.

Table 1.1: Example table with math and verbatim texts.

System	Representation
Rendered Version	$P_n^{(\alpha, \beta)}(\cos(a\Theta))$
Generic $\text{\LaTeX}$	<code>P_n^{\{(\alpha, \beta)\}}(\cos(a\Theta))</code>
Semantic $\text{\LaTeX}$	<code>\JacobipolyP{\alpha}{\beta}{n}@{\cos@{a\Theta}}</code>
Maple	<code>JacobiP(n, alpha, beta, cos(a*Theta))</code>
Mathematica	<code>JacobiP[n, \[Alpha], \[Beta], Cos[a \[CapitalTheta]]]</code>
SymPy	<code>jacobi(n,Symbol('alpha'),Symbol('beta'),cos(a*Symbol('Theta')))</code>

And a figure.

Table 1.2: Table with colorful ticks and crosses.

$\LaTeX$	Rendering	MM	SP	ST	WA	LCT <sub>1</sub>
$\int_a^b x \, dx$	$\int_a^b x dx$	✗	✓	✗	✓	✗
$\int_a^b x \, \mathrm{d}x$	$\int_a^b x dx$	✗	✗	✗	✓	✗
$\int_a^b x \backslash, \, dx$	$\int_a^b x dx$	✓	✓	✗	✓	✗
$\int_a^b x \backslash; \, dx$	$\int_a^b x dx$	✗	✓	✗	✓	✗
$\int_a^b x \backslash, \, \mathrm{d}x$	$\int_a^b x dx$	✗	✗	✗	✓	✗
$\int_a^b \frac{dx}{x}$	$\int_a^b \frac{dx}{x}$	✗	✓	✗	✓	✗
$\sum_{n=0}^N n^2$	$\sum_{n=0}^N n^2$	✓	✓	✓	✓	✓
$\sum_{n=0}^N n^2 + n$	$\sum_{n=0}^N n^2 + n$	?	?	✗	?	?
$\{n \choose m\}$	$\binom{n}{m}$	✗	✗	✗	✓	✗
$\mathrm{binom}\{n\}\{m\}$	$\binom{n}{m}$	✓	✓	✓	✓	✓
$P_n^{(\alpha, \beta)}(\cos(a\Theta))$	$P_n^{(\alpha, \beta)}(\cos(a\Theta))$	✓	✗	✗	✗	✓
$\cos(a\Theta)$	$\cos(a\Theta)$	✓	✓	✓	✓	✓
$\frac{d}{dx} \sin(x)$	$\frac{d}{dx} \sin(x)$	✗	✓	✗	✓	✗

And a lot of different information boxes. Take a look at `boxexample.tex` for further details.

**Research Objective**  
  
Your thesis objective

**Research Tasks Box**  
  
I Curabitur dictum gravida mauris.  
II Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna.  
III Donec vehicula augue eu neque.  
IV Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas.  
V Mauris ut leo.

**Small Icon Info Box**  
With additional infos.

**Example Box**  
With an example



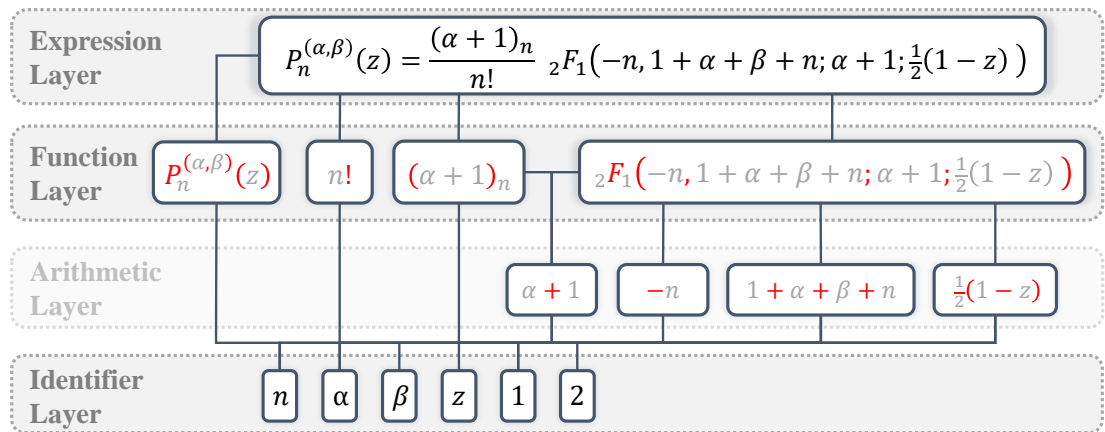






Figure 1.1: Long caption directly below the picture.

**Single Line Info Box:** With normal font following.




“Discovering Mathematical Objects of Interest — A Study of Mathematical Notations” by **André Greiner-Petter**, Moritz Schubotz, Fabien Müller, Corinna Bretinger, Howard S. Cohl, Akiko Aizawa, and Bela Gipp. **In:** *Proceedings of the Web Conference (WWW)*, 2020.


Chapter 2 — [\[1\]](#)

**Definition 1.1: Definition Box**


A nice definition box.

**Translation Box**

Usually you want nice code box inside, see the next box as an example.

**Translation Box with Code**

```
1 P_n^{\{(\alpha, \beta)\}}(z) = \frac{(\alpha+1)_n}{n!} {}_2F_1\left(-n, 1+\alpha+\beta+n; \alpha+1; \frac{1}{2}(1-z)\right)
```

**Translation Box with Custom Code**

```
1 diff( exp(z^2)*erfc(z), [z$(n)] ) = (-1)^(n)*(2)^(n)*factorial(n)*exp(z^2)*erfc(n, z)
```

Redundant parentheses removed to improve readability.



### Translation of Bailey's Transformation of Very-Well-Poised ${}_8\phi_7$

```
QHypergeometricPFQ[{a, q*(a)^(Divide[1,2]), -q*(a)^(Divide[1,2]), b, c, d, e, f}, {
  a^(Divide[1,2]), -(a)^(Divide[1,2]), a*q/b, a*q/c, a*q/d, a*q/e, a*q/f}, q,
  Divide[(a)^(2)*(q)^(2), b*c*d*e*f]]
== Divide[Product[QPochhammer[Part[{a*q, a*q/(d*e), a*q/(d*f), a*q/(e*f)}, i], q,
  Infinity], {i, 1, Length[{a*q, a*q/(d*e), a*q/(d*f), a*q/(e*f)}]}], Product[
  QPochhammer[Part[{a*q/d, a*q/e, a*q/f, a*q/(d*e*f)}, i], q, Infinity], {i, 1,
  Length[{a*q/d, a*q/e, a*q/f, a*q/(d*e*f)}]}]] * QHypergeometricPFQ[{a*q/(b*c
  ), d, e, f}, {a*q/b, a*q/c, d*e*f/a}, q, q]
+ Divide[Product[QPochhammer[Part[{a*q, a*q/(b*c), d, e, f, (a)^(2)*(q)^(2)/(b*d*
  e*f), (a)^(2)*(q)^(2)/(c*d*e*f)}, i], q, Infinity], {i, 1, Length[{a*q, a*q/(b
  *c), d, e, f, (a)^(2)*(q)^(2)/(b*d*e*f), (a)^(2)*(q)^(2)/(c*d*e*f)}]}],
  Product[QPochhammer[Part[{a*q/b, a*q/c, a*q/d, a*q/e, a*q/f, (a)^(2)*(q)^(2)/
  (b*c*d*e*f), d*e*f/(a*q)}, i], q, Infinity], {i, 1, Length[{a*q/b, a*q/c, a*q/
  d, a*q/e, a*q/f, (a)^(2)*(q)^(2)/(b*c*d*e*f), d*e*f/(a*q)}]}]]]
* QHypergeometricPFQ[{a*q/(d*e), a*q/(d*f), a*q/(e*f), (a)^(2)*(q)^(2)/(b*c*d*
  e*f)}, {(a)^(2)*(q)^(2)/(b*d*e*f), (a)^(2)*(q)^(2)/(c*d*e*f), a*(q)^(2)/(d
  *e*f)}, q, q]
```

Linebreaks are manually added to improve readability.



### A Code Box

```
1 <mrow>
2   <msub>
3     <mi>P</mi>
4     <mi>n</mi>
5   </msub>
6   <mo>
7     <!-- Invisible
8     Funct. Appl.
9     Unicode U+2061 -->
10  </mo>
11  <mrow>
12    <mo>(</mo>
13    <mi>x</mi>
14    <mo>)</mo>
15  </mrow>
16 </mrow>
```



### A Code Box With Caption

```
1 <mrow></mrow>
```

Listing 1.1: With Caption Text

## 1.2 Example Section

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla

vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

1.3 Example Outline

**Chapter 1** Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis.

**Chapter 2** Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis.

**The Appendix** Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis.

1.3.1 Example Overview of Publications

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Table 1.3: Example full caption of a table.

Ch.	Venue	Year	Type	Length	Author Position	Venue Rating	Ref.
2	Scientometrics	2020	Journal	Full	1 of 7	SJR Q1	[2]
	WWW	2020	Conference	Full	1 of 7	Core A*	[1]



*I don't know half of you half as well as I should like, and I like  
less than half of you half as well as you deserve.*

Bilbo Baggins - *The Lord of the Rings*

## CHAPTER 2

### Related Work

#### Contents

2.1	Background and Overview .....	7
2.2	Formats and Conversions .....	7
2.3	Presentation and Content .....	7
2.3.1	Subsection .....	7
2.3.1.1	Subsubsection .....	7
2.3.1.2	Subsubsection .....	8
2.3.2	Subsection 2 .....	8
2.3.3	Subsection 3 .....	8
2.4	Closing Section .....	8

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

### 2.1 Background and Overview

### 2.2 Formats and Conversions

### 2.3 Presentation and Content

#### 2.3.1 Subsection

##### 2.3.1.1 Subsubsection

#### Paragraph

**2.3.1.2** Subsubsection

**2.3.2** Subsection 2

**2.3.3** Subsection 3

**2.4** Closing Section

BACK MATTER

Appendix

Contents

Appendix ..... 9

A My First Appendix ..... 9

B Another Appendix ..... 9

C Appendix With Subsections ..... 9

    C.1 A Nested Subsection ..... 9

        C.1.1 With Subsubsections ..... 9

    C.2 Another Subsection ..... 10

    C.3 And Another ..... 10

D My Last Appendix ..... 10

Glossary ..... 11

Bibliography of Publications, Submissions & Talks ..... 13

Bibliography..... 15

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

- A My First Appendix
- B Another Appendix
- C Appendix With Subsections
  - C.1 A Nested Subsection
    - C.1.1 With Subsubsections
  - And a Paragraph

**C.2** Another Subsection

**C.3** And Another

**D** My Last Appendix



## BACK MATTER

---

### Glossary

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#### Symbols

$$\text{mBM25}(t, d) = \max_{d \in D} \frac{(k+1) \text{IDF}(t) \text{ITF}(t, d) \text{TF}(t, d)}{\max_{t' \in d|_{c(t)}} \text{TF}(t', d) + k \left(1 - b + \frac{b \text{AVG}_{\text{DL}}}{|d| \text{AVG}_C}\right)}$$

Our mathematical BM25 ranking to measure the importance of a given Mathematical Objects of Interest (MOI)  $t$  in a document  $d \in D$  which is part of a corpora  $D$ .  $\text{IDF}(t)$  is the inverse-document frequency,  $\text{ITF}(t, d)$  the inverse-term frequency of  $t$  in  $d$ ,  $\text{TF}(t, d)$  the term frequency of  $t$  in  $d$ ,  $\text{AVG}_{\text{DL}}$  the average document length (number of terms) in  $D$ ,  $\text{AVG}_C$  the average complexity of terms in  $D$ ,  $c(t)$  the complexity of  $t$ , and  $b, k$  are parameters. 1

#### B

##### BM25 — Okapi BM25

Is a ranking function to calculate the relevance of results in a search engine [3]. The underlying idea of BM25 is that words that appear regularly only in a few documents are more *important* for that document than words that appear everywhere across the entire corpora. 1

#### C

##### CORE — Computing Research and Education Association of Australasia

Is an association of university departments that provide assessments of major conferences in the computing disciplines. The main categories are A\* (flagship), A (excellent), B good to very good, and C for other ranked conferences that meet minimum standards, see <http://portal.core.edu.au/conf-ranks/> [accessed 2021-10-01]. 5

#### S

##### Scientometrics:

An international journal with an 5-year IF of 3.702 for quantitative aspects of the science of science, communication in science and science policy. According to <https://academic-accelerator.com/5-Year-Impact-Factor/Scientometrics> [accessed 2021-10-01] it is placed 18 of 227 journals in the field of library and information sciences. 5

#### W

##### WWW — The Web Conference

An annual major conference with the focus on the world wide web (has a CORE rank of A\*). 5



## BACK MATTER

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### Bibliography of Publications, Submissions & Talks

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- [2] **A. Greiner-Petter**, A. Youssef, T. Ruas, B. R. Miller, M. Schubotz, A. Aizawa, and B. Gipp. “Math-Word Embedding in Math Search and Semantic Extraction”. In: *Scientometrics* 125.3 (2020-12), pp. 3017–3046. ISSN: 0138-9130, 1588-2861. DOI: [10.1007/s11192-020-03502-9](https://doi.org/10.1007/s11192-020-03502-9). URL: <https://link.springer.com/10.1007/s11192-020-03502-9> (visited on 2021-06-30) (cit. on p. 5).



## BACK MATTER

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### Bibliography

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- [3] S. E. Robertson and H. Zaragoza. “The Probabilistic Relevance Framework: BM25 and Beyond”. In: *Foundations and Trends in Information Retrieval* 3.4 (2009), pp. 333–389. DOI: [10.1561/15000000019](https://doi.org/10.1561/15000000019) (cit. on pp. 1, 11).