College of Computing and Technology

Fortune S. Mhlanga, Professor and Dean
Computing and Technology

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Turn your passion for computing and technology into a great future! The mission of the College of Computing and Technology (CCT) is to advance scholarship in key domains of computing and technology in accordance with the principles of Lipscomb University and to engage in activities that improve the welfare of society and enhance the reputation of Lipscomb University. The college offers innovative and uniquely multi-disciplinary programs that prepare graduates for promising careers in computing and technology. The CCT prepares students for a future in a market where there are dozens of careers to choose from and graduates receive among the highest salaries. The college is intent on bringing to its students collaborative partnerships with industry, business, government, schools and nonprofit organizations that provide invaluable, real-world learning experiences. This is an exciting time to be in the CCT. Discover how we can prepare you to build the next generation of computing and technology tools, and to be among the architects that actually lead the future.

Distinctives of the College of Computing and Technology

The CCT has so much to offer:

- **Flexibility of degree programs to support a variety of career options:** One of the greatest strengths of the CCT lies in its interesting variety of courses. In the first place, students may choose from one of seven degree programs. Within each degree program, students choose a concentration area from a variety of options, including computer networking, computer systems, computer theory, database security, game development, information technology entrepreneurship, mobile computing, network security and system administration.

- **Internships and part-time employment:** Regardless of the degree program students are required to do an internship, for at least one semester, with a company in the industry. The CCT also assists its students seeking appropriate part-time employment with industry around Nashville.

- **Undergraduate research opportunities:** The CCT offers students “the best of both worlds”—research and attentive teaching. The college accords students, including incoming freshmen and transfers, with the opportunity to participate in paid undergraduate research on a competitive basis. This includes summer research and the rare opportunity for undergraduate students to attend and present their work at student conferences.

- **Teaching assistantship opportunities:** The CCT offers paid teaching assistantships to its junior and senior students on a competitive basis.

- **Beyond the classroom:** The CCT offers numerous opportunities to be involved with activities, outside of the classroom setting, to further enhance students’ educational experiences. Faculty members in the school serve as advisers for student organizations such as ACM (Association for Computer Machinery) mainly for computer science students, AITP (Association of Information Technology Professionals) mainly for information technology applications and Web application development students, ISSA (Information Systems Security Association) mainly for information security students, and UPE (Upsilon Pi Epsilon) the international honor society for all students in the computing and technology disciplines.

- **Study abroad:** Many students take advantage of the numerous study abroad options offered by Lipscomb University. Since we strongly believe that studying abroad can be an enriching, if not life-changing experience, CCT works with students to integrate courses taken abroad into their program of study.

- **Eventual opportunity to shine for the Lord:** Finally, the CCT allows Lipscomb to more fully achieve its mission of educating students for Christian service throughout the world. It is difficult to think of any discipline that opens more doors, has the potential of touching more people, or facilitates more communication and interaction among individuals than computing and informatics. From the boardroom to the assembly line, to the game room or to the mission field, individuals with technology skills are in high demand, are constantly sought out, and have unique opportunities to work, serve, speak and shine for the Lord in ways that others simply cannot.
Career Opportunities

- Application programmers
- Business continuity managers
- Database administrators
- Information technology administrators
- Information technology entrepreneurs
- Internet consultants
- Mobile and game developers
- Network analysts
- Operations managers
- RFID systems engineers
- Software engineers
- Start-up company partners
- Systems analysts and designers
- Technological research scientists
- Telecommunication analysis
- Web application developers
- Web server administrators
- Website administrators
- Website designers

Computational Biology

The Bachelor of Science in Computational Biology offers students the ability to explore the deep computational, mathematical modeling, simulation and big data aspects of biological science, drawing from courses in our existing biology, computer science and data science programs. This program is a perfect choice for students planning to pursue careers in any of the data-intensive biological sciences, or for those who seek to distinguish themselves in preparation for graduate studies in data science, medicine or biomolecular science. Students wishing to continue on to medical school should see their advisor for a list of additional recommended biology elective courses.

Computer Science

The computer science major and minor provide the opportunity to explore the theoretical and scientific aspects of computing. The program provides preparation both for employment and for graduate programs in computing.

Computer science is mathematically rigorous and spans the range from theory through programming to cutting-edge development of computing solutions. The computer science major, or degree program, is broad, rigorous and structured in a way that supports in-depth and systematic study of algorithmic processes—their theory, analysis, design, efficiency, implementation and application. It trains students to think creatively and logically to solve large and complex problems and to communicate with clarity and precision. It sets the stage for graduate study or immediate employment in a wide variety of careers in scientific research, industry, business and government and is an attractive major for the incoming freshman and also for the continuing student who is considering a new field of study. It is the ideal major for the student who is passionate about developing the ability to:

- find elegant solutions to problems and puzzles;
- use mathematical analysis and logical rigor to evaluate such solutions;
- model complex problems through the use of abstractions, attention to details and hidden assumptions;
- recognize variants of the same problem in different settings;
- retarget known efficient solutions to problems in new settings;
- adapt to new technologies and new ideas; and
- devise new and better ways of using computers to address particular challenges.

The computer science minor introduces the concepts of data organization and software construction and gives the student a basis to continue further study. The minor is a good partner for any of the majors offered in the Raymond B. Jones College of Engineering as well as several majors in the College of Arts and Sciences.

Computer Science and Mathematics

The Bachelor of Science in Computer Science and Mathematics offers a heavy dose of both the computational and mathematical aspects of the computing sciences. Among our most rigorous undergraduate degree programs, this option allows students to study advanced topics in computer science and mathematics in preparation for top-tier graduate study or premier industry and R&D placements.

Data Science

The B.S. in data science degree program focuses on the relationship between data, technology, and people. The program integrates courses in logical reasoning, computer programming, big data, data analytics, human—computer interaction and other skills that help students to put technology to better use. It has a mandatory internship requirement and students team up with classmates on capstone senior projects that showcase their skills to potential employers. Graduates from the program will be able to apply their tech knowledge to areas of interest—such as biology, business, environmental management, health care, telecommunications, sustainable practice and Web development—to create new uses for technology and the way people interact with it. They are adept at designing, refining and building information systems to extract knowledge from data. They are attuned to the needs that drive people to seek information. And, they understand the increasingly complex social and organizational environments in which people seek to fill their information needs—in theoretical, virtual and physical spaces. They are ambassadors for the transformative power of data when applied ethically and effectively.
**Game Development**

The Bachelor of Science in Game Development degree program allows students to study and explore the creation of games and game software at a level of rigor expected from a traditional computer science program. An amalgamation of computer science, game design, artificial intelligence, game theory, computer graphics, simulation, and advanced mathematics, this program offers students true insight into the knowledge areas required to create modern games and game software. Students will explore games as an artistic and expressive medium, game theory, principles of game design, game critique and evaluation, game development engines, graphics and sound, emergent gameplay, the business of creating games, collaborative development, and gaming with a purpose.

**Information Security**

The field of information security has grown and evolved significantly in recent years. It is expected that in the U.S. alone, thousands of professionals in the information security field will be added to the workforce. Information security professionals are concerned with the confidentiality, integrity and availability of data regardless of the form the data may take: electronic, print or other forms. Governments, military, corporations, financial institutions, hospitals and private businesses amass a great deal of confidential information about their employees, customers, products, research and financial status. Most of this information is collected, processed and stored on electronic computers, and transmitted across networks to other computers. Protecting confidential information is a business requirement, and in many cases, also an ethical and legal requirement. The information security major, or degree program, offers a deep grounding covering the breadth of information security from theoretical frameworks through models to policies and ethical practices. It focuses on security challenges, threats and requirements for operating systems, computer architectures, networking protocols and organizations’ data and information. It is the ideal major for the student who is passionate about developing the ability to:

- apply the technologies and procedures professionals use to secure business systems;
- identify the information security risks and create effective strategies to stop them;
- discover how information security is essential to organizational success;
- possess the knowledge to analyze the role of security within an organization as well as educate corporate employees about their security responsibilities;
- analyze the professional, legal and ethical impact of information security on individuals, business organizations and society;
- apply industry standard techniques to secure large-scale networks; and
- gain the competencies necessary to plan, customize, and manage large-scale secure network and operating system configuration for optimum business applications and/or plans.

The minor in information security combines both theoretical concepts and technical skills to prepare students for a career in information security, including ethical hacking, forensics, networking and security management.

**Information Technology**

Information technology (IT) is the study, design, creation, utilization, support and management of computer-based information systems, especially software applications and computer hardware. IT is not limited solely to computers though. With technologies quickly developing in the fields of mobile devices, the field of IT is quickly moving from compartmentalized computer-focused areas to other forms of mobile and distributed technology. The IT major develops broad, integrated knowledge spanning the range from telecommunications and computer networking through computer-based information systems to management of IT applications and projects. It is the ideal major for the student who is passionate about developing the ability to:

- evaluate current and emerging computing and information technologies;
- apply, configure and manage computing and information technologies;
- assess the impact of computing and information technologies on individuals, organizations and society;
- gain the business knowledge and skills needed to be successful in a competitive and challenging global information-technology driven economy;
- complement integrated IT knowledge with a strong understanding of key managerial and organizational concepts; and
- develop skill sets that are aligned with industry needs and problem-solving of real-world computing and information technology challenges.

The information technology minor is designed to provide students with a general knowledge of the requirements of commercial computing. It can be very helpful to business students who expect to be involved in corporate computing issues. This program matches very well with any of the majors offered by the College of Business.

**Information Technology Management**

The information technology management (ITM) major prepares students for various careers in the area of business information systems. The curriculum includes a strong business foundation coupled with information technology applications and business systems design and implementation. Graduates with an understanding of both business and technology are in high demand. According to the Nashville Technology Council, the demand for information technology professionals in Nashville has recently increased 120 percent with almost 1,000 unfilled positions in 2012.
Software Engineering

The B.S. in Software Engineering degree program has been created in response to the growing importance of software to the national infrastructure and the rapid rise in demand for professional software engineers. Software engineering is a top-rated profession. It was named one of the best jobs of 2013 by CareerCast.com, based on work environment, physical demands, outlook, income and stress. The hiring outlook for software engineers is favorable, thanks largely to new, exciting technology like smart phones, tablet applications and cloud (online-hosted) software. Likewise, the U.S. Bureau of Labor Statistics projects that job opportunities in the field of software engineering will continue to expand through 2018—and a bachelor's degree will be a prerequisite for many of these positions.

The program is a multidisciplinary university degree which draws on the strengths of existing Lipscomb University programs in computer science, information technology and mathematics. It provides a curriculum that encompasses behavioral and technical aspects of software engineering, focusing on the most advanced practices, including the equally critical human factor in software development, testing and validation for producing high quality, sophisticated and dependable software products. The program is designed specifically for students interested in a range of application domains, including game development, database systems and security, information technology entrepreneurship, mobile computing, programming theory and applications, and Web application development.

The minor in software engineering combines a core programming sequence with a selection of software engineering courses to prepare students for a career in which software development skills and software project planning and execution may be required.

Web Application Development

Web development is a broad term for the work involved in developing a website for the Internet (World Wide Web) or an intranet (a private network). This can include Web design, Web content development, client liaison, client-side/server-side scripting, Web server and network security configuration, and e-commerce development.

However, among Web professionals, “Web development” usually refers to the main non-design aspects of building websites: writing markup and coding. Web development can range from developing the simplest static single page of plain text to the most complex Web-based Internet applications, electronic businesses or social network services. The Web application development major, or degree program, integrates tools and technology needed to understand the language of Web design and development and how to take that knowledge into a professional career creating a variety of interactive Web content. It is the ideal major for the student who is passionate about developing the ability to:

- understand technology and how people interact with it;
- design elegant Web-based solutions, engage users while exploring the science of efficient animated websites, Internet programming and utilizing multimedia interactive structure, development and emerging philosophies;
- learn about the creation of effective and efficient animated websites, Internet programming and utilizing multimedia elements for special effects;
- begin entry-level work in areas like website design, online animation, Web interface design and Web programming;
- gain skills in website creation, information architecture, use of graphics, navigation and multimedia; and
- join the Internet explosion.

The Web design minor is designed to give students a general understanding of website development and can be very useful to business, art and education majors who expect to be involved in Web development in their careers.

150-hour Five-Year Accelerated Master's Degree Programs

Undergraduate computing students in certain programs may optionally complete a combined bachelor's/master's degree program in five years. Students must complete a minimum of 120 undergraduate hours and the 30 hours required for the master's degree at Lipscomb, for a minimum total of 150 hours, in order to receive both degrees. Following is a summary of the program requirements and other details.

First, the student enrolls at Lipscomb and pursues a major toward a bachelor's degree and begins working toward completion of their degree. Then, a series of actions are taken to both declare and then complete the 150-hour combined master's program.

Fall semester, junior year:
- The student declares his/her intention to pursue the 150-hour program.
- The student requests an advising meeting to update his/her degree plan to ensure that the required program change (see below) can be accommodated and scheduled.

Spring semester, junior year:
- The student takes the GRE and has the scores sent to Lipscomb.
- The student requests at least two recommendations from Lipscomb faculty, which are forwarded to the director of graduate programs in the College of Computing and Technology.
- The student provides all other information as required for application to the graduate program at Lipscomb.
Senior year (provided the student is admitted to the master’s program):

• Lipscomb waives the requirements of at least 6 hours (courses waived are specific to the program) in its bachelor's degree program.
• The student enrolls in a minimum of two three-hour graduate courses (5000-level or above; maximum of two per semester; prerequisites apply).

The student is awarded a bachelor’s degree provided that the student completes at least 120 hours of undergraduate work (including any undergraduate transfer courses) and satisfies all other degree requirements plus a minimum of 6 hours of graduate work. The 6 hours of graduate work taken during the senior year count towards the completion of the master’s degree. Upon completion of the remaining graduate course work, the student receives the master’s degree.

Grades received in the two graduate courses taken during the senior year will not be used in computing the student’s final GPA for the bachelor’s but will be used to compute the GPA for the master’s degree.

Introductory Course for Engineering, Mathematics, & Science Majors

Computer Applications - Math/Science (Computer Science 1041) surveys computing tools and techniques that are useful for scientific studies and is primarily designed for students with majors or minors in the Raymond B. Jones College of Engineering, mathematics and the sciences.

Requirements for Majors

Computational Biology Major

B.S. degree program
Total hours required— 126
General education hours required— 38 hours
Mathematics and physical science requirements satisfied by the major
Required courses for the major area— 63 hours
Biology (6 hrs will count toward Gen. Ed.) 1134, 1144, 2114, 3114, 4013, 4002
Computer Science 1122, 1213, 1223, 2223, 2233, 2243, 3623, 3433
Data Science 2063, 3123, 3223, 3323, 4133, 4223
Mathematics (3 hrs will count toward Gen. Ed.) 1314, 3213
Elective courses (25 hrs) Students planning to attend medical school should see their advisor for a list of recommended elective courses in Biology, Chemistry, Mathematics and Physics.

Computer Science and Mathematics Major

B.S. degree program
Total hours required— 129-131
General education hours required— 38 hours
Mathematics and physical science requirements satisfied by the major
Required courses for the major area— 91-93 hours
Computer Science 1122, 1213, 1223, 2223, 2233, 2243, 2252, 2313, 3623, 4053, 4223, 4413, 4423, 4433, 4453
Computing and Technology 395V*
Information Security 3323
Information Technology 2223
Mathematics 1314, 2314, 2324, 3053, 3123, 3133, 3213, 4113, 4303
Physics 2414 (with lab), 2424 (with lab) Software Engineering 3223

*CCI 395V has variable credit (1-3 hours)

Computer Science Major

B.S. degree program
Total hours required— 131-134
General education hours required— 38 hours
Specific courses required—
Bible 4213
Economics 2413
Mathematics and physical science requirements satisfied by the major
Required courses for the major area— 84-86 hours
Computer Science 1122, 1213, 1223, 2223, 2233, 2243, 3623, 3713, 4053, 4223, 4413, 4453
Computing and Technology 395V*
Information Security 3113
Information Technology 2223, 3313
Mathematics 1314, 2314, 3123, 3213
Physics 2414 (with lab), 2424 (with lab) Software Engineering 3223

Concentration courses (choose one concentration area)— 9-10 hrs
Computer Networking:
IT 3323, IT 4323, SEC 3323
Computer Systems:
CS 3333, EECE 3813, EECE 4254
Computer Theory:
CS 4423, CS 4433, CS 4443
Database Security:
SEC 3313, SEC 3323, SEC 4313
Database Systems and Security:
CS 4443, SEC 3323, SEC 4313
Game Development:
GD 3253, GD 3263, GD 3273
Mobile Development:
CS 3243, CS 3333, CS 4013
Network Security:
IT 3323, SEC 3323, SEC 4323
Software Engineering:
SENG 4113, SENG 4123, SENG 4323

Note: A pure mathematics minor is automatically satisfied by the computer science major.

*CCI 395V has variable credit (1-3 hours)
Data Science Major
B.S. degree program
Total hours required — 126-128
General education hours required — 38 hours
Specific courses required —
  Bible 4213
  Economics 2413
  Management 3503
  Mathematics requirement satisfied by major
Required courses for major area — 79-81 hours
  Entrepreneurship 2503
  Computing and Technology 395V*, 4613
  Data Science 1123, 2063, 3123, 3213, 3223, 3323, 4133, 4223
  Information Security 3113
  Information Technology 1213, 2223, 2233, 3313, 3413, 3423
  Marketing 3503, 3573
  Mathematics 1113, 2053, 2183
  Operations and Supply Chain Management 3503
Concentration courses (choose one concentration area) — 9 hours
  Bioinformatics:
    BY 1133, BY 2113, BY 3113
  Business Informatics:
    Select three (AC 3553, BA 3503, MK 4563, MK 4203)
  Environmental Management Informatics:
    ESS 4123, ESS 4213, ESS 4223
  Health Care Informatics:
    DS 4003, DS 4013, DS 4103
  IT Entrepreneurship:
    ENT 3543, MK 3553, ENT 4453
  Sustainability Performance Informatics:
    ESS 2013, ESS 2123, ESS 4223
  Web Development:
    IT 3223, IT 3233, MK 3403

*CCI 395V has variable credit (1-3 hours)

Game Development Major
B.S. degree program
Total hours required — 127-129
General education hours required — 38 hours
Specific courses required —
  Bible 4213
  Management 3503
  Economics 2413
  Mathematics and physical science requirements satisfied by the major
Required courses for major area — 80-82 hours
  Computer Science 1213, 1233, 2223, 2233, 2243, 2252, 3233, 3243, 3252, 4453
  Computing and Technology 395V*, 4613
  Game Development 1123, 3253, 3263, 3273
  Information Technology 1213, 2223, 2233
  Mathematics 1314, 2183, 2314, 3053, 3213
  Physics 2414 (with lab)
  Software Engineering 3223, 4113
Concentration courses (choose one concentration area) — 9 hours
  Algorithms:
    CS 3623, 4423, 4433

Information Security Major
B.S. degree program
Total hours required — 126-129
General education requirement — 38 hours
Specific courses required —
  Bible 4213
  Economics 2413
  Mathematics requirement satisfied by major
Required courses for the major area — 79-81 hours
  Accounting 2503
  Entrepreneurship 2503
  Computer Science 1122, 1213, 1233, 2223, 2233, 2243, 2323, 3523
  Computing and Technology 395V*, 4613
  Information Security 3113, 3313, 3323, 3333, 4053, 4313, 4323
  Information Technology 2223, 3313, 3323
  Marketing 3503, 3573
  Mathematics 1314, 2103, 2314, 3123
Concentration courses (choose one concentration area) — 9-10 hours
  Computer Systems:
    CS 3333, EECE 3813, EECE 4254
  Game Development:
    CS 3253, CS 3263, CS 3273
  Information Technology Entrepreneurship:
    ENT 3543, MK 3553, ENT 4453
  Mobile Computing:
    CS 3243, CS 3333, CS 4013
  System Administration:
    IT 3333, IT 3343, and SEC 3333 or BA 3703
  Web Application Development:
    IT 3223, IT 3233, and IT 2223 or MK 3403

Note: A general business minor is automatically satisfied by the information security major.

*CCI 395V has variable credit (1-3 hours)
Information Technology Major
B.S. degree program
Total hours required—126-128
General education requirement—38 hours
Specific courses required—
  Bible 4213
  Economics 2413
  Mathematics requirement satisfied by major
Required courses for the major area—76-78 hours
  Accounting 2503, 2513
  Computer Science 1213, 1233, 2233, 2243
  Computing and Technology 395V*, 4613
  Information Security 3113
  Information Technology 1123, 2043, 2223, 3313, 3323, 3413, 3423, 4323, 4423
  Management 3503
  Marketing 3503, 3573
  Mathematics 1113, 2053, 2103, 2183
Concentration courses (choose one concentration area)—9 hrs
  Game Development:
    GD 3253, GD 3263, GD 3273
  Information Technology Entrepreneurship:
    ENT 3543, MK 3553, ENT 4453
  Information Security:
    SEC 3313, IT 3343, SEC 3333
  Mobile Computing:
    CS 3243, CS 3333, CS 4013
  System Administration:
    IT 3333, IT 3343, and SEC 3333 or BA 3703
  Web Application Development:
    IT 3223, IT 3233, and IT 2223 or ITM 3013
  Electives—3 hrs

Note: A general business minor is automatically satisfied by the information technology major.
*CCI 395V has variable credit (1-3 hours)

Information Technology Management Major
B.S. degree program
Total hours required—126-128
General education requirement—38 hours
Specific courses required—
  Bible 4213
  Economics 2413
  Mathematics requirement satisfied by major
Required courses for the major area—79-80 hours
  Accounting 2503
  Computing & Technology 395V*, 4613
  Computer Science 1213, 1233, 2223, 2243, 2243, 2252, 2323, 3233, 3523, 3623
  Information Security 3113
  Information Technology 2223, 2233, 3313
  Mathematics 1314, 2183, 3053, 3213
  Software Engineering 3223, 4023, 4113, 4123, 4323
Concentration courses (choose one concentration area)—9 hrs
  Game Development:
    CS 3253, CS 3263, CS 3273
  Database Systems and Security:
    CS 4443, SEC 3323, SEC 4313
  Information Technology Entrepreneurship:
    ENT 3543, MK 3553, ENT 4453
  Mobile Computing:
    CS 3243, CS 3333, CS 4013
  Programming Theory and Applications:
    CS 3713, CS 4213, CS 4223
  Web Application Development:
    IT 3223, IT 3233, MK 3403
  Electives—2-3 hrs

*CCI 395V has variable credit (1-3 hours)

Software Engineering Major
B.S. degree program
Total hours required—127-130
General education requirement—38 hours
Specific courses required—
  Bible 4213
  Economics 2413
  Management 3503
Required courses for the major area—78-80 hours
  Accounting 2503
  Computing & Technology 395V*, 4613
  Computer Science 1122, 1213, 1233, 2223, 2233, 2243, 2252, 2323, 3233, 3523, 3623
  Information Security 3113
  Information Technology 2223, 2233, 3313
  Mathematics 1314, 2183, 3053, 3213
  Software Engineering 3223, 4023, 4113, 4123, 4323
Concentration courses (choose one concentration area)—9 hrs
  Database Systems and Security:
    CS 3253, CS 3263, CS 3273
  Database Systems and Security:
    CS 4443, SEC 3323, SEC 4313
  Information Technology Entrepreneurship:
    ENT 3543, MK 3553, ENT 4453
  Mobile Computing:
    CS 3243, CS 3333, CS 4013
  Programming Theory and Applications:
    CS 3713, CS 4213, CS 4223
  Web Application Development:
    IT 3223, IT 3233, MK 3403
  Electives—2-3 hrs

*CCI 395V has variable credit (1-3 hours)

Web Application Development Major
B.S. degree program
Total hours required—126-129
General education requirement—38 hours
Specific courses required—
  Bible 4213
  Economics 2413
Mathematics requirement satisfied by major
Required courses for the major area— 74-76 hours
Communication 2144
Computer Science 1213, 1233, 2243
Computing and Technology 395V*, 4613
Entrepreneurship 2503
Information Security 3113
Information Technology 1123, 1213, 2043, 2223,
2233, 3223, 3313, 3233, 3413, 3423, 4053
Information Technology Management 4003
Marketing 3403, 3503, 3573
Mathematics 1113, 2183

Concentration courses (choose one concentration area)— 9 hrs
Game Development:

GD 3253, GD 3263, GD 3273
Information Technology Entrepreneurship:
ENT 3543, MK 3553, ENT 4453
Information Security:
SEC 3313, IT 3343, SEC 3333
Mobile Computing:
CS 3243, CS 3333, CS 4013
System Administration:
IT 3333, IT 3343, and SEC 3333 or BA 3703
Electives – 5-6 hrs

Note: A general business minor is automatically satisfied by the
information technology major.

*CCI 395V has variable credit (1-3 hours)

Requirements for Minors

Computer Science Minor
Total hours required— 21
Specific courses required—
Computer Science 1213, 1233, 2233, 2323, 4223
Six hours of electives chosen from
Computer Science 3623, 3523, 4413
Software Engineering 3223

Data Science Minor
Total hours required— 21
Specific courses required—
Computer Science 1213, 1233, 4223
Data Science 3213, 3223, 4223

Information Security Minor
Total hours required— 21
Specific courses required —
Computer Science 1213, 1233
Information Security 3113, 3313
Information Technology 3313
Six hours of electives chosen from
Information Security 3323, 3333, 4313, 4323

Information Technology Minor
Total hours required— 21
Specific courses required —
Computer Science 1213, 1233, 2233, 2243
Information Technology 2223, 3313 and 4423 or
ITM 4003

Software Engineering Minor
Total hours required— 21
Specific courses required —
Computer Science 1213, 1233, 2223, 2243
Software Engineering 3223 4123, 4323

Web Development Minor
Total hours required— 20
Specific courses required—
Computer Science 1213, 1233, 2243
Information Technology 1213, 2223, 2233, 3223

Online Web Design/Development Certificates
The School of Computing and Informatics offers three online certificates of undergraduate study in Web design and
development. The target audience are individuals who already have an undergraduate degree but may wish to build skills in
Web design and Web application development and to attain a certification. The three certificate programs are defined by their
courses of study, and comprise specialties in front-end Web design, back-end Web development, or both front-end and
back-end specialties.

Design Certificate (Front-End)
Total hours required— 18
Specific courses required —
IT 1213 Graphic Design Studio
IT 1123 Future of Computing
CS 1213 Introduction to Computer Programming
IT 2223 Web Development I
IT 3223 Web Development II
IT 2233 User Interface Design

Development Certificate (Back-End)
Total hours required— 21
Specific courses required—
IT 1123 Future of Computing
CS 1213 Introduction to Computer Programming
IT 2223 Web Development I
CS 1233 Object-Oriented Design/Programming
IT 2233 User Interface Design
CS 2243 Database Management
IT 3233 Web Server Technologies

Design/Development Certificate (Front/Back-End)
Total hours required— 27
Specific courses required —
IT 1213 Graphic Design Studio
IT 1123 Future of Computing
CS 1213 Introduction to Computer Programming
IT 2223 Web Development I
IT 3223 Web Development II
IT 2233 User Interface Design
CS 1233 Object-Oriented Design/Programming
CS 2243 Database Management
IT 3233 Web Server Technologies
Course Descriptions

Computer Science (CS)

1041 Computer Applications—Math/Science (1) F, SP
Use of computer software for mathematical and scientific applications. Problem solving with application software including graphical representation of solutions and data, equation editing, symbolic mathematics, statistical software, scientific internet resources, images and animation. Laboratory, 2 hours.

1122 Introduction to Computer Science (2) F, SP
Survey of topics in computer science. Appreciating computer science as a discipline, with light introductions to object-oriented paradigms. Topics include introduction to and appreciation of problem solving, programming languages and their translators, software engineering, computer architecture, operating systems, networks, algorithms, social and ethical issues, and artificial intelligence.

1213 Introduction to Computer Programming (3) F, SP
Problem analysis and the development of algorithms and computer programs in a modern high-level language. Introduces the use of a high-level object-oriented programming language as a problem-solving tool, including basic data structures and algorithms, object-oriented programming techniques and software documentation. Prerequisites: Computer Science 1233 with a grade of “C” or higher.

1233 Object-Oriented System Design and Programming (3) F, SP
Introduces more advanced elements of object-oriented programming, including dynamic data structures, recursion, searching and sorting, and advanced object-oriented techniques. Prerequisite: Computer Science 1213 with a grade of “C” or higher.

2233 Mathematical Structures for Computer Science (3)
Introduction to logic, propositional equivalences, predicates and quantifiers, methods of proof, mathematical induction, recursive definition and algorithms, program correctness, representing relations, closures of relations, equivalence relations, partial orderings, Boolean matrices, invertible matrices, systems of linear equations, permutations and combinations, sequences and recurrence relations, graph terminology and representation, connectivity, Euler and Hamiltonian paths, shortest path algorithms, introduction and applications of trees, tree traversal algorithms, spanning trees, minimum spanning trees. The course also incorporates a significant programming component. Prerequisite: Math 1314 with a grade of “C” or higher.

2223 Data Structures and Algorithms (3) F, SP
Implementation and application of fundamental data structures and computing algorithms used in computer science, including searching and sorting; elementary abstract data types including linked lists, stacks, queues, trees and graphs. Particular emphasis is given to the use of object-oriented design and data abstraction in the creation and application of these data structures. Some elementary algorithm analysis is also covered. Prerequisites: Computer Science 1233 and Math 2103 with grades of “C” or higher.

2243 Database Management Systems (3) SP
Introduction to database concepts and the relational database model. Topics include SQL, normalization, design methodology, DBMS functions, database administration, and other database management approaches such as client/server databases, object oriented databases, and data warehouses. Strong emphasis on database system design and application development. Prerequisite: Computer Science 1233 with a grade of “C” or higher.

2252 Competition Programming (2) SP
Introduction to an interesting variety of subjects in programming, algorithms, and discrete mathematics through puzzles and problems which have appeared in the International ACM Programming Contest and similar venues. Skills required for programming contests, which will include evaluation of problem difficulty, solving problems in teams, and working under time pressure. Implementation of algorithms will be done in an object-oriented programming language such as C++ or Java. It is expected that the best students from this course will represent Lipscomb at the regional ACM Programming Competition and possibly at the international ACM Competition. Prerequisite: Computer Science 2233 with a grade of “C” or higher.

2323 Computer Organization (3) F
Introduction to computer organization with emphasis on the lower level abstraction of a computer system including digital logic, instruction set and assembly language programming. Topics include data representation, logic gates, simplification of logical expressions, design and analysis of simple combinational circuit such as decoders and multiplexers, flip-flops and registers, design, and analysis of simply synchronous sequential circuit, random-access and read-only memories, instruction set architecture and programming in assembly language. Prerequisites: Computer Science 1233 and Math 2103, with grades of “C” or higher.

2323 Computer Graphics (3) F
Design and implementation of object-oriented graphical user interfaces (GUI) and two-dimensional computer graphics systems. Implementation methodologies including callbacks, handlers, event listeners, design patterns, layout managers, and architectural models. Mathematical foundations of computer graphics applied to fundamental algorithms for clipping, scan conversion, affine and convex linear transformations, projections, viewing, structuring, and modeling. Prerequisites: Computer Science 2233 and Math 3213 with grades of “C” or higher.

2324 Mobile Device Programming (3) SP
Introduction to programming for the mobile devices (such as Apple iPhone, iPod Touch, iPad and Android) using Software Development Kits (SDKs). Mobile application development will focus on object-oriented programming appropriate to mobile devices. Insight into current common procedures for getting mobile application work academically published. Prerequisites: Computer Science 1233, 2243 and Information Technology 3313 with grades of “C” or higher.

2352 Programming Challenges (2) F
Development and implementation of advanced algorithms, as well as the skills required for programming competitions. The student will learn to select appropriate algorithms for a
given problem, integrate multiple algorithms for solving a complex problem, design new algorithms, and implement them in C++ or Java. Prerequisite: Computer Science 2252 with a grade of "C" or higher.

3333 Mobile and Distributed Computing Systems (3) F
Architectures of mobile and distributed computing systems, mobile and distributed operating systems, middleware, SOA and distributed services, network infrastructure for mobile and distributed computing systems. Prerequisites: Computer Science 2233, 2243 and Information Technology 3323 with grades of "C" or higher.

3433 Numerical Methods (3) SP
Offered odd numbered years
Finding roots of equations, error analysis, simultaneous linear equations, numerical integration, least squares approximations, and numerical solutions for ordinary differential equations. Prerequisites: Math 2314 and Computer Science 2233 with grades of "C" or higher.

350V Special Topics in Computer Science (1-3)
Offered on demand
Selected topics from the field of computer science. The course may be either lecture or laboratory oriented depending upon the topic selected. The study represents an in-depth approach to specific areas of interest to the students. Repeatable for credit with director's approval. Prerequisite: Consent of the instructor.

3523 Operating Systems (3) SP
Introduction to operating system concepts including system organization for uniprocessors and multiprocessors, scheduling algorithms, process management, deadlocks, paging and segmentation, files and protection, and process coordination and communication. Prerequisites: Computer Science 2233 and 2323 with grades of "C" or higher.

3623 Design and Analysis of Algorithms (3) F
Study of the techniques for designing algorithms and for analyzing the time and space efficiency of algorithms. The algorithm design techniques include divide-and-conquer, greedy algorithms, dynamic programming, randomized algorithms and parallel algorithms. The algorithm analysis includes computational models, best/average/worst case analysis and computational complexity (including lower bounds and NP-completeness). Prerequisites: Computer Science 2233 and Math 2903 with grades of "C" or higher.

3713 Comparative Programming Languages (3) SP
Discussion of the important issues in the specification, design and implementation of programming languages with emphasis on imperative programming. Emphasis is on evaluating alternative ways of providing various symbols, abstractions, definitions, theorems, proofs, programming language features and trade-offs involved. Topics include syntactic specification, data types, and the like, abstraction mechanisms, sequence control, data control, storage management, functional programming and about its capabilities and limitations, universal models introduction to programming verification. Several languages are used to illustrate these programming language concepts. Prerequisite: Computer Science 2233 with a grade of "C" or higher.

4013 Future Mobile and Social Computing Systems (3) SP
Research and development R&D) or project-based course to build futuristic proof-of-concept online social and mobile computing system prototypes. Prerequisite: Computer Science 3243 with a grade of "C" or higher.

4053 Senior Seminar in Computer Science (3) SP
Required of all computer science majors in their senior year. Assessment of degree to which computer science program outcomes have been achieved; reflection on and synthesis of computer science academic experience; preparation for transition to professional employment or graduate school. Prerequisites: Senior standing and 30 hours of Computer Sciences courses.

4223 Compiler Construction (3) F
Study of the theory and design techniques used in compiler construction, including lexical analysis, parsing, grammars, semantic analysis, code generation and optimization. Each student will implement a subset of a compiler. Prerequisites: Computer Science 2233, 3623 with grades of "C" or higher.

4413 Fundamentals of Automata and Formal Language Theory (3) SP
Introduction to fundamental concepts of automata theory and formal languages including finite automata, regular expressions, formal language theory and pushdown automata. Prerequisite: Computer Science 3713 with a grade of "C" or higher.

4423 Computability and Complexity Theory (3) SP
Rigorous introduction to theoretical foundations of computer science, addressing a number of interrelated topics and formally defining a computer, an algorithm and what is computable. Close reading of important theorems and proofs. Significant use of mathematical lemmas, corollaries, logical reasoning, inductive proofs, are used to introduce how to reason precisely about computation and prove mathematical theorems of computation such as Turing machines, undecidability, and computational complexity. Prerequisites: Computer Science 3623 and 4413 with grades of "C" or higher.

4433 Algorithmic Graph Theory (3) F
The elements of the theory of graphs and directed graphs with motivating examples from communication networks, data structures, etc., shortest paths, depth first search, matching algorithms, parallel algorithms, minimum spanning trees, basic complexity theory, planarity, and other topics. Programming assignments are included. Prerequisite: Computer Science 3623 with a grade of "C" or higher.

4443 Database Theory and Applications (3) SP
Introduction to the theory, methods, and techniques widely used today to design, build, and implement modern database systems. Emphasis is on the relational data model, with topics including relational algebra, SQL, entity-relationship model, normalization, design algorithms, query processing, transaction processing, and object-oriented databases. Prerequisites: Computer Science 2233, 2243 and Math 2903 (or Math 2103) with grades of "C" or higher.

4453 Artificial Intelligence (3) SP
An exploration of concepts, approaches and techniques of artificial intelligence: specification, design, and implementation of selected applications of intelligent software agents and multi-agent systems. Computational models of intelligent behavior, including problem solving, knowledge representation, reasoning, planning, decision
making, learning, perception, action, communication and interaction. Reactive, deliberative, rational, adaptive, learning and communicative agents and multi-agent systems. Prerequisites: Computer Science 3623, Math 3123 and 3213 with grades of “C” or higher.

Computing and Technology (CCT)

1123  Zen and Art of Computing (3)
A study of modern computing technologies developed by computer, data and information scientists that keep the global digital information age moving forward. Topics include tools and artifacts of the digital citizen, appropriate uses of technology in society, and software to maximize your effectiveness as a student.

395V  Internship (1-3) F, SP, SU
Provides the opportunity for a student to gain experience with his/her computing major in a work setting. Credit is awarded according to the scale published by the Career Development Center. Prerequisites: junior standing and the permission of the undergraduate program director. Repeatable up to six hours.

401V  Independent Study (1-3) F, SP, SU
Independent study research in a selected topic; title to be approved by the major professor and undergraduate program director; culminating research paper to be kept on file. Prerequisites: advanced standing, ability and the approval of undergraduate program director and faculty advisor. Repeatable for up to six hours. This course may satisfy SALT Tier II requirement.

4613  Senior Project (3) SP
Design and implementation of a suitable information or software system. Projects to be proposed and/or approved by the instructor. Prerequisites: Senior standing and CS 2243 or IT 3233, and 3413 with grades of “C” or higher.

Data Science (DS)

1123  Introduction to Data Science (3)
Introduction to latest trends in data science, including topics such as Big Data, predictive models, tools and technologies to support large scale analytics, research methods, decision modeling, and case studies. Lecture, 3 hours.

2063  Modern Computing Applications for Data Science (3)
Introduction to modern data science applications such as SAS, JMP, Tableau, Enterprise Miner, Hadoop, and other enterprise level applications for data analysis, visualization, collection, and research.

3123  Information Ethics and Policy (3) F
Framework for analyzing the ethical, legal, economic, and socio-political issues surrounding information, information technologies, and the information industries. Policy and ethical issues of information access and control including intellectual property, file sharing, free speech, privacy, and national security. Prerequisite: DS 3213 or SEC 3113.

3213  Principles of Data Science (3) F
Principles of data science including theories, concepts, and principles of information, information seeking, cognitive processing, knowledge representation and restructuring, and their relationship to physical and intellectual access to information. Development of information systems for storage, organization, and retrieval. Prerequisite: Mathematics 1113.

3223  Information Structures (3) SP
Introduction to the concepts and structures used to analyze, store, manage, and present information and navigation. Topics include information analysis and organization methods, XML, and metadata concepts and application. Prerequisite or corequisite: DS 3213.

3323  Principles of Statistical Analysis and Decision Modeling (3)
Introduction to the research process investigating information needs, creation, organization, flow, retrieval and use. Stages include: research definition, questions, objectives, data collection and management, data analysis, and data interpretation. Techniques include: observation, interviews, questionnaires, and transaction-log analysis. Prerequisite: DS 2223 and Math 2183.

350V  Special Topics in Data Science (1-3)
Offered on demand
Selected topics from the field of data science. The course may be either lecture or laboratory oriented depending upon the topic selected. The study represents an in-depth approach to specific areas of interest to the students. Repeatable for credit with director's approval. Prerequisite: Consent of the instructor.

4003  Decision Support Systems (3) SP
This course allows students to explore the history, evolution and current applications of decision support. The course emphasizes the unique challenges of data representation and information retrieval techniques that are foundational to decision support systems. Students will evaluate the value of decision support systems in contrast with the complexities of implementation in the current medical, legal, financial technological and cultural context. Prerequisite: Admittance to accelerated master's degree in health care informatics.

4013  Information Systems Management (3) SP
The role of Information Systems within the organization and how they can be used to make operations more efficient save time and energy will be discussed. In addition, the methods to use these strategically are evaluated. The use of critical thinking skills to explore methods of using information systems to increase productivity and, if necessary, as the competitive advantage will be a large component of this course. Prerequisite: Admittance to accelerated master's degree in health care informatics.

4103  Introduction to Health Care Informatics (3) SP
This course surveys the fundamental concepts and activities of informatics as applied to health care. Topics include computer-based medical records, electronic health record, knowledge-based systems, decision theory and decision support, e-Health, ARRA/HITECH and Meaningful Use and the personal health record. Students will learn health care informatics history, informatics competencies, concepts, legal and ethical implications and applications within the health care industry. The course will introduce the student to the software development life cycle; human factors issues in health care informatics; critical issues affecting the development and implementation of information and communication systems and technologies, professional practice trends and explore some of the emerging information and communication technology in health
4133 Research Methods in Data Science (3) F
Introduction to the research process investigating information needs, creation, organization, flow, retrieval and use. Stages include: research definition, questions, objectives, data collection and management, data analysis, and data interpretation. Techniques include: observation, interviews, questionnaires, and transaction-log analysis. Prerequisite: DS 3223 or CS 2243, and Math 2183.

4223 Data Mining and Analysis (3) SP
Computational techniques for analysis of large, complex datasets, covering fundamental aspects as well as modern data mining and analysis techniques. Prerequisite: DS 3223 and CS 2243.

Game Development (GD)
1123 Introduction to Game Design and Development (3) F
Fundamentals of game design, games as an artistic and expressive medium, game theory, modern gaming technologies, game critique and evaluation, game development engines, emergent gameplay, the business of creating games, collaborative development, and gaming with a purpose. Prerequisite: None.

3253 Game Development I (3) SP
Introduction to the design and implementation of computer games, including real-time graphics, audio and interactive multimedia programming techniques. Prerequisite: Computer Science 2233 with a grade of “C” or higher.

3263 Game Development II (3) F
Advanced game programming techniques, including 3D graphics, 3D audio, game physics and networking for multi-player games. Prerequisite: Game Development 3253 with a grade of “C” or higher.

3273 Collaborative Serious Games Development (3) SP
Advanced team-based game development on applications of interactive technology for video game domains such as education, health, training, analytics, visualization, simulation and therapy. Prerequisite: Game Development 3263 with a grade of “C” or higher.

Information Security (SEC)
3113 Fundamentals of Information Security (3) SP
An introduction to the security of digital information including: threats; regulations; risk management; attack detection and response; cryptography; forensics; and technical training and certifications. Prerequisites: Information Technology 2223 and Computer Science 1213 with grades of “C” or higher.

3313 Introduction to Policy and Procedures (3) F
Establishing information security policies and procedures for organizations. Identification of relevant contracts, laws, and regulations constraining organization, and the setting of procedures to be used in day-to-day operations. Prerequisite: Information Security 3113 with a grade of “C” or higher.

3323 Cryptography (3) F
Security requirements for telecommunication over the Internet and other communication networks, various conventional and public-key encryption protocols, digital encryption standard, RSA and EIGamal cryptographic systems, digital signature algorithm and analysis of its crypto-immunity, and access sharing schemes. Prerequisites: Math 2103 and 3123 with grades of “C” or higher.

3333 Introduction to Business Continuity and Recovery Planning (3) SP
Maintenance of information and the processes of how to continue in business in the face of data loss, and planning for the recovery in the event of such loss. Prerequisite: Information Security 3131 with a grade of “C” or higher.

350V Special Topics in Information Security (1-3)
Offered on demand
Selected topics from the field of information security. The course may be either lecture or laboratory oriented depending upon the topic selected. The study represents an in-depth approach to specific areas of interest to the students. Repeatable for credit with director’s approval. Prerequisite: Consent of the instructor.

4053 Senior Seminar in Information Security (3) SP
Required of all information security majors in their senior year. Assessment of degree to which information security program outcomes have been achieved; reflection on, and synthesis of, information security academic experience; preparation for transition to professional employment or graduate school. Prerequisites: Senior standing in information security and 15 hours of SEC courses.

4193 Ten-Day Travel Course in Information Security (3) Optional
The travel course is designed to give students insight into various organizations’ operations and how they handle the several aspects of information security. Students will observe the security of the physical plant, how Human Resources protects data by making informed hiring decisions, how data is secured as well as networks and communications. Note: This course is offered during Wintermester and is offered on demand at additional cost. Prerequisites: Senior standing in information security and 15 hours of SEC courses. Travel, 3 hours.

4313 Database Security (3) F
Security challenges and threats in database systems and state-of-the-art security technologies, including multi-level security, covert channels, and security measures for relational and object-oriented database systems. In addition to the security issues, the courses addresses issues related to distributed databases and current technologies, such as service oriented architecture, cloud computing, etc. Prerequisites: Computer Science 2243 and Information Security 3113, 3323 with grades of “C” or higher.

4323 Network Security (3) SP
Advanced knowledge of network security. Topics include design and implementation of some important public key systems: RSA and Elliptic Curve algorithms; concepts of quantum cryptography; quantum computing and cryptography; wireless computing and cryptography; design, implementation and configuration of firewalls in depth; design, implementation and configuration of intrusion detection systems; prevention systems; advanced network security architectures; advanced wireless security; principles and practices; security in trusted-based...
computing environments; and quantum cryptography. Prerequisite: Information Technology 3323 and Information Security 3323 with grades of "C" or higher.

**Information Technology (IT)**

**1123 Future of Computing (3) F, SP**  

**1213 Graphic Design Studio (3) F**  
Basics of graphic design using the Adobe Creative Suite of applications. Integration of design fundamentals with core Adobe Creative suite methodologies: Photoshop, Illustrator, InDesign, Dreamweaver and Flash. Lecture, laboratory, 3 hours.

**2043 Information Technology Applications (3) F, SP**  
Emphasis on using the computer as a decision-making tool. Theory and applications of various software packages, including word processing, electronic spreadsheets, databases and presentation software. Prerequisites: None. Lecture/laboratory, 3 hours.

**2223 Web Application Development I (3) F, SU**  
Survey of Web development techniques. Emphasis on developing and maintaining websites with topics including basic Web site design, HTML, XHTML, and CSS coding. Use of content management systems (CMS) and software packages such as Photoshop. Prerequisites: None. This course may satisfy the SALT Tier II requirement.

**2233 User Interface Design (3) SP**  
Provides an introduction to human–computer interface design and evaluation with an emphasis on graphical user interfaces for software products. Covers design principles and theory, user interface design and evaluation with an emphasis on graphical user interfaces for software products. Covers design principles and theory, web usability and selected basic research in the areas of human factors and human cognition. Prerequisite: IT 2223 with a grade of "C" or higher.

**3121 Fundamentals of Database Concepts and Data Analytics (1) SU**  
Leveling course for graduate students with no prior background in database systems. Model organization data and business rules, logical and physical design of relational databases, data warehousing, data mining, and data administration. Prerequisite: Application to a master's program in the School of Computing and Informatics.

**3131 Fundamentals of Data Communications and Network Management (1) SU**  
Leveling course for graduate students with no prior background in database systems. Concepts and terminology of data communications, network design, client/server architecture, distributed information systems with focus on telecommunications architecture and management. Prerequisite: Application to a master's program in the School of Computing and Informatics.

**3223 Web Application Development II (3) SP**  
Advanced skills in Web application development. Topics include use of HTML5, CSS3, JavaScript, jQuery, frameworks, AJAX, discussions, etc. with introduction to MVC. Emphasis on using available technologies to produce a variety of website types with appreciable user interfaces. Prerequisite: IT 2233 and CS 1213 with grades of "C" or higher.

**3233 Web Server Technologies (3) F**  
Application design using server technologies to transfer data from websites to and from databases. Topics include scripting languages such as ASP, PHP, data structuring languages such as XML and other server technologies. Prerequisites: IT 2233, CS 1213, and CS 2243 with grades of "C" or higher.

**3313 Network Principles (3) F, SP**  
Overview of current computer network theory and practice. Hardware requirements, network media and topologies, protocols and access methods, the Open Systems Interconnection (OSI) and internet models. Prerequisites: CS 1213 with a grade of "C" or higher.

**3323 Wireless Networks and Mobile Systems (3) F**  
Introduction to wireless networks and link protocols, mobile networking including support for the Internet Protocol suite, mobile middleware, and mobile applications. Prerequisite: IT 3313 with a grade of "C" or higher.

**3333 Network Administration (3) F**  
Administration of peer-to-peer and client/server networks. Hands-on experience with commercial client and server software. Topics include pre-installation planning, network installation, network software architecture, server configuration, client configuration, profiles and logon scripts, user account management, policies, resource sharing and security, disk management, remote access, backup and recovery, performance monitoring and network optimization. Prerequisite: IT 3313 with a grade of "C" or higher.

**3343 Database Administration (3) SP**  
Database (e.g. Oracle) creation, including table spaces, user accounts, views, indexes, and other objects necessary to support an application. Understanding the internal structures and organization of database systems (e.g. Oracle). Account maintenance, data import and export, system backup, and performance tuning and monitoring. Prerequisite: CS 2243 with a grade of "C" or higher.

**3413 Systems Analysis and Design (3) F**  
Introduction to analysis and design techniques, project management tools, data collection tools and system documentation tools. Communication skills are emphasized. Proper input/output design techniques, database, etc. are included in selection of appropriate implementation. Evaluation of hardware/software options relating to feasibility. Prerequisite: CS 2243 with a grade of "C" or higher.

**3423 Project Management (3) SP**  
Design and implementation of realistic information system projects while working in a team environment. Prerequisite: IT 3413 or SENG 3223 with grades of "C" or higher.

**350V Special Topics in Information Technology (1-3) Offered on demand**  
Selected topics from the field of information technology. The course may be either lecture or laboratory oriented depending upon the topic selected. The study represents an in-depth approach to specific areas of interest to the students. Repeatable for credit with director's approval. Prerequisite: Consent of the instructor.

**4053 Senior Seminar in Web Development (3) SP**  
Required of all web application development majors in their senior year. Assessment of degree to which web application development program outcomes have been
achieved; reflection on, and synthesis of, web application development academic experience; ethical- professional- creative expectations for the practicing web developer; preparation for transition to professional practice. Prerequisites: Senior standing in web application development and 30 hours of IT courses.

**4323 Modern Telecommunications (3) SP**
Comprehensive overview, including current status and future directions. Topics include review of evolution of telecommunications; voice and data services; basics of signaling, digital transmission, network architecture, and protocols; local area, metropolitan, and wide area networks and narrow band ISDN; asynchronous transfer mode and broadband ISDN; and satellite systems, optical communications, cellular radio, personal communication systems, and multimedia services. Provides examples of real-life networks to illustrate basic concepts and gain further insight. Prerequisite: IT 3323 with a grade of “C” or higher.

**4423 Management of Information Technology (3) F**
The role of information technology in organizations and their strategic use for providing competitive advantage through the use of real-world case studies. Use of critical thinking skills to explore methods of using information systems to increase market share in organizational settings. Prerequisites: Junior standing and IT 3413 with a grade of “C” or higher.

**Information Technology Management (ITM)**

350V **Special Topics in IT Management (1-3)**  
Offered on demand  
Selected topics from the field of IT Management. The course may be either lecture or laboratory oriented depending upon the topic selected. The study represents an in-depth approach to specific areas of interest to the students. Repeatable for credit with director’s approval. Prerequisite: Consent of the instructor.

4003 **Principles of Technology Management (3) SP**  
This course covers the role of technology within the organization and how it can be used to make operations more efficient, save time and energy. In addition, the methods to use technology strategically are evaluated. The use of critical thinking skills to explore methods of using technology to increase productivity and, if necessary, as the competitive advantage will be a large component of this course. Prerequisites: Junior standing and IT 3413 with a grade of “C” or higher.

4013 **Telecommunications Network Management (3) F**  
In-depth study of telecommunications network management technology systems. Architecture, functions, methods and protocols necessary to design modern telecommunications network management systems. Network management standards such as Telecommunications Management Network (TMN) and Simple Network Management Protocol (SNMP). Basic network management concepts, protocols and methods with real-world examples used to address these. Management aspects of planning and controlling/decision making for telecommunication networks: human resources, financial planning and control, marketing, cost/benefit analysis. Marketing aspects of telecommunications networks. Prerequisite: Junior standing and permission of undergraduate programs director.

4023 **Data & Knowledge Management (3) SP**  
This course includes a focus on the process of data and knowledge management and associated business intelligence parameters. Data management: modeling, using, securing and sharing organizational data resources. Business intelligence: applications and technologies for gathering, storing, analyzing and providing access to help enterprise users make better business decisions. Knowledge management: effective deployment of technology, organizational practices and processes to increase an organization’s utilization of its knowledge capital. Prerequisites: Junior standing and IT 3413 with a grade of “C” or higher.

**Software Engineering (SENG)**

3223 **Principles of Software Engineering (3) SP**  
Survey of techniques, methods and theories used in the analysis, design, implementation, and testing of software. Prerequisites: Computer Science 2233 and Computer Science 2243 with grades of “C” or higher.

350V **Special Topics in Software Engineering (1-3)**  
Offered on demand  
Selected topics from the field of software engineering. The course may be either lecture or laboratory oriented depending upon the topic selected. The study represents an in-depth approach to specific areas of interest to the students. Repeatable for credit with director’s approval. Prerequisite: Consent of the instructor.

4023 **Requirements Engineering and Modeling (3) SP**  
Perspectives on software engineering processes, in-depth study of requirements engineering and an overview of various modeling techniques applicable to requirements analysis and specification, including UML and formal methods. Prerequisites: SENG 3223 and junior or senior standing.

4113 **Software Architecture and Design (3) F**  
The process of constructing software, including the structural views of software components and their characteristics and interrelationships at a high level of abstraction. The course also covers the design principles that govern the purpose, structure, development and evolution of software components. Prerequisites: SENG 3223 and junior or senior standing.

4123 **Software Testing and Verification (3) SP**  
Fundamental concepts of software quality assurance and testing, functional testing, GUI-based testing tools, control flow based test adequacy criteria, data flow based test adequacy criteria, white box-based testing tools, software quality and reliability, testing management techniques and support tools, and covers team-oriented project using methods, techniques and practices learned. Prerequisites: SENG 3223 and junior or senior standing.

4323 **Agile Software Development (3) SP**  
This course provides an in-depth treatment of Agile Software Development, a highly iterative, customer-focused, team-based, test-driven method for developing software; study of principles and fundamental concepts that drive Agile, borrowing from many of the Agile variations (Scrum, Extreme Programming, etc.); and application of Agile’s dynamic and adaptable principles within the context of an organization. Prerequisites: SENG 3223 and junior or senior standing.