Computer Science Course Descriptions (COMP)

- Prerequisite Chart

CMPSC 101 — INTRODUCTION TO C++ PROGRAMMING (3)
Properties of algorithms, languages, and notations for describing algorithms, applications of a procedure-oriented language to problem solving. A student may receive credit for only one of the following courses: CMPSC 101, 200, 201, 202, 121.

CMPSC 121 — INTRODUCTION TO PROGRAMMING TECHNIQUES (3)
Design and implementation of algorithms. Structured programming. Problem solving techniques. Introduction to a high-level language, including arrays, procedures, and recursion.
Prerequisite: MATH 110 as prerequisite or MATH 140 as concurrent.

CMPSC 122 — INTERMEDIATE PROGRAMMING (3)
Object-oriented programming, recursion, fundamental data structures (including stacks, queues, linked lists, hash tables, trees, and graphs), the basics of algorithmic analysis, and an introduction to the principles of language translation.
Prerequisite: CMPSC 121.

CMPSC 131 — PROGRAMMING AND COMPUTATION I: FUNDAMENTALS (3)
This course introduces the fundamental concepts and processes of solving computational problems through the design, implementation, testing and evaluation of efficient and robust computer programs. The concepts include basic computational constructs found in imperative, object-oriented and functional programming languages such as iteration, conditionals, functions, recursion, and datatypes.
Prerequisite: MATH 110 as prerequisite or MATH 140 as concurrent.

CMPSC 132 — PROGRAMMING AND CCOMPUTATION II: Data Structures (3)
This course builds upon the foundations of programming and computation by introducing and studying the data structures and programming language features that support the design and construction of large-scale software systems. It introduces the foundations of object-oriented programming, the design and analysis of efficient algorithms using important data structures, and programming techniques that support reusable and modular program components, including data abstraction, polymorphism, and higher-order functions.
Prerequisite: CMPSC 121 or CMPSC 131.

CMPSC 221 — OBJECT ORIENTED PROGRAMMING WITH WEB-BASED APPLICATIONS (3)
This course will continue with object-oriented programming and will introduce graphics, virtual machines, programming language concepts and web-based programming using Java.
Prerequisite: CMPSC 132 or equivalent.

CMPSC 312 — COMPUTER ORGANIZATION AND ARCHITECTURE (3)
Data representation, digital logic, instruction set/control logic, machine/assembly languages, advanced architectures, memory hierarchy, I/O devices, overall system design.
Prerequisite: CMPSC 131 or equivalent.

CMPSC 313 — ASSEMBLY LANGUAGE PROGRAMMING (3)

Program design, addressing modes, subroutines, parameter passing, stacks, bit manipulation, text processing, DOS functions, macros, I/O, high level language interfaces.
Prerequisite: CMPSC 312

CMPSC 330: Advanced Programming in C++ (3)

In-depth study of various programming paradigm including procedural, object oriented, and generic programming in C++ programming language. The primary goals of this course are (1) to provide students with an in-depth knowledge of different programming paradigms, (2) to provide students with the ability to design and develop software using the paradigm that is appropriate to a given problem, and (3) to provide students with the programming concepts that are applicable to programming in other languages. The secondary goal of this course is to expose students to a diverse range of programming tasks using C++ programming language that is frequently used in the follow up courses as well as in industry.
Prerequisite: C or better in CMPSC 132

CMPSC 360 — DISCRETE MATHEMATICS FOR COMPUTER SCIENCE (3)

Discrete mathematics and foundations for modern computer science. Topics include sets, relations, logic, algorithms, graphs, finite state machines and regular expressions.
Prerequisite: CMPSC 132

CMPSC 412 — DATA STRUCTURES LAB (1.5)

Programming with common data structures; recursion; stacks, queues, dictionaries, priority queues; string searching and manipulation; sorting; trees; combinatorics.
Concurrent: CMPSC 462 or CMPSC 465

CMPSC 413 — ALGORITHMS LAB (1.5)

Programming with common algorithm design techniques; divide and conquer, greedy method, dynamic programming, and tree and graphy traversals.
Concurrent: CMPSC 463 or CMPSC 465

CMPSC 414 — CONTEST PROGRAMMING (1)

Programming Contest Questions; Common Data Structures; Strings; Sorting; Searching; Combinatorics; Number Theory; Graph Algorithms; Dynamic Programming.
Concurrent: CMPSC 221 or CMPSC 330

CMPSC 421 — NET-CENTRIC COMPUTING (3)

This course introduces JavaScript and AJAX for creating Rich Internet Applications, and XML for client-server communication and Web Services.
Prerequisite: CMPSC 221 or SWENG 311

CMPSC 430 — DATABASE DESIGN (3)

Relational database model, query languages, integrity, reliability, normal forms for design.
Concurrent: CMPSC 462

CMPSC 436 — COMMUNICATIONS AND NETWORKING (3)

Data transmission, basic signaling, data encoding, error control, communication protocols, security, network topologies, routing, switching, internetworking, emerging high speed networks.
Prerequisite: CMPSC 312

CMPSC 438 — COMPUTER NETWORK ARCHITECTURE AND PROGRAMMING (3)

Network architectures, communication protocols, internetworking, network security, client-server computing, web application development,

programming with APIs.
Prerequisite: CMPSC 312, CMPSC 221; CMPSC 330

CMPSC 441 — ARTIFICIAL INTELLIGENCE (3)
Problem solving, search techniques including local search and genetic algorithms, knowledge representation, planning, learning, and neural networks.
Prerequisite: CMPSC 462

CMPSC 444 — SECURE PROGRAMMING (3)
Secure software design principles/practice, common threats, applied cryptography, trust management, input validation, OS-/programming language- specific issues, software validation.
Prerequisite: CMPSC 221 or CMPSC 330

CMPSC 445 — APPLIED MACHINE LEARNING IN DATA SCIENCE (3)
Applied machine learning techniques are used in many different areas, such as the classification, visualization and analysis of data, clustering, and understanding of natural languages for human-computer interactions. This course will start with an overview of supervised and unsupervised learning, and introduce the associated libraries. It covers basic machine learning concepts, tasks, and workflow using an example classification problem based on K-nearest neighbors, Naïve Bayes, Support Vector Machine (SVM), K-means, and implementation using Python libraries. Natural language processing (NLP) techniques including n-gram models, grammar, parse trees, and part-of-speech tagging will be discussed.
Prerequisite: STAT 318, MATH 220, CMPSC 132

CMPSC 446 — DATA MINING (3)
Data Mining is the process of discovering patterns, correlations, and trends, in large data sets. This course is designed to provide an overview of the data mining process, with an emphasis on data management, pattern discovery, and cluster analysis.
Prerequisite: STAT 318, MATH 220, DS 220

CMPSC 455 — INTRODUCTION TO NUMERICAL ANALYSIS I (3)
Floating point computation, numerical rootfinding, interpolation, numerical quadrature, direct methods for linear systems. Students may take only one course for credit from CMPSC (MATH) 451 and CMPSC (MATH) 455.
Prerequisite: MATH 220, MATH 230 or MATH 231, 3 credits of programming

CMPSC 457 — COMPUTER GRAPHICS ALGORITHMS (3)
Graphics systems/hardware, color models, transformations, projections, clipping, hidden line/surface removal, aliasing, parametric curves/surfaces, 3D modeling, animation.
Prerequisite: CMPSC 330, MATH 220

CMPSC 460 — PRINCIPLES OF PROGRAMMING LANGUAGES (3)
Design and implementation of high level programming languages and survey of language paradigms including imperative, functional, and object-oriented programming.
Prerequisites: CMPSC 312, CMPSC 462
Concurrent: CMPSC 469

CMPSC 462 — DATA STRUCTURES (3)
In-depth theoretical study of data structures such as balanced trees, hash tables, priority queues, B-trees, binomial heaps, and Fibonacci heaps.
Prerequisites: C or better in MATH 141 and C or better in CMPSC 132 and C or better in CMPSC 360 and CMPSC 330

CMPSC 463 — DESIGN AND ANALYSIS OF ALGORITHMS (3)
Recurrences, algorithms design techniques, searching, sorting, selection, graph algorithms, NP-completeness, approximation algorithms, local

optimization algorithms.
Prerequisites: CMPSC 462,
Concurrent: STAT 301 or MATH 318 or STAT 318

CMPSC 469 — FORMAL LANGUAGES WITH APPLICATIONS (3)

Regular, context free, recursive, and recursively enumerable languages; associated machine models; applications.
Prerequisite: CMPSC 360

CMPSC 470 — COMPILER CONSTRUCTION (3)

Compiler design and implementation; scanning, parsing, semantic analysis, optimization (including static analysis), code generation, garbage collection, and error detection.
Prerequisite: CMPSC 312, CMPSC 330, CMPSC 462, CMPSC 469

CMPSC 472 — OPERATING SYSTEM CONCEPTS (3)

Theoretical and practical issues of operating systems design and implementation, process management, concurrent programming, memory management, scheduling, I/O, and security.
Prerequisites: CMPSC 312, CMPSC 462, CMPSC 469, C or better in CMPSC 330,

CMPSC 475 — MOBILE APPLICATIONS PROGRAMMING (3)

Development of software for devices including smart phones, tablets, handheld units, and other general purpose computing platforms.
Prerequisites: CMPSC 221, CMPSC 312, CMPSC 462

CMPSC 487W — SOFTWARE ENGINEERING AND DESIGN (3)

Software development process, life cycle; requirements analysis, specification, design, prototyping, testing, project management, and documentation.
Prerequisite: ENGL 202C, CMPSC 330

CMPSC 488 — COMPUTER SCIENCE PROJECT (3)

Project design and implementation with an emphasis on team work, documentation, and the employment and integration of computer science concepts.
Prerequisite: CMPSC 487W

CMPSC 495 — INTERNSHIP (1-18)

Supervised off-campus, nongroup instruction including field experiences, practica, or internships. Written and oral critique of activity required.
Prerequisite: Prior approval of proposed assignment by instructor

CMPSC 496 — INDEPENDENT STUDIES (1-18)

Creative projects, including research and design, which are supervised on an individual basis and which fall outside the scope of formal courses.

CMPSC 497 — SPECIAL TOPICS (1-9)

Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.

Typically offered special topic courses include:

- Natural Language Processing
- Computer Forensics
- Data Mining

COMPUTER SCIENCE, B.S. (CAPITAL)

Begin Campus: Any Penn State Campus

End Campus: Harrisburg

Degree Requirements

For the Bachelor of Science degree in Computer Science, a minimum of 120 credits is required:

Requirement	Credits
General Education	45
Requirements for the Major	88

13 of the 45 credits for General Education are included in Requirements for the Major. This includes: 3 credits of GWS courses, 6 credits of GQ courses, and 4 credits of GN courses.

First-Year Seminar: Incoming first-year students are required to complete a course with the suffix S, T, or X, or the PSU abbreviation.

Requirements for the Major

To graduate, a student enrolled in the major must earn a grade of C or better in each course designated by the major as a C-required course, as specified by Senate Policy 82-44 (https://senate.psu.edu/policies-and-rules-for-undergraduate-students/82-00-and-83-00-degree-requirements/#82-44).

Common Requirements for the Major (All Options)

Code	Title	Credits
Prescribed Courses		
CMPSC 312	Computer Organization and Architecture [1]	3
CMPSC 430	Database Design [1]	3
CMPSC 460	Principles of Programming Languages [1]	3
CMPSC 462	Data Structures [1]	3
CMPSC 463	Design and Analysis of Algorithms [1]	3
CMPSC 469	Formal Languages with Applications [1]	3
CMPSC 472	Operating System Concepts [1]	3
CMPSC 487W	Software Engineering and Design [1]	3
CMPSC 488	Computer Science Project [1]	3
MATH 220	Matrices	2
PHYS 211	General Physics: Mechanics	4
Prescribed Courses: Require a grade of C or better		
CMPSC 330	Advanced Programming in C++	3
CMPSC 360	Discrete Mathematics for Computer Science [1]	3
ENGL 202C	Effective Writing: Technical Writing	3
MATH 140	Calculus With Analytic Geometry I	4
MATH 141	Calculus with Analytic Geometry II	4
Additional Courses		
STAT/MATH 318	Elementary Probability	3
or STAT/MATH 414	Introduction to Probability Theory	
Requirements for the Option		
Select an option		35

[1] Students must earn a 2.5 or higher grade point average in the following courses:
- For the General Option: CMPSC 221, CMPSC 312, CMPSC 360, CMPSC 430, CMPSC 460, CMPSC 462, CMPSC 463, CMPSC 469, CMPSC 470, CMPSC 472, CMPSC 487W, and CMPSC 488
- For the Data Science Option: DS 220, CMPSC 312, CMPSC 360, CMPSC 430, CMPSC 445, CMPSC 446, CMPSC 460, CMPSC 462, CMPSC 463, CMPSC 469, CMPSC 472, CMPSC 487W, and CMPSC 488

Requirements for the Option
Data Science Option (35 credits)
Available at the following campuses: Abington, Harrisburg

Code	Title	Credits
Prescribed Courses		
CMPSC 441	Artificial Intelligence	3
CMPSC 445	Applied Machine Learning in Data Science [1]	3
CMPSC 446	Data Mining [1]	3
DS 220	Data Management for Data Sciences [1]	3
STAT 401	Experimental Methods	3
STAT 462	Applied Regression Analysis	3
Prescribed Courses: Require a grade of C or better		
CMPSC 131	Programming and Computation I: Fundamentals	3
CMPSC 132	Programming and Computation II: Data Structures	3
Additional Courses		
Select at least 6 credits from the following:		6
CMPSC 313	Assembly Language Programming	
CMPSC 412	Data Structures Lab	
CMPSC 413	Algorithms Lab	
CMPSC 414	Contest Programming	
CMPSC 421	Net-centric Computing	
CMPSC 438	Computer Network Architecture and Programming	
CMPSC 444	Secure Programming	
CMPSC/MATH 455	Introduction to Numerical Analysis I	
CMPSC 457	Computer Graphics Algorithms	
CMPSC 470	Compiler Construction	
CMPSC 475	Applications Programming	
CMPSC 496	Independent Studies	
CMPSC 497	Special Topics	
MATH 401	Introduction to Analysis I	
MATH 410	Complex Analysis for Mathematics and Engineering	
MATH 411	Ordinary Differential Equations	
MATH 412	Fourier Series and Partial Differential Equations	
MATH 425	Introduction to Operations Research	
MATH 430	Linear Algebra and Discrete Models I	
MATH 435	Basic Abstract Algebra	
MATH 448	Mathematics of Finance	
MATH 465	Number Theory	
MATH 468	Mathematical Coding Theory	
MATH 485	Graph Theory	

Code	Title	Credits
MATH 496	Independent Studies	
MATH 497	Special Topics	
STAT/MATH 415	Introduction to Mathematical Statistics	
STAT 463	Applied Time Series Analysis	

Supporting Courses and Related Areas

Select 5 credits of unrestricted electives at 100-400 level		5

[1] Students must earn a 2.5 or higher grade point average in the following courses:
- For the General Option: CMPSC 221, CMPSC 312, CMPSC 360, CMPSC 430, CMPSC 460, CMPSC 462, CMPSC 463, CMPSC 469, CMPSC 470, CMPSC 472, CMPSC 487W, and CMPSC 488
- For the Data Science Option: DS 220, CMPSC 312, CMPSC 360, CMPSC 430, CMPSC 445, CMPSC 446, CMPSC 460, CMPSC 462, CMPSC 463, CMPSC 469, CMPSC 472, CMPSC 487W, and CMPSC 488

General Option (35 credits)
Available at the following campuses: Abington, Harrisburg

Code	Title	Credits
Prescribed Courses		
CMPSC 221	Object Oriented Programming with Web-Based Applications [1]	3
CMPSC 470	Compiler Construction [1]	3
Additional Courses		
Select 9 credits from the following:		9
CMPSC 313	Assembly Language Programming	
CMPSC 412	Data Structures Lab	
CMPSC 413	Algorithms Lab	
CMPSC 414	Contest Programming	
CMPSC 421	Net-centric Computing	
CMPSC 438	Computer Network Architecture and Programming	
CMPSC 441	Artificial Intelligence	
CMPSC 444	Secure Programming	
CMPSC 445	Applied Machine Learning in Data Science	
CMPSC 446	Data Mining	
CMPSC/MATH 455	Introduction to Numerical Analysis I	
CMPSC 457	Computer Graphics Algorithms	
CMPSC 475	Applications Programming	
CMPSC 496	Independent Studies	
CMPSC 497	Special Topics	
MATH 425	Introduction to Operations Research	
MATH 485	Graph Theory	
Select 6 credits from the following:		6
CMPSC 313	Assembly Language Programming	
CMPSC 412	Data Structures Lab	
CMPSC 413	Algorithms Lab	
CMPSC 414	Contest Programming	
CMPSC 421	Net-centric Computing	
CMPSC 438	Computer Network Architecture and Programming	
CMPSC 441	Artificial Intelligence	

Code	Title	Credits
CMPSC 444	Secure Programming	
CMPSC 445	Applied Machine Learning in Data Science	
CMPSC 446	Data Mining	
CMPSC/MATH 455	Introduction to Numerical Analysis I	
CMPSC 457	Computer Graphics Algorithms	
CMPSC 475	Applications Programming	
CMPSC 496	Independent Studies	
CMPSC 497	Special Topics	
MATH 401	Introduction to Analysis I	
MATH 410	Complex Analysis for Mathematics and Engineering	
MATH 411	Ordinary Differential Equations	
MATH 412	Fourier Series and Partial Differential Equations	
MATH 425	Introduction to Operations Research	
MATH 430	Linear Algebra and Discrete Models I	
MATH 435	Basic Abstract Algebra	
MATH 448	Mathematics of Finance	
MATH 465	Number Theory	
MATH 468	Mathematical Coding Theory	
MATH 485	Graph Theory	
MATH 496	Independent Studies	
MATH 497	Special Topics	
STAT 401	Experimental Methods	
STAT/MATH 415	Introduction to Mathematical Statistics	
STAT 462	Applied Regression Analysis	
STAT 463	Applied Time Series Analysis	
Additional Courses: Require a grade of C or better		
CMPSC 121	Introduction to Programming Techniques	3
or CMPSC 131	Programming and Computation I: Fundamentals	
CMPSC 122	Intermediate Programming	3
or CMPSC 132	Programming and Computation II: Data Structures	
Supporting Courses and Related Areas		
Select 3 credits of unrestricted electives at 300-400 level		3
Select 5 credits of unrestricted electives at 100-400 level		5

[1] Students must earn a 2.5 or higher grade point average in the following courses:
- For the General Option: CMPSC 221, CMPSC 312, CMPSC 360, CMPSC 430, CMPSC 460, CMPSC 462, CMPSC 463, CMPSC 469, CMPSC 470, CMPSC 472, CMPSC 487W, and CMPSC 488
- For the Data Science Option: DS 220, CMPSC 312, CMPSC 360, CMPSC 430, CMPSC 445, CMPSC 446, CMPSC 460, CMPSC 462, CMPSC 463, CMPSC 469, CMPSC 472, CMPSC 487W, and CMPSC 488

General Education

Connecting career and curiosity, the General Education curriculum provides the opportunity for students to acquire transferable skills necessary to be successful in the future and to thrive while living in interconnected contexts. General Education aids students in developing intellectual curiosity, a strengthened ability to think, and a deeper sense of aesthetic appreciation. These are requirements for all baccalaureate

students and are often partially incorporated into the requirements of a program. For additional information, see the General Education Requirements (https://bulletins.psu.edu/undergraduate/general-education/baccalaureate-degree-general-education-program/) section of the Bulletin and consult your academic adviser.

The keystone symbol appears next to the title of any course that is designated as a General Education course. Program requirements may also satisfy General Education requirements and vary for each program.

Foundations (grade of C or better is required and Inter-Domain courses do not meet this requirement.)
- **Quantification (GQ):** 6 credits
- **Writing and Speaking (GWS):** 9 credits

Breadth in the Knowledge Domains (Inter-Domain courses do not meet this requirement.)
- **Arts (GA):** 3 credits
- **Health and Wellness (GHW):** 3 credits
- **Humanities (GH):** 3 credits
- **Social and Behavioral Sciences (GS):** 3 credits
- **Natural Sciences (GN):** 3 credits

Integrative Studies
- **Inter-Domain Courses (Inter-Domain):** 6 credits

Exploration
- **GN,** may be completed with Inter-Domain courses: 3 credits
- **GA, GH, GN, GS, Inter-Domain courses.** This may include 3 credits of World Language course work beyond the 12th credit level or the requirements for the student's degree program, whichever is higher: 6 credits

University Degree Requirements
First Year Engagement
All students enrolled in a college or the Division of Undergraduate Studies at University Park, and the World Campus are required to take 1 to 3 credits of the First-Year Seminar, as specified by their college First-Year Engagement Plan.

Other Penn State colleges and campuses may require the First-Year Seminar; colleges and campuses that do not require a First-Year Seminar provide students with a first-year engagement experience.

First-year baccalaureate students entering Penn State should consult their academic adviser for these requirements.

Cultures Requirement
6 credits are required and may satisfy other requirements

- United States Cultures: 3 credits
- International Cultures: 3 credits

Writing Across the Curriculum
3 credits required from the college of graduation and likely prescribed as part of major requirements.

Total Minimum Credits
A minimum of 120 degree credits must be earned for a baccalaureate degree. The requirements for some programs may exceed 120 credits. Students should consult with their college or department adviser for information on specific credit requirements.

Quality of Work
Candidates must complete the degree requirements for their major and earn at least a 2.00 grade-point average for all courses completed within their degree program.

Limitations on Source and Time for Credit Acquisition
The college dean or campus chancellor and program faculty may require up to 24 credits of course work in the major to be taken at the location or in the college or program where the degree is earned. Credit used toward degree programs may need to be earned from a particular source or within time constraints (see Senate Policy 83-80 (https://senate.psu.edu/policies-and-rules-for-undergraduate-students/82-00-and-83-00-degree-requirements/#83-80)). For more information, check the Suggested Academic Plan for your intended program.

COMPUTER SCIENCE, B.S. (CAPITAL)

Begin Campus: Any Penn State Campus

End Campus: Harrisburg

Suggested Academic Plan

The suggested academic plan(s) listed on this page are the plan(s) that are in effect during the 2023-24 academic year. To access previous years' suggested academic plans, please visit the archive (https://bulletins.psu.edu/undergraduate/archive/) to view the appropriate Undergraduate Bulletin edition (*Note: the archive only contains suggested academic plans beginning with the 2018-19 edition of the Undergraduate Bulletin*).

General Option: Computer Science, B.S. at Harrisburg Campus

The course series listed below provides **only one** of the many possible ways to move through this curriculum. The University may make changes in policies, procedures, educational offerings, and requirements at any time. This plan should be used in conjunction with your degree audit (accessible in LionPATH as either an **Academic Requirements** or **What If** report). Please consult with a Penn State academic adviser on a regular basis to develop and refine an academic plan that is appropriate for you.

First Year

Fall	Credits	Spring	Credits
CMPSC 121 or 131*#	3	CMPSC 122 or 132*#	3
MATH 140*#†	4	MATH 141*#†	4
ENGL 15, 15S, 30T, or ESL 15‡	3	PHYS 211†	4
General Education Course	3	CAS 100A or 100S‡	3
General Education Course (GHW)	1.5	General Education Course	3
	14.5		**17**

Second Year

Fall	Credits	Spring	Credits
CMPSC 221	3	CMPSC 330*	3
MATH 220	2	CMPSC 360*	3
General Education Course (PHYS 212 recommended)	3-4	ENGL 202C‡	3
General Education Course	3	General Education Course	2-3
General Education Course	3	General Education Course	3
		General Education Course (GHW)	1.5
	14-15		**15.5-16.5**

Third Year

Fall	Credits	Spring	Credits
CMPSC 312	3	CMPSC 430	3
MATH/STAT 318 or STAT 414	3	CMPSC 462	3
General Education Course	3	CMPSC 469	3
CMPSC/MATH/STAT elective chosen from department list[1]	3	CMPSC/MATH/STAT elective chosen from department list[1]	3
100-400 level elective	3	300-400 level elective	3
	15		**15**

Fourth Year

Fall	Credits	Spring	Credits
CMPSC 463	3	CMPSC 460	3
CMPSC 472	3	CMPSC 470	3
CMPSC 487W	3	CMPSC 488	3
CMPSC/MATH/STAT electives chosen from department list[1]	6	CMPSC/MATH/STAT elective chosen from department list[1]	3
		Open Electives 100-400 level	0-2
	15		**12-14**

Total Credits 118-122

* Course requires a grade of C or better for the major

‡ Course requires a grade of C or better for General Education

Course is an Entrance to Major requirement

† Course satisfies General Education and degree requirement

[1] 9 credits should be in CMPSC.

[2] Students must earn a 2.5 or higher grade point average in the following courses: CMPSC 221, 312, 330, 360, 430, 460, 462, 463, 469, 470, 472, 487W, and 488.

[3] Students in the Computer Science (COMP_BS) major are required to complete 21 of the 27 credits of 400-level prescribed courses for the major, including the senior capstone course, at Penn State Harrisburg. This is in compliance with Faculty Senate Policy 83-80.5.

[4] CMPSC/MATH/STAT electives should be chosen from the following lists:
  - CMPSC 313, 412, 413, 438, 441, 444, 445, 446 455, 457, 475, 496, 497
  - MATH 401, 411, 412, 425, 430, 431, 435, 445, 449, 450, 455, 465, 468, 496, 497
  - STAT 401, 415, 462, 463

University Requirements and General Education Notes:

US and IL are abbreviations used to designate courses that satisfy Cultural Diversity Requirements (United States and International Cultures).

W, M, X, and Y are the suffixes at the end of a course number used to designate courses that satisfy University Writing Across the Curriculum requirement.

General Education includes Foundations (GWS and GQ), Knowledge Domains (GHW, GN, GA, GH, GS) and Integrative Studies (Inter-domain) requirements. N or Q (Honors) is the suffix at the end of a course number used to help identify an Inter-domain course, but the inter-domain attribute is used to fill audit requirements. Foundations courses (GWS and GQ) require a grade of 'C' or better.

Data science Option: Computer Science, B.S. at Harrisburg Campus

The course series listed below provides **only one** of the many possible ways to move through this curriculum. The University may make changes in policies, procedures, educational offerings, and requirements at any time. This plan should be used in conjunction with your degree audit (accessible in LionPATH as either an **Academic Requirements** or **What If** report). Please consult with a Penn State academic adviser on a regular basis to develop and refine an academic plan that is appropriate for you.

First Year

Fall	Credits	Spring	Credits
CMPSC 131*#	3	CMPSC 132*#	3
MATH 140*#†	4	MATH 141*#†	4
ENGL 15, 15S, 30T, or ESL 15‡	3	PHYS 211†	4
General Education Course	3	CAS 100A or 100S‡	3
General Education Course (GHW)	1.5	General Education Course	3
	14.5		**17**

Second Year

Fall	Credits	Spring	Credits
CMPSC 221	3	CMPSC 360*	3
MATH 220	2	STAT 401	3
General Education Course (PHYS 212 recommended)	3-4	ENGL 202C‡	3
General Education Course	3	General Education Course	3
General Education Course	3	General Education Course	2-3
		General Education Course (GHW)	1.5
	14-15		**15.5-16.5**

Third Year

Fall	Credits	Spring	Credits
CMPSC 312	3	CMPSC 430	3
CMPSC 330*	3	CMPSC 445	3
CMPSC 441	3	CMPSC 462	3
MATH/STAT 318 or STAT 414	3	CMPSC 469	3
General Education Course	3	100-400 level elective	3
	15		**15**

Fourth Year

Fall	Credits	Spring	Credits
CMPSC 463	3	CMPSC 446	3
CMPSC 472	3	CMPSC 460	3
CMPSC 487W	3	CMPSC 488	3
STAT 462	3	CMPSC/MATH/STAT elective chosen from department list	3
CMPSC/MATH/STAT elective chosen from department list	3	Open Electives 100-400 level	0-2
	15		**12-14**

Total Credits 118-122

* Course requires a grade of C or better for the major

‡ Course requires a grade of C or better for General Education
\# Course is an Entrance to Major requirement
† Course satisfies General Education and degree requirement

1. Students must earn a 2.5 or higher grade point average in the following courses: DS 220, CMPSC 312, 330, 360, 430, 441, 460, 445, 446, 462, 463, 469, 472, 487W, and 488.
2. Students in the Computer Science (COMP_BS) major are required to complete 27 of the 33 credits of 400-level prescribed courses for the major, including the senior capstone course, at Penn State Harrisburg. This is in compliance with Faculty Senate Policy 83-80.5.
3. CMPSC/MATH/STAT electives should be chosen from the following lists:
   - CMPSC 313, 412, 413, 438, 444, 455, 457, 470, 475, 496, 497
   - MATH 401, 411, 412, 425, 430, 431, 435, 445, 449, 450, 455, 465, 468, 496, 497
   - STAT 415, 463

University Requirements and General Education Notes:

US and IL are abbreviations used to designate courses that satisfy Cultural Diversity Requirements (United States and International Cultures).

W, M, X, and Y are the suffixes at the end of a course number used to designate courses that satisfy University Writing Across the Curriculum requirement.

General Education includes Foundations (GWS and GQ), Knowledge Domains (GHW, GN, GA, GH, GS) and Integrative Studies (Inter-domain) requirements. N or Q (Honors) is the suffix at the end of a course number used to help identify an Inter-domain course, but the inter-domain attribute is used to fill audit requirements. Foundations courses (GWS and GQ) require a grade of 'C' or better.

Mathematical Science Course Descriptions (MATH)

Prerequisite chart for

- General Option
- Secondary Education Option

MATH 140 (GQ) — Calculus With Analytic Geometry I (4)
Functions, limits; analytic geometry; derivatives, differentials, applications; integrals, applications. Students may only take one course for credit from MATH 110, 140, 140A, 140B, and 140H.
Prerequisite: MATH 022, MATH 026; or MATH 040 or MATH 041 or satisfactory performance on the mathematics placement examination

MATH 141 (GQ) — Calculus with Analytic Geometry II (4)
Derivatives, integrals, applications; sequences and series; analytic geometry; polar coordinates. Students may take only one course for credit from MATH 141, 141B, and 141H.
Prerequisite: MATH 140, MATH 140A, MATH 140B or MATH 140H

MATH 220 (GQ) — Matrices (2-3)
Systems of linear equations; matrix algebra; eigenvalues and eigenvectors; linear systems of differential equations.
Prerequisite: MATH 110, MATH 140 or MATH 140H

MATH 230 — Calculus and Vector Analysis (4)
Three-dimensional analytic geometry; vectors in space; partial differentiation; double and triple integrals; integral vector calculus. Students who have passed either Math 231 or 232 may not schedule Math 230 or 230H for credit.
Prerequisite: MATH 141 or MATH 141H

MATH 250 — Ordinary Differential Equations (3)
First- and second-order equations; special functions; Laplace transform solutions; higher order equations. Students who have passed MATH 251 may not schedule this course for credit.
Prerequisite: MATH 141

MATH 251 — Ordinary and Partial Differential Equations (4)
First- and second-order equations; special functions; Laplace transform solutions; higher order equations; Fourier series; partial differential equations.
Prerequisite: MATH 141 or MATH 141H

STAT 301 — Statistical Analysis I (3)
Probability concepts; nature of statistical methods; elementary distribution and sampling theory; fundamental ideas relative to estimation and testing hypotheses.
Prerequisite: 3 credits of calculus

MATH 315 — Foundations of Mathematics (3)
A consideration of selected topics in the foundations of mathematics, with emphasis on development of basic meaning and concepts.
Prerequisite: MATH 141

MATH 318 (STAT 318) — Elementary Probability (3)

Combinatorial analysis, axioms of probability, conditional probability and independence, discrete and continuous random variables, expectation, limit theorems, additional topics. Students who have passed either MATH(STAT) 414 or 418 may not schedule this course for credit.
Prerequisite: MATH 141

MATH 401 — Introduction to Analysis I (3)
Review of calculus, properties of real numbers, infinite series, uniform convergence, power series. Students who have passed Math 403 may not schedule this course.
Prerequisite: MATH 230 or MATH 231

MATH 412 — Fourier Series and Partial Differential Equations (3)
Orthogonal systems and Fourier series; derivation and classification of partial differential equations; eigenvalue function method and its applications; additional topics.
Prerequisite: MATH 230; MATH 250 or MATH 251

MATH 421 — Complex Analysis (3)
Infinite sequences and series; algebra and geometry of complex numbers; analytic functions; integration; power series; residue calculus; conformal mapping, applications.
Prerequisite: MATH 230, MATH 232 or MATH 405; MATH 401 or MATH 403

MATH 425 — Introduction to Operations Research (3)
Nature of operations research, problem formulation, model construction, deriving solution from models, allocation problems, general linear allocation problems, inventory problems.
Prerequisite: MATH 141 and MATH 220

MATH 427 — Foundations of Geometry (3)
Euclidean and various non-Euclidean geometries and their development from postulate systems. Students who have passed MATH 427 may not schedule MATH 471.
Prerequisite: MATH 230 or MATH 231

MATH 430 — Linear Algebra and Discrete Models I (3)
Vector spaces, linear transformations, matrices determinants, characteristic values and vectors, systems of linear equations, applications to discrete models.
Prerequisite: MATH 220

MATH 431 — Linear Algebra and Discrete Models II (3)
Vector spaces, linear transformations, matrices, determinants, characteristic values and vectors, systems of linear equations, applications to discrete models.
Prerequisite: MATH 430

MATH 435 — Basic Abstract Algebra (3)
Elementary theory of groups, rings, and fields. Students who have passed MATH 435 may not schedule MATH 470.
Prerequisite: MATH 311W or MATH 315

MATH 449 — Applied Ordinary Differential Equations (3)
Differential and difference equations and their application to biology, chemistry, and physics; techniques in dynamical systems theory.
Prerequisites: MATH 250 or MATH 251

MATH 450 — Mathematical Modeling (3)
Constructing mathematical models of physical phenomena; topics include pendulum motion, polymer fluids, chemical reactions, waves, flight, and chaos.
Prerequisite: either MATH 315 and MATH 430 or MATH 405 or MATH 412

MATH 455 — Introduction to Numerical Analysis I (3)

Floating point computation, numerical rootfinding, interpolation, numerical quadrature, direct methods for linear systems. Students may take only one course for credit from MATH 451 and MATH 455.
Prerequisite: CMPSC 201, CMPSC 202 or CMPSC 121; MATH 220; MATH 230 or MATH 231

MATH 465 — Number Theory (3)

Elements, divisibility of numbers, congruences, residues, and forms.
Prerequisite: MATH 311W

MATH 468 — Mathematical Coding Theory (3)

Shannon's theorem, block codes, linear codes, Hamming codes, Hadamard codes, Golay codes, Reed-Muller codes, bounds on codes, cyclic codes.
Prerequisite: MATH 311W; advanced calculus

MATH 475W — History of Mathematics (3)

A global survey of the history of mathematics as viewed as a human response to cultural, political, economic, and societal pressures.
Prerequisite: MATH 315 or MATH 311W

MATH 496 — Independent Studies (1-18)

Creative projects, including research and design, which are supervised on an individual basis and which fall outside the scope of formal courses.

MATH 497 — Special Topics (1-9)

Formal courses given infrequently to explore, in depth, a comparatively narow subject which may be topical or of special interest.