

# Distributed Systems

CS425/ECE428

March 20 2023

*Instructor: Radhika Mittal*

# Today's agenda

- Exam Review

# Midterm exam: March 22-24

- Detailed instructions shared on CampusWire (post #378).
  - Go over them again.
  - Reserve a slot if you haven't already.
  - Submit your Letters of Accommodations to CBTF, if required.
  - Syllabus: everything covered in class upto and including Paxos.
  - Closed-book exam: cannot refer to any materials / cheat sheets.
  - CBTF will provide calculator and scratch paper.
  - CBTF student office hours tomorrow (March 21<sup>st</sup>) at 3pm in case you have any questions for them.

# Midterm exam: March 22-24

- Syllabus:
  - everything up to and including Paxos.
- Exam duration: 50mins
  - Extra time to check-in and settle in.

# PrairieLearn

- Exam format:
  - Multiple choice questions:
    - Single answer correct; True/False
    - Multiple answers may be correct.
  - Numerical questions
    - No step marking!

# PrairieLearn: interface example

Quizzes1: Practice Quiz

This is Quizzes 1: Practice Quiz for CS 425 / ECE 428

I certify that I am Radhika Mittal and I am allowed to take this assessment.

I pledge on my honor that I will not give or receive any unauthorized assistance on this assessment and that all work will be my own.

**I certify and pledge the above.**

Start assessment

# PrairieLearn: interface example

Quizzes1: Practice Quiz

This assessment will only be graded after it is finished. You should save answers for all questions and your exam will be graded later. You can use the **Finish assessment** button below to finish and calculate your final grade.

Total points: 15      Assessment is **open** and you can answer questions.  
Available credit: 100% until 10:45, Sat, May 20 ⓘ

Time remaining: 29 min

Question	Submission status	Points
<b>Practice Question</b>		
Question 1	unanswered	5
Question 2	unanswered	10

- Submit your answer to each question with the **Save** button on the question page.
- After you have answered all the questions completely, click here: **Finish assessment**

This demo has only two questions. Your midterm will display more questions.

# PrairieLearn: interface example

## Question 2: Testing Question

What is your favorite course?

- (a) CS 425
- (b) CS 438
- (c) ECE 428
- (d) ECE 391
- (e) CS 423

Select all possible options that apply. 

What is the minimum number of computers in a distributed system?



Is the answer to this question true?

- (a) true
- (b) false

Save

10 points available for this attempt

## Quizzes 1

Assessment overview

Time remaining: 29 min

## Question

Submission status: **unanswered**

Total points: — /10

Auto-graded question

Report an error in this question 

Previous question

Next question

 Attached files




# PrairieLearn: interface example

**Question 2: Testing Question**

What is your favorite course?

- (a) CS 425
- (b) CS 438
- (c) ECE 428
- (d) ECE 391
- (e) CS 423

Select all possible options that apply. 

What is the minimum number of computer science courses you have taken?  
integer

Is the answer to this question true?

- (a) true
- (b) false

[Save](#)

10 points available for this attempt

**Checkbox**

You must select at least 1 option. You will receive a score of  $100\% * (t - f) / n$ , where  $t$  is the number of true options that you select,  $f$  is the number of false options that you select, and  $n$  is the total number of true options. At minimum, you will receive a score of 0%.

**Quizzes 1**

[Assessment overview](#)

Time remaining: 29 min

**Question**

Submission status: **unanswered**

Total points: — /10

Auto-graded question

[Report an error in this question](#)

[Previous question](#)

[Next question](#)

[Attached files](#)

# PrairieLearn: interface example

The screenshot displays the PrairieLearn interface for a question. The question is titled "Question 2: Testing Question" and asks "What is your favorite course?" with multiple-choice options (a) CS 425, (b) ECE 391, (c) ECE 428, (d) CS 438, and (e) CS 423. A second question asks "What is the minimum number of computers in a distributed system?" with a text input field containing "0". A "Save" button is visible, and the question is worth 10 points. The submission status is "invalid, not gradable". The error message states "Format Error" and "No answer was submitted." for option (c). The interface also shows a sidebar with "Quizzes 1", "Question", "Submitted answer", "Attached files", and "Staff information".

**Question 2: Testing Question**

What is your favorite course?

- (a) CS 425
- (b) ECE 391
- (c) ECE 428
- (d) CS 438
- (e) CS 423

Select all possible options that apply. ?

What is the minimum number of computers in a distributed system?

0 ?

Is the answer to this question true?

- (a) true
- (b) false

**Save** 10 points available for this attempt

**Submitted answer** **invalid, not gradable** ? hide ^

Submitted at 2022-03-08 09:37:31 (CST)

**Format Error**

(a) C No answer was submitted.  
(c) ECE 428

0 **Invalid** Why ?

**Quizzes 1**

**Assessment overview**

**Question**

**Submission status:** **invalid**

**Points:** 10

**Report an error in this question**

**Previous question**

**Next question**

**Attached files**

**No attached files**

**Attach a file**

**Attach text**

**Staff information**

**Staff user:**

Radhika Mittal  
radhikam@illinois.edu

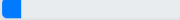
You must attempt all subparts of a given question for the question to be gradable.

# PrairieLearn: interface example

Quizzes1: Practice Quiz

This assessment will only be graded after it is finished. You should save answers for all questions and your exam will be graded later. You can use the **Finish assessment** button below to finish and calculate your final grade.

Total points: 15      Assessment is **open** and you can answer questions.  
Available credit: 100% until 10:45, Sat, May 20 ⓘ

 Time remaining: 26 min

Question	Submission status	Points
<b>Practice Question</b>		
Question 1	<b>saved</b>	5
Question 2	<b>invalid</b>	10

- Submit your answer to each question with the **Save** button on the question page.
- After you have answered all the questions completely, click here: **Finish assessment**

📎 Attached files

*No attached files*

Attach a file 📎

Attach text 📎


Valid responses saved for other questions will not be affected.

# PrairieLearn: interface example


Question 2: Testing Question

What is your favorite course?

- (a) CS 425
- (b) ECE 391
- (c) ECE 428
- (d) CS 438
- (e) CS 423

Select all possible options that apply. 

What is the minimum number of computers in a distributed system?

Is the answer to this question true?

- (a) true
- (b) false

[Save](#) 10 points available for this attempt

Quizzes 1

[Assessment overview](#)

Question


Submission status: **invalid**

Points: 10

[Report an error in this question](#)

[Previous question](#)

[Next question](#)

 Attached files

No attached files

[Attach a file](#)

[Attach text](#)

# PrairieLearn: interface example

**Question 2: Testing Question**

What is your favorite course?

- (a) CS 425
- (b) ECE 391
- (c) ECE 428
- (d) CS 438
- (e) CS 423

Select all possible options that apply. ?

What is the minimum number of computers in a distributed system?

 ?

Is the answer to this question true?

- (a) true
- (b) false

**Save** 10 points available for this attempt

Submitted answer 2 **saved, not graded** hide ^

Submitted at 2022-03-08 09:38:53 (CST)

(a) CS 425  
(c) ECE 428  
0 (a) true

Submitted answer 1 **invalid, not gradable** show v

Submitted at 2022-03-08 09:37:31 (CST)

**Quizzes 1**

**Assessment overview**

**Question**

Submission status: **saved**

Points: 10

[Report an error in this question](#)

**Previous question**

**Next question**

**Attached files**

No attached files

[Attach a file](#)

[Attach text](#)

**Staff information**

**Staff user:**  
Radhika Mittal  
radhikam@illinois.edu

**Question:**

# PrairieLearn: interface example

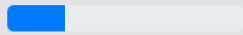
## Quizzes1: Practice Quiz

This assessment will only be graded after it is finished. You should save answers for all questions and your exam will be graded later. You can use the **Finish assessment** button below to finish and calculate your final grade.

Total points: 15

Assessment is **open** and you can answer questions.

Available credit: 100% until 10:45, Sat, May 20 ⓘ



Time remaining: 22 min

Question	Submission status	Points
<b>Practice Question</b>		
<a href="#">Question 1</a>	<b>saved</b>	5
<a href="#">Question 2</a>	<b>saved</b>	10

- Submit your answer to each question with the **Save** button on the question page.
- After you have answered all the questions completely, click here: **Finish assessment**

# Disclaimer for our agenda today

- Quick reminder of the relevant topics we covered in class, that are included in your midterm.
- Not meant to be an exhaustive review!
- Go over the slides for each class.
  - Refer to lecture videos and textbook to fill in gaps in understanding.

# Topics for your midterm

- System model and Failures
- Failure Detection
- Clock Synchronization
- Event ordering and Logical Timestamps
- Global Snapshot
- Multicast
- Mutual Exclusion
- Leader Election
- Synchronous Consensus and Paxos



# Topics for your midterm

- System model and Failures
  - What is a distributed system?
  - Relationship between processes
  - Synchronous and Asynchronous Systems
  - Types of failures

# Topics for your midterm

- Failure Detection
  - Ping-ack and Heartbeats: what are appropriate timeout values?
  - Correctness of failure detection algorithms (accuracy and completeness).
  - Performance of failure detection algorithms (bandwidth usage and worst-case failure detection times).
  - Extending to a system of  $N$  processes.

# Topics for your midterm

- Clock Synchronization
  - Clock skew and drift rates
  - External vs Internal Synchronization
  - Clock synchronization in synchronous systems
  - Cristian Algorithm
  - Berkeley Algorithm
  - NTP Symmetric mode synchronization

# Topics for your midterm

- Event ordering and Logical Timestamps
  - Happened before relationship
  - Lamport Clocks
  - Vector Clocks

# Topics for your midterm

- Global Snapshots
  - Process and channel states
  - Consistent cuts
  - Chandy-Lamport algorithm
  - Runs and Linearizations
  - Safety and liveness properties, stable global predicates

# Topics for your midterm

- Multicast
  - Basic multicast
  - Reliable multicast
  - Ordered multicast: FIFO, Causal, Total
    - How to implement these?

# Topics for your midterm

- Mutual Exclusion
  - Central server algorithm
  - Ring-based algorithm
  - Ricart Agrawala algorithm
  - Maekawa algorithm (breaking deadlock not in your syllabus)
  - Analyzing these algorithms:
    - Safety, liveness, and ordering
    - Client delay, Synchronization delay, and Bandwidth.

# Topics for your midterm

- Leader Election
  - Ring election algorithm (Chang and Roberts algorithm)
  - Bully algorithm
  - Analyzing these algorithms:
    - Safety and liveness for synchronous and asynchronous systems
    - Turnaround time and bandwidth



# Topics for your midterm

- Synchronous Consensus and Paxos
  - Round-based algorithm for synchronous consensus
  - Impossibility of consensus in asynchronous systems (proof not in your syllabus).
  - Paxos algorithm
    - Three roles: proposer, acceptor, learner.
    - Phase 1: *prepare* request and response.
      - When will an acceptor respond?
    - Phase 2: *accept* request (if applicable)
      - When will an accept request be sent?
      - What will be the proposed value?
    - When is a value implicitly decided? How is the value shared with the learners?  
What is required to guarantee safety?

# Topics for your midterm

- System model and Failures
- Failure Detection
- Clock Synchronization
- Event ordering and Logical Timestamps
- Global Snapshot
- Multicast
- Mutual Exclusion
- Leader Election
- Synchronous Consensus and Paxos

**Good luck!**