**Telecommunication Systems (TELE)**

**TELE 5310. Fundamentals of Communication Systems. 4 Hours.**
Explores the underlying physical layer technologies used in the telecommunications industry. Introduces communications basics such as the concept of a channel, noise, SNR, sampling, Shannon's law, Nyquist limit, crosstalk, echo, multiplexing, as well as the transition from analog to digital, including line coding, synchronization, BER, and framing. Covers signal types, spectral analysis, and source coding. Discusses digital and carrier modulation technologies; spread-spectrum modulation; and multiuser radio communications, including radio link analysis, propagation, multipath fading, antennas, and spectrum issues. Introduces error correction and detection coding. Provides an overview of fiber optic communication systems, including sources, amplifiers, and multichannel systems.

**TELE 5320. Telecommunications Architecture and Systems. 4 Hours.**
Seeks to provide an understanding of the telecommunications network today and how it is evolving. Focuses primarily on the Public Switched Telephone Network—architecture, network systems, and call control—and on cellular wireless systems. Topics include coding of audio and video sources, including PCM, compression techniques, standards; digital transmission, SONET/SDH, network synchronization, digital switching; and the optical core. Addresses network survivability, traffic engineering, routing, and numbering. Explores issues in call control, signaling, and telephony services including DTMF, SS7/CCS architectures and protocols, and signaling. Discusses cellular networks, including radio communications, cellular core, wireless access technologies, handoff, second- and third-generation standards, mobility management, voice and data architectures. Introduces evolution of the network to packet: media and signaling protocols, QoS issues, PSTN interworking.

**TELE 5330. Data Networking. 4 Hours.**
Provides the basics of data networking protocols and architectures. Topics include protocol architecture of the internet; application protocols such as FTP, SMTP and HTTP, web caching, DNS, CDN, and P2P applications; use of TCP and UDP socket programming to develop network applications in Python; transport protocols, including TCP, UDP, and TCP congestion control; IP protocol, addressing, IPv4 and IPv6, NATs, ICMP, and tunnels; routing algorithms and OSPF; data link protocols, encoding, framing, error control, and PPP; switched LANs, ARPs, Ethernet, and VLANs; wireless LANs and 802.11 protocols; and network security—encryption, message integrity, authentication protocols, key management, SSL/TLS, IPsec, and 802.11i.

**TELE 5331. Lab for TELE 5330. 0 Hours.**
Addresses a range of networking components, including routers, switches, and Linux servers, and how they are configured to create a virtual environment. Covers the installation and configuration of networking concepts such as DNS, DHCP, and firewalls and the creation of virtual environments. Requires students, working in teams, to configure one or more components; the teams then must interconnect the components to form a small network. In the process of configuration and integration, students are exposed to troubleshooting at various protocol layers and have an opportunity to become familiarized with different operating systems and networking tools.

**TELE 5340. Telecommunications Public Policy and Business Management. 4 Hours.**
Introduces students to business management issues, such as basic accounting, finance, marketing, and operations in the telecommunications field, and also topics such as the time value of money and decision making. Also includes issues of human relations, organizational behavior, and business strategy. Provides an understanding of the regulatory environment of the telecommunications industry. Topics include universal service, service quality tariffs, the Modified Final Judgment and Telecom Act of 1996, market restrictions and segmentation, the current competitive environment in the United States and internationally, interconnection including unbundling, collocation, economic issues, and global trends in market reform.

**TELE 5350. Telecom and Network Infrastructure. 4 Hours.**
Provides in-depth treatment of the wireline and wireless infrastructure of the network supporting all telecommunication, internet, and enterprise applications. Covers the basics of communications—source coding, baseband and broadband modulation and transmission, channel coding, spread-spectrum, multiuser radio communications, radio link analysis, and propagation. Also covers the wireline core network—digital and optical transmission, framing, network synchronization, asynchronous and synchronous multiplexing, cross connects, SONET/SDH, DWDM, OTN, protection switching, and network availability. Addresses wireline (DSL, digital cable, FTTH, PONs) and wireless access (cellular, Wi-Fi), frequency reuse, and handoff. Also addresses support of data transport (switched Ethernet, VLAN, IP, MPLS) and application networks (PSTN, mobile core, internet, IPTV, and virtual networks).

**TELE 5360. Internet Protocols and Architecture. 4 Hours.**
Provides in-depth treatment of protocols used in the internet, wireless access, and enterprise networks. Topics include protocols for network layer QoS (including DiffServ, ECN, RSVP, MPLS); protocols for security, including both access control and network-level security (e.g., X.509, SSL/TLS, IPsec, IKE, EAP); protocols for inter-domain routing (BGP); protocols to support multicast, broadcast, and streaming applications; protocols to support host mobility, large server deployments, content distribution, and enterprise networks (VLANs, etc); and protocols to support IPv6 (e.g., address assignment) and its interoperability with IPv4. Also covers network design architectures for cloud computing, data centers, content distribution, layer-2 networks, etc., and discusses general scaling issues for large networks.

**TELE 5500. Linux/UNIX Systems Management for Network Engineers. 4 Hours.**
Introduces UNIX/Linux in a networking/Internet environment. Covers operating system concepts, tools, and utilities; networking and security issues; and data and text processing using scripts and filters. Addresses basic administrative tasks such as managing users, file systems, security, and software. Covers networking topics such as network configuration, daemon processes, SSH, DNS, DHCP, diagnostic tools, and the use of scripts and automation to manage applications and systems, as well as security topics such as name and authentication services, access control lists, file modification protections, and firewalls.

**TELE 5976. Directed Study. 1-4 Hours.**
Offers independent work under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.
TELE 5978. Independent Study. 1-4 Hours.
Offers work performed under individual faculty supervision. May be repeated without limit.

TELE 6100. Mobile Wireless Communications and Networking. 4 Hours.
Studies communications and networking issues in providing broadband wireless access to mobile applications. Discusses networking technologies required by converged IP-based applications. Covers converged network architectures and the interworking of different generations of access technologies with the Evolved Packet Core (EPC). Registration limited and by application only; it is expected that all students have prior knowledge of digital communications, radio propagation, cellular networks, and second-generation wireless standards.

TELE 6200. Advanced Data Networking. 4 Hours.
Addresses data networking topics not covered in TSMG 5330 and issues of topical importance in both the Internet and the enterprise. Takes a big-picture approach, looking at the network as a whole. Identifies and studies common architectural components, protocol mechanisms, and design/implementation principles and trade-offs based on scaling, performance, and security considerations. Focuses throughout on technologies being deployed in the network core (i.e., not access) to support the enterprise, content delivery, and virtualization. Typical technologies include VLANs, large flat Layer-2 network design, media streaming, multimedia protocols, P2P architectures and protocols, structured and unstructured overlays, content distribution, caching and replication, CDN architectures, data center networks, virtual routing, and load balancing. Uses case studies throughout.

TELE 6350. IP Telephony. 4 Hours.
Provides a comprehensive overview of IP telephony architectures and protocols, with emphasis on SIP, the Session Initiation Protocol. Topics include a review of classical circuit-switched telephony, especially signaling, a review of IP networking, especially routing and addressing; peer and master-slave protocols for IP telephony (SIP, H.323, MGCP); speech coding; the transport of real-time traffic over IP (RTP and RTCP); bandwidth control; and issues in network quality of service, such as traffic modeling, dimensioning, and QoS mechanisms. Emphasis on SIP includes call flows, network components, security, routing, and advanced services.

TELE 6360. Operation Support Systems in Telecommunications. 4 Hours.
Introduces Operation Support Systems (OSS) in telecommunications: their purpose, components, processes, and architectures. Covers OSS that support service and network provisioning, customer care, ordering, billing, network management among other support functions, and the telecommunication management network (TMN) architecture and network management protocols. Addresses the role of vendors in providing OSS and the range of services offered, including wireline voice and data; DSL; FTTP; wireless and mobile services; and video, cable, and integrated services. Seeks to provide understanding of how the Internet is changing OSS interconnections models and how the regulatory environment impacts OSS interconnections and architecture. Other topics include the impact of new services on OSS; new software technologies such as Web services, service-oriented architecture (SOA), work flow; and trends in next-generation OSS and OSS architectures.

TELE 6370. Perspectives in Telecommunications Policy. 4 Hours.
Examines the interrelationship of technological change, business objectives, and governmental policy goals on outcomes in telecommunications markets. Analyzes perspectives and cases from various nations to give students an opportunity to become familiar with public and private institutions, as well as other interest groups, that shape the agenda and outcomes of telecommunications policy in various countries. Emphasizes changing regulatory approaches, such as the increased reliance on network unbundling and the impact of technological changes on market forces and policy decisions. Examines how national policy objectives are formulated and issues associated with broadband deployment. Also evaluates policies designed to introduce competition into monopoly markets, the impact of Internet and wireless technologies on policy and markets, and emerging policy issues associated with network neutrality and Internet governance.

TELE 6380. Consulting Project in Telecommunications. 4 Hours.
Provides an opportunity to work on a consulting project with management from telecommunications companies and other companies with project needs relating to telecommunications. Projects may include assessing market, regulatory, and technology challenges involved in the implementation of broadband services; evaluating the impact of technology changes on specific market segments; researching needs for new functionality in telecommunications billing and operation support systems; valuing intellectual property in telecommunications companies and related industries; researching technological and business trends in the global telecommunications market. Studies an opportunity to work in teams and be guided by a faculty advisor resulting in a presentation and report for the client company. Students also have an opportunity to develop teamwork, project management, and communications skills.

TELE 6400. Software-Defined Networking. 4 Hours.
Introduces the foundational theories and technologies of software-defined networking (SDN), a new paradigm in computer networking that allows a logically centralized software program to control the behavior of an entire physical network. Discusses SDN technologies, such as the OpenFlow specification and OpenDaylight controller, and introduces students to SDN applications and network function virtualization (NFV). Offers hands-on exposure to popular open-source software and technologies through student projects. Requires good knowledge of Java or Python.

TELE 6600. Special Topics—Telecommunication Policy. 1-4 Hours.
Covers state-of-the-art material of current interest. May be repeated up to eight times.

TELE 6601. Special Topics—Systems. 1-4 Hours.
Description to come. May be repeated up to eight times.

TELE 6602. Special Topics—Business. 1-4 Hours.
Description to come. May be repeated up to eight times.

TELE 6603. Special Topics—Networking. 1-4 Hours.
Description to come. May be repeated up to eight times.

TELE 6945. Master’s Project. 4 Hours.
Offers theoretical or experimental work under individual faculty supervision.

TELE 6962. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

TELE 6964. Co-op Work Experience. 0 Hours.
Provides eligible students with an opportunity for work experience. May be repeated without limit.
TELE 6965. Co-op Work Experience Abroad. 0 Hours.
Provides eligible students with an opportunity for work experience abroad. May be repeated without limit.