# Computer Science Major and Minor Curriculum Requirements

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# Contents

# 1 Introduction

The CS Major programme is designed to train students in computational thinking and computer science based epistemology. On the one hand it will expose the students to the argumentative methods in CS: logic, algorithm and process design, optimization, correctness and efficiency, complexity classes, completeness and soundness arguments, automated theorem proving and verification, limits of computation and information, universal computation, data-driven methods of machine learning, language models and data science, security and privacy. On the other hand it will train students in the basics of the practical aspects of computer systems: architecture, operating systems and networking, and data management.

The programme has a strong interdisciplinary focus with opportunities for intergration with both the sciences and the social sciences. The students can do projects in and choose electives from a variety of areas including core computer science, machine learning, security, computer vision and natural language processing, social networking and social graphs, computational finance, weather modelling, healthcare applications, computational biology, and various other aspects of digitalisation and society. The students will also be able to engage with the interdisciplinary centres associated with the department.

This document outlines the curriculum requirements for the following Major, Minor, and Concentration programs in Computer Science.

| Major Options | |
|---|---|
| 1. | 4-year BSc (Hons) in Computer Science (2) |
| 2. | 4-year BSc (Hons) with Research in Computer Science (3) |
| 3. | 3-year BSc in Computer Science (4) |
| **Minor and Concentration Options** | |
| 4. | Minor in Computer Science (5.1) |
| 5. | Minor in Data Science and AI (5.2) |
| 6. | Concentration in Computer Science (5.3) |

# 2 4 Year BSc Hons

The 4-year BSc Hons degree in Computer Science mandates a minimum of 160 credits for completion, ensuring a well-rounded education encompassing both core computer science knowledge and broader academic experiences.

| Total Credits 160 | | | | | |
|---|---|---|---|---|---|
| FC Credits 36 | Major Credits 80 | | Open Credits 38 | Co-curricular Credits 4 | Internship Credits 2 |
| | Core 68 | Electives 12 | | | |
| | Core Courses 64 | Capstone Project 4 | | | |

These credits are classified into 5 categories:

- FC Credits: A total of 36 credits dedicated to foundation courses. See §6.
- Major Credits: A minimum of 80 credits from the Computer Science Department, divided as follows:

- The student must complete 68 credits of CS core courses given in §2.1
- Additionally, students must complete a minimum of 12 credits in CS elective courses. Independent Study Modules offered by CS faculty are eligible as CS electives, with a maximum of 4 credits allowed through ISMs.
- To fulfill the major requirements, students must achieve a minimum grade of "B-" in both CS-1102 and CS-1110.

- Open Credits: The remaining 38 academic credits can be earned by taking courses from any department within the university, including the Computer Science Department.
- Co-curricular: 4 credits.
- Internship: 2 credits.

## 2.1 Computer Science Core for 4 Year BSc Hons

| Code | Course | Credits |
|---|---|---|
| **Basic Science and Maths** | | |
| MAT-2020 | Probability and Statistics | 4 |
| MAT-1001 | Linear Algebra | 4 |
| MAT-1000 | Calculus | 4 |
| BIO-1200/ PHY-1220 | Either Biology primer or Physics primer | 4 |
| **Computational thinking** | | |
| CS-1102 | Introduction to Computer Science | 4 |
| CS-1110 | Discrete Mathematics | 4 |
| CS-2212 | Data Structures and Algorithms | 4 |
| CS-2102 | Programming Laboratory | 2 |
| CS-3210 | Design and Analysis of Algorithms | 4 |
| CS-3410 | Introduction to Machine Learning | 4 |
| CS-3510 | Data Science and Management | 4 |
| CS-3610 | Information Security | 2 |
| CS-3330 | Theory of Computation | 4 |
| CS-3340 | Programming Languages and Translation | 4 |
| **Systems and software** | | |
| CS-2710 | Computer Organisation and System | 4 |
| CS-3710 | Operating Systems | 2 |
| CS-3810 | Design Practices in CS | 4 |
| CS-3620 | Computer Networks | 2 |
| **Capstone Project** | | |
| CS-4998 | Capstone Project | 4 |
| | **Total** | 68 |

### 2.1.1 Capstone Project

The capstone project enables final-year (4th year) students to engage in an in-depth exploration of a topic selected in consultation with their faculty supervisor(s). Conducted under the guidance of a faculty adviser, the project emphasizes implementation, requiring students to design, develop, and demonstrate a functional application or system. The work must be thoroughly documented in a comprehensive technical report.

## 2.2 Example Path for 4 Year BSc Hons.

| Monsoon Semester | Spring Semester |
|---|---|
| **1st Semester** | **2nd Semester** |
| Calculus | Introduction to Computer Science |
| | Discrete Mathematics |
| **3rd Semester** | **4th Semester** |
| Probability and Statistics | Design and Analysis of Algorithms |
| Linear Algebra | Computer Organisation and Systems |
| Data Structures and Algorithms | Computer Networks (2 credits) |
| Programming Laboratory (2 credits) | Information Security (2 credits) |
| **5th Semester** | **6th Semester** |
| Design Practices in CS | Theory of Computation |
| Introduction to Machine Learning | Data Science and Management |
| Operating Systems (2 credits) | Programming Languages and Translation |
| **7th Semester** | **8th Semester** |
| Capstone Project | |
| | |
| ** Incorporate either BIO-1200 or PHY-1220, along with 12 credits of Computer Science electives, into your four-year curriculum in addition to the courses mentioned above | |

# 3 4 Year BSc Hons with Research

The 4-year BSc Hons with Research degree in Computer Science mandates a minimum of 160 credits for completion, ensuring a well-rounded education encompassing both core computer science knowledge and broader academic experiences.

| Total Credits 160 | | | | | |
|---|---|---|---|---|---|
| FC Credits 36 | Major Credits 92 | | Open Credits 26 | Co-curricular Credits 4 | Internship Credits 2 |
| | **Core** 76 | **Electives** 16 | | | |
| | Core Courses 64 | Capstone Thesis 12 | | | |

These credits are classified into 5 categories:

- FC Credits: A total of 36 credits dedicated to foundation courses. See §6.
- Major Credits: A minimum of 92 credits from the Computer Science Department, divided as follows:

  - 64 credits of CS core courses and a 12-credit capstone thesis, as specified in §3.1
  - Additionally, students must complete a minimum of 16 credits in CS elective courses. Independent Study Modules offered by CS faculty are eligible as CS electives, with a maximum of 4 credits allowed through ISMs.
  - To fulfill the major requirements, students must achieve a minimum grade of "B-" in both CS-1102 and CS-1110.

- Open Credits (26): The remaining 26 academic credits can be earned by taking courses from any department within the university, including the Computer Science Department.
- Non-Academic Credits (6): A minimum of 6 non-academic credits. They include
- Co-curricular: 4 credits.
- Internship: 2 credits.

## 3.1 CS Core for 4 Year BSc Hons with Research

| Code | Course | Credits |
|---|---|---|
| **Basic Science and Maths** | | |
| MAT-2020 | Probability and Statistics | 4 |
| MAT-1001 | Linear Algebra | 4 |
| MAT-1000 | Calculus | 4 |
| BIO-1200/ PHY-1220 | Either Biology primer or Physics primer | 4 |
| **Computational thinking** | | |
| CS-1102 | Introduction to Computer Science | 4 |
| CS-1110 | Discrete Mathematics | 4 |
| CS-2212 | Data Structures and Algorithms | 4 |
| CS-2102 | Programming Laboratory | 2 |
| CS-3210 | Design and Analysis of Algorithms | 4 |
| CS-3410 | Introduction to Machine Learning | 4 |
| CS-3510 | Data Science and Management | 4 |
| CS-3610 | Information Security | 2 |
| CS-3330 | Theory of Computation | 4 |
| CS-3340 | Programming Languages and Translation | 4 |
| **Systems and software** | | |
| CS-2710 | Computer Organisation and System | 4 |
| CS-3710 | Operating Systems | 2 |
| CS-3810 | Design Practices in CS | 4 |
| CS-3620 | Computer Networks | 2 |
| **Capstone Thesis** | | |
| CS-4999 | Capstone Thesis | 12 |
| | **Total** | 76 |

### 3.1.1 Capstone Thesis

Enrollment in the Capstone Thesis is based on a screening process that considers a student's performance in the capstone project (CS-4998). Students pursuing a thesis are expected to build upon the goals and milestones established during CS-4998.

They are required to produce a comprehensive dissertation that outlines the problem, includes a thorough literature survey, and presents the key findings or contributions. While the thesis may involve coding and implementation, the primary emphasis is on research.

Upon completion of the thesis, students must deliver an oral presentation summarizing their work and outlining potential directions for future research.

To encourage outstanding work, projects that make a substantial contribution to research or its application will be considered for the Best Thesis Award. Students must submit two copies of the final thesis.

## 3.2  Example Path for 4 Year BSc Hons with Research

| Monsoon Semester | Spring Semester |
|---|---|
| **1st Semester** | **2nd Semester** |
| Calculus | Introduction to Computer Science |
| | Discrete Mathematics |
| **3rd Semester** | **4th Semester** |
| Probability and Statistics | Design and Analysis of Algorithms |
| Linear Algebra | Computer Organisation and Systems |
| Data Structures and Algorithms | Computer Networks (2 credits) |
| Programming Laboratory (2 credits) | Information Security (2 credits) |
| **5th Semester** | **6th Semester** |
| Design Practices in CS | Theory of Computation |
| Introduction to Machine Learning | Data Science and Management |
| Operating Systems (2 credits) | Programming Languages and Translation |
| **7th Semester** | **8th Semester** |
| Capstone Thesis (4 credits) | Capstone Thesis (8 credits) |
| ** Incorporate either BIO-1200 or PHY-1220, along with 16 credits of Computer Science electives, into your four-year curriculum in addition to the courses mentioned above. | |

# 4  3 Year BSc

While the primary degree is a four-year program, students have the option to exit at the end of three years. Those who choose this path are awarded a 3-year B.Sc. Hons. degree in Computer Science, which requires the completion of a minimum of 120 credits.

| Total Credits 120 | | | | |
|---|---|---|---|---|
| FC Credits 36 | CS Credits 60 | Open Credits 18 | Co-curricular Credits 4 | Internship Credits 2 |
| | Core 52    Electives 8 | | | |

These credits are classified into five categories:

- FC Credits: A total of 36 credits dedicated to foundation courses. See §6.
- Major Credits: A minimum of 60 credits from the Computer Science Department, divided as follows:

  - 52 credits of CS core courses, as specified in §4.1
  - Additionally, students must complete a minimum of 8 credits in CS elective courses. Independent Study Modules offered by CS faculty are eligible as CS electives, with a maximum of 4 credits allowed through ISMs.
  - To fulfill the major requirements, students must achieve a minimum grade of "B-" in both CS-1102 and CS-1110.

- The remaining 18 academic credits can be earned by taking courses from any department within the university, including the Computer Science Department.
- Non-Academic Credits: A minimum of 6 non-academic credits. They include
- Co-curricular: 4 credits.
- Internship: 2 credits.

## 4.1 CS Core for 3 Year BSc

| Code | Course | Credits |
|---|---|---|
| **Basic Science and Maths** | | |
| MAT-2020 | Probability and Statistics | 4 |
| MAT-1001 | Linear Algebra | 4 |
| MAT-1000 | Calculus | 4 |
| BIO-1200/ PHY-1220 | Either Biology primer or Physics primer | 4 |
| **Computational thinking** | | |
| CS-1102 | Introduction to Computer Science | 4 |
| CS-1110 | Discrete Mathematics | 4 |
| CS-2212 | Data Structures and Algorithms | 4 |
| CS-2102 | Programming Laboratory | 2 |
| CS-3410 | Introduction to Machine Learning | 4 |
| CS-3510 | Data Science and Management | 4 |
| CS-3610 | Information Security | 2 |
| **Systems and software** | | |
| CS-2710 | Computer Organisation and System | 4 |
| CS-3710 | Operating Systems | 2 |
| CS-3810 | Design Practices in CS | 4 |
| CS-3620 | Computer Networks | 2 |
| | **Total** | 52 |

## 4.2 Example Path for 3 Year BSc

| Monsoon Semester | Spring Semester |
|---|---|
| 1st Semester | 2nd Semester |
| Calculus | Introduction to Computer Science |
| | Discrete Mathematics |
| 3rd Semester | 4th Semester |
| Probability and Statistics | Computer Organisation and Systems |
| Linear Algebra | Computer Networks (2 credits) |
| Data Structures and Algorithms | Information Security (2 credits) |
| Programming Laboratory (2 credits) | |
| 5th Semester | 6th Semester |
| Design Practices in CS | Data Science and Management |
| Introduction to Machine Learning | |
| Operating Systems (2 credits) | |
| ** Incorporate either BIO-1200 or PHY-1220 into your four-year curriculum in addition to the courses mentioned above. | |

# 5 Minors and Concentration in Computer Science

## 5.1 Minor in Computer Science

To obtain a Minor in Computer Science, a student must successfully complete 24 academic credits, typically equivalent to six courses, all offered by the Computer Science department.

The following courses are mandatory:

1. CS-1102: Introduction to Computer Science
2. CS-1110: Discrete Mathematics
3. CS-2212: Data Structures and Algorithms

In addition, students must complete three courses offered by the Computer Science department. ISMs do not count as valid CS electives toward the minor requirements.

## 5.2 Minor in AI and Data Science

To obtain a Minor in Data Science and AI, a student must successfully complete 24 academic credits - typically equivalent to six courses - offered by the Department of Computer Science.

The following courses are mandatory:

| Code | Course | Credits |
|---|---|---|
| CS-1102 | Introduction to Computer Science | 4 |
| CS-1110 | Discrete Mathematics | 4 |
| CS-2212 | Data Structures and Algorithms | 4 |
| CS-3410 | Introduction to Machine Learning | 4 |
| CS-3510 | Data Science and Management | 4 |

In addition, students are required to complete **one additional** course from the AI and ML basket, which currently includes the following: CS-4410 Advanced Machine Learning, CS-4440 Artificial Intelligence, CS-5410 Reinforcement Learning, and CS-5440 Trustworthy AI.

ISMs do not count as valid CS electives toward the minor requirements.

## 5.3 Concentration in Computer Science

To obtain a Concentration in Computer Science, you must successfully complete 16 academic credits, typically equivalent to four courses, all offered by the Computer Science department. The following courses are mandatory:

1. CS-1102: Introduction to Computer Science
2. CS-1110: Discrete Mathematics
3. CS-2212: Data Structures and Algorithms

In addition, you must select one additional course from those offered by the Computer Science department. ISMs are not considered valid CS electives for fulfilling the Concentration requirements.

# 6 Foundation Courses

Ashoka University requires each student to take 9 Foundation Courses. Each of these courses is mandatory.

These courses are not formal gateways into the Major programmes, but distinctive courses that introduce students to the foundations of thought and various styles of thinking, and also to inter- and transdisciplinary approaches.

For more details, visit https://www.ashoka.edu.in/programme/foundation-courses/.

| | Foundation Courses | | |
|---|---|---|---|
| S. No. | Course Code | Credits | Course |
| 1 | | 4 | Introduction to Critical Thinking |
| 2 | | 4 | Great Books |
| 3 | | 4 | Literature and the World |
| 4 | | 4 | Indian Civilizations |
| 5 | | 4 | Environmental Studies |
| 6 | | 4 | Mind and Behaviour |
| 7 | | 4 | Economy, Politics and Society |
| 8 | | 4 | Principles of Science |
| 9 | | 4 | Quantitative Reasoning and Mathematical Thinking |

# 7 Computer Science Curriculum

At the core of the computer science curriculum lie three foundational pillars: *Basic Science and Maths*, *Computational Thinking*, and *System and Software*. These pillars represent the essential aspects of computer science education that every aspiring CS major must master. We have designed our core courses within each of these areas to provide you with a strong and well-rounded foundation in computer science. Beyond the core courses, the department also offer a wide range of elective courses - spanning various knowledge areas of computer science education.

## 7.1 Computer Science Core Courses

| Course Code | Credits | Course |
|---|---|---|
| **Basic Science and Mathematics** | | |
| MAT-2020/ CS-1209/ PHY-1208 or MAT-2020/ CS-1209 | 4 | Probability and Statistics |
| MAT-1001/ CS-2210 or MAT-1001/ CS-2210/ PHY-1001 | 4 | Linear Algebra |
| MAT-1000 | 4 | Calculus |
| BIO-1200 | 4 | Biology Primer |
| PHY-1220 | 4 | Physics Primer |
| **Computational Thinking** | | |
| CS-1102 | 4 | Introduction to Computer Science |
| CS-1110 | 4 | Discrete Mathematics |
| CS-2212 | 4 | Data Structures and Algorithms |
| CS-2102 | 2 | Programming Laboratory |
| CS-3210 | 4 | Design and Analysis of Algorithms |
| CS-3410 | 4 | Introduction to Machine Learning |
| CS-3510 | 4 | Data Science and Management |
| CS-3610 | 2 | Information Security |
| CS-3330 | 4 | Theory of Computation |
| CS-3340 | 4 | Programming Languages and Translation |
| **Systems and Software** | | |
| CS-2710 | 4 | Computer Organisation and System |
| CS-3710 | 2 | Operating Systems |
| CS-3810 | 4 | Design Practices in CS |
| CS-3620 | 2 | Computer Networks |

**Credit Hours and Student Workload**

4 credits typically correspond to 4 contact hours per week - 3 hours of lectures and 1 hour of either a discussion session or office hour. In addition, students are expected to spend about 2

hours per credit per week on independent study outside of class.

**Course Code Numbering Scheme**

Each Computer Science course follows a structured numbering scheme to indicate its level and area:

- **First Digit:** Reflects the typical year of study when the course should be taken. Courses numbered 1xxx are first-year courses, 2xxx are second-year courses, and so on.

- Courses numbered **5xxx and beyond** are primarily for graduate-level study.

- Some **4xxx courses** may also be cross-listed as graduate-level courses, allowing both advanced undergraduate and graduate students to enroll.

- **Second Digit:** Represents the broad knowledge area within Computer Science (e.g., theory, systems, artificial intelligence, etc.).

- **Third and Fourth Digits:** Primarily serve to distinguish courses within the same category and resolve numbering conflicts.

## 7.2 Computer Science Electives

The following is a non-exhaustive list of Computer Science elective courses that are regularly offered.

| S. No. | Course Code | Course |
|---|---|---|
| 1 | Digitalization and Privacy | CS-4101 |
| 2 | The New Geography of the Information Age | CS-4110 |
| 3 | Special Topics in Media Analysis | CS-4111 |
| 4 | Numerical Algorithms and Optimization | CS-4220 |
| 5 | Graph Algorithms | CS-4230 |
| 6 | Advanced Machine Learning | CS-4410 |
| 7 | Natural Language Processing - Theory and Applications | CS-4420 |
| 8 | Computer Vision | CS-4430 |
| 9 | Artificial Intelligence | CS-4440 |
| 10 | Introduction to Quantitative Finance | CS-4520 |
| 11 | Cryptography and Network Security | CS-4620 |
| 12 | Information and Coding Theory | CS-4621 |
| 13 | Computing in the Cloud | CS-4622 |
| 14 | Operating Systems | CS-4710 |
| 15 | Computer Graphics and Computational Imaging | CS-4910 |
| 16 | Signalling Games of Social Networks | CS-4911 |
| 17 | Randomised Algorithms | CS-5210 |
| 18 | Advanced Algorithms | CS-5211 |
| 19 | Symbolic Logic and Applications | CS-5310 |
| 20 | Reinforcement Learning | CS-5410 |
| 21 | Trustworthy AI | CS-5440 |

## 7.3   Core Courses Prerequisites in Computer Science

| Course | Pre-requisistes |
|---|---|
| **Basic Science and Mathematics** | |
| MAT-2020/ CS-1209/ PHY-1208 or MAT-2020/ CS-1209 | |
| MAT-1001/ CS-2210 or MAT-1001/ CS-2210/ PHY-1001 | |
| MAT-1000 | |
| BIO-1200 | |
| PHY-1220 | |
| **Computational Thinking** | |
| CS-1102 Introduction to Computer Science | Mathematics in Grades XI and XII. Alternatively, a minimum of B grade in MAT-1000 |
| CS-1110 Discrete Mathematics | Mathematics in Grades XI and XII. Alternatively, a minimum of B grade in MAT-1000 |
| CS-2212 Data Structures and Algorithms | CS-1102, CS-1110 |
| CS-2102 Programming Laboratory | CS-1102, CS-1110 |
| CS-3210 Design and Analysis of Algorithms | CS-2212 |
| CS-3410 Introduction to Machine Learning | CS-2212, MAT-2020/ CS-1209/ PHY-1208 or MAT-2020/ CS-1209, MAT-1001/ CS-2210 or MAT-1001/ CS-2210/ PHY-1001 |
| CS-3510 Data Science and Management | CS-2212, CS-3410 |
| CS-3610 Information Security | CS-2212 |
| CS-3330 Theory of Computation | CS-2212 |
| CS-3340 Programming Languages and Translation | CS-2212 |
| **Systems and Software** | |
| CS-2710 Computer Organisation and System | CS-1102 |
| CS-3710 Operating Systems | CS-2212, CS-2710 |
| CS-3810 Design Practices in CS | CS-2212, CS-2710 |
| CS-3620 Computer Networks | CS-2212 |