



International Institute of Information Technology Bangalore

Curriculum Document

B.Tech. in Data Science and Artificial Intelligence
B.Tech. (Hons) in Data Science and Artificial Intelligence
Batch 2024 - 2028

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1 About IIIT Bangalore

International Institute of Information Technology Bangalore (IIIT-B) is a Deemed to be University founded in 1998. The Vision of IIIT-B is to **build on the track record set by India in general and Bangalore in particular, to enable India to play a key role in the global IT scenario through a world-class institute with a focus on education and research, entrepreneurship and innovation.**

IIIT-B mission is to contribute significantly to Information Technology for transforming the lives of individuals and society, and efficient conduct of sustainable businesses, social enterprises and Governments. The three pillars that help IIIT-B be at the forefront of Computing Education in the country are:

Education

- Undergraduate, Post Graduate, PhD, PG Diploma, Certification Programmes

Research

- Spans across all areas of computing cutting across 7 research domains

Innovation and Entrepreneurship

- Promoting entrepreneurship and start-ups through various initiatives

2 Curriculum Design Principles

The field of computing has evolved considerably in the last few years with both the science and technology advancing at unprecedented pace. The technologies and underlying computing systems have also evolved, considerably improving the ease-of-implementation of some of the tasks that earlier took much more training and experience. These changes require engineering pedagogy ought to suitably adapt – to reflect the changed nature of the discipline, as well as to update courses with the more recent technology platforms.

IIIT Bangalore has adopted the following key guiding principles in design of this curriculum:

- The focus of curriculum design is the 4-year BE/B Tech program benchmarked against the best institutions of the country
- Exercise the flexibility offered by AICTE curriculum guidelines to enable the students to fully benefit from high quality faculty and world-class lab and research infrastructure available at IIIT-B
- Motivate fast learners and high performers by giving them the option to obtain deep expertise leading to the award of **Honours with a specialization** OR explore auxiliary areas leading to the award of **Minor in another department**
- Introduce discipline courses early in order to provide exposure to skill-oriented courses like programming early in the scheme of study. This early exposure to discipline courses provides the students with more time to absorb and develop a strong foundation

3 Graduate Attributes

Curriculum of a program is finally a network of credit units – courses (core, disciplinary core, disciplinary elective, open), internships, practice, projects, etc. which help achieve program goals. Program goals can be stated as attributes the students should possess on graduation, i.e. statements about the learning, values, capabilities etc. of graduates. These are called Graduate Attributes (GAs). A program typically has:

- **General GAs:** which are often common across many similar programs (e.g. B Techs) and focus on generalized skills and capabilities in the graduate.
- **Discipline GAs:** are discipline specific attributes, which focus on understanding of different concepts and systems related to the discipline, and on competencies and skills in that discipline.

Together the GAs define the goals of the program. The aim of IIT-B's curriculum design is to evolve a curriculum that can develop in students the stated graduate attributes. While specifying the GAs and designing a curriculum for it, a basic constraint is kept in mind: a full B Tech program has 8 semesters, each with about 5 full courses. GAs should specify only what can be taught and absorbed in this time box

Desired Graduate Attributes for the B.Tech. program adopted from AICTE model curriculum document are given below. The curriculum design focuses more on delivering the discipline GAs, while strengthening the general GAs, where possible. GAs should be read by adding this at the start of each: **“At graduation time, a student should have...”**:

General Graduate Attributes
G1 Ability to identify a problem, analyse using design thinking techniques, and evolve innovative approaches for solving it.
G2 Ability to apply mathematical concepts and techniques in problem solving.
G3 Ability to function effectively in multi-cultural teams to accomplish a common goal.
G4 Ability to communicate effectively with a wide range of audience.
G5 Ability to self-learn and engage in life-long learning and upgrade technical skills
G6 An understanding of professional and ethical responsibility
G7 Ability to undertake small research tasks and projects.
G8 An entrepreneurial mind set for opportunities using technology and innovations.
G9 An understanding of impact of solutions on economic, societal, and environment context.
G10 Strong emotional intelligence, human and cultural values

4 General Norms for B.Tech. Programmes

This section elaborates on the common norms applicable across all B.Tech. programmes offered by IIIT-B.

4.1 Programme Outcomes

Following are the Programme Outcomes (POs) of the IIIT-B B.Tech. Programmes.

- PO1. Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- PO2. Problem Analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.
- PO3. Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- PO4. Conduct Investigations of Complex problems:** Use research-based knowledge and research methods, including the design of experiments, analysis, and interpretation of data, and synthesis of the information to provide valid conclusions.
- PO5. Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
- PO6. The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- PO7. Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- PO8. Ethics:** Apply ethical principles and commit to professional ethics and responsibilities, and norms of the engineering practice
- PO9. Individual and Teamwork:** Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.
- PO10. Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-Long Learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning (LLL) in the broadest context of technological change.

PO13. Research and Development: Independently carry out research /investigation and development work to solve practical problems.

4.2 Credit System

All courses in the curriculum have credits allocated to them. The credit definition follows the L:T:P:C system where L (Lecture) indicates the number of credit hours under Lecture category, T (Tutorial) indicates the number credit hours under Tutorial category, P (Practical) indicates the number of credit hours under the Practical category, and C (Credits) indicates the total credits associated as a combination of Lecture hours, Tutorial hours and Practical hours. **One** credit hour under “L” and “T” translates into **one** hour of instruction. **One** credit hour under “P” translates into **two** hours of instruction.

Grading System

IIIT-B follows a 4-point credit system for all programmes. Every student’s academic performance is measured using Cumulative Grade Point Average (CGPA) which can take the values between 0.00 and 4.00 (inclusive). The CGPA is calculated as a weighted average of student’s grade and the credits associated with the courses completed by the student.

Following table shows the number grade points associated with each letter grade:

Letter Grade	Grade Points
A	4.00
A-	3.70
B+	3.40
B	3.00
B-	2.70
C+	2.40
C	2.00
D	1.00
F	0.00
S	Grade points not applicable
X	Grade points not applicable

4.3 Course Categories

All programmes at IIIT Bangalore follow Choice-Based-Credit-System (CBCS) as recommended by AICTE. CBCS allows students to exercise their choice in selecting elective courses as per their interest. The different categories of courses included in the IIIT-B curriculum is given in the following table.

S. No.	Course Category	Description
1.	Engineering Core	General Core courses are those that considered to be foundational to all B.Tech. programmes and are compulsory for all students enrolled in B.Tech. programmes.
2.	Branch Core	Branch Core courses are considered to be foundational in nature to a particular branch of student (e.g., DSAI). Branch Core courses are compulsory for all students who are pursuing B.Tech. in that particular branch.
3.	Elective	Under the Choice Based Curriculum System, students are given the choice to enrol in multiple courses as per their preference. Such courses are called Electives. The curriculum specifies the minimum number of electives students are expected to complete.
4.	Branch Elective	Branch Electives constitute the set of elective courses that are specific to their Branch (e.g., specific to DSAI branch). Students are expected to enrol in a specified number of Branch Electives as part of the curriculum.
5.	Open Elective	Open Electives are those courses that are open to students belonging to all the Departments provided the necessary course pre-requisites are satisfied.
6.	Project Elective (PE)	Project Elective (PE) is a special type of elective intended to give experiential learning for the student by giving them an opportunity to work on a project under the guidance of a faculty member.
7.	Reading Elective (RE)	Reading Elective (RE) is a special type of elective intended to give research-orientation for the student by giving them an opportunity to do systematic study of a research area under the guidance of a faculty member.
8.	Internship	Internship refers to credits earned through extended project work taken up in the industry or other academic institutions either within India or outside India. Specified number of internship credits are mandatory for all students.

4.4 Multi-Disciplinary Courses

In line with the recommendations of NEP 2020, the IIIT-B B.Tech. Curriculum includes provisions for students to pursue courses from multiple disciplines. In addition to formal courses, avenues to pursue it in extra-curricular are also provided. The following table lists the various disciplines that are covered as part of the B.Tech. Curriculum.

S. No.	Discipline	Details
1.	Engineering	Courses in Computer Science, Electronics, Communication, Data Science, Robotics and Artificial Intelligence areas of Engineering.
2.	Humanities and Social Science (HSS)	Courses in English, Communication, Economics, Digital Society, Product Management, Ethics
3.	Creative Arts	Workshops conducted by Theater Club, Music Club, Art Club
4.	Indian Knowledge Systems (IKS)	Courses in Yoga and related areas
5.	Healthcare	Project Elective courses covering Assistive Technologies for visually impaired, mobility impaired, and mental health

5 Other Common Courses

Apart from the above courses from Engineering curriculum, the students also need to compulsorily pass other non-credit general courses as specified in the following tables.

5.1 Physical Education

Course Name	Credits
Physical Education 1	0
Physical Education 2	0

5.2 Value Added Learning Program (VALP)

In order to develop a well-rounded perspective above and beyond the Engineering curriculum, students are expected to enrol in courses listed under the Value-Added Learning Programme (VALP) announced from time to time.

The following non-credit courses as mandated by AICTE would be conducted under VALP

Course Name	Credits
Induction Program	0
Environmental Sciences	0
Indian Constitution	0
Essence of Indian Knowledge Systems	0

Students can also choose from additional courses in Music, Art, Dance, Life Skills, etc. announced from time to time.

VALP courses may be provided via on-campus programmes or through MOOCs.

6 Degree Variants

The curriculum of IIT Bangalore supports three variants that the students can opt for depending upon their interest and capabilities. The variants have been carefully designed to allow the student to develop into a well-rounded professional with expert guidance from experienced faculty. This section elaborates the three main variants of the B.Tech. Degree that students can choose to pursue.

6.1 Variant #1 - B.Tech. in one of the branches

Every student who gets admission to the B.Tech. programme at IIT Bangalore is automatically eligible to pursue and obtain a Degree in Bachelor of Technology in the branch to which the student has been given admission.

The curriculum requirements for this default variant is self-contained and meets all the norms for the award of B.Tech. degree and achieving the PO, PSO, and CO associated with the programme.

6.2 Variant #2 – B.Tech. (Honours)

Students who are fast learners are given an opportunity to graduate with B.Tech. (Honours) if they do a specified number of **extra courses** AND maintain a **high CGPA** as per the norms specified in the curriculum. Students graduating with B.Tech. (Honours) have the opportunity to showcase their deep knowledge in one of the areas of specialization with-in the students' branch of study.

6.3 Variant #3 – B.Tech. with Minor

Students who are desirous of expanding their knowledge and skills may choose to pursue a Minor by doing the requisite number of **extra courses** from a Department other than their own Department or Branch. Students graduating with B.Tech. with Minor have the opportunity expand their breadth of knowledge across multiple branches of study.

7 Detailed Curriculum for B.Tech. in DSAI

7.1 Programme Specific Outcomes (PSO)

PSO1. Collect, curate, store, and manage large volumes of data systems for the purpose of analysing the data using scientific approaches

PSO2. Identify, formally model, define, solve and deploy computing solutions built using the principles of Data Science, Artificial Intelligence, Machine Learning and other related approaches.

7.2 Curricular Structure

This section and subsequent sections describe the curriculum for the proposed undergraduate B. Tech. (Bachelor of Technology) program in DSAI (Data Science and Artificial Intelligence). The sections detail the overall program structure, total credits with a semester-wise break-up of the credits and a break-up of the credits with reference to the various groups of core and elective courses.

Table 1. Overall B. Tech. Programme Structure (minimum 150 credits)

Semester 1 (15 weeks)	22 credits ● 6 core courses
Semester 2 (15 weeks)	20 credits ● 5 core courses
Semester 3 (15 weeks)	24 credits ● 6 core courses
Semester 4 (15 weeks)	20 credits ● 5 core courses
Semester 5 (15 weeks)	20 credits ● 5 core courses
Semester 6 (15 weeks)	16 credits ● 4 electives
Semester 7 (15 weeks)	20 credits ● 5 electives
Semester 8 (15 weeks)	12 credits ● Project/Internship/Thesis

The course credits earned over 8 semesters are grouped into the following categories:

- Humanities and Social Sciences (HSS)
- Mathematics and Basic Sciences (MBS)
- Systems (Sys)
- Eng. Core (EC)
- DSAI Core
- General Electives
- Bachelor's Thesis/Project/Internship

The break-up of credits under each category is in the table below. The courses under each category are in the tables that follow.

Data Science Artificial Intelligence (DSAI)	
Heads	Credits
Humanities and Social Sciences (HSS)	16
Mathematics and Basic Sciences	20
Systems (Sys)	12

Eng. Core (EC)	22
DSAI Core	40
General Electives	32
Internship/Bachelor's Thesis/Project	12
Total	154

Table 2: Category-wise Distribution

8 Category-wise Course Listing

8.1 Humanities and Social Sciences (HSS)

The courses under this category are listed in the following table

Course Name	Credits	L:T:P:C
Economics	4	3:1:0:4
English	2	2:0:0:2
Technical Communication	2	2:0:0:2
AI Ethics	4	3:1:0:4
Data and Society	4	3:1:0:4

Table 5: HSS

8.2 Mathematics and Basic Sciences (MBS)

The following table lists the courses under this category.

Course Name	Credits	L:T:P:C
Math 1 (Calculus and Differential Equations)	4	3:1:0:4
Math 2 (Probability and Random Processes)	4	3:1:0:4
Math 3 (Linear Algebra)	4	3:1:0:4
Math 4 (Optimization)	4	3:1:0:4
Physics - 1	4	3:1:0:4

Table 6: Mathematics and Basic Sciences

8.3 Systems

Course Name	Credits	L:T:P:C
Introduction to Computer Architecture and Operating Systems	4	3:1:0:4
Database Systems	4	3:1:0:4
Signals and Systems	4	3:1:0:4

8.4 Engineering Core

The following table contains the courses under the category of core courses exclusive to DSAI.

Eng. Core Course Name	Credits	L:T:P:C
C and Python	4	2:0:4:4
Data Structures and Algorithms	4	3:1:0:4
Data Structures Lab	2	0:2:0:2
Discrete Math	4	3:1:0:4
Statistics for Data Science	4	2:0:4:4
Design and Analysis of Algorithms	4	3:1:0:4

8.5 DSAI Core

The following table contains the courses under the category of core courses exclusive to DSAI.

DSAI Core Course Name	Credits	L:T:P:C
Statistical Machine Learning	4	3:1:0:4
Foundations of AI	4	3:1:0:4
Neural Networks and Deep Learning	4	3:1:0:4
ML Production Engineering	4	3:1:0:4
Computational Learning Theory	4	3:1:0:4
Advanced Deep Learning	4	3:1:0:4
Big data Systems	4	3:1:0:4
Data Modeling	4	3:1:0:4
Reinforcement Learning	4	3:1:0:4

Data Visualization	4	3:1:0:4
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Table 5 : DSAI Core

8.6 Electives and Branch Electives

Apart from the courses specified in the previous sections, DSAI students need to take **at least 8** elective courses, each carrying 4 credits. While students are given the flexibility to choose their electives from various departments, out of the 8 electives, 2 electives will be considered as DSAI branch electives (BE) and these must be chosen from the pool of DSAI electives only.

The students can plan their electives starting from the 6th semester to the 7th semester. The elective courses can be spanned across various departments.

8.7 Project and Reading Electives

A project elective (PE) is a special type of 4-credit elective, where a student registers for a semester-long project under the supervision of a faculty member and is graded based on the project delivered. PEs are intended to provide hands-on experiential learning and are suitable for those who want to gain employable skills.

Similarly, a reading elective (RE) is a special type of 4-credit elective, where a student registers under a faculty member for some advanced-level research topic. Typically, the student will be provided some research material to read and present (for example, a set of research papers or some chapters from a research monogram) and the student is graded based on how well the student has understood and presented the material. REs are intended to provide the necessary skills for carrying out research and are suitable for those who want to pursue research by writing a Thesis.

Note that PEs and Res are **optional**. A **maximum** of 2 PE/RE can be taken by a student throughout their entire programme. Note that PE and RE **do not** count towards branch electives.

8.8 Bachelor's Project / Thesis / Internship

A student can do either a 12-credit B.Tech project or a 12-credit thesis under the supervision of a faculty member at IITB during their 8th semester. Alternatively, students also have an option to do a 12-credit internship during their 8th semester.

9 B.Tech. (Hons.) in DSAI

B.Tech. students who are fast learners and having a good CGPA are encouraged to take the path towards graduating with B.Tech. Honours in DSAI. The Degree will be titled B.Tech. (Hons.) in DSAI.

Students need to meet the following requirements for graduating with B.Tech. (Hons.) in DSAI:

- Earn 20 additional credits in one of the areas of specialization in DSAI
- Have a CGPA of 3.5 or above out of 4.0 at the time of graduation

The additional credits can be earned to specialize in one of the following listed domains.

- DSAI Algorithms

- DSAI in Data Domains (e.g., NLP, Vision)

To get a specialization, a student must earn an additional 20 credits in that specific domain by doing **additional** elective courses offered in that domain. Note that a **maximum** of 2 PE/PE can be counted for getting a specialization. Moreover, these additional electives must be **different** from the branch electives.

<u>DSAI Algos</u>	<u>DSAI in data domains</u>
Algorithms for uncertainty	NLP
Multiagent Systems	Visual Recognition
Bayesian Methods & PGM	Adv. Data Visualization
Neurosymbolic AI	Generative AI for Vision
Few-shot learning	Recommendation Systems
Self-supervised learning	Geo Information Systems
Networks and Semantics	Generative AI for NLP
Quantum Computation and Machine Learning	3D Vision
	Spatio-Temporal Data analytics

The above lists of areas for specialization are subject to changes and refinements from time to time. Also, note that students can complete B.Tech. (DSAI) programme **without** the requirement of doing any specialization towards obtaining a Honours degree.

10 B.Tech. (DSAI) with Minor

B.Tech. (DSAI) students can obtain breadth of knowledge by doing a minor in a non-CSE area by completing an **additional** 20 credits from any other Department. The Minor could be in one of the following listed areas.

- VLSI (VLSI Systems) offered by Department of ECE
- SSY (Software Systems) offered by Department of CSE
- TCS (Theoretical Computer Science) offered by Department of CSE
- DT (Digital Society) offered by Department of Digital Humanities and Societal Systems (DHSS).

Note that a **maximum** of 2 PE/RE can be counted for getting a Minor.

The above lists of areas for minor are subject to changes and refinements from time to time. Also, note that students can complete B.Tech. (DSAI) programme **without** the requirement of doing a Minor.

11 Course Sequencing for BTech (DSAI)

The tentative course sequencing for the DSAI branch is given in the following table. The Department may choose to fine-tune the sequencing from time to time.

Course Name	Credits	Course Category
SEMESTER 1	20	
Math-1 (Calculus and Differential Equations)	4	Mathematics and Basic Sciences
Math-2 (Probability & Random Processes)	4	Mathematics and Basic Sciences
Introduction to Computer Architecture and Operating Systems	4	Systems
Programming IA (C)	2	Eng. Core
Programming IB (Python)	2	Eng. Core
English	2	Humanities and Social Sciences
Economics-1	2	Humanities and Social Sciences
Physical Education-1	0	Others
SEMESTER 2	24	
Math-3 (Linear Algebra)	4	Mathematics and Basic Sciences
Statistical Machine Learning	4	Data Science Artificial Intelligence Core
Data Structures and Algorithms	4	Eng. Core
Data Structures Lab	2	Eng. Core
Database systems (Theory)	3	CSE Core
Database systems (Lab)	1	CSE Core
Statistics for Data Science	4	Eng. Core
Economics-2	2	Humanities and Social Sciences
Physical Education-2	0	Others
SEMESTER 3	24	
Foundations of AI	4	Data Science Artificial Intelligence Core
Neural Networks and Deep Learning	4	Data Science Artificial Intelligence Core
Math-4 (Optimization)	4	Mathematics and Basic Sciences
Physics-1	4	Mathematics and Basic Sciences
Signals and Systems	4	Systems
Discrete Math	4	Eng. Core
SEMESTER 4	22	
Design and Analysis of Algorithms	4	Eng. Core
Data and Society	4	Humanities and Social Sciences
Data Modeling	4	Data Science Artificial Intelligence Core
Advanced Deep Learning	4	Data Science Artificial Intelligence Core
Data Visualization	4	Data Science Artificial Intelligence Core

Course Name	Credits	Course Category
Technical Communication	2	Humanities and Social Sciences
SEMESTER 5	20	
Computational Learning Theory	4	Data Science Artificial Intelligence Core
Reinforcement Learning	4	Data Science Artificial Intelligence Core
AI Ethics	4	Humanities and Social Sciences
Big data Systems	4	Data Science Artificial Intelligence Core
ML Production Engineering	4	Data Science Artificial Intelligence Core
SEMESTER 6	16	
Elective – 1	4	Elective
Elective – 2	4	Elective
Elective – 3	4	Elective
Elective – 4	4	Elective
SEMESTER 7	16	
Elective – 5	4	Elective
Elective – 6	4	Elective
Elective – 7	4	Elective
Elective – 8	4	Elective
SEMESTER 8	16	
B.Tech. Project / Thesis / Internship	16	Project/Thesis/Internship

Table 8: Course Sequencing for B.Tech (DSAI)

(1 Humanities and Social Science Elective course needs to be completed by the student in any semester starting from the 4th semester to the 7th semester as a graduation requirement)