Lecture 27 – Course Review

COSE215: Theory of Computation

Jihyeok Park

2025 Spring

Goal of This Course

PLRG

What is the *mathematical model* of computers?

Goal of This Course

PLRG

What is the *mathematical model* of computers?

Turing Machine!

Let's learn **Turing Machine**

Goal of This Course

PLRG

What is the *mathematical model* of computers?

Turing Machine!

Let's learn **Turing Machine**

Is it possible to solve *every problem* using computers?

Goal of This Course

PLRG

What is the *mathematical model* of computers?

Turing Machine!

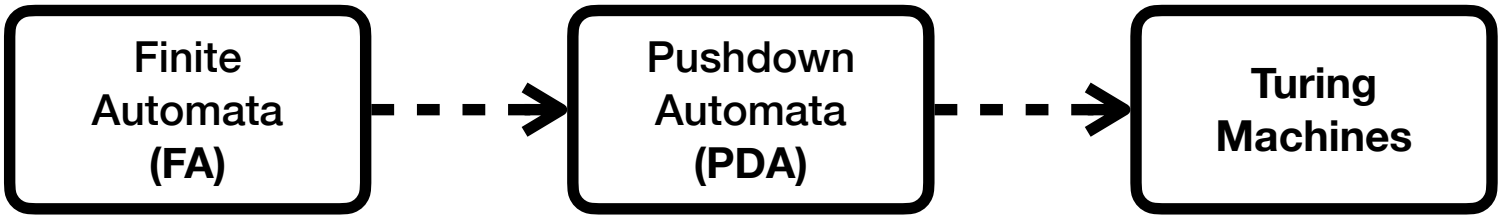
Let's learn **Turing Machine**

Is it possible to solve *every problem* using computers?

No!

Let's learn **Undecidability** and **Intractability**

Roadmap: Towards Turing Machine



Finite Automata (FA)

Regular Expressions and Languages
Applications: text search, etc.

Pushdown Automata (PDA)

Context-Free Grammars (CFGs) and Languages (CFLs)
Applications: programming languages, natural language processing, etc.

Turing Machines (TMs)

Extensions of Turing Machines
Undecidability and Intractability

Summary

	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata			
(Part 0) Basic Concepts			

Summary

	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata			
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**		

Summary

	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata			
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**	(Lecture 2) **Scala**	

Summary

	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata	(Lecture 3) DFA		(Lecture 3) RL
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**	(Lecture 2) **Scala**	

Summary

PLRG

	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata	(Lecture 4) (Lecture 3) NFA $\rightleftarrows$ DFA		(Lecture 3) RL
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**	(Lecture 2) **Scala**	

Summary

	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata	(Lecture 4) NFA ⇄ (Lecture 3) DFA ⇄ (Lecture 5) ϵ-NFA		(Lecture 3) RL
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**	(Lecture 2) **Scala**	

Summary

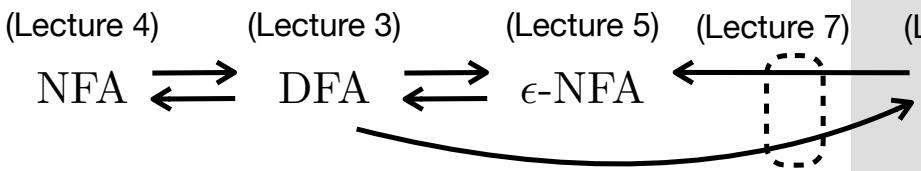
PLRG

	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata	(Lecture 4) (Lecture 3) (Lecture 5) NFA $\rightleftarrows$ DFA $\rightleftarrows$ ϵ-NFA	(Lecture 6) RE	(Lecture 3) RL
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**	(Lecture 2) **Scala**	

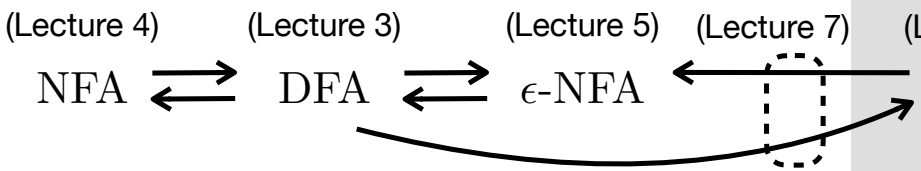
Summary

	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata	(Lecture 4) NFA ⇄ (Lecture 3) DFA ⇄ (Lecture 5) ϵ-NFA ← (Lecture 7) → (Lecture 6) RE		(Lecture 3) RL
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**	(Lecture 2) **Scala**	

Summary

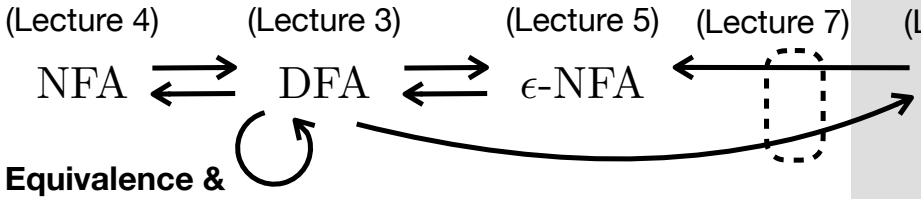
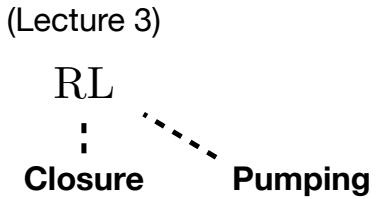
	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata			(Lecture 3) RL **Closure Properties** (Lecture 8)
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**	(Lecture 2) **Scala**	

Summary

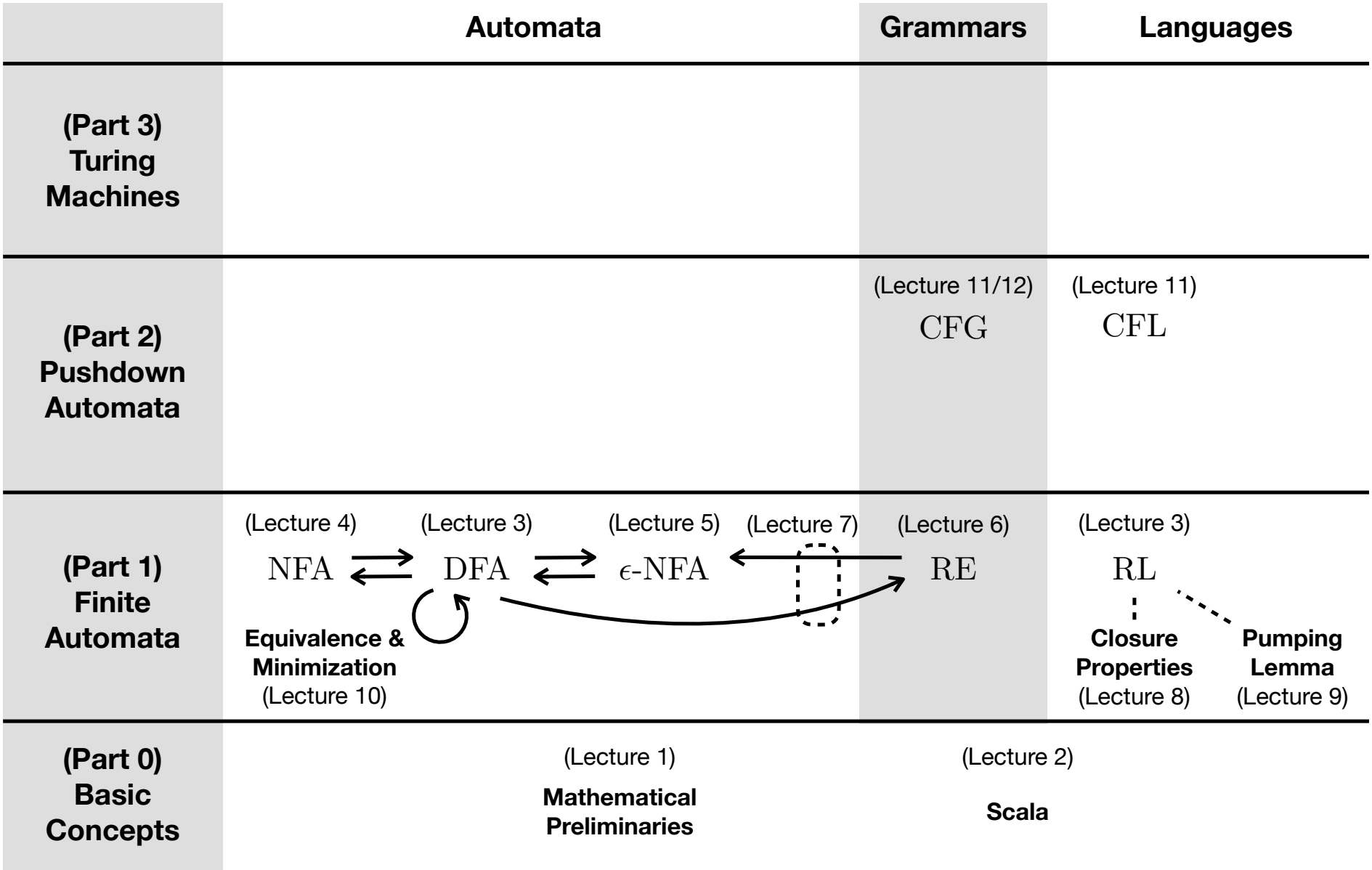
	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata			(Lecture 3) RL **Closure Properties** (Lecture 8) **Pumping Lemma** (Lecture 9)
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**	(Lecture 2) **Scala**	

Summary

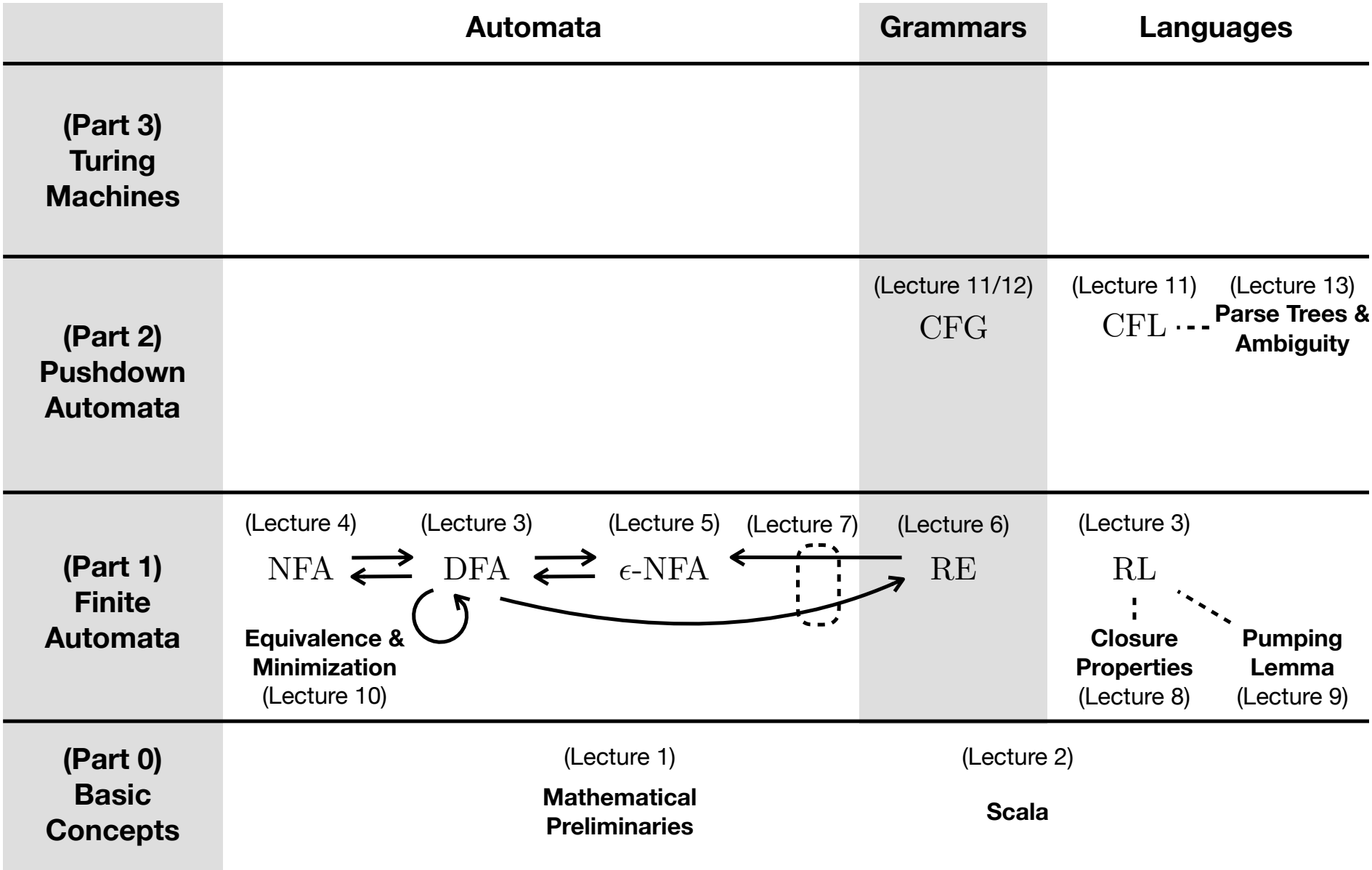
PLRG

	Automata	Grammars	Languages
(Part 3) Turing Machines			
(Part 2) Pushdown Automata			
(Part 1) Finite Automata	 **Equivalence & Minimization** (Lecture 10)		 **Closure Properties** (Lecture 8) **Pumping Lemma** (Lecture 9)
(Part 0) Basic Concepts	(Lecture 1) **Mathematical Preliminaries**	(Lecture 2) **Scala**	

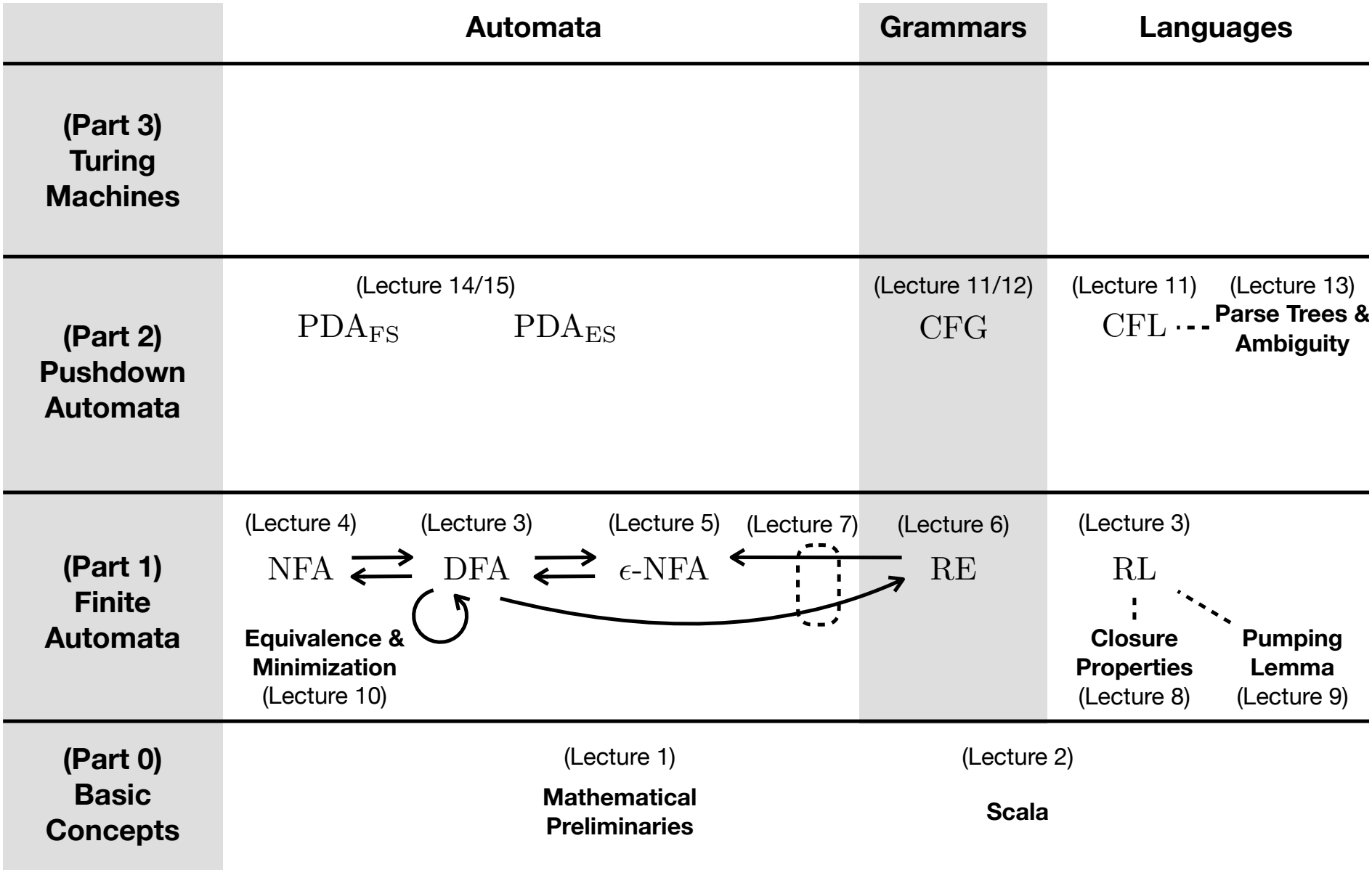
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Part 2) Pushdown Automata
(Lecture 11/12)
CFG
(Lecture 11)
CFL
(Part 1) Finite Automata
(Lecture 4)
NFA
(Lecture 3)
DFA
(Lecture 5)
ϵ-NFA
(Lecture 7)
(Lecture 6)
RE
(Lecture 3)
RL
Equivalence & Minimization
(Lecture 10)
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Part 0) Basic Concepts
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

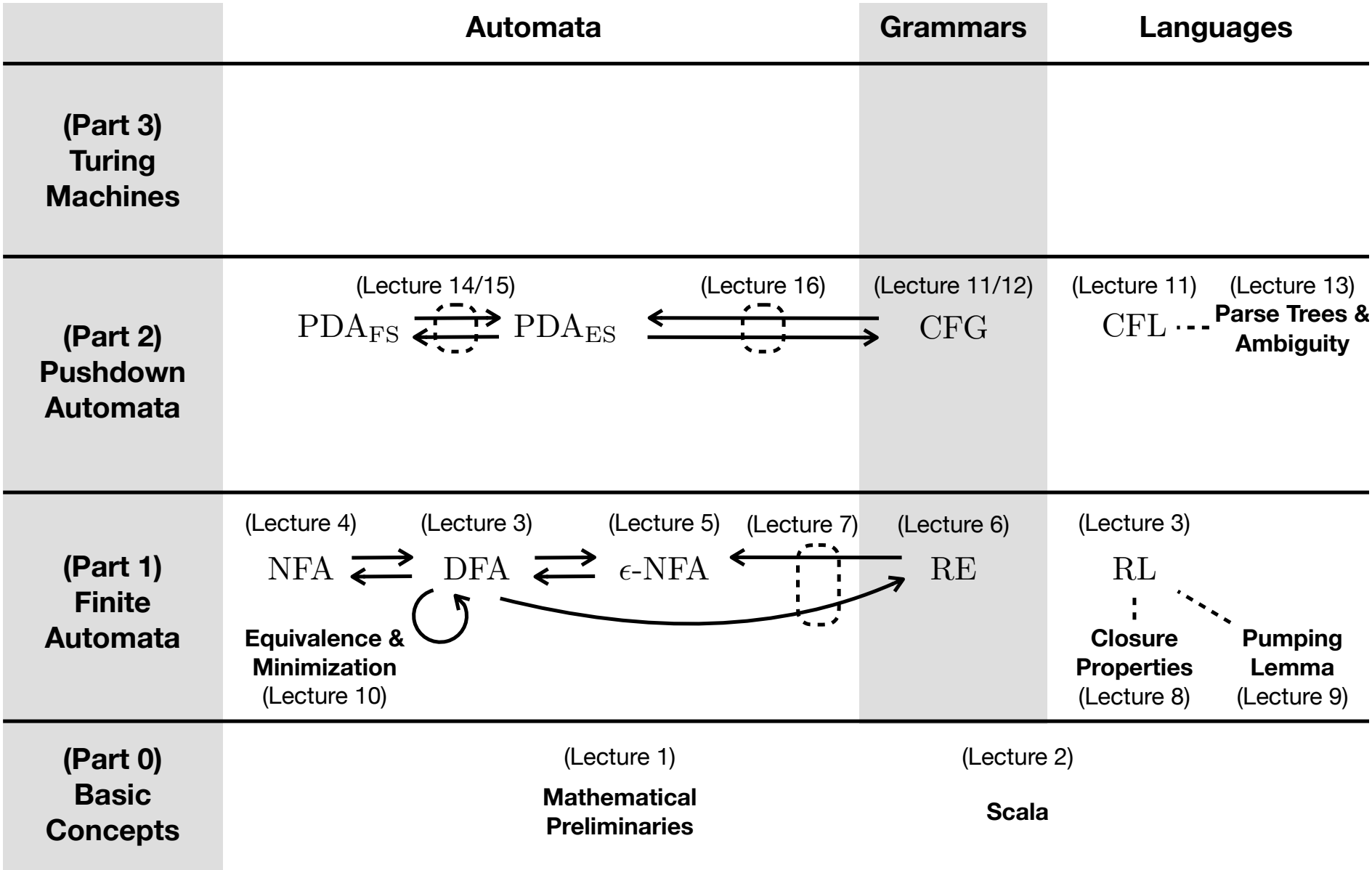
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Part 2) Pushdown Automata
(Part 1) Finite Automata
(Part 0) Basic Concepts
(Lecture 11/12)
CFG
(Lecture 11)
CFL
(Lecture 13)
Parse Trees & Ambiguity
(Lecture 4)
NFA
(Lecture 3)
DFA
(Lecture 5)
ϵ-NFA
(Lecture 7)
(Lecture 6)
RE
(Lecture 3)
RL
Equivalence & Minimization
(Lecture 10)
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

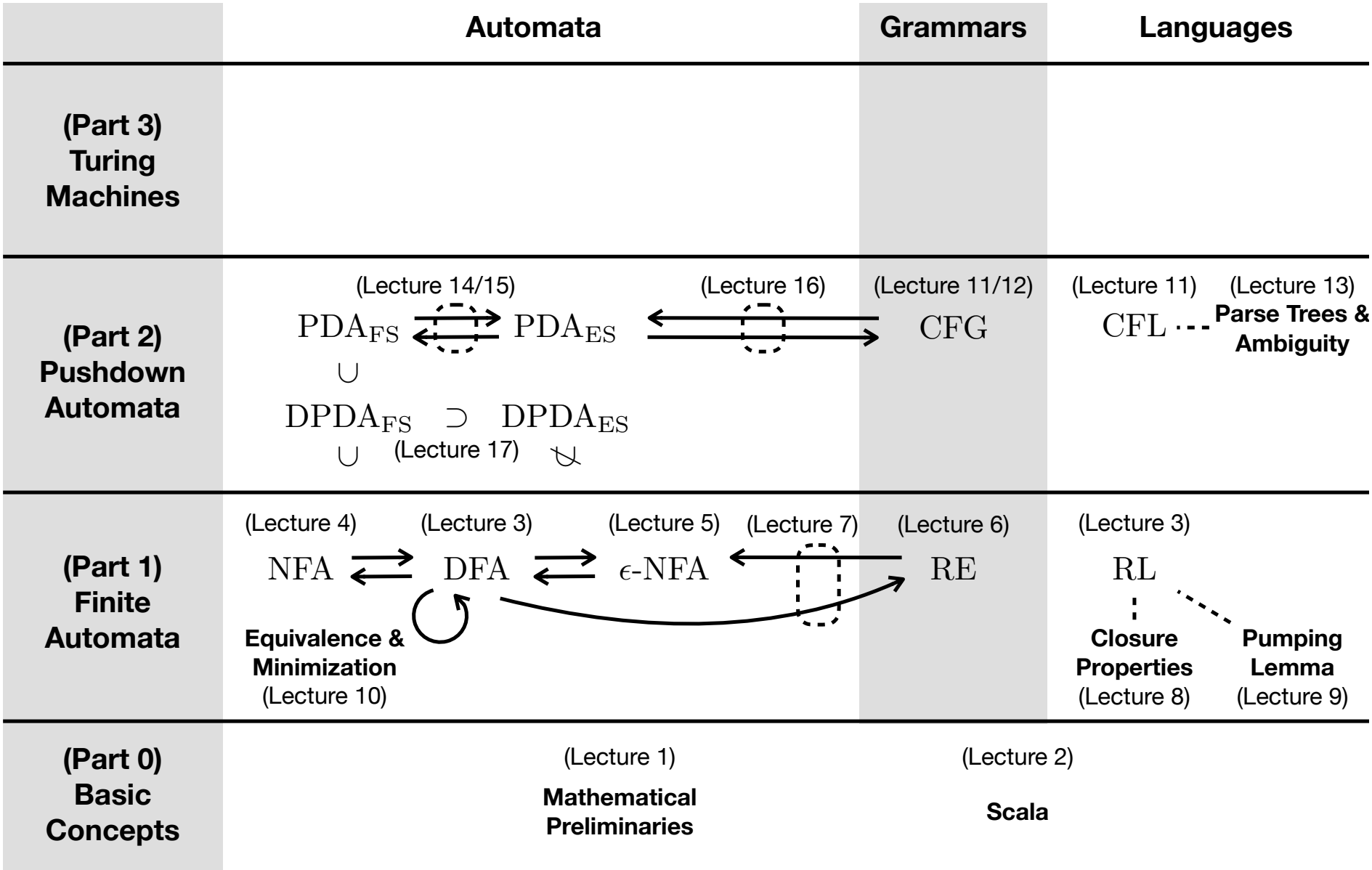
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Part 2) Pushdown Automata
(Lecture 14/15)
PDA_FS
PDA_ES
(Lecture 11/12)
CFG
(Lecture 11)
CFL
(Lecture 13)
Parse Trees & Ambiguity
(Part 1) Finite Automata
(Lecture 4)
NFA
(Lecture 3)
DFA
(Lecture 5)
ϵ-NFA
(Lecture 7)
(Lecture 6)
RE
(Lecture 3)
RL
Equivalence & Minimization
(Lecture 10)
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Part 0) Basic Concepts
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

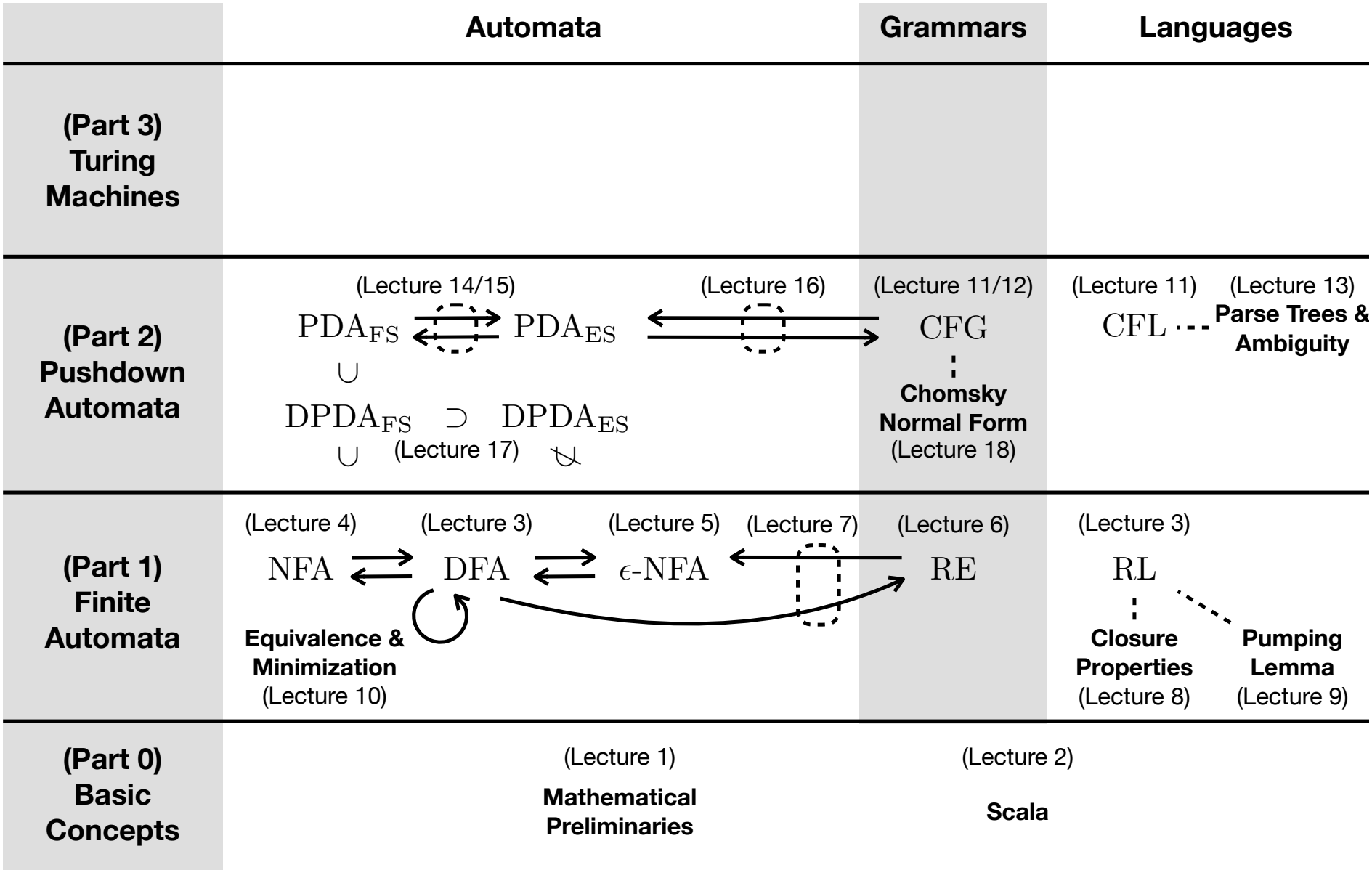
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Part 2) Pushdown Automata
(Part 1) Finite Automata
(Part 0) Basic Concepts
(Lecture 14/15)
PDA_FS
PDA_ES
(Lecture 16)
(Lecture 11/12)
CFG
(Lecture 11)
CFL
(Lecture 13)
Parse Trees & Ambiguity
(Lecture 4)
NFA
(Lecture 3)
DFA
(Lecture 5)
ϵ-NFA
(Lecture 7)
(Lecture 6)
RE
(Lecture 3)
RL
Equivalence & Minimization
(Lecture 10)
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

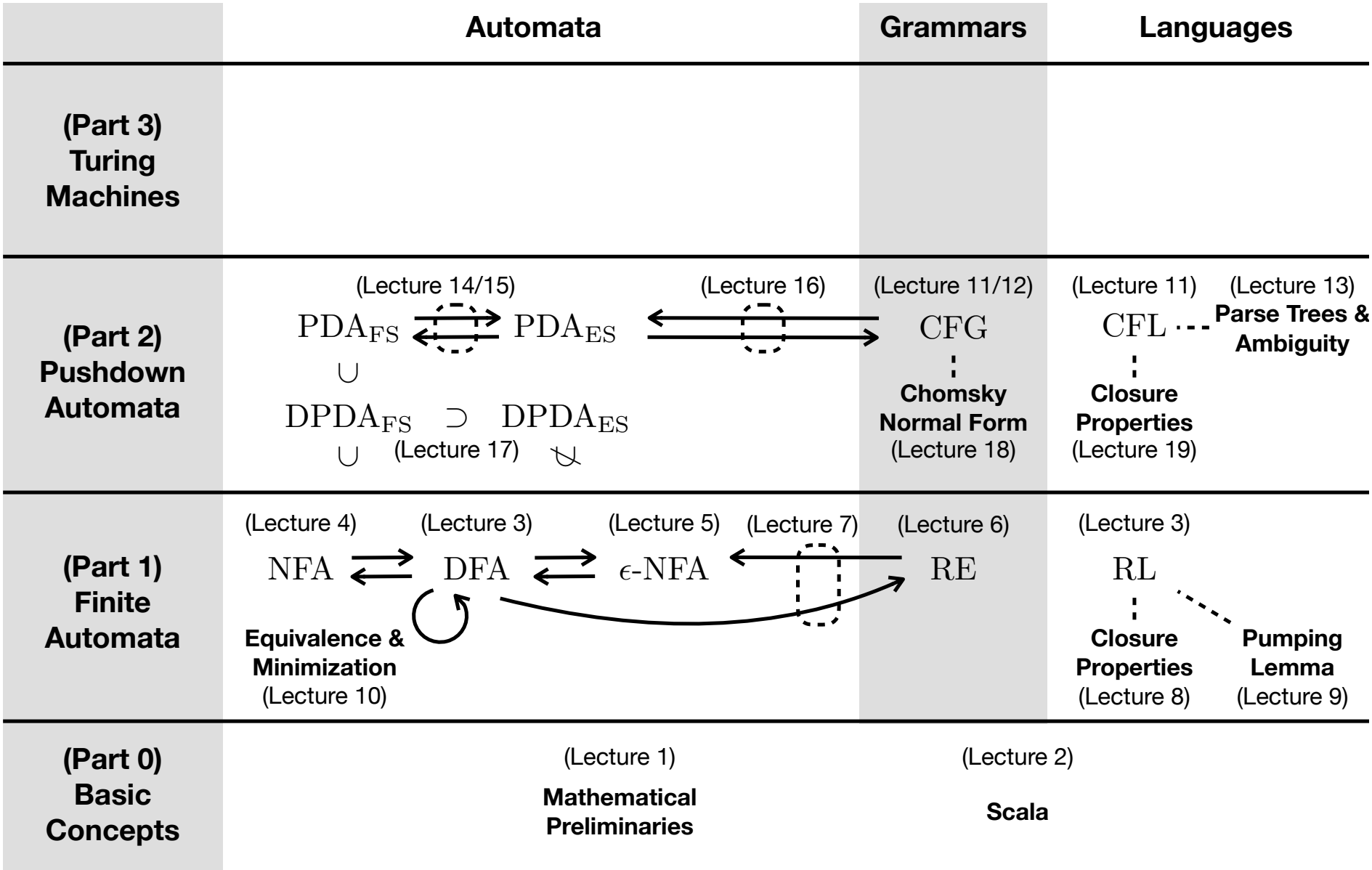
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Part 2) Pushdown Automata
(Part 1) Finite Automata
(Part 0) Basic Concepts
(Lecture 14/15)
(Lecture 16)
(Lecture 11/12)
(Lecture 11)
(Lecture 13)
PDA_FS
PDA_ES
CFG
CFL
Parse Trees & Ambiguity
DPDA_FS
DPDA_ES
(Lecture 17)
(Lecture 4)
(Lecture 3)
(Lecture 5)
(Lecture 7)
(Lecture 6)
(Lecture 3)
NFA
DFA
ϵ-NFA
RE
RL
Equivalence & Minimization
(Lecture 10)
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

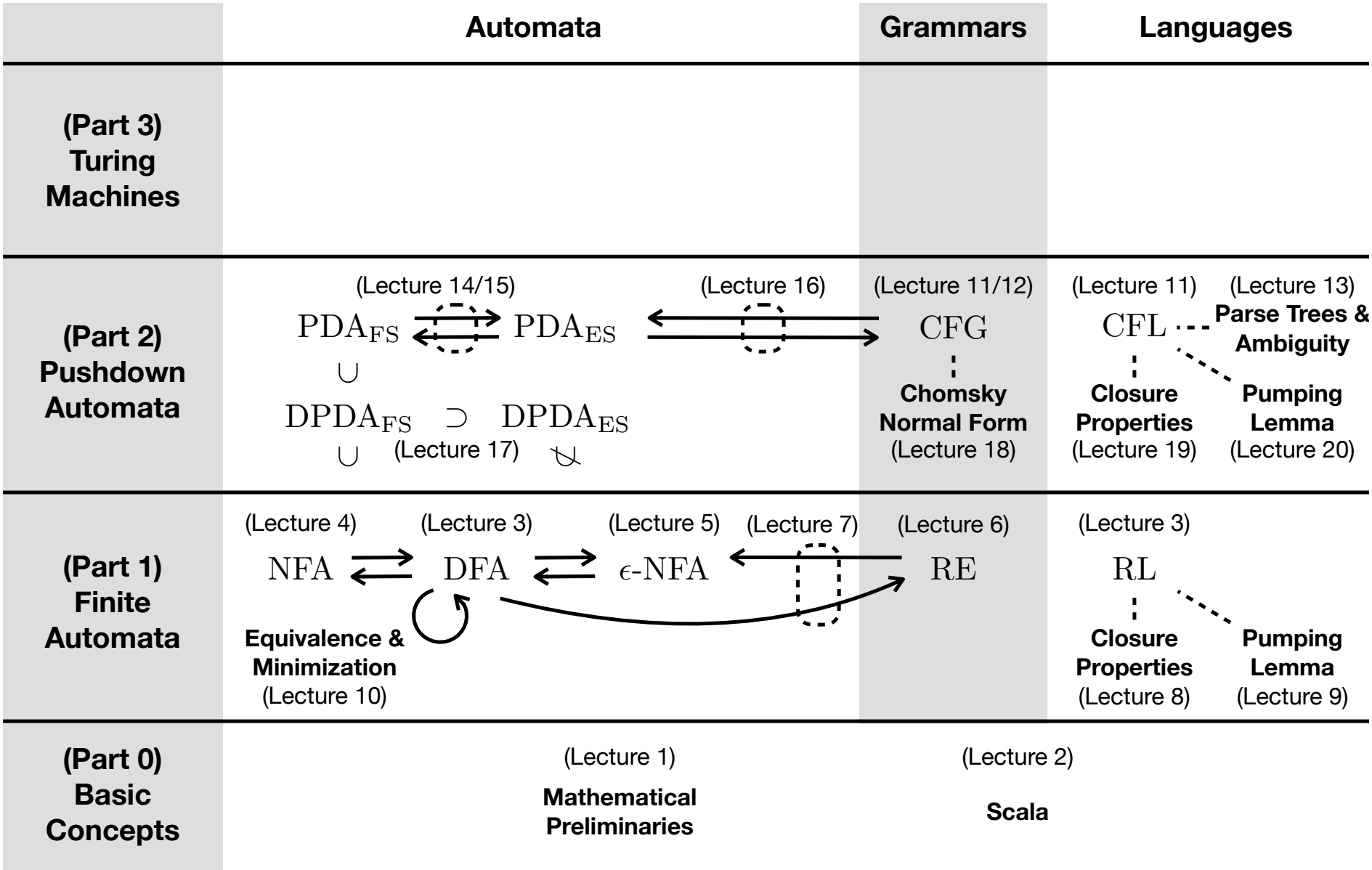
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Part 2) Pushdown Automata
(Part 1) Finite Automata
(Part 0) Basic Concepts
(Lecture 14/15)
(Lecture 16)
(Lecture 11/12)
(Lecture 11)
(Lecture 13)
PDA_FS
PDA_ES
CFG
CFL
Parse Trees & Ambiguity
DPDA_FS
DPDA_ES
(Lecture 17)
Chomsky Normal Form
(Lecture 18)
(Lecture 4)
(Lecture 3)
(Lecture 5)
(Lecture 7)
(Lecture 6)
(Lecture 3)
NFA
DFA
ϵ-NFA
RE
RL
Equivalence & Minimization
(Lecture 10)
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

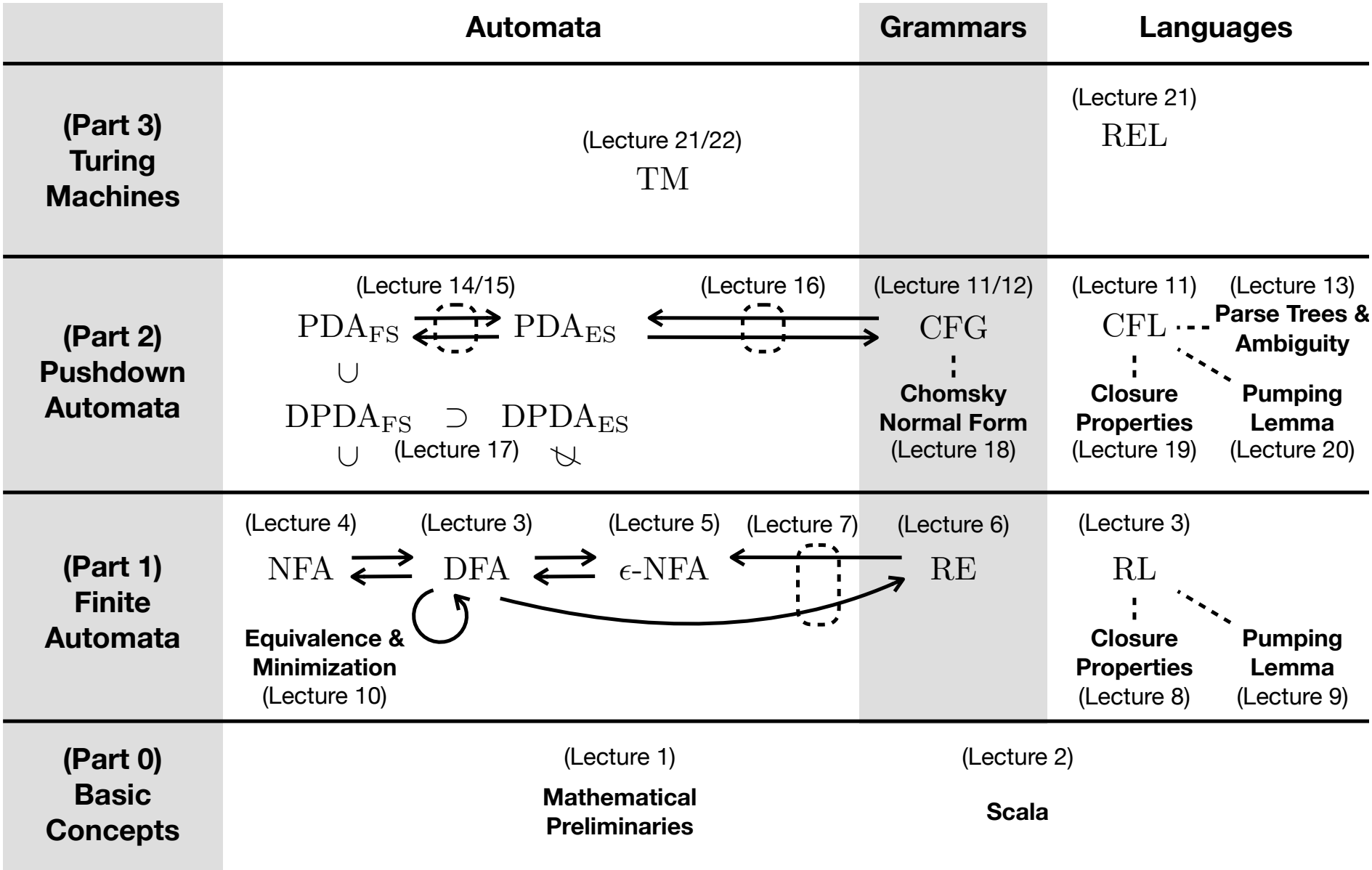
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Part 2) Pushdown Automata
(Part 1) Finite Automata
(Part 0) Basic Concepts
(Lecture 14/15)
(Lecture 16)
(Lecture 11/12)
(Lecture 11)
(Lecture 13)
PDA_FS
PDA_ES
CFG
CFL
Parse Trees & Ambiguity
DPDA_FS
DPDA_ES
(Lecture 17)
Chomsky Normal Form
(Lecture 18)
Closure Properties
(Lecture 19)
(Lecture 4)
(Lecture 3)
(Lecture 5)
(Lecture 7)
(Lecture 6)
(Lecture 3)
NFA
DFA
ϵ-NFA
RE
RL
Equivalence & Minimization
(Lecture 10)
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

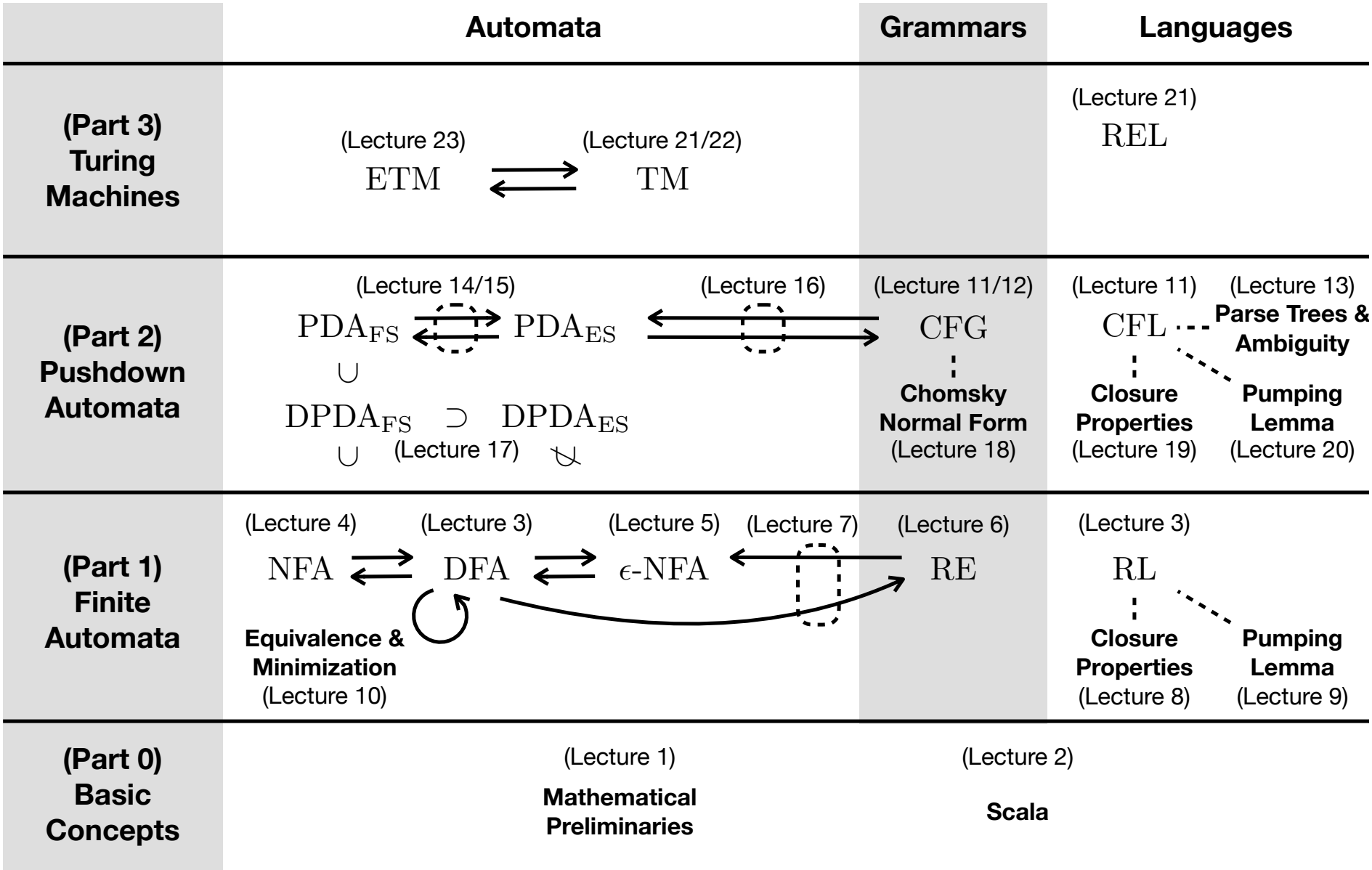
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Part 2) Pushdown Automata
(Part 1) Finite Automata
(Part 0) Basic Concepts
(Lecture 14/15)
(Lecture 16)
(Lecture 11/12)
(Lecture 11)
(Lecture 13)
PDA_FS
PDA_ES
CFG
CFL
Parse Trees & Ambiguity
DPDA_FS
DPDA_ES
(Lecture 17)
Chomsky Normal Form (Lecture 18)
Closure Properties (Lecture 19)
Pumping Lemma (Lecture 20)
(Lecture 4)
(Lecture 3)
(Lecture 5)
(Lecture 7)
(Lecture 6)
(Lecture 3)
NFA
DFA
ϵ-NFA
RE
RL
Equivalence & Minimization (Lecture 10)
Closure Properties (Lecture 8)
Pumping Lemma (Lecture 9)
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

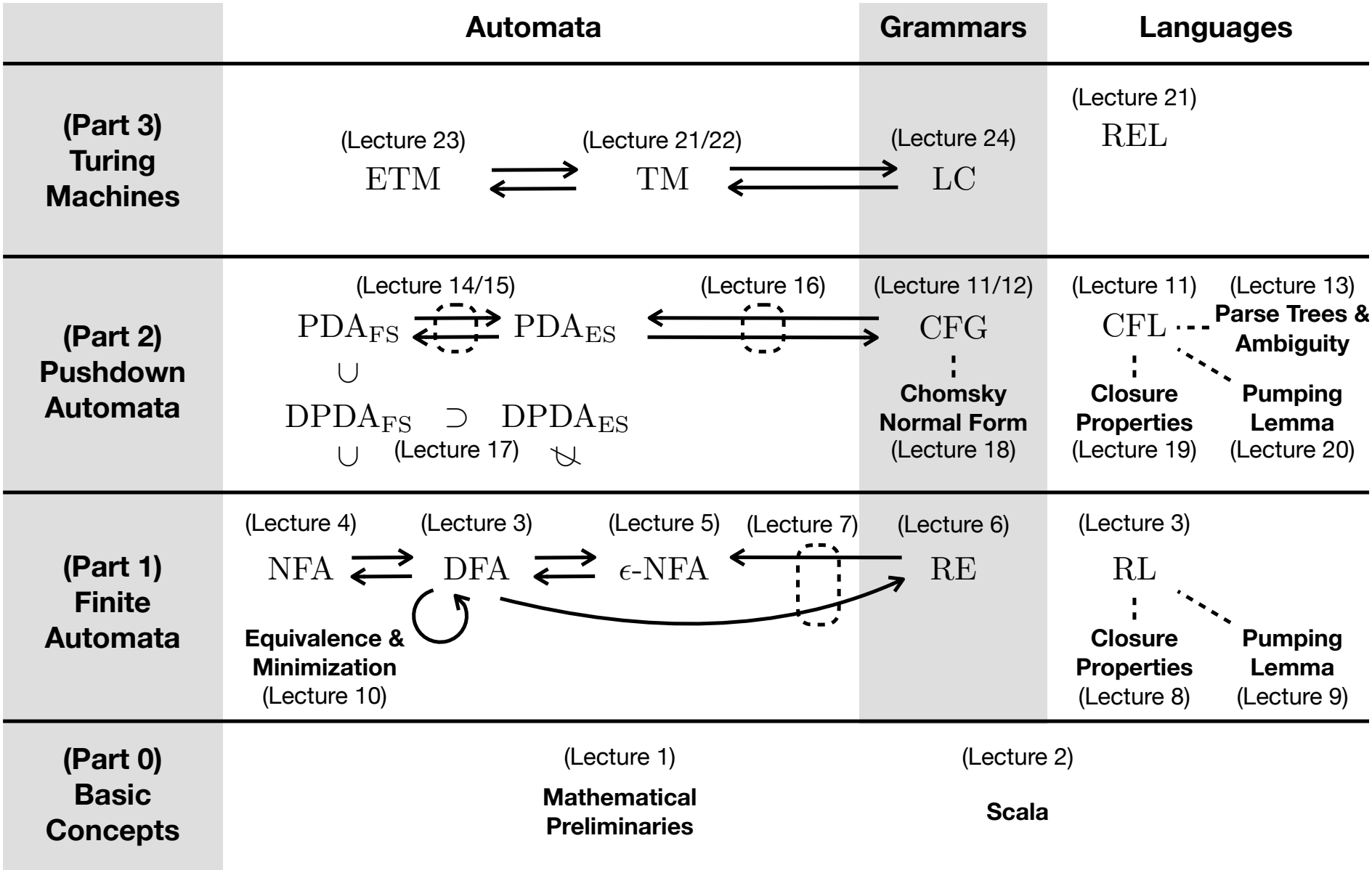
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Lecture 21/22)
TM
(Lecture 21)
REL
(Part 2) Pushdown Automata
(Lecture 14/15)
PDA_FS
PDA_ES
(Lecture 16)
DPDA_FS
DPDA_ES
(Lecture 17)
(Lecture 11/12)
CFG
Chomsky Normal Form
(Lecture 18)
(Lecture 11)
CFL
(Lecture 13)
Parse Trees & Ambiguity
Closure Properties
(Lecture 19)
Pumping Lemma
(Lecture 20)
(Part 1) Finite Automata
(Lecture 4)
NFA
(Lecture 3)
DFA
(Lecture 5)
ϵ-NFA
(Lecture 7)
(Lecture 6)
RE
Equivalence & Minimization
(Lecture 10)
(Lecture 3)
RL
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Part 0) Basic Concepts
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

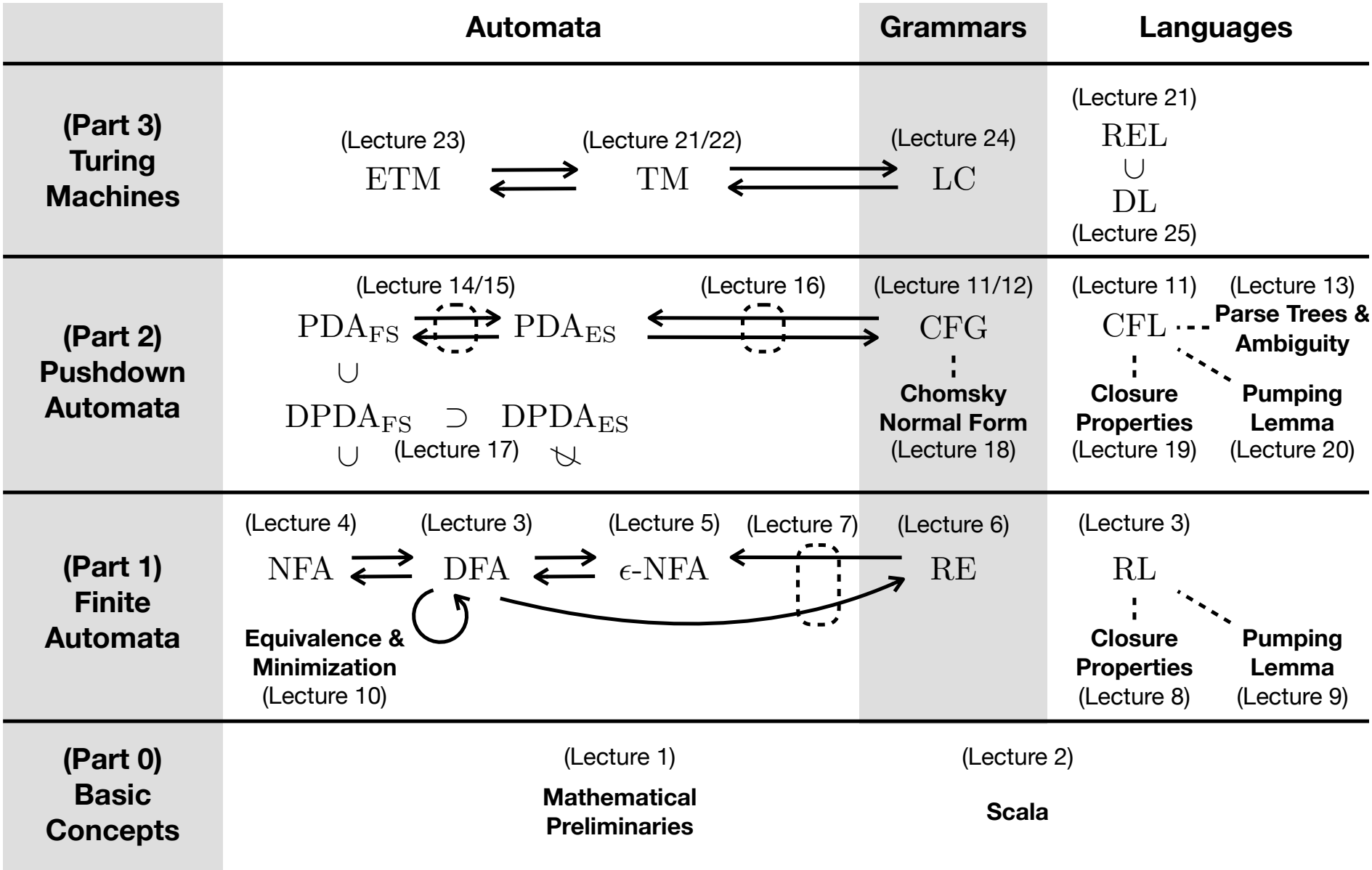
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Lecture 23)
ETM
(Lecture 21/22)
TM
(Lecture 21)
REL
(Part 2) Pushdown Automata
(Lecture 14/15)
PDA_FS
PDA_ES
(Lecture 16)
DPDA_FS
DPDA_ES
(Lecture 17)
(Lecture 11/12)
CFG
Chomsky Normal Form
(Lecture 18)
(Lecture 11)
CFL
Closure Properties
(Lecture 19)
(Lecture 13)
Parse Trees & Ambiguity
Pumping Lemma
(Lecture 20)
(Part 1) Finite Automata
(Lecture 4)
NFA
(Lecture 3)
DFA
(Lecture 5)
ϵ-NFA
(Lecture 7)
(Lecture 6)
RE
Equivalence & Minimization
(Lecture 10)
(Lecture 3)
RL
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Part 0) Basic Concepts
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

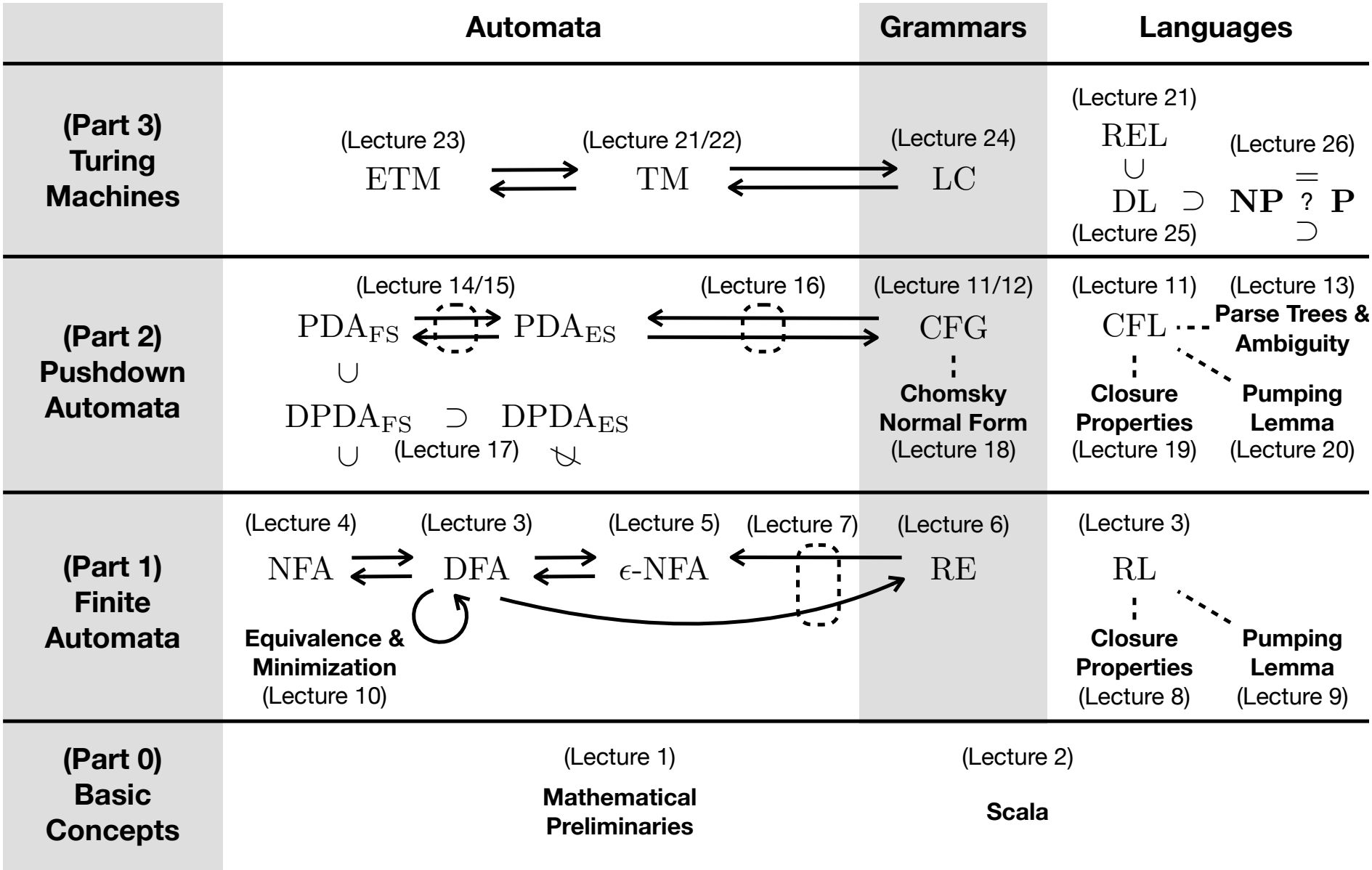
Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Lecture 23)
ETM
(Lecture 21/22)
TM
(Lecture 24)
LC
(Lecture 21)
REL
(Part 2) Pushdown Automata
(Lecture 14/15)
PDA_{FS}
PDA_{ES}
(Lecture 16)
DPDA_{FS}
$\supset$
DPDA_{ES}
(Lecture 17)
(Lecture 11/12)
CFG
Chomsky Normal Form
(Lecture 18)
(Lecture 11)
CFL
(Lecture 13)
Parse Trees & Ambiguity
Closure Properties
(Lecture 19)
Pumping Lemma
(Lecture 20)
(Part 1) Finite Automata
(Lecture 4)
NFA
(Lecture 3)
DFA
(Lecture 5)
ϵ-NFA
(Lecture 7)
(Lecture 6)
RE
Equivalence & Minimization
(Lecture 10)
(Lecture 3)
RL
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Part 0) Basic Concepts
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Lecture 23)
ETM
(Lecture 21/22)
TM
(Lecture 24)
LC
(Lecture 21)
REL
∪
DL
(Lecture 25)
(Part 2) Pushdown Automata
(Lecture 14/15)
PDA_FS
PDA_ES
(Lecture 16)
(Lecture 11/12)
CFG
(Lecture 11)
CFL
(Lecture 13)
Parse Trees & Ambiguity
∪
DPDA_FS ⊃ DPDA_ES
∪ (Lecture 17) ∅
Chomsky Normal Form
(Lecture 18)
Closure Properties
(Lecture 19)
Pumping Lemma
(Lecture 20)
(Part 1) Finite Automata
(Lecture 4)
NFA
(Lecture 3)
DFA
(Lecture 5)
ϵ-NFA
(Lecture 7)
(Lecture 6)
RE
(Lecture 3)
RL
Equivalence & Minimization
(Lecture 10)
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Part 0) Basic Concepts
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

Summary


Automata
Grammars
Languages
(Part 3) Turing Machines
(Lecture 23)
ETM
(Lecture 21/22)
TM
(Lecture 24)
LC
(Lecture 21)
REL
DL
(Lecture 25)
(Lecture 26)
NP ? P
(Part 2) Pushdown Automata
(Lecture 14/15)
PDA_FS
PDA_ES
(Lecture 16)
DPDA_FS
DPDA_ES
(Lecture 17)
(Lecture 11/12)
CFG
Chomsky Normal Form
(Lecture 18)
(Lecture 11)
CFL
(Lecture 13)
Parse Trees & Ambiguity
Closure Properties
(Lecture 19)
Pumping Lemma
(Lecture 20)
(Part 1) Finite Automata
(Lecture 4)
NFA
(Lecture 3)
DFA
(Lecture 5)
ϵ-NFA
(Lecture 7)
(Lecture 6)
RE
Equivalence & Minimization
(Lecture 10)
(Lecture 3)
RL
Closure Properties
(Lecture 8)
Pumping Lemma
(Lecture 9)
(Part 0) Basic Concepts
(Lecture 1)
Mathematical Preliminaries
(Lecture 2)
Scala

Final Exam

The final exam will be given in class.

Date: 13:30-14:45 (1 hour 15 minutes), June 23 (Mon.).

Location: 301, Aegineung (애기능생활관 301호)

Coverage: Lectures 14 – 26

Format: 8 questions with closed book and closed notes

- Yes/No questions about concepts in the theory of computation.
- Construction of automata or grammars for given languages.
- Proofs of given statements related to automata or grammars.
- etc.

Note that there is **no class** on **June 18 (Wed.)**.

Please refer to the **previous exams** in the course website:

https://plrg.korea.ac.kr/courses/cose215/

I hope you enjoyed the class!

Jihyeok Park
jihyeok_park@korea.ac.kr
https://plrg.korea.ac.kr