Cybersecurity, MS

School of Interdisciplinary Informatics, College of Information, Science & Technology

Vision Statement
The School of Interdisciplinary Informatics (Si2) is the academic home of the Master of Science (MS) in cybersecurity (previously information assurance). Cybersecurity is a rapidly expanding, multi-faceted science that integrates a diverse set of disciplines to address fundamental problems in the design, development, implementation and support of secure information systems. The Master of Science is a full graduate degree program balancing theory with practice in order to provide students with the knowledge and skills necessary to protect information systems. Because of the wide variety of subject areas to which cybersecurity can be applied, this degree program has two paths; cyber operations, a concentration with highly technical content, and interdisciplinary, with the opportunity for the students to tailor the degree to specific management goals. Students may also choose between a thesis or capstone exit option based on their individual interests.

Program Contact Information
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Admissions
Application Deadlines (Spring 2021, Summer 2021, and Fall 2021)
• Fall: July 1
• Spring: December 1
• Summer: April 1

Program-Specific Requirements
1. All applicants must have the equivalent of a four-year undergraduate degree.
2. Applicants are required to have a command of oral and written English. Those who do not hold a baccalaureate or other advanced degree from the United States OR a baccalaureate or other advanced degree from a predetermined country on the waiver list, must meet the minimum language proficiency score requirement in order to be considered for admission. Minimum acceptable scores are:
   a. Paper-based TOEFL: 550
   b. Internet-based TOEFL: 80
3. International applicants without a baccalaureate or equivalent degree from the United States are required to submit GRE scores. There is no minimum GRE requirement, but for international applicants the score will be one factor used in evaluating the student’s portfolio.
4. At least one but no more than three letters of recommendation from references who can evaluate your work and/or academic achievements.
5. Statement of Purpose: a two-page, double-spaced, word-processed essay that addresses the following two topics:
   a. Discussion of two accomplishments that demonstrate your potential for success in the graduate program
   b. Discussion of your unique personal qualities and life experiences that distinguish you from other applicants to this graduate program
6. Resume (include work experience and background)
7. Applicants with International Transcripts: Any applicant to this program who has completed undergraduate or graduate coursework at an international higher education institution outside of the United States may submit transcripts and degree certificates (with an English translation) in lieu of a course-by-course transcript evaluation from World Education Services (https://www.wes.org/) (WES), Educational Credential Evaluators (https://www.ece.org/) (ECE), or Educational Perspectives (https://www.edperspective.org/). This graduate program will conduct an in-house credential evaluation of your transcript(s).
   • UNO reserves the right to require a course-by-course evaluation from WES, ECE, or Educational Perspectives if the program is unable to complete an evaluation or should there be any questions or concerns about the documentation that is received. You will be notified by the individual program if an external course-by-course evaluation is required.
   • *Note: If you are admitted, official transcripts and degree certificates (with an English translation)/official course-by-course transcript evaluation, and any applicable official exam scores are required.
8. Interview (optional): Although not required, the graduate program committee may ask to conduct a telephone interview to further assess the experiences of the applicant.

Requirements
Foundation Courses
Foundation courses ensure that all students in the degree have a solid groundwork upon which to build the rest of the program. These courses not only provide essential prerequisite knowledge and skills for other courses in the program, but they also contain a distinct body of knowledge that is an important part of the cybersecurity professional’s education. All foundation courses are required for all students, however, students who have obtained an undergraduate degree in a related field may already have this foundation. In such a case, most, if not all, foundation courses are waived. Students with undergraduate degrees in other disciplines, including computer science, management information systems, or engineering, will usually require one or more foundation courses. Occasionally, a student’s work experience may be sufficient to waive one or more of the foundation courses.

Waivers for foundation courses are potentially granted by the graduate program committee upon the recommendation of the faculty member who is responsible for an individual course. Students requesting a waiver for a particular course should be prepared to meet with a faculty member and answer questions in the area of the course. They should bring to the meeting any relevant transcripts, course syllabi, course material, or evidence of practical experience. Some foundation courses may have an option for testing out.
Foundation courses cannot be used to satisfy the 33 semester hours required for the MS in Cybersecurity (CYBR) degree. Students who have not completed all the foundation course requirements may be admitted on a provisional status until those requirements have been completed. All foundation courses must be completed prior to or concurrent with the first six (6) hours of MS in CYBR graduate coursework.

**Foundation Requirements**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CSCI 2240</td>
<td>INTRODUCTION TO C PROGRAMMING</td>
<td>3</td>
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<tr>
<td>or CYBR 2250</td>
<td>LOW-LEVEL PROGRAMMING</td>
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<tr>
<td>CSCI 3550</td>
<td>COMMUNICATION NETWORKS</td>
<td>3</td>
</tr>
<tr>
<td>or ISQA 3400</td>
<td>INFORMATION TECHNOLOGY INFRASTRUCTURE</td>
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<tr>
<td>CYBR 3350</td>
<td>SECURITY ADMINISTRATION - LINUX</td>
<td>3</td>
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<tr>
<td>or CYBR 3370</td>
<td>SECURITY ADMINISTRATION - WINDOWS</td>
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Total Credits 9

**Degree Requirements**

**Capstone Option**

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<thead>
<tr>
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<tbody>
<tr>
<td>CYBR 8366</td>
<td>FOUNDATIONS OF CYBERSECURITY</td>
<td>3</td>
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<tr>
<td>or CSCI 8366</td>
<td>FOUNDATIONS OF CYBERSECURITY</td>
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<tr>
<td>CYBR 8410</td>
<td>CRYPTOGRAPHY AND NETWORK SECURITY</td>
<td>3</td>
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<td>CYBR 8420</td>
<td>SOFTWARE ASSURANCE</td>
<td>3</td>
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<tr>
<td>or CSCI 8420</td>
<td>SOFTWARE ASSURANCE</td>
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<tr>
<td>CYBR 8490</td>
<td>CYBER INVESTIGATIONS</td>
<td>3</td>
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**Concentration**

Select a concentration 18

CYBR 8950 GRADUATE CAPSTONE IN INFORMATION ASSURANCE 3

Total Credits 33

**Thesis Option**

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<tr>
<td>CYBR 8490</td>
<td>ADVANCED DIGITAL FORENSICS</td>
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**Concentration**

Select a concentration 15

CYBR 8990 THERESIS IN CYBERSECURITY 6

Total Credits 33

**Exit Requirements:**

- Capstone 3 Credits CYBR 8950
- Thesis 6 Credits CYBR 8990
  - All candidates should carefully review the Graduate College requirements for forming a Supervisory Committee, Thesis/Thesis

Equivalent Proposal Approval Forms and final approval and submission of a thesis.

**Cyber Operations Concentration**

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<tr>
<td>CYBR 8000</td>
<td>CENTER OF ACADEMIC EXCELLENCE-CYBER OPERATIONS COMPLETION CERTIFICATE</td>
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</tbody>
</table>

Select 18 hours from the following:

- CYBR 8396 MOBILE DEVICE FORENSICS
- CYBR 8436 QUANTUM COMPUTING AND CRYPTOGRAPHY
- CYBR 8440 SECURE SYSTEMS ENGINEERING
- CYBR 8446 INDUSTRIAL CONTROL SYSTEM SECURITY
- CYBR 8450 APPLIED CRYPTOGRAPHY
- CYBR 8456 HOST-BASED VULNERABILITY DISCOVERY
- CYBR 8460 SECURITY OF EMBEDDED SYSTEMS
- CYBR 8466 NETWORK-BASED VULNERABILITY DISCOVERY
- CYBR 8470 SECURE WEB APPLICATION DEVELOPMENT
- CYBR 8480 SECURE MOBILE DEVELOPMENT
- CYBR 8546 COMPUTER SECURITY MANAGEMENT
- CYBR 8900 INDEPENDENT STUDY AND RESEARCH IN CYBERSECURITY
- CYBR 8910 INTERNSHIP
- CYBR 8996 SPECIAL TOPICS IN INFORMATION ASSURANCE
- CSCI 8430 TRUSTED SYSTEM DESIGN, ANALYSIS AND DEVELOPMENT

Total Credits 18

**Interdisciplinary Concentration**

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<tr>
<td>CYBR 8490</td>
<td>ADVANCED DIGITAL FORENSICS</td>
<td>3</td>
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**Concentration**

Select 15 hours from the following:

- ISQA 8060 RESEARCH IN MIS
- ISQA 8080 SEMINAR IN MANAGEMENT INFORMATION SYSTEMS
- ISQA 8530 E-COMMERCE SECURITY
- ISQA 8546 COMPUTER SECURITY MANAGEMENT
- ISQA 8560 INFORMATION WARFARE AND SECURITY
- ISQA/CYBR 8570 INFORMATION SECURITY POLICY AND ETHICS
- ISQA 8580 SECURITY RISK MANAGEMENT AND ASSESSMENT
- ISQA 8596 IT AUDIT AND CONTROL
- CSCI 8340 DATABASE MANAGEMENT SYSTEMS II
- CSCI 8430 TRUSTED SYSTEM DESIGN, ANALYSIS AND DEVELOPMENT

Total Credits 33
CSCI 8530  ADVANCED OPERATING SYSTEMS  
CSCI/MATH 8566  NUMBER THEORY & CRYPTOGRAPHY  
CSCI 8610  FAULT TOLERANT DISTRIBUTED SYSTEMS  
CYBR 8080  SPECIAL TOPICS IN INFORMATION ASSURANCE  
CYBR 8900  INDEPENDENT STUDY AND RESEARCH IN CYBERSECURITY  
CYBR 8910  INTERNSHIP  
CYBR 8986  SPECIAL TOPICS IN INFORMATION ASSURANCE  

Total Credits 18

Quality of Work Standards
The Graduate College’s Quality of Work Standards shall be applied to foundation courses as well as courses taken as part of the degree program. In particular, the GPC will recommend to the Graduate College that any

1. Student receiving a grade of “C+” or below on any foundation course will be dismissed from the program or, in the case of unclassified or non-degree students, be automatically dismissed.
2. Student receiving a grade of “C+” or “C” in any foundation course will be placed on probation or dismissed from the program.
3. Student not maintaining a “B” (3.0 on a 4.0 scale) average in foundation courses will be placed on probation or dismissed from the program.

CYBR 8000  CENTER OF ACADEMIC EXCELLENCE-CYBER OPERATIONS COMPLETION CERTIFICATE (0 credits)
This course is utilized to provide a specific designation for students that have completed the Center of Academic Excellence - Cyber Operations coursework. It is a zero credit hour class used to designate the completion of this focus area in the cybersecurity curriculum. 
Prerequisite(s)/Corequisite(s): Instructor Permission. The program committee will work with the UG advisors to ascertain that the student has fulfilled all requirements for this designation-if he/she has or will within the last semester, they will be allowed to register for this class. 

CYBR 8080  SPECIAL TOPICS IN INFORMATION ASSURANCE (1-6 credits)
The course provides a format for exploring advanced research areas for graduate students in Information Assurance and related fields. Specific topics vary, in keeping with research interests of faculty and students. Examples include applied data mining, mobile security, web services and applications, vulnerability assessments, cloud computing security, and other issues in Information Assurance research. 
Prerequisite(s)/Corequisite(s): Instructor Permission.

CYBR 8366  FOUNDATIONS OF CYBERSECURITY (3 credits)
Contemporary issues in computer security, including sources for computer security threats and appropriate reactions; basic encryption and decryption; secure encryption systems; program security, trusted operating systems; database security, network and distributed systems security, administering security; legal and ethical issues. (Cross-listed with CYBR 4360, CSCI 8366) 
Prerequisite(s)/Corequisite(s): CSCI 3320 or CSCI 8325 OR ISQA 3400 OR By instructor permission

CYBR 8386  COMPUTER AND NETWORK FORENSICS (3 credits)
Computer forensics involves the preservation, identification, extraction and documentation of computer evidence stored on a computer. This course takes a technical, legal, and practical approach to the study and practice of incident response, computer forensics, and network forensics. Topics include legal and ethical implications, duplication and data recovery, steganography, network forensics, and tools and techniques for investigating computer intrusions. This course is intended as a second course in information assurance for undergraduate students as well as other qualified students. It is also intended as a foundation course for graduate digital forensics studies. 
Prerequisite(s)/Corequisite(s): CYBR 1100, CIST 3600, CSCI 3500 or ISQA 3400, CYBR 3350 or CYBR 3370; or instructor permission.

CYBR 8396  MOBILE DEVICE FORENSICS (3 credits)
Mobile device forensics is the science of recovering digital evidence from a mobile device under forensically sound conditions using accepted methods. The aim of this course is to introduce students to acceptable approaches for collecting, analyzing and reporting data from a mobile device forensics investigation. Topics include: an introduction to digital and mobile device forensics, mobile forensics standards, acquisition methods (manual, logical, physical and provider-side), Android and iOS file system analysis, decoding approaches, application data analysis, and report writing. Students will be required to perform several investigations in a controlled lab environment, including acquiring forensically sound evidence and analyzing these, using industry standard tools. (Cross-listed with CYBR 4390).

CYBR 8410  DISTRIBUTED SYSTEMS AND NETWORK SECURITY (3 credits)
The course aims at understanding the issues surrounding data security, integrity, confidentiality and availability in distributed systems. Further, we will discuss various network security issues, threats that exist and strategies to mitigate them. This course will cover topics in cryptography, public key infrastructure, authentication, hashing, digital signatures, ARP protection, IP and IPSEC, IP Tables, SSL/TLS, firewalls, etc. (Cross-listed with CSCI 8410) 
Prerequisite(s)/Corequisite(s): IASC 8366 or equivalent(s); or instructor permission. Not open to non-degree graduate students.

CYBR 8420  SOFTWARE ASSURANCE (3 credits)
Software assurance is a reasoned, auditable argument created to support the belief that the software will operate as expected. This course is an intersection of knowledge areas necessary to perform engineering activities or aspects of activities relevant for promoting software assurance. This course takes on a software development lifecycle perspective for the prevention of flaws. (Cross-listed with CSCI 8420) 
Prerequisite(s)/Corequisite(s): CSCI 4830 or CSCI 8836 OR by permission of the Instructor. Not open to non-degree graduate students.

CYBR 8436  QUANTUM COMPUTING AND CRYPTOGRAPHY (3 credits)
The course builds an understanding of exciting concepts behind quantum computing and quantum cryptography. In doing so it will introduce the principles of qubits, superposition, entanglement, teleportation, measurement, quantum error correction, quantum algorithms, quantum key exchange, quantum encryption, and secure quantum channels that are built using these principles. It will also discuss advantages of quantum computing and cryptography over classical computing and cryptography and limitations thereof. The students will come out with a working understanding of the field of quantum computing and quantum cryptography. During the course, students will also implement several of the quantum algorithms. (Cross-listed with CYBR 4430)
CYBR 8440 SECURE SYSTEMS ENGINEERING (3 credits)
This course takes a global risk-based view of the process of defining, verifying, validating and continuously monitoring secure information systems. The course will investigate a number of secure system solutions, starting with the definition of the system security needs, and tracing through methods of verification and validation of security controls, as well as ways to continually monitor the corresponding assurances. (Cross-listed with CSCI 8440)
Prerequisite(s)/Corequisite(s): CSCI 8366 or IASC 8366.

CYBR 8446 INDUSTRIAL CONTROL SYSTEM SECURITY (3 credits)
The objective of this course is to research vulnerabilities into, and provide guidance for securing, industrial control systems (ICS). ICS is a general term that encompasses several types of control systems, including supervisory control and data acquisition (SCADA) systems, distributed control systems (DCS), and other control system items such as Programmable Logic Controllers (PLC). The student will learn to identify network and device vulnerabilities and potential countermeasures to these weaknesses. (Cross-listed with CYBR 4440)
Prerequisite(s)/Corequisite(s): CSCI 3550.

CYBR 8450 APPLIED CRYPTOGRAPHY (3 credits)
In this course we will implement stream and block ciphers in different modes, public key algorithms, hash functions, message authentication codes, random number generators, etc. Along the way we will also explore weaknesses of these algorithms and implement well-known attacks on them. We will also solve crypto challenges and puzzles. This is a hands-on course and will require programming proficiency. The preferred language will be Python; you can, however, use other object oriented languages.
Prerequisite(s)/Corequisite(s): CSCI 8410 or CYBR 8410

CYBR 8456 HOST-BASED VULNERABILITY DISCOVERY (3 credits)
The class will cover security issues at an implementation and hardware level. The students will learn assembly language and the use of a reverse assembler and debugger. This will allow the student to analyze various 'packing' algorithms for computer viruses, the viruses themselves, operating system 'hooking', 'fuzzing', and other machine code, host-based exploits. The class will be using both Windows and Linux as operating systems. (Cross-listed with CYBR 4450.)
Prerequisite(s)/Corequisite(s): CSCI 3710 and CYBR 2250.

CYBR 8466 NETWORK-BASED VULNERABILITY DISCOVERY (3 credits)
The course is an advanced class in which the students learn various techniques for testing for and identifying security flaws in network software and web applications. Internet technologies such as HTTP, DNS, DHCP, and others are examined in the context of cyber security. Students are expected to participate in numerous hands-on experiments related to Information Assurance with respect to web technologies. (Cross-listed with CYBR 4460)
Prerequisite(s)/Corequisite(s): CSCI 3550

CYBR 8470 SECURE WEB APPLICATION DEVELOPMENT (3 credits)
Web applications are pervasive fixtures of 21st century culture. Web application security is an inclusive, amorphous, term that spans application level security, i.e. ensuring high level code cannot be exploited, server level security, i.e. ensuring server resources such as databases and file systems cannot be exploited, and network security, i.e. ensuring unauthorized parties cannot access a server or tamper with user sessions. This course cross-cuts the web application security concepts across the different categories above and takes a heavily hands-on approach to introduce students to the world of secure web app. design and development.
Prerequisite(s)/Corequisite(s): Instructor Permission

CYBR 8480 SECURE MOBILE DEVELOPMENT (3 credits)
Mobile devices are already pervasive fixtures of 21st century culture and increasingly the internet of things (IoT) and wearables are proliferating throughout the world. As this proliferation occurs, numerous vendor-centric and third-party mobile, wearable, and internet of things apps are being created by developers and downloaded by end-users with little to no thought about the security and privacy of the information used and collected by the apps. This course examines this issue from a development point of view to a) introduce mobile/wearable/IoT architectures and technologies, b) increase student application development competencies with these technologies, and c) integrate secure design principles into the ideation, design, and testing phases during development.
Prerequisite(s)/Corequisite(s): CYBR 8470 or Instructor Permission

CYBR 8546 COMPUTER SECURITY MANAGEMENT (3 credits)
The purpose of this course is to integrate concepts and techniques from security assessment, risk mitigation, disaster planning, and auditing to identify, understand, and propose solutions to problems of computer security and security administration. (Cross-listed with CIST 4540, CYBR 4540, ISQA 8546)
Prerequisite(s)/Corequisite(s): IASC 4360 or permission of the instructor.

CYBR 8570 INFORMATION SECURITY POLICY AND ETHICS (3 credits)
The course will cover the development and need for information security policies, issues regarding privacy, and the application of computer ethics. (Cross-listed with ISQA 8570)
Prerequisite(s)/Corequisite(s): CIST 2100 or BSAD 8030, or permission of instructor.

CYBR 8900 INDEPENDENT STUDY IN INFORMATION ASSURANCE (1-3 credits)
The course provides a format for exploring advanced research areas for graduate students in Information Assurance and related fields. The class is designed for students that would like to explore specific Information Assurance topics at a greater depth, or topics that are not currently a part of the IA curriculum. The class is proposed and organized by the student, with participating faculty mentoring.
Prerequisite(s)/Corequisite(s): Instructor Permission

CYBR 8910 INTERNSHIP (1-3 credits)
The purpose of this course is to provide the students with an opportunity for practical application and further development of knowledge and skills acquired in the MS in CyberSecurity (CYBR) program. The internship gives students professional work experience and exposure to the challenges and opportunities faced by IT professionals in the workplace.
Prerequisite(s)/Corequisite(s): Students must have completed a minimum of 12 credit hours towards the MS in CYBR program. Instructor permission is required to register. Not open to non-degree graduate students.

CYBR 8950 GRADUATE CAPSTONE IN INFORMATION ASSURANCE (3 credits)
This is the graduate capstone course where students extend and apply their knowledge in defining, implementing, and assessing secure information systems. Students will demonstrate their ability to specify, apply, and assess different types of countermeasures at different points in the enterprise with a special focus on system boundaries. Students will complete and defend a Certification and Accreditation package. This course is intended for graduate students in the MS in IA degree program, coursework option, that are close to graduation (see prerequisites). This course replaces the MS in IA comprehensive examination requirement.
Prerequisite(s)/Corequisite(s): CYBR 8366, CYBR 8410, and CYBR 8456 and concentration area (systems or management and policy). Students must have 6 credit hours or less left in the program.
CYBR 8986 SPECIAL TOPICS IN INFORMATION ASSURANCE (1-3 credits)
The course provides a format for exploring advanced research areas for undergraduate students in Information Assurance and related fields. Specific topics vary, in keeping with research interests of faculty and students. Examples include applied data mining, mobile security, web services and applications, vulnerability assessments, cloud computing security, and other issues in Information Assurance research. (Cross-listed with CYBR 4980)
Prerequisite(s)/Corequisite(s): Instructor Permission.

CYBR 8990 THESIS IN INFORMATION ASSURANCE (1-6 credits)
A research project, designed and executed under the supervision of the chair and approval by members of the graduate student’s thesis advisory committee. In this project the student will develop and perfect a number of skills including the ability to design, conduct, analyze and report the results in writing (i.e., thesis) of an original, independent scientific investigation.
Prerequisite(s)/Corequisite(s): Instructor Permission.

CYBR 9460 SECURITY OF EMBEDDED SYSTEMS (3 credits)
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, which is specifically designed for a particular function. Industrial machines, automobile electronic systems, medical equipment, cameras, household appliances, airplanes, and vending machines, are among the myriad possible hosts of an embedded system. This course covers forward-looking topics in the security of embedded systems, including topics such as logic circuit obfuscation, hardware security methods, network setup exploits, and other ‘lower level’ computer architecture subjects with respect to cybersecurity.
Prerequisite(s)/Corequisite(s): CYBR 8366 - Foundations of Information Assurance