

# CS 4316/5313: Computer Networks

**Instructor:** Dr. Deepak K. Tosh

**Semester:** SPRING 2022

**Email:** [dktosk@utep.edu](mailto:dktosk@utep.edu)

**Class Hrs.:** MW, 4:30–5:50PM

**Office Hrs.:** MW, 1–2PM (Zoom)

**Classroom:** CCSB 1.0202

## COVID-19 PRECAUTION STATEMENT

The Center for Disease Control and Prevention recommends that people in areas of substantial or high COVID-19 transmission **wear face masks when indoors in groups of people**. The best way that **Miners can take care of Miners is to get the vaccine/boosters**. If you still need the vaccine, it is widely available in the El Paso area, and will be available at no charge on campus during the first week of classes. For more information about the current rates, testing, and vaccinations, please visit [epstrong.org](http://epstrong.org).

Please stay home if you have been diagnosed with COVID-19 or are experiencing COVID-19 symptoms. If you are feeling unwell, please let me know as soon as possible, so that we can work on appropriate accommodations. If you have tested positive for COVID-19, you are encouraged to report your results to [covidaction@utep.edu](mailto:covidaction@utep.edu), so that the Dean of Students Office can provide you with support and help with communication with your professors. The Student Health Center is equipped to provide COVID-19 testing.

## A. Course Description

This course offers in-depth concepts of computer networks and with technical foundations of the Internet. Topics to cover include overview of network models, architectures, applications, network programming interfaces (e.g. sockets), protocols and algorithms for routing and transport, congestion control, addressing, local area networks, medium access control, and network security. This course will cover various networking concepts as well as protocols and discuss on how they cohesively work together to provide unique Internet services, with emphasizing on

1. Application, transport network, and link layers
2. Layering benefits through top-down approach in TCP/IP and OSI stack
3. Emergence of software-defined networking and its performance impacts

## B. Course Objective

The objective of this course is to provide deeper understanding of the generic principles, components, and design of modern computer networks with a focus to learn the working mechanism of Internet.

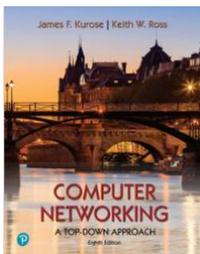
## C. Course Outline (TENTATIVE)

1. Course Overview and Intro (1 Week)
  - a. What is the Internet?
  - b. Edge and Core
  - c. Performance, Protocol Layering
  - d. Protocol Layering, Security
2. Application Layer (1.5 Weeks)
  - a. Principles of Network Applications

- b. The World Wide Web, HTTP, and Email
- c. Email, DNS
- d. P2P, Video Streaming, CDNs
- 3. Transport Layer (2.5 Weeks)
  - a. Principles of Transport, UDP
  - b. Reliable Data Transfer
  - c. TCP and Congestion
  - d. TCP's Congestion Control
- 4. Network Layer: Data Plane (2 Weeks)
  - a. Overview and Addressing
  - b. Dissecting a Router
  - c. Internet Protocol (IP)
  - d. Generalized forwarding and SDN
- 5. Network Layer: Control Plane (2 Weeks)
  - a. Routing Algorithms
  - b. Intra-AS routing
  - c. Routing among ISPs
  - d. SDN control plane
  - e. Network management (ICMP and SNMP)
- 6. Link Layer and LANs (1 Week)
  - a. Intro to Link Layer, Multiple Access Links
  - b. Error detection and correction
  - c. ARP
  - d. LANs, Virtual networks/links
- 7. Network Security
  - a. Cryptography primer
  - b. Email Security
  - c. TLS and IPsec

**Note:** We may cover advanced topics that are beyond the textbook. In that case, the instructor will upload the electronic copies of the handouts/weblinks in the Blackboard.

## D. Required Materials/Books



"Computer Networking: A Top-Down Approach" by James F. Kurose and Keith W. Ross. (8<sup>th</sup> Edition)

**Required Prior Knowledge** – (1) You must know how to write programs in C and Python. These two programming languages will be heavily used in the assignments; (2) You must be familiar to use VirtualBox or VMWare to configure and network among multiple VMs. Please visit the following links to learn more about them.

- 1) Learn C - <https://www.learn-c.org/>
- 2) Learn Python - <https://www.learnpython.org/>

3) VirtualBox - <https://www.virtualbox.org/manual/>

## E. Course Assignments and Grading Policies

Your semester grade will be based on a weighted combination of homework assignments, quizzes, participation, and exam. The approximate percentages for each category are given in the following and the final grade will be calculated using weighted average of these items.

### Grade Distribution

	Undergraduate (in %age)	Graduate (in %age)
Quizzes and participation	15	10
Assignments	45	35
Term paper & presentation	15 (bonus – to cover for missing assignments)	20
Midterm	20	15
Final	20	20

### Letter Grades

Total Score	90-100	80-89	70-79	60-69	59 and Below
Grade	A	B	C	D	F

**\*\* Students are required to agree to the UTEP College of Engineering's [Honor Code](#). This means, you pledge to practice academic honesty, integrity and fair dealing, tolerance, and respect to each other in this class.**

**Important Note:** You will have *one week to appeal* for your grades after the graded assignments and tests are returned. So, please keep this in mind if you think that there is a problem/issue with the grading of your work.

#### a. Assignments

There will be tentatively 5 homework assignments, approximately two per month. Through these assignments, students will develop concrete understanding on various protocols at each layer of TCP/IP stack: application, transport, network, and data link layer. Some specific assignments will be required to be done in group of 2. In this case, the instructor will create groups by picking students randomly and each team must provide the list of individual contributions made in the assignment.

**Note-1:** Students/Teams may be asked to demonstrate their assignments and answer additional follow up questions, whenever the instructor needs to verify the originality of their works. It is student's responsibility to come prepared while demonstrating his/her work. If the student could not answer, the 50% of the respective question's score will be deducted.

**Note-2:** Uniqueness and plagiarism will be strictly checked in the submitted codes, documents, reports etc. If the instructor finds plagiarized submission, the student will be reported to dean's office and score for that assignment will be given as zero.

**Note-3:** Any external materials referred to solve the assignment tasks must be CITED as references in the reports.

#### b. Quizzes, and Participation

The instructor plans to take multiple short quizzes **prior to the class** and after the class to assess student understandings. Students must read the assigned chapters and watch videos before coming to classes. This will ensure students to be prepared with the material to take short quizzes on **iClicker**. Please make sure to either bring a laptop to the class or install iClicker on your smartphone to take the quizzes in class. Also note that the “iClicker REEF” is already integrated in the Blackboard for your convenience.

#### c. Midterm and Final Exam

There will be **two midterms** and **one final** exam. The final exam will be conducted on the day of UTEP’s allotted day, which is **9<sup>th</sup> May (4 pm - 6 pm)**. Each exam will be conducted in-person. The tentative date for Midterm-1 is 28<sup>th</sup> Feb, and Midterm-2 is 4<sup>th</sup> April. The format of the exams will be further discussed in the class and announced later. Students will not be allowed to take the tests before/after the allocated testing hours. The best of two midterm scores will be considered in the final grade calculation.

#### d. Term Paper and Presentation

A team of 3 students (at max) will explore and investigate 12-15 recent research papers on cutting-edge networking/security topic. Here, the teams and the topics must be approved by the instructor. Towards end semester, each group will submit a term paper of 6-8 pages length and present their findings to the class. The teams should promptly meet with the instructor and decide a research topic to explore. The evaluation details of this component will be provided later in class. Please note that this is a mandatory work for the graduate students but optional for undergraduate students. However, we highly encourage the undergraduate students to take part in this activity and so, we allocate a bonus of 15% that may cover toward missing assignments. For graduate students, 20% of total grades is allocated towards this activity. The term papers are due on **18<sup>th</sup> April** and the group presentations will be held during last three classes.

#### **Late Submission Policy:**

- **No extension** on the **assignment or quiz** submission due dates will be given, unless there are special medical emergencies.
- Late submissions will be penalized with 10% deduction per day up to a maximum of 5 days. Submission after 5 days of due date will receive 0 points.

#### **Make-up Work Policy:**

Make-up work will be given only in the case of a documented emergency. Note that make-up work may be in a different format than the original work, may require more intensive preparation, and may be graded with penalty points. If you miss an assignment and the reason is not considered excusable, you will receive a **zero**. It is therefore important to reach out to me—in advance if at all possible—and explain with proper documentation why you missed a given course requirement. Once a deadline has been established for make-up work, no further extensions or exceptions will be granted.

### **Incomplete Grade Policy:**

Incomplete grades may be requested only in exceptional circumstances after you have completed at least half of the course requirements. Talk to me immediately if you believe an incomplete is warranted. If granted, we will establish a contract of work to be completed with deadlines.

## F. Course Outcomes

### Knowledge and Comprehension

1. Understand and describe the layered design of protocol model
2. Working mechanism of application layer protocols: http, email, ftp, etc.
3. Understand the unreliable and reliable transport protocols along with various flow control and error control mechanisms
4. Understand routing protocols, network filtration techniques, and network virtualization
5. Learn the importance of network and data plane segregation in SDN
6. Understand security implications of various protocols at each layer

### Application and Analysis

1. Compare performance of both reliable and unreliable transport protocols.
2. Design addressing mechanism for predefined local area network
3. Analyze and evaluate a number of data link, network, and transport layer protocols
4. Capture and process the live network traffic for deep packet analysis

### Synthesis and Evaluation

1. Program network communication services for client/server and construct network filtering components.
2. Design and implement a reliable transport protocol using network programming interface (e.g. datagram sockets)
3. Evaluate performance metrics of the implemented reliable transport protocol

## G. Technology Requirements

Class will meet at the scheduled time at the **CCSB 1.0202**. However, the office hours are planned to be held in ZOOM (link can be found in the Blackboard left side panel). Beginning of every week, the instructor will update the course content in the Blackboard learning management system. Therefore, please ensure to have stable Internet and a laptop with working microphone & webcam to connect with instructor and accessing course materials. If you encounter technical difficulties beyond your scope of troubleshooting, please contact the [Help Desk](#) as they are trained specifically in assisting with technological needs of students.

## H. Course Communication

We will use the following mediums to stay communicated.

- **Office Hours:** The office hours will be held on Zoom for your questions and comments about the course.
  - Office Hour Zoom Link: Enabled in Blackboard left side panel
  - Office Hours: Mondays and Wednesdays: **1-2 PM, Mountain Standard Time**
- **Email:** UTEP e-mail is the best way to contact me, in case you were not able to meet during office hours. I will make every attempt to respond to your e-mail within 24-48 hours of receipt. When e-mailing me, be sure to email from your UTEP student account and please

put the course number in the subject line. In the body of your e-mail, clearly state your question. At the end of your e-mail, be sure to put your first and last name, and your university identification number.

**Note:** *Please, do not email me in the last minute asking for help on the assignments. You may not get a quick answer, rather be early on attempting such activities.*

- **Discussion Board:** If you have a question that you believe other students may also have, please post it in the Help Board of the discussion boards inside of Blackboard. Please respond to other students' questions if you have a helpful response.
- **Announcements:** Check the Blackboard announcements frequently for any updates, deadlines, or other important messages. Although the announcements typically go via email, please make sure to read those emails.

## I. Class Recordings

I will upload pre-recorded topic-wise videos in the Blackboard for offline reference to the students. The use of recordings will enable you to have access to class lectures, group discussions, and so on in the event you miss a synchronous or in-person class meeting due to illness or other extenuating circumstance. Our use of such technology is governed by the Federal Educational Rights and Privacy Act (FERPA) and UTEP's acceptable-use policy. A recording of class sessions will be kept and stored by UTEP, in accordance with FERPA and UTEP policies. Your instructor will not share the recordings of your class activities outside of course participants, which include your fellow students, teaching assistants, or graduate assistants, and any guest faculty or community-based learning partners with whom we may engage during a class session. **You may not share recordings outside of this course. Doing so may result in disciplinary action.**

## J. Netiquette and Standards of Conduct

Students are expected to conduct themselves in a professional and courteous manner, as prescribed by the Standards of Conduct. Students may discuss work assignments and programming exercises in a general way with other students, but the solutions must be done independently. Similarly, groups may discuss group project assignments with other groups, but the solutions must be done by the group itself. Graded work should be unmistakably your own. You may not transcribe or copy a solution taken from another person, book, or other source, e.g., a web page. Professors are required to -- and will -- report academic dishonesty and any other violation of the Standards of Conduct to the Dean of Students. Some **key points** to remember:

- Always consider audience. Remember that members of the class and the instructor will be reading all the postings.
- Respect and courtesy must be provided to classmates and to instructor at all times. No harassment or inappropriate postings will be tolerated.
- When reacting to someone else's message, address the ideas, not the person. Post only what anyone would comfortably state in a F2F situation.
- Blackboard is not a public Internet venue; **all postings to it should be considered private and confidential.** Whatever is posted on in these online spaces is intended for classmates and professor only. Please do not copy documents and paste them to a publicly accessible website, blog, or other space. If students wish to do so, they have the ethical obligation to first request the permission of the writer(s).

## K. Copyright Statement for Course Materials

All materials used in this course are protected by copyright law. The course materials are only for the use of students currently enrolled in this course and only for the purpose of this course. They may not be further disseminated.

## L. Academic Dishonesty and Code of Honor

Academic dishonesty is strictly prohibited and is considered a violation of the UTEP Handbook of Operating Procedures. It includes, but is not limited to, cheating, plagiarism, and collusion. Cheating may involve copying from or providing information to another student, possessing unauthorized materials during a test, or falsifying research data on laboratory reports. Plagiarism occurs when someone intentionally or knowingly represents the words or ideas of another as one's own. Collusion involves collaborating with another person to commit any academically dishonest act. Any act of academic dishonesty attempted by a UTEP student is unacceptable and will not be tolerated. All suspected violations of academic integrity at The University of Texas at El Paso must be reported to the [Office of Student Conduct and Conflict Resolution \(OSCCR\)](#) for possible disciplinary action. To learn more [HOOP: Student Conduct and Discipline](#).

**Note:** Students are required to agree to the UTEP College of Engineering's [Honor Code](#).

## M. Accommodations Policy

UTEP is committed to providing reasonable accommodations and auxiliary services to students, staff, faculty, job applicants, applicants for admissions, and other beneficiaries of University programs, services and activities with documented disabilities in order to provide them with equal opportunities to participate in programs, services, and activities in compliance with sections 503 and 504 of the Rehabilitation Act of 1973, as amended, and the Americans with Disabilities Act (ADA) of 1990 and the Americans with Disabilities Act Amendments Act (ADAAA) of 2008. Reasonable accommodations will be made unless it is determined that doing so would cause undue hardship on the University. Students requesting an accommodation based on a disability must register with the [UTEP Center for Accommodations and Support Services](#).

## N. Student Resources

UTEP provides a variety of student services and support:

- [UTEP Library](#): Access a wide range of resources including online, full-text access to thousands of journals and eBooks plus reference service and librarian assistance for enrolled students.
- [Help Desk](#): Students experiencing technological challenges (email, Blackboard, software, etc.) can submit a ticket to the UTEP Helpdesk for assistance. Contact the Helpdesk via phone, email, chat, website, or in person if on campus.
- [University Writing Center \(UWC\)](#): Submit papers here for assistance with writing style and formatting, ask a tutor for help and explore other writing resources.
- [Math Tutoring Center \(MaRCS\)](#): Ask a tutor for help and explore other available math resources.

- [Military Student Success Center](#): UTEP welcomes military-affiliated students to its degree programs, and the Military Student Success Center and its dedicated staff (many of whom are veterans and students themselves) are here to help personnel in any branch of service to reach their educational goals.
- [RefWorks](#): A bibliographic citation tool; check out the RefWorks tutorial and Fact Sheet and Quick-Start Guide.

# COURSE CALENDAR

Week	Date (Mon)	Topic	Date (Wed)	Topic	Assignments	Reading	
1	1/18/21		1/20/21	Course Overview and Introductions to networks			
2	1/25/21	Introductions to networks – Internet, performance metrics	1/27/21	Introductions to networks – protocol layering, Application Layer – Principles	A1: Socket Program	KR 1.1 – 1.5	
3	2/1/21	Application Layer – WWW, HTTP, Socket Programming	2/3/21	Application Layer – Email, DNS		KR 2.1 – 2.4	
4	2/8/21	Application Layer – P2P, CDNs	2/10/21	Transport Layer – Principle, UDP, Reliable transport protocol design	A2: E-mail Client	KR 2.5 - 2.7	
5	2/15/21	Transport Layer –Reliable transport protocol design, pipelined protocols	2/17/21	Transport Layer –GBN, SR protocol		KR 3.1 - 3.4	
6	2/22/21	Transport Layer –congestion control (causes, costs)	2/24/21	Transport Layer –congestion control (approaches), TCP fairness	A3: Reliable transport protocol	KR 3.5 - 3.6	
7	3/1/21	Transport Layer Recap and hands on	3/3/21	<b>MIDTERM Review</b>		KR 3.6, 3.7	
8	3/8/21	<b>MIDTERM EXAM</b>	3/10/21	Network Data Plane Layer – Forwarding, inside of router		KR 4.1	
9	3/15/21	<b>SPRING BREAK</b>	3/17/21	<b>SPRING BREAK</b>	A4: packet capture		
10	3/22/21	Network Data Plane Layer – inside of router, scheduling, IPv4 overview	3/24/21	Network Data Plane Layer – IPv4 addressing, fragmentation, NAT, IPv6		KR 4.2 - 4.3	
11	3/29/21	Network Data Plane Layer –General forwarding, SDN	3/31/21	Network Control Plane Layer – Routing algorithms (LS and DV)	A5: NAT	KR 4.4; 5.1, 5.2	<b>DROP deadline</b>
12	4/5/21	Network Control Plane Layer – Intra AS and inter AS routing (OSPF and BGP protocols)	4/7/21	Network Control Plane Layer – SDN control plane, OpenFlow, other SDN controllers		KR 5.3, 5.4	
13	4/12/21	Network Control Plane Layer – ICMP and SNMP	4/14/21	Network Layer Recap and Hands on	A6: SDN	KR 5.5-5.7	
14	4/19/21	Link Layer – Introduction, Error detection and correction, media access protocols	4/21/21	Link Layer – CSMA/CD, Token ring, DOCSIS		KR 6.1, 6.2	
15	4/26/21	Link Layer – Addressing, ARP, RARP, and switching	4/28/21	Link Layer – VLANs, link virtualization, Data center networking, Use case study	Assign Submission Due - Weekend midnight	KR 6.3 - 6.5; 6.7	
16	5/3/21	<b>Final Review - 1</b>	5/5/21	<b>Final Review - 2</b>			
		<b>FINAL EXAM</b>	<b>May 10, 2021 @ 9 AM - 9 PM (In Blackboard)</b>				