CSE 4703S:Introduction to Computer Networks



Raj Jain

Washington University in Saint Louis
Saint Louis, MO 63130
Jain@wustl.edu

Audio/Video recordings of this lecture are available on-line at:

http://www.cse.wustl.edu/~jain/cse4703-26/

Student Questions

©2026 Raj Jain



Overview

- Why Study Computer Networking?
- The Goal of This Course
- Instructor
- Grading
- Contents of the course
- Tentative Schedule

Student Questions

Networking = "Plumbing"

- Networking is the "plumbing" of computing
- Almost all areas of computing are network-based.
  - Distributed computing
  - Big Data
  - Cloud Computing
  - Internet of Things
  - Smart Cities
- Networking is the backbone of computing.







We are in the Internet Age.

Student Questions

©2026 Raj Jain

Networking is Fueling All Sectors of Economy

- Networking companies are among the most valued: Apple, AT&T, Samsung, Verizon, Microsoft, China Mobile, Alphabet, Comcast, NTT, IBM, Intel, Cisco, Amazon, Facebook, …

  ⇒ All tech companies that are hiring currently are networking companies
- Note: Apple became highly valued only after it switched from computing to communications (iPhone)



Networking = Economic Indicator

Student Questions

Selecting the Right Field

- An important question for **students**, academics, entrepreneurs, and companies
- Goal: To impact
- Follow the **paradigm shifts**:
  - 1980: Ethernet
  - 1990: ATM Networks
  - 2000: Optical Networks
  - 2005: Wireless Networks
  - 2008: Next Generation Internet/SDN
  - …
  - 2025: Whatever is being **hyped** this year?

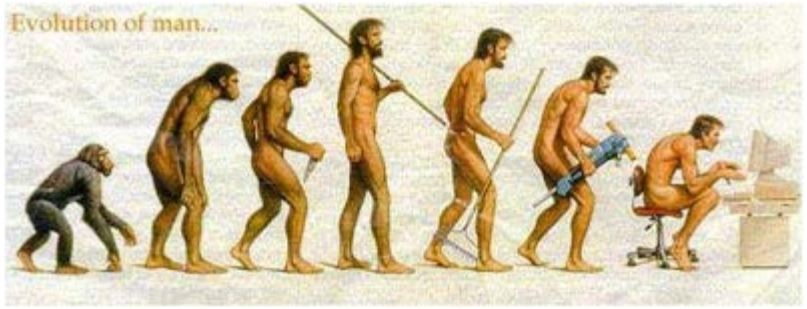


Industries adapt by necessity.
Academics continue to develop deeper expertise in what they already know.

Student Questions

©2026 Raj Jain

Internet Age



- Distributed Computing
- Cloud Computing
- Mobile Computing ⇒ Smart Phones
- Streaming Video ⇒ YouTube
- Social Networking ⇒ FaceBook
- Big Data
- Machine Learning ⇒ Artificial Intelligence
- Online Shopping ⇒ Amazon, eBay, Google
- Most fields today – Education, Health, Environment – are advancing simply because of advances in networking.

Student Questions

©2026 Raj Jain

Current Hot Topics in Networking



1. Internet of Things (IoT)
2. Cybersecurity
3. Cloud Computing
4. Software Defined Networking
5. Wireless Networking
6. Internet of AI agents
7. Quantum Networking

Student Questions

©2026 Raj Jain

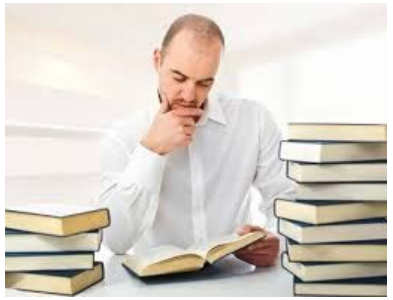
Trend: Smart Everything

 Smart Watch	 Smart TV	 Smart Car
 Smart Health	 Smart Home	 Smart Kegs
 Smart Space	 Smart Industries	 Smart Cities

Student Questions

What's Smart?

- Old: Smart = Can think ⇒ Computation
  = Can Recall ⇒ Storage
- Now: Smart = Can find quickly, Can Delegate
  ⇒ Communicate = Networking
- Smart Grid, Smart Meters, Smart Cars, Smart Homes, Smart Cities, Smart Factories, Smart Smoke Detectors, …



Not-Smart



Smart

- Smart = Apply the latest **technology** to solve problems.

Student Questions

Trend: Smart to Intelligent

 Intelligent Clock	 Intelligent TV	 Intelligent Car
 Intelligent Health	 Intelligent Home Security	 Intelligent Microwave
 Intelligent Light	 Amazon Alexa	 Google Assistant

Student Questions

Trend: Security & Cyber Warfare

- Security of computers, companies, smart grid, and nations
- Nation-states are penetrating other nations' computers
  5th domain of warfare (after land, sea, air, space)
- In 2010, the US set up the US Cyber Command
- The UK, China, Russia, Israel, and North Korea have similar centers
- Many cyber wars: North Korea vs. USA, Israel vs. Syria, South Korea vs. North Korea. India vs. Pakistan, …



Old



New

Ref: http://en.wikipedia.org/wiki/Cyber_war

Student Questions

©2026 Raj Jain

Internet of Harmful Things

Researchers at DEFCON 3 hacked a smart toilet, making it flush incessantly and closing the lid repeatedly and unexpectedly and causing a **Denial of Service** Attack.



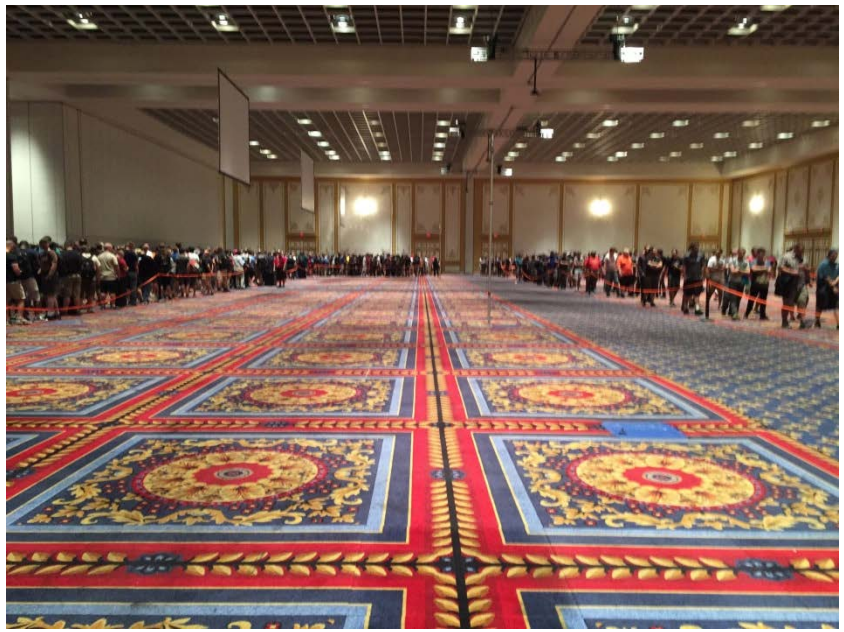
Ref: http://www.computerworld.com/article/2486502/security0/worm-may-create-an-internet-of-harmful-things--says-symantec--take-note--amazon-.html

Student Questions

©2026 Raj Jain

DEFCON







- Hacker's conference
- Held in Las Vegas every July
- 20,000+ attendees
- All anonymous

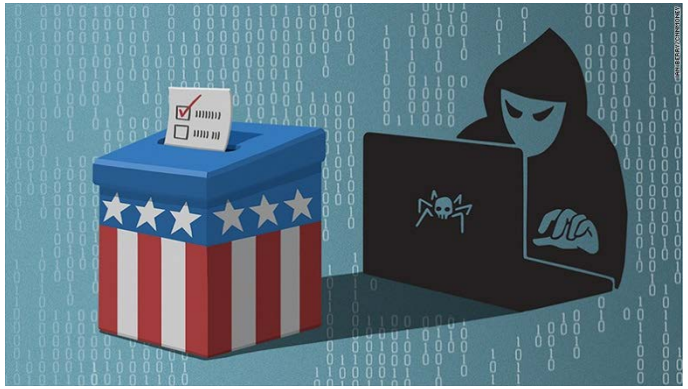
Ref: https://www.ethicalhacker.net/features/opinions/first-timers-experience-black-hat-defcon

Student Questions

©2026 Raj Jain

Recent DEFCON Topics

- Hacking voting machines
- Hack connected-vehicles
- Hacking the cloud
- Hacking travel routers
- Clone RFID in real-time
- Breaking the Uber badge ciphers
- Counterfeit hardware security devices, RSA tokens
- Fool antivirus software using AI
- How to track government spy planes
- Break Bitcoin hardware wallets
- DARPA Cyber Grand Challenge (2015, 2016)



Student Questions

Trend: Cloud Computing

- August 25, 2006: Amazon announced EC2
  ⇒ Birth of Cloud Computing in reality
  (Prior theoretical concepts of computing as a utility)
  $10 B in 2016, a growth rate of 49% with 17% margins, much higher than the overall Amazon business



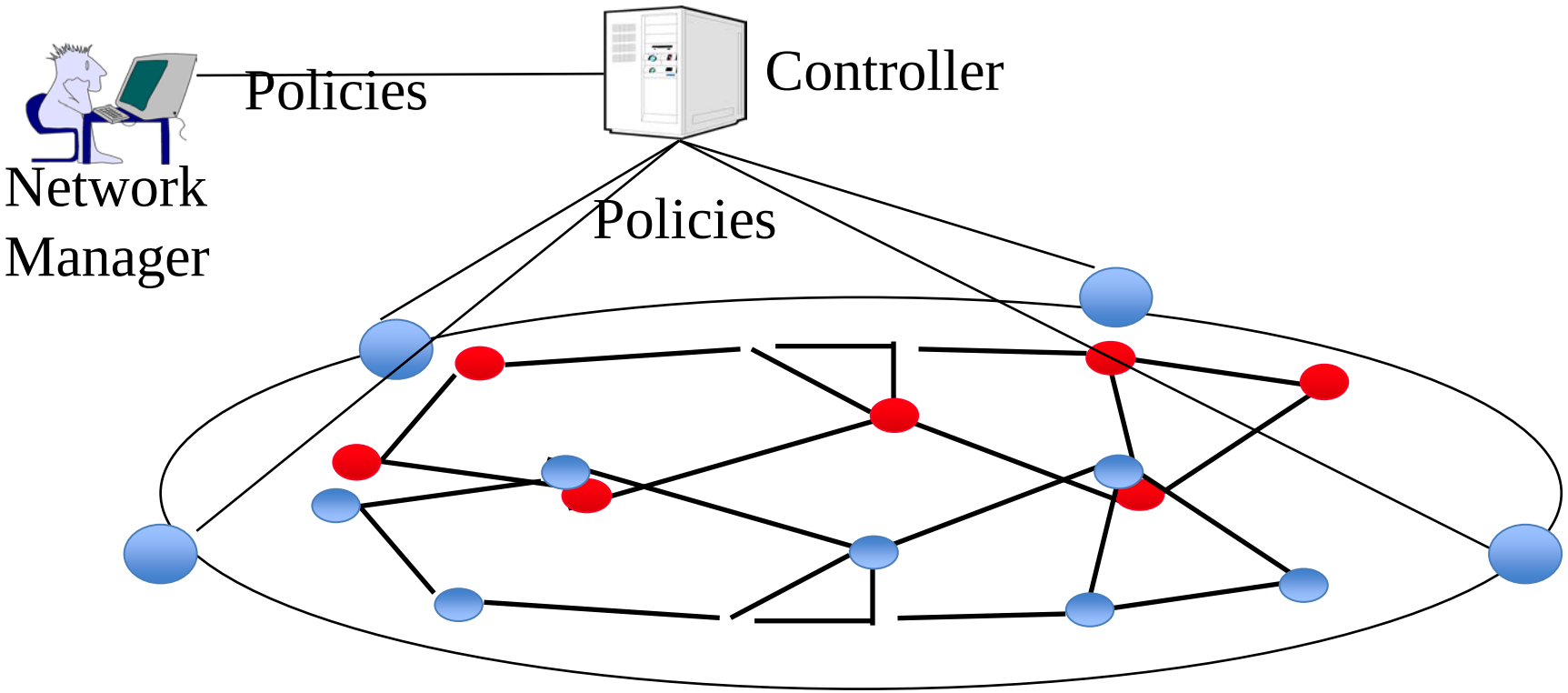
- Cloud Computing:
  - Applications through the Internet (Google Docs)
  - Computing through Internet (Amazon EC3)
  - Storage and backup through the Internet (iCloud, Google Drive)

Student Questions

©2026 Raj Jain

Software Defined Networking

- Using standard networking hardware
  ⇒ Allows managing large networks using the software.



Student Questions

©2026 Raj Jain

Goal of This Course

- The first course in networking
- Fundamentals
- Broad coverage of key areas of networking
- Networking background for networking applications in other areas of computing
- This is a course on Networking Architecture
- This is not a course on network building or usage
- You will be able to understand protocols
- An example of the difference between architecture and implementation is the computer architecture course and a course on the Intel Pentium Chip.
- This is the first networking course.
- The basis for more advanced networking courses

Student Questions

©2026 Raj Jain

What Will You Learn?

1. What messages and messages are exchanged when you fetch a web page?
2. What messages are used to send/receive emails?
3. How do the names, such as www.google.com, get translated to IP addresses such as 74.125.73.104?
4. What is done to avoid congestion under overload?
5. How is the path on the Internet determined?
6. What happens if bits in a packet get corrupted?
7. How does Wi-Fi or Ethernet work?
8. What is the difference between Wi-Fi, Ethernet, IP, and TCP?
9. What is done to handle audio/video on the Internet?
10. How can you guarantee security on the Internet?

Student Questions

©2026 Raj Jain

Networking Courses at WUSTL

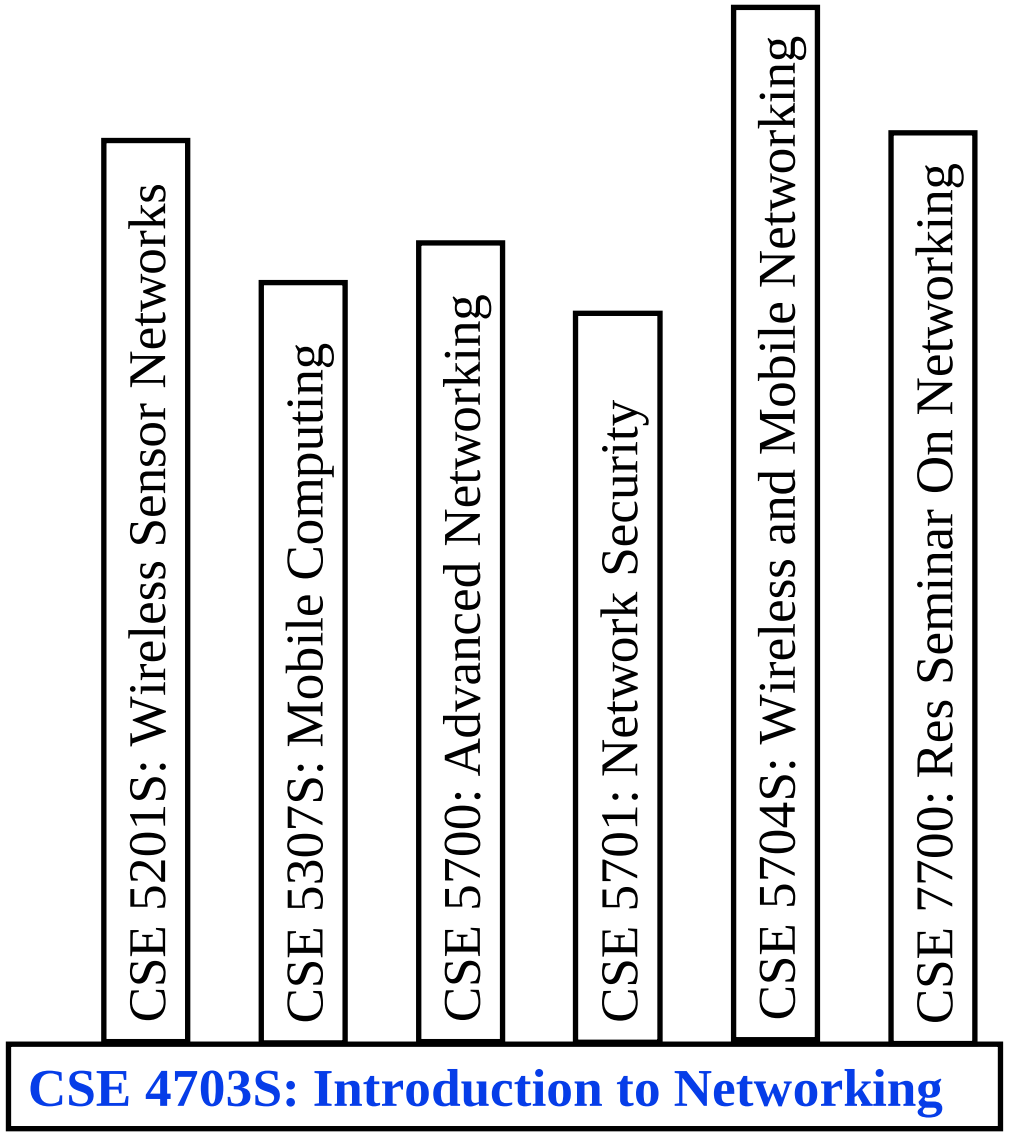
1. **CSE 4703: Introduction To Computer Networks** (Spring 2022) – Prerequisite for all other networking classes
2. CSE 5201S: Wireless Sensor Network
3. CSE 5307S: Mobile Computing
4. **CSE 5700S: Advanced Networking:** Clouds, Big Data, SDN, IoT (Fall 2021)
5. **CSE 5704S**: **Wireless and Mobile Networking** (Fall 2020)
6. **CSE 5701S: Network Security**
7. CSE 7700: Research Seminar On Networking and Communications



Student Questions

©2026 Raj Jain

Networking Foundation



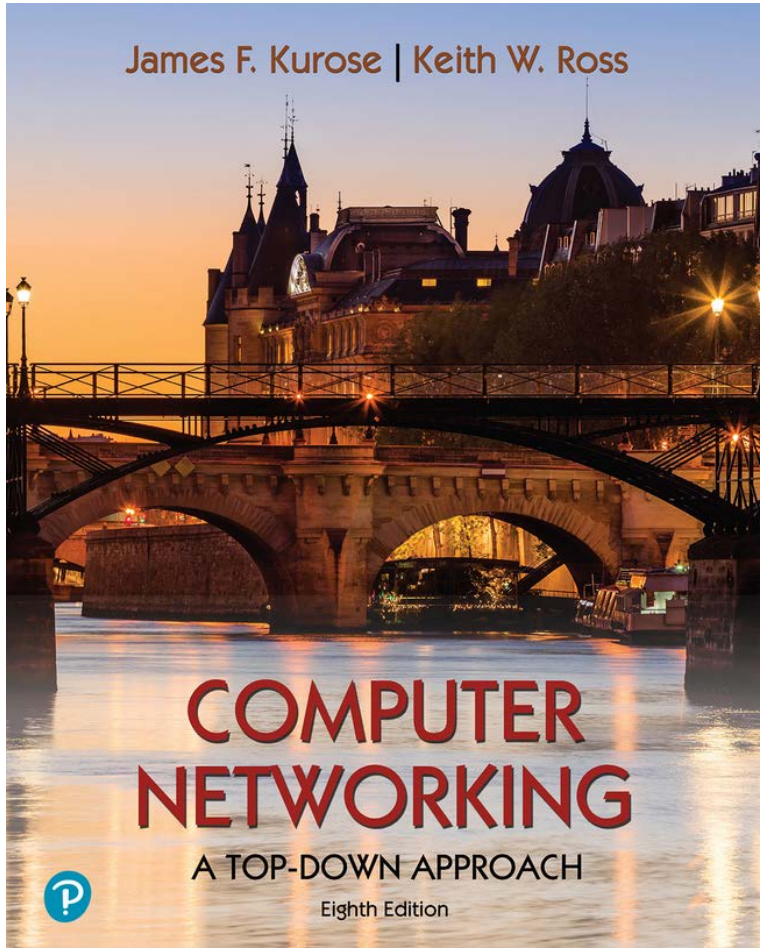
Student Questions

©2026 Raj Jain

Textbook

- J.F. Kurose and K.W. Ross, "Computer Networking" **8th Edition**, Pearson, 2021, ISBN: 9780136681557, 764 pp. **Required**.

- Get the latest edition. Do not use older editions. If you use the international edition, it should be dated later than 2020 and have 764 pages.



Student Questions

©2026 Raj Jain

Textbook (Cont)

- Only key concepts will be covered in the class.
  You are expected to read the rest of the book.
- Please ask questions in the next class about any concepts that are not clear to you.
- The material covered in the class will include some concepts from other textbooks. Please pay attention to the class lecture.

Student Questions

©2026 Raj Jain

Prerequisite

- General knowledge of computer systems organization
  - Memory
  - System bus
  - Interrupt
  - CPU
  - Binary, decimal, and hexadecimal representations
  - Bits, bytes
  - Storage: Memory and disk
- CSE 1301: Computer Science I or equivalent

Student Questions

Tentative Schedule

Class	Day	Date	Topic	Chapter
1	Monday	1/12	Course Overview	
2	Wednesday	1/14	Computer Networks and the Internet (Part 1)	1
	Monday	1/19	MLK Jr. Holiday	
3	Wednesday	1/21	Computer Networks and the Internet (Part 2)	1
4	Monday	1/26	Application Layer (Part 1): HTTP	2
5	Wednesday	1/28	Application Layer (Part 2): SMTP,DNS,P2P	2
6	Monday	2/2	Transport Layer (Part 1): Design Issues	3
7	Wednesday	2/4	Transport Layer (Part 2): UDP,Flow Control	3
8	Monday	2/9	Transport Layer (Part 3): TCP,TCP Congestion Control	3
			The Network Layer: Data Plane (Part 1: Network Layer Basics)	4
9	Wednesday	2/11	Network Layer Data Plane (Part 2: IP Datagram,NAT,UPNP,DHCP)	4
10	Monday	2/16	Exam 1 review	1-3
11	Wednesday	2/18	Exam 1	1-3

Student Questions

©2026 Raj Jain

Tentative Schedule (Cont)

Class	Day	Date	Topic	Chapter
12	Monday	2/23	Network Layer Data Plane (Part 3: SDN)	4
			The Network Layer: Control Plane (Part 1: Dijkstra's, Bellman-Ford Algorithms)	5
13	Wednesday	2/25	The Network Layer: Control Plane (Part 2: OSPF and BGP)	5
14	Monday	3/2	The Network Layer: Control Plane (Part 3: SDN Controller + ICMP + SNMP)	5
15	Wednesday	3/4	The Link Layer and LANs (Part 1): Functions	6
	Monday	3/9	Spring Break - No class	
	Wednesday	3/11	Spring Break - No class	
16	Monday	3/16	The Link Layer and LANs (Part 2): CRC	6
17	Wednesday	3/18	The Link Layer and LANs (Part 3): Multiple Access, Ethernet, VLANs, MPLS, Data	6
18	Monday	3/23	Exam 2 Review	3-6
19	Wednesday	3/25	Exam 2	3-6

Student Questions

©2026 Raj Jain

Tentative Schedule (Cont)

Class	Day	Date	Topic	Chapter
20	Monday	3/30	Wireless and Mobile Networks (Part 1): Wireless Characteristics, LANs and PANs	7
21	Wednesday	4/1	Wireless and Mobile Networks (Part 2): Mobility Management	7
22	Monday	4/6	Security in Computer Networks (Part 1): Cryptography	8
23	Wednesday	4/8	Security in Computer Networks (Part 2)	8
24	Monday	4/13	Security in Computer Networks (Part 3)	8
25	Wednesday	4/15	Security in Computer Networks (Part 4)	8
26	Monday	4/20	Exam 3 Review	7-8
27	Wednesday	4/22	Exam 3	7-8

- **Note that Exam 3 is on Wednesday, April 22, 2026.**
- **The dates for all exams are fixed. No substitute exams.**
- **Everyone has to take the first two exams.**

Student Questions

©2026 Raj Jain

Grading

- Exams (Best 2 of 3) 60%
- Class participation 5%
- Class Quizzes 10%
- Homeworks 15%
- Labs 10%
- Grading is by your percentile in the class as follows:

Percentile	87%	74%	61%	48%	35%	22%	9%
Grade	A+	A	A-	B+	B	B-	C+ and below

- **Pass/Fail:** Anyone getting over **66**% of the highest achieved grade in the course will pass. For example, if 96 is the highest score, the passing grade will be 67.2

Student Questions

©2026 Raj Jain

Exams

- There are three exams.
- All exams are 50 minutes long.
- One note sheet of 8.5” x 11” (both sides) is allowed, along with a simple calculator (TI-30).
- Exams consist of numerical as well as multiple-choice (true-false) questions.
- There is a negative grading on incorrect multiple-choice questions. Grade: +1 for correct. -1/(n-1) for incorrect.
- All students, including the graduating seniors, are graded similarly.

Student Questions

Lab Exercises

- Most modules will have a lab component.
- Some labs require writing a short program to do what the protocol would do
- You should be able to do most labs on your computer
- You need to know C++ and Python

Student Questions

©2026 Raj Jain

Homework Submission

- All homework is due on the following Monday before the class unless specified otherwise. Homeworks due on Exam Review day are due on the previous Friday so that all grades are available to you before the Exam Review.
- Any late submissions, if allowed, will *always* have a penalty. 10% per day until the solutions are disclosed in the class. This penalty is automatically applied by Canvas, even if you are just 1 minute late.
- All homework should be submitted online on Canvas. In case of multiple attempts, only the last grade is recorded. A late penalty is also applied if the last attempt is after the due date. If permitted, max attempts are 3.
- The class handout number identifies all homework.
- All homework should be in a separate file.
- Please write CSE4703 in the subject field of all emails related to this course.

Student Questions

©2026 Raj Jain

Homework Grading

- Grading basis: Method + Correct answer
- If possible, show how you got your answer
  - Show intermediate calculations.
  - Show equations or formulas used.
  - If you use a spreadsheet, a statistical package, or write a program, turn it in with the homework.
- Since most homework is auto-graded by Canvas, this may not apply.

Student Questions

©2026 Raj Jain

Quizzes

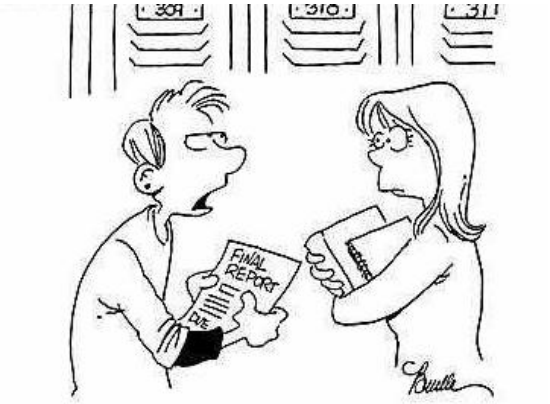
- Each class will start with a simple quiz about the topics covered in the previous class. Remember to review the slides before class.
- The quiz scores are counted separately.

Student Questions

©2026 Raj Jain

Academic Integrity

- Academic integrity is expected in homework, quizzes, and exams.
- All submitted solutions are expected to be yours and not copied from others, solution manuals, the Internet, or **AI.**
- The school requires us to report all integrity violations to the department.



"I don't know what plagiarizing is, so I'm gonna take the easy way out and just copy something off the internet."

Cartoon Source: https://www.tarleton.edu/stulife/judicial/integrity/index.html

Student Questions

©2026 Raj Jain

Office Hours

- By Appointment
- Teaching Assistants: Chenliang Tian
- TA Hours: Sunday 3-4 PM
- All meetings with the TA will be via Zoom.
  The link will be posted on Piazza or Canvas.

Student Questions

©2026 Raj Jain

After-Class Discussions

- We will use Piazza for in-between-class urgent questions.
- No participation points for questions on Piazza.
  Get points if you help by answering a question.
- Help by pointing to the correct direction and not by giving the correct answer to be submitted.
- Never publish an answer, even if incorrect, anywhere online, including on Piazza.
- If a question is not urgent and can wait till the next class, please bring it up in the class ⇒ Get class participation points.
- Find our class page at:

https://piazza.com/wustl/spring2026/cs4703

Student Questions

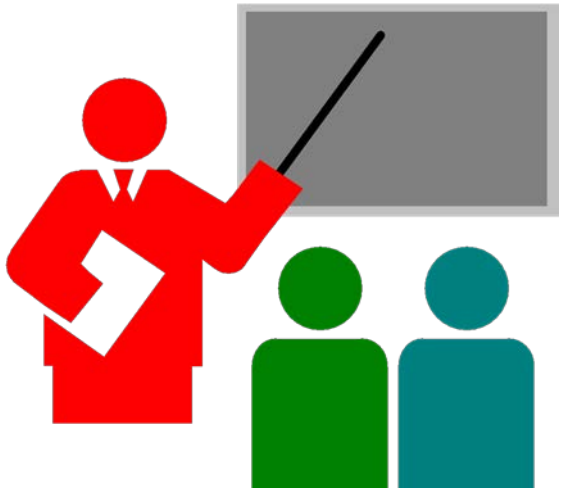
©2026 Raj Jain

Attending Classes via Zoom

- All sessions of this course throughout this semester will be remote using Zoom.
- Keep your microphone mute.
- Zoom report also shows when a student joined and when they left. It is used for your attendance.
- Students should join with their full name and WUSTL email.
- If you join with a different email, Zoom will mark you as a guest and will not give you marks for the quiz.
- Although the class discussions are being recorded. However, videos will NOT be posted.

Student Questions

Summary



- Computer networking is important for all areas of computing
- The first course in computer networking
- This is a foundational course for computer science.
- Get ready to work hard

Student Questions

Quiz 0: Prerequisites

- True or False?
- T F

1. ☐ ☐ Transmitting 100 bytes @ 800 bit/sec will take 1 sec.
2. ☐ ☐ A system with 32kB memory can hold only 16000 ASCII characters
3. ☐ ☐ A system with 2GB memory is the same as that with 2GB disk.
4. ☐ ☐ The CPU uses interrupts to stop an ongoing I/O.
5. ☐ ☐ Binary representation of 9 is 1001
6. ☐ ☐ 0A in Hexadecimal is 11 in decimal system.
7. ☐ ☐ For I = A Sin (2πft+ φ), the frequency is f.
8. ☐ ☐ 5 modulo 2 is 1
9. ☐ ☐ Two entries, "P" and "Q" are pushed sequentially on a stack. A "pop" operation on the stack will produce P.
10. ☐ ☐ If *x* is 0, then after *x*++, *x* will be 1.
11. ☐ ☐ The sum of two vectors [1, 1] and [1, 2] is [1, 2].

Marks = Correct Answers _____ - Incorrect Answers _____ = _____

Student Questions

©2026 Raj Jain

Scan This to Download These Slides





Raj Jain
http://rajjain.com

http://www.cse.wustl.edu/~jain/cse473-26/i_0int.htm

Student Questions

Related Modules



CSE567M: Computer Systems Analysis (Spring 2013),
https://www.youtube.com/playlist?list=PLjGG94etKypJEKjNAa1n_1X0bWWNyZcof

CSE473S: Introduction to Computer Networks (Fall 2011),



https://www.youtube.com/playlist?list=PLjGG94etKypJWOSPMh8Azcgy5e_10TiDw



Wireless and Mobile Networking (Spring 2016),
https://www.youtube.com/playlist?list=PLjGG94etKypKeb0nzyN9tSs_HCd5c4wXF

CSE571S: Network Security (Fall 2011),



https://www.youtube.com/playlist?list=PLjGG94etKypKvzfVtutHcPFJXumyyg93u



Video Podcasts of Prof. Raj Jain's Lectures,
https://www.youtube.com/channel/UCN4-5wzNP9-ruOzQMs-8NUw

Student Questions

©2026 Raj Jain