CYBERSECURITY (MS)

Program Director: Jeffrey McConnell, PhD (mcconnel@canisius.edu)

The M.S. in Cybersecurity program is designed to train cybersecurity professionals to meet the needs of business, industry, educational institutions, and government agencies locally and nation-wide. The program provides a cutting-edge curriculum that prepares graduates to succeed as a cybersecurity professional or researcher.

The Cybersecurity MS is designed as a full-time (with a part-time option), face-to-face program. Students without a computer science background may take a set of courses as preparatory that would otherwise be waived for those with the applicable undergraduate courses. The program is in line with curricular recommendations from the ACM Cybersecurity Curricula and the NSA’s Center of Academic Excellence (CAE) in Cyber Defense.

Admissions Requirements
- Students from any undergraduate major are welcome to apply, as long as they have acquired a bachelor’s degree prior to the start of classes.
- Cumulative GPA of 2.8 or higher.
- Students may apply at any time. We have rolling admissions.
- Student preparation and background are used to determine if some introductory courses may be waived.

Materials to be Submitted
- Free Online Application (https://www.canisius.edu/admissions/apply-canisius/), with essay
- An official transcript from each college attended
- Official GRE or GMAT score (optional)
- Resumé (optional)
- One or two Letters of Recommendations (optional)

Policies
Academic Standing
The Cybersecurity program follows the College of Arts and Sciences on students’ academic standing. (http://catalog.canisius.edu/graduate/academics/academic-policies/#academicstandingtext)

Matriculation and Continued Program Enrollment
The Cybersecurity program follows the Canisius College policy for matriculated students (http://catalog.canisius.edu/graduate/admission-matriculation/#Matriculation) that expects students to maintain a continuous program of academic work.

Registration and Credit Hours
Cybersecurity students must be registered for at least 4.5 credits per semester to maintain eligibility for financial aid (if they are eligible). A full load is at least 9 credit hours. No student may register for more than 12 credit hours in any semester.

Curriculum

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSC 511</td>
<td>Introduction to Programming</td>
<td>3</td>
</tr>
<tr>
<td>CSC 511L</td>
<td>and Introduction to Programming Lab</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT 591</td>
<td>Discrete Mathematics</td>
<td>3</td>
</tr>
</tbody>
</table>

Required Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSC 530 &amp; 530L</td>
<td>Operating System Design and Distributed Computing and Operating System Design and Distributed Computing Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>CYB 500 &amp; 500L</td>
<td>Cybersecurity Principles and Cybersecurity Principles Lab</td>
<td>3</td>
</tr>
<tr>
<td>CYB 510</td>
<td>Cybersecurity Policies, Ethics, and Law</td>
<td>3</td>
</tr>
<tr>
<td>CYB 520 &amp; 520L</td>
<td>Ethical Hacking and Penetration Testing and Ethical Hacking and Penetration Testing Lab</td>
<td>3</td>
</tr>
<tr>
<td>CYB 540 &amp; 540L</td>
<td>Network and Internet Security and Network and Internet Security Lab</td>
<td>3</td>
</tr>
<tr>
<td>CYB 600 &amp; 600L</td>
<td>Secure Software Engineering and Secure Software Engineering Lab</td>
<td>3</td>
</tr>
<tr>
<td>CYB 610</td>
<td>Cybersecurity Project</td>
<td>3</td>
</tr>
<tr>
<td>CSC 610 &amp; 610L</td>
<td>Database Management and Database Management Lab</td>
<td>3</td>
</tr>
</tbody>
</table>

Choose from the following (minimum 6 cr.):

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYB 580</td>
<td>Cybersecurity Seminar</td>
<td>1</td>
</tr>
<tr>
<td>CYB 599 &amp; 599L</td>
<td>Cybersecurity Special Topics and Cybersecurity Special Topics Lab</td>
<td>3</td>
</tr>
<tr>
<td>CYB 611</td>
<td>Cybersecurity Thesis</td>
<td>1</td>
</tr>
<tr>
<td>CYB 620 &amp; 620L</td>
<td>Applied Cryptography and Applied Cryptography Lab</td>
<td>3</td>
</tr>
<tr>
<td>CYB 697</td>
<td>Cybersecurity Internship</td>
<td>1</td>
</tr>
<tr>
<td>CYB 699</td>
<td>Advanced Cybersecurity Topics</td>
<td>1</td>
</tr>
<tr>
<td>DAT 511</td>
<td>Data Stewardship: Preparation, Exploration and Handling of Big Data</td>
<td>3</td>
</tr>
<tr>
<td>DAT 514 &amp; MAT 500</td>
<td>Data Mining and Machine Learning and Topics in Applied Mathematics (The combination of these two courses fulfills the elective credits)</td>
<td>6</td>
</tr>
</tbody>
</table>

Total Credits: 39

Courses

Computer Science (CSC) (p. 1), Cybersecurity (CYB) (p. 2), Data Analytics (DAT) (p. 3), Mathematics (MAT) (p. 3)

Computer Science (CSC)

CSC 511 Introduction to Programming 3 Credits
This foundational course will teach you the basics of computer programming using the Python language. You will design, code, test, and debug computer programs for textual and graphical applications.
Corequisite: CSC 511L.
Offered: every fall, spring, & summer.

CSC 511L Introduction to Programming Lab 0 Credits
Required lab for CSC 511.
Corequisite: CSC 511.
Offered: every fall, spring, & summer.
CSC 512 Data Structures and Algorithms 3 Credits
The primary focus of this course is data structures and their accompanying algorithms, including recursive algorithms. In order to judge between competing algorithms or alternative data structures, we will use analysis to discover the time and memory bounds of various approaches. We will also use object-oriented programming as a useful way of constructing abstract data types and in general structuring complex programs. Several debugging tools and approaches will be explored, especially hand tracing of algorithms. The Python programming language will be our main vehicle.
Prerequisite: CSC 511 or CSC 111. Corequisite: CSC 512L.
Offered: every fall, spring, & summer.

CSC 512L Data Structures and Algorithms Lab 0 Credits
Required lab for CSC 512.
Corequisite: CSC 512.
Offered: every fall, spring, & summer.

CSC 530 Operating System Design and Distributed Computing 3 Credits
The design of operating system software, distributed applications, client/server and other models, security issues, and parallel programming on a High Performance Computing Cluster.
Prerequisite: A minimum grade of C in CSC 502 & CSC 502L. Corequisite: CSC 530L.
Offered: every fall.

CSC 530L Operating System Design and Distributed Computing Laboratory 0 Credits
Required lab for CSC 530.
Prerequisite: A minimum grade of C in CSC 502 & CSC 502L. Corequisite: CSC 530L.
Offered: every fall.

CSC 610 Database Management 3 Credits
This course presents an introduction to the design and use of database systems. Traditional databases will be the primary focus, centering on the relational model (SQL and related tools). There will be some discussion of large-scale information retrieval in the form of the NoSQL movement and data mining. Ethical, social and security issues will also be covered in an introductory fashion.
Prerequisite: CSC 112 or CSC 512; may be taken concurrently.
Offered: every fall & spring.

CSC 610L Database Management Lab 0 Credits
Required lab for CSC 610.
Prerequisite: CSC 512L. Corequisite: CSC 610.
Offered: every fall & spring.

Cybersecurity (CYB)

CYB 500 Cybersecurity Principles 3 Credits
This course examines the landscape and the broad areas of cybersecurity which includes topics such as: Symmetric & Public-Key Encryption, Access Control, Database Security, Malware, DoS (Denial-of-Service) Attacks, Intrusion Detection & Firewalls, Software Security, Security Management & Policies, Internet Security, and Legal & Ethical Aspects of Cybercrime. Students will also complete hands-on labs and exercises to reinforce their working knowledge of computer, network and information security topics.
Prerequisite: DAT 513 and DAT 513L may be taken concurrently, and.
Corequisite: CYB 500L.
Offered: every fall & spring.

CYB 500L Cybersecurity Principles Lab 0 Credits
Required lab for CYB 500.
Corequisite: CYB 500.
Offered: every fall & spring.

CYB 501 Cybersecurity Principles for Business 3 Credits
This course examines the landscape and the broad areas of cybersecurity which includes topics such as: Symmetric & Public-Key Encryption, Access Control, Database Security, Malware, DoS (Denial-of-Service) Attacks, Intruision Detection & Firewalls, Software Security, Security Management & Policies, Internet Security, and Legal & Ethical Aspects of Cybercrime.
Offered: every fall & spring.

CYB 510 Cybersecurity Policies, Ethics, and Law 3 Credits
This course focuses on the practical aspects of information security and assurance. Topics covered include access control models, information security governance, and information security program assessment and metrics. Coverage on the foundational and technical components of information security is included to reinforce key concepts. The course includes up-to-date information on changes in the field, such as national and international laws and international standards like the ISO 27000 series.
Offered: every spring.

CYB 520 Ethical Hacking and Penetration Testing 3 Credits
This course provides an in-depth understanding of how to effectively protect computer networks. Students will learn the tools and penetration testing methodologies used by ethical hackers. In addition, the course provides a thorough discussion of what and who an ethical hacker is and how important they are in protecting corporate and government data from cyber attacks. Students will learn updated computer security resources that describe new vulnerabilities and innovative methods to protect networks. Also covered is a thorough update of federal and state computer crime laws, as well as changes in penalties for illegal computer hacking.
Prerequisite: CYB 500 and CYB 500L; may be taken concurrently.
Corequisite: CYB 520L.
Offered: every spring.

CYB 520L Ethical Hacking and Penetration Testing Lab 0 Credits
Required Lab for CYB 520
Prerequisite: CYB 500 and CYB 500L.
Offered: every spring.

CYB 540 Network and Internet Security 3 Credits
The purpose of this course is to provide a practical survey of network security applications and standards. The emphasis is on applications that are widely used on the Internet and for corporate networks, and on standards (especially Internet standards) that have been widely deployed. The first part of the course will cover a concise survey of the cryptographic algorithms and protocols underlying network security applications, including encryption, hash functions, message authentication, and digital signatures. The second part of the course will cover important network security tools and applications, including key distribution, Kerberos, X.509v3 certificates, Extensible Authentication Protocol, S/MIME, IP Security, SSL/TLS, IEEE 802.11i WiFi security, and cloud security. Finally, we will look at system-level security issues, including the threat of and countermeasures for malicious software and intruders, and the use of firewalls.
Prerequisites: CSC 502, CYB 500, and DAT 513. Corequisite: CYB 540L.
Offered: every fall.

CYB 540L Network and Internet Security Lab 0 Credits
Required lab for CYB 540
Corequisite: CYB 540.
Offered: every fall.
**CYB 580 Cybersecurity Seminar** 3 Credits
This a graduate seminar course in which students will give oral presentations of scientific data. Students attend presentations as well as prepare and present on various topics in cybersecurity for faculty and other students. The seminars is expected to enhance the student’s public speaking skills and to provide experience in preparing scientific presentations for professional settings. To help students improve as speakers, each student will receive feedback from fellow students and the instructor.
Offered: every fall.

**CYB 599 Cybersecurity Special Topics** 3 Credits
Current topics in Cybersecurity of interest to faculty and students. Possible topics include: Malware Analysis & Reverse Engineering, Bitcoin & Cryptocurrencies, Machine Learning & Security, Computer Forensics, etc.
Prerequisites: CSC 502 and CYB 500. Corequisites: CYB 599L.
Offered: every fall.

**CYB 599L Cybersecurity Special Topics Lab** 0 Credits
Required lab for CYB 599.
Corequisites: CYB 599.
Offered: every fall.

**CYB 600 Secure Software Engineering** 3 Credits
The purpose of this course is to provide secure programming practices that are necessary to develop applications that withstand cyber-attacks and common software exploits. The first part of the course will cover the fundamentals of software security and implementing a continuous risk management framework throughout the software development lifecycle. The second part of the course will cover the Seven Touchpoints for software security as well as code reviews and software penetration testing. Finally, we will look at adopting a secure development lifecycle (SDL) in an enterprise setting.
Prerequisite: CSC 502, CYB 500, and DAT 513. Corequisites: CYB 600L.
Offered: every spring.

**CYB 600L Secure Software Engineering Lab** 0 Credits
Required lab for CYB 600
Corequisites: CYB 600.
Offered: every spring.

**CYB 610 Cybersecurity Project** 3 Credits
This course requires the culmination of knowledge and laboratory experience gained from the MS in Cybersecurity program as students will have the opportunity to design and implement a graduate capstone project. Students may complete this project for a real-world application or in a laboratory setting that pertains to the greater field of cybersecurity. Students must defend their work in an open project defense and complete a written report of their work before a letter grade is awarded.
Prerequisite: CYB 520.
Offered: every fall, spring, & summer.

**CYB 611 Cybersecurity Thesis** 3 Credits
The purpose of the thesis course is to provide the students the opportunity to work with a faculty advisor on a research problem in cybersecurity. Completion of the thesis will require scholarly research methods to produce a significant thesis document that is comparable to a peer-reviewed publication. This course should be taken during the last semester of the MS program and the final thesis and oral presentation (defense) will be evaluated by a faculty committee before a grade is awarded.
Prerequisite: CYB 610.
Offered: every fall & spring.

**CYB 620 Applied Cryptography** 3 Credits
This course will introduce the concepts of modern cryptography, including a combination of both theoretical foundations and practical applications of cryptography used in the real world. This course complements all of the CYB 5xx cybersecurity courses by taking a deeper look into cryptography to grasp a better understanding of cryptographic primitives, algorithms, attacks, and protocols. At the end of this course, students will have a proper foundation of modern cryptography and be able to apply cryptographic techniques in the design and analysis of secure computing systems.
Prerequisites: CSC 502, CYB 520, and CYB 540 (CYB 540 can be taken concurrently). Corequisite: CYB 620L.
Offered: every fall.

**CYB 620L Applied Cryptography Lab** 0 Credits
Required lab for CYB 620
Corequisite: CYB 620.
Offered: every fall.

**CYB 697 Cybersecurity Internship** 3 Credits
The application of the knowledge and skills acquired from the MS in Cybersecurity program in a real-world professional setting. Students will be responsible for arranging a practicum/internship with a business or organization that is related to cybersecurity. The outline of work duties and evaluative methods are established by the student and the internship mentor/supervisor and approved by the faculty advisor prior to initiation of the course.
Prerequisite: CYB 500.
Offered: every fall, spring, & summer.

**CYB 699 Advanced Cybersecurity Topics** 3 Credits
In-depth study of a topic related to cybersecurity.
Prerequisite: permission of instructor.
Offered: occasionally.

**Mathematics (MAT)**

**MAT 591 Discrete Mathematics** 3 Credits
Fundamental topics with computer science applications. Sets and logic, propositional and predicate calculus, elements of combinatorics and counting, elementary discrete probability, functions and relations, and graphs.
Offered: every fall.

**Roadmap**

**Full-Time**

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYB 500 &amp; 500L</td>
<td>CYB 510</td>
<td>CYB 610</td>
</tr>
<tr>
<td>CSC 610 &amp; 610L</td>
<td>CYB 520 &amp; 520L</td>
<td>CYB 600 &amp; 600L</td>
</tr>
<tr>
<td>CSC 530 &amp; 530L</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CYB 650 &amp; 540L</td>
<td>CYB 540</td>
<td>CYB 620 &amp; 620L</td>
</tr>
<tr>
<td>One of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CYB 599 &amp; 599L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CYB 611</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CYB 697</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part-Time

First Year

Fall
CYB 500 & 500L
CSC 610 & 610L

Spring
CYB 510
CYB 520 & 520L

Second Year

Fall
CYB 540 & 540L
CSC 530 & 530L

Spring
CYB 600 & 600L
CYB 610

Third Year

Fall
CYB 620 & 620L
One of the following:
CYB 599 & 599L
CYB 611
CYB 697

Learning Goals & Objectives

On completing the MS program, students will be able to:

1. Assess Risks and Threats
   - Perform information security risk assessment, identify potential threats, and develop threat mitigation strategies.
   - Identify malicious activities and attacks, and recommend appropriate response capabilities.

2. Implement Policies and Respond to Incidents
   - Describe security design principles and identify security mechanisms to implement desired security principles.
   - Implement security defense technologies.
   - Carry out incident response activities and support cyber-crime investigation.
   - Perform audit procedures, evaluate the strengths and weaknesses of the security mechanisms, and develop contingency plans.

3. Communicate and Educate on Cybersecurity Issues
   - Describe individual privacy rights, related laws and regulations, and the use of information assurance technologies to support the enforcement of these rights.
   - Describe the responsibilities of all levels of users related to the threats against information systems.
   - Communicate information security concepts to individuals with diverse levels of computing skills.