Final Exam Review

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CS 421: Natural Language Processing

Fall 2019

Exam Format

True/False (30%)

- 20 questions, 1.5 points each
- No partial credit (autograded)

Multiple Choice (40%)

- 16 questions, 2.5 points each
- No partial credit (autograded)

Problem Solving (30%)

- 4 questions, 7.5 points each
- Show work for partial credit (graded manually)

Bonus Question (10%)

- Problem-solving question
- Points added to exam score (max exam score = 100)

Sample Final Exam

- Currently available on Piazza (@264)
- Solution will be posted after class

What should I study?

- Questions designed based on **slides**, **assignments**, **previous midterms**, and **previous midterm reviews**

- Problem solving questions similar but not identical to **problem solving examples** (e.g., computing evaluation metrics) in slides

What content will the exam cover?

- Everything!
- Final exam is **comprehensive**
- Sample final exam reflects the distribution of new (after Midterm 2) versus previous (prior to Midterm 2) material

Midterm 1

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

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Midterm 2

N-Grams

Language Modeling

Word Embeddings

Cosine Similarity

Naive Bayes

Text Classification

Evaluation Metrics

Feedforward Neural Networks

Recurrent Neural Networks

New Material

Information extraction

Named entity recognition

Temporal analysis

Chatbots

Task-based dialogue systems

Question answering

Summarization

Machine translation

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

- Forward-backward algorithm
- 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
- Derivatives
- Log values
- Language model interpolation
- Word embedding visualization techniques
- Implementation details for GloVe, ELMo, or BERT
- Backpropagation equations
  - Do have a general sense of how backpropagation works
- Implementation details for LSTM and GRU gates
- Rhetorical structure theory
- Bayesian noisy channel model

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?

Two hours

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True/False

Multiple Choice

Solution Time!

o					
m					
l					
e					
#					
	#	b	e	r	t

- Compute the minimum edit distance between the words *bert* and *elmo*. Provide the full minimum edit distance table, with backpointers, and indicate the backtrace (similar to what you did for Assignment 1). Assume that:
  - ins_cost(x) = del_cost(x) = 2
  - sub_cost(x, y) = $\begin{cases} 3 \text{ if } x \neq y \\ 0 \text{ if } x = y \end{cases}$

Problem-Solving Questions

	#	b	e	r	t
o	8↓				
m	6↓				
l	4↓				
e	2↓				
#	**0**	2←	4←	6←	8←
	#	b	e	r	t

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Problem-Solving Questions

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o	8↓				
m	6↓				
l	4↓				
e	2↓				
#	**0**	2←	4←	6←	8←
	#	b	e	r	t

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Problem-Solving Questions

o	8↓				
m	6↓				
l	4↓				
e	2↓	3↙			
#	**0**	2←	4←	6←	8←
	#	b	e	r	t

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Problem-Solving Questions

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o	8↓				
m	6↓				
l	4↓				
e	2↓	3↙	2↙		
#	**0**	2←	4←	6←	8←
	#	b	e	r	t

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Problem-Solving Questions

o	8↓				
m	6↓				
l	4↓				
e	2↓	3↙	2↙	4←	
#	**0**	2←	4←	6←	8←
	#	b	e	r	t

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Problem-Solving Questions

o	8↓	9↓✓	8↓	9↓✓	10↓✓
m	6↓	7↓✓	6↓	7↓✓	8✓
l	4↓	5↓✓	4↓	5✓	7←✓
e	2↓	3✓	2✓	4←	6←
#	**0**	2←	4←	6←	8←
	#	b	e	r	t

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Problem-Solving Questions

o	8↓	9↓✔	8↓	9↓✔	10↓✔
m	6↓	7↓✔	6↓	7↓✔	8✔
l	4↓	5↓✔	4↓	5✔	7←✔
e	2↓	3✔	2✔	4←	6←
#	**0**	2←	4←	6←	8←
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Problem-Solving Questions

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m	6↓	7↓✔	6↓	7↓✔	8✔
l	4↓	5↓✔	4↓	5✔	7←✔
e	2↓	3✔	2✔	4←	6←
#	**0**	2←	4←	6←	8←
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Problem-Solving Questions

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m	6↓	7↓✔	6↓	7↓✔	8✔
l	4↓	5↓✔	4↓	5✔	7←✔
e	2↓	3✔	2✔	4←	6←
#	**0**	2←	4←	6←	8←
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Problem-Solving Questions

o	8↓	9↓✓	8↓	9↓✓	10↓✓
m	6↓	7↓✓	6↓	7↓✓	8✓
l	4↓	5↓✓	4↓	5✓	7←✓
e	2↓	3✓	2✓	4←	6←
#	**0**	2←	4←	6←	8←
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Problem-Solving Questions

o	8↓	9↓✔	8↓	9↓✔	10↓✔
m	6↓	7↓✔	6↓	7↓✔	8✔
l	4↓	5↓✔	4↓	5✔	7←✔
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#	**0**	2←	4←	6←	8←
	#	b	e	r	t

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Problem-Solving Questions

	#	b	e	r	t
o	8↓	9↓✓	8↓	9↓✓	10↓✓
m	6↓	7↓✓	6↓	7↓✓	8✓
l	4↓	5↓✓	4↓	5✓	7←✓
e	2↓	3✓	2✓	4←	6←
#	**0**	2←	4←	6←	8←

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Problem-Solving Questions

o	8↓	9↓✓	8↓	9↓✓	10↓✓
m	6↓	7↓✓	6↓	7↓✓	8✓
l	4↓	5↓✓	4↓	5✓	7←✓
e	2↓	3✓	2✓	4←	6←
#	**0**	2←	4←	6←	8←
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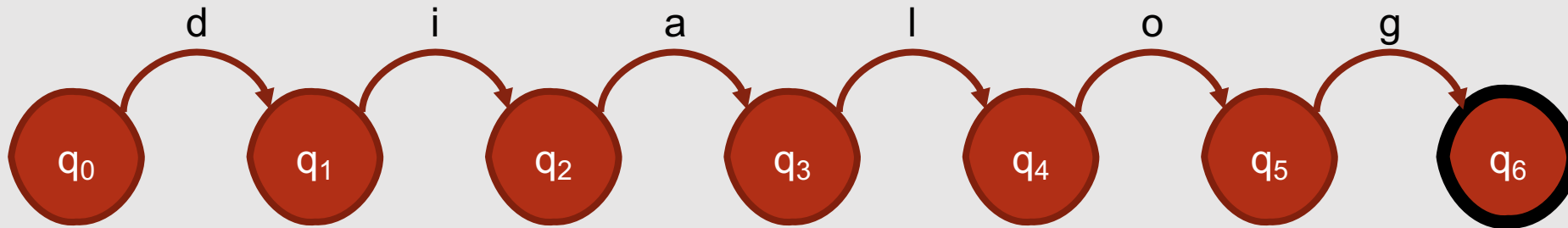 - sub_cost(x, y) = $\begin{cases} 3 \text{ if } x \neq y \\ 0 \text{ if } x = y \end{cases}$

Problem-Solving Questions

Problem-Solving Questions

- Draw a finite state automaton that matches the regular expression: dialog(ue)?

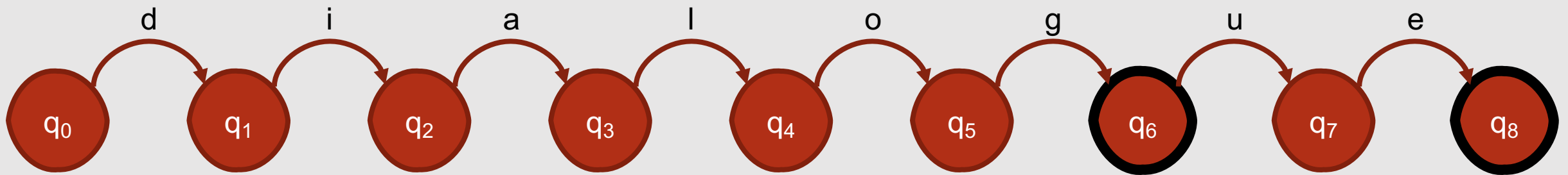# Problem-Solving Questions

- Draw a finite state automaton that matches the regular expression: dialog(ue)?

Problem-Solving Questions

- Draw a finite state automaton that matches the regular expression: dialog(ue)?

	W1	W2	W3
winter	2	1	2
exam	2	2	1
final	1	2	1

Problem-Solving Questions

Consider the following word embeddings for *winter*, *exam*, and *final*.

Compute the cosine similarities between (a) *winter* and *final*, and (b) *exam* and *final*, to determine whether *winter* or *exam* is closer to *final*.

	W1	W2	W3
winter	2	1	2
exam	2	2	1
final	1	2	1

Consider the following word embeddings for *winter*, *exam*, and *final*.

Compute the cosine similarities between (a) *winter* and *final*, and (b) *exam* and *final*, to determine whether *winter* or *exam* is closer to *final*.

$$cos(x,y) = \frac{x \cdot y}{|x||y|} = \frac{\sum_{i=1}^{N} x_i y_i}{\sqrt{\sum_{i=1}^{N} x_i^2} \sqrt{\sum_{i=1}^{N} y_i^2}}$$

	W1	W2	W3
winter	2	1	2
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Problem-Solving Questions

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$\cos(\text{winter, final}) = \dfrac{2*1+1*2+2*1}{\sqrt{2^2+1^2+2^2}\sqrt{1^2+2^2+1^2}}$

	W1	W2	W3
winter	2	1	2
exam	2	2	1
final	1	2	1

$$\cos(x,y) = \frac{x \cdot y}{|x||y|} = \frac{\sum_{i=1}^{N} x_i y_i}{\sqrt{\sum_{i=1}^{N} x_i^2} \sqrt{\sum_{i=1}^{N} y_i^2}}$$

Problem-Solving Questions

Consider the following word embeddings for *winter*, *exam*, and *final*.

Compute the cosine similarities between (a) *winter* and *final*, and (b) *exam* and *final*, to determine whether *winter* or *exam* is closer to *final*.

$$\cos(\text{winter, final}) = \frac{2*1+1*2+2*1}{\sqrt{2^2+1^2+2^2}\sqrt{1^2+2^2+1^2}} = \frac{6}{\sqrt{9}*\sqrt{6}}$$

	W1	W2	W3
winter	2	1	2
exam	2	2	1
final	1	2	1

Consider the following word embeddings for *winter*, *exam*, and *final*.

Compute the cosine similarities between (a) *winter* and *final*, and (b) *exam* and *final*, to determine whether *winter* or *exam* is closer to *final*.

$$\cos(x,y) = \frac{x \cdot y}{|x||y|} = \frac{\sum_{i=1}^{N} x_i y_i}{\sqrt{\sum_{i=1}^{N} x_i^2}\sqrt{\sum_{i=1}^{N} y_i^2}}$$

cos(winter, final) = $\frac{2*1+1*2+2*1}{\sqrt{2^2+1^2+2^2}\sqrt{1^2+2^2+1^2}} = \frac{6}{\sqrt{9}*\sqrt{6}}$

cos(exam, final) = $\frac{2*1+2*2+1*1}{\sqrt{2^2+2^2+1^2}\sqrt{1^2+2^2+1^2}} = \frac{7}{\sqrt{9}*\sqrt{6}}$

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	W1	W2	W3
winter	2	1	2
exam	2	2	1
final	1	2	1

$$\cos(x,y) = \frac{x \cdot y}{|x||y|} = \frac{\sum_{i=1}^{N} x_i y_i}{\sqrt{\sum_{i=1}^{N} x_i^2}\sqrt{\sum_{i=1}^{N} y_i^2}}$$

$\cos(\text{winter, final}) = \frac{2*1+1*2+2*1}{\sqrt{2^2+1^2+2^2}\sqrt{1^2+2^2+1^2}} = \frac{6}{\sqrt{9}*\sqrt{6}}$

$\cos(\text{exam, final}) = \frac{2*1+2*2+1*1}{\sqrt{2^2+2^2+1^2}\sqrt{1^2+2^2+1^2}} = \frac{7}{\sqrt{9}*\sqrt{6}}$

Problem-Solving Questions

Consider the following word embeddings for *winter*, *exam*, and *final*.

Compute the cosine similarities between (a) *winter* and *final*, and (b) *exam* and *final*, to determine whether *winter* or *exam* is closer to *final*.

Problem-Solving Questions

- Compute the mean reciprocal rank for a question answering system that provides the following ranked lists of answers to the specified questions. Reference answers are provided for each question.

When is the last day of the fall semester?

December 13, 2019

Candidate	Rank
December 11	1
Friday	2
December 13, 2019	3
Friday the 13th	4

When does the spring semester begin?

January 13, 2020

Candidate	Rank
January 1	1
January 13, 2020	2
January 20, 2020	3
Next year	4

Problem-Solving Questions

- Compute the mean reciprocal rank for a question answering system that provides the following ranked lists of answers to the specified questions. Reference answers are provided for each question.

Rank: 3
Reciprocal Rank: 1/3

When is the last day of the fall semester?

December 13, 2019

Candidate	Rank
December 11	1
Friday	2
December 13, 2019	3
Friday the 13th	4

When does the spring semester begin?

January 13, 2020

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Next year	4

Problem-Solving Questions

- Compute the mean reciprocal rank for a question answering system that provides the following ranked lists of answers to the specified questions. Reference answers are provided for each question.

When is the last day of the fall semester?

December 13, 2019

Candidate	Rank
December 11	1
Friday	2
December 13, 2019	3
Friday the 13th	4

Rank: 3
Reciprocal Rank: 1/3

When does the spring semester begin?

January 13, 2020

Candidate	Rank
January 1	1
January 13, 2020	2
January 20, 2020	3
Next year	4

Rank: 2
Reciprocal Rank: 1/2

Problem-Solving Questions

- Compute the mean reciprocal rank for a question answering system that provides the following ranked lists of answers to the specified questions. Reference answers are provided for each question.

When is the last day of the fall semester?

December 13, 2019

Candidate	Rank
December 11	1
Friday	2
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Friday the 13th	4

When does the spring semester begin?

January 13, 2020

Candidate	Rank
January 1	1
January 13, 2020	2
January 20, 2020	3
Next year	4

Rank: 3
Reciprocal Rank: 1/3

Rank: 2
Reciprocal Rank: 1/2

Mean Reciprocal Rank
= (1/3 + 1/2) / 2 = 5/12

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Bonus Question

- Compute the ROUGE-1 score for the candidate summary, given the provided reference summary. Ignore punctuation.

Have a great break, and see you next year!

Have a fun break, and see you next decade!

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Bonus Question

- Compute the ROUGE-1 score for the candidate summary, given the provided reference summary. Ignore punctuation.

Have a great break, and see you next year!

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Have

a

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Have a great break, and see you next year!

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Have	Have
a	a
great	fun
break	break
and	and
see	see
you	you
next	next
year	decade

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Bonus Question

- Compute the ROUGE-1 score for the candidate summary, given the provided reference summary. Ignore punctuation.

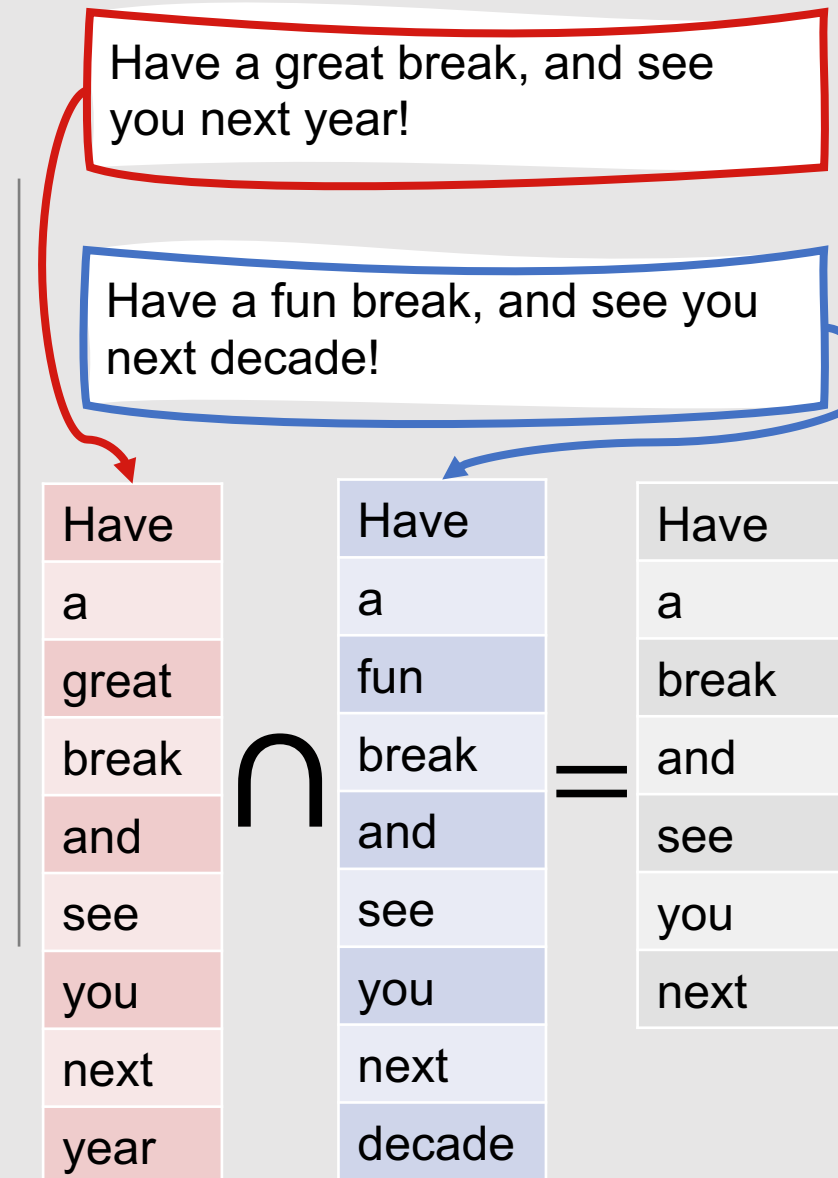Have a great break, and see you next year!

Have a fun break, and see you next decade!

| Have |
| a |
| great |
| break |
| and |
| see |
| you |
| next |
| year |

∩

| Have |
| a |
| fun |
| break |
| and |
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| next |
| decade |

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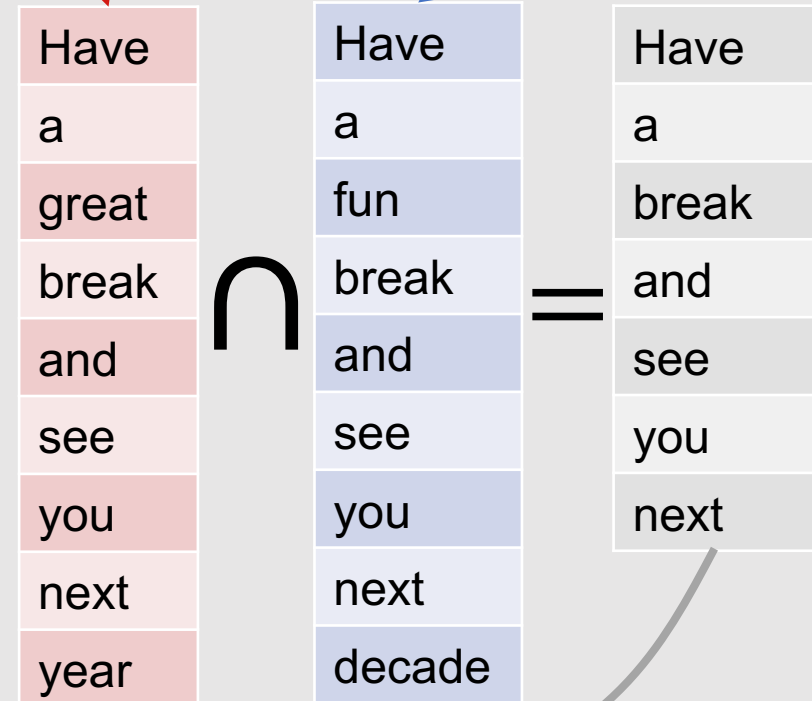| Have |
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Have a great break, and see you next year!

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Have	Have	Have
a	a	a
great	fun	break
break	break	and
and	and	see
see	see	you
you	you	next
next	next	
year	decade	

$\cap$ $=$

ROUGE-1 = 7/9

A few remaining details….

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

Exam Time:

Wednesday, December 11, from **10:30 a.m. to 12:30 p.m.**

Good luck!

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