BACHELOR OF SCIENCE IN CYBERSECURITY

School of Theoretical and Applied Science

Program Summary

The Bureau of Labor Statistics highlights Cyber Security as an occupation growing "much faster than average", with a projected growth of 32% in 2023[1]. The average salary for Cybersecurity professionals is over $110,000/yr[2]. Cybersecurity professionals are skilled in computer networks and systems, computer programming, and information management. Most professionals in the field have a bachelor's degree in Computer Science or a related discipline, although due to the large employment gap, professional certifications are also common in the industry. Within the past five years, institutions have begun to offer concentrations in Cybersecurity - either as a concentration within Computer Science or Information Management Technology - **or** as a standalone degree which merges critical concepts from both disciplines.

The proposed major would be housed within the School of Theoretical and Applied Science, and contains core Computer Science coursework merged with cybersecurity-specific Mathematics, Computer Science, and Information Management coursework. Students will have deep Computer Science skills due to the foundational programming sequence, and develop their specialty in cybersecurity through advanced coursework covering both the technical aspects of the fields (networks, data, cyber-defence, threat assessment) and the broader intersections of the field with topics such as information management, ethics, and relevant policy and law.

The major is truly an interdisciplinary collaboration leveraging coursework already existing within TAS and ASB, with just one additional course being added within the CMPS course catalog. The major does not have an immediate staffing need, and any additional staffing needs will be driven by enrollment (not faculty speciality needs).

Curriculum and Assessment

Program Goals

1. Produce graduates with competency in programming at the level where security vulnerabilities are found.
2. Produce graduates with competency in computer architecture, networks and operating systems.
3. Produce graduates prepared to collaborate with organizations in implementing cybersecurity posture.

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[1] https://www.bls.gov/ooh/computer-and-information-technology/information-security-analysts.htm
[2] https://www.comparitech.com/blog/vpn-privacy/cybersecurity-employment-study/

4. Produce graduates who are able to contextualize cybersecurity challenges and solutions within ethical and legal parameters of the field.
5. Produce graduates with knowledge of how cryptography functions and how it relates to cybersecurity.
6. Produce graduates with experience assessing and implementing defenses to a broad set of cybersecurity threats.
7. Produce graduates who have had exposure to cybersecurity across a broad range of systems and application concepts.
8. Produce graduates who have had deep experience across an entire application or security project.

Student Learning Outcomes

1. **[PROGRAMMING]** Demonstrated programming competence in systems programming languages such as C or C++.
2. **[ARCH-OS-NET]** Demonstrate understanding of computer architecture, including data storage, TCP/IP networking, registry memory, runtime scheduling, resource management, and security protocols within the operating system.
3. **[INFO-MGMT]** Demonstrated knowledge of principles of information technology within an organization.
4. **[ETHICS-LAW]** Demonstrate a broad understanding of relevant literature on ethical and legal issues pertaining to computing technology and security.
5. **[CRYPTO]** Demonstrated understanding of cryptography in relation to computer and network / internet security.
6. **[CYBER-DEF]** Demonstrated experience in identifying and assessing vulnerability, threat intelligence, penetration testing, and defending against common attack vectors in cyberinfrastructure
7. **[APP-BREADTH]** Demonstrated ability to relate cybersecurity concepts to critical areas of software development, such as database systems, web application, and operating systems.
8. **[APP-DEPTH]** Demonstrated ability to apply cybersecurity concepts to real-world scenarios through experience developing large programming and systems projects.

Short names for objectives in [**BRACKET-BOLD**] will be used in the curriculum map below.

Degree Requirements

Coure Courses **48 Credits**	CMPS 147 COMP SCI 1
	CMPS 148 COMP SCI 2
	CMPS 231 DATA STRUCTURES
	CMPS 220 ASSEMBLY
	INFO 224 PRINCIPLES OF INFORMATION TECHNOLOGY
	DATA 225 ETHICS OF TECHNOLOGY

	OR INFO 315 COMPUTER LAW & ETHICS
	MATH 240 CRYPTOGRAPHY
	CMPS 327 NETWORK PROGRAMMING **OR** INFO 335 NETWORKS AND DISTRIBUTED PROCESSING
	CMPS 305 CYBER SECURITY
	CMPS 3XX CYBER AND NETWORK DEFENSE *NEW COURSE*
	CMPS 311 OPERATING SYSTEMS
	CMPS 450 SENIOR PROJECT
MATH Prerequisites **8 Credits**	MATH 121 CALCULUS
	MATH 237 DISCRETE STRUCTURES
Cyber Electives Pick 4 - **16 Credits** **AT LEAST ONE** elective must from INFO	INFO 316 INTRO TO DIGITAL FORENSICS
	INFO 342 SYSTEMS ANALYSIS & DESIGN
	INFO 441 IT MANAGEMENT
	CMPS 285 MOBILE DEVELOPMENT
	CMPS 315 THE UNIX ENVIRONMENT
	CMPS 364 DATABASE SYSTEMS **OR** INFO 333 DATABASE MANAGEMENT SYSTEMS
	CMPS 369 WEB APPLICATION DEVELOPMENT

4-year Course Plan

First Year			
Fall Semester	**Credits**	**Spring Semester**	**Credits**
CMPS 147 - Computer Science 1	4	CMPS 148 - Computer Science 2	4
Gen Ed: MATH 110-Precalculus	4	CMPS 220 - Assembly Language Programming	4
Gen Ed: INTD 101-First Year Seminar	4	MATH 121 -Calculus 1	4
Gen Ed: CRWT 102 - Critical Reading and Writing II	4	GenEd: AIID 201 - Studies in the Arts & Humanities	4
		TAS Pathways Module 1	
	16		16
Second Year			
Fall Semester	**Credits**	**Spring Semester**	**Credits**
CMPS 231 - Data Structures	4	CMPS 311-Operating Systems **WI**	4
MATH 237-Discrete Structures or MATH 205-Mathematical Structures **WI**	4	INFO 224 - Principles of Information Technology	4
Gen Ed: SOSC 110-Social Science Inquiry	4	Gen Ed Global Awareness	4
Gen Ed: Values & Ethics - **DATA 225 Ethics of Technology OR INFO 315 COMPUTER LAW & ETHICS**	4	Gen Ed Scientific Reasoning	4
TAS Pathways Module 2		TAS Pathways Module 3	

	16		16

Third Year

Fall Semester	Credits	Spring Semester	Credits
CMPS 305 - Cyber Security	4	CMPS 3XX - Cyber and Network Defense	4
CMPS 327 - Network Programming **OR** INFO 335 - Networks and Distributed Processing	4	CMPS/INFO/ELECTIVE 1 of 4	4
Gen Ed Culture & Creativity, Systems Sustainability & Society or Historical Perspectives	4	Gen Ed Culture & Creativity, Systems Sustainability & Society or Historical Perspectives	4
Open Elective	4	Open Elective	4
	16		16

Fourth Year

Fall Semester	Credits	Spring Semester	Credits
MATH 240 - Cryptography	4	CMPS/INFO/ELECTIVE 4 of 4	4
CMPS/INFO/ELECTIVE 2 of 4	4	CMPS 450: Senior Project **WI**	4
CMPS/INFO/ELECTIVE 3 of 4	4	Open Elective	4
Open Elective **OR** Gen Ed: Values & Ethics if DATA 225 not taken	4	Open Elective	4
	16		16

Total Credits Required: 128 Credits
GPA Required: 2.0
WI: Writing Intensive   3 Required in the Major

Direct and Indirect Measures

Direct Measure - Review of student work: For each outcome, specific coursework will be directly evaluated by faculty in the INFO, MATH, CMPS, or DATA disciplines. In the case of courses, a faculty member not teaching the course from which the assignment is drawn will be selected to perform the evaluation.

The following indirect methods will be used to assess student outcomes

- Student Exit Surveys
- Industry Partner Surveys

Assessment Process

Each of the student learning outcomes are addressed and can be assessed through required courses. **Direct measures** will include review of course assignments / exam question responses. **Indirect measures** will include exit surveys from students.

- **A** - signifies the most likely course where a given learning outcome will be assessed. The courses not only specifically address the learning outcome in their syllabus, they have specific assignments that lend themselves to **direct** assessment.
- **X** - signifies that the course outcomes listed in syllabi directly reference the Cybersecurity outcome. In some cases, these outcomes use different terms and language than as presented in this program's outcomes, however they are closely aligned. These cells will be used for assessment.
- **O** - signifies that while the course does not specifically list the program outcome in its own outcomes, the course does cover concepts related to the program outcome listed. These cells will not be used for assessment.

Course	PROGRAMMING	ARCH-OS-NET	INFO-MGMT	ETHICS-LAW	CRYPTO	CYBER-DEF	APP-BREADTH	APP-DEPTH
The following 4 courses make up the programming core of the Computer Science major. They are all requirements for 300-level CMPS courses.								
CMPS 147	X							
CMPS 148	A							
CMPS 231	X							
CMPS 220	X	X						
CMPS 311 requires Calculus (MATH 121) and Discrete Structures (MATH 237) and is for some CMPS 300-level courses								
CMPS 311		A			O	O	A	
MATH 121		PRE-REQ						
MATH 237		PRE-REQ						
The following 6 courses are required for the Cybersecurity major and have outcomes directly tied to the major's program outcomes.								
INFO 224			A	O				
DATA 225			X	X		O		
INFO 315			X	X			X	
MATH 240					A		O	
CMPS 305				A	O	A		
CMPS 327[3]			A		O	O	X	
INFO 335			A		O	O	X	
CMPS 3XX Cyber & Network Defense				X	O	A		
The Computer Science capstone course will be modified to accommodate Cybersecurity majors. Their project have the same goals (depth and general application of curriculum), however student projects will have a cybersecurity focus.								
CMPS 450	X							A
The following are electives for the Cybersecurity major and address various program outcomes.								
INFO 316			X	X			X	

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[3] CMPS 327 requires completion of CMPS 311 Operating Systems

CMPS 285							X	
CMPS 315		X				O	X	
CMPS 364					O	O	A	
INFO 333		X			O	O	A	
CMPS 369					O		A	
INFO 342			O				O	
INFO 441			O				O	

Alignment with College Mission and Strategic Plan

The program also aligns with the College's Mission

1. **Interdisciplinary** - The program is interdisciplinary by design, requiring coursework from Computer Science, Data Science (TAS), and Information Management (ASB).

2. **Experiential** - All Cyber Security students are required to complete a capstone project, which is a hands-on experience involving large scale project development (CMPS 450).

The BS in Cybersecurity is well aligned with the College's Strategic plan - in particular goals three and four: (3) Advance Innovation as the College's Promise and Obligation to its Students, Community, and the State of New Jersey, **and**, (4) Improving Long-term Financial Strength. We can further link the major to specific objectives outlined in the Strategic Plan:

Objective 1.3: To increase the number of students transferring from partner institutions: Cybersecurity is a dramatically growing field, and community colleges are rapidly adopting cybersecurity curriculums at the associate level.

For example:

Bergen County Community College
https://bergen.edu/ce/courses-programs/business-and-technology/cybersecurity-bootcamp/

Passaic County Community College
https://catalog.pccc.edu/program/104/

Morris County Community College
https://www.ccm.edu/academics/divdep/bmet/department-of-information-technologies/ccm-center-for-cyber-security/

Ramapo's Cybersecurity major will offer an attractive opportunity for transfer students and articulation agreements with community colleges in the region.

Objective 1.8: To facilitate student success, in terms of completion and employment, via experiential learning: As described above, the cybersecurity field has a well recognized employment gap, with many more job opportunities than qualified candidates. Ramapo's Cybersecurity major will produce graduates which meet and exceed the qualifications for these high quality jobs.

Objective 3.1: To facilitate curricular innovation and to ensure that curriculum remains founded in the liberal arts, relevant, attuned to students' needs, and responsive to the economic environment: A Cybersecurity major is responsive to regional economic environmental initiatives. The proposed major also integrates required and elective coursework

centered around ethics and law in technology. Ramapo's Cybersecurity major will produce students with unique skill sets - due to our liberal arts requirements, and these skill sets will improve our students' viability in the market.

Objective 4.4: To publicly position the College through advocacy, marketing and public relations as the premier public college in the region: The combination of a B.S. Cybersecurity, along with our BS and MS in Data Science, Computer Science, and Applied Mathematics continues to build up on the Center for Data, Mathematical and Computational Science strength and focus. This cluster of degree programs in technology fields, with an established focus on differentiating the Ramapo College's brand of liberal arts focused technical majors will continue to increase the College's footprint in these areas.

4. Impact on other Programs

The major draws on coursework from Computer Science, Mathematics, Information Management Technology, and Data Science. The largest impact is on the computer science major, with 9 required courses in the cybersecurity major that are within computer science. We anticipate modest strain (1-2 section increase per AY) on computer science staffing given a cohort size of 15-20 additional cybersecurity students. The majority of the impact will be at lower levels (CMPS 147, 148, 231), and in the most recent academic years these courses have had enough available seats to absorb most of this increase without additional sections.

Calculus (MATH 121) and Discrete Structures (MATH 237) are offered regularly and already service several majors. The impact on Mathematics will be seen primarily for MATH 240 Cryptography. This course will need to be offered on a regular basis - which until relatively recently it has not.

INFO 224, INFO 315, INFO 316, INFO 333, INFO 335, INFO 342, and INFO 441 have been included in this proposal with the support of the Information Management convening group. INFO 224 runs regularly, and is the only required course in the major out of the Information Management group.

DATA 225 Ethics of Technology will likely see increased section needs in the future since it has been added to the General Education program. The Data Science convening group has made arrangements to begin to offer this course each semester, which will be adequate to support Cybersecurity majors in the future.

Attached as supporting material are email correspondence indicating convening group support from all of the above.

5. Other Programs in the Region

Most programs for Cybersecurity are tracks and concentrations within either (or both) the Computer Science or Information Technology / Management majors. Stevens Institute of Technology has a standalone major similar to our proposal. While this program could have also been constructed as a track within our own Computer Science major, building a standalone major allows us to create room for interdisciplinary coursework, and secondarily create a more visible program.

Institution	Degree Program
Kean University	Cybersecurity Track within Computer Science Major
	Cybersecurity Track within IT Major
	Cybersecurity Trach within MS in Computer Science
Montclair State University	MS in Cybersecurity (4+1 with Computer Science and 4+1 with Information Technology)
New Jersey Institute of Technology	Certificate in Foundations of Cybersecurity & Privacy
	MS in Cybersecurity and Privacy
Rowan University	Coursework within Computer Science major
	MS in Cybersecurity
Rutgers University	Cybersecurity Track within Computer Science Major
	Cybersecurity Concentration within IT Major
	Cybersecurity Graduate Certificate
	MBS in Cybersecurity
Saint Peter's University	Cybersecurity Track within Computer Science major
	Master of Science in Cybersecurity
Stevens Institute of Technology	BS in Cybersecurity
	MS in Cybersecurity
William Patterson	Certificate in Cybersecurity

6. Student and Labor Market Demand

Dice.com reports that for every 100 cybersecurity positions open, there are 69 available professionals to fill the positions[4]. The Bureau of Labor Statistics highlights Cyber Security as an occupations grouping "much faster than average", with a projected growth of 32% in 2023[5]. The average salary for Cybersecurity professionals is over $110,000/yr[6]. There is considerable demand among our students and prospective students for a program in cybersecurity - it is one of the most common requests the computer science convening group hears at open houses and recruitment events. This interest comes from a much more recognized need for cybersecurity in our society - with cybersecurity becoming a priority at both the corporations we work within and in our personal lives. October has even been designated Cybersecurity Awareness Month by National Cybersecurity and Infrastructure Security Agency (CISA)[7].

We also recognize that the technology field changes rapidly. Our students are best served when they acquire broad knowledge, applicable not just to a current trend, but to all of the critical skills required of the larger field. In many ways, the Cybersecurity major is a very specific *track* in Computer Science - our students will have computer science skills very close to the level of our Computer Science majors. The Cybersecurity major sacrifices coursework across broader Computer Science sub-disciplines - software development, computer graphics, artificial intelligence, robotics - in order to make room for cybersecurity-specific coursework, **however** our students will have the types of Computer Science skills that will allow them to navigate a career that may change in the future. We believe this is a critical differentiator between our program and majors that do not emphasize programming coursework - and prepares our students not just for entry level positions in cybersecurity, but **successful and long careers** in the field.

Enrollment Projection

Class	2024	2025	2026	2027	2028
Freshman	10	15	25	25	25
Sophomore	0	10	15	25	25
Junior	0	0	10	15	25
Senior	0	0	0	10	25
Total	**10**	**25**	**50**	**75**	**100**

[4] https://www.dice.com/career-advice/cybersecurity-job-gap-remains-huge
[5] https://www.bls.gov/ooh/computer-and-information-technology/information-security-analysts.htm
[6] https://www.comparitech.com/blog/vpn-privacy/cybersecurity-employment-study/
[7] https://www.cisa.gov/cybersecurity-awareness-month

Undergraduate Enrollment					

Space, Personel, and Faculty Line Requirements

- No new faculty lines or classroom space is needed for this major. We anticipate a need in the future (3-5 years) for additional faculty based on projected growth in Computer Science **and** Cybersecurity, but this will not be needed unless those enrollment growth projections are realized.
- The DMC Center has space and resources to service the students in the new major.