



Midterm 1 Review

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CS 421: Natural Language
Processing

Fall 2019

Exam Format

True/False (30%)

- 15 questions, 2 points each
- No partial credit (autograded)

Multiple Choice (40%)

- 8 questions, 5 points each
- No partial credit (autograded)

Problem Solving (30%)

- 3 questions, 10 points each
- Show work for partial credit (graded manually)

Bonus Question (10%)

- Problem solving-ish question with multiple parts
- Points added to exam score (max exam score = 100)

Sample Midterm

- Currently available on Piazza (@119)
- Solution will be posted after class

What should I study?



- Questions designed based on **slides** and **assignments**
- Problem solving questions similar but not identical to **problem solving examples** (e.g., stepping through CKY algorithm) in slides
- Questions based on assignments will be simpler than their assignment counterparts!
 - Regex will only appear in true/false and multiple-choice questions

What
content will
the exam
cover?

Text preprocessing (including regular expressions)

Edit distance

Finite state automata

Finite state transducers

Hidden Markov models

Part of speech tagging

Formal grammars

Syntactic parsing

Dependency parsing

First-order logic

What will I for sure *not* need to memorize?

- Forward-backward algorithm (see HMM slides)
- Part-of-speech tags associated with specific treebanks
 - Know major parts of speech like nouns and verbs, but no need to know treebank-specific things like NN, NNP, NNS, and NNPS
- Dependency relations associated with specific treebanks
 - Have a basic understanding of things like direct objects, but no need to know treebank-specific things like csubj, xcomp, cop, etc.
- Computational complexities (e.g., forward algorithm runs in $O(TN^2)$ time)

What should I bring to the exam?

- Pen or pencil
- UIN (you'll need to write it on the first page of the exam)
- This exam will be:
 - Closed note
 - Closed book
 - Closed device
- You will not need a calculator



How long will the exam last?

Full class period, if needed (75
minutes)



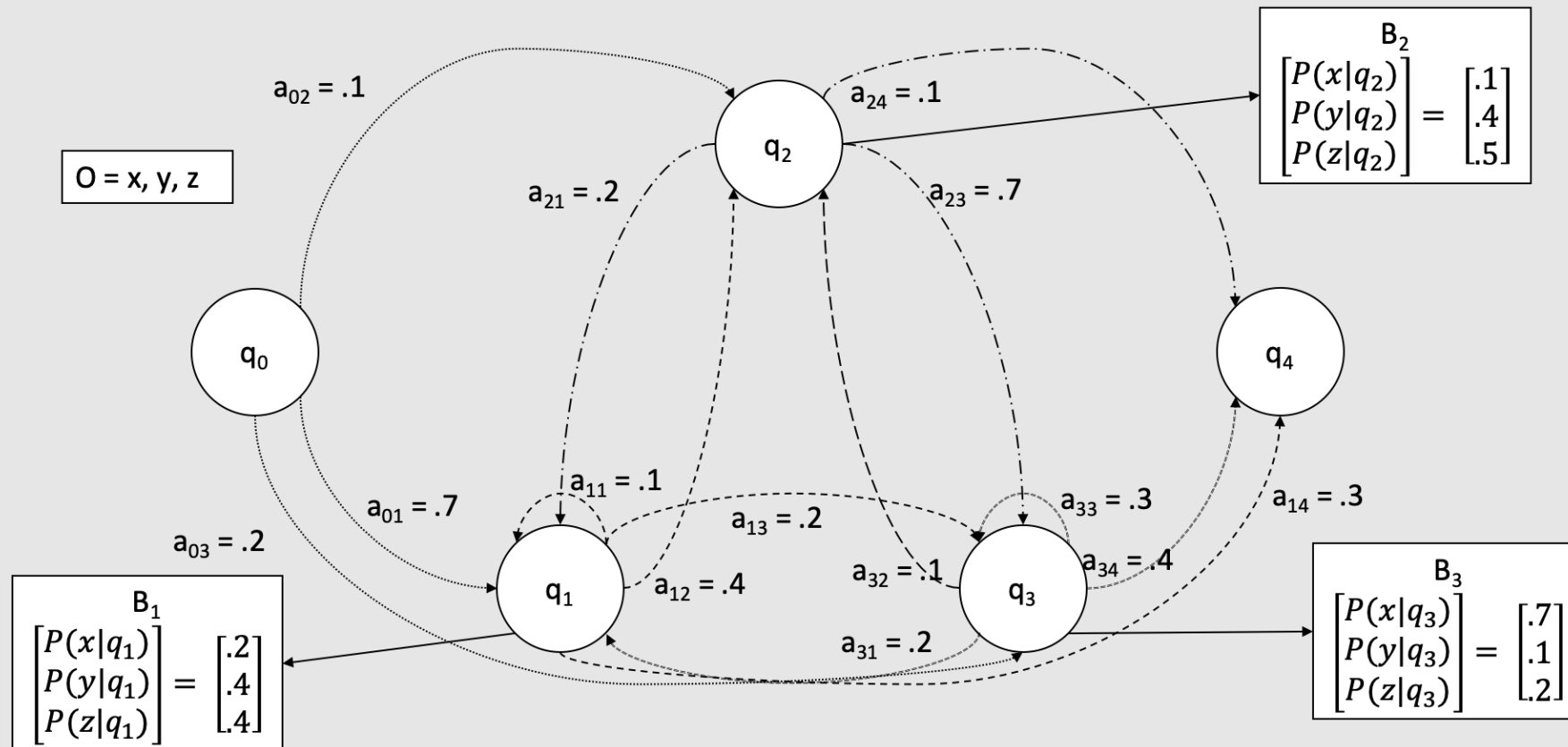
True/False

**Multiple
Choice**

Solution Time!

Problem-Solving Questions

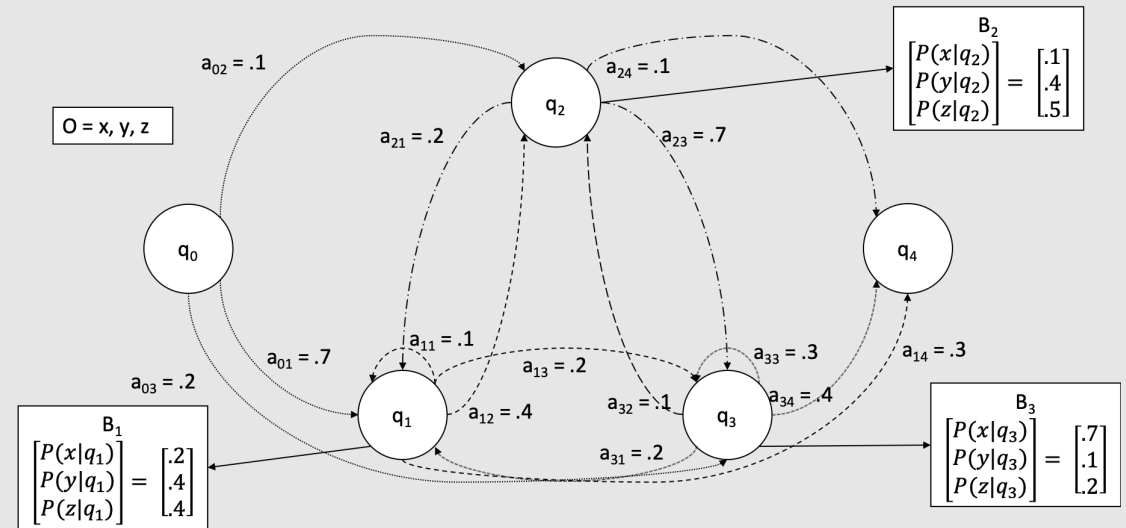
Create a state transition matrix for the Hidden Markov Model shown below.



Problem-Solving Questions

target

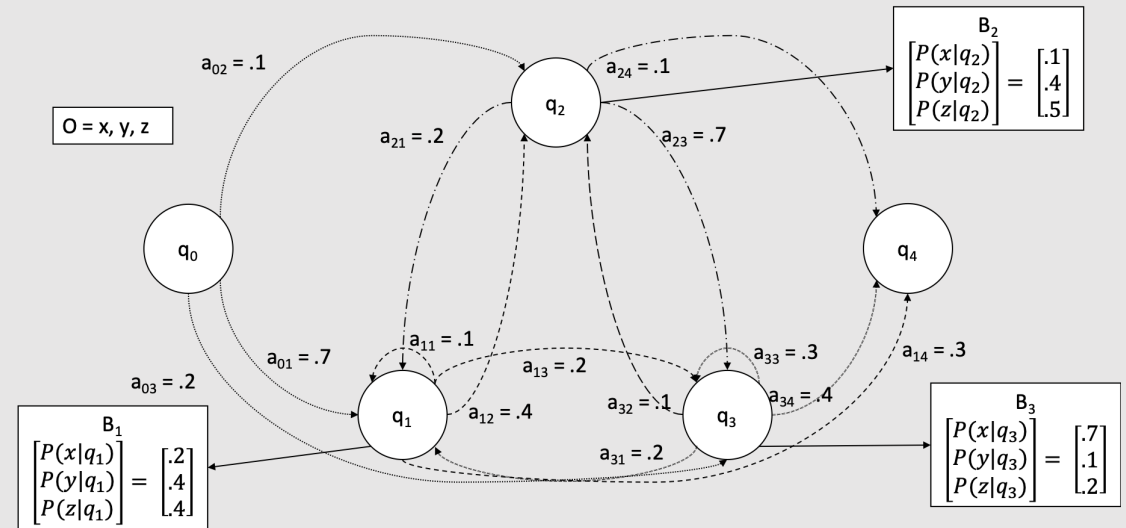
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀					
	q ₁					
	q ₂					
	q ₃					
	q ₄					
	q ₄					



Problem-Solving Questions

target

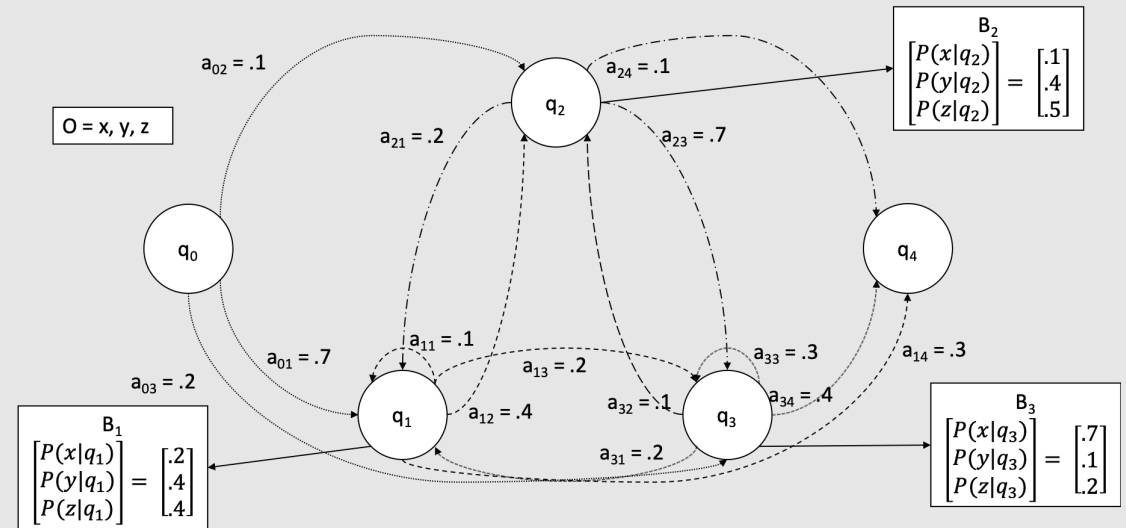
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀	N/A				
	q ₁	N/A				
	q ₂	N/A				
	q ₃	N/A				
	q ₄	N/A				
	q ₄	N/A				



Problem-Solving Questions

target

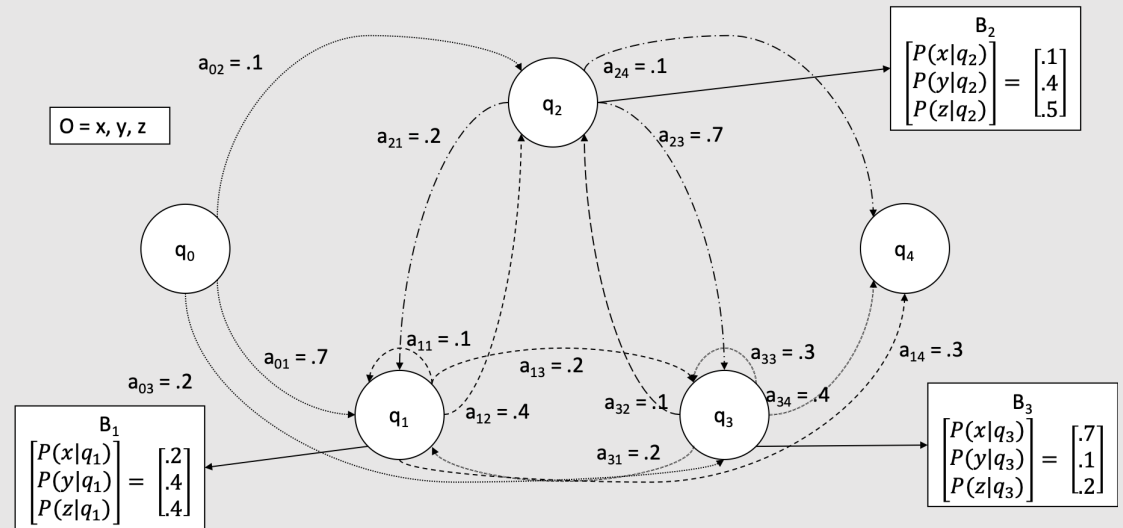
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀	N/A				
	q ₁	N/A				
	q ₂	N/A				
	q ₃	N/A				
	q ₄	N/A	N/A	N/A	N/A	N/A
	q ₄	N/A	N/A	N/A	N/A	N/A



Problem-Solving Questions

target

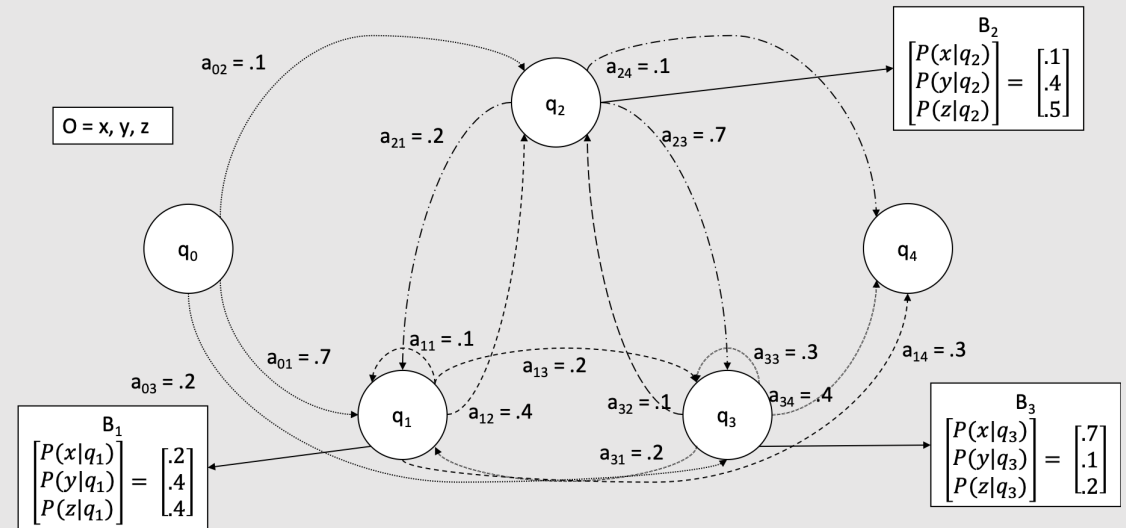
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀	N/A	0.7			
	q ₁	N/A				
	q ₂	N/A				
	q ₃	N/A				
	q ₄	N/A	N/A	N/A	N/A	N/A
	q ₄	N/A	N/A	N/A	N/A	N/A



Problem-Solving Questions

target

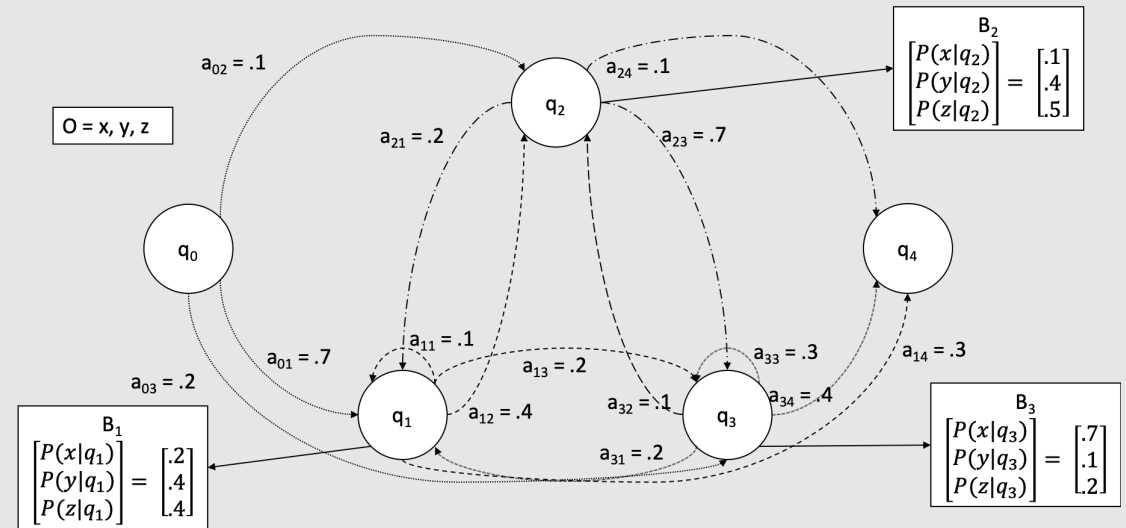
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀	N/A	0.7	0.1	0.2	N/A
	q ₁	N/A				
	q ₂	N/A				
	q ₃	N/A				
	q ₄	N/A	N/A	N/A	N/A	N/A
	q ₄	N/A	N/A	N/A	N/A	N/A



Problem-Solving Questions

target

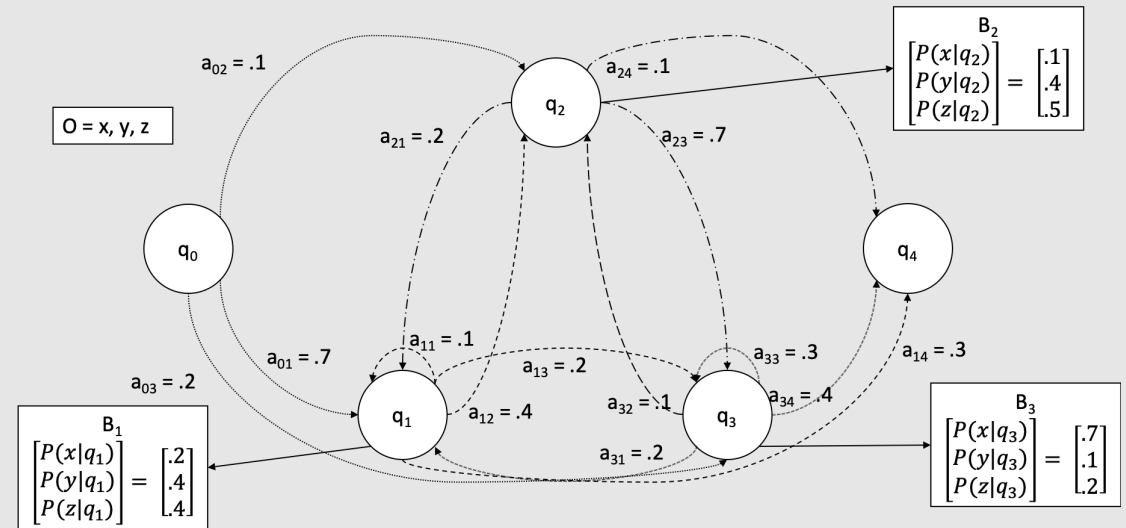
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀	N/A	0.7	0.1	0.2	N/A
	q ₁	N/A	0.1			
	q ₂	N/A				
	q ₃	N/A				
	q ₄	N/A	N/A	N/A	N/A	N/A
	q ₄	N/A	N/A	N/A	N/A	N/A



Problem-Solving Questions

target

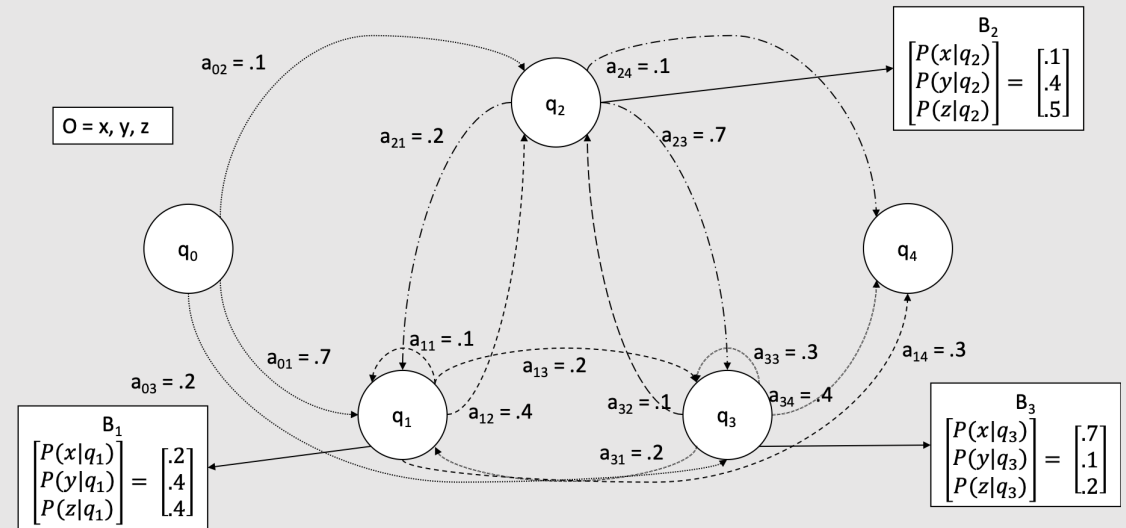
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀	N/A	0.7	0.1	0.2	N/A
	q ₁	N/A	0.1	0.4	0.2	0.3
	q ₂	N/A				
	q ₃	N/A				
	q ₄	N/A	N/A	N/A	N/A	N/A
	q ₄	N/A	N/A	N/A	N/A	N/A



Problem-Solving Questions

target

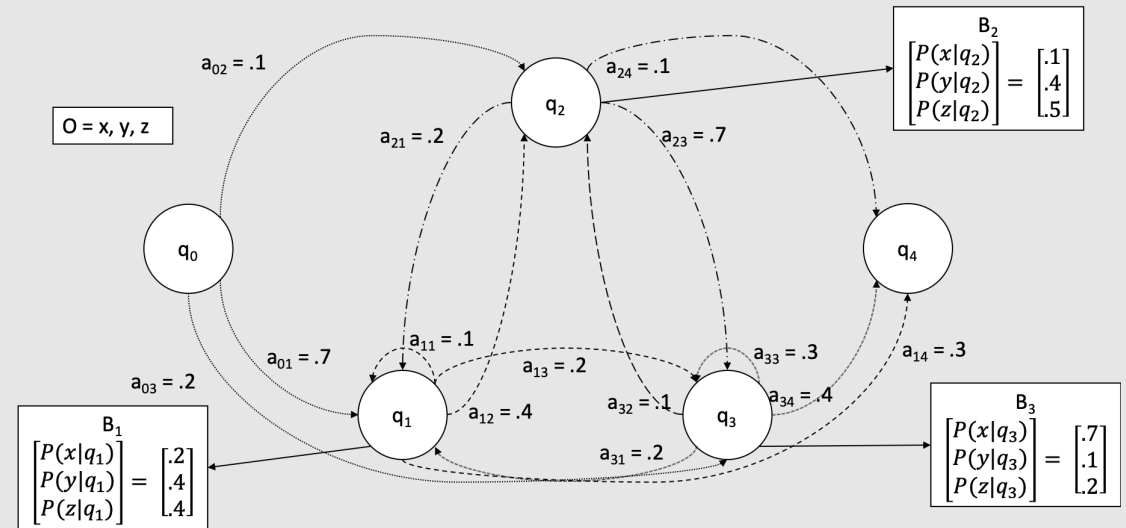
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀	N/A	0.7	0.1	0.2	N/A
	q ₁	N/A	0.1	0.4	0.2	0.3
	q ₂	N/A	0.2			
	q ₃	N/A				
	q ₄	N/A	N/A	N/A	N/A	N/A
	q ₄	N/A	N/A	N/A	N/A	N/A



Problem-Solving Questions

target

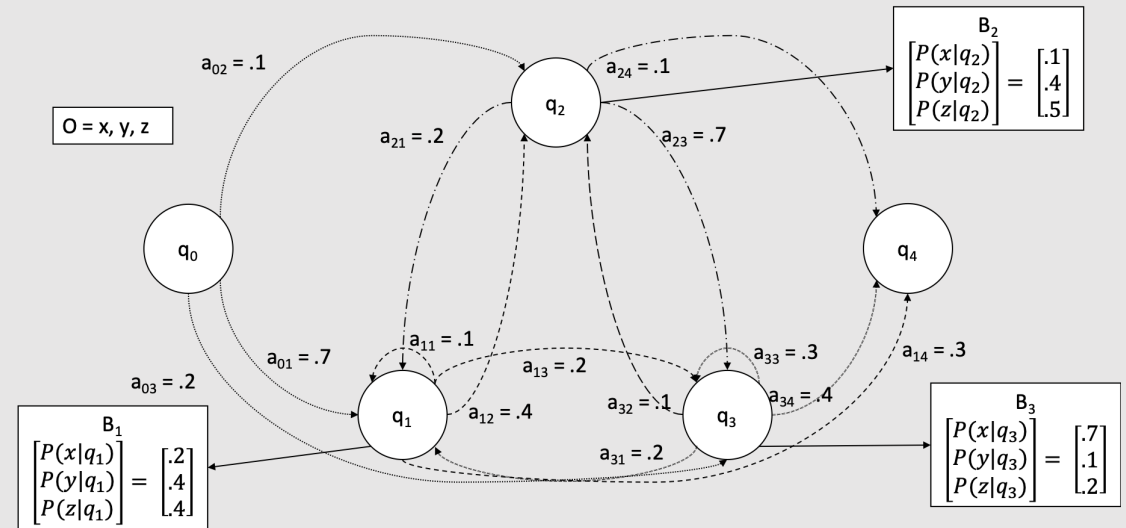
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀	N/A	0.7	0.1	0.2	N/A
	q ₁	N/A	0.1	0.4	0.2	0.3
	q ₂	N/A	0.2	N/A	0.7	0.1
	q ₃	N/A				
	q ₄	N/A	N/A	N/A	N/A	N/A
	q ₄	N/A	N/A	N/A	N/A	N/A



Problem-Solving Questions

target

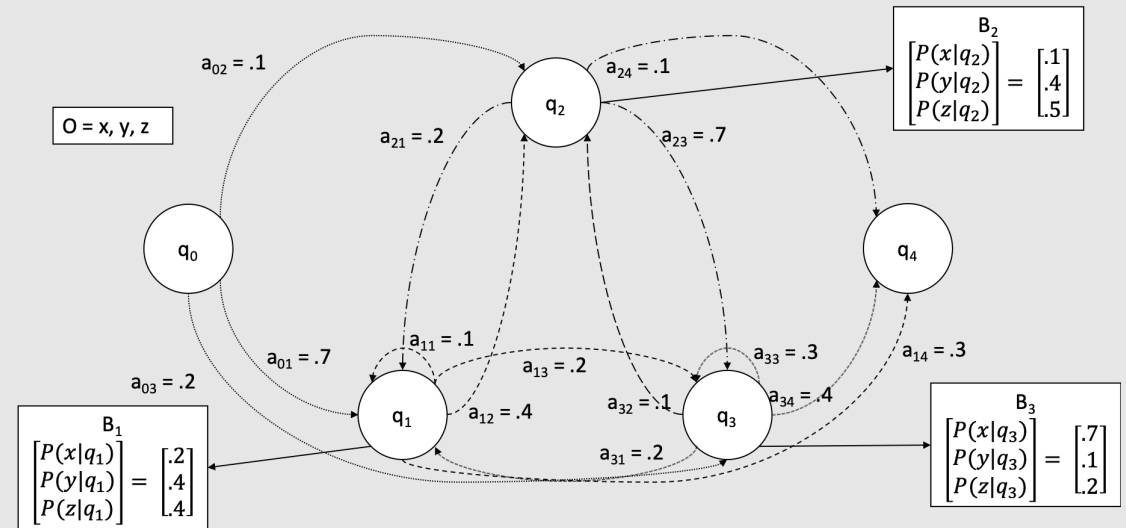
		target				
		q ₀	q ₁	q ₂	q ₃	q ₄
source	q ₀	N/A	0.7	0.1	0.2	N/A
	q ₁	N/A	0.1	0.4	0.2	0.3
	q ₂	N/A	0.2	N/A	0.7	0.1
	q ₃	N/A	0.2			
	q ₄	N/A	N/A	N/A	N/A	N/A



Problem-Solving Questions

target

	target				
	q ₀	q ₁	q ₂	q ₃	q ₄
source					
q ₀	N/A	0.7	0.1	0.2	N/A
q ₁	N/A	0.1	0.4	0.2	0.3
q ₂	N/A	0.2	N/A	0.7	0.1
q ₃	N/A	0.2	0.1	0.3	0.4
q ₄	N/A	N/A	N/A	N/A	N/A



Problem Solving Questions

- Given the following set of production rules (already in Chomsky Normal Form), use the CKY algorithm to parse the following sentence: *Book the flight*. Show the complete parse table.

- $S \rightarrow VP NP$
- $NP \rightarrow Det Noun$
- $NP \rightarrow book \mid flight$
- $VP \rightarrow Verb NP$
- $VP \rightarrow book \mid include \mid prefer$
- $Noun \rightarrow book \mid flight$
- $Verb \rightarrow book \mid include \mid prefer$
- $Det \rightarrow an \mid the$

Problem Solving Questions

- $S \rightarrow VP NP$
- $NP \rightarrow Det Noun$
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- $Det \rightarrow an \mid the$

	book	the	flight
book			
the			
flight			

Problem Solving Questions

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- $Verb \rightarrow book \mid include \mid prefer$
- $Det \rightarrow an \mid the$

	book	the	flight
book			
the			
flight			

Problem Solving Questions

- $S \rightarrow VP NP$
- $NP \rightarrow Det Noun$
- $NP \rightarrow \text{book} \mid \text{flight}$
- $VP \rightarrow Verb NP$
- $VP \rightarrow \text{book} \mid \text{include} \mid \text{prefer}$
- $Noun \rightarrow \text{book} \mid \text{flight}$
- $Verb \rightarrow \text{book} \mid \text{include} \mid \text{prefer}$
- $Det \rightarrow \text{an} \mid \text{the}$

	book	the	flight
book	NP VP Noun Verb		
the			
flight			

Problem Solving Questions

- $S \rightarrow VP NP$
- $NP \rightarrow Det Noun$
- $NP \rightarrow book \mid flight$
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	book	the	flight
book	NP VP Noun Verb		
the		Det	
flight			


Problem Solving Questions

- $S \rightarrow VP NP$
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- $NP \rightarrow book \mid \text{flight}$
- $VP \rightarrow Verb NP$
- $VP \rightarrow book \mid include \mid prefer$
- $Noun \rightarrow book \mid \text{flight}$
- $Verb \rightarrow book \mid include \mid prefer$
- $Det \rightarrow an \mid the$

	book	the	flight
book	NP VP Noun Verb		
the		Det	
flight			NP Noun


Problem Solving Questions

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- $NP \rightarrow Det Noun$
- $NP \rightarrow book \mid flight$
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	book	the	flight
book	NP VP Noun Verb		
the		Det	
flight			NP Noun

Problem Solving Questions

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- $NP \rightarrow Det Noun$
- $NP \rightarrow book \mid flight$
- $VP \rightarrow Verb NP$
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- $Noun \rightarrow book \mid flight$
- $Verb \rightarrow book \mid include \mid prefer$
- $Det \rightarrow an \mid the$

	book	the	flight
book	NP VP Noun Verb		
the		Det	
flight			NP Noun


Problem Solving Questions

- $S \rightarrow VP NP$
- $NP \rightarrow \text{Det Noun}$
- $NP \rightarrow \text{book} \mid \text{flight}$
- $VP \rightarrow \text{Verb NP}$
- $VP \rightarrow \text{book} \mid \text{include} \mid \text{prefer}$
- $\text{Noun} \rightarrow \text{book} \mid \text{flight}$
- $\text{Verb} \rightarrow \text{book} \mid \text{include} \mid \text{prefer}$
- $\text{Det} \rightarrow \text{an} \mid \text{the}$

	book	the	flight
book	NP VP Noun Verb		
the		Det	NP
flight			NP Noun

Problem Solving Questions

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- $NP \rightarrow Det Noun$
- $NP \rightarrow book \mid flight$
- $VP \rightarrow Verb NP$
- $VP \rightarrow book \mid include \mid prefer$
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- $Verb \rightarrow book \mid include \mid prefer$
- $Det \rightarrow an \mid the$

	book	the	flight
book	NP VP Noun Verb		
the		Det	NP
flight			NP Noun

The table is a 4x4 grid. The top row contains the words 'book', 'the', and 'flight'. The left column contains the words 'book', 'the', and 'flight'. The cell at row 2, column 4 contains a question mark icon. A blue arrow points from the question mark icon to the cell at row 2, column 2. Another blue arrow points from the question mark icon down to the cell at row 3, column 4. The cells at (2,2), (3,2), and (3,3) are shaded gray.

Problem Solving Questions

- $S \rightarrow VP NP$
- $NP \rightarrow Det Noun$
- $NP \rightarrow book \mid flight$
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	book	the	flight
book	NP VP Noun Verb		 S VP
the		Det	NP
flight			NP Noun

Problem Solving Questions

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	book	the	flight
book	NP VP Noun Verb		S VP
the		Det	NP
flight			NP Noun

Problem Solving Questions

- Given an input alphabet $\Sigma = \{a, b, c\}$ and an output alphabet $\Delta = \{b, c\}$, write a finite state transducer that replaces every instance of a with b . All other input should be mirrored in the output (so, e.g., abc should be converted to bbc).

Problem Solving Questions

- Transitions needed:
 - a:b
 - b:b
 - c:c
- Input length:
 - Unknown
- Final state criteria:
 - Any output character can be the final state
- No multi-character transitions involved



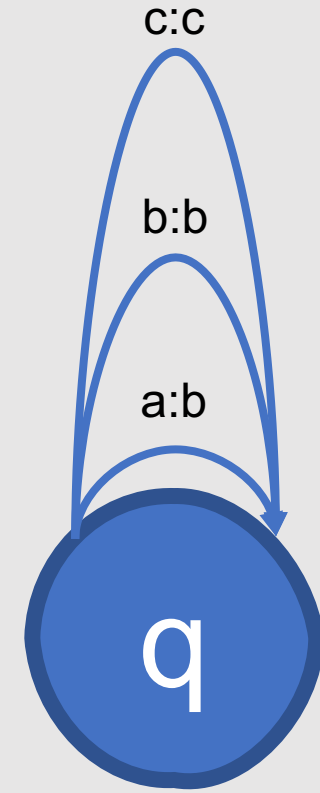
Problem Solving Questions

- Transitions needed:
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 - c:c
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Problem Solving Questions

- Transitions needed:
 - a:b
 - b:b
 - c:c
- Input length:
 - Unknown
- Final state criteria:
 - Any output character can be the final state
- No multi-character transitions involved



Bonus Question

Solution Time!

A few remaining details.....



Exam Location: Same classroom as always (TBH 180G)



Exam Time: Same time as class (Tuesday from 9:30-10:45 a.m.)

Good luck!
